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INTERNATIONAL TELECOMMUNICATION UNION

CCIR

INTERNATIONAL
RADIO CONSULTATIVE
COMMITTEE

RECOMMENDATIONS AND REPORTS OF THE CCIR, 1986

(ALSO QUESTIONS, STUDY PROGRAMMES,
RESOLUTIONS, OPINIONS AND DECISIONS)

XVIth PLENARY ASSEMBLY
DUBROVNIK, 1986

VOLUME XI – PART 1

BROADCASTING SERVICE (TELEVISION)



Geneva, 1986

CCIR

1. The International Radio Consultative Committee (CCIR) is the permanent organ of the International Telecommunication Union responsible under the International Telecommunication Convention "... to study technical and operating questions relating specifically to radiocommunications without limit of frequency range, and to issue recommendations on them..." (International Telecommunication Convention, Nairobi 1982, First Part, Chapter I, Art. 11, No. 83).

2. The objectives of the CCIR are in particular:

- a) to provide the technical bases for use by administrative radio conferences and radiocommunication services for efficient utilization of the radio-frequency spectrum and the geostationary-satellite orbit, bearing in mind the needs of the various radio services;
- b) to recommend performance standards for radio systems and technical arrangements which assure their effective and compatible interworking in international telecommunications;
- c) to collect, exchange, analyze and disseminate technical information resulting from studies by the CCIR, and other information available, for the development, planning and operation of radio systems, including any necessary special measures required to facilitate the use of such information in developing countries.



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XVith PLENARY ASSEMBLY
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**PLAN OF VOLUMES I TO XIV
XVITH PLENARY ASSEMBLY OF THE CCIR**

(Dubrovnik, 1986)

VOLUME I	Spectrum utilization and monitoring.
VOLUME II	Space research and radioastronomy.
VOLUME III	Fixed service at frequencies below about 30 MHz.
VOLUME IV-1	Fixed-satellite service.
VOLUMES IV/IX-2	Frequency sharing and coordination between systems in the fixed-satellite service and radio-relay systems.
VOLUME V	Propagation in non-ionized media.
VOLUME VI	Propagation in ionized media.
VOLUME VII	Standard frequencies and time signals.
VOLUME VIII-1	Land mobile service. Amateur service. Amateur-satellite service.
VOLUME VIII-2	Maritime mobile service.
VOLUME VIII-3	Mobile satellite services (aeronautical, land, maritime, mobile and radiodetermination). Aeronautical mobile service.
VOLUME IX-1	Fixed service using radio-relay systems.
VOLUME X-1	Broadcasting service (sound).
VOLUMES X/XI-2	Broadcasting-satellite service (sound and television).
VOLUMES X/XI-3	Sound and television recording.
VOLUME XI-1	Broadcasting service (television).
VOLUME XII	Transmission of sound broadcasting and television signals over long distances (CMTT).
VOLUME XIII	Vocabulary (CMV).
VOLUME XIV-1	Information concerning the XVith Plenary Assembly: Minutes of the Plenary Sessions. Administrative texts. Structure of the CCIR. Lists of CCIR texts.
VOLUME XIV-2	Alphabetical index of technical terms appearing in Volumes I to XIII.

All references within the texts to CCIR Recommendations, Reports, Resolutions, Opinions, Decisions, Questions and Study Programmes refer to the 1986 edition, unless otherwise noted; i.e., only the basic number is shown.

DISTRIBUTION OF TEXTS OF THE XVITH PLENARY ASSEMBLY OF THE CCIR IN VOLUMES I TO XIV

Volumes I to XIV, XVIth Plenary Assembly, contain all the valid texts of the CCIR and succeed those of the XVth Plenary Assembly, Geneva, 1982.

1. **Récommendations, Reports, Resolutions, Opinions, Decisions**

1.1 *Numbering of these texts*

Recommendations, Reports, Résolutions and Opinions are numbered according to the system in force since the Xth Plenary Assembly.

In conformity with the decisions of the XIth Plenary Assembly, when one of these texts is modified, it retains its number to which is added a dash and a figure indicating how many revisions have been made. For example, Recommendation 253 indicates the original text is still current; Recommendation 253-1 indicates that the current text has been once modified from the original. Recommendation 253-2 indicates that there have been two successive modifications of the original text, and so on. Within the text of Recommendations, Reports, Resolutions, Opinions and Decisions, however, reference is made only to the basic number (for example Recommendation 253). Such a reference should be interpreted as a reference to the latest version of the text, unless otherwise indicated.

The tables which follow show only the original numbering of the current texts, without any indication of successive modifications that may have occurred. For further information about this numbering scheme, please refer to Volume XIV-1.

1.2 *Recommendations*

Number	Volume	Number	Volume	Number	Volume
48	X-1	367	II	478	VIII-1
80	X-1	368-370	V	479	II
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139	X-1	374-376	VII	481-484	IV-1
162	III	377, 378	I	485, 486	VII
182	I	380-393	IX-1	487-493	VIII-2
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218, 219	VIII-2	407, 408	X/XI-3	497	IX-1
239	I	410-412	X-1	498	X-1
240	III	414, 415	X-1	500	XI-1
246	III	417	XI-1	501	X/XI-3
257	VIII-2	419	XI-1	502, 503	XII
265	X/XI-3	428	VIII-2	505	XII
266	XI-1	430, 431	XIII	508	I
268	IX-1	433	I	509, 510	II
270	IX-1	434, 435	VI	513-517	II
275, 276	IX-1	436	III	518-520	III
283	IX-1	439	VIII-2	521-524	IV-1
290	IX-1	441	VIII-3	525-530	V
302	IX-1	443	I	531-534	VI
305, 306	IX-1	444	IX-1	535-538	VII
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328, 329	I	457, 458	VII	555-557	IX-1
331, 332	I	460	VII	558	IV/IX-2
335, 336	III	461	XIII	559-562	X-1
337	I	463	IX-1	564	X/XI-3
338, 339	III	464-466	IV-1	565	XI-1
341	V	467, 468	X-1	566	X/XI-2
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362-364	II	475, 476	VIII-2	576-578	II

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1.2 Recommendations (cont.)

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581	V	609-611	II	643-644	X-1
582, 583	VII	612, 613	III	645	X-1 + XII
584	VIII-1	614	IV-1	646-647	X-1
589	VIII-2	615	IV/IX-2	648, 649	X/XI-3
591	VIII-3	616-620	V	650-652	X/XI-2
592-596	IX-1	621	VI	653-656	XI-1
597-599	X-1	622-624	VIII-1	657	X/XI-3
600	X/XI-2	625-631	VIII-2	658-661	XII
601	XI-1	632-633	VIII-3	662-666	XIII
602	X/XI-3	634-637	IX		
603-606	XII	638-641	X-1		

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32	X-1	322	VI ⁽¹⁾	493	XII
109	III	324	I	496, 497	XII
111	III	327	III	499	VIII-1
122	XI-1	336	V	500-501	VIII-2
137	IX-1	338	V	509	VIII-3
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181	I	342	VI	518	VII
183	III	345	III	519-522	I
184	I	347	III	524-526	I
195	III	349	III	528	I
197	III	354-357	III	530	I
200	III	358	VIII-1	533, 534	I
203	III	363, 364	VII	535, 536	II
204, 205	IV-1	371, 372	I	536-541	II
208	IV-1	374-376	IX-1	542	VIII-1
209	IV/IX-2	378-380	IX-1	543	II
212	IV-1	382	IV/IX-2	546	II
214	IV-1	383-385	IV-1	548	II
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224	II	393	IV/IX-2	562-565	V
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238, 239	V	409	XI-1	574, 575	VI
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⁽¹⁾ Published separately.

1.3 *Reports (cont.)*

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672-685	II	800	X/XI-3	951-955	X/XI-2
687	II	801, 802	XI-1	956	XI-1
692-697	II	803	X/XI-3	958, 959	XI-1
699, 700	II	804, 805	XI-1	961, 962	XI-1
701-704	III	807-812	X/XI-2	963, 964	X/XI-3
706, 707	IV-1	814	X/XI-2	965-970	XII
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743, 744	VIII-2	879-880	V	1016, 1017	VII
747-749	VIII-2	882-885	V	1018-1025	VIII
751	VIII-3	886-895	VI	1026-1044	VIII-2
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778	VIII-1	925-929	VIII-3	1077-1089	XI-1
779-789	IX-1	930-934	IX-1	1090-1096	XII
790-793	IV/IX-2	936-942	IX-1		

1.3.1 *Note concerning Reports*

The individual footnote "Adopted unanimously" has been dropped from each Report. Reports in this Volume have been adopted unanimously except in cases where reservations have been made which will appear as individual footnotes.

1.4 *Resolutions*

Number	Volume	Number	Volume	Number	Volume
4	VI	61	XIV-1	76	X-1
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15	I	63	VI	79-83	XIV-1
20	VIII-1	64	X-1	86, 87	XIV-1
23	XIII	66	XIII	88	I
24	XIV-1	71	I	89	XIII
26, 27	XIV-1	72, 73	V	90-95	XIV-1
33	XIV-1	74	VI	96	XI-1
39	XIV-1				

1.5 *Opinions*

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11	I	45, 46	VI	73	VIII-1
14	IX-1	49	VIII-1	74	X-1
15	X-1	50	IX-1	75	XI-1
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26-28	VII	59	X-1	82	VI
32	I	63	XIV-1	83	XI-1
35	I	64	I	84	XIV-1
38	XI-1	65	XIV-1	85	VI
40	XI-1	66	III	86	XIII
42	VIII-1	67-69	VI		

1.6 Decisions

Number	Volume	Number	Volume	Number	Volume
2	IV-1	45	III	61	II
3-5	V	50	V	63	III
6	VI	51	X/XI-2	64	IV-1
9-11	VI	52	X-1	65	VII
18	XII	53, 54	I	66	XI-1
19	XIII	56	I	67, 68	XII
27	I	57	VI	69	VIII-1
32	VIII-3	58	XI-1	70	IV-1
42	XI-1	59	X/XI-3	71	VIII-3 + X-1
43	X/XI-2	60	XI-1	72	X-1 + XI-1

1.6.1 Note concerning Decisions

Since Decisions were adopted by Study Groups, use was made of the expression “Study Group . . . , Considering” and the expression “Unanimously decides”, replaced by “Decides”.

2. Questions and Study Programmes

2.1 Text numbering

2.1.1 Questions

Questions are numbered in a different series for each Study Group: where applicable a dash and a figure added after the number of the Question indicate successive modifications. The number of a Question is completed by an *Arabic figure indicating the relevant Study Group*. For example:

- Question 1/10 would indicate a Question of Study Group 10 with its text in the original state;
- Question 1-1/10 would indicate a Question of Study Group 10, whose text has been once modified from the original; Question 1-2/10 would be a Question of Study Group 10, whose text has had two successive modifications.

2.1.2 Study Programmes

Study Programmes are numbered to indicate the Question from which they are derived, if any, the number being completed by a capital letter which is used to distinguish several Study Programmes which derive from the same Question. The part of the Study Programme number which indicates the Question from which it is derived makes no mention of any possible revision of that Question, but refers to the current text of the Question as printed in this Volume. Examples:

- Study Programme 1A/10, which would indicate that the current text is the original version of the text of the first Study Programme deriving from Question 1/10;
- Study Programme 1C/10, which would indicate that the current text is the original version of the text of the third Study Programme deriving from Question 1/10;
- Study Programme 1A-1/10, would indicate that the current text has been once modified from the original, and that it is the first Study Programme of those deriving from Question 1/10.

It should be noted that a Study Programme may be adopted without it having been derived from a Question; in such a case it is simply given a sequential number analogous to those of other Study Programmes of the Study Group, except that on reference to the list of relevant Questions it will be found that no Question exists corresponding to that number.

References to Questions and Study Programmes within the text are made to the basic number as well as for other CCIR texts.

2.2 Arrangement of Questions and Study Programmes

The plan shown on page II indicates the Volume in which the texts of each Study Group are to be found, and so reference to this information will enable the text of any desired Question or Study Programme to be located.

VOLUME XI-1

BROADCASTING SERVICE (TELEVISION)

(Study Group 11)

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BROADCASTING SERVICE (TELEVISION)

STUDY GROUP 11

Terms of reference:

To study:

1. technical aspects of the broadcasting service and the broadcasting-satellite service when these services are used for television;
2. standards for video-frequency equipment, for motion picture films intended for television and for all forms of television recording, to facilitate the international exchange of programmes.

1982-1986 *Chairman:* M. KRIVOCHEEV (USSR)
Vice-Chairmen: C. A. SIOCOS (Canada)
 WU XIANLUN (China (People's Republic of))
 S. E. AGUERREVERE R. (Venezuela)

1986-1990 *Chairman:* M. KRIVOCHEEV (USSR)
Vice-Chairmen: S. E. AGUERREVERE R. (Venezuela)
 A. TODOROVIC (Yugoslavia (Socialist Federal Republic of))
 WU XIANLUN (China (People's Republic of))
 R. ZEITOUN (Canada)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP 11

1. Introduction

Study Group 11 is engaged in comprehensive studies on the technical aspects of television broadcasting.

It is working under the terms of reference adopted by the XVth Plenary Assembly which include the following:

1. the study of the technical aspects of the broadcasting service (television), including the use of satellites;
2. the study of standards for motion-picture films intended for television and for all forms of television recording relevant to the international exchange of programmes.

A number of studies are also being carried out under this heading jointly with other Study Groups, particularly Study Group 10 and the CMTT.

The main subjects covered are as follows:

- characteristics of monochrome and colour television systems;
- additional television services;
- picture quality and the parameters affecting it;
- technical data for planning television networks, protection ratios, television receivers and antennas;
- the international exchange of television programmes, monitoring and measuring;
- digital coding of television signals;
- recording of television programmes;
- television broadcasting-satellite service;
- terminology.

Study Group 11 considered proposals contained in the Decisions adopted by the XVth CCIR Plenary Assembly aimed at the improvement of the efficiency of the Study Groups.

Study Group 11 contributed to the elaboration of the technical bases for the World Administrative Radio Conference and the Regional Administrative Conference. This activity related in particular to the Second Session of the Regional Administrative Conference for FM Sound Broadcasting in the VHF band (Region 1 and certain countries concerned in Region 3) CARR-1(2) held in 1984, with regard to protection ratios for television; the First Session of the World Administrative Radio Conference on the Use of the Geostationary-Satellite Orbit and the Planning of the Space Services Utilizing it (WARC ORB-85) and also the First Session of the Regional Administrative Conference to Review and Revise the Provisions of the Final Acts of the African VHF/UHF Broadcasting Conference (AFBC(1)) Geneva, 1963.

2. Organization of work

In order to speed up the study of the main subjects, Interim Working Parties (IWPs) were established. In addition to intensive activities carried out by correspondence, they held a number of meetings during the study period.

IWP 11/3 was constituted under Decision 33, to speed up and coordinate studies on broadcasting systems for the transmission of alphanumeric and graphical information. The Chairman is Professor Cappuccini (Italy). It held several meetings in the course of which it prepared new Recommendation 653: "Teletext systems", as well as other texts relating to additional television services.

IWP 11/4 was established under Decision 41 to deal with questions relating to the quality of television pictures. The Chairman of this IWP is Mr. Goussot (France). The IWP prepared a new Recommendation 654: "Subjective quality of television pictures in relation to the main impairments of the analogue composite television signal" and a new Report 1082: "Methods for measuring the intrinsic picture quality of current and new television systems" and other related texts.

IWP 11/5 was set up according to Decision 42 to study the question of protection ratios. The terms of reference of this IWP were extended (Circular-letter 260 of 23 July 1984) in view of the need to develop technical bases for the forthcoming AFBC(1). IWP 11/5 worked under the chairmanship of Mr. Kussmann (Federal Republic of Germany), who replaced Mr. Dinsel (Federal Republic of Germany) but Mr. Dinsel continued to deal with the subject of protection ratios. Following a proposal by the African Administrations, Mr. El Fayoumi (Egypt) and Mr. Edane Nkwele (Gabon) served as Vice-Chairmen of IWP 11/5. This IWP prepared a report on the technical bases for the forthcoming AFBC(1) in conjunction with Study Group 5, as well as new Recommendation 655: "Radio-frequency protection ratios for AM vestigial sideband television systems", new Reports 1085: "Planning methods for terrestrial television in VHF/UHF bands", 1086: "Frequency planning constraints", and other texts.

IWP 11/6 was set up under Decision 58 to study the basic parameters of a high-definition television system. The Chairman is Mr. Tadokoro (Japan), and the Vice-Chairmen are Mr. Green (United States of America) and Mr. Habermann (Federal Republic of Germany). The IWP held meetings in Switzerland, the United Kingdom and Japan. High-definition television systems were demonstrated. As a result of its activities, IWP 11/6 developed: "Proposal for a new Recommendation – Parameter values for signal generation in HDTV studios and for international exchange of HDTV programmes"* and amendments to Report 801: "The present state of high-definition television".

IWP 11/7 was set up under Decision 60 to study digital television standards. The Chairman is Mr. Heightman (United Kingdom), and the Vice-Chairmen are Mr. Davies (Canada) and Mr. Saito (Japan). The activities of this IWP were concerned with the further extension of Recommendation 601: "Encoding parameters of digital television for studios", the study of digital interfaces and the reduction of the bit rate. It prepared a new Recommendation 656: "Interfaces for digital component video signals in 525-line and 625-line television systems" and a new Report 1089: "Bit-rate reduction for digital television signals" and other texts.

* The XVIth CCIR Plenary Assembly decided to include this text as Annex II to Report 801.

Useful joint activities have been carried out by Joint Interim Working Parties of Study Groups 10 and 11:

JIWP 10-11/1, which was established under Decision 43, presided over by Mr. D. Sauvet-Goichon (France), prepared texts relating to the effective use of the geostationary-satellite orbit by the broadcasting-satellite service for the First Session of the WARC ORB-85.

JIWP 10-11/2 was established pursuant to Decision 44. Working under the chairmanship of Dr. Siocos (Canada), it prepared texts on the planning of the broadcasting-satellite service in Region 2 for RARC SAT-83.

JIWP 10-11/3, set up under Decision 51 which has Mr. O. Mäkitalo (Sweden) as Chairman, has prepared texts on new systems for the transmission of picture and sound signals and additional information. In particular, the work of this Group provided the basis for the first proposals on television standards for satellite television broadcasting.

JIWP 10-11/4 was established under Decision 59 to deal with the basic parameters of video recording. The Chairman is Mr. P. Zaccarian (CBS). It has prepared numerous important texts on video recording and cinematographic film used for television, electronic news gathering, etc.

The manner in which the work of these IWPs is organized, under the direction of experienced experts, has been largely responsible for the progress achieved. An important contribution was made by the Chairmen of the Working Parties during the Interim and Final Meetings of Study Group 11. I should like to express to all of them, as well as to the Vice-Chairmen of Study Group 11, my warmest gratitude.

JIWP 10-11/5 was proposed to be established for joint studies on services using data broadcasting. Study Group 11 prepared and approved on its part new Decision 72 which was then submitted to the XVIth Plenary Assembly for approval by other interested parties.

3. Characteristics of monochrome and colour television systems

Television broadcasting systems have undergone considerable development, as summarized in Annex I. This text was prepared at the Final Meeting of Study Group 11 to inform the participants in the XVIth CCIR Plenary Assembly of the general trends in television development, which may assist them in the adoption of the relevant decisions.

The situation with regard to high-definition television (HDTV) deserves particular attention. This problem was widely discussed and a text was unanimously adopted for inclusion in the report of the Chairman of Study Group 11 to the CCIR Plenary Assembly, as well as the "Proposal for a new Recommendation – Parameter values for signal generation in HDTV studios and for international exchange of HDTV programmes".*

Matters relating to high-definition television are also considered in Report 801: "The present state of high-definition television" and new Report 1075: "High-definition television by satellite".

On this basis, a text was drafted amending Decision 58 on the continuation of the activity of IWP 11/6 with a view to completing the work on the proposals for the new Recommendation and studies connected with HDTV signal transmission.

Report 624: "Characteristics of television systems" refines some of the parameters of existing systems. The results of the studies carried out on high-quality television systems are set out in new Report 1077.

4. Additional television services

Considerable progress was achieved in the study of systems for the transmission of additional information.

New Recommendation 653: "Teletext systems" was prepared. This text proposes four systems. Table I defines teletext services together with the technical parameters of each of the four systems.

It was decided to publish a description of teletext systems in a special CCIR booklet and its contents were prepared.

* The XVIth CCIR Plenary Assembly decided to include these texts as Annexes I and II to Report 801.

Possible forms of additional information and methods of multiplexing the television signal in terrestrial and satellite broadcasting are discussed in Report 802: "Additional broadcasting services using a television or narrow-band channel". Problems connected with the transmission of television sub-titles are dealt with in the new Report 1080: "International exchange of television programmes with data-encoded captions (sub-titles)".

The results of studies on conditional access television systems are contained in new Report 1079: "General characteristics of a conditional access broadcasting system". New Report 1078 for the first time deals with the question of time and date information transmission. Studies were continued on the transmission of sound information as part of the video signal (Report 958).

The results of tests carried out on additional information transmission systems are described in Report 956: "Data broadcasting systems: signal and service quality, field trials and theoretical studies". A decision was adopted on the setting up jointly with Study Group 10 of an Interim Working Party on services using data broadcasting. Professor Cappuccini (Italy) was appointed chairman.

5. International exchange of television programmes, monitoring and measurement

To facilitate the international exchange of television programme signals, Recommendation 472: "Video-frequency characteristics of a television system to be used for the international exchange of programmes between countries that have adopted 625-line colour or monochrome systems" was revised by modifying the tolerances for the field-blanking intervals in the transmission of additional information.

A new Report 1081 was prepared: "Synchronization necessary for the satisfactory reception of sound and picture signals", which deals with new problems arising from the non-synchronization of the sound and picture signals occurring with the use of memory devices and also from different channel lengths for the picture and the accompanying sound.

Report 628: "Automatic monitoring and control of television operation" was amended. A new test signal was added.

6. Picture quality evaluation and relevant parameters

The evaluation of TV picture quality is of particular topical importance from the standpoint of improving existing systems and the advent of new TV broadcasting systems.

A new Recommendation 654: "Subjective quality of television pictures in relation to the main impairments of the analogue composite television signal" was prepared with formulae and graphs showing picture quality impairment characteristics as a function of linear and non-linear distortion values as well as of the signal-to-noise ratio.

Recommendation 500: "Method for the subjective assessment of the quality of television pictures" was supplemented by requirements imposed on observers with regard to their sharpness of sight and colour perception.

New Report 1082: "Methods for measuring the intrinsic picture quality of current and new television systems" was prepared describing a method for the definition and comparison of television pictures obtained in different broadcasting systems. The method is based on a random selection by the observer of grading scales, followed by their standardization.

7. Technical data for the planning of television broadcasting networks, protection ratios, television receivers and antennas

In conjunction with Study Group 5, considerable efforts were devoted to the preparation of a CCIR report on technical bases for the AFBC(1).

A new Recommendation 655 was prepared: "Radio-frequency protection ratios for AM vestigial sideband television systems".

A first step towards the international standardization of methods of planning television broadcasting networks took the form of new Report 1085: "Planning methods for terrestrial television in VHF/UHF bands".

An important new Report 1086 was prepared: "Frequency planning constraints", which discusses the limitations imposed by television receivers as well as by common antenna systems in the transmission of certain TV and VHF FM programmes.

It was decided to continue the work of IWP 11/5, including in its terms of reference, problems primarily connected with the further improvement of protection ratios. The existing texts relating to the subject were also revised.

A joint meeting of Study Groups 10 and 11 discussed a draft new Decision on the constitution of a JIWP for the preparation by several Study Groups of the technical bases for criteria governing the shared use of the VHF and UHF bands allocated to the fixed, mobile and broadcasting services in Region 3 in connection with the forthcoming Regional Conference. Since the interests of a number of Study Groups were involved, the question of the establishment of the JIWP and its terms of reference have been resolved in the light of the comments of each Study Group at the XVIth Plenary Assembly (Resolution 94).

8. Digital coding of television signals

The widespread adoption of digital methods in television would be materially assisted by new texts produced on this subject.

A new Recommendation 656 was prepared: "Interfaces for digital component video signals in 525-line and 625-line television systems". This Recommendation should play an important part in the installation of digital studios, since it contains complete information on the design of links between digital devices.

Recommendation 601 was revised: "Encoding parameters of digital television for studios". It is noted in particular that for the prevention of sampling interference (occurrence of spurious frequencies), the coded signal spectra should be limited. The Recommendation contains a note referring to the parameters of the luminance signal filter. It is pointed out that they should be regarded as provisional.

A new Report 1089 was prepared on bit-rate reduction: "Bit-rate reduction for digital television signals". It contains new concepts and methods for reducing the bit rate applied in video signal coding. It also discusses various approaches to the problem of assessing picture quality with curtailment of redundancy.

Additional material was inserted in Report 629: "Digital coding of colour television signals" and Report 962: "The filtering, sampling and multiplexing for digital encoding of colour television signals".

Decision 60 was revised: "Digital television standards". This Decision relates to the continuance of IWP 11/7 and revises its terms of reference.

With a view to enhancing efficiency and the coordination of studies on problems bearing on the transmission of digital television signals on communication channels, Study Groups 10 and 11 and the CMTT jointly revised the text of Decision 18: "Digital systems for the transmission of sound and television signals".

9. Recording of television programmes

Joint activity with Study Group 10 led to significant progress in the preparation of texts on video recording. A new Recommendation 657 was prepared: "Digital television tape recording". It contains requirements for 19.01 mm video tapes used in cassettes for the helical scan recording of digital video signals using the 4 : 2 : 2 standard (see Recommendation 601) with four high-quality sound signals (see new Recommendation 646) and various service information. As an Annex to new Recommendation 657 an explanatory text was prepared: "Bases for the digital television tape recording standard" containing the main principles on which the standard is to be based.

In the field of analogue television recording Recommendation 469 "Standards for the international exchange of television programmes on magnetic tape" was updated.

A substantial revision was carried out of Report 803: "International exchange of Electronic News Gathering (ENG)", for the purpose of improved standardization of equipment and to facilitate the international exchange of recorded programmes. Other texts relating to the magnetic tape and film recording of television programme signals were also revised. A new Study Programme 18T/11 was prepared: "Recording of high-definition television programmes on cinematographic film".

10. Satellite television broadcasting

In conjunction with Study Group 10, the following basic problems were explored:

- television broadcasting systems;
- technical bases for the planning of services (including Questions related to sharing with other services);
- feeder link characteristics;
- parameters of individual links of systems.

The decisions of the WARC ORB-85 are reflected in the various texts. In connection with television broadcasting systems, new Recommendation 650 was prepared: "Television standards for satellite broadcasting in the channels defined by the WARC-BS 1977 and the RARC-83". Consideration is given to the possibility of using both newly developed and existing television systems in broadcasting-satellite services in the 12 GHz band.

Newly developed systems are described in new Report 1073: "Television standards for the broadcasting-satellite service". Examples of new systems have been added to Report 215: "Systems for the broadcasting-satellite service (sound and television)".

Questions relating to the transmission from a satellite of multiplexed analogue picture signal components are discussed in new Report 1074, bearing the same title. New Report 1075 deals with high-definition television transmission.

All the texts relating to the planning of the broadcasting-satellite services were revised, with the exception of Report 951: "Sharing between the inter-satellite service and the broadcasting-satellite service in the vicinity of 23 GHz". Substantial amendments were made to Report 952: "Technical characteristics of feeder links to broadcasting satellites". The revised version of the Report embodies all the basic principles adopted by the WARC-85 concerning the planning of feeder links in the broadcasting-satellite service in the 12 GHz band and, in particular, the technical parameter values recommended by the Conference as necessary for the establishment of a feeder link Plan in Regions 1 and 3.

A new Recommendation 652 was prepared: "12 GHz receiving earth-station antenna and satellite transmitting antenna reference patterns for the broadcasting-satellite service". Report 473: "Characteristics of ground receiving equipment for the broadcasting-satellite service" was supplemented by material relating to the measurement of the performance of the receiving equipment.

The preparation for the WARC ORB(2) is a formidable task, particularly with regard to the tasks assigned to the CCIR by the WARC ORB-85 concerning satellite television broadcasting. In this connection, new terms of reference were established for JIWP 10-11/1 (Decision 43-3) and 10-11/3 (Decision 51-2). JIWP 10-11/1 will deal with questions of feeder links, etc., while JIWP 10-11/3 will be concerned with television systems for satellite broadcasting, including problems of high-definition television satellite broadcasting.

Both JIWPs are to submit their initial reports to the Joint Interim Working Party (Study Groups 1, 2, 4, 5, 8, 9, 10 and 11) established by the CCIR to prepare the joint CCIR report for the WARC ORB(2).

Mr. D. Sauvet-Goichon (France) will continue as Chairman of JWP 10-11/1; Mr. R. M. Barton (Australia) and Mr. W. G. Richards (United States of America) were appointed as Vice-Chairmen and two other Vice-Chairmen have been selected from the developing countries: Mrs. L. Nakonechnyj (Brazil) and Mr. R. S. Sastry (India). Mr. O. Mäkitalo (Sweden) will remain as Chairman of JWP 10-11/3, assisted by Mr. T. Nishizawa (Japan) and Mr. G. Chouinard (Canada) as Vice-Chairman and by two other Vice-Chairmen appointed from the developing countries: Mr. S. K. Chemai (Kenya) and Mr. Sulaiman Al-Ali Samaan (Saudi Arabia).

11. Texts of interest to the developing countries

Under Resolution 33 "Technical Cooperation", Study Group 11 took account of the interests of the developing countries in texts containing technical information required for the introduction and development of television broadcasting services.

Administrations of countries which have recently introduced television broadcasting services or which are intending to do so may find it useful to consult the Recommendations and Reports containing basic information on the planning of terrestrial and satellite services and the criteria governing the international exchange of television programmes, as well as the material relating to video recording (Sections 5, 7 and 9 of this Introduction). Also under this heading, Study Group 11 is providing a contribution in the form of the technical bases for the forthcoming (1986) Regional African Conference on VHF/UHF broadcasting.

12. Main tasks in the forthcoming study period

In the next study period, work will have to be continued along the lines traced by existing Questions and Study Programmes.

It will be necessary to refine the technical bases for the planning of terrestrial and satellite television broadcasting and in particular to plan services in new frequency bands and make provision for sharing between services. In this process, consideration will have to be given to the possibility of introducing additional services using the television signal.

Studies will have to be continued on systems permitting a substantial improvement in the quality of television pictures, both by upgrading existing broadcasting systems and by introducing new, high-definition systems. Progress may be expected in methods of producing stereoscopic images.

Considerable promise is seen in the use of digital techniques, which calls for the continued study of standards designed to promote the introduction of digital equipment, in the first instance in studio installations, including video recording and digital television receivers.

A wide variety of problems remains to be explored in connection with the international exchange of television programmes, ranging from video recording and electronic news gathering to standard methods of assessing picture quality.

Existing measuring methods must be improved and new ones elaborated, particularly in view of the advent of new television broadcasting systems. The development of broadcasting techniques means a corresponding need to keep the terminology up to date.

In conclusion, it may be pointed out that television broadcasting is developing extremely rapidly throughout the world. The existing broadcasting systems are being improved and new systems and services are emerging; picture quality is improving and new methods of programme conservation are being introduced. The CCIR is keeping abreast of all studies relating to television broadcasting at the international level.

ANNEX I

A SURVEY OF PRESENT AND POSSIBLE FUTURE TELEVISION SYSTEMS

The first television services were introduced in the 1930s. Since that time, systems using a variety of scanning structures have been devised, but only two scanning structures have survived to the present time (625/50 and 525/60, 2 : 1 interlaced). In current systems, the same scanning structure is used throughout the television chain (production, distribution and display) — see Report 624 and Recommendation 470.

The advent of colour television in the 1950s did not modify the situation. Colour information was encoded in the same bandwidth as the monochrome signal, and three colour coding systems were introduced (NTSC, SECAM, PAL), which in principle can be associated with each of the two above-mentioned scanning structures, although in practice NTSC is used in the 525/60 version and SECAM and PAL in the 625/50 version (see Report 624).

More recently, the use of analogue or digital *component* signals in television studios was made possible by developments in television equipment technology, notably advances in digital techniques. The advantages of using digital component signals in the production studio in terms of studio signal processing, common equipment features, the compatible evolution of future systems and the international programme exchange are summarized in Recommendation 601. The use of analogue components in the studio for particular applications and as a bridge to the introduction of the all digital component studio are described in new Report 1077.

Following the definition of the component digital studio standard (Recommendation 601), component emission standards have been developed to provide the viewer with the benefits of component signals and other enhancements; the systems based on the use of time multiplexed analogue components (MAC) are described in new Report 1074 and specified in new Report 1073. Some of these systems also allow for an aspect ratio wider than the conventional 4 : 3 (extended definition television, see new Report 1077). In principle, MAC type emission signals should be derived from digital or analogue Y, U, V component production signals, although during an interim period they may be derived from *composite* signals by means of professional-grade decoders (in this case with 4 : 3 aspect ratio).

Further improvements in picture quality can be obtained by the use of a higher resolution scanning structure for production and for the display, whilst retaining the conventional scanning structure for distribution. As an example, a signal generated in a 625/50 non-interlaced format can be scan-converted to a 625/50 2:1 interlaced format for distribution, and restored to the original format at the display. Scan conversion at the display can improve picture quality, even when the signal is produced with a conventional scanning structure (see new Report 1077).

The highest picture quality will be obtained with high-definition television (HDTV). Studies on HDTV started in Japan at the beginning of the 1970s having in mind a large-screen *display*.

The main factors involved include a wider aspect ratio, a doubling of the spatial resolution compared to that of Recommendation 601, that it is specified in digital form, with a simple relationship to Recommendation 601 and improved colorimetry.

At present a proposal for a single world-wide production standard is under consideration (see Report 801).

Distribution of HDTV signals will occur either through wideband channels or through one or more WARC-BS-77 or RARC-83 channels. In cases where bandwidth compression must be introduced, this is likely to cause some impairment to picture quality (see Report 801 and new Report 1075). Scan conversion at the display may not be necessary with HDTV, although in principle a further improvement in picture quality could be obtained with this technique.

A major problem in considering HDTV emission is the limited radio-frequency spectrum available. For these reasons the WARC ORB-85 charged the CCIR with the task of carrying out studies to find out, preferably on a world-wide basis, the technical parameters and the frequency bands appropriate for HDTV transmissions by satellite.

Conclusions

Advances in the development of television technology have led to a situation where the major links in the television chain (production, distribution, display) may be specified using different but related standards. Bearing in mind the large number of options, new television systems should be introduced at the proper time, in such a way as to bring improved services to the users, to keep the possibility of further developments, but not to impose unnecessary penalties on the existing services.

SECTION 11A: CHARACTERISTICS OF SYSTEMS FOR MONOCHROME AND COLOUR TELEVISION

Recommendations and Reports

RECOMMENDATION 470-2*

TELEVISION SYSTEMS

(Question 1/11)

(1970-1974-1986)

The CCIR,

CONSIDERING

- (a) that many countries have established satisfactory monochrome television broadcasting services based on either 525-line or 625-line systems;
- (b) that a number of countries have established (or are in the process of establishing) satisfactory colour television broadcasting services based on the NTSC, PAL or SECAM systems;
- (c) that the use of video component signals, signals consisting of the luminance and two colour difference signals, with time compression and time division multiplexing, may offer picture quality benefits, using new types of television receivers;
- (d) that it would add further complications to the interchange of programmes to have a greater multiplicity of systems,

UNANIMOUSLY RECOMMENDS

1. that, for a country wishing to initiate a monochrome television service, a system using 525 or 625 lines as defined in Report 624 is to be preferred;
2. that, for monochrome 625-line systems, the video-frequency characteristic described in Recommendation 472 is to be preferred;
3. that, for a country wishing to initiate a colour television service, one of the systems defined in Report 624, or any compatible improved versions of these systems, is to be preferred. However, other systems based on the use of video components that have been defined in Report 1073 can be considered.

Note. — Pre-1986 editions of the CCIR volumes, and in particular that of 1982, contain a complete description of system E used in France until 1984, and system A used in the United Kingdom until 1985.

REPORT 624-3

CHARACTERISTICS OF TELEVISION SYSTEMS

(Question 1/11)

(1974-1978-1982-1986)

The following Tables, given for information purposes, contain details of a number of different television systems in use at the time of the XVIth Plenary Assembly of the CCIR, Dubrovnik, 1986.

A list of countries and geographical areas, and the television systems used, are given in Annex I.

Specifications of the SECAM IV colour television system, which is still under consideration, are given in Annex II.

* New television systems intended for satellite broadcasting are covered in Recommendation 650 and Report 1073.

TABLE I — Basic characteristics of video and synchronizing signals

Item	Characteristics		System								
			M	N ⁽¹⁾	B, G	H	I	D, K	K1	L	Rec. 472 ⁽²⁾
1	Number of lines per picture (frame)		525	625	625	625	625	625	625	625	625
2	Field frequency, nominal value (fields/second) ⁽³⁾		60 (59.94)	50	50	50	50	50	50	50	50
3	Line frequency f_H and tolerance when operated non-synchronously (Hz) ⁽³⁾ ⁽⁴⁾		15 750 (15 734.264 $\pm$ 0.0003%)	15 625 $\pm$ 0.15% ($\pm$ 0.00014%)	15 625 ⁽⁵⁾ $\pm$ 0.02% ($\pm$ 0.0001%)	15 625 $\pm$ 0.02% ($\pm$ 0.0001%)	15 625 $\pm$ 0.00002% (⁽⁶⁾)	15 625 ⁽⁵⁾ $\pm$ 0.02% ($\pm$ 0.0001%)	15 625 $\pm$ 0.02% ($\pm$ 0.0001%)	15 625 $\pm$ 0.02% ($\pm$ 0.0001%)	15 625 $\pm$ 0.02% ($\pm$ 0.0001%)
3 (a)	Maximum variation rate of line frequency valid for monochrome transmission (%/s) ⁽⁷⁾ ⁽⁸⁾		0.15 ⁽⁹⁾		0.05	0.05	0.05	0.05	0.05	0.05	
4 ⁽¹⁰⁾	Nominal and peak levels of the composite video signal (see Fig. 1) (%)	blanking level (reference level)	0	0	0	0	0	0	0	0	
		peak-white-level	100	100	100	100	100	100	100	100	
		synchronizing level	−40	−40 (−43)	−43	−43	−43	−43	−43	−43	
		difference between black and blanking level	7.5 $\pm$ 2.5	7.5 $\pm$ 2.5 (0)	0	0	0	0-7	0 (colour) 0-7 (mono.)	0 (colour) 0-7 (mono.)	0 ⁺⁵ −0
		peak level including chrominance signal	120		133 ⁽¹¹⁾		133	115 ⁽¹²⁾	115 ⁽¹²⁾	124 ⁽¹²⁾	

TABLE 1 (continued)

Item	Characteristics	System								
		M	N ⁽¹⁾	B, G	H	I	D, K	K1	L	Rec. 472 ⁽²⁾
5	Assumed gamma of display device for which pre-correction of monochrome signal is made	2.2	2.2 (2.8)	2.8 ⁽¹³⁾						⁽¹⁴⁾
6	Nominal video bandwidth (MHz)	4.2	4.2	5	5	5.5	6	6	6	5.0 or 5.5 or 6.0
7	Line synchronization	see Table I-1								
8	Field synchronization	see Table I-2								

⁽¹⁾ The values in brackets apply to the combination N/PAL used in Argentina.

⁽²⁾ Figures are given for comparison.

⁽³⁾ Figures in brackets are valid for colour transmission.

⁽⁴⁾ In order to take full advantage of precision offset when the interfering carrier falls in the sideband of the upper video range (greater than 2 MHz) of the wanted signal a line-frequency stability of at least 2×10^{-7} is necessary.

⁽⁵⁾ The exact value of the tolerance for line frequency when the reference of synchronism is being changed requires further study.

⁽⁶⁾ When the reference of synchronism is being changed, this may be relaxed to $15\,625 \pm 0.02\%$.

⁽⁷⁾ These values are not valid when the reference of synchronism is being changed.

⁽⁸⁾ Further study is required to define maximum variation rate of line frequency valid for colour transmission. See in this regard [CCIR, 1978-82]. In the UK this is 0.1 Hz/s [CCIR, 1982-86b].

⁽⁹⁾ The values used in Japan are ± 0.1 .

⁽¹⁰⁾ It is also customary to define certain signal levels in 625-line systems, as follows:

Synchronizing level = 0

Blanking level = 30

Peak white-level = 100

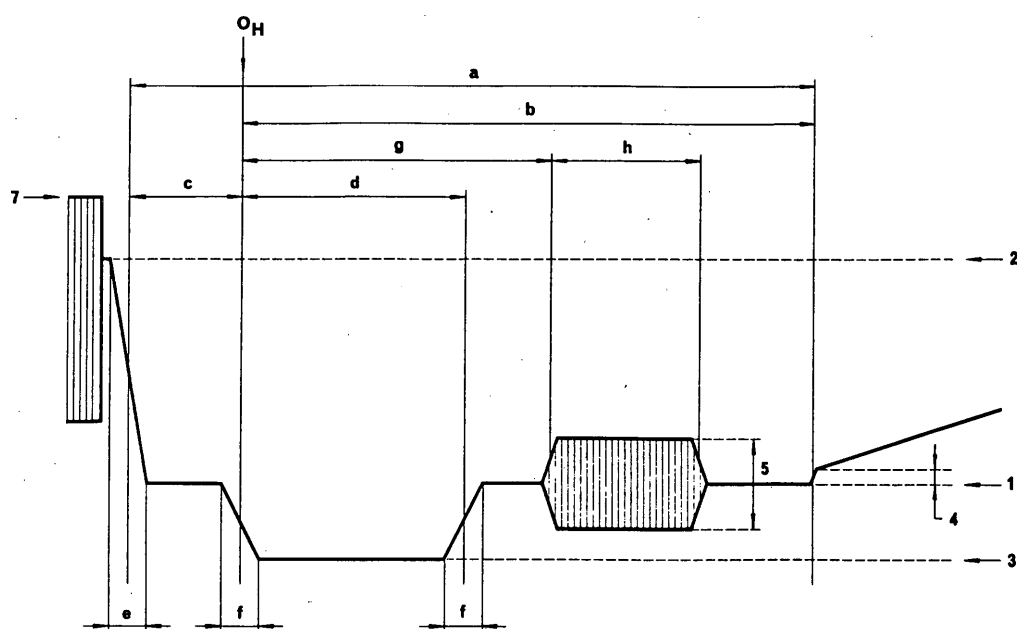
For this scale, the peak level including chrominance signal for system D, K/SECAM equals 110.7. (See [CCIR, 1982-86a].)

⁽¹¹⁾ Value applies to PAL signals.

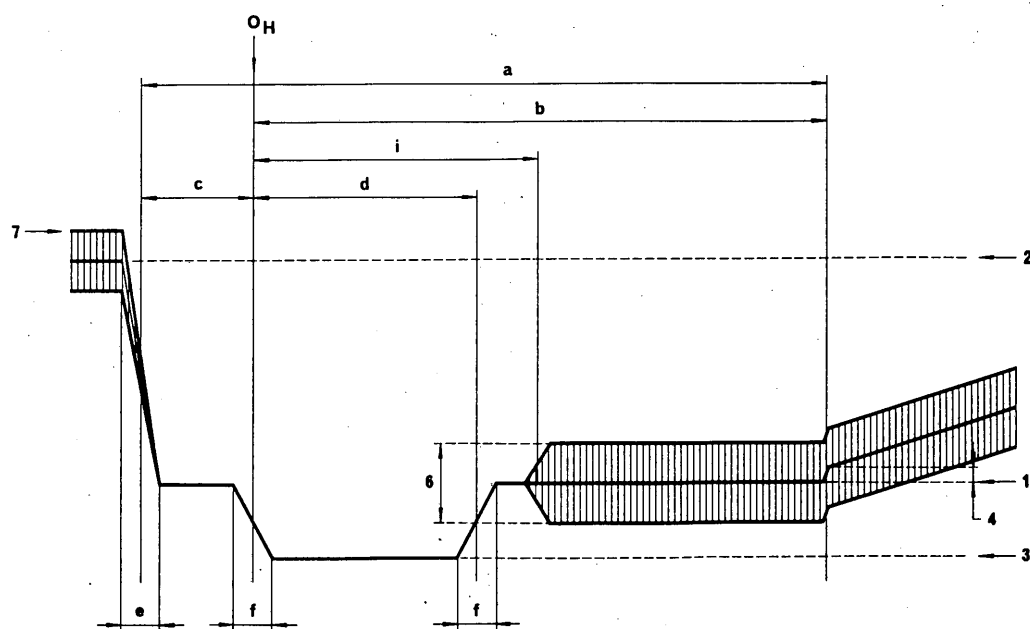
⁽¹²⁾ Values apply to SECAM signals. For programme exchange the value is 115.

⁽¹³⁾ Assumed value for overall gamma approximately 1.2. The gamma of the picture tube is defined as the slope of the curve giving the logarithm of the luminance reproduced as a function of the logarithm of the video signal voltage when the brightness control of the receiver is set so as to make this curve as straight as possible in a luminance range corresponding to a contrast of at least 1/40.

⁽¹⁴⁾ In Recommendation 472, a gamma value for the picture signal is given as approximately 0.4.



(a) NTSC and PAL systems



(b) SECAM system

FIGURE 1 — Levels in the composite signal and details of line-synchronizing signals

1 blanking level	4 difference between black and blanking levels
2 peak white-level	5 peak-to-peak value of burst
3 synchronizing level	6 peak-to-peak value of colour sub-carrier
	7 peak level including chrominance signal

TABLE I-1 — *Details of line synchronizing signals (see Fig. 1)*
 Durations (measured between half-amplitude points on the appropriate edges) for various systems

Symbol	Characteristics	M ⁽¹⁾	N ⁽²⁾	B, G, H, I, D, K, K1, L (see also Rec. 472)
<i>H</i>	Nominal line period (μs)	63.492 (63.5555)	64	64 ⁽³⁾
<i>a</i>	Line-blanking interval (μs)	10.2 to 11.4 (10.9 ± 0.2)	10.24 to 11.52 (12 ± 0.3)	12 ± 0.3 ⁽⁴⁾
<i>b</i>	Interval between time datum (<i>O_H</i>) and back edge of line-blanking pulse (μs)	8.9 to 10.3 (9.2 to 10.3)	8.96 to 10.24 (10.5)	10.5 ⁽⁵⁾
<i>c</i>	Front porch (μs)	1.27 to 2.54 (1.27 to 2.22)	1.28 to 2.56 (1.5 ± 0.3)	1.5 ± 0.3 ⁽⁴⁾ ⁽⁶⁾
<i>d</i>	Synchronizing pulse (μs)	4.19 to 5.71 (4.7 ± 0.1)	4.22 to 5.76 (4.7 ± 0.2)	4.7 ± 0.2
<i>e</i>	Build-up time (10 to 90%) of the edges of the line-blanking pulse (μs)	≤ 0.64 (≤ 0.48)	≤ 0.64 (0.3 ± 0.1)	0.3 ± 0.1
<i>f</i>	Build-up time (10 to 90%) of the edges of the line-synchronizing pulses (μs)	≤ 0.25	≤ 0.25 (0.2 ± 0.1)	0.2 ± 0.1 ⁽⁷⁾

⁽¹⁾ Values in brackets apply to M/NTSC.

⁽²⁾ The values in brackets apply to the combination N/PAL used in Argentina.

⁽³⁾ In France, and the countries of the OIRT, the tolerance for the instantaneous line period value is ± 0.032 μs.

⁽⁴⁾ In 625-line countries using Teletext System B as specified in the Annex to Recommendation 653 to reduce the possibilities of data loss, the following values are preferred [CCIR, 1982-86c and d]:

a) line blanking interval: $12^{+0.0}_{-0.3}$ μs

c) front porch: $1.5^{+0.3}_{-0.0}$ μs

⁽⁵⁾ Average calculated value, for information. For system I the value is 10.4 [CCIR, 1982-86b].

⁽⁶⁾ For system I, the values are 1.65 ± 0.1.

⁽⁷⁾ For system I, the values are 0.25 ± 0.05.

FIGURE 2 – Details of field-synchronizing waveforms

FIGURES 2-1 – Diagrams applicable to all systems except M

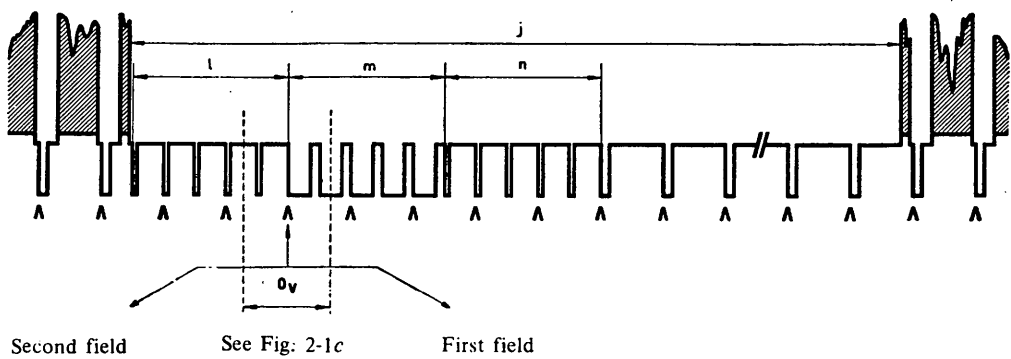


FIGURE 2-1a – Signal at beginning of each first field

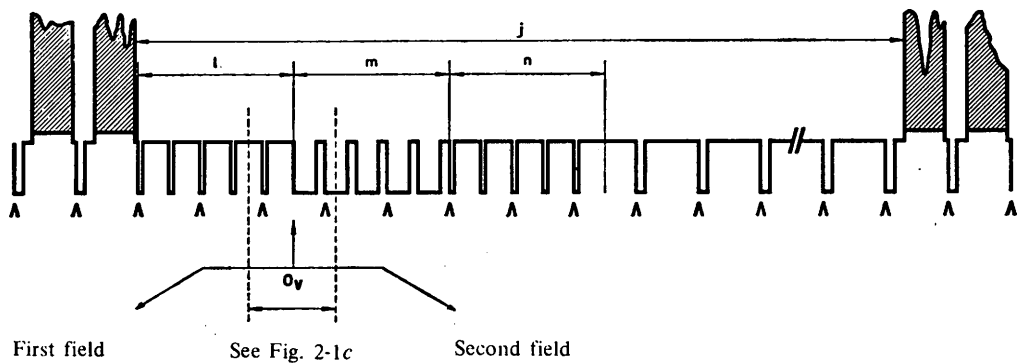
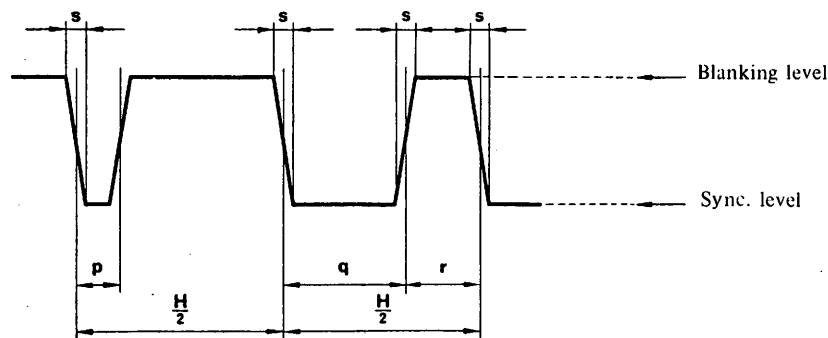


FIGURE 2-1b – Signal at beginning of each second field

- Note 1. – $\wedge \wedge \wedge$ indicates an unbroken sequence of edges of line-synchronizing pulses throughout the field-blanking period.
- Note 2. – At the beginning of each first field, the edge of the field-synchronizing pulse, O_v , coincides with the edge of a line-synchronizing pulse if l is an odd number of half-line periods as shown.
- Note 3. – At the beginning of each second field, the edge of the field-synchronizing pulse, O_v , falls midway between the edges of two line-synchronizing pulses if l is an odd number of half-line periods as shown.



(The durations are measured between the half-amplitude points on the appropriate edges).

FIGURE 2-1c – Details of equalizing and synchronizing pulses

FIGURE 2 – Details of field-synchronizing waveforms

FIGURES 2-2 — *Diagrams applicable to system M*

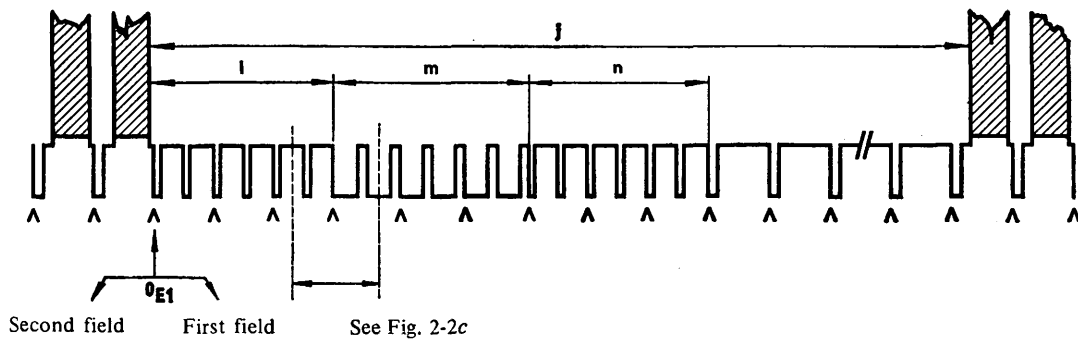


FIGURE 2-2a — *Signal at beginning of each first field*

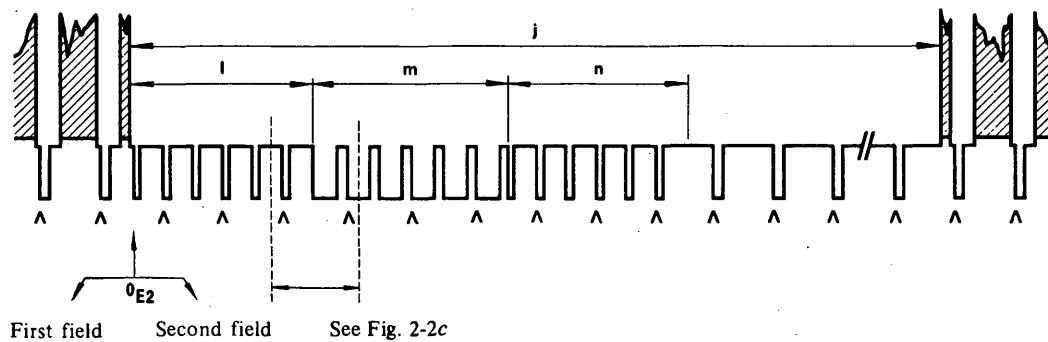
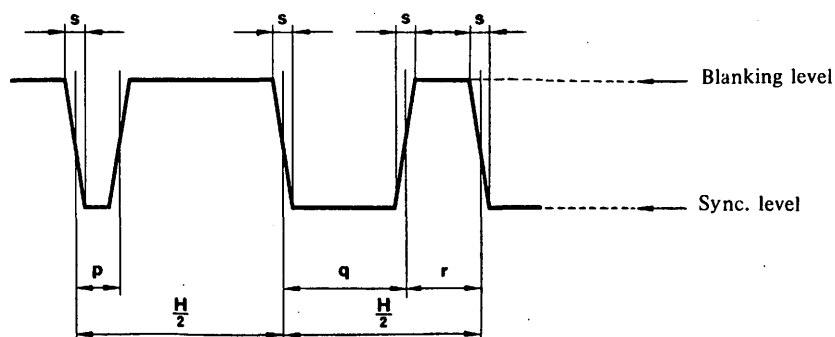


FIGURE 2-2b — Signal at beginning of each second field

Note 1. – $\wedge$ indicates an unbroken sequence of edges of line-synchronizing pulses throughout the field-blanking period.

Note 2. – Field-one line numbers start with the first equalizing pulse in Field 1, designated OP_1 in Fig. 2-2a

Note 3. — Field-two line numbers start with the second equalizing pulse in Field 2, one-half-line period after OE₂ in Fig. 2-3b.



- Sync. level

FIGURE 2-2c — Details of equalizing and synchronizing pulses

TABLE I-2 — Details of field synchronizing signals (see Fig. 2)
Duration (measured between half-amplitude points on the appropriate edges) for various systems

Symbol	Characteristics	M	N ⁽¹⁾	B, G, H, I, D, K, K1, L (see also Rec. 472)
v	Field period (ms)	16.667 ⁽²⁾ (16.6833)	20	20
j	Field-blanking interval (for H and a , see Table I-1)	(19 to 21) $H + a$ ⁽³⁾	(19 to 25) $H + a$ (25 $H + a$)	25 $H + a$
j' ⁽⁴⁾	Build-up time (10 to 90%) of the edges of field-blanking pulses (μ s)	≤ 6.35	≤ 6.35 (0.3 $\pm$ 0.1)	0.3 $\pm$ 0.1
k ⁽⁴⁾	Interval between front edge of field-blanking interval and front edge of first equalizing pulse (μ s)	(1.5 $\pm$ 0.1)		3 $\pm$ 2 ⁽⁵⁾ (systems B/SECAM, G/SECAM, D, K, K1 and L only; no ref. in Rec. 472)
l	Duration of first sequence of equalizing pulses	3 H	3 H (2.5 H)	2.5 H
m	Duration of sequence of synchronizing pulses	3 H	3 H (2.5 H)	2.5 H
n	Duration of second sequence of equalizing pulses	3 H	3 H (2.5 H)	2.5 H
p	Duration of equalizing pulse (μ s)	(2.3 $\pm$ 0.1) ⁽⁶⁾	2.30 to 2.56 (2.35 $\pm$ 0.1)	2.35 $\pm$ 0.1
q	Duration of field-synchronizing pulse (μ s)	27.1 (nominal value)	26.52 to 28.16 (27.3)	27.3 ⁽⁷⁾ (nominal value)
r	Interval between field-synchronizing pulse (μ s)	(4.7 $\pm$ 0.1)	3.84 to 5.63 (4.7 $\pm$ 0.2)	4.7 $\pm$ 0.2 ⁽⁸⁾
s	Build-up time (10 to 90%) of synchronizing and equalizing pulses (μ s)	≤ 0.25	≤ 0.25 (0.2 $\pm$ 0.1)	0.2 $\pm$ 0.1 ⁽⁹⁾

⁽¹⁾ The values in brackets apply to the combination N/PAL used in Argentina.

⁽²⁾ The value in brackets applies to the M/NTSC system.

⁽³⁾ The following values are used in Japan:

$0.07 v + 0.01 v$ for colour transmission,

$0.05 v + 0.03 v$ for monochrome transmission,

where v is the field period.

⁽⁴⁾ Not indicated in the diagram.

⁽⁵⁾ This value is to be specified more precisely at a later date.

⁽⁶⁾ The following specification is also applied in Japan: an equalizing pulse has 0.45 to 0.5 times the area of a line-synchronizing pulse.

⁽⁷⁾ For system I: 27.3 $\pm$ 0.1.

⁽⁸⁾ For system I: 4.7 $\pm$ 0.1.

⁽⁹⁾ For system I: 0.25 $\pm$ 0.05.

TABLE II – Characteristics of video signal for colour television

Item	Characteristics	Colour television system									
		M/NTSC		M/PAL		B, D, G, H, N/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM	N/PAL ⁽¹⁾		
2.1	Assumed chromaticity coordinates (CIE, 1931) for primary colours of receiver	x Red 0.67 0.33 Green 0.21 0.71 Blue 0.14 0.08				x Red 0.64 0.33 Green 0.29 0.60 Blue 0.15 0.06		(2)			
2.2	Chromaticity coordinates for equal primary signals $E'_R = E'_G = E'_B$	Illuminant C $x = 0.310$ $y = 0.316$ (3)		Illuminant D ₆₅ $x = 0.313$ $y = 0.329$ (2)							
2.3	Assumed gamma value of the receiver for which the primary signals are pre-corrected (4)	2.2				2.8					
2.4	Luminance signal	$E'_Y = 0.299 E'_R + 0.587 E'_G + 0.114 E'_B$ (5) E'_R, E'_G and E'_B are gamma – pre-corrected primary signals (6)									
2.5	Chrominance signals (Colour difference)	$E'_I = -0.27(E'_B - E'_Y) + 0.74(E'_R - E'_Y)$ $E'_Q = 0.41(E'_B - E'_Y) + 0.48(E'_R - E'_Y)$		$E'_U = 0.493(E'_B - E'_Y)$ $E'_V = 0.877(E'_R - E'_Y)$		$D'_R = -1.902(E'_R - E'_Y)$ $D'_B = 1.505(E'_B - E'_Y)$					
2.6	Attenuation of colour difference signals	dB MHz $E'_I \begin{cases} < 3 \text{ at } 1.3 \\ \geq 20 \text{ at } 3.6 \end{cases}$ $E'_Q \begin{cases} < 2 \text{ at } 0.4 \\ < 6 \text{ at } 0.5 \\ \geq 6 \text{ at } 0.6 \end{cases}$		dB MHz $E'_U \begin{cases} < 2 \text{ at } 1.3 \\ > 20 \text{ at } 3.6 \end{cases}$ $E'_V \begin{cases} < 2 \text{ at } 1.3 \\ > 20 \text{ at } 3.6 \end{cases}$		dB MHz $E'_U \begin{cases} < 3 \text{ at } 1.3 \\ > 20 \text{ at } 4 \end{cases}$ $E'_V \begin{cases} < 3 \text{ at } 1.3 \\ > 20 \text{ at } 4 \end{cases}$		dB MHz $D'_R \begin{cases} \leq 3 \text{ at } 1.3 \\ \geq 30 \text{ at } 3.5 \end{cases}$ $D'_B \begin{cases} \leq 3 \text{ at } 1.3 \\ \geq 30 \text{ at } 3.5 \end{cases}$ Low frequency pre-correction not taken into account (7)		dB MHz $E'_U < 3 \text{ at } 1.3$ $E'_V > 20 \text{ at } 3.6$	

See notes at the end of Table II.

TABLE II (continued)

Item	Characteristics	Colour television system					
		M/NTSC	M/PAL	B, D, G, H, N/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM	N/PAL (1)
2.7	Low frequency pre-correction of colour difference signals					For sinusoidal signals: $D'_{R^*} = A_{BF}(f)D'_R$ $D'_{B^*} = A_{BF}(f)D'_B$ $A_{BF}(f) = \frac{1+j(f/f_1)}{1+j(f/3f_1)}$ f = signal frequency (kHz) $f_1 = 85 \text{ kHz}$ (See Fig. 6 for the amplitude response) (8)	
2.8	Time-coincidence error between luminance and chrominance signals (μs)	<0.05 Excluding pre-correction for receiver response					
2.9	Equation of composite colour signal	$E_M = E'_Y + E'_Q \sin(2\pi f_{sc}' + 33^\circ) + E'_I \cos(2\pi f_{sc}' + 33^\circ)$ where: E'_Y , see item 2.4 E'_Q and E'_I , see item 2.5 f_{sc} , see item 2.11 (See also Fig. 4a)	$E_M = E'_Y + E'_U \sin 2\pi f_{sc}' \pm E'_V \cos 2\pi f_{sc}'$ where: E'_Y , see item 2.4 E'_U and E'_V , see item 2.5 f_{sc} , see item 2.11 The sign of the E'_Y component is the same as that of the sub-carrier burst (changing for each line) (see item 2.16 and Fig. 4b)			$E_M = E'_Y + G \cos 2\pi (f_{OR}' + \Delta f_{OR} \int_0^t D'_{R^*} dt)$ or $E_M = E'_Y + G \cos 2\pi (f_{OB}' + \Delta f_{OB} \int_0^t D'_{B^*} dt)$ alternately from line to line where: E'_Y , see item 2.4 f_{OR} and f_{OB} , see item 2.11 Δf_{OR} and Δf_{OB} , see item 2.12 D'_{R^*} and D'_{B^*} , see item 2.7 G , see item 2.13	
2.10	Type of chrominance sub-carrier modulation	Suppressed-carrier amplitude-modulation of two sub-carriers in quadrature				Frequency modulation	

See notes at the end of Table II.

TABLE II (continued)

Item	Characteristics	Colour television system					
		M/NTSC	M/PAL	B, D, G, H, N/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM	N/PAL ⁽¹⁾
2.11	Chrominance sub-carrier frequency (a) nominal value and tolerance (Hz)	$3\,579\,545 \pm 10$	$3\,575\,611.49 \pm 10$	$4\,433\,618.75 \pm 5$	$4\,433\,618.75 \pm 1$ ⁽⁹⁾ ⁽¹⁰⁾	$f_{OR} = 4\,406\,250 \pm 2000$ $f_{OB} = 4\,250\,000 \pm 2000$ ⁽¹¹⁾	$3\,582\,056.25 \pm 5$
	(b) relationship between chrominance sub-carrier frequency f_{sc} and line frequency f_H	$f_{sc} = \frac{455}{2} f_H$	$f_{sc} = \frac{909}{4} f_H$	$f_{sc} = \left(\frac{1135}{4} + \frac{1}{625} \right) f_H$		Unmodulated sub-carrier at beginning of line $282 f_H$ for f_{OR} $272 f_H$ for f_{OB} ⁽¹²⁾	$f_{sc} = \left(\frac{917}{4} + \frac{1}{625} \right) f_H$
2.12	Bandwidth of chrominance sidebands (quadrature modulation of sub-carrier) (kHz)	$+620$ f_{sc} -1300	$+600$ f_{sc} -1300	$+570$ f_{sc} ⁽¹³⁾ -1300	$+1066$ f_{sc} -1300		$+620$ f_{sc} -1300
	or					Nominal deviation $D^* = 1$ ⁽¹⁴⁾	
	Frequency deviation of chrominance sub-carrier (frequency modulation of sub-carrier) (kHz)					Δf_{OR} ⁽¹⁵⁾ 280 ± 9 (± 14)	$+350 \pm 18$ (± 35) -506 ± 25 (± 50)
						Δf_{OB} ⁽¹⁵⁾ 230 ± 7 (± 11.5)	$+506 \pm 25$ (± 50) -350 ± 18 (± 35)

See notes at the end of Table II.

TABLE II (continued)

Item	Characteristics	Colour television system					
		M/NTSC	M/PAL	B, D, G, H, N/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM	N/PAL (1)
2.13	Amplitude of chrominance sub-carrier	$G = \sqrt{E'_I{}^2 + E'_Q{}^2}$	$G = \sqrt{E'_U{}^2 + E'_V{}^2}$ (16) (17)			$G = M_0 \frac{1 + j 16F}{1 + j 1.26F}$ where the peak-to-peak amplitude, $2M_0$ is $23 \pm 2.5\%$ of the luminance amplitude (between blanking level and peak-white) and $F = \frac{f}{f_0} - \frac{f_0}{f}$ where $f_0 = 4286$ kHz and f is the instantaneous sub-carrier frequency. The deviation of frequency, f_0 , from its nominal value due to misalignment of the circuits concerned should not exceed ± 20 kHz. (See Fig. 7 for the amplitude response)	
2.14	Synchronization of chrominance sub-carrier	Sub-carrier burst on blanking back porch	Sub-carrier burst on blanking back porch				
	(g) Start of sub-carrier burst (see Fig. 1a) (μ s)	4.71 to 5.71 (5.3 nominal) at least 0.38μ s after the trailing edge of line synchronization signal	5.8 ± 0.1 after epoch O_H	5.6 ± 0.1 after epoch O_H (18)			
	(h) Duration of sub-carrier burst (see Fig. 1a) (μ s)	2.23 to 3.11 (9 ± 1 cycles)	2.52 ± 0.28 (9 ± 1 cycles)	2.25 ± 0.23 (10 ± 1 cycles)			2.51 ± 0.28 (9 ± 1 cycles)

See notes at the end of Table II.

TABLE II (continued)

Item	Characteristics	Colour television system																																																								
		M/NTSC	M/PAL	B, D, G, H, N/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM	N/PAL (1)																																																			
2.15	Peak-to-peak value of chrominance sub-carrier burst (see Fig. 1a) (19)	4/10 of difference between blanking level and peak white-level ± 10%	3/7 of difference between blanking level and peak white-level ± 10% For systems D and I the tolerance is ± 3% (16) (17) (16)																																																							
2.16	Phase of chrominance sub-carrier burst (see Fig. 1a)	180° relative to (E'B - E'Y) axis (see Fig. 4a) In the NTSC sequence of four colour fields, field 1 is identified in accordance with Note (20) (see also Fig. 5c)	135° relative to E'U axis with the following sign (see Fig. 4b) <table border="1"><tr><td rowspan="4">Line</td><td colspan="8">Field Number (21)</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td colspan="8">Burst blanking sequence (see Figs. 5a and 5b)</td></tr><tr><td>I</td><td>II</td><td>III</td><td>IV</td><td>I</td><td>II</td><td>III</td><td>IV</td></tr><tr><td>even</td><td>-</td><td>-</td><td>+</td><td>+</td><td>-</td><td>-</td><td>+</td><td>+</td></tr><tr><td>odd</td><td>+</td><td>+</td><td>-</td><td>-</td><td>+</td><td>+</td><td>-</td><td>-</td></tr></table>			Line	Field Number (21)								1	2	3	4	5	6	7	8	Burst blanking sequence (see Figs. 5a and 5b)								I	II	III	IV	I	II	III	IV	even	-	-	+	+	-	-	+	+	odd	+	+	-	-	+	+	-	-		
Line	Field Number (21)																																																									
	1	2	3	4	5		6	7	8																																																	
	Burst blanking sequence (see Figs. 5a and 5b)																																																									
	I	II	III	IV	I	II	III	IV																																																		
even	-	-	+	+	-	-	+	+																																																		
odd	+	+	-	-	+	+	-	-																																																		
2.17	Blanking of chrominance sub-carrier	Following each equalizing pulse and also during the broad synchronizing pulses in the field-blanking interval	11 lines of field-blanking interval: 260 to 270 522 to 7 259 to 269 223 to 8 (See Fig. 5b)	9 lines of the field-blanking interval: lines 311 to 319 inclusive 623 to 6 inclusive 310 to 318 inclusive 622 to 5 inclusive (See Fig. 5a)		(a) from leading edge of line-blanking signal up to i = 5.6 ± 0.2 (µs) after epoch OH, i.e. during c + i (see Fig. 1b) (22) (b) During field-blanking interval, excluding frame identification signals, or, in countries where this is possible, during the whole of the field-blanking interval (see item 2.18)																																																				

See notes at the end of Table II.

TABLE II (continued)

Item	Characteristics	Colour television system					
		M/NTSC	M/PAL	B, D, G, H, N/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM	N/PAL (1)
2.18	Synchronization of chrominance sub-carrier switching during line blanking	See item 2.16. For signals used in programme integration, the tolerance on the coincidence between the reference sub-carrier and the horizontal synchronizing pulses is nominally $0 \pm 40^\circ$ of the reference sub-carrier	By E'_V chrominance component of sub-carrier burst (See item 2.16)			In the SECAM system, one of two colour synchronization methods can be chosen: - line identification: by chrominance sub-carrier reference signals on the line-blanking back porch⁽²³⁾ - by identification signals occupying 9 lines of field-blanking period: (a) line 7 to 15 in 1st and 3rd field (b) line 320 to 328 in 2nd and 4th field (See Fig. 9)⁽²⁴⁾ <i>Shape of video signals corresponding to identification signals:</i> For lines D'_R — Trapezoid with linear variation from beginning of line on $15 \pm 5 \mu s$ from 0 up to level +1.25 and then constant at the level $+1.25 \pm 0.06 (\pm 0.13)$ (See Fig. 8)	

See notes at the end of Table II.

TABLE II (continued)

Item	Characteristics	Colour television system					
		M/NTSC	M/PAL	B, D, G, H, N/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM	N/PAL (1)
						For lines D'_B—Trapezoid with linear variation from the beginning of the line on $18 \pm 6 \mu s$ ($20 \pm 10 \mu s$) from 0 down to level -1.52 and then constant at the level -1.52 ± 0.07 (± 0.15) (see Fig. 8) ⁽¹⁵⁾ <i>Peak-to-peak amplitude of identification signals:</i> For lines D'_B: 500 ± 50 mV For lines D'_R: 540^{+40}_{-50} mV if amplitude of luminance signal (between blanking level and peak white) equals 700 mV <i>Maximum deviation during transmission of identification signals (kHz):</i> For lines D'_R: $+350 \pm 18$ (± 35) For lines D'_B: -350 ± 18 (± 35) ⁽¹⁵⁾	

See notes next page.

- (¹) These values apply to the combination N/PAL used in Argentina. Only those values are given in this column which are different from the values given in the column B, G, H, N/PAL.
- (²) For SECAM systems and for existing sets, it is provisionally allowed to use the following chromaticity coordinates for the primary colours and white:

	x	y
Red	0.67	0.33
Green	0.21	0.71
Blue	0.14	0.08
White	0.310	0.316 (C-white)

- (³) In Japan, the chromaticity of studio monitors is adjusted to a D-white at 9300 K.
- (⁴) The primary signals are pre-corrected so that the optimum quality is obtained with a display having the indicated value of gamma.
- (⁵) In certain countries using the SECAM systems and in Japan it is also permitted to obtain the luminance signal as a direct output from an independent photo-electric analyser instead of from the primary signals.
- (⁶) For the SECAM system, it is allowable to apply a correction to reduce interference distortions between the luminance and chrominance signals by an attenuation of the luminance signal components as a function of the amplitude of the luminance components in the chrominance band.
- (⁷) This value will be defined more precisely later.
- (⁸) The maximum deviations from the nominal shape of the curve (see Fig. 6) should not exceed ± 0.5 dB in the frequency range from 0.1 to 0.5 MHz and ± 1.0 dB in the frequency range from 0.5 to 1.3 MHz.
- (⁹) When the signal originates from a portable or overseas source the tolerance on the frequency may be relaxed to ± 5 Hz. Maximum rate of variation of f_{SC} : 0.1 Hz/s.
- (¹⁰) This tolerance may not be maintained during such operational procedures as "genlock".
- (¹¹) A reduction of the tolerance is desirable.
- (¹²) The initial phase of the sub-carrier undergoes in each line a variation defined by the following rule:
From frame to frame: by 0° : 180° : 0° : 180° and so on, and also from line to line in either one of the following two patterns:
 0° : 0° : 180° : 0° : 0° : 180° : and so on,
or 0° : 0° : 0° : 180° : 180° : 180° : and so on.
- (¹³) $f_{SC} \pm 1300$ kHz is adopted in the People's Republic of China.
- (¹⁴) The unity value represents the amplitude of the luminance signal between the blanking level and the peak white-level.
- (¹⁵) Provisionally, the tolerances may be extended up to the values given brackets.
- (¹⁶) During transmission of a monochrome programme of significant duration, in order to ensure satisfactory operation of colour-killers in receivers, all signals having the same nominal frequency as the colour sub-carrier that appears in the line-blanking interval, should be attenuated by at least 35 dB below the peak-to-peak value of the burst given in item 2.15, column 3 of Table II, and shown as item 5 in Fig. 1.
- (¹⁷) The value given in Note (¹⁶) is accepted on a tentative basis.
- (¹⁸) Transmitter pre-correction for receiver group delay is not included.
- (¹⁹) For the use of automatic gain control circuits, it is important that the burst amplitude should maintain the correct ratio with the chrominance signal amplitude.
- (²⁰) Field 1 of the sequence of four fields in the NTSC video signal is defined by a whole line between the first equalizing pulse and the preceding horizontal synchronizing pulse and a negative-going zero-crossing of the reference sub-carrier nominally at the 50% point of the first equalizing pulse. The zero-crossing of the reference sub-carrier shall be nominally coincident with the 50% point of the leading edges of all horizontal synchronizing pulses for programme integration at the studio.
- (²¹) Field 1 of the sequence of eight colour fields is defined as that field, where the phase ϕ E'_{U} of the extrapolated E'_{U} component (see item 2.5 of Table II) of the video burst at the half amplitude point of the leading edge of the line synchronizing pulse of line 1 is in the range $-90^\circ \leq \phi E'_{U} < 90^\circ$.
- (²²) The value of the tolerance will be defined more precisely later.
- (²³) The line identification method is preferable, because it will enable agreements to be reached subsequently on the suppression of frame identification signals in international programme exchanges. In the absence of such agreements, signals meeting the SECAM standard are regarded as comprising such identification signals.
In France, a decree of 14 March 1978 specified that colour TV receivers placed on sale on or after 1 December 1979 must use the line identification method of decoding [CCIR, 1982-86e].
- (²⁴) The order in which the identification signals D_R^* and D_B^* appear on the four fields of a complete cycle given in Fig. 9 is in conformity with Recommendation 469.

TABLE III – Characteristics of the radiated signals (monochrome and colour)

Item	Characteristics		M	N (1)	B, G	H	I	D, K	K1	L
1	Frequency spacing (see Fig. 10)	Nominal radio-frequency channel bandwidth (MHz)	6	6	B: 7 G: 8	8	8	8	8	8
2		Sound carrier relative to vision carrier (MHz)	+4.5 (2)	+4.5	+5.5 ±0.001 (3), (4), (5)	+5.5	+5.9996 ±0.0005	+6.5 ±0.001	+6.5	+6.5
3		Nearest edge of channel relative to vision carrier (MHz)	–1.25	–1.25	–1.25	–1.25	–1.25	–1.25	–1.25	–1.25
4		Nominal width of main sideband (MHz)	4.2	4.2	5	5	5.5	6	6	6
5		Nominal width of vestigial sideband (MHz)	0.75	0.75	0.75	1.25	1.25	0.75	1.25	1.25
6	Minimum attenuation of vestigial sideband (dB at MHz) (6)		20 (–1.25) 42 (–3.58)	20 (–1.25) 42 (–3.5)	20 (–1.25) 20 (–3.0) 30 (–4.43) (7)	20 (–1.75) 20 (–3.0)	20 (–3.0) 30 (–4.43)	20 (–1.25) 30 (–4.33 ±0.1) (8) (9)	20 (–2.7) 30 (–4.3) ref.: 0 (+0.8)	15 (–2.7) 30 (–4.3) ref.: 0 (+0.8)
7	Type and polarity of vision modulations		C3F neg.	C3F neg.	C3F neg.	C3F neg.	C3F neg.	C3F neg.	C3F neg.	C3F pos.
8	Levels in the radiated signal (% of peak carrier)	Synchronizing level	100	100	100	100	100	100	100	< 6
		Blanking level	72.5 to 77.5	72.5 to 77.5 (75 ± 2.5)	75 ± 2.5 (10)	72.5 to 77.5	76 ± 2	75 ± 2.5	75 ± 2.5	30 ± 2
		Difference between black level and blanking level	2.88 to 6.75	2.88 to 6.75	0 to 2 (nominal)	0 to 7	0 (nominal)	0 to 4.5 (11)	0 to 4.5	0 to 4.5
		Peak white-level	10 to 15	10 to 15 (10 to 12.5)	10 to 12.5 (10) (12)	10 to 12.5	20 ± 2	10 to 12.5 (13) (14)	10 to 12.5	100 (≈ 110) (15)

See notes at the end of Table III.

TABLE III (continued)

Item	Characteristics	M	N ⁽¹⁾	B, G	H	I	D, K	K1	L
9	Type of sound modulation	F3E	F3E	F3E	F3E	F3E	F3E	F3E	A3E
10	Frequency deviation (kHz)	± 25	± 25	± 50	± 50	± 50	± 50	± 50	
11	Pre-emphasis for modulation (µs)	75	75	50	50	50	50	50	
12	Ratio of effective radiated powers of vision and sound ⁽¹⁶⁾	10/1 to 5/1 ⁽¹⁷⁾	10/1 to 5/1	20/1 to 10/1 (³) (¹⁸) (¹⁹)	5/1 to 10/1	5/1 10/1 ⁽²⁰⁾	10/1 to 5/1 ⁽²¹⁾	10/1	10/1
13	Pre-correction for receiver group-delay characteristics at medium video frequencies (ns) (see also Fig. 3)	0	$\begin{pmatrix} 1 \text{ MHz } 0 \pm 100 \\ 1 \text{ MHz } 0 \pm 100 \\ 1 \text{ MHz } 0 \pm 60 \end{pmatrix}$	⁽²²⁾			^(23a)		
14	Pre-correction for receiver group-delay characteristics at colour sub-carrier frequency (ns) (see also Fig. 3)	−170 (nominal)	$\begin{pmatrix} +60 \\ -170 & -40 \end{pmatrix}$	−170 (nominal) ⁽²²⁾			^(23b)		

⁽¹⁾ The values in brackets apply to the combination N/PAL used in Argentina.

⁽²⁾ In Japan, the values $+4.5 \pm 0.001$ are used.

⁽³⁾ In the Federal Republic of Germany a system of two sound carriers is used, the frequency of the second carrier being 242.1875 kHz above the frequency of the first sound carrier. The ratio between vision/sound e.r.p. for this second carrier is 100/1. For further information on this system see Report 795. For stereophonic sound transmissions a similar system is used in Australia with vision/sound power ratios being 20/1 and 100/1 for the first and second sound carriers respectively.

⁽⁴⁾ New Zealand uses a sound carrier displaced 5.4996 MHz from the vision carrier.

⁽⁵⁾ The sound carrier for single carrier sound transmissions in Australia may be displaced 5.5 ± 0.005 MHz from the vision carrier.

⁽⁶⁾ In some cases, low-power transmitters are operated without vestigial-sideband filter.

⁽⁷⁾ For B/SECAM and G/SECAM: 30 dB at −4.33 MHz, within the limits of ± 0.1 MHz.

⁽⁸⁾ In some countries, members of the OIRT, additional specifications are in use:

(a) not less than 40 dB at $-4.286 \text{ MHz} \pm 0.5 \text{ MHz}$,

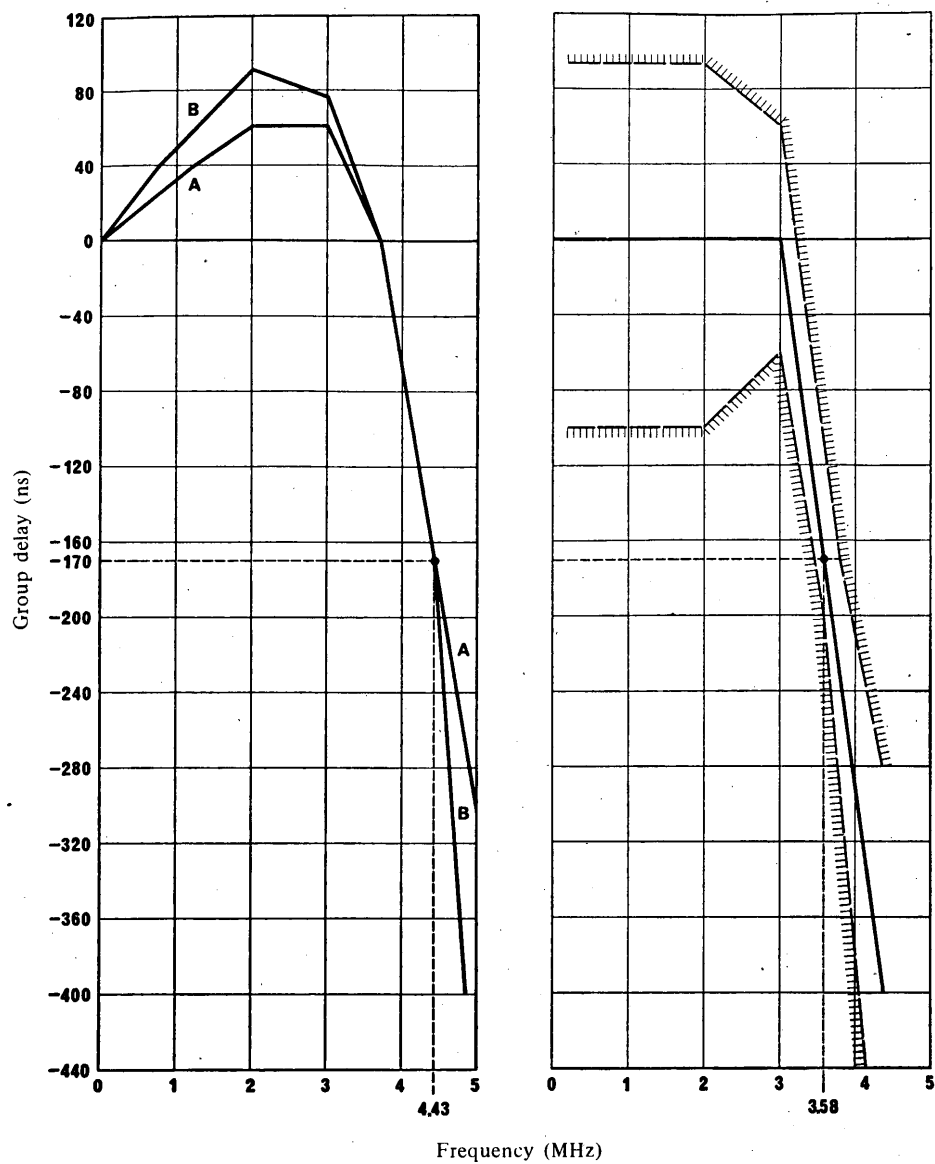
(b) 0 dB from -0.75 MHz to $+6.0 \text{ MHz}$,

(c) not less than 20 dB at $\pm 6.375 \text{ MHz}$ and higher;

Reference: 0 dB at $+1.5 \text{ MHz}$.

⁽⁹⁾ In the People's Republic of China, the attenuation value at the point (-4.33 ± 0.1) has not yet been determined.

- (¹⁰) Australia uses the nominal modulation levels specified for system I.
- (¹¹) In the People's Republic of China, the values 0 to 5 have been adopted.
- (¹²) Italy is considering the possibility of controlling the peak white-level after weighting the video frequency signal by a low-pass filter, so as to take account only of those spectrum components of the signal that are likely to produce inter-carrier noise in certain receivers when the nominal level is exceeded. Studies should be continued with a view to optimizing the response of the weighting filter to be used.
- (¹³) The USSR has adopted the value $15 \pm 2\%$.
- (¹⁴) A new parameter "white level with sub-carrier" should be specified at a later date. For that parameter, the USSR has adopted the value of $7 \pm 2\%$.
- (¹⁵) The peak white-level refers to a transmission without colour sub-carrier. The figure in brackets corresponds to the peak value of the transmitted signal, taking into account the colour sub-carrier of the respective colour television system.
- (¹⁶) The values to be considered are:
- the r.m.s. value of the carrier at the peak of the modulation envelope for the vision signal. For system L, only the luminance signal is to be considered. (See Note (¹⁵) above);
 - the r.m.s. value of the unmodulated carrier for amplitude-modulated and frequency-modulated sound transmissions.
- (¹⁷) In Japan, a ratio of 1/0.15 to 1/0.35 is used. In the United States, the sound carrier e.r.p. is not to exceed 22% of the peak authorized vision e.r.p.
- (¹⁸) It may be that the Austrian Administration will continue to use a 5/1 power ratio in certain cases, when necessary.
- (¹⁹) Recent studies in India [CCIR, 1982-86] confirm the suitability of a 20/1 ratio of effective radiated powers of vision and sound. This ratio still enables the introduction of a second sound carrier.
- (²⁰) The ratio 10/1 is used in the Republic of South Africa.
- (²¹) In the People's Republic of China, the value 10/1 has been adopted.
- (²²) In the Federal Republic of Germany and the Netherlands the correction for receiver group-delay characteristics is made according to curve B in Fig. 3a). Tolerances are shown in the table under Fig. 3a). From [CCIR, 1966-69] it is learned that Spain uses curve A. The OIRT countries using the B/SECAM and G/SECAM systems use a nominal pre-correction of 90 ns at medium video frequencies. In Sweden, the pre-correction is 0 ± 40 ns up to 3.6 MHz. For 4.43 MHz, the correction is -170 ± 20 ns and for 5 MHz it is -350 ± 80 ns. In New Zealand the pre-correction increases linearly from 0 ± 20 ns at 0 MHz to 60 ± 50 ns at 2.25 MHz, follows curve A of Fig. 3a from 2.25 MHz to 4.43 MHz and then decreases linearly to -300 ± 75 ns at 5 MHz. In Australia, the nominal pre-correction follows curve A up to 2.5 MHz, then decreases to 0 ns at 3.5 MHz, -170 ns at 4.43 MHz and -280 ns at 5 MHz. Based on studies on receivers in India, the receiver group delay pre-equalization proposed to be adopted in India at 1 MHz, 2 MHz, 3 MHz, 4.43 MHz and 4.8 MHz are +125 ns, +150 ns, +142 ns, -75 ns and -200 ns respectively.
- (^{23a}) Not yet determined. The Czechoslovak Socialist Republic proposes +90 ns (nominal value).
- (^{23b}) Not yet determined. The Czechoslovak Socialist Republic proposes +25 ns (nominal value).



(a) B/PAL and G/PAL systems
(See Table III (22)).

(b) M/PAL and M/NTSC systems

FIGURE 3 - Curve of pre-correction for receiver group-delay characteristics

Nominal values and tolerances (ns)

Frequency (MHz)	Curve A	Curve B
0.25		$+ 5 \pm 0$
1.00	$+ 30 \pm 50$	$+ 53 \pm 40$
2.00	$+ 60 \pm 50$	$+ 90 \pm 40$
3.00	$+ 60 \pm 50$	$+ 75 \pm 40$
3.75	0 ± 50	0 ± 40
4.43	-170 ± 35	-170 ± 40
4.80	-260 ± 75	-400 ± 90

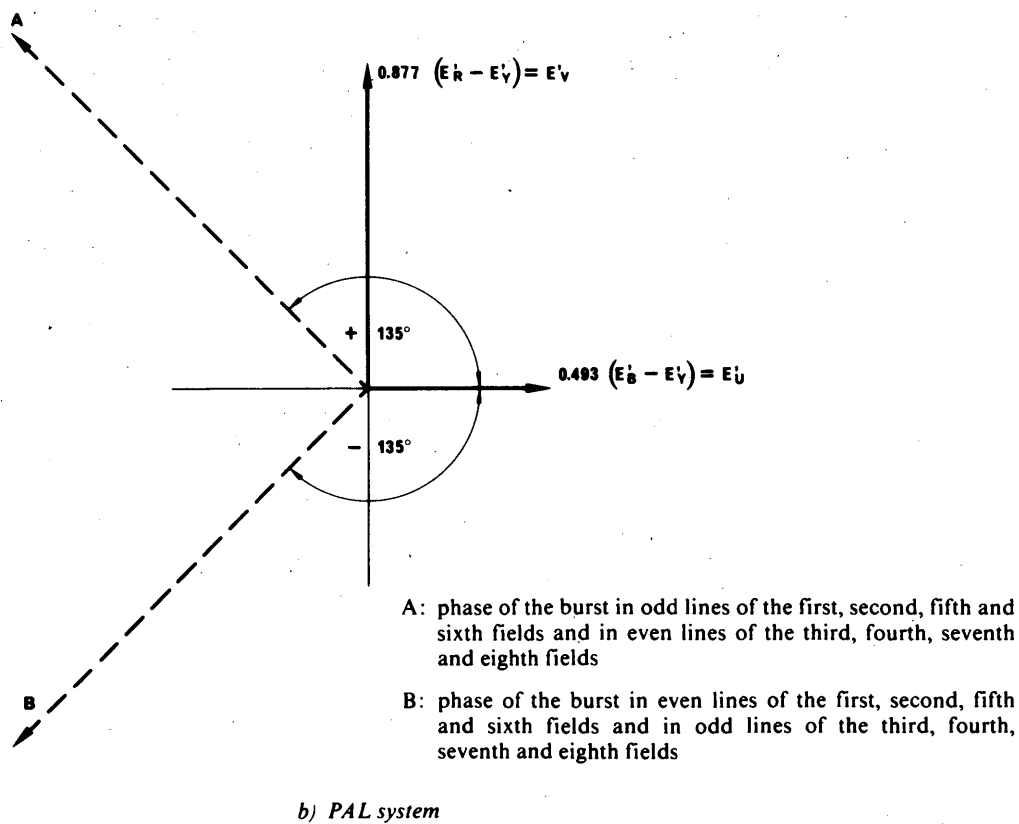
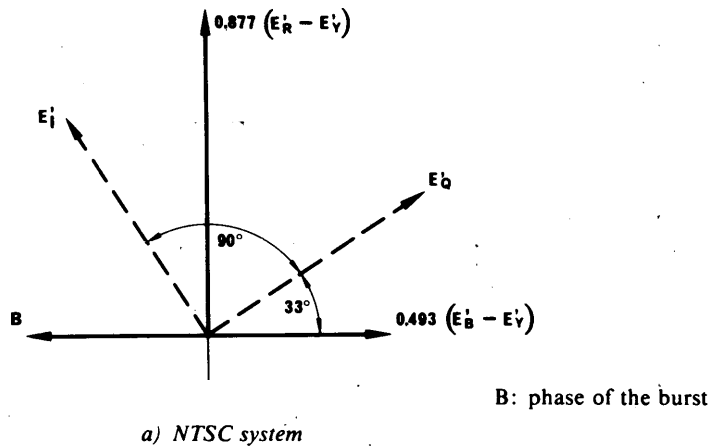


FIGURE 4 -- Chrominance axes and phase of the burst

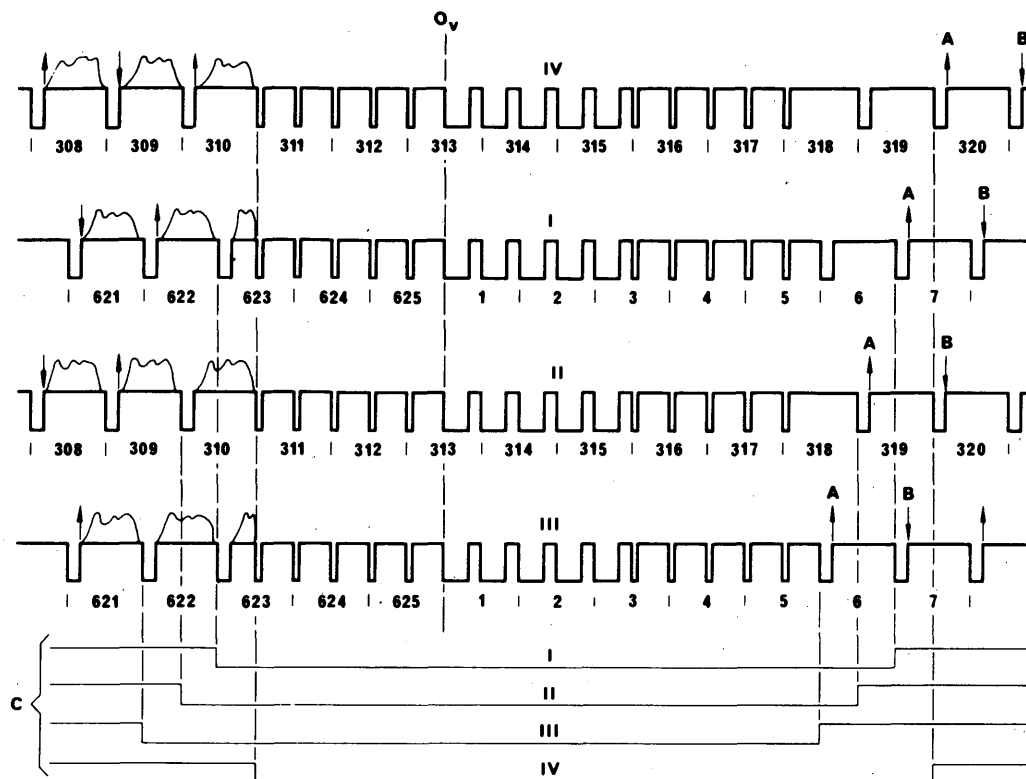


FIGURE 5a — Burst-blanking sequence in the B, G, H and I/PAL systems

O_v : field-synchronizing datum

I, II, III, IV: first and fifth, second and sixth, third and seventh, fourth and eighth fields (see item 2.16 of Table II)

A: phase of burst; nominal value $+135^\circ$

B: phase of burst; nominal value -135°

C: burst-blanking intervals

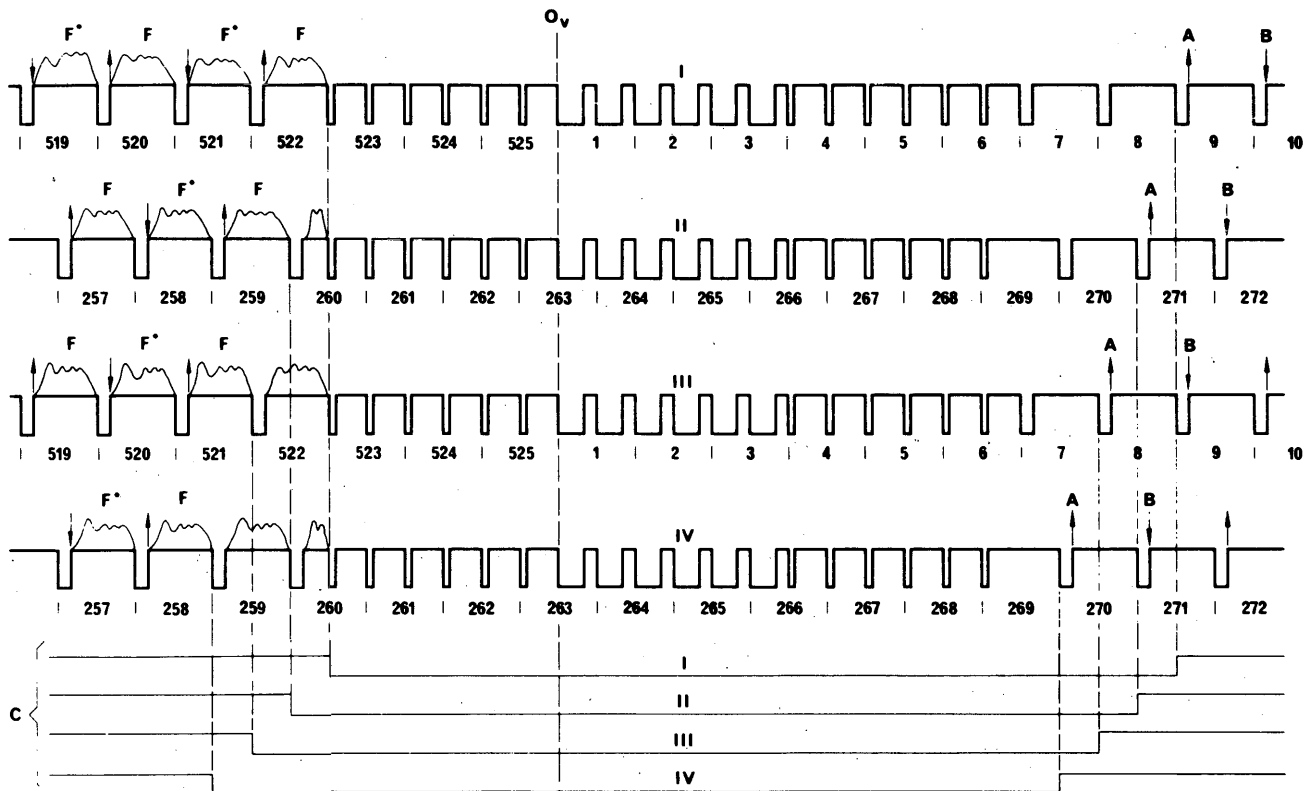


FIGURE 5b — Burst-blanking sequence in M/PAL system

- O_v : field-synchronizing datum
 I, II, III, IV: first and fifth, second and sixth, third and seventh, fourth and eighth fields (see item 2.16 of Table II)
 A: phase of burst; nominal value $+135^\circ$
 B: phase of burst; nominal value -135°
 C: burst-blanking intervals

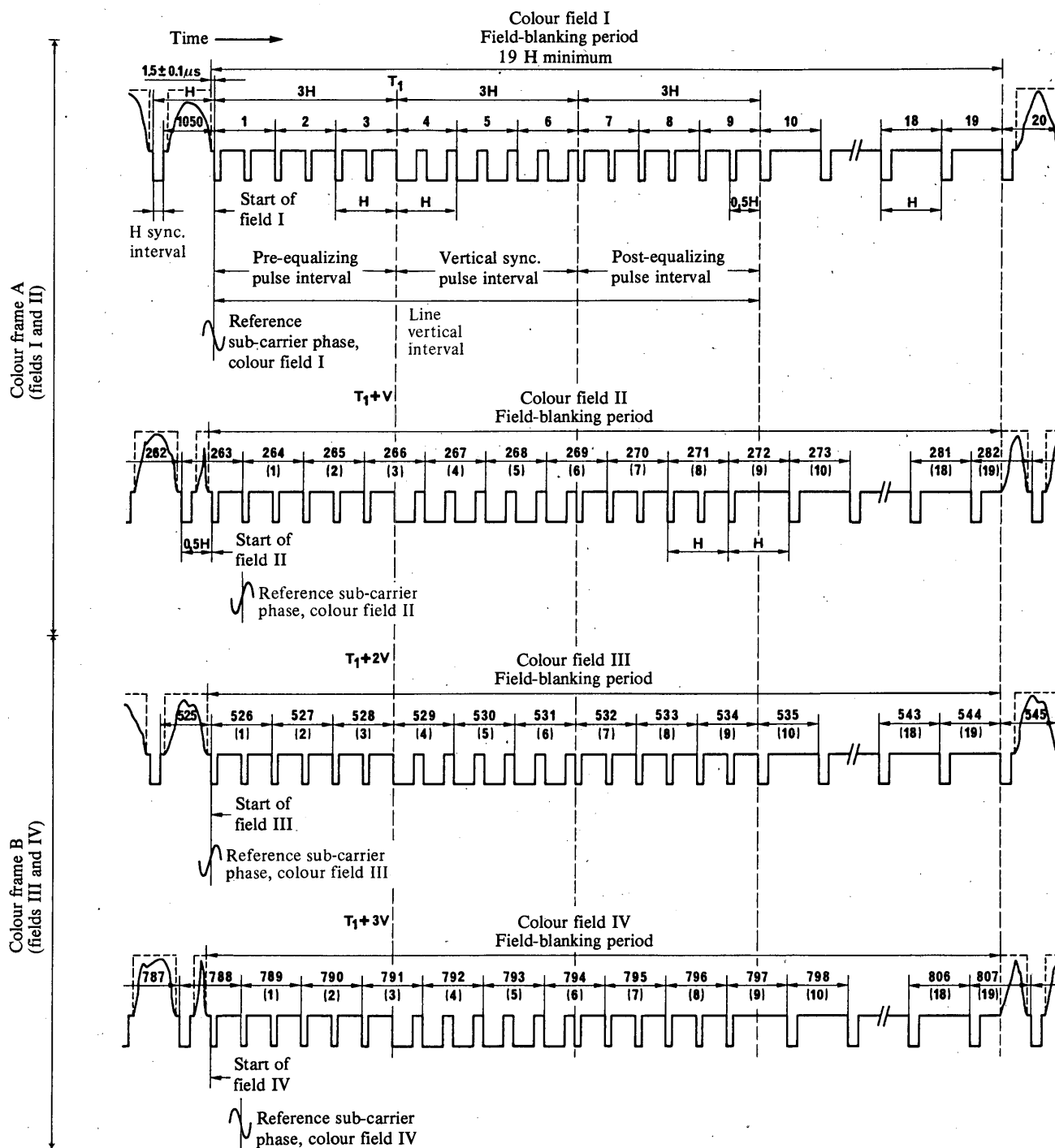


FIGURE 5c — Burst-blanking sequence in M/NTSC System

Note. — The numbering of specific lines is in accordance with new engineering practice. Line numbers in parentheses () represent an alternative method of line numbering used in some systems in some countries.

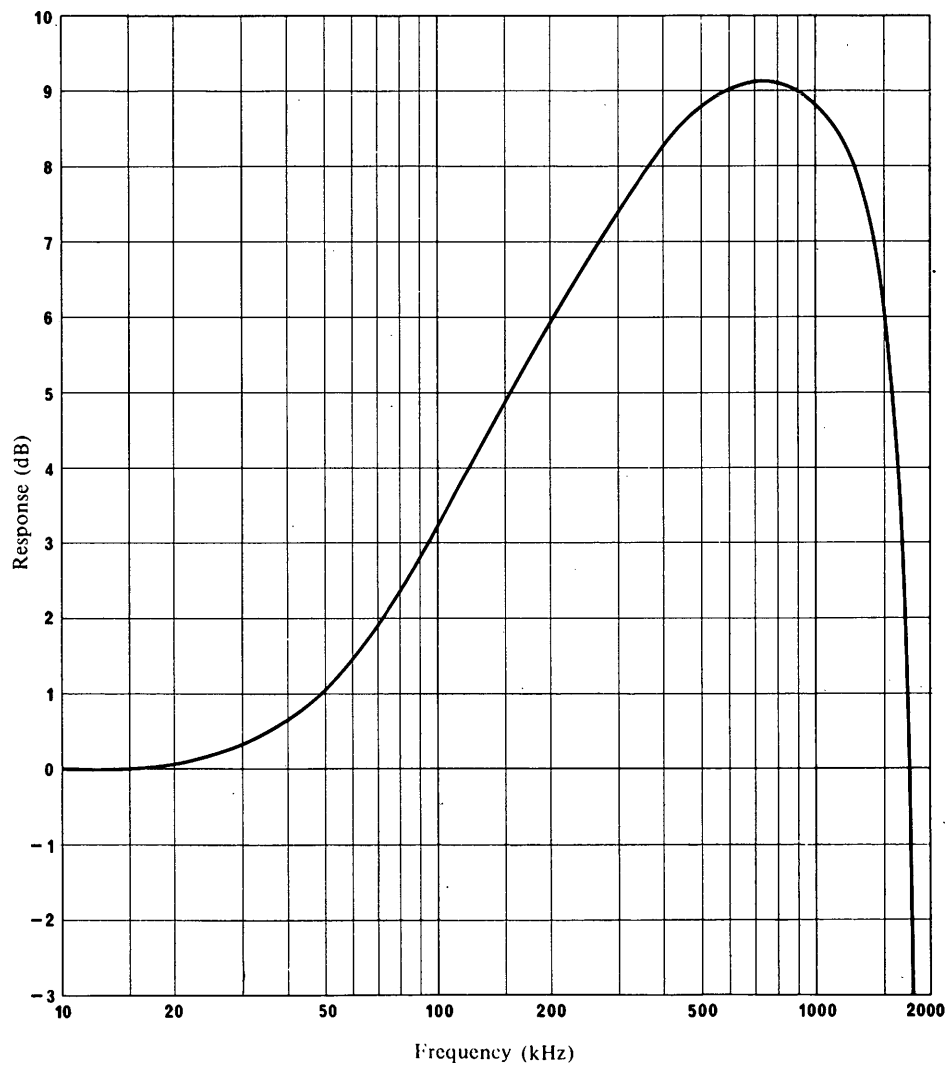


FIGURE 6 – Nominal response of transfer function resulting from the video-frequency precorrection circuit $ABF(f)$ and the low-pass filter (See Table II, item 2.7)

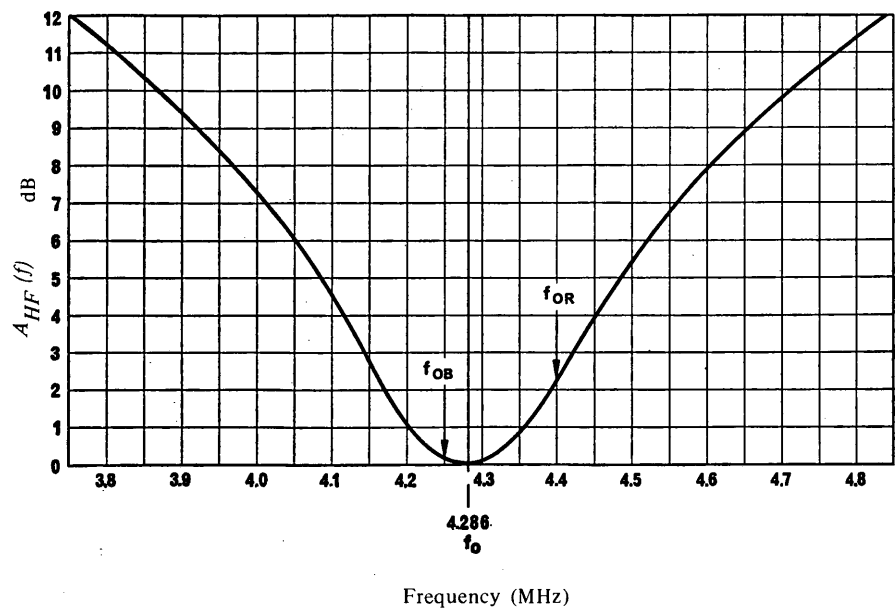


FIGURE 7 – Attenuation curve of frequency correction $A_{HF}(f)$
Deviations from the nominal curve outside point f_0 must not exceed ± 0.5 dB

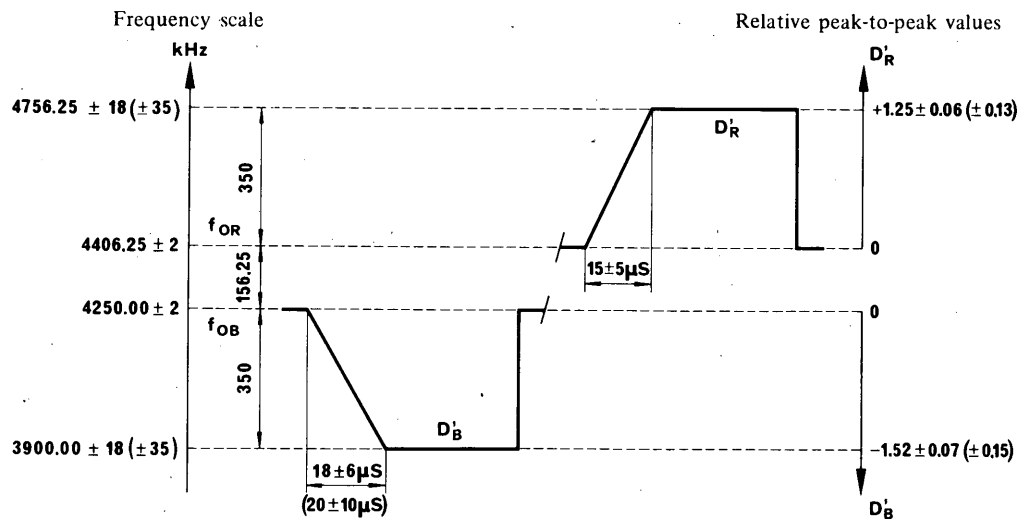


FIGURE 8 – Shape of video signals corresponding to the chrominance synchronization signals

The value 1 represents the amplitude of the luminance signal between the blanking level and the white level. Provisionally, the tolerances may be extended up to the values given in brackets.

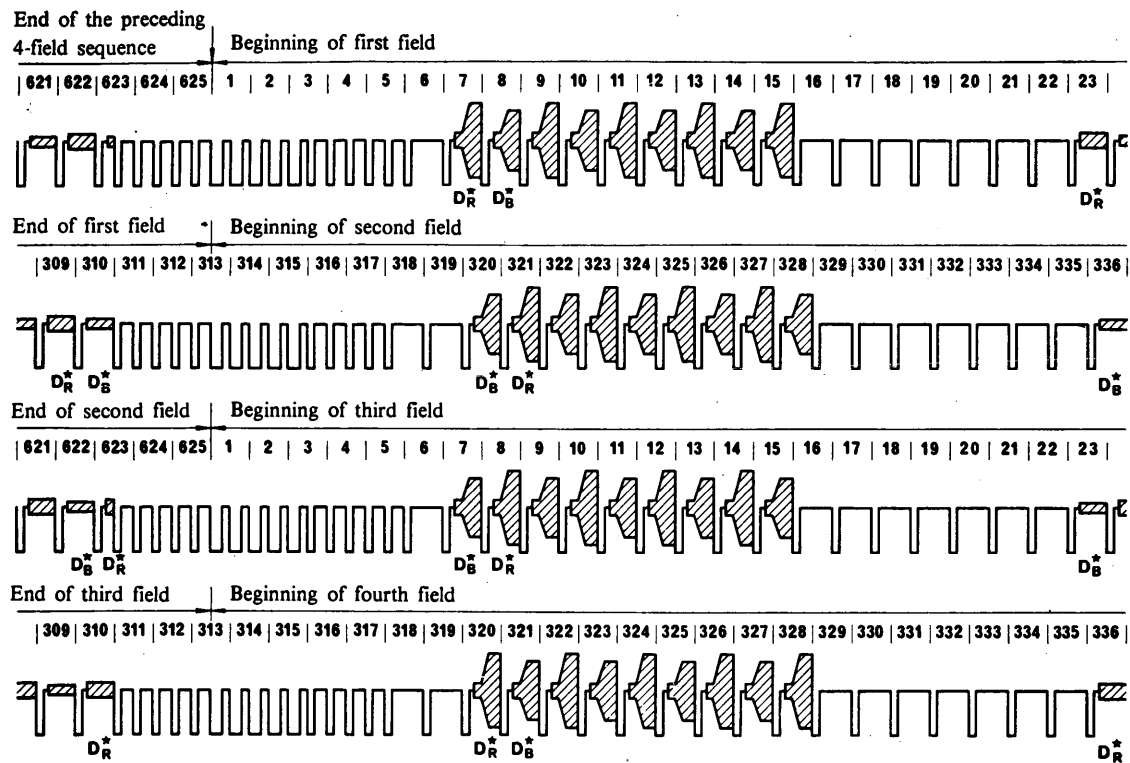


FIGURE 9 – Sequence of DR^* or DB^* signal over four consecutive fields

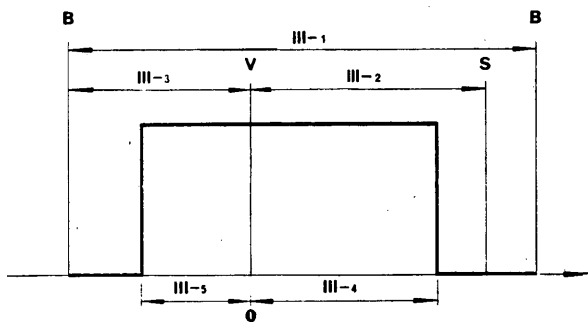


FIGURE 10 – Significance of items 1 to 5 in Table III

- B : Channel limit
- V : Vision carrier
- S : Sound carrier

Information on the results of the comparative laboratory tests carried out on the various colour television systems in the period 1963-1966 by broadcasting authorities, administrations and industrial organizations, together with the main parameters of systems may be found in Reports 406 and 407, XIIth Plenary Assembly, New Delhi, 1970.

All television systems listed in this Report employ an aspect ratio of the picture display (width/height) of 4/3, a scanning sequence from left to right and from top to bottom and an interlace ratio of 2/1, resulting in a picture (frame) frequency of half the field frequency. All systems are capable of operating independently of the power supply frequency.

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[1978-82]: 11/251 (EBU).

[1982-86]: a. 11/286 (USSR); b. 11/273 (United Kingdom); c. 11/365 (Australia); d. 11/376 (Germany (Federal Republic of)); e. 11/297 (France); f. 11/397 (India).

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[1966-69]: XI/136 (United Kingdom); XI/194 (Netherlands).

[1970-74]: 11/1 (EBU); 11/63 (USA); 11/276 (Germany (Federal Republic of)).

[1974-78]: 11/54 (OIRT); 11/440 (OIRT).

ANNEX I

SYSTEMS USED IN VARIOUS COUNTRIES/GEOGRAPHICAL AREAS

Explanation of signs used in the table:

- * : planned (whether the standard is indicated or not);
- : not yet planned, or no information received;
- / : the abbreviation following the stroke indicates the colour transmission system in use (NTSC, PAL or SECAM).

(Figures in brackets refer to the notes following the table.)

Note by the Director, CCIR. — Information received after the XVth CCIR Plenary Assembly has been included by the CCIR Secretariat (see Note 11).

Country/Geographical area	System used in bands:	
	I/III VHF broadcasting (Band 8)	IV/V UHF broadcasting (Band 9)
Afganistan (Democratic Republic of)	D/SECAM	—
Algeria (Algerian Democratic and Popular Republic)	B/PAL (11)	G/PAL (11)
Germany (Federal Republic of)	B/PAL	G/PAL
Angola (People's Republic of)	I/PAL (11)	— (11)
Netherlands Antilles	M	—
Saudi Arabia (Kingdom of)	B/SECAM	G/SECAM
Argentine Republic	N/PAL	N/PAL
Australia	B/PAL (17)	B/PAL (17)
Austria	B/PAL	G/PAL (1)
Bahrain (State of)	B/PAL	G/PAL
Bangladesh (People's Republic of)	B/PAL	—
Belgium	B/PAL	H/PAL
Benin (People's Republic of)	K1* (16)	K1* (16)
Bermuda	M/NTSC	—
Burma (Socialist Republic of the Union of)	M/NTSC	—
Bolivia (Republic of)	M/NTSC	M/NTSC
Brazil (Federative Republic of)	M/PAL	M/PAL
Brunei Darussalam	B/PAL	—
Bulgaria (People's Republic of)	D/SECAM	K/SECAM
Burkina Faso	K1/SECAM (11)	K1*/SECAM (11)
Burundi (Republic of)	K1* (16)	K1* (16)
Cameroon (Republic of)	B/PAL	G*/PAL
Canada	M/NTSC	M/NTSC
Central African Republic	K1* (16)	K1* (16)
Chile	M/NTSC	M/NTSC
China (People's Republic of)	D/PAL	D/PAL
Cyprus (Republic of)	B/SECAM	G/SECAM
Colombia (Republic of)	M	M*
Comores (Islamic Federal Republic of)	— (11)	— (11)
Congo (People's Republic of the)	K1* (16)	K1* (16)
Korea (Republic of)	M/NTSC	M/NTSC
Costa Rica	M/NTSC	M/NTSC
Côte d'Ivoire (Republic of)	K1* (16)	K1* (16)
Cuba	M/NTSC	M/NTSC
Denmark (Including Greenland and Faeroe Islands)	B/PAL	G/PAL
Djibouti (Republic of)	B/SECAM (11)	— (11)
Egypt (Arab Republic of)	B/SECAM (11)	G/SECAM (11)
United Arab Emirates	B/PAL	G/PAL
Spain	B/PAL	G/PAL
United States of America	M/NTSC	M/NTSC
Ethiopia	B/PAL	G*/PAL
Finland	B/PAL	G/PAL
France	L/SECAM (8)	L/SECAM (8)
Gabonese Republic	K1* (16)	K1* (16)
Ghana	B/PAL (11)	G*/PAL (11)
Gibraltar	B/PAL	G/PAL
Greece	B/SECAM	G/SECAM
Guinea (Republic of)	K1* (15) (16)	K1* (15) (16)
Equatorial Guinea (Republic of)	B/PAL (11)	— (11)
Hong Kong	—	I/PAL
Hungarian People's Republic	D/SECAM	K/SECAM
India (Republic of)	B/PAL	—
Indonesia (Republic of)	B/PAL	—
Iran (Islamic Republic of)	B/SECAM	G/SECAM
Ireland	I/PAL (4)	I/PAL (4)
Iceland	B/PAL	G*
Israel (State of)	B/PAL	G/PAL (6)
Italy	B/PAL	G/PAL
Jamaica	N	—
Japan	M/NTSC	M/NTSC
Jordan (Hashemite Kingdom of)	B	G*

Country/Geographical area	System used in bands:	
	I/III VHF broadcasting (Band 8)	IV/V UHF broadcasting (Band 9)
Kenya (Republic of)	B/PAL (11)	G*/PAL (11)
Kuwait (State of)	B/PAL	G*/PAL (10)
Lesotho (Kingdom of)	I*/PAL (11)	I*/PAL (11)
Liberia (Republic of)	B/PAL	—
Libya (Socialist People's Libyan Arab Jamahiriya)	B*/SECAM (16)	G* (16)
Luxembourg	B/PAL	G/PAL, L/SECAM
Madagascar (Democratic Republic of)	K1* (16)	K1* (16)
Malaysia	B/PAL	G/PAL
Malawi	B*/PAL (11)	G*/PAL (11)
Maldives	B/PAL	—
Mali (Republic of)	B/SECAM (11)	— (11)
Malta (Republic of)	B/PAL	—
Morocco (Kingdom of)	B/SECAM	G/SECAM (11)
Mauritius	B/SECAM	—
Mauritania (Islamic Republic of)	B/SECAM (11)	— (11)
Mexico	M/NTSC	M/NTSC
Monaco	L/SECAM	G/PAL, G/SECAM
Montserrat	M/NTSC	—
Niger (Republic of the)	K1* (16)	K1* (16)
Nigeria (Federal Republic of)	B*/PAL (11)	I*/PAL (11)
Norway	B/PAL	G*/PAL (3)
New Zealand	B/PAL (13)	G/PAL (13)
Oman (Sultanate of)	B/PAL	G/PAL
Uganda (Republic of)	B (9) (11)	G* (9) (11)
Pakistan (Islamic Republic of)	B/PAL	G/PAL
Panama (Republic of)	M/NTSC	M*/NTSC
Papua New Guinea	B/PAL	G/PAL
Netherlands (Kingdom of the)	B/PAL	G/PAL
Peru	M/NTSC	M/NTSC
Poland (People's Republic of)	D/SECAM	K/SECAM
Portugal	B/PAL	G/PAL
Qatar (State of)	B/PAL	G/PAL
Syrian Arab Republic	B/PAL	G/PAL
German Democratic Republic	B/SECAM	G/SECAM
Roumania (Socialist Republic of)	D/PAL	K/PAL
United Kingdom of Great Britain and Northern Ireland	— (5)	I/PAL
Rwanda (Republic of)	K1* (16)	K1* (16)
St. Christopher and Nevis	M/NTSC	—
Senegal (Republic of the)	K1* (16)	K1* (16)
Sierra Leone	B (14) (16)	G* (16)
Singapore (Republic of)	B/PAL	G*/PAL (12)
Somali Democratic Republic	B* (16)	G* (16)
Sri Lanka (Democratic Socialist Republic of)	B	—
South Africa (Republic of)	I/PAL	I/PAL
Sweden	B/PAL	G/PAL
Switzerland (Confederation of)	B/PAL	G/PAL (7)
Surinam (Republic of)	M/NTSC	—
Tanzania (United Republic of)	I* (11)	I* (11)
Chad (Republic of the)	K1* (16)	K1* (16)
Czechoslovak Socialist Republic	D/SECAM	K/SECAM
Thailand	B/PAL	G/PAL*
Togolese Republic	K1* (16)	K1* (16)
Tunisia	B/SECAM, PAL (2)	G/SECAM, PAL (2)
Turkey	B/PAL	G/PAL
Union of Soviet Socialist Republics	D/SECAM	K/SECAM
Uruguay (Oriental Republic of)	N/PAL	—
Venezuela (Republic of)	M	—
British Virgin Islands	M/NTSC	—
Viet Nam (Socialist Republic of)	D/SECAM	K/SECAM
Yugoslavia (Socialist Federal Republic of)	B/PAL	G/PAL
Zaire (Republic of)	K1* (15) (16)	K1* (15) (16)
Zambia (Republic of)	B/PAL	G*/PAL
Zimbabwe (Republic of)	B/PAL	G*/PAL

Note 1. — Austria reserves the right to the possible use of additional frequency-modulated sound carriers, in the band between 5.75 and 6.75 MHz, in relation to the picture carrier.

Note 2. — In Tunisia SECAM is used for broadcasting the national programmes; PAL is used for rebroadcasting other programmes.

Note 3. — No definite decision has been taken about the width of the residual sideband, but this country is willing to accept the assumption that for planning purposes the residual sideband will be 0.75 MHz wide.

Note 4. — System I will be used at all stations though with a vision to sound ratio of up to 10/1. In addition Ireland reserves the right to the possible use of an additional sound carrier in the band between 5.5 MHz and 6.75 MHz in relation to the vision carrier.

Note 5. — The United Kingdom has ceased to use Bands I and III for television broadcasting.

Note 6. — No final decision has been taken about the width of the residual sideband, but for planning purposes this country is willing to accept the assumption of a residual sideband 1.25 MHz wide.

Note 7. — The Swiss Administration is planning to use additional frequency-modulated sound carriers, in the frequency interval between the spacings of 5.5 and 6.5 MHz in relation to the picture carrier, at levels lower than or equal to the normal level of the sound carrier, for additional sound-tracks or for sound broadcasting.

Note 8. — In the French Overseas departments and territories, the system K1 is used instead of L/SECAM which is used in the metropolitan area.

Note 9. — Uganda is already committed to Standard B in band III. Standard G is planned for bands IV and V although further consideration will be given to other standards when bands IV and V stations are to be commissioned.

Note 10. — In Kuwait, if the services are called upon to broadcast in a second language, the frequencies between 5.5 MHz and 6.5 MHz could be used to provide an additional frequency-modulation sub-carrier.

Note 11. — The Indications are based on information provided by the respective country at the African Broadcasting Conference (AFBC(1)), Nairobi, September/October, 1986.

Note 12. — Singapore reserves the right to use additional frequency-modulation sound channels in the band between 5.5 and 6.5 MHz in relation to the picture carrier, for additional sound channels for sound broadcasting.

Note 13. — In New Zealand the frequency spacing between the vision carrier and the sound carrier is 5.4996 ± 0.0005 MHz and the modulation levels are identical to those of System I.

Note 14. — Sierra Leone now uses Standard B but reserves the right to use any other standard compatible with the Plan.

Note 15. — Zaire and Guinea (Republic of), planning has been based on Standard K1, but they reserve the right to use any other standard compatible with the Plan when they introduce television.

Note 16. — The Indications and Notes 14 and 15 are based on indications and notes given in the Final Acts of the VHF/UHF African Broadcasting Conference, Geneva, 1963.

Note 17. — Australia uses nominal modulation levels as specified for System I. The sound carrier for single carrier sound transmissions in Australia may be displaced 5.5 ± 0.0005 MHz from vision carrier. For stereophonic sound transmission the first sound carrier is 5.5 ± 0.0005 MHz from the vision carrier and the second sound carrier is 242.1875 kHz above this frequency.

ANNEX II

CHIEF TECHNICAL CHARACTERISTICS OF THE SECAM IV COLOUR TELEVISION SYSTEM

1. Signals transmitted

SECAM IV is compatible with standard black-and-white 625-line television systems, except system N. The luminance signal is obtained from gamma-corrected primary signals E'_R , E'_G , E'_B , and corresponds to the equation:

$$E'_Y = 0.30 E'_R + 0.59 E'_G + 0.11 E'_B$$

The colour information is transmitted by two colour-difference signals:

$$D'_R = \frac{1}{1.14} (E'_R - E'_Y)$$

$$D'_B = \frac{1}{2.03} (E'_B - E'_Y)$$

Before modulation, the frequency band of the colour-difference signals occupies more than 1.5 MHz.

2. Transmission procedure

The colour-difference signals are transmitted by modulation of a sub-carrier. They are differentiated from one line to the next as follows:

Signal transmitted during one of the lines

$$E_{S1} = \{\sqrt{D_B'^2 + D_R'^2} + E_p\} \cos \{\omega_0 t + \varphi(t)\}$$

Signal transmitted during the following line

$$E_{S2} = \{\sqrt{D_R'^2 + D_B'^2} + E_p\} \cos (\omega_0 t + \varphi_0)$$

where:

E_p is a d.c. voltage equal to 10% of the maximum signal,

$$\varphi(t) = \arctan (D'_B / D'_R)$$

3. Frequency of the colour sub-carrier

The frequency of the colour sub-carrier is equal to: $f_0 = 4.43361875$ MHz. It is related to the line sweep frequency, $f_H = 15\,625$ Hz, by the following equation:

$$f_0 = (284 - 1/4) f_H + 25 \text{ Hz.}$$

4. Colour synchronization signal

The receiver switch is synchronized by synchronization signals transmitted with the composite video signal. They represent six wave trains of the colour sub-carrier, each train lasting about 40 μ s. They are transmitted during the field returns in the 6th-11th lines of the first field and in the 319th-324th lines of the second field. During the even lines, the sub-carrier phase in the train is $\varphi = 90^\circ$, and during all the odd lines $\varphi = 180^\circ$. The amplitude of each wave train is equal to 30% of the composite signal E'_Y measured between the white and black levels.

5. Reception procedure

The colour-difference signals D'_R and D'_B are obtained by multiplication of the transmitted signals $E_{(2n+1)}$ and E_{2n} , each signal being delayed in turn by the duration of one line. The level of the signal E_{2n} must be 10 to 20 times higher than that of the signal $E_{(2n+1)}$.

To obtain the correct polarity for the signals $E'_{B-\gamma}$ and $E'_{R-\gamma}$ at each line, a switch working to the line periodicity is used.

REPORT 1077

ENHANCED QUALITY TELEVISION SYSTEMS

(Question 42/11)

(1986)

1. Introduction

Since the development of electronic television, the art has experienced a continuous evolutionary development which has produced a stream of improvements in the quality of pictures displayed to the viewer. A quantum step in quality occurred with the introduction of colour. New digital technology now offers storage, filtering and processing capabilities that will permit separate scanning standards for the picture source, emission and in the display, thereby providing increased quality through conventional television systems. New distribution media having wider bandwidth, such as broadcasting satellites, will permit new services with increased definition and wider aspect ratios.

2. Definition of terms

The term *enhanced television* designates a number of different improvements applicable to 525/60 and 625/50 television systems, providing an aspect ratio of 4:3, either with unchanged or with new emission standards.

The term *extended definition television* implies new systems that are based upon 525/60 or 625/50 scanning, but providing a wider aspect ratio and increased resolution.

3. Areas of possible quality enhancements

Enhancement of signal quality is expected to be introduced in the areas listed below, all of which will contribute, in a varying degree, to improving the overall quality of the received television picture:

- alias effects generated by the scanning process;
- luminance/colour difference cross-effects;
- signal processing capability;
- generation of moiré and non-linear signal distortion in video tape recorders;
- immunity to transmission impairments;
- receiver decoding and display techniques.

4. Enhancement potential of various signal formats

4.1 Composite formats

The composite signal formats NTSC, PAL and SECAM suffer from noticeable signal impairment due to cross colour and cross luminance. Significant quality improvements can be achieved by the use of multi-dimension separation filters based on line stores or frame stores. Complementary pre-filtering of the video before colour encoding can further improve picture quality.

Methods for achieving some of these improvements are discussed in the references [Khleborodov, 1971; Wendland, 1979; Clarke, 1981; Jackson and Tan, 1981; Tonge, 1981; Schönfelder, 1983].

The British Broadcasting Corporation demonstrated the use of picture stores for PAL decoding to a joint EBU/SMPTE Meeting in London in April 1980 [Clarke, 1981] and the effects of motion-adaptive luminance/chrominance separation methods at the International Broadcast Convention (IBC) in 1982 [Clarke, 1982].

The picture quality possible from the use of field stores in the receiver to process conventional PAL signals was demonstrated by Philips N.V. at the International Television Symposium at Montreux in 1983.

When appropriate filtering is applied ahead of the display, further improvements in the effective vertical resolution can be achieved by filtering at the source. The so-called Kell effect, that results from the excess Nyquist margin in the vertical sampling (scanning) of the image that must be allowed at the camera to avoid aliasing, reduces the effective vertical resolution of a television system.

Studies in the Federal Republic of Germany have shown that oversampling (double line-rate scanning) at the camera, followed by vertical filtering and aperture corrections, followed by subsampling (selecting alternate lines) for transmission, can increase the Kell factor to a number approaching unity, thus increasing the effective vertical resolution of a television system by a factor of 30-40%. When this technique is combined with display filtering (§ 6), much larger increases in vertical resolution should be possible [Wendland, 1979].

The theoretical aspects of source and display filtering are presented in [Tonge, 1981].

4.2 *Analogue component formats*

Further improvements in picture quality can be obtained by the use of signals in analogue component form due to the absence of luminance/chrominance cross-talk, the possible expansion of colour difference bandwidth and the elimination of artifacts caused by the high-frequency and high-amplitude sub-carrier present in composite systems.

The digital television experiments that preceded the adoption of Recommendation 601 clearly showed the advantages of handling video signals in component rather than composite form.

The use of analogue components may be viewed as either an evolutionary step towards the all-digital studio based on Recommendation 601 or as a system which in itself provides an adequate level of performance except in certain specialized areas. In both cases a high level of compatibility should exist between the digital component signals, the analogue component forms used in many portable equipments, the analogue component forms used in the studio and for satellite broadcasting, and the relevant composite signals.

When the main concern is to maintain compatibility with existing equipments and infra-structures, the work reported in [CCIR, 1982-86a, b] indicates that subject to further study a MAC 3-1-0 time compression and time-division multiplex coding is feasible with slight modifications to existing equipment, and that a MAC 4-2-0 coding is feasible with more major modifications. Experiments have shown that the pictures obtained with a MAC 3-1-0 coding are clearly superior to those obtained with SECAM coding. Existing analogue recording, distribution and switching equipment was used in the studio, and mixing options were proposed. Re-utilization of existing equipment would permit a flexible transition to digital operation.

The use of video, in component form, has many advantages for the studio compared to composite video, when critical operations such as colour matte and picture manipulation are considered. The CCIR has already defined a signal format (see Recommendation 601) and suggested an interface arrangement (see Recommendation 656) for a digital component signal and there is now a need to define equivalent signal forms and interfaces for the analogue component signal, thus allowing the benefits of components to be realized at an early date. The technology for analogue component equipment is a small extension from current designs and leads to a logical progression towards the digital component studio [Baldwin, 1983]. In Study Programme 42A/11, the essential issues are outlined. In the United States of America, SMPTE has already set up a Working Group on Analogue Component Video charged with arriving at a draft standard for studio application at an early date. There is general agreement among those active in the field, that a signal form employing time-compression and time-division multiplexing is the most attractive one.

In the case of the recorder, the benefits have already been demonstrated in both 525-line and 625-line countries, through modifications to existing recorders which show improved quality with no increase in tape consumption.

[CCIR, 1982-86c] describes the hardware implications and problem areas when recording multiplexed analogue signals derived from a family of digital standards as described in [CCIR, 1982-86b] on conventional 25.4 mm video tape recorders. It concludes that only MAC signals of the form 4-2-0 or 3-1-0 lend themselves to an economical modification of existing recorders.

4.2.1 *Main studio equipment*

A wealth of information regarding the quality obtainable in 525-line and 625-line television systems by the use of components and the resulting improvements in production processing [SMPTEJ, 1981; EBU, 1981; Nishizawa *et al.*, 1981; CCIR, 1978-82a, b, c, d] has been generated; it seems that an analogue component system would offer a quality considerably above that of composite (NTSC, PAL, SECAM) systems but that technology and economic considerations impose a limit somewhat below that of the digital component 4:2:2 system, particularly if the constraints of current equipment and of recording standards are considered. It appears that colour signal bandwidths of 2 to 2.2 MHz are feasible with a modest improvement in luminance performance. There could be significant improvements in colour noise and the elimination of cross-effects and vertical artifacts (PAL and SECAM). Intermodulation effects such as differential gain and phase would also be eliminated if a time-multiplexed component format were to be employed.

Time-multiplexed analogue components can be routed through conventional coaxial cables, amplifiers and cross-point matrices, provided the signal bandwidth is not excessive and cross-talk behaviour in the frequency range above 5 MHz can be controlled. Most current equipment for picture origination can provide component outputs suitable for generating time-multiplexed analogue signals.

For the mixer, the use of analogue components will improve colour matte and eliminate the decode/re-encode functions found in many special effects systems. The result will be better quality and somewhat less complexity.

4.2.2 *Lower quality applications*

When portability concerns are paramount, or the use of a narrower bandwidth recorder or emission channel is important, then a signal based on line-sequential transmission of colour difference signals may be adequate, in spite of the resolution loss and vertical colour aliasing introduced [CCIR, 1982-86d]. Work in [CCIR, 1982-86a; Schachlbauer, 1983] indicates that a quality level considerably better than that of composite signals can be obtained in this way using equivalent channels.

Luminance bandwidths of about 4 MHz and colour difference signal bandwidths of about 2 MHz are achievable in a 6 MHz channel bandwidth. Commercial equipment employing two recording channels is available with similar performance.

[CCIR, 1982-86e] describes an interface for equipment interconnection of an electronic news-gathering system. This system illustrates the evolutionary tendency in production systems and provides considerably improved ENG quality.

4.2.3 *Circuit transmission*

The transmission of the analogue component signals between studio centres or between an OB site and its associated control studio, for example, will certainly be required. Due to the lack of a colour sub-carrier in such signals, it appears that some relaxation of frequency response and of linearity requirements can be tolerated.

In the case of studio signals, having a bandwidth of 9 to 11 MHz, new or updated equipment might be required. A number of alternatives are possible and should be the subject of joint studies with the CMTT. It should be noted, however, that these video signals will have close compatibility with the 4:2:2 digital standard and hence any digital transmission systems (and associated bit-rate reduction) installed for such digital video signals will be suitable also for analogue component signals converted into the 4:2:2 digital form. In the case of analogue transmission facilities, the best arrangement is not yet clear. (See Question 24/CMTT.)

In Italy, an investigation has been carried out by RAI [CCIR, 1982-86f] with the purpose of assessing the possibility of transmitting television signals, having a baseband bandwidth greater than conventional systems in the network of contribution links with a channel spacing according to Recommendation 382. The preliminary results show the possibility of exploiting the network with signals having a bandwidth of up to 10 MHz. A foreseen application consists of the use of time-compressed and multiplexed analogue components for the contributions from one studio centre to another; the actual bandwidth of the luminance and of the two simultaneous colour-difference components is close to that of Recommendation 601.

In the case of lower quality signals (§ 4.2.2), a transmission channel bandwidth of perhaps 5 or 6 MHz will suffice, making it possible to use existing facilities, established for composite signals, as long as the specified waveform maintains adequate clamping.

[CCIR, 1982-86g] gives an overview of objective measurement methods for analogue component transmission systems and notes that the methods of measurement in Recommendation 567 supplemented by the response to a T sine-squared pulse may be suitable, provided that the T and $2T$ pulse widths are appropriately chosen for the channel bandwidths. The correlation between these objective parameters and subjective quality, however, remains to be confirmed.

A test signal for routine measurements of the T -pulse response which may be useful for analogue component systems is described in [CCIR, 1982-86h].

4.2.4 Emission

The emission aspects of analogue component signals in the broadcasting-satellite service are discussed in Report 1074.

The use of time-multiplexed analogue components was initially proposed in the United Kingdom [Lucas and Windram, 1981] for new broadcasting-satellite services in that country.

The substantial improvements achievable from the transmission of time-multiplexed analogue components combined with postfiltering at the display were demonstrated widely in 1982 by the Independent Broadcasting Authority.

4.3 Digital component formats

Experience has shown that digital component equipment can provide unsurpassed capability in terms of high and constant quality together with processing flexibility.

Recommendation 601 describes a family of coding standards for studio operation. Reports 629 and 962 provide additional information on the associated filtering and on digital television in general.

Recommendation 656 specifies interfaces for the equipment using the main digital studio level of Recommendation 601 and, also gives further information on the operation of such interfaces.

Recommendation 657 specifies the format for the interchange of programmes recorded digitally on magnetic tape.

Studies in the United States of America have concluded that digital component signals in accordance with Recommendation 601 are the preferred format for in-plant distribution of enhanced television signals, even if derived from component analogue or high line-rate sources [CCIR, 1982-86i].

5. Extended systems

A few extended definition systems have been described and demonstrated.

In Japan, the time compressed integration (TCI) multiplexing system has been developed [CCIR, 1982-86j] for use in HDTV broadcasting by satellite, but the concept is also applicable to extended systems [Rhodes, 1982].

In the Netherlands and the United Kingdom, the concept of time-multiplexed analogue components has been extended and applied to the vertical or horizontal dimension so that wider aspect ratios are more readily obtained [Long, 1983; Windram *et al.*, 1983; CCIR, 1982-86k].

At the International Television Symposium at Montreux in 1983, Philips N. V. demonstrated the feasibility of a 5 : 3 aspect ratio in a system with line-multiplexed (vertical) luminance and colour-difference components.

In the United Kingdom, the IBA has developed a system based on the 625-line C-MAC/packet coding scheme for the single-channel transmission of wide aspect ratio extended television, and also for BSS in the 12 GHz band [Windram *et al.*, 1983]. This system is called enhanced C-MAC.

In [CCIR, 1982-86l] it is claimed that it is possible that extended C-MAC itself could be used as a transmission system for a higher line-rate HDTV production standard based on a 50 Hz field rate. (For example, the enhanced C-MAC transmission format could interface readily with a 625-line non-interlaced source.) It is also claimed that an enhanced transmission system could then equally be seen as an HDTV-transmission system using vertical sub-sampling.

6. Display enhancement

The possible future availability of low-cost field stores in domestic receivers will permit separating the display scanning parameters from those of the emission standard. Cross-colour and cross-luminance can be essentially eliminated by luminance/chrominance separation using frame stores. An increase in the field frequency can eliminate large area flicker. An increase in the number of lines displayed per picture height can reduce or eliminate the interline flicker and the line crawl that occur in conventional television systems.

Methods for achieving some of these improvements are discussed in [Wendland, 1979, 1982; Jackson and Tan, 1981; Lucas and Windram, 1981; Sandbank and Moffat, 1983; Schönfelder, 1983].

In Japan, a scan-conversion system using a motion-adaptive spatio-temporal interpolation filter with receiver frame memory has been developed [Nishizawa and Tanaka, 1982; CCIR, 1982-86m] to reduce interlaced line-scanning impairments. It improves picture quality for both still and moving pictures.

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APPENDIX I

The major links in the television chain (production, distribution, display) may be specified using different but related standards. Table I identifies in its "boxes" the basic elements of present and possible future television systems. The boxes of the same line correspond to standards of different quality levels. Conversion between production standards is envisaged according to operational requirements. Television services use different paths going from production to display; paths in the vertical direction represent the most straight forward way of implementing one service, nevertheless, oblique paths are usable if required. As an example, a signal produced in analogue components (box 2) may feed a composite signal distribution network (box 5) and decoded for display in a conventional form (box 9). On the other side the same production signal may feed a multiplexed-analogue-components signal distribution network (box 6) and could in turn feed either a conventional *RGB* display (box 10) or an improved display using scanning up-conversion (box 11).

TABLE I — *A tentative classification of TV standards:
arrows indicate the main paths of interest*

Field of application of baseband standards	Systems based on conventional scanning structures (625/50 or 525/60 2 : 1 interlaced)		Systems based on higher resolution scanning structures and wider aspect ratio	
Production of television programmes	PAL/SECAM/NTSC (Rep. 624) 1 ↓	Analogue <i>Y</i> , <i>R-Y</i> , <i>B-Y</i> components (Rep. 1077) Digital <i>Y</i> , <i>C_R</i> , <i>C_B</i> components (Rec. 601) 2 ↓	625/50 and 525/60 related extended-definition television (Rep. 1077) 3 ↓	HDTV production (Rep. 801) 4 ↓
Distribution of television programmes (transmission and emission)	PAL/SECAM/NTSC (Rep. 624) 5 ↓	Time-compressed and multiplexed analogue <i>Y</i> , <i>R-Y</i> , <i>B-Y</i> components (MAC) (Reps. 1073, 1074, 1077) 6 ↓	Extended-definition television distribution 7 ↓	HDTV distribution 8 ↓
Display of broadcast programmes	<i>R</i> , <i>G</i> , <i>B</i> components (decoded from composite) 9	<i>R</i> , <i>G</i> , <i>B</i> components (derived from <i>Y</i> , <i>R-Y</i> , <i>B-Y</i>) 10	Up-converted <i>R</i> , <i>G</i> , <i>B</i> components 11	HDTV <i>R</i> , <i>G</i> , <i>B</i> components 12

RECOMMENDATION 471-1

NOMENCLATURE AND DESCRIPTION OF COLOUR BAR SIGNALS

(Question 1/11)

(1970-1986)

The CCIR,

CONSIDERING

- (a) that a number of different colour bar signals used for measurement and adjustment purposes are recorded on magnetic tape, transmitted on national and international circuits or radiated from television transmitters;
- (b) that the particular signal in use cannot be readily recognized from the video picture-signal waveform;

(c) that coloured patterns comprising several vertical bars of colour, involving only the primary hues and their complements at particular values of saturation and in descending order of luminance, are frequently used to confirm the correct operation of colour coding, decoding and processing equipment,

UNANIMOUSLY RECOMMENDS

1. that the following nomenclature is used to identify and distinguish between colour bar signals;

1.1 a colour bar generator is assumed to have three outputs corresponding respectively to the red, green and blue primary colour signals, (E'_R , E'_G and E'_B) which are then used as input signals to a colour coder. The signal amplitudes enumerated below refer to these coder input signals expressed as a percentage of the white level (see, for example, Recommendation 567, Part B, § B.1 and Report 624, Fig. 1), taking this as 100% with the blanking level as zero. During the transmission of colour bars the signal levels should be enumerated in the following order, with an oblique stroke between the numbers:

- the primary colour signal level during the transmission of the “white” colour bar, i.e. maximum value of E'_R , E'_G and E'_B ;
- the primary colour signal level during the transmission of the “black” colour bar, i.e. minimum value of E'_R , E'_G and E'_B ;
- the maximum level of the primary colour signal during transmission of “coloured” colour bars, i.e. maximum value of E'_R or E'_G or E'_B ;
- the minimum level of the primary colour signal during transmission of “coloured” colour bars, i.e. minimum value of E'_R or E'_G or E'_B .

Example: Four versions of colour bars are in general use and are illustrated in Fig. 1, which shows the individual components of the red, green and blue primary colour signals as they are generated for four different types of colour bar signal. This data would be expressed as follows:

Colour bars (a) 100 / 0 / 100 / 0

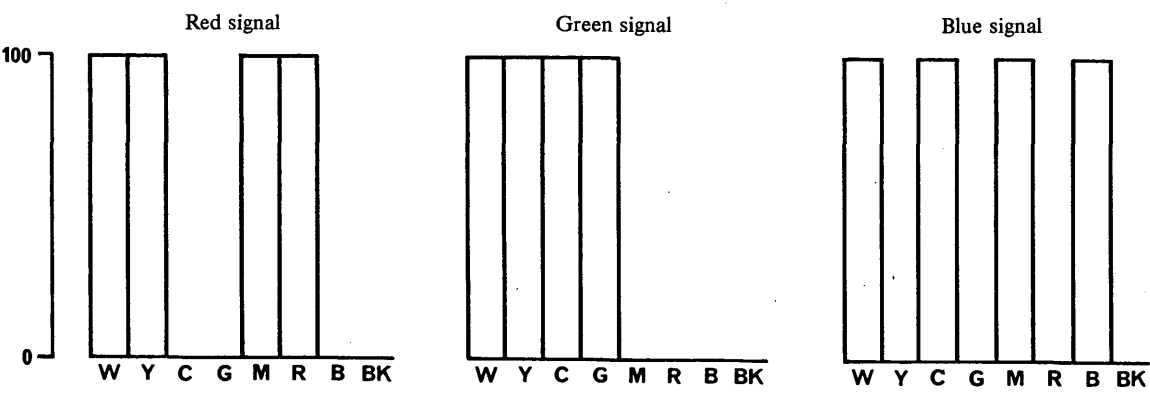
Colour bars (b) 100 / 0 / 75 / 0

Colour bars (c) 100 / 0 / 100 / 25

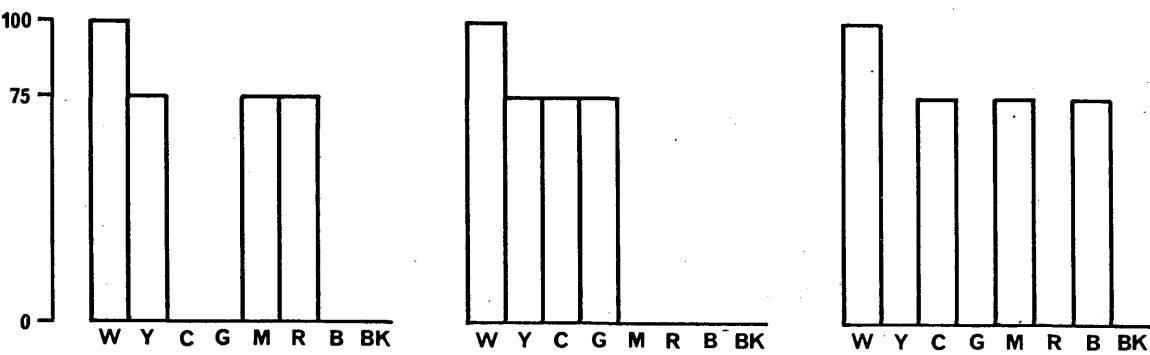
Colour bars (d) 75 / 7.5 / 75 / 7.5

2. that the waveforms shown in Fig. 1 be used to ensure conformity between measurements made in different operational environments;

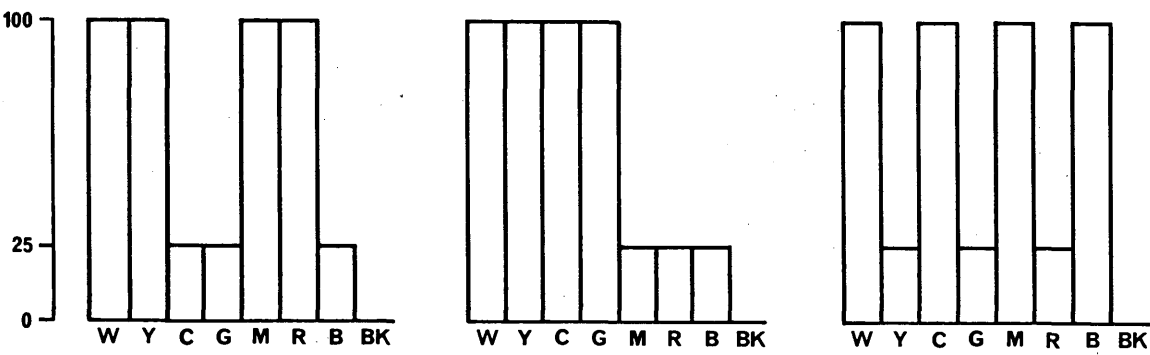
3. that all definitions and calculations relating to descriptions of colour bars shall be consistent with Report 624.



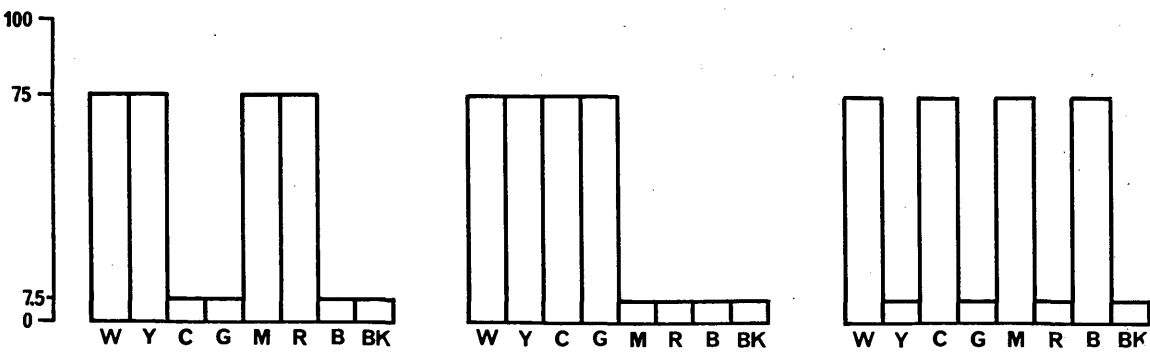
(a) 100/0/100/0 colour bars



(b) 100/0/75/0 colour bars



(c) 100/0/100/25 colour bars



(d) 75/7.5/75/7.5 colour bars

FIGURE 1 — Relative amplitudes of colour bars for different types of generator

W: white Y: yellow C: cyan (turquoise) G: green M: magenta (purple) R: red B: blue BK: black

REPORT 476-1

COLORIMETRIC STANDARDS IN COLOUR TELEVISION

(Question 1/11)

(1970-1974)

1. In 1953, when the NTSC colour television system was adopted for transmission in the United States of America, the colorimetry of the system was based on three specific primary colours and a reference white. The coordinates of the primaries were:*

Red:	$x = 0.67$	$y = 0.33$
Green:	$x = 0.21$	$y = 0.71$
Blue:	$x = 0.14$	$y = 0.08$

The reference white chosen was standard

White C:	$x = 0.310$	$y = 0.316$

2. When the PAL and SECAM systems were first designed, they were based upon the colorimetric standards of NTSC. As a result, the coefficients used for determining the signals involved in coding PAL and SECAM (the luminance signal and the colour-difference signals) were directly based upon the chromaticities given in § 1.

3. However, it has been recognized that there have been continuing changes in the chromaticities of the phosphors used in making colour picture tubes over the years, and that those actually used do not have the same primary chromaticities as those which served to establish the coding of systems. Nevertheless, in all systems the coefficients used for determining the signals involved in coding (the luminance signal and the colour-difference signals) are directly based upon the chromaticities and white point given in § 1.

4. Several solutions have been proposed or implemented, in different countries, for compensating or correcting the effect upon colour reproduction of this difference between the receiver characteristics and the standards given in § 1.

5. The United States of America continues to base the colorimetry of its transmissions upon NTSC primaries whose chromaticities and white point are defined in § 1. Studio monitors are adjusted to a reference white of D_{65} . However, because picture tubes do not yet contain phosphors whose chromaticities are the same (or very nearly the same) as those defined in § 1, approximate corrections, involving operations upon the electrical signals, are made in receivers in order to achieve satisfactory colour reproduction. Further, to achieve greater consistency in colour transmissions, the United States of America recommends that the picture monitors used in studios should also contain correction circuits which cause the colour reproduction to approximate to that which would have been obtained if the picture tubes used in the monitors had contained phosphors with the primary chromaticities shown in § 1.

6. In Japan, the colorimetry of the system is based upon the primary chromaticities and white point given in § 1. Studio monitors are adjusted to a white point of D , 9300 K.

7. In the 625-line PAL and SECAM systems, the colorimetry is now based upon the three specific primary colours:**

Red:	$x = 0.64$	$y = 0.33$
Green:	$x = 0.29$	$y = 0.60$
Blue:	$x = 0.15$	$y = 0.06$

and reference white D_{65} **.

These chromaticities are closely representative of the phosphors incorporated in the picture tubes of many of the receivers and studio monitors used in those countries that have adopted the 625-line PAL and SECAM systems. Thus, in such receivers and monitors, no electrical corrections are required in order to achieve good colour reproduction. Further, in order to improve the consistency of colour reproduction, when the television receiver is switched from one programme to another, it has been suggested that the chromaticities of the phosphors used in studio monitors should be standardized. The assessment is based upon a method of tolerance which takes account of both the primary chromaticities of the tube phosphors and the effect of their combined chromaticities upon the reproduction of a typical skin tone.

* The coordinates are given in the CIE system (1931).

** These coordinates are given in the CIE system (1931). For 625-line SECAM systems, it is provisionally permitted (for existing equipment), to use the chromaticity coordinates and reference white given in § 1.

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REPORT 801-2

THE PRESENT STATE OF HIGH-DEFINITION TELEVISION

(Question 27/11, Study Programmes 27A/11 and 27B/11)

(1974-1978-1982-1986)

1. Introduction

Large screen, high-definition television is the target for the next step in television, and may bring about a new standard system which will be common throughout the world.

A high-definition television system is a system designed to allow viewing at about three times picture height such that the transmission system is virtually or nearly transparent to the level of detail that would have been perceived in the original scene by a viewer with average visual acuity.

This generally implies in comparison with conventional television systems:

- spatial resolution in the vertical and horizontal directions of about twice that available with Recommendation 601;
- any worthwhile improvements in temporal resolution beyond that achievable with Recommendation 601 with no significant cost penalties;
- improved colour rendition;
- separate colour-difference and luminance signals;
- a wider aspect ratio; and
- multi-channel high fidelity sound. (*Note.* – Sound systems for HDTV are the subject of Question 47/10.)

HDTV production will be used to provide source signals for a variety of media outlets. These could include the following possibilities:

- BSS in the bands above 12 GHz;
- services in one or more WARC-BS-77 channels;
- services in one or more RARC BS-83 channels;
- motion picture origination;
- electronic displays in theatres;
- terrestrial broadcast services or cable networks; and
- domestic tape or disc systems.

A single standard could be beneficial to programme producers as well as broadcasting organizations and viewers.

This Report summarizes results of studies and experiments obtained in the world in technical developments under Question 27/11. See also Report 630 for video recording, and Report 1075 for satellite broadcasting.

2. Technical matters concerning the studio standard

2.1 *Picture presentation objectives*

2.1.1 *Preferred angle of view*

When observers are closer to pictures, the area occupied by the pictures in their viewing field increases, and this gives observers an increased feeling of involvement in the space created by pictures. This increased sensation of reality becomes apparent when the viewing angle exceeds 20° [CCIR, 1982-86a].

2.1.2 *Viewing distance*

Experiments using still-picture slides show that viewing distances of $2H$ to $3H$ (H stands for the picture height) are preferred. This corresponds to a viewing angle of 40° to 30° . When pictures are moving, however, the preferred viewing distance is closer to $3H$, because of the additional factor of dizziness.

If the viewing distance is too small, observers experience eye fatigue after a certain time. It is therefore desirable to limit the minimum viewing distance to 2 m [CCIR, 1982-86a].

2.1.3 *Display size*

From subjective assessments on the sensation of reality with different sizes of picture and with various viewing angles, it seems that larger size pictures generate a larger sensation of reality for a constant viewing angle, and a picture area of more than 0.8 m^2 can be considered appropriate for HDTV [CCIR, 1982-86a].

2.1.4 *Contrast and brightness*

From various experiments on television picture display, it is considered appropriate to take 50 : 1 as the minimum contrast ratio for HDTV.

Taking account of the effect of ambient illumination on the screen, a peak picture brightness of $150\text{-}250 \text{ cd/m}^2$ can be considered appropriate as the brightness for HDTV [CCIR, 1982-86a, b].

2.2 *Fundamental considerations on basic parameters*

2.2.1 *Aspect ratio*

Wider aspect ratios increase the observers involvement in the pictures. Various psychophysical experiments have shown that, depending upon the size of the picture, a wider aspect ratio ranging from 5 : 3 (1.67 : 1) to 2 : 1 would be attractive for HDTV. Experimental equipment has been made with an aspect ratio of 5 : 3 [CCIR, 1982-86a].

Further studies by one administration have shown that by increasing the aspect ratio to 16 : 9 (5.33 : 3, 1.78 : 1) and using the traditional movie industry technique of "shoot-and-protect" (centering the action in the smallest common area), compatibility can be achieved with most current movie film of aspect ratios ranging from 4 : 3 (1.33 : 1) to 2.35 : 1 [CCIR, 1982-86c].

2.2.2 *Horizontal sampling*

The definition of HDTV given in § 1 defines the horizontal resolution for HDTV as being twice that of current conventional television systems. Recommendation 601 defines a sampling system for the current 625/50 and 525/60 television standards as requiring 720/360 samples (luminance signal/colour-difference signal) for the digital active line period. To achieve twice the resolution would require 1440/720 samples per digital active line period for a picture with the same aspect ratio.

For the wider aspect ratio being discussed for HDTV, the number of samples per digital active line period must be increased by the ratio of the new aspect ratio to the current 4 : 3 aspect ratio. For example, in the case of an aspect ratio of 16 : 9, the corresponding number of samples per digital active line period would be 1920/960.

The total number of samples per line would include the number of samples required for the line-blanking period. Although the need for line-blanking period can be eliminated by the use of appropriate stores, there are practical limitations in electron-beam cameras and in display devices which make a line-blanking period essential in the short term [CCIR, 1982-86b].

2.2.3 *Vertical sampling (number of active lines per frame)*

Various studies, relating visual acuity to static vertical resolution and the viewing distance, have shown that the static vertical resolution, as viewed on a television monitor, is affected by the scanning method (interlace or sequential), the frame/field rate and the persistence of the display device.

In an experiment using a monochrome system with a 69 cm (27 inches) high-resolution cathode-ray tube display, sharpness improvement by increasing the number of lines began to saturate at about 1500 lines with 2 : 1 interlace for a viewing distance of $3H$ [CCIR, 1978-82a], and with 2125 lines, sufficient sharpness was obtained at a viewing distance of $2H$ [CCIR, 1974-78].

For a television picture with 2 : 1 interlace and a viewing distance of three times picture height, at least 1000 active lines are required to achieve twice the vertical resolution of current television systems [CCIR, 1982-86b].

It has been shown in recent studies that with more than 1000 active lines, the resolution would compare favourably with that of 35 mm film theatrical presentations, which has historically been perceived as the high quality presentation format [Hayashi, 1981; Kaiser *et al.*, 1985].

If the number of active lines is greater than 1024, an additional bit is required in the address circuit of picture processing equipment [CCIR, 1978-82b].

2.2.4 *Temporal sampling (field frequency)*

There are two distinct issues associated with this topic. The first is dynamic resolution which refers to the spatial resolution for images which move. The second is repetition rate which is determined by the criterion of smooth motion portrayal.

The dynamic resolution is determined by the integration time of the photo-sensitive material used in the camera and the temporal sampling rate determined by the field frequency [CCIR, 1982-86b].

Tests by the BBC using camera pictures sequentially scanned and displayed at 50, 60, 70 and 80 Hz frame-rates have demonstrated a progressive improvement in quality on moving picture detail as the field rate is increased. Picture quality at 80 Hz was judged to be two grades better than at 50 Hz, and one grade better than at 60 Hz for representative rates of continuous motion [Childs and Tanton, 1985; CCIR, 1982-86d].

Dynamic resolution can also be improved by reducing integration time by shuttering. Experiments carried out with 60 Hz cameras have shown that the integration time can be reduced by 25% without impairing motion portrayal and with corresponding improvement in dynamic resolution. Camera sensitivity and temporal aliasing penalties should be studied further [CCIR, 1982-86b].

The field and frame frequency of the television signal also determines, in a simple system, the refresh rate of the display. It influences the perception of large area flicker [CCIR, 1982-86e]. It is, however, not essential that the refresh rate be the same as the television signal field-rate. This is discussed further in § 5.

2.2.5 *Scanning structure (interlace or sequential scanning)*

It has been reported that the distraction caused by scanning lines with a 2 : 1 interlace is about the same as that caused by sequential scanning with 40% fewer lines [CCIR, 1978-82a]. However, under these conditions the sequentially scanned signal would require 20% more bandwidth.

The interlaced scanning structure under certain conditions may introduce a display artifact referred to as "interline twitter" and "line crawl"; these artifacts are also related to the sources and display characteristic as well as to the frame-rate and the number of scanning lines per frame. It is desirable to avoid the occurrence of these artifacts. In interlaced systems, the spatially adjacent lines are dislocated in time, thereby introducing complexities in signal processing [CCIR, 1982-86b].

In the case of a basic interlaced studio standard, the hierarchical progression of interlace to sequential scanning may be considered in two ways. It may be possible to use sequential scan in parts of the studio chain or in the display where the two-fold increase in bandwidth requirement can be accommodated. The other use of a hierarchical approach would be to evolve from interlace to sequential in the future as the technological constraints imposed by doubling the bandwidth requirement become less severe [CCIR, 1982-86b].

2.2.6 *Colorimetric aspects*

It is very important to establish an optimum colorimetric system within the HDTV system in order to provide high colour fidelity. Compatibility with existing conventional systems may be regarded as a second priority.

Discussions on the colorimetric aspects can be found in [CCIR, 1982-86b, f; Powell, 1985]. The following are the main issues considered:

2.2.6.1 *Choice of primary colours*

Sets of primary colours have been proposed which include XYZ primaries, the present EBU phosphors and the present NTSC phosphors.

The colour primaries selected should be widely separated so as to reproduce the widest possible range of colours, yet not so widely separated that they cannot be realized by available phosphors with sufficiently good conversion efficiency.

Further study is needed, preferably in association with manufacturers of picture tubes, to establish whether more recently developed phosphors can provide a better set of primaries, and if so, whether they would be sufficiently different from one of the two existing standards to justify change [CCIR, 1982-86b].

2.2.6.2 *System reference white*

There seems to be general agreement to adopt illuminant D65 for the reference white of the HDTV system. An adaptively switched white balance has also been proposed [CCIR, 1982-86b].

2.2.7 *Gamma correction*

In order to fulfill the constant luminance principle, a system having gamma correction only at the receiver has been considered in contrast to the current television system where gamma pre-correction is applied before luminance and colour-difference signal matrixing [CCIR, 1982-86b]. When displays other than CRT are used, or inter-system conversion is required, the required additional corrections add further distortions [CCIR, 1982-86f].

In the new proposal, processing is carried out with signals which are linearly proportional to the light input. However, a non-linear transmission-reception amplitude characteristic must be introduced, otherwise dark areas of the picture become more sensitive to transmission noise. Further discussion can be found in [CCIR, 1982-86b; Schafer and Golz, 1984; Yuyama and Yano, 1984].

2.3 *Technical aspects for the establishment of a studio standard*

2.3.1 *Standards conversion**

The major media applications for standards conversion are likely to be the following:

- existing conventional television system using composite signals;
- motion pictures for theatre release using film stock;
- emission systems using component signals based on currently used scanning standards;
- studio systems using component signals based on currently used scanning standards;
- HDTV emission.

Conversion quality should be evaluated within the quality range of each outlet media. Standards conversion may include conversion of the aspect ratio, the number of lines and the field-rate. The field-rate conversion has been found to present the most serious problem [CCIR, 1982-86b].

Tests by the BBC on the field-rate conversion of picture signals, using time-invariant (non-adaptive) interpolation, have demonstrated that an appreciably higher quality of converted picture is attainable with conversion from an 80 Hz field-rate to 60 or 50 Hz than when converting between 60 and 50 Hz. Conversion from 80 Hz was judged to give a picture quality up to two grades better than 60 to 50 Hz or 50 to 60 Hz conversion with similar picture material. In each case however, converted pictures were deemed to be inferior to pictures originated on the output standard [Childs and Tanton, 1985].

* There will be an operational requirement for conversion from existing conventional television standards to HDTV for archival material originated on an existing standard (see Study Programme 2B/11).

A new standards converter from 1125/60/2:1 HDTV to 625/50/2:1 PAL, based on motion-adaptive techniques has been developed in Japan. In the system, a sequentially scanned 625/60 signal is obtained first from the original 1125/60 signal by means of a two-field interpolator or an intra-field line interpolator. Then, field-rate conversion from 625/60 sequential to 625/50 sequential is achieved by means of a complex system, which selects the output of either one of four motion compensated processes or a linear-interpolation process. The selector is controlled by a motion signal. Finally, the signal undergoes sequential-to-interlace conversion [CCIR, 1982-86g].

Subjective tests have been carried out in several countries using a single stimulus subjective assessment technique and the five-grade quality scale. Since movement rendition was a critical issue, the test pictures consisted of moving sequences classified as "critical but not unduly so" [CCIR, 1982-86b, h].

During tests in Japan, the motion portrayal of the converted pictures was assessed to be almost the same as that of direct PAL pictures except for the rotating disc sequences (the appearance of scenes similar to the rotating discs was measured as 0.04% of programme time in two Japanese television channels during one week.) In some sequences, the converted pictures were evaluated higher than the direct PAL pictures. On average, the converted pictures were scored approximately 4.2, and the difference between the converted pictures and the direct PAL pictures was approximately 0.35 using the five-grade quality scale in the assessment made by experts [CCIR, 1982-86g].

Similar tests carried out in Europe have shown that the motion portrayal quality difference between PAL direct and the converted pictures was still perceptible (between zero and one grade). However, considering the future, the results of the subjective assessments and an initial analysis of potential areas of evolution of the performance of this converter, lead the EBU specialists to believe that a quality essentially equivalent to PAL quality will be possible within a reasonable period of time [CCIR, 1982-86h].

It was also reported that the motion portrayal quality of the PAL converted pictures was significantly better (between 1.5 and 3.5 grades) than motion portrayal at 25 Hz picture update rate (representative of film as scanned by a telecine) [CCIR, 1982-86h].

For the conversion to the motion picture film, it has been suggested that a non real-time conversion may also be used [CCIR, 1982-86b].

The quality of conversion to 4:2:2 component signals and those MAC-type signals where the bandwidths are wider than for PAL is less clear at the moment, and requires further study.

It is generally felt within EBU that conversion in the HDTV domain from one field-rate to another is unlikely to be satisfactory in the foreseeable future [CCIR, 1982-86h].

2.3.2 *Lighting flicker*

In an environment where the shooting field-rate is not the same as the local electrical mains frequency, beat frequency flicker can occur in certain circumstances. This situation has long existed in Japan, and techniques used for reducing the visibility of this flicker have been reported [CCIR, 1982-86b, i]. This problem is probably solvable, and need not weigh heavily in the choice of field-rate, although further work is required to confirm this [CCIR, 1982-86h].

2.3.3 *Hum*

Power-supply hum effects on vision can be removed by proper design of equipment [CCIR, 1982-86j].

3. **Transmission formats**

Subjective evaluation tests regarding the required bandwidth were carried out for the 1125-line system as a first step of the study. Values of 20 MHz and 7 MHz were obtained for the luminance and colour-difference signal respectively [CCIR, 1974-78].

A noise weighting function which can be applied to systems which differ in the number of lines and in aspect ratio has been reported, and is being used for the calculation of transmission parameters [CCIR, 1978-82a].

In a frequency division multiplexed composite signal, called HLO-PAL (Half-Line Offset PAL), the colour-difference sub-carrier signal corresponding to the narrow-band colour-difference signal (C_n) is located adjacent to the luminance signal (Y); while another signal corresponding to the wide-band colour-difference (C_w) is located around the same sub-carrier, and its lower sideband is partly interleaved with the luminance signal with a half-line offset. This signal has been used widely for distribution and transmission tests of the HDTV signals [CCIR, 1982-86k].

In a time division multiplexed signal, called TCM (time compression multiplexing) signal, the colour-difference signals are compressed, and the luminance signal and one of the colour-difference signals are multiplexed. Thus, colour-difference signals are transmitted line-sequentially. The proposed TCM signal bandwidth for a 1125-line system is 20 MHz [Tsuboi *et al.*, 1985].

In another time division multiplexing signal, called TCI (Time Compressed Integration) signal, there are several versions depending on the simultaneous or sequential arrangement of colour-difference signals and on the difference compression ratios [Fujio and Kubota, 1982].

A scan conversion system for HDTV with motion-adaptive techniques, called FCFE (Frame Conversion Fineness Enhance), has also been developed. It converts 2 : 1 interlaced scanning to progressive scanning at the receiver. This is considered to be useful for the reduction of bandwidth required for HDTV transmission [CCIR, 1982-86k, l and m].

A bandwidth reduction system, called MUSE (Multiple Sub-sampling Encoding) system, has been developed to transmit HDTV signals via satellite using a single channel in the 12 GHz band. The baseband signal bandwidth is 8.1 MHz. It uses 4 : 1 dot-interlaced sub-sampling which employs inter-field and inter-frame offsets. More general description can be found in Report 1075.

It is reported that non-linear pre- and de-emphasis has been used very effectively in FM transmission of HDTV signals [Fujio and Kubota, 1982].

Digital transmission has been discussed [Phillips and Harvey, 1978; CCIR, 1978-82a], and it could become competitive with analogue FM transmission in the future, with regard to the required bandwidth and transmitter power.

4. Emission consideration

It is envisaged that HDTV broadcasting will mainly be accomplished within the broadcasting-satellite service (BSS). As the use of the 42 and 85 GHz bands will not be practical for several years to come, in the first instance HDTV broadcasting by satellite will have to be carried out either in the 12 GHz or the 22 GHz band.

The 22 GHz band is allocated to BSS on an exclusive basis in Japan. In Regions 2 and 3, it is allocated to BSS on a shared basis with other services, and there is no allocation in Region 1. It is noted, however, that such an allocation could be made at some future competent ITU conference.

More information is given in Report 1075, which analyses the possibilities for the emission of HDTV signals in the available frequency bands. In particular, it recognizes that, under certain conditions, the 22 GHz band may be technically suitable for this purpose.

HDTV broadcasting in the 12 GHz band must take account of the existing frequency plans, and therefore a single worldwide HDTV studio standard must be such as to allow conversion to emission standards using one or more WARC-BS-77 or RARC BS-83 channels [CCIR, 1982-86b].

Up to now, the following systems have been proposed or are under study:

- a single channel 1125/60/2 : 1 system called MUSE [Kimura and Ninomiya, 1984].

Results of the simulation tests of transmission using these facilities prove the feasibility of HDTV transmission through a single channel planned at WARC-BS-77 or RARC BS-83 [CCIR, 1982-86n];

- a 1050/60/2 : 1 dual-channel system providing easy compatibility with MAC-type 525-line receivers [Rossi *et al.*, 1984].

This system broadcasts 1050-line HDTV pictures with an aspect ratio of 5 : 3, and has been demonstrated in experimental form [CCIR, 1982-86b];

- a dual-channel system providing easy compatibility with MAC-type 625-line receivers [Sauerburger and Stenger, 1984].

This system is under study, and offers the possibility of transmitting 1250-line, 50 fields/s, 2 : 1 interlace HDTV picture with an aspect ratio of 5 : 3 using two E-MAC type signals [CCIR, 1982-86b].

Recently, production of receivers with inherent multi-standard capability is increasing in quantity, and this may alleviate the compatibility problem in the future [CCIR, 1982-86b].

5. Display consideration

Subjective tests carried out by one administration have shown that, using CRT technology, for a screen brightness of 150 cd/m² and a field-rate of 60 Hz, large area flicker is visible but not disturbing. At a field-rate of 50 Hz and a screen brightness of 60 cd/m² the flicker was judged annoying [CCIR, 1982-86b]. Another administration carried out tests using a light source and a variable duration shutter. The tests showed that large area flicker at a brightness of 200 cd/m² became imperceptible at frequencies greater than 80 Hz [CCIR, 1982-86e].

New display devices under development (e.g. light valves) show display characteristics different from those of CRT based systems and may therefore provide improved flicker behaviour.

Using frame stores and, when necessary, interpolation electronics, the display refresh rate can be higher than the television signal field-rate [CCIR, 1982-86b]. This allows for the possibility of removing large area flicker by display processing, however, it is likely to impose a cost penalty, and possibly a quality penalty [CCIR, 1982-86h].

6. Consideration of sound

Relevant documentation on this subject with reference to Study Programme 47C/10, has been submitted to Study Group 10 and is discussed there in detail. It is noted here only for information [CCIR, 1982-86o, p and q].

7. Equipment development

Technical feasibility of studio equipment such as cameras, VTRs and displays are reported in [CCIR, 1982-86b]. A home-use VTR and a videodisc player using the MUSE signals have already been developed in Japan [Kimura and Ninomiya, 1984].

Among HDTV equipment, displays are of special importance in the determination of standards for HDTV signal format and for HDTV broadcasting. For this reason, the present state of display technology is summarized in this section.

Large screen CRT displays of high resolution using the shadow-mask principle and a delta gun have been developed with an aspect ratio of 5 : 3 and a screen size of up to 102 cm (40 inches) diagonal. They have achieved a limiting resolution of 1000 TV lines in the horizontal direction and 750 lines in the vertical direction with a peak-white brightness of 100 to 150 cd/m².

Recent developments in projection displays have included a rear-projection display with a 140 cm (55 inches) diagonal, and a front-projection display with a 280 cm (110 inches) diagonal. An extra large screen projector for HDTV was also developed for use at Expo '85 with a screen size of 1020 cm (400 inches) and a peak-white brightness of 150 cd/m². Excellent pictures have been obtained with all these displays.

Although the ultimate goal of an HDTV display is said to be the hang-on-wall type flat panel, no proposal has yet been made for HDTV. It can be anticipated that a large step forward in the development of displays will take place if the demand is strong, as was the case when colour television was developed. In some countries, developments of gas-discharge panels and liquid crystal displays are in progress [CCIR, 1982-86b].

8. Future work

The following items are recommended by the IWP 11/6 (1983-1985) for future work [CCIR, 1982-86b]:

- methods of conversion;
- motion portrayal;
- colorimetry;
- upward extensibility of HDTV;
- concepts of a family of HDTV studio standards;
- subjective assessments including potential impairments arising in HDTV systems, source material for HDTV assessment, methodology, grade differential for transparency and subjective assessment of standards converted pictures;

- downstream processing;
- lighting flicker elimination;
- HDTV emission formats;
- HDTV studio interface.

9. Requirement for further studies of HDTV studio standard parameters

All administrations are aware of the urgent need expressed in some parts of the world to make use of an HDTV studio standard. The considerable progress in standardizing HDTV for studio application and the current position as presented to the XVIth CCIR Plenary Assembly [CCIR, 1982-86r] is reproduced in Annex I. Administrations are invited to conduct studies as rapidly as possible following the general guidelines which are given in Annex III.

Progress in HDTV technology and component design has resulted in HDTV production equipment now being available from sources in several countries.

A number of HDTV production facilities using certain of the parameter values given in Annex II are in operation in various parts of the world.

There is also a need for the HDTV studio standard to accommodate future broadcasting systems compatible with existing scanning standards.

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ANNEX I

CURRENT POSITION OF STUDY GROUP 11 ON HDTV

1. Introduction

In 1983 an Interim Working Party was established by Study Group 11 with the aim, as a first step, of establishing a draft Recommendation for a single world-wide HDTV studio production standard.

The members of Study Group 11 are united in their wish for a single world-wide HDTV standard, and all recognize the positive benefits of this. There is general agreement among all administrations regarding the need for a single system of approximately twice the horizontal and vertical resolution of existing TV systems and having a wide aspect ratio. In addition, agreement exists on the use of components, expressed in both analogue and digital form, the latter to be closely related to Recommendation 601. There remains, however, discussion about the precise parameter values, such as those concerning scanning, appropriate to achieve this aim.

There were, at the time of the 1985 CCIR Final Meetings, a number of different perspectives, each of which is founded on genuine concerns and studies.

2. First point of view

The 1125/60/2:1 parameters were submitted for consideration as the basis for a single world-wide standard. Many administrations in both 525/60 and 625/50 countries support this proposal which was an output document (excluding the reservation note) of IWP 11/6 [CCIR, 1982-86a] following two years of intensive study. Extensive technical evidence, based on both objective and subjective testing shows that this proposal meets the requirements of a single world-wide HDTV studio standard outlined in the terms of reference establishing IWP 11/6. These administrations argue that the benefits of a single world-wide standard achieved in a timely manner are clearly preferable to the emergence of multiple standards. These administrations support the proposal for a new Recommendation [CCIR, 1982-86b] which is reproduced in Annex II to this Report.

3. Second point of view

Many other administrations, using the 625/50 standard, have reservations about, and are not able to accept, the 1125/60/2:1 parameter values at this time; there are a number of issues to be studied before a commitment is made to this, or any other, set of parameter values. One of the major, and as yet unresolved issues, is how the 1125/60/2:1 system will fit into the future broadcasting and transmission systems to be used in a 50 Hz environment, and secondly, what the system's relationship is to Recommendation 601. The first point is in line with Study Programme 27A/11, and a similar approach is indicated for stereoscopic television in Study Programme 1C/11. These administrations support the note of reservation given in the proposal for a new Recommendation [CCIR, 1982-86b] which is reproduced in Annex II to this Report.

4. Conclusion

The discussion is continuing in a spirit of mutual understanding. Administrations are aware of the urgent need expressed in some parts of the world to make use of an HDTV studio standard and they are conducting studies on HDTV parameter values as rapidly as possible.

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ANNEX II

PROPOSAL FOR A NEW RECOMMENDATION

PARAMETER VALUES FOR SIGNAL GENERATION IN HDTV STUDIOS AND FOR INTERNATIONAL EXCHANGE OF HDTV PROGRAMMES

The CCIR,

CONSIDERING

- (a) that an HDTV studio standard must provide pictures with approximately twice the horizontal and vertical spatial resolution of, and a larger aspect ratio than, studio sources using existing standards;
- (b) that there exists a broad range of applications for HDTV;
- (c) that there has been substantial progress made in high-definition television technology for production equipment;
- (d) that multiple different standards will cause difficulties among broadcasters in the future;
- (e) that the advantages of a single HDTV world-wide standard include lower HDTV equipment costs for broadcasters and viewers, easier exchange of programmes and technical information, and encouragement to the ideal of international solutions to common technical problems;
- (f) that HDTV studio signals will also be used as sources for current and currently proposed broadcast television systems;
- (g) that conversion to existing 625/50 and 525/60 composite standards can be provided with good quality;
- (h) that an HDTV studio standard must be specified in digital form with a simple relationship to Recommendation 601;
- (i) that the transfer to and from film can be provided with adequate quality,

RECOMMENDS

that the following standard parameters be used for generation of signals in high-definition television studios and for the international exchange of high-definition television programmes:

Number of scanning lines:	1125
Number of active lines:	1035
Field rate:	60.00 Hz
Scanning method:	2 : 1 interlace
Aspect ratio:	Horizontal 16 : vertical 9
Samples per active line:	1920 for luminance 960 for colour difference

Note. — A number of administrations using the 625/50 standard have reservations about the parameter values above, and at this time are not able to accept these as a basis for a single world-wide HDTV studio and international exchange standard. They believe that reconsideration of some values may be needed. Every effort will be made to work in accordance with Decision 58.

ANNEX III

GUIDELINES FOR PARAMETERS FOR A HIGH-DEFINITION
TELEVISION STUDIO STANDARD

CONSIDERING

- (a) that an HDTV studio standard should make possible a major improvement in quality over conventional 525/625 systems, when viewed on a large screen of 1 m diagonal size or larger;
- (b) that an HDTV studio standard should make possible large-screen viewing with a spatial resolution comparable to 35 mm cinematographic film;
- (c) that there has been substantial progress made with high-definition television technology relating to production equipment;
- (d) that the advantages of a single world-wide standard include lower equipment costs for broadcasters and viewers, easier exchange of programmes and technical information, and encouragement to the ideal of international solutions to common technical problems;
- (e) that HDTV signals will be used as sources for current and proposed broadcast television systems and for motion picture films;
- (f) that there exists a broad range of applications for HDTV;
- (g) the existence of Recommendation 601;
- (h) that there has been considerable progress in standards conversion techniques to existing composite standards and motion picture films,

IT IS SUGGESTED that a single world-wide high-definition studio standard should:

1. be based on the use of separate luminance and colour-difference components;
2. provide signals with approximately twice the horizontal and vertical resolution of studio sources using existing standards;
3. have an aspect ratio of greater than 4 : 3;
4. allow conversion to the existing 625/50 and 525/60 standards with a quality virtually equivalent to that available from signals generated directly in the existing standards, and should allow transfer to film with adequate quality;
5. allow conversion to an HDTV broadcasting and emission standard to be used in countries currently using 50 Hz or 60 Hz field rates;
6. be specified in both analogue and digital form from the outset and should take into account the parameters specified in Recommendation 601.

Note. — Account should be taken of emerging enhanced and HDTV broadcasting systems.

REPORT 312-4

CONSTITUTION OF A SYSTEM OF STEREOSCOPIC TELEVISION

(Study Programme 1C/11)

(1963-1966-1970-1978-1982)

1. Methods of providing stereoscopic television have long been the subject of study. Projects carried out in various countries have led to production of industrial systems. However, many of the methods thus developed utilize professional equipment in closed-circuit and are not practical for public three-dimensional television. Most methods propose that the reproduced stereoscopic images be overlapped and channelled separately so each reaches the proper eye of the viewer.

The first method, based on the optical stereoscope, reproduces two small spacially separated images, one for each eye. Larger image separations require prismatic viewing devices or prismatic spectacles to produce visual registration of the two images. The prism spectacles cause annoying eye fatigue when the viewer looks away from the television images. A second method consists of two overlapping images, each produced in a different colour; and the use of similarly coloured filters to separate the two images, sometimes mounted in spectacles. Colour filtered glasses may cause psychological and physiological viewing problems and do not produce a full colour picture. A third method provides two overlapping images, polarized in different orthogonal planes, together with the use of spectacles with similarly polarized filters to separate the two images.

Several methods of separating the stereo images without the use of spectacles or viewing devices have been designed. These make use of gratings, or Fresnel or lenticular screens in association with cathode-ray receiver displays. When two stereo images are used these methods have more serious limitations as to permissible viewing positions than do methods employing spectacles. Recently, methods have been developed using multiple stereo images with lenticular-type screens which provide expanded viewing positions. Holographic three-dimensional television requires excessive bandwidth and its perfection is not expected in the immediate future.

2. The transmission of a stereoscopic television picture requires the simultaneous or successive transmission of several separate signals. Methods have been suggested for reducing the bandwidth required. This question has many aspects in common with the development and techniques used in colour television. Various solutions for reproducing the stereoscopic television picture have been envisioned. Presently, electronic image tubes are used to pick up the picture, and direct view or projection cathode-ray tubes are used to display the picture. In the near future charge-coupled matrix devices will be employed for pick-up and display. The flat matrix devices provide very accurate positioning of each picture element.

3. A practical stereoscopic television system requires:

- Orthoscopic three-dimensional display (the depth of the scene should appear natural and without viewer discomfort);
- group viewing (almost any location in the room should provide good stereoscopic viewing);
- compatibility (three-dimensional colour receivers should display a stereoscopic transmission in full depth and a two-dimensional transmission monoscopically; present two-dimensional receivers should display a stereoscopic transmission monoscopically);
- non-degraded picture (the colorimetry and resolution of a three-dimensional colour television picture should be comparable to a present two-dimensional colour picture);
- minimal modification of video standards (the industry and government specifications should not require extensive revision); and
- moderate price (the cost and complexity of converting studio and station television equipment and the cost of the stereoscopic television receiver should not be significantly greater than the conversion from monochrome to colour).

4. Three examples of proposed stereoscopic television systems, which meet some or all of the above requirements, are given below:

- stereo-pair system without spectacles using a charge-coupled matrix pick-up and a flat screen matrix display with a lenticular screen accurately positioned in accord with picture elements [CCIR, 1978-82a];
- stereo-pair system with polarized spectacles using a stereoscopic colour television camera to pick-up two images, transmission of images on two channels or with bandwidth reduction means on one channel, and display with special polarized direct view cathode-ray tube or by projection [CCIR, 1978-82b];
- multiple stereo-image system without glasses using special stereoscopic colour television camera to pick-up a panoramic sequence or continuum of stereo images, transmission of multiple images on several channels or with bandwidth reduction means on one channel, and panoramic display in a special direct view lenticular-type cathode-ray tube or by projection on a lenticular-type screen [CCIR, 1978-82b].

5. [CCIR, 1958; 1962a and b; 1963-66a and b; 1966-69; 1974-78; and 1978-82a and b] and their bibliographies, contain information on the question of stereoscopic television.

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SECTION 11B: ANCILLARY TELEVISION SERVICES

Recommendations et Reports

RECOMMENDATION 653

TELETEXT SYSTEMS*

(Study Programme 29B/11)

(1986)

The CCIR,

CONSIDERING

- (a) that several countries have developed and established satisfactory teletext systems;
- (b) that it would be highly desirable to assure the compatibility of such systems with the videotex (interactive videography) systems;
- (c) that a proliferation of such systems would add further complication to the interconnection of such systems,

UNANIMOUSLY RECOMMENDS

1. that for a country wishing to initiate a teletext service, one of the four systems in Annex I is to be preferred.**

ANNEX I

CHARACTERISTICS OF TELETEXT SYSTEMS

1. Introduction

This Annex provides information about the teletext systems, developed for use with television systems of Recommendation 470 whose characteristics are described in Report 624.

An outline description of the essential elements of the teletext systems is given in Table I and the accompanying diagrams (Figs. 6, 7, 8 and 9). The structure of the Table is based, as far as practicable, on the ISO reference model.*** For fully detailed specifications of the systems, see [CCIR, 1985].

Table II lists the countries and systems used.

2. Definition of the teletext service

A digital data broadcasting service which may be transmitted either within the structure of an analogue television signal or by using digital modulation systems. The service is primarily intended to display text or pictorial material in two-dimensional form reconstructed from coded data on the screens of suitably equipped television receivers.

Note. — At the present time, the field-blanking interval is, in most cases, used for the data broadcasting service, but a possible option exists for extending the data broadcasting service to occupy all active lines in a television signal. The effect on protection ratios for television broadcasting has been studied for 625-line systems and the results published in Recommendation 655.

3. A layered model for describing teletext systems

A hierarchical organization of communication functions for teletext data broadcasting systems is presented in Fig. 1, where the functional items, listed at each hierarchical level, do not refer to specific implementation solutions, but to the overall logical features that are considered sufficient to characterize the service and performance of a typical teletext system.

* Also referred to as broadcast videography.

** The transmission layers of all the recommended systems can be generally applied. However, further studies are required for the presentation layer requirements of some non-Latin based and non-alphabetic writing systems.

*** ISO 7498 (1984) "Basic reference model for open systems interconnection".

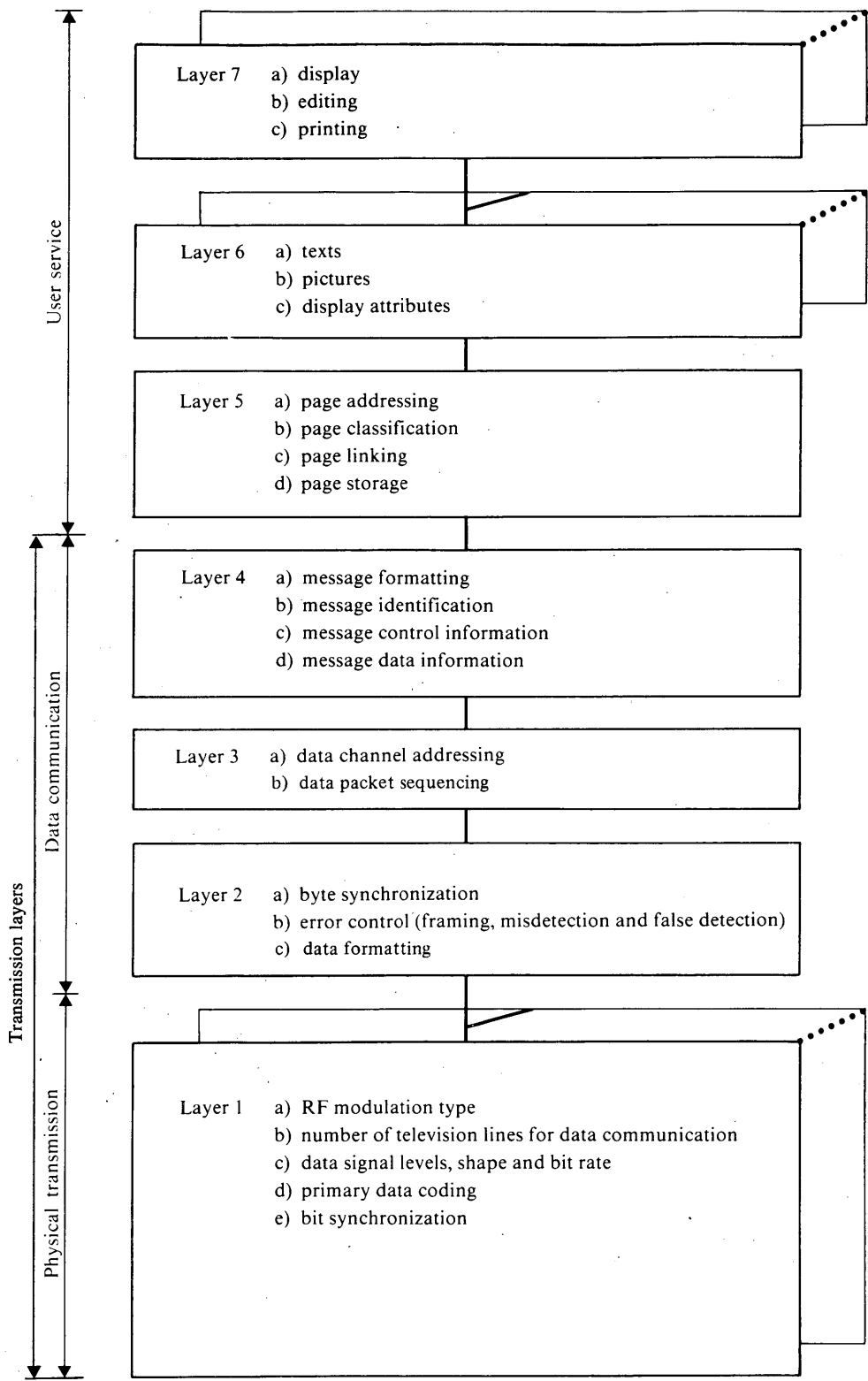


FIGURE 1 — A functional layered model for the description of teletext systems

According to this functional model, services may be delivered by arranging the information into logical groupings, delivering them to lower layers for transmission and, after reception, reconstituting the information into the proper form for use by the recipient.

In what follows, the names of the layers are those adopted by the ISO in ISO 7498 (1984) "Basic reference model for open systems interconnection". Some of these names are used in broadcasting technology to express different concepts. This particularly applies to the terms "network" and "link" and care must be taken to avoid confusion.

Layer 1: Physical

Within a given broadcast transmission system this layer relates to the electrical transmission of the data signal and includes such items as bit rate and pulse shaping.

Layer 2: Link

This layer includes logical functions related to the data transmission such as digital frame synchronization techniques, data formatting and error control procedures.

Layer 3: Network

This layer includes logical functions related to multiplexing and demultiplexing of data packets belonging to different communication flows. Examples of such functions are data channel addressing and data packet sequencing.

Layer 4: Transport

This layer provides the function of arranging the data in a way suitable for transfer from one point to another, by such means as segmenting data into groups of information, delivering them to the lower layers for transmission to the distant point and there reconstituting the groups of information and arranging them in a proper sequence.

Layer 5: Session

This layer includes data handling functions which are intended to assist the user to gain access to services. Examples of such functions are access control and page classification.

Layer 6: Presentation

This layer comprises data presentation functions. Examples are the codings used for the presentation of text, pictures and sound.

Layer 7: Application

This layer refers to practical use of the potential facilities provided by the lower layers for a given type of service.

Examples are captioning, telesoftware and cyclic teletext.

4. Transmission characteristics

The logical structure of different elements of the teletext data and their relationship to the television signal are illustrated in Figs. 2, 3, 4 and 5.

4.1 Data line (Fig. 2)

A data line is a television line, the active part of which is assigned to digital data. The data content is subdivided into a bit synchronization sequence followed by a *data unit*.

4.2 Data unit (Fig. 3)

A data unit is a logical unit of data, subdivided into a byte synchronization sequence and a *data packet*.

4.3 Data packet (Fig. 4)

A data packet is an identifiable information package which comprises:

- a *prefix* providing for functions such as addressing, packet size indication, packet continuity indication and designation of packet type;
- a *data block* containing control signals or user information;
- in some systems, a *suffix* to perform the function of error detection or correction at the packet level.

4.4 Data group (Fig. 5)

A data group is an identifiable group of data blocks containing information from the same source.

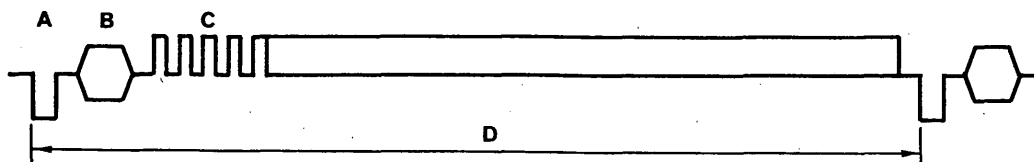


FIGURE 2 – Data line

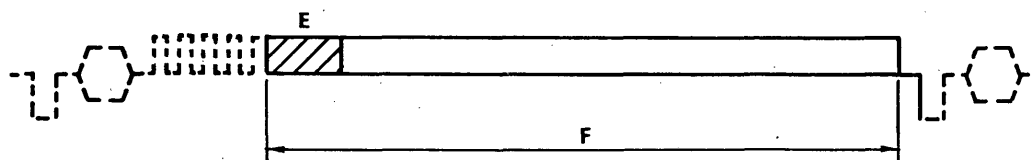


FIGURE 3 – Data unit

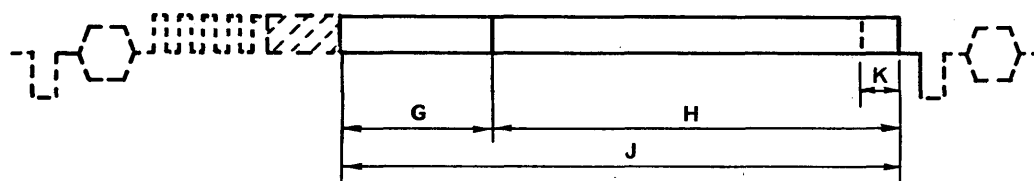


FIGURE 4 – Data packet

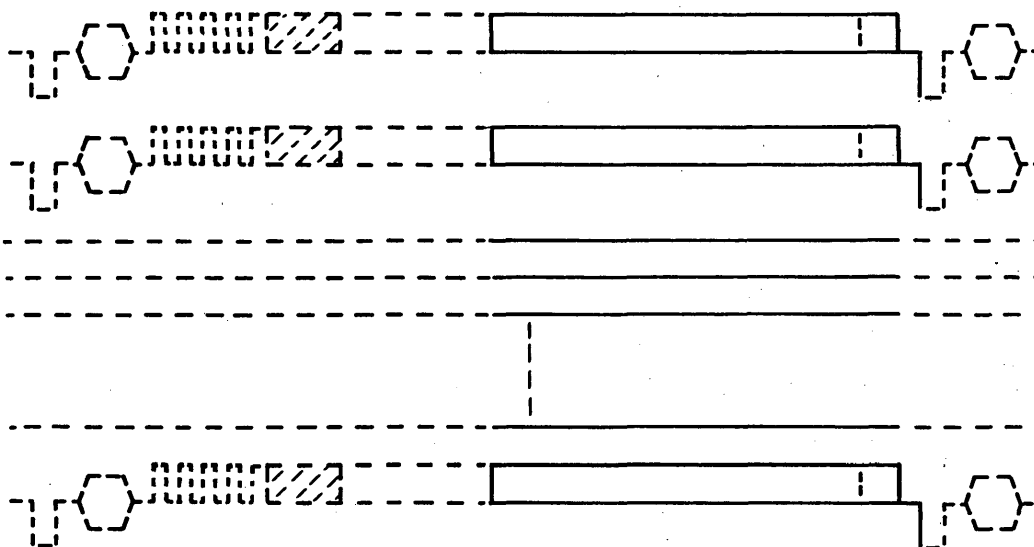


FIGURE 5 – Data group

A: line sync.	F: data unit
B: colour burst	G: prefix
C: bit sync.	H: data block
D: data line	J: data packet
E: byte sync.	K: suffix where applicable

5. Presentation layer characteristics

In specifying the presentation layer of teletext systems, substantive account has been taken of the work of the CCITT on videotex systems in its Recommendations T.100 and T.101 (Malaga-Torremolinos, 1984). The work of ISO TC 97/SC2 on character repertoires and coding for all writing systems and languages has also to be taken into account.

5.1 Repertoires

Certain characters of importance for the captioning functions of teletext services are not included in any of the presentation layer syntaxes defined in Annexes to CCITT Recommendation T.101 (Malaga-Torremolinos, 1984). These are:

1		Telephone
2		} Off-screen indicators
3		

5.2 Source coding

The code tables for characters and pictorial commands for the presentation of Latin alphabet based alphanumeric and pictorial information are identical with the respective videotex code tables of the Annexes of CCITT Recommendation T.101 (Malaga-Torremolinos, 1984), with the exception of additional characters as indicated in § 5.1. For some coding formats, the controls, commands and instruction sequences are also identical to those of the respective videotex coding standards. For other formats a precisely equivalent set of controls and description/instruction sequences are defined.

5.2.1 Alphanumeric coding

These codes are used to display text. Alphanumeric graphic elements include alphabetic letters, syllabic characters and ideographic characters with or without diacritical signs, figures, punctuation marks and special signs.

5.2.2 Mosaic coding

These codes are used to construct drawings by means of block mosaic, smooth mosaic and line drawing characters. Each element defines part of a pattern and occupies one character position. Two forms of presentation are defined:

- separated: each element is surrounded by a border of the background colour;
- contiguous: elements adjoin one another.

5.2.3 Dynamically re-definable character sets (DRCS)

Character sets in which some, or all, of the characters may be defined at the source and downloaded into the receiver, which can then use them as graphic elements.

5.2.4 Geometric coding

These codes are used to construct drawings of various types by a succession of elements such as points, lines and surfaces.

5.2.5 Photographic coding

These codes are used to cause the generation of individual picture elements for the display of an image. Continuous tone images as well as pattern oriented displays including graphics characters are included.

TABLE 1a — Description of the essential elements of teletext systems specified for 625/50 television systems

Teletext system	A	B	C	D ⁽¹⁾
Layer 1: Physical				
1.1 Time slot usable for data	Active part of any TV line subject to availability			
1.2 Data positioning (relative to line sync. timing reference ⁽²⁾)	10.5 ± 0.32 µs	Bit 13 is reference plus 12.0 µs (+1.0, -0.4)	10.48 ± 0.34 µs	
1.3 Data amplitude ⁽²⁾ logical 0 logical 1	<i>S</i> : sync. <i>D</i> : pedestal <i>A</i> : data $D/S = 0 (\pm 3\%)$ $A/S = 7/3(+0, -10\%)$ for positive modulation $A/S = 14/9(-0, +6\%)$ for negative modulation	Black level ± 2% 66% (± 6%) of black-to-white excursion	0 IRE units 70 IRE units for negative modulation 100 IRE units for positive modulation	
1.4 Bit rate	6.203125 Mbit/s ± 0.005%	6.9375 Mbit/s ± 25 × 10 ⁻⁶	5.734375 Mbit/s ⁽³⁾ (367 × line frequency)	
1.5 Data shaping ⁽²⁾	Sine square	Spectral shaping is skew symmetrical about 0.5 bit rate	Typically a raised cosine 100% roll-off spectrum, followed by a video low pass filter	
1.6 Data coding	Binary NRZ	Binary NRZ	Binary NRZ	
1.7 Data line including clock run-in	320 bits	360 bits	288 bits (The first 16 bits of alternating 1's and 0's constitute the clock run-in)	
Layer 2: Link				
2.1 Digital frame synchronization	Byte 3 = 11100111 [CCIR, 1985; Part 1.1, § 1.3.5]	Byte 3 = 11100100	Byte BS = 11100111	
2.2 Length of data unit	38 bytes	43 bytes	34 bytes (excluding clock run-in)	

Note. — For ⁽¹⁾, ⁽²⁾ and ⁽³⁾ see end of Table 1b.

TABLE Ia (continued)

Teletext system	A	B	C	D (!)
2.3 Format indicator	Byte 8 (byte 5 in short prefix)	Not required	PS byte	
2.4 Error detection/correction				
2.4.1 Byte error detection – parity	Odd parity on teletext data bytes	Odd parity for bytes 4 to 45 Even parity for bytes 1 to 3	Odd parity	
2.4.2 Byte error detection/correction	8/4 Hamming code on bytes 4 to 8 (4 and 5 in short prefix)	8/4 Hamming code for bytes 4 and 5; 8/4 and 24/18 for extension packets numbers 26, 27, 28 and 29	8/4 Hamming code on all bytes in the prefix, data group header, record header	
2.4.3 Block error detection/correction	No	Bytes 44 and 45 of designated data blocks carry a cyclic redundancy check word (CRC)	Suffix bytes indicated by bits b8b6 of the PS byte	
Layer 3: Network				
3.1 Data channel addressing	Bytes 4, 5 and 6 [CCIR, 1985; Part 1.1, § 1.4]	Bytes 4 and 5 of all packets	Bytes P1, P2, P3	
3.2 Data packet sequencing	Byte 7	Bytes 4 and 5 of all packets	Byte C1	
3.3 Length of prefix	5 bytes (long prefix) or 2 bytes (short prefix)	2 bytes	5 bytes	
3.4 Length of data block	Given by value of byte 8 (byte 5 in short prefix) according to a look-up table [CCIR, 1985; Part 1.1, § 1.4.1.2]	40 bytes	0, 26, 27 or 28 bytes indicated by bits b8b6 of PS byte	

TABLE Ia (continued)

Teletext system	A	B	C	D ⁽¹⁾
Layer 4: Transport				
4.1 Group of data blocks	Start = SOH-RS (0/1-1/14) End = ETX-EOT (0/3-0/4) [CCIR, 1985; Part 1.1, § 4.2.1]	In page-oriented services: – start by page header packet, bytes 4 to 13 – termination by next page header packet For independent data services: – packets 30 and 31. See [CCIR, 1985] for details	Byte GT indentifying 16 types of data group	
4.2 Data group size	1920 bytes max. [CCIR, 1985; Part 1.1, Annex 4.5, § 4.2]	1024 bytes or multiples of 1024 bytes	Bytes S1, S2, and F1, F2	
4.3 Data group integrity				
4.3.1 Continuity	No	Automatic	Byte GC	
4.3.2 Error detection/correction	No	Packet 27, bytes 44 and 45 of designated data blocks carry a cyclic redundancy check word (CRC)	Suffix bytes identified by bits b8b6 of the PS byte	
4.4 Data group sequencing	No	Packets 27, bytes 7 to 42 of designated data blocks	L1, L2 for a given page address	
Layer 5: Session				
5.1 Indicator of type of session				
5.1.1 Cyclic/non-cyclic	Address of data channel (N2 = 96, for example) [CCIR, 1985; Part 1.2, § 3]	Not required	RT = 0/RT = 1	

TABLE Ia (continued)

Teletext system	A	B	C	D ⁽¹⁾
5.1.2 Access control	Y16b2b4b6 [CCIR, 1985; Part 1.1, Annex 4.2, § 1.3]	Packet 27, bytes 7 to 42 of designated data blocks	Under study	
5.1.3 Terminal facilities	Y15b6b8 [CCIR, 1985; Part 1.1, Annex 4.2, § 1.3]	Display/processable, packet 27, byte 43 of designated data blocks	Basic TTx service recognizes RT = 0, 1, 2 and 3; RT = 4 to 13 are reserved; RT = 14 and 15 are for broadcaster use	
5.1.4 Protocol	Y11b2b4b6b8 [CCIR, 1985; Part 1.1, Annex 4.2, § 1]	Packet 27, byte 43 of designated data blocks		
5.1.5 Batch	No	Packet 27, byte 43 of designated data blocks		
5.1.6 Addressed to user	No	Packet 28, designated data blocks		
5.1.7 Priority	Magazine 0 (N2 = 0)	Not required	RT = 3	
5.1.8 Application	Row 0 (C1 = C2 = C3 = 0 [CCIR, 1985; Part 1.1, Annex 4.1])	Packet 27, byte 43	RT = 2	
5.2 Page classification			Record designator byte, RD, bit 6 = 1 indicates presence of classification sequence	
5.2.1 Normal	C1 C2 C3 E(0...A) except 000	Not required	RT = 0 or 1 and absence of other page classification indicators	
5.2.2 Subtitle	C1 C2 C3 = 10 Y22b8 = 0 [CCIR, 1985; Part 1.2, § 3]	Control bit in page header packet	Y1 ₃ b8 = 1	
5.2.3 Delayed/inhibited display	Y13b8 = 1 [CCIR, 1985; Part 1.1, Annex 4.2, § 1.2]	Control bit in page header packet	Y1 ₃ b6 = 1	
5.2.4 Linked	Y25Y26 [CCIR, 1985; Part 1.1, Annex 4.2, § 2]	Packet 27, byte 43 of designated data blocks	Header extension bytes (HE)	

TABLE 1a (continued)

Teletext system	A	B	C	D ⁽¹⁾
5.2.5 Index	Y12b4 = 1 [CCIR, 1985; Part 1.1, Annex 4.2, § 1.1]	See 5.3	Y1 ₃ b4 = 1	
5.2.6 Alarm	Y12b8 = 1 [CCIR, 1985; Part 1.1, Annex 4.2, § 1.1]	See 5.3	Y1 ₅ b8 = 1, Y1 ₅ b6 = 1 (RT = 3)	
5.2.7 Update	Y13b4b6 Y12b6 [CCIR, 1985; Part 1.1, Annex 4.2, § 2]	Control bit in page header packet	Y1 ₅ b4 = 1, version # (Y1 ₆) updated	
5.2.8 Priority	C1 = C2 = C3 = A [CCIR, 1985; Part 1.1, Annex 4.1] Y12b2 = 1 [CCIR, 1985; Part 1.1, Annex 4.2, § 1.1]	See 5.3	Y1 ₅ b8 = 1, Y1 ₅ b6 = 0 (RT = 3) (Applies only to television mode)	
5.2.9 Programme related	Y22b8 = 0 [CCIR, 1985; Part 1.1, Annex 4.2, § 2]	Packet 30, bytes 22 to 25 of designated data blocks	See subtitle and priority page classifications	
5.2.10 Newsflash	Y22b8 = 0 [CCIR, 1985; Part 1.1, Annex 4.2, § 2]	Control bit in page header packet	Access through data channel B00, page address 0. Y1 ₆ updated	
5.2.11 Support	No	Packet 27, bytes 7 to 42 of designated data blocks	Support record address FFF, Y1 ₅ b2 = 1 Support needed Y1 ₄ b2 = 1	
5.2.12 Scrolling	No	Scrolling region defined by packet 26, bytes 7 to 45 of designated data blocks	See [CCIR, 1985]	
5.2.13 Cover	Y22b4 = 1 [CCIR, 1985; Part 1.1, Annex 4.2, § 2]	Control bit in page header packet	Data channel 0, page 0 or other page 0 addresses	
5.2.14 Reveal	Y13b8 = 0 [CCIR, 1985; Part 1.1, Annex 4.2, § 1.2]	Control bit in page header packet or user operation	Y1 ₅ b8 = 0, Y1 ₅ b6 = 1 (RT = 3)	

TABLE Ia (continued)

Teletext system	A	B	C	D ⁽¹⁾
5.3 Page access information				
5.3.1 Network label	Row 0 ($C_1 = C_2 = C_3 = 0$) or $N_2 = (0 \text{ or } 99)$	Packet 30, bytes 13 and 14 of designated data blocks	$RT = 2$, see [CCIR, 1985]	
5.3.2 Date and time	Row 0 ($C_1 = C_2 = C_3 = 0$), if any	Packet 30, bytes 15 to 21 of designated data blocks	$RT = 2$, see [CCIR, 1985]	
5.3.3 Page address	$C_1 C_2 C_3$ [CCIR, 1985; Part 1.1, Annex 4.1]	Bytes 6 and 7 of page header packet	$A_1 A_2 A_3$ and $RD \text{ b}2 = 1$ for $A_4 - A_9$ (extended address)	
5.3.4 Sub-page address	If $Y_{12}b_6 = 0$, then $Y_{25} Y_{26}$, [CCIR, 1985; Part 1.1, Annex 4.2, § 2]	Bytes 8 to 11 of page header packet	$Y_{14} b_8 = 1$ (more) and extended address as above	
5.3.5 Logical data delimiter	Not required, see presentation layer	Not required	Not required. Consequence of record header format itself	
5.3.6 Page reconstruction	L [CCIR, 1985; Part 1.1, § 4.2.2.3]	Not required	Update defined by $Y_{15} b_4 = 1$ and Y_{16} (version #)	
5.3.7 Cyclic marker	No	Not required	$Y_{14} b_6 = 1$ ($RT = 3$) (Subcycle marker if $RT = 0$ or 1)	
5.3.8 Programme identification	$N_2 = 0$, row 0	Packet 30, bytes 22 to 25 of designated data blocks	$RT = 2$, see [CCIR, 1985]	
5.3.9 Initial page address	Cover page, $Y_{12}b_2$ [CCIR, 1985; Part 1.1, Annex 4.2, § 1.1]	Packet 30, bytes 7 to 12 of designated data blocks	Data channel 0, page 0	
5.3.10 Search indicator	No	Packet 27, byte 6 of designated data blocks	$RT = 2$, see [CCIR, 1985]	

TABLE Ia (continued)

Teletext system	A	B	C	D (1)
5.3.11 Auto acquisition	If Y12b6 = 0, then Y25 Y26 + C1 C2 C3 [CCIR, 1985; Part 1.1, Annex 4.2, § 2]	As 5.3.9 and 5.3.12	Y14 b4 = 1	
5.3.12 Page linking	No	Packet 27, bytes 7 to 42 of designated data blocks	Header extension bytes (HE)	
5.4 Conditional access				
5.4.1 Control word synchronization	First US of an article [CCIR, 1985; Part 1.1, § 5.2.3]	Packet 28, bytes 7 to 45 of designated data blocks	Under study	
5.4.2 Initialization complement	C1 C2 C3 L [CCIR, 1985; Part 1.1, § 5.2.3]	Packet 28, bytes 7 to 45 of designated data blocks		
5.4.3 Entitlement checking messages	C1 C2 C3 = FFF, US 3/F 3/F [CCIR, 1985; Part 1.1, § 5.3.1]	Packet 1 to 24 when designated for this function		
5.4.4 Audience segmentation	Y16b2b4b6 [CCIR, 1985; Part 1.1, § 5.3.1]	Packet 28, bytes 7 to 45 of designated data blocks		
5.4.5 Descrambling generator	Pseudo-random generator [CCIR, 1985; Part 1.1, Annex 5.1]	See 5.4.1		
5.4.6 Descrambling procedure	XOR [CCIR, 1985; Part 1.1, § 5.2.3]	See 5.4.1		
Layer 6: Presentation	CCITT Rec. T.101 Syntax 2, Annex C, Profile 2 and [CCIR, 1985]	See [CCIR, 1985]	CCITT Recommendation T.101, Data Syntax III and [CCIR, 1985]	
Layer 7: Application	Practical use of the potential facilities provided by the lower layers leads to services such as: access to pages of information, music with text, subtitling, telesoftware, etc. Further information specific to each system is given in [CCIR, 1985]			

TABLE 1b — Description of the essential elements of teletext systems specified for 525/60 television systems

Teletext system	A	B	C	D
Layer 1: Physical				
1.1 Time slot usable for data	Active part of any TV line subject to availability			
1.2 Data positioning (relative to line sync. timing reference) ⁽²⁾		Bit 13 is reference plus 11.7 μ s (± 0.175)	10.48 $\pm 0.34 \mu$ s	9.78 $\pm 0.35 \mu$ s
1.3 Data amplitude ⁽²⁾ logical «0» logical «1»		Black level $\pm 2\%$ 70% ($\pm 6\%$) of black-to-white excursion	0 IRE units 70 IRE units for negative modulation 100 IRE units for positive modulation	0 ± 2.5 IRE units 70 ± 2.5 IRE units
1.4 Bit rate		5.727272 Mbit/s $\pm 25 \times 10^{-6}$	5.727272 Mbit/s ⁽³⁾ (364 $\times$ line frequency)	5.727272 Mbit/s $\pm 3 \times 10^{-6}$ (364 $\times f_H$; 8/5 $\times f_{sc}$)
1.5 Data shaping ⁽²⁾		Spectral shaping is skew symmetrical about 0.5 bit rate	Typically a raised cosine 100% roll-off spectrum, followed by a video low pass filter	Spectrum shaping... Controlled cosine roll-off, roll-off factor 0.6, cut-off frequency 0.5 $\times$ bit rate
1.6 Data coding		Binary NRZ	Binary NRZ	Binary NRZ
1.7 Data line including clock run-in		296 bits	288 bits (The first 16 bits of alternating 1's and 0's constitute the clock run-in)	296 bits (bytes ⁽⁴⁾ 1 to 37. Bytes 1 and 2 comprise clock run-in)
Layer 2: Link				
2.1 Digital frame synchronization		Byte 3 = 11100100	Byte BS = 11100111	Byte 3 = 11100101

TABLE 1b (continued)

Teletext system	A	B	C	D
2.2 Length of data unit		35 bytes	34 bytes (excluding clock run-in)	35 bytes
2.3 Format indicator		Not required	PS byte	
2.4 Error detection/correction				
2.4.1 Byte error detection – parity		Odd parity for bytes 4 to 37 Even parity for bytes 1 to 3	Odd parity	
2.4.2 Byte error detection/correction		8/4 Hamming code for bytes 4 and 5; 8/4 and 24/18 for extension packets numbers 26, 27, 28 and 29	8/4 Hamming code on all bytes in the prefix, data group header, record header	
2.4.3 Block error detection/correction		Bytes 7 and 8 of designated data blocks carry a cyclic redundancy check word (CRC)	Suffix bytes indicated by bits b8b6 of the PS byte	(272, 190) majority logic decodable difference set cyclic code on bytes 4 to 37 as a block
Layer 3: Network				
3.1 Data channel addressing		Bytes 4 and 5 of all packets	Bytes P1, P2, P3	Byte 4 and the data line position
3.2 Data packet sequencing		Bytes 4 and 5 of all packets	Byte CI	Byte 5 (bits 1 to 4)
3.3 Length of prefix		2 bytes	5 bytes	14 bits (byte 4 and byte 5, bits 1 to 6)
3.4 Length of data block		32 bytes	0, 26, 27 or 28 bytes indicated by bits b8b6 of PS byte	22 bytes (D-bytes ⁽⁵⁾ 1 to 22)

TABLE 1b (continued)

Teletext system	A	B	C	D
Layer 4: Transport				
4.1 Group of data blocks		In page-oriented services: – start by page header packet, bytes 4 to 13. – termination by next page header packet. For independent data services: – packets 30 and 31. See [CCIR, 1985] for details	Byte GT indentifying 16 types of data group	Byte 5, bit 6 = 1 and D-byte 1 = 00/1 indicate the data block contains a data group header. D-bytes 2 to 7 constitute the data group header.
4.2 Data group size		1024 bytes or multiples of 1024 bytes	Bytes S1, S2 and F1, F2	D-bytes 4 and 5 ⁽⁶⁾
4.3 Data group integrity				
4.3.1 Continuity		Automatic	Byte GC	A data group is a series of data blocks sequentially transmitted in a data channel. (See 3.1 and 3.2)
4.3.2 Error detection/correction		Packet 27, bytes 7 and 8 of designated data blocks carry a cyclic redundancy check word (CRC)	Suffix bytes identified by bits b8b6 of the PS byte	D-bytes 21 and 22 carry a cyclic redundancy check (CRC) if D-byte 20 is 01/7, 00/3 or 00/4
4.4 Data group sequencing		Packet 27, bytes 7 to 36 of designated data blocks	L1, L2 for a given page address	D-byte 3 ⁽⁶⁾ ; byte 5, bit 5 = 1 delimits transmission units
Layer 5: Session				
5.1 Indicator of type of session				
5.1.1 Cyclic/non-cyclic		Not required	RT = 0/RT = 1	HI ⁽⁷⁾ = 01/14 02/0 or 01/14 02/1, H-byte ⁽⁸⁾ 7, bit 1

TABLE Ib (continued)

Teletext system	A	B	C	D
5.1.2 Access control		Packet 27, bytes 7 to 36 of designated data blocks	Under study	
5.1.3 Terminal facilities		Display/processable, packet 27, byte 37 of designated data blocks	Basic TTx service recognizes RT = 0, 1, 2 and 3; RT = 4 to 13 are reserved; RT = 14 and 15 are for broadcaster use	
HI = 01/14 02/0 or 01/14 02/1, H-byte 8				
5.1.4 Protocol		Packet 27, byte 37 of designated data blocks		HI = 01/14 02/0 or 01/14 02/1, H-byte 7, bits 5-8
5.1.5 Batch		Packet 27, byte 37 of designated data blocks		HI = 01/14 02/0 or 01/14 02/1, H-byte 7, bit 2 = 1
5.1.6 Addressed to user		Packet 28, designated data blocks		
5.1.7 Priority		Not required	RT = 3	
5.1.8 Application		Packet 27, byte 37	RT = 2	
5.2 Page classification			Record designator byte, RD, bit 6 = 1 indicates presence of classification sequence	
5.2.1 Normal		Not required	RT = 0 or 1 and absence of other page classification indicators	HI = 01/14 02/1 H-byte 7, bit 3 = 0 and bit 4 = 0 and H-byte 9, bit 5 = 0 and bit 6 = 0
5.2.2 Subtitle		Control bit in page header packet	Y1 ₃ b8 = 1	HI = 01/14 02/1, H-byte 7 bit 3 = 1 and bit 4 = 1
5.2.3 Delayed/inhibited display		Control bit in page header packet	Y1 ₃ b6 = 1	

TABLE 1b (continued)

Teletext system	A	B	C	D
5.2.4 Linked		Packet 27, byte 37 of designated data blocks	Header extension bytes (HE)	All pages in a batch-type programme are linked (see 5.1.5) HI = 01/14 02/0, H-byte 9, bits 1 to 4 indicate the page linkage structure
5.2.5 Index		See 5.3	Y ₁₃ b4 = 1	
5.2.6 Alarm		See 5.3	Y ₁₅ b8 = 1, Y ₁₅ b6 = 1 (RT = 3)	
5.2.7 Update		Control bit in page header packet	Y ₁₅ b4 = 1, version # (Y ₁₆) updated	HI = 01/14 02/0 or 01/14 02/1, H-byte 10, bit 2
5.2.8 Priority		See 5.3	Y ₁₅ b8 = 1 Y ₁₅ b6 = 0 (RT = 3) (Applies only to television mode)	
5.2.9 Programme related		Packet 30, bytes 22 to 25 of designated data blocks	See subtitle and priority page classifications	HI = 01/14 02/0 or 01/14 02/1, H-byte 7, bit 3 = 1 and bit 4 = 0
5.2.10 Newsflash		Control bit in page header packet	Access through data channel B00, page address 0. Y ₁₆ updated	HI = 01/14 02/1, H-byte 9, bit 5 = 1 and bit 6 = 0 and H-byte 7, bit 3 = 0 and bit 4 = 0
5.2.11 Support		Packet 27, bytes 7 to 36 of designated data blocks	Support record address FFF, Y ₁₅ b2 = 1 Support needed Y ₁₄ b2 = 1	HI = 01/14 02/0
5.2.12 Scrolling		Scrolling region defined by packet 26, bytes 7 to 36 of designated data blocks	See [CCIR, 1985]	HI = 01/14 02/1, H-byte 9, bit 6 = 1
5.2.13 Cover		Control bit in page header packet	Data channel 0, page 0 or other page 0 addresses	

TABLE Ib (continued)

Teletext system	A	B	C	D
5.2.14 Reveal		Control bit in page header packet or user operation	$Y_{15} b8 = 0, Y_{15} b6 = 1$ (RT = 3)	
5.3 Page access information				
5.3.1 Network label		Packet 30, bytes 13 and 14 of designated data blocks	RT = 2, see [CCIR, 1985]	HI = 01/14 02/2, H-bytes 5 to 7
5.3.2 Date and time		Packet 30, bytes 15 to 21 of designated data blocks	RT = 2, see [CCIR, 1985]	
5.3.3 Page address		Bytes 6 and 7 of page header packet	$A_1 A_2 A_3$ and RD b2 = 1 for A_4-A_9 (extended address)	HI = 01/14 02/0 or 01/14 02/1 or 01/14 02/3, H-byte 4, bits 1 to 4 and H-byte 5 (PR = 000~999)
5.3.4 Sub-page address		Bytes 8 to 11 of page header packet	$Y_{14} b8 = 1$ (more) and extended address as above	HI = 01/14 02/1, H-byte 6 (PA = 00~99)
5.3.5 Logical data delimiter		Not required	Not required. Consequence of record header format itself	01/14 N: HI ⁽⁷⁾ (N: parameter byte) 01/15 N: DI ⁽⁹⁾ (N: parameter byte)
5.3.6 Page reconstruction		Not required	Update defined by $Y_{15} b4 = 1$ and Y_{16} (version #)	HI = 01/14 02/3
5.3.7 Cyclic marker		Not required	$Y_{14} b6 = 1$ (RT = 3) (subcycle marker if RT = 0 or 1)	
5.3.8 Programme identification		Packet 30, bytes 22 to 25 of designated data blocks	RT = 2, see [CCIR, 1985]	HI = 01/14 02/2, DI = 01/15 03/13
5.3.9 Initial page address		Packet 30, bytes 7 to 12 of designated data blocks	Data channel 0, page 0	

TABLE Ib (continued)

Teletext system	A	B	C	D
5.3.10 Search indicator		Packet 27, byte 6 of designated data blocks	RT = 2 see [CCIR, 1985]	
5.3.11 Auto acquisition		As 5.3.9 and 5.3.12	Y1 ₄ b4 = 1	
5.3.12 Page linking		Packet 27, bytes 7 to 36 of designated data blocks	Header extension bytes (HE)	HI = 01/14 02/1 DI = 01/15 03/5 P-byte (¹⁰) 5 to 9
5.4 Conditional access				
5.4.1 Control word synchronization		Packet 28, bytes 7 to 36 of designated data blocks	Under study	Under study
5.4.2 Initialization complement		Packet 28, bytes 7 to 36 of designated data blocks		
5.4.3 Entitlement checking messages		Packets 1 to 25 when designated for this function		
5.4.4 Audience segmentation		Packet 28, bytes 7 to 36 of designated data blocks		
5.4.5 Descrambling generator		See 5.4.1		
5.4.6 Descrambling procedure		See 5.4.1		
Layer 6: presentation		See [CCIR, 1985]	CCITT Recommendation T.101, Data syntax III and [CCIR, 1985]	See [CCIR, 1985]

TABLE Ib (continued)

Teletext system	A	B	C	D
Layer 7: Application	Practical use of the potential facilities provided by the lower layer leads to services such as: access to pages of information, music with text, subtitling, telesoftware, etc. Further information specific to each system is given in [CCIR, 1985].			

- (¹) Parameters for 625-line 50-field applications are subject to further study.
- (²) Parameters for data positioning, amplitude and shaping may be altered to suit particular transmission requirements.
- (³) Bit rate parameter may be altered to suit particular transmission requirements.
- (⁴) "Byte" number indicates a byte position in the data line.
- (⁵) "D-byte" number indicates a byte position in the data block.
- (⁶) Data group header bytes (see 4.1).
- (⁷) Data header identifier (see 5.3.5).
- (⁸) "H-byte" number indicates a byte position in a data header.
- (⁹) Protocol data unit identifier.
- (¹⁰) "P-byte" number indicates a byte position in the protocol data unit.

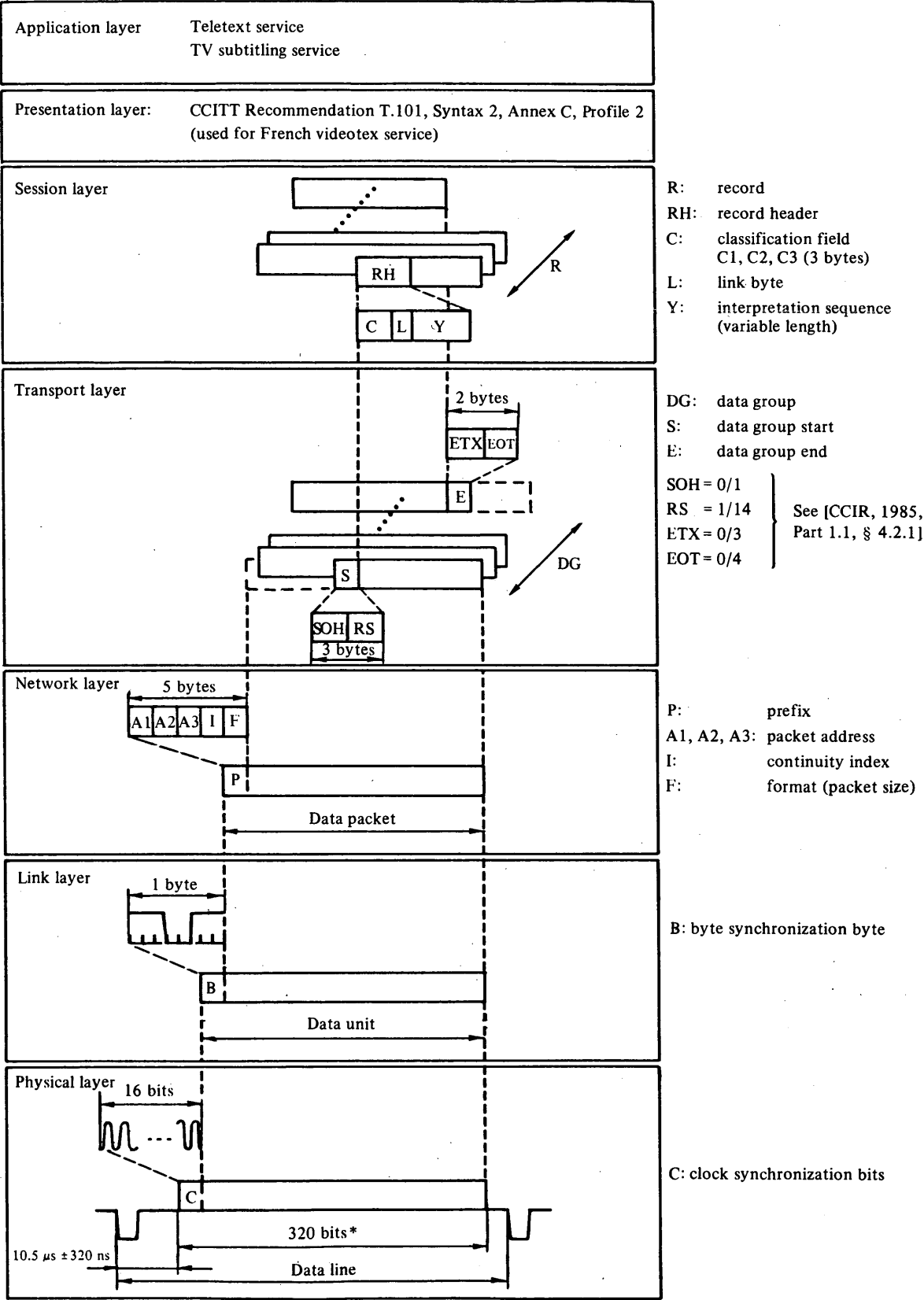


FIGURE 6 – Layered structure of teletext system A

* See Note 2 of Table I.

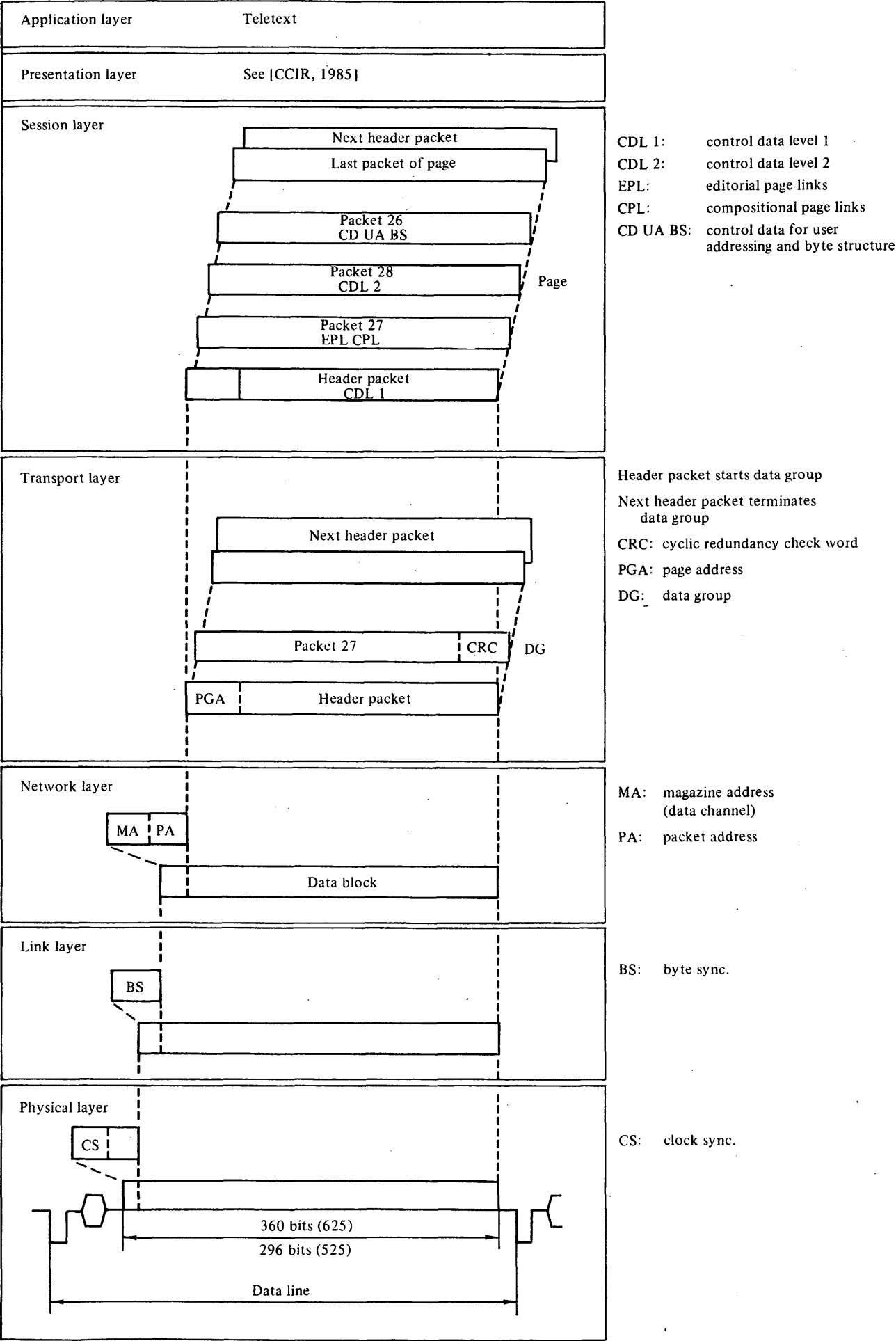


FIGURE 7 – Layered structure of teletext system B

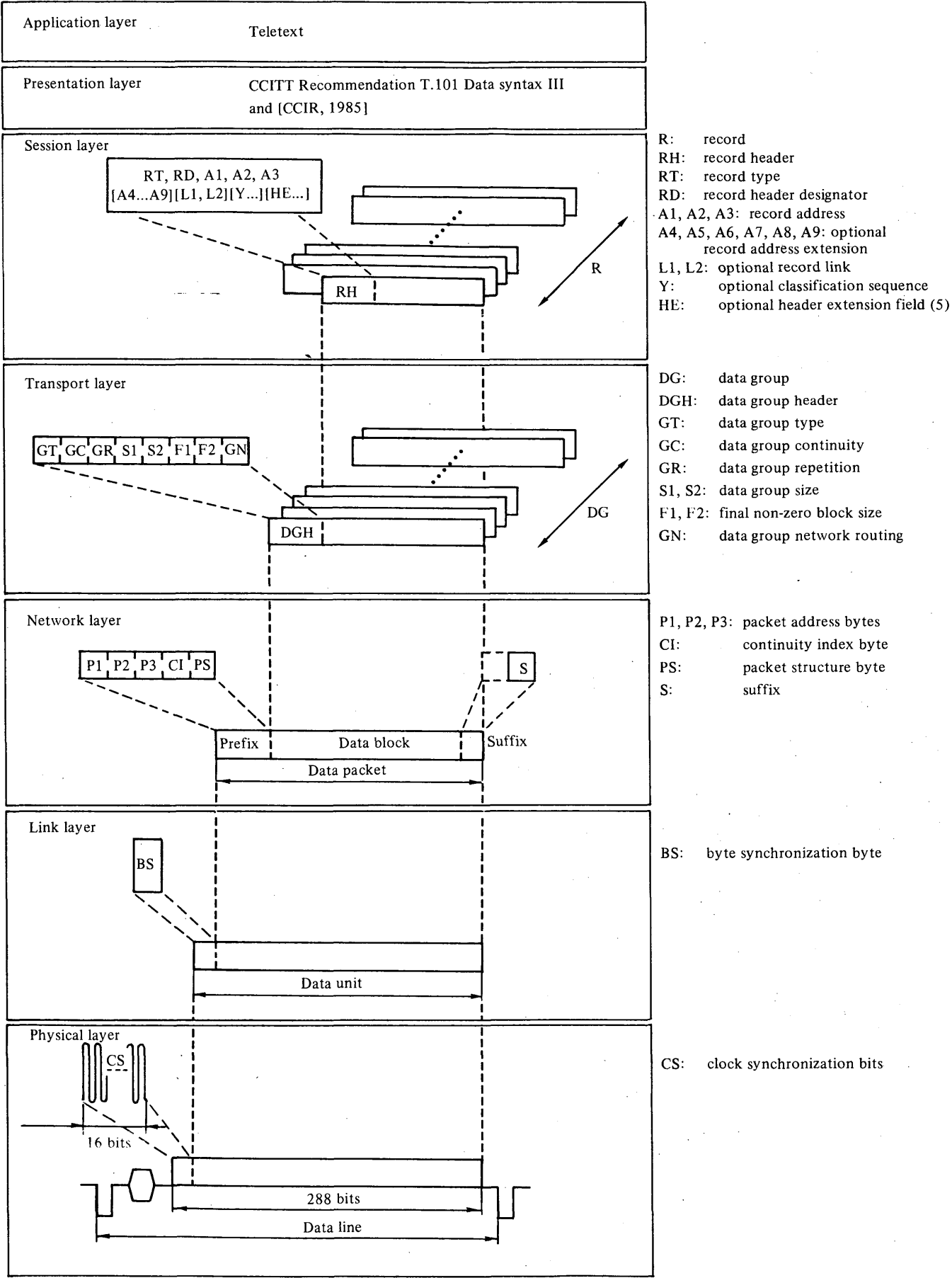


FIGURE 8 – Layered structure of teletext system C

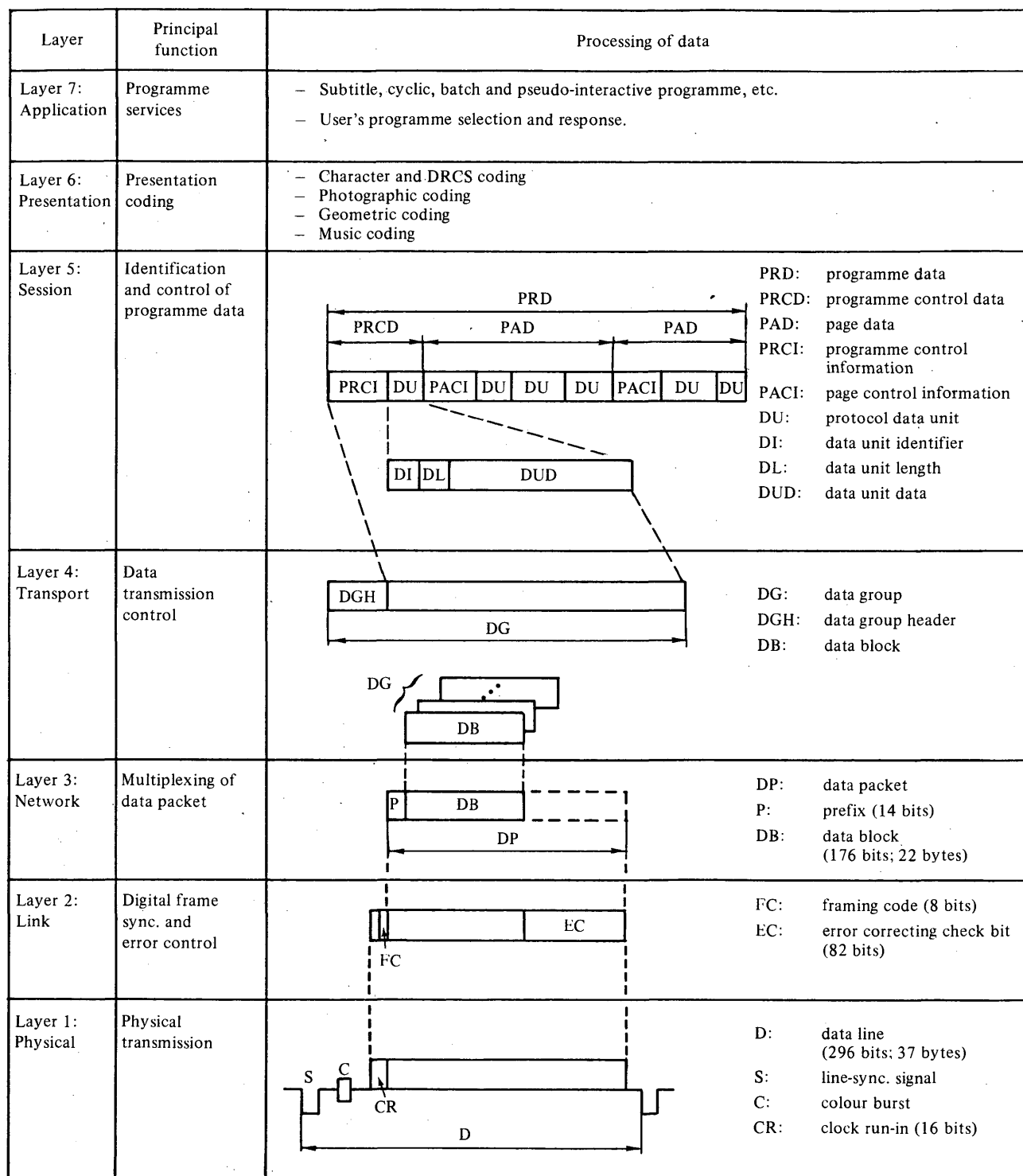


FIGURE 9 – Layered structure of teletext system D

TABLE II* — *Teletext systems used in various countries/geographical areas*

Country/geographical area	Teletext system specified (1986)	Remarks
Germany (Federal Republic of)	B	Modified
Australia	B	
Belgium	A and B	
Brazil	C	
Burkina Faso	None	
Canada	C	
Cyprus (Republic of)	None	
Colombia (Republic of)	A	
Denmark	B	
United States of America	C	
France	A	
India (Republic of)	A	
Italy	B	
Japan	D	
Malaysia	B	
Malawi	None	
Maldives (Republic of)	None	
Mexico	None	
New Zealand	B	
Oman (Sultanate of)	None	
Netherlands (Kingdom of)	B	Experimentally
Poland (People's Republic of)	B	
Syrian Arab Republic	None	
United Kingdom of Great Britain and Northern Ireland	B	Primary character with national variation to also accommodate the Afrikaans language
South Africa (Republic of)	B	
Singapore (Republic of)	B	
Sweden	B	

* Administrations are invited to provide the appropriate entries for Table II.

REFERENCES

[CCIR, 1985]: Specification of teletext systems, Provisional descriptive booklet (consisting of CCIR, 1982-86: 11/422(Rev.1) (Study Group 11); 11/282 (United Kingdom); 11/345 (France); 11/352, 11/413 (Japan); 11/382 (Canada)).

REPORT 802-2 *

ADDITIONAL BROADCASTING SERVICES USING A TELEVISION OR NARROW-BAND CHANNEL

(Question 29/11, Study Programmes 29A/11, 29C/11 and 29H/11)

(1978-1982-1986)

1. Introduction

Many countries are now broadcasting information and other services in a television channel, in addition to normal television services. Most of these use digital data broadcasting, and probably the most widely-known at the present time are the teletext systems described in Annex I to Recommendation 653, while other systems use analogue techniques.

A classification of additional services is given in Table I, which, for completeness, also includes services using sound-broadcasting channels.

The sections of this Report are as follows:

- section 2 deals with multiplexing and organizational methods for data broadcasting;
- section 3 deals with the services which use data broadcasting systems;
- section 4 is concerned with still-picture television broadcasting (SPTV).

2. Digital data broadcasting systems

2.1 *Multiplexing methods within the television channel*

Recent work on defining methods for broadcasting television, sound and data signals in one satellite channel, has led to the description of new multiplexing systems, some of which may eventually be adapted for terrestrial broadcasting. However, for ease of reference, and association with other CCIR Reports, the various methods are referred to under the application for which they were first developed.

2.1.1 *Methods for terrestrial broadcasting*

a) *Time division multiplexing (TDM)*

At present, most systems use this method, inserting the data signals into television lines in the field blanking time, (data lines), or into the line blanking time of the video signal. The teletext systems described in Annex I to Recommendation 653 use data lines which, in the absence of television picture signals, may extend throughout the active field time as well as the field blanking time; though the television line and field synchronizing signals are preserved.

Some possibilities for incorporating the sound information in the video signal in terrestrial broadcasting are given in Report 958. Studies within the EBU [CCIR, 1978-82a] show that there would be compatibility problems with existing receivers, but if a special strategy for implementing a new transmission standard could be followed, an estimated capacity corresponding to four high-quality sound channels could be obtained in 625-line systems. Such a technique may provide an opportunity for broadcasting data.

The influence of the data signal on television protection ratios is under study and some results are available in Recommendation 653 for 625-line B or G/PAL television. Some recent results concerning the protection of a data broadcasting service for television system L are quoted in [CCIR 1982-86a].

b) *Frequency division multiplexing (FDM)*

Experiments are in progress with television services having an extra digitally modulated sub-carrier which may be used for sound or data broadcasting. These are described briefly in Report 795, with references.

* This Report should be brought to the attention of the CCITT.

TABLE I — *A classification of identified additional services which may be provided by data broadcasting systems*

Additional services ⁽¹⁾	Television broadcasting channel multiplex		⁽²⁾ Sound broadcasting channel multiplex
	Time division multiplex (TDM)	Frequency division multiplex (FDM)	AM or FM channel
1. Teletext	Reports 802 (§ 3.1), 956; Recommendations 653, 655		
2. Sub-titling	Reports 802 (§ 3.2.1), 1080; Recommendation 653		
3. Service and programme identification	Reports 802 (§ 3.2.2), 1073; Recommendation 653		Report 463 ⁽³⁾ ⁽⁴⁾
4. Programme delivery	Reports 802 (§ 3.2.3), 1073 Recommendation 653		Report 463 ⁽⁴⁾
5. Speech-quality sound	Report 802 (§ 3.2.4.1) Report 958 Report 954, Report 632 Report 1073	Report 795 ⁽²⁾ ⁽³⁾ Report 954 Report 632 ⁽³⁾	Report 632 ⁽³⁾
6. Synthesized sound	Report 802 (§ 3.2.4.2); Recommendation 653		
7. Broadcast audiography	Report 802 (§ 3.2.5)		Report 463 ⁽³⁾ ⁽⁴⁾
8. Data for processing (includes "telesoftware")	Report 802 (§ 3.2.6)		Report 1061
9. Broadcasting of time and date in coded form	Reports 802 (§ 3.2.6.1), 1073 and 1078; Recommendation 653		
10. Independent data services	Reports 802 (§ 3.2.7) and 1073; Recommendation 653	Report 1073	
11. Broadcast facsimile	Report 802 (§ 3.2.8)		Report 463 ⁽⁴⁾
12. Still picture television	Report 802 (§ 4) ⁽³⁾		Report 463 ⁽³⁾ ⁽⁴⁾

Note. — The modulation is assumed to be digital, unless otherwise stated.

⁽¹⁾ Conditional-access techniques may be used with television and sound and any of the additional services 1-12 (see § 3.3 of this Report, Reports 1073, 1079 and Recommendation 653).

⁽²⁾ The systems for these services are being studied by Study Group 10.

⁽³⁾ Service may partly be provided using analogue modulation.

⁽⁴⁾ Report 463 while not referring to "teletext" does deal with the transmission of supplementary information including text using FM sound broadcasting.

2.1.2 *Methods of multiplexing for satellite broadcasting*

Information on this topic is available from other CCIR Reports as follows:

- Report 632: “Broadcasting-satellite service (sound and television) – *Technically suitable methods of modulation*”

Although the main topic of this Report is *modulation* methods, some information is given on multiplexing.

- Report 954: “Multiplexing methods for the emission of several digital audio signals and also data signals in broadcasting”

This describes two multiplexing methods known as “system A” or “continuous” which is an FDM system and “system B” or “interrupted” which is a TDM system.

- Report 1073: “Television standards for the broadcasting-satellite service”

This describes several well-developed systems providing for data broadcasting and known as C-MAC/packet, D2-MAC/packet, B-MAC and digital sub-carrier/NTSC.

These systems provide for sharing of the entire WARC-BS-77 channel capacity among the different services. Means for assisting users to access the different services possible within one WARC channel, and the different WARC channels, are provided. Further information on this aspect is given in § 3.2.2 below.

a) *Time division multiplexing (TDM)*

The systems described in Report 1073 also allow baseband time division multiplexing with the video signal.

While it is expected that satellite data broadcasting services will progressively make use of a digital sound/data multiplex, during a transitional period, teletext using present standards may be adapted to the transmission in the field blanking interval of any television signal. This is desirable for teletext service continuity, but is also necessary because, at present, there is no recognized system to utilize the sound/data multiplex, though one system has been proposed [CCIR, 1982-86b].

Report 1073 describes several TDM systems:

C-MAC/packet : A radio-frequency multiplexing system: available bit rate approximately 3 Mbit/s.

D2-MAC/packet : A baseband multiplex using duobinary coding: available bit rate approximately 1.5 Mbit/s.

B-MAC : A baseband multiplex system using quaternary coding with an available bit rate of approximately 1.6 Mbit/s.

b) *Frequency division multiplexing (FDM)*

Report 1073 describes a system known as digital sub-carrier/NTSC which uses a digitally-modulated sub-carrier giving an available bit rate of approximately 2.0 Mbit/s.

2.2 *Organization of the multiplex*

The organization of the data multiplex is defined by a certain number of characteristics and parameters concerning the available resource and sharing mode:

- available resource;
- method of multiplexing data from different sources;
- identification of a data channel;
- number of available data channels;
- specification of a data channel.

General descriptions of the data broadcasting systems that have been used primarily for the teletext service are given in Annex I to Recommendation 653. The use of a packet transmission technique for broadcasting data is described on the basis of the lowest four layers of the ISO reference model for open system interconnection.

Similarly, the sound/data multiplex of the MAC/packet direct satellite broadcasting systems described in Report 1073 uses a packet multiplexing structure to allocate the available digital resource to the various sound and data sources.

2.3 *Digital interfaces for transmission and reception*

In general, it is necessary to provide interfaces to permit the transmission of digital data from a number of different sources. Since broadcasting is a unidirectional transmission medium, it is not possible to adapt the characteristics of the transmission to comply with the requirements of the receiving equipment in each case. It is therefore necessary to adapt the transmission speed of each source to the available bit rate, taking into account the relative priority of each source. For example, sound may have the highest priority, and sub-titles a higher priority than teletext. Such an interface has been defined in [Bliveau *et al.*, 1980], the regulation of the bit rate being achieved by the use of a "hand-shaking" procedure at the sending end.

Furthermore, the interface, and compatibility, with other data networks must often be considered. For example, the interfacing of an SPTV system with several telephone data channels is described in [CCIR, 1982-86c].

3. **Digital data broadcasting services using the capability within a television channel**

3.1 *The teletext service*

The definition of the teletext service is as follows:

A digital data broadcasting service which may be transmitted either within the structure of an analogue television signal or by using digital modulation systems. The service is primarily intended to display text or pictorial material in two-dimensional form reconstructed from coded data on the screens of suitably equipped television receivers.

Four teletext systems are recommended for international adoption in Recommendation 653. They are described in Annex I to Recommendation 653 where they are referred to as systems A, B, C and D, viz:

- System A : the system proposed by France
- System B : the system proposed by the United Kingdom
- System C : the system proposed by Canada
- System D : the system proposed by Japan

There is now extensive literature describing the development of these systems and an overview is given in [Cominetti, 1985]. Many further references are given in the Bibliography. The results of field trials and theoretical studies, in particular, are given in Report 956.

Exchange between and combination of pages from different teletext data sources may be required when a programme of a particular content or structure is to be composed, for example a regional programme which is to include parts of a nationwide teletext programme. Besides the use of different data lines in the field blanking interval of the television signal for different teletext programmes or the interconnection of two or more teletext computers through data links, a "teletext combiner" device might be used to combine pages from several input cycles, exchange predefined pages and suppress unwanted pages. The combiner also allows for an uncomplicated insertion of "on-tape" sub-titles in an existing programme cycle [CCIR, 1982-86d].

3.2 *Systems for other new services*

The services listed below also rely upon data broadcasting. The number of these services is increasing. Some may also be provided by use of teletext systems.

3.2.1 *Sub-titling (closed-captions)*

Sub-titling services associated with teletext services or the dedicated "line-21" system [Lentz *et al.*, 1978] have been in operation for several years. Improved operational methods and equipment have been developed [Holmberg *et al.*, 1981; Lambourne, 1983; Baker *et al.*, 1984]. Sub-titling provided through data broadcasting can be multi-language and multi-level [CCIR, 1978-82b; Sechet 1980a, b]. In France, multilingual sub-titling equipment, with independent language management has been produced and presented. This possibility is particularly important with the advent of broadcasting satellites. Existing production systems permit only the broadcasting of sub-titles prepared in advance. Systems for producing sub-titles in real time or with a slight time lag are still under study [Renoullin and Pinon, 1985].

The number of languages that can be provided simultaneously is limited in practice only by the transmission resource, but a reasonable maximum corresponds to about 10 to 20 languages or levels in normal operating conditions.

The transfer of sub-title data for transmission may either be rapid and directly in the form in which it is immediately to be transmitted, or at a lower data rate. In the latter case, a minimum serial data rate of 130 bytes/s is required for the transfer — or recording — of sub-titles in one language concurrently with the main programme material [CCIR, 1982-86e]. If a small increase in the minimum inter-sub-title time could be accepted, then the transfer — or recording — could employ the “user bits” of the EBU time code [EBU, 1982] for a single sub-title channel (i.e. 100 bytes/s).

Some statistics relating to sub-title services by means of teletext systems A and B are also presented in [CCIR, 1982-86e].

The international exchange of television programmes containing sub-titling data is dealt with in [CCIR, 1982-86f].

3.2.2 *Service and programme identification*

Where many broadcast transmissions can be received, especially when an RF channel might carry several services, programmes or independent information items, the need arises for the broadcasting of data that will help the user by:

- facilitating access to the desired RF channel;
- defining actual organization of the different signal components within the RF channel (if this is varied from time to time);
- facilitating access to a desired service which is one of several services within an RF channel. (A service may have several components of different types.)

In direct satellite broadcasting, a large number of transmissions are likely to be receivable at each point. For each transmission, several services are likely to be available. It is therefore desirable to adopt a common and comprehensive identification system within the geographical area which is served in accordance with a regional plan, such as that established by the WARC-BS-77.

As an example, the EBU service identification system within the MAC/packet family of systems is based on the use of a dedicated data channel within the digital sound/data multiplex, together with the sending of RF channel and TDM control data in line 625. The processing of the RF channel and TDM configuration data allows the receiver to separate the analogue part of the TDM multiplex, that is to say, the picture, from its digital part, which is the packet multiplex. The processing of the information conveyed by the dedicated channel gives access to the various services and to the various components of each service, and to programme items within each service. Such a system could also be the basis for a service and programme identification system for terrestrial broadcasting.

3.2.3 *Programme delivery*

The programme delivery service facilitates the remote control from a transmission source of recordings made by receiving equipment which is capable of pre-selecting the television programme to be recorded. The service may include two parts:

- the list of scheduled programmes, to permit (or facilitate) pre-selection; the sub-unit is optional;
- recording device remote-control orders.

Experiments in France have been reported in which control codes inserted into data packets were multiplexed with the television signal at a very low data rate [Gautier *et al.*, 1975]. The codes may be used to control recording equipment and delayed programme distribution in cable networks.

The pre-selection assistance function is implemented by a teletext magazine with two types of information:

- pages describing the programmes to come;
- non-displayable codes for identifying the programmes while they are being broadcast.

The recording device remote-control orders are transmitted over a special data channel.

In the Federal Republic of Germany, a system known as VPS (video programming system), which uses 2.5 Mbit/s bi-phase coded data in lines 16 and 329, as specified in [EBU, 1977] is employed for the remote control of suitably equipped domestic video tape recorders [CCIR, 1982-86g]. There are plans to introduce this system in Austria and Switzerland.

Certain items of data conveyed by the EBU service identification system mentioned in § 3.2.2 can also be used for programme delivery.

3.2.4 *Sound*

3.2.4.1 *Speech-quality sound*

An experimental system has been developed in Italy [Ardito *et al.*, 1980; CCIR, 1978-82c] to provide a commentary channel to a teletext programme, or auxiliary speech channels to a television programme for multilingual purposes.

The sound commentary is time-multiplexed with the teletext programme and makes use of the same structure of the data signal. In the proposed system, speech pauses are exploited in order to reduce the average channel occupation.

3.2.4.2 *Synthesized sound*

This type of service may be provided, for example, by means of teletext system D (see Annex I to Recommendation 653) and allows text and graphics to be accompanied by synthesized music if required. The addition of this facility to the other teletext systems (§ 3.1) is planned.

3.2.5 *Broadcast audiography*

A service called "audiography" in France [CCIR, 1974-78a] has been the subject of studies and tests, in particular in the Netherlands, the United States of America, Canada and France. The service, in which it is proposed that broadcast signals should contain digitally-coded sound with associated graphics information, enables a drawing in course of execution to be reconstituted (teledrawing or telewriting).

The signal used for the teledrawing may be obtained by means of a conversion pad for transforming the coordinates of a stylus into electrical signals. The speed of the pencil movements by which a drawing or a handwritten text is produced is, on average, sufficiently low to require a passband of a few Hertz only.

Possible applications could include the broadcasting of educational programmes (in the form of lecture) consisting of a lecturer's comments, diagrams, formulae, etc., drawn on a blackboard. The receiving system's television screen would thus act as a distant "electronic blackboard".

3.2.6 *Data for processing*

These services are rapidly growing in importance. They involve the broadcasting of data which is intended for machine processing but not primarily for the purpose of producing an image on the user's television screen. The best-known example of this type of service is "Telesoftware". In general, "Telesoftware" services provide computer programs for use with personal computers in the hands of the general public.

"Telesoftware" services, broadcast as part of a teletext service, were the subject of experiments several years ago [Vivian and Overington, 1978] and there are now public services in some countries [CCIR, 1982-86h].

"Telesoftware" has also been broadcast by use of coded tones from sound broadcasting and television sound transmitters.

Other services under the general heading of "data for processing" may be intended for the remote control of machines (but excluding programme delivery services). An example is the broadcasting of low data-rate signals, for remote-control switching (see Report 1061).

3.2.6.1 *Broadcasting of time and date in coded form*

Time and date is an important item of information in broadcasting. When broadcasting across time-zone boundaries, especially from broadcasting satellites, a common convention for broadcasting time and date in coded form is desirable. Recommendations 457 and 460 provide such a convention, and its use in broadcasting is proposed in [CCIR, 1982-86i]. Report 1078 deals further with this matter.

3.2.7 *Independent data services*

The independent data services make use of the data broadcasting systems to broadcast various types of data intended for suitable terminals connected to data receivers. In this case, unlike that of the other services, the organization of the data is the responsibility of the user. Examples of services that have already been used operationally are the transmission of:

- news agency bulletins;
- lists of stolen credit cards;
- educational software for schools.

The system of data packet broadcasting which is in operation in France and known as DIDON [CCIR, 1974-78b; Noirel, 1975; Blineau *et al.*, 1980] is currently being used for such services.

The field of application of these services can be expanded greatly if a conditional-access system is used (see § 3.3).

3.2.8 *Broadcast facsimile*

In a system described in [CCIR, 1974-78c], the picture is basically graphic, at two levels. It is described by dots and the resolution is very high (typically of the order 1700×2400 dots per picture). The filling rate may be very high. Hence the picture cannot be displayed on a cathode ray screen due to insufficient resolution, and to the large memory required. Display is effected on paper, which also ensures storage. This is the broadcast facsimile service, also known as the "broadcast newspaper".

3.3 *Systems to provide conditional access to services*

The conditional access facility may be applied to all services, including the television services. Methods for controlling access required the use of encryption techniques in conjunction with scrambling. A conditional access television service has existed in France since November 1984. It is operated over a national land broadcasting network using bands I and III for the main transmitters. The scrambling techniques are pseudo-random delay of the wanted line part for video and spectrum reversal for sound [Marti and Mauduit, 1975]. Access entitlement control and management operations are effected simultaneously by providing a personal code to each subscriber and introducing the code in the decoder by means of a keyboard. Further information is given in Report 1079.

4. **Still-picture television (SPTV) broadcasting systems using a television or narrow-band channel**

4.1 *SPTV broadcasting systems using the time structure of the television signal*

Two examples have been studied in Japan [Numaguchi, 1975]. These are described below.

4.1.1 *Multi-channel full-field system*

The broadcast signal is composed of still-picture television signals and digitally encoded signals for the accompanying sound [Ando and Yamane, 1973; Yamane *et al.*, 1980; CCIR, 1974-78d and e]. The still pictures comprising one programme are transmitted for only one frame period, in sequence with an interval of 5 to 10 s between pictures. A control code signal is added at the beginning of each picture signal for identifying the programme to which each still picture belongs. The sound signals of all the programmes are digitally encoded and time-division multiplexed by PCM technique.

The picture signals and the sound signals are further multiplexed by time-sharing in the ratio 1/2 television frames and broadcast by modulating a vision carrier.

At the receiving end, the picture signal of a desired programme is extracted from the received signal with the aid of the address code signal and is stored in a magnetic disc memory or a digital IC memory so it can be displayed continuously on a television screen.

Transmission experiments with broadcast signals have been carried out using the medium-scale broadcasting satellite for experimental purposes (BSE), and successful results were obtained. [Hasegawa *et al.*, 1980; CCIR, 1978-82d].

4.1.2 *System using the field-blanking interval of a television signal*

In this system [CCIR, 1974-78f; Harada, 1976], each of the still-picture signals is broadcast by inserting its scan-line components successively into the field-blanking intervals of a main television signal. A multifunction control code signal is inserted in each still-picture signal in order to identify the programme to which each picture belongs.

Accompanying sound is transmitted by additional sound channels multiplexed with the sound carrier.

4.2 *SPTV broadcasting system using a television or narrow-band channel*

In this class of system, the digital SPTV signals are first formed within a narrow-band signal channel. Such a system has been studied in the USSR [CCIR, 1978-82e].

A possible application of the system is the broadcasting of signals from a public information centre to a large number of users. Other applications (e.g. conference communications, subscriber video services etc.), are envisaged which are being studied by the CCITT. Broadcasting of the information is based on the use both of time and frequency multiplexing techniques in television and/or sound-broadcasting channels.

Investigations of various technical parameters have been carried out with particular reference to the number of picture elements per line, number of bits per picture element, change-over time and bit rate and their influence on the service quality [Minashin *et al.*, 1979]. Concerning transmission aspects, it has been shown that to reduce the effect of errors, particularly when methods of reducing redundancy are used, codes must be employed to correct both single and multiple errors [Braude-Zolotarev *et al.*, 1979].

Experiments conducted in the USSR on still-picture transmission using non-switched connection lines of urban telephone networks have shown that effective correction of errors of various structures can be assured by the use of convolutional auto-orthogonal codes and an optimized threshold decoding algorithm. This technique makes it possible to transmit still-picture digital signals virtually error-free on channels having an error probability of as much as 5×10^{-3} [Braude-Zolotarev and Krasnoselsky, 1982; CCIR, 1982-86].

Particular attention must also be paid to the protection of the control and still-picture synchronizing signals. Detailed information is given in [CCIR, 1978-82f]. Further studies are required on more efficient methods of coding both of SPTV signals and the accompanying sound signal. Further study is also required of means to enhance noise immunity.

The results of these studies must be drawn to the attention of CCITT Study Groups XV and XVIII concerning coding and compatibility with the integrated services digital networks (ISDN).

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REPORT 956-1

DATA BROADCASTING SYSTEMS: SIGNAL AND SERVICE QUALITY, FIELD TRIALS AND THEORETICAL STUDIES

(Question 29/11, Study Programme 29C/11)

(1982-1986)

1. Introduction

Data broadcasting systems utilizing television networks are already implemented in different countries for providing a multitude of services. The quality of these services depends on:

- the characteristics of the data transmission channel;
- the effect of these characteristics on the intended services.

To provide a suitable service, measurements on data transmission channels are necessary and appropriate methods have to be devised.

Part I of this Report deals with the measurement of the quality of broadcast digital data channels, Part II discusses the effects of the transmission channel on the service quality in the case of teletext* and Part III discusses the issues of field trials and theoretical studies undertaken in different countries.

This Report includes a table giving the results of these tests and studies, in concise form. Annexed to the Report are definitions of the systems used, for field trials and introductory service, to facilitate interpretation of the results.

PART I

MEASUREMENT OF THE QUALITY OF BROADCAST DIGITAL DATA CHANNELS

1. General

Data packets inserted in some lines (data lines) of a video signal are corrupted, like the video signal itself, by noise and distortion. Given the digital nature of a data signal, the effects of these impairments are different from those produced on the analogue video signal and cannot be easily deduced on the basis of measurements carried out on conventional television test signals, such as described in Recommendation 473 (Insertion test signals) [CCIR, 1978-82a].

The quality of a digital data channel and the data acquisition circuit of its decoder may be defined in terms of percentage of data which, at the receiving site, are lost or discarded, or are accepted with errors. In this light, it is possible to define parameters representing loss or error ratios, some of which provide an indication of the performance of a data channel and the data acquisition circuit of its decoder irrespective of its use. Others refer only to particular applications, such as teletext.

In addition, the following analogue measurements can be carried out on a data signal:

- measurement of data levels,
- measurements related to eye pattern displays,
- measurement of decoding margin.

2. Digital measurements

2.1 Data packet loss- and bit error ratios

Digital data, inserted in a data line, consists of three parts:

- the initial run-in signal for bit synchronization;
- the framing code for byte synchronization;
- the data packet,** consisting of a number of bytes forming the prefix which contains the address and, in the case of certain prefix organizations, format and continuity index bytes, together with the data block**.

* The terms "teletext" and "broadcast videography" are, at present, used interchangeably (see Appendix II to Recommendation 662).

** Some administrations are not able to support completely this particular sub-division of the data line without further study.

In the case of certain data broadcasting systems, the data block is followed by a suffix for error-correction purposes.

Two impairments which can occur to the data packet [CCIR, 1978-82b] are:

- misinterpretation of the prefix, which results in the loss of the whole packet or a part of it, or its assignation to a wrong data channel,
- errors in the data block.

Since the data channel address is usually protected by special techniques (such as Hamming codes) the probability of a data packet being assigned to a wrong channel is usually very low. Thus, the most important parameter which quantifies the first type of impairment is the data packet loss-ratio. If the data packet does not contain a format description, it can be either totally lost or totally retained. In this case, the data packet loss-ratio can be simply defined as the percentage of transmitted data packets which has not been received. On the other side, when a format description is contained in the prefix, a misinterpretation of it can cause the loss of only part of the data, or the incorrect read-out of non-existing data. For this more complex case a convenient measurement method has not yet been proposed.

The second type of impairment (errors in the data block) is mainly characterized by the parameter "bit error ratio", defined as the percentage of the *received** bits that are affected by error. For the definition of a suitable error-correcting strategy, the knowledge of the statistical properties of errors may also be useful (for example, the probability of consecutive errors, or the distribution of errors along the data line).

Measurement methods for the data packet and byte synchronization loss-ratio and the bit error ratio are described in [Dublet, 1977; Noirel, 1978]. These also include measurements of the statistical properties of errors. The test signal is a conventional data packet, when the data block is filled up with a pseudo-random sequence.

2.2 *Measurements on particular data sequences*

It may be interesting, in order to investigate certain phenomena, to use fixed data sequences, so chosen as to be particularly sensitive to the distortions introduced by the system under test. An example of the fixed sequence is the "clock cracker", namely a sequence including as frequently as possible the maximum distance between transitions. This is used to test a type of clock-recovery circuit which makes use of all the data sequence, rather than solely the run-in sequence. It is also used to measure data levels [Croll, 1977].

Another example is a data sequence made of bytes, each of which contains a parity bit. This sequence allows the quality of the data broadcasting channel to be measured on a byte basis. It is also possible to make a rough estimate of the distribution of errors, which may be either random or concentrated on those bytes which produce a bit configuration particularly sensitive to inter-symbol interference.

Measurements of various types of error and loss ratios in conventional and specially protected (bi-phase) teletext signals are described in [Cominetti *et al.*, 1976]. These parameters may also be calculated using a comprehensive mathematical model [Vardo, 1977; Cominetti *et al.*, 1978].

3. **Analogue measurements**

A list of analogue parameters relating to a data signal is given in the Appendix I.

3.1 *Measurement of data levels*

Since the data signal is normally affected by overshoots, the identification of all-zeros and all-ones levels is not obvious and often requires special techniques.

Direct inspection of the data waveform on the oscilloscope provides reliable results only with low noise and distortions. The measurement is more reliable in the presence of long strings of 1's and 0's, as provided by some data test signals, such as the data pulse and bar and the clock cracker sequence (see § 4).

When noise and distortion are such as to prevent an accurate measurement, a suitable low-pass filter may be used to remove the overshoots [Croll, 1977; Chambers, 1976].

* When a data block is lost, the contained bits are not taken into account when determining the bit error ratio.

3.2 *Measurements related to eye pattern displays*

An eye pattern is obtained by superimposing the various bit cells present in a data stream. A detailed analysis of the properties of eye patterns is contained in [Hutt, 1976a].

To obtain a reliable eye pattern display, a test signal made up of a pseudo-random sequence of sufficient length (at least $2^8 - 1$ bits) is required. Furthermore, most or possibly all of the available bit cells should be included in the display. When such a test signal is not available, it may be acceptable to derive the eye pattern from the normal data signal.

The signal called "data pulse and bar" may be used to obtain an eye-shaped diagram by superimposition of the positive and negative data pulse. This simplified diagram provides an outer limit for the inner boundary of the eye. It is clear, in fact, that the eye formed by all sequences is always smaller than that formed by two isolated pulses.

Eye patterns are usually displayed on the screen of an oscilloscope, but methods have also been devised to have them displayed on a picture monitor [Croll, 1977] or have them recorded on paper by means of an X-Y plotter. For measurement at the reception site, a recently developed digital version of the method is described in [Vernhet and Frossard, 1985]; it uses "sliding" sampling of the data pulse (sampling frequency/bit frequency = $83/128$). The result is displayed on a television receiver by means of a graphic processor. The display is synchronized by juxtaposing the characteristic instants calculated statistically for each packet. The advantage of this synchronization method is that the display is independent of a clock synchronization system and is close to the reference eye.

Eye patterns may be classified following two different criteria. The first distinction is between "linear" and "Lissajous" eye patterns. The former are obtained with a linear time-base, the latter with a sinusoidal time-base at half the clock frequency. This second type of display has been introduced mainly to overcome practical difficulties due to the limited bandwidth of oscilloscope X inputs. It has a symmetrical shape and provides a simple read-out of the eye height, which in this display coincides with the maximum aperture of the eye [CCIR, 1978-82c].

The second distinction is between "reference" and "receiver" eye pattern. The first is obtained with an "ideal" clock, i.e. a clock free of jitter and correctly phased. This is the data reference clock, which may be available during laboratory tests [Croll, 1977]. Alternatively a reference signal at half the clock frequency may be inserted in the line preceding the data line; this signal, delayed by 1 line, may be used to generate the time-base for the display.

The "Receiver" eye pattern is generated using, as a time-base, a signal obtained from the clock regenerated in the data receiver. While "reference" eye patterns provide an indication of the quality of the data channel, irrespective of the particular receiver used, the other type of display gives also an indication of the performance of the receiver.

Methods for the display of the various types of eye patterns are described in [Croll, 1977; Chambers, 1976; Holder, 1977; Hutt and Dean, 1978; CCIR, 1978-82d]. In the case of purely linear distortion, it is possible to theoretically compute the eye pattern from the $1T$ pulse, or, preferably, from the data pulse waveform [Lucas, 1976; Croll and Wright, 1976]. However, the procedure to do this is time-consuming and the results often inaccurate.

When a complete eye pattern display is not required, but only an approximate evaluation of the eye height is desired, this may be obtained by direct inspection of the data waveform [Holder, 1977; Hutt, 1976b]. The method assumes that the eye height is given by the difference between the lowest positive and the highest negative cusps of the data signal. This may not be true in the presence of noticeable quadrature or phase distortion.

An improvement of the direct inspection method is as follows. When the bit rate of the data signal is integrally related to line frequency, a clock signal may be derived from the line frequency and used to trigger Gaussian-shaped constant amplitude pulses with a half-amplitude duration of approximately 20 ns. These pulses, after phase adjustment, are added to the data signal, so that all the sampling points in the data signal are raised by a fixed quantity and can be clearly identified. With this method [Holder, 1977], a greater accuracy in the measurement of the eye height is obtained, but a more complicated instrumentation is required.

4. **Data test signals**

In § 2 and 3, various data test signals have been mentioned. These are summarized here for convenience:

Pseudo-random sequences: These are used for the measurement of bit error-ratio and packet loss-ratio and for the display of eye pattern [Dublet, 1977; Noirel, 1978].

Fixed data sequences: These are used for various purposes. An example is the sequence used in [Cominetti *et al.*, 1976] for the measurement of various types of error ratios and loss ratios. Another example is the "clock cracker sequence". This is a data line containing a character sequence including as frequently as possible the maximum distance between transitions. It is used to test the clock recovery circuit in the data receiver and to measure data levels [Croll, 1977; CCIR, 1978-82e and f].

Data pulse and bar: This signal is made up of an isolated data positive pulse, followed by a data bar (sequence of 1's), containing an isolated data negative pulse. It is used to obtain an eye-shaped diagram by superimposition of the two pulses, to measure data levels, and to analytically derive the eye pattern, in the presence of purely linear distortion [Croll, 1977].

Combined test sequence: A combination of clock run-in, data pulse and bar and a fixed data-sequence including all combinations of 7 successive bits, to provide a test half-line for inclusion in the field-blanking interval, complemented on alternate fields, has been illustrated [Holder, 1977].

5. Measuring equipment

Instruments for the automatic measurement of the decoding margin (parameter 9 of Appendix I) has been developed in the UK [Holder, 1977; Dean and Hutt, 1980].

Another equipment, also developed in the UK, displays the number of character parity errors produced by a slicing level which varies between the all-zeros and all-ones levels [Sherry, 1976].

Other instruments employing different measurement techniques have been developed [CCIR, 1978-82d]. An equipment developed in Italy [Cominetti *et al.*, 1983; CCIR 1982-86] has the capability of carrying out the basic teletext measurements using a pseudo-random data sequence or conventional teletext signals.

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[1982-86]: 11/98 (Italy).

APPENDIX I TO PART I

PROPOSED DATA SIGNAL PARAMETERS – CONCEPTUAL DEFINITIONS

1. *All-zeros level*: the level resulting from a continuous stream of “zero” pulses.
2. *All-ones level*: the level resulting from a continuous stream of “one” pulses.
3. *Mid-level*: the level midway between all-zeros and all-ones levels.
4. *Basic amplitude*: the difference between the all-zeros and the all-ones levels.
5. *Zeros overshoots*: the amount by which the peak value of the signal extends beyond the all-zeros level.
6. *Ones overshoots*: the amount by which the peak value of the signal extends beyond the all-ones level.
7. *Peak-to-peak amplitude*: the sum of basic amplitude, zeros overshoots and ones overshoots.
8. *Eye height*: in a noise-free data signal, the eye height reflects the smallest difference which may exist between any “zero” pulse and any “one” pulse over all signal sampling positions. It is expressed as a proportion of the basic amplitude. (In practice, the sampling positions depend on the type of clock used, which must be specified).
9. *Decoding margin*: in a non-return-to zero (NRZ) data signal the decoding margin reflects the greatest difference which may exist between extreme logical decision levels for a given bit error-rate, when the signal samples are referred to the run-in timing and equally spaced at the data rate. It is expressed as a proportion of a specified basic amplitude.
10. *Eye width*: in a noise-free data signal, the eye width is the interval over which true data results from comparison of the signal with a specified decision level. It is expressed as a proportion of the bit period.
11. *Proportional jitter*: in a noise-free data signal, the proportional jitter at a particular decision level is the proportion of the bit period not occupied by the eye width.
12. *Decoding threshold*: this term relates to a terminal which accepts an input data signal and which provides output characters primarily intended for display. For a given degradation of a particular input signal, the decoding threshold is the smallest acceptable decoding margin of the input signal, for a defined character failure ratio.

PART II

ASSESSMENT OF TELETEXT SERVICE QUALITY

1. Introduction

For a teletext service, the picture quality is as important a parameter as for television. It should be emphasized however, that the evaluation methods and criteria described in Recommendation 500, “Method for the subjective assessment of the quality of television pictures” do not cover all aspects of the teletext picture quality assessment. Relevant material on the subjective quality of alphanumeric and graphics pictures is also found in Annex VI to Report 405 [CCIR, 1978-82a].

Hitherto the influence of errors (appearing in the teletext transmission process) on picture quality has been the aspect of main interest, in this document provisionally called the “conformity” aspect. It might be expected that a global assessment will gain in importance as teletext services become established. Such a global assessment would also include the usefulness of the typographic facilities of the system and the display performance of the receiver and would be based on the properties of the human eye and mind. The effect of these principles on characters generated by systems other than the dot matrix system requires further study.

The following text discusses in a tutorial manner the various technical factors which have an influence on the picture quality. Information access, which is an important quality aspect of a teletext service, is discussed briefly. It is based on studies carried out within the EBU [CCIR, 1978-82b].

In [CCETT, 1981] a wider choice of criteria is proposed and the complementation of objective measurements by subjective assessments is suggested.

2. Picture quality characteristics

One tentative list of picture characteristics is:

- the typographic facilities provided by the system;
- the display quality provided by the display device;
- the “conformity” of the picture as received and displayed by the receiver, related to the picture that would be displayed by the same receiver if there were no errors in the received bit stream (i.e. there are no bit errors after the data acquisition process).

This classification could be appropriate when the technical causes for a quality defect or the limits for the attainable quality are to be analyzed.

The characteristics may be difficult to separate but “typographical facilities” is intended to reflect such items as: character sets, pictorial facilities, display attributes and page layout functions given in the system specification. “Display quality” is intended to reflect the influence of the picture generating and display circuits and the picture tube of the receiver, while the “conformity” is intended to reflect the influence of the transmission, error protection and coding/decoding processes.

Another classification of picture quality parameters could be appropriate when a global assessment of the picture quality is made through viewer tests and when there is no direct interest in separating the causes of the defects. Then such properties as legibility, reading speed and visual comfort could be appropriate. This type of assessment is described in [CCIR, 1978-82a, c].

2.1 *Typographical facilities provided by the system*

A teletext specification normally specifies in a detailed way which facilities are available to form the message to be conveyed. Some important facilities are:

- the character repertoire;
- the display format, i.e. the number of rows available on a page and the maximum number of characters per row;
- the display modes, e.g. normal, boxed or mixed display;
- the display attributes, e.g. background colour, character size and flashing display, and the way they can be used.

For systems using geometrical or photographic coding principles, additional characteristics of importance can be defined.

It should be observed that a service might not utilize all available facilities. Also, receivers might be in use which cannot fully exploit all facilities in the transmitted messages. These receivers should fall back on an appropriate substitution facility or the editor should provide a substitution.

2.2 *The dependence of the picture quality on the properties of the display device*

2.2.1 *General*

Some technical parameters such as character size, luminance levels, resolution, etc., could be measured by appropriate instruments at the face of the picture tube.

With the help of human observers, performance measurements could be made, based on psychophysical methods, which measure such aspects as recognition of representative stimuli and reading speed. Such measurements are absolute in the sense that the performance is not compared with the performance of a reference display device, but the method can be used in comparisons of display devices. Appropriate test pages should be used and the viewing conditions kept under control.

Teletext may sometimes be viewed under different conditions from television. The picture is also of a different nature, and the viewing conditions specified in Recommendation 500 might have to be revised when applied to teletext [CCIR, 1978-82a, c]. This concerns both ambient conditions such as viewing distance and room illumination and conditions of the display device itself, such as the luminance of the active and inactive parts of the screen.

2.2.2 *Technical factors of importance*

With the display formats defined in Europe (24 or 25 rows per page and 40 characters per row), it is possible to reproduce most of the alphanumeric characters with a satisfactory resolution, so that they can be easily identified by the viewer. However, some difficulties arise for some upper-case accented letters and special symbols. Further study is required in order to find the best way of representing these

characters taking into account the constraints due to the number of television lines per field (vertical resolution), the bandwidth of the video amplifiers in the television receiver (horizontal resolution) and the characteristics of the picture tube.

Apart from the factors mentioned above, the quality of the display also is influenced by other factors, some of which are mentioned below:

- resolution of the character matrix and its font;
- stability of the teletext display when a noisy television signal is received;
- use of internally generated non-interlaced scanning to eliminate flicker on the teletext display;
- use of a character rounding technique in order to improve the character shape. (This technique, however, can be implemented only with conventional television scanning or by means of special receivers, e.g. those conceived for compatible but higher quality type of television display without interlace flicker);
- use of multi-level RGB signals in character representation;
- variable character spacing.

Some indications of the influence of the display circuit characteristics and/or current colour picture tubes for consumer application on the picture quality are given in a theoretical study [CCIR, 1982-86a]. This study concludes that assuming 40 characters with 2-level dot matrix character generation, the upper limit of the horizontal dimension of the character matrix is 12 pels for the case of a 26-inch colour picture tube having 500 useful pels per television line and 8 pels for the case of a 14-inch colour picture tube having 340 useful pels per television line.

Further study would be desirable within an appropriate international body to find the best compromise between cost and performance of the display device. Work is in progress to define the relationship between the various parameters of the character cells and the extent to which the corresponding texts are acceptable. A theoretical study made at the CCETT [Sallio and Morin, 1983] showed that for characters having a fixed definition of 8 pels by 10 television lines, margins are needed for a visual optimum which lead to a 9×14 fixed matrix; for a variable character definition of horizontal resolution size (M pels) by 10 television lines, the optimum, including margins is a $(M + 2) \times 14$ matrix. This optimum only provides 18 rows of text instead of 25 rows, for 625-line non-interlaced display systems.

Studies of the readability of textual screens in terms of colour contrasts on alpha-mosaic standard videotex screens (use of eight colours) have made it possible to differentiate between these screens according to the criteria of objective performance, subjective performance and the projective value of a colour combination [Sallio, 1983]. The measurements obtained show that readability in terms of colour contrasts seems to be difficult to evaluate, since it depends on several variables; the respective importance of the variables discerned varies from one colour contrast to another and a number of autonomous and dependent relations have been observed. The main results obtained may be summarized as follows:

- “physical” readability often seems to be linked with dark/light or light/dark contrasts;
- the use of colour in videography is justified only to the extent to which the colour combinations used will enhance the type of message to be given (informative or projective).

2.3 *Conformity of the picture*

2.3.1 *Classification of conformity defects*

Transmission errors cause various forms of conformity defects. As mentioned at the beginning of § 2 and as is described in more detail in § 2.3.2 and its sub-paragraphs, the nature of the defects and their frequencies of occurrence depend on several factors.

The relative severity of the defects depends in a complicated way on the content of the page, e.g. text or pictorial material, and its composition. An exhaustive study is therefore difficult. An attempt to list the various defects that are of interest for pages containing text gives the following result:

Layout defects:

- page loss,
- page interference,
- incomplete page,
- row loss,
- row interference,
- incomplete row,
- displaced row,
- displaced string of characters.

Display defects:

- incorrect character display (false or blank character),
- display of error symbols,
- incorrect display attributes*.

For mosaic pictures, it would be appropriate to describe the conformity defects in other terms. Alpha-geometric and alpha-photographic coded pictures would require a further set of terms.

For pages with text and where there is some redundancy, i.e. where the message could be understood even if some isolated characters (letters) were missing or incorrect, layout defects are the most serious because they may lead to the loss of many contiguous characters. For pages where there is no redundancy in the message, for example when a page contains a table giving numerical values, incorrect character display is a very serious form of defect.

2.3.2 *Factors influencing conformity*

Distortion of the signal waveform during the transmission process and interference from other sources result in bit errors in the output from the data acquisition circuits in the receiver. The error characteristics are a measure of the data channel quality. Lack of data channel quality causes conformity impairment, but the grade of impairment also depends on the transmission format, coding scheme and the error control provisions, both at the transmitting and receiving end.

2.3.2.1 *Data channel quality*

The quality of the digital data channel is usually expressed through its average data block loss ratio and the average error ratio of the bits in the received blocks. Measurement and specification of the quality are described in Part I of this Report and in Document [CCIR, 1978-82d].

Experience shows [IRT, 1980] that errors may depend on the bit-patterns within the data block. Average bit error and data block loss ratios do not therefore always permit an accurate deduction of the performance of a receiver which is connected to the channel. The errors obtained also depend on the design of the data acquisition circuits, and therefore the performance assessed with one type of receiver or measuring instrument will not always predict the performance of another type. [IRT, 1980 and RAI, 1979] show that the relative merits of different designs depend on the type of waveform distortion prevailing.

These characteristics of the data channel, due to the data acquisition circuits of the receiver and preceding receiver circuits, have to be taken into account when test pages for conformity assessment are designed (see § 2.3.3.2).

2.3.2.2 *Transmission format and coding schemes*

Two basic transmission format principles are being used at present.

The fixed-format principle has a predefined relationship between the transmission format (i.e. the positions of the character codes on a television data line), a location in the page memory in the decoder, and for level 1 decoding, the display format (i.e. the position of the corresponding characters in the text rows). For fixed-format systems with "level 2 decoding", when the information complexity requires it, information supplementary to the "level 1" version of the page is transmitted with packet addresses corresponding to rows that are not displayed ("ghost rows"). The fixed-format principle is maintained since the addresses for the supplementary information and the associated character data are related to the transmission format.

In variable-format systems, the information is represented by a unique data stream, significant in itself (i.e. whether a code is "spacing" or "non-spacing" is defined by the codes themselves), and where separation between rows is given by a particular code (sequence). A variable-format system allows the transmitted information to be compressed.

Present teletext systems and proposed variants use a 7-bit code to describe the alphanumeric set. Mosaic and supplementary alphanumeric sets are obtained through videotex code extension techniques in variable-format systems. In fixed-format systems, special but related techniques are used, some of which are mentioned above.

Variable-format systems are sometimes regarded as more sensitive to layout defects than fixed-format systems, which rely on synchronization imparted by the television synchronization signals. However both fixed- and variable-format methods allow for the introduction of specific means for error correction through redundancy, obviously at some cost in transmission efficiency.

* Some incorrect character size attributes might cause layout defects.

Experience with transmission of the fixed-format system operating at "level 2" has been gained and an analysis has shown that no loss of ruggedness occurs in comparison with operation at "level 1" [CCIR, 1978-82e].

Experience has been gained with a fixed format system for text, including ideographic characters, using photographic coding. Field and laboratory tests of a second generation system employing alpha-DRCS-photographic coding found little difference between fixed and variable transmission formats. The variable format was adopted because of its flexibility [CCIR, 1982-86b].

2.3.2.3 *Error protection provisions*

2.3.2.3.1 *Some protection methods*

Error protection can be obtained by adding error control information to the transmitted information and then utilizing this in the receiver. Some error protection measures that are used or are being discussed are:

- addition of a parity bit to each display and control character. Detected parity errors normally cause a display character to be represented by a space and a control function not to be performed. Alternatively a special error symbol could be displayed.
- use of particularly effective error protection for data in which errors could cause severe defects, especially layout defects. One example is (8/4) Hamming coding for such layout functions as page- and row-numbers; this allows single bit errors to be corrected. Another example is the use in variable-format systems of redundant control character sequences for layout, display attribute and code extension functions. These sequences may be processed in the decoder by using algorithms which reduce the risk of missing the control function and/or accepting a false one;
- addition to the transmitted message of a means to provide a cyclic redundancy check of the entire page content. This could be used to give the viewer an automatic indication of the conformity of the displayed page. This check can also be made by adding together individual checks on every packet used to transmit one page. For a receiver with a multiple page store it could be of great value for controlling the loading of pages so that the corruption of a stored correct page by errors in later acquisitions is avoided;
- addition of a means of forward error-correction which permits data to be corrected before they are decoded. It is very effective to organize a data packet as an error correcting code. One example of this is the use of a majority-logic-decodable (272, 190) shortened difference set cyclic code [CCIR, 1982-86c] which can correct any errors up to 8 bits, either random or burst in a data packet of 272 bits.

2.3.2.3.2 *Protection levels*

The error protection provisions at the transmitting end can be adapted to the typical reception conditions of the geographical area served by the transmitter. Adaptions can also be made to any special conformity requirements of a particular page.

Particularly for variable-format systems, the concept of "protection levels" has been introduced. Level "0" could be the use of no redundant control codes at all, i.e. the same as in videotex, level "1" could be the use of redundancy where errors could cause severe layout defects, while level "2" could add redundancy to all display attribute codes. This possibility exists, for example, in the systems described in Annex II, § 3.2.1 and 3.2.2.

The level of protection should be indicated in the message in order to control the error correction facilities in the receiver.

Experience indicates that some protection in the transmitted message through redundancy may become necessary when the bit error ratio of the data channel rises to 10^{-4} .

2.3.2.3.3 *Decoding algorithms*

The logic rules for decoding the redundant code sequences have to be chosen with respect to the types of sequences and their relative frequency of occurrence, which to some extent is dependent on the language, the content of the page (e.g. text or pictorial elements), and the relative severity of the defects. The efficiency of an algorithm depends both on the size of the read-only memory (ROM) available and the redundancy in the message. To some degree, the ROM size and the redundancy are interchangeable, i.e. the transmission efficiency could be increased through increasing the algorithm complexity.

Some studies of redundant code sequences and possible algorithms have been made [CCETT, 1980], but further study is necessary.

2.3.3 *Assessment of conformity*

2.3.3.1 *Computer simulation*

The conformity under given conditions can be investigated through simulation methods. Thus, for a specified system, a statistical measure of the conformity could be calculated in the form of the relative probabilities of occurrence of the various defects by taking account of the error protection, data channel and page characteristics.

Simulation should be an efficient method both for optimizing the error protection provisions of a system or receiver and for assessing the conformity that would be obtained under given conditions.

As stated in § 2.3.2.1, experience indicates that the data channel quality might be difficult to specify in the form required by the simulation model.

2.3.3.2 *Test pages for conformity assessment*

Test pages could be used when simulation is not possible or when the representativeness of a simulation is to be checked. In addition to the representative pages that are needed in the latter case, the following two types of page could be of use:

2.3.3.2.1 *Test pages for assessing the quality of the data channel*

The quality should normally be measured by methods described in part I of this Report. When no special measuring instruments and signals are available, a rough assessment of the bit-error ratio can be made by observing a test page. The content of this page should be such that there is little risk of layout and display attribute defects occurring. This would mean that the page should comprise only characters of the GO set. For variable-format systems, some care might have to be taken to avoid codes and code sequences which a particular algorithm could decode as a control function when bit errors occur. Alternatively, the algorithm should not be used during the assessment.

The composition of the page should be such that errors are easily observed.

It could be of value to include those character sequences which are expected to be the most critical with respect to the characteristics of data acquisition circuits in use and the types of signal distortion encountered. Such a page could be said to be critical with respect to the distortion of the data signal waveform.

2.3.3.2.2 *Test pages for assessing the service quality in field trials*

A page of this type makes it possible to assess the influence of the data channel quality on the conformity of the displayed page. It should be composed so as to be more critical than a normal page with respect to layout and display attribute defects. Its actual content would depend on the system used and its typical error correction provisions. It would contain accented characters, mosaics, display attributes and layout functions to a great extent. More than one page might be needed to cover all critical points.

It might be difficult to define common test pages for different systems. Care has to be taken in the composition of the pages so that they test any combinations of decoder design principles, type of signal distortion and bit patterns that are particularly critical.

2.3.3.3 *Test pages for other purposes*

When a global assessment of the picture quality is to be made, the typographical facilities of the system and the quality provided by the display device have to be taken into account in addition to conformity aspects. The pages used should be representative for the service, or, for some types of assessment, critical with respect to legibility and visual comfort.

The teletext viewer would require means for verifying the correct function of his receiving installation. Test pages of the types described in § 2.3.3.2 could be used for this. Probably more than one page would be required to test all typographical facilities in the receiver.

There is also a need for appropriate test pages in industry and for maintenance purposes.

2.3.3.4 *Automatic methods*

It appears to be relatively simple to check the quality of reception, i.e. the data channel quality, by automatic methods. These could be based on the character parity check, a page check sum or on the regular transmission of a pseudo random bit sequence or other special signal. If the detection of the errors could be made at the display language level instead of at the transmission language level, a check of the conformity is obtained.

As the observation of test pages is a demanding task, automatic methods could be of great value both for the teletext service public and in technical studies.

2.3.3.5 *Conformity grades and assessment criteria*

Repetitive transmission is normally used and advantage is normally taken of this to provide error protection in the receivers. The assessment criteria that have been used hitherto and those that are proposed below therefore assume this. The criteria thus indicate that conformity could be a function of the access time.

When conformity is assessed with a test page of the second type in § 2.3.3.2, four grades of conformity with associated criteria are proposed:

Grade 4: there are no defects after the first acquisition of the page.

Grade 3: there are defects after the first acquisition of the page, but they disappear at the second acquisition.

Grade 2: there are defects after the first acquisition of the page, but they disappear after more than two acquisitions.

Grade 1: defects remain after successive acquisitions of the page.

The reliability of the assessment will depend on the number of "first acquisitions", i.e. samples, which are made. The grade obtained for a majority of samples should be stated. For grade 3, a larger number of samples appears necessary for a reliable assessment than for other grades.

Grade 4 could be said to reflect a conformity that would be regarded by the viewer as "normally perfect" or better. Grade 3 corresponds to a situation where correct display is obtained at the expense of an increased access time which could be accepted by some viewers. Grade 2 would provide a correct display after a normally unacceptably long access time, which, however, could be accepted in some applications of multiple-page memory decoders. Grade 1 differs from grade 2 in that the displayed page does not converge to a correct display.

The criteria are not based upon any graded scale of conformity impairments. They only very indirectly relate to the grade of conformity for the first acquired page by stating the number of repeated acquisitions that are necessary for the impairments to disappear.

Other criteria e.g. [BBC, IBA, IRT, 1975] have been used in field trials. They are:

Criterion A: no errors received in 10 s for entire data stream.

Criterion B: no visible errors in each of three consecutive new acquisitions of one page.

Criterion C: no visible errors remaining on the second writing of one page.

In general, satisfaction of these criteria will depend upon the coding strategy and will therefore correspond to different bit-error ratios for different teletext systems. It is desirable to establish the relationship between quality evaluation criteria such as B and C, and the bit-error ratio. Assumptions regarding the performance of the teletext decoder will then permit the establishment of acceptance limits for parameters such as eye height which allow the performance of the transmission path to be related to the bit-error ratio. Such a relationship has been studied in [Lucas, 1976].

3. **Information access aspects**

The amount of information that is available in a teletext service and the access time for a selected page are important aspects. A basic measure is the mean access time which is half the product of the number of pages in the transmission cycle and the mean page transmission time. To find the mean access time for a particular system, a representative set of pages for the service must be used as the basis for calculation of the mean page transmission time. Studies have been conducted [CCETT, 1982] on the assessment of the inconvenience caused by delay occurring between the user's request and the display of the requested information in the specific context of broadcast videography. First results, subject to confirmation, show that an access time of about 12 s corresponds to "slightly annoying". Moreover, the results obtained prove to be dependent on the semantic contents of the screens.

Other studies [Treurniet *et al.*, 1985] examined the relation between system response time and various degrees of viewer annoyance. The proportion of viewers "slightly annoyed" or worse (A_s) increased with the square root of observed delay:

$$A_s = 0.129 \cdot \sqrt{d} + 0.030$$

Corresponding equations for the proportion of viewers "moderately annoyed" or worse (A_m) and "very annoyed" or worse (A_v) were respectively:

$$A_m = 0.059 \cdot \sqrt{d} - 0.008 \text{ and}$$

$$A_v = 0.020 \cdot \sqrt{d} - 0.030$$

Multipages and other special page repetition patterns as well as use of multiple-page memories, make it more difficult to characterize the access time performance. Another factor is the relation between conformity and access time, as mentioned in § 2.3.3.5, which would mean that for a site with bad reception conditions, the access time would be longer than for a "good" site within the same transmitter service area.

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PART III *

RESULTS OF FIELD TRIALS AND THEORETICAL STUDIES

1. Introduction

Since 1977, the CCIR has been informed of numerous field trials and theoretical studies undertaken on the various characteristics of data broadcasting [CCIR, 1978-82a, b, c, d, e, f, g, h, i and j]. More than fifty such documents have been reported, covering the effects of virtually all elements in the transmission path, from the data pulse generator to the display, that might significantly affect the probability of satisfactory data reception. This section consists in general of a synthesis of the conclusions given in those documents, arranged in such a way that their implications may be appreciated easily. Attention has been concentrated on the results relevant to the teletext systems developed in the United Kingdom and France [CCIR, 1978-82j], although some information on Canadian and Japanese developed systems is included also. In order to facilitate reference to the numerous documents, this synthesis has been subdivided into sections corresponding to the different stages in the transmission path: the data pulse generator, the main transmitter, the rebroadcast transmitter, propagation and the receiving antenna system, and the receiver itself. Miscellaneous and general studies, and including those of transmission by satellite, are considered separately. Where full references are not given, the original documents on which this section is based are internal reports of the organizations that supplied them. Copies of these reports can be made available on request by the organizations concerned. Brief details of each of these internal reports, and of certain other studies are presented in Table I.

* It is intended that this survey of field trials and theoretical studies will not appear in future editions of the CCIR Volumes.

TABLE I — *Brief details of studies on characteristics of data broadcasting*

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
(1)	BBC April 1977	UK teletext	B, G	% cosine roll-off, multi-path interference, IF response, demodulator type	Eye height	Recommendation that CEEFAX data signals should have pulse-shape whose spectrum has a 70% cosine roll-off truncated at 5 MHz. Filter details given in Addendum
(2)	UKIBA August 1975 (Revised)	UK teletext	I	Ratio of data signal-to-random noise	Errors in characters, display headers, rows of text, etc.	Probability of at least one undetectable error per page of text with a television S/N ratio of 17 dB
3	UKIBA August 1976	UK teletext	B, G	Receiving locations in Bavaria; NRZ and biphas coding	Eye height, $1T$ pulse response	Graphs showing good correlation of measured eye height with that predicted on the basis of the $1T$ pulse response; computed relationships between the error ratio and S/N ratio for various values of teletext pulse-to-bar ratio; comparison of computed and measured relationships between error ratio and S/N ratio
(4)	UKIBA 1975	UK teletext	I	Transmitter characteristics within existing specifications	Eye height	If transmitter characteristics are evenly distributed within the existing specification, the average transmitted eye height will be 43.7%. However, the actual characteristics and eye height are in fact better
5	UKIBA 1976	UK teletext	I	Principal elements in the transmission chain up to the receiver input, extrapolated from observed values	Eye height	Distribution of eye height at various points in the transmission chain, including consideration of data regeneration and cable distribution systems. 96.8% of potential television audience would get at least 25% eye height with existing transmitting network in UK. Improvement to 98.7% possible by installing data regenerators. Further improvement possible by use of better domestic aerials
6	BBC UKIBA IRT 1976	UK teletext	B	Existing or typical VHF receiving locations in Bavaria; prototype domestic and professional receivers	4 levels of character and bit error probability, eye height	There is no close correspondence between television picture quality and teletext reception quality. Criterion C (no visible error after two receptions of one page) was satisfied with domestic receivers at 88% of locations. The corresponding minimum field strength was 52 dB(μ V/m) (on the basis of average multipath echoes). The transmitted eye height was at least 68%

Note. — The numbers in brackets indicate a theoretical study.

TABLE I (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
(7)	RAI October 1974	Various	B, G	Receiver tuning, demodulation; 2.5 Mbit/s biphase and 5.0 Mbit/s NRZ coding	Data waveform, eye height, error probability	Computation indicates that, under practical operating conditions, it is desirable to use speeds of between 2.5 and 4.5 Mbit/s for NRZ data transmission in the field-blanking period; bit error ratio of 1 in 10^5 can then be achieved with a signal-to-noise ratio of 21 dB. Biphase coding is even more rugged, but involves halving the data-transmission rate
(8)	RAI 1975	Various	B, G	Data signal amplitude, ratio of reflected to direct signal, propagation delay, instantaneous phase difference; 2.5 Mbit/s biphase coding and 5.0 Mbit/s NRZ coding	Data waveform, eye height, error probability	Computation indicates that, for domestic data broadcasting limited by white noise or single-path RF reflections and for envelope demodulation, the preferred data signal amplitude is 0.5 V. Where the reflected signal amplitude is 20% of the direct signal and has the worst-case delay, a bit error ratio of 1 in 10^4 should be obtained with a signal-to-noise ratio of 27 dB for 5 Mbit/s NRZ code and 20.4 dB for 2.5 Mbit/s biphase code
(9)	RAI 1975	Various	B, G	Data signal amplitude, phase distortion; 2.5 Mbit/s biphase coding, and 5.0 Mbit/s NRZ coding	Data waveform, eye height, error probability	Computation indicates that the preferred data amplitude is 0.5 V for envelope demodulation. With three similar television transposers without phase correction in cascade, the signal-to-noise ratio must be 28 dB (an increase of 4.4 dB) to achieve a maximum bit error probability of 1 in 10^5 in the case of 5 Mbit/s NRZ; whereas the same bit error probability is achieved with a signal-to-noise ratio of 19.2 dB (1.3 dB increase) in the case of 2.5 Mbit/s biphase code
(10)	RAI 1977	Various	B, G	Receiver tuning, phase distortion, single-path reflections; 2.5 Mbit/s biphase coding and 5.0 Mbit/s NRZ coding	Data waveform, eye height, error probability	Computation of the relationship between the signal-to-noise ratio and the bit error ratio for synchronous demodulation shows that with 0.7 V data signals the advantage over envelope demodulation with 0.5 V data signals is 3.1 dB for biphase code and 3.8 dB for binary NRZ, in the case of simultaneous presence of phase distortion and single-path reflection; however, if 0.5 V data signals are used, the advantages are only 0.8 dB and 2 dB respectively
(11)	CCETT June 1977	DIDON-ANTIOPE	L	Amplitude, phase and quadrature distortion; receiver tuning, demodulation	Bit error probability (data waveform, eye height and sampling threshold in Annex II)	Computation of the relationships between the bit error and loss ratios and the signal-to-noise ratio for different values of receiver mistuning, group delay and IF bandwidth, in the cases of synchronous and envelope demodulation

TABLE I (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
12	RAI October 1977	UK teletext and others	B, G	Receiving location; 3.47 Mbit/s biphase coding and 6.9 Mbit/s NRZ coding	Bit error probability, character error and character loss probability, some waveforms and eye diagrams	Comparison of biphase and NRZ coding systems at locations in the Piedmont area of Italy, and correlation with picture quality, showed that: – there were no sites fed from the main transmitter where the picture quality was acceptable but 6.9 Mbit/s NRZ data failed – the biphase system had an average 5-6 dB safety margin over NRZ at these sites – at certain sites fed from transposers, the picture quality was acceptable but NRZ data failed; at these sites, the biphase data were never found to fail
13	BBC July 1976	UK teletext	I	Relative level of the sound carrier, amplitude of the data signal; receiver and its tuning	Relationship between the data signal amplitude and the vision-to-sound carrier ratio at the threshold of impairment	Non-linearity in receivers and multipath propagation are the principal factors responsible for interference in the sound channel; receivers should be designed to accept a vision-to-sound carrier ratio of 19 dB without audible impairment due to data transmission
(14)	BBC August 1977	UK teletext	I	Address protection method	Error susceptibility of various methods of address transmission in terms of bit error probability	Hamming code preferable to unprotected transmission or transmission protected by collation
15	PTT/CH July 1977	UK teletext	B, G	Receiving location, transmission chain	Picture quality, scale of character loss or error	Little correlation between picture quality and teletext quality at the same reception point. Using a domestic receiver installed in measuring vehicle, the picture quality was considered to be "good" or better at 60% of locations and "quite good" or better at 92% of locations, whereas the teletext page was fault-free at only 47% of the same locations
16	PTT/CH November 1977	UK teletext	B, G	Receiving location, transmission chain	Picture quality, scale of character loss or error	By means of using a better receiver than in the first series of tests, fault-free pages of teletext were received at 70% of the locations tested in the first series. When other sites were included, the pages were fault-free on first acquisition at 65% of sites and at 75% of sites on second acquisition

TABLE 1 (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
17	PTT/CH RAI December 1977	UK teletext, etc.	B, G	Receiving location, transmission chain, possible use of cable distribution; 3.47 Mbit/s biphase coding or 6.9 Mbit/s NRZ coding	Picture quality, bit error ratio, character loss or error, video signal-to-noise ratio, eye height distribution, etc.	Properly designed and maintained cable distribution systems do not appear to introduce much signal degradation, although some loss of video signal-to-noise ratio occurs at peripheral sites. Short reflections and attenuation of the higher video frequencies may cause severe impairment to data reception. The advantage of biphase coding over NRZ coding in noise margin is between 2 and 13 dB for a character error probability of 2.3×10^{-2}
18	ITCA 1976	UK teletext	I	Receiving location (46 existing installations only)	Eye height, picture quality, etc.	There is little correlation between eye height and television picture characteristics. The probability of satisfactory domestic UK teletext reception on all three programmes in the London area is 89%, and 94% on at least one programme
19	UKIBA 1977	UK teletext	I	Receiving location (58 existing installations only); main and rebroadcast transmissions	Eye height, picture quality, etc.	The probability of satisfactory domestic UK teletext reception on at least one programme is between 92 and 95% in the area studied. The television picture quality was at least "rather poor" at 96% of sites. The eye height is loosely correlated with the <i>K</i> -rating of the 2 <i>T</i> pulse
20	UKIBA 1977	UK teletext	I	Receiving point (using measuring vehicle at random locations in a hilly area)	Eye height, character error rate, field strength, picture quality, etc.	The UHF teletext service is limited principally by the field-strength. Substantial improvement in domestic reception may be obtained by using better aerials. A character error ratio of less than 8.3×10^{-3} was obtained on all three programme services at 98% of locations in one area and 94% of locations in another area
21	CCETT December 1977	DIDON-ANTIOPE	L, M	Intelsat satellite (Atlantic and Indian Ocean); 6.2 and 4.3 Mbit/s	Bit error ratio, data loss rate, number of disturbances per hour, using pseudorandom signal	Bit error ratio of 2×10^{-7} and 3×10^{-5} were obtained for a loop via the Atlantic Intelsat satellite at 4.3 Mbit/s and 6.2 Mbit/s respectively. The character loss rate was 1 in 10^4 in both cases
22	CCETT January 1978	DIDON-ANTIOPE	L	Reception points chosen at random in a mountainous region, programme service, receivers, decoders	Bit error ratio, data loss rate using pseudo-random sequences, picture quality	In a mountainous area, the service area for teletext is not closely correlated with that for television pictures. The error ratio varies significantly from one programme service to another, a bit error ratio of at most 1 in 10^5 was obtained at 81% of receiving points

TABLE I (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
23	ITCA February 1978	UK teletext	I	Reception points on UHF, VHF and HF cable distribution systems	Eye height	Where correctly designed and maintained, cable distribution systems do not significantly impair data signals. Installation of a data regenerator at the head-end could improve the eye height of the distributed signal. Both VHF-UHF and HF-UHF converters may introduce distortion, especially the latter
(24)	CCETT July 1977	DIDON-ANTIOPE	L	Modulation characteristics in transmission of a television signal containing data by direct broadcasting satellite	Bit error ratio as a function of the C/N ratio for a deviation of 4 MHz/V	The frequency deviation has little influence on the bit error ratio. The interference level of 30 dB adopted by the World Administrative Radio Conference has no influence on the bit error ratio. An allowance of 1 dB should be made for asymmetry and energy dispersion, etc. The bit error ratio is then 1 in 10^4 for a C/N ratio of 10.5 dB and 1 in 10^6 for C/N of 12.7 dB
25	BBC March 1978	UK teletext	I	Use of a transverse equaliser to modify the pulse waveform	Eye height	It is possible to obtain significant improvement in the transmitted eye height by precorrection of the data signal (from 21% to 66% in the case of a deliberately misaligned transmitter)
26	IRT April 1978	Not relevant	B, G	245 domestic and monitor receivers of different makes and ages; data transmission line in the field blanking	Visible interference in the picture	It appears that few domestic receivers manufactured since 1973 and picture monitors manufactured since 1976 are affected by signals in lines 6/319 onwards. None built since 1973 are affected by signals in lines 12/325 onwards
27	IRT May 1978	UK teletext	B	Receiving location	Photographs of vertical-interval test line, 2T pulse, data line	Analysis showing the reasons for failure to receive teletext satisfactorily in 24 cases, observed in the field tests described in [Chambers <i>et al.</i> , 1975]
28	CCETT July 1978	DIDON	L	Receiving location	Bit error ratio, as a function of the field strength, short and long echoes, use of collective aerials	Likelihood of impairment due to echoes (23%) and low field strength (4%) in an urban area
29	CCETT July 1978	DIDON	L	Reception points, transmission network	Bit error ratio, bit loss rate	In a mountainous region, the total coverage of the data service is numerically similar to that of television (85%) for a bit error ratio of 1 in 10^4 . The principal cause of impairment is phase distortion due to both the transmission network and reflections (echoes). The picture quality and data quality at particular receiving points are not closely correlated

TABLE 1 (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
(30)	CCETT April 1978	DIDON	L, G	Bit frequency; envelope detection or synchronous demodulation	Bit error ratio	Theoretical analysis indicates that a bit rate of 6.2 Mbit/s provides a good compromise between data rate and robustness, in both system L and system G
(31)	CCETT 1977	DIDON	L	Transmitter characteristics, receiver characteristics, echoes, signal-to-noise ratio	Bit error ratio	Theoretical analysis shows that the group delay characteristic of the overall transmission path (including the receiver) is of considerable importance. Numerous graphs and tables showing the relationship between the transmission characteristics and the bit error ratio, etc.
32	PTT/CH August 1978	DIDON	B, G	4.3, 6.2 and 6.9 Mbit/s; ratio of echo to direct signal, echo delay, phase envelope or quasi-synchronous detection	Characteristics of echo for a bit error ratio of 1 in 10^4	The impairment due to echoes depends on both the phase and delay, as well as the receiver design and the bit rate. There is no significant difference between positive and negative echoes
(33)	RAI April 1978	Various	B, G	3.47, 5.0, 6.9 Mbit/s NRZ and biphas coding, also all-Hamming coded characters, various types of distortion, sampling instant, etc.	Signal-to-noise ratios corresponding to character loss probabilities of 2.3 in 10^2 and 1.7 in 10^4	The biphas system always produces the best results, but at the price of a reduced data rate. Phase distortion and streaking are most critical for NRZ. The 5 Mbit/s NRZ coding system might be a compromise between ruggedness and data rate
34	Swedish Telecom September 1978	UK teletext	B, G	Receiving installation fed from collective aerial systems: programme service	Eye height, insertion-test signals in 50 homes	Some 86% (VHF) and 83% (UHF) of the television audience using master aerials would be able to receive UK teletext taking an eye height of 25% as criterion, whereas 98% and 94% respectively have satisfactory television picture quality. A good correlation is found between certain insertion test-signal parameters and the measured eye height
35	PTT/CH September 1978	DIDON	B, G	Receiving point, programme service at 16 typical sites; envelope, quasi-synchronous and synchronous detection; 4.3, 6.2 and 6.9 Mbit/s	Distribution of eye height, bit rate and loss rate	There is little difference between the types of detector used, at a bit error ratio of 1 in 10^4 . A reduction in the bit rate from 6.9 to 6.2 Mbit/s (10%) gives an average improvement of 13% in the number of successful reception cases. A reduction to 4.3 Mbit/s (38%) gives an improvement of 26%. Short-delayed echoes are the predominant cause of unsuccessful data reception

TABLE I (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
36	UKIBA October 1978	UK teletext	I	Receiving locations in UK in the service areas of various transmitters	25 000 observations of eye height and picture quality	Group-delay performance of transmitters is important. Rebroadcast transmitters cause less degradation of data performance than relay transmitters (demodulation + remodulation). Synchronous detectors are superior to envelope detectors. At no location examined by a survey vehicle equipped with domestic type aerials was the field-strength adequate for television but teletext unsatisfactory due to echoes. In existing domestic installations, 32% of the cases of teletext failures were due to echoes
37	TEKO (IRT/ARD/ZDF) November 1978	UK teletext	B, G	Receiving location (with measuring vehicle and at existing domestic installations)	Colour picture quality, teletext error ratio	The use of the UK teletext system is a surprisingly good means of providing an auxiliary data signal. With a few exceptions, there is close correspondence between picture quality and fault-free teletext reception. Although the figures for teletext failure are probably pessimistic due to the choice of receiving location, there are certainly places within the colour television service area where teletext is impossible to receive. There are no special problems in modern collective aerial systems, but individual aerials may require adjustment or replacement in a few cases
38	Sweden July 1980	Not relevant	B, G	Group delay precorrection of television transmitters at medium video frequencies	Bit error ratio	On consideration of the lack of standardisation of the group-delay characteristic of receivers it is proposed that the desirability of eliminating precorrection at the transmitter should be studied
39	UK June 1980	UK teletext	I	Reception site, with reception from main and rebroadcasting stations	Eye height; identification of source of teletext reception problems	Review of various studies of the coverage achieved by teletext broadcasting, indicating that at least 94% of existing domestic television receiving installations an eye height of 25% or more is available. The source of problems at 2.4% of sites was insufficient signal strength, that at 1.6% was reflections, and at 1.1% both inadequate signals and reflections

TABLE 1 (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
40	Japan October and November 1979	Japanese teletext	M	Reception site, using a domestic receiver in a vehicle. 84 sites chosen for difficult conditions: echoes, impulsive noise, beat interference. Chains of transmitters and transposers	Subjective evaluation of: – TV picture – teletext display Bit error ratio	Relationship between subjective quality of teletext display and input level, echo amplitude, impulsive noise and beat interference, showing that the teletext was generally less inspired than television pictures; e.g. teletext display was on average grade 4 where television pictures were grade 3. The teletext display was hardly impaired when the bit error ratio was less than 5×10^{-3} confirming choice of Japanese standard
41	RAI November 1978	Not relevant	B, G	Data-transmission line in television field-blanking period; 166 monochrome and 88 colour receivers, from 33 manufacturers	Visible interference in the picture	A survey, in November 1978, of television receivers in use in Italy showed that data broadcasting could not be undertaken in lines earlier than 13/326 in the case of colour receivers and 16/329 in the case of monochrome receivers regardless of the year of manufacture, without visible interference of the television picture
42	UK	UK teletext DIDON-ANTIOPE	I	Use of fixed-format or non-fixed-format teletext system	System reliability data transmission rate, storage capacity required	The choice of synchronous fixed-format transmission for the UK teletext system allows the receiver performance to be relaxed and its complexity reduced compared with some other systems. Ruggedness is achieved without introducing uneconomic redundancy into the coded message, or reduction of the data rate
43	DPS July 1980	UK teletext DIDON-ANTIOPE	G	Measurements were made at the bases of the receiving antennas of different rebroadcast stations. For both systems, UK teletext and DIDON-ANTIOPE, the same clock frequency of 6.9 MHz was used, and the same best pictures were transmitted simultaneously	Differences in decoding margin for three single errors per teletext page occurring on an average	The results of the field trial show that the signals of the line-asynchronous system were received at all measurement points with the same, or somewhat more reliable, quality than those of the line-synchronous system. Though the measurement results were partly affected by the characteristics of the decoders used, it became apparent that the ANTIOPE system used for the measurements was by no means more susceptible to errors than the UK teletext system
(44)	DOC Canada	Broadcast Videotex (TELIDON)	M	Throughput, efficiency, optimal block length for various error ratios	Reduced waiting times for perfectly received pages of information. Improvements of between 10 per page = 10^{-3} and 1000 per page = 10^{-5}	Theoretical studies show overall reduction of error ratios through use of forward error-correcting, double error-detecting product code is used. Trade-offs between decoding failures and decoding errors indicate coding strategies to use in implementing complete or incomplete decoders

TABLE I (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
45	CCETT December 1980	DIDON via OTS	L	Bit frequency (4.2, 4.9, 5.5, 6.2, 6.9 Mbit/s), presence of sound sub-carrier, modulation factor (300 or 700 mV) receiver tuning, signal-to-noise ratio	On RF signal: C/N ratio On video-data signal: – eye diagram – error ratio	The use of data broadcasting in a satellite-broadcasting channel is compatible with the characteristics of the latter. These tests with the OTS satellite have confirmed the possibility of using a high bit frequency. The satellite-broadcasting service will give data broadcasting the advantage of a stable and homogeneous quality within the whole coverage area, unlike terrestrial broadcasting
46	IRT August 1980	UK teletext DIDON-ANTIOPE	B, G	37 critical reception sites in the service area of a main transmitter and the associated relay transmitters	Teletext display (using criterion "C" and fault free reception in two of three single acquisitions); bit error ratio	The comparative field trial with the ANTIOPE and the UK teletext systems led to the following conclusions, taking into account that the different decoder instrumentation with regard to clock recovery and the data acquisition affected to some extent the measurement results: – no significant difference between the two systems with regard to their transmission reliability at all measurement points; – the UK teletext system gives a greater protection for the framing whereas the ANTIOPE system gives a greater protection for the data regarding certain control and display functions
47	RAI June 1979	Various	B, G, I, L	Effects of various impairment and their relationship with the components of a TV transmission chain	Bit error ratio, eye height, correlation-coefficients	No significant inconvenience observed in production centres and distribution networks. Main transmitter linear distortions of the data signal may be reduced by means of transversal equalizer. Group-delay and quadrature distortion in rebroadcast transmitters can be eliminated by data regeneration. Phase distortion of unequalized transposers and short-delayed positive echoes may cause severe impairment on the data signal
48	Japon September 1977	Japanese teletext	M	Inserting lines in field blanking intervals, bit rate (1.79, 2.86, 4.09, 5.73 Mbit/s). Receiving locations, chains of transmitters and transposers	Interference with existing receivers, bit error ratio, eye height	Lines after line 16/279 can be used without interference with existing receivers. An NRZ signal up to 5.73 Mbit/s can be used in the system M if bit error ratio of 1 in 10^3 is allowed
49	Japan 1978	Japanese teletext	M	Chains of transmitters and transposers	Bit error ratio	Correction of group delay distortion in the transposers reduced bit error ratio from 10^{-1} to less than 10^{-3} at the last stage of the chain

TABLE I (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
50	Sweden August 1980	UK teletext	B, G	A number of receivers were subject to signal degradation through the addition of a positive echo at baseband level. The amplitude and delay of the echo were varied	Eye height required for satisfactory reception. The teletext display was used for verification	There is a significant spread in performance between receiver sets. The eye heights required also depend on the echo delay. Generally, eye heights greater than 25% were required.
51	CBS 1979-80	Modified ANTIOPE and modified UK teletext	M	Data bit rates from 3.7 to 6.2 Mbit/s, asynchronous and synchronous systems, field blanking lines 13 through 16, VHF and UHF	Bit error ratio, eye height, field strength and 2T response, subjective evaluation: – television picture – teletext display	Satisfactory teletext reception was achieved with both systems, at all data rates up to approximately 5.8 Mbit/s. No significant difference in error performance was noted between the two systems. Lines 15 and 16, of both fields, appear to be suitable immediately for teletext
52	UK June 1980	UK teletext	I	Echoes and noise added to signal		Methods of measurement compatible with those of the IEC are described and limiting conditions are defined
53	Japan December 1979	Japanese teletext	M	Input signal level of the receiver (Transmission through broadcasting satellite)	Subjective evaluation of the television and teletext. Bit error ratio	When C/N is more than 8 dB bit error ratio is less than 3×10^{-3} and quality of the teletext is better than grade 4. Transmission via a broadcast satellite showed no specific problem
54	Japan September to November 1980	Japanese teletext	M	Reception sites using domestic receivers in vans, 204 sites at random selection and 92 sites chosen for difficult condition of echoes, impulsive noise, beat interference. 33 re-broadcasting stations, 7 cable systems	Subjective evaluation of the television and teletext. Bit error ratio	The service area of the teletext is the same as that of the television broadcast
55	ABC (Australia) February/March 1979	UK teletext	B	Three television transmissions, in Bands I and III; existing domestic reception points	The percentage of receiving locations at which the parity error rate is less than the specified value, for each transmission	There are always significantly more locations at which the parity error rate is less than any specified value in the case of transmissions in Band III than in the case of transmissions in Band I, for error rates corresponding to the criteria adopted in Study No. 6. This is attributed mainly to the presence of short-delay echoes, and it is considered that the most appropriate solution is improvement within the receiver, as this must in any case be replaced when teletext reception is required

TABLE I (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
56	UK 1980	UK teletext	B, G, I	Comparison of error behaviour between decoding level 1 and decoding level 2	Displayed character errors	The ruggedness of the data carried by the packets providing supplementary characters and additional non-spacing attributes is compared with that of the basic level. It is concluded that there is no reduction in ruggedness and that similar integration occurs in the decoder store
57	ABC (Australia) 1981	UK teletext DIDON- ANTIOPE	B	– Broadcasting Band (I or III) – Bit rate in Band I	Bit error ratio	Tests in Sydney have shown that a teletext service on Band I at bit rates of 6.9 and 6.2 Mbit/s could be unacceptable to about 38% of the population. A reduction of the bit rate to 4.9 Mbit/s could increase the coverage by 10%
58	RTVE 1981, 1982	DIDON- ANTIOPE	B, G	Receiving, location. Transmitter distribution network, including satellite transmission. Receivers	Subjective teletext quality, bit error ratio; proportion of locations at which teletext reception is satisfactory. TV lines available for teletext. Television quality, pulse response, field strength, video S/N ratio, error threshold	With the original RTVE transmitter network, teletext reception was satisfactory at only 50% of locations. After re-equipment, teletext coverage increased to approximately the same as television coverage. Reception in industrial areas or via collective antenna systems is least satisfactory
(59)	RAI 1983	Not relevant	B, G	Collective television receiving installations, 6.9 Mbit/s-NRZ coding	Data waveforms, eye height, ITS response	Theoretical results, supported by experimental tests, indicate that teletext reception can be difficult because of imperfect matching between the various parts of the distribution network. Technical suggestions are made in order to improve the existing installations and allow for a better teletext reception
60	Japan September to October 1981	Japanese teletext	M	The number of insertion lines. Receivers	Interference with existing receivers	Line 15/278 to line 21/284 (inclusive) compatible with existing receivers
61	Japan September to October 1982	Japanese teletext	M	29 receiving sites in the areas with impulsive and multipath interference	Effect of error-correction methods	An error-correction method using a majority-logic-decodable (272, 190) cyclic code is most suitable for Japanese teletext utilizing an alpha-DRCS-photographic coding scheme
62	Japan February to March 1982	Japanese teletext by coded transmission	M	Transmission format. Reception sites. 34 sites chosen among locations with severe interference caused by echoes, impulsive noise, 9 re-broadcasting stations	Subjective evaluation of television picture. Bit error ratio. Correct reception rate. Character error rate	Little difference in conformity defects between variable-format and fixed-format

TABLE 1 (continued)

Study No.	Organization/Date	Data system	TV system	Variables	Results observed or calculated	Summary of conclusions
63	IRT 1982	UK teletext DIDON- ANTIOPE	B	- Inserting lines in the field-blanking interval - Addressing facilities of both systems	- Interference of the normal TV reception - Disturbances of the teletext reception	- Lines after line 12/325 can be used without interference with existing TV receivers - Coexistence of the UK teletext and the DIDON-ANTIOPE system in the same TV channel is given without disturbances when the same bit-rate, the same run-in and framing code is chosen if DIDON data channel addresses are chosen among unused combinations of the magazine and row address group of the UK system
64	JRT 1983	UK teletext DIDON- ANTIOPE	B, G	Receiving locations in the service area of various transmitters and transposers, production centre, distribution network, transmitters, collective antenna system, receivers and laboratory measurement	Bit error ratio, decoding margin, visible interference in the picture, assessment of teletext pages, influence of noise and echo and 2T asymmetry	Where teletext reception proved unsatisfactory this was mainly due to echoes in urban and mountainous areas. Receivers manufactured after 1973 were not disturbed by data signals inserted in line 11/324 and subsequent lines. The existing character matrix height led to reading difficulties in reading Yugoslav upper case accented letters with both teletext systems
65	Japan February to March 1982	Japanese teletext by alpha-DRCS-photographic coding scheme	M	28 receiving sites: impulse and multipath interference area	Bit error pattern data. The effects of error correction	Error correction capability by HV parity 8/4 Hamming and 16/11 Hamming codes are not enough for Japanese teletext using alpha-DRCS-photographic coding scheme
66	DOC Canada 1985	Broadcast videotex (TELIDON)	M	Subjective quality and usefulness, requests for retransmission, image content, bit error ratio	No significant reduction in requests for retransmission or proportion of negative quality and usefulness ratings for bit error ratios of 1×10^{-4} or less	Probability of error in data to be displayed should not be greater than 1×10^{-4}
67	DOC Canada 1985	Broadcast videotex (TELIDON)	M	Subjective annoyance ratings, mean system response time	A significant linear relation between the square root of mean system response time and the proportion of ratings that were below a given rating	Some proportion of viewers will be annoyed to some extent with any delay in system response time
68	Japan October 1983 to March 1984	Japanese teletext by alpha-DRCS-photographic coding scheme	M	148 receiving sites subject to various types of impairment; fringe, ghost, impulse. Re-broadcasting and cable network areas	The effect of error correction	According to the correct reception rate defined below, more than 99% can be obtained by the (272, 190) difference-set cyclic code under the subjective television picture grade of 2.5. The correct reception rate = (the number of correct reception pages)/(the number of all transmitted pages)
69	Japan August to November 1984	Japanese teletext by alpha-DRCS-photographic coding scheme	M	256 receiving sites: randomly sampled in the Tokyo and Osaka television service areas	Teletext coverage in conventional television coverage areas	Teletext and television coverage areas are nearly equal

2. The data pulse generator

The influence of the characteristics of the transmitted pulse shape has been considered from both the theoretical and experimental aspects in [Kallaway and Mahadeva, 1977]. On the basis of the use of NRZ coding at 6.9 Mbit/s, for 625/50 systems, a spectrum having 70% cosine roll-off truncated at 5 MHz is proposed. The use of predistortion of this pulse in order to compensate for the characteristics of the transmitter is examined in [BBC, 1978]: the use of a transverse equaliser is considered to be particularly advantageous in the case of transmitters that have marginal performance. Studies undertaken in France using a theoretical model of a data channel [Blineau *et al.*, 1980] have shown the importance of making a judicious choice of the characteristics of the roll-off filters used to shape the data waveform, so as to take account not only of the eye height, but also of its width and the amplitude of overshoots.

3. Production centres

The data signal is normally inserted into the video signal either at the input to the distribution network or at the input of the main transmitters. However, some data signals which are strictly related to a television programme (e.g. sub-titles) may travel inside a production centre.

In this case, troubles may be caused by sync regenerators, which can erase the data lines in the field blanking interval or, if the blanking window is not properly adjusted, can cut the first or last portion of the data signal, unless a data regenerator is employed. Video tape recorders, apart from the troubles caused by sync regenerators, can introduce distortions which, in the case of multiple copies, can even make a data signal unusable.

Errors in teletext pages can also be introduced by in-house monitoring systems (distribution of local signals on VHF in the production centre) due to incorrect pre-correction for receiver group delay [JRT, 1983; CCIR 1982-86a].

No other inconvenience has been observed in production centres [Cominetti and D'Amato, 1979].

4. The distribution network

Little information is available on the impairment caused to a data signal by the distribution network. However, it can be stated that a modern, well-aligned radio link or other parts of the distribution network should not introduce any noticeable impairment. The distortion caused by the distribution network in general or poor performance radio links in particular can be eliminated by the use of data regenerators [Cominetti and D'Amato, 1979].

5. The main transmitter

The effect of the television transmitter is considered in several studies for 625/50 systems, both on its own and as part of the transmission chain. According to [IBA, 1975], the average transmitted eye height for 6.9 Mbit/s NRZ data would be only 44% if system I transmitters had characteristics evenly distributed within the existing specification. The maintenance of transmitter performance solely within normal limits based on television test waveform measurements is thus not sufficient to ensure good data transmission. In practice, performance averages 72% (standard deviation 8%) according to [Sherry, 1978]. In this reference it is also concluded that more attention will have to be paid to group delay performance than had hitherto been considered to be necessary in the television service. A field trial undertaken in Spain [CCIR, 1982-86b] showed that in the case of old main and re-broadcast transmitters, poor signals, due mostly to phase distortion, were obtained. With modern equipment the results were satisfactory.

Theoretical studies and measurements made in France [Blineau *et al.*, 1980; Vardo, 1980] have shown that it was possible and desirable to require transmitters to comply with specifications such that data broadcasting may take place with minimum distortion. A simple means of verifying these specifications is the use of a template for the eye diagram.

In order to reduce the problem of quadrature distortion in the case of negative-modulation television systems, and also the likelihood of interference in the sound channel of receivers using the "Intercarrier" technique, it is therefore proposed in [RAI, 1975a] to use data pulse amplitude of 0.5 V (70% of peak white). It is proposed that studies be undertaken of the extent to which transmitter pre-correction for receiver group delay at medium video frequencies should be standardized [CCIR, 1978-82a].

6. Rebroadcast transmitters and transposers

Rebroadcast transmitters and transposers are generally used to serve areas where propagation is particularly difficult, notably due to topographical features that give rise to reflections and zones of low field strength. They also introduce distortion of the amplitude and phase characteristics of the vision signal and quadrature distortion of envelope if demodulation to video frequency is employed. Numerous studies have therefore been

undertaken to examine the impairment to data broadcasting attributable to their use. For example, tests undertaken in France [Blineau *et al.*, 1980; Blineau and Dublet, 1980] have shown that the difficulties of reception encountered in mountainous areas are in part due to the widespread use of rebroadcast transmitters in those areas.

So far as the 525/60 television system is concerned, tests on a five-stage transposer chain carried out in Japan showed that corrections of group delay distortion in the transposers markedly reduce bit errors due to the distortion [Numaguchi *et al.*, 1979].

For 625/50 negative-modulation systems, among various theoretical studies [RAI, 1975a] shows that in the case of a chain of three transposers and a receiver with envelope detection, the minimum video signal-to-noise ratio must be increased by 4.4 dB to maintain a bit error probability of 1 in 10^5 with 5 Mbit/s NRZ coding. Only a few of the field trials deal specifically with the case of rebroadcast transmitters. In summarizing measurements on chains of transmitters and transposers, Sherry [1978] quotes a reduction of eye height from 72% (standard deviation 8.2%) to 61.6% (standard deviation 12.4%) for two rebroadcast transmitters fed by two main transmitters (10 samples). It also quotes reductions from 72% to 56.8% (standard deviation 7.2%) for one relay transmitter employing envelope detection (10 samples). The reference [Sherry, 1977a] gives details of measurements made at random locations within two hilly areas each served by three co-sited rebroadcast transmitters. A measuring vehicle was used, and with NRZ data at 6.9 Mbit/s, a character error ratio of better than 8.3×10^{-3} was obtained at 94-98% of locations for the first acquisition of the page. However, at certain selected sites fed by transposers in the Piedmont region of Italy, NRZ-coded data at 6.9 Mbit/s was unusable although the picture reception was satisfactory. On the other hand, a 3.47 Mbit/s bi-phase system offered a good performance in the same critical conditions. This is believed to be due to both the particular spectral distribution of the bi-phase signal, and the possibility offered by this system to recover the received characters containing two equal elements (i.e. 00 and 11) in only one bit, making use of the character parity check [Cominetti and D'Amato, 1977].

7. Transmission via satellite

Four studies provide information on broadcast data transmission via satellite:

- a field trial of point-to-point transmission via a telecommunication satellite, showing that no special precautions need to be taken [Blineau *et al.*, 1980];
- a laboratory study of the relationship between the bit error ratio and the received carrier-to-noise ratio (C/N) in the case of direct satellite broadcasting, showing that an allowance of 1 dB on the theoretical value is required in practice for system L [CCIR, 1974-78];
- an extensive field trial of the transmission of full field data broadcasting signals through a satellite broadcasting channel, using various bit rates, has confirmed the possibility of using a high bit rate in this application [Blineau *et al.*, 1980];
- in experimental transmission of teletext signals inserted into television signals of the system M through the broadcasting satellite for experiment, the impairment of the received teletext was better than Grade 4 (5-grade scale) and the bit error ratio was less than 3×10^{-3} when the C/N ratio was more than 8 dB [CCIR, 1978-82i].

8. Propagation and the receiving antenna system

Approximately half of the documents reviewed in Part III deal wholly or partly with the impairment of broadcast data signals attributable to propagation and the receiving aerial system. Apart from a comprehensive theoretical study of the complete data transmission channel given in [Blineau *et al.*, 1980], most documents consist of reports of field trials undertaken using a mobile receiving installation within the service area of one or more main rebroadcast transmitting stations. The principal conclusions that may be drawn from the mass of individual observations are as follows:

The less favourable conditions for data reception are those in which strong short-delay echoes are likely to affect the received signal, such as in the neighbourhood of mountainous topography or tall buildings [IRT, 1978a; Blineau *et al.*, 1980; Blineau and Dublet, 1980; Swiss PTT, 1978a; IRT, 1980]. For 625/50 systems, the results of field trials show that in these conditions, the correlation between satisfactory television picture reception and satisfactory data reception is low [BBC, IBA, IRT, 1975; Swiss PTT, 1977a; Sherry and White, 1976; Blineau *et al.*, 1980; Blineau and Dublet, 1980], but in the case of system I and NRZ data at 6.9 Mbit/s, or system L and 6.2 Mbit/s, the percentage of locations at which satisfactory data reception is possible is numerically similar to that at which satisfactory picture reception may be obtained [Lucas, 1976]: from 85% [Blineau *et al.*, 1980; Blineau and Dublet, 1980], to 95% [Sherry, 1977b]. Doc. [Swiss PTT, 1978b] indicated that the relative sign of the echo did not in general matter. It is estimated [IBA, 1976] that 96.8% of the existing television audience in the United Kingdom would have access to NRZ-coded data at 6.9 Mbit/s with an eye height of at least 25%, and this could be increased to 98.7% by the use of data regenerators at transmitter inputs. In summarizing the results of extensive field trials in the UK, [Sherry, 1978; CCIR, 1978-82b] conclude that it is predominantly the signal-to-noise ratio that limits the data-broadcasting service area. When reception at different locations was evaluated using domestic

aerials mounted on a survey vehicle, no location was found at which the field strength was adequate for television but teletext reception failed due to echoes. However, in tests using existing domestic aerial installations, 32% of teletext failures were due to echoes; significant improvement of data reception may be obtained in such cases by optimizing the aerial and feeder.

According to a comparative study of reception of teletext transmissions at 6.9 Mbit/s in Bands I and III [Bridle, 1979], the bit error ratio measured at typical locations with existing domestic antenna/feeder installations is significantly worse in Band I than in Band III. For example, there were approximately half as many locations at which three consecutive fault-free acquisitions could be obtained from transmissions in Band I as there were in the case of transmissions in Band III. This is attributed mainly to the use of antennas having characteristics in Band I that are less directive than in Band III, so that the relative amplitude of short-delay echoes is likely to be greater in the former case.

The number of locations at which, under unfavourable conditions, data reception at bit-error ratios of 1 in 10^4 or lower can be obtained, can be increased by 13% by reducing the bit rate by 10%, from 6.9 to 6.2 Mbit/s (with NRZ coding and systems B and G). An improvement of 26% can be obtained by reducing the bit rate 38% to 4.3 Mbit/s [Swiss PTT, 1978a]. Even greater improvement can be obtained by the use of bi-phase code, though only at the cost of halving the data rate [RAI, 1975b]. Measurements in Australia using the low VHF band, Band I [ABC, 1981], indicate that an increase of 10% or more in coverage could be achieved by reducing the bit rate by 29%, from 6.9 Mbit/s to 4.9 Mbit/s. The influence of the bit rate (6.9, 6.2 and 4.3 Mbit/s) on the reception quality of NRZ-coded data signals has been evaluated in Italy [CCIR, 1978-82g]. The results have shown that the mean values of the eye-height distributions at 6.9 and 6.2 Mbit/s are approximately the same and a noticeable improvement is obtained only with the bit rate of 4.3 Mbit/s which would assure a correct reception with present commercial decoders for nearly all television users in Italy.

The complete series of tests undertaken in France in flat country, urban areas and mountainous regions [Blineau *et al.*, 1980; Blineau and Dublet, 1980] have enabled it to be calculated that the proportion of the population situated in locations where data at 6.2 Mbit/s can be received from UHF broadcasts by means of the DIDON system with a bit error ratio of better than 1 in 10^4 is about 98%, and that the proportion potentially able to receive such signals with a bit error ratio of better than 1 in 10^7 is about 74%. Furthermore, these results have verified that in this type of network the bit errors approximately satisfy the criterion of independence.

With regard to the advantages and disadvantages of the use of cable distribution, field trials in Switzerland and the United Kingdom suggest that properly designed and maintained systems do not introduce much signal degradation, although some loss of video signal-to-noise ratio occurs at peripheral terminals [Swiss PTT, 1977b; White, 1976]. No degradation of the teletext could be perceived in cable systems such as CATV and MATV in Japan [CCIR, 1978-82i]. On the other hand, observations in Sweden on receiving installations fed from existing collective aerial systems indicate that in fact a significantly lower percentage (86 or 83%) provides satisfactory data reception with NRZ code at 6.9 Mbit/s than satisfactory picture quality (98 or 94%) [Swedish Telecommunication Administration, 1978]. A theoretical analysis of teletext reception problems in master antenna installations of a type widely used in Italy, is described in [CCIR 1982-86c; Cominetti and Stroppiana, 1984]. From the results of the analysis, which show good correspondence with experimental laboratory tests, it is concluded that teletext reception can be difficult because of the impairment introduced by non-uniform amplitude and group delay/frequency-response of the head-end unit and by imperfect matching between the various parts of the distribution network. Technical suggestions are made in the document for improving the existing installations, in such a way that teletext reception quality might be significantly improved. Further improvement is expected to be obtained by including an automatic echo equalizer in the decoder. Nevertheless, residual impairment, due to non-linear effects (e.g. intermodulation and cross-modulation products) may still remain. These could be reduced by proper alignment of head-end amplifiers and converters. Both VHF-UHF and HF-UHF converters may introduce distortion of the data signal, especially the latter [White, 1976]. A comparative study in Japan of the subjective television picture quality with system M and the accompanying teletext display obtained at typical receiving locations using NRZ coding at 5.73 Mbit/s indicated that the teletext display was on average one grade better, and that insignificant impairment of the teletext display occurred with a bit error ratio of less than 5×10^{-3} [CCIR, 1978-82c]. It should be noted that Sub-Committee 12G of the IEC is responsible for preparing Recommendations for the design of cable distribution networks suitable for the transmission of teletext signals.

Laboratory tests on the 525/60 Canadian teletext system [Hearty and Treurniet, 1985] examined the effects of bit error ratios on a variety of viewer responses. The studies showed that (for both text and graphics) retransmission requests, negative quality ratings, and negative usefulness ratings reduced to minimum levels as the bit error ratio was decreased to 1×10^{-4} .

For Japanese teletext using the (272, 190) differential set cyclic code, a correct reception ratio of more than 99% can be obtained even under the subjective television picture grade of 2.5. It is confirmed that teletext and conventional television coverage areas are nearly equal [CCIR, 1982-86d].

Tests are currently being undertaken in Canada to determine what problems, if any, arise in the distribution of teletext signals at various bit rates by cable networks carrying large numbers of television channels.

9. Receiver performance

9.1 Compatibility aspects

Several studies have considered the visibility, on existing receivers, of data signals broadcast during various lines in the field-blanking period of 625/50 television systems. According to [IRT, 1978b], none of a representative sample of PAL colour and monochrome receivers and picture monitors made in the Federal Republic of Germany since 1973 are affected by data in line 12/325 and subsequent lines, and most receivers and picture monitors manufactured since 1973 and 1976 respectively are unaffected by data signals in line 6/319 onwards. Additional field trials carried out in the Federal Republic of Germany in 1982 confirm the possibility of using lines 13/326 onwards for teletext [CCIR, 1982-86e]. Results obtained in Italy [Salvadorini and Zetti, 1979] in November 1978 show that colour television receivers were not disturbed by data signals inserted in line 13/326 onwards, while monochrome receivers did not allow the use of lines before line 16/329. However, taking into account the normal renewal rate of television receivers, it is hoped that in the near future the use of lines before 16/329 will become possible.

The results of a study made in Spain [CCIR, 1982-86b] indicate that television lines from line 13 onwards may be used to carry data signals without visible disturbance to the pictures displayed by receivers in general use. Results obtained in Yugoslavia show that receivers manufactured after 1973 were not disturbed by data signals inserted in line 11/324 and subsequent lines [CCIR, 1982-86a].

Tests on existing television receivers in the home were carried out with the 525/60 system in Japan in 1976 [Numaguchi *et al.*, 1977] and in 1981 [CCIR, 1982-86f]. The results showed the possibility of using line 15/278 onwards. However, receiver manufacturers have been working to improve the performance of receivers so as to allow the use of lines as early as 10/273.

The susceptibility of certain receivers to interference in the sound channel due to the presence of data signals in the field-blanking period of the television signal has been examined in the United Kingdom, and it is concluded that non-linearity in receivers and multipath propagation are the principal factors responsible for such interference [Gilchrist, 1976]. A study made in Spain [CCIR, 1982-86b] reported interference to the sound channel due to the presence of data signals in the field-blanking period in the case of receivers having a particular IF response. This could be eliminated by modifying the IF response.

9.2 Data receiver performance

Methods of measurement and limiting conditions for teletext receivers have been defined in the United Kingdom [CCIR, 1978-82d].

The use of a theoretical model [Blineau *et al.*, 1980; RAI, 1979] has made it possible to study the performance of a data receiver as functions of two of its principal characteristics: the clock recovery method used and the technique used to determine the operating level of the data slicer.

Measurements made in Sweden using NRZ coding at 6.9 Mbit/s with a number of commercially available receivers show that the eye height they require depends on the delay of the positive echo that simulates the signal degradation. The performance spread between sets of the same type was significant. Generally, eye heights greater than 25% were required to achieve acceptable reception [CCIR, 1978-82e].

A minimum value of eye height of 25% at the receiver input has been adopted as the basis for receiver design in the United Kingdom. According to a theoretical study [Lucas, 1975], it is probable that approximately one character per full page will be received with an even non-zero number of wrong bits in the case of NRZ coding at 6.94 Mbit/s with a television signal-to-noise ratio of 17 dB. A comparison of three receivers employing envelope, quasi-synchronous and synchronous demodulation with adequate input signal level showed significant differences in the percentage of locations under unfavourable conditions at which satisfactory data reception was obtained [Swiss PTT, 1978a]; the order of merit varied at different data rates, but the receiver with synchronous demodulation was generally the best, as is predicted by theoretical studies [RAI, 1977; Vardo, 1977a]. The percentages of the locations examined in an area of unfavourable conditions in Switzerland (NRZ data of 6.94 Mbit/s) at which fault-free pages were obtained on first acquisition, increased from 47% to 70% when a better receiver was used [Swiss PTT, 1977a and c].

The studies have also demonstrated the significance of the bit rate in determining the probability of satisfactory data reception with the 625/50 system [CCETT, 1978]. The effects due to the limited bandwidth of receivers, possibly further reduced by mistuning, and of errors in the slicing level, etc., are examined theoretically and in detail in [Cominetti and Stroppiana, 1974; Vardo 1977b]. In [Swiss PTT, 1978a], it is likely that the differences in the percentage of locations at which a bit error ratio of at most 1 in 10^4 was obtained (91% at 4.3 Mbit/s, 77% at 6.2 Mbit/s and 53% at 6.9 Mbit/s with the receiver using synchronous demodulation in the field trial under unfavourable conditions in Switzerland), were due mainly to the receiver performance.

The utility of incorporating an automatic echo-equalizer in the receiver has been studied by means of a field trial undertaken in Switzerland with NRZ-coded data signals at different bit rates. It was found that the use of the equalizer enabled reception quality to be obtained at the highest bit rate (6.9 Mbit/s) better than that obtained without the equalizer at the lowest bit rate (4.3 Mbit/s) [CCIR, 1978-82f; Voorman *et al.*, 1981].

10. Miscellaneous aspects

Finally, several studies concerned other aspects of data broadcasting. They consisted of:

- a discussion of the implications of the choice between fixed-format and variable-format teletext systems notably with regard to decoder design, concluding that the former is preferable [CCIR, 1978-82g];
- the results of a comparative field trial in which measurements were made of reception of simultaneously-propagated signals of line-asynchronous and line-synchronous teletext systems, indicating that the former were received at all points with reliability the same as, or greater than, the latter [IRT, 1978a];
- the results of another comparative field trial with the line-synchronous and the line-asynchronous systems concluding that no significant difference between the two systems could be established with regard to their transmission reliability [IRT, 1980];
- a comparative laboratory test on fixed-format and variable-format teletext systems, made with the same bit rate (6.9 Mbit/s), pulse-shaping filter and input circuitry for the two decoders, indicated that both systems have approximately the same performance, notably with regard to the minimum signal-to-noise ratio at which no errors remain after the second acquisition of a page [CCIR, 1978-82h];
- laboratory and field tests carried out in Japan on transmission format showed that there was little difference in the number of conformity defects between variable-format and fixed-format [CCIR, 1982-86g];
- a theoretical analysis and a field trial on the simultaneous transmission of the United Kingdom teletext and the French DIDON-ANTIOPE teletext system in the same TV transmission channel, indicating that the systems may co-exist without disturbance of teletext reception when the same bit-rate, the same run-in and the same framing code is used if the DIDON data channel addresses of the French system are chosen among unused combinations of the magazine and row address group of the United Kingdom system [CCIR, 1982-86e];
- a theoretical comparison of different techniques of protecting the display address instructions in which the use of Hamming code is shown to be more efficient than unprotected transmission or repetition and collation [Chew, 1977];
- computer simulation and field tests on the comparison of error-correction methods using a horizontal and vertical (HV) parity code, an 8/4 and a 16/11 Hamming code and their interleaved arrangements, and a majority-logic-decodable (272, 190) cyclic code, indicating that the cyclic code is most suitable for the error-correction method for Japanese teletext [CCIR, 1982-86h and i];
- a theoretical analysis of the advantages and disadvantages of the use of various strategies for forward error-correction in the case of a teletext system based on picture-description instructions [Sablatash and Storey, 1980];
- a theoretical study of the definite window length for the framing byte, in order to reduce the chance of false detection [CCIR, 1982-86j].

11. General studies

Most of the documents deal with particular aspects of data broadcasting, but there are several general studies which consider virtually the whole transmission chain. The conclusions of the general studies have been mentioned where appropriate in the foregoing synthesis, but for convenience a list of the corresponding documents is given here:

- theoretical studies: [Chew, 1977; Vardo, 1977b; Cominetti *et al.*, 1978];
- field tests: [IBA, 1976; BBC, IBA, IRT, 1975; Swiss PTT, 1977a; Swiss PTT, 1977b; Swiss PTT, 1977c; Blinneau *et al.*, 1980; Sherry, 1978; Hofmann and Lau, 1979; CCIR, 1978-82b; IRT, 1980; CBS, 1980];
- the reference [Cominetti and D'Amato, 1979] gives a survey of field tests and theoretical studies in Europe up to June, 1979.

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(See § 1 "Introduction" for information regarding
the availability of certain documents)

[Unless otherwise indicated, the title of each article is given
in the language in which it is published]

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ANNEX I
 "UK TELETEXT" SYSTEM
 (United Kingdom)

In Table I, the name of the data system which was the subject of the individual study or test is quoted as "UK teletext" in several instances.

In order that the corresponding entries under "Summary of conclusions" of Table I may be correctly interpreted, it is necessary to define the system tested, as precisely as possible. For this purpose the following sections of the specification of the system, proposed for international adoption (Annex I to Report 957; Geneva, 1982) apply:

Study No.	Applicable sections of Annex I to Report 957 (Geneva, 1982)
1	All
2	1-11, inclusive
3	All
4	
5	
6	
13	1-11, inclusive
14	All
15	All
16	1-11, inclusive
17	
18	
19	
20	
23	All
25	All
27	1-11, inclusive
34	All
36	All
37	1-11, inclusive
39	All
42	1-11, inclusive
46	1-11, inclusive
50	All
51	1-11, inclusive
52	
55	
56	1-14, inclusive

ANNEX II
 "DIDON-ANTIOPE" TELETEXT SYSTEM
 (France)

1. Introduction

This Annex gives a general description of the main characteristics of the DIDON-ANTIOPE teletext system. It has four parts. The first part (§ 2) describes the display characteristics of a videographic message. The second part (§ 3) describes the coding used. The third part (§ 4) describes how the data is structured for teletext transmission ("record" level protocol). The fourth part (§ 5) describes the data broadcasting system.

This presentation reflects the basic principles underlying the design of the system: separation of the various functions in their implementation and definition of specific interfaces between these functions. Each section gives the main characteristics of a function, not a detailed specification.

This system, which is currently in operation in France, has been used as a basis for the development of the system which is described in Annex II to Report 957 (Geneva, 1982), proposed for international adoption.

2. Display characteristics of a videographic message on a home television screen

2.1 General

From its basic conception, ANTIOPE is an explicit data description language, the specifications of which are set forth in § 3. Its application to videography involves a set of restrictions imposed on the use of the language.

Accordingly, the use of page setting codes enables rows of text of any length to be transmitted, and only the choice of the television set as display unit imposes limitations of format. This example applies also to the other elements of the language: functions, repertoires, etc. With the ANTIOPE language, descriptions can be given of complex pictures and of multi-alphabetic texts and the display characteristics described below result from the technical and economic choices made for the videography services:

- use of the domestic television receiver
- cost-saving for the decoder.

It should be understood that these choices depend on the current market situation and apply to a first generation of systems and services (named the “basic level”).

2.2 *Format*

The format depends on the possibilities of the television screen. In 625-line systems, the screen may have a maximum of 25 rows of 10 lines each. The zero row cannot be used for publishing information. Each row has a maximum of 40 characters. The usable part of the screen therefore consists of 960 defined character positions.

2.3 *Repertoires*

2.3.1 *Repertoire of characters*

The character repertoire consists of three parts:

- alphanumeric characters: a repertoire of about 300 shapes has been defined by the ISO and the CCITT. This repertoire should be recognized by all terminals, even if in a given country or with a particular make an exact representation is impossible (see the fall-back presentation modes below, § 2.4). This repertoire consists of alphabetic characters, the Latin alphabet and punctuation or special characters;
- mosaic characters: a repertoire of 64 elementary shapes and of 64 derivative shapes known respectively as contiguous and separated mode mosaics are included in the system;
- source-defined characters: certain terminals may fail to recognize these characters which belong to repertoires dynamically built-up during operation rather than when the terminal was produced. These characters are used for alphabetic extensions for non-Latin alphabets, repetitive graphic shapes (symbols, logos, pictograms) or videographic writing.

2.3.2 *Repertoire of functions*

The display functions comprise:

- sets of 8 colours,
- a set of 4 sizes,
- a set of attention functions (flashing, polarity, lining),
- a set of insertion functions (boxing, masking).

Moreover, all or part of the screen may be transparent, showing either its previous contents or a television picture as initial background.

Although it is theoretically possible to change all these functions freely, even within the same character space the technical and economic choices which led to the definition of the terminals’ basic level entail the following constraints:

- a single 8-colour set (a priori red, yellow, green, blue, magenta, deep cyan, black and white) per page,
- two palette colours at most per character space (colour of the character, background colour),
- only the background may be transparent,
- certain functions (insertion, lining and, except for the mosaic repertoire, background colour) cannot be changed from one character space to another and require spacing if they are to be taken into consideration. The simultaneous change of several of these functions requires only one space.

Certain functions may apply to “border areas”, i.e. part of the screen outside the writing area. This is the case of background colours, including the transparent background which then designates the television picture. The effect produced by dynamic modifications of this function (called “full-screen background attribute”) on the active writing part is not defined by the standard.

2.4 *Fall-back presentation modes*

A terminal may not itself be able to reproduce the basic alphanumerical repertoire (300 characters) or some of the latter's functions. In that case, it must be capable of identifying the character or function received and representing it by default (fall-back presentation mode). Some examples are given below.

Accented characters may be represented either by the corresponding non-accented character or by an accented character which is visually similar ($\bar{A}$ instead of $\tilde{A}$, for example).

Special symbols may be represented by a semantically similar symbol (\$ or £ by α ; «, » “,” by ").

The repertoire of separate mode mosaics may be represented by the repertoire of contiguous mode mosaics.

The colour set may be replaced by a grey set or even by a two-tone representation (black and white).

The fall-back presentation modes used take into account the technical and economic constraints associated with the receiver.

In some cases, it is essential for the editor to be familiar with these fall-back presentation modes.

3. **Coding of the display message**

3.1 *Introduction*

The transmission coding (language) used in the ANTIOPE system respects the following basic principles:

3.1.1 the description of the screens is fully explicit; in particular, it is not necessary for any message to take into account the particular behaviour of a range or generation of terminals;

3.1.2 maximum compatibility is sought between the languages used in videotex or teletext applications in order to achieve the following two objectives:

- to facilitate the transmission of the same data by different communication media,
- to simplify the construction of compatible terminals.

In the following paragraphs, the language used for typographic mode screen coding is explained. The coding of other modes (photographic, geometric and downloading) is under study.

3.2 *Description*

Two language levels (level 0 and level 1) are defined at present. They are distinguished by the inclusion (in the level 1 language) of provisions relating to error protection devices within the message (other mechanisms of course exist at other levels for this purpose; these are under study).

In addition to these description languages, the broadcast mode uses data structuring which matches the characteristics of this medium and the possibilities of cyclical or block transmission of messages comprising several successive pages. This structure is described in § 4.

3.2.1 *Level 0 of the description language*

At this level, the language entirely conforms to the description language developed by the CCITT and the ISO; reference may therefore be made to CCITT Recommendation S.100 (ex S.g.), ISO/DP 6937.

3.2.2 *Level 1 of the description language*

This level is constructed from the preceding 0 level, the following two rules being observed:

- it imposes no restriction on the nature or the content of the messages transmitted, other than those concerning the mode of their appearance and their evolution in time,
- it may be readily interpreted by a terminal designed essentially for the level 0 language.

In order to conform to these rules, error protection is introduced at level 1, with the use, for example, of the following devices:

- redundancies (repetitions),
- definition of compulsory sequences for the (combined) transmission of certain codes,
- limitations concerning the (dynamic) management of the active writing position.

In reference [TDF, 1981], a full description of these devices (and more generally of the level 1 language) will be found.

4. "RECORD" level protocol

4.1 Introduction

In the ANTIOPE system, a videographic message is transmitted by means of one (or more) logical unit(s) called RECORD(S). Each of these records is structured in four consecutive areas:

(Start of record) — (Record header) — (Data) — (End of record)

1 2 3 4

The 2nd area (Record header) performs the following functions, which constitute a record level protocol:

4.1.1 the source-to-terminal "connecting" functions (e.g. selection of messages by the terminal),

4.1.2 general information concerning the nature of the data carried by area 3 of the record (presentation of data).

Note 1. — The record level protocol described below provides, *by itself* and for several applications (e.g. teletext, subtitling, etc.), a satisfactory solution to problems of source-to-terminal connection. However, studies are under way with a view to defining additional connection devices (at higher levels, e.g. magazine level protocol). An important note on this subject is found in § 4.5.2 below.

Note 2. — The start of record is coded SOH-RS.
The end of record is coded ETX-EOT.

4.2 General structure of the record header

The record header is made up of a series of Hamming-encoded bytes (i.e. 4 information bits + 4 protection bits per byte) and has three successive parts, as follows:

(record header) = (classification sequence) — (linking byte) — (interpretation sequence).

4.3 Classification sequence

Enables transmission of a "classification number" identifying the message in the file of messages to be transmitted, and assists in connecting the source to the receiver (e.g. selection of a "page" by means of its "number").

This sequence comprises a fixed number of bytes which is a function of the maximum number of messages to be transmitted over the same "data channel". In France this number has been set at 3, giving a maximum addressing capacity of 4096 records; moreover, the values taken by these bytes make it possible to proceed to a preliminary classification of the nature of the messages carried by the record:

4.3.1 values between 0 and 9 (Hex.): the record is concerned with the transmission of a videographic message;

4.3.2 values between A and F (Hex.) the record is concerned with the transmission of another type of message (e.g. control, call for higher level protocols, data, etc.).

4.4 Linking byte

Since the architecture of some terminals may require each record to be shorter than or equal to a certain maximum length (e.g. 1 kbyte, 2 kbyte, etc.), the link byte enables the transmission of a longer message to be divided into several "linked" records (which may or may not be consecutive, and naturally bear the same number).

4.5 Interpretation sequence

This sequence, the length of which varies *dynamically* as a function of its content, informs the receiver about the nature of the message transmitted and its general characteristics.

It plays a *dominating* role in problems of compatibility between the various service levels or generations.

Although its technical structure (cf. § 5.1 below) is largely unaffected by the type of service being provided, the same may not apply to the meaning of the bytes it contains (cf. § 5.2).

Note. — In the case of linked records, only the first record comprises an interpretation sequence.

4.5.1 Technical structure

This comprises two types of bytes:

- designation bytes Y_{0i}
- interpretation bytes Y_{1i} to Y_{16} associated with the Y_{0i} designation bytes
- each byte comprises 4 significant bits: b_2 , b_4 , b_6 and b_8 .

4.5.1.1 Mechanism of the designation byte

- bits b_4 , b_6 and b_8 of Y_{0i} specify whether the byte-pairs $\{Y_{i1}, Y_{i2}\}$ for b_4 , $\{Y_{i3}, Y_{i4}\}$ for b_6 , and $\{Y_{i5}, Y_{i6}\}$ for b_8 are sent or not (in that order) after byte Y_{0i} .
- bit b_2 of Y_{0i} specifies whether or not another designation byte $Y_{0,i+1}$ is sent after the interpretation bytes associated with Y_{0i} (or after Y_{0i} , if b_4 , b_6 and b_8 of Y_{0i} are all zeros).

4.5.1.2 General principle of "value by default"

When, in the message sent, the information bits of a pair of interpretation bytes $\{Y_{ij}, Y_{ij+1}\}$ are all zeroes, the pair in question does not have to be transmitted.

In such circumstances, only messages with characteristics that are different from those most frequently encountered in the totality of messages to be transmitted will call for the transmission of an interpretation sequence that is longer than 1 byte (Y_{01}).

4.5.2 Content of the interpretation byte

Reference [TDF, 1981] contains a precise definition of the data carried by each interpretation byte, when the record sent relates to the transmission of a videographic message.

These data are concerned with:

- contribution to management of the source-to-terminal connection (e.g. cover, summary, alarm, running, etc. pages);
- a description of the nature and context of the message (e.g. screen description or screen control message, partial description message, message of finished or unfinished length, existence or non-existence of a "magazine" level protocol*, etc.);
- a description of the resources required by the terminal and the type of language used (e.g. repertoires required, encyphered or plain language, protected or unprotected language, etc.);
- a description of the default values of the display attributes.

5. Data broadcasting system

The data packet broadcasting system, known as DIDON, may use any time slot corresponding to the active duration of a television signal line to transmit a data packet. The characteristics described below are those of the DIDON system as used in a standard L television channel. They may easily be adapted to other standards.

5.1 Electrical characteristics and bit synchronization

5.1.1 The electrical characteristics of the data signal are as follows:

- $F_{bit} = 6.203\,125\text{ MHz } (+0.005\%)$
- coding NRZ/L
- sine-squared shaping
- amplitude and position of the data signal in relation to the blanking level defined by the following values:

$$D/S = 0 (\pm 3\%)$$

D : pedestal

S : amplitude of the sync pulse

$$A/S = \frac{7}{3} (+0\% - 10\%)$$

A : amplitude of the wanted signal

$$(A/S = \frac{7}{6} \text{ in certain special planning cases})$$

- position of the leading edge of the data signal in relation to the line sync pulse defined by the following value:

$$T = 10.5\text{ }\mu\text{s} \pm 320\text{ ns}$$

(during the preceding 2 μs , the luminance component of the signal is maintained at the blanking level).

5.1.2 A bit synchronization burst consisting of a sequence of sixteen alternate 1's and 0's enables the receivers to be synchronized at bit level.

5.2 Byte synchronization and procedure

A synchronization word consisting of one byte enables the receivers to synchronize at the byte level (this byte is followed by a maximum number, N_{max} , of 37 bytes (having regard to the F_{bit} value adopted)).

* "Magazine" level protocols have not yet been specified. The value of the corresponding bit is therefore zero.

The byte synchronization word may have three different values, each of which corresponds to a special packet procedure:

PB = 11100111 : packet procedure No. 1

PB = 10110100 : packet procedure No. 2

PB = 00100001 : packet procedure No. 3

PB: procedure byte.

5.3 *Packet procedures*

The packet procedure defines the role of the various bytes making up the prefix. All these bytes belong to a Hamming code.

Three packet procedures may be used; the corresponding prefixes comprise, respectively:

5.3.1 *Packet procedure No. 1* (characterized by PB = 11100111):

- a packet identifier on 3 bytes
- a continuity index on 1 byte
- a format indicator on 1 byte

5.3.2 *Packet procedure No. 2* (characterized by PB = 10110100):

- a packet identifier on 1 byte
- a format indicator on 1 byte

5.3.3 *Packet procedure No. 3* (characterized by PB = 00100001):

- a packet identifier on 2 bytes

5.4 *Channel procedures*

A digital channel is the link established by the network between a data source and the terminal(s) using the data in question.

The channel procedure defines the method of forming a digital channel using a set of packets.

The only channel procedure currently defined consists in assigning the same identifier to all the packets corresponding to a channel. Under packet procedure No. 1, the value of the continuity index increases by 1 (modulo 16) for each packet sent over the channel.

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ANNEX III

"TELIDON" TELETEXT SYSTEM

(Canada)

This Annex briefly describes in layered format the design of the Canadian broadcast videography (teletext) system which was used in field trials. The system described hereunder has been used as a basis for the development of the system described in Annex II to Report 957 (Geneva, 1982) proposed for international adoption. In this system text and pictures are encoded in the alpha-geometric coding scheme as defined in CCITT Recommendations S.100 and F.300

Layer 1 (Physical layer)

Bit rates: Various bit rates have been tested: 3.95, 4.58, 5.19 and 5.72 Mbit/s corresponding to 251, 291, 330 and 364 respectively times the horizontal line frequency.

Modulation and Data Encoding: Amplitude modulation with non-return-to zero (NRZ) binary encoded signal, ranging from 7.5 IRE units (binary 0) to 70 IRE units (binary 1).

Pulse shape: Controlled raised cosine filter with 70% and 100% roll off, followed when necessary by a low pass filter with a cut off of 4.2 MHz.

Bit synchronization: 16 alternating bits of 1's and 0's leading in with a 1 which starts 10.2 μ s after the half-amplitude point of the leading edge of the horizontal synch pulse.

Layer 2 (Link layer)

Byte synchronization: An optimum triplet of framing codes was chosen. The framing code used is:

1	0	0	0	0	1	1	1	= 135 ₁₀
b ₈	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	

The other two compatible sequences are:

1	0	1	0	0	1	0	0	= 164 ₁₀
0	1	1	0	1	1	1	1	= 111 ₁₀
b ₈	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	

Layer 3 (Network layer)

A data packet consists of a 5-byte prefix, a data block and a single byte suffix.

The prefix consists of a 3-byte Hamming encoded packet address and a 2-byte Hamming encoded continuity count:

P ₁	P ₂	P ₃	Cl ₁	Cl ₂

The packet address allows 4096 different channels and provides for interleaving of packets from different services. A time separation of 4 ms between any two packets having the same channel number for both field blanking and full field operation, is specified.

The continuity count permits 208 (256-48) packet sequence checking as indicated below:

Cl ₁	Cl ₂	
0	0 - F	Record header
1 to D	0 - F	Count = 208
E	0 - F	Reserved
F	0 - F	Record end

The data block contains 16, 20, 24 or 28 bytes depending on the bit rate.

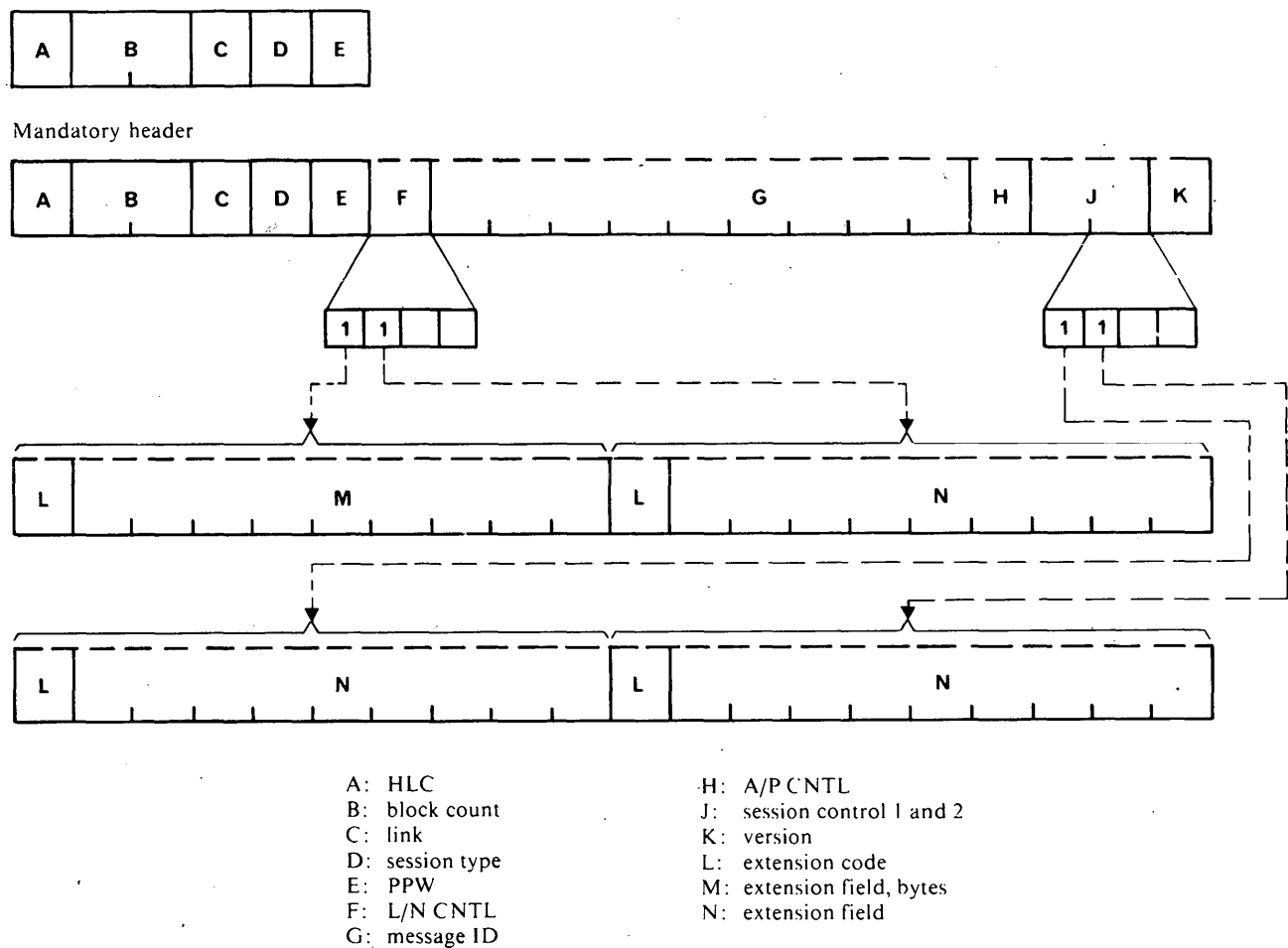
A single byte suffix is comprised of a longitudinal odd parity check of all bytes in the data block, which themselves contain an odd parity check in the most significant bit (b₈) of each byte. This information forms the basis of the product code used to correct any single bit error and detect all double errors in each data block.

Layer 4 (Transport layer)

The data group brackets the record completely.

Layer 5 (Session layer)

The record consists of data blocks of information from the same source. The record consists of a record header followed by control or information data. The format of the record header is shown after:



The first 6 bytes are mandatory and must be processed correctly by all decoders. The optional bytes may be interpreted by various levels of decoders. The header length code (HLC) determines the number of bytes in the header.

Layer 6 (Presentation layer)

The presentation layer makes use of the alpha-geometric coding scheme the basis of which forms part of the CCITT Recommendations S.100 and F.300. Pictorial drawings are defined by picture description instructions (PDIs). The drawing commands specify the geometric primitives of POINT, LINE, ARC, RECTANGLE, POLYGON and BIT (photographic mode). The display format consists of 20 rows of 40 characters as the default mode.

ANNEX IV
"JAPANESE TELETEXT" SYSTEM
(Japan)

The first generation Japanese teletext system which utilizes a photographic coding scheme exclusively is capable of transmitting and displaying ideographic letters and graphics, as well as Latin letters. In the system, text and graphics are transmitted as separate dots and are not encoded, although information for control functions and display attributes is encoded. The system requires the use of a frame memory at the receiver, instead of the character generator used in other systems. An outline of the system is given in Annex III to Report 957, Geneva, 1982.

Another Japanese teletext system which utilizes a character coding scheme as well as photographic and geometric coding has also been developed as a second generation teletext for Japan. The system has increased transmission capacities by a factor of about ten compared with the first-generation system. The basic parameters of the technical standard of the system are given in Annex I to Recommendation 653.

Field trials described in Table I were carried out in order to contribute to the development of these systems.

ANNEX V*

GLOSSARY, GIVING EQUIVALENTS IN ENGLISH, FRENCH AND SPANISH
OF CERTAIN TERMS IN THE FIELD OF TELETEXT

Note. — In order to facilitate the use of this glossary, the terms are listed in alphabetical order in each language with cross-referencing by means of numbers. The list in English alphabetical order, which forms the first table, gives the equivalents in the other languages directly; where no recognized equivalent is known, the letter “Z” has been inserted. Alternative translations are indicated where appropriate.

Ref.	English	Français	Español
1	Access time	Temps d'accès	Tiempo de acceso
2	Address byte	Octet d'identification	Byte de dirección
3	Addressing	Adressage	Direccionamiento
4	Alarm page	Page d'alarme	Página de alarma
5	Background colour	Couleur du fond	Color de fondo
6	Previous entry has been deleted		
7	Binary state	Etat binaire	Estado binario
8	Bit error	Erreur d'élément binaire	Error de bits
9	Bit rate	Débit binaire	Velocidad binaria
10	Previous entry has been deleted		
11	Boxing	Incrustation	Enmarcado (Incrustación)
12	Broadcasting of data by packets	Diffusion de données par paquets	Radiodifusión de datos en paquetes
13	Byte	Octet	Byte
14	Byte synchronization	Synchronisation des octets Reconstitution des octets	Sincronización de bytes
15	Character	Caractère	Carácter
16	Character code	Code de caractère	Código de carácter
17	Character rectangle	Rectangle de caractère	Rectángulo de carácter
18	Character rounding	Lissage des caractères	Redondeo de caracteres
19	Character row	Rangée de caractères	Fila de caracteres Renglón
20	Character set	Jeu de caractères	Juego de caracteres
21	Character string	Zone de caractères	Zona de caracteres
22	Clock run-in	Salve de synchronisation d'éléments binaires	Salva de sincronización de bits Secuencia de sincronización de bits

* This text was formerly part of Report 957; the text of a supplementary glossary, giving the equivalents, in German and Italian, of these terms, is available on request from the CCIR Secretariat, Geneva, and the EBU Technical Centre, Brussels.

Ref.	English	Français	Español
23	Clock synchronization	Synchronisation d'horloge	Sincronización de reloj
24	Clock-cracker	Séquence de test de stabilité d'horloge	Secuencia de prueba de la estabilidad del reloj
25	Coding	Codage	Codificación
26	Conceal	Masquage	Ocultación
27	Concealed page	Page à secret	Página oculta
28	Contiguous mosaics characters	Caractères mosaïques jointifs	Caracteres mosaicos contiguos
29	Continuation pages	Pages suite	Páginas continuación multipáginas
30	Continuity index	Indice de continuité	Índice de continuidad
31	Control bit	Élément binaire de commande Bit de commande	Bit de control
32	Control character	Caractère de commande	Carácter de control
33	Control page	Page de service	Página de servicio
34	Cycling sub-pages	Pages à tiroir	Ciclado subpáginas multipáginas
35	Data block	Bloc de données	Bloque de datos
36	Data bridge	Transcripteur de données	Transcriptor de datos
37	Data channel	Voie numérique	Canal de datos
38	Data channel address	Adresse de la voie numérique	Dirección del canal de datos
39	Data channel identifier	Identificateur de la voie numérique	Identificador del canal de datos
40	Data line	Ligne de données	Línea de datos
41	Data packet	Paquet de données	Paquete de datos
42	Data Regenerator	Répéteur régénérateur	Regenerador de datos
43	Default option	Option par défaut	Opción por defecto
44	Delete character	Caractère d'oblitération	Carácter de obliteración
45	Display attribute	Attribut de visualisation	Atributo de visualización
46	Display character	Caractère visualisé	Carácter visualizado
47	Display colour	Couleur de visualisation	Color de visualización
48	Display mode	Fonction de visualisation	Modo de visualización
49	Double width	Double largeur	Anchura doble
50	Down loaded alphabets	Alphabets mous Alphabets logiciels	Alfabetos cargados desde la fuente
51	DRCS (Dynamically redefinable character sets)	JCDR (Jeux de caractères dynamiquement redéfinissables)	JCDR (Juego de caracteres dinámicamente redefinibles)
52	Erasure	Effacement	Borrado
53	Field blanking interval	Intervalle de suppression de trame	Intervalo de borrado de trama
54	Framing code	Mot de synchronisation octets Code de trame	Código de sincronismo de bytes Código de encuadre de trama

Ref.	English	Français	Español
55	Graphics character (replaced by “mosaic character”)	Caractère semi-graphique	Carácter gráfico
56	Incompletely displayed page	Page à transmission partielle	Página visualizada parcialmente
57	Index page	Sommaire	Página índice
58	Line	Ligne	Línea
59	Magazine	Magazine	Revista (o magazine)
60	Magazine address	Numéro de voie d’un magazine	Dirección de revista (o magazine)
61	Primary set	Jeu primaire	Juego primario
62	Mapped display	Visualisation directe de la mémoire	Visualización directa de la memoria
63	Matrix	Matrice	Matriz
64	Message bit	Elément binaire du message	Bit de mensaje
65	Mosaic character	Caractère mosaïque	Carácter mosaico
66	Multipages	Pages multiples	Multipáginas
67	Multiple alphabets	Alphabets multiples	Alfabetos múltiples
68	NRZ (Non-return-to-zero)	Non retour à zéro	NRZ (No retorno a cero)
69	Packeting	Mise en paquets	Empaquetado
70	Page	Page	Página
71	Page address identification	Identification du numéro de page	Identificación de la dirección de página
72	Page assembly	Mise en page	Composición de página
73	Page erasure interval	Intervalle d’effacement de page	Intervalo de borrado de página
74	Page header	En-tête de page	Encabezamiento de página
75	Page identification	Identification de page	Identificación de página
76	Pagination	Mise en page	Paginación
77	Parallel (character defined) attribute	Attribut défini par caractère	Atributo definido a nivel de carácter
78	Parity bit	Elément binaire de parité	Bit de paridad
79	Parity check	Contrôle de parité	Control de paridad
80	Parity control (seldom used)	Contrôle de parité	Control de paridad
81	Prefix	Préfixe	Prefijo
82	Presumed option	Option par défaut	Opción por defecto
83	Protection bit	Elément binaire de protection	Bit de protección
84	Previous entry has been deleted		
85	Raised cosine	Cosinus surélevé	Coseno elevado a potencia
86	Reversed background	Fond inverse	Fondo invertido

Ref.	English	Français	Español
87	Rotating pages (seldom used)	Pages tournantes	Páginas rotantes
88	Rounded character	Caractère lisse	Carácter redondeado
89	Row	Rangée	Fila Renglón
90	Row address	Adresse de rangée	Dirección de fila Dirección de renglón
91	Row format	Format de rangée	Formato de fila Formato de renglón
92	Row number	Numéro de rangée	Número de fila Número de renglón
93	Row-adaptive transmission	Transmission optimisée	Transmisión exclusiva de los renglones ocupados
94	Supplementary set	Jeu supplémentaire	Juego suplementario
95	Self-changing pages (seldom used)	Pages à tiroir	Multipáginas
96	Separated mosaics characters	Caractères mosaïques disjoints	Caracteres mosaicos separados
97	Serial (string defined) attribute	Attribut défini par zone	Atributo definido a nivel de zona
98	Shift-register	Registre à décalage	Registro de desplazamiento
99	Signalling pulse (seldom used)	Impulsion de base	Impulso base
100	Size variation	Taille variable	Tamaño variable
101	Skew-symmetry	Z	Simetría de oblicuidad
102	Source definable characters	Caractères dynamiquement redéfinissables	Caracteres definibles en la fuente
103	String separator	Séparateur de zone	Separador de zona
104	Sub-page	Page à transmission partielle	Subpágina
105	Subcode	Sous-adressage	Subcódigo
106	Subcoded page	Page avec sous-adressage	Página con subcódigo
107	Subcoded sub-page	Page à transmission partielle avec sous-adressage	Subpágina con subcódigo
108	Subtitles	Sous-titres	Subtítulos
109	Summary page	Page de sommaire	Página índice
110	Telesoftware	Télélogiciel	Teleprogramación
111	Three-code escape sequence	Séquence d'échappement à trois codes	Secuencia de escape a tres códigos
112	Previous entry has been deleted		
113	Previous entry has been deleted		
114	Title page	Page de garde	Página de portada
115	Two-code escape sequence	Séquence d'échappement à deux codes	Secuencia de escape a dos códigos

Ref.	English	Français	Español
116	Previous entry has been deleted		
117	Previous entry has been deleted		
118	Unit pulse (basic pulse)	Impulsion de base	Impulso base
119	Updated page	Page nouvellement remise à jour	Página actualizada

REPORT 958-1 *

**POSSIBILITIES FOR INCORPORATING THE SOUND INFORMATION
IN THE VIDEO SIGNAL IN TERRESTRIAL TELEVISION**

(Question 1/11, Study Programme 1H/11)

(1982-1986)

1. Introduction

At some time in the future it may be possible to implement a new system in terrestrial television in which the sound information is incorporated in the video signal. The implementation of such a system while at the same time maintaining compatibility with existing television broadcasting systems, poses many problems which must still be resolved. The present Report is a first response to § 1 of Study Programme 1H/11.

2. Compatibility requirements

The EBU [CCIR, 1978-82a] has taken into consideration the various items mentioned in Study Programme 1H/11 and has come to the conclusion that in terrestrial television the following requirements must be fulfilled to ensure compatibility with existing systems:

- the inserted digital sound signal should not cause any unacceptable interference with the performance of existing receivers;
- the new system should at least allow for the use of either two independent high quality channels, or stereophony, or four to six independent speech channels, and switching to those various modes should be made automatic;
- the reception quality of a transmitter should be limited by the degradation of the picture and *not* by that of the sound signals.

The last requirement seems to be fulfilled if the new system will allow for a sound quality definitely better than the corresponding vision quality, in all reception conditions where the vision quality is at least grade 1.5 (in a 5-grade scale) [CCIR, 1982-86].

It is felt desirable that the new technology be developed with a view to achieving a single overall system suitable for satellite as well as for terrestrial broadcasting applications and that this be done in such a way that the configuration for terrestrial television forms a compatible sub-system of the overall system [CCIR, 1978-82b].

3. Compatibility tests with existing receivers

In order to study the feasibility of integrating sound information into the video signal, preliminary tests with system M have been carried out in Japan [CCIR, 1978-82c], to investigate the compatibility with existing television receivers in the case of pulse signals inserted into the line blanking interval and of line synchronizing signals modified as shown in Fig. 1.

* This Report is also of interest to Study Group 10 and the CMTT.

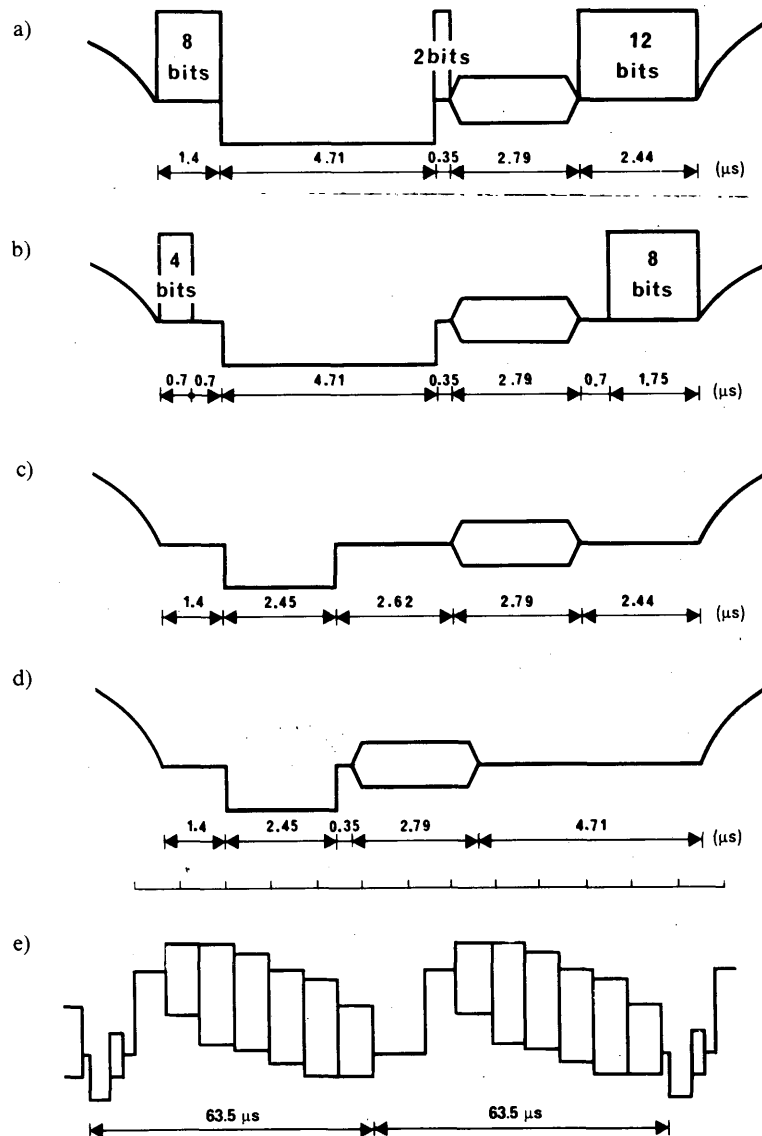


FIGURE 1 — Waveform of signals for tests with system M

The results showed that the signals tested were incompatible with receivers currently on the market. However, it seems possible that compatible receivers might be developed by improving their signal processing circuits since several receivers tested were not impaired by the test signals.

Preliminary compatibility tests with existing modern receivers for systems PAL/B have been carried out in Sweden [CCIR, 1978-82d], in which the whole horizontal blanking interval on every other line was used for a 8.86 Mbit/s digital signal; alternatively, two successive such lines were followed by two original lines (Fig. 2). The results showed that the signals caused more or less serious picture or synchronization impairments and that no real compatibility was obtained.

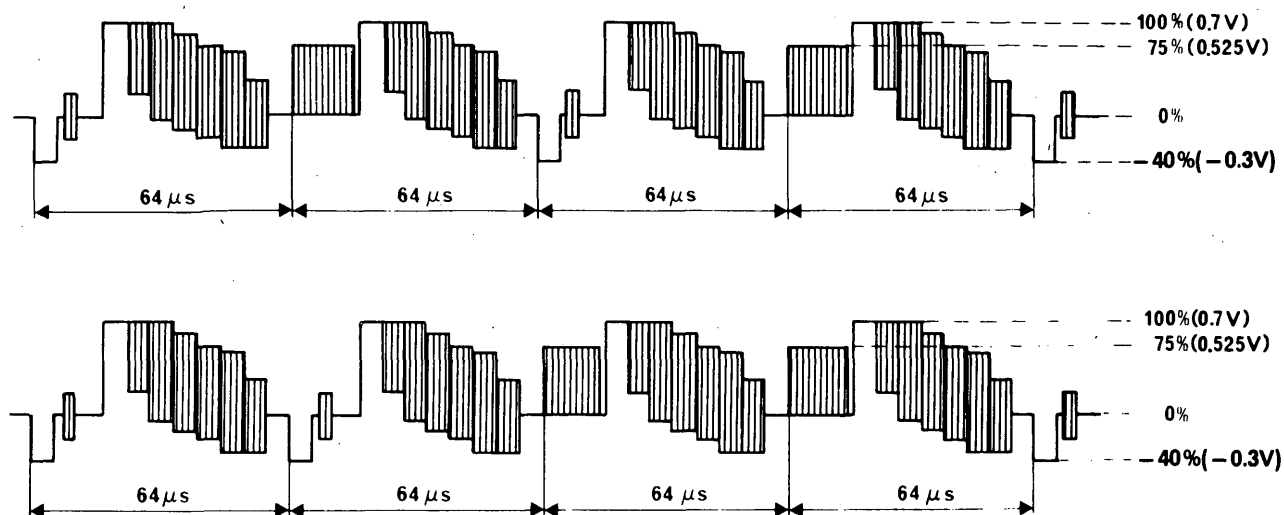


FIGURE 2 — Waveform of test signals for system PAL

4. Introduction of a digital system

The EBU has considered various practical aspects of implementing a new transmission standard whereby digital signals are included in the line-blanking interval and has come to the following conclusions for a 625-line PAL signal. Further work is required to determine whether these conclusions apply also to other systems, in particular the SECAM system.

- Experiments with conventional receivers have shown that any new system with digital signals in the line blanking interval is not likely to be compatible with existing receivers. This is true even if only alternate line blanking intervals (or similar schemes for partial use) are used.
- In order to achieve the greatest sound capacity viz. four high-quality sound channels (see Report 632), it is necessary to introduce digital signals within the entire blanking interval of every line.
- Because of the problem of incompatibility and the desirability of introducing any new system within the shortest possible transition period (about 15 years corresponding to one generation of receivers), it would be necessary to adopt a new generation of receivers within that period. This situation cannot be avoided by adopting the partial use of blanking periods either on a temporary or permanent basis.
- Such receivers should have circuits which can function with the standard waveform during the transition period and with the digital signals once the new transmission system is introduced. This circuitry could be contained entirely within the receiver or else could be included in a device external to the receiver, to be connected via standardized external plugs*. The latter solution would probably offer the greatest receiver flexibility.
- Special services such as cable or pay television could probably implement digital sound in the video waveform during the transition period.
- A possible disadvantage of the digital system in terrestrial broadcasting is the somewhat increased sensitivity of the picture to impairments arising from multipath propagation. This occurs when the delayed digital signal appears in the active picture period and arises from its greater visibility as compared with a normal waveform in the line blanking period.
- Further work is required on the quality of sound achieved under certain unfavourable propagation conditions.

REFERENCES

CCIR Documents

[1978-82]: a. 11/60 (EBU); b. 10-11S/7 (EBU); c. 11/75 (Japan); d. 11/298 (EBU).
[1982-86]: 11/35 (EBU).

* The Director, CCIR, is invited to draw the attention of the IEC to the necessity for the standardization of such interface plugs and sockets. CENELEC Technical Committee TC 103 have drafted such a standard (see CENELEC Doc. pr. GN 50 049).

REPORT 1078 *

THE BROADCASTING OF TIME AND DATE INFORMATION IN CODED FORM

(Question 29/11)

(1986)

Time and date information is already included in broadcast programmes in various ways. Direct methods, such as the audible time signal with a spoken announcement or the display of a calendar and clock-face in a television picture, provide the information in a form easily recognizable by listeners and viewers. Indirect methods make use of auxiliary data transmission channels, such as are provided by teletext, radio-data and the audio/data multiplex of satellite broadcasting, to convey this information in a coded form particularly suitable for controlling the operation of machines.

In the case of broadcasting within a geographically small country, a transmission carrying the time and date information that is correct at the point of origin also provides time and date information that is valid at the point of reception. However, even with domestic terrestrial broadcasting and cable services, in some cases the points of transmission and reception are situated in different time zones, corresponding to a time difference which is almost everywhere an integral multiple of 30 min. In some instances these differences themselves change during the year, due to the practice of implementing "daylight-saving" time in some countries.

Already there are cases, notably in HF broadcasting, where a transmission is received over a large geographical area containing many time zones, and, conversely, signals from most parts of the world can be received at any one point. In these cases, there would be a particular advantage in adopting a common standard time reference to permit the relative timings of programmes from different sources, and their local times at the point of reception, to be determined without the need for detailed current information on world time zones and various calendar conventions.

A similar situation will arise with the advent of satellite broadcasting, and in this particular case, it is expected that the accompanying data multiplex will include coded time and date information as part of programme and service identification (see Report 1073). This information may then be used directly to control automatically the reception of several programmes in sequence, in accordance with the predetermined instructions of the user.

Suitable common world-wide time and date conventions have already been defined in Recommendations 460 and 457. These refer to the use of Coordinated Universal Time (UTC), and the Modified Julian Date (MJD), a five-digit decimal day count incremented at midnight UTC. This information is sufficient to determine relative timings of programmes. Knowledge of the local offset from UTC at the point of reception would allow the local time and date to be inferred from time and date codes regardless of their origin. If the local offset at the point of origination was added as supplementary information to the coded signal, it would allow the time and date at the source to be calculated where required.

In order to avoid ambiguity when data broadcast from various sources are processed at various points, not all of which may be within the same time zone, and to allow calculations of time intervals to be made independent of time zones and "daylight-saving" time discontinuities, it is proposed** that all coded broadcast time and date signals should be expressed only in UTC and MJD, in accordance with Recommendations 457 and 460. A coded local offset, expressed in multiples of half an hour with range -12 to +15 h, may be appended when required to indicate the difference between this time and that currently applicable locally within a particular time zone [CCIR, 1982-86a].

A more complete account of the conventions for the expression of standard time and date, and a method for conversion between date conventions [CCIR, 1982-86b] are given in Annex I.

The conventions are being followed in teletext transmissions in the United Kingdom [CCIR, 1982-86c].

REFERENCES

CCIR Documents:

[1982-86]: a. 11/53 (EBU); b. 11/73 (United Kingdom); c. 11/72 (United Kingdom).

* This Report should be brought to the attention of Study Group 7.

** Administrations are invited to submit additional contributions to this Report, possibly leading to a new Recommendation.

ANNEX 1

A NOTE ON STANDARD TIME AND DATE CONVENTIONS

1. Introduction

There are already international standards concerning the distribution of time and date information. This Annex indicates how these standards relate to each other, and to the needs of broadcasting.

Time and date information is used to label the actual or nominal point of origin of material (a document, a television or radio programme) or the actual or anticipated point of receipt. The difference represents the propagation delay. There is also a requirement for indicating local clock-time and date in their own right, or for use together with such labels for assisting decisions or controlling processes associated with broadcasting.

The broadcasting and telecommunications environment provides the possibility of sending signals world-wide within 1 s of time. It is therefore necessary to accommodate the variations in local time (and date) in any method of coding intended to be consistent world-wide. There are also known discontinuities in local time (the duplicated hour at the end of "summer time", and the "leap second") to be taken into account.

2. Standard time

The standard unit of time is the second, obtained by defining the frequency of the caesium atomic transition as 9 192 631 770 Hz. For the purpose of creating a regular time scale these seconds are counted to give days, hours and minutes since 1 January 1958. This is known as International Atomic Time (TAI). This time scale, based on a physical property, drifts out of step with a time scale, such as Universal Time (UT) or Greenwich mean time (GMT), obtained from astronomical observation. Since the origin of TAI was set in agreement with UT at the beginning of 1958, TAI has advanced by about 21 s with respect to UT. In order to provide a time scale with seconds coincident to those of TAI, but within a close tolerance (± 0.8 s) of UT, a version of TAI offset by a whole number of seconds is maintained by the Bureau international de l'heure (BIH). This is known as Coordinated Universal Time (UTC). The tolerance is maintained by occasionally adding (or, in principle, deleting) a single second to make a 61 s (or 59 s) minute. The preferred occasions are at the end or middle of the year, with at least eight weeks' notice. For example, one of these "leap seconds" occurred at 0000 h UTC on 1 July 1982 when the UTC seconds marker sequence was:

30 June 1982	23 h 59 min 59 s
	23 h 59 min 60 s
1 July 1982	00 h 00 min 00 s

All of the standard time signals used by broadcasters world-wide are derived from the UTC time scale, and the times are often, wrongly, referred to in terms of Greenwich mean time (GMT) and an offset. For reasons given above, the UTC time signal known in the UK as "the Greenwich time signal", will sometimes differ from true GMT by more than half a second. This confusion of name is of little practical consequence in everyday life, but it is significant to astronomers, navigators and lawyers.

Recommendation 460 recommends "that all ... time signal emissions conform as closely as possible to Coordinated Universal Time (UTC) ... from 1 January 1975".

2.1 Time offsets

In practice all countries refer their national time or times to UTC with an offset. There are 38 different offsets currently in use. Except for Nepal (+5 h 40 min) all the offsets are multiples of half an hour and range from -11 h (Samoa) to +14 h (Anadyr, USSR, in summer time). Many countries advance their time by one hour during local summer (dependent on hemisphere); exceptionally Cook Islands advance by half an hour. There are various dates and times for summer time changes. Within some countries (Australia, Canada) there are some time zones differing by half an hour. There are some states (Queensland, Australia; Arizona and Indiana, USA) which, unlike their neighbours, do not adopt summer time.

It would probably be sufficient to provide a method of signalling a local time offset with a six-bit code giving half an hour steps in a range -12 to +15 h. In some applications, the local offset of the programme source or of the transmitter would be signalled; in other cases, the local offset applicable to the receiver site would be required.

3. Date

The change of date varies, of course, with local time, so a common broadcast standard for date would be referred to UTC and it would be corrected, if necessary, by the operation of the local offset.

There are several calendars in use world-wide but a simple common reference, the Modified Julian Date (MJD), has been defined for this purpose. This is a five-digit decimal number increasing by one at midnight UTC. The origin of the count is 17 November 1858, because at midday on that date the Julian Day (used by astronomers to give continuity from 4713 BC) reached the figure 2 400 000. A more convenient reference is 31 January, 1982 when the MJD was 45 000. It is a simple matter to calculate time intervals, even over many days, by use of MJD and UTC (provided the occasional leap second is known or can be neglected).

Recommendation 457 recommends that for modern timekeeping and dating requirements, a decimal day count should be used wherever necessary; the calendar day should be counted from 0000 h TAI, UTC or UT, and be specified by a number with five significant figures.

Although not defined in any standards, it is convenient to use the idea of a local day number which is advanced or delayed by the local time offset and which changes at local midnight.

3.1 Week number

For many commercial purposes, and for planning broadcast programme schedules, it is convenient to work in terms of day of the week, week number and year.

There is an international standard (ISO 2015) for the numbering of weeks. This can be summarized by saying that weeks begin on Mondays, and that week 1 of a year contains the first Thursday of January. The week number can be associated with a day of the week (conventionally, Monday = 1 to Sunday = 7) and a year to specify a particular date. Note that occasional years (about 5 in 28) have 53 weeks, and that the “week-year” of a date in the inclusive range 29 December to 3 January may differ from the “calendar” year. The relation between week number and MJD is given in § 4.

Although the ISO week numbering system is in general use world-wide, other week number systems remain within certain organizations. In some cases, the week number of Monday accords with ISO but the week is taken to run from Saturday to Friday for example. In other cases, even the years containing 53 weeks are different.

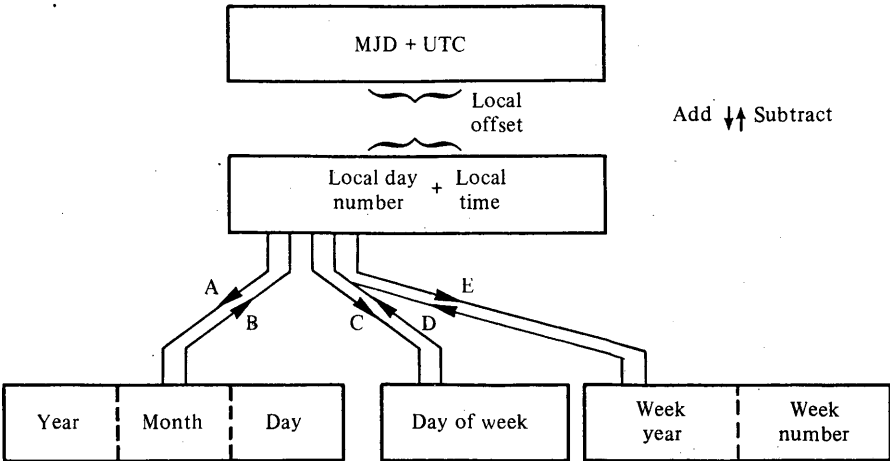
3.2 Calendar date

The various calendar systems in use are well-known and, in most cases, well defined. In these cases, it is possible to generate a formula for conversion between calendar systems, the convenient intermediate standard being the MJD. The information for conversion between MJD and the Gregorian calendar is given in § 4.

Certain calendar systems depend on a suitably qualified person witnessing an event (e.g. the first sighting of a crescent moon, or the sighting of a particular type of fish off a Pacific Island) and these can only be related to the MJD after the event.

4. Conversion between time and date conventions

The types of conversion which may be required are summarized in the diagram below.



The conversion between MJD + UTC and the local day number + local time is simply a matter of adding or subtracting the local offset. This process may of course involve a "carry" or "borrow" from the UTC affecting the MJD. The other five conversion routes shown in the diagram are as follows:—

Note. — These formulae are applicable from 1 March 1900 to 28 February 2100 inclusive.

Symbols used: MJD: Modified Julian Date
 Y: year from 1900 (e.g. for 2003, Y = 103)
 M: month from January = 1 to December = 12
 D: day of month from 1 to 31
 WY: "week number" year from 1900
 WN: week number according to ISO 2015
 WD: day of the week from Monday = 1 to Sunday = 7
 K, L, M', W, Y': intermediate variables
 INT: integer part, ignoring remainder
 MOD 7: remainder (0-6) after dividing integer by 7
 *: multiplication

- A: To find Y, M, D from MJD:
 $Y' = \text{INT}((\text{MJD} - 15\,078.2)/365.25)$
 $M' = \text{INT}((\text{MJD} - 14\,956.1 - \text{INT}(Y' \cdot 365.25))/30.6001)$
 $D = \text{MJD} - 14\,956 - \text{INT}(Y' \cdot 365.25) - \text{INT}(M' \cdot 30.6001)$
 If $M' = 14$ or $M' = 15$ then $K = 1$ else $K = 0$
 $Y = Y' + K$
 $M = M' - 1 - K \cdot 12$
- B: To find MJD from Y, M, D:
 If $M = 1$ or $M = 2$ then $L = 1$ else $L = 0$
 $\text{MJD} = 14\,956 + D + \text{INT}((Y - L) \cdot 365.25) + \text{INT}((M + 1 + L \cdot 12) \cdot 30.6001)$
- C: To find WD from MJD:
 $\text{WD} = ((\text{MJD} + 2) \text{ MOD } 7) + 1$
- D: To find MJD from WY, WN, WD:
 $\text{MJD} = 15\,012 + \text{WD} + 7 \cdot (\text{WN} + \text{INT}((\text{WY} \cdot 1461/28) + 0.41))$
- E: To find WY, WN from MJD:
 $W = \text{INT}((\text{MJD}/7) - 2144.64)$
 $\text{WY} = \text{INT}((W \cdot 28/1461) - 0.0079)$
 $\text{WN} = W - \text{INT}((\text{WY} \cdot 1461/28) + 0.41)$

Example:

MJD = 45218	W = 4315
Y = (19)82	WY = (19)82
M = 9 (September)	WN = 36
D = 6	WD = 1 (Monday)

REPORT 1079

GENERAL CHARACTERISTICS OF A CONDITIONAL-ACCESS BROADCASTING SYSTEM

(Question 37/11)

(1986)

1. Introduction

The present Report presents principles for conditional-access systems worked out by the EBU for application to satellite television by France and the United Kingdom, where the principles have been applied to teletext services. Some details of these applications are given in Table I at the end of the Report.

The principles may also be applied to conventional television and sound broadcasting systems as well as to additional services other than the teletext services listed in Report 802.

2. Components of a conditional access system

There are two distinct and in many cases independent components:

2.1 *Scrambling**

This is the process of rendering a service of no value to unauthorized users by changing certain of its characteristics under the control of the conditional access system at the sending end.

2.2 *Access control**

This is the provision of information to enable authorized users to descramble the service. The availability of this information is controlled by transmitting it in encrypted* form.

3. The requirements to be satisfied by a conditional access system

3.1 *Security*

The security of the system is the degree of difficulty encountered by an unauthorized user in attempting to gain access to the service.

There are two aspects:

- descrambling the signal without reference to the access control process. This is a function of the nature of the services and the scrambling method;
- obtaining the access control key* in an unauthorized manner. This is a function of the security of the algorithms used and the method of key distribution.

3.2 *Access modes*

A conditional access system will be more effective if there is a range of access modes.

Examples are:

- period availability – authorization runs from a starting time to a finishing time;
- programme or service item – availability is for a specific service item, whether or not it is completely used;
- service charge (commonly called “pay per view”) – the charge or use of credit is proportional to the duration of use and/or the value of the service involved.

The access modes need to be variable with respect to several parameters, for example:

- time;
- various segments of the service;
- groups of intended users.

3.3 *Equipment standardization*

To provide maximum economy of manufacturing scale for receiving equipment and to simplify management and maintenance:

- common equipment should be standardized so that it can cater for as many service options as possible;
- the “secret” components should be within a secure module with a standardized interface**.

3.4 *Access management*

The definition of conditional access is based on the formal concept of *entitlement* to access, which can be implemented in various forms. An entitlement gives to its holder an *authorization* to access the related service.

* See Annex I for definitions.

** This subject has already been discussed in the EBU in connection with the specifications for conditional access for the broadcasting-satellite service (BSS) (see Report 1073).

3.5 Avoidance of impairments to the service

Three types of impairment are significant:

- impairment to the finally available service due to the scrambling/descrambling process;
- impairments due to faulty or unreliable acquisition of the access control data;
- uneconomic use of the resources due to the management or transmission overheads involved.

3.6 Interaction with digital processing

It should be noted that certain scrambling processes may conflict with some operations of digital signal processing techniques, for instance bit-rate reduction.

4. General description of a conditional access system

4.1 General

Conditional access requires that the information must be *scrambled* before it is broadcast. This process is under the control of a scrambling sequence obtained from a *pseudo-random generator*.

The descrambling process at the receiving end requires the same sequence (in this case the descrambling sequence) to recover the original signal.

To provide this sequence and to ensure synchronism between the sending and receiving processes, the starting condition of the pseudo-random bit stream generator is controlled by an *initialization word*.

To achieve security, access-related information permitting recovery of the initialization word is transmitted in an encrypted form, according to the access modes in use (see Fig. 1). The detailed structure of this process is given in Fig. 2 and in the following sections.

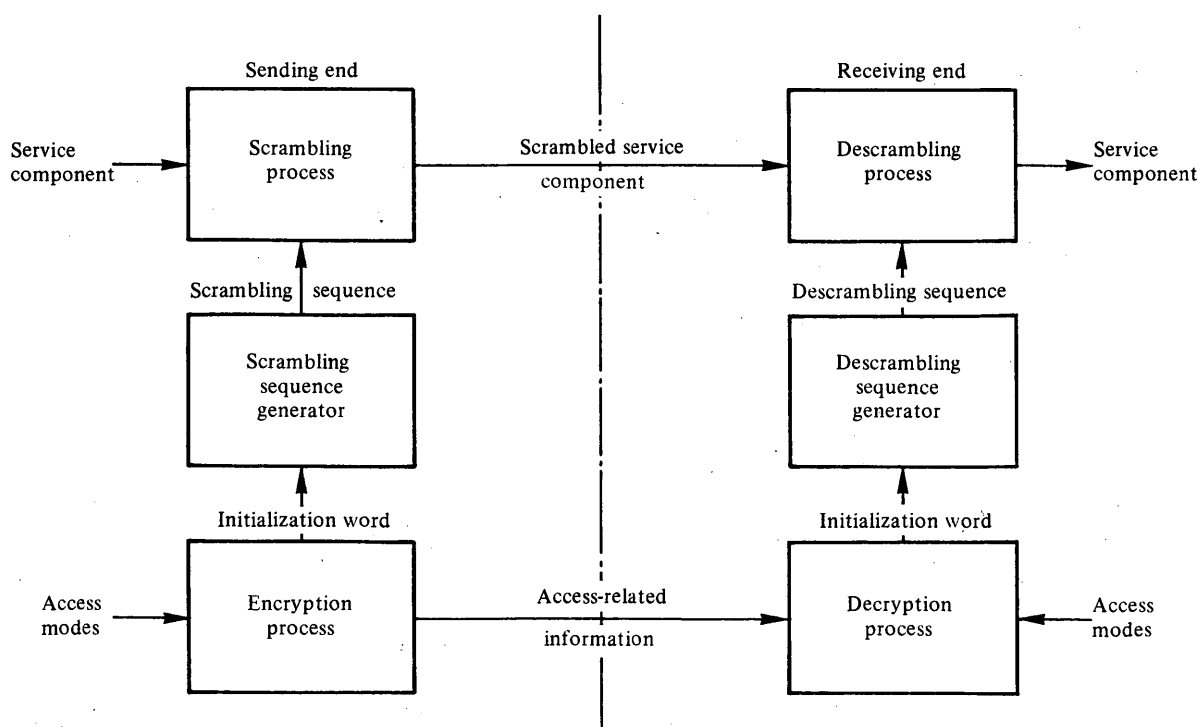


FIGURE 1 – Basic conditional access system

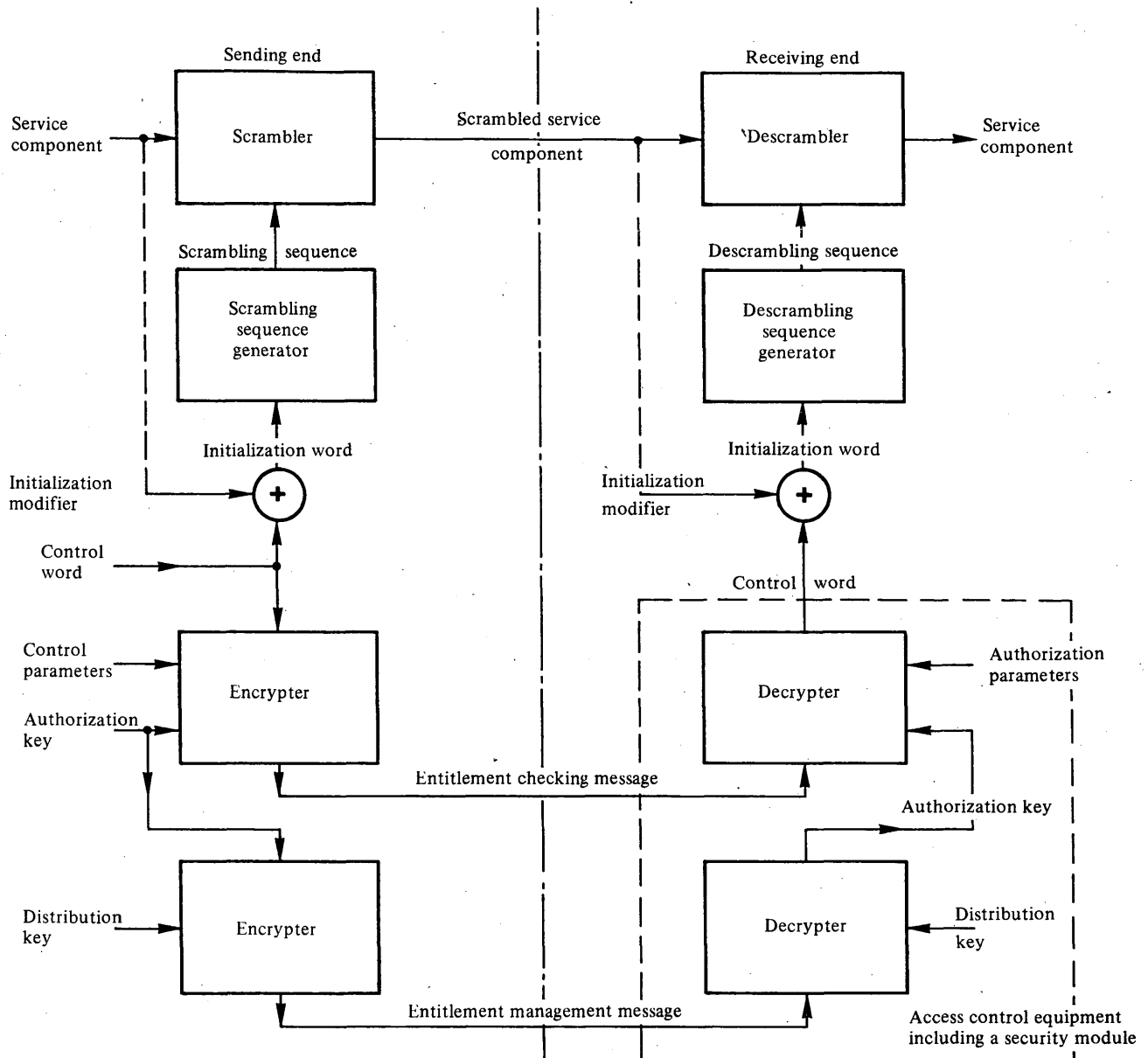


FIGURE 2 – Functional description of a conditional access system

Note. – Two encrypters and decrypters are shown in this figure for clarity. In practice, only one of each may be necessary if the encryption algorithm controlled by the authorization key and the one controlled by the distribution key are the same.

4.2 Initialization word

Conditional access to a service component is in fact equivalent to conditional access to the initialization word, which has two components: the *control word* and the *initialization modifier*.

4.3 Control word

The control word is the basic element of security. Its value is chosen arbitrarily and it may be changed during the service operation to enhance security.

The control word is communicated to the receiver as follows:

- at the sending end, according to the access mode in use, an encryption algorithm supplies encrypted versions of the control word, which are transmitted in special records. These are the *access entitlement checking messages*;
- at the receiving end, the access control equipment applies the inverse algorithm to regenerate the control word.

4.4 Initialization modifier

The initialization modifier is used in order to impose sufficiently short scrambling sequences to provide security, while avoiding the need for too frequent calculation of the control word. Thus, the use of different initialization modifiers for each structural unit of scrambled information causes the initialization word to change sufficiently frequently.

4.5 Control word index

To operate a segmented service, it is necessary to manage several related control words. These are identified by means of *indices*. The control word index used to access a unit of scrambled information must be obtainable from the transmitted signal.

5. Access entitlement checking messages

Each of these messages comprises:

- the control word index;
- a control word change flag: a change of state indicates a change of value of the control word;
- an *authorization pointer* which identifies the authorization key located in the receiver security module to which the message is addressed;
- a *control parameter* which supplies value (e.g. date, price, etc.) for comparison limits set to these values, in the receiver security module, called the *authorization parameters*;
- the encrypted control word.

In order to descramble a unit of information, the receiver must previously have acquired the control word from an access entitlement checking message bearing the appropriate index.

For optimum efficiency, access entitlement checking messages relating to the same control word but corresponding either to different user groups or to different types of access control equipment should be grouped under the same index. Although this is not its only application, the indexing system described above enables the advance transmission of entitlement checking messages.

The conditional access equipment creates a table of active control words which is updated by the access entitlement checking messages independently of the scrambled data. To identify the correct control word, the descrambling device supplies the access control equipment with the corresponding index. The management of this table is a part of the facilities provided at the interface between the descrambler and the access control equipment.

6. Access entitlement management messages

The processing of an access entitlement management message validates or provides the entitlement. This process takes place within the security module associated with a cryptographic calculation involving a *distribution key*. This distribution key is used to encrypt and decrypt messages and/or authorization keys addressed to individual receivers. The corresponding cryptograms constitute the validation signal and are carried as part of the access entitlement management message.

In conditional access broadcasting systems, the access management messages may be broadcast. This is known as “over-air addressing”. The access management messages may, however, also be distributed by other media.

7. Access control equipment

This equipment includes a security module that is supplied with entitlement checking messages. This module may be buried or detachable (for example, smart card). The access control equipment communicates with the descrambler through a physical interface and logic circuits. The standardization of this interface is important in order to permit:

- the independence of the security module and the descrambling function built into the receiver;
- further development of the access control equipment.

If the security module contains an authorization with the same identifier as the authorization pointer in the entitlement checking message, it provides a control word if, in addition, the control parameters fulfil the conditions of the received authorization parameters. These may include:

- a date requirement, with the date in the control parameter falling between the starting and expiry dates in the authorization parameter;
- a price requirement by which an authorization may be provided only if a charge is accepted by the security module.

A transaction involving the security module may include three distinct stages:

- preliminary instructions, if present (e.g. password, user acceptance, etc.);
- operating instructions using the security module;
- result processing (e.g. delivery of control word).

Because a variety of security modules may be used, it would be desirable for the access control equipment to be independent of specific transactions. This independence can be provided if the access control equipment can interpret a sequence of instructions arranged in a specific language and transmitted within specific messages.

8. Applications

Conditional access techniques have been applied to some teletext systems (see Recommendation 653), satellite-broadcasting systems (see Report 1073) and terrestrial broadcasting systems (see Report 802). Some examples are given in Table I.

TABLE 1 — Examples of implementation of a conditional-access system

Reference in this Report	Teletext system A [CCIR, 1982-86, Part I, Chapter 5]	Teletext system B [CCIR, 1982-86, Part II]	MAC/packet family (Report 1073, C-MAC/packet and D2-MAC/packet)
Scrambling process § 4.1	Exclusive-OR combination of the data bytes with the bytes of a pseudo-random generator. An interpretation byte in the header indicates whether the record is scrambled or not. See § 3.1	Exclusive-OR combination of the data bytes with the bytes of a pseudo-random generator. Packet 27 links designate the page as scrambled. See § 20.1	<i>Picture</i> : double cut component rotation or single cut line rotation under the control of a pseudo-random generator <i>Sound</i> : exclusive-OR combination bit by bit of the data bits with the bits of a continuously running pseudo-random generator
Pseudo-random generator § 4.1	Combination of three multi-stage linear feedback shift register. See Annex I	Use of one-way function employing cipher feedback algorithm. See Notes to § 20	<i>Picture</i> : two multi-stage linear feedback shift registers <i>Sound</i> : two multi-stage linear feedback shift registers initializing a further multi-stage linear feedback shift register
Pseudo-random generator synchronization § 4.1	First byte following the first US-X-Y sequence of the record. See § 2.3	First data byte of packet 0 of a designated page. See § 20	Start of each picture frame
Initialization word § 4.2	12 bytes, see § 2.3	56 bits page key. See § 20.1	60 bits
Control word § 4.3	8 random bytes, see § 2.1	56 bits current system key. See § 20.1.3	60 bits being either randomly chosen or a cryptogram of the 256 frames counter
Initialization modifier § 4.4	4 bytes following the record header. See § 2.3	Not applicable	The 8 bits frame-count
Entitlement checking messages (ECM) § 5	Designated records with classification numbers FFF and $Y_{11} = 1$; byte Y_{12} gives the index of the control word. Each message is introduced by the sequence US-3/F-3/F and comprises: — 3 bytes for the authorization pointer — 3 bytes for the control parameter — 16 bytes for the encrypted control word. See § 3.2	Designated packets include 22 bits authorization and control parameters, 112 bits encrypted control word. See § 20.1.3	Packets designated in the service identification channel. The contents of these packets are not specified and are at the free choice of the service provider
Control word index § 4.5	Byte Y_{16} of scrambled record for descrambling and byte Y_{12} of ECM for updating. See § 3.1 and 3.2	Not applicable	Not applicable

TABLE I (continued)

Reference in this Report	Teletext system A [CCIR, 1982-86, Part I, Chapter 5]	Teletext system B [CCIR, 1982-86, Part II]	MAC/packet family (Report 1073, C-MAC/packet and D2-MAC/packet)
Change of control word and flag § 5	Bit b_8 of byte Y_{12} of ECM. See § 3.2	Current and new key words included in a designated packet of the user addressing. See § 20.2	A new control word is transmitted every 256 frames and becomes the current control word when the frame count equals 0
Entitlement management message (EMM) § 6	Entitlement is currently managed by a Videotex system on a telecommunication network. See § 1.3	Entitlement is managed by over-air addressing of receiving equipment using shared and unique user addressing packets. See § 20.2	Packets designated in the SI channel. The contents of these packets is not specified and is at the free choice of the service provider
Access control equipment § 7	Built into the receiver and including a smart card reader. See § 1.3	Built into the receiver or functionally separate at service provider choice	Functionally separated from the other parts of the receiver, by means of an interface to be standardized
Security module § 7	Smart card, with interface proposed for ISO standardization [ISO, 1986]	Built-in or detachable module or smart card	Two solutions are proposed: – the smart card or – a built-in module

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[1982-86]: 11/139 (EBU); 11/307 (France); 11/308 (France); 11/379 (Canada).

ANNEX I

SOME TERMS AND DEFINITIONS RELATED
TO CONDITIONAL-ACCESS BROADCASTING SYSTEMS

Scrambling [in broadcasting] (Embrouillage, aleatorización)

Alteration of the characteristics of a broadcast vision/sound/data signal in order to prevent unauthorized reception of the information in a clear form. This alteration is a specified process under the control of the conditional-access system (sending end).

Descrambling [in broadcasting] (Désembrouillage, desaleatorización)

Restoration of the characteristics of a broadcast vision/sound/data signal in order to allow reception of the information in a clear form. This restoration is a specified process under the control of the conditional-access system (receiving end).

Note 1. — The terms scrambling and descrambling are applicable to both analogue and digital signals.

Note 2. — The terms should not be used to describe processes such as energy dispersal in a satellite system.

Conditional access control

The function of the conditional-access control at the sending end is to generate the scrambling control signals and the "keys" associated with the service.

The function of the conditional-access control at the receiving end is to produce the descrambling control signals in conjunction with the "keys" associated with the service.

Note. — The word "key" is used in the above definitions in a general sense equivalent to that of Question 37/11.

Encryption and *decryption* are terms used for methods which are used to protect (and interpret) some of the information within the "access-related messages" which have to be transmitted from the sending end to the receiving end of the conditional-access control functions.

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[1982-86]: 11/139 (EBU); 11/228 (Working Group on Terminology).

REPORT 1080

INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES
WITH DATA-ENCODED CAPTIONS (SUB-TITLES)

(Question 29/11, Study Programme 29G/11)

(1986)

1. Introduction

This Report considers the methods used in the international exchange of television programmes which contain data-encoded captions (sub-titles).

These considerations relate to the work of Study Group 11 but methods of international exchange include television magnetic tape recording, satellite and long-distance transmission links. It will therefore be necessary to inform the CMTT and Study Group 10 of this work and, where necessary, refer questions to them. Such questions may include the choice of line numbers in the field-blanking interval for captions.

Further information on captions and teletext services can be found in Report 802 and on teletext systems in Recommendation 653.

Usually, the caption data is according to one of the teletext systems although in North America a low-speed method, using Line 21, developed by the Public Broadcasting Service (PBS) [Lentz *et al.*, 1978] is also in widespread use.

These "closed" captions are displayed, at the viewer's choice, with the picture by means of a special decoder associated with the receiver. Captions are usually in the language of the programme and intended as a service to persons with impaired hearing. Captions may be provided in languages other than the programme sound, or in the case of special educational programmes, explanatory text or graphics may be used. The use of captions is expected to increase, especially multi-language captions in the case of direct satellite broadcasting.

Captions are an integral part of the programme. Caption data can be broadcast in the field-blanking interval, either confined to certain lines or included within part of a total teletext package which contains other material not related to the programme.

Methods of caption exchange include the use of several different types of computer floppy discs. The caption data on these discs is related to the programme videotape using the SMPTE or EBU time-and-control code, details of which are available in Reports 630 and 963.

2. Data requirements

It has been reported that for most alphabetic writing systems, the peak data rate needed reaches 130 characters per second, for an unconstrained use of captions in a single language. This allows for the worst-case (infrequent) occurrence of a very long caption immediately succeeding very short captions. A lower data rate would suffice for the majority of captions and would be sufficient for all captions if the inter-caption time could be constrained [CCIR, 1982-86a]. For captions in a single language, one data line per field is more than adequate for any of the teletext systems.

3. Current exchange methods

3.1 *Field-blanking interval data formats*

These methods use a teletext or specific data format in the field-blanking interval of the video signal, which can allow the captions to accompany the programme and be exchanged using videotape or international connection circuits.

The various current uses of the lines in the field-blanking interval are detailed in Reports 314 and 823.

When recording on videotape, consideration should be given to repeating the caption data to reduce the effects of tape drop-out.

3.1.1 *Data using dedicated lines*

According to some current practices, caption data is confined to (a) nominated line(s) and has an exclusive magazine number. The only data on the(se) line(s) is from the caption source. The data can be separated by a line-number-triggered selector or by the magazine number. If there is more than one language, each is identified by its assigned page number.

Use of an exclusive data line 21(334) system [Drake, 1983] for national and international exchange of captioned programmes between Australia and New Zealand has been reported [CCIR, 1982-86b, c]. The captions are in teletext system B format which is operated in the "parallel mode" with an exclusive page number (888 or 801). The system is used for satellite, long-distance links and videotape programme exchange. A "captioned" programme can be received through a link or replayed from a videotape and be broadcast independently of any local teletext system.

3.1.2 *Data using a dedicated teletext channel*

An alternative way of specifically identifying captioned material is through the use of a dedicated teletext data channel, magazine number or page number. This approach makes efficient use of the field-blanking interval in that captioned material can be multiplexed with other teletext data on any available line.

3.2 Longitudinal track data formats

Results of tests carried out on the longitudinal track of a 19 mm (3/4 inch) U-format videotape recorder suggest that a single language could be carried in the user bits of the SMPTE or EBU time-and-control code which normally occupies a single longitudinal sound track. With a higher data rate, additional languages could be carried [CCIR, 1982-86a].

These methods are useful for the exchange of television recordings for programme evaluation (see Recommendation 602) because smaller format VTRs and VCRs will not record teletext type data in the field-blanking interval.

4. Data format standards conversion

Standards conversion may be necessary between the various data formats, often in conjunction with video standards conversion. Experimental conversion between the PBS 0.5 Mbit/s Line 21 system and system B teletext has been reported [Lambourne *et al.*, 1984].

5. The need for standardization

Signals are likely to be partially or completely deleted when carried in arbitrarily assigned lines in the field-blanking period by television recording and distribution equipment. Deletion at points of international connection may also occur. Further problems may arise when new system designs using digital techniques are employed.

Standardization is therefore required to ensure the integrity of the caption data. The designation of lines that would not be subject to deletion, to be used for caption data would avoid this problem.

In addition, it may be desirable to establish preferred operating practices for use with particular systems.

As an example, Annex I describes the practices adopted by Australia and New Zealand.

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[1982-86]: a. 11/330 (EBU); b. 11/366 (Australia); c. CMTT/209 (Australia).

ANNEX I

OPERATING PRACTICE FOR THE EXCHANGE OF CAPTIONED PROGRAMMES USING SYSTEM B TELETEXT BETWEEN AUSTRALIA AND NEW ZEALAND

The following information is provided to facilitate the international exchange of captioned programmes by a variety of methods including videotape and international transmission circuits.

1. Lines 21 and 334 in the television field-blanking interval should be used and other information on these lines should be avoided.
2. Appropriate operating practices should be exercised during editing and replay of videotape to ensure the data is not blanked, clipped or shifted to another line by time base correction or video processing.
3. To overcome corruption due to tape drop-out effects and for the improvement of marginal reception conditions, the data of each sub-title page should be repeated.
4. If data regeneration is used then the data should not be corrupted, line shifted or delayed by more than one TV frame.

5. The data and "control bits" should be set as follows:

5.1 The teletext caption signal is assigned to magazine 8, page 88 (P888) or magazine 8, page 01 (P801).

5.2 Caption page is selected (C6 set to 1).

5.3 An update indicator is sent on each page (C8 set to 1).

5.4 Parallel magazine mode is selected (C11 set to 0). This should present few difficulties where national systems operate in serial mode as the caption data attached to the incoming/outgoing programme will necessarily need to be redirected into/out of the local teletext system where the mode aspect can be reset.

5.5 Care should be taken to overcome special operational problems such as "sticking captions" at the conclusion of a programme segment. A header row with an erase page command (C4 set to 1) sent about a second, before the end of the programme would correct this problem. Additionally, as a clock would be irrelevant in the case of tape relay, the word "CAPTIONS" could be included in the last eight character positions of the header row for convenient user checking.

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SECTION 11C: CONTROL, MEASUREMENT AND INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES

Recommendation and Reports

RECOMMENDATION 472-2*

**VIDEO-FREQUENCY CHARACTERISTICS OF A TELEVISION SYSTEM
TO BE USED FOR THE INTERNATIONAL EXCHANGE OF
PROGRAMMES BETWEEN COUNTRIES THAT HAVE ADOPTED
625-LINE COLOUR OR MONOCHROME SYSTEMS**

(Questions 1/11, 2/11)

(1970-1974-1986)

The CCIR

UNANIMOUSLY RECOMMENDS

1. the video characteristics, given below, for the international exchange of programmes between countries that have adopted 625-line colour or monochrome television systems. In particular, countries that use Systems B, C, D, G, H, I, K, K1 and L will facilitate programme interchange by adopting these characteristics.

Note 1. — The details concerning the line-blanking and field-blanking intervals are listed in the same order and are designated by the same symbols as in Report 624.

Note 2. — This Recommendation is not intended to apply to Standard N.

2. General characteristics

2.1	Number of lines per picture:	625
2.2	Line frequency and tolerance f_H (Hz) ⁽¹⁾	
	— monochrome transmissions:	$15\,625 \pm 0.02\%$
	— colour transmissions:	$15\,625 \pm 0.0001\%$
2.3	Field frequency f_v (Hz):	$(2/625) f_H$
2.4	Picture-frame frequency f_p (Hz):	$(1/625) f_H$
2.5	Gamma of picture signal:	approx. 0.4
2.6	Nominal video bandwidth (MHz):	5, or 5.5, or 6 ⁽²⁾
2.7	Nominal difference between black level and blanking level (as a percentage of the luminance amplitude):	0_{-0}^{+5}

3. Details of line-blanking interval ⁽³⁾

(μs)

(H)	Nominal duration of a line:	$H = 64$
(a)	Line-blanking interval:	12 ± 0.3 ⁽⁶⁾
(b)	Interval between datum (0_H) and back edge of line-blanking signal (average calculated value for information):	10.5
(c)	Front porch:	1.5 ± 0.3 ⁽⁶⁾
(d)	Synchronizing pulse:	4.7 ± 0.2
(e)	Build-up time (10-90%) of line blanking edges:	0.3 ± 0.1
(f)	Build-up time (10-90%) of line-synchronizing pulses:	0.2 ± 0.1

* This Recommendation should be brought to the attention of Study Groups 4 and 9 and the CMTT.

4. Details of the field-blanking interval

(j) Field-blanking period:	25 H $\pm$ a ⁽⁴⁾
(k) Build-up time (10-90%) of field-blanking edges as in (e):	0.3 $\pm$ 0.1
(l) Duration of first equalizing pulse sequence:	2.5 H, or 3 H ⁽⁵⁾
(m) Duration of field-synchronizing pulse sequence:	2.5 H, or 3 H ⁽⁵⁾
(n) Duration of second equalizing pulse sequence:	2.5 H, or 3 H ⁽⁵⁾
(p) Duration of equalizing pulse (one half the value given in (d)):	2.35 $\pm$ 0.1
(q) Duration of field-synchronizing pulse (average calculated value for information):	27.3
(r) Interval between field-synchronizing pulses as in (d):	4.7 $\pm$ 0.2
(s) Build-up time (10-90%) of field-synchronizing pulses as in (f):	0.2 $\pm$ 0.1
- (1) When the reference of synchronism is being changed, the tolerance for colour transmissions may be increased to $\pm 0.01\%$ (see Report 624). Attention is drawn to the desirability of adding to these characteristics a value for the maximum rate of change of line frequency.
- (2) The attention of Study Groups 4 and 9 and the CMTT is drawn to the desirability of subsequently standardizing tolerances for corresponding transmission characteristics applicable to all 625-line systems. For international routine measurements, it is suggested that the test signals be based on a single reference frequency which could be 5 MHz, particularly by countries using systems with nominal video bandwidth of 6 MHz. For example, this suggestion is not contrary to the use of a frequency close to 6 MHz in a multiburst test signal.
- (3) The nominal value of the picture-synchronizing signal ratio is 7/3. For details of permitted tolerances in long-distance transmissions, see Recommendation 567.
- (4) In the blanking interval, lines 16, 17, 18, 19, 20, 21 and 329, 330, 331, 332, 333 and 334 are reserved for the reception of any special signals.
- (5) These values may be subject to revision in the case where a single equalizing pulse system might be adopted (see [CCIR, 1963-66] and Report 626).
- (6) In 625-line countries using teletext system B as specified in Annex I to Recommendation 653, to reduce the possibilities of data loss, the following values are preferred [CCIR, 1982-86a, b]:
- | | |
|-----------------------------|---|
| (a) line-blanking interval: | 12 ^{+0.0} _{-0.3} μ s |
| (c) front porch: | 1.5 ^{+0.3} _{-0.0} μ s |

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[1982-86]: a. 11/365 (Australia); b. 11/376 (Germany (Federal Republic of)).

REPORT 628-3

AUTOMATIC MONITORING AND CONTROL OF TELEVISION OPERATION

(Question 15/11)

(1974-1978-1982-1986)

1. Use of insertion reference signals (IRS) in the television studio complex

1.1 Purpose of insertion reference signals

Study Programme 12A/11 recognizes the possibility of using insertion signals as a reference and certification tool for adjustment of the waveform characteristics of a distorted programme signal, so that the original characteristics of the picture may be restored. Such insertion signals are called "insertion reference signals".

1.2 *Insertion points*

Insertion reference signals are inserted on the video signal at all certification points; that is, at all points where qualified personnel are present who can verify that the technical parameters of the programme signal are correct, and that the content of the programme picture, as seen on a picture monitor, is also correct. The insertion reference signals stay with the programme signal at all times, and may only be erased and replaced at recertification points down-stream (if any).

As an example, the outputs of film and slide scanners, television cameras or vision mixers, etc., can be certification points; at these points technical personnel check that the inserted IRS are undistorted and that the programme signal parameters are correct. In particular, they verify that the level of the programme peak white does not exceed the level of the white bar in the IRS.

1.3 *Correction points*

Automatic correctors that can correct most of the linear distortions of the IRS signals are available on the market. The correctors may be used for instance automatically to correct luminance level, chrominance level, burst amplitude and sync amplitude, etc.

An automatic correction by means of IRS can be effected on the output of the switcher in the continuity suites that feed the television distribution networks; in this way, all signals distributed on the networks conform to the standard and to the artistic intention of the programme director. It should be noted that in the USA particular insertion reference signals (VIR) are fed throughout the television system, down to the user's television receiver, which could incorporate an IRS correction circuit.

Manual correction with IRS may be carried out at recertification points; this occurs in the case of a studio vision mixer that corrects, switches on the output and recertifies a remote signal such as one coming from a film scanner.

IRS may also be used to advantage to make small adjustments in the alignment of television tape-machines when playing programme tapes. The output of television tape-machines can thus be considered to some extent as a correction point.

1.4 *Waveform of the national insertion reference signals*

Many countries believe that the waveforms adopted for IRS should preferably be the same as certain of the waveforms adopted for international insertion test signals (ITS) [CCIR, 1978-82a]. However, it may not be necessary to adopt all the ITS waveforms for certification purposes [CCIR, 1978-82b; Zaccarian, 1978]. Other countries prefer to use a different and much simpler waveform for the insertion reference signal. In any case, it is important to make sure that, at the input to the international distribution network, the IRS are deleted after they have been used to make the necessary corrections. This is in order to ensure that there is no possibility of confusion with ITS which may subsequently be inserted, in accordance with Recommendation 473.

The EBU has recommended [CCIR, 1978-82a] that its member organizations operating with 625-line 50 field television systems and wishing to introduce IRS should employ the signals shown in Figs. 1 and 2 (taken from Recommendation 473), preferably inserted in lines 17 and 330 respectively. If, for reasons of economy, it is desired to use only one of these signals, the signal shown in Fig. 1 should be inserted only in line 17, or alternatively, the signal shown in Fig. 2 should be inserted only in line 330.

In the United States of America the VIR signal is transmitted by all major television networks and is inserted locally by many television stations. A complete description of the VIR signal is contained in an engineering bulletin published by the Electronics Industry Association [EIA, 1982]. The waveform of the signal is depicted in Fig. 3.

2. **Use of insertion test signals (ITS) for the automatic monitoring of television transmitting stations**

During recent years, it has been the custom to design transmitting stations for unattended operation. This has led to a growing demand for automatic measuring systems capable of checking transmitter performance and providing alarms and status information for control stations. This automatic equipment is generally arranged to measure important characteristics of the television signal such as the synchronizing pulses, blanking intervals and the main features of an insertion test signal located in the field-blanking period. The equipment may also check the frequency of the vision and sound carriers and, in some cases, the continuity of the sound channel may be checked by detecting the presence of a super audio pilot signal. In the case of transposers, the insertion test signal measurement results may be regarded as sufficient evidence of correct operation of the sound channel.

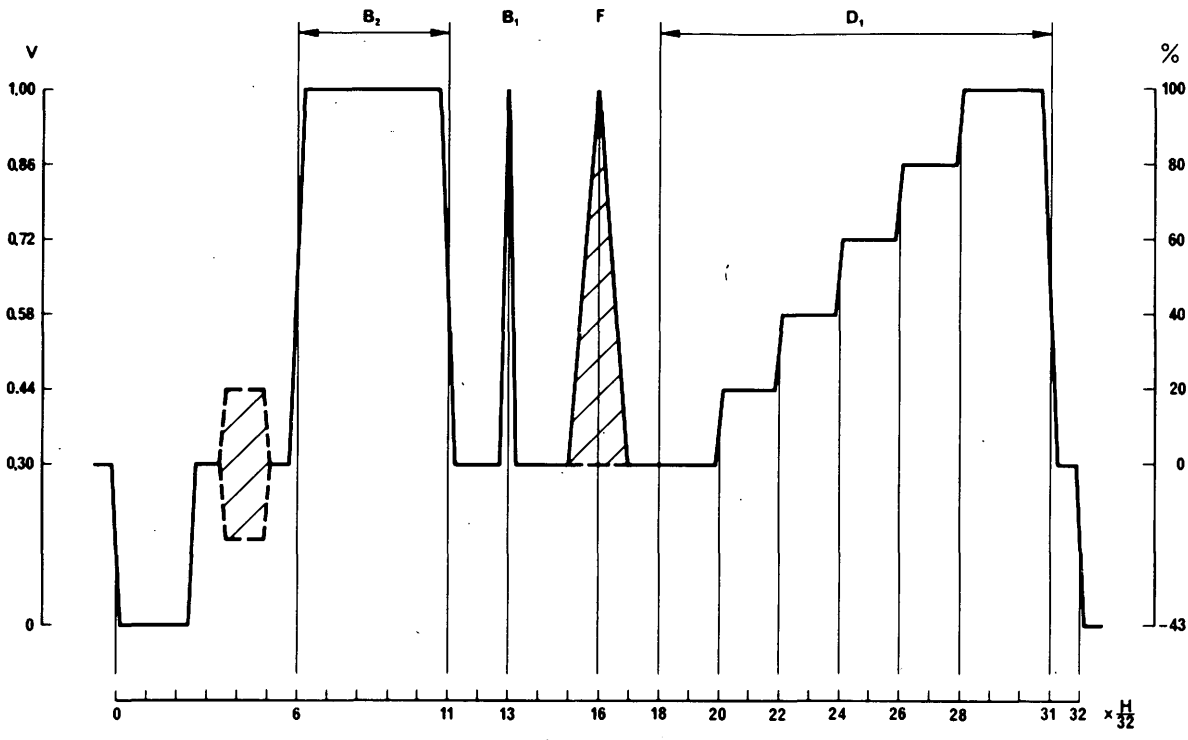


FIGURE 1 — IRS signals recommended by the EBU for insertion in line 17

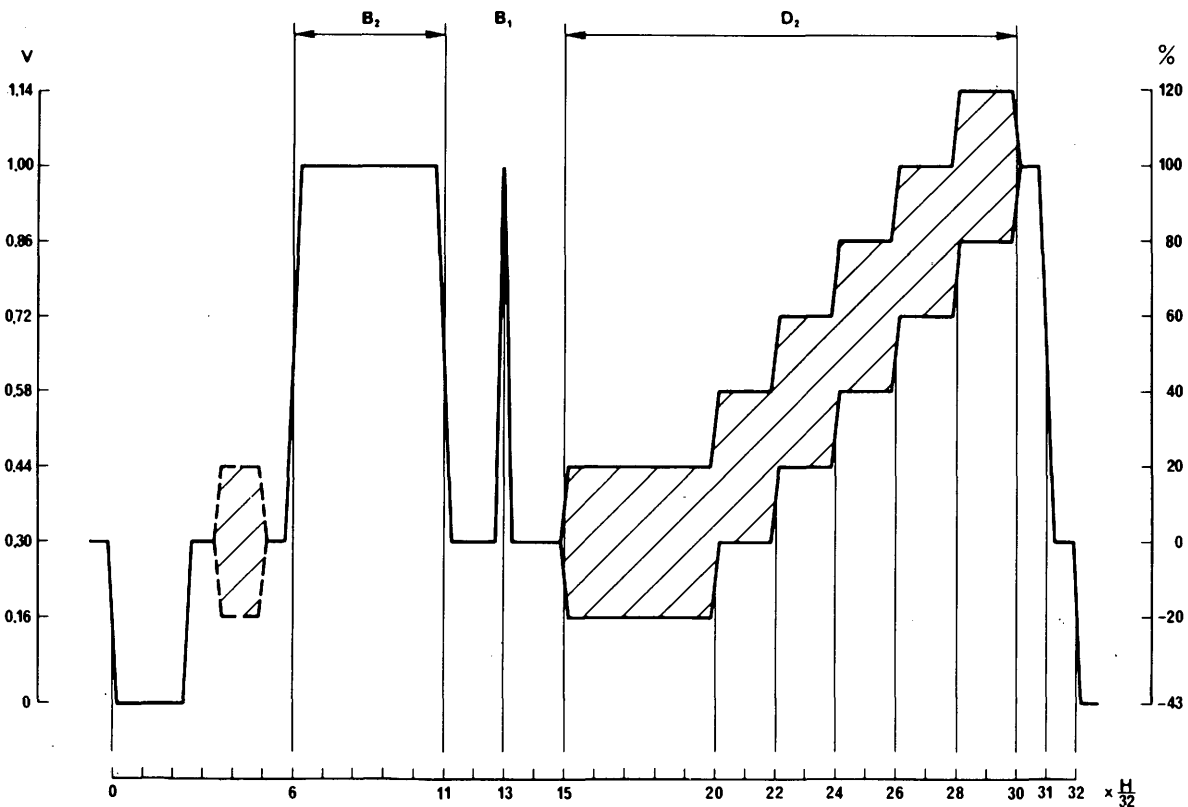


FIGURE 2 — IRS signals recommended by the EBU for insertion in line 330

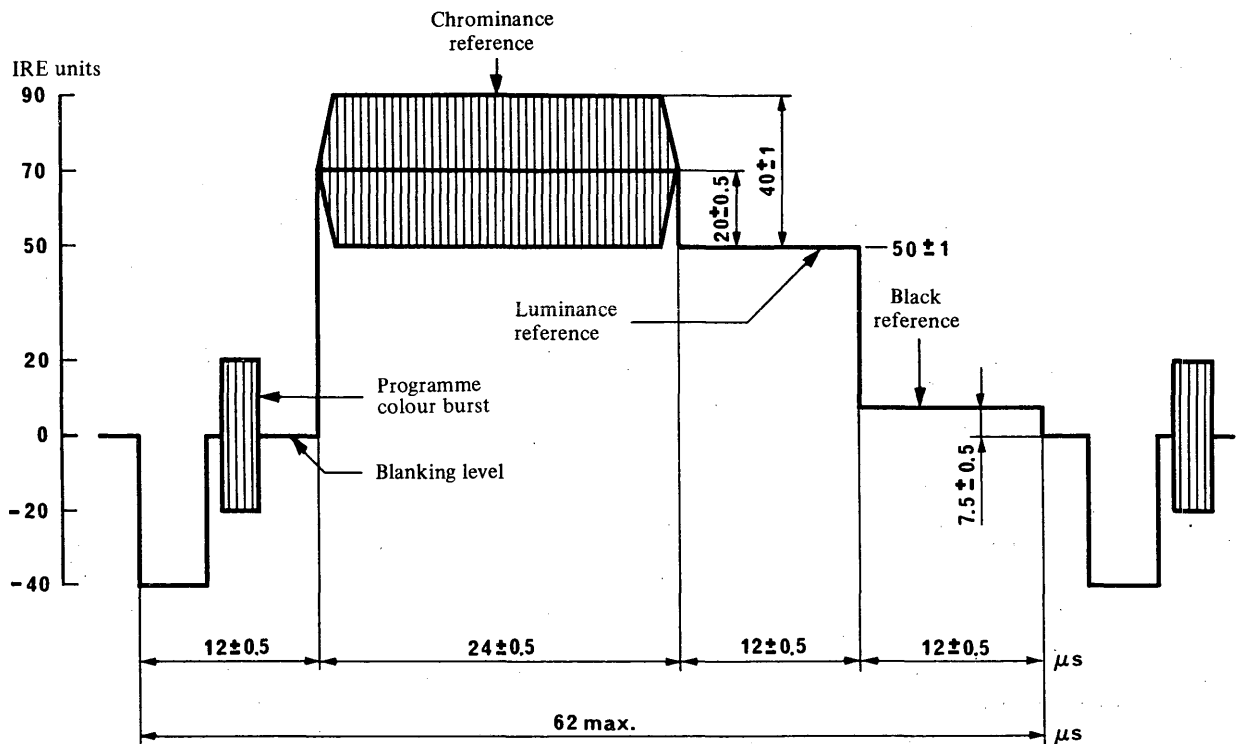


FIGURE 3 – The VIR signal recommended for use in the United States of America

- Note 1.* – The VIR signal is inserted on line 19 of both television fields.
- Note 2.* – Peak-to-peak variation of any nominally constant level: 0.5 IRE max.
- Note 3.* – Luminance transitions rise and fall times (10%-90%): $0.25 \pm 0.05 \mu s$.
- Note 4.* – Chrominance reference rise and fall times (10%-90%): $1.0 \pm 0.25 \mu s$.
- Note 5.* – Chrominance reference phase: same as programme colour burst $\pm 1^\circ$.
- Note 6.* – Chrominance reference harmonic distortion: 1% max.
- Note 7.* – All tolerances are provisional and apply at the point where the VIR is inserted into a programme.

The facilities needed for the automatic monitoring of a network of broadcasting stations may either be located at each of the stations to be monitored, or, in another method, a central master station may employ a more comprehensive system which is able to make measurements by direct reception of the remote stations. While the transmitter is in programme service, it is convenient to monitor the radio-frequency signal by feeding the measuring system from a high quality receiver or demodulator. A similar set of measurements may be needed for the point to point link network which distributes the signal to the main transmitting stations. Both sets of measurements may often be performed by the same operational system which is able therefore to supervise the link networks as well as the transmitters.

The recent emergence of the integrated circuit micro-processor has led to the design of equipment which allows wholly digital measuring techniques to be applied to on-site test line parameter analysis and noise measurement [James and Watson, 1975]. This approach results not only in greater versatility, but affords appreciable economies in both size and cost over comparable analogue measuring equipment capable of taking executive corrective action.

Report 411 discusses automatic methods of measuring and supervising video test signals. The methods described are equally applicable to the monitoring of transmitting stations.

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REPORT 311-6

THE PRESENT POSITION OF STANDARDS CONVERSION

(Question 2/11, Study Programme 2B/11)

(1963-1966-1970-1974-1978-1982-1986)

Although early methods of standards conversion involved electro-optical image transfer techniques, methods of conversion which do not require the use of the image-transfer method have been developed, and are employed in the United Kingdom and in Japan. These are field converters for both monochrome and colour television which, in the past, used ultrasonic delay lines as the storage medium.

Work in the United Kingdom and in Japan has led to the successful development of digital field converters, employing stores based on dynamic shift registers or random access memories having the capacity to store two, three or four fields. These digital converters are now in wide use at earth stations and broadcasting centres throughout the world. Operations with these equipments have confirmed that converters of this type can be relatively small in size, and are likely to prove very stable in service and economic in terms of running costs. In general, they include far fewer pre-set and operational controls than corresponding analogue equipments. The performances of the digital equipments are noticeably better than that of previous converters and the signal-to-noise ratio at the output can be significantly better than that at the input.

A new standards conversion algorithm has been developed [CCIR, 1982-86a] which uses a position interpolation technique for frame rate conversion in addition to the conventional linear interpolation in order to solve the problem of motion judder. This algorithm was successfully applied to a standards converter from 1125/60 to PAL in order to meet the requirement that the high-definition television should be converted to the existing television systems keeping a quality essentially equivalent to that of those systems.

The results of the subjective test for the output picture quality of this converter carried out by several broadcasting organizations show that the quality difference between the converted pictures and the direct PAL pictures is small. It is believed that a quality essentially equivalent to PAL quality will be possible within a reasonable period of time [CCIR, 1982-86b].

The conversion algorithm used in this converter can be applied not only to the conversion between the existing television systems but also to the conversion between television systems and film systems.

A considerable amount of work on the design and production of converters has been carried out in several countries. For the benefit of workers in this field of activity, a bibliography follows.

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REPORT 804

DEFINITIONS OF PARAMETERS FOR AUTOMATIC MEASUREMENT OF TELEVISION INSERTION TEST SIGNALS

(Question 15/11, Study Programme 15D/CMTT)

(1978)

At the Interim Meeting of the CCIR, Geneva, 1976, the need for definitions of parameters for automatic measurement of insertion test signals (Recommendation 473) was recognized. At that time a draft text for such a Recommendation was prepared by the CMTT and contributions were invited from all administrations on the application of those definitions.

The CMTT at their meeting in 1977 adopted a revised text specifying a set of parameters in the form of Recommendation 569. It is believed that it would greatly simplify operational procedures if a unified set of parameter definitions could be adopted for use on point-to-point links, transmitters and studio signals. It is, therefore, desirable that the set of definitions given in the CMTT Recommendation should be used in the studio and transmitter areas. Further contributions are needed on the application of these parameter definitions at all points in the studio and transmitter chain.

REPORT 477-2

TRANSCODING OF COLOUR TELEVISION SIGNALS FROM ONE COLOUR SYSTEM TO ANOTHER

(Study Programme 2A/11)

(1970-1978)

The different colour systems now being used on the various 625-line television standards require, for international exchange of colour television programmes, that, when the colour television system employed in the originating country differs from that of the receiving country, a means be provided of changing the colour television system. Since no change of line or field frequency is necessary but only a change in the coding of the colour information, the process for effecting this change has been given the name of "transcoding".

A considerable amount of work on the design and production of transcoding equipment has been carried out in several countries. For the benefit of workers in the field of activity, a bibliography follows.

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REPORT 1081

**SYNCHRONIZATION NECESSARY FOR THE SATISFACTORY RECEPTION
OF SOUND AND PICTURE SIGNALS**

(Question 35/11)

(1986)

1. Introduction

Loss of time relationship between sound and picture can occur in two principal areas:

- where picture processing equipment, such as synchronizers, standards converters, digital production effects units, etc., introduces delay in the picture signal, without similar delays to the associated sound signal;
- where sound and picture are sent over separate circuits, particularly if one circuit is terrestrial and the other satellite.

2. Effects of variations in the relative timing of sound and picture

Studies have been made in Australia [CCIR, 1982-86] into the effect of varying the relative timing of sound and picture. These studies indicate that when the sound is advanced with respect to picture by $\frac{1}{2}$ picture frame, the error is detectable, and when advanced by 1 picture frame, it is subjectively annoying with critical material.

Where the sound is delayed with respect to the picture, the effect appears to be less critical. A delay of 1 picture frame is detectable, but a delay of up to 4 picture frames can be tolerated.

These results compare with those reported in Report 412.

3. Methods of adjustment

In analogue sound systems, there is no timing reference which can be used to adjust the relative timing between sound and picture. Therefore, once the timing relativity is disturbed, the realignment can be done only by subjective judgment, for example, synchronizing speech with lip movement.

Where sound and picture are carried over separate circuits, it is desirable to obtain alignment by using suitable test signals which can serve the same function as the clapper board in the film industry.

Where the timing relationship is disturbed because of the introduction of video processing equipment during actual programme production, accurate correction is difficult at the receiving end. A programme producer or an intermediate organization may have facilities to measure the delay introduced in the picture signal path and be able to add equipment delay in the sound signal path.

4. Accumulation of delays

In longer circuits involving several organizations, it is not uncommon for small delays to be introduced by each organization. While each individual delay may be acceptable, the cumulative error can become excessive. Moreover, when a programme is compiled from different segments received from different origination points each having different relative timing errors, subsequent retiming is impractical.

5. Conclusion

It is important that the relative timing of sound and picture be preserved within reasonable limits to avoid unacceptable impairment to the programme. It is desirable that each organization processing the signal ensures that the timing is correct at the point of exchange.

Australian experience suggests that a maximum tolerance of +1 frame to -4 frames for sound relative to picture should be maintained. However, for critical programme material, it should be possible to adjust the sound delay to within +1 frame to -2 frames of the picture signal.

Modern picture processing units that produce delays often generate data relating to the delay. This data can then be used to automatically adjust sound delay units.

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SECTION 11D: PICTURE QUALITY AND THE PARAMETERS AFFECTING IT

Recommendations and Reports

RECOMMENDATION 500-3

METHOD FOR THE SUBJECTIVE ASSESSMENT OF THE QUALITY
OF TELEVISION PICTURES

(Question 3/11, Study Programmes 3A/11, 3B/11, 3C/11)

(1974-1978-1982-1986)

The CCIR,

CONSIDERING

- (a) that a large amount of information has been collected about the methods used in various laboratories for the assessment of picture quality;
- (b) that examination of these methods shows that there exists a considerable measure of agreement between the different laboratories about a number of aspects of the tests;
- (c) that the adoption of a single standardized method is of the greatest importance in the exchange of information between various laboratories;
- (d) that routine or operational assessments of picture quality and/or impairments using a five-grade quality and impairment scale made during routine or special operations by certain supervisory engineers, can also make some use of certain aspects of the methods recommended for laboratory assessments,

UNANIMOUSLY RECOMMENDS

that the general methods of test, the grading scales and the viewing conditions for the assessment of picture quality, described in Annex I should be used for laboratory experiments and for operational assessments whenever possible.

ANNEX I

METHOD FOR LABORATORY ASSESSMENT OF PICTURE QUALITY

1. Introduction

Before giving details of the method, it should be remarked that the ultimate purpose of tests is to discover the acceptability of some impairment whose complete elimination may be uneconomic to achieve. Although in a normal television audience there will be some "expert observers"*, the proportion of them is thought to be so small that it is proper to concentrate the objective of the laboratory tests on the opinions of non-experts, because the use of experts could lead to results which are much more critical than would be obtained with normal television viewers. The philosophy which leads to preference being given to the opinions of non-experts is also applied to the choice of test pictures and viewing conditions which are chosen to be more critical than average but not unduly so. As tests with non-expert observers tend to be lengthy, it is often desirable that a quick test should be carried out by experts. In this case, a smaller number of observers can be used. However, it should be noted that in certain circumstances tests carried out with expert observers may not be a satisfactory substitute for tests carried out by non-expert observers [CCIR, 1963-66]. In cases of doubt, the relationship between expert and non-expert opinion should be investigated.

The statistical design of experiments has been well considered and documented; the amount of data which needs to be collected depends upon such interrelated factors as the confidence level which is needed in the answer, the standard deviation in the measurements, and the relative magnitude of the effect which it is required to detect. The following suggestions are intended as guide lines to assist in formulating a considered experimental assessment programme**.

* The term "expert observers" is considered to apply to observers who have had recent extensive experience in observing picture quality or impairments, particularly of the type being studied in the subjective test.

** Report 405 gives detailed information on the application of these guiding principles. Recommendation 600 also contains some additional information relating to specific applications.

2. Details of the method

2.1 Observers

Observers may be either expert or non-expert.

Normally, the experiments should be carried out with non-expert observers (see Introduction). These observers should be appropriately introduced to the test method, the grading scale and the impairments or processes to be assessed. Remarks likely to influence the rating should be avoided.

The number of observers should be at least ten, and preferably about twenty. In all cases, the number and type of the observers, as well as the details of their introduction to the test should be specified.

2.2 Grading scales

The five-grade scales are listed in Table I. It is important to restrict the definitions of the grades to those given in Table I; according to the nature of the problem it may be more appropriate to use a quality scale or an impairment scale.

TABLE I

Five-grade scale	
Quality	Impairment
5 Excellent	5 Imperceptible
4 Good	4 Perceptible, but not annoying
3 Fair	3 Slightly annoying
2 Poor	2 Annoying
1 Bad	1 Very annoying

It is recommended that results should be presented in the form given above although it is recognized that, to suit local practices, some laboratories may wish to invert the order of the numbering or to replace the numbers with letters when an experiment is being carried out.

The scale which has been used, that is, an impairment or a quality scale, should always be quoted along with the results of an experiment.*

For certain types of experiment, a comparison scale is more convenient than a quality or impairment scale; in such cases the scale of Table II is recommended:

TABLE II - Comparison scale

+3	Much better
+2	Better
+1	Slightly better
0	The same
-1	Slightly worse
-2	Worse
-3	Much worse

* In view of the large number of documented results which have been obtained using six-grade scales, it is desirable to have a means of transforming results so that these data can still be used. Uncertainties arise in attempting to transform results obtained from one scale into another scale, particularly arising from definitions of the grades. However, as a first approximation, the following linear relationship can be used to transform a mean value A_6 obtained in an experiment using a six-grade scale (Report 405, Notes 7 and 9) into a corresponding mean value A_5 in the five-grade scale:

$$A_5 = 5.8 - 0.8 A_6$$

2.3 Test pictures

About five still pictures and/or sequences including moving subject matter, as appropriate, should be used. Normally, these should be pictures that are more critical than average pictures, but not unduly so, taking into account the specific assessments being made. For example, certain effects are best evaluated by using scenes containing bright saturated colours viewed by colour cameras. Other effects may dictate the use of sharp, contrasted edges, detailed areas and/or de-saturated colours with a low level of brightness. In assessments where the effects of movement do not cause specific impairments the use of still pictures should be preferred. However, test patterns should not normally be included. The visual scenes and the signal sources used should be described in the presentation of the results.

2.4 Viewing conditions

The preferred viewing conditions are affected by the field frequency of the television system. Table III shows the conditions for systems with 50 and 60 fields/s.

TABLE III

Condition	Field frequency	50 fields/s	60 fields/s
<i>a</i>	Ratio of viewing distance to picture height	6 ⁽¹⁾	4 to 6 ⁽²⁾
<i>b</i>	Peak luminance on the screen (cd/m ²)	70 ± 10 ⁽³⁾	70 ± 10
<i>c</i>	Ratio of luminance of inactive tube screen (beams cut off) to peak luminance	≤ 0.02	≤ 0.02
<i>d</i>	Ratio of the luminance of the screen when displaying only black level in a completely dark room, to that corresponding to peak white	approximately 0.01	
<i>e</i>	Ratio of luminance of background behind picture monitor to peak luminance of picture	approximately 0.01 ⁽⁴⁾	approximately 0.15
<i>f</i>	Other room illumination	low ⁽⁵⁾	low
<i>g</i>	Chromaticity of background	white ⁽⁶⁾	D ₆₅
<i>h</i>	Ratio of solid angle subtended by that part of the background which satisfies this specification, to that subtended by the picture	≥ 9	

⁽¹⁾ Normally 6; if a different ratio is used, this should be stated.

⁽²⁾ In the United States of America the average viewing distance in the home is approximately ten times picture height (300 to 340 cm) [Nathan *et al.*, 1985].

⁽³⁾ Normally (70 ± 10) cd/m², or (220 ± 30) asb ⁽⁷⁾, but certain tests may require luminances outside the tolerances, for example, because of flicker, defocusing, etc.

⁽⁴⁾ If the ratio is greater than 0.1, the chromaticity has to be nearer to Illuminant D₆₅ ⁽⁸⁾.

⁽⁵⁾ The specification is loosely phrased here, since the precise value is not critical, provided it does not conflict with condition *c*.

⁽⁶⁾ Not very critical. Any white in the region between standardized illuminants A and D₆₅. See, however, Note ⁽⁴⁾.

⁽⁷⁾ 1 apostilb (asb) = $\frac{1}{\pi}$ candela per square metre (cd/m²).

⁽⁸⁾ Illuminants standardized by the International Commission on Illumination (CIE); see International Electrotechnical Vocabulary, Group 45, No. 45-15-145.

2.5 *Presentation*

The pictures and impairments should be presented in random sequence with the proviso that the same picture (i.e. test scene or sequence) should never be presented on two successive occasions with the same or different levels of impairment.

When using the quality or impairment scale, the range of impairments should be chosen, wherever practicable, so that all grades are used by the majority of observers; a grand mean score (averaged over all judgements made in the experiment) close to 3 should be aimed at, to standardize results.

A session should not last more than roughly half an hour, including the explanations and preliminaries; the test sequence could begin with a few pictures indicative of the range of impairments; judgements of these pictures would not be taken into account in the final results.

2.6 *Choice of test procedure*

In the conduct of a laboratory subjective assessment, the details of the procedure used, including the choice of grading scale, must remain at the discretion of the experimenter. However, if the results are to be compared with those of other experimenters, the details of the procedures used should, in principle, be identical and, in practice, the differences should be minimal. This desirable move towards rationalization of the methods for subjective assessment should be considered having regard to the essential properties of such methods, namely, validity, reliability, sensitivity, identification of bias and convenience of application.

A few procedures which have become well established, being successfully used in different laboratories, are compared in summary form in Table IV. The choice of procedure for a particular test will depend on the purpose of the test; for example, the best procedure for an experiment aimed at rank ordering digital codecs will be different from one aimed at establishing protection ratios.

Appendix I gives details of the main features of the most frequently used procedures, supplementing or modifying the requirements of § 2.1 to § 2.5 and providing some guidance on the choice of test procedures.

3. **Analysis and presentation of results**

Under study. Annexes II and III to Report 405 summarize the present state of the studies.

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TABLE IV — Preferred procedures and their applications

Short name	Single-stimulus, quality	Single stimulus, impairment	EBU	Double-stimulus	Comparison scale	Two level anchoring
Source	Prosser <i>et al.</i> [1964]	Recommendation 600	Bernath <i>et al.</i> [1981]	White and Allnatt [1980]	Corbett [1974]	CCIR [1978-82]
Scale	5-grade quality	5-grade impairment	5-grade impairment	Continuous quality	7-grade comparison (of quality)	5-grade quality
Reference picture	None	None	Identified	Not identified	Not identified	None (indirect referencing)
Desired grand mean score	3 ⁽¹⁾	Not investigated	3	No requirement	Not applicable	No requirement
Application	General purpose	Protection ratios	General purpose	Where range and/or absolute values of impairment magnitude are small	Rank ordering	General purpose
Criterion	Quality	Annoyance and/or perception threshold	Annoyance and/or perception threshold	Quality	Quality	Quality

⁽¹⁾ This desideratum can be relaxed where the absolute subjective magnitude is not important.

APPENDIX I

CHOICE OF TEST PROCEDURE

This Appendix supplements the requirements of § 2.1 to § 2.5 by providing details of test procedures which are being successfully used in different laboratories and, where appropriate, indicates the types of tests for which each is most suitable. Features common to most of the procedures are described first and then the details of the procedures which differ are given.

When presenting the results of a subjective test, the procedure used should be identified and information provided on the number and type of observers, choice of test pictures, type of reference signals (if used), viewing ratio (if other than $6H$), etc.

1. Observers

Non-expert observers are preferred although the use of experts is not precluded. It is however essential not to pool the assessments of experts and non-experts unless statistical tests have shown that the two sets of results do not differ significantly.

In general, observers should be screened for visual acuity and (except for monochrome tests) for colour vision using special test charts; they should have normal colour vision and normal or corrected-to-normal visual acuity [CCIR, 1982-86].

2. Test environment

The test should be conducted in an environment which is free from visual and auditory distractions. A viewing room, three sides of which are draped in gathered white curtains, with the fourth side (to the rear of the observers) draped in grey curtains, is preferred. Low-level ambient illumination with a colour temperature of about 6500 K should be used (see also § 2.4).

3. Test equipment

The performance of the basic test channel should be of the best possible quality. When a reference picture (declared or undeclared) is used in the test, it should be of the highest quality appropriate to the system under test. It may be formed from R , G , B , or Y , $(R-Y)$, $(B-Y)$, component signals, or composite colour video signals that have been coded only once, as appropriate. However, the same reference standard should be used throughout a session.

Information on the alignment of picture sources and displays is contained in Annex VII to Report 405.

4. Test pictures

For tests using still pictures, the EBU has selected nine 35 mm slides (available from the EBU) primarily intended for digital studies, from which most of the test material can be drawn. This does not preclude the use of other picture material as indicated in § 2.3. Sequences of moving pictures, essential for the assessment of certain kinds of impairment, are still under study.

5. Viewing conditions

The setting-up of picture monitors to comply with the viewing conditions of § 2.4 can be aided by the use of the PLUGE test signal, about which more information is given in Annex VII to Report 405.

6. Presentation

At the start of a test session observers should be introduced to their task and the grading system to be used by means of a neutrally worded pre-recorded announcement accompanied by examples which the observers should be asked to rate. The choice of pictures and impairments in the examples differs slightly in the different procedures.

The randomized presentation of pictures and impairments, § 2.5, may be based on a randomized-block design, derived from Graeco-Latin squares [Fisher and Yates, 1970] to evenly balance the effects of all factors over the experiment as a whole. Where the desired structure does not permit a complete balance, an important requirement is that it should be possible to assess any adaptation effects in the observers that occur during both the preliminary demonstrations and the main part of the experiment.

7. Grand mean score

The requirement for a grand mean score close to 3, which is given in § 2.5, only applies to the procedures in § 8.1 and § 8.2 of this Appendix. In the other procedures it is of less importance.

In the procedures of § 8.1 and § 8.2, if the grand mean score actually achieved in an experiment falls outside the range 2.92 to 3.08, consideration should be given to repeating the experiment with suitably modified impairment levels.

8. Brief details of procedures

8.1 *Single-stimulus procedure using quality grading scale*

This procedure is essentially that of [Prosser *et al.*, 1964] and employs the five-grade quality scale.

It is primarily intended for the assessment of impairments over a full range of subjective magnitudes. Although it can be employed with smaller ranges, it is known [Corbett, 1970] that the rating standards employed by observers may then be different. One possibility of dealing with restricted-magnitude impairments which has been shown to be viable is to “embed” the test impairment(s) among a number of other impairment conditions, similar in character but with the preferred full range of magnitudes.

At the start of each session, recorded instructions are given, observers being asked to rate the quality of each picture condition in turn, using the following 5-grade quality scale:

- A (Excellent)
- B (Good)
- C (Fair)
- D (Poor)
- E (Bad)

Generally the scale has been used to rate overall picture quality, but it can also be used for other characteristics, e.g. the quality of legibility [White, 1980; 1981].

No numbers are associated with the grades on the record sheets used by the observers. The scale is illustrated, in the form shown above, at the top of each sheet. Observers record each opinion by ticking the appropriate square of a matrix, in which the rows are labelled A to E, and the columns correspond to the successive picture-conditions that are displayed, termed “presentations”. Two such matrices, catering for a total of 40 presentations, are conveniently contained on one side of an A4 sheet together with the grading scale.

For recording observers’ opinions, use may also be made of forms designed with a view to facilitating data preparation for computer input.

A number of demonstration pictures containing impairments typifying those to be assessed are first presented. They can, if desired, be selected from among the picture conditions in the test proper. It is pointed out that these preliminary demonstrations typify what is to be seen in the test itself but do not necessarily cover the full range of conditions. Observers rate the demonstrations but these assessments are not included in the main analysis.

Where the experiment is of a suitable type, the observers are offered as long as they wish to form their opinions. Normally 10 s is found sufficient for the display of each picture condition, irrespective of whether the pictures are stills or moving sequences. Pictures are removed for about 15 s between successive presentations, while observers record their opinions. Thus the experiment may proceed at a uniform rate. If there are more picture conditions than can be dealt with at a single session lasting about half an hour, observers may be recalled on subsequent days for up to three further sessions. It is often preferable to employ completely fresh observers, if these are conveniently available.

8.2 Procedure using the impairment scale and a reference picture (EBU method)

The EBU requiring directly comparable results from different laboratories on subjective quality assessments has agreed a method using the 5-grade impairment scale (Table I) and a reference picture. It was designed mainly for the assessment of digital television pictures but is not restricted to this application. The use of a reference is to give better precision (i.e. standard deviation) for low impairment situations and the use of the impairment scale is to obtain a direct measurement of the perceptibility threshold as well as larger impairment magnitudes.

The method is described in more detail in [Bernath *et al.*, 1981]. The general principles were drawn from [Sallio and Kretz, 1978].

Each session corresponds to a sequence of presentations. The first session is a preliminary “warm-up” session, the results from which are later ignored. A presentation uses the same picture, and has four phases: the reference picture period of 10 s, a mid-grey separation period of 3 s, the test condition period (10 to 15 s, depending on the complexity of the impairment to be assessed) and a mid-grey period of 10 s for voting. Voting is limited to the last period. Each test presentation is given twice in each test session to check the coherence of each observer. The test pictures and impairment conditions are in a random order which changes from session to session, but avoid two successive presentations with the same visual scene. In a session, the reference picture is assessed twice, as a test condition.

The total session does not last more than 30 min and the same observers have at least a half-day gap between two sessions. The two votes obtained on the same test condition and picture by the same observer which differ by more than two grades are omitted. If more than 15% of the assessments for a test condition are so omitted, then it is stated (but generally it is not more than 5%). Results are presented separately for each viewing distance, picture, etc., unless quite unnecessary. For each test parameter, the mean score and the standard deviation of the subjective assessment are stated.

8.3 Double stimulus procedure using pairs of continuous quality-rating scales

This procedure was announced in [White and Allnatt, 1980]. It is intended for use in tests with a limited range of impairment magnitudes, and in particular where the impairments are very small, as in digital codecs of good quality. It avoids the efforts and expense of obtaining results having no particular application, when the “embedding technique” (see § 8.1) is used with the single-stimulus quality-grading procedure.

The procedure invokes the concept of comparison with an unimpaired picture, but defers *explicit* comparison until the analysis stage. One condition in every pair is always the unimpaired reference picture, but its position is changed in quasi-random fashion and observers are not told which of the two it is. The observers rate each picture individually on an absolute scale. Although they are able to make comparisons between each pair of pictures if they wish, they are not asked to do so. It is because the picture conditions are assessed in pairs, that the procedure is termed a double-stimulus procedure.

As any improvement in precision due to the availability of a reference condition would be reduced by quantizing error if any of the grading scales of § 2.2 were to be used, a continuous quality-rating scale is used. The scale has been arranged to resemble the existing quality-grading scale (Table I) as closely as possible. The score sheet contains pairs of such scales each 100 mm high, spaced 10 mm apart, the space between the members of each pair being 5 mm. The appropriate definitions (excellent, good, fair, poor, bad) appear only on the left of the first scale. For more information see [Macdiarmid and Darby, 1982]. Observers register their opinions by marking the scales in order, corresponding to successive picture conditions.

The desideratum, expressed in § 2.5, that the grand mean score should be close to the value at mid-scale does not apply.

Two satisfactory variants of the procedure have been described. In the first [White and Allnatt, 1980], each observer attends separately, and is allowed to switch instantaneously between the two picture conditions until he is satisfied that he has established his opinion of each. In the second [Macdiarmid and Darby, 1982], the observers attend in small groups and, prior to recording results, each pair of conditions is shown three times to enable observers to assess quality and identify differences. Then, each pair of conditions is displayed twice while results are recorded. Each individual picture is displayed for 3 s with instantaneous switching between conditions. The total time required to obtain each pair of test results is therefore 30 s. Which of the two variants should be used is a matter of convenience.

8.4 Procedure using the quality scale with high and low indirect anchoring*

This method [CCIR, 1978-82a] is intended to give indirect anchoring at both ends of the scale. It uses a number of unimpaired pictures, and a number of heavily degraded pictures which are presented and judged during the test in the same way as the other pictures. The anchoring effect is only indirect because the observers are not informed of the presence of the top and bottom reference pictures.

As indirect anchoring is applied at both ends of the scale, the full range of impairments of § 2.5 need not be used in a given session nor is it necessary to standardize the grand mean score. A complete experiment should be arranged as follows:

- in order to keep the time required for sessions as short as possible, not more than 2 or 3 values of the distortion to be investigated should be tested in the same session. So several sessions are usually needed for the complete experiment and for each session it will be better to use a new group of observers;
- for each value of the distortion a group of 5 or more pictures should be chosen;
- two groups of 4 or more pictures each, to serve respectively as high quality and low quality references, should be chosen as well;
- the impairment used for the low quality reference must correspond to a score of approximately 1.5. The addition of white noise at the level of 19 dB S/N ratio could be used for the purpose;
- the usual precautions should be taken during the presentation (random sequences, etc.);
- [CCIR, 1978-82b] suggests avoiding repeated use of the same picture several times in the course of the presentation, in order to keep biasing as low as possible.

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CCIR Documents

- [1978-82]: a. 11/357 (Italy); b. 11/322 (Italy).
 [1982-86]: 11/328 (USSR).

* Some form of anchoring is always implicit in all the procedures in the sense that it is necessary to standardize the rating process. "Indirect" corresponds to standardizing the adaptation phenomena [Corbett, 1970] by means of the range of impairments in a test session.

REPORT 405-5

SUBJECTIVE ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(Question 3/11, Study Programmes 3A/11, 3B/11)

(1966-1970-1974-1978-1982-1986)

Recommendation 500 proposes a method for subjective assessment of the quality of television pictures and provides a partial answer to Study Programme 3A/11. However, as many results of subjective experiments which have been carried out in different countries using different methods are already available and in use, it is considered important that the details of the grading scales and methods of test employed should remain on record. This information is summarized in Annex I.

In order to facilitate the comparison of results among different laboratories it would be useful to list the types of experiments for which the different scales (that is quality, impairment and comparison) are best used.

Study Programme 3A/11 calls for studies on the analysis and presentation of the results of subjective tests. Contributions have been received on this topic from a number of administrations and Annex II lists and summarizes these contributions.

Annex III is an example of one such method. Administrations are invited to provide further contributions on all aspects of this important topic.

Annex IV describes a number of procedures using either the quality scale, or the impairment scale, and includes a comparison of the results obtained with a number of different methods and a discussion of their relative merits.

Annex V is a first attempt to describe methods for testing the performance of digital television systems.

Annex VI describes an initial tentative description of the methods of measuring the subjective quality of alphanumeric and graphic pictures.

Annex VII concerns the specifications and alignment procedures for signal sources and displays.

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CCIR Documents

[1966-69]: XI/158 (France); XI/159 (France).

[1970-74]: 11/89 (France); 11/26 (Canada); 11/111 (Italy).

TABLE I - Conditions for laboratory assessments

Reference	UK [CCIR, 1963-66a]	EBU, OIRT [CCIR, 1963-66c and d]			Germany (Federal Republic of) [CCIR, 1963-66b]			Japan [CCIR, 1963-66e and 1966-69a]		USA [CCIR, 1963-66f]	USA [CCIR, 1966-69b]	Italy [CCIR, 1966-69c]	China (People's Republic of) [CCIR 1978-82]
Observers Category Number	Non-expert 20-25	≥ 6			Non-expert ≥ 10			Non-expert 20-25		Non-expert approx. 200	Expert ≥ 10	Non-expert approx. 20	Non-expert 250 expert 65
Grading scale Type Number of grades	Quality 5 (Note 1)	Impairment 6 (Note 9)	Quality 6 (Note 7)	Comparison 7 (Note 11)	Impairment 5	Quality 5	Comparison 5	Impairment 5 (Note 3)	Quality 5 (Note 2)	Quality 6 (Note 8)	Impairment 7 (Note 10)	Comparison 5 (Note 5)	Quality 5
Test pictures Number	4-8	5			≥ 5			≥ 3		2-8	3-4	6	5
Viewing conditions													
Ratio of viewing distance to picture height	6	4-6			6			6-8		6-8	4	6	4-10
Peak luminance on the screen (cd/m ²) ⁽²⁾	50	41-54			50			Approx. 400 (monochrome) 74-84 (colour) (Note 12)		70 (Note 12)	170 (mono- chrome) 34 (colour) (Note 12)	50	85
Contrast range of the picture	Not specified				Not specified			30/1 to 50/1		Not specified			
Luminance of inactive tube screen (cd/m ²)	≤ 0.5	0.5			≤ 0.5			Approx. 5 (monochrome)		2		Approx. 0.5	
Luminance of backcloth (cd/m ²) ⁽³⁾	1 illuminant C				Approx. 2.5 ⁽¹⁾			Not specified					
Room illumination, average (lx)	3							Not specified		6-5			
Presentation	Random sequence of pictures and impairments				Random sequence of pictures and impairments			Random sequence of pictures and impairments		Random sequence of impairments	Random sequence of impairments	Random sequence of pictures and impairments	Random sequence of pictures and impairments

⁽¹⁾ For monochrome only.⁽²⁾ 1 cd/m² = 1 nt = 3.14 asb = 0.29 ft-L.⁽³⁾ Ambient luminance at the end of the room as seen by the viewer.

TABLE II - Conditions for assessment during programme transmission

Reference	OIRT [CCIR, 1966-69d]		Canada [CCIR, 1966-69e]
Observers Category Number	Expert 1 or 2		Expert 1 or 2
Grading scale Type Number of grades	Impairment 6 (Note 9)	Quality 6 (Note 7)	Impairment 5 (Note 4)
Pictures Type	Television programmes		Television programmes
Viewing conditions Ratio of viewing distance to picture height Angle of view, from a line normal to the face of the monitor Luminance, on the screen, at reference white (cd/m ²) Chromaticity of the screen at reference white Luminance of the inactive tube screen Luminance of "light surround" (cd/m ²) Chromaticity of "light surround"	4-6 Adapted to the ambient illumination		4-6 ≤30° 70 ± 7 Illuminant D As low as practicable 10.5 ± 3.5 (Note 14) Illuminant D

Five-grade scales

Quality scales

Note 1. - A Excellent
B Good
C Fair
D Poor
E Bad

Note 2. - 5 Excellent
4 Good
3 Fair
2 Bad
1 Very bad

Impairment scales

Note 3. - 5 Imperceptible
4 Perceptible but not annoying
3 Somewhat annoying
2 Severely annoying
1 Unusable

Note 4. - 1 Imperceptible (implied grade)
2 Detectable
3 Noticeable
4 Objectionable
5 Unsuitable for broadcast

Comparison (fidelity) scales

Note 5. - 1 Equal
2 Slightly different
3 Different
4 Very different
5 Extremely different

Note 6. - +2 Much better
+1 Better
0 The same
-1 Worse
-2 Much worse

Six-grade scales*Quality scales*

- Note 7.* — 1 Excellent
 2 Good
 3 Fairly good
 4 Rather poor
 5 Poor
 6 Very poor

- Note 8.* — 1 Excellent: the picture is of extremely high quality, as good as you could desire.
 2 Fine: the picture is of high quality providing enjoyable viewing; interference is perceptible.
 3 Passable: the picture is of acceptable quality; interference is not objectionable.
 4 Marginal: the picture is poor in quality and you wish you could improve it; interference is somewhat objectionable.
 5 Inferior: the picture is very poor but you could watch it; definitely objectionable interference is present.
 6 Unusable: the picture is so bad that you could not watch it.

Impairment scale

- Note 9.* — 1 Imperceptible
 2 Just perceptible
 3 Definitely perceptible but not disturbing
 4 Somewhat objectionable
 5 Definitely objectionable
 6 Unusable

Seven-grade scales*Impairment scale*

- Note 10.* — 1 Not perceptible
 2 Just perceptible
 3 Definitely perceptible, but only slight impairment to picture
 4 Impairment to picture, but not objectionable
 5 Somewhat objectionable
 6 Definitely objectionable
 7 Extremely objectionable

Comparison scale

- Note 11.* — -3 Much worse
 -2 Worse
 -1 Slightly worse
 0 Same as
 +1 Slightly better
 +2 Better
 +3 Much better

Note 12. — These higher values of peak luminance can be used with 60-field systems.

Note 13. — Document [CCIR, 1963-66g], points out the need for subjective assessment of picture quality during an international programme exchange. The document provides instructions on how to carry out the assessment, and also a list of terms related to the parameters subjected to assessment. The operational experience gained during transmissions in the Intervision network shows that in spite of the variety of monitoring devices used, adequate agreement on the assessment of picture quality was achieved by the technical staff.

Note 14. — The expression "light surround" is defined as the light visible to the observer from a plane or from behind a plane coincident with, and surrounding but not including, the viewing screen. It is provided over an area at least eight times the area of the monitor screen, or, in the case of adjacent monitors, over an area at least four times the total monitor screen area.

Note 15. — It is important that users of category rating scales recognize that verbal labels do not always define equal intervals, nor will these labels be interpreted uniformly across cultural and language boundaries.

REFERENCES

CCIR Documents

- [1963-66]: a. XI/16 (United Kingdom); b. XI/31 (Federal Republic of Germany); c. XI/33 (EBU); d. XI/45 (CCIR Secretariat); e. XI/140 (Japan); f. XI/145 (United States of America); g. XI/149 (OIRT).
- [1966-69]: a. XI/155 (Japan); b. XI/8 (United States of America); c. XI/45 + XI/181 (Italy); d. XI/46 (OIRT); e. XI/146 (Canada).
- [1978-82]: 11/132 (China (People's Republic of)).

ANNEX II

ANALYSIS AND PRESENTATION OF THE RESULTS OF TELEVISION SUBJECTIVE TESTS

1. Introduction

Methods of analyzing and presenting experimental data relating the degradation of a television signal to the consequent picture impairment, assessed subjectively, have up to now varied considerably among experimenters. Such differences add to the difficulty of comparison of results which may already exist due to variations in experimental method. Generally, the techniques that have been used fall into the four following categories:

1.1 In what is probably the simplest method, numbers in an arithmetic series are assigned to the grades of the assessment scale, thus making possible the computation of a mean subjective score (from the reactions of all observers) corresponding to a given magnitude of objective impairment. The results are usually presented as a smooth-curve plot of mean score against objective magnitude. Statistically, the mean is the most efficient estimator of central tendency of the data, but it gives no information about the distribution of opinions regarding a given impairment condition.

1.2 In a second method [Cavanaugh and Lessman, 1971], analysis is made of the cumulative proportions of observers judging the subjective quality of a given picture condition as being in or above a stated grade. The results are presented as a family of cumulative probability curves for the various grades. The large amount of detail presented tends to make interpretation difficult.

1.3 A third method [CCIR, 1966-69] employs mean score, as described for the method of § 1.1, but provides summarized information about opinion distributions by quoting the standard deviation of scores about the mean. The method works well for mean scores in the vicinity of mid-scale, but is complicated by the inevitable reduction in standard deviation for low and high values of mean, due to the bounded nature of the scales and the associated phenomenon known as "skewing".

1.4 This difficulty in the method of § 1.3 is overcome in a fourth method [Prosser *et al.*, 1964]. Here again, the method of § 1.1 is relied upon to describe the central tendency of opinions. Use is made of the assumption that the distributions of opinions for a given type of impairment are matched by a theoretical model which can be readily derived from the binomial distribution. Thus the complete experimental results can be summarized in terms of mean score coupled with a statement of the "order" of the binomial model.

1.5 Later, system M experimenters who had previously favoured the method of § 1.2 have modified their analysis procedure. Like the method of § 1.4, the new method [Lessman, 1972] is based on a generalized distribution model linked to mean score. Unlike the method of § 1.4, the distribution model is based on the concept of a normal distribution, quantized according to the number of grades. This new analytical procedure is still being studied and evidence about its relative advantages and disadvantages has not yet been published.

A somewhat similar model has also been described [Allnatt, 1973] by a system I experimenter who employs the method of § 1.4. The model employs quantizing intervals which, although symmetrically arranged, are not equal. Calculations are greatly simplified by using the logistic function to calculate both the distribution curve and the quantizing interval. Analysis in terms of the model is comparable in complexity to the method of § 1.4. Match to the data is claimed to be better than for any other known all-embracing model, but the improvement compared with the binomial-type is slight. The benefit of the new model is most likely to be found in the many problems to be encountered in the application of results, where it will be advantageous to work in terms of distributions based on a notional continuous scale of opinion level.

1.6 In some cases it is only necessary to evaluate the perceptibility threshold of an impairment rather than the complete relationship between subjective evaluations and objective impairment. The "random stimuli" method is proposed [CCIR, 1974-78a]. Two slightly different definitions of the threshold may be used, either corresponding to the maximum standard deviation of assessments or to 50% of the positive observations [CCIR, 1974-78b].

However, it should be remembered that knowledge of the threshold of perceptibility alone is insufficient in the treatment of any but the simplest situations.

1.7 Apart from the above fundamental differences, interpretation and comparison are further complicated by a number of points of detail:

1.7.1 The grading scale may be in terms of "quality" or "impairment", one being roughly, but in general not exactly, the inverse of the other. The number of grades in the scale has varied between 5 and 7.

1.7.2 Numerical scores are sometimes ordinal numbers which may either increase or decrease with the magnitude of the judged attribute. Alternatively the scores may be normalized so that the range of mean scores is from 0 to 1.

1.7.3 Objective impairment magnitudes may be expressed either directly or in such terms as signal/noise ratio. They may be in arithmetic or logarithmic (dB) units.

2. Subjective-impairment units

Although the present concern is with analysis of results, it is useful to take a note of a requirement that frequently arises in application.

Under practical viewing conditions, a number of impairments may arise simultaneously. As it is impracticable to test all the possible combinations, a "law of addition" of impairments can be of great benefit.

An empirical law, which has been used [Lewis and Allnatt, 1968; Allnatt, 1979; CCIR, 1970-74a], states that if $\bar{u}_1, \bar{u}_2, \dots, \bar{u}_r, \dots, \bar{u}_n$ are the respective normalized mean scores for n unrelated impairments taken separately, the normalized mean score $\bar{u}$ for all impairments taken simultaneously is given by:

$$\frac{1}{\bar{u}} - 1 = \sum_{r=1}^n \left(\frac{1}{\bar{u}_r} - 1 \right) \quad (1)$$

While a possible psychophysical basis for the law of addition in the above equation remains a matter for speculation [Siocos, 1972; Allnatt, 1979], all the relevant experimental data available at the present time confirms that it appears to be valid to an accuracy sufficient for most, if not all, practical purposes [CCIR, 1974-78c]; although the multiple regression analysis quoted below may provide an interesting approach.

Consideration of design objectives is facilitated by expressing subjective impairment magnitudes in the form of directly summable quantities. As equation (1) suggests, this can be done very simply by transforming the mean score $\bar{u}$ into units of subjective impairment, termed "imps", by means of the relation $I = (1/\bar{u} - 1)$ imps. The I scale ranges from zero for the "perfect" picture ($\bar{u} = 1$) to infinity at the other extreme ($\bar{u} = 0$). $I = 1$ imp at the "mid-opinion" point given by $\bar{u} = 0.5$.

In the presentation of results, convenient mark points may be placed on the I scale, for example, 1/8, 1/4, 1/2 and 1 imp. When the term "imp" was originally introduced [Lewis and Allnatt, 1965 and 1968], its proponents intended that it should be related to a particular quality grading scale and narrowly defined test arrangements [Prosser *et al.*, 1964; Corbett, 1970], with a view to providing as near an absolute basis as possible for results. Subsequently it has become clear that some qualification of results will almost always be necessary. For example, scales and observers' standards could vary from place to place, translation of the scale into another language produces an unknown effect, and sometimes it may be desired to apply the test technique to a television system for which broadcast-viewing conditions are unsuitable. It is suggested that details should be given of test arrangements which might affect results.

The following remarks offer some guidance to interpretation of the mark points when a particular set of conditions [Prosser *et al.*, 1964; Corbett, 1970; Allnatt and Bragg, 1968] is used. The 1/8 imp mark point represents a low level of impairment, of the same order as the residual impairment normally found with a laboratory set-up consisting of a high-grade slide scanner and picture monitor. Experience suggests that 0.25 imp may be taken as a practical design objective for each of the major impairments that may occur in a system, such as a national one, of moderate size and complexity. At the present time, 0.5 imp appears to be a reasonable design objective for each major impairment in a complex system involving transmission over a chain of long-distance international links.

One final word of caution is that the use of the "law of addition" to find the overall impairment resulting from the simultaneous presence of component impairments, should not be used to add impairments having the same subjective effect, but resulting from the errors of different objective parameters (e.g., in the PAL system, chrominance phase and chrominance gain errors both give rise to saturation impairments in the image). In this case, the overall impairment should first be calculated in objective terms from each of the errors of the individual objective parameters [CCIR, 1970-74a].

A preliminary study of an alternative approach to the problem of multiple simultaneous impairments, has been reported [CCIR, 1970-74b]. In this, multiple linear regression analysis is shown to give satisfactory results with a set of available data. However, studies are continuing to examine the range of validity of the expression obtained; to examine the use of non-linear regression models and to extend the range of data used for checking the validity of the method.

Studies concerning the influence of multiple simultaneous impairments on D/PAL colour television pictures have been carried out in the People's Republic of China and satisfactory results have been obtained [CCIR, 1978-82a].

Some new results [Sallio and Kretz, 1982; CCIR, 1978-82b and c] suggest that the question of the applicability of imp units to subjective cumulation is still open.

A large-scale experiment on the effects of noise and co-channel interference in FM satellite broadcasting systems [CCIR, 1982-86a] has shown that the "law of addition" of imp units gives adequate accuracy; the maximum difference between calculated and observed results was 0.3 at a mean opinion score of 2.5, decreasing to less than 0.1 as the opinion scores approach grades 1 or 5.

Studies have been carried out in the USSR [CCIR, 1982-86b] using the SECAM system which led to the formulation of a law of impairment summation expressed by a system of equations [Gofaizen *et al.*, 1979a and b; Gofaizen *et al.*, 1983]:

$$\begin{cases} \frac{1}{\bar{u}} - 1 = \left[\sum_{r=1}^n \left(\frac{1}{\bar{u}_r} - 1 \right)^v \right]^{1/v} \\ v = \frac{v_{max} + v_{min} c I_{\Sigma}}{1 + c I_{\Sigma}} \end{cases}$$

where $v_{max} = 2.5$; $v_{min} = 0.5$; $c = 0.6$. This law expresses the addition of impairments with an exponent v depending in turn on the resulting impairment; in the case of near-zero impairments, $v = 2.5$, whereas with increasing impairment v diminishes, tending to a value of 0.5.

In the range of resulting impairments less than 1 imp, we may apply a value $v = 2$ with sufficient accuracy for all practical purposes, i.e., the proposed law may be reduced to a law of quadratic addition of impairments [Gofaizen and Epifanov, 1976]:

$$\frac{1}{\bar{u}} - 1 = \left[\sum_{r=1}^n \left(\frac{1}{\bar{u}_r} - 1 \right)^2 \right]^{1/2}$$

here the resulting impairment is the weighted sum of the partial impairments:

$$I_{\Sigma} = \sum_{r=1}^n W_r I_r$$

in which the weighting coefficients are equal to the relative values of the partial impairments, i.e. $W_r = I_r / I_{\Sigma}$.

An alternative approach based on a continued product of normalized mean scores, as described in [CCIR, 1982-86c and d], is used in a microprocessor-controlled monitoring system operated on television transmission channels in the German Democratic Republic. It computes an overall quality figure from objective measurements on the insertion test signal.

Further contributions to the study of the evaluation of the effects of multiple simultaneous impairments are invited. It is believed that the requirement on grand mean score in § 2.5 of Recommendation 500 is of particular importance in experiments designed to verify alternative laws of addition.

3. Opinion distribution

3.1 *Statistical models of opinion distribution*

In §§ 1.4 and 1.5 reference was made to models based on the binomial and normal distributions. [CCIR, 1970-74c] summarizes the binomial type models referred to in § 1.4; [CCIR, 1970-74d] summarizes, in its Annex, the data analysis method based on the normal distribution, and referred to in § 1.5.

It has been shown that the above two methods, to a good degree of approximation, can be directly related to one another as the logarithm of the impairment unit is both linearly related to the objective impairment and very nearly normally distributed, when the opinion distribution is taken as binomial [Siocos, 1972]. While this virtual correspondence should make it possible, if desired, to retain both the above methods of representing distribution, the advisability of recommending a single method should be studied.

3.2 *Double-stratified technique*

It is an important matter to examine the standard deviation of mean scores. Usually the test pictures need to be systematically selected, but sometimes it may be desired to use pictures drawn at random from a large population. In such a case, consideration should be given to the statistical properties of the double-stratified sample that may be obtained [CCIR, 1974-78d; Miceli and Orlando, 1977]. By this means, standard deviations can be evaluated and the results could suggest a possible economic compromise in future similar experiments, by proper choice of the relative numbers of observers and pictures used.

4. Use of comparison scale

A contribution [CCIR, 1970-74e] on comparison scales has shown that when the recommended 7-grade comparison scale is used for comparing pictures impaired by random noise, a more linear relationship between comparison grade and signal-to-noise ratio is obtained if the numerical weighting attached to the comparison grades is 4, 2, 1, 0, -1, -2, -4 rather than 3, 2, 1, 0, -1, -2, -3.

5. Prediction of the error in a subjective assessment test

If the true subjective grade of a test condition is considered to be the average obtained with a very large number of observations, it is possible to calculate the relationship between this true grade and the mean grade obtained by a practical experiment (with a realistic number of observations).

It is possible to calculate the "expected error" associated with the number of observations at a defined confidence level. A 95% confidence level, for example, is a reasonable reference, and with this figure in mind it is possible to delineate the relationship between the number of observations and the maximum expected error (making certain statistical assumptions) [Miceli and Orlando, 1977; CCIR, 1978-82d]. This varies with mean grade and is given (for a mean grade of 3) in Fig. 1. Figure 2 shows the correction factor to be applied for mean scores above and below 3.

The "expected error" can be visualized as the half-amplitude of the area of uncertainty within which the result of the test is expected to approximate the true value to be measured at the selected confidence level. From Fig. 1 it can be seen that roughly equal numbers of pictures and observers give the lowest expected error for a given number of observations (see for example, points P and Q).

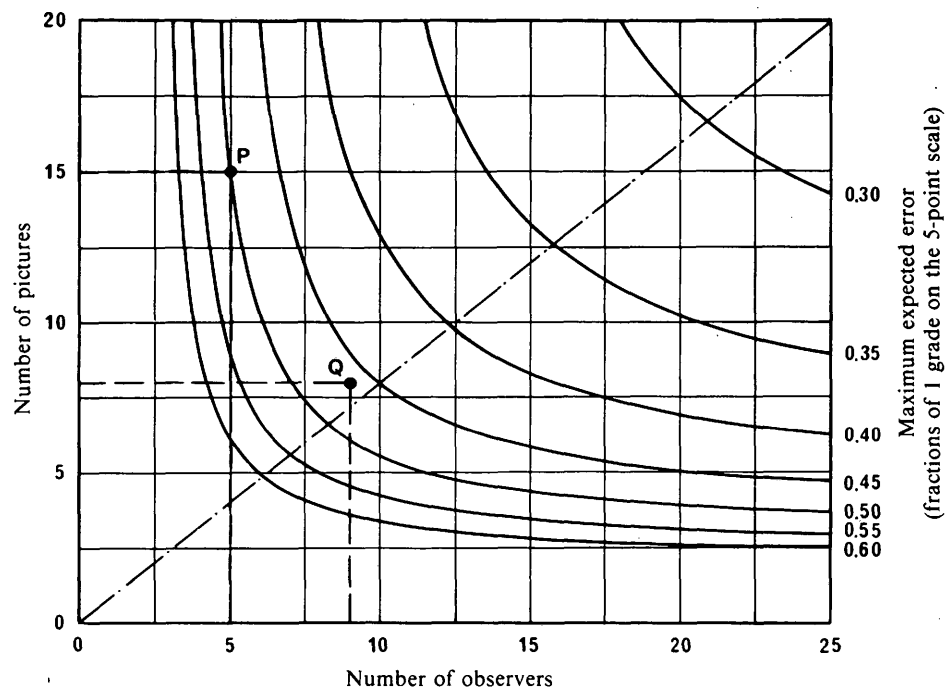


FIGURE 1 — Curves giving the maximum expected error in a subjective assessment test, as a function of the number of observers and the number of pictures, for a confidence level of 95%

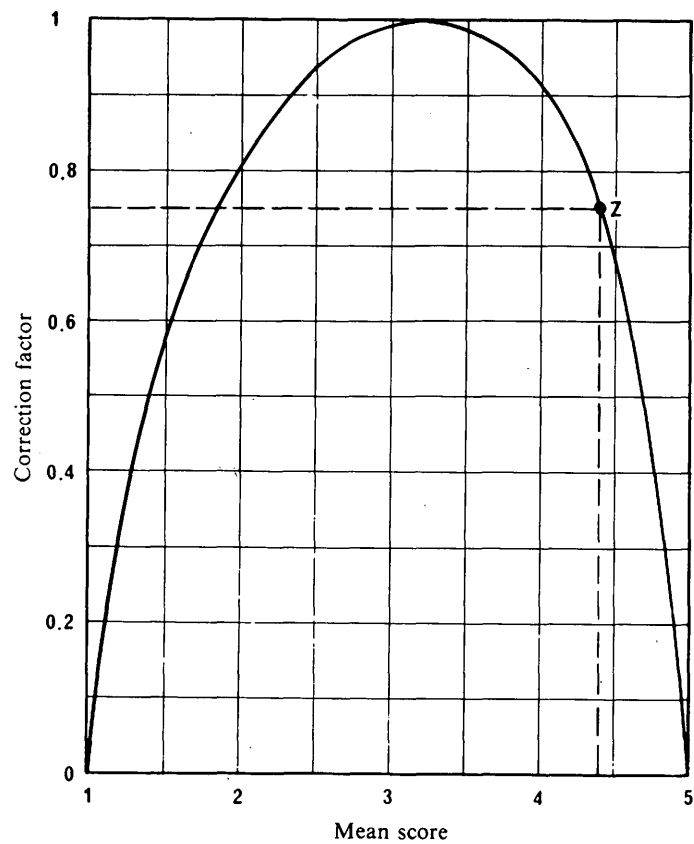


FIGURE 2 — Curve giving the correction factor to be applied to the maximum expected error computed by means of Fig. 1, if the mean score is not 3

As an example of the application of the curves, if for instance a subjective test has been made with 9 observers and 8 pictures the maximum expected error is 0.47 (from Fig. 1, point Q). If the mean grade was 4.40, the correction factor (from Fig. 2, point Z) would be 0.75, so the "expected error" at 95% probability would be $0.47 \times 0.75 = 0.35$. The curves were derived from analogue colour television experiments based on Recommendation 500 and using reasonably critical pictures. They may however serve as a good approximation for other test conditions. It would certainly be helpful if some experiments were carried out to derive exact curves for the other cases.

The general principles given above always apply generally, but the degree to which the errors are in practice below the maximum, when critical pictures are used, is the subject of discussion. Some experiments point to successful application in this case, but other workers believe that the subject should be studied further.

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ANNEX III

EXAMPLE OF A METHOD OF PROCESSING THE RESULTS OF SUBJECTIVE TESTS

To provide a unified method of presenting the results of subjective tests using a particular cause of impairment, the following example describes the sequence of operations which can be carried out.

1. Processing test results for a particular value of impairment

The objective magnitude of the impairment is characterized by a particular number according to the convention appropriate to the particular effect; for example, signal/noise ratio in decibels, differential phase distortion in degrees, etc. This numerical value is called D and is defined more precisely in § 2.

The tests carried out with D constant, according to the principles set out in Recommendation 500 lead to a certain distribution of scores on the 5-point scale used. This distribution includes the differences in judgment between observers and the effect of a variety of conditions associated with the experiment, for example the use of several pictures.

In what follows U denotes the quality grade (1 to 5) on the scale used.

The analysis of the distribution gives, for each grade U_i , the proportion of the total opinions p_i (note that $\sum_i p_i = 1$).

The analysis of this distribution can be made by two methods:

1.1 By simply calculating the direct mean score,

$$\bar{U} = \sum_{i=1}^5 i \times p_i \quad (2)$$

1.2 By finding a mathematical model (or interpolating function) which smooths out the random errors in the measured proportions p_i .

The different solutions to this problem which have been proposed fall under two main classifications. Firstly, models which yield directly the proportions in the five grades. An example of such a model is:

- a modified binomial distribution [Prosser *et al.*, 1964] which is described by its mean score and order (an integer).

The second class of models comprises those which are based on the concept of a smooth distribution function in terms of a continuous variable. Such a model can yield a distribution in terms of opinion grades, which can be matched to the experimental data, by a suitable process of quantization. Examples of such models are:

- the approximation by a Gaussian function, an example of which is given in [Lessman, 1972]. Such a function can be conveniently described by its mean and its standard deviation.
- the approximation by a logistic function [Allnatt, 1973]. The distribution is described by its median value and its width parameter (both being continuous variables).

Note 1. — The choice of method will depend both on the particular features of the distribution encountered in the experimental results, and also, on the mathematical treatment envisaged for the application of results.

Note 2. — In fitting the chosen model to the experimental results for a given impairment condition, an efficient method of adjustment is simply to equate the mean and standard deviation of grades yielded by the model, to those actually found.

Note 3. — In an experiment with a given type of impairment, it is commonly found that a single value of width parameter (or binomial order, etc.) suffices to fit a well-chosen model to all the impairment conditions tested. Differences between the standard deviation actually found for a given impairment condition and that yielded by the model are no greater than can be accounted for by sampling error. Indeed, it has been found that a single width parameter can apply to many different types of impairment. Thus the finding of a distribution model with a width parameter which will apply to all impairment conditions in an experiment, and the establishment of a relationship between central tendency (mean or median) and objective magnitude can be treated as separate operations.

According to circumstances it may be appropriate for the next stage of the analysis to be made in terms either of the model mean (or median) or of the mean of the categorized distribution yielded by the model. It will suffice for what follows to have obtained the deduced mean score U_m , which may be identical to the direct mean score $\bar{U}$, but sometimes may differ slightly from it.

2. Processing to find the relationship between U_m and D

The next step in processing the data is to establish the relationship between the mean score U_m (or $\bar{U}$) and the objective measure of the distortion D as D is varied. The process which follows consists of finding a simple continuous relationship between U_m and D . The approximation of this experimental relationship by a logistic function is particularly interesting.

The processing of the data U_m can be made as follows:

2.1 The scale of values U_m is normalized by taking a continuous variable u such that,

$$u = (U_m - 1)/4 \quad (3)$$

when U_m is in the range 1 to 5.

2.2 Graphical representation of the relationship between u and D shows that the curve tends to be a skew-symmetrical sigmoid shape provided that the natural limits to the values of D extend far enough from the region in which u varies rapidly.

The function $u = f(D)$ can now be approximated by a judiciously chosen logistic function, as given by the general relation:

$$u = 1/[1/u_0 + \exp(D - D_M)G] \quad (4)$$

where G may be positive or negative.

In this expression the presence of the constant u_0^* will be noted. It represents, in the function $u = f(D)$, the asymptotic value of u for the very small impairment.

This peculiarity of the curve $u = f(D)$ is frequently encountered and characterizes the fact that even for a level of impairment which is theoretically zero, the mean quality grade obtained in the course of the tests does not reach the limiting value $U_m = 5$, or $u = 1$. As a result of various imperfections of the picture, the measured value is u_0 .

2.3 The value u obtained from the optimum logistic function approximation is used to provide a deduced numerical value I according to the relation:

$$I = (1/u) - 1 \quad (5)$$

In the case where the value u_0 is not equal to 1, this transformation provides a limiting value of I , as

$$I_0 = (1/u_0) - 1 \quad (6)$$

2.4 If I_{exp} is the raw result obtained from equations (4) and (5), a correction is made to this result by the relation, $I_u = I_{exp} - I_0$.

It is convenient in practice, for the graphical representation of the values of I_u as a function of the impairment D , to use a logarithmic scale for I_u . This convenience results from the fact that the logistic function being used to represent the relationship takes the form of a straight line in this graph. The expression for this relationship is effectively:

$$I_u = \exp(D - D_M)G \quad (7)$$

It will be observed that in such a graph the experimental values, processed to obtain corresponding values of I_u , will be sensibly on a straight line.

Interpolation by a straight line is simple and in some cases of an accuracy which is sufficient for the straight line to be considered as representing the impairment due to the effect measured by D .

* In the publications this constant is also designated H .

In this representation, the direct measurement of the impairment by the value D is shown on a linear scale. The slope of the characteristic is then expressed by:

$$S = \frac{D_M - D}{\log_e I} = \frac{1}{G}$$

and, for the particular value of D where $I = e$ and $I = 1/e$, we get:

$$|S| = D_M - D = \Delta D$$

Figure 3 shows the representation thus obtained. The values of I are expressed, in accordance with the proposals which have been made by Lewis and Allnatt [1965] in "imp" units.

The straight line may be termed the impairment characteristic associated with the particular impairment being considered. It will be noted that the straight line can be defined by the characteristic values D_M and G of the logistic function.

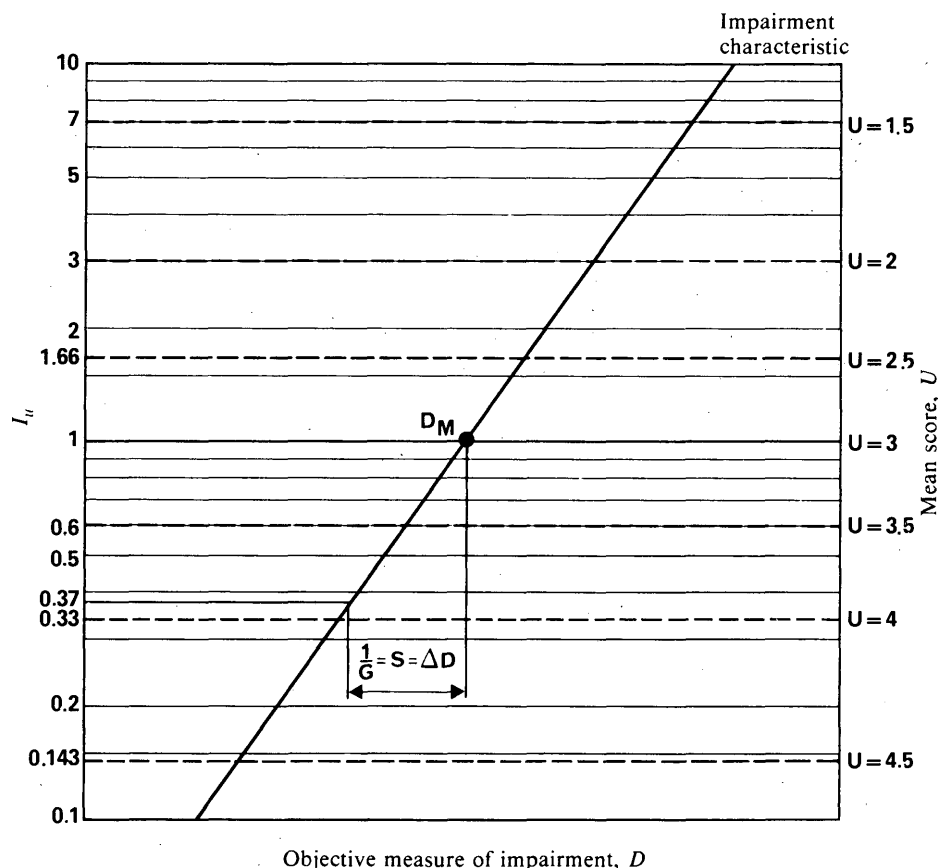


FIGURE 3 — Representation of the impairment characteristic
 U — Mean score, 5-grade scale

2.5 Adjustment for the residual impairments: an alternative approach

The relation $I_{exp} = I_u + I_0$ described at the beginning of § 2.4 is used to adjust the results for the residual impairment corresponding to u_0 or I_0 . In a comprehensive study [CCIR, 1978-82a, b and c; Kretz, 1981; Sallio and Kretz, 1982], comparisons between an absolute procedure and a procedure using direct anchoring with a reference unimpaired picture (see Annex IV, §§ 1.1.1, 1.2 and 3.1) provide another basis for the adjustment of the residual impairment. A shift applied to u values ($u' = u + 1 - u_0$) is found to correspond very satisfactorily to the data. According to this analysis equation (4) would become:

$$u = (u_0 - 1) + 1/[1 + \exp(D - D_M)G] \quad (4a)$$

then, an imp value can be calculated from adjusted u' data, by setting:

$$I_u = (1/u') - 1 \quad (5a)$$

and equation (7) is seen to be also applicable, the rest of the analysis remaining unaltered.

However, it should be noted that this technique fails when scores are very low, and thus cannot be regarded as satisfactory for all purposes.

2.6 Arithmetic measure of objective impairment

Where the conventional objective measure of impairment is arithmetic in nature, the relationship with u will generally not be skew-symmetrical and it will be necessary to employ logarithms. However, the arithmetic measure, which will be designated d , and such that $d < 1$ if d is a ratio (e.g. noise voltage/signal voltage) might be considered the more basic one and it is of interest to examine the function relating u with d .

$$D = \log_e d$$

and,

$$D_M = \log_e d_M$$

Substituting D and D_M in the logistic equation (4), it can be shown that,

$$u = 1/[(1/u_0) + (d/d_M)^G] \quad (8)$$

from which (as in § 2.4, equation (7)),

$$I_u = (d/d_M)^G$$

In this case, with the logarithmic scales I and d , the slope is expressed by the relationship between d , I and d_M

$$G = \frac{\log_e I}{\log_e (d/d_M)}$$

and $|G|$ can be found using the particular value of D where $I = e$ or $I = 1/e$.

It may be considered that the corresponding values of G (or equally those arising from values D which are natural logarithms) are of more fundamental significance than those from values of D expressed in decibels, or a logarithmic measure other than natural logarithms. Accordingly, it is proposed to reserve G exclusively for values appropriate to equation (8), as this usage is common in the literature and particularly because an extensive set of results, expressed in these terms, has been published (Report 959).

When, in practice, the value shown on the impairment scale is the expression in *decibels* of the relation, which will then be designated by D and shown on a linear scale, we shall get:

$$D = 20 \log_{10} (1/d), \quad \text{i.e.} \quad 1/d = 10^{D/20}$$

For the linear characteristic, the slope is given by

$$G' = \frac{\log_e I}{\log_e (d/d_M)} = \frac{\log_e I}{\left[\frac{D_M - D}{20} \right] \log_e(10)} = 8.686 \frac{\log_e I}{D_M - D}$$

Values of G arising from values of D expressed in decibels may conveniently be designated G' .

Therefore, $G = 8.686 G'$.

2.7 Adjustment for "residual impairment" based on linear conversion of the experimental curve — "scale boundary effect"

The residual impairment considered in the previous sections arises because observers are aware of deficiencies in the "unimpaired" picture due to such effects as flicker, the scanning structure, etc. and consequently, they grade the quality less than "excellent". The appropriate methods of adjustment for this "residual impairment" (§ 2.4 and 2.5) involve some shift in the scores at the centre of the scale.

A different type of "residual impairment", which may be termed "scale boundary effect", has been indentified [CCIR, 1982-86] which appears to arise from a psychological reluctance by the observers to use the extreme grades of the scale. This can affect both ends of the scale equally leaving the centre (grade 3) unaffected. It is advisable to make an adjustment for "residual impairment" of this type when the impairments being assessed are small ($I \ll 1$).

An appropriate adjustment, avoiding a shift in the centre of the scale, can be made by applying the following formula to relate the true to the experimental scores [Gofaizen *et al.*, 1983]:

$$U' = 2 \frac{U - 3}{U_0 - 3} + 3$$

where:

U' : true score on the 5-grade scale;

U : experimental score;

U_0 : experimental score without distortions.

For the normalized quality scores, the formula is written as follows:

$$u' = \frac{u + u_0 - 1}{2u_0 - 1}$$

where:

$$u' = \frac{1}{1 + I_u} = \frac{1}{1 + \exp(D - D_M)G}$$

Here, equation (4a) is converted into:

$$u = 1 - u_0 + \frac{2u_0 - 1}{1 + \exp(D - D_M)G} \quad (4b)$$

while equation (7) and the entire subsequent analysis may be used without any change.

3. Conclusions

The processing of subjective test data which is described above has two advantages:

- the impairment characteristic is a straight line;
- in very many cases, the values of I appear to possess the property of summability when several sources of impairment which are not correlated are present simultaneously on the picture.

It is desirable that for each of the causes of impairment known to be important, the results of a subjective test should be available as an impairment characteristic presented in this form. The establishment of a collection of these characteristics would facilitate the use of the results of subjective tests.

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ANNEX IV

TEST PROCEDURES

This Annex describes and discusses various test procedures for organizing subjective assessment tests. Recommendation 500 gives much information about subjective assessment and the more commonly used test procedures. Section 1 of this Annex describes additional and new procedures; § 2 describes the virtual sample technique; § 3 gives information on results obtained by some of the procedures in comparable situations; § 4 gives some additional evidence, and § 5 discusses different arguments related to the choice of an appropriate method for various situations.

1. Description of procedures

This section presents descriptions of various procedures additional to those described in Recommendation 500, including new procedures intended to solve new problems. The descriptions cover such items as grading scales, design of the presentation sequence, definition of an impaired condition and so on. The validity of these items is not necessarily restricted to the particular procedure being described.

1.1 Procedure using the quality scale with direct anchoring*

To study the role of a reference picture, a new method has been designed [Kretz and Sallio, 1981]. In this method, the 5-grade quality scale from Recommendation 500 is used and the procedure is the same as for the procedure of the EBU method (see below § 1.2): a reference picture is displayed before each picture to be assessed and the observers are told to rate the pictures in relation to the reference which is said to correspond to grade 5 ("excellent"). With this procedure, direct anchoring of the rates at the top of the scale is obtained with the quality grading scale.

1.2 Procedure using sequences of moving pictures

Recommendation 500 specifies conditions for the subjective assessment of the quality of both still and moving pictures. Nevertheless, there have been few studies reported which deal with some of the basic features of measurement of the subjective quality of moving picture sequences. These features include:

- the elements on which the observer bases his decision are often transitory;
- it may be difficult for the observer to analyse and assess all the elements of the sequence in a single viewing;
- the perception of certain impairments may be different for still and moving pictures.

As a first attempt to define a suitable procedure, a study [CCIR, 1982-86a] using the impairment scale with a reference picture (EBU method) has examined several modes of presentation of moving picture sequences. The impairment used was multiple generations of video tape recordings.

* Some form of anchoring is always implicit in all the procedures in the sense that it is necessary to standardize the rating process. Here the term "direct anchoring" refers to *explicit* anchoring. "Indirect" anchoring corresponds to standardizing the adaptation phenomena [Corbett, 1970] by means of the range of impairments in a test session.

The following preliminary conclusions may be drawn on the basis of the mean scores and standard deviations. Firstly, sequences longer than 10 s seem to be too long and, secondly, repetition of the sequences to give the observers more opportunity to analyse and assess the scenes does not seem to improve the quality of the assessments. The conclusion of this preliminary study appears to be that a single presentation of about 8-10 s is preferred. Additionally, the results show that the assessments of the same impairments on still and moving picture sequences can differ significantly.

The foregoing conclusions are preliminary and are based on results with a single type of impairment; the results with motion-dependent impairments could differ significantly. Further studies in this important area are urgently required.

2. The virtual sample technique

2.1 The main sources of errors in subjective tests are essentially two:

- random (i.e. stochastic) errors, and
- systematic errors.

Provided the objective conditions of the test have been standardized, the nature of the errors is purely related to the parameters used in the design of the tests (number of observers, pictures, procedure used, etc.).

Stochastic errors are very easy to recognize. In the case of a relationship between distortion magnitude and picture-quality, they lead to some dispersion of the experimental mean scores around the fitted curve (e.g. obtained by least squares method). Standardization of test procedures usually tends to reduce stochastic errors but due to their nature they can be further reduced by statistical averaging (the use of a fitted mathematical function is one kind of averaging).

Systematic errors are difficult to recognize because they are almost unrelated to random errors. Usually they act by shifting the previously mentioned curve (biasing) and/or affecting its slope. Once a certain degree of systematic errors have been introduced in the experimental results, they cannot be averaged out by statistical methods.

2.2 The “virtual sample” is constituted by a relatively large number of observers (e.g. 50 or more) and also by a large number of pictures (e.g. 40 or more). It is called the “virtual sample” because it is not used in its entirety for the actual assessment tests; rather, it is used as a population from which small samples of manageable size are repeatedly drawn.

Taking the example in which a relationship between given distortion magnitudes and picture quality is to be found, and having in mind that the aim of the virtual sample technique is to use different samples of observers and pictures for different test conditions, the complete planning of the experiments when following the virtual sample technique should be as follows:

- a number of test conditions (e.g. 8 to 10 values of the distortion magnitude) should be selected;
- a number of groups each made up of no more than 2 or 3 non-contiguous test conditions should be formed;
- for each test condition, a random sample of 5 to 6 test pictures is chosen from the complete set (virtual sample), so each group of test conditions will have 2 or 3 such sets of test pictures. For each group a sample of 8 to 10 observers should be selected from the complete set (virtual sample). In this way we have different test pictures for different test conditions in the same group;
- for each group of test conditions, a session following the procedure given in § 8.4 of the Appendix to Recommendation 500;
- the mean scores should be calculated and then fitted by least squares using a suitable function (e.g. the “logistic function”);
- some statistical tests should be carried out for the goodness of fit, and the final output of the experiment will be the fitted curve just obtained.

If more accuracy is required for the fitted curve, the experiment may be repeated as a new experiment, and the corresponding mean scores should be averaged with the past ones before performing the new least squares fit.

There is general agreement that the technique is appropriate for complex impairments at least in relation to observers. However, some administrations believe it may not be economical in the case of a single impairment.

3. Results of directly comparable experiments

This section describes results obtained with different assessment procedures applied to the same experimental material (pictures and impairments). Naturally, when a method is used in a specific situation account must be taken of numerous parameters and the conclusions drawn from such experiments, as described in this section, take only some of these factors into consideration. This is discussed in detail in § 5.

3.1 *Comparison of the results obtained by single stimulus method and EBU method*

The two procedures described in § 8.1 and § 8.2 of the Appendix to Recommendation 500 have been subjected to a series of comparative experiments [CCIR, 1978-82a, b and c; Sallio and Kretz, 1982]. Different types of impairment were used: analogue filtering, additive noise (in two different contexts), cross-modulation transfer noise, edge-busyness, (in two different contexts), accumulation of additive noise and edge-busyness, transmission errors at 34 Mbit/s (in two different impairment ranges). Twenty independent groups of ten non-expert observers (one group for each type of impairment and each procedure) participated in the tests (a total of 46 sessions was necessary for each method). The comparisons of the results obtained were analyzed in terms of average grades and standard deviation, separately for each viewing distance. The following conclusions were drawn:

- the two methods lead to objective-to-subjective relationship curves with very similar curve shapes. There is a shift between the characteristic obtained by each method. The quality rating curve tends to be rather below impairment ratings curve (EBU method). At mid-scale (grade 3), the standard deviations of the scores are at maximum and are very close for both procedures (at 6H, 0.84 for the single-stimulus method and 0.79 for the EBU method);
- the impairment scale procedure using a reference picture produces an average grade for reference picture very close to the highest grade (4.88 on average), showing good anchoring for the ratings at the top of the scale;
- the quality scale procedure leads to an average grade for reference pictures which varies from almost 0 to one grade below the highest grade (4.56 on average). This seems to be due to the absolute nature of the rating;
- the two methods tested are both sensitive to the context and the range of the impairments presented in a session. These two subjective phenomena have identical effects on the two methods. It would therefore seem important in presenting the results, to describe the precise conditions (range of impairments presented in each session, context within a session); this allows a better understanding of the results;
- in the range between “imperceptible” and “perceptible but not annoying” (around grade 4.5), the procedure using impairment scale and a reference, leads to standard deviations of the scores 1.4 times smaller than with the quality scale procedure; thus the former procedure seems to give better precision, and might allow the number of scores toward the top of the scales to be halved.

These results suggest that it may be possible to obtain a transformation of quality mean grades into impairment mean grades obtained using the EBU procedure by shifting the experimental results by the amount associated with the residual impairment (mean grade for unimpaired pictures). The transformation of impairment mean grades into quality mean grades is suggested by shifting the experimental values by half a grade, although this value is not completely stable (see also Annex III to this Report). Due to the bounded nature of the scale, these transformations cannot apply at the bottom end of the scale.

3.2 *Comparisons of results obtained with other methods*

To study in more detail the role of reference pictures, anchoring and grading scale, several methods have been tested on the same type of impairment [CCIR, 1978-82b]. This study consisted of a comparison of the results obtained with the two previously mentioned methods (§ 3.1) and the results obtained with various other methods. The following aspects were investigated:

- the use of the 5-grade impairment scale and of a continuous impairment scale, of the 5-grade quality scale and of a continuous quality scale, all with a reference picture for direct anchoring (in effect the EBU procedure using different scales);
- the use of a continuous quality scale using a double stimulus procedure close to the one described in § 8.3 of the Appendix to Recommendation 500.

The following conclusions were drawn:

- good anchoring is possible in the upper part of the range with an EBU type of presentation but using a 5-grade quality scale and informing the observers that the reference picture should correspond to the grade “excellent”;

- the comparison of results obtained by methods which differ only in the use of a discrete or a continuous rating scale shows that neither the continuous quality scale nor the continuous impairment scale provides more information than the recommended 5-grade scales (comparable means and standard deviations);
- with the double stimulus method which does not provide direct anchoring, the mean score for reference is not close to the top of the score range. The standard deviations obtained by this method are not significantly lower than those obtained by the method recommended by the EBU;
- the implementation of continuous scales gives rise to some problems: certain observers (non-experts) find them difficult to use and analyzing and presenting the results of the experiments becomes more complicated.

3.3 *Comparisons of the results obtained using 5- and 6-grade quality and 6-grade impairment scales*

The comparison of the performance of the 5-grade quality scale and a 6-grade impairment scale have been reported in [Allnatt and Corbett, 1974], and recently re-examined with particular reference to performance near the threshold of visibility [Allnatt, 1980]. The procedure was the same except for the scale used. The 6-grade impairment scale differs from the present Recommendation 500. Two types of impairment were considered, one with 625-line monochrome television using a 2 μ s undistorted echo, and the other with opaque photographs impaired by blur. Results were analyzed only in terms of mean score. The main conclusion of this study is that the impairment scale offers no advantage in respect of sensitivity with impairments below the threshold of visibility. However, it should be pointed out that this experiment does not represent results that would be obtained by comparing the single stimulus method and the EBU method.

4. **Some other experimental evidence**

Experimental evidence from other sources is available, some of it differing from that in § 3. A considerable body of results exists in the case of the single-stimulus quality-grading method, relating to all its important properties.

Results support the applicabilities of the Imp transformation (see for example [Macdiarmid and Allnatt, 1978], also Annex II) as a law of addition of subjective impairments. This law is used to adjust for the effect of residual impairment in analysis, and operates differently from the transformation using shifting of the mean scores, advocated in § 3.1.

As regards the double-stimulus quality grading method, the standard deviations of differences between pairs of scores at the same presentation have been found to be lower than those of the individual scores, when impairments are small. A transformation is required to give the equivalent standard deviations in terms of a 5-grade scale, and at zero impairment values of about 0.13 were found with a fairly wide range of impairment using random noise [White and Allnatt, 1980], and 0.35 in assessment of a high quality digital codec [CCIR, 1978-82d]. In other experiments with digital television [IBA, 1981] the value was 0.22. Comparable values found in similar experiments [Kretz and Sallio, 1981] were 0.25 at 4H, 0.45 at 6H for zero impairment.

Comparison [CCIR, 1978-82d] of measurements of a digital codec using the double stimulus method with those using the single stimulus method with the test impairments embedded among a number of other wide-range impairments, support the finding of White and Allnatt [1980] that adaptation due to indirect anchoring effects are considerably reduced by using double stimulus as compared to the single stimulus method.

Results obtained using an impairment scale show that it is inadvisable, in measuring the visibility of separate impairments, to present them in the same sequence [CCIR, 1982-86b]. Such a procedure might introduce a bias, since the observers will tend to compare the effect of the different impairments. It would therefore seem preferable, when measuring the visibility of separate impairments, to present only a single type of impairment for assessment in each display sequence.

5. **Discussion**

The aim of specifying a procedure in detail is to minimize the random variation of results that is not due to systematic differences between different populations of observers found when, say, the results of independent tests are compared or combined. This is the common aim of all the procedures described, but there are other factors which are seen as giving strength to particular procedures. These relate to the degree of discrimination of results that is worthwhile, and the degree of complexity and elaborateness of the test procedure. The more complex and elaborate the procedure, the more time-consuming and costly it may be. Central to the discussion on the choice of procedure is the accuracy needed and how much is to be gained in terms of the results achieved.

The procedures described in § 8 of the Appendix to Recommendation 500 select a combination of quality or impairment scale with the regular use of a reference picture, either signified as such or not, or indirect anchoring by impairment range. Procedure 8.1 is the simplest method for organization; the analysis of results for 8.1 and 8.2 of the Appendix to Recommendation 500 and § 1.1 of this Annex are about the same complexity; the organization of 8.2 and 8.3 of the Appendix to Recommendation 500 and § 1.1 of this Annex are about the same, but the analysis of results for 8.3 takes longer. Method 8.4 generally requires more sessions than the other procedures and is designed to reduce systematic errors. A comparison of results obtained by some of the methods for certain impairments is given in § 3, and other experimental evidence in § 4 of this Annex.

It is clear that each method is seen as having certain strengths and that the choice among them is not a simple one. It is impossible to do full justice to the arguments presented in a report of this kind, but essentially the main arguments which have influenced workers in the field are as follows.

The choice of procedure is related to the choice of grading scale, whether it should be continuous or discrete, and the way in which observers should be asked to make the correct use of the scale.

As regards the relative value of the quality scale and the impairment scale, some see the "quality" concept as more closely related to viewers interests, and, furthermore, beneficial because if an "impairment" actually improves the picture, the results reflect this. On the other hand, others see the impairment scale as easier to interpret and as having the advantage of allowing measurement of a threshold of perception (between grade 4 and 5 on the impairment scale). It would appear that there is an equal preference of observers opinion between the two scales but there is evidence that it may be possible, in some or all cases, to relate the two semantic axes by an appropriate formula, and work is continuing in this field.

The arguments for a continuous scale are that sometimes the extra organization and analysis time are justified because fine discrimination is both possible and needed. The arguments for a discrete scale are that no better results can be achieved with a continuous scale, for reasons that include the fact that non-experts are, in practice, no more discriminating than the discrete scale allows.

The need for some form of anchoring is recognized by all, and this can be achieved in various ways. Some workers suggest that for impairments which are of interest over a wide range of values, no specific regular reference picture is needed, because the standardized wide range of impairments itself causes observers to correctly orientate themselves on the scale. For experiments using only very small impairments an anchor picture should be provided, but it should not be signified as such, because this would make the observation environment too artificial. The double stimulus procedure may have an advantage in measurements of impairments of small magnitude such as in future systems. Other workers argue that the regular, signified, use of a reference picture (high-quality) helps observers to orientate themselves on the scale and that the results of experiments demonstrate this, particularly for small impairments. Another approach which is believed to be valuable is to use two unsignified reference pictures (high and low-quality).

As regards the EBU method, a grade for the reference, in one case as low as 4.63 was found. In a work by the Australian Broadcasting Commission [1981] a grade for the reference of 4.42 was noted in one case. In SMPTE assessments, using NTSC and RGB as references with observers taken from the broadcasting industry, reference picture grades of 4.7 were noted. Some workers believe that the reason for low values may include insufficient procedural control or non-consistent reference quality, as related to the necessary direct anchoring. In those cases, correction for residual impairment seems necessary as for single-stimulus procedures. Further studies in relation to other procedures may be relevant.

In a move towards rationalization of methods, it should be possible, in the next CCIR study period, to bring major elements of the procedures together and confine alternatives to only certain parts. It is encouraging to note that in a recent practical situation (the study of the relationship between impairment and different digital sampling frequencies [CCIR, 1978-82e, f and g]), where careful procedural rules were applied, virtually the same mean scores were achieved by entirely independent tests using different procedures (§ 8.2 and 8.3 of the Appendix to Recommendation 500).

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ANNEX V

SUBJECTIVE PICTURE QUALITY IN DIGITAL TELEVISION SYSTEMS

Picture impairments in digital television systems are, in general, different from those that occur in analogue systems, and depend on the methods of coding and redundancy reduction employed. Consequently, in early laboratory studies of coding systems which seek to compare different systems or to optimize a particular system, it may be advantageous to use different testing techniques specially chosen to visually distinguish specific impairments more clearly.

Dynamic test pictures have advantages when testing digital and mixed analogue-digital-analogue systems. These test pictures should include linear and rotational movement as well as slow signal-amplitude fluctuations [CCIR, 1974-78]; the latter fluctuations can reveal quantizing contour effects in almost uniform areas.

Test motion pictures comprising 26 short sequences of a range of subjects with differing types of movement and including camera operations such as panning, zooming etc. have been made using the system M, NTSC, standards. They have been used for subjective evaluation of adaptive interfield and intrafield prediction coding schemes [Murakami *et al.*, 1981].

In some cases, subjective assessments may usefully be supported by instrumental methods. The "comparison-field" (e.g. split-screen) technique has been proposed for testing digital systems [Krivosheev, 1976]. In this method, comparison fields are displayed side by side with those areas of the original picture which are being studied. Two types of such fields are used: synthesized fields and natural fields. The first type is generated electronically, and by suitable choices of brightness, chromaticity, structure and configuration can correspond closely with the picture being assessed. Measurements of quantizing noise may be made using this method. The second type of comparison field consists of parts of the original picture; this type can, for example, be used when comparing the input to, and output from, a system.

The use of zone plate test patterns for studying the performance of digital signal-processing techniques such as spatial and temporal filtering, sub-sampling, interpolation etc. has been described [Weston, 1982]. Test patterns should not be used in subjective tests (see Recommendation 500) but, because the zone plate patterns are particularly useful in distinctively revealing some of the impairments due to digital processing, their use can aid the selection of critical test material using real pictures for subjective assessments.

In consideration of the following points:

- higher reproducibility and reliability of evaluation results,
- universal applicability to coding systems,
- ease of matching with physical measurements,

a method of evaluating the quality of digitally processed pictures may be composed of three steps. They are:

- classification of picture quality impairments into degradation factors psychologically independent of each other using an objective criterion;
- selection of physical measures to specify picture quality of the classified degradation factors;
- quantification of picture quality using the selected physical measures.

Reference [Kobayashi, 1977] presents results of the method in the intrafield coded picture case, indicating that picture quality impairments arising from the intrafield coding process can be classified into the following four degradation factors: slope overload, edge busyness, false contouring and granular noise. These results also indicate that the respective degradation factors can be specified using step response rise time, step response jitter width, signal (peak-to-peak) to minimum quantizing error (peak-to-peak), and the weighted signal (peak-to-peak) to analogue random noise (RMS) at the point of subjective equivalence (PSE).

For interframe coding, references [CCIR, 1982-86; Hishiyama and Inoue, 1984] indicate that impairments introduced can be classified into the following four degradation factors: temporarily restrained noise, temporal slope overload, jerkiness and mosaic-like impairment. The references also indicate that physical measures for specifying the respective factors are maximum noise amplitude, the rise time of a moving edge, maximum pulse duration (the pulse width of the difference between input and output signals when the step pulse with constant velocity in the horizontal direction is used as a test signal), and the sub-sampling ratio (the number of picture elements (pels) to be transmitted to the total number of picture elements (pels)).

Comparison of coding algorithms may be carried out by considering the trade-off relation between bit-rate reduction and the corresponding picture quality degradation arising from each type of signal processing employed. Reference [Inoue and Hishiyama, 1984] shows the results of an investigation of the signal processing employed in interframe coding algorithms.

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ANNEX VI

SUBJECTIVE QUALITY OF ALPHANUMERIC AND GRAPHIC PICTURES

Different types of new services may be transmitted in television channels; they use digital codes to describe alphanumeric and graphic pictures (see Report 802). Some transmission parameters have an effect on the quality of displayed pictures: page resolution (number of rows per page and number of characters per row) in the case of alphasosaic coding of teletext, character cell resolution (number of pixels and lines per cell) in the case of DRCS coding, picture resolution in the case of broadcast audiography, facsimile or teletext. Further, the effects of transmission errors which may effect the codes should also be considered. Thus, measurements of quality and determinations of objective-to-subjective relationships for these parameters are necessary.

The contribution [CCIR, 1978-82a] gives a detailed summary of the different aspects of quality assessment for these pictures which have characteristics distinct from those of conventional television pictures. Parameters such as pixel format, character cell resolution, spacings, colours, layout, ... have effects on various quality attributes: legibility, quality, comfort, annoyance, effort of reading, fatigue and aesthetic considerations. Two main aspects were discussed: the viewing conditions and the assessment methods.

1. Viewing conditions

Recommendation 500 defines viewing conditions for television pictures corresponding to low illumination levels in the room. It is likely that alphanumeric and graphic pictures would be viewed also in normal lighting conditions. Thus, a complementary set of viewing conditions is suggested for study: illumination of 500 lux, screen maximum luminance from 70 to 200 cd/m², screen contrast ratio from 30 to 50 and a value of 1/4 for the ratio of background luminance (from the walls of the room) to maximum screen luminance. Viewing distance is also discussed (from 4 to 8 times picture height).

2. Assessment methods

A considerable number of studies have been made on typographical aspects. Most of them have used what might be called "performance measures" like detection or recognition thresholds, recognition ratio, speed of reading, etc. Very few have used "subjective measures" which are of a conventional use in television. It is felt that new systems transmitted in television channels should have good performance (for example, percentage of good recognition of letters higher than 95%). Quality scale and impairment scale from Recommendation 500 could thus be used efficiently although studies are needed to establish the way in which these scales can be related to legibility. A comparison with speech quality assessment methods (CCITT) was tried and a 5-grade scale of "effort of reading" is suggested for studies.

The contribution [CCIR, 1978-82b] compares results of subjective assessments made using two different 5-grade scales given below:

– excellent legibility	– no reading effort
– good legibility	– attention necessary, but no appreciable reading effort
– fair legibility	– moderate reading effort
– poor legibility	– substantial reading effort
– bad legibility	– very substantial reading effort

(Quality of legibility scale) (Reading effort scale)

The scale on the left concerns legibility, the one on the right, the reading effort (it was found important to make each wording of grades explicit). The mean values of the scores obtained with the reading effort scale are generally higher than those obtained with the legibility scale and the range actually used by the observers is higher in the case of the reading effort scale.

Another experiment [White, 1980 and White, 1981] used the quality scale in Note 1 of Annex I of this Report (in accordance with Recommendation 500) to assess opinion of both overall quality and overall legibility of typescript transmitted by a television system of variable line standard and bandwidth. For each condition, two models, one of greater complexity and accuracy, but both invoking the concept of "Imp-scale" addition (Annex II), were discovered to describe the combined effects of limited horizontal and vertical definition. Legibility was also measured in terms of proportion of correctly identified characters. However, legibility in such terms remained high when quality was low, and it is evident that, usually, the former criterion is less useful.

Another study [Sallio and Morin, 1981] carried out comparisons of performance and subjective methods on printed text material using fixed-width and variable-width characters. Subjective methods were shown to be the more sensitive. The same type of study was repeated using a cathode-ray tube display, applying this time only subjective methods. The use of these subjective methods produced results concerning the visually optimum sizes of fixed and variable matrices.

At the moment, too few experiments have been made on the subjective quality of alphanumeric and graphic pictures in the television field; it would be very useful if administrations could make contributions on the subject.

3. Assessment context

A recent contribution [CCIR, 1982-86] describes a new approach to service assessment. When user activities in the service under study can be defined accurately, assessments are not made according to the conventional method of presenting images and simply asking viewers for standard subjective assessments (e.g., Recommendation 500). Instead, viewers use the images presented as if they were using the service under study and all evaluations are performed in this context [e.g. Hearty and Treurniet, 1985].

Service-use emulation does not preclude the use of conventional subjective measures. Instead, it establishes a context for subjective evaluations that is more appropriate to the service under study. Moreover, it may permit the use of objective measures of viewer performance and the development of new subjective measures that are particularly appropriate to the service and parameters under study e.g. [Hearty and Treurniet, 1985]. Finally, it establishes a more secure basis for generalizing assessments from the laboratory to the service under study.

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ANNEX VII

SPECIFICATIONS AND ALIGNMENT PROCEDURES FOR PICTURE SIGNAL SOURCES AND DISPLAYS

Differences in the alignment procedures and performance of the picture signal sources and the picture displays used in subjective tests may contribute to differences between the results obtained in such tests in different laboratories. Study Programme 3A/11, recognizing this problem, invites studies on the minimum performance specifications and on the alignment procedures that can be recommended for picture signal sources and for picture displays to be used in subjective tests.

The EBU has recommended to its member organizations [CCIR, 1978-82] a detailed alignment procedure for grade 1 colour monitors used in television production centres. Although referring to monitors used for a different purpose, this contribution is nevertheless relevant to the monitors used in subjective tests because both these applications require high-quality and reproducible performance standards. The document is therefore noted as a valuable preliminary input to the studies on picture sources and displays.

Broadcasting organizations throughout the world need some means of achieving accurate and consistent line-up of their picture monitors on a routine operational basis. A survey carried out in 1984 [CCIR, 1982-86a] showed that many broadcasters are using a type of test waveform known as PLUGE, an acronym derived from picture line-up generating equipment. This type of waveform was introduced in 1960, and since that time different broadcasting organizations have made slight modifications to suit their own circumstances. The current situation is that most broadcasters use variations of the PLUGE signal and their methods of alignment vary slightly.

In these days when the exchange of programme material both within countries and internationally is the norm, it would be helpful if all picture monitors could be aligned to a consistent standard, and it is therefore recommended that all PLUGE generators should be adjusted to produce the same waveform, as far as is sensibly possible, and that monitors should be set up using a consistent procedure.

1. Details of the PLUGE waveform

All PLUGE generators produce a waveform which gives two closely-spaced narrow vertical strips on the left-hand side of the picture, one slightly darker and one slightly lighter than the background, together with a broad bar on the right (see Fig. 4). These signals occupy approximately three-quarters of the picture height while the remaining area is at blanking or pedestal level. In more recent generators the broad bar is divided into four equal areas, one at white level and the other three at descending grey levels. In older generators, the broad bar is divided into two equal areas, one at white level and the other at a grey level.

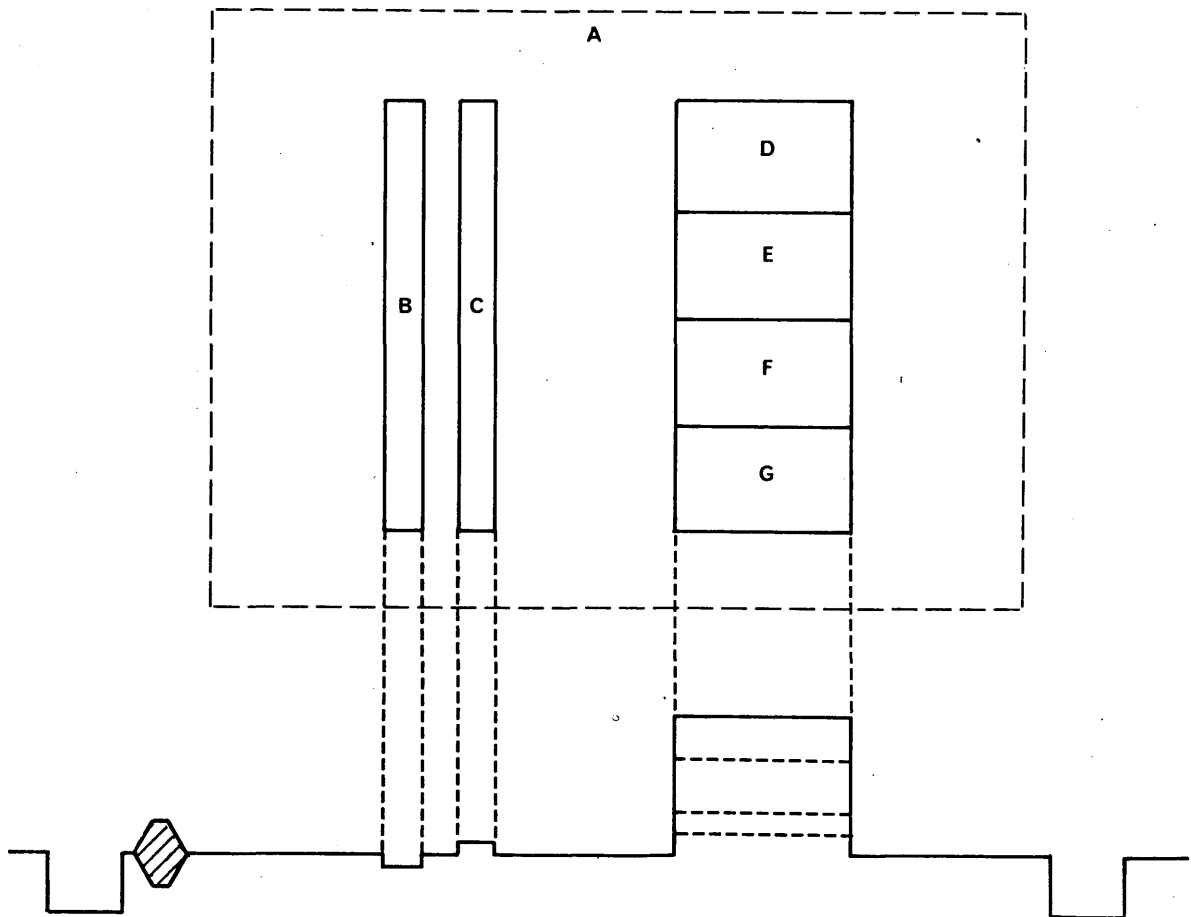


FIGURE 4 – Basic PLUGE display with waveform

- A: blanking or pedestal level background
- B: just blacker than background
- C: just brighter than background
- D: peak white
- E: 1st grey bar
- F: 2nd grey bar
- G: 3rd grey bar

2. Variations in PLUGE waveform parameters

The 1984 survey revealed the following differences (see Table III) between the PLUGE-type signals used in different countries.

TABLE III

Country	Pedestal amplitude (mV)	Narrow pulses signal amplitude (mV)		White level luminance for 700 mV bar amplitude (cd/m ²)
Austria (ORF)	20	+ 28	− 28	
Canada (CBC)	52.5	+ 14	− 14	
Federal Republic of Germany (IRT)	0 or 49	+ 14	− 14	80
Netherlands (NOS)	− 21	+ 14	− 14	(¹)
New Zealand (TVNZ)	20	+ 20	− 20	70
Sweden (Swedish Television)	0	+ 14	− 14	(²)
United Kingdom	0	+ 14	− 14	70/100

(¹) Separate full-field signal used — 70 cd/m².

(²) 100 cd/m² white-level bar on all lines.

Note. — In North America, SMPTE Engineering Recommendation ER-1 includes a PLUGE signal as part of the colour bar test signal for monitor alignment.

3. Proposed procedure for use of the PLUGE waveform

The usual recommended operational procedure is to adjust the brightness control so that the background and the darker strip are both invisible while the lighter strip can still be distinguished. Alternatively, the brightness control is set so that the darker strip is just, but only just, indistinguishable from the background. Provided that a narrow pulse amplitude of about 2% of the black and white excursion (about 14 mV) is used, either procedure will give virtually the same brightness control setting, at which the background level corresponds with the effective tube cut-off point.

The white level luminance is adjusted, by means of the contrast control, to a luminance level which varies with different organizations, but Recommendation 500 gives 70 ± 10 cd/m².

To achieve a refined setting of the brightness control, it is recommended that all PLUGE generators should be adjusted to produce narrow pulses of $\pm 2\%$ amplitude, with reference to a black-to-white transition. It is also recommended that the width of the narrow pulses, and the interval between the two should each have nominal durations of 2.3 μ s, to provide areas of adequate size.

To ensure that all signals between black level and white level will produce a visible image on the screen, it is essential that black level should be not greater than blanking level. Consequently, it is recommended that the PLUGE signal should contain no pedestal (i.e. the background level should be blanking level).

It is recommended that the preferred signal should incorporate a broad bar containing a white area and three equal areas of descending brightness, to facilitate the adjustment of grey-scale tracking. However, it is considered that this feature is of secondary importance, and the PLUGE generators providing only one grey area are suitable for use as standard sources, provided that the other recommendations are satisfied. In order to ensure that the colour decoder of a monitor is working in its colour mode, it is recommended that a standard colour burst is included in the waveform.

One of the most completely specified waveforms is that of the United Kingdom, shown in Fig. 5.

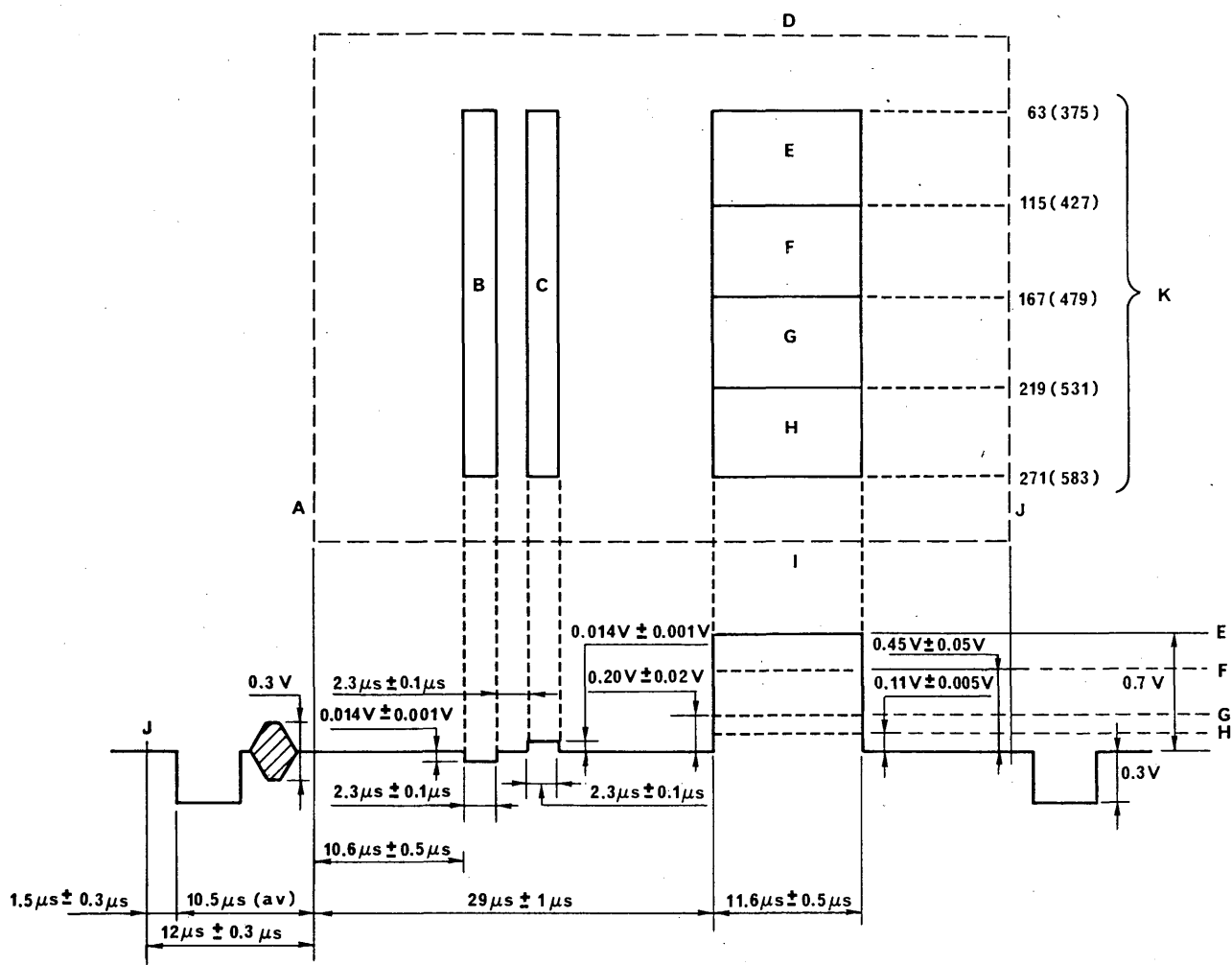


FIGURE 5 – Example of PLUGE waveform (625-line PAL)

- A: line-blanking finish
- B: black bar
- C: dark grey bar
- D: field-blanking finish
- E: white
- F: grey level 1
- G: grey level 2
- H: grey level 3
- I: field-blanking start
- J: line-blanking start
- K: line numbers where transition occurs (first and second fields)

Using this waveform, the monitor brightness control should be adjusted under standard viewing conditions to the maximum value for which the transition between the darker narrow strip and the background is indistinguishable, while the lighter narrow strip is clearly visible.

It is considered that the white level luminance should be determined by the user's requirements, although it is recommended that similar levels should be used for specific purposes.

For the time being, it is suggested that laboratory assessments should be made using a white level luminance of 70 cd/m², in accordance with Recommendation 500, but that a luminance level of about 100 cd/m² is more appropriate for control-room applications.

4. Conclusion

An ideal picture monitor alignment procedure would completely standardize the light transfer characteristic (video signal level to light reaching the observer's eyes) of the monitor. The light transfer characteristic resulting from monitor alignment with PLUGE may be dependent on room ambient light level. At present, the interaction of monitor faceplate characteristics (CRT surface and light absorption in CRT faceplate) with veiling illumination (room light falling on the CRT faceplate) is not completely understood. Thus the PLUGE signal should be considered as a means to match monitors of identical optical characteristics used in a common viewing environment.

At present the PLUGE signal is specified only in analogue composite form. Further work is needed to specify an equivalent digital version.

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REPORT 959-1

EXPERIMENTAL RESULTS RELATING PICTURE QUALITY TO OBJECTIVE MAGNITUDE OF IMPAIRMENT

(Question 3/11, Study Programme 3B/11)

(1982-1986)

1. Introduction

- *Study Programme 3B/11* calls for the establishment, in an appropriate form, of the relationship between the objective parameters of impaired television signals and the subjective assessment of displayed picture quality;
- *Recommendation 500* defines the methods of subjective assessment of television picture quality;
- *Recommendation 567* describes the objective parameters of typical transmission impairment and measuring methods as well as the corresponding test signals;
- *Report 405, in Annex III*, gives the basis for processing the results of subjective tests to arrive at a unified method of presenting what is called an impairment characteristic, the value of the objective measurement of impairment being related to the mean score of the picture assessment and the "imp" unit scale;
- *Report 405, in Annex II*, gives the law of addition which best covers the cumulative effect of a number of simultaneous distortions expressed individually by a numerical value;
- *Report 313* gives a general bibliography of all documents related to the evaluation of the picture quality.

2. Classification of major types of impairments (composite colour systems (PAL, SECAM and NTSC))

This section concerns only distortions of the analogue composite signal in conformity with the measurement methods of Recommendation 567. It does not deal with the characteristics associated with component-based colour systems, both analogue and digital.

It concerns natural pictures, portraits, detailed natural scenes and does not deal with graphic and alphanumeric pictures.

2.1 Classification

A large number of results have been published in the technical literature (see Report 313). Comparison of the results frequently shows, for each type of impairment, a large measure of dispersion which may be attributable to considerable differences in the test conditions, particularly regarding the choice of pictures, the subjective measurement method (which includes the picture assessment scale and the relative viewing distance), the source equipment and the adjustment procedure. The receiving equipment and the setting-up procedure may also influence the results.

The dispersion also reflects the variety of the television equipment in use, and new measurements are not likely to produce major changes in an average interpretation of currently available results.

By adopting, for each type of distortion an impairment characteristic regarded as representative of an average situation, it is possible to provide a reference basis for the most common practical applications, and this may enable a correction factor to be introduced for situations defined with special precision.

Having regard to the sources of impairment commonly taken into account by researchers, it seems possible to make a classification consisting of a first group of distortions for which it is desirable to establish an impairment characteristic, and a second group for which the adoption of an impairment characteristic may be considered less important in practice or unsuitable for the statistical processing used to arrive at such a characteristic. For this group, it might suffice to give only a few figures as examples.

Recommendation 654 lists distortions and impairments of the first group and the impairment characteristics for each. The first group concerns:

- 1 – Short-time linear distortion
- 2 – Differential gain
- 3 – Differential phase
- 4 – Luminance-chrominance gain inequality
- 5 – Luminance-chrominance delay inequality
- 6 – Continuous random noise (unweighted white noise)
- 7 – Echo

The second group concerns:

- 1 – Line-time linear distortion
- 2 – Field-time linear distortion
- 3 – Long-time linear distortion
- 4 – Luminance signal insertion gain
- 5 – Synchronization signal insertion gain
- 6 – Steady-state delay-frequency response
- 7 – Luminance-on-chrominance and chrominance-on-luminance intermodulation
- 8 – Chrominance signal linear distortion
- 9 – Non-linear distortion of the luminance signal
- 10 – Non-linear distortion of the chrominance signal
- 11 – Spectral band of luminance signal
- 12 – Spectral band of colour difference signals
- 13 – Sine-wave interference
- 14 – Narrow-spectrum random noise
- 15 – Recurrent low-frequency hum
- 16 – Impulsive noise

2.2 *Experimental results*

Tables I and II present results of particular importance.

Table I gives the results of studies in the United Kingdom. These studies were carried out using the method of Recommendation 500, additional details of the tests being in accordance with § 1 of Annex IV to Report 405. They apply directly to System I/PAL but small adjustments may be necessary for other systems.

Recourse should be made elsewhere [Macdiarmid and Allnatt, 1978; CCIR 1978-82a] for a list of references to detailed descriptions of the original work (see Report 313).

Table II presents results of investigations conducted in the German Democratic Republic [CCIR, 1978-82b] on System B/SECAM. The methods of Recommendation 500 were largely used here. In some types of impairment, the coefficients G and d_M are missing because in these cases the formula mentioned below does not sufficiently describe the relation.

In both tables, values of subjective impairment* may be readily determined from the formula:

$$I_u = (d/d_M)^G \text{ imp}$$

Definitions of the objective magnitude d are given in the notes to the Tables.

For convenience, objective magnitudes in the units conventionally used are also listed for the mark points of 1, 1/2, 1/4 and 1/8 imp (see Annex II to Report 405). The corresponding mean scores on the quality scale of Recommendation 500 are 3.0, 3.7, 4.2 and 4.6.

3. *New studies on impairments*

3.1 The results which appear in the preceding sections concern only the distortions sustained by the analogue composite signal, measured in accordance with the methods of Recommendation 567 and applicable to TV pictures corresponding to natural scenes.

The new developments in television systems, such as component analogue systems (MAC), digital television, systems of graphic or alphanumeric picture transmission, lead to new methods of measurement and new results, certain aspects of which are already mentioned in Report 405 and Report 956.

3.2 *Bandwidth of the luminance component*

Regarding the activity and interest newly shown for colour systems based on components, both analogue and digital, the interest for the characteristic linking subjective quality to the bandwidth of the components is useful and opportune.

Throughout the studies, which led to the adoption of digital studio standards (Recommendation 601), numerous experiments have been made concerning the bandwidth of component signals.

The effective bandwidth of the channel conveying the luminance component of a television signal between picture source and picture display determines the amount of blurring of the displayed picture. In composite colour systems (PAL, SECAM and NTSC), the presence of a colour sub-carrier and the means of decoding the composite signal modify the effective luminance bandwidth in a manner dependent on the details of the decoder design. However, in monochrome systems and the emerging colour systems using separate component transmission, the bandwidth of the luminance channel is known and its effect on picture quality can therefore be determined.

Bandwidth is defined here (assuming a low-pass channel) as the frequency at which the insertion loss of the channel is 3 dB greater than the average loss at low frequencies.

The impairment produced by a given reduction of bandwidth depends significantly on:

- the viewing distance; the impairment is greater at closer viewing distances
- the type of picture displayed; graphics and alphanumerics are most sensitive while pictures with low-contrast details, such as portraits, are least sensitive.

* The values of I may be used for the addition of impairments applying one of the known summation laws (see Report 405, Annex II, § 2).

TABLE I – Experimental results for System I/PAL

Impairment	Note (see over)	G	d_M	Mark point values (dB, except where stated)			
				1-imp	1/2-imp	1/4-imp	1/8-imp
Wideband random noise	1						
Luminance weighting	2	2.41	0.0167	36	38	41	43
Chrominance weighting	2	2.79	0.0327	30	32	34	36
Unified weighting	3	2.5	0.0123	38	41	43	45
Unweighted 5 MHz	4	2.6	0.0315	30	32	35	37
Unweighted 5.5 MHz	4	2.6	0.0330	30	32	34	37
Unweighted 6 MHz	4	2.6	0.0345	29	32	34	36
Localised random noise*	5						
3.2 kHz		1.73	0.0113	39	42	46	49
7.5 kHz		2.79	0.0271	31	33	36	38
Sine-wave noise*	6						
1 kHz		1.26	0.00546	45	50	55	60
3.2 kHz		1.26	0.0185	35	39	44	49
1 MHz		1.23	0.00765	42	47	52	57
3.2 MHz		1.19	0.0779	22	27	32	37
Undistorted crosstalk	7						
Pulse-and-bar signal		1.28	0.0155	36	41	46	50
Colour-bar signal		1.68	0.0291	31	34	38	41
Differentiated crosstalk	7						
Colour-bar signal		1.77	0.0422	27	31	34	38
Differential gain	8	2.86	0.437	44%	34%	27%	21%
Linear waveform distortion*	9						
K rating	10	2.35	0.113	11%	8.4%	6.3%	4.7%
Positive echo delay (µs):	11						
0.2		2.54	0.361	9	11	14	16
0.3		2.54	0.251	12	14	17	19
0.5		2.54	0.166	16	18	20	23
1		2.54	0.107	19	22	24	27
2		2.54	0.0814	22	24	27	29
5		2.54	0.0699	23	25	28	30
13		2.54	0.0668	24	26	28	31
Negative echo delay (µs):	11						
0.2		2.06	0.883	1	4	7	10
0.3		2.06	0.592	5	7	10	13
0.5		2.06	0.360	9	12	15	18
1		2.06	0.192	14	17	20	23
2		2.06	0.116	19	22	25	27
Gain inequality	12	2.86	0.564	56%	44%	35%	27%
Delay inequality	13	2.41	355	350 ns	270 ns	200 ns	150 ns

* Monochrome test.

Notes referring to Table I:

Note 1. — “Wideband random noise” tests were made with random noise having several spectra, each extending over all the video-frequency band. Here, d is the r.m.s. voltage of the noise expressed as a proportion of the nominal peak-to-peak excursion of the luminance signal (normally 0.7 V). The mark point values are expressed as signal/noise ratios, in decibels, given by $-20 \log d$.

The quoted results have been combined from separate monochrome and colour tests, in which the requirement for the luminance channel in the colour tests was found to be rather less stringent than for monochrome. The more stringent result has been adopted but the ratio of the luminance and chrominance mid-opinion values has been based on the colour test. The values for G for the two tests were in close agreement.

Note 2. — Mark points are based on the subjective effect in the luminance channel or the chrominance channel alone, noise being measured through the appropriate weighting network (Recommendation 451, Geneva, 1974).

Note 3. — Mark points are based on the total subjective effect, noise being measured through the unified weighting network of Recommendation 567.

Note 4. — Mark points are based on the total subjective effect of flat noise extending up to 6 MHz but limited to the upper frequency designated prior to unweighted measurement. Results are not greatly affected by moderate departures of the noise spectrum from uniformity.

Note 5. — “Localized random noise” tests were each made with narrowband random noise, centered on the stated frequency, designed to simulate the noise produced by cascaded video amplifiers supplied by power units of a certain type. The definitions of d and the mark point values are identical with those for wideband random noise (Note 1). No weighting network is involved.

Note 6. — “Sine-wave noise” tests were each made at a frequency, close to the stated nominal frequency, at which the effect was worst. Here d is the peak-to-peak voltage of the noise expressed as a proportion of the nominal peak-to-peak excursion of the luminance signal (normally 0.7 V). The mark point values are expressed as signal/noise ratios, in decibels, given by $-20 \log d$.

Note 7. — “Undistorted crosstalk” and “differentiated crosstalk” tests were made with the stated disturbing signals, whose line or sub-carrier frequencies were offset to give the worst effect. Differentiated crosstalk is that in which the crosstalk voltage is proportional to frequency. In both cases, d is taken as the peak-to-peak voltage of the “picture” portion of the crosstalk waveform, expressed as a proportion of the nominal peak-to-peak excursion of the luminance signal (normally 0.7 V), when measured with a luminance or chrominance pulse-and-bar disturbing signal as appropriate. The mark point values are expressed as signal/crosstalk ratios, in decibels, given by $-20 \log d$.

Note 8. — Based on a small preliminary experiment. The result is essentially for chrominance gain at mid-grey level relative to that at black and will probably tend to over-estimate the subjective impairment when applied to a measurement of maximum error. d is taken as the proportional voltage error. (See § 2.1 of Recommendation 654.)

Note 9. — Based on tests with undistorted echo covering the range 0.2 to 13 μ s (0.2 to 2 μ s for negative echo).

Note 10. — d is the proportionate value of K as defined in Recommendation 451, Geneva, 1974. Results for positive echo were used as a transfer standard in determining the appropriate values of G and d_M . Mark points for K are expressed as percentages.

Note 11. — d is the magnitude of echo expressed as a proportion of that of (signal + echo), echo polarity being taken into account. The mark point values are expressed as (signal + echo)/echo ratios, in decibels, given by $-20 \log d$.

Note 12. — “Gain inequality” tests were concerned with gain differences of the chrominance channel with respect to the luminance channel; d is taken as the proportional error of chrominance signal voltage. The mark point values are simply values of d expressed as percentages.

Note 13. — “Delay inequality” tests were concerned with delay differences of the chrominance channel with respect to the luminance channel; d is the relative delay, in nanoseconds, of the chrominance signal. The mark point values are expressed directly as values of d .

TABLE II - Experimental results for System B/SECAM

Impairment	Note	G	d_M	Mark point values (dB, except where stated)	
				1-imp	1/8-imp
Wideband random noise 0 to 5 MHz, luminance weighting	1	3.88	0.0118	38.5	43.2
Wideband random noise 0 to 20 kHz, luminance	1	2.96	0.00868	41.2	47.3
Hum heterodyning	2	1.08	0.0684	23.3	40.0
Crosstalk:					
- of luminance signal	3	2.02	0.0102	39.8	48.7
- of chrominance signal	3	3.27	0.240	12.4	17.9
Positive echo delay (µs):	4				
0.2		2.13	0.248	12.1	20.6
0.3		2.03	0.222	13.1	21.9
0.5		1.90	0.190	14.4	23.9
1		1.74	0.149	16.5	26.9
?		1.57	0.111	19.1	30.6
5		1.35	0.0668	23.5	36.9
Delay inequality	5	2.31	543 ns	543 ns	221 ns
Rise time	6	3.64	267 ns	267 ns	151 ns
Non-linearity	7			48%	14%
Level deviation	8			-1.7/+2.4	-0.1/+0.8

Note 1. — White noise in the frequency band mentioned was used. Here d represents the r.m.s. voltage of the noise expressed as a proportion of the nominal peak voltage of the luminance signal (0.7 V). The mark point values are expressed as signal/noise ratios, in decibels, given by $-20 \log d$.

Note 2. — The subjective effect of hum also depends on harmonic content, on the hum frequency, and on the type of receiver. The table gives an average value as a good approach to practical conditions. Here d is the ratio of the peak-to-peak value of the hum voltage to the peak level of the luminance signal (0.7 V).

Note 3. — The interfering signals were respectively an electronic monochrome picture and colour bar signal.

Note 4. — d means the ratio of echo to signal.

Note 5. — Here d expresses directly the delay time between the luminance and the chrominance channel.

The experiments showed no great differences in the subjective assessment of positive or negative deviations of the same magnitude.

Note 6. — The 10 to 90% rise time of an ideal step, after passing through the transmission channel in question was measured as d .

Note 7. — The non-linearity of the amplitude characteristic can be evaluated by amplitude measurement of a small audio signal, A , superimposed on a saw-tooth signal.

The value obtained,

$$d = \frac{A_{max} - A_{min}}{A_{max}} \times 100\%$$

is not sufficient to indicate the subjective effect on the picture quality because the shape of the amplitude characteristic is also of importance. The mark point given is valid only for gently curved characteristics.

Note 8. — In the SECAM system the deviations of level result in changes of colour saturation. Here d means the difference between peak-to-peak amplitude of the luminance signal and its nominal value (0.7 V), divided by this nominal value.

The impairment characteristics illustrated in Fig. 1 give results for two viewing distances (4 and 6 times picture height) and two classes of picture (graphics and natural scenes with large amounts of detail).

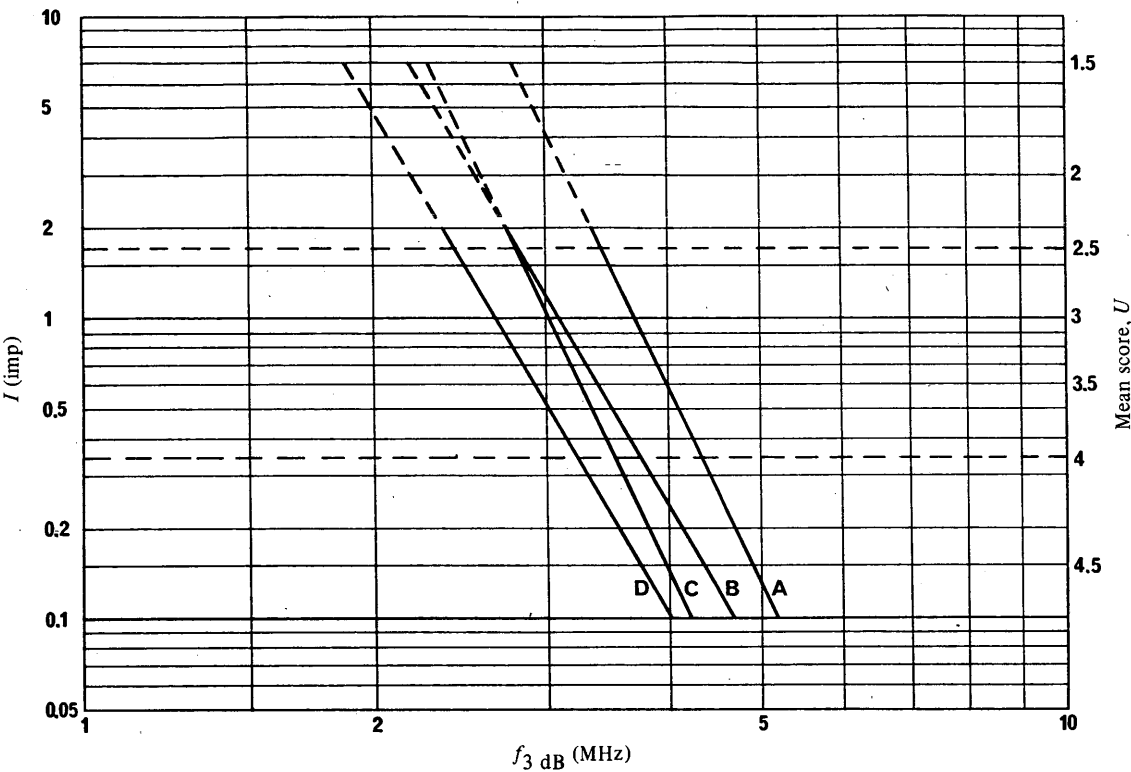


FIGURE 1 – Impairment characteristics for bandwidth restriction of the luminance signal

- A: graphics and alphanumerics – viewing distance = 4 H
- B: graphics and alphanumerics – viewing distance = 6 H
- C: detailed natural scenes – viewing distance = 4 H
- D: detailed natural scenes – viewing distance = 6 H
- U: mean score, 5-grade scale

The results apply to 625-line systems:

- impairment factor: $d = f_3 \text{ dB}$
 $f_3 \text{ dB}$: 3 dB bandwidth (MHz)
- mid-opinion values ($I = 1$):

viewing distance:	4 H	6 H
graphics	$d_M = 3.70$	$d_M = 3.09$
scenes	$d_M = 3.02$	$d_M = 2.67$
- slope

viewing distance:	4 H	6 H
	$G = 6.80$	$G = 5.60$

REFERENCES

MACDIARMID, I. F. and ALLNATT, J. W. [1978] Performance requirements for the transmission of the PAL coded signal. *Proc. IEE*, Vol. 125, 571-580.

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REPORT 1082

METHODS FOR MEASURING THE INTRINSIC PICTURE QUALITY OF CURRENT AND NEW TELEVISION SYSTEMS

(Question 3/11, Study Programme 3A/11)

(1986)

Recommendation 500 and Report 405 address the measurement of the effect of signal impairments on subjective picture quality. However, the frequent use of the word "quality" in these documents could be misleading. While the use of the five-grade impairment or quality scales may be appropriate for the subjective evaluation of signal *impairments*, their use for the evaluation of intrinsic picture *quality* is not always appropriate.

Many administrations are now investigating new systems such as improved, enhanced and high-definition television systems. Their purpose is to devise television systems capable of producing higher picture quality. Thus, there is now a need for methods for assessing and comparing the intrinsic quality of television systems as opposed to evaluating the degradations to quality within a given system.

This Report is a start towards the development of the methodologies required. Annex I contains the description of a method which uses magnitude estimation to directly estimate ratios of picture quality. Annex II describes an experiment, measuring the quality of several television systems, which compares results using the method described in Annex I, with results using the five-grade quality-grading scale recommended in Recommendation 500.

ANNEX I

RATIO-SCALING METHOD FOR THE EVALUATION OF PICTURE QUALITY

1. Introduction

Because it permits the broadest range and variety of statistical operations, the ratio scale allows one not only to rank the order of the elements being scaled but also to describe the relative magnitudes of any chosen attribute of those elements. One can determine, for example, not only that picture A is better than picture B, but also *how much better*. A category scale allows only a determination of rank order and not of the intervals in between. The most appropriate psychophysical method for generating ratio scales of picture quality is magnitude estimation.

The method of magnitude estimation has been used throughout the world since the middle 1950s. The scales yield ratio and therefore equal-interval data. With ratio-scale data, it is legitimate to calculate geometric or harmonic means, as well as arithmetic means, and to calculate percentage variations as well as standard deviations. This increased precision allows a more complete description of the data. The observers generate their own scales and therefore avoid one important failing of fixed scales, that of imposing potentially inappropriate verbal labels and numbering systems.

2. Experimental test methodology

2.1 Procedure

In the method of magnitude estimation, the observers produce their own scales as the experiment progresses. The observer is presented with a series of pictures, in random sequence (preferably in a different order to each observer) and is asked to assign a numerical value of quality to each picture presented. The instructions should include the following information and be modelled on this example:

You will be presented with a series of pictures in random order. Your task is to judge the picture QUALITY of each by assigning numbers to them. Rate the first picture any number that seems appropriate to you. Then assign numbers to successive presentations, in proportion, in such a way that they reflect your subjective impression. There is no limit to the range of numbers you may use. You may use whole numbers, decimals, or fractions. Try to make each number match the picture quality as you perceive it. For example, if one picture looks three times better than another, assign a number three times greater; if it looks only one-fifth as good, assign a number one-fifth as great.

The range and number of stimuli should be as large as is reasonable for the particular experiment so as not to restrict the observer to a small set of conditions and to allow the observer to use all those criteria available for making quality evaluations. Each stimulus is ordinarily presented twice (more presentations have been found to give little or no additional information).

2.2 *Judgement of "ideal"*

In order to establish a reference to make it possible to compare test results obtained in different laboratories with different television systems, test pictures, etc., the observers should be asked, at the end of each test session, to assign the numerical value appropriate to their conception of picture quality which they would consider "ideal". The "ideal" is intended to refer to the single best possible picture quality imaginable produced by any imaging system. In the analysis of the data (see § 2.6), the judgement of the "ideal" (i.e. that number) will be normalized to become the number 100, and this value will provide a uniform standard.

2.3 *Observers*

It has been found that the ratios of the geometric means become stable when fifteen observers are used (of course, more can be used if desired).

2.4 *Test pictures*

The appropriateness of the test pictures depends upon the specific experiment being conducted and cannot be specified here. Image motion should certainly be included in the assessment of advanced television systems. Still imagery will continue to be important and in order to provide continuity, it is advisable, whenever appropriate, to use standard test scenes.

2.5 *Presentation*

The pictures should be presented in random sequence with the proviso that the same picture (i.e. test scene or sequence) should not be presented on two successive occasions at the same quality level. If possible, a different random sequence should be presented to each observer. The initial stimulus picture for each observer should be varied, but the quality level need not be. It is advisable to begin each sequence somewhere in the middle of the range, not at either end point.

A viewing session should last approximately one half-hour, including the explanations and preliminaries. The test sequence could begin with a few pictures indicative of the range of picture quality (but it need not, and the observer absolutely should not be told what the range might be). Judgements of these preliminary presentations would not be taken into account in the final results.

2.6 *Normalizing and averaging magnitude estimates*

The most appropriate and commonly used measure of central tendency with magnitude-estimation data is the geometric mean. It takes into account the distribution of the responses and has the advantage of preventing an extreme judgement from overly influencing the result. It gives an unbiased estimate of the expected value of the logarithms of the magnitude estimates. Despite the different numbers that the different observers may have assigned to the first stimulus, no normalizing is necessary prior to averaging. The ratios of the geometric means remain unaffected even though the observers use different units for their subjective scales. However, normalization will become necessary for certain subsequent statistical operations and for inter-laboratory comparison. To accomplish this, the following calculations for normalizing to the "ideal" should be followed for each observer's data.

The geometric means will be normalized so as to give the "ideal" the standardized value of 100. To accomplish this, the geometric mean of the numerical responses should be calculated. All the geometric means are then multiplied by the common factor $100/R_i$ (where R_i is the numerical value of the "ideal" response). This simple procedure serves to define the "ideal" as 100 and at the same time to adjust the mean responses to all of the other stimuli in proportion.

ANNEX II

A COMPARISON OF PICTURE QUALITY ASSESSMENTS
BY CATEGORY RATING AND MAGNITUDE ESTIMATION**1. Introduction**

A pair of picture quality experiments was conducted [CCIR, 1982-86] using the quality grading scale of Recommendation 500 and, for comparison, those of the method of magnitude estimation. The purpose was to examine the effect of context on the two test methodologies. The reason for such interest at this time is the emergence of highly improved television pictures and its effect of stretching the range of picture qualities. Little prior research has used magnitude estimation to evaluate picture quality, although the work which has been done, has shown magnitude estimation to be the better method. Moreover, no work has assessed high-definition television picture quality. Two stimulus ranges were tested on otherwise equivalent stimulus material and observers.

2. Procedure**2.1 Test method**

Each observer was tested individually and two quality assessment methods were used. The category rating scale evaluation used the quality scale of Recommendation 500 as a method for estimating the quality of the test images. The mean scores for each test picture were calculated. The magnitude estimation evaluation followed the procedures outlined in Annex I to this Report.

2.2 Apparatus and arrangement

The observers sat at a viewing distance of three times picture height. Both CRT displays were run at 60 Hz field rate and had 19-inch (48.3 cm) diagonals.

There were four levels of picture quality in one test and five in the other; A, B, C and D respectively stand for 525-line NTSC, notch filter decoder; 525-line NTSC, comb filter decoder; RGB direct from the camera; and high definition. All of these pictures were considered to be of good to excellent quality (narrow range). The X and Y stimulus levels in the extended range test were 525-line NTSC, notch filtered with noise added. The S/N levels for this extended range test were 22 (X) and 32 (Y) dB. In this test there were fewer RGB data points because each observer scaled RGB only once, as the last judgement of each test session.

Approximately five weeks separated the two tests.

2.3 Observers

All 67 observers had normal or corrected-to-normal visual acuity and colour vision as tested with a Snellen Chart and Ishihara colour plates respectively. No observer had ever participated in a magnitude estimation experiment but a few had experience with five-grade scales.

Three groups of observers participated.

A group of 9 "experts" was gathered from within the laboratory. They were men who work in the field of television engineering. Their ages ranged from 27 to 65 years.

A group of 47 non-experts was also gathered from within the laboratory. They were women and men whose ages ranged from 33 to 60 years.

A group of 11 high school students was gathered to balance the total group. They were males and females, 16 years of age.

2.4 Viewing conditions

The viewing conditions were generally kept in accordance with Recommendation 500 except for the viewing ratio which was three times picture height.

2.5 Test pictures

The three test pictures were 8 × 10-inch (25.4 cm) colour transparencies of the Stamford, Connecticut area. They were illuminated by a Porta-Pattern. These pictures were selected specifically to ensure the highest quality possible and a reasonable amount of high spatial frequency information.

Two cameras were trained on the Porta-Pattern: a medium quality 525-line camera and an 1125-line HDTV camera. All pictures were fed from the cameras to encoders when appropriate, or else directly to the displays.

3. Results

3.1 Five-grade scale tests

Figure 1 shows the results of the two category scale tests. The three quality levels which were common to both tests shifted to some degree. The notch-filtered picture shifted most – from 1.88 to 3.56 – a shift of 63% of the total range from minimum to maximum response. In other words, the shift in the rating from the narrow range experiment to the wide range experiment was nearly as great as the entire range of ratings used in the narrow range experiment.

Note also the apparent lack of meaning of the verbal labels: a picture which had been rated “poor” became “good”.

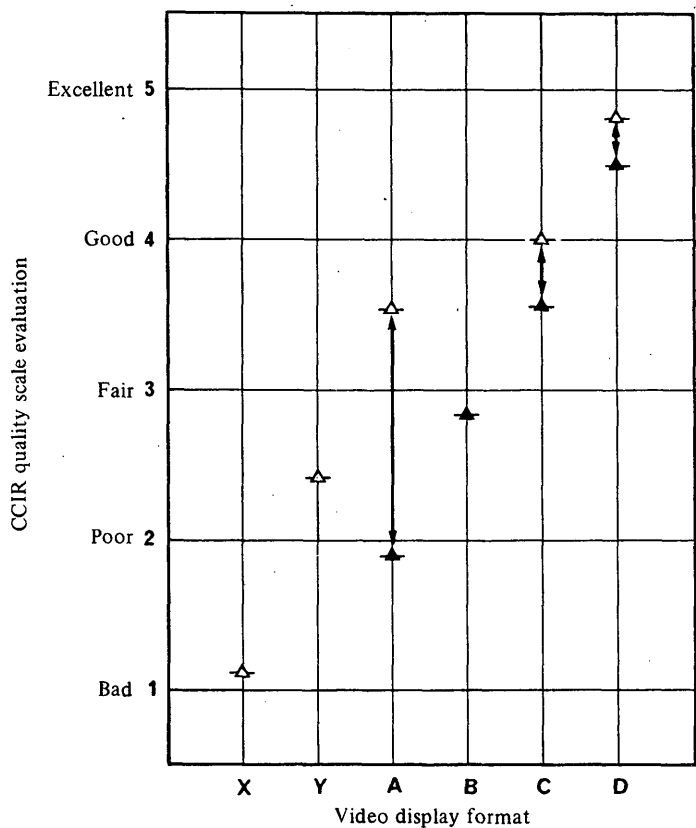


FIGURE 1 – Five-grade scale tests

- ▲ Narrow range
- △ Wide range
- ↕ Response shift

3.2 Magnitude estimation tests

Figure 2 shows the results of the two magnitude tests. Similar shifts are present here, but they were quite small compared with those of the five-grade scale. Again, the notch-filtered picture was shifted the most, but in this case, the analogous shift was only 34% (as opposed to 63%).

Another point of interest is the fact that when the stimulus range stretched, the observers' numbers stretched. The total range of numbers used in the narrow range test was 43 (19.5 to 62.5) while in the expanded range test it was more than 60 (4.12 to 64.5). This is further evidence that the magnitude scale was more suited to the task and more naturally adaptable. Observers behaved more appropriately by expanding their scales in response to a wider range of stimulus quality. With the quality scale, when the stimulus range stretched, the numbers and labels had nowhere to go.

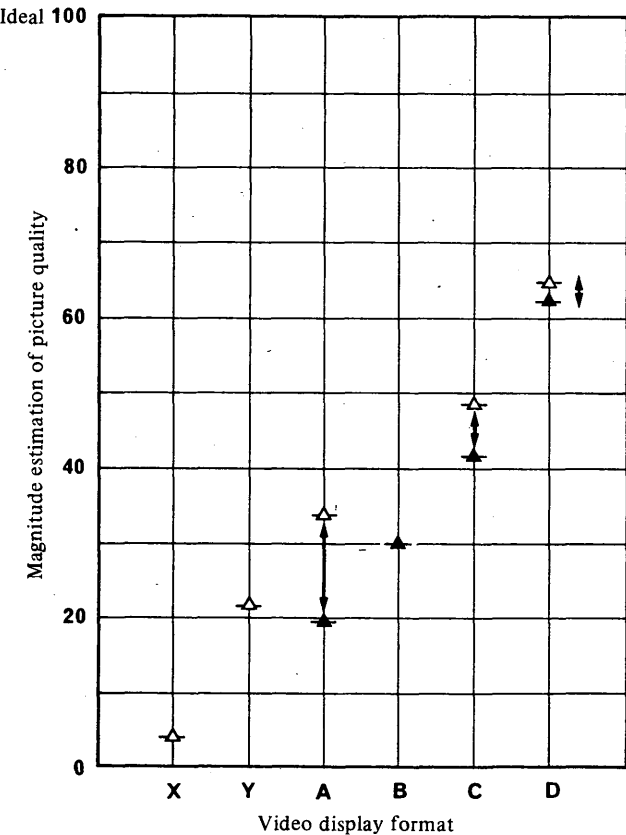


FIGURE 2 – *Magnitude estimation tests*

- ▲ Narrow range
- △ Wide range
- ↑↓ Response shift

Finally, it is interesting to note that the results of the relatively “naive” high school students showed very little effect of stimulus range, that is, there was little shift between the narrow and wide range tests as shown in Fig. 3.

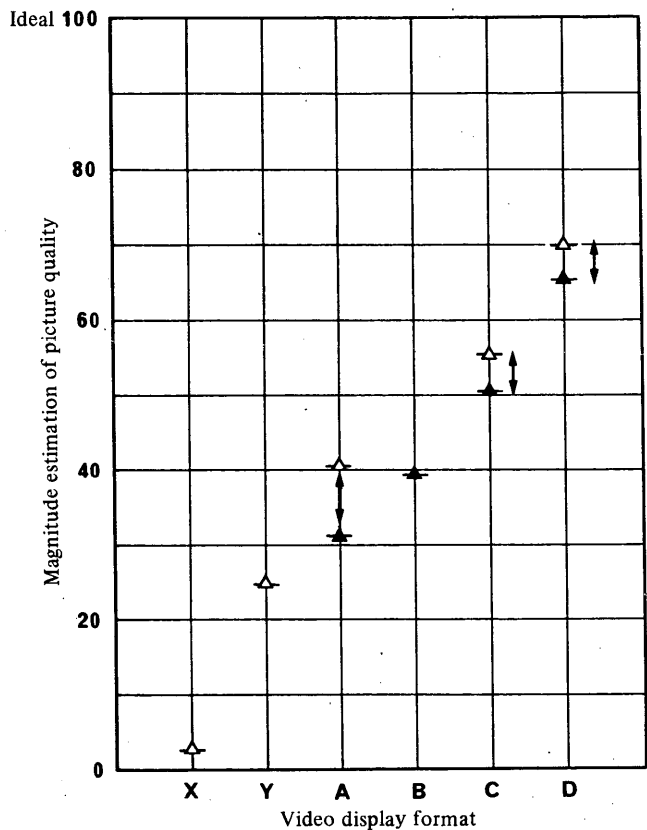


FIGURE 3 – *Magnitude estimation tests (high school students)*

- ▲ Narrow range
- △ Wide range
- ↕ Response shift

4. Summary

For the judgement of intrinsic picture quality, these results demonstrate that ratings on a five-grade category scale show large effects of stimulus range (context), making problematic any interpretation of the labels attached to the average ratings. However, such effects can be diminished when it is practicable to design the experiment so that the grand mean score is close to 3.0. Magnitude estimations, by contrast, showed much smaller effects of context, and have the virtue of providing meaningful ratios and intervals in the numerical responses; for instance, the results showed that the notch-filtered pictures were assessed to be only 0.33 to 0.5 as high in quality as the best high-definition pictures.

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[1982-86]: 11/379 (USA).

REPORT 1083

ADVANCED STATISTICAL PROCESSING OF SUBJECTIVE TEST RESULTS

(Study Programme 3A/11)

(1986)

1. Introduction

Recommendation 500 and Report 405 describe preferred methods to be used when conducting subjective tests on the quality or impairment of television signals affected by distortion or interference. Methods are described to assess the performance of a given television system, under a given amount of a specific distortion or interference, leading to a result represented by a single statistical value. Methods are also described to assess the performance of a given television system, under several amounts of a given distortion or interference, leading to a result represented by a statistical curve.

It often happens that an assessment is required on the statistical performance obtained when testing a family of devices, under several conditions of distortion or interference, although the devices in the family exhibit a wide spread in their performance characteristics. This is the case, for example, when tests are made to ascertain the statistical subjective quality, provided by a population of television receivers, for a range of interference levels. An advanced statistical treatment method can be applied to the data obtained in such subjective tests, in order to permit a statistical presentation of the results of the test, in a simple and readily understandable form.

2. Procedure description

This method finds application in the case of subjective tests performed on a sample of the population of a given type of equipment when their susceptibility to an impairment factor is tested.

For each equipment in the sample, the subjective scores for a number of levels of the impairment factor are collected and, for each level, the mean score is calculated.

As a first processing step, a least square fitting of the mean scores is performed, for instance by means of the well-known logistic function (see also Report 405, Annex III, § 2). This process generates a family of curves, each describing the behaviour of a particular equipment, with a large spread of characteristics among them (see Fig. 1).

Subsequently, an adjustment for the residual impairment, as described in Annex III to Report 405, is applied on each curve, but scaling it from 0 to 100 instead of the usual 0 to 1. This permits the plot to be read in terms of "percentage of full quality" or "relative quality in percent" as in Fig. 2.

It is difficult to draw conclusions by just examining such a complete set of curves, and it is also meaningless merely to take the average of them, even if some additional information about the spread of the curves is available.

However, a statistical synthesis of the experimental results can be plotted in the form of a boundary line that divides the representation plane in two regions (Fig. 2). The first region, located below the boundary line, will contain the curves pertaining to no more than $x\%$ of the whole equipment population in the lower quality range; the second region, located above the boundary line, will contain the curves pertaining to the equipment population in the higher quality range. The parameter x can be selected at will.

The procedure to plot this boundary is to compute the limit values for D_M and G (parameters of the logistic function, defined in Annex III to Report 405) so that the boundaries of their joint distribution for a given probability (e.g. 10%) can be identified. Based on the two limit values thus computed, the two limit cases for the logistic function are then plotted.

Then, for each value of the impairment factor under test, the worst case is chosen; it is thus possible to trace a piecewise line, bounding the two regions for the given percentage of equipment population.

The boundary line thus found, is such that no more than $x\%$ (e.g. 10% in Fig. 2) of equipment population, can be expected to have characteristic curves falling in the region under the boundary and thus showing a performance worse than the one described by the boundary. The remaining population can be expected to display a better performance and to be described by curves falling above the boundary.

This kind of representation is helpful in the utilization of the results of a subjective test and it is expected to provide more reliable results than those obtainable by other methods.

A more complete description of the method can be found in [CCIR, 1982-86].

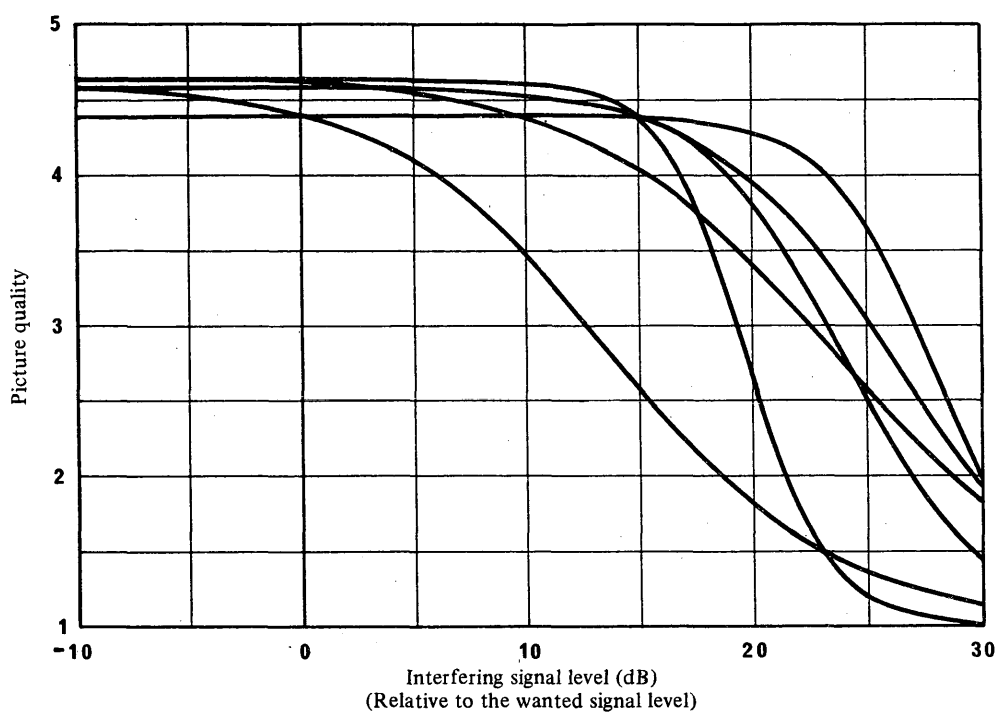


FIGURE 1 – Behaviour of 6 commercial receivers for continuous interference coming from the adjacent inferior channel

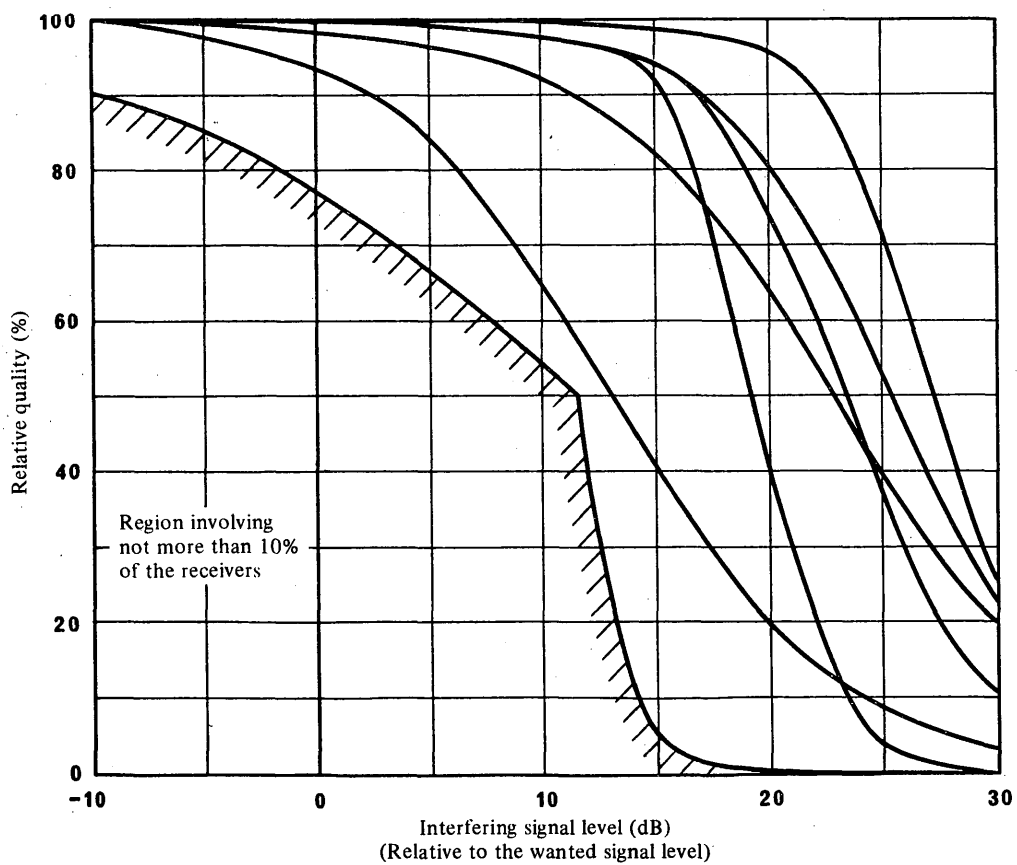


FIGURE 2 – Behaviour of 6 commercial receivers for continuous interference coming from the adjacent inferior channel and region involving not more than 10% of the receivers

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REPORT 404-2

**DISTORTION OF TELEVISION SIGNALS DUE TO THE USE OF VESTIGIAL
SIDE BAND EMISSIONS**

(Study Programme 9A/11)

(1966-1970-1974)

This Report provides a synthesis of all information in the documents enumerated in Report 404 (1966) supplemented by new data based on studies carried out by the OIRT, and other contributors (see bibliography).

1. Introduction

Vestigial-sideband emission of television signals and their reception with receivers using demodulation with a Nyquist slope give rise to different kinds of distortion:

- linear distortion due to group-delay differences in the receiver circuits, both along the Nyquist slope and in relation to the necessary attenuation on sound carrier of the lower adjacent channel;
- non-linear distortion due to the envelope demodulation, in the form of quadrature distortion, and to crosstalk between the luminance and the chrominance signals.

These distortions result in the deterioration of the quality of the received television picture.

Theoretical and practical investigations have been recently carried out in many countries with the aim, on one hand, of obtaining a quantitative picture of the distortion of television signals due to the use of vestigial-sideband transmission and, on the other hand, of finding methods of reducing this distortion as well as of determining the degree of the picture quality improvement as perceived by viewers. Such improvement can be ensured by the correction of distortion or the selection of the optimal width of the lower sideband and the steepness of the Nyquist slope.

2. Analysis of the television signal distortion

The distortion of television signals, arising in the vestigial-sideband transmission, depends on several factors such as the steepness of the Nyquist slope (i.e. the relative width of the vestigial sideband), the modulation depth, and the position of the vision carrier on the Nyquist slope. This distortion can be presented either as depending on frequency, i.e. by the amplitude and group-delay characteristics, or as depending on time, by the transient characteristic.

The television signal distortion due to the vestigial-sideband transmission affects the build-up time (10 to 90%) of the transient characteristic, or causes voltage overshoots.

When analyzing the distortion by means of the approximated calculation method [CCIR, 1963-66a; Dobesch, 1966], the following conclusions can be drawn:

- the distortion increases with the modulation depth;
- the build-up time diminishes with the decreasing steepness of the Nyquist slope (i.e. the increasing useful width of the vestigial sideband);
- the influence of the changes of the vision carrier position on the Nyquist slope with regard to the value of distortion depends, to a great extent, on the steepness of the Nyquist slope — it diminishes with the decreasing steepness;
- the shift of the vision carrier on the Nyquist slope within 0 and -1.5 MHz in relation to the nominal position generally tends to decrease the distortion (decreased build-up time and overshoots, improved symmetry of the transient characteristic).

It can be presumed that in industrial receivers the Nyquist slope, within the established tolerances, can be approximated by straight lines. In this case the calculated results are highly accurate in practical conditions. Thus it follows that a further decrease of the steepness of the Nyquist slope will not result in an essential improvement of the video signal form.

Similar results have been obtained by computer calculations. It is noted [CCIR, 1963-66b] that a change of the steepness of the Nyquist slope from 0.75 to 1 MHz does not lead to a perceptible decrease of distortion.

3. Establishment of tolerances for television signal distortion

Measurements of the frequency responses of television transmitters are usually effected between the transmitter input and the Nyquist demodulator output. In this case the measurement results reflect the actual distortion of television signals at the receiving end.

As mentioned above the characteristics can be presented as depending on time, or as depending on frequency. Investigations [CCIR, 1963-66c] have shown that transient characteristics are more useful, because they afford a result closer to the visible effect of the distortion on the received television picture. On the basis of the assessed picture quality, the admissible distortion value can be determined. Under such conditions the amplitude-frequency characteristic is of lesser importance.

Attention should be drawn to the fact that at present no methods are known enabling transformation of tolerances of characteristics in the time domain into tolerances of characteristics in the frequency domain, and vice versa. Even so the danger exists that an equipment may have transient characteristics within the tolerances, while the amplitude-frequency characteristic exceeds the respective tolerances.

Tests have also shown [CCIR, 1963-66c] that transmitter phase correction can be easily effected on the basis of the transient characteristic, the same results being obtained as on the basis of measurement of the group-delay characteristic.

So far sufficient data for the establishment of tolerances of television signal distortion have not been obtained. From theoretical calculations [CCIR, 1963-66b] it follows that the difference between the group-delay on the vision carrier frequency and that on the central video frequency — corresponding to a Nyquist slope of 0.75 MHz — is approximately 150 ns. It has also been proved that the non-uniformity of group-delay higher than 50 ns in the vicinity of the vision carrier frequency causes considerable distortion of the transient characteristics.

For measurements on a television transmitter with the Nyquist demodulator, it is proposed that adequate tolerance masks be used for determining the admissible deviations of the individual characteristics from nominal responses [OIRT, a]. These masks determine separately the parameters of the transmitter and those of the Nyquist demodulator [OIRT, b] as well as the parameters of the entire transmitter-demodulator channel.

Theoretical calculations of T and $2T$ sine-squared pulse distortion in the Nyquist demodulator have shown that the amplitude of $2T$ sine-squared pulse at the demodulator output attains:

- 80% without demodulator phase correction,
- 100% with demodulator phase correction;

and the amplitude of T sine-squared pulse:

- 76% without demodulator phase correction,
- 80% with demodulator phase correction,

in relation to the input pulse amplitude.

It has also been calculated that the distortion of 4.43 MHz sub-carrier pulse with $20T$ sine-squared envelope, originating in the Nyquist demodulator, need not be taken into consideration and that the distortion at the base of the pulse does not exceed 3% when applying phase correction to the demodulator.

4. Investigation of possibilities for improving picture quality

To improve the quality of television pictures, distorted due to the use of vestigial-sideband transmission, several investigations have been carried out along two basic lines:

- pre-correction of distortion while maintaining the existing standards for the width of the vestigial sideband, and
- broadening of the vestigial sideband.

4.1 *Correction of the television signal distortion.*

Long-term investigations of the correction of television signal distortion have led to the conclusion that in this way a considerable improvement of the signal form can be obtained [CCIR, 1963-66d]. With this in view, both correction of linear distortion with the aid of phase filters and correction of quadrature distortion were used on the transmitter. Measurements effected under laboratory conditions and on a number of transmitters have shown that television signal distortion can be almost entirely eliminated in this way.

In relation to colour-television signals the quadrature component causes two types of distortion: incorrect reproduction of the brightness of coloured areas, and phase modulation of the vision carrier, depending on the degree of modulation.

It has been shown that the correction of quadrature distortion can entirely eliminate both effects.

With the aim of confirming the measurement results of the correction of linear and quadrature distortion investigations of picture quality have been carried out on the basis of subjective tests [CCIR, 1963-66e]. The results of these measurements make it possible to establish the following:

- the improvement of picture quality obtained by group-delay correction is greater than that obtained by quadrature correction,
- after an optimal correction of both types of distortion no deterioration of the picture quality can be observed;
- in rebroadcasting transmissions with two successive modulation and demodulation processes quadrature correction should be used.

The usefulness of linear-distortion correction has been investigated in system L [CCIR, 1963-66f]. Some improvement of the transient characteristic has been obtained (decreased overshoots from 7% to 4% and decreased streaking). A further improvement of the picture quality can be obtained by quadrature correction.

4.2 *Broadening of the vestigial sideband*

In order to verify the influence of broadening the vestigial sideband on the subjective picture quality assessed by viewers, investigations of the picture quality with 0.75 MHz and 1.25 MHz vestigial-sideband transmissions have been carried out [CCIR, 1963-66g]. Investigations with the aid of various characteristic pictures have confirmed that most viewers note a better picture quality in the case of transmission with a broader vestigial sideband, the degree of improvement depending on the contents of the picture. Differences in quality were almost indiscernible only in pictures with low contrast and a small number of details.

As regards broadening of the vestigial sideband, the opinion has been expressed [OIRT, a] that the reduction of the steepness of the Nyquist slope tends to decrease the non-uniformity of group-delay and the quadrature distortion, as well as the sensitivity of the receiver to heterodyne frequency variations. For channels in Bands IV/V, 1.5 MHz is considered to be the optimum value. At the same time, attention has been drawn to the fact that broadening of the vestigial sideband decreases the protection between adjacent channels and that this is connected with transmitter network planning and the establishment of protection ratios.

5. **Effects of quadrature distortion on the insertion test signals described in Recommendation 473, Annex I**

A complete theoretical investigation on this subject has been carried out in Italy [CCIR, 1970-74; D'Amato, 1971], and calculations have been made for the case of systems B and G.

A hypothetical "transmitter-demodulator chain" has been considered, with the following characteristics:

- all the circuits have a flat group-delay frequency response;
- the overall amplitude-frequency response of the radio-frequency intermediate-frequency circuits varies linearly from 0 to 1 over the frequency range ($f_v - 0.75$ MHz) to ($f_v + 0.75$ MHz) and is equal to 1 for frequencies greater than $f_v + 0.75$ MHz (f_v being the video-carrier frequency);
- the amplitude-frequency response of all the video-frequency circuits is equal to 1 over the range 0 to 5 MHz and to 0 for frequencies greater than 5 MHz;
- the depth of modulation at white level is 10%;
- the depth of modulation at black level is 73%.

With these assumptions, the distortion which affect the elements of the insertion test signal are those summarized in Table I. As regards distortion of the white bar, $2T$ and $20T$ pulse, the theoretical results of Table I agree with results of an experimental investigation carried out in the Federal Republic of Germany [IRT, 1970].

TABLE I

Signal element	Parameter	Values ⁽¹⁾ for system B, G
White bar leading (trailing) edge (shaped by the network generating the 2T pulse)	Undershoot amplitude Half-amplitude delay (lead) Rise time (fall time)	3% 69 ns 240 ns
2T pulse (half-amplitude duration: 200 ns)	Amplitude reduction Half-amplitude duration Main negative echoes amplitude	11% 156 ns 6.7%
20T pulse	Base-line depression Amplitude reduction Phase distortion	6% 13.8% 5° 50'
Chrominance bar	Chrominance peak amplitude Chrominance-to-luminance intermodulation	92.1% 9.9%
Luminance staircase	Line-time non-linearity distortion	0%
Staircase with chrominance superimposed	Differential gain ⁽²⁾ Differential phase Line-time non-linearity distortion (altered by chrominance-to-luminance intermodulation) ⁽²⁾	3.7% 0° 4.4%

⁽¹⁾ All values expressed as percentages are referred to the nominal amplitude of the picture signal (0.7V).

⁽²⁾ As the sub-carrier at the white level gives rise to over modulation, the step at the white level is not considered.

It must be remembered that these characteristics are not representative of normal equipment designs where the response in the frequency range of the colour sub-carrier is reduced to minimize quadrature distortion.

6. Receivers employing synchronous demodulation of the intermediate-frequency signal

The use of an ideal synchronous demodulator for the intermediate-frequency signal eliminates quadrature distortion due to vestigial-sideband transmission and practical circuits show a very considerable advantage over envelope detection in this respect. However, quadrature distortion can arise due to shifts in the phase of the vision carrier relative to the sideband. Such phase shifts may occur at the transmitter or in the receiver circuits.

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REPORT 313-6

ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(Question 3/11)

(1959-1963-1966-1970-1974-1978-1982-1986)

During recent years extensive studies have been made in many laboratories on the assessment of the quality of television pictures and the respective methods of measurement, both for monochrome and colour television. Since these studies cannot yet be considered to be concluded, it seems appropriate, with a view to facilitating future work, to give a list of documents and publications bearing on this question.

Such a list would serve both to avoid duplication of work and to enable comparisons to be made with results already found elsewhere. It may be extended to include subsequent publications on this subject and would be a valuable aid, within the scope of Question 3/11, in arriving at suitable standard methods for measuring the various kinds of picture distortion in television.

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 [1982-86]: 11/133 (India); 11/134 (10-11S/55) (Canada); 11/266 (CMTT/152) (Japan); 11/306 (France); 11/388 (China (People's Republic of)).

RECOMMENDATION 654

**SUBJECTIVE QUALITY OF TELEVISION PICTURES IN RELATION TO THE MAIN
IMPAIRMENTS OF THE ANALOGUE COMPOSITE TELEVISION SIGNAL**

(1986)

The CCIR,

CONSIDERING

- (a) that Recommendation 500 specifies the method to be used for the subjective assessment of the quality of television pictures with a view to determining the relationship between that quality and the objective value of the specific distortion;
- (b) that Recommendation 567 describes the objective parameters of typical transmission impairment and the corresponding measurement methods and test signals;
- (c) that many experimental findings have been published concerning distortion to the composite signal in 525 and 625-line colour-television systems in NTSC, PAL and SECAM coding and that, despite considerable dispersion, those results can be used for determining an impairment characteristic which is representative of an average situation;*
- (d) that it would be useful to have impairment characteristics which are accepted as reference values,

UNANIMOUSLY RECOMMENDS

- that, with regard to the transmission characteristics applicable to the composite colour television signal, the impairment characteristics referred to in this Recommendation should be regarded as a particular way of expressing the relationship between the picture quality and the objective value of each of the distortions in question, assuming that only one of them is present at any one time;
- that these impairment characteristics correspond to a viewing distance equal to six times the picture height;
- that the use of these characteristics for $I \geq 2$ (see Report 405, Annex III) (represented by a dotted line in Figs. 1 to 6 of this Recommendation) requires great caution.

1. Continuous random noise

The signal-to-noise ratio is measured, unweighted, in accordance with Recommendation 567, Part C, § 3.2.1.

This method is applicable to all 525 and 625-line systems.

The reference impairment characteristic concerns only the impairment due to uniform-spectrum noise (white noise). The correction factors applicable to the different situations are known.

* For the application of this Recommendation to countries using systems D and K, further studies are needed.

The reference impairment characteristic is shown in Fig. 1. It conforms to the following relations:

- impairment factor: $d = \frac{N_{r.m.s.}}{L}$ or $D = \left[\frac{L}{N_{r.m.s.}} \right]_{dB} = 20 \log \frac{1}{d}$ (dB)
- mid opinion value ($I = 1$): $d_M = 0.0355$ or $D_M = 29$ dB
- slope: $G = 2.22$

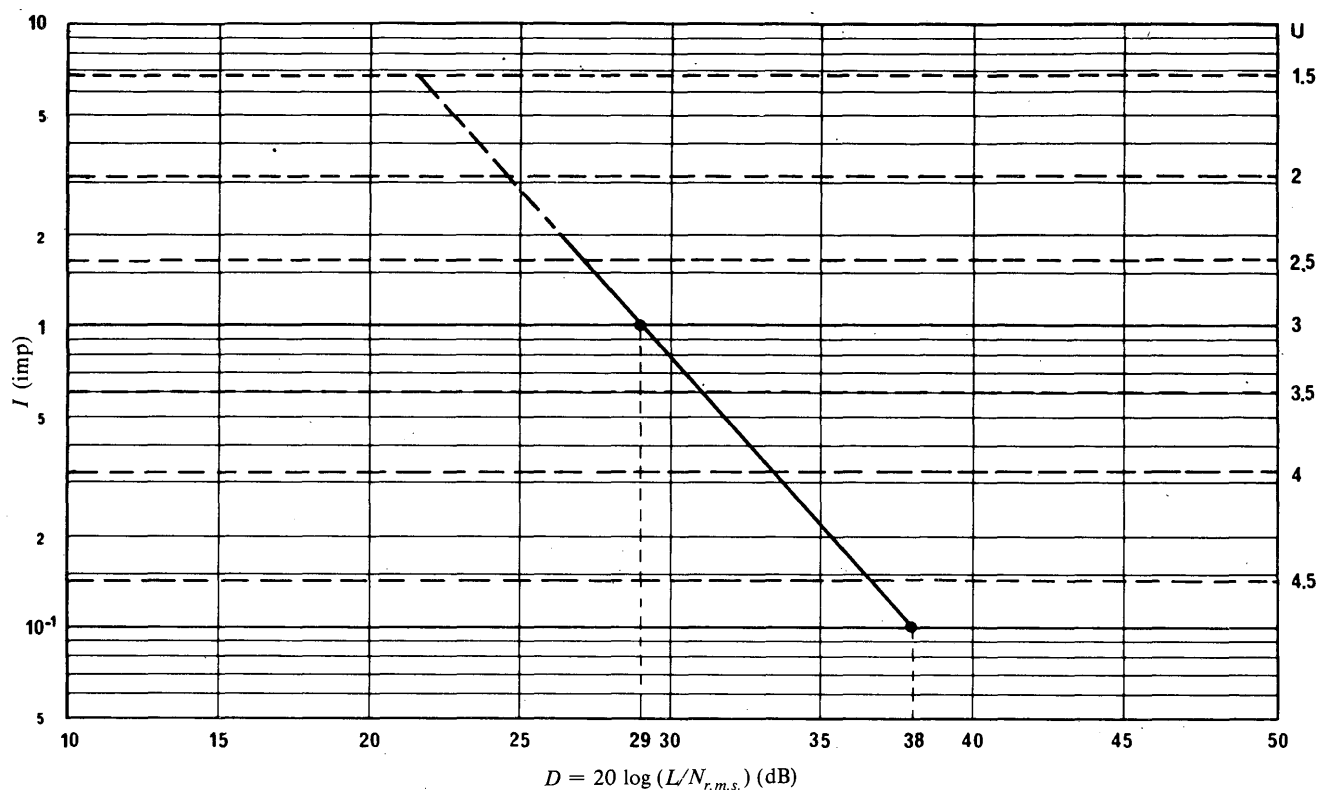


FIGURE 1 — Impairment characteristic for unweighted white noise

2. Non-linear distortion

2.1 Differential gain

The differential gain is measured in accordance with Recommendation 567, Part C, § 3.4.1.3.

Impairment of the picture depends on the distribution of distortion on the luminance scale. The most critical variation corresponds to an increase in the amplitude of the superimposed colour sub-carrier as the luminance amplitude varies from the black level (A_0) to the white level (A_{max}), which corresponds to distortion measured in terms of value x .

Impairment depends also on the colour coding system.

The reference impairment characteristic is illustrated in Fig. 2 and corresponds to a distortion situation offering the least favourable distribution. It conforms to the following relations:

- impairment factor: $d = x = 100 \left| \frac{A_{max} - A_0}{A_0} \right|$

- mid opinion value ($I = 1$):
 - NTSC and PAL systems: $d_M = 43\%$
 - SECAM system: $d_M = 65\%$
- slope (deviation of d between $I = 1$ and $I = 0.37$):
 - NTSC and PAL systems: $S = 15\%$
 - SECAM system: $S = 13\%$

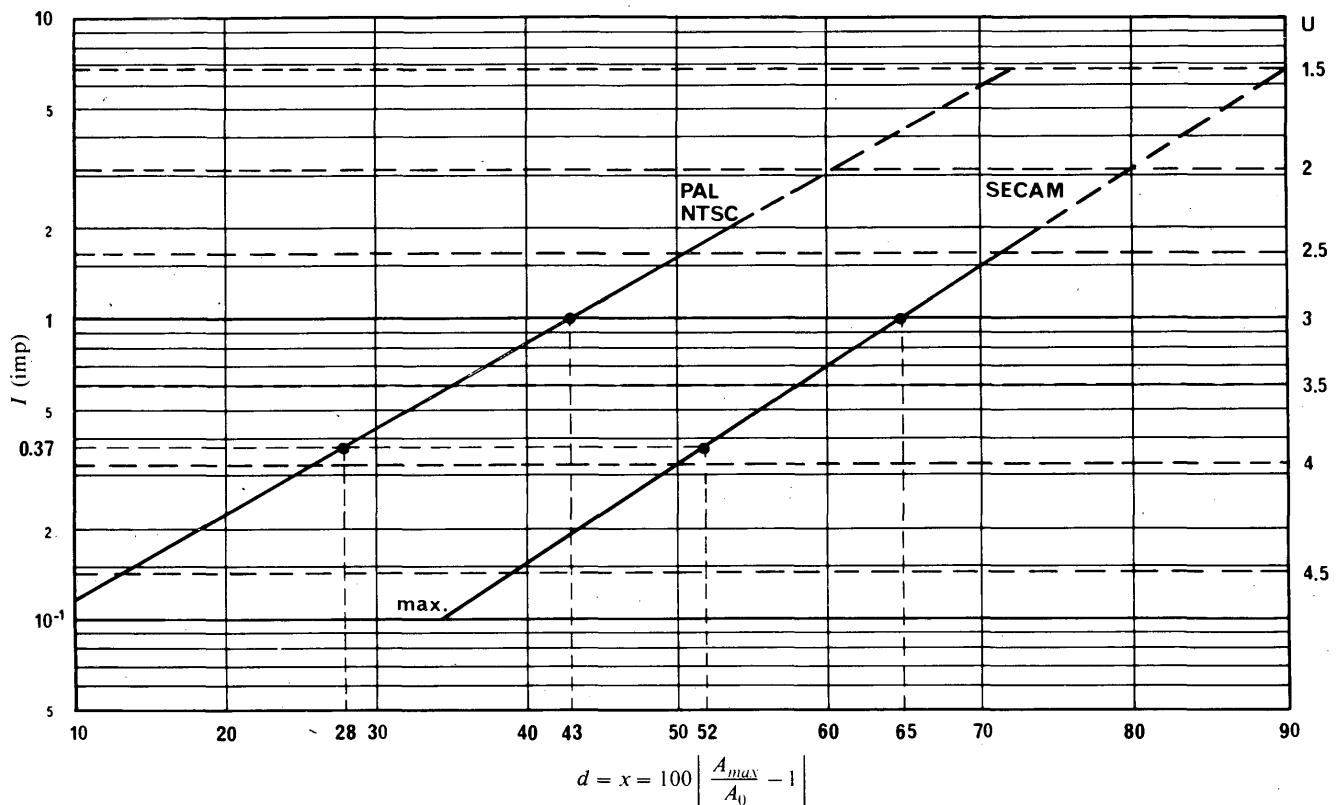


FIGURE 2 — Impairment characteristic for differential gain

2.2 Differential phase

The differential phase is measured in accordance with Recommendation 567, Part C, § 3.4.1.3.

The picture impairment depends on the distribution of distortion on the luminance scale. The most critical variation corresponds to a negative variation in the phase difference from the black level (Φ_0) to the white level (Φ_{min}), which corresponds to a distortion measured in terms of value $-y$.

The impairment depends also on the colour coding system.

The impairment characteristic is illustrated in Fig. 3 and corresponds to a distortion situation offering the least favourable distribution. It conforms to the following relations:

- impairment factor: $d = y = | \Phi_{min} - \Phi_0 |$
- or $D = \log d$

— mid opinion value ($I = 1$):

NTSC system:	$d_M = 10^\circ$
PAL system:	$d_M = 50^\circ$
SECAM system:	$d_M = 65^\circ$

— slope:

all systems:	$G = 2.5$

Note. — In the case of the PAL system, the fact that the impairment characteristic is a straight line has not been verified.

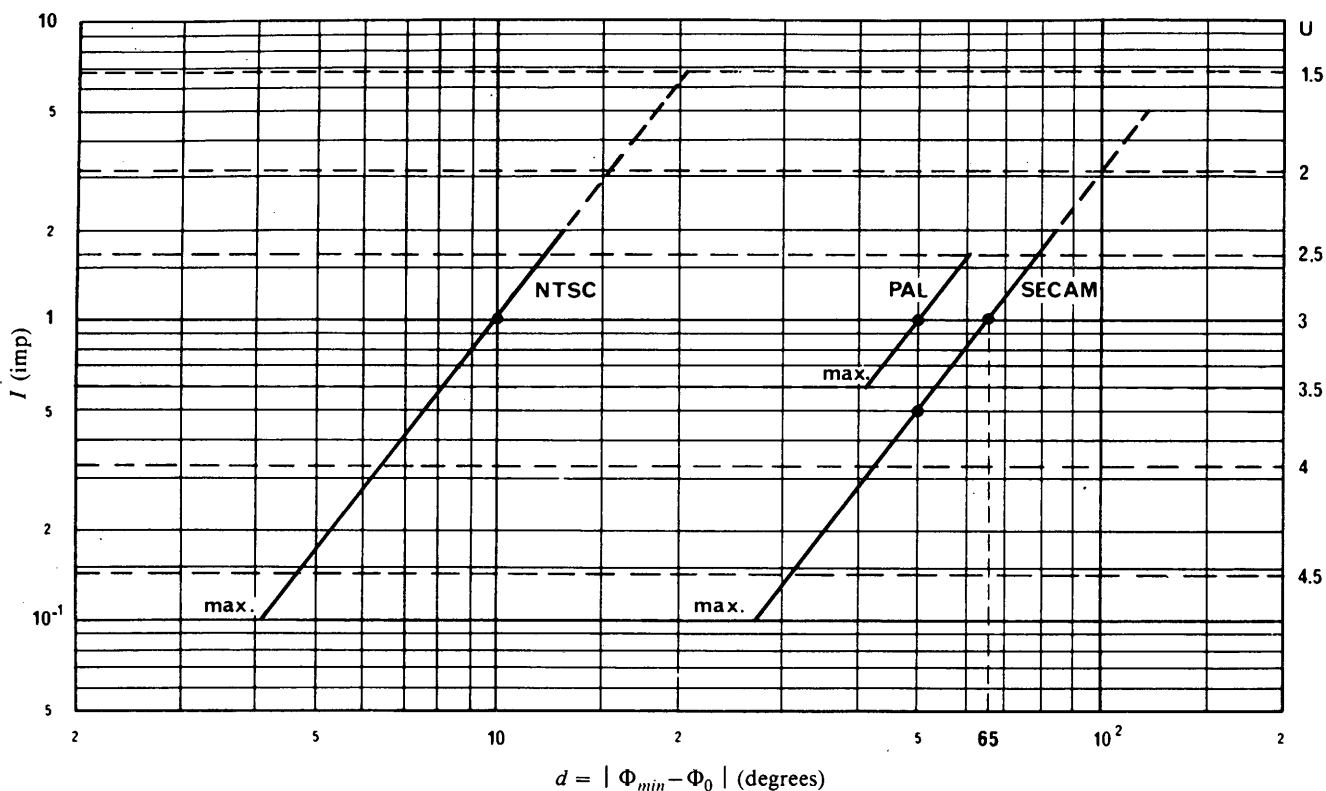


FIGURE 3 — Impairment characteristic for differential phase

3. Linear distortion

3.1 Short-time waveform distortion

Short-time linear distortion is measured in accordance with Recommendation 567, Part C, § 3.5.1.4, by expressing the difference, as a percentage, between the peak value of the pulse B_1 , i.e., B_1 , and the value of the luminance amplitude, i.e., L . The impairment characteristic value is:

$$d = \left| \frac{L - B_1}{L} \right| \times 100 \quad (\%)$$

Impairment does not depend on the sign of $L - B_1$.

Impairment does not depend on the colour coding system.

The pulse-to-bar $2T$ ratio, i.e., $\frac{B_1}{L} = 1 - \frac{d}{100}$ can be calculated from the value d .

The impairment characteristic is illustrated in Fig. 4. It corresponds to the following conditions:

– impairment factor:
$$d = \left| \frac{L - B_1}{L} \right| \times 100 \quad (\%)$$

Logarithmic scale in values of d ;

– mid opinion value ($I = 1$): $d_M = 40\%$

– slope: $G = 2.32$

Note. – Short-time linear distortion is often expressed by the K factor explained in Annex IV to Part C of Recommendation 567.

This factor is such that $K = \frac{d}{4}$.

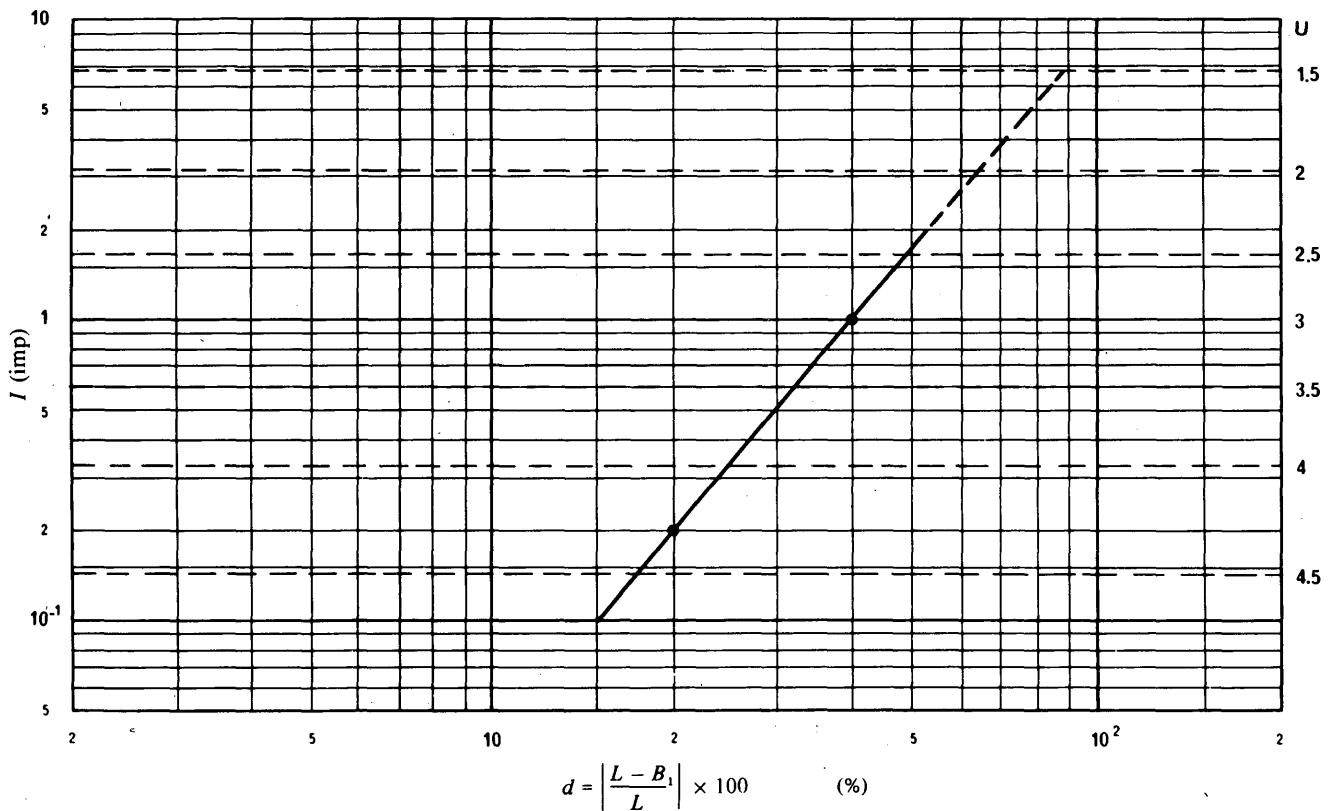


FIGURE 4 – Impairment characteristic for short-time linear distortion

3.2 Chrominance-luminance inequalities

3.2.1 Gain inequality

Chrominance-luminance gain inequality is measured in accordance with Recommendation 567, Part C, § 3.5.3.1, the absence of distortion being expressed by equality between the luminance (E_L) and chrominance (E_C) amplitudes.

Impairment depends on the coding system and the curve is valid only for the NTSC and PAL systems. There is only an indirect effect on the SECAM system.

The impairment characteristic is illustrated in Fig. 5. It conforms to the following relations:

– impairment factor:
$$d = \frac{E_C - E_L}{E_L} \quad (\text{logarithmic scale})$$

– mid opinion value ($I = 1$): $d_M = 63\%$

– slope: $G = 2.33$

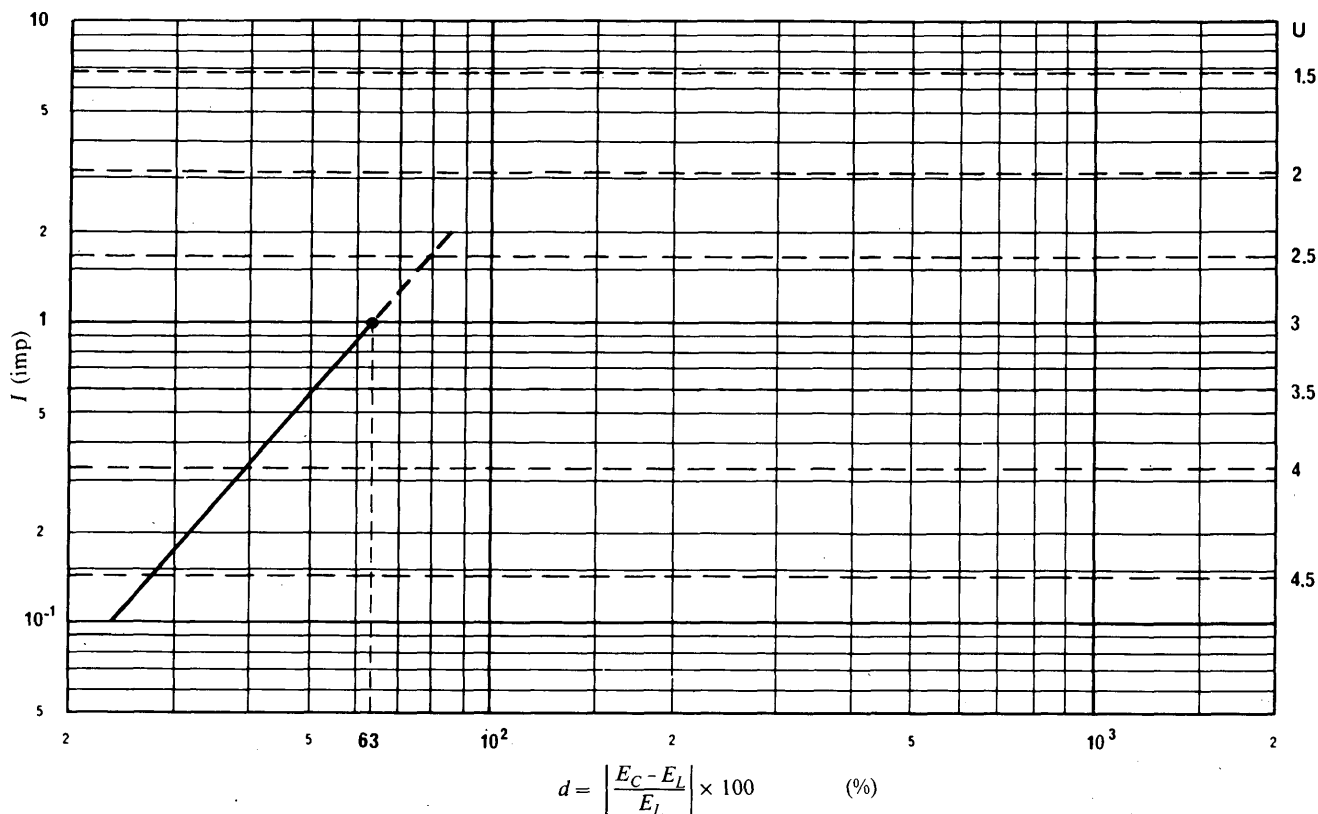


FIGURE 5 — Impairment characteristic for chrominance-luminance gain inequalities

3.2.2 Delay inequality

Delay inequality is measured in accordance with Recommendation 567, Part C, § 3.5.3.2, using the signal F (modulated 20 T pulse for 625-line systems and 12.5 T pulse for 525-line systems).

The value thus measured corresponds closely to that of the group delay of a band-limiting network in which τ_g increases with the frequency. In this case, the value of d corresponds to the value $\Delta\tau_g$ measured at colour sub-carrier frequency.

This value is appreciably different from, and higher than, that obtained by direct measurement of the time separation between a characteristic instant of a steep luminance front and the equivalent characteristic instant of the associated chrominance transition front for the same impairment and therefore the same quality level.

The impairment characteristic meets the following conditions (Fig. 6):

(a) for the 625-line systems

- impairment factor: $d = \Delta\tau_g$ at 4.43 MHz
- $\Delta\tau_g$ = delay difference
- Logarithmic scale in $\Delta\tau$ expressed in ns;
- mid opinion value ($I = 1$): $d_M = 400$ ns
- slope: $G = 2.32$

(b) for the 525-line systems

- impairment factor: $d = \Delta\tau_g$ at 3.58 MHz
- $\Delta\tau_g$ = delay difference
- Logarithmic scale in $\Delta\tau$ expressed in ns;
- mid opinion value ($I = 1$): $d_M = 200$ ns
- slope: $G = 1.76$

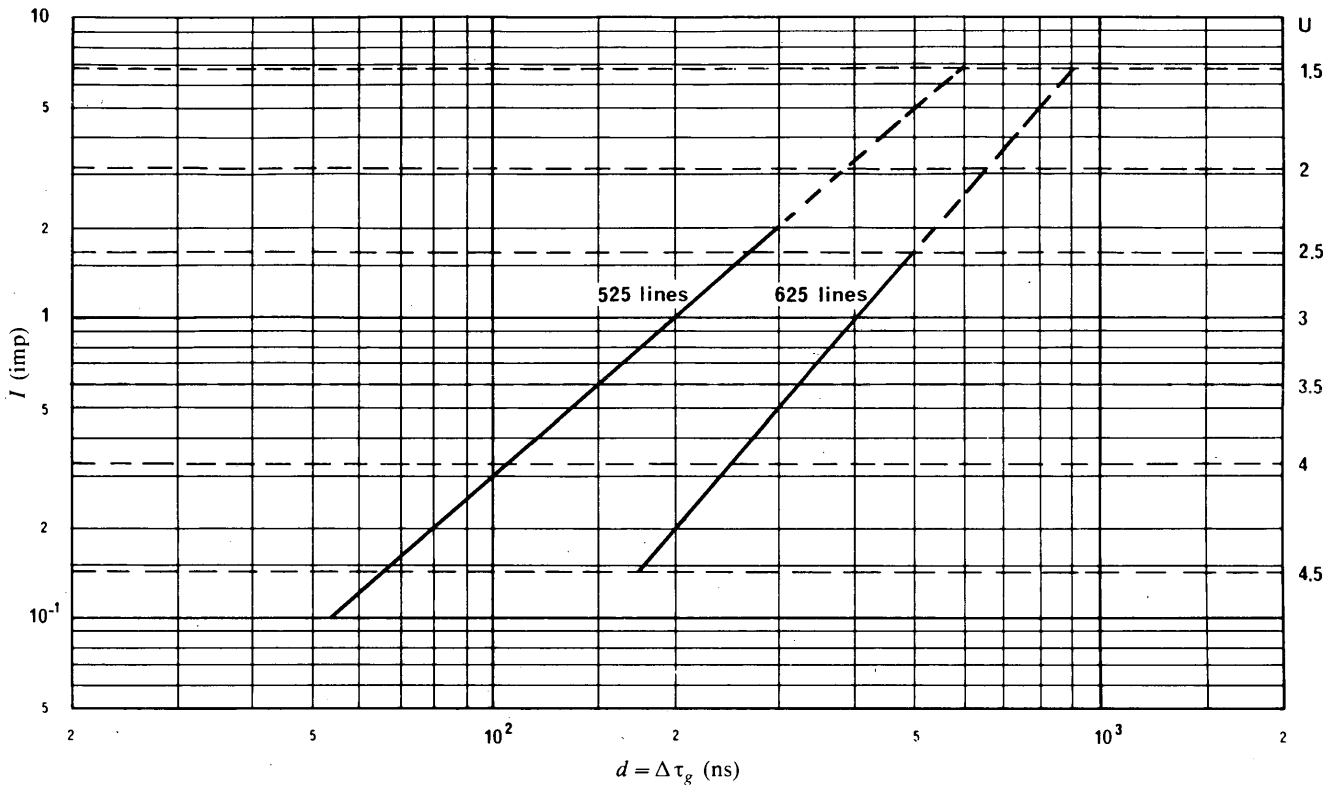


FIGURE 6 – Impairment characteristic for chrominance-luminance delay inequality

4. Echo

Consideration is given to the effect of superimposing a direct signal and a reflected signal producing a permanent “ghost” picture, an example of which is described in Report 478.

Impairment depends on:

- the polarity of the echo, and it is noted that maximum impairment occurs with a positive echo;
- the time separation between the direct signal and the echo signal;
- the distortion of the echo signal.

The impairment characteristic illustrated in Fig. 7 corresponds to the case of an undistorted positive echo 1 μs behind the direct signal (E = echo amplitude, S = signal amplitude).

When the echo delay time is less than 1 μs, the following results apply to monochrome television or to the luminance signal in colour television. In the case of colour signals, additional effects occur which, in the PAL and NTSC systems, can be interpreted by using the gain inequality characteristic.

This characteristic meets the following conditions:

– impairment factor:
$$d = \frac{E}{S} \text{ or } D = 20 \log \frac{S}{E} \quad (\text{dB})$$

– mean value ($I = 1$):
$$d_M = 0.126 \text{ or } D_M = 18 \text{ dB}$$

– slope:
$$G = 2.33$$

For time separations other than 1 μs, the value D_1 should be corrected as shown in Fig. 8.

Thus the value D_x for $\Delta t = X$ is corrected to $D_1 = D_x - \Delta D$ to obtain the corresponding impairment value in Fig. 7.

The slope of the characteristic is not substantially altered.

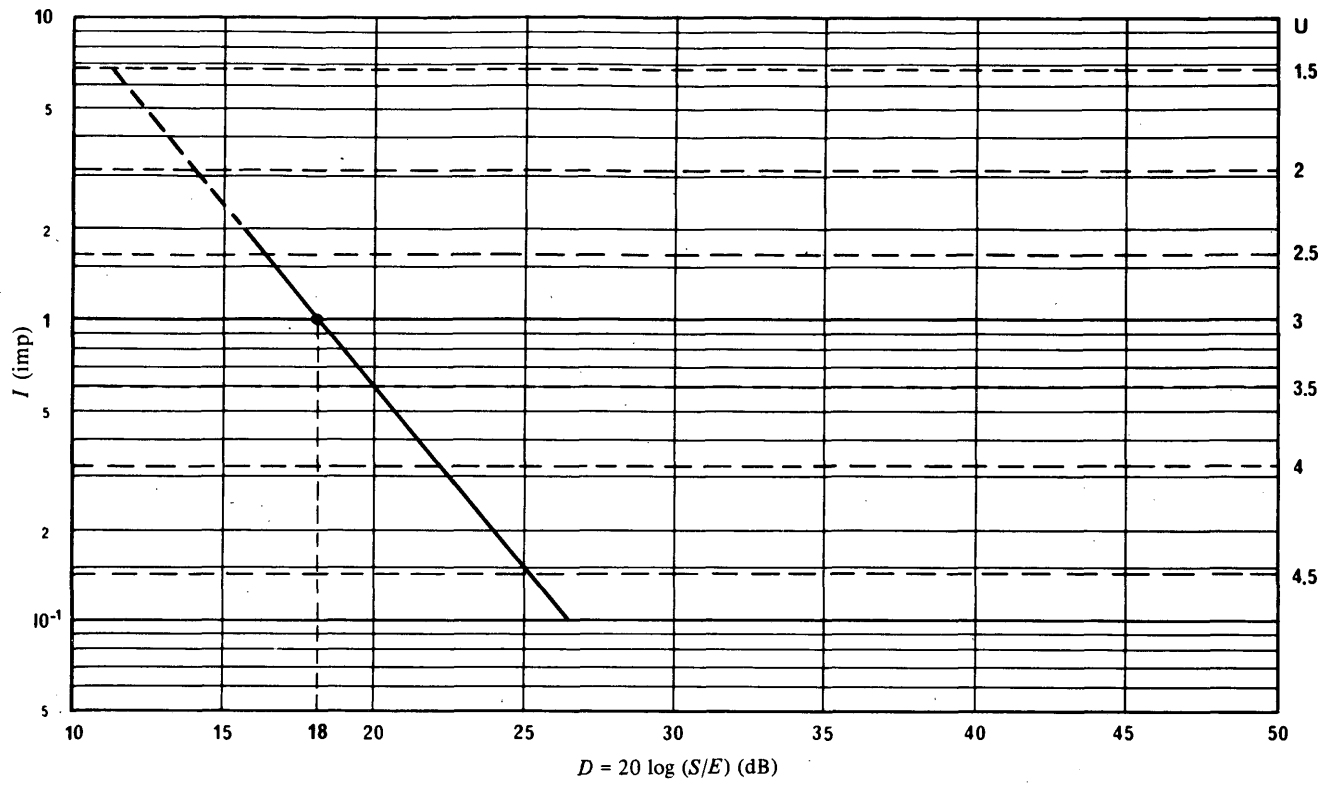


FIGURE 7 — Impairment characteristic for an undistorted positive echo having a delay of 1 μs

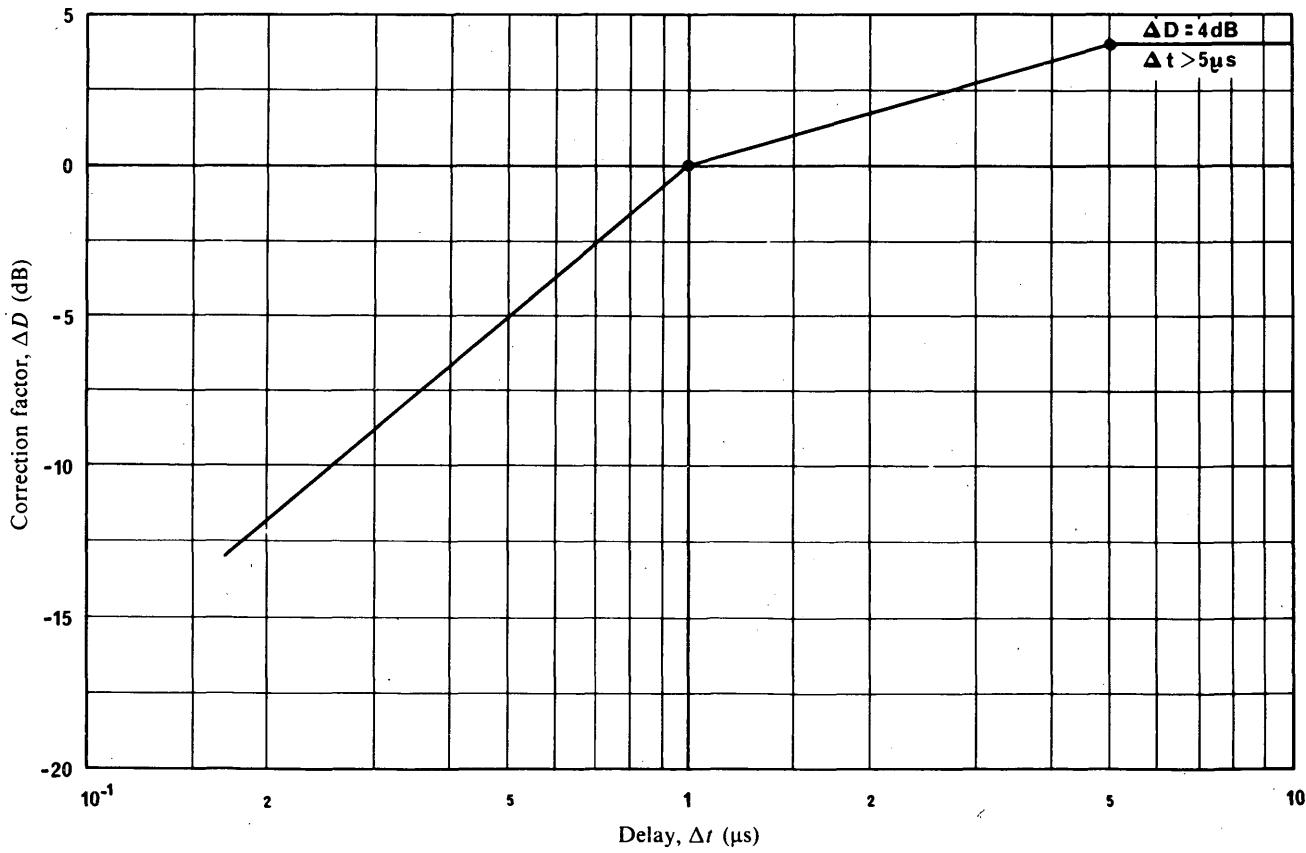


FIGURE 8 — Correction factor to be applied to the abscissa values of D in Fig. 7 to obtain the signal/echo ratio for other values of delay

SECTION 11E: PLANNING OF TELEVISION NETWORKS, PROTECTION RATIOS TELEVISION RECEIVERS AND ANTENNAS

Recommendations and Reports

RECOMMENDATION 417-3

MINIMUM FIELD STRENGTHS FOR WHICH PROTECTION MAY BE SOUGHT IN PLANNING A TELEVISION SERVICE

(1963-1966-1970-1986)

The CCIR

UNANIMOUSLY RECOMMENDS

- that when planning a television service in Bands I, III, IV or V, the median field strength for which protection against interference is planned should never be lower than:

TABLE I

Band	I	III	IV	V
dB ($\mu\text{V/m}$)	+48	+55	+65 ⁽¹⁾	+70 ⁽¹⁾

⁽¹⁾ The values shown for Bands IV and V should be increased by 2 dB for the 625-line (OIRT) system.

These values refer to the field strength at a height of 10 m above ground level;

- that the percentage of time for which the protection may be sought should lie between 90% and 99%.

Note 1. — In arriving at the figures shown in § 1, it has been assumed that, in the absence of interference from other television transmissions and man-made noise, the minimum field strengths at the receiving antenna that will give a satisfactory grade of picture, taking into consideration receiver noise, cosmic noise, antenna gain and feeder loss, are: +47 dB ($\mu\text{V/m}$) in Band I, +53 dB in Band III, +62 dB* in Band IV and +67 dB* in Band V.

Note 2. — Further information concerning the planning of television services for sparsely populated regions is contained in Report 409.

Note 3. — In a practical plan, because of interference from other television transmissions, the field strengths that can be protected will generally be higher than those quoted in § 1 and the exact values to be used in the boundary areas between any two countries should be agreed between the Administrations concerned.

Note 4. — The broadcasting band designations I, III, IV and V derive from the European VHF/UHF Broadcasting Conference, Stockholm, 1961 and the African VHF/UHF Broadcasting Conference, Geneva, 1963. The frequency ranges at that time were:

Band I	41- 68 MHz
Band III	162-230 MHz
Band IV	470-582 MHz
Band V	582-960 MHz

According to the Radio Regulations (1982) the bands allocated to the Broadcasting Service start at 47 MHz (Band I) and 174 MHz (Band III) respectively.

* The values shown for Bands IV and V should be increased by 2 dB for the 625-line (OIRT) system.

REPORT 481

RATIO OF WANTED-TO-UNWANTED SIGNAL IN TELEVISION

Subjective assessment of multiple co-channel interference

(Question 4/11, Study Programme 4A/11)

(1970)

1. This Report summarizes work in the United Kingdom on the subjective effect of a combination of several co-channel interfering signals of constant, but not necessarily equal, levels. The document does not consider the situation in which the signals vary appreciably with time. It includes consideration of transmissions with very high carrier-frequency stability (precision offset) but not special cases where carrier frequencies might be phase-locked.

The interferences are considered to be in one of two classes, viz., "related" and "unrelated" interferences. The related class only arises in cases involving transmitters with precision control of the carrier frequency, i.e., control with a precision of the order of 1 Hz. The laws proposed for related interferences apply to a group of interferences for which either:

- the frequency offsets relative to the wanted signal are close to $(n \pm 1/3)$ times line-frequency, where n is a small integer, but precisely adjusted for minimum visibility of interference;
- the interfering signal frequencies, apart from those covered above, are equal to one another within a few hertz.

For example, two-thirds and five-thirds line-frequency precision offsets can be considered as being in the related class, and it is unimportant whether the offset frequency is above or below the wanted signal. Similarly, all precision zero offset interferences can be regarded as in the related class.

On the other hand, all non-precision offset interferences are to be regarded as unrelated. In the cases where both related and unrelated interferences are present, the related interferences should first be added in accordance with the appropriate law; the two classes can then be added together as if they were single unrelated interfering signals. For the purpose of dealing with co-channel signals with different offsets it is convenient to measure the interfering signals in terms of protected field strength defined below:

If R_r : protection ratio (dB) applicable to the r th interfering signal for a given subjective impairment

and I_r : level (dB(μ V/m)) of the r th interfering signal,

then $P_r = R_r + I_r$ is the protected field strength (dB(μ V/m)) applicable to the r th interfering signal.

2. Unrelated interferences appear to combine according to a simple power-addition law:

$$0.1 P = \log_{10} \sum_{r=1}^n 10^{0.1 P_r} \quad (1)$$

3. For impairment grades near grade 3.5 (using the scale given in Note 2, Annex I, to Report 405) related interferences tend to follow a different law. From the limited experimental work, it appeared that a (voltage)^{1.5} law represented the method of combination at least as well as any other law. Such a law may be written:

$$0.075 P = \log_{10} \sum_{r=1}^n 10^{0.075 P_r} \quad (2)$$

4. For certain types of calculation it may be easier to use the following law which was equally accurate for the cases covered by the experiments (up to seven interfering signals):

$$0.1 P = \log_{10} \left[10^{0.1 P_1} + 2 \sum_{r=2}^n 10^{0.1 P_r} \right] \quad (3)$$

where P_1 is the protected field strength applicable to the largest interfering signal alone.

5. For low interference levels (corresponding to grade 2.5 or less on the six-point impairment scale) there was a trend for all types of interfering signals (related or unrelated) to combine by the simple power-addition law given in § 2.

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RECOMMENDATION 655*

RADIO-FREQUENCY PROTECTION RATIOS FOR AM VESTIGIAL SIDEBAND TELEVISION SYSTEMS

(Question 4/11, Study Programme 4A/11)

(1986)

The CCIR,

UNANIMOUSLY RECOMMENDS

that the protection ratios given in this Recommendation should be used for planning purposes.

Studies are still required to allow completion of information on protection ratios applicable to:

- data signals,
- sound signals,
- out-of-channel response,
- within-channel response above the video range,
- 525-line systems,
- system B in the UHF range,
- synchronized carrier operation.

1. Introduction

The RF protection ratio is the minimum value of wanted-to-unwanted signal ratio, usually expressed in decibels at the receiver input, determined under specified conditions such that a specific reception quality is achieved at the receiver output.

1.1 The values of protection ratio quoted apply to interference produced by a single source. Except where otherwise stated, the ratios apply to tropospheric (*T*) interference and correspond closely to a slightly annoying impairment condition. They are considered to be acceptable only if the interference occurs for a small percentage of the time, not precisely defined but generally considered to be between 1% and 10%. For substantially non-fading unwanted signals, it is necessary to provide a higher degree of protection and ratios appropriate to continuous (*C*) interference should be used (see Annex I). If the latter are not known, then the tropospheric (*T*) values increased by 10 dB can be applied.

Values applicable to limit of perceptibility (*LP*) are given for information only.

1.2 Significantly strong wanted input signals can require higher protection ratio because of non-linear effects in the receiver.

* This Recommendation incorporates the substance of Recommendation 418 and Report 306 which are hereby cancelled.

1.3 For 625-line systems, the reference impairment levels are those which correspond to co-channel protection ratios of 30 dB and 40 dB with a frequency-offset between vision carriers close to two-thirds of the line frequency but adjusted for maximum impairment, the precise frequency difference being 10.416 kHz. These conditions approximate to impairment grades 3 (slightly annoying) and 4 (perceptible but not annoying) and respectively apply to tropospheric (*T*) and continuous (*C*) interference.

1.4 It should be noted that the amplitude of a vision-modulated signal is defined as the r.m.s. value of the carrier at peaks of the modulation envelope (taking no account of the chrominance signal in positive-modulation systems), while that of a sound-modulated signal is the r.m.s. value of the unmodulated carrier, both for amplitude modulation and for frequency modulation.

For planning purposes it may be assumed that the power in the chrominance channel does not exceed a value which is 16 dB lower than the power in the vision carrier during peaks of the modulation envelope.

1.5 The protection ratio values are not affected if digital data are included in the field-blanking interval of the unwanted television signal. However, certain values are affected in the case of a full-field data unwanted signal; in particular, it is not possible to achieve the full advantages of precision offset operation.

1.6 The relationship between the vision carrier frequencies of the wanted and unwanted signal is as follows (see Annex II):

1.6.1 *Non-controlled condition*

No special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

1.6.2 *Non-precision offset*

Difference between the nominal frequencies of the wanted and unwanted carriers is suitably related to the line frequency, the tolerance of the carrier frequencies being ± 500 Hz.

The line synchronization of television receivers must be sufficiently immune to periodic interference if full advantage of carrier offset operation is to be achieved.

1.6.3 *Precision offset* (see Annex III)

Difference between the nominal frequencies of the wanted and unwanted carriers is suitably related to the line and field frequencies, but with a tolerance of each of the nominal carrier frequencies of the order of ± 1 Hz and stability of the line frequencies equal to or better than 1×10^{-6} . In order to take full advantage of precision offset when the interfering carrier falls in the upper video range (greater than 2 MHz) of the wanted signal, a line-frequency stability of at least 2×10^{-7} is necessary.

2. Co-channel interference

In this section, the protection ratios between two television signals apply only for interference due to the modulated vision carrier of the unwanted signal. Additional protection may be necessary if the wanted sound carrier is affected, or if the unwanted sound carrier lies within the wanted vision channel (e.g. the unwanted sound carrier of system G lies within the vision channel of system K). For all protection ratio figures in this section, the following corrections have to be made:

When the wanted signal is modulated negatively and the unwanted signal is modulated positively (L/SECAM), the values should be increased by 2 dB.

When the wanted signal is modulated positively and the unwanted signal is modulated negatively, the values should be reduced by 2 dB.

Correction is not necessary if the wanted and unwanted signals have the same modulation polarity.

2.1 *Carriers separated by less than 1000 Hz, non-controlled systems having the same or different line-standard*

Protection ratio: 45 dB, tropospheric interference.

2.2 *Carriers separated by parts of the line frequency, systems having the same line-standard, non-precision offset*

TABLE I — Protection ratio, tropospheric interference carrier separation up to about $\pm 36/12 f_{line}$ (about ± 50 kHz) where f_{line} = line frequency

Offset of line frequency	1/2, 3/2, 5/2, ...	1/3, 2/3, 4/3, ...
625-line system (dB)	27	30
525-line system (dB)	25	28

2.3 625-line systems, carriers separated by multiples of a twelfth of the line frequency up to about $\pm 36/12 f_{line}$ (about ± 50 kHz)

These protection ratio values do not necessarily apply for greater carrier separations.

TABLE II — Protection ratio between 625-line systems

Offset (multiples of 1/12 line-frequency)		0	1	2	3	4	5	6	7	8	9	10	11	12
Non-precision offset Transmitter stability ± 500 Hz	Tropospheric interference	45	44	40	34	30	28	27	28	30	34	40	44	45
	Continuous interference	52	51	48	44	40	36	33	36	40	44	48	51	52
	Limit of perceptibility	61	60	57	54	50	45	42	45	50	54	57	60	61
Precision offset Transmitter stability ± 1 Hz	Tropospheric interference	32	34	30	26	22	22	24	22	22	26	30	34	38
	Continuous interference	36	38	34	30	27	27	30	27	27	30	34	38	42
	Limit of perceptibility	42	44	40	36	36	39	42	39	36	36	40	44	48

Limit of perceptibility — only for information.

(Value in the first column is only valid for the 0/12 case. All other values between 1/12 and 12/12 are the same by addition or subtraction of integral multiples of 12/12 up to $\pm 36/12$.)

3. Adjacent-channel interference

The given protection ratios apply to tropospheric interference and are defined in terms of wanted and unwanted vision carrier levels. For continuous interference, the values should be increased by 10 dB.

Adjacent-channel protection ratios cannot be determined directly from the overlapping channel protection ratio curves shown in § 5 because for certain systems the values may be affected by special measures in the receiver, e.g. sound traps.

3.1 Lower adjacent-channel interference

The worst interference on the picture signal from another signal, using the same standard, results from the sound signal in the lower adjacent channel. However, some improvement in protection is achieved if the unwanted sound carrier and the wanted vision carrier are separated by an effective offset in the vicinity of an odd multiple of half line-frequency. This is particularly noticeable during periods without sound modulation when the improvement can be as much as 10 dB; with modulation, the improvement is only 2-3 dB.

Linear correction should be made to take into account vision-to-sound power ratios different from those assumed in the following sub-sections.

3.1.1 VHF bands

The figures below relate to the cases where the separation between the wanted vision carrier frequency and the unwanted sound carrier frequency is 1.5 MHz and the ratio between the unwanted vision and unwanted sound powers is 7 dB.

- Protection ratio: for frequency-modulated sound carrier
- systems N and M: – 10 dB
 - all other systems: – 6 dB
- for amplitude-modulated sound carrier
- system L (vision-to-sound power ratio 10 dB): + 17 dB

3.1.2 UHF bands

Protection ratio: for the 525-line systems in a 6 MHz channel: – 10 dB.

For the various 625-line systems for use in 8 MHz channels in the UHF bands, Table III gives the protection required by a signal of any system against a lower adjacent-channel signal of the same or any other standards, assuming a vision-to-sound power ratio of 7 dB for unwanted signals of standards D, G, H, I and K and 10 dB for standards K1 and L. A correction must be made for different vision-to-sound power ratios.

TABLE III – Protection ratio from lower adjacent-channel interference (UHF bands) for 625-line systems

Wanted signal \ Unwanted signal	Protection ratio (dB)					
	G	H	I	D, K	K1	L
G	– 6	– 6	– 6	– 6	– 9	– 5
H	– 6	– 6	– 6	+ 16	+ 13	+ 17
I	– 6	– 6	– 6	+ 16	+ 13	+ 17
D, K	– 6	– 6	– 6	– 6	– 9	– 5
K1	– 6	– 6	– 6	– 6	– 9	+ 17
L	– 6	– 6	+ 3	+ 16	+ 13	+ 17

3.2 Upper adjacent-channel interference – VHF and UHF bands

- Protection ratio:
- for system N: – 10 dB
 - for systems D and K: – 6 dB
 - for all other systems: – 12 dB

4. Image-channel interference

The protection ratio required will depend on the intermediate frequency and image-channel rejection of the receiver, and on the type of unwanted signal falling in the image channel. It can be determined by subtracting the image rejection figure from the required protection ratio for overlapping channels. Table IV shows this situation for the UHF bands. The wanted vision channel can be affected by the unwanted vision carrier, by the unwanted sound carrier, or by both.

Image-channel rejection:

systems D, K and K1: 30 dB
 system I: 50 dB
 system M (Japan): 60 dB (VHF) and 45 dB (UHF)
 all other systems: 40 dB

TABLE IV — Protection ratio from image-channel interference
 625-line systems (UHF bands)

Unwanted signal Wanted signal	Protection ratio (dB)					Image channel	Remarks
	G, H	I	D, K	K1	L		
G	+2	-1	-8	-11	-7	$n + 9$	Interference from sound carrier
H	+2	-1	-6	-9	-5	$n + 9$	
I	-10	-7	-7	-10	-6	$n + 9$	
D, K	+2	-12	-9	-12	-6	$n + 8$	Interference from sound carrier
	+13	+13	+13	+13	+15	$n + 9$	Interference from vision carrier
K1	0	+4	+8	+5	+9	$n + 9$	Interference from sound carrier
	+17	+17	+17	+17	+19	$n + 10$	Interference from vision carrier
L	+1	+1	-1	-4	0	$n - 9$	Interference from sound carrier
	-14	-14	-14	-14	-12	$n - 8$	Interference from vision carrier

The image-channel protection ratios in Table IV apply to tropospheric interference, and are defined in terms of wanted and unwanted vision carrier levels assuming a vision-to-sound power ratio of 7 dB for standards D, G, H, I and K and 10 dB for standards K1 and L. A correction must be made for different vision-to-sound power ratios. For continuous interference, the values should be increased by 10 dB.

5. Overlapping channel interference

All figures and tables in this section give protection ratios to be applied when a CW signal lies within the vision channel of the wanted transmission, the wanted vision signal being negatively modulated.

Corrections to be made for positively modulated wanted vision signals and for other types of potentially interfering signals are as given in Table V.

TABLE V – Correction values for different wanted and unwanted signals

Wanted signal \ Unwanted signal	Correction factors (dB)				
	CW	TV-negative	TV-positive	FM-sound	AM-sound
Vision signal negative modulated	0	–2	0	0	+4
Vision signal positive modulated	–2	–4	–2	–2	+2

When the unwanted signal is a television signal, two calculations of protection ratio are necessary: one for the unwanted vision carrier and one for the unwanted TV sound carrier. The protection ratios shown for unwanted frequency-modulated sound carriers do not apply to non-precision and precision offset conditions. Nevertheless, a reduction of 2 dB relative to the non-controlled condition (curves A and A') is achieved for non-precision carriers with offsets within the luminance frequency range between 3/12 and 9/12 of the line frequency, and within the chrominance frequency range at 0/12, 1/12, 5/12, 6/12, 7/12, 11/12 and 12/12 of the line frequency.

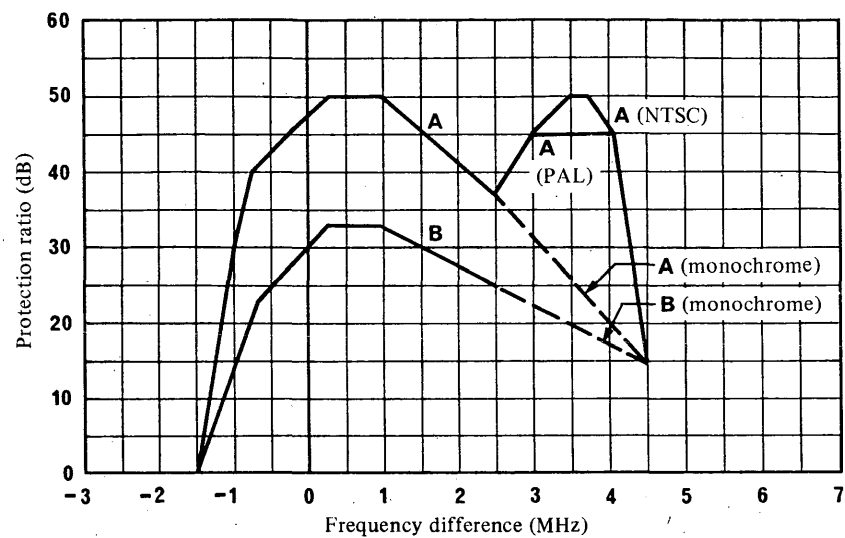
5.1 525-line systems

Figure 1 and Table VI show protection ratios for tropospheric interference. For continuous interference, the values should be increased by 10 dB. The unwanted signal is a CW carrier. For other types of unwanted signal, the given correction factors should be applied.

5.2 625-line systems

Figures 2 to 4 and Tables VII to IX give protection ratios applicable for tropospheric and continuous interference, and for limit of perceptibility. The values shown refer to the case of a wanted negatively modulated vision signal affected by an unwanted CW signal. The previously indicated corrections apply when considering other combinations of wanted and unwanted signals.

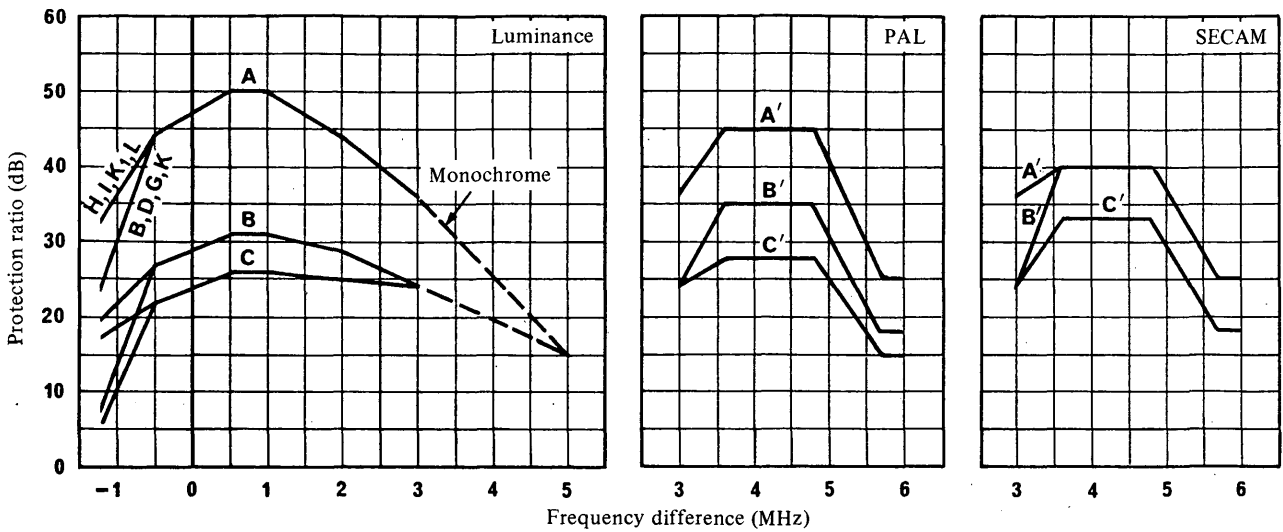
The curves shown in Figs. 2 to 4 are examples that can be derived directly from the associated tables. They illustrate the full range of protection ratio possibilities from the worst case of non-controlled condition (curves A and A') to the best achievable using either non-precision offset (curves B and B') or precision offset (curves C and C'). The curves A, B and C are related to the luminance frequency range, the curves A', B' and C' to the chrominance frequency range for the PAL and SECAM systems. For frequency differences below –1.25 MHz or above 6 MHz, the protection ratio can be derived by linear extrapolation to the channel limit.



Frequency difference (MHz)		-1.5	-1.0	-0.75	0.3	1.0	2.5	3.0	3.5	3.7	4.1	4.5
A	NTSC (dB)								50	50	45	
A	PAL (dB)	0	30	40	50	50	37	45	45	45		15
A	Monochrome (dB)											
B	Monochrome (dB)	0	15		33	33	25					15

FIGURE 1 and TABLE VI – 525-line systems (M/NTSC and M/PAL)
Tropospheric interference. Unwanted signal: CW carrier

Curves A: non-controlled condition
B: non-precision offset condition
(1/3, 2/3, 4/3, 5/3, all of the line frequency)



Offset (multiples of 1/12 line- frequency)		Curve	Frequency difference (MHz) (separation between wanted and unwanted carriers)											
			Luminance range								PAL		SECAM	
			-1.25 ⁽¹⁾	-1.25 ⁽²⁾	-0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0 ⁽³⁾	3.6-4.8 ⁽⁴⁾	5.7-6.0 ⁽³⁾
0	NO	A	32	23	44	47	50	50	44	36	35	18	40	25
	PO		23	11	32	34	40	40	37	31	28	15	33	18
1	NO		31	20	43	46	49	49	42	34	39	20	40	25
	PO		23	11	33	36	39	39	36	31	31	16	33	18
2	NO		28	17	39	42	45	45	39	32	42	22	40	25
	PO		21	9	29	32	35	35	33	29	34	17	33	18
3	NO	A'	25	13	34	36	39	39	35	29	45	25	40	25
	PO		19	7	25	28	31	31	29	26	35	18	33	18
4	NO		22	10	30	32	35	35	32	27	42	22	40	25
	PO	C	17	5	22	24	26	26	25	24	34	17	33	18
5	NO		20	8	28	30	32	32	30	25	39	20	40	25
	PO	C	17	5	22	24	26	26	25	24	31	16	33	18
6	NO	B,B'	19	7	27	29	31	31	29	24	35	18	40	25
	PO		17	5	24	26	28	28	26	24	28	15	33	18
7	NO		20	8	28	30	32	32	30	25	35	18	40	25
	PO	C,C'	17	5	22	24	26	26	25	24	28	15	33	18
8	NO		22	10	30	32	35	35	32	27	39	20	40	25
	PO	C	17	5	22	24	26	26	25	24	31	16	33	18
9	NO		25	13	34	36	39	39	35	29	42	22	40	25
	PO		19	7	25	28	31	31	29	26	34	17	33	18
10	NO		28	17	39	42	45	45	39	32	39	20	40	25
	PO		21	9	29	32	35	35	33	29	31	16	33	18
11	NO		31	20	43	46	49	49	42	34	35	18	40	25
	PO		23	11	33	36	39	39	36	31	28	15	33	18
12	NO	A	32	23	44	47	50	50	44	36	35	18	40	25
	PO		23	11	32	40	40	40	37	31	28	15	33	18
Protection ratio (dB)														

FIGURE 2 and TABLE VII — 625-line systems
Tropospheric interference

(1) H, I, K1, L television systems.

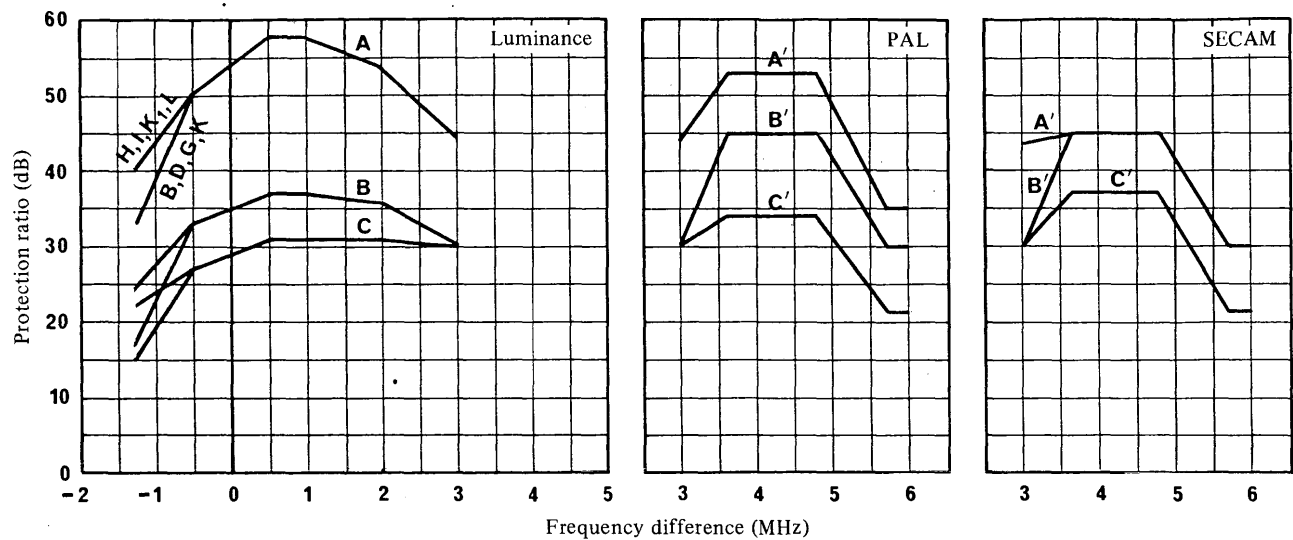
(2) B, D, G, K television systems.

(3) B, G television systems: range is 5.3-6.0 MHz.

(4) D/SECAM and K/SECAM: add 5 dB.

NO: non-precision offset

PO: precision offset



Offset (multiples of 1/12 line- frequency)		Curve	Frequency difference (MHz) (separation between wanted and unwanted carriers)											
			Luminance range								PAL		SECAM	
			-1.25 ⁽¹⁾	-1.25 ⁽²⁾	-0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0 ⁽³⁾	3.6-4.8 ⁽⁴⁾	5.7-6.0 ⁽³⁾
0	NO	A	40	32	50	54	58	58	54	44	45	30	45	30
	PO		30	22	37	38	44	44	42	36	34	21	37	21
1	NO		38	30	49	53	57	57	53	43	48	32	45	30
	PO		29	22	38	40	42	42	41	36	36	22	37	21
2	NO		34	27	46	50	55	55	51	41	51	33	45	30
	PO		27	20	34	36	38	38	37	34	39	24	37	21
3	NO	A'	30	23	42	46	50	50	46	38	53	35	45	30
	PO		24	17	30	32	34	34	33	31	40	26	37	21
4	NO		28	21	38	42	45	45	42	35	51	33	45	30
	PO	C	22	15	27	29	31	31	31	30	39	24	37	21
5	NO		26	19	35	38	41	41	38	32	48	32	45	30
	PO	C	22	15	27	29	31	31	31	30	36	22	37	21
6	NO	B, B'	24	17	33	35	37	37	36	30	45	30	45	30
	PO		23	16	29	32	33	33	32	30	34	21	37	21
7	NO		26	19	35	38	41	41	38	32	45	30	45	30
	PO	C, C'	22	15	27	29	31	31	31	30	34	21	37	21
8	NO		28	21	38	42	45	45	42	35	48	32	45	30
	PO	C	22	15	27	29	31	31	31	30	36	22	37	21
9	NO		30	23	42	46	50	50	46	38	51	33	45	30
	PO		24	17	30	32	34	34	33	31	39	24	37	21
10	NO		34	27	46	50	55	55	51	41	48	32	45	30
	PO		27	20	34	36	38	38	37	34	36	22	37	21
11	NO		38	30	49	53	57	57	53	43	45	30	45	30
	PO		29	22	38	40	42	42	41	36	34	21	37	21
12	NO	A	40	32	50	54	58	58	54	44	45	30	45	30
	PO		30	22	37	44	44	44	42	36	34	21	37	21

FIGURE 3 and TABLE VIII — 625-line systems
Continuous interference

(1) H, I, K1, L television systems.

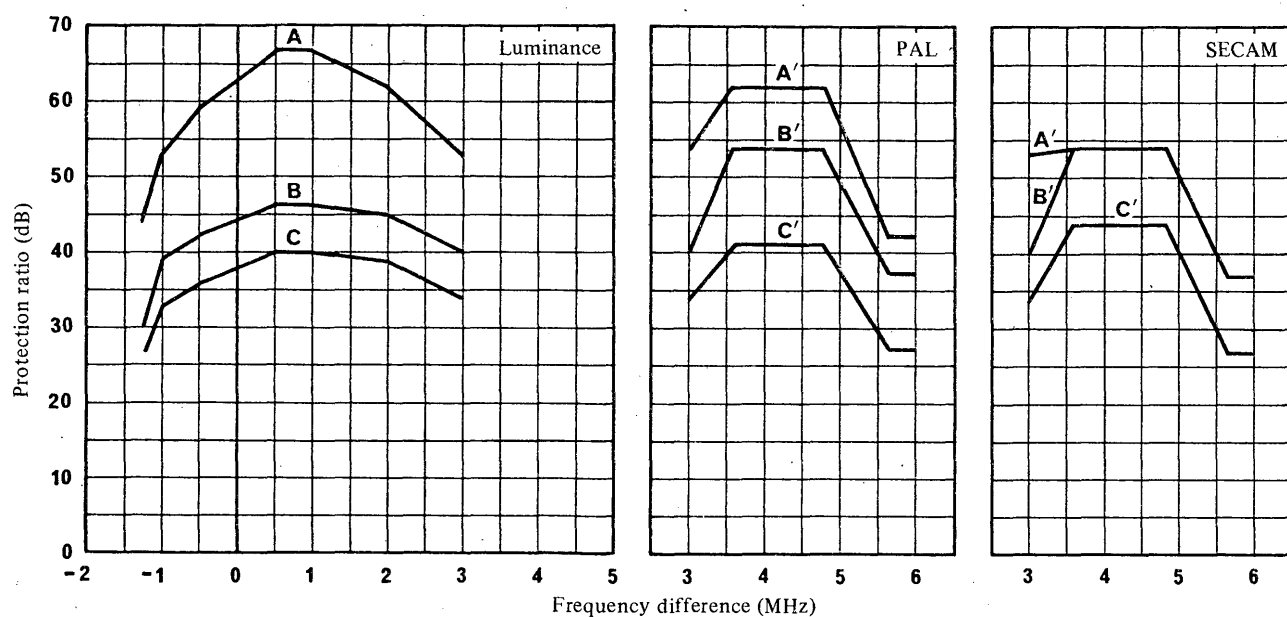
(2) B, D, G, K television systems.

(3) B, G television systems: range is 5.3-6.0 MHz.

(4) D/SECAM and K/SECAM: add 8 dB.

NO: non-precision offset

PO: precision offset

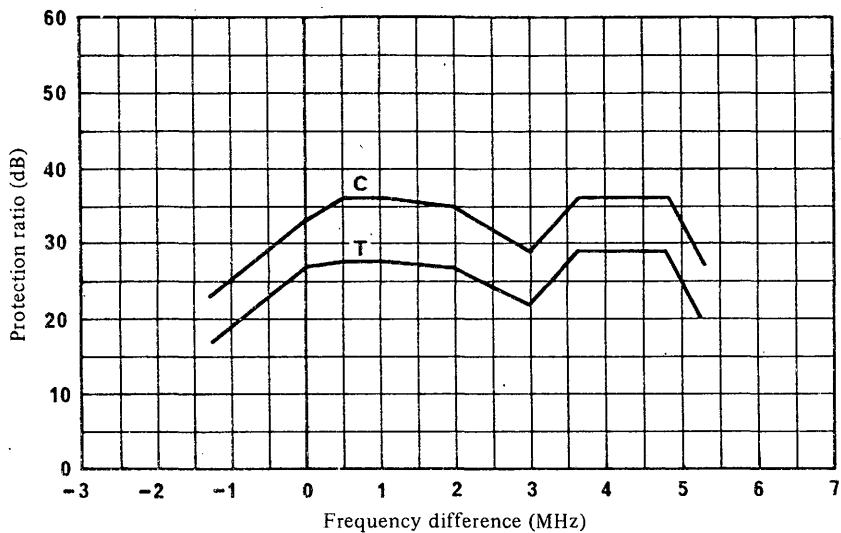


Frequency difference (MHz)		-1.25	-1.0	-0.5	0.0	0.5	1.0	2.0	3.0	3.6	4.8	5.7
A	PAL	44	53	59	63	67	67	62	53	62	62	42
	SECAM									54	54	37
B	PAL	30	39	42	44	46	46	45	40	54	54	37
	SECAM											
C	PAL	26	33	36	38	40	40	39	34	41	41	27
	SECAM									44	44	

FIGURE 4 and TABLE IX — 625-line systems
Limit of perceptibility (for information only)

5.3 Television signal affected by data signals

The inclusion of digital data such as teletext in the field-blanking interval has no effect on the required protection ratios. However, the full improvement resulting from non-precision or precision offset operation is not achievable when the unwanted signal carries a full-field data signal. In this case, Fig. 5 shows the minimum values for all offset and non-offset conditions given in § 5.2. The curves in Fig. 5 apply to full-field data signals with pulse amplitude at 66% of the peak white-to-blanking level. The values should be increased linearly for higher modulation levels.



Frequency difference (MHz)	-1.25	0.0	0.5	1.0	2.0	3.0	3.6	4.8	5.25
Tropospheric interference (T)	17	27	28	28	27	22	29	29	20
Continuous interference (C)	23	33	36	36	35	29	36	36	27

FIGURE 5 and TABLE X — 625-line systems — B/PAL and G/PAL
Protection from full-field data signals

6. Protection ratio for sound signals

Protection ratios applicable to the wanted sound signal are given in Table XI for both tropospheric and continuous interference. The values quoted refer to the level of the wanted sound carrier. In the case of a two-sound carrier transmission, each sound carrier must be separately considered. Multiplex modulated sound signals may require higher protection.

For an unwanted vision carrier, subtract 2 dB; for an unwanted amplitude-modulated sound carrier, add 4 dB.

The maximum deviation of the wanted FM sound carrier is assumed to be ± 50 kHz. A linear correction should be made for other deviations.

The weighted signal-to-noise ratio will be improved by approximately 8 dB if, for example, 5/3 line-frequency offset is used instead of 2/3 line-frequency offset.

TABLE XI — Protection ratio for wanted sound carriers
Unwanted signal: CW or FM sound carrier

Difference between wanted sound carrier and unwanted carrier (kHz)	Wanted sound signal			
	Tropospheric interference		Continuous interference	
	FM	AM	FM	AM
0	32	40	39	50
15	30	40	35	50
50	22	10	24	15
250	−6	7	−6	12

BIBLIOGRAPHY

DINSEL, S. and SIPEK, E. [April, 1985] Frequency offset in television — theory and application. *EBU Rev. Tech.*, **210**, 64-71.

ANNEX I

TROPOSPHERIC AND CONTINUOUS INTERFERENCE

When using the protection ratios in planning, it is necessary to determine whether, in the particular circumstances, the interference should be considered as tropospheric or continuous. This can be done by comparing the nuisance fields for the two conditions, the nuisance field being defined as the field strength of the interfering transmitter (at its pertinent e.r.p.) enlarged by the relevant protection ratio.

Thus, the nuisance field for continuous interference:

$$E_C = E(50, 50) + P + A_C$$

and the nuisance field for tropospheric interference:

$$E_T = E(50, t) + P + A_T$$

where:

$E(50, t)$: field strength (dB(μV/m)) of the interfering transmitter, normalized to 1 kW, and exceeded during $t\%$ of the time;

P : e.r.p. (dB(1 kW)) of the interfering transmitter;

A : protection ratio (dB),

and where the indices C and T indicate continuous and tropospheric interference, respectively.

The protection ratio for continuous interference is applicable when the resulting nuisance field is stronger than that resulting from tropospheric interference, that is, when $E_C > E_T$.

This means that A_C should be used in all cases when:

$$E(50, 50) + A_C > E(50, t) + A_T$$

ANNEX II

DIFFERENT OFFSET CONDITIONS

The required protection ratio varies considerably depending on the frequency relationship between the wanted and the unwanted carriers and their frequency tolerance. The greatest protection is required when the frequency of one or both carriers is "non-controlled".

Less interference is possible and therefore lower protection ratios are required for non-precision offset (line frequency offset). Non-precision offset takes advantage of the line frequency structure of the video signal and, in particular, it is advantageous to offset the carriers by multiples of one-half or one-third of the line frequency. The long-term stability of these favourable protection ratios can only be guaranteed, however, if the frequencies of the wanted and unwanted signals are kept constant within ± 500 Hz.

Precision offset takes further advantage of the field frequency structure of the video spectrum. The least protection is required when both carriers are "precision offset" controlled within a tolerance of ± 1 Hz for the wanted and unwanted carriers.

Figure 6 shows the main characteristics of offset operation and plots in schematic form the protection ratio curves between $0/12 f_{line}$ and $12/12 f_{line}$. These curves are cyclic and their extensions to the left and right are symbolized by broken lines. These various conditions illustrated are similar within the luminance range up to about ± 3 MHz.

The upper and lower curves indicate, respectively, the protection ratios obtained with non-precision and precision offset. More precisely, these two curves trace the envelope of a series of fluctuations in the protection ratio which swings between the two curves at field frequency as represented by the thin line.

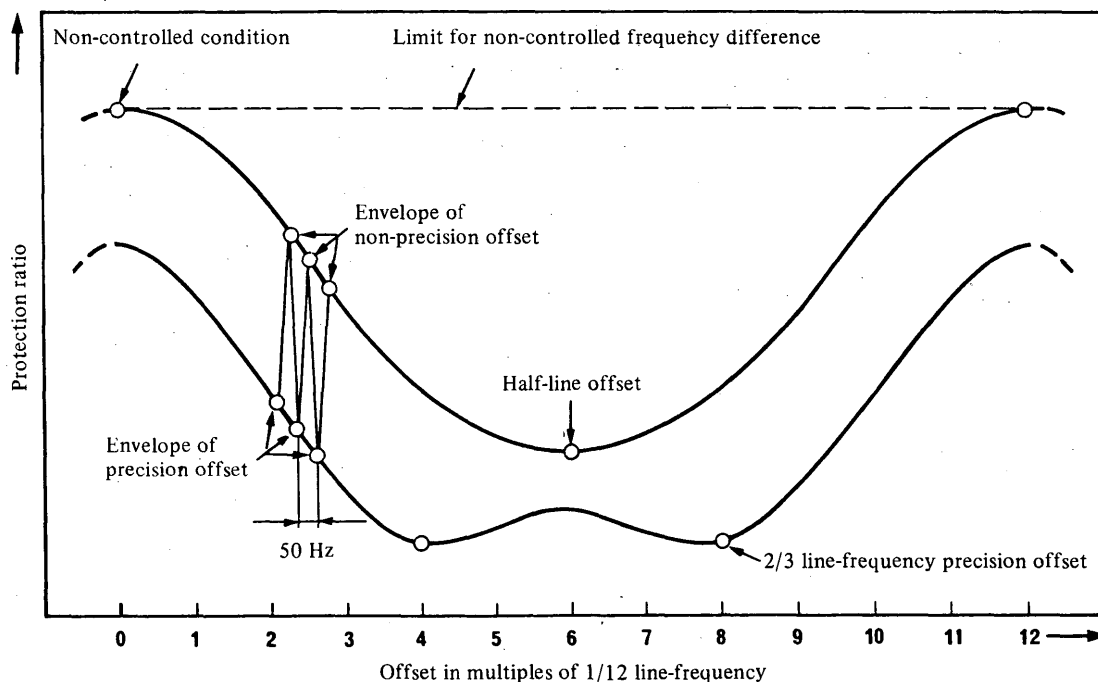


FIGURE 6 – Schematic protection ratio curves with different offset positions

Co-channel protection ratio curves in the vicinity of $0/12$, $4/12$, and $6/12$ line frequency (625-line systems)

Figure 7 gives examples of protection ratio curves for the three most important offset positions ($0/12$, $4/12$ and $6/12 f_{line}$). The curves in each graph relate to tropospheric interference, continuous interference and the limit of perceptibility.

The white and black points indicate the positions for non-precision and precision offset respectively. The reference impairment points for tropospheric and continuous interference are also indicated in the figure.

When operating TV transmitter networks with synchronized as well as phase-locked carriers, the protection ratio values are slightly reduced.

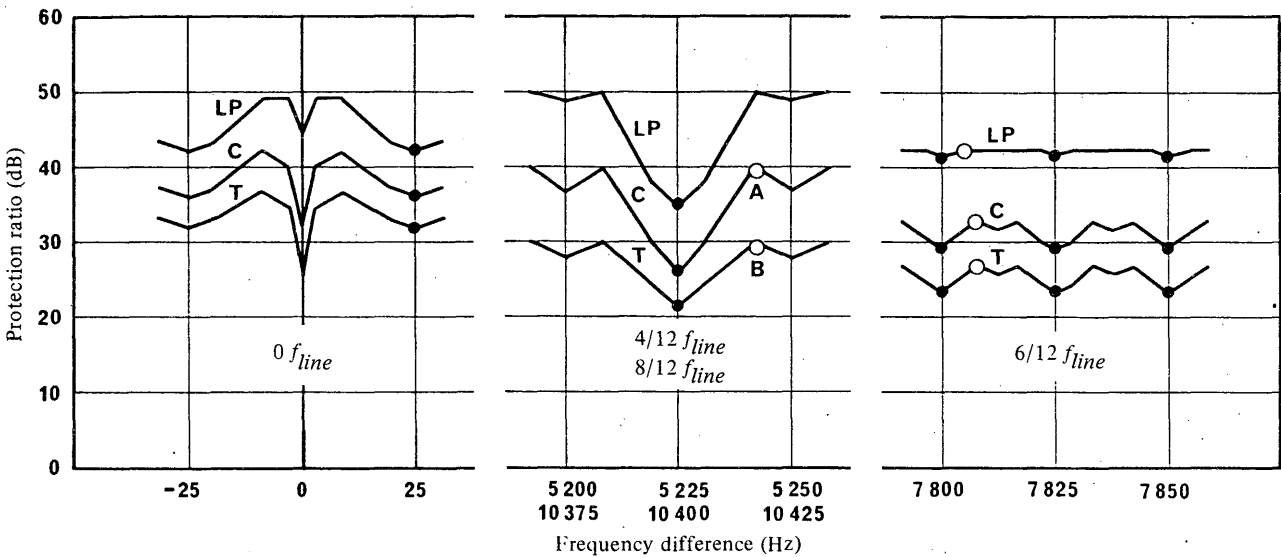


FIGURE 7 – Precise structure of the protection ratio curves for different offset positions

- Curves T: tropospheric interference
- C: continuous interference
- LP: limit of perceptibility
- A: continuous interference reference point
- B: tropospheric interference reference point
- Non-precision offset
- Precision offset

ANNEX III

FREQUENCIES FOR PRECISION OFFSET

Table XII lists the possible frequencies for precision offset in the vicinity of each twelfth of line frequency. For the luminance frequency range, the frequencies shown in the table end with 25 Hz up to $6/12 f_{line}$ and with 100 Hz beyond this frequency. Two possibilities are shown for $6/12 f_{line}$ (7800 and 7825 Hz) because at this point the spectral lines are symmetrical and thus of the same amplitude. The offset frequencies are expressed in twelfths of line frequency.

Alternative frequencies in the vicinity of each offset position, which differ by integer multiples of 50 Hz and by integral multiples of 15 625 Hz from the values given, are possible. The term “precision offset” always refers to a difference between the true frequencies of the wanted and unwanted transmitters, and not to an offset of a transmitter from its nominal carrier frequency.

If the frequency difference between wanted and unwanted carrier exceeds the normalized range specified in Table XII, one has to subtract integral multiples of 15 625 Hz. For computer calculations, formulae are given below for all precision-offset frequency differences in the luminance and in the chrominance range for 625-line systems.

TABLE XII — Normalized precision offset between 0/12 and 12/12 of line frequency

Luminance range: for all 625-line systems
Chrominance range: only PAL and SECAM systems

Offset (multiples of 1/12 line-frequency)	Precision offset frequency (Hz)		
	Luminance range	Chrominance range	
		PAL	SECAM
0	25	5	0
1	1 325	1 305	1 302
2	2 625	2 605	2 604
3	3 925	3 905	3 906
4	5 225	5 205	5 208
5	6 525	6 505	6 510
6	7 800 or 7 825	7 810	7 812
7	9 100	9 120	9 115
8	10 400	10 420	10 417
9	11 700	11 720	11 719
10	13 000	13 020	13 021
11	14 300	14 320	14 323
12	15 600	15 630	15 625

Luminance range:

$$f_p = m \times 15\,625 \pm (2n + 1) \times 25$$

$$m \leq 192, n \leq 156$$

Chrominance range:

— PAL systems

$$f_p = m \times 15\,625 \pm (2n + 1) \times 25 + k$$

$$m \geq 216 \text{ and}$$

$$k = -20 \text{ for } 0 \leq n < 143$$

$$k = -15 \text{ for } 143 \leq n < 169$$

$$k = -5 \text{ for } 169 \leq n < 299$$

$$k = +5 \text{ for } 299 \leq n \leq 312$$

— SECAM systems

$$f_p = m \times 15\,625 + 2n \times \left(25 + \frac{25}{624}\right)$$

with m, n, k integers

Computation of operational offset frequencies in a network with transmitter triplets

Precision offset techniques are usually introduced to provide solutions of particular interference problems between two co-channel transmitters. In operational television networks, co-channel transmitters are situated at the corner of a triangle. A typical line offset (non-precision offset) situation for such a transmitter triplet is: nominal vision carrier frequency $-2/3 f_{line}$, $\pm 0 f_{line}$, and $+2/3 f_{line}$ or in twelfths: 8M, 0, 8P (M = minus; P = plus). A transmitter triplet A-B-C consists of three transmitter pairs A-B, A-C and B-C. Introduction of precision offset for the above-mentioned example means a possible reduction of interference for all three pairs of the transmitter triplet. In practice, only 35% of all the theoretically possible transmitter triplets have full improvement for all three pairs, the residual 65% triplets have one or two pairs in non-precision offset.

Table XIII shows a complete and normalized list of these 35% possible cases within the range between 0P and 12P which secure an improved interference situation for all three transmitter pairs within a triplet, when precision offset is used.

With a simple rule, determination of precision offset frequencies for transmitter triplets is possible: All transmitter triplets which cannot translate to the normalized cases of Table XIII contain at least one pair without precision offset.

TABLE XIII — Possible offset combinations allowing precision offset for all transmitter pairs in transmitter triplets

Case	Offset	Frequency (Hz) (625-line systems)		
1	0 — 0P — 6P	0	25	7 800
2	0 — 0P — 6P	0	25	7 825
3	0 — 1P — 6P	0	1 325	7 800
4	0 — 1P — 7P	0	1 325	9 100
5	0 — 2P — 6P	0	2 625	7 800
6	0 — 2P — 7P	0	2 625	9 100
7	0 — 2P — 8P	0	2 625	10 400
8	0 — 3P — 6P	0	3 925	7 800
9	0 — 3P — 7P	0	3 925	9 100
10	0 — 3P — 8P	0	3 925	10 400
11	0 — 3P — 9P	0	3 925	11 700
12	0 — 4P — 6P	0	5 225	7 800
13	0 — 4P — 7P	0	5 225	9 100
14	0 — 4P — 8P	0	5 225	10 400
15	0 — 4P — 9P	0	5 225	11 700
16	0 — 4P — 10P	0	5 225	13 000
17	0 — 5P — 6P	0	6 525	7 800
18	0 — 5P — 7P	0	6 525	9 100
19	0 — 5P — 8P	0	6 525	10 400
20	0 — 5P — 9P	0	6 525	11 700
21	0 — 5P — 10P	0	6 525	13 000
22	0 — 5P — 11P	0	6 525	14 300
23	0 — 6P — 6P	0	7 800	7 825
24	0 — 6P — 7P	0	7 825	9 100
25	0 — 6P — 8P	0	7 825	10 400
26	0 — 6P — 9P	0	7 825	11 700
27	0 — 6P — 10P	0	7 825	13 000
28	0 — 6P — 11P	0	7 825	14 300
29	0 — 6P — 12P	0	7 800	15 600
30	0 — 6P — 12P	0	7 825	15 600

Example

The aim of this calculation is the transformation of all three offset positions into the range between 0P and 12P (see Table XIII). Each single transmitter can be moved by multiples of line frequency, that means by multiples of 12/12 (see Step 2). Moving of any twelfths is allowed, when all transmitters are moved by the same number of twelfths (see Step 1).

Given: Transmitter triplet
line offset position:

A	B	C
18M	8P	2P

Step 1

Set one transmitter to 0 by linear translation:

+18	+18	+18
0	26P	20P

Result:

Step 2

Translation of transmitter B and C into the range between 0P and 12P by subtracting or adding multiple of the line frequency:

	-24	-12
0	2P	8P

Result:

Step 3

Selection of precision offset frequencies from Table XIII:

0	2 625	10 400	Hz

Step 4

Step 2 has to be compensated:

	+31 250	+15 625	Hz
0	+33 875	+26 025	Hz

Result:

Step 5

Step 1 has to be compensated:	- 23 400	- 23 400	- 23 400	Hz
Result:	- 23 400	+ 10 475	+ 2 625	Hz
equivalent to	18M	8P*	2P	

REPORT 478-1

GHOST IMAGES IN TELEVISION

(Question 6/11, Study Programme 6A/11)

(1970-1986)

1. Secondary radiation from masts in the neighbourhood of transmitting antennas

When a television radiator is sited too close to another antenna structure “ghost” images displaced from the wanted picture can occur over a large proportion of the service area due to re-radiation of the transmissions from the other mast. These “ghosts” can be termed “permanent ghosts” since they cannot generally be reduced by the use of receiving antenna directivity except in the vicinity of the transmitting station. In this way, they are distinguished from “local ghosts” which may be seen only by viewers situated close to large re-radiating structures and which can sometimes be reduced by suitable orientation of a directional receiving antenna.

It has been suggested that under good viewing conditions, “ghost images” will produce negligible impairment for a ratio of 32 dB or more between the direct and re-radiated signals. This figure applies where the time separation is 2 μs or more and may be less for smaller time separations [CCIR, 1966-69; Mertz, 1953].

It has been established, as the result of theoretical studies and experimental work [Allnatt and Prosser, 1965; Hill, 1964] that, where the reflecting structure is at least as high as the antenna, the level of the re-radiated signals decreases at a rate of about 3 dB for each doubling of the distance separating the masts. In Bands I and III, this variation can be appreciably modified by ground reflection, which can increase or reduce it by as much as 6 dB.

Table I gives the distances in kilometres at which the ratio between the direct and re-radiated signals is 32 dB neglecting the effect of ground reflection for different frequencies and different types of mast. It is assumed that the reflecting mast is at least 60 m higher than the transmitting antenna.

TABLE I

Frequency (MHz)	50		200		800	
Polarization	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
Cylindrical mast, 3 m diameter	1.4	1.4	1.2	1.2	1.2	1.2
Triangular lattice mast, 3 m side, least favourable orientation	1.5	2.4	1.5	0.9	2.4	2.4
Square lattice mast, 2.5 m side, least favourable orientation	2.4	2.4	2.9	1.2	1.7	1.7

The ratio of the direct and reflected signals is modified by the horizontal radiation pattern of the transmitting antenna.

* To reduce the sound interference between transmitter B and C, an offset position of 20P = 26 100 Hz (enlarged by 12P = 15 625 Hz) would be preferable. In this case picture interference is unchanged.

2. Effects of multipath propagation

Experiments have been carried out in India [CCIR, 1982-86a] to determine the protection ratio requirements appropriate to television pictures with positive "ghost" images delayed by 0.4, 0.8 and 1.4 μ s. The results in terms of mid-opinion assessments are summarized in Table II. In each case the 90% opinion values are about 4 dB higher.

TABLE II

Impairment grade (Rec. 500)	Protection ratio (dB) for delay:		
	0.4 μ s	0.8 μ s	1.4 μ s
5	18	26	30
4	12	18	20

It was found that the results for colour and monochrome hardly differed. Likewise, use of moving or still pictures had little effect on the assessments.

3. Ghost prediction methods

A mathematical method for prediction of ghost delay and ghost amplitude has been developed in Canada [CCIR, 1982-86b]. This method relates primarily to the VHF bands. However, an appropriate correction is proposed for the UHF bands.

The method also includes a prediction of resulting picture quality according to the CCIR 5-grade scale used in Recommendation 500 based upon subjective measurements made in Canada of signals having varying amounts of ghost time delay and amplitude. However, some of these quality predictions do not correlate well with those given in Report 960 and further study is desirable. The conditions under which the Canadian subjective tests were made are not defined and care should be taken in interpreting the results of such test programmes.

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REPORT 1084

PROTECTION RATIOS FOR DIGITAL DATA SIGNALS MULTIPLEXED WITH TELEVISION SIGNALS

(1986)

1. Introduction

Recommendation 655 does not specify the protection ratios applicable when the wanted signal is a digital data signal multiplexed with the television signal.

This Report describes an interference criterion suitable for a signal of this type, and calculates protection ratios for an interfering emission in one of the channels adjacent to the wanted channel, in the image channel, or in an overlapping channel.

2. Interference criterion

For digital data reception, neither the 5-grade scale in Recommendation 500 nor the 4-grade teletext picture impairment criteria proposed in Part II of Report 956 can be used to assess the effect of interference, since a reduction of only a few decibels in the wanted-to-unwanted signal ratio will reduce quality from the maximum to the minimum grade. A given wanted-to-unwanted signal ratio in a geographical area characterizes the percentage of users in this area who lose reception. The interference criterion must thus be related to the bit error ratio (BER) and its geographical distribution.

It may be considered that a BER of less than 10^{-4} (1 error for about a page of teletext system A) permits satisfactory reception, and that impairment due to an interfering emission is equivalent to a given increase in the noise level at the RF input of the television receiver. The interference criterion is determined by the choice of the equivalent increase in noise level (or noise back-off).

As an illustration, the curves in Fig. 1 portray the results of previous statistical studies [Blineau *et al.*, 1980] and show the geographical distribution of BER for a teletext system A signal in the following two cases:

- A : mountainous region, TV receiver with envelope detection, good quality teletext receiver;
- B : urban region, TV receiver with quasi-synchronous detection, good quality teletext receiver.

The increase in BER equivalent to a noise back-off of 1 dB and 3 dB has been indicated on the curves for both measurement conditions.

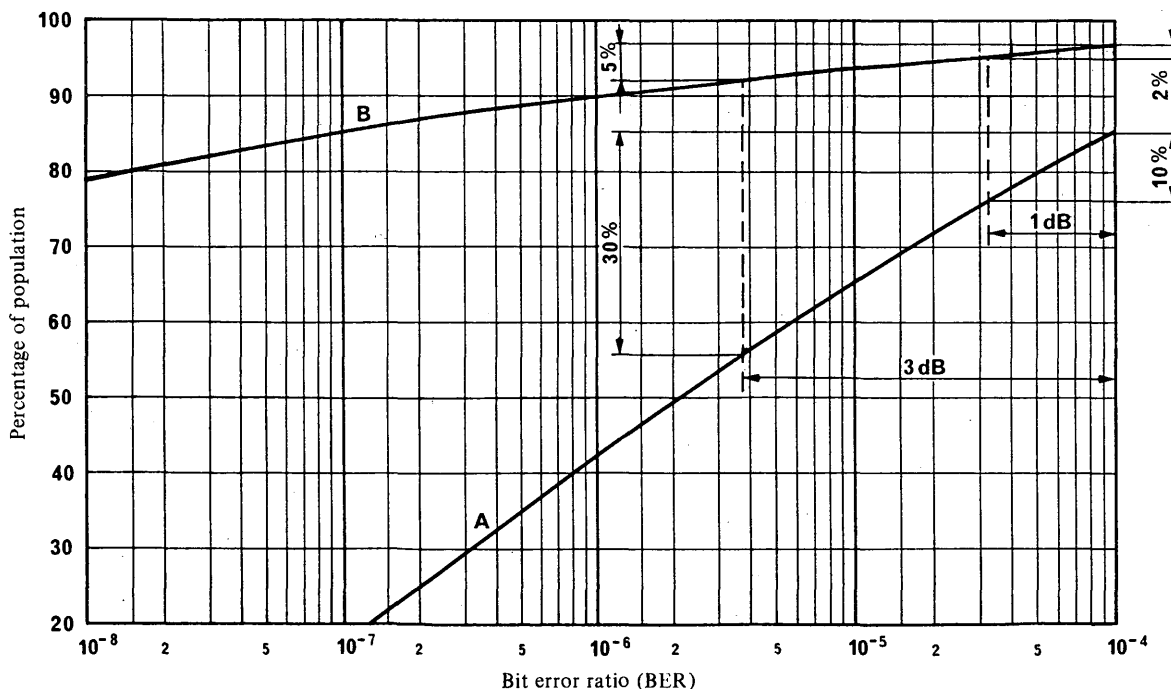


FIGURE 1 – Bit error ratio distribution: percentage of the population enjoying BER below a specified value

From a first approximation, it appears that a 1 dB noise back-off causes a loss of reception for 2% to 10% of users, whereas a 3 dB noise back-off causes a loss of reception for 5% to 30% of users, depending on the area and the television receiver performances.

Two interference criteria were thus considered: a stringent criterion (noise back-off = 1 dB) applicable particularly in areas where reception is difficult, and a less stringent criterion (noise back-off = 3 dB) applicable in areas with easy reception.

Note. — No distinction need be made between tropospheric and continuous interference. The ratio between the level of an interfering signal tolerable for 1% to 10% of the time (BER probably between 10^{-3} and 10^{-4}) and that of an interfering signal tolerable for 50% of the time (BER probably less than 10^{-5}) is only 2 to 3 dB.

3. Protection ratios for digital data signals

The protection ratio values which appear in this section are based on the method outlined in § 2 and relate to teletext system A signals multiplexed with an L/SECAM standard television signal. Further studies are necessary for other types of signal.

The values in question are given in Table I (where the interfering emission is an L standard emission and Fig. 2 (where the interfering emission is a continuous wave (Curve A'), an L standard TV emission (Curve B') or a full frame teletext signal (Curve C')). They relate to a stringent interference criterion (noise back-off = 1 dB). A less stringent interference criterion (noise back-off = 3 dB) produces values about 5 dB lower.

TABLE I

Position of the interfering emission	Image channel	Lower adjacent channel	Upper adjacent channel
Protection ratio for data signals (dB)	- 22	- 17	- 16

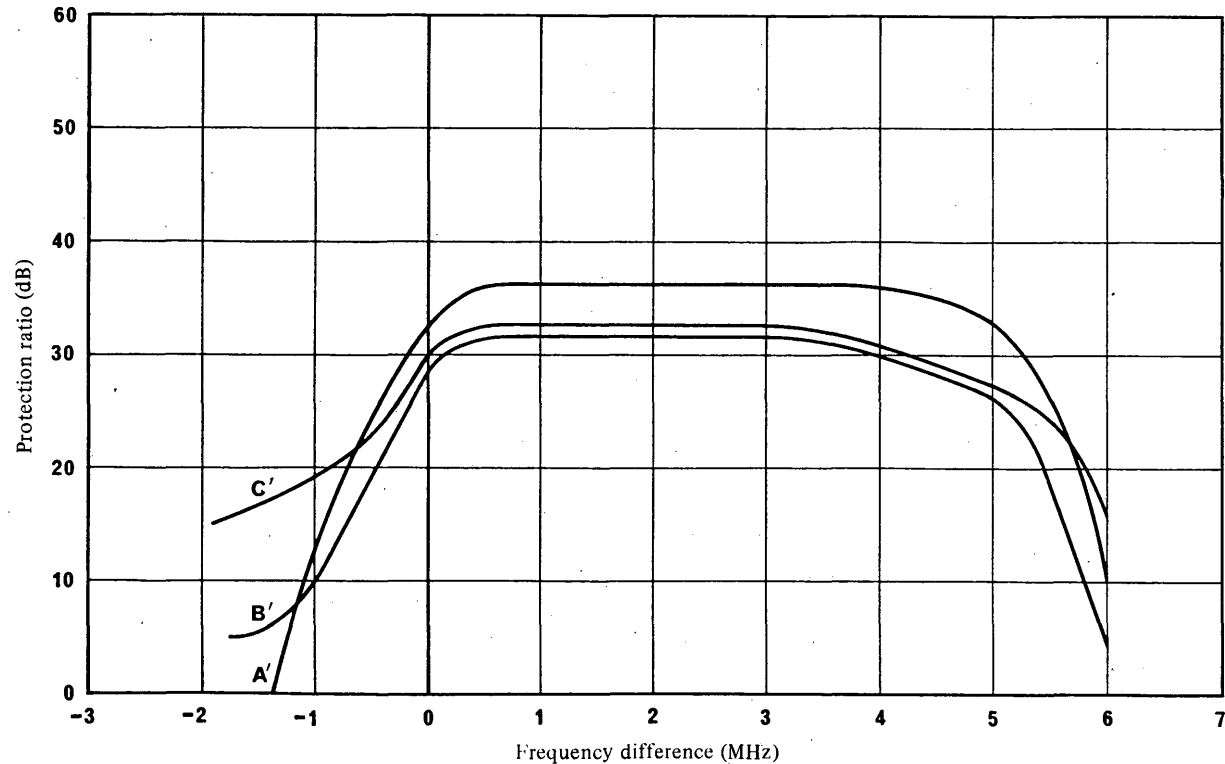


FIGURE 2 – Protection ratios for teletext system A signals

4. Comparison with the protection ratios for television signals

Table II and Fig. 3 compare the protection ratios for L/SECAM standard television signals (Recommendation 655) and digital data signals (noise back-off = 1 dB).

- Image channel or adjacent channel interference:
The reduction in the protection ratios is due in part to the improvement in television receiver selectivity (Recommendation 655 is based on receivers not equipped to receive data signals).
- Overlapping channel interference:
The protection ratios are comparable or even higher for digital data signals when frequency offset is used.

TABLE II

Position of the interfering emission	Image channel	Lower adjacent channel	Upper adjacent channel
Protection ratio for an L standard television emission (dB)	0	+17	-12

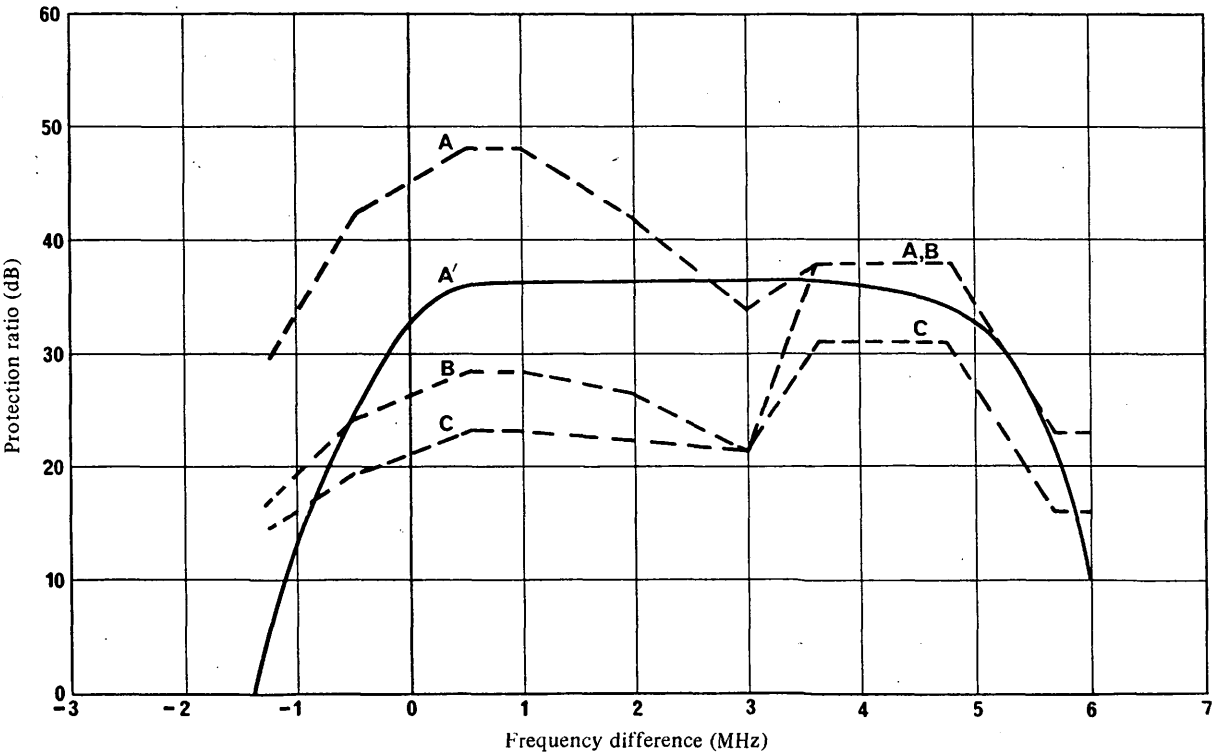


FIGURE 3 – Protection ratio for a television signal (L standard) and a teletext system-A signal (interfering signal: continuous wave)

- Curves A: non-controlled condition
A': teletext system A
B: best non-precision offset
C: best precision offset

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RECOMMENDATION 565 *

**PROTECTION RATIOS FOR 625-LINE TELEVISION AGAINST
RADIONAVIGATION TRANSMITTERS OPERATING
IN THE SHARED BANDS BETWEEN 582 AND 606 MHz**

(Questions 4/11 and 39/11)

(1978)

The CCIR,

CONSIDERING

- (a) the Final Acts of the European VHF/UHF Broadcasting Conference, Stockholm, 1961 **, and the Special Agreement relating to the use of the band 582-606 MHz by the radionavigation service, Brussels, 1962;
- (b) the assumption, which remains to be fully confirmed, that the results of tests carried out with monochrome television signals are also applicable to colour television;
- (c) that protection ratios should be such that they are satisfied for 99% of the time;
- (d) that values of protection ratios refer to the conditions at the input to the television receiver;
- (e) that the level of the television signal is expressed in terms of the power at the peak of the modulation envelope;
- (f) that the level of the radionavigation signal is expressed as the power at peak-pulse level,

UNANIMOUSLY RECOMMENDS

that the values of protection ratio given below should be used in determining the protection available to monochrome or colour-television systems operating in the band 582 to 606 MHz:

1. Protection ratios required when the radionavigation signal falls within the passband of the television receiver

When the radionavigation signal falls within the passband of the television receiver, the required signal-to-interference ratio should be:

- 10 dB for systems with negative modulation,
- 15 dB for systems with positive modulation.

The ratio is sensibly constant over the greater part of the passband of the television receiver, but decreases in accordance with the selectivity of the receiver as shown in Fig. 1.

The protection ratios given in Fig. 1 do not relate to interference to the sound channel from signals of the radionavigation services. Further studies should be carried out on this subject.

* This Recommendation constitutes a partial answer to Question 39/11. It should be brought to the attention of Study Group 8.

** However, at the European VHF/UHF Broadcasting Conference, Stockholm, 1961, some delegates made reservations as to the prospect of fulfilling the technical criteria in actual planning.

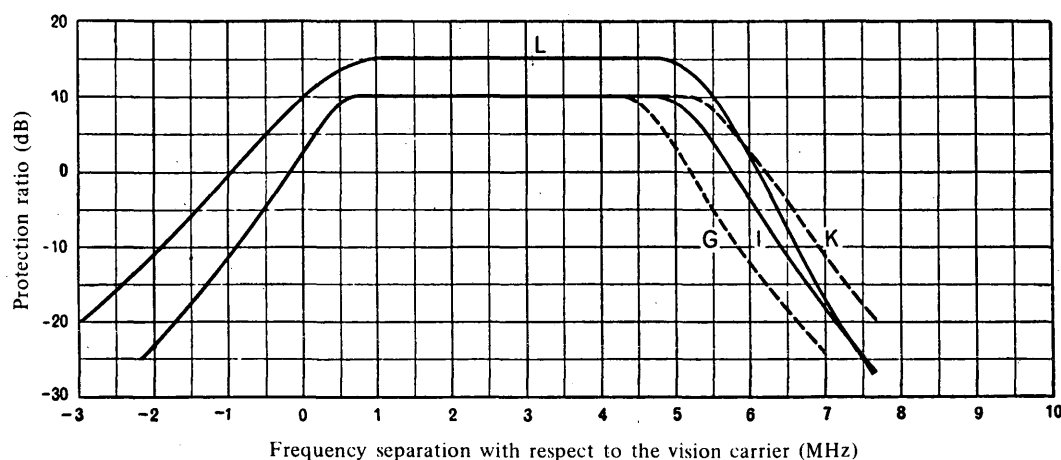


FIGURE 1 — Protection ratio required by system L, G, I and K picture signals against a radionavigation signal in the band 582 to 606 MHz

2. Protection ratios required when the radionavigation signal falls outside the passband of the television receiver

Reference should be made to Recommendation 655 for image channel interference.

No information exists at present on adjacent channel interference.

Note. — Other interference effects (intermodulation) are likely to occur if radionavigation stations, which in general use high peak powers and highly directional antennas, are situated near receiving locations, especially where the television signal is weak.

RECOMMENDATION 266

PHASE CORRECTION OF TELEVISION TRANSMITTERS NECESSITATED BY THE USE OF VESTIGIAL-SIDEBAND TRANSMISSION

(Study Programme 9A/11)

(1959)

The CCIR,

CONSIDERING

- (a) that the transmission of television signals using vestigial-sideband techniques gives rise to distortion;
- (b) that this distortion consists of linear distortion (in-phase errors) and non-linear distortion (quadrature errors);
- (c) that with average pictures, the depths of modulation are low and thus the non-linear distortion is less than the linear distortion;
- (d) that linear distortion arises partly from the transmitter and partly in the receiver;
- (e) that due regard has to be paid to future design and development of television receivers as well as to the differing degree of phase errors in existing receivers,

UNANIMOUSLY RECOMMENDS

1. that linear pre-correction shall be introduced into the television picture transmitter, so as to compensate for that part of the linear distortion arising from the errors in the radiated signal;
2. that the television picture transmitter may also introduce a correction to compensate for linear distortions arising in the receiver, but this correction shall not exceed one half of that necessary to compensate a receiver using normal minimum phase-shift networks and with an amplitude characteristic corresponding to the television standard concerned;
3. that the pre-correction allowed in § 2 applies only to frequencies between zero and up to approximately half the video bandwidth.

RECOMMENDATION 419-1

DIRECTIVITY OF ANTENNAS IN THE RECEPTION
OF TELEVISION BROADCASTING

(Question 26/11, Study Programme 26A/11)

(1963-1986)

The CCIR,

UNANIMOUSLY RECOMMENDS

that the characteristics of directivity of the receiving antennas of Fig. 1 can be used for planning terrestrial television services in broadcasting Bands I, III, IV and V.

Note 1. — It is considered that the discrimination shown will be available at the majority of antenna locations in built-up areas. At clear sites in open country, slightly higher values will be obtained.

Note 2. — The curves in Fig. 1 are valid for signals of vertical or horizontal polarization, when both the wanted and the unwanted signals have the same polarization.

Note 3. — Bands I, III, IV and V are defined in Note 4 of Recommendation 417.

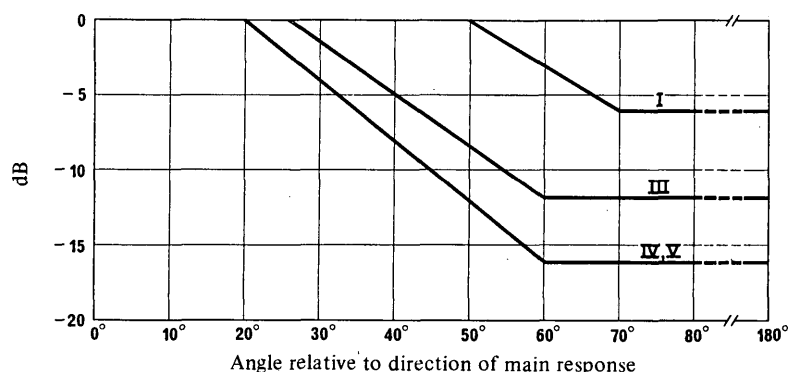


FIGURE 1 — Discrimination obtained by the use of directional receiving antennas in broadcasting

(The number of the broadcasting band is shown on the curve)

REPORT 625-3

**CHARACTERISTICS OF TELEVISION RECEIVERS
AND RECEIVING ANTENNAS ESSENTIAL FOR FREQUENCY PLANNING**

(Question 26/11, Study Programme 26A/11)

(1974-1978-1982-1986)

1. Introduction

Many characteristics of television receivers may be defined, together with methods of measurement and practical values. Question 26/11 and Study Programme 26A/11 call for the study of the principal characteristics which may be required for frequency planning.

These characteristics are tabulated in § 4 of this Report in which it is suggested that the most recent mean numerical values should be collected.

The quality of the picture displayed and of the sound heard depends on characteristics of the complete television system from the studio to the receiver screen or loud-speaker, and in this context the main parameters of a television receiver, other than those primarily involved in frequency planning, may be of interest. The CCIR has collected a great deal of data which is embodied in various Recommendations and Reports, but much of this has been rendered obsolete by the development of receiver design techniques.

The definition of these characteristics, the measuring method applied and the presentation of the results in Tables I, III, IV and V should be taken, where available, from IEC Publications 107-1, 107-2 and 597-2.

It is important that CCIR definitions of receiver performance characteristics should not contradict those of the IEC. If this occurs, action should be taken by both organizations to resolve the difference.

Attention is drawn to the importance of effective participation by CCIR representatives in IEC work, especially in the field of definitions and methods of measurement of television receiver characteristics (Sub-Committee 12A). This information is important for planning and for achieving satisfactory quality targets in an overall television system, from picture source up to and including the receiver.

Apart from these characteristics, those relating to interference caused by television receivers should conform to the relevant CISPR recommendations.

2. Categories of receivers

2.1 An overall appraisal of picture quality should take into consideration the category of receivers which will be used in the broadcasting system envisaged.

It is proposed that data recorded in future for this Report should relate only to the mean values of characteristics for receivers that are typical of good, current engineering practice in the country in question. This is to avoid undue influence being exerted on future planning standards by receiver designs at the extreme upper and lower ends of the performance range.

A reference receiver could be defined taking into account the mean values and possible appropriate amendments to them (Report 805).

2.2 Receivers for direct broadcasting from satellites

The results of the many studies on characteristics of the receivers for broadcasting from satellites may be found in Report 473.

3. Receiving antennas

The numerical values of antennas characteristics contained in Recommendation 419 and Reports 122 and 482 relate to antennas *in situ*. Only data relating to the directivity, forward gain and cross-polarization protection of antennas tested under idealized conditions in a suitable site need be recorded.

The necessary definitions and measuring methods are contained in IEC Publications 597-1 and 597-2.

4. Principal characteristics required for planning

4.1 List of characteristics

TABLE I

Item	Characteristic	Publication IEC 107-1			Remarks
		Definition	Measuring Method	Presentation of results	
1	Noise-limited sensitivity	Clause 105 and Clause 109	Clause 110	For a peak-to-peak luminance signal-to-non-weighted noise ratio of 30 dB	The most unfavourable value for each of the broadcasting bands
2	Protection ratios	See § 4.3 of this Report			
3	Rejection of adjacent picture carrier	Clause 136	Clause 137	Clause 138	The most unfavourable value for each of the broadcasting bands
4	Rejection of adjacent sound carrier	Clause 136	Clause 137	Clause 138	
5	Image-frequency rejection	Clause 146	Clause 147	Clause 138	
6	Intermediate-frequency rejection	Clause 144	Clause 145	Clause 138	
7	Oscillator position	High or low			
8	Tuning tolerance	Clause 47	Clause 48	Clause 51	As a function of time
9	Receiver radiation	As specified in CISPR Recommendation No. 24/2			
10	Susceptibility of receiver to external interference	Under study			Interference not entering by the antenna
11	Intermediate-frequency values	See Table II			For the determination of the value of the intermediate frequency, see the example given in Doc. 44 of the African Broadcasting Conference, Geneva, 1963

4.2 *Examples of intermediate frequencies for television receivers*

TABLE II

No. of lines in system	Country	Standard	Channel limits at intermediate frequency (MHz)	Intermediate frequency (MHz)	
				Sound-channel	Video-channel
405	UK	A	33.40 to 38.40	38.15	34.65
525	USA	M	41 to 47 ⁽¹⁾	41.25	45.75
525	Japan	M	54 to 60 ⁽²⁾ ⁽⁴⁾	54.25	58.75
625	Spain, Norway, Netherlands, Federal Republic of Germany, Sweden, Switzerland, Italy ⁽²⁾ , Yugoslavia	B, G	33.15 to 40.15	33.40	38.90
	USSR and some OIRT countries	D, K	31.25 to 39.25	31.50	38.00
	France	L	31.00 to 39.50	39.20 ⁽³⁾	32.70 ⁽³⁾
	UK	I	33.25 to 41.25	33.50	39.50
	African countries ⁽⁵⁾	K1	33.45 to 41.45	33.70	40.20
819	France	E	25.10 to 39.50	39.20 ⁽³⁾	28.05 ⁽³⁾

⁽¹⁾ According to Electronic Industries Association Standard Recommendation No. 109 C.

⁽²⁾ Protected bands.

⁽³⁾ According to Recommendation No. 103 of the Syndicat des Constructeurs d'appareils radiorécepteurs et téléviseurs (SCART).

⁽⁴⁾ Television receivers, all channels (VHF and UHF).

⁽⁵⁾ Calculated from Doc. 44 of the African Broadcasting Conference, Geneva, 1963.

The multiplicity of values of the intermediate frequency is a cause of increased cost of receivers, particularly those suitable for frontier regions where countries use standards with different radio frequencies.

Reception of television programmes with different standards may require as many as five pairs of values of the intermediate frequency involving the same number of multi-standard receiver types.

4.3 *Radio-frequency protection ratios (see item 2, Table I)*

Protection ratio as a parameter for frequency planning is defined as the ratio of wanted to unwanted signal levels at the receiver input, required to produce a specified grade of picture (or sound) impairment. Protection ratio cannot, in general, be obtained from objective measurements made of the parameters normally used to define receiver performance, for example, selectivity, overload, etc., but can be obtained by subjective tests made in accordance with Recommendation 500. The value will depend, among other things, on the nature of the wanted signal (monochrome, PAL, SECAM, etc.), on the type of unwanted signal (television, sound, pure CW, etc.) and on the frequency separation. The tests should be made on the types of interference described in Recommendation 655, except for co-channel interference.

The information should be presented in the form of graphs and/or numerical values showing the protection ratio observed for interference assessed as a Grade 4 impairment "Perceptible but not annoying" (Recommendation 500), as a function of frequency separation between the wanted and unwanted signals for each type of unwanted signal. Any dependence of the protection ratio on the wanted signal level should be indicated (owing to the non-linearity of the input stages). The graphs should cover frequency separation from zero to 1 or 2 channel widths above and below the wanted signal frequencies.

For frequency planning purposes the protection ratio figures so obtained are modified to take account of the grade of impairment that can be tolerated, bearing in mind the percentage of time the impairment will be suffered. For this purpose additional observations for more than one grade of impairment are valuable.

Protection ratios for image channel interference are also relevant to some aspects of international frequency planning and should be noted.

Protection ratios appropriate to the out-of-channel response of the receivers can be determined by direct subjective comparison with the in-channel response [Price, 1981].

5. Results

5.1 The numerical values listed in Tables III and V are mean values taken from an extensive series of objective measurements, carried out in accordance with IEC Publications 107 and 138. Administrations are requested to review the numerical values listed in Tables III and V to determine if those values are valid when performing measurements in accordance with the new versions, Publications 107-1 and 597-2. Administrations are encouraged to perform whatever measurements may be necessary to have those values up-dated accordingly.

The following tables are an example of how the numerical values of characteristics may be presented.

5.2 *Principal characteristics*

TABLE III

Item	Characteristic	Country					
		Italy	United Kingdom ⁽¹⁾				
1	Noise-limited sensitivity (dBm) Broadcasting band I III IV/V 12 GHz	⁽²⁾ ⁽³⁾ -60 -60 -55	-65				
2	Protection ratio (dB) Broadcasting band I III IV/V 12 GHz	See Rec. 655					
3	Rejection of adjacent picture carrier (dB) Broadcasting band I III IV/V 12 GHz	⁽⁴⁾ -40 -40 -40	-56				
4	Rejection of adjacent sound carrier (dB) Broadcasting band I III IV/V 12 GHz	⁽⁴⁾ -40 -40 -40	-43				
5	Image frequency rejection (dB) Broadcasting band I III IV/V 12 GHz	⁽⁵⁾ -50 -50 -44	-51				
6	Intermediate frequency rejection (dB) Broadcasting band I III IV/V 12 GHz	⁽⁶⁾ -40 -50 -50	-47				
7	Oscillator position Broadcasting band I III IV/V 12 GHz	High	High				

See notes at the end of Table III.

TABLE III (continued)

Item	Characteristic	Country					
		Italy	United Kingdom ⁽¹⁾				
8	Tuning tolerance (kHz) Broadcasting band I III IV/V 12 GHz	± 350 ± 350 ± 350 } ⁽⁷⁾	± 50 ⁽⁸⁾				
9	Receiver radiation Broadcasting band I III IV/V 12 GHz	⁽⁹⁾	⁽⁹⁾				
10	Susceptibility of receiver to external interference Broadcasting band I III IV/V 12 GHz						
11	Intermediate frequency values Broadcasting band I III IV/V } 12 GHz	See Table I (Item 11)	(See Table I)				

⁽¹⁾ The following characteristics relate to System I colour television receivers [CCIR, 1974-78].

⁽²⁾ For a luminance signal-to-unweighted noise ratio of 30 dB and a normalized output level.

⁽³⁾ IEC Publication 107, Clause 3.3.2.

⁽⁴⁾ IEC Publication 107, Clause 4.2.

⁽⁵⁾ IEC Publication 107, Clause 4.5.2.

⁽⁶⁾ IEC Publication 107, Clause 4.4.2.

⁽⁷⁾ The tuning tolerance must be reduced to ± 50 kHz if the television set is provided with a teletext decoder. This tuning tolerance is achievable using an automatic frequency control or a frequency synthesizer.

⁽⁸⁾ With automatic frequency control.

⁽⁹⁾ See CISPR Recommendation No. 24/3 (1970).

Note. – In the future, measurements should be carried out in accordance with the revised version i.e. IEC Publication 107-1. The new references in the footnotes will be as follows:

⁽³⁾ IEC Publication 107-1, Clause 110.

⁽⁴⁾ IEC Publication 107-1, Clause 137.

⁽⁵⁾ IEC Publication 107-1, Clause 147.

⁽⁶⁾ IEC Publication 107-1, Clause 145.

6. Data relating to the receiving station

This section gives data on typical television antennas.

6.1 Antenna characteristics

For each of the channels to be received, the antenna characteristics to be considered are given in Table IV, which contains references to the relevant publications of the IEC.

TABLE IV

Characteristic	Definition	Measuring method (IEC Publication 597-2)	Remarks
Number of elements	See Note 1	Clauses 3.2 and 5.1	In relation to a half-wave dipole
Impedance (ohms)	IEC Publication 597-1		
Gain in the nominal band (dB)	IEC Publication 597-1		
Passband (MHz)	Derived from the above characteristic Tolerance on each usable channel ± 2 dB	Clause 3.3	
Directivity pattern	IEC Publication 597-1		
Angle of aperture (degrees)	Measured on the main lobe of the directivity pattern, with a 3 dB attenuation in relation to the maximum		
Attenuation of the back lobe in relation to the main lobe	Measured on the directivity pattern (dB)		
Cross polarization attenuation (dB)	Measured as in Note 2 with a linearly polarized emission		

Note 1. — For a Yagi-type antenna, the radiating elements are conductors designed to be excited by the wanted transmission.

The following may be distinguished:

- the driven element which supplies the wanted radio-frequency power through its two output terminals;
- the directors which are situated between the main radiator and the transmitter to be received;
- the reflectors which are situated behind the main radiator.

Other types of antenna may include plane or corner conductor systems. In that case, they will be described briefly.

Note 2. — The cross polarization attenuation is still under consideration by the IEC. Until the IEC fills this gap, the measuring arrangement for the directivity pattern or gain should be used, and the attenuation obtained should be measured by turning the relative polarization through 90°, between the emission and the antenna.

Note 3. — For each channel which can be received, the gain should be expressed in relation to a half-wave dipole.

6.2 Results

Typical values for the characteristics listed in Table IV are shown in Table V.

TABLE V

Characteristic	Country									
Number of elements Broadcasting band I III IV/V	France									
	2	4								
	3	10								
	8	22								
Impedance ⁽¹⁾ (Ω) Broadcasting band I III IV/V	75	300								
	75	300								
	75	75								
Gain in the nominal band (dB) Broadcasting band I III IV/V	4 ⁽³⁾	8 ⁽³⁾								
	5	12								
	10	16								
Passband (MHz) Broadcasting band I III IV/V	11	8								
	15	15								
	80	80								
Angle of aperture Broadcasting band I III IV/V	59 ⁽³⁾	52 ⁽³⁾								
	58	36								
	46	26								
Back lobe attenuation (dB) Broadcasting band I III IV/V	10	16								
	>20	32								
	>20	>22								
Cross polarization attenuation (dB) ⁽²⁾ Broadcasting band I III IV/V	15	20								
	20	>20								
	>20	>20								

(1) The 300 Ω nominal values are reduced to the nominal value of the antenna system used.

(2) As indicated Note(2) to Table IV, further studies are still required on this subject. However, protection against a linearly polarized wave, whose polarization plane is perpendicular to that of the antenna, should be greater than 20 dB. This limit only applies to reception in the main lobe of the antenna.

(3) In band I (lower part of band 8), the very high value of the ratio Δf/f makes typical values measured at the picture-carrier frequencies more significant.

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[1982-86]: 11/409 (Italy).

REPORT 482-1

**RECOMMENDED CHARACTERISTICS FOR COLLECTIVE AND
INDIVIDUAL ANTENNA SYSTEMS FOR DOMESTIC RECEPTION OF
SIGNALS FROM TERRESTRIAL TRANSMITTERS**

(Question 7/11)

(1970-1986)

1. Scope

Installations may be classified according to the number of users served. An individual antenna serves one user, even though it may be associated with several receivers. A collective antenna serves all or part of a building and hence a larger number of users.

This Report applies to antenna systems for individual or collective use designed to receive television broadcasts in bands 8 (VHF) and 9 (UHF) and also to the associated equipment of such systems: the transmission line, amplifiers, couplers, etc., used to convey the signal to the television receivers, taking into account the transmission of data signals (e.g. teletext) in the structure of the television waveform.

- It does not apply to television antennas for cabled distribution systems.
- Reference is made to IEC Publication No. 728 (1982).
- The relevant figures identified by “*” are based on investigations carried out in Italy [CCIR, 1982-86a, b].

2. General input requirements

The received input signals lie in those parts of band 8 (VHF) and band 9 (UHF) allocated to terrestrial broadcasting and used for television.

The field strength of the wanted signal should be sufficient to be protected against interference.

3. Receiving system configuration

3.1 Individual reception

The receiving system consists of the antenna, the connecting cable and the television receiver.

3.2 Collective reception

The receiving system consists of the antenna (or a group of antennas), the head-end amplifiers, converters, filters, etc.), the distribution network and the television receivers.

4. Antenna characteristics

4.1	In unbalanced systems, the nominal impedance should be	75 Ω
	In balanced systems, the nominal impedance should be	300 Ω

4.2 Reflection coefficient:

television signals only:	< 0.33
television and data signals:	< 0.2*

- 4.3 Gain: should be expressed relative to that of a half-wave dipole for each of the channels to be received.
- 4.4 Gain variation within a channel: ± 0.5 dB*
- 4.5 Front-to-back ratio: > 18 dB
- 4.6 Protection against a linearly polarized wave whose polarization plane is perpendicular to that of the antenna (reception in the main lobe): > 20 dB
- 4.7 Directivity characteristics: see Recommendation 419.

5. Coaxial cable characteristics

- 5.1 Nominal impedance: 75Ω

6. Performance requirements of the receiving systems

6.1 Vision carrier levels

6.1.1 The vision carrier levels at system outlets (measured across a 75Ω termination or referred to 75Ω) for each channel should not exceed the following values:

	<i>Minimum</i>	<i>Maximum</i>
Band 8 (VHF) television	0.7 mV (−52 dBm)	14 mV (−26 dBm)
Band 9 (UHF) television	1.0 mV (−49 dBm)	14 mV (−26 dBm)

Where several adjacent channels are distributed, the maximum carrier levels at the RF input socket of the television receiver should be at a reduced level in order to avoid intermodulation in the television receiver itself [CCIR, 1982:86b].

6.1.2 The maximum carrier-level differences between distributed television channels at system outlets should not exceed 12 dB in band 8 (VHF) and not exceed 15 dB for a system covering both bands 8 (VHF) and 9 (UHF). The maximum level difference between adjacent channels should not exceed 3 dB.

6.2 Mutual isolation between system outlets

The isolation between two different outlets must be at least 22 dB for all the frequencies in the broadcasting bands. This value assumes that the frequency allocation and the intermediate frequency of the receivers have been planned to avoid interference.

Note 1. — This value is raised to 46 dB between an outlet for television signals in bands 8 and 9 and an outlet for frequency modulation sound broadcasting signals with two different users. The selection circuits required form an integral part of the installation.

Note 2. — The minimum isolation figure of 22 dB is under study; a higher value is a requirement in some countries.

6.3 Response variations with frequency within a television channel at any system outlet

6.3.1 Amplitude response

The variation of the amplitude response over any television channel should not be more than ± 2 dB relative to that at the vision carrier frequency, and the slope of the variation should not be more than 0.5 dB within any frequency range of 0.5 MHz.

6.3.2 Group-delay response

The group-delay variation within any television channel must not be more than 50 ns*.
This value is relaxed to 100 ns* if the television channels do not carry any data signal.

6.4 Reflection coefficient

In order to meet the above requirements for amplitude and delay response, the reflection coefficient of the passive and active equipment used in the receiving system should not exceed the following values:

	Television only	Television and data *
Passive equipment	≤ 0.33	≤ 0.2
Couplers and filters	≤ 0.33	≤ 0.2
Active equipment	≤ 0.33	≤ 0.2

6.5 Oscillators and other equipment used in the system

The levels of the energy radiated and the energy re-injected into the distribution system should be less than the values which may be specified by the CISPR.

The total frequency drift of the oscillators should not exceed the value of ± 50 kHz* (relaxed to ± 75 kHz if the television channels do not carry data signals) for variations in the supply voltage of $\pm 10\%$ and a temperature range of -10°C to $+55^\circ\text{C}$. This value applies to both band 8 (VHF) and band 9 (UHF).

6.6 Carrier-to-noise ratio

The carrier-to-noise ratio at any point from the head-end input to the system outlets shall not be less than the values given in Table I, where the noise bandwidth is also indicated.

TABLE I

System	Minimum carrier-to-noise ratio (dB)	Noise bandwidth (MHz)
625-line system I	43	5.08
B, C, G and H	43	4.75
L and K1	43	5.58
D and K	43	5.75
525-line system M	42	3.33

6.7 Intermodulation

6.7.1 Channel amplifiers or converters

When measured by the method described in IEC Publication No. 728, the ratio of the reference level relative to the interference signal shall not be less than 54 dB.

6.8 Interference

The installation should cause neither interference at fixed frequencies nor cross-modulation products (between signals from different transmitters) which, assuming they are referred to the receiver input, would interfere with reception from the wanted transmitters, in the service area as defined by the protected field.

6.9 Reception of data signals in the collective antenna systems

The introduction of teletext and other data services (see Report 802) requires that the technical characteristics of the receiving installations ensure satisfactory reception quality for both television and data services.

Theoretical and experimental investigations carried out in Italy [Cominetti and Stroppiana, 1984] have shown that, because of the different nature of the two signals (analogue and digital), the potential audience can be different for the two services particularly in the case of reception through collective antenna systems. Teletext reception in such installations poses special problems mainly caused by the many potential sources of impairments, such as channel converters, amplifiers, filters, coaxial cables and other passive components used to distribute the signals to the user's outlet.

Further investigations are necessary to ensure comparable performance regarding reception of television and data services.

REFERENCES

COMINETTI, M. and STROPPIANA, M. [1984] Ricezione Teletext negli impianti centralizzati d'antenna. *Elettronica e Telecomunicazioni*, 2.

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[1982-86]: a. 11/349 (Italy); b. 11/359 (Italy).

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REPORT 805-1

SUBJECTIVE QUALITY TARGETS OF OVERALL TELEVISION SYSTEMS *

Characteristics of reference receiving installations

(Question 14/11, Study Programme 14B/11)

(1978-1982)

1. Introduction

Many characteristics of television receivers may be defined together with methods of measurement and practical values. Question 14/11 and Study Programme 14B/11 call for the study of the principal characteristics of television receiving installations which may be required in meeting the necessary subjective quality targets for an overall television system.

The quality of the picture displayed and of the sound heard depends on characteristics of the complete television system from the studio to the receiver screen or loud-speaker, and in this context the main parameters of a television receiver, other than those primarily involved in frequency planning, may be of interest. The CCIR has collected a great deal of data which is embodied in various Recommendations and Reports, but much of this has been rendered obsolete by the development of receiver design techniques.

Table I of § 4 of this Report lists technical parameters which contribute to the determination of overall picture quality. Table II of § 5 gives typical measured values by way of example.

* Information on specifications for low-cost monochrome television receivers is to be found in Report 483.
Information on the characteristics of television receivers and receiving antennas is to be found in Report 625.

The definition of these characteristics, the measuring method applied and the presentation of the results in Table I should be taken, where available, from IEC Publication 107-1 and 107-2, and are provided purely for information purposes, since this latter document is provisional and still incomplete. These Tables will need to be amended accordingly when the revised version is published.

It is important that CCIR definitions of receiver performance characteristics should not contradict those of the IEC. Where this occurs, action should be taken by both organizations to resolve the difference.

Attention is drawn to the importance of effective participation by the CCIR representatives in IEC work, especially in the field of definitions and methods of measurement of television receiver characteristics (Sub-Committee 12A). This information is important for planning and for achieving satisfactory quality targets in an overall television system, from picture source to receiver.

Table I relates only to monochrome receivers. The characteristics of colour receivers will be added at a later stage.

2. Categories of receivers

2.1 Overall picture quality should take into consideration the category of receivers which will be used in the broadcasting system envisaged.

It is proposed that data recorded, in future, for this report should relate only to the mean values of characteristics for receivers that are typical of good, current engineering practice in the country in question. This is to avoid undue influence being exerted on future planning standards by receiver designs at the extreme upper and lower ends of the performance range.

A reference receiver could be defined taking into account the mean values and possible appropriate amendments to them.

2.2 Receivers for direct satellite broadcasts

No practical data are yet available. However, references are given below in which the results of the many studies on the subject may be found in Report 473 [CCIR, 1974-78a and b].

3. Receiving antennas

The numerical values of antennas characteristics contained in Recommendation 419 and Reports 122 and 482 relate to antennas *in situ*. Only data relating to the directivity, forward gain and cross-polarization protection of antennas tested under idealized conditions in a suitable site need be recorded.

The necessary definitions and measuring methods are contained in IEC Publications 597-1 and 597-2.

Additional information and data on antenna characteristics can be found in Report 625.

4. Characteristics contributing to overall reception quality

TABLE I

Item	Parameter	Reference IEC Publication 107-1			Remarks
		Definition	Measuring method	Presentation of result	
1	Passband (radio frequency and intermediate frequency): - video (MHz) - audio (kHz)	Clause 136	Clause 137 under consideration	Clause 138	For an attenuation of 0 dB rel. to vision carrier
2	Maximum luminance white (cd/m ²)	2.4.1 ⁽¹⁾	2.4.1.2 ⁽¹⁾	2.4.1.3 ⁽¹⁾	For a black level of 2 cd/m ² . The point at which the bars corresponding to... MHz are no longer visible
3	Picture resolution (lines)	2.6.1 ⁽¹⁾	2.6.2 ⁽¹⁾		
4	Interlace ratio (%)		Clause 99		
5	Maximum distortion of the picture outline (%)	Clause 78	Clause 79	Clause 80	Total distortion
6	Scanning non-linearity (%)	Clause 73	Clause 74	Clause 75	
7	Audio frequency response characteristic (Hz)	Clause 27 ⁽²⁾	Clause 28 ⁽²⁾	Clause 29 ⁽²⁾	Overall electrical characteristics
8	Maximum useful electric output power (W)	Clause 17 ⁽²⁾	Clause 18 ⁽²⁾	Clause 19 ⁽²⁾	
9	Transmodulation: - vision into sound (dB) - sound into vision (dB)	Clause 45 or 51 ⁽²⁾ Clause 151	Clause 46 or 52 ⁽²⁾ Clause 152	Clause 47 or 53 ⁽²⁾	
10	Maximum usable input signal (dBm)	Clause 132	Clause 133		The most unfavourable value for each broadcasting band

(1) These characteristics have not yet been taken into consideration by the IEC for inclusion in the new edition. It is proposed that the articles of IEC Publication 107 (1960) as indicated above, should be used as provisional references.
(2) Ref. IEC Publication 107-2.

5. Results

5.1 The numbered values listed in Table II are mean values taken from an extensive series of objective measurements. The results for Canada show the sample mean and include the sample standard deviation (σ).

TABLE II

		Country				
Item	Parameter	Italy	Canada ⁽¹²⁾			
1	Selectivity (dB) Video Broadcasting band I III IV/V 12 GHz- Sound Broadcasting band I III IV/V 12 GHz	(¹) -6(²) -26	VHF band: - 6 dB points High gain = 3.7 MHz ($\sigma = 0.3$) Low gain = 3.6 MHz ($\sigma = 0.4$)			
2	Maximum luminance white (cd/m ²)	(³) 100(⁴)	208 ($\sigma = 48$)			
3	Picture resolution (lines)	320(⁵)	241 ($\sigma = 28.3$)			
4	Interlace ratio (%)	40/60(⁶)	-			
5	Distorsion of the picture outline (%)	3(⁷)	H: 2.3 ($\sigma = 1.1$) V: 2.9 ($\sigma = 1.1$)			
6	Scanning non-linearity (%)	5 to 8(⁸)	H: 7.2 ($\sigma = 4.4$) V: 6.4 ($\sigma = 2.7$)			
7	Audio frequency response characteristic (Hz)	120 to 7000(⁹)	78 ($\sigma = 67$) to 5700 ($\sigma = 1800$)			
8	Maximum useful electric power (W)	1,2(¹⁰) 2	1.6 ($\sigma = 0.5$)			
9	Transmodulation: - vision into sound (dB) - sound into vision (dB)	(¹¹) -30 -40	-			
10	Maximum usable input signal (dBm)	-30	-			

H: horizontal V: vertical

⁽¹⁾ Measurements carried out in accordance with IEC Publication 107, Clause 4.2.⁽²⁾ Rejection values for 4 MHz.⁽³⁾ Measurements carried out in accordance with IEC Publication 107, Clause 2.4.1.⁽⁴⁾ For a black level of 3 cd/m² (for a picture tube without a grey filter).⁽⁵⁾ Measurements carried out in accordance with IEC Publication 107, Clause 2.6.⁽⁶⁾ Measurements carried out in accordance with IEC Publication 107, Clause 2.9.⁽⁷⁾ Measurements carried out in accordance with IEC Publication 107, Clause 2.3.3.⁽⁸⁾ Measurements carried out in accordance with IEC Publication 107, Clause 2.3.2 and for $\pm$ dB relative to 1000 Hz.⁽⁹⁾ Measurements carried out in accordance with IEC Publication 107, Clause 12.3.⁽¹⁰⁾ Measurements carried out in accordance with IEC Publication 107, Clause 13.2.5.The power value of 1.2 W corresponds to a tube whose diagonal is < 51 cm (20 in.) and the power value of 2 W corresponds to a tube whose diagonal is ≥ 51 cm (20 in.).⁽¹¹⁾ Measurements carried out in accordance with IEC Publication 107, Clauses 4.8.2.3 and 4.8.2.5.⁽¹²⁾ [Munak and Gourgon, 1979].*Note.* - In the future, measurements should be made in accordance with the revised version, i.e. IEC Publication 107-1. The new references in the footnotes will be as follows:⁽¹⁾ IEC Publication 107-1, Clause 137.⁽³⁾ IEC Publication 107 (1960), Clause 2.4.1 (provisional reference).⁽⁶⁾ IEC Publication 107-1, Clause 99.⁽⁷⁾ IEC Publication 107-1, Clause 77.⁽⁸⁾ IEC Publication 107-1, Clause 74.⁽⁹⁾ IEC Publication 107-2, Clause 27.⁽¹⁰⁾ IEC Publication 107-2, Clause 18.⁽¹¹⁾ IEC Publication 107-1, Clause 152.

Measurements on maximum usable input signal level shall be carried out in accordance with IEC Publication 107-1, Clauses 133 and 135.

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[1978-82]: 11/106 (Canada).

REPORT 122-3

**ADVANTAGES TO BE GAINED BY USING ORTHOGONAL WAVE
POLARIZATIONS IN THE PLANNING OF BROADCASTING SERVICES
IN BANDS 8 (VHF) AND 9 (UHF)**

Sound and television

(1956-1959-1970-1974-1982)

Investigations have been conducted in several countries to ascertain the advantages which can be obtained in sound and television broadcasting by using polarization discrimination in reception. The results of extensive studies made in Europe by the Federal Republic of Germany, France, Italy and the United Kingdom and also in the United States of America, have been made available in documents at Warsaw, 1956 and Geneva, 1958; and a reasonably definite answer may now be given to the question.

1. Band 8 (VHF)

In this band of frequencies, between 30 and 300 MHz, the median value of discrimination that can be achieved at domestic receiving sites by the use of orthogonal polarization may be as much as 18 dB, and under these conditions, the values exceeded at 90% and 10% of the receiving sites are about 10 dB and 25 dB respectively.

The values of discrimination are likely to be better in open country and worse in built-up areas or places where the receiving antenna is surrounded by obstacles. For domestic installations in densely populated districts, the median values of 18 dB will usually be realized only at roof level; and this value may be reduced to 13 dB or less at street level.

No significant changes in the polarization of waves in band 8 due to transmission through the troposphere have been observed over distances exceeding 200 km. Furthermore, there have been no reports of systematic changes in polarization effects with frequency in the metric band, neither with distance nor with type of terrain.

It must be emphasized, however, that to realize the discrimination ratios mentioned above, certain precautions are necessary at both the transmitting and receiving installations; cases have been reported in which, for a transmitter of horizontally polarized waves, some 7% of the radiated power was vertically polarized. It is clear that if the best discrimination is to be obtained for co-channel operation, the transmitters and antenna systems must be designed and installed so as to radiate as much as possible of the total power on the assigned polarization.

In the same way, to achieve the desired discrimination at the home receiving installation, the reception of the undesired orthogonally polarized waves on the antenna feeder and on the receiver itself must be reduced to the minimum practicable value.

It should, however, be noted that the above-mentioned advantage from the use of orthogonal polarizations can only be obtained when, in general, the polarization of the receiving antennas conforms to that of the wanted signal. In cases where the polarization of the receiving antennas is random, e.g. when in VHF-FM sound broadcasting, antennas for domestic and car reception have different polarization, no general advantage can be expected from making systematic use of orthogonal polarization and this may be detrimental to reception under these conditions.*

2. Band 9 (UHF)

Experiments have been conducted in the United Kingdom to determine the polarization discrimination in band 9 (UHF) of receiving antennas at typical urban and rural sites. The results of measurements showed that for orthogonally polarized signals arriving in the direction of main response of the antenna, the discrimination obtained is similar to that already described above for frequencies in band 8 (VHF), although the factor exceeded for 90% of receiving sites was only 8 dB (as compared with 10 dB for band 8 (VHF)). In the case of discrimination against orthogonally polarized signals arriving within the arc $180^\circ \pm 90^\circ$ relative to the direction of main response, measurements confirmed that at least 20 dB discrimination is achieved at 90% of receiving sites. As a result of these investigations, for television planning purposes in band 9 (UHF); the United Kingdom uses values of antenna discrimination for orthogonal transmissions which exceed the values for co-planar transmissions given in Recommendation 419, by 8 dB (total value: 8 dB) in the range of 0° to 20° relative to the direction of main response and by 4 dB (total value: 20 dB) in the range 60° to 180° . Linear interpolation is applied for the range 20° to 60° as in the existing curve for discrimination between co-planar transmissions.

As in band 8, care is necessary to ensure that the transmitter and receiver respectively do not emit or receive radiation of the undesired polarization. Apart from this, however, experience indicates that in band 9 (UHF), the use of horizontal polarization offers advantages, because of the greater directivity obtainable at the receiving antennas; this reduces the effect of reflected waves, particularly in town areas. The European Broadcasting Union, therefore, considers that frequency assignments in these bands should be based on the general use of horizontal polarization, though exceptions may be made in cases where orthogonal polarization is necessary to achieve the desired protection.

3. Conclusion

From the studies described above, it is clear that the use of orthogonal polarization for broadcasting stations operating in the same frequency channel is of material assistance in discriminating against the reception of undesired signals. Worth-while advantages are obtainable over the whole band of frequencies from 40 to 500 MHz and within the normal broadcasting service ranges. From the uniformity of the discrimination obtained over these frequencies, it is considered to be almost certain that the advantages will extend to the top of the broadcasting band in band 9 at nearly 1000 MHz.

However, in VHF-FM sound broadcasting, no advantage should be expected in cases where the polarizations of the receiving antennas are random and, hence, do not necessarily conform to that of the wanted transmission.*

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[1956]: Warsaw 267, 435 and 512.

[1958]: Geneva V/1, V/6, V/12, V/23 and V/27.

[1970-74]: United Kingdom, 11/267.

* This paragraph originated in Study Group 10.

REPORT 483-4*

SPECIFICATIONS FOR LOW-COST MONOCHROME TELEVISION RECEIVERS

(Question 13/11)

(1970-1974-1978-1982-1986)

This Report is a reply to Question 13/11. It presents values for the characteristics of low-cost television receivers suitable for home and community use. Values are based on information in [CCIR, 1966-69a, b, c, d and e; 1970-74; 1974-78].

1. General

1.1 *Types of receiver*

These specifications apply to two types of low-cost monochrome television receiver giving a satisfactory performance:

Type A: Receivers intended to give acceptable performance at the lowest possible cost.

Type B: Receivers intended to give good performance at a reasonable cost.

Generally speaking *Type A* receivers would be home receivers whereas *Type B* receivers would often be community receivers.

It should be noted that in establishing the performance specifications listed below due consideration was given to the situation prevailing in many developing countries where the normal utilities have not reached the required level. As a result of this, the requirements of certain parameters of a television receiver are severe and this adds to the cost.

1.2 *Power supply*

Where feasible, the use of a.c. mains operated receivers is recommended. In some countries, battery-operated receivers are at present either of lower performance, or of higher cost.

The administrations concerned should specify the television standard to be employed and the mains voltage and frequency, if the receivers are to be mains-operated. Particular emphasis should be given to any difference that may exist between the mains frequency and the field frequency of the television system, whether due to intentional differences or to temporary disturbances.

For battery-operated receivers, satisfactory performance should be secured with the battery voltage 15% below the nominal value.

1.3 *Controls*

The following controls, at least, should be available to the user:

- power switch,
- channel selector and tuning,
- contrast,
- brightness,
- sound volume.

1.4 *Planning of uses*

In planning the uses of these receivers, administrations should take account of their differing characteristics, the range of signal intensity expected, and the possibilities for special antennas, pre-amplifiers and low-loss radio-frequency feeders.

Although it is desirable that receivers should be capable of operation on all channels, receivers equipped to receive only the channels of the transmitters serving the given area and conforming to the frequency plan may be acceptable.

* This Report is also of interest to Study Group 1.

Administrations should further take account of the effect of the size of the screen and the cabinet on cost. The recommended values given are considered appropriate for the expected use of the receivers.

The receivers should be simple, robust and well protected against the environment. Those intended for use in areas of high temperature, high humidity or dust, should be treated so that they can be used under the climatic conditions specified by the administration concerned. Appropriate tests, consistent with the relevant IEC Publications, should be prepared by the administrations concerned. The IEC Publications quoted in the text are the most up-to-date issues at the time of preparation of the Report. Administrations are requested to review the numerical values given in the Report to determine if those values are valid for measurements performed in accordance with the quoted IEC Publications.

1.5 *Safety*

The receiver should comply with the safety recommendations of IEC Publication 65.

1.6 *Methods of measurement*

The methods of measurement and the tests to be employed should be those recommended in relevant paragraphs of IEC Publications 106 (1974), 107-1 and 107-2. National regulations or tests differing from these standards should be quoted.

1.7 *Receiver tuning*

For all the measurements which follow, the receiver should be accurately tuned as described in IEC Publication 107-1, clause 37 or, if this is not appropriate, in some other specified manner.

2. *General specifications*

	<i>Type A</i>	<i>Type B</i>
2.1 <i>Recommended size (diagonal) for the screen</i>	28 cm (11 in.) or larger	48 cm (19 in.) or larger
2.2 <i>Frequency bands</i>	VHF or VHF and UHF	VHF or VHF and UHF
	(see § 1.4 above, second sub-paragraph)	

2.3 *Power supply for a.c. operation*

Frequency:

– nominal value (Hz)	To be specified by the administration concerned	
– maximum permissible variation (Hz)	± 2	± 2

Note. – If this variation is greater, the cost of the receiver will inevitably be higher.

Voltage:

– nominal value (V)	To be specified by the administration concerned	
– maximum permissible variation without extra equipment (%)	± 10	± 10
– surges of ...* ms duration and changes in amplitude of (%)	± 30	± 30

Note. – It will be up to the user to provide a means of voltage control for variations greater than ± 10%.

* The value is under study

3. Input characteristics

	<i>Type A</i>	<i>Type B</i>
3.1 <i>Input impedance at the antenna terminals (Ω)</i>	75 or 300	75 or 300
3.2 <i>Toleration of surge discharges at the input circuit</i> <i>(IEC Publication 315-1, clauses 25 and 26)</i> Energy of each discharge (μJ)	...	...
3.3 <i>Maximum noise figure (dB) (least favourable channel)</i>		
Band 8 — VHF	10	8
Band 9 — UHF	16	12
3.4 <i>Noise-limited sensitivity at a signal-to-noise ratio of 30 dB and standard output (IEC Publication 107-1, clauses 109 and 110) (dBm)</i>		
Band 8 — VHF	−50	−60
Band 9 — UHF	−40	−55
3.5 <i>Characteristic of the automatic gain control</i> <i>(IEC Publication 107-1, clauses 117, 118 and 119)</i> (−20 to −50 dBm) (dB)	8	6
3.6 <i>Maximum input level</i> <i>(IEC Publication 107-1, clauses 132 and 133)</i>		

4. Output characteristics

4.1 <i>Minimum audio-frequency response characteristic within 6 dB (IEC Publication 107-2, clauses 26, 27 and 28) (Hz)</i>	150 to 5000	150 to 5000
4.2 <i>Maximum useful electric output power (IEC Publication 107-2, clauses 17, 18 and 19) (W)</i>	0.5	2
4.3 <i>Minimum picture resolution* (IEC Publication 107 (1960), sub-clause 2.6)** (lines per picture height)</i>		
— 6 MHz channel systems (4.5 MHz inter-carrier frequency)	225	280
— 7 or 8 MHz channel systems (5.5, 6 or 6.5 MHz inter-carrier frequency)	270	320
4.4 <i>Minimum brightness at white level for a black level of 3 cd/m² (IEC Publication 107, ** 1960, sub-clause 2.4.1)</i>		
— 50 fields/s system (cd/m ²)	70	120
— 60 fields/s system (cd/m ²)	70	150
4.5 <i>Minimum interlace ratio</i> <i>(IEC Publication 107-1, clause 99)</i>	30/70	30/70
4.6 <i>Maximum picture motion expressed as a percentage of picture height for a difference of 1 Hz between the mains frequency and the field frequency (IEC Publication 107-1, clauses 70, 71 and 72) (%)</i>	0.8	0.4

* Alternatively, administrations may wish to specify their requirements on resolution in terms of an electrical bandwidth measurement (e.g. according to IEC Publication 107-1, clauses 163, 164 and 165) in which case the requirement must be negotiated with manufacturer.

** Since this point does not yet appear in the available parts of revised IEC Publication 107, reference to the 1960 edition must provisionally be retained.

	Type A	Type B
4.7 <i>Maximum relative non-linearity of scan over a complete field (IEC Publication 107-1, clauses 73, 74 and 75) (%)</i>	10	10
4.8 <i>Maximum distortion of the picture outline (IEC Publication 107-1, clauses 76 and 77) (%)</i>	10	6
5. Interference		
5.1 <i>Intermediate frequency</i>		
The picture and sound intermediate frequencies used in the receivers should be in accordance with those chosen for the establishment of the given frequency plan. * For standard K1, see, for instance, Doc. 44 of the African Broadcasting Conference, Geneva, 1963.		
5.2 <i>Minimum rejection of the upper adjacent picture carrier (IEC Publication 107-1, clauses 136, 137 and 138) (dB)</i>	26	32
5.3 <i>Minimum rejection of the lower adjacent sound carrier (IEC Publication 107-1, clauses 136, 137 and 138) (dB)</i>	30	35
5.4 <i>Minimum image rejection (IEC Publication 107-1, clauses 146 and 147) (dB)</i>		
Band 8 — VHF	40	40
Band 9 — UHF	20	25
5.5 <i>Minimum intermediate-frequency rejection (IEC Publication 107-1 clauses 144 and 145) (dB)</i>		
Band I — VHF	20	20
Band III — VHF	30	30
Bands IV, V — UHF		
5.6 <i>Transmodulation and intermodulation (IEC Publication 107-1, clauses 153 to 158) (dB)</i>		
Vision into sound	30	30
Sound into vision	40	40
5.7 <i>Minimum attenuation of the sound carrier relative to the vision carrier at the video detector (IEC Publication 107-1, clauses 136 to 138) (dB)</i>	30	34

Note 1. — This requirement is to avoid beats in the receiver between the sound carrier and a subsequent colour sub-carrier.

Note 2. — An attenuation of 20 dB will be sufficient for both types of receivers in areas where transmissions are made only in black and white.

5.8 *Radiation (IEC Publication 106)*

In accordance with Recommendation No. 24/2 of the CISPR

Note. — Unless otherwise specified by the administration concerned, no measurements will be made below 0.5 MHz (LF Broadcasting).

* For economic reasons the number of different intermediate frequencies should be kept to a minimum (see Report 184).

6. Stability

	<i>Type A</i>	<i>Type B</i>
6.1 <i>Maximum drift of the local oscillator between 2 min and 60 min after the picture appears (IEC Publication 107-1, clauses 49, 50 and 51) (kHz)</i>		
VHF	± 300	± 300
UHF	± 500	± 500
6.2 <i>Drift of the local oscillator due to a change of +5 to -10% in the supply voltage (IEC Publication 107-1, clauses 52 and 53) (kHz)</i>		
VHF	± 200	± 200
UHF	± 300	± 300
6.3 <i>Minimum range of lock-in (IEC Publication 107-1 clause 93) (%)</i>		
Vertical	± 1	± 1
Horizontal		
6.4 <i>Minimum range of hold (IEC Publication 107-1, clause 93) (%)</i>		
Vertical	± 2	± 2
Horizontal		

7. Reliability

The precise specification of reliability for a complete equipment is a subject under general study at the present time but manufacturers of receivers of the type considered in this Report should utilize as far as it is possible components already reliability tested under appropriate conditions. Since it is expected that these receivers will be closely based on ones already in quantity production, data on the reliability performance of such receivers should be available under normal operating conditions.

The following figures are only provisional objectives suggested for receiver manufacturers and should on no account be considered as part of any contract.

	<i>Type A</i>	<i>Type B</i>
Desirable minimum mean operating time between failures requiring servicing, averaged over a production run (hours)	1000	1000

ANNEX I**SPECIFICATIONS FOR LOW-COST TELEVISION RECEIVERS**

This Annex is attached for information.

1. Television receivers manufactured in the U.S.S.R. [CCIR, 1978-82, 1982-86] are classified into two categories: fixed and portable.
2. The classification is based on the differences in the basic technical characteristics which to a large extent determine picture and sound quality as well as the cost of the receivers.
3. Low-cost receivers in both categories may possess the following characteristics (standard D, K) as shown in Table I.

TABLE 1

Characteristics	Typical values of characteristics (see Note 1)	
	Portable	Fixed
1	2	3
1. Size (diagonal) of screen (cm)	not more than 45	not less than 50
2. Frequency bands (see Note 2)	I, II, III, IV, V	I, II, III, IV, V
3. Noise-limited sensitivity of picture channel (dBm)	VHF -69 UHF -66	VHF -69 UHF -66
4. Synchronization-limited sensitivity (dBm)	VHF -74 UHF -70	VHF -74 UHF -70
5. Efficiency of the automatic gain control when the input signal is changed (from -15 to -62.5 dBm) - maximum change of the output luminance signal (dB)	3	2
6. Minimum picture resolution (lines): - horizontally	400 (see Note 3)	450
- vertically	400	500
7. Maximum non-linearity of picture over a complete field (%): - horizontally	± 10	± 8
- vertically	± 10 (see Note 3)	± 8
8. Maximum geometrical distortions (%)	3 (see Note 3)	2
9. Noise-limited sensitivity of the sound channel (dBm)	VHF -74 UHF -68	VHF -74 UHF -68
10. Maximum output power of a sound channel (W), not less than For television sets with a 40 and 51 cm screen	(See Notes 2, 3)	4 2
11. Minimum reproducible frequency range relative to reference level (Hz)	100-10 000 (see Note 3)	80-12 000
12. Maximum residual heterodyne frequency drift in self-tuning (kHz)	± 100 (see Note 3)	± 100
13. Minimum selectivity (dB): - band -1.5 MHz and less	28	38
- point -1.5 MHz	30	40
- point +8 MHz	30	45
- band +8 MHz and above	reduced by 6 dB/MHz	reduced by 6 dB/MHz
14. Drift of local oscillator frequency due to changes of supply voltage of +5 to -10% (kHz) in bands I-III	± 300	± 200
15. Maximum admissible input signal, not less than (dBm)	-10	-10
16. Minimum value of maximum brightness (cd/m ²)	140 (see Note 3)	150
17. Intermediate frequency (MHz) of: - picture signals	38	38
- sound signals	31.5	31.5

TABLE 1 (continued)

Characteristics	Typical values of characteristics (see Note 1)	
	Portable	Fixed
1	2	3
18. Maximum permissible background distortion due to unsynchronized mains		
– geometrical (%)	0.7	0.5
– brightness (dB)	40 (see Note 3)	40
19. Maximum variation of raster size (%)		
– due to heating	5	5
– due to changes of supply voltage of +5% to –10%	6	6
20. Maximum relative unevenness of the flat part of the square pulses (%) (see Note 4)		
– line frequencies (2T pulse-bar)	7	7
– field frequencies	7	7
21. Maximum luminance-chrominance delay inequality (ns) (see Note 4)	± 150	± 150
22. Maximum non-linear distortion of the chrominance signal (%) (see Note 4)	10	10
23. Maximum permissible level of video/audio interference (dB)	– 30	– 36

Note 1. – The parameters were measured in accordance with IEC Publications 107-1 and 107-2.

Note 2. – To be determined by user requirements.

Note 3. – For television sets with screens of less than 40 cm, the values will be fixed for the specific model.

Note 4. – Standards established for colour television.

REFERENCES

CCIR Documents

[1966-69]: a. XI/53 (Italy); b. XI/132 (United Kingdom); c. XI/164 (France); d. XI/185 (Italy); e. XI/192 (India).

[1970-74]: 11/120 (Netherlands).

[1974-78]: 11/148 (USSR).

[1978-82]: 11/125 (USSR).

[1982-86]: 11/123 and 11/367 (USSR)

REPORT 1085

PLANNING METHODS FOR TERRESTRIAL TELEVISION IN VHF/UHF BANDS

(Question 43/11)

(1986)

1. General

Broadcasting-transmitter networks should be planned in such a way that the required coverage of the area is provided using the minimum number of frequencies. The coverage area of each transmitter depends upon a number of technical factors, for example: transmitter power, minimum usable field-strength, radio-frequency protection ratio, the distance between transmitters sharing the same or adjacent channels, channel spacing, bandwidth of emission and factors influencing wave propagation. It may also depend on the channel distribution scheme.

When a large number of channels is to be planned or replanned for a particular AM or FM sound or television service, it has been found that utilizing the spectrum efficiently can prove difficult when only empirical methods are employed. For this reason, a theory of uniform transmitter networks was developed during the late 1950s and early 1960s [Eden and Kaltbeitzler, 1950; Eden *et al.*, 1960a, b; Fastert, 1960].

This method can be applied with success when some uniformity of standards exists for the services to be planned. Furthermore, the frequency band to be planned should be constrained as little as possible, i.e. there should ideally be complete freedom in assigning any frequency to any transmitter.

This theory is not only useful in designing new transmitter networks or remodelling existing ones, but also provides a powerful tool for determining optimal technical parameters such as channel spacing, transmitter characteristics, etc., and identifying the best attainable coverage.

Some countries may prefer to have a complete area coverage with a small number of programmes and others to sacrifice total area coverage in favour of providing more programmes in the more highly populated areas. In these cases, uniform network theory can be used to provide some reference values for attainable coverage. This can help when comparing the differing networks of individual countries which have chosen different methods for achieving their internal coverage. (For example, see [O'Leary, 1984] but care must be taken when using this method to include all relevant factors.)

The methods described below have already been used during the VHF/UHF European Broadcasting Conference (Stockholm, 1961), the African VHF/UHF Conference (Geneva, 1963) and the Regional Administrative Conference for FM Sound Broadcasting in the VHF band (CARR-1(2)), Geneva, 1984. They also helped in preliminary studies for the Geneva 1975 LF/MF Broadcasting Conference.

In this Report all data used as examples refer only to 625-line systems. The attention of administrations using other systems is drawn to this fact. Additional data concerning all systems are required.

2. Theoretical techniques for an international plan

2.1 General

Planning techniques resulting from the principle of uniform transmitter networks may be considered to comprise two basic elements:

- geometrically regular lattices,
- linear channel-distribution schemes.

Because of the many parameters and effects that may have an impact on frequency planning, e.g. varying propagation conditions, transmitter powers, transmitting-antenna heights and directivities, and terrain irregularities, the problem first requires simplification by assuming all transmitters to have equal powers, to have omnidirectional antennas all at the same height and with the same polarization, and to be situated on an infinitely extended area forming a geometrically regular lattice; also that propagation conditions do not exhibit variations throughout the area considered.

The development of such regular lattices is discussed in some detail in Annex I and leads to the following basic conclusions:

- full area coverage can most economically be provided by a lattice having equilateral elementary triangles i.e. having equally spaced geographically adjacent transmitters. Some overlap coverage is inevitable if complete area coverage is to be achieved. This can be expressed in terms of a "coverage factor". i.e. the sum of individual coverage/total area to be covered. The reciprocal of the coverage factor is often referred to as the coverage efficiency. This coverage factor has a minimum value of 1.21 for the optimum case of equilateral elementary triangles;
- because, for television broadcasting, the required co-channel protection ratio predominates over those for other frequency spacings by a large amount, optimum coverage is also likely to be achieved by maximizing the spacing of co-channel transmitters, i.e. by ensuring equilateral co-channel triangles;
- only particular numbers of channels allow both co-channel and elementary triangles to be equilateral. These are known as "rhombic numbers" and require that the number of channels, C , is such that:

$$C = a^2 + ab + b^2$$

where a and b are non-zero integers and without a common divisor.

For values of $C < 80$, these numbers are given by:

a	1	2	3	3	4	4	5	5	5	5	6	7	7	7	8
b	1	1	1	2	1	3	1	2	3	4	1	1	2	3	1
C	3	7	13	19	21	37	31	39	49	61	43	57	67	79	73

If, however, the total spectrum available for the network does not correspond to a number of channels coincident with a "rhombic number", a solution using the full available number of channels will still be possible but this will generally mean adopting a lattice formation in which either the co-channel or elementary triangles will not be equilateral. Such a solution may well permit substantially better coverage than that obtainable by restricting spectrum usage to that corresponding to the next lower rhombic number. Exceptionally, other channel numbers can also permit both equilateral elementary and co-channel triangles but in such cases linear channel distributions (see Annex I, § 3) cannot be used and hence interference levels are not necessarily uniform through the lattice. An example of such a network is given in Fig. 14.

If it is considered more important to have the elementary triangles equilateral, this may be achieved by a transformation (e.g. affine) which retains the longest side and rotates and extends the remaining sides to make them equal. An example of such a transformation for an 8-channel lattice is indicated in Fig. 3b.

Having once established lattices of the type described above, the problem is then to arrange the channels required in such a way as to minimize interference, remembering that every co-channel rhombus forms only part of a lattice extending over the whole planning area. The derivation of linear distribution schemes is discussed in some detail in Annex I.

Such a linear distribution has the property of having an identical interference situation on all channels, except for those on the highest and lowest frequencies (in cases where adjacent-channel interference is relevant).

The method can be extended to the case (an example of this is given in § 2.6) where it is desired to provide n programmes from each site using a total of nC channels in contiguous sub-bands each of C channels. In this case the channels assigned to each transmitter will be:

$$c, c + C, c + 2C, \text{ etc.,} \quad \text{where } 0 \leq c \leq C - 1$$

2.2 Implications of applying regular lattice planning principles in specific terrestrial television bands

In the following sections, the application of these principles to the specific numbers of channels available in each band will be considered, and at the same time these examples will be used to develop further aspects of these planning principles.

However, before considering the implications in individual bands, it is appropriate to consider which frequency relationships, additional to co-channel, need to be taken into account in television network planning (see Report 1086).

These are:

Frequency relationship	Channel difference	Comments
Adjacent channel	1	See below
Radiation from local oscillator	4 or 5	For channel spacings and receiver intermediate frequencies in general use
Image channel	8, 9 or 10	

For any lattice based on approximately equilateral elementary triangles, it follows that any transmitter will be spaced almost equidistantly from six other transmitters which, except in the case of lattices with a very small number of channels, will all be on different channels. It follows therefore that unless very distorted elementary triangles are adopted, no lattice having less than eight channels can avoid having adjacent-channel overlaps. Figure 2b) shows an example of a 7-channel lattice which avoids adjacent-channel overlaps at the cost of distorting the elementary triangles hence requiring a substantial increase in the coverage radius required of individual transmitters.

2.3 Band I

The full extent of this band is 21 MHz. Hence, the maximum number of channels available is three for any transmission system currently in use having 7 MHz bandwidth. Only one form of lattice is possible with three channels, which has the following characteristics:

- the three channels at the apexes of the elementary triangles;
- equilateral elementary and co-channel triangles (three is a rhombic number);
- co-channel spacing = $\sqrt{3}$ times the spacing between adjacent transmitters;
- for complete coverage, the maximum distance between any transmitter and the nearest point on the coverage area of the next co-channel transmitter (at centroid of elementary triangle) is twice the coverage radius.

The implication of a) is that adjacent-channel overlaps are inevitable.

The implication of d) is that complete area coverage is only possible (even if any allowance for multiple interference or interference from other than co-channel transmitters is neglected), when the field strength at the extremity of the coverage radius exceeds that at twice the distance by at least the value of the required co-channel protection ratio.

Figure 1 shows, taking a three-channel lattice as an example, how a systematic use of frequency offsets and use of both horizontal and vertical polarization can reduce co-channel interference. In the general case, polarization discrimination can also be used to reduce adjacent-channel interference. However, in the particular case of three channels (as shown in Fig. 1), this is of limited advantage since the middle channel (B) is equidistant from two of each adjacent channels and polarization discrimination could only be obtained against one of each pair. The same principles, can of course, be applied to any lattice. It may be seen that:

- the separation distance between co-channel transmitters without either polarization or offset protection is now three times that between adjacent channel transmitters;
- all of the nearest ring of six co-channel transmitters have offsets but only three also have the opposite polarization (this is because while three offset options are possible, there are only two polarizations).

In view of the high values of co-channel protection required for a television service, even taking account of the reduction in interference possible by frequency offset and polarization discrimination, full area coverage cannot be provided by a three-channel lattice, i.e. it is not possible to provide complete coverage over an extended area using Band I alone.

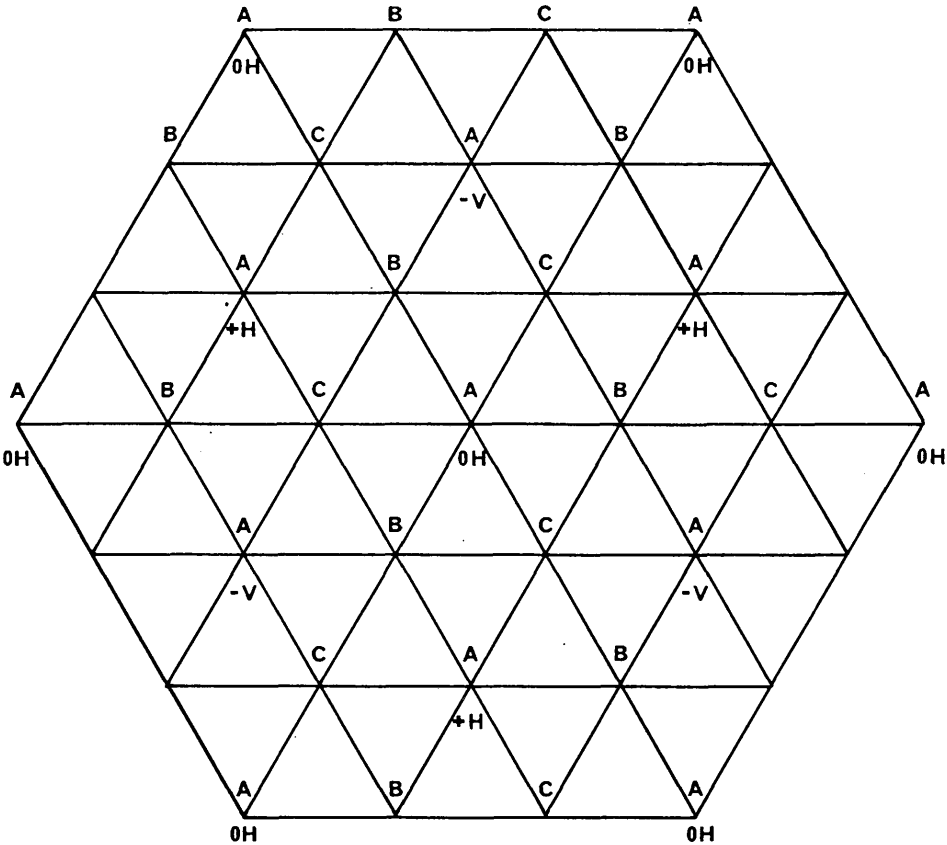


FIGURE 1 – 3-channel lattice demonstrating use of frequency offsets and polarization to reduce interference

A, B, C: channels
H, V: polarizations
0, +, -: offsets (1/3 line time-base)

Offsets and polarizations shown for channel A only

2.4 Band III

The total available spectrum is 56 MHz, permitting either 7 channels of 8 MHz channel width or *vice versa*. Whereas television systems using both 7 and 8 MHz nominal bandwidth are in use in ITU Region 1, it should be noted that in the UHF television bands a channelling of 8 MHz has been adopted throughout the Region. It would seem therefore that in any future planning this standard should also be adopted uniformly. Moreover, adoption of 8 MHz channelling would not preclude retention of television systems requiring 7 MHz nominal bandwidth if desired. However, for completeness, the following discussion examines both 7- and 8-channel lattices.

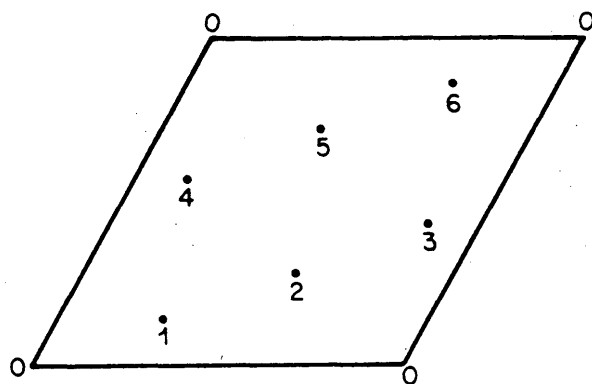
2.4.1 Seven-channel lattice

Superficially, the most appropriate lattice is that indicated in Fig. 2a) which has equilateral elementary and co-channel triangles (possible because 7 is a “rhombic number”).

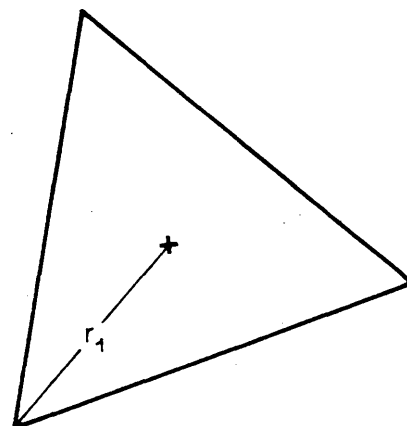
The lattice has the following characteristics:

- overlaps between adjacent channels;
- a co-channel distance of $\sqrt{7}$ times the distance between geographically adjacent transmitters. (The ratio of co-channel distance to the distance between transmitters is $\sqrt{\text{No. of channels}}$. This is an intrinsic characteristic of such a lattice.)

An alternative form of 7-channel lattice is that shown in Fig. 2b). This was the lattice adopted for Band III by the African VHF/UHF Broadcasting Conference (Geneva, 1963). The preference for this lattice was presumably based on the greater adjacent-channel distances, but, as indicated by Figs. 2c) and 2d), this was obtained at the cost of a considerable distortion to the elementary triangles and consequently a need for a 22% greater coverage radius by individual transmitters to achieve complete area coverage.

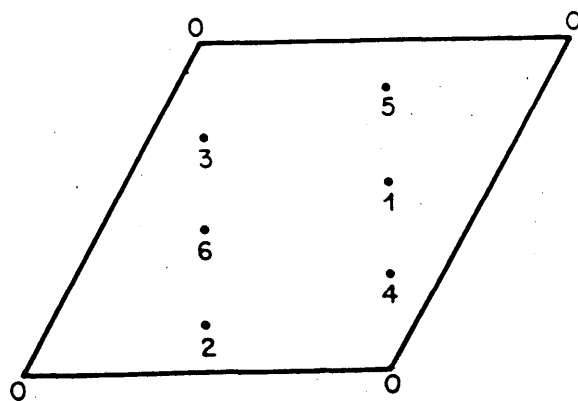


a) Equilateral elementary triangles

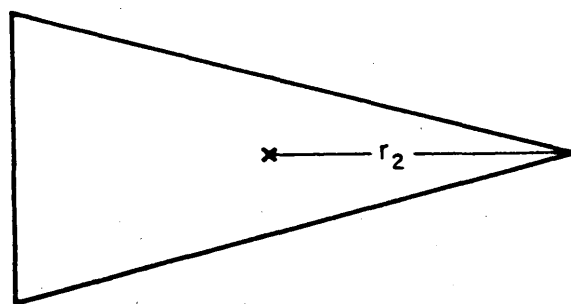


c) Elementary triangle from a)

r_1 : minimum radius for complete coverage



b) Avoiding adjacent channel overlaps



d) Elementary triangle from b)

r_2 : minimum radius for complete coverage

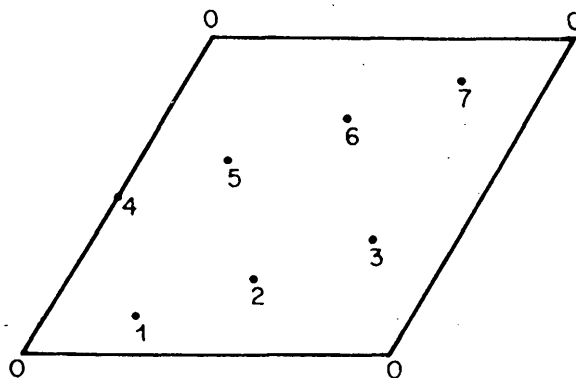
Ratio $r_2/r_1 = 1.22$

Note. — Figs. c) and d) are scaled to same co-channel distance.

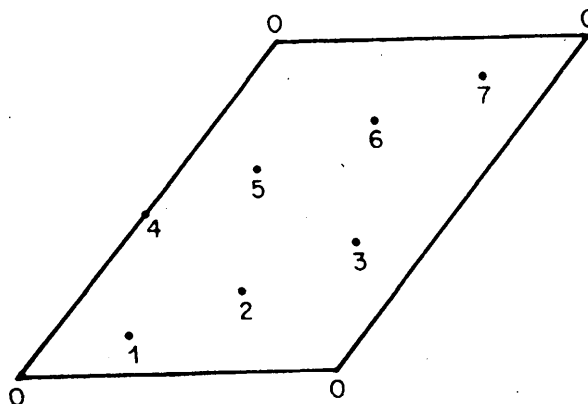
FIGURE 2 — Examples of 7-channel lattices

2.4.2 Eight-channel lattice

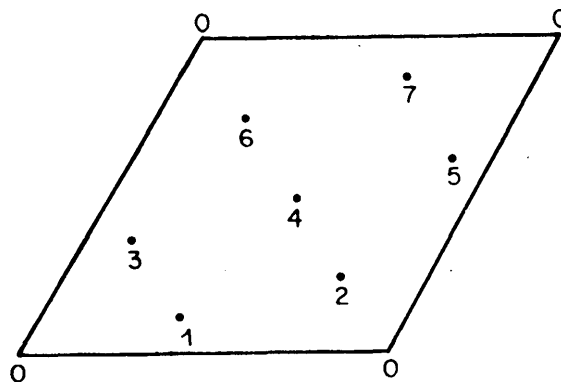
Not being a rhombic number, it is not possible to construct a linear channel distribution with both equilateral elementary and co-channel triangles. The lattice most closely approximating to this is that shown in Fig. 3a) (equilateral co-channel) and Fig. 3b) (normalized to give equilateral elementary triangles). Figure 3c) indicates an alternative lattice having more distorted elementary triangles for which the smallest distance between transmitters is not equal to that between adjacent channels. This does not, however, preclude some adjacent-channel overlap if full area coverage is to be achieved.



a) Nearest approximation to equilateral elementary triangles



b) Lattice a) transformation to give equilateral elementary triangles



c) Alternative to reduce importance of adjacent-channel interference

FIGURE 3 – Examples of 8-channel lattices

2.5 General comments on planning in VHF television bands

As previously mentioned, it is not possible to produce full coverage over an extended area with the three channels available in Band I. Such a single coverage can, however, be expected with the seven or eight channels available in Band III, but this band cannot generally provide two coverages. In any case, the extent of sporadic-E propagation in the lower Band I channels causes severe restrictions on the percentage of time for which a service may be achieved.

In principle, it would be possible to use both Bands I and III together in a coordinated manner to provide a high degree of area coverage with two programmes, i.e. using five channels for each programme. However, this implies adoption of a 7-MHz channelling system in at least one of the bands.

This also presents the following problems:

- while it is logical to use two of the three Band I channels together to ensure equal coverages, this may present engineering problems at the transmitter site;
- the third (presumably middle) Band I channel would in any event have to be used in conjunction with a Band III channel, thereby increasing antenna costs at both transmitting and receiving terminals and presenting problems in achieving equal coverages;
- the principles of linear lattice planning, as previously described, cannot be applied to such a composite network in view of the different propagation characteristics and non-continuous channelling.

Nevertheless, it is possible to envisage the use of a combined Band I and III two-programme network based on a 10-channel lattice such as indicated in Fig. 4 with the channels paired as shown. It will be appreciated that for such a pairing then, if channels 0-2 are in Band I, each Band I channel is paired with one in Band III. To keep two Band I channels together, the positions of channels 2 and 7 and of channels 3 and 9 could be transposed. As this particular lattice has 2-channel spacings on one side of each elementary triangle, it might be thought that pairings could be made along this axis. However, it is not possible to produce complete pairings of alternative numbers in a consecutive sequence unless the total is divisible by four.

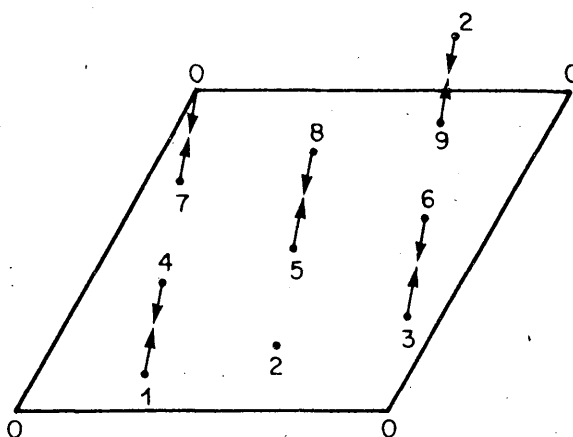


FIGURE 4 – 10-channel lattice indicating "pairings" to provide two programmes

2.6 The UHF band

Although the UHF band consists of Bands IV and V, it is convenient for planning purposes to consider these as a single entity. An 8 MHz channelling scheme was adopted in these bands by both the European and African Broadcasting Conferences (Stockholm, 1961 and Geneva, 1963, respectively). Channels were numbered consecutively from 21 (470-478 MHz) to 81 (950-958 MHz) the upper limit of Band IV being channel 34 and the lower limit of Band V being channel 35. With a total of 61 channels in the two bands (even though all may not be fully available for broadcasting) it is clear that multiple coverages can be provided.

The concept of subdividing the total band into sub-bands allocated to individual coverages/programmes, as was done in the African area of the Regional Administrative Conference for FM Sound Broadcasting in the VHF band (CARR-1(2)), Geneva, 1984, presents problems in the UHF television band because it would imply a wide range of spectrum usage in each coverage area. This in turn produces engineering difficulties due to the large bandwidth required of both transmitting and receiving antennas.

Because different countries in the overall planning area may have differing requirements, it may be more convenient to base planning on the use of a single 61-channel lattice designed so as to enable frequencies to be "grouped" together in different ways. This method was adopted by both the European (1961) and African (1963) Broadcasting Conferences.

The lattice used at the European Broadcasting Conference is represented in Fig. 5 and that for the African Broadcasting Conference in Fig. 6. Both have as a common feature, frequency separations of three channels between adjacent transmitters in one direction through the lattice. This permits easy "grouping" for three programmes using channels n , $n + 3$, $n + 6$.

Extension to four programmes by adding $(n + 9)$ would not be appropriate, firstly because this represents a large spread in one dimension of the lattice, and secondly because of the risk of image channel interference between channels n and $n + 9$. However, the lattice adopted at the 1961 Stockholm Conference also has 10 channel spacings between adjacent transmitters in another direction through the lattice, enabling groupings to be made either of n , $n + 3$, $n + 6$, $n + 10$ (see Note) or n , $n + 3$, $n + 6$, $n + 13$. Of these, the former is preferable in respect of total spread of spectrum, the latter preferable in respect of the location spread within the lattice configuration. Without further extension of the location spread within the lattice, it is possible to envisage further extensions of this "grouping" principle within the "European" lattice to provide:

- five programmes using: n , $n + 3$, $n + 7$, $n + 10$, $n + 13$;
- six programmes using: n , $n + 3$, $n + 6$, $n + 10$, $n + 13$, $n + 16$.

Note .— Or, as a symmetrical alternative, n , $n + 4$, $n + 7$, $n + 10$.

The lattice adopted at the 1963 African Conference appears less amenable to extension of "groupings" above three programmes without unduly large spectrum spread or the introduction of an image channel relationship, n and $n + 9$, at the same transmitter site.

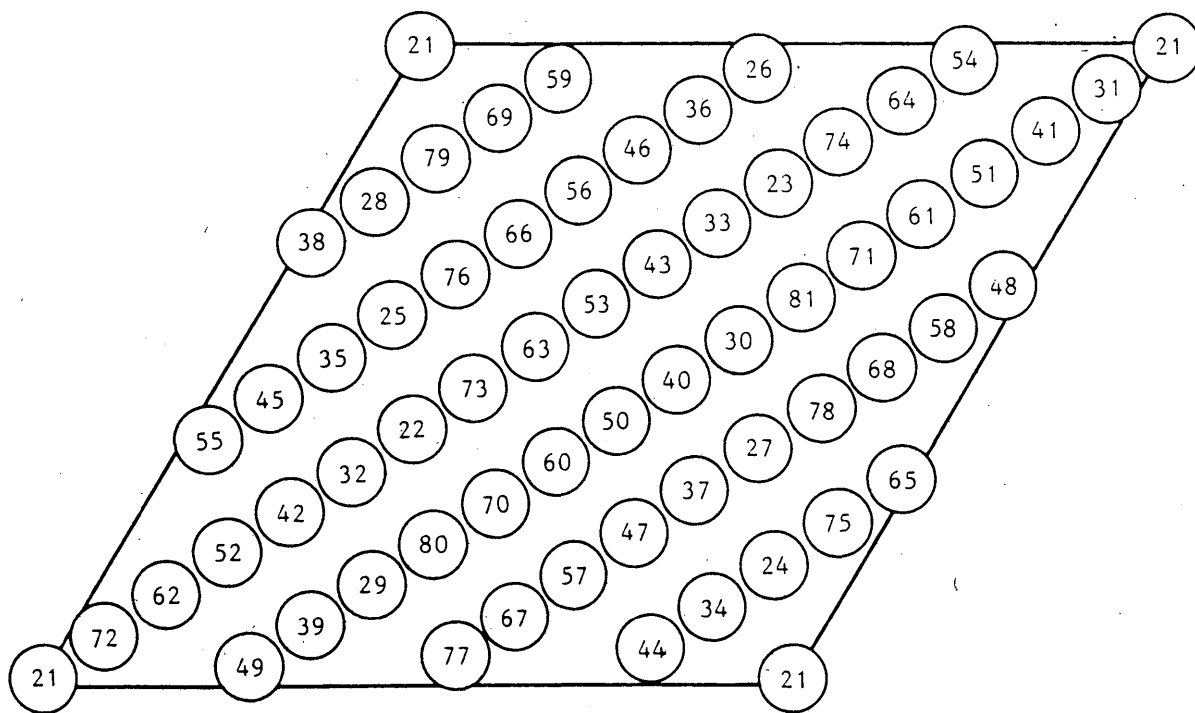


FIGURE 5 – *Theoretical apportionment of channels in Bands IV and V, adopted by the European Broadcasting Conference (Stockholm, 1961)*

3. Capacity of the TV bands

3.1 Capacity of the VHF bands

As previously discussed, Band I can, at most, provide three channels and this only if a 7 MHz channelling system is adopted. Unless used for purposes not requiring complete area coverage, this band can therefore only be considered as a supplement to Band III.

The combined VHF band can provide 9 channels, if a transmission system requiring 8 MHz channelling is used and either 10 or 11 channels for a system requiring only 7 MHz channelling. In the former case, it would be unrealistic to consider providing coverage of more than a single programme using VHF only, but with 10 channels there is an option of providing two programmes with fairly high, although probably not total, area coverage. In such a case, it would seem desirable to attempt to minimize interference as much as possible by systematic use of both horizontal and vertical polarization.

It must also be remembered that in a practical situation the simplifications introduced into the theory (see § 2.1) will not generally apply. One result is that more channels will be needed for a given degree of coverage than the theory suggests. Other problems are mentioned in § 2.5.

Any form of composite Band I/Band III coverage will entail additional costs for the broadcasting authority because of the need for separate transmitting antennas. The use of log-periodic receiving antennas may avoid this requirement for the viewer, provided that both services use the same polarization in individual areas, although such an antenna would be physically rather large.

A further option to be considered if two programmes are to be provided at VHF is to complete coverage by means of UHF relays. This may well be practicable in countries where it is not intended to provide more than three programmes within the UHF band.

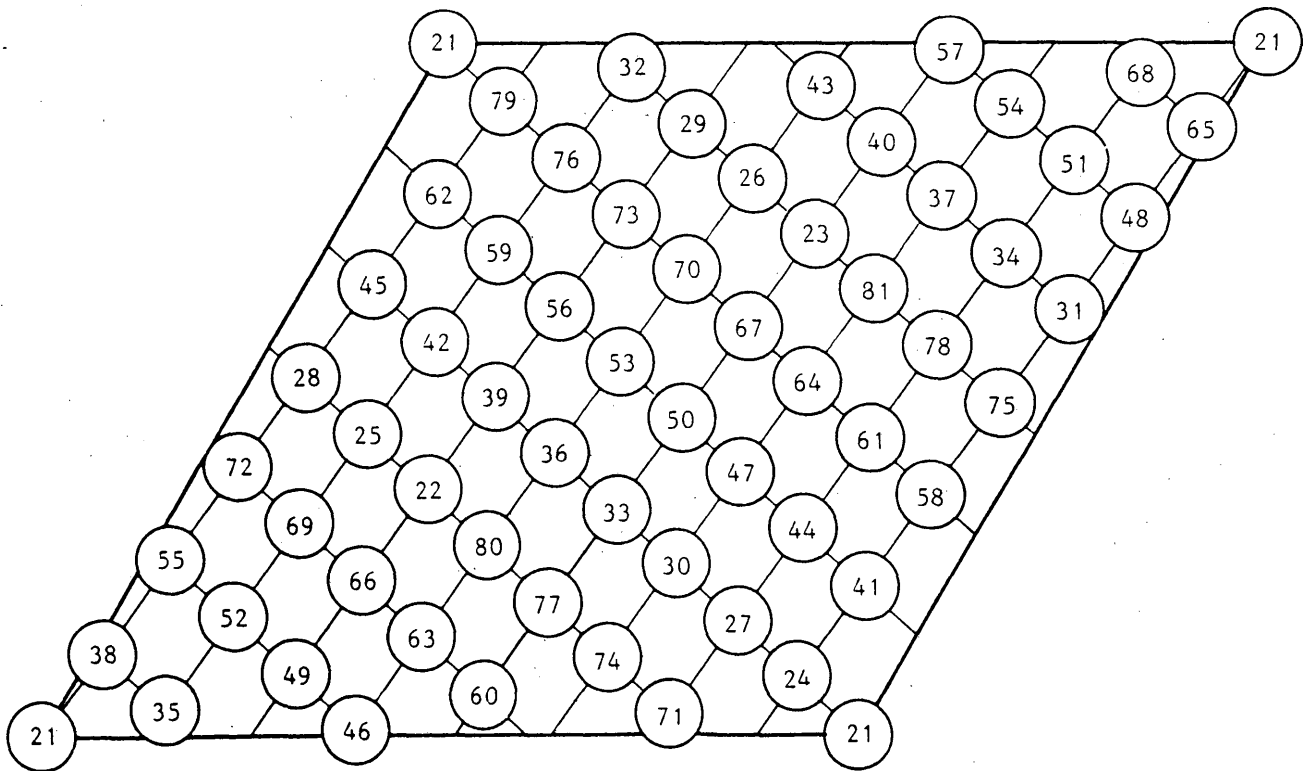


FIGURE 6 – Bands IV and V – Theoretical lattice adopted by the African Broadcasting Conference (Geneva, 1963)

3.2 Capacity of the UHF bands

Experience gained in Europe may be used to estimate the capacity of the UHF bands in a practical case. It has to be noted that a maximum of only 48 channels (21 to 68) is available and that there is a gap of up to 5 channels between Bands IV and V which is unavailable for broadcasting in parts of Europe. However, it has generally been found possible to achieve three programme coverage with protection against interference for 99% of the time. In some cases, for example in the United Kingdom, the time for which protection is achieved has been reduced to 95% and it has then been found possible to achieve four programme coverage.

In any case, it is necessary to consider whether area coverage or population coverage is being sought. If the population distribution is fairly uniform, there may be little difference between the two concepts. However, if much of the population is concentrated into urban areas, there can be a large difference. In this case, it may be possible to achieve coverage of the urban areas with larger number of programmes than would be the case if a more uniform coverage had been the aim.

4. Assessment of planned coverage

In either the VHF or UHF bands, it is desirable to relate predicted or measured field-strength values to the satisfaction of television viewers with the quality of their received vision and sound signals. If this is to be done, it is important that the distribution of measurement locations should be heavily influenced by the population density. The method described in Report 228 is not appropriate if the population density is not uniform. It is also necessary to consider the extent to which non-standard receiving installations may be used by viewers. The use of high-gain antennas or low-noise pre-amplifiers in areas of low population density permits an extension of the coverage achieved by a transmitter without requiring an increase in the field-strength values provided.

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ANNEX I

LATTICE PLANNING: BASIC PRINCIPLES FOR THE DEVELOPMENT OF GEOMETRICALLY REGULAR LATTICES HAVING LINEAR CHANNEL DISTRIBUTIONS

1. Basic assumptions

It is assumed that all transmitters:

- have the same powers, effective antenna heights and polarization and are all non-directional; and
- are situated on an infinitely extended area having uniform propagation characteristics.

2. Geometrically regular lattices

Transmitters are considered to be situated at the points of intersection of two sets of parallels, each equidistant and covering the whole area. These two sets of parallels subdivide the area into parallelograms each corresponding to one intersection point, i.e. to one transmitter site. Hence complete coverage would be obtained if each transmitter uniquely provided coverage of an area equal in size (although almost certainly not in shape) to the parallelogram.

For convenience, a third set of parallels may be considered to be drawn through the intersection points, thereby dividing each parallelogram into two equal triangles. Assuming non-directional transmitting antennas and hence circular coverage areas (in the absence of interference or with uniform interference) complete area coverage requires the coverage range r_c of each transmitter to be equal to the largest of the distances from corners to centroid of the elementary triangle (see Fig. 7). Some coverage overlap is inevitable but for efficient coverage this should be minimized.

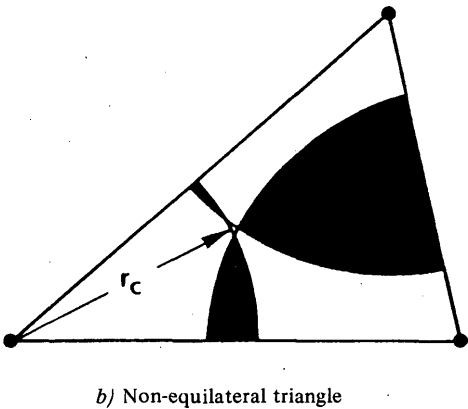
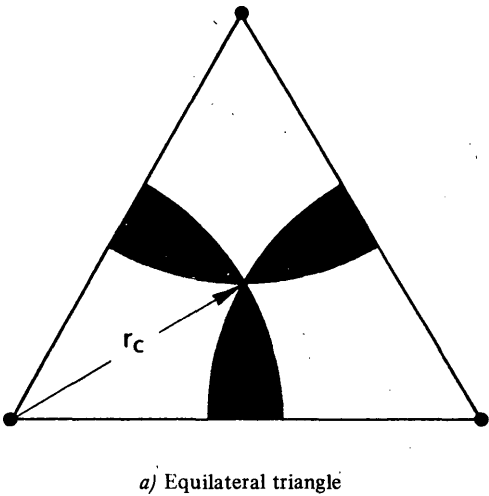


FIGURE 7 – Examples of elementary lattice triangles showing necessary overlaps to achieve complete coverage

Such minimum overlap results if the triangles are equilateral although the increase in overlap will be slight for small deviations from the equilateral condition. In this optimal condition, the parallelograms become rhombi, and the distance from each corner to the centroid of the triangle = $r/\sqrt{3}$. For this condition, the coverage area of each transmitter (Sc) is given by:

$$Sc = \pi \left(\frac{r}{\sqrt{3}} \right)^2 = \frac{\pi r^2}{3}$$

and the area of each parallelogram $S = \frac{\sqrt{3} r^2}{2}$

The quotient Sc/S is known as the coverage factor (or alternatively S/Sc as the coverage efficiency). The highest value of Sc/S is that obtained with equilateral triangles and is equal to $2\pi/3\sqrt{3} = 1.21$. Despite giving a lower coverage efficiency, the use of a lattice with non-equilateral triangles may have advantages in some circumstances. This will be discussed when channel distribution is considered.

High co-channel protection ratios, of the order of 30-45 dB even for non-continuous interference, are required in television broadcasting. Consequently, co-channel coverage areas must not overlap but also be well separated. From the above explanations, it is clear that if the co-channel transmitters form an equilateral triangular lattice with distances, D , between neighbouring co-channel transmitters, the maximum coverage factor, c , will result:

$$c = 2\pi r_c^2 / \sqrt{3} D^2$$

Full area coverage will require the use of a sufficiently large number of channels, C . Identical co-channel triangular lattices for these C channels should then be superimposed in such a way that the resulting lattice is entirely geometrically regular again. The number of possible solutions to this problem is rather restricted.

All possible solutions can be found if the co-channel parallelogram (or rhombus) is subdivided by two sets of $C - 1$ equidistant lines, parallel to either pair of sides of the parallelogram. In Figs. 8a), and 9a), this is shown for an equilateral co-channel lattice and $C = 7$, or $C = 12$, respectively. Geometrical regularity of the resulting lattice of elementary triangles is obtained when each of the $C - 1$ parallels of one set contains just one transmitter. The $C - 1$ parallels of the other set contain also just one transmitter, if C is a prime number (e.g. 7). If C is the product of two or more primes, p_i , (e.g. $12 = 2 \times 2 \times 3$) there are also solutions whereas in the other

set only parallels which are multiples of p_i (or of their products $\prod_{i=1}^{i < n} p_i$) carry p_i (or $\prod_{i=1}^{i < n} p_i$) transmitters (Figs. 9c) to 9e)). For $C = 7$, all possible solutions (except one which need not be considered as all transmitters would lie at one of the sides of the triangle) are shown in Figs. 8b) to 8f).

It is advantageous at this stage to introduce a system of non-rectangular coordinates (x , y) having its origin (0, 0) in the lower left-hand corner and the coordinates being directed towards the lower right-hand corner (x) or the upper left-hand corner (y), respectively. The subdividing parallels are at unity distance from one another.

In this system of coordinates, all the solutions of Figs. 8b) to 8f) have one transmitter at $y = 1$ but its position with respect to x varies between $x = 1$ and $x = 5$. The coordinates of all the other transmitters in each of the solutions are multiples of the respective first one, e.g. in Fig. 8b, the coordinates are (1, 1), (2, 2), (3, 3), (4, 4), (5, 5) and (6, 6). Coordinates exceeding C can be normalized by reducing the real multiple by C or by a multiple of C , as the original and the resulting values of the coordinate are congruent to each other modulo C .

It can be seen from Figs. 8b) to 8f) that some of the solutions are "symmetrical" ones (triangular symmetry) e.g. those of Figs. 8c) and 8e), or those of Figs. 8b), 8d) and 8f). This reduces the number of "genuine" solutions to two. Hence, it follows that, except for $C = 3$ with one genuine solution, all of them can be found if the coordinates of one of the transmitters are assumed to be $x \leq C/2$, and $y = 1$ (or *vice versa*), i.e., to the left of the dashed vertical lines in Figs. 8a) and 9a) and, more precisely, inside the parallelogram formed by dashed lines. Thus, in the example of Fig. 8 ($C = 7$) only the coordinates (1, 1) and (2, 1) need to be considered, whereas in the example of Fig. 9 ($C = 12$) only "genuine" solutions are presented.

The solutions of Figs. 8 and 9 are derived from an equilateral co-channel triangular lattice. In such a lattice the square of the distance, d , between coordinates (x_1, y_1) and (x_2, y_2) with $(x_2 - x_1) = a$ and $(y_2 - y_1) = b$ is $d^2 = a^2 + ab + b^2$. In Figs. 8 and 9 the co-channel rhombus has a sidelength, D , which corresponds, in either case, to C units, and an area $S = \sqrt{3} D^2/2 = \sqrt{3} C^2/2$. If this area is subdivided into C congruent elementary parallelograms, each area will be $S_c = \sqrt{3} C/2$ and, in the case where the elementary area is a rhombus, $S_c = \sqrt{3} d^2/2$, i.e. $d^2 = C$. Figures 8 and 9 show that the elementary triangles are, in general, not equilateral and have sidelengths d_1 , d_2 and d_3 . Only in exceptional cases (Figs. 8c) and 8e)) is the elementary triangle equilateral. Solutions where both the co-channel and the elementary triangles are equilateral exist only when C is a rhombic number, i.e. when there are two integers, a and b , which fulfil the equation $C = a^2 + ab + b^2$. This is a consequence of the fact that the coordinates of all transmitters can only be integers. Equality of the areas of equilateral and non-equilateral triangles exists if:

$$3d^4 = 4d_1^2 d_2^2 - (d_1^2 + d_2^2 - d_3^2)^2$$

Example: in Fig. 9d) the sidelengths are:

$$d_1 = \sqrt{13}, d_2 = 3, d_3 = 4$$

hence:

$$3d^4 = 4 \times 13 \times 9 - (13 + 9 - 16)^2$$

or

$$d^2 = \sqrt{13 \times 12 - 12} = 12 = C$$

Values of rhombic numbers for $C < 80$, together with originating integers a and b are given in § 2.1 of the main text. This also lists some of the basic conclusions derivable from the above considerations of the present Annex.

Some further conclusions are also possible:

- if transmitters situated at the corners of the co-channel rhombus suffer interference from other transmitters situated elsewhere on the area of that rhombus and using different channels, e.g. adjacent or image channels, then the distance of such transmitters from the corners should be maximized, i.e. they should be situated as closely as possible to the triangles centroid. Such interference will, nevertheless, lead to a reduction in coverage and, to compensate for this loss, an increase in the required number of channels will be necessary;
- the effect of interference depends mainly on the distance between the transmitters involved and the protection ratio required. Because of the smaller distance between the centroid and the corners of the co-channel triangles, it may happen that co-channel interference is no longer predominant. This does not apply to most television systems. For information, it may be noted that it applies particularly in the case of adjacent-channel interference at 100 kHz spacing in FM sound broadcasting. In such circumstances, equilateral elementary triangles may be preferable to equilateral co-channel triangles. However, regardless of what solution is chosen, the number of channels required for full area coverage will increase.

3. Linear channel distribution schemes

Having established the geometric nature of the lattice, it remains to find an arrangement for the C channels necessary for full coverage in such a way that interference is minimized. At this stage it seems appropriate to recall that every co-channel rhombus is part of an infinitely extended lattice consisting of C regularly superimposed co-channel lattices. Each result obtained by the lattice-planning method will therefore be characterized by a periodical repetition in all directions of the geometry and channel arrangement shown, by way of examples, on the area of a co-channel rhombus.

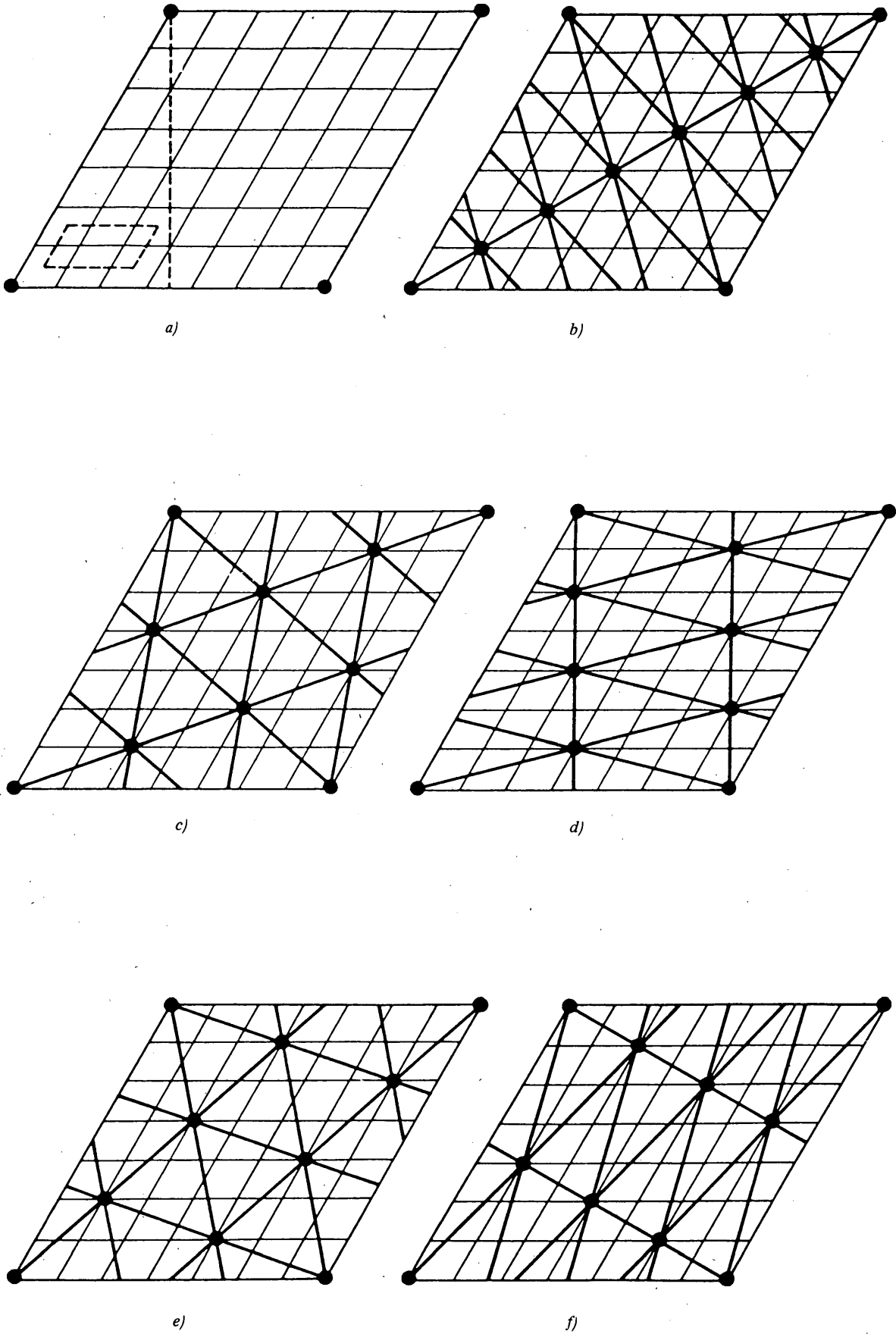


FIGURE 8 – Derivation of possible channel distribution for an equilateral co-channel lattice with $C = 7$

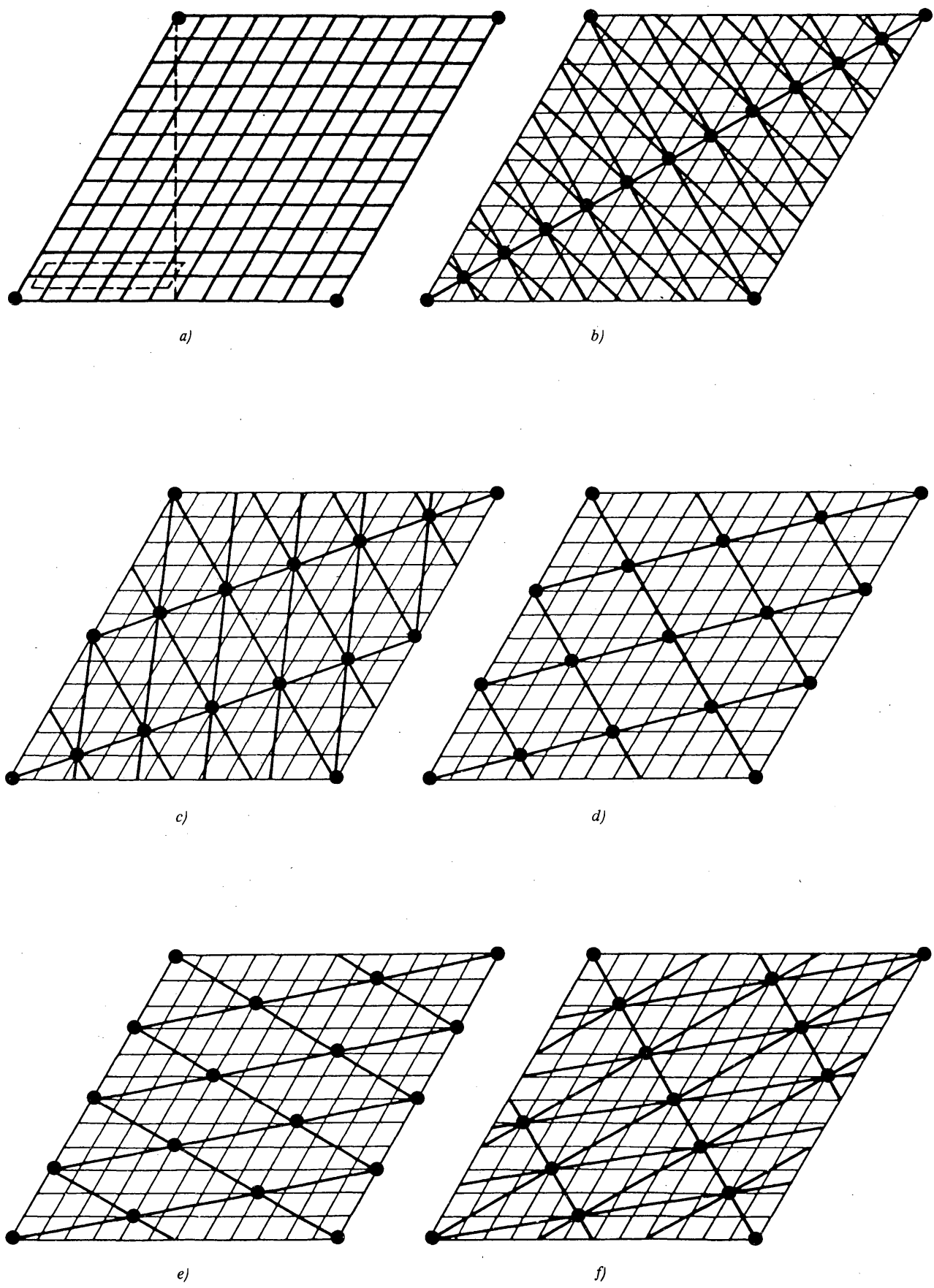


FIGURE 9 – Derivation of possible channel distribution for an equilateral co-channel lattice with $C = 12$

For the purpose of channel-arrangement considerations, it seems appropriate to use channel number 0 as a reference and to assign it in any one example to the corners of the co-channel rhombus. As a consequence, the numbers of the channels (1, 2, ... $C - 1$) in the arrangement will automatically be characteristic of the difference in channel numbers between the transmitter under study and those at the corners of the co-channel rhombus. However, when considering, as an example, adjacent-channel interference, it must be borne in mind that this type of interference does not only exist between channels 0 and 1, but also between channels 1 and 2, 2 and 3, etc. For reasons of simplicity and for reasons of the regularity of the resulting channel-distribution scheme, it seems appropriate to assign channel 1 to a transmitter at coordinate (x_1, y_1) which, according to earlier explanations, should be fairly close to the centroid, and channel 2 to the transmitter at coordinates $(2x_1, 2y_1)$, etc. This implies that channel numbers assigned to equidistant transmitters situated along a straight line will have the same difference. If this difference is greater than 1 channel, numbers greater than C may result which should be normalized by subtraction of C , or a multiple of C . The original and normalized channel numbers are, thus, congruent to each other modulo C . The resulting channel-distribution schemes are called linear distributions. Of course, other solutions exist, but non-linear distributions, although not necessarily useless, are less manageable, these are discussed briefly in § 5.

For the study of coverage efficiency, the consideration of linear channel-distribution schemes is advantageous since the interference situation in each of the C superimposed co-channel lattices is identical, except for some irregularities linked to the lower and upper of the C channels. This exception can, however, be disregarded if the C channels are assumed to form a cyclical system of channels where channels 0 and $C - 1$ are adjacent to each other. Such adjacency would, by the way, result if it were attempted to obtain coverage with n programmes by using a sequence of subsequent channels subdivided into n groups of C channels each. A cyclical system of channels is shown in Fig. 10.

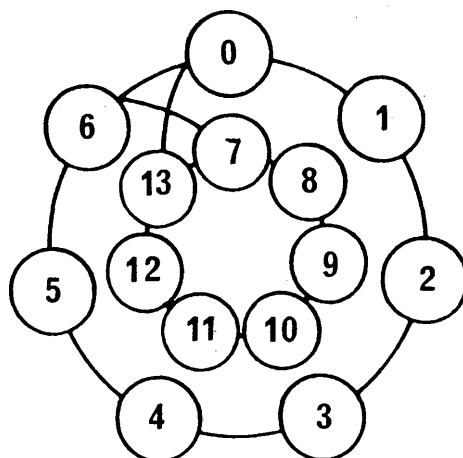
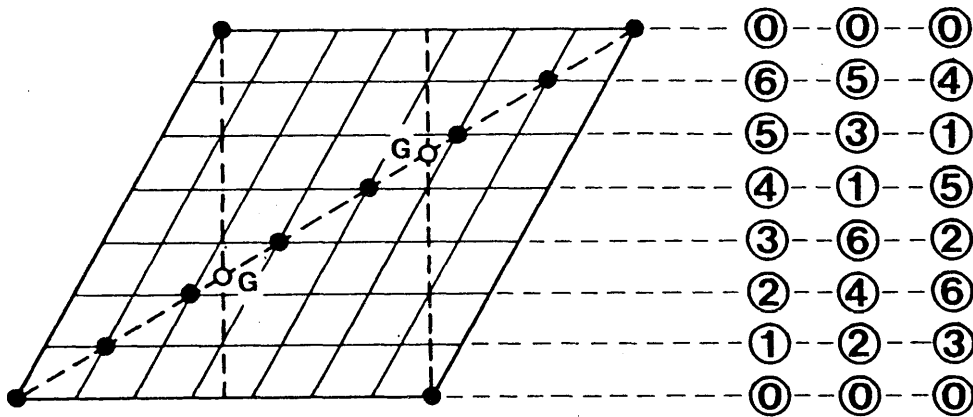


FIGURE 10 – Cyclical system of channel grouping ($n = 2$)

As the interference situation in all C channels as well as for each transmitter in any one of the co-channel lattices is identical, the coverage areas of all transmitters are also identical, both in size and shape. Verification of the coverage obtained by all transmitters in the C channels does, therefore, not require more than the determination of the coverage area of one single transmitter.

Linear channel distribution schemes also allow interference other than co-channel to be taken into account. For the television service, these include interference from the adjacent channels (± 1), from the image channel ($+8$ or ± 9 or $+10$) and from the local oscillator of a receiver tuned to channel ± 4 or -5 . These channels should ideally be located in the vicinity of the centroid of one of the two triangles forming a co-channel rhombus. Their distance from the corners should, in principle, be larger if the protection ratio is greater. In linear-channel distribution schemes, for reasons of symmetry, channels with equal difference from that of the reference transmitter but of opposite sign are at symmetrical positions relative to these two centroids.

Remembering that channels z and $C - z$ are symmetrical to each other, there can obviously exist no more than $C/2$ different channel distributions, i.e., taking the example of Fig. 8b), only three; these are shown in Fig. 11 and indicated in the three columns. The two centroids are marked by the symbol G . The third solution would provide the largest distance from the corners to the adjacent channels. In the example of Fig. 8c), the distance of each transmitter from the nearest corner is identical; hence, the possible three solutions are, in this case, equivalent, so that in reality there exists only one single "genuine" solution because of additional symmetry. This special condition occurs where C is a rhombic number and the lattice comprised of equilateral triangles.

FIGURE 11 – Examples for channel allocation in a regular equilateral lattice ($C = 7$)

The number of possible solutions increases, in principle, with the number of channels necessary for full coverage. However, the difference in channel numbers, Δ , between neighbouring transmitters and the numbers of channels available, C , should have no factor (other than 1) in common, since in such a case only channel numbers that are multiples of this common factor would be used, whereas the remaining channel numbers would be unused. It is obvious that in such circumstances no linear channel-distribution scheme could ever be obtained. Hence, the full number of $C/2$ solutions (the integral part of this fraction) will only exist if C is a prime number. If C is the product of two or more primes, the number of solutions is considerably lower. For $C = 12$, for example, only two solutions exist; they are shown in Fig. 12 for the geometry example of Fig. 9f). Once again the two centroids are marked by the letter G. Neither solution is entirely satisfactory when used with this geometry.

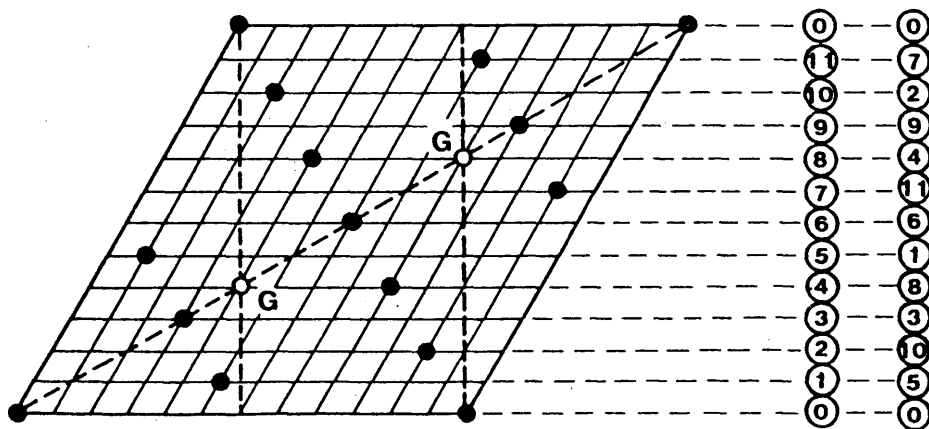
FIGURE 12 – Examples for channel allocation in a regular equilateral lattice ($C = 12$)

Figure 13 shows an example for $C = 19$, the elementary triangles of this solution are equilateral. The channel-distribution scheme selected is fairly appropriate for UHF television broadcasting systems G, I or L, as it takes the best possible account of interference with channel differences of 1, 9 and 18, assuming that the 61 channels comprising the full UHF band are subdivided to provide three programmes each with 19 frequencies. The distance of these channels from the corners are $\sqrt{3}$ times, 2 times and $\sqrt{3}$ times the sidelength of the elementary triangle, respectively. The position with a channel difference of 5 is fairly unsatisfactory, as it is immediately adjacent to that of the reference channel. It can easily be verified that, with this geometry, no solution can be found for which the channel differences of 1, 5, 9 and 18 are all equally good and satisfactory.

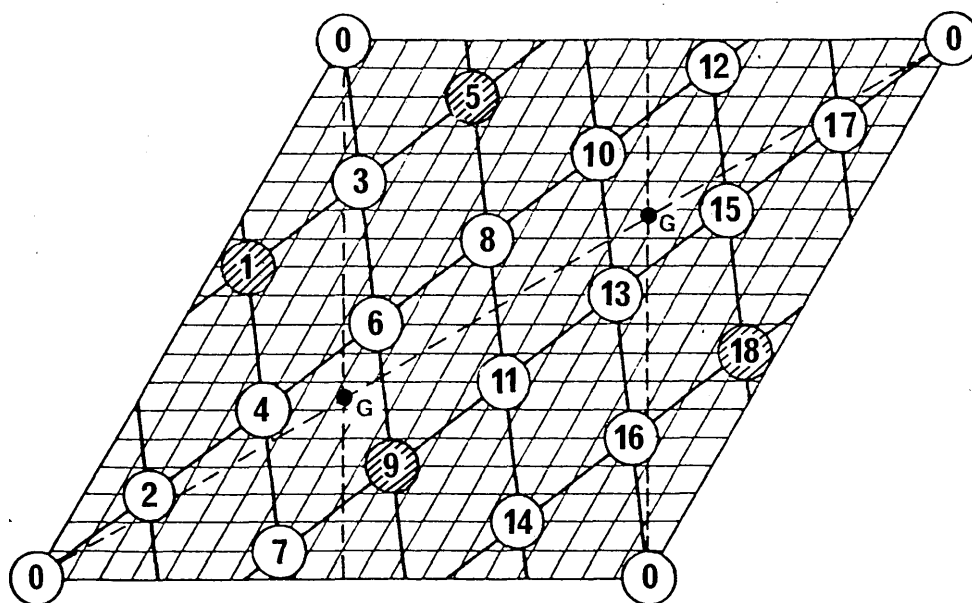


FIGURE 13 – Example of 19-channel lattice – Appropriate for UHF television in the case of three programmes to be provided in separate sub-bands

It can be concluded at this stage that the problem of achieving full area coverage can be solved, using the flow-chart of Fig. 14 by determining:

Step 1: The coverage factor, $c_{(1)}$, when only one channel is used and when, in the absence of noise, account is only taken of co-channel interference:

$$c_{(1)} = 2\pi r_1^2 / \sqrt{3} D^2$$

Step 2: The minimum number of channels, C_{min} , necessary to provide full coverage: $C_{min} \cong 1.2/c_{(1)}$.

Step 3: The most favourable geometry (equilateral or near-equilateral elementary triangles) for C_{min} or slightly larger values, if necessary or appropriate.

Step 4: The most appropriate channel-distribution scheme for the geometrical solution of step 3.

Step 5: The coverage factor, c_1 , obtainable with any of the C channels taking account of all types of interference:

$$c_1 = 2\pi r_1^2 / \sqrt{3} D^2$$

Step 6: The coverage factor, c , obtainable with all channels: $c = c_1 C$.

Step 7: The power level necessary to permit noise-free reception at a distance r_1 from the transmitter for about 90% of the locations.

- To obtain the optimum result, Steps 3 and 4 may require repetition in an iterative procedure;
- if the power level determined in Step 7 exceeds a reasonable or a predetermined value, either the co-channel distance, D , has to be reduced and the whole procedure to be repeated, or the number of channels, C , has to be increased;
- if in Step 6 the resulting coverage factor, c , is not equal to (for equilateral elementary triangles), or sufficiently greater than (for non-equilateral elementary triangles), 1.2, the whole procedure has to be repeated starting either with Step 3 or, if necessary, from the beginning, however with an increased value of C . An affine transformation may be of help, if interference from other channels exceeds, or is comparable to, co-channel interference.

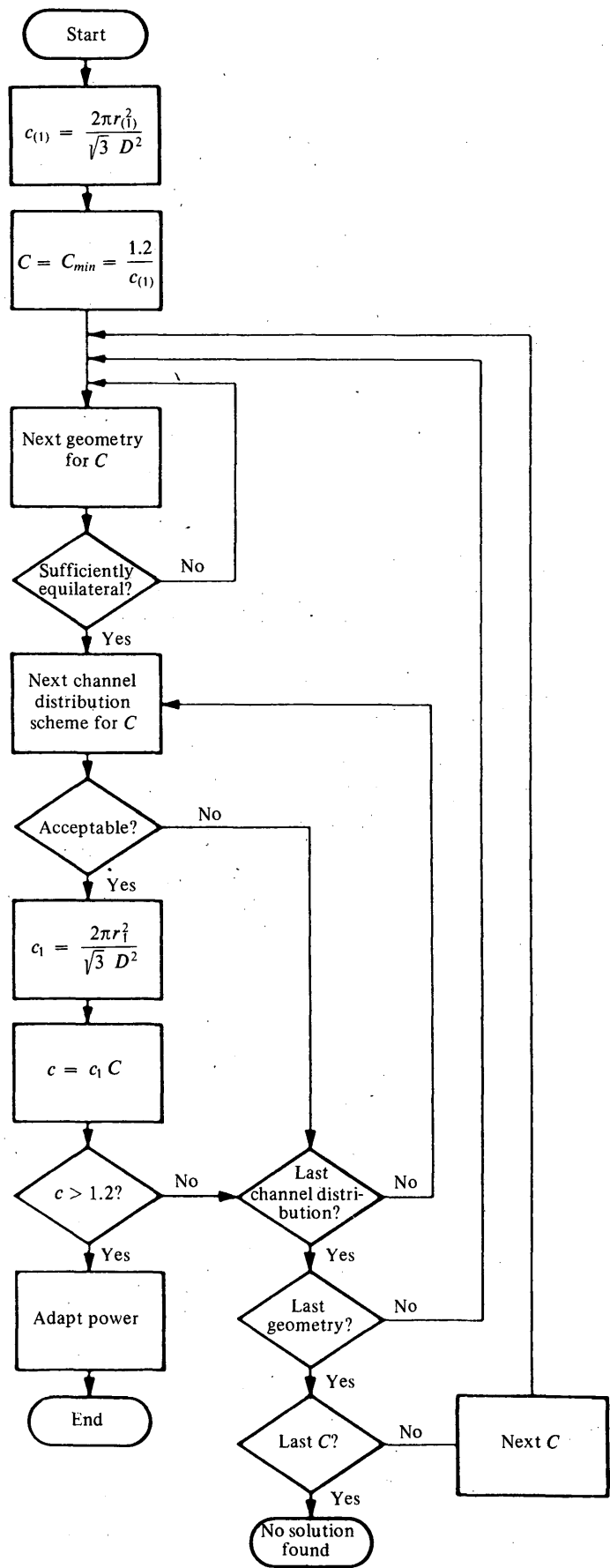


FIGURE 14 – Flow-chart for determining regular lattices

4. Multiple coverage and channel grouping

Having solved the optimization problem of obtaining full area coverage with a minimum number of channels, it is fairly easy to solve the problem of providing full area coverage with more than one programme. It is obvious that the number of channels, C , necessary for coverage with P programmes is $C_P = CP$. This may be achieved either:

- by extending the cyclical system of C channels to comprise P cycles of C channels each; in Fig. 10 this solution is shown for $C = 7$ and $P = 2$. This solution takes advantage of the fact that in a cyclical system channels $C - 1$ and C are already adjacent to each other. Hence, in principle, no further interference will need to be considered with the only exception of those types of interference which were not previously involved because of the small number of channels used. For example, in Fig. 11, as only 7 channels are used, no image-channel interference can arise from channel +9. This will change when multiple coverage with 7 channels per programme is envisaged since channel 2 in the second network is 9 channels above channel 0 in the first network, etc.;
- by treating the entirety of C_P channels as a whole, i.e., a single lattice of C_P channels.

The first method ensures identical coverages with P programmes, apart from specific exceptions such as smaller adjacent-channel interference levels on the highest and lowest channels. It provides equal channel spacings of transmissions at each site, which can be considered to have both advantages and disadvantages. The second method is more flexible since the number of lattice solutions increases with the total number of channels. It involves grouping together P lattice assignments at each single site. These should be selected from points in close proximity to each other. If more than two channels are grouped at a single site and the channels are obtained from a straight line through the lattice, they will, as with the first method, have equal spacings.

The grouping implied in the second method involves a certain amount of distortion of the basic lattice. This need not be detrimental but it is obvious that it is the elementary triangles resulting from the grouping rather than those of the original basic lattice which should be near-equilateral. For this reason basic solutions with elementary triangles which are far from equilateral may be of interest.

5. Non-linear distributions

It was stated earlier that non-linear channel distributions may also provide valid solutions, but are generally less manageable. Figure 15 shows such a non-linear distribution based on a 9-channel lattice by way of example. This has the feature of providing a lattice with co-channel and elementary triangles that are both equilateral even though 9 is not a rhombic number. It may be seen that this distribution does not have the property of equal steps in channel numbers in any one direction through the lattice. Because of this, interference levels will not necessarily be the same at all transmitter locations.

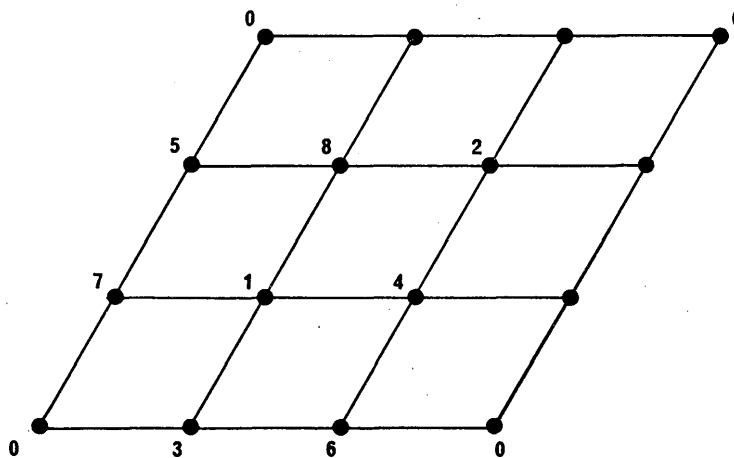


FIGURE 15 – Example of non-linear network for 9 channels

REPORT 485-1

CONTRIBUTION TO THE PLANNING OF BROADCASTING SERVICES

(Question 4/11, Study Programme 4B/11)

(1970-1982)

PART I

STATISTICS OF SERVICE

1. The protection ratio is frequently used in the planning and assignment of broadcast stations and service, both visual and aural. It is usually defined as the minimum permissible power ratio of the wanted-to-interfering signals available at the receiver input, to provide the desired quality grade of service. Because the field strengths which induce the receiver input signals vary with time and from location to location it is necessary to include some of the statistics of this variability in the description of service and for the protection of this service.

The television or frequency-modulation broadcasting service to a relatively small area in the presence of a single source of interference may be described by an algebraic-statistical equation (1). A small area is one for which changes in the type of terrain and in the distance from the pertinent transmitting antennas are negligible in terms of determining the median values of field strength.

$$R(Q) = E_d(50,50) - E_u(50,50) + G_d - G_u - H(T) - H(L) \quad (1)$$

where

$$H(T) = k(T) \sqrt{\sigma_{td}^2 + \sigma_{tu}^2}$$

$$H(L) = k(L) \sqrt{\sigma_{ld}^2 + \sigma_{lu}^2}$$

$R(Q)$: protection ratio (dB) of the wanted to the interfering signal at the receiver input required to provide a service quality Q under non-varying conditions. Subscripts d and u refer to the wanted and unwanted signals, respectively;

$E(L', T')$: the level of field strength exceeded for T' % of the time in at least L' % of the locations (dB rel. 1 $\mu\text{V/m}$);

$E(50,50)$: median field strength in time and location (dB rel. 1 $\mu\text{V/m}$);

G : effective receiving antenna gain in the pertinent direction (dB);

$k(X)$: standard normal variate, tabulated in many statistical textbooks:

$$k(50) = 0; k(70) = -0.525; k(90) = -1.282; k(99) = -2.326;$$

σ_t : standard deviation for variation in field strength with time (dB);

σ_l : standard deviation for variation in field strength from location to location (dB).

For the purpose of describing service, equation (1) may be interpreted as follows. If service of quality grade Q is defined to be available at a given location only when the protection ratio at the receiver input exceeds the required value $R(Q)$, i.e. the non-varying protection ratio is exceeded for T % of the time, then in the area for which equation (1) holds, at least L % of the locations will have this quality of service, $Q \cdot H(T)$ and $H(L)$ are the factors which represent the effects upon the service to the area of the signal variability in time and with location, respectively.

In equation (1) the following assumptions have been made:

- the various fields have approximately Gaussian distributions both in time and with location. Experience [USA] indicates that this is a fair approximation between the 5% and 95% levels;

- both the time correlation and location correlation between the desired and interfering signals are negligible. Terms including these correlation terms may be added to the radicals of $H(T)$ and $H(L)$, if desired;
- the variability in antenna gain throughout the small area is assumed to be negligible. Terms for the variability in antenna gain may be added to the radical of $H(L)$ but such terms should be minor for outdoor installations compared with the location variability of the field strength.

It is noted from equation (1) that there are three interdependent parameters needed to describe the service to the area — i.e. Q , L , T . For convenience, Q and T are usually standardized and with these standard values of T and Q a value of L may be computed from (1). For example, Q may be chosen as “satisfactory” service and T as 90% or 99%. When several sources, i , of interference, including noise, are present at the area, the L_i for each source of interference acting independently and alone may be computed from equation (1), and the resultant L may be computed as the product of the values of L_i so long as the values of Q and T are the same for the individual computations of L_i [USA].

$$L = \prod_{i=1}^{i=n} L_i = L_1 L_2 \dots L_n \quad (2)$$

The above resultant value of L is a reasonably good approximation for values of L equal to 50% or greater.

Equation (1) may be rearranged to give:

$$R(Q) + H(T) + H(L) = Ed(50,50) - E_u(50,50) + G_d - G_u \quad (3)$$

The right-hand side of equation (3) is recognized as being equal to the ratio of the median value of the wanted-to-interfering signal powers at the receiver input. When the signals are of the non-varying type, $H(T)$ and $H(L)$ are zero and the ratio of the median values of the receiver input powers is equal to the ratio $R(Q)$. But, when there is time and location variability (and T or L exceeds 50%) a greater ratio of median receiver input powers is required for the same quality of service Q , the increase being represented by $H(T)$ and $H(L)$ for time and location variability in signal strength, respectively. In effect, a statistical, multi-dimensional protection ratio may be created to represent the left-hand side of equation (3).

For allocation and assignment computations $R(Q)$ may be combined with $H(L)$ and sometimes $H(T)$ to create a new multi-dimensional power input statistical ratio which is more easily used with available propagation data. These ratios have often been confused with the non-varying protection ratios. When possible $H(T)$ should be combined with the median values of field strength to avoid the creation of a statistical protection ratio which varies with distance.

For protection of service areas iso-service contours of equal location probability L (Q and T being preset) are drawn to depict the coverage of the broadcasting station and these iso-service contours are protected. Standard values for L need to be adopted by the CCIR in addition to presently recognized standards for T and Q , to set protection standards for iso-service contours under conditions of signals variable in time and with location.

2. Co-channel television interference

For this type of protection, $H(L)$ is combined with $R(Q)$, and $H(T)$ is merged with $E_u(50,50)$. Thus, under the assumption that the time fading ranges of the interfering fields are at least twice as great as those for the wanted fields:

$$R(L, Q) = R(Q) + H(L) \approx Ed(50,50) - E_u(50,100 - T) + G_d - G_u \quad (4)$$

$$E_u(50,50) + H(T) \approx E_u(50,100 - T)$$

$R(L, Q)$ is convenient for use in computations to protect the service of the wanted station, especially since it is not dependent upon distance. However, $R(L, Q)$ may be frequency dependent, since $H(L)$ is frequency dependent, as shown in Table I. This Table is given as an example only and for various types of terrain, the values of σ may be higher or lower than those given.

3. Adjacent-channel interference

When the fading of the interfering signal is much smaller than that for the wanted signal, $H(T)$ may be combined with $E_d(50,50)$. Such would be the case for adjacent-channel interference in System M, if the value of $R(Q) = -20$ dB, as proposed in [CCIR, 1966-69] is adopted. For such conditions:

$$\begin{aligned} R(L, Q) &= R(Q) + H(L) \approx E_d(50, T) - E_u(50, 50) + G_d - G_u \\ E_d(50, 50) - H(T) &\approx E_d(50, T) \end{aligned} \quad (5)$$

When the time fading of the wanted and interfering signals are approximately the same, $H(T)$ cannot be conveniently combined with one of the median field strength signals. $H(T)$ is then assumed to have a typical value which is independent of distance, and is combined with $R(Q)$ and $H(L)$.

$$R(L, T, Q) = R(Q) + H(L) + H(T) \approx E_d(50, 50) - E_u(50, 50) + G_d - G_u \quad (6)$$

4. Conclusion

It is concluded that defining only the non-varying protection ratio for the broadcast services is not sufficient to define the quality of a service nor to define protection requirements for such service. It is also necessary to define the percentage of time T for which this ratio is to be exceeded as well as the percentage of locations L for which the desired quality of service Q is desired. Given this more completely specified statistical quality of service, available propagation and antenna pattern data may be employed to determine the ratio of wanted to interfering field strengths which may be needed to provide the required protection. From these field strengths the required service contours and station separation may be compiled.

TABLE 1 - Examples of values for $H(L)$

Frequency (MHz)	70	100	200	700
$\sigma_{Id} = \sigma_{Iu} = \sigma_I$ (dB)	7	7	8	12
$H(50)$ (dB)	0	0	0	0
$H(70)$ (dB)	-5	-5	-6	-9
$H(90)$ (dB)	-12	-12	-15	-22
$H(99)$ (dB)	-23	-23	-26	-39

REFERENCES

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PART II

DEFINING QUALITY OF SERVICE FOR TELEVISION BROADCASTING

1. Introduction

Part I indicates that three inter-dependent parameters, i.e. quality grade, location and time, are required to describe service to an area. Standardization on these parameters is essential in planning for the protection of a television service and an approach towards this objective is outlined in the following sections.

2. Grading system

Before agreement can be reached on which grade of service should become standard, it is essential to agree on the classification system to be used. The 5-point scale system used in Recommendation 500 appears satisfactory for this purpose. It would, however, be useful to have the grade identified in terms of the median as required in the calculation methods suggested in Part I, § 1. While Annex II to Report 405 indicates methods for assessing the impact of additional interfering signals on quality grade, these approaches do not take the location parameters into account.

3. Percentage of time

Recommendations 417 and 418 indicate that the broadcasting service should be protected for a period of time between 90% and 99%. If the period of time selected is 90% it means that the desired quality of service will not be met 10% of the time. Moreover, since the minimum quality of service during that 10% of the time is not specified it could be of unusable quality and still meet the indicated objective for broadcasting. The quality of service during the worst 1% to 10% of the time is a factor which, under certain conditions, must be taken into account.

In the case of interference from other television broadcasting stations it is not really essential to specify the quality of service during the worst 1% to 10% of the time because of the nature of propagation variation, i.e. if good quality is available 90% of the time, the quality would not be unusable in the remaining 10% of the time but rather it would deteriorate gradually for smaller time intervals. If, however, the interference source is intermittent (e.g. from a land mobile system) and the percentage of "on" time is factored into the protection criteria for broadcasting, it is evident that the normal 90% to 99% protection times may have to be increased in order to avoid the possibility of unusable signals 10% to 1% of the time. Moreover, in some cases the "on" time interval is difficult to establish or control especially if multiple interference sources are permitted. It is therefore suggested that such interference sources may have to be considered as transmitting continuously when assessing their impact on television.

4. Standardization of Q and T

Equation (3) in Part I describes the relationship between the "service quality" grade Q , percentage of locations L , and percentage of time T . In terms of Recommendation 500, Q must be interpreted as the *impairment* grade due to interference and/or noise.

It is evident that it is possible to describe the same service in terms of all three parameters Q , T , L in an infinite number of ways. If, however, two of the parameters are fixed, the third variable may be used to complete the description of service. Thus if appropriate values for Q and T are fixed, the service can be described in terms of the corresponding L .

Since Q and T may take on a range of values it is suggested that boundaries on these values be determined. Recommendation 417 implies that at least a satisfactory grade of service is required in the absence of interference before protection may be sought. It is recommended therefore that Grade 3.5 be used as the lower boundary. Within the prime coverage area of a television transmitter however, a performance somewhat better than Grade 3.5 is generally expected at most locations. Since Grade 5, for various reasons, is often unachievable in practice, it seems inappropriate to standardize on it. On the other hand, Grade 4.5 with its minor imperfections, is usually achievable with adequate signal strengths and it is therefore recommended that Grade 4.5 be used as the upper boundary in terms of picture impairment for standardization purposes.

Recommendation 417 indicates that the percentage of time for which protection may be sought should lie between 90% and 99%. It is therefore recommended that 90% and 99% of the time be used as the lower and upper boundaries of time for standardizing on quality of service in the absence of interfering signals.

It is suggested that if the two lower boundaries (i.e. Grade 3.5, 90% of the time) are applied to the extremity of the coverage area and the two upper boundaries (i.e. Grade 4.5, 99% of the time) are applied to the prime coverage area, it will agree with the general expectations of planners for television service.

5. Percentage of locations

While this parameter is an essential factor in describing the quality of broadcast service no attempt has been made at standardization. Several approaches to standardization are possible and a relative rather than an absolute standard is proposed herein. The reference impairment proposed in this case is that ensuing from thermal noise as the only source of impairment. The objective of this approach is to ensure that a significant percentage of viewers are unaffected by the introduction of interfering sources.

With respect to standardizing on the percentage of locations which should receive the standardized values of Q and T , two options exist. It is possible to specify the percentage of locations directly and, by making estimates regarding typical receiving installations, determine the corresponding median field strength. Alternatively, it is possible to specify a median field strength and, by making estimates regarding typical receiving installations, determine the corresponding percentage of locations. Of these two, the second option is preferred, firstly because a field strength level is more readily confirmed than a percentage of locations, secondly because the percentage of locations does not have to be determined with accuracy for the purpose of calculating protection from interfering sources, and thirdly because a definite field strength for the desired signal is the most useful parameter for the purpose of calculating protection ratios. The relationship between field strength, quality of service and assumptions is described elsewhere [O'Connor, 1968]. In the absence of interference the field strengths close to those given in Recommendation 417 can provide Grade 3.5 service 90% of the time at approximately 60% of the locations (5-point scale). Field strengths some 17 dB greater can provide Grade 4.5 service 99% of the time at approximately 75% of the locations [CCIR 1978-82].

6. Suggested standard

It is therefore suggested that agreement be reached to adopt impairment Grade 3.5 for 90% of the time at the extremity of the protected area and Grade 4.5 for 99% of the time at locations where median field strengths are at least 17 dB greater than at the extremity. If agreement can be reached on these or similar criteria, a simple method of assessing the impact of interfering sources on reception quality becomes available.

7. Interfering sources

Part I shows that, where an interfering source is present and is expressed in terms of the same Q and T of the desired signal, the resulting L (provided L is greater than 50%) may be estimated as the product of L_d and L_i , where L_d is the percentage of locations receiving the desired quality in the absence of interfering signals, and L_i is the percentage of locations which would receive the desired quality if the interfering signal were the only additional source of degradation. L_i is therefore proportional to the number of locations which would continue to receive the stated Q and T after the introduction of the interfering signal. Thus once agreement has been reached on standardized values of Q and T , the impact of an interfering source can be estimated simply by requiring the interfering source to be expressed in terms of the same Q and T and then specifying the value of L_i . For example, L_i would have to have a value of 90% if it is desired to ensure that service in a coverage area is not degraded at more than 10% of the locations receiving the desired quality in the absence of interference.

The value of L_i which is acceptable may vary depending on the nature of the interference, the location within the coverage area for which protection is sought, and the protective measures which might be taken.

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REPORT 1086

FREQUENCY PLANNING CONSTRAINTS

(625-line systems)

(Question 43/11)

(1986)

1. Introduction

In order to ensure effective planning of terrestrial television broadcasting services in the frequency ranges 47-68 MHz (Band I), 174-230 MHz (Band III) and 470-960 MHz (Bands IV and V), it may be necessary to take into account certain constraints on the use of frequencies in order to avoid interference to other TV broadcast transmissions and to ensure compatibility with other broadcasting services, e.g. with the sound broadcasting service in the frequency range 87.5-108 MHz.

This Report identifies the constraints that may result from the technical limitations of receiver design and also from the transmission of several TV and VHF/FM sound broadcast programmes from the same site or from non co-sited transmissions with overlapping service areas. Co-channel, adjacent-channel and image-channel transmissions are dealt with in Recommendation 655.

Interfering signals can be maintained at acceptable levels by ensuring sufficient geographical separation between the transmitting stations involved, but the limited part of the spectrum allocated to television broadcasting services requires economy in frequency usage and demands the re-use of channels at distances as short as possible.

No account is taken of interference resulting from radiation of harmonics and intermodulation products at transmitter sites, on the assumption that the broadcasting authority can take the necessary precautions to reduce such spurious radiation to acceptable levels.

2. Constraints introduced by television broadcast receivers**2.1 Television receiver local-oscillator radiation**

Because of the possibility of interference being caused by the use of superheterodyne receivers, the use of certain channels is precluded. Receiver local-oscillators, except for system L, operate at frequencies between 36.9 and 40.2 MHz above the vision carrier of the wanted signal. Hence, if the channel separation is 7 or 8 MHz and channel n is used by one service, the choice of channel $n + 4$ or $n + 5$ for a neighbouring service depending on the system used (see table in § 4) would result in interference being caused from local oscillators in receivers which are tuned to channel n . For system L, the local oscillator operates at a frequency 32.7 MHz below the vision carrier, thus the channel interfered with in this case is $n - 4$.

The above information is derived from Report 625.

Additionally, with such a difference in channel numbers, interference caused by an intermediate frequency beat may occur. In practice, these problems are gradually decreasing with improved receiver technology.

Radiation from television receivers in the range 47-68 MHz may affect VHF/FM reception. This may occur when the television local-oscillator frequency lies near the carrier frequency of a VHF/FM transmission (see Report 946).

2.2 Image channel

Image-channel interference occurs when transmissions are separated by about twice the intermediate frequency. The image channel affecting receivers tuned to channel n would be $n + 9$, except for systems B ($n + 10$), for systems D and K ($n + 8$ and $n + 9$), system K1 ($n + 9$ and $n + 10$) and system L ($n - 9$).

Although the improved image-channel rejection characteristics of modern receivers minimize the problem, rejection is not complete and the situation should be avoided in preparing a frequency plan. Image-channel interference is not a problem within Bands I and III.

2.3 Harmonics from VHF/FM receiver local-oscillators

Second or third harmonics of VHF/FM receiver local-oscillators, depending on whether the local-oscillator frequency is high or low respectively, may fall within Band III. It would therefore be preferable to choose the VHF/FM transmission frequencies and the television channels in such a way that this condition does not occur; however, this can not be generally taken into account when preparing frequency plans.

2.4 Harmonics and intermodulation products generated under overload conditions in receivers

High input levels of VHF/FM and/or television signals can lead to non-linearities in the input stage of receivers, giving rise to the generation of harmonics and intermodulation products. A general consideration of such interference mechanisms when elaborating a frequency plan is not possible. Problems should be solved on an individual basis, e.g. notch filters and attenuators might be used in the receiving installation.

3. Transmitting antenna system limitations

In many instances, co-sited television transmissions may utilize a common antenna system. The minimum possible frequency separation is determined by the practical design limitations of combining units.

For planning purposes, the minimum frequency spacing should in general be not less than 2 channels in Bands I and III and 3 in Bands IV and V. Although it is also technically feasible to design combining units to operate at spacings down to 2 channels in Bands IV and V, these may become more expensive, particularly for high power transmitters.

It is theoretically possible to assign adjacent channels to co-sited transmitters provided that two emissions are orthogonally polarized and with similar e.r.p. However, there are likely to be significant engineering problems at the transmitter site. In addition, severe problems are to be expected at receiving installations which will have to use separate antenna systems to receive the two signals.

4. Conclusions for television planning procedures

Table I indicates, for the various television systems, the differences in channel numbers which should be avoided for co-sited transmitters, because of radiation from local oscillators or image-channel interference. For non co-sited transmitters with overlapping coverage areas, the problems are considered to be less severe. It would be prudent, however, to avoid those channel relationships in initial planning.

TABLE I

System	Difference in channel numbers	
	Local-oscillator radiation	Image-channel interference
<i>Bands I and III</i>		
B, I, K1	5	—
D, L	4	—
<i>Bands IV and V</i>		
B	5	10
D, K	4	8, 9
G, H, I	5	9
K1	5	9, 10
L	4	9

It should be noted that these constraints refer to uniform channel spacing for the whole planning area. In the case of transmitters using different systems and/or different channel spacings, with overlapping coverage areas, a detailed case-by-case investigation is necessary.

REPORT 1087*

**FREQUENCY SHARING BETWEEN THE BROADCASTING SERVICE (TELEVISION)
AND THE FIXED AND MOBILE SERVICES BELOW 1 GHz**

(Question 39/11)

(1986)

1. Introduction

The WARC-79 increased the number of frequency bands that might be shared between the broadcasting service and the fixed and mobile services below 1 GHz.

This Report examines possible criteria for sharing the spectrum between these services.

2. Possible ways of sharing

If the same portion of the frequency spectrum is allocated to two or more services, sharing may be effected in one of the following ways:

- use of the same frequency band by different services at different times;
- simultaneous use of different parts of the shared bands by different services;
- simultaneous use of the same parts of the shared bands by different services, but in separate geographical areas;

2.1 *Sharing by using separate hours of operation*

As channel assignments to broadcasting stations are usually made on an unlimited time basis, time sharing appears impossible. In practice, broadcast schedules often indicate that the stations are out of operation for several hours each day, and sharing might then seem feasible. However, apart from the fact that the timing of schedules will vary from country to country, broadcast transmissions for maintenance purposes outside programme hours are essential. In addition, important events may require substantial extension of the normal programme schedules from time to time. Furthermore, considerable expansion of the hours of television broadcasting can be foreseen. Under these circumstances it may be difficult, if not impossible, to reach a time-sharing agreement on even a national basis without limiting the present broadcasting services and prohibiting further expansion.

2.2 *Sharing by using separate frequencies of operation*

This type of band sharing requires, in its simplest form, a subdivision of the allocated bands into different parts. However, this is not really a case of frequency sharing, because each individual part of the spectrum could be expected to be allotted to only one service on a national basis.

In more complex cases, sharing of this type could mean the use of frequencies, or frequency ranges, by one service interleaved with the frequencies used by the other service. This situation can be found, for example, in band 9 in those parts of the European Broadcasting Area where system G is used. Sharing under these conditions may be considered to be a possibility. It should not, however, be overlooked that the number of countries in which this type of sharing might be implemented is fairly limited and that the planning of the television services in this band has been made on the basis of protection ratios which apply for 8 MHz channel separation.

2.3 *Sharing by geographical separation*

This simultaneous use of shared bands by different services in separate geographical areas should be such that each service is not essentially affected by interference from the other service. Whether or not two different services can share the same part of the spectrum under these conditions, depends on several factors including propagation, the minimum field strength to be protected, and the required protection ratio.

* This Report constitutes a partial answer to Question 39/11. It should be brought to the attention of Study Groups 8 and 9.

Service areas of television transmitters can be presented in the form of maps, where the limit is determined by a field-strength contour derived from statistical propagation curves. The actual service area will normally differ due to terrain irregularities. For the broadcasting service, it is essential that the actual service area be protected against interference from other services. Consideration should also be given to the need to afford protection for rebroadcast purposes. The greatest care must therefore be taken to identify the area in which protection of the broadcasting service is required.

When the present bands 8 and 9 were planned for television, careful consideration was given to protection from stations in the television service. Individual stations, rebroadcast stations and networks were established without regard to the possibility of frequency sharing with other services in the future. These television systems may therefore be very sensitive to interference from a completely different service. Where sharing is contemplated, great care must be exercised if established viewing patterns are not to be adversely affected.

Another possibility is to interleave within a television channel at frequencies or frequency ranges between the vision carrier, the colour sub-carrier and the sound carrier, where the protection required is relatively low. However, existing CCIR texts contain limited information about the interference potential of the television signal to other services. This problem needs further study. It should be noted that, particularly in Bands I and III, the feasibility of sharing of this type may be complicated by the use of overlapping television channels.

Nevertheless, careful planning of frequency assignments to stations of the fixed and/or land mobile services might lead to further improvements in spectrum utilization without resulting in additional interference to broadcasting stations operating in the same frequency range. However, it seems to be inevitable that sharing with other services would lead to a reduction in flexibility for the further development of the broadcasting service. The addition of new broadcasting stations, and the re-assignment of channels to existing stations, will become more difficult, the more extensively the band is shared. This holds true when the other service is operated on a secondary or permitted basis, whereas any further development of the broadcasting service could be rendered impossible when the other service is operated on a primary basis.

3. Out-of-channel interference

It is known that the broadcasting service is susceptible to interference by stations of another service at frequencies outside the wanted channel. Overloading effects, neighbouring channel interference, image-channel interference or oscillator radiation can lead to a deterioration of the service provided by a broadcasting station if care is not exercised. A study carried out in Ireland on interference effects from mobile stations to broadcasting reception when the bands allocated are adjacent to one another indicates that care has to be taken when different services make use of adjacent bands in the same area. Further study is needed to assess the problem more fully.

4. Basic considerations for the establishment of sharing criteria

In considering the case of interference from stations of other services to the broadcasting service, it is necessary to recognize that the public is very sensitive to interference to broadcasting reception. It is therefore desirable to protect not only the service areas but also to take into account areas of poor reception. This is perhaps more important in cases where the broadcasting service has been well established for a long period of time.

In establishing sharing criteria the following should be taken into account:

4.1 *Minimum field strengths to be protected*

According to Recommendation 417 the minimum (median) field strengths for which protection may be sought in planning are 48, 55, 65 or 70 dB(μ V/m) for Bands I, III, IV and V, respectively. It is noted that some countries may use different values.

Improvements have been made in television receivers, antennas and preamplifiers, and many viewers enjoy adequate reception with field strengths lower than those shown above. Present coverages sometimes take this into account by allowing for secondary service zones.

In such instances it would be desirable, or even essential, to seek protection to lower values, the level being determined by the available field strength of the wanted signal and the degree of protection against interference already afforded. With respect to these requirements for protection, values as low as 46 and 49 (see Report 409), 53 and 58 dB(μ V/m) for Bands I, III, IV and V, respectively, could be envisaged. Studies to recommend final values are in progress.

4.2 *Protection ratios*

Where appropriate, the protection ratios given in Recommendation 655 should be used. Further studies are needed for modulation types not covered in these texts.

4.3 *Multiple interference*

The effect of multiple interference sources requires further study.

4.4 *Interference assessments*

Interference assessments should be made for several reception points within the service area of the television transmitter. These points should be those which would seem to be most likely to suffer from interference.

4.5 *Receiving antenna discrimination*

The antenna directivity response curves of Recommendation 419 apply to all types of unwanted signals including transmissions by fixed, base and mobile stations.

The protection afforded by orthogonal polarization discrimination (see Report 122) could also be expected to apply to fixed and base stations. However, it could be anticipated that this advantage would be significantly less in the case of mobile stations, and for planning purposes could be ignored.

4.6 *Rebroadcast stations*

For rebroadcast stations, it is necessary to ensure that both the received and transmitted television channels are protected against interference.

4.7 *Mobile stations*

The area in which mobile stations are operated must be well defined. Calculations should be made for locations of the mobile station nearest to the service area of the broadcasting transmitter and for more elevated locations within the operation area using appropriately increased effective antenna heights.

Furthermore, problems of overloading of television receivers may occur in cases where the mobile station is in the near vicinity of a television receiving site.

5. **Conclusion**

The possibilities of sharing between the television broadcasting service and the fixed and mobile services have been studied generally with the aim of forming a basic framework for the establishment of sharing criteria. Only the effects of sharing on the broadcasting service have been taken into account.

Extensive studies are necessary to assess the effects of sharing quantitatively before being in a position to firmly establish sharing criteria.

EBU studies [CCIR, 1982-86] covering part of Europe have shown that from consideration of existing average co-channel distances in the television networks, and of minimum separation distances for base stations of the land mobile service in Bands I and III, the following could be tentatively concluded:

- in Band I, base stations of the land mobile service may normally be inserted in the existing, not completely exploited TV spectrum. The interfering effect on the receiving end of transposers has not been taken into account and may be the more critical factor in some instances;
- in Band III, base stations of the land mobile service could normally be inserted only in TV networks which are built up of high-power transmitters only. In fact, the base stations would in this case replace the low-power transmitters of the TV service in a country and make further development of the TV networks in that country impossible;
- the interfering effects of mobile stations need further study;
- the specific possibilities of sharing may differ widely, both from country to country and within a single country.

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[1982-86]: 11/249 (EBU).

REPORT 626-1

SIMPLIFICATION OF SYNCHRONIZING SIGNALS IN TELEVISION

(Question 1/11, Study Programme 1E/11)

(1974-1978)

Proposals have been made that the television synchronizing signal should be simplified firstly by reducing the number of equalizing pulses [CCIR, 1963-66; 1966-69; 1970-74a, b and c; Recommendation 472, note (5)] and secondly reducing the number of broad pulses [CCIR, 1970-74a and b]. Study Programme 1E/11 requests investigation into the effect of reducing the number of equalizing pulses.

The simplification of the synchronizing signal leads to a simplification of synchronizing generators and also makes available more line-periods of the field-blanking interval for injecting test or measuring signals, standard reference frequencies [CCIR, 1970-74d], commercial information (e.g. facsimile transmissions), auxiliary audio signals for bilingual programmes, sub-titles for the deaf, remote control and supervision of unattended centres [CCIR, 1970-74b] or for the transmission of any other information.

Studies [CCIR, 1970-74d] have been made which indicate that, in the member countries of OIRT, the characteristics of the receivers are such that the "second" sequence of equalizing pulses may be completely eliminated without deterioration of the quality of line interlace and, furthermore, the number of equalizing pulses in the "first" sequence may be reduced to one of standard duration, according to Fig. 1. These results are confirmed by experiments [CCIR, 1970-74c] carried out in the USSR, not only upon receivers, but also upon monitors, radio-relay equipment, transmitters, video tape recorders and industrial television equipment. These experiments have also shown an improved performance with video tape recorders, receivers and other equipment containing flywheel circuits [CCIR, 1970-74c]. In the USSR, the use of a single pre-equalizing pulse and no post-equalizing pulses (Fig. 1) is permitted. However, the reduction in the number of broad pulses leads to impairment of interlace and other disadvantages, and thus has been proved unacceptable [CCIR, 1970-74c and d]. Following laboratory studies and experiments carried out in operational conditions by the OIRT [CCIR, 1974-78a], it was decided to continue to investigate the possibility of simplifying synchronizing signals.

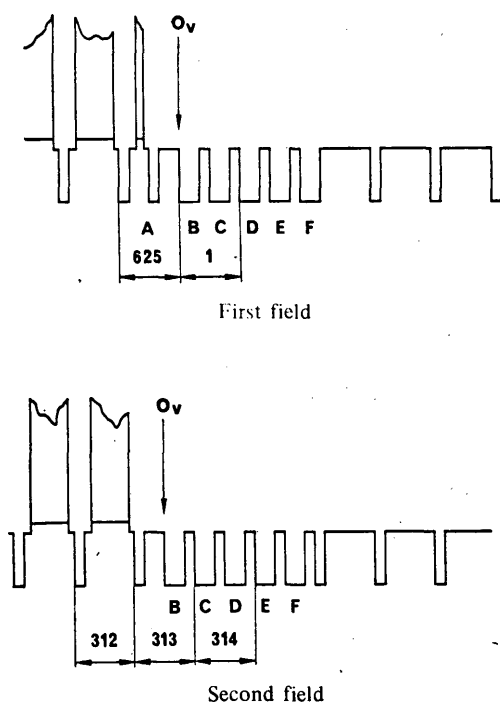


FIGURE 1

A : Single equalising pulse at the end of each second field
B, C, D, E, F : broad pulses

Note. — Experiments mentioned in [CCIR, 1970-74a and b] examined effect of deleting broad pulses F and E and replacing them by line sync. pulses where appropriate.

Laboratory experiments [CCIR, 1970-74b] and field trials conducted in Italy [CCIR, 1974-78b] seem to indicate that one pre-equalizing pulse and no post-equalizing pulses are satisfactory for domestic receivers, provided that the single pre-equalizing pulse, situated in the middle of line number 625 (Fig. 1) has a duration of about 2.8 μ s. The same set of experiments included tests in which not only was the number of pre-equalizing pulses reduced to one and the post-equalizing pulses absent, but also the number of broad pulses was progressively reduced from five to two (see Note to Fig. 1). It was found that with this form of field-synchronizing waveform, the number of broad pulses could, in the foreseeable future, be reduced to three without appreciable increase in receiver instability.

Experiments carried out in the United Kingdom [CCIR, 1970-74a] on monochrome and colour receivers with a pre-equalizing pulse in the middle of line number 625, no post-equalizing pulses and only three broad pulses (Fig. 1 and Note), revealed that a small but significant number of receivers suffered impairment of interlace, probably due to the 2.5 μ s duration of the single pre-equalizing pulse operating upon receivers having integrators with a time-constant less than 100 μ s. The reduced number of broad pulses (three) also produced a tendency for the "vertical hold" controls of some receivers to require more critical adjustment.

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- [1963-66]: XI/115 (United Kingdom).
- [1966-69]: XI/55 (USSR).
- [1970-74]: a. 11/266 (United Kingdom); b. 11/309 (Italy); c. 11/340 (USSR); d. 11/34 (OIRT).
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REPORT 409-4

BOUNDARIES OF THE TELEVISION SERVICE AREA IN
RURAL DISTRICTS HAVING A LOW POPULATION DENSITY

(1966-1970-1978-1982-1986)

Where television services are to be provided for a sparsely populated region, in which better receivers and antenna installations are likely to be employed than those considered in Recommendation 417, administrations may find it desirable to establish the appropriate median field strength for which protection against interference is planned as low as shown in Table I.

TABLE I

Band	I	III	IV	V
dB(μ V/m)	+ 46	+ 49	+ 58	+ 64

These values refer to the field strength at a height of 10 m above ground level.

In the absence of interference other than noise, field strengths of the order of 40 dB(μ V/m) in Band I, 43 dB(μ V/m) in Band III, 52 dB(μ V/m) in Band IV and 58 dB(μ V/m) in Band V can give satisfactory pictures; however, it is generally observed that the public begin to lose interest in installing television reception equipment when the field strength falls much below these levels.

The values given in this Report have been obtained from field-strength investigations at the edge of the coverage area and picture quality assessments for Bands I and III in rural districts of Australia [CCIR, 1963-66], India [CCIR, 1974-78] and Italy, and for Bands IV and V at both rural and urban locations in Italy and the United Kingdom [CCIR, 1982-86]. It may be noted that in Bands IV and V where man-made noise is not generally a problem, the field-strength values quoted for rural areas may also be applied in urban areas.

Note. — See Recommendation 417.

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[1974-78]: 11/439 (India).

[1982-86]: 11/247 (EBU).

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REPORT 484-2

RATIO OF PICTURE-SIGNAL TO SYNCHRONIZING-SIGNAL

(Question 1/11, Study Programme 1D/11)

(1970-1974-1986)

Study Programme 1D/11 considers the possibility of adopting one single figure for expressing the ratio of picture-signal to synchronizing-signal, for both the video and the radiated signals, independently of the systems employed.

It is considered desirable that such a ratio should reach as high a value as possible, compatible with receiver requirements.

It is felt that, to reduce the relative amplitude of the synchronizing signal below the values normally used, might give rise to difficulties in receivers and some types of studio equipment.

At the present time, the possible values of picture-signal to synchronizing-signal ratios that can be considered for a single standard are as follows: 7/3 and 10/4.

Since the ratio 10/4 is the higher of the two and is more generally used for radiated signals (some countries using it also for the video signal), administrations should consider the possibility of adopting this value in the future.

Recent investigations in the Federal Republic of Germany have shown that it is possible with modern receivers to reduce the relative amplitude of the synchronizing signal significantly, below a value corresponding to a ratio of 10/4. A ratio of, for example, 8/2 can easily be afforded without affecting the synchronization reliability of the receivers [CCIR, 1970-1974]. Further studies should therefore be carried out to investigate the effect of a reduction to such a ratio on all parts of a television system. The cost of the necessary modification of the transmission facilities to a ratio of 8/2 must also be taken into account before administrations can be asked to consider the adoption of such a value in the future.

Recent studies on receivers in India confirm stability with a ratio of picture signal to synchronizing signal of 8/2 [CCIR, 1982-86].

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CCIR Documents

[1970-74]: 11/72 (Germany (Federal Republic of)).

[1982-86]: 11/397 (India).

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REPORT 961-1

TERRESTRIAL TELEVISION BROADCASTING IN THE 12 GHz BAND (BAND VI)

(Question 1/11, Study Programme 1G/11)

(1982-1986)

1. Introduction

Experimental amplitude-modulation terrestrial television broadcasting systems in the 12 GHz band have been set up in the Federal Republic of Germany [CCIR, 1974-78a], in the Netherlands [CCIR, 1974-78b], and in Switzerland [CCIR, 1974-78c] for system G, and in Japan for system M [CCIR, 1974-78d and e]. Further, an operational station for the same broadcasting system has been working in Japan since 1979 [CCIR, 1978-82a].

The WARC-BS-77 has established for Regions 1 and 3 a frequency and orbital position Assignment Plan for the broadcasting-satellite service in the 12 GHz band shared with the terrestrial broadcasting service. The Regional Administrative Radio Conference, Geneva, 1983 has established an analogous Plan for the broadcasting-satellite service in Region 2.

2. Technical characteristics

2.1 Systems using amplitude modulation

2.1.1 Characteristics of the radiated signal

Both amplitude modulation and frequency modulation are applicable to terrestrial television broadcasting in the 12 GHz band. A system of amplitude modulation requires higher transmitting powers but will allow more television channels.

Amplitude modulated television signals in the 12 GHz band should conform to the standards given in Report 624 so that they can be received by a conventional television receiver equipped with a frequency converter.

2.1.2 Protection ratio

The ratio of wanted-to-unwanted signal power at the receiver input is an important factor in planning terrestrial television systems. The protection ratio required when considering interference between two amplitude-modulation vestigial-sideband (AM-VSB) television signals is given in Recommendation 655. The protection ratio between two frequency modulation television signals can be found in Report 634.

The required ratios are essentially independent of frequency band. However, in applying them to the planning of a terrestrial system in the 12 GHz band, it is necessary to take into account both signal fading and the frequency stability of transmitters. With regard to the latter, an experiment in Japan has shown that it is not practicable to use precision offset techniques for AM-VSB systems in the 12 GHz band [CCIR, 1978-82b].

2.1.3 Equipment characteristics

2.1.3.1 Transmitter

Specifications of AM-VSB transmitters for a terrestrial television service in the 12 GHz band can be virtually the same as those in Bands III, IV and V.

In order to simplify the transmitters, the vision carrier could be amplified together with its accompanying sound carrier, but this may cause intermodulation. In Japan, the ratio of sound to vision power has been altered from 1/4 in Bands III, IV and V, to 1/10 in the 12 GHz band in order to reduce the 920 kHz beat between the sound carrier and the colour sub-carrier.

2.1.3.2 Receiving equipment

In experiments so far reported, the frequency converters used at the receiving points have only to change the frequency from the 12 GHz band to a frequency within Bands IV and V. The converter has been mounted directly behind the parabolic reflector, giving rise to negligible feeder loss. Experience gained has led to the conclusion that a converter noise figure of 7 to 10 dB can be realized without excessive cost, and that considering transmitting power, converter noise figure, mounting facilities, beamwidth and influence of wind, an antenna diameter of 40 cm is reasonable.

For establishing the standards for terrestrial television broadcasting in the 12 GHz band in Japan, a converter with a noise figure of 10 dB, equipped with an antenna of 40 cm diameter, was assumed. In practice, converters with noise figures of 6 to 8 dB have been used in Japan.

2.2 Television using frequency modulation

For FM television systems, only limited information is available and further studies are required. However, some tests [CCIR, 1982-86] to determine basic propagation conditions have been carried out in the United States of America.

3. The minimum power flux-density

At frequencies above 1 GHz it is common practice to use the power flux-density, expressed in W/m^2 , as a measure for the signal strength.

The signal strength in this band has been calculated taking account of the above considerations and of the necessity of having a figure for the planning of a terrestrial amplitude-modulation broadcasting network in the 12 GHz band.

Table I gives the characteristic parameters for the calculation of the minimum power flux-densities, derived from the experimental and operational systems mentioned above.

The power flux-density Φ ($\text{dB}(\text{W}/\text{m}^2)$) at the receiving point is given by:

$$\Phi = F + 10 \log k T B + (S/N)_{RF} - 10 \log a \quad \text{dB}(\text{W}/\text{m}^2) \quad (1)$$

The proposed minimum power flux-densities for a satisfactory grade picture at the receiving antenna range from $-85.5 \text{ dB}(\text{W}/\text{m}^2)$ to $-70.2 \text{ dB}(\text{W}/\text{m}^2)$ for amplitude-modulation systems. The differences in the values are due to different assumptions for the picture quality, the receiver noise performance and the receiving antenna gain, as shown in Table I.

A minimum power flux-density of $-70 \text{ dB}(\text{W}/\text{m}^2)$ has been adopted for the operational AM system in Japan.

4. Polarization of transmission

Measurements of scattered waves from objects local to the receiving antenna have been carried out in the 12 GHz band in urban Tokyo. From the results, it has been found that the use of horizontally- or vertically-polarized transmission is advantageous over circularly-polarized transmission to reduce interference to other service areas where orthogonal polarization is used. Although it has been found that there is an advantage in using circularly-polarized transmissions to reduce multipath interference (see Report 562), in practice multipath interference need not be taken into account. Measurements in urban areas of Tokyo have shown that picture impairment, due to multipath interference alone is no lower than grade 4 on the 5-grade scale (Recommendation 500), provided that the impairment due to noise is no lower than grade 3 or the field strength is not more than 20 dB below the free space value. This performance can be achieved by using a parabolic reflector receiving antenna of at least 40 cm diameter and a frequency converter having a noise figure of 6 dB [Saito *et al.*, 1977].

In Japan, the transmissions are normally horizontally polarized, but where necessary, vertical polarization is used.

TABLE I

Television system		G (Germany, Federal Republic of)	G (Switzerland)	M ⁽¹⁾ (Japan)	G/FM (Switzerland)
Noise figure of converter (dB)	F	10	9	10	9
Radio-frequency signal-to-noise ratio at input to television receiver (dB)	$(S/N)_{RF}$	43 ⁽²⁾	40 ⁽³⁾	42	19 ⁽⁴⁾
Diameter of parabolic reflector (m)	D	0.6	0.6	0.4	0.6
Efficiency of antenna (%)	η	50	—	50	—
Miscellaneous losses in reception (misalignment etc.) (dB)	L	—	—	2	—
Antenna gain (dB rel. isotropic radiator)	G	34.5	34	31	34
Effective antenna area $10 \log a$ (a in m^2)	A	—8.5	—	—14	—
$10 \log kTB$ (dBW)	—	—137 ⁽⁵⁾	—	—136.2 ⁽⁶⁾	—
Minimum power flux-density (dB(W/m ²))	P	—75.5	—80	—70.2	—101

⁽¹⁾ Operational system.

⁽²⁾ $(S/N)_{RF}$ at the edge of the service area when using an antenna with a cosecant vertical pattern producing the same fieldstrength in the entire service area.

⁽³⁾ Corresponds to grade 4.5 of Recommendation 500.

⁽⁴⁾ $(S/N)_{RF}$ at receiver input; modulation index $m = 1$.

⁽⁵⁾ Noise bandwidth $B = 7$ MHz.

⁽⁶⁾ Noise bandwidth $B = 6$ MHz.

5. Effect of interference

In planning a terrestrial network, interference can be a factor which determines the required flux density of the wanted signal. Methods of calculating field strength or transmission loss which are of interest for assessing interference probabilities are indicated in Reports 562 and 569.

6. Effects of propagation

For the planning of a terrestrial broadcasting system in the 12 GHz band, losses due to diffraction by buildings are of particular importance; consideration may also have to be given to attenuation due to precipitation. Relevant information is given in Report 562.

During investigations in San Francisco using a 20 MHz bandwidth FM system [Bentz, 1982] very little diffraction around obstacles or penetration through obstacles — including foliage — was noted. However, in many cases of obstructed transmission paths, it was possible to use a reflection as a better source of the signal. Because of the highly directional beam of the receiving antenna, whether a horn or parabolic dish, it was possible to select a *single* reflection. For this reason multipath interference was rarely encountered. Rain attenuation was considerable, as indicated by long-term measurements at fixed locations, and would have to be taken into account in the system design in the form of adequate transmitter power. Based on the parameters of this specific test, satisfactory reception was reported at approximately 70% of the desired target area.

7. Frequency-sharing with the broadcasting-satellite service

Frequency-sharing between the broadcasting-satellite service (BSS) and terrestrial services is discussed in Report 631. Frequency-sharing between the BSS and the terrestrial television service in the 12 GHz band can be accomplished by operating terrestrial transmitters in those parts of the band not used by the BSS in the area where the transmitters are situated.

It is important from the viewpoint of spectrum utilization to know the factors affecting the required separation between the operating frequencies of both services. In Japan, field and laboratory tests were conducted using Japan's medium-scale broadcasting satellite for experimental purposes (BSE) and terrestrial broadcasting transmitters in the 12 GHz band. The tests have shown that even in the worst case there is a high probability that interference to reception of a broadcasting-satellite service from unwanted signals is not determined by intermodulation in the receiver but by its selectivity. The receivers used for the tests were of a type using a diode-mixer converter (see Report 473). Interference from the BSE to the terrestrial broadcasting service in a channel overlapping the BSE signal was not observed during the tests [CCIR, 1978-82b].

8. Operational system

In 1977, eighteen television channels in the frequency range 12.092 GHz to 12.2 GHz were assigned for terrestrial television services in Japan to improve reception in areas where signals in Bands III, IV and V are severely degraded by multi-path interference. The first operational translator station started service in an area of Tokyo in 1979. The station provides seven AM-VSB channels at a maximum e.i.r.p. of 6.7 W/channel. The maximum coverage distance from the transmitter is about 1 km, defined by a required power flux-density of $-70 \text{ dB(W/m}^2\text{)}$ [Momoura and Kikuchi, 1979].

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SECTION 11F: DIGITAL METHODS OF TRANSMITTING TELEVISION INFORMATION

Recommendations and Reports

RECOMMENDATION 601-1

ENCODING PARAMETERS OF DIGITAL TELEVISION FOR STUDIOS*

(Question 25/11, Study Programmes 25G/11, 25H/11)

(1982-1986)

The CCIR,

CONSIDERING

- (a) that there are clear advantages for television broadcasters and programme producers in digital studio standards which have the greatest number of significant parameter values common to 525-line and 625-line systems;
- (b) that a world-wide compatible digital approach will permit the development of equipment with many common features, permit operating economies and facilitate the international exchange of programmes;
- (c) that an extensible family of compatible digital coding standards is desirable. Members of such a family could correspond to different quality levels, facilitate additional processing required by present production techniques, and cater for future needs;
- (d) that a system based on the coding of components is able to meet some, and perhaps all, of these desirable objectives;
- (e) that the co-siting of samples representing luminance and colour-difference signals (or, if used, the red, green and blue signals) facilitates the processing of digital component signals, required by present production techniques,

UNANIMOUSLY RECOMMENDS

that the following be used as a basis for digital coding standards for television studios in countries using the 525-line system as well as in those using the 625-line system:

1. Component coding

The digital coding should be based on the use of one luminance and two colour-difference signals (or, if used, the red, green and blue signals).

The spectral characteristics of the signals must be restricted to eliminate aliasing. When using one luminance and two colour-difference signals as defined in Table I, this can be achieved by using filters as defined in Annex III, Figs. 1 and 2. When using E'_R , E'_G , E'_B signals or luminance and colour-difference signals as defined in Table II of Annex I, the characteristics defined by Fig. 1 of Annex III will apply.

Note. — The values shown for the luminance filter, used when sampling at 13.5 MHz, given in Fig. 1 of Annex III should be considered as provisional. Administrations are requested to perform urgent studies to confirm these values.

2. Extensible family of compatible digital coding standards

The digital coding should allow the establishment and evolution of an extensible family of compatible digital coding standards.

It should be possible to interface simply between any two members of the family.

The member of the family to be used for the standard digital interface between main digital studio equipment, and for international programme exchange (i.e. for the interface with video recording equipment and for the interface with the transmission system) should be that in which the luminance and colour-difference sampling frequencies are related in the ratio 4 : 2 : 2.

* Main digital television terms used in the Recommendation are defined in Report 629.

In a possible higher member of the family the sampling frequencies of the luminance and colour-difference signals (or, if used, the red, green and blue signals) could be related by the ratio 4 : 4 : 4. Tentative specifications for the 4 : 4 : 4 member are included in Annex I (see Note).

Note. — Administrations are urgently requested to conduct further studies in order to specify parameters of the digital standards for other members of the family. Priority should be accorded to the members of the family below 4 : 2 : 2. The number of additional standards specified should be kept to a minimum.

3. Specifications applicable to any member of the family

3.1 Sampling structures should be spatially static. This is the case, for example, for the orthogonal sampling structure specified in § 4 of the present Recommendation for the 4 : 2 : 2 member of the family.

3.2 If the samples represent luminance and two simultaneous colour-difference signals, each pair of colour-difference samples should be spatially co-sited. If samples representing red, green and blue signals are used they should be co-sited.

3.3 The digital standard adopted for each member of the family should permit world-wide acceptance and application in operation; one condition to achieve this goal is that, for each member of the family, the number of samples per line specified for 525-line and 625-line systems shall be compatible (preferably the same number of samples per line).

4. Encoding parameter values for the 4 : 2 : 2 member of the family

The following specification (Table I) applies to the 4 : 2 : 2 member of the family, to be used for the standard digital interface between main digital studio equipment and for international programme exchange.

TABLE I — Encoding parameter values for the 4:2:2 member of the family

Parameters	525-line, 60 field/s ⁽¹⁾ systems	625-line, 50 field/s ⁽¹⁾ systems
1. Coded signals: Y , C_R , C_B	These signals are obtained from gamma pre-corrected signals, namely: E'_Y , $E'_R - E'_Y$, $E'_B - E'_Y$ (Annex II, § 2 refers)	
2. Number of samples per total line: — luminance signal (Y) — each colour-difference signal (C_R , C_B)	858 429	864 432
3. Sampling structure	Orthogonal, line, field and frame repetitive. C_R and C_B samples co-sited with odd (1st, 3rd, 5th, etc.) Y samples in each line	
4. Sampling frequency: — luminance signal — each colour-difference signal	13.5 MHz ⁽²⁾ 6.75 MHz ⁽²⁾ The tolerance for the sampling frequencies should coincide with the tolerance for the line frequency of the relevant colour television standard	
5. Form of coding	Uniformly quantized PCM, 8 bits per sample, for the luminance signal and each colour-difference signal	
6. Number of samples per digital active line: — luminance signal — each colour-difference signal	720 360	
7. Analogue-to-digital horizontal timing relationship: — from end of digital active line to 0_H	16 luminance clock periods	12 luminance clock periods
8. Correspondence between video signal levels and quantization levels: — scale — luminance signal — each colour-difference signal	0 to 255 220 quantization levels with the black level corresponding to level 16 and the peak white level corresponding to level 235. The signal level may occasionally excursion beyond level 235 225 quantization levels in the centre part of the quantization scale with zero signal corresponding to level 128	
9. Code-word usage	Code-words corresponding to quantization levels 0 and 255 are used exclusively for synchronization. Levels 1 to 254 are available for video	

⁽¹⁾ See Report 624, Table I.⁽²⁾ The sampling frequencies of 13.5 MHz (luminance) and 6.75 MHz (colour-difference) are integer multiples of 2.25 MHz, the lowest common multiple of the line frequencies in 525/60 and 625/50 systems, resulting in a static orthogonal sampling pattern for both.

ANNEX I

TENTATIVE SPECIFICATION OF THE 4:4:4 MEMBER OF THE FAMILY

This Annex provides for information purposes a tentative specification for the 4:4:4 member of the family of digital coding standards.

The following specification could apply to the 4:4:4 member of the family suitable for television source equipment and high quality video signal processing applications.

TABLE II — *A tentative specification for the 4:4:4 member of the family*

Parameters	525-line, 60 field/s systems	625-line, 50 field/s systems
1. Coded signals: Y , C_R , C_B or R , G , B	These signals are obtained from gamma pre-corrected signals, namely: E'_Y , $E'_R - E'_Y$, $E'_B - E'_Y$ or E'_R , E'_G , E'_B	
2. Number of samples per total line for each signal	858	864
3. Sampling structure	Orthogonal, line, field and frame repetitive. The three sampling structures to be coincident and coincident also with the luminance sampling structure of the 4:2:2 member	
4. Sampling frequency for each signal	13.5 MHz	
5. Form of coding	Uniformly quantized PCM. At least 8 bits per sample	
6. Duration of the digital active line expressed in number of samples	At least 720	
7. Correspondence between video signal levels and the 8 most significant bits (MBS) of the quantization level for each sample: — scale — R , G , B or luminance signal ⁽¹⁾ — each colour-difference signal ⁽¹⁾	0 to 255 220 quantization levels with the black level corresponding to level 16 and the peak with level corresponding to level 235. The signal level may occasionally excursion beyond level 235 225 quantization levels in the centre part of the quantization scale with zero signal corresponding to level 128	

⁽¹⁾ If used.

ANNEX II

DEFINITION OF SIGNALS USED IN THE DIGITAL CODING STANDARDS

1. Relationship of digital active line to analogue sync. reference

The relationship between 720 digital active line luminance samples and the analogue synchronizing references for 625-line and 525-line systems is shown below.

TABLE III

525-line, 60 field/s systems	122 T	720 T	16 T	
0_H (leading edge of line syncs., half-amplitude reference)		Digital active-line period	0_H	Next line
625-line, 50 field/s systems	132 T	720 T	12 T	

T : one luminance sampling clock period (74 ns nominal).

The respective numbers of colour-difference samples can be obtained by dividing the number of luminance samples by two. The (12, 132) and (16, 122) were chosen symmetrically to dispose the digital active line about the permitted variations. They do not form part of the digital line specification and relate only to the analogue interface.

2. Definition of the digital signals Y , C_R , C_B , from the primary (analogue) signals E'_R , E'_G and E'_B

This section describes, with a view to defining the signals Y , C_R , C_B , the rules for construction of these signals from the primary analogue signals E'_R , E'_G and E'_B . The signals are constructed by following the three stages described in § 2.1, 2.2 and 2.3 below. The method is given as an example, and in practice other methods of construction from these primary signals or other analogue or digital signals may produce identical results. An example is given in § 2.4.

2.1 Construction of luminance (E'_Y) and colour-difference ($E'_R - E'_Y$) and ($E'_B - E'_Y$) signals

The construction of luminance and colour-difference signals is as follows:

$$E'_Y = 0.299E'_R + 0.587E'_G + 0.114E'_B \quad (\text{See Note})$$

whence:

$$\begin{aligned} (E'_R - E'_Y) &= E'_R - 0.299E'_R - 0.587E'_G - 0.114E'_B \\ &= 0.701E'_R - 0.587E'_G - 0.114E'_B \end{aligned}$$

and:

$$\begin{aligned} (E'_B - E'_Y) &= E'_B - 0.299E'_R - 0.587E'_G - 0.114E'_B \\ &= -0.299E'_R - 0.587E'_G + 0.886E'_B \end{aligned}$$

Note. — Report 624 Table II refers.

Taking the signal values as normalized to unity (e.g., 1.0 V maximum levels), the values obtained for white, black and the saturated primary and complementary colours are as follows:

TABLE IV

Condition	E'_R	E'_G	E'_B	E'_Y	$E'_R - E'_Y$	$E'_B - E'_Y$
White	1.0	1.0	1.0	1.0	0	0
Black	0	0	0	0	0	0
Red	1.0	0	0	0.299	0.701	-0.299
Green	0	1.0	0	0.587	-0.587	-0.587
Blue	0	0	1.0	0.114	-0.114	0.886
Yellow	1.0	1.0	0	0.886	0.114	-0.886
Cyan	0	1.0	1.0	0.701	-0.701	0.299
Magenta	1.0	0	1.0	0.413	0.587	0.587

2.2 Construction of re-normalized colour-difference signals (E'_{C_R} and E'_{C_B})

Whilst the values for E'_Y have a range of 1.0 to 0, those for $(E'_R - E'_Y)$ have a range of +0.701 to -0.701 and for $(E'_B - E'_Y)$ a range of +0.886 to -0.886. To restore the signal excursion of the colour-difference signals to unity (i.e. +0.5 to -0.5), coefficients can be calculated as follows:

$$K_R = \frac{0.5}{0.701} = 0.713; K_B = \frac{0.5}{0.886} = 0.564$$

Then:

$$E'_{C_R} = 0.713 (E'_R - E'_Y) = 0.500E'_R - 0.419E'_G - 0.081E'_B$$

and:

$$E'_{C_B} = 0.564 (E'_B - E'_Y) = -0.169E'_R - 0.331E'_G + 0.500E'_B$$

where E'_{C_R} and E'_{C_B} are the re-normalized red and blue colour-difference signals respectively (see Notes 1 and 2).

Note 1. — The symbols E'_{C_R} and E'_{C_B} will be used only to designate re-normalized colour-difference signals, i.e. having the same nominal peak-to-peak amplitude as the luminance signal E'_Y , thus selected as the reference amplitude.

Note 2. — In the circumstances when the component signals are not normalized to a range of 1 to 0, for example, when converting from analogue component signals with unequal luminance and colour-difference amplitudes, an additional gain factor will be necessary and the gain factors K_R , K_B should be modified accordingly.

2.3 Quantization

In the case of a uniformly-quantized 8-bit binary encoding, 2^8 , i.e. 256, equally spaced quantization levels are specified, so that the range of the binary numbers available is from 0000 0000 to 1111 1111 (00 to FF in hexadecimal notation), the equivalent decimal numbers being 0 to 255, inclusive.

In the case of the 4:2:2 system described in this Recommendation, levels 0 and 255 are reserved for synchronization data, while levels 1 to 254 are available for video.

Given that the luminance signal is to occupy only 220 levels, to provide working margins, and that black is to be at level 16, the decimal value of the luminance signal, $\bar{Y}$, prior to quantization, is:

$$\bar{Y} = 219 (E'_Y) + 16,$$

and the corresponding level number after quantization is the nearest integer value.

Similarly, given that the colour-difference signals are to occupy 225 levels and that the zero level is to be level 128, the decimal values of the colour-difference signals, $\bar{C}_R$ and $\bar{C}_B$, prior to quantization are:

$$\bar{C}_R = 224 [0.713 (E'_R - E'_Y)] + 128$$

and:

$$\bar{C}_B = 224 [0.564 (E'_B - E'_Y)] + 128$$

which simplify to the following:

$$\bar{C}_R = 160 (E'_R - E'_Y) + 128$$

and:

$$\bar{C}_B = 126 (E'_B - E'_Y) + 128$$

and the corresponding level number, after quantization, is the nearest integer value.

The digital equivalents are termed Y , C_R and C_B .

2.4 Construction of Y , C_R , C_B via quantization of E'_R , E'_G , E'_B

In the case where the components are derived directly from the gamma pre-corrected component signals E'_R , E'_G , E'_B , or directly generated in digital form, then the quantization and encoding shall be equivalent to:

$$E'_{R_d} \text{ (in digital form)} = \text{int} (219 E'_R) + 16$$

$$E'_{G_d} \text{ (in digital form)} = \text{int} (219 E'_G) + 16$$

$$E'_{B_d} \text{ (in digital form)} = \text{int} (219 E'_B) + 16$$

Then:

$$Y = \frac{77}{256} E'_{R_d} + \frac{150}{256} E'_{G_d} + \frac{29}{256} E'_{B_d}$$

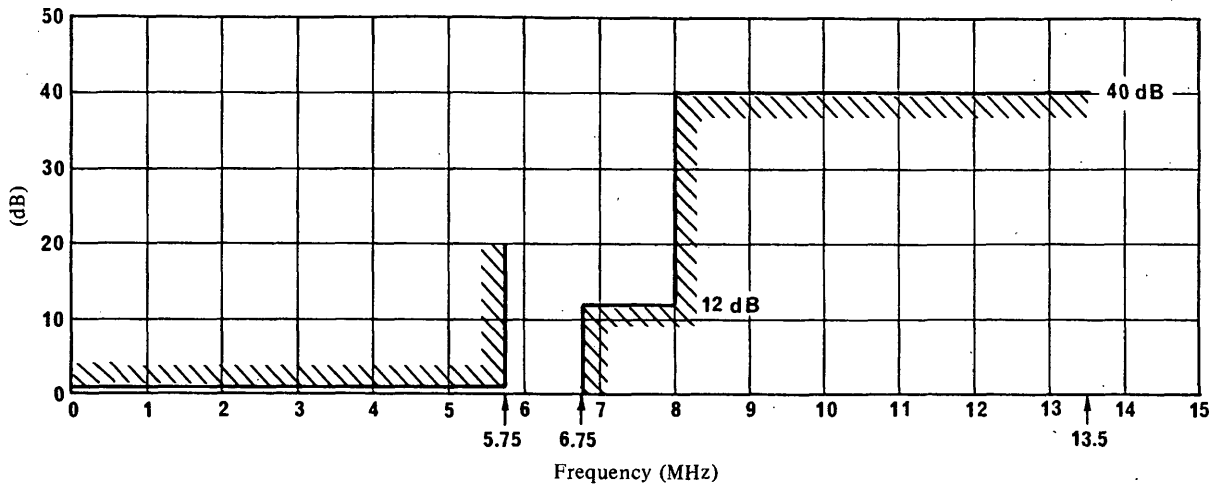
$$C_R = \frac{131}{256} E'_{R_d} - \frac{110}{256} E'_{G_d} - \frac{21}{256} E'_{B_d} + 128$$

$$C_B = -\frac{44}{256} E'_{R_d} - \frac{87}{256} E'_{G_d} + \frac{131}{256} E'_{B_d} + 128$$

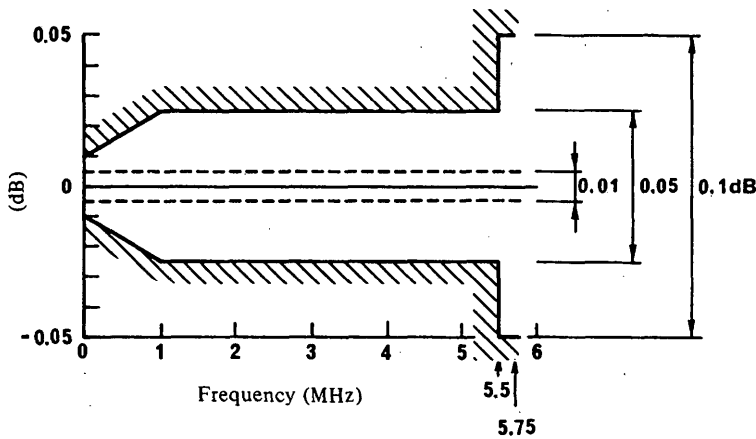
taking the nearest integer coefficients, base 256. To obtain the 4:2:2 components Y , C_R , C_B , low-pass filtering and sub-sampling must be performed on the 4:4:4 C_R , C_B signals described above. Note should be taken that slight differences could exist between C_R , C_B components derived in this way and those derived by analogue filtering prior to sampling.

ANNEX III

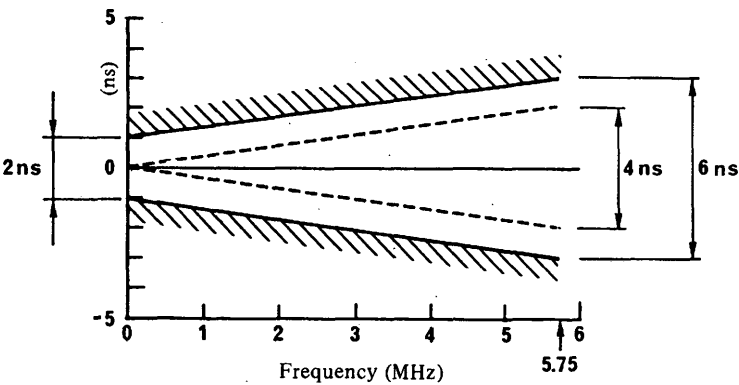
FILTERING CHARACTERISTICS



a) Template for insertion loss/frequency characteristic



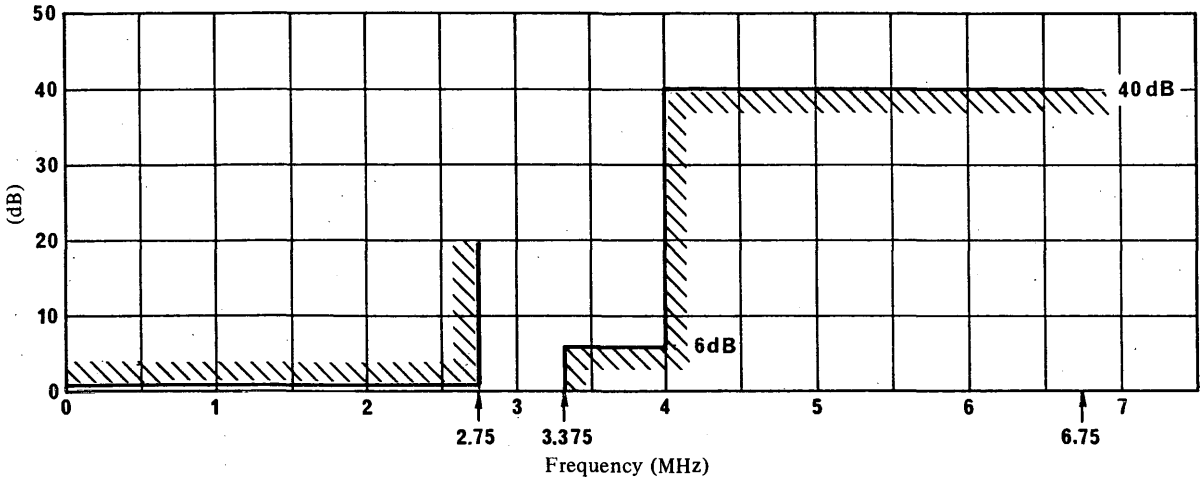
b) Passband ripple tolerance



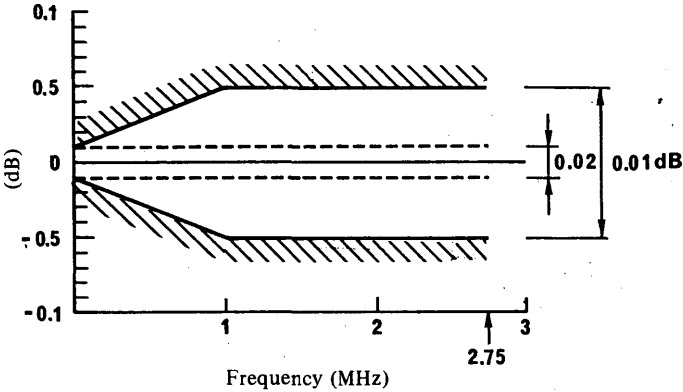
c) Passband group-delay tolerance

FIGURE 1 – Specification for a luminance or RGB signal filter used when sampling at 13.5 MHz

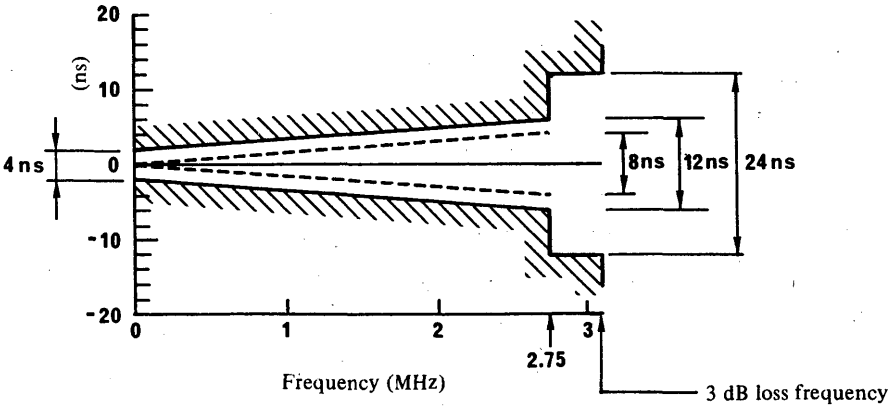
Note. – The lowest indicated values in b) and c) are for 1 kHz (instead of 0 MHz).



a) Template for insertion loss/frequency characteristic



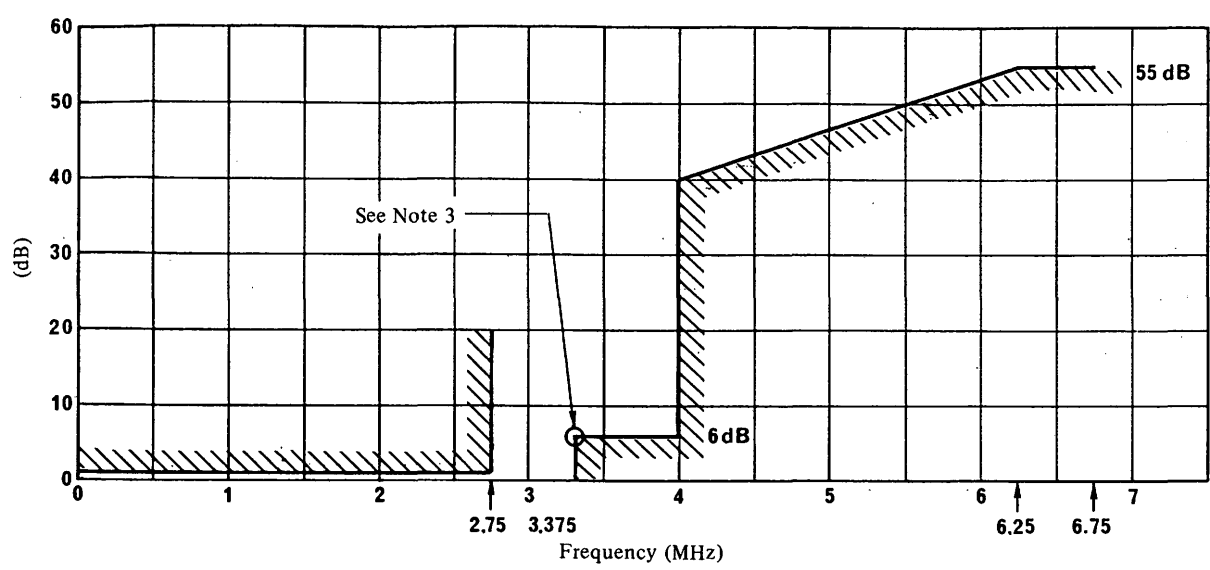
b) Passband ripple tolerance



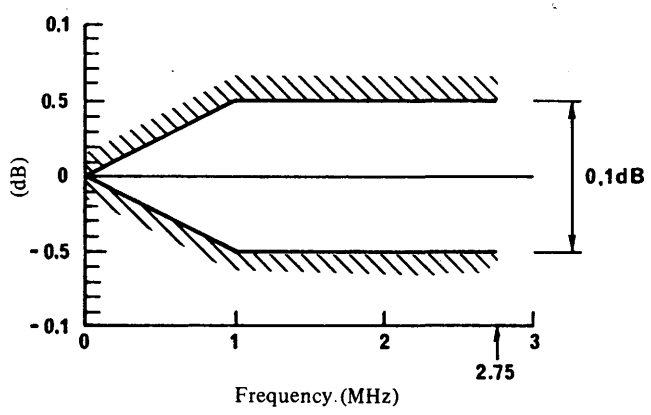
c) Passband group-delay tolerance

FIGURE 2 – Specification for a colour-difference signal filter used when sampling at 6.75 MHz

Note. – The lowest indicated values in b) and c) are for 1 kHz (instead of 0 MHz).



a) Template for insertion loss/frequency characteristic



b) Passband ripple tolerance

FIGURE 3 – Specification for a digital filter for sampling-rate conversion from 4 : 4 : 4 to 4 : 2 : 2 colour-difference signals

Notes to Figs. 1, 2 and 3:

- Note 1.* – Ripple and group delay are specified relative to their values at 1 kHz. The full lines are practical limits and the dashed lines give suggested limits for the theoretical design.
- Note 2.* – In the digital filter, the practical and design limits are the same. The delay distortion is zero, by design.
- Note 3.* – In the digital filter (Fig. 3), the amplitude/frequency characteristic (on linear scales) should be skew-symmetrical about the half-amplitude point, which is indicated on the figure.
- Note 4.* – In the proposals for the filters used in the encoding and decoding processes, it has been assumed that, in the post-filters which follow digital-to-analogue conversion, correction for the $(\sin x/x)$ characteristic of the sample-and-hold circuits is provided.

REPORT 629-3

DIGITAL CODING OF COLOUR TELEVISION SIGNALS

(Question 25/11, Study Programmes 18L/11, 25G/11, 25L/11 and 25M/11)

(1974-1978-1982-1986)

1. Introduction

Study Group 11 has brought together, during the study period 1982-1986 and previously, a large amount of information concerning the coding, processing, transmission and recording of picture signals in digital component form in the studio. This work has resulted in Recommendation 601 concerning the encoding of the digital video signal for studio production, and Recommendation 656 concerning studio interfaces for the digital video signal.

Additionally, this work has been taken into account in the Recommendation for the digital recording format (Recommendation 657) and the studies by Study Group 11 on bit-rate reduction (Report 1089) and the CMTT studies concerning the transmission of picture signals.

This Report summarizes the work on coding methods for signals within the studio complex, derived from both analogue and digital sources, and provides the basis for Recommendation 601 concerning the encoding parameters of the digital television signal in the studio. This is complimented by Report 962 which concerns the filtering, sampling, and multiplexing of digital signals.

2. Basic principles

Two different approaches to the coding problem have been proposed:

- *component coding*: in this approach the luminance and colour difference signal components are digitally coded separately and transmitted as separate bit streams, time-multiplexed together. When the colour television signal exists in the composite NTSC, PAL or SECAM form, it will be necessary first to separate the signal into its luminance and colour difference components;
- *composite coding*: in this method the composite colour signal is coded in its composite form as a single bit stream.

The first method has advantages over the second because, in the future, it will be possible for the signal to be transmitted in digital form, from the source to the broadcasting transmitter. Only at the broadcasting transmitter will it be necessary to generate the composite signal. Thus, at least for transmission purposes, the differences between NTSC, PAL and SECAM would disappear with a consequent simplification of the problems of the international exchange of programmes [CCIR, 1974-78a], except when different scanning standards are involved. (International programme exchange refers to the provision of the interface required for video tape recording equipment and of the interface with transmission equipment.) The second method is claimed to have advantages when, as is likely to happen during the period in which digital techniques are being introduced into broadcasting, the complete chain contains several digital and analogue sections in cascade.

Most administrations now agree that there would be considerable advantages in using component coding for studio standards. The reasons for this are as follows:

- recent technological developments, particularly in the fields of semiconductor storage and magnetic recording have opened up new and attractive possibilities in electronic picture processing and special effects. Such facilities have only been available in the past using expensive film techniques [CCIR, 1978-82a];
- component coding offers a uniform world standard, with the exception of field rate. Such a standard has the greatest number of significant parameter values common to 525-line and 625-line systems. It allows equipment and operation to have the maximum number of common features, a situation which is not achievable with analogue or composite digital standards. Except for field rate (which could be switchable), studios throughout the world would use many items of common equipment and programme production and exchange would be much simplified.

In determining the bit rate reduction method that might be used at the studio, prior to interconnection to any long-distance transmission facilities, it is important to take account of the digital hierarchies being standardized by the CCITT [CCIR, 1974-78b].

In [CCIR, 1978-82b], the EBU has proposed that, to facilitate international exchange of programmes, a signal based upon the separate coding of luminance and colour-difference signals should be used. Studies conducted by the EBU have clearly demonstrated the value of digital coding in avoiding some of the limitations associated with PAL and SECAM systems and indicate the feasibility of a universally compatible digital standard [CCIR, 1978-82c]. Considerations such as this, combined with similar proposals from other administrations, resulted in Recommendation 601 which suggests that the use of component coding is to be preferred for all studio and international exchange purposes.

3. Coding methods

The initial processes in all digital coding methods which are under study are sampling and quantizing.

3.1 *Bandwidths and sampling*

The sampling process is determined by three basic factors:

- the sampling structure, i.e. the relative position of the samples in space and time;
- the number of samples per line;
- the filtering process, which may be one-, two-, or three-dimensional.

The sampling structure mentioned above may, or may not, be repetitive with respect to the picture. Likewise, the number of samples per line may, or may not, be constant from line to line.

The classical theory requires the sampling frequency to be equal to or greater than, twice the highest signal frequency, i.e. Nyquist sampling. However, studies have shown that lower sampling frequencies (i.e. sub-Nyquist sampling) can be used in practice [Messerschmid, 1969].

3.1.1 *For component signals*

The EBU [CCIR, 1974-78c] has suggested that those countries digitally coding the separate components should use a sampling structure repetitive from picture to picture. This approach is supported by [CCIR, 1974-78d]. Repetitive sampling structures may be either orthogonal [CCIR, 1974-78e] or interleaved.

Report 962 describes in some detail the work leading to the choice of sampling parameters listed in Recommendation 601 as the basis for a studio code and so only a brief summary is required here.

A number of sampling frequencies for the luminance signal of the 4:2:2 level were studied by administrations, in particular 12 MHz, 12.5 MHz, 13 MHz, 13.5 MHz and 14.3 MHz. The factors studied, which would have a potential bearing on the choice of sampling frequency, included basic picture quality, picture quality after processing, cost-performance relations, potential capacity of digital VTRs, bit-rate reduction to transmission hierarchy levels and compatibility with composite signals and composite coding.

During the course of their studies, some administrations saw advantages in choosing a sampling frequency related to their composite signal colour sub-carrier frequency, because this could be advantageous in a mixed use of component and composite coding nationally. However, they considered that the benefits of a world-wide unification of sampling-frequency might alter the balance of advantages in favour of the agreed value.

A luminance sampling frequency of 13.5 MHz was adopted for a world-wide standard. It is a compromise between, on the one hand, the need to choose values which allow practically realizable and economic equipment and, on the other, the need to allow a sufficient degree of picture processing. Also, this frequency is the only one in the range of 12 to 14.3 MHz that permits an integer number of samples per lines for both the 525 and the 625 line systems [CCIR, 1978-82d, e, f, g, h, i and j]. The sampling frequency applied to the colour-difference signals was set at half that applied to the luminance signal after checking that this would allow adequate quality in chroma-key (colour matte) processing. The digital interface for studio equipment is discussed in Report 1088 entitled "Interfaces for digital video signals in 525-line and 625-line television systems".

It was anticipated that present and envisaged applications of television are unlikely to be covered by a single set of digital parameters. *An extensible family of compatible digital coding standards* corresponding to different applications was therefore proposed [CCIR, 1978-82k, l and m].

The members of the family are denoted by a sequence of integer numbers such as 4:2:2 or 4:4:4. These numbers represent the relation of the sampling frequency for the luminance signal (first number) to the sampling frequencies for the colour difference signals (subsequent numbers). The convention adopted is that the number 4 represents the main sampling rate of 13.5 MHz (nominal). Thus, for example, the 4:2:2 member of the family is characterized by 13.5 and 6.75 MHz sampling frequencies for the luminance and the colour difference signals respectively as defined in Recommendation 601.

One possible set of such standards is considered in [CCIR, 1978-82m] as corresponding to the following levels:

- a studio standard;
- a lower standard using the same scanning parameters but resulting in lower bit rates and costs, suitable for lower quality applications;
- a higher quality standard having a capability beyond that provided by present scanning standards.

In [CCIR, 1978-82n] it is suggested that an internationally compatible digital code would be a component code incorporating line-locked (orthogonal) sampling, an identical number of samples per line for both the 525- and 625-line systems and membership in an extensible family of compatible digital codes having simply related sampling frequencies. The definition of preferred sampling frequencies should be the subject of further studies.

Subjective assessments of an extensible family of component coded digital television systems were performed during 1980 and 1981 by the EBU [CCIR, 1978-82d and f], the SMPTE [CCIR, 1978-82g], and by NHK in Japan [CCIR, 1978-82o; Nishizawa *et al.*, 1981]. The tests included the binary derived family members 4:4:4, 4:2:2 and 4:1:1 with luminance sampling frequencies ranging from 12 MHz to 14.3 MHz. The results of all these tests were consistent and tended to verify the 4:2:2 member as the preferred selection for the standard studio interface and verified the choice of a sampling frequency of 13.5 MHz as an appropriate compromise between acceptable picture quality after processing and bit-rate requirements. This is also supported by [CCIR, 1978-82e].

[CCIR, 1978-82k] presents a description of an extensible family of compatible digital codes which is based upon a component code bearing the ratios of sampling rates of 4:1:1 (luminance to colour-difference). Such codes would be easily transcodable to an NTSC composite digital interface code and the family could be readily extensible upward to be suitable for higher definition television when advances in technology warrant it. Also, the family of codes is extensible downward to lower definition interface codes for special applications, e.g. electronic news gathering.

[CCIR, 1978-82p] suggests design criteria and a possible application for a lower level within an extensible family of compatible digital codes. System parameters and test results are given for an experimental codec operating at half of the bit rate of the main studio standard. This system features non-binary relationship between luminance sampling frequencies of related levels and a 3:1 relationship between sampling frequencies of luminance and line sequentially encoded colour difference signals. [CCIR, 1982-86a] describes a subjective evaluation, using static text pictures of a number of possible lower level standards, including the effects of line- and field-offset sub-sampling and of line sequential processing of the colour-difference signals. [CCIR, 1982-86b] contains a theoretical study of the picture distortion encountered when using line sequential transmission of colour-difference signals with a cycle of two fields.

Rossi [1981] describes a set of digital filters adapted for a binary family, that accomplishes a two-to-one sampling rate down conversion, a one-to-two sampling rate up conversion, by comb filter interpolation.

There are equipment advantages for members of a family to have compatible numbers of samples per line. The members of the digital family should be chosen having regard to other possible television signal representations, in order to limit the number and complexity of transcoding operations in the signal chain. [CCIR, 1982-86c] lists some of the representations that have been proposed.

The nominal durations of the active-lines for 525/60 and 625/50 systems are slightly different. To bring the two systems together in the digital component domain, a "digital active line" (DAL) is defined. This has sufficient digital samples to cover either the 525/60 or 625/50 active lines. There are obvious advantages in that both systems now need precisely the same amount of digital line storage, and the DAL can be processed in exactly the same way for either the 525 or 625 line systems. The number of samples associated with analogue blanking is different, but this need not be carried through into the digital component domain. Blanking appropriate to the national broadcasting standard should be applied at the point where the signal is converted to analogue.

The 525 active line is the longer of the two, and with the tolerances currently in practical use, more than 710 samples are needed to cover a line. The 720 samples per digital active line given in Recommendation 601 was chosen because it conveniently meets this requirement.

Definition of luminance (E'_Y) and colour-difference ($E'_R - E'_Y$) and ($E'_B - E'_Y$) signals

A proposal for the construction of luminance and colour difference signals forms part of Recommendation 601 as follows:

$$E'_Y = 0.299 E'_R + 0.587 E'_G + 0.114 E'_B \quad (\text{See Note})$$

whence

$$\begin{aligned} (E'_R - E'_Y) &= E'_R - 0.299 E'_R - 0.587 E'_G - 0.114 E'_B \\ &= 0.701 E'_R - 0.587 E'_G - 0.114 E'_B \end{aligned}$$

and

$$\begin{aligned} (E'_B - E'_Y) &= E'_B - 0.299 E'_R - 0.587 E'_G - 0.114 E'_B \\ &= -0.299 E'_R - 0.587 E'_G + 0.886 E'_B \end{aligned}$$

Note. — Report 624 Table II refers.

Taking the signal values as normalized to unity (e.g., 1.0 V maximum levels), the values obtained for white, black and the saturated primary and complementary colours are as follows:

TABLE I

Condition	E'_R	E'_G	E'_B	E'_Y	$E'_R - E'_Y$	$E'_B - E'_Y$
White	1.0	1.0	1.0	1.0	0	0
Black	0	0	0	0	0	0
Red	1.0	0	0	0.299	0.701	-0.299
Green	0	1.0	0	0.587	-0.587	-0.587
Blue	0	0	1.0	0.114	-0.114	0.886
Yellow	1.0	1.0	0	0.886	0.114	-0.886
Cyan	0	1.0	1.0	0.701	-0.701	0.299
Magenta	1.0	0	1.0	0.413	0.587	0.587

While the values for E'_Y have a range of 1.0 to 0, those for $(E'_R - E'_Y)$ have a range of +0.701 to -0.701 and for $(E'_B - E'_Y)$ a range of +0.886 to -0.886. To restore the signal excursion of the colour-difference signals to unity (i.e. +0.5 to -0.5), coefficients can be calculated as follows:

$$K_R = \frac{0.5}{0.701} = 0.713; K_B = \frac{0.5}{0.886} = 0.564;$$

Then

$$E'_{C_R} = 0.713 (E'_R - E'_Y) = 0.500 E'_R - 0.419 E'_G - 0.081 E'_B$$

and

$$E'_{C_B} = 0.564 (E'_B - E'_Y) = -0.169 E'_R - 0.331 E'_G + 0.500 E'_B$$

where E'_{C_R} and E'_{C_B} are the re-normalized red and blue colour-difference signals respectively.

In the case of a uniformly-quantized 8-bit binary encoding, 2^8 , i.e. 256, equally spaced quantization levels are specified, so that the range of the binary numbers available is from 0000 0000 to 1111 1111 (00 to FF in hexadecimal notation), the equivalent decimal numbers being 0 to 255, inclusive.

In the case of the 4:2:2 system described in Recommendation 601, levels 0 and 255 are reserved for synchronizing data, while levels 1 to 254 are available for video.

Given that the luminance signal is to occupy only 220 levels, to provide working margins, and that black is to be at level 16, the decimal value of the luminance signal, $\bar{Y}$, prior to quantization, is:

$$\bar{Y} = 219 (E'_Y) + 16,$$

and the corresponding level number after quantization is the nearest integer value.

Similarly, given that the colour-difference signals are to occupy 225 levels and that the zero level is to be level 128, the decimal values of the colour-difference signals, $\bar{C}_R$ and $\bar{C}_B$, prior to quantization are:

$$\bar{C}_R = 224 [0.713 (E'_R - E'_Y)] + 128$$

and

$$\bar{C}_B = 224 [0.564 (E'_B - E'_Y)] + 128$$

which simplify to the following:

$$\bar{C}_R = 160 (E'_R - E'_Y) + 128$$

and

$$\bar{C}_B = 126 (E'_B - E'_Y) + 128$$

and the corresponding level number, after quantization, is the nearest integer value.

The digital equivalents are termed Y , C_R and C_B .

It has been pointed out in [CCIR, 1982-86d] that further consideration of the relationship between analogue video levels and quantization levels may be necessary in the light of current operational margin requirements.

Note. — The quantization and encoding for the construction of Y , C_R , C_B from signals other than luminance and colour difference signals are considered in § 2.4 of Annex II to Recommendation 601.

3.1.2 For composite signals

The sub-Nyquist technique can be applied by sampling the PAL composite signal at a rate of twice the sub-carrier frequency [Devereux and Phillips, 1974]. The digital codec employing such sampling uses filtering which introduces minor losses of diagonal luminance resolution and vertical chrominance resolution. However, further filtering of this nature in any subsequent sub-Nyquist sampling process should not cause any further resolution impairment [Stott and Phillips, 1977].

For system M/NTSC there is a tendency to use a sampling frequency of three or four times the colour sub-carrier frequency. However, [CCIR, 1974-78f] describes studies of a coding system which uses a sampling frequency that is an integer multiple of line frequency. The sub-Nyquist sampling technique has also been used with NTSC signals [Rossi, 1976].

Patel [1980] describes the effects of low-pass filtering on the analogue composite signal of system I/PAL. It is concluded that chrominance ringing is dominant and that improved delay correction can mitigate the resulting impairment.

3.1.3 Compatibility between composite and component signals

In [CCIR, 1974-78c] the EBU draws attention to the need for compatibility between the proposed methods for composite and component coding of 625-line signals.

EBU experiments [CCIR, 1978-82b] have shown that good quality analogue PAL to digital YUV coding and decoding, when using line-locked sampling, can be achieved provided a sophisticated codec is used.

3.1.4 *Change of sampling frequency*

Within a given system (using either composite or component coding) it may be necessary to change the sampling frequency.

A method is described in [CCIR, 1974-78g] which may be used with system M/NTSC for changing the sampling frequency from 4 to 3 times the NTSC sub-carrier frequency and vice versa.

In [CCIR, 1974-78h], which proposes the possible use of two sampling frequencies in the digital PAL studio, it is pointed out that a signal sampled at $4 f_{sc}$ may be very easily converted to a signal sampled at $2 f_{sc}$ and vice versa. However, when the sampling frequency is changed from $2 f_{sc}$ back to $4 f_{sc}$ the minor impairments associated with $2 f_{sc}$ sampling remain; nevertheless, the effect upon resolution is not cumulative.

3.1.5 *Sampling frequency tolerance*

The sampling frequencies used should comply with the requirements of associated television systems. In particular the tolerance for component signal sampling frequencies should be equal to that for line frequency in the relevant colour television standard [CCIR, 1982-86e, f].

3.2 *Linear PCM*

The basic form of digital coding is linear PCM, where the value of each digital "word" represents the uniformly quantized amplitude of a sample of the baseband signal [CCIR, 1970-74a and b].

Preliminary results of an experiment using 7 PCM codecs in cascade when coding NTSC composite signals are presented in [CCIR, 1974-78i].

[CCIR, 1978-82q] describes experiments to determine the picture impairments introduced when up to 10 codecs are used. Composite NTSC signals were coded using various numbers of bits per sample and sample frequencies of $3 f_{sc}$ and $4 f_{sc}$. The signal-to-noise ratio of the source was high.

A study on PCM codecs using 8 bits per sample [CCIR, 1982-86g; Devereux, 1983] draws attention to the importance of the performance of both the basic coder/decoder and associated circuitry in determining the performance of a cascaded chain of codecs. Of particular importance are: pre- and post-filters; blanking-level stabilization; quantization distortion, particularly on signals with high rate-of-rise (or fall); timing jitter on clock pulses; line-time non-linearity. In a well-designed codec where the foregoing have been taken into account, quantization noise is likely to be the dominant impairment, and this is shown to be about 2 dB worse than theoretical in the codecs tested. A cascaded connection of 8 codecs is shown to increase the quantization noise by approximately the expected 9 dB.

4. *Measurements*

In general the picture impairments introduced in digital television systems are quite different from those introduced in analogue systems. Impairments may be caused by the coding equipments or by degradation of the digital signal, such as errors, jitter and slips. The former may be picture dependent.

4.1 *Subjective assessment*

At present subjective assessment is the only technique useful in practice for the evaluation of digital television systems and it is therefore important that the method used should be in accordance with Recommendation 500 and as suggested in Reports 313 and 405. Special attention should be paid to the choice of picture material. For example, in [CCIR, 1974-78j], the use of pictures involving either linear or rotational movement is proposed. This document also suggests that slow periodic fluctuations in picture signal amplitude may be useful.

For subjective assessment of interfield or interframe coding methods (which are important for high-efficiency bit-rate reduction of digital television signals), moving test pictures are essential. [CCIR, 1982-86h] describes the factors to be considered in the preparation of such moving test pictures and presents an example set which consists of 26 moving scenes. Study for a standard set of such test pictures is encouraged under Study Programme 3A/11.

4.2 *Objective measurements*

Studies have been made to define objective parameters, measurements of which could be related to the subjective impairments [CCIR, 1974-78k; Kretz, 1977]. One approach consists of considering separately the various impairments which may affect different types of picture information (e.g. plain areas, contours, fine details). Recent studies [CCIR, 1978-82r] indicate that picture-quality impairments arising from digital transmission

can be classified into several categories of disturbance which are independent of each other in terms of their effects upon subjective picture quality. The physical terms to express the respective categories of disturbance for intraframe coding are defined and can be measured using well-known test signals such as the staircase and sawtooth signals. [CCIR, 1982-86i] shows a method for classifying picture quality impairments by using psychological factor analysis, in such cases where the classification procedure cannot take place *a priori*.

Combinations of analogue and digital equipments will continue to be employed in studios before all-digital studios come into operation. In this interim period the video signal will undergo a number of analogue-digital-analogue conversions. Each conversion in either direction is a potential source of picture impairments.

Present analogue test methods are suitable for many measurements of mixed analogue-digital-analogue signal paths in studios, but it is recognised that some measurements provide results which are made unreliable by digital signal processing.

New test signals to ease these difficulties have been proposed. [CCIR, 1974-78j] suggests the use of a sine-squared pulse of half-amplitude duration somewhat less than half the active line period, with superimposed colour sub-carrier, as a test signal for the measurement of quantization noise [Krivosheev, 1976].

[CCIR, 1974-78l] proposes a line-duration sawtooth signal with superimposed colour sub-carrier for the measurement of differential gain and differential phase.

In [CCIR 1978-82s] a method is suggested for the measurement of distortion introduced by digital processes wherein the processed signal in digital form is subtracted from the original signal also in digital form, thereby providing greater accuracy. Analysis can then be performed on either digital measuring equipments or existing analogue measuring equipments.

Weston [1982] describes a digital test-signal generator for testing equipments and systems using two and three-dimensional signal processing. It produces, *inter alia*, electronic zone plate test patterns which may be stationary (two dimensional) or moving (three-dimensional). The zone plate signals form a powerful diagnostic aid for studying the properties of such processes as spatial and temporal filtering, sub-sampling, interpolation etc., and for optimizing the algorithms used. As in other types of frequency-responses measurements, the results are most useful qualitatively; the quantitative results are difficult to relate to a subjective assessment using real pictures. Nevertheless, tests with zone plate patterns can be used distinctively to reveal particular impairment modes and thus critical real pictures.

5. Bibliography

In addition to the references explicitly cited in this Report, a Bibliography of several publications on the subject of digital television is appended. The referenced papers are not repeated in the Bibliography.

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[1974-78]: a. 11/64 (Japan); b. 11/354 (Japan); c. 11/374 (EBU); d. 11/354 (France); e. 11/317 (Japan); f. 11/314 (Japan); g. 11/329 (USA); h. 11/410 (United Kingdom); i. 11/331 (USA); j. 11/409 (USSR); k. 11/65 (France); l. 11/330 (USA).

[1978-82]: a. 11/36 (United Kingdom); b. 11/14 (EBU); c. 11/15 (EBU); d. 11/330 (EBU); e. 11/328 (USSR); f. 11/285 (EBU); g. 11/292 (USA); h. 11/339 (OIRT); i. 11/342 (Canada); j. 11/344 (Japan); k. 11/31 (USA); l. 11/16 (EBU); m. 11/114 (France); n. 11/33 (USA); o. 11/343 (Japan); p. 11/278 (Germany (Federal Republic of)); q. 11/80 (Japan); r. 11/87 (Japan); s. 11/248 (Japan).

[1982-86]: a. 11/22 (Japan); b. 11/90 (USSR); c. 11/81 (United Kingdom); d. 11/23 (Japan); e. 11/46 (EBU); f. 11/135 (OIRT); g. 11/65 (United Kingdom); h. 11/19 (Japan); i. 11/26 (Japan).

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REPORT 962-1

**THE FILTERING, SAMPLING AND MULTIPLEXING FOR DIGITAL ENCODING
OF COLOUR TELEVISION SIGNALS**

(Question 25/11, Study Programme 25H/11)

(1982-1986)

1. Introduction

Report 629 provides a brief introduction to the subjects of bandwidth and sampling as relevant to the process of encoding component signals into digital form.

In order to ensure that the total bit rate of the digital signal is not excessive, it is clearly necessary to determine the bandwidths of the luminance and colour-difference signals which are adequate to provide high-quality broadcasting signals (which may be in the analogue composite form). Further, when considering the filtering and sampling of component signals, it is also necessary to bear in mind that proposals have been made to use such signals in digital form for purposes which could be more demanding than conventional broadcasting (see § 2.3). In particular, attention must be paid to the constraints imposed by modern programme production techniques, taking into account the quality margin required by the increasing demand for picture-processing operations [Akrich and Zaccarian, 1981].

In choosing the sampling parameters to be used for component signals, the sampling frequencies are, clearly, closely related to the bandwidths of the component signals, but other parameters are concerned with the picture sampling structure or structures (see § 3).

The number of bits necessary to describe each sample is discussed in § 4.

In order to handle a single byte stream in the studio when component coding is used, time-multiplexing of the three byte streams is required. Some possible arrangements are discussed in § 5.

2. Bandwidths

This section is divided in three sub-sections, the two following sub-sections outline the results of subjective tests aimed at establishing the overall luminance and colour-difference signal bandwidths, respectively. The third sub-section discusses the implications with regard to these bandwidths, taking into account the needs of studio signal-processing operations.

2.1 Luminance-signal bandwidth

[CCIR, 1978-82a and b] give the results of tests by members of the EBU, to determine the relationship between subjective quality and the bandwidth of the luminance component, using a 625-line system and monochrome display. The tests were carried out using a method described in Report 405, using the impairment scale and pictures slightly more critical than average, as required by Recommendation 500.

The main conclusion indicates that bandwidth-limiting to 4.5 MHz (at -3 dB) using sharp cut off low-pass filtering introduces an impairment which is imperceptible to 50% of the observers at a viewing distance of four times the picture height (see Fig. 1a). The results indicate that the effects of filtering on electronically-generated captions are less critical than those on the pictures. These studies did not show the expected advantage for the use of a comb filter (with sub-Nyquist-sampling) when compared with a low pass filter cutting off at half the sampling frequency.

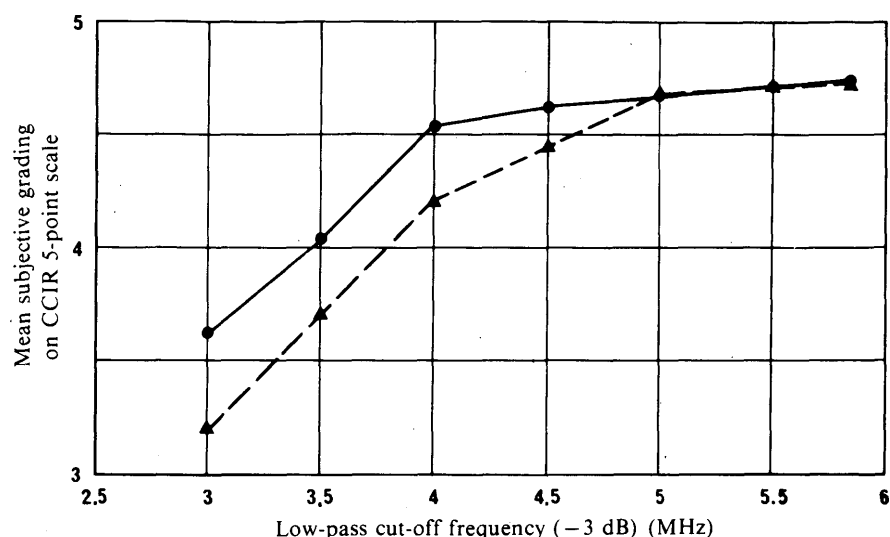


FIGURE 1a — Low-pass filtering.
Mean values of the results obtained in seven laboratories,
using 625-line test pictures

- viewers at a distance of six times picture height
- ▲— viewers at a distance of four times picture height

The subjective test results obtained in these EBU tests have been analyzed in accordance with the method described in Annex III of Report 405 and this work is described in [CCIR, 1978-82c]. The result of the analysis is presented in Fig. 1(b). The same document discusses the substantial effect of the choice of picture material and the large spread of the results which can occur when Recommendation 500 is not followed. It also expresses the view that an impairment criterion of $I = 0.05$ (corresponding to grade 4.8 in a five grade scale) is appropriate and that consequently the minimum bandwidth of the luminance signal should be 5.8 MHz.

Tests carried out in Poland, and described in [CCIR, 1978-82d] also indicate that the luminance-signal bandwidth should not be less than 4.5 MHz for 625-line systems.

[CCIR, 1978-82e] describes work by the U.S.S.R. which concludes that the appropriate bandwidth for the luminance signal is 6.0 MHz.

The relationship between picture quality and luminance-signal bandwidth, for 525-line systems, has been investigated in Japan [CCIR, 1978-82f]. Separate tests were carried out, using colour pictures, for two different values of colour-difference signals bandwidth; the filters used in the luminance and colour-difference channels were of the Thomson type (i.e. relatively slow cut-off). The results of the tests indicate that a luminance-signal bandwidth of 5.6 MHz is suitable.

2.2 Colour-difference signal bandwidth

Tests in Poland [CCIR, 1978-82d] indicate that, for 625-line systems, the bandwidth of each colour-difference signal should be not less than 1.5 MHz, a result which agrees with that given in [CCIR, 1978-82e] from the U.S.S.R.

The work described in [CCIR, 1978-82f] also included tests to determine the colour-difference signal bandwidth appropriate to 525-line systems. The relationship between picture quality and colour-difference signal bandwidth was determined by separate tests, using colour pictures, in which two different values of luminance-signal bandwidth were involved. From the results it is concluded that the colour-difference signal bandwidth should have a value of approximately 2.8 MHz (Fig. 2).

Experiments conducted in France [Sabatier and Sallio, 1981; Sabatier and Chatel, 1981] show very similar results for 625-line systems.

Investigations to establish the optimum characteristic for limiting the bandwidth of colour-difference signals are outlined in [CCIR, 1978-82g]. These studies, carried out in the Federal Republic of Germany, were made assuming that the maximum bandwidth available (the Nyquist limit) was 2.0 MHz.

Studies involving subjective tests have been made to determine the optimum characteristics for a filter, also with a bandwidth of 2.0 MHz; these studies are described in [CCIR, 1978-82h].

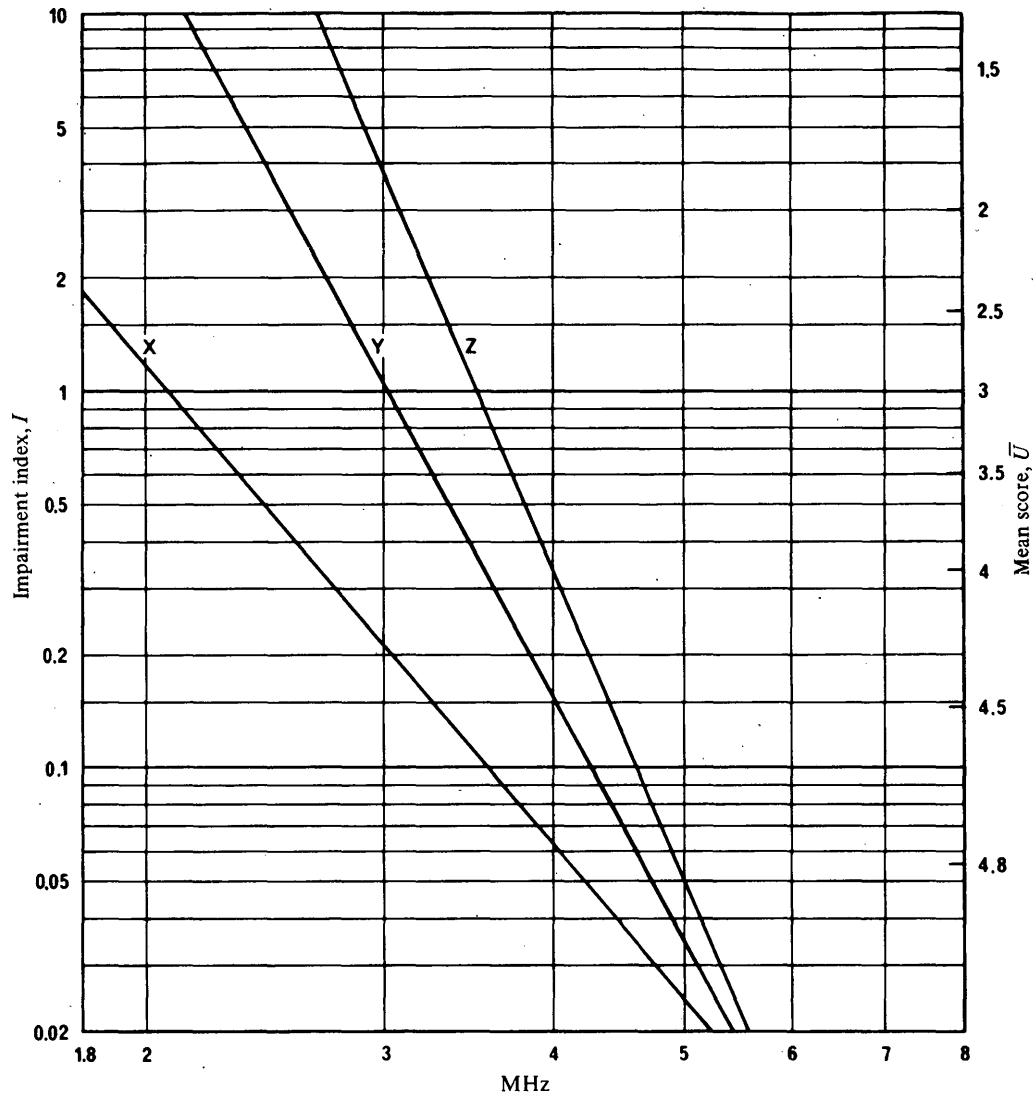


FIGURE 1b — Impairment characteristics for bandwidth restriction, from EBU experiments: spread of results from different laboratories. Viewing distance is 4 times picture height

Curves X: laboratory A (the least critical)
 Y: average of results from 7 laboratories
 Z: laboratory B (the most critical)

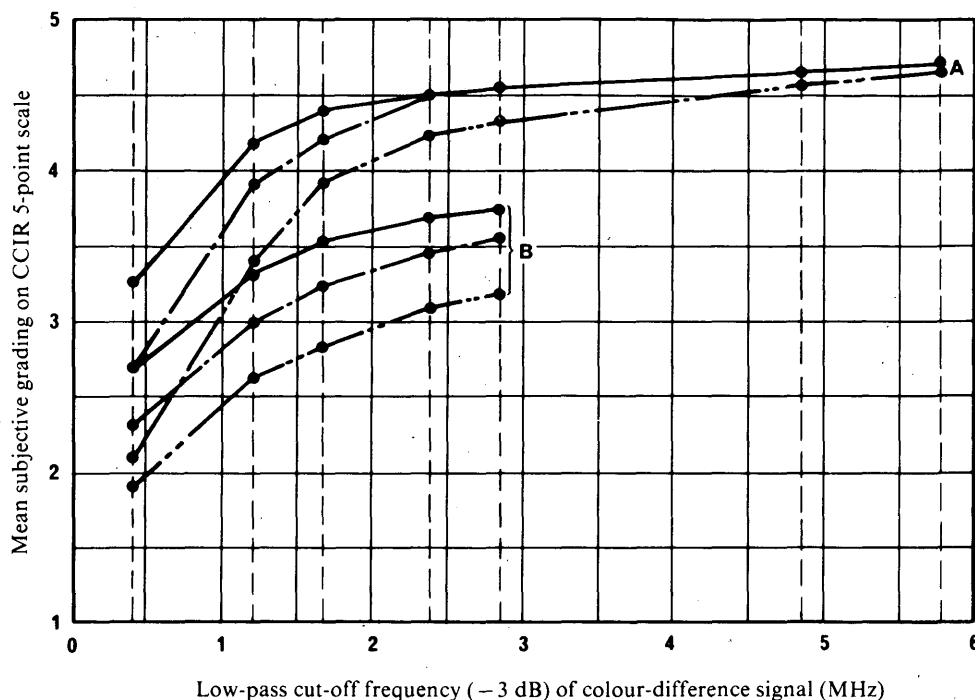


FIGURE 2 — Relationship between colour-difference signal bandwidth and picture quality (525-line systems)

Curves A: Y signal bandwidth 5.8 MHz (−3 dB)
 B: Y signal bandwidth 2.9 MHz (−3 dB)

— viewers at a distance of 6 times picture height
 - - - viewers at a distance of 4 times picture height
 - · - viewers at a distance of 2.5 times picture height

2.3 Bandwidth requirements for studio signal-processing applications

It must be borne in mind that the values of the luminance-signal bandwidth arrived at in § 2.1 and 2.2 are those regarded as desirable when considering the overall signal chain prior to the broadcast transmitter. [CCIR, 1978-82i] discusses the need for increased luminance and colour-difference signal bandwidths when considering signal processing in the studio. It is pointed out, first, that the luminance bandwidth must be adequate to permit a reasonable amount of picture recomposition, without causing a perceptible impairment of the output picture. Secondly, [CCIR, 1978-82i] argues that the bandwidths of the colour-difference signals must be sufficient to enable good results to be obtained with chroma-key (colour-matte). [CCIR, 1978-82h] also discusses colour-difference signal bandwidth requirements in the context of the chroma-key (colour-matte) process. It expresses the opinion that a colour-difference signal sampling frequency of 6 to 7 MHz (half that used for the luminance signal) is satisfactory with regard to both picture quality and chroma-key (colour-matte) requirements, provided that the filtering characteristic shows 12 dB attenuation at half the sampling frequency; further, the frequencies at which the attenuation values are 12 dB and 3 dB should be related by the ratio 1.25 : 1.

The general problem of the design of the band-limiting filters used in the digital coding of television signals has been studied in Italy [CCIR, 1978-82j]. Computer simulations were used to investigate the influence of several design parameters on the amplitude of overshoot and the amount of aliasing.

Experiments in the People's Republic of Poland are reported in [CCIR, 1982-86a] on the luminance filtering characteristics preferred for an environment where the luminance bandwidth of 6 MHz is used for conventional composite systems. A 6 MHz passband, insertion loss tolerance ± 0.05 dB, attenuation 15 dB at 6.75 MHz, and 40 dB at 7.5 MHz are suggested.

[CCIR, 1982-86b] reports studies in the USSR which, taking into account the circumstances above, and additional practical design considerations, propose a 5.75 MHz passband, insertion loss tolerance 0.1 dB, attenuation 20 dB at 6.75 MHz and 40 dB at 7.5 MHz for the luminance filter.

In Italy [CCIR, 1982-86c] a study was made using computer simulation of pre- and post-filter characteristics based on minimization of the weighted influence of over-shoots and aliasing. The study provided valuable preliminary data, which subsequently led to support for luminance and colour-difference filtering characteristics of the kind in [CCIR, 1982-86d].

A careful study of the performance of a cascaded chain of PCM codecs [CCIR, 1982-86e, f; Devereux, 1982] has shown that after minimizing the instrumental deficiencies of the codecs, the most important avoidable impairment which remains is due to the passband amplitude and phase responses of the analogue pre- and post-filters, and proposals for these characteristics are made in the above documents.

The OIRT [CCIR, 1982-86g] has studied the proposal to use a cut-off frequency of 5.75 MHz for the luminance signal in the digital 4 : 2 : 2 standard. This is nearer to the value of the 6 MHz cut-off frequency for the video signals specified by standards D, K, K1 and L (see Report 624). The value of 6 MHz for the band-limiting filter is also being studied.

Based on the results of the studies mentioned above, and an examination of the problems of the practical realization of efficient filters to meet the requirements of all administrations, the characteristics given in Fig. 1 of Annex III to Recommendation 601 were drawn up.

The study has been continued [CCIR, 1982-86d, f; Devereux, 1984] to determine specifications for filters for the colour-difference signals for the 4 : 2 : 2 coding standard of Recommendation 601. In these studies special attention has been given to:

- (a) the need to maximize the usable bandwidths of both luminance and colour-difference signals;
- (b) the need to ensure negligible impairments due to passband tolerances when a number of filter pairs are cascaded in a transmission chain;
- (c) complementing (b) above, the need to avoid unnecessarily stringent values and tolerances;
- (d) the need for the specifications of both analogue and digital filters to be capable of being met in production at reasonable cost.

Resulting from these studies, the specification for analogue filters for colour-difference signals sampled at 6.75 MHz are given in Fig. 2 of Annex III to Recommendation 601. The specification for a corresponding digital filter for sampling rate conversion between signals sampled at 13.5 MHz and signals sampled at 6.75 MHz is given in Fig. 3 of Annex III to Recommendation 601.

Some guidance on the practical implementation of the filters recommended in Annex III to Recommendation 601 is given in the following paragraphs.

In the proposals for the filters used in the encoding and decoding processes, it has been assumed that, in the post-filters which follow digital-to-analogue conversion, correction for the $(\sin x/x)$ characteristic is provided. The passband tolerances of the filter plus $(\sin x/x)$ corrector plus the theoretical $(\sin x/x)$ characteristic should be the same as given for the filters alone. This is most easily achieved if, in the design process, the filter, $(\sin x/x)$ corrector and delay equalizer are treated as a single unit.

The total delays due to filtering and encoding the luminance and colour-difference components should be the same. The delay in the colour-difference filter (Fig. 2 of Annex III to Recommendation 601) is double that of the luminance filter (Fig. 1 of Annex III to Recommendation 601). As it is difficult to equalize these delays using analogue delay networks without exceeding the passband tolerances, it is recommended that the bulk of the delay differences (in integral multiples of the sampling period) should be equalized in the digital domain. In correcting for any remainder, it should be noted that the sample-and-hold circuit in the decoder introduces a flat delay of one half a sampling period.

The passband tolerances for amplitude ripple and group delay are recognized to be very tight. Present studies indicate that it is necessary so that a significant number of coding and decoding operations in cascade may be carried out without sacrifice of the potentially high quality of the 4 : 2 : 2 coding standard. Due to limitations in the performance of currently available measuring equipment, manufacturers may have difficulty in economically verifying compliance with the tolerances of individual filters on a production basis. Nevertheless, it is possible to design filters so that the specified characteristics are met in practice, and manufacturers are required to make every effort in the production environment to align each filter to meet the given templates.

Subjective assessments of the visibility threshold for colour signal ringing were carried out in Japan. The results show that the visibility threshold is reached with 2.5% or less, for electronically generated patterns and characters, and with 5% or more, for general pictures. Based on the results of the assessments, a colour-signal shaping-filter was designed, for which the total disturbance due to ringing and aliasing was less than 2.5%. This characteristic can be realized by a digital transversal filter [CCIR, 1982-86h].

3. Sampling parameters

The sampling process is determined by three basic factors:

- the sampling structure, i.e. the relative position of the samples in space and time;
- the number of samples per line;
- the filtering process, which may be one-, two-, or three-dimensional.

The sampling structure mentioned above may, or may not, be repetitive with respect to the picture. Likewise, the number of samples per line may, or may not, be constant from line to line. In all the examples given below the sampling patterns were picture-locked.

A general theoretical survey is given in [Kretz and Sabatier, 1981].

Some comparisons between orthogonal and quincunx sampling patterns are given in [CCIR, 1978-82d]. These indicate that the orthogonal pattern has some advantages.

3.1 Sampling rates

The EBU has studied the problem of defining a standard set of essential coding parameters for television studio equipment. The work was carried out with four main objectives:

- to eliminate, in the production area, the differences between the existing 625-line systems;
- to ensure that the picture quality obtained is as high as, or higher than, that obtainable with good modern practice using analogue techniques;
- to ensure that the standard is suited to technology that is available at present, or is likely to be available in the near future;
- to arrive at parameter values which take into account the needs of picture processing in the studio.

In a first series of studies [CCIR, 1978-82k] orthogonal sampling was used with sampling rates of $768 f_H$ (line frequency) for the luminance signal and $256 f_H$ for the colour-difference signals; the colour-difference samples were co-sited and each pair of colour-difference samples was co-sited with a luminance sample.

These studies indicated that further work was necessary, with particular regard to the influence of picture-processing requirements on the choice of sampling rates.

The sampling parameters discussed in [CCIR, 1978-82k] are considered in [CCIR, 1978-82l] with regard to their suitability for digital-signal transmission at a rate of 140 Mbit/s. The view is expressed that signals based upon these sampling parameters would be of higher quality than those now provided by analogue transmissions.

The EBU has carried out a further series of studies relating to sampling rates. This work included experiments to assess the picture quality available using a number of parameter-set values within the range 12 : 4 : 4 to 14.3 : 7.15 : 7.15 where the numbers in these ratios correspond to the sampling frequencies (in MHz) used for the luminance signal and for the two colour-difference signals, respectively. Apart from the 12 : 4 : 4 set, all the parameter sets assessed had a ratio of 2 : 1 between the luminance and colour-difference sampling frequencies. [CCIR, 1978-82m; EBU, 1981] outlines these investigations and discuss the results obtained with each of the parameter-set values, with regard to a number of attributes.

First, concerning the picture quality obtained after one analogue *RGB* to digital *YUV* conversion, the results indicate, in broad terms, that the 12 : 6 : 6 parameter set gives a perceptibly better performance than the 12 : 4 : 4 set. However, they also indicate that the performance of the 14.3 : 7.15 : 7.15 set, in this regard, is not significantly better than that obtained using the 12 : 6 : 6 set.

Secondly, with regard to the quality of chroma-key (colour-matte) obtained, the results indicate that, while the 12 : 6 : 6 set clearly provides a better performance than the 12 : 4 : 4 set, a relatively steady improvement in performance can be noted as the luminance and colour-difference sampling frequencies are further increased to their maximum values, i.e. conforming to the 14.3 : 7.15 : 7.15 set.

Thirdly, it was found that, in tests involving a moderate amount of horizontal picture expansion, no aliasing could be observed, using natural (non-electronically generated) test pictures, for all luminance-signal sampling frequencies within the range 12 : 6 : 6 to 14.3 : 7.15 : 7.15. However, using an electronically generated horizontal-frequency sweep, aliasing decreased with increasing sampling frequency; the decrease was most noticeable in the range 12 to 13 MHz.

Finally, with regard to bit-rate reduction, the studies show that it is possible to reduce the bit-rate of a signal conforming to the 14.3 : 7.15 : 7.15 set so as not to exceed 140 Mbit/s, without affecting the picture quality or the potential capability for chroma-key (colour-matte) processing.

Some of the above-mentioned results were derived from work undertaken in the UK, which is described in detail in [CCIR, 1978-82n]. This work included tests on two parameter sub-sets, in order to investigate the properties of systems possibly qualifying as lower members of the family of compatible digital coding standards. In one of the sub-sets the luminance- and colour-difference signal sampling frequencies were related by the ratio 4 : 1.

The subjective tests involved in this work were carried out using the "double-stimulus" method described in the Appendix I of Recommendation 500 and reference pictures derived by digitally coding the input signals according to the 14.3 : 14.3 : 14.3 parameter set. The detailed subjective-test results obtained during the above-mentioned tests have been analysed by the method described in Annex III of Report 405, and the results of the analysis, described in [CCIR, 1978-82o], are given in terms of the impairment index I and the mean score $\bar{U}$. From the analysis it can be concluded that, with regard to basic picture quality the 13.5 : 6.75 : 6.75 parameter set is characterized by an impairment index I of 0.03 at 4 H (i.e. a mean score greater than 4.8) and that the corresponding results related to chroma-key (colour-matte) performance are $I = 0.3$ and $\bar{U} = 4.0$.

In the USSR consideration has been given to the sampling parameters suitable for standards D and K. Early work included the study of a system in which the luminance signal was sampled orthogonally at a rate of $800 f_H$ (12.5 MHz), and each of the colour-difference signals were similarly sampled at $200 f_H$ (3.125 MHz); the investigation is outlined in [CCIR, 1978-82e]. In studies described in [CCIR, 1978-82p] the sampling parameters for digital TV studios were revised as it was found desirable to increase the sampling frequencies to about 13 to 13.5 MHz and 6.5 to 6.75 MHz for the luminance and colour-difference signals respectively.

[CCIR, 1978-82q] reports the results of comprehensive subjective tests which were carried out with the objective of determining the relationship between the reproduced colour-picture quality and the sampling frequencies and sampling structures used for the luminance and colour-difference signals.

A standard, designed to be a member of the family of digital coding standards below that recommended as the main studio standard is described in [CCIR, 1978-82r]. In this standard the luminance signal is sampled at 10.125 MHz and the useful bandwidth extends to 5 MHz. The colour-difference signals are sampled at a frequency equal to 3.375 MHz, and have a bandwidth of 1.5 MHz. Further studies are necessary to select the best sampling structure for this system. The system is known as a 3 : 1 system, owing to, first, the particular ratios used to calculate the sampling frequencies from the frequencies recommended for the main studio standard and, secondly, the use of line-sequential coding of the colour-difference signals. It is claimed that the picture quality obtained from this system is at least equal to that obtained using a conventional analogue PAL codec.

A system for coding a television signal at a bit rate of 70 Mbit/s using the DPCM method (folded quantization with 5 bit/sample) is described in [CCIR, 1982-86i; Wengenroth, 1982]. The sampling frequencies for luminance and colour-difference signals are derived from the studio standard by means of a digital filter which gives a conversion of the sampling frequency in the ratio 6 : 5. Line-sequential transmission is foreseen for the two colour difference signals.

Extensive subjective tests, using a method described in Report 405, Annex IV, were carried out in the USA using digitally coded component signals conforming to the 525-line standard; these are outlined in [CCIR, 1978-82s; SMPTE Journal, 1981]. The tests covered luminance-signal sampling rates corresponding to 768, 864 and 912 samples per total line and ratios of luminance-signal to colour-difference signal bandwidth of 4 : 4 : 4, 4 : 2 : 2, 4 : 1 : 1 and 2 : 1 : 1. Tests were carried out with regard to basic picture quality and on the properties of the various parameter sets with regard to production processes such as picture expansion, chroma-key (colour-matte), multi-generation digital recording and digital decoding from, and encoding into, analogue M/NTSC composite colour signals.

These tests confirm the selection of the 4 : 2 : 2 parameter set as the one preferred as a studio standard, and showed that a small but rising picture quality was obtained with increase of sampling rate.

Subjective tests with similar sampling parameters were carried out in Japan, and these are described in [CCIR, 1978-82t]. The tests included digital chroma-key (colour-matte) processing for parameter sets with luminance-signal sampling frequencies of 12.1, 13.6 and 14.3 MHz. The two main results can be summed up in the following way: first, the picture quality decreases gradually as the sampling frequency of the colour-difference signals decreases from a value equal to that used for the luminance signal, to a quarter of that value and, secondly, the picture quality obtained using the chroma-key (colour-matte) process decreases significantly as the sampling frequency used for the colour-difference signals is reduced; this decrease is more marked when the sampling frequency is reduced from half that used for the luminance signal to a quarter of that value.

[CCIR, 1982-86j; Khleborodov, 1983] contain a theoretical study of picture distortions in line-sequential transmission of colour-difference signals with a two-field cycle.

[CCIR, 1982-86k] describes results of subjective assessments of picture quality obtained with 4:1:1, 4:2:0, 2:1:1 and 3:1:0 coding, including the effects of line- and field-offset sub-sampling, and of line-sequential processing of the colour-difference signals; these tests used stationary test pictures. The results showed that the picture quality for 2:1:1 with field-offset sub-sampling was superior to that of the other members with a similar bit rate for most of the pictures tested.

- [CCIR, 1982-86l] reports subjective tests on a 2:1:1 system employing field-offset sub-sampling which suggests that satisfactory portrayal of movement can be achieved.

3.2 Changing the sampling rate

Sampling rate changing is a process required in many picture processing operations. One example is that involved in converting the signals conforming to one member of the family of compatible coding standards to another. [CCIR, 1978-82u] describes a filtering process, based on comb filtering of the upper part of the signal spectrum, which enables signals to be converted easily between various members of a binary-related family (4:4:4; 4:2:2; 2:1:1). [CCIR, 1978-82t; Nishizawa *et al.*, 1981] include the description of a very sophisticated interpolation low-pass filter intended for the same purpose.

Change of sampling rate is also required when the family of compatible digital coding standards is not based upon binary ratios. [CCIR, 1978-82v] indicates that the design of the interpolating filter need not be unduly complicated, provided that the change of sample rate involves a ratio described by a rational number.

In [CCIR, 1982-86m] it is shown how various source coding procedures and bit-rate reduction techniques can be used to adapt the various members of the family of compatible digital coding standards to suitable levels of the transmission hierarchy based on 2048 kbit/s.

In order to avoid quality losses due to sampling frequency conversions and coding procedures in tandem and to eliminate the need for transcoding equipment to be set up at all transmission network nodes operating at different bit-rates, it is desirable to carry out bit-rate conversion at the television studio in accordance with the bit rate of the circuit section having the narrowest bandwidth.

Thus signals transmitted through a point-to-point link consisting of the tandem connection of sections of different capacity should be coded in conformity with the section having the smallest capacity, unless it is necessary for a signal of higher quality to be available at an intermediate point.

4. Uniformly quantized PCM

The basic form of digital coding is uniformly quantized PCM, where the value of each digital "word" represents the uniformly quantized amplitude of a sample of the baseband signal.

In all the examples given above, 8 bits per sample uniform quantizing is proposed for the luminance signal and for the colour-difference signals [CCIR, 1978-82e, k, l and w].

5. Multiplexing methods

The single-channel transmission of digitally encoded component signals requires that the three separately encoded signals, describing the luminance and two colour-difference signals, respectively, be combined together in time-multiplex form.

[CCIR, 1978-82x] compares two forms of multiplex. In the first, the three digital words describing each picture element are grouped together; in the second the words describing the luminance-signal values of all the picture elements in one line are grouped together, and this group of words is followed by two groups each describing the corresponding colour-difference signal values. The comparison concludes that the first arrangement is more economic but that the second is more advantageous with regard to monitoring.

[CCIR, 1978-82k] discusses a multiplexing structure identical to the first of those described above.

The work on the digital encoding of component signals carried out in the U.S.S.R. and described in [CCIR, 1978-82e], includes a multiplex arrangement in which the signals are transmitted in the order Y, D_R, Y, Y, D_B, Y , where Y represents a luminance signal value and D_R and D_B represent colour-difference signal values.

[CCIR, 1982-86n] describes a multiplexer which combines two signals, each having a bit rate of approximately 70 Mbit/s, to produce a signal at the fourth order of the hierarchical level, namely 139 264 kbit/s. Each 70 Mbit/s tributary may contain either one digital television signal or two signals of 34 368 kbit/s. The frame alignment signal and the net bit rate of the two tributaries are adjusted to the requirements of both telephony and television. Accordingly, it may be possible for digital television signals to be adapted to other hierarchical bit rates. The insertion of a frame alignment signal at the interface between the television studio and the transmission system would considerably facilitate the transmission of television signals in the integrated services digital network (ISDN).

[CCIR, 1982-86o] describes the results of studies on a bit-parallel transmission method which permits easy transcoding both to and from a bit-serial format having a bit rate of 108 Mbit/s using two channels, and also to and from a 216 Mbit/s single channel format. [CCIR, 1982-86p] gives some details on the 2×108 Mbit/s parallel-serial and 216 Mbit/s serial interfaces.

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RECOMMENDATION 656

INTERFACES FOR DIGITAL COMPONENT VIDEO SIGNALS IN 525-LINE AND 625-LINE TELEVISION SYSTEMS

(1986)

The CCIR,

CONSIDERING

- (a) that there are clear advantages for television broadcasting organizations and programme producers in digital studio standards which have the greatest number of significant parameter values common to 525-line and 625-line systems;
- (b) that a world-wide compatible digital approach will permit the development of equipment with many common features, permit operating economies and facilitate the international exchange of programmes;
- (c) that to implement the above objectives, agreement has been reached on the fundamental encoding parameters of digital television for studios in the form of Recommendation 601;
- (d) that the practical implementation of Recommendation 601 requires definition of details of interfaces and the data streams traversing them;
- (e) that such interfaces should have a maximum of commonality between 525-line and 625-line versions;
- (f) that in the practical implementation of Recommendation 601 it is desirable that interfaces be defined in both serial and parallel forms;
- (g) that digital television signals produced by these interfaces may be a potential source of interference to other services, and due notice must be taken of No. 964 of the Radio Regulations,

UNANIMOUSLY RECOMMENDS

that where interfaces are required for component-coded digital video signals in television studios, the interfaces and the data streams that will traverse them should be in accordance with the following description, defining both bit-parallel and bit-serial implementations.

1. Introduction

This Recommendation describes the means of interconnecting digital television equipment operating on the 525-line or 625-line standards and complying with the 4 : 2 : 2 encoding parameters as defined in Recommendation 601.

Part I describes the signal format common to both interfaces.

Part II describes the particular characteristics of the bit-parallel interface.

Part III describes the particular characteristics of the bit-serial interface.

PART I

COMMON SIGNAL FORMAT OF THE INTERFACES

1. General description of the interfaces

The interfaces provide a unidirectional interconnection between a single source and a single destination.

A signal format common to both parallel and serial interfaces is described in § 2 below.

The data signals are in the form of binary information coded in 8-bit words. These signals are:

- video data;
- timing reference codes;
- ancillary data;
- identification codes.

2. Video data

2.1 Coding characteristics

The video data is in compliance with Recommendation 601, and with the field-blanking definition shown in Table I.

TABLE I — Field interval definitions

		625	525
V-digital field blanking	Field 1		
	Start (V=1)	Line 624	Line 1
	Finish (V=0)	Line 23	Line 10
Field 2	Start (V=1)	Line 311	Line 264
	Finish (V=0)	Line 336	Line 273
F-digital field identification			
Field 1	F=0	Line 1	Line 4
Field 2	F=1	Line 313	Line 266

Note 1. — Signals F and V change state synchronously with the end of active video timing reference code at the beginning of the digital line.

Note 2. — Definition of line numbers is to be found in Report 624. Note that digital line number changes state prior to 0_H as shown in Fig. 1.

2.2 Video data format

The data words 0 and 255 (00 and FF in hexadecimal notation) are reserved for data identification purposes and consequently only 254 of the possible 256 words may be used to express a signal value.

The video data words are conveyed as a 27 Mwords/s multiplex in the following order:

$C_B, Y, C_R, Y, C_B, Y, C_R$, etc.

where the word sequence C_B, Y, C_R , refers to co-sited luminance and colour-difference samples and the following word, Y , corresponds to the next luminance sample.

2.3 Timing relationship between video data and the analogue synchronizing waveform

2.3.1 Line interval

The digital active line begins at 244 words (in the 525-line standard) or at 264 words (in the 625-line standard) after the leading edge of the analogue line synchronization pulse, this time being specified between half-amplitude points.

Figure 1 shows the timing relationship between video and the analogue line synchronization.

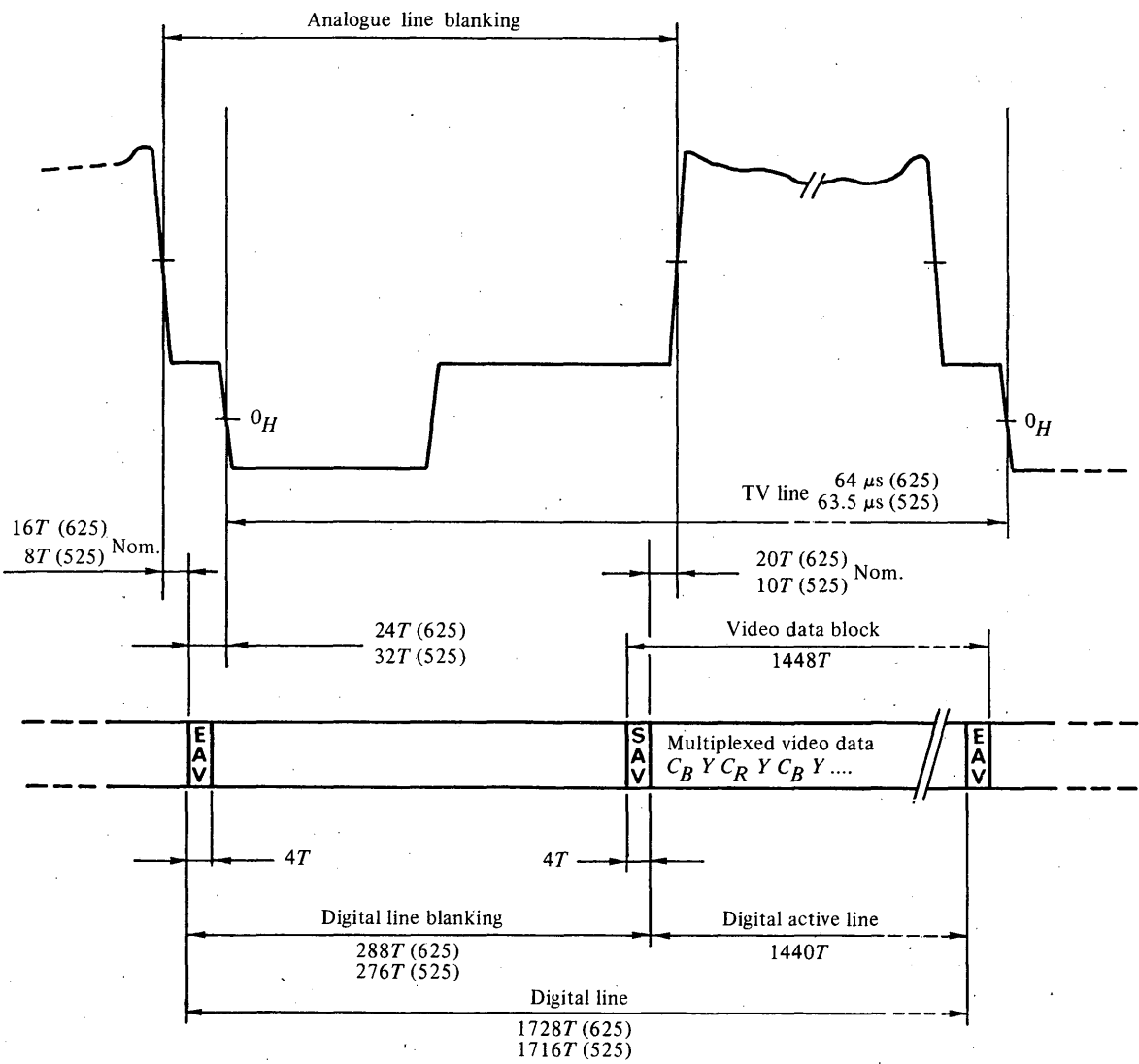


FIGURE 1 – Data format and timing relationship with the analogue video signal.

T: clock period 37 ns nom.
SAV: start of active video timing reference code
EAV: end of active video timing reference code

2.3.2 Field interval

The start of the digital field is fixed by the position specified for the start of the digital line: the digital field starts 32 words (in the 525-line systems) and 24 words (in the 625-line systems) prior to the lines indicated in Table I.

2.4 Video timing reference codes (SAV, EAV)

There are two timing reference codes, one at the beginning of each video data block (Start of Active Video, SAV) and one at the end of each video data block (End of Active Video, EAV) as shown in Fig. 1.

Each timing reference code consists of a four word sequence in the following format: FF 00 00 XY. (Values are expressed in hexadecimal notation. Codes FF, 00 are reserved for use in timing reference codes.) The first three words are a fixed preamble. The fourth word contains information defining field 2 identification, the state of field blanking, and the state of line blanking. The assignment of bits within the timing reference code is shown below in Table II.

TABLE II – Video timing reference codes

Word	Bit No.							
	7 (MSB)	6	5	4	3	2	1	0 (LSB)
First	1	1	1	1	1	1	1	1
Second	0	0	0	0	0	0	0	0
Third	0	0	0	0	0	0	0	0
Fourth	1	F	V	H	P ₃	P ₂	P ₁	P ₀

F = 0 during field 1
1 during field 2

V = 0 elsewhere
1 during field blanking

H = 0 in SAV
1 in EAV

P₀, P₁, P₂, P₃: protection bits (see Table III).

MSB: most significant bit.

LSB: least significant bit.

Table I defines the state of the V and F bits.

Bits P_0 , P_1 , P_2 , P_3 , have states dependent on the states of the bits F, V and H as shown in Table III. At the receiver this arrangement permits one-bit errors to be corrected and two-bit errors to be detected.

TABLE III — *Protection bits*

Bit No.	7	6	5	4	3	2	1	0
Function	Fixed 1	F	V	H	P_3	P_2	P_1	P_0
0	1	0	0	0	0	0	0	0
1	1	0	0	1	1	1	0	1
2	1	0	1	0	1	0	1	1
3	1	0	1	1	0	1	1	0
4	1	1	0	0	0	1	1	1
5	1	1	0	1	1	0	1	0
6	1	1	1	0	1	1	0	0
7	1	1	1	1	0	0	0	1

2.5 Ancillary data

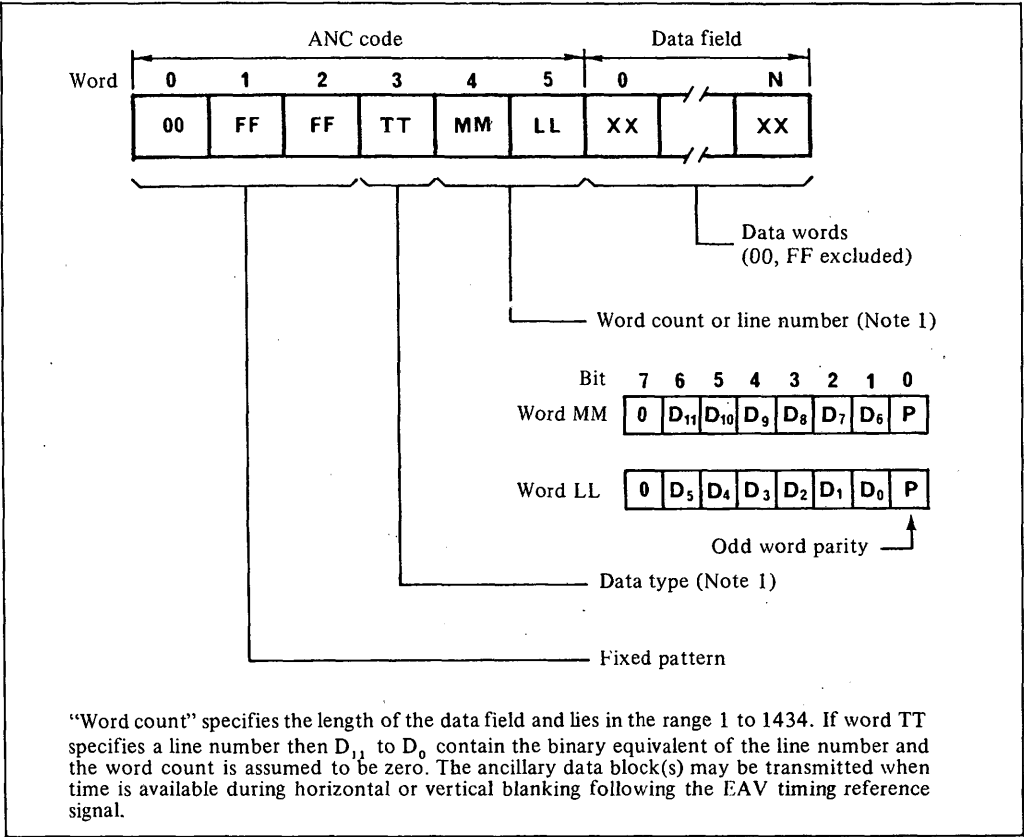
Provision is made for ancillary data to be inserted synchronously into the multiplex during the blanking intervals at a rate of 27 Mwords/s. Such data is conveyed by one or more 7-bit words, each with an additional parity bit (LSB) giving odd parity.

Each ancillary data block, when used, should be constructed as shown in Table IV from the timing reference code ANC and a data field.

2.6 Data words during blanking

The data words occurring during digital blanking intervals that are not used for the timing reference code ANC or for ancillary data are filled with the sequence 80, 10, 80, 10, etc. (values are expressed in hexadecimal notation) corresponding to the blanking level of the C_B , Y, C_R , Y signals respectively, appropriately placed in the multiplexed data.

TABLE IV – Ancillary data block



Note 1. – The precise location of the ancillary data blocks and the coding of words 3, 4 and 5 require further study.

PART II

BIT-PARALLEL INTERFACE

1. General description of the interface

The bits of the digital code words that describe the video signal are transmitted in parallel by means of eight conductor pairs, where each carries a multiplexed stream of bits (of the same significance) of each of the component signals, C_B, Y, C_R, Y. The eight pairs also carry ancillary data that is time-multiplexed into the data stream during video blanking intervals. A ninth pair provides a synchronous clock at 27 MHz.

The signals on the interface are transmitted using balanced conductor pairs. Cable lengths of up to 50 m (≈ 160 feet) without equalization and up to 200 m (≈ 650 feet) with appropriate equalization (see § 6) may be employed.

The interconnection employs a twenty-five pin D-subminiature connector equipped with a locking mechanism (see § 5).

For convenience, the eight bits of the data word are assigned the names DATA 0 to DATA 7. The entire word is designated as DATA (0-7). DATA 7 is the most significant bit.

Video data is transmitted in NRZ form in real time (unbuffered) in blocks, each comprising one active television line.

2. Data signal format

The interface carries data in the form of 8 parallel data bits and a separate synchronous clock. Data is coded in NRZ form. The recommended data format is described in Part I.

3. Clock signal

3.1 General

The clock signal is a 27 MHz square wave where the 0-1 transition represents the data transfer time. This signal has the following characteristics:

Width: 18.5 ± 3 ns

Jitter: Less than 3 ns from the average period over one field.

3.2 Clock-to-data timing relationship

The positive transition of the clock signal shall occur midway between data transitions as shown in Fig. 2.

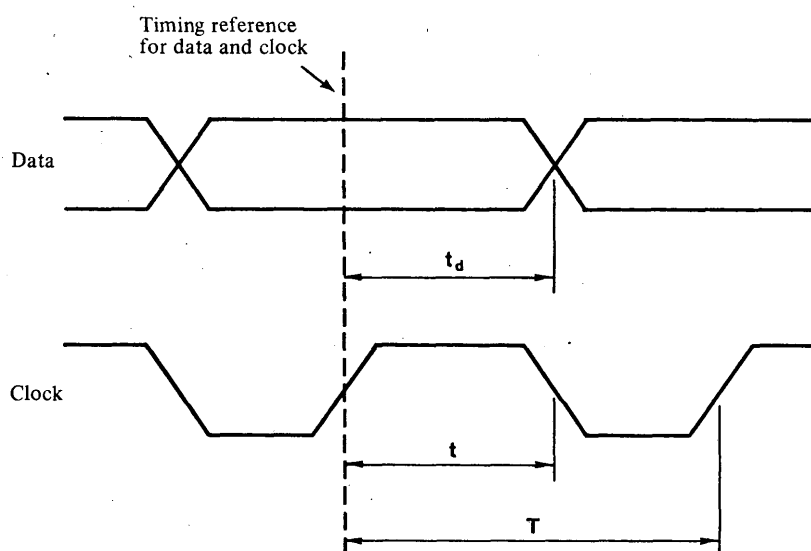


FIGURE 2 – Clock-to-data timing (at source)

Clock period (625): $T = \frac{1}{1728 f_H} = 37$ ns

Clock period (525): $T = \frac{1}{1716 f_H} = 37$ ns

Clock pulse width: $t = 18.5 \pm 3$ ns

Data timing – sending end: $t_d = 18.5 \pm 3$ ns

f_H : line frequency

4. Electrical characteristics of the interface

4.1 General

The interface employs nine line drivers and nine line receivers.

Each line driver (source) has a balanced output and the corresponding line receiver (destination) a balanced input (see Fig. 3).

Although the use of ECL technology is not specified, the line driver and receiver must be ECL-compatible, i.e. they must permit the use of ECL for either drivers or receivers.

All digital signal time intervals are measured between the half-amplitude points.

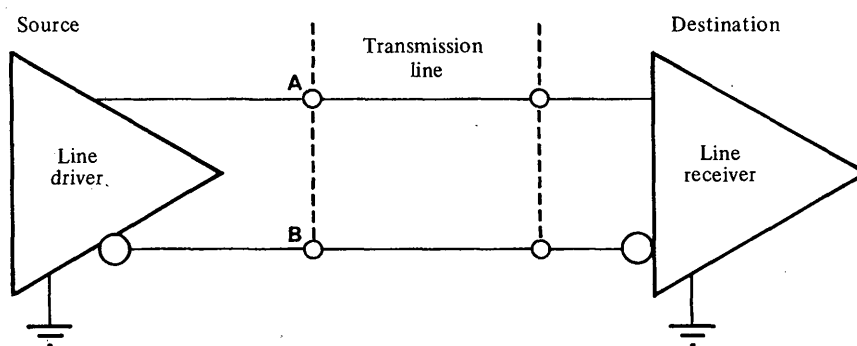


FIGURE 3 – Line driver and line receiver interconnection

4.2 Logic convention

The A terminal of the line driver is positive with respect to the B terminal for a binary 1 and negative for a binary 0 (see Fig. 3).

4.3 Line driver characteristics (source)

4.3.1 *Output impedance*: 110 Ω maximum.

4.3.2 *Common mode voltage*: $-1.29 \text{ V} \pm 15\%$ (both terminals relative to ground).

4.3.3 *Signal amplitude*: 0.8 to 2.0 V peak-to-peak, measured across a 110 Ω resistive load.

4.3.4 *Rise and fall times*: less than 5 ns, measured between the 30% and 80% amplitude points, with a 110 Ω resistive load. The difference between rise and fall times must not exceed 2 ns.

4.4 Line receiver characteristics (destination)

4.4.1 *Input impedance*: 110 $\Omega \pm 10 \Omega$.

4.4.2 *Maximum input signal*: 2.0 V peak-to-peak.

4.4.3 *Minimum input signal*: 185 mV peak-to-peak.

However, the line receiver must sense correctly the binary data when a random data signal produces the conditions represented by the eye diagram in Fig. 4 at the data detection point.

4.4.4 *Maximum common mode signal*: $\pm 0.5 \text{ V}$, comprising interference in the range 0 to 15 kHz (both terminals to ground).

4.4.5 *Differential delay*: Data must be correctly sensed when the clock-to-data differential delay is in the range between $\pm 11 \text{ ns}$ (see Fig. 4).

5. Mechanical details of the connector

The interface uses the 25 contact type D subminiature connector specified in ISO Document 2110-1980, with the contact assignment shown in Table V.

Connectors are locked together by a one-piece slide lock on the cable connectors and locking posts on the equipment connectors. Cable connectors employ pin contacts and equipment connectors employ socket contacts. Shielding of the interconnecting cable and its connectors must be employed (see Note).

Note. – It should be noted that the ninth and eighteenth harmonics of the 13.5 MHz sampling frequency (nominal value) specified in Recommendation 601 fall at the 121.5 and 243 MHz aeronautical emergency channels. Appropriate precautions must therefore be taken in the design and operation of interfaces to ensure that no interference is caused at these frequencies. Emission levels for related equipment are given in CISPR Recommendation: “Information technology equipment – limits of interference and measuring methods” Document CISPR/B (Central Office) 16. Nevertheless, No. 964 of the Radio Regulations prohibits any harmful interference on the emergency frequencies.

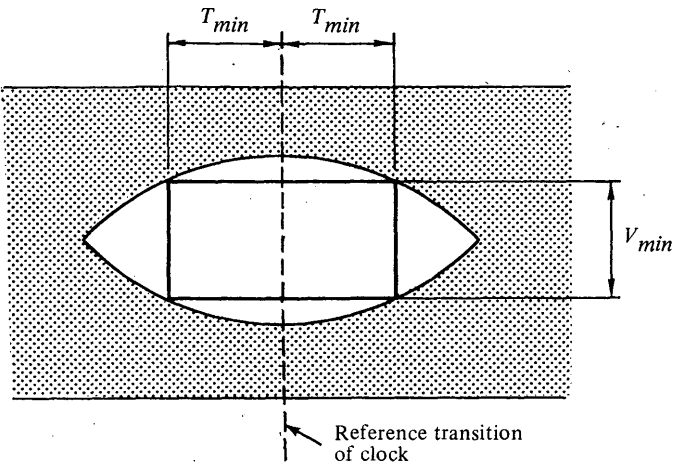


FIGURE 4 – Idealized eye diagram corresponding to the minimum input signal level

$T_{min} = 11\text{ ns}$
 $V_{min} = 100\text{ mV}$

Note. – The width of the window in the eye diagram, within which data must be correctly detected comprises $\pm 3\text{ ns}$ clock jitter, $\pm 3\text{ ns}$ data timing (see § 3.2), and $\pm 5\text{ ns}$ available for differences in delay between pairs of the cable.

TABLE V – Contact assignments

Contact	Signal line	Contact	Signal line
1	Clock A	14	Clock B
2	System ground	15	System ground
3	Data 7A (MSB)	16	Data 7B
4	Data 6A	17	Data 6B
5	Data 5A	18	Data 5B
6	Data 4A	19	Data 4B
7	Data 3A	20	Data 3B
8	Data 2A	21	Data 2B
9	Data 1A	22	Data 1B
10	Data 0A	23	Data 0B
11	Spare A-A	24	Spare A-B
12	Spare B-A	25	Spare B-B
13	Cable shield	—	—

Any spare pairs connected to contacts 11,24 or 12,25 are reserved for bits of lower significance than those carried on contacts 10,23.

6. Line receiver equalization

To permit correct operation with longer interconnection links, the line receiver may incorporate equalization.

When equalization is used, it should conform to the nominal characteristics of Fig. 5. This characteristic permits operation with a range of cable lengths down to zero. The line receiver must satisfy the maximum input signal condition of § 4.4.

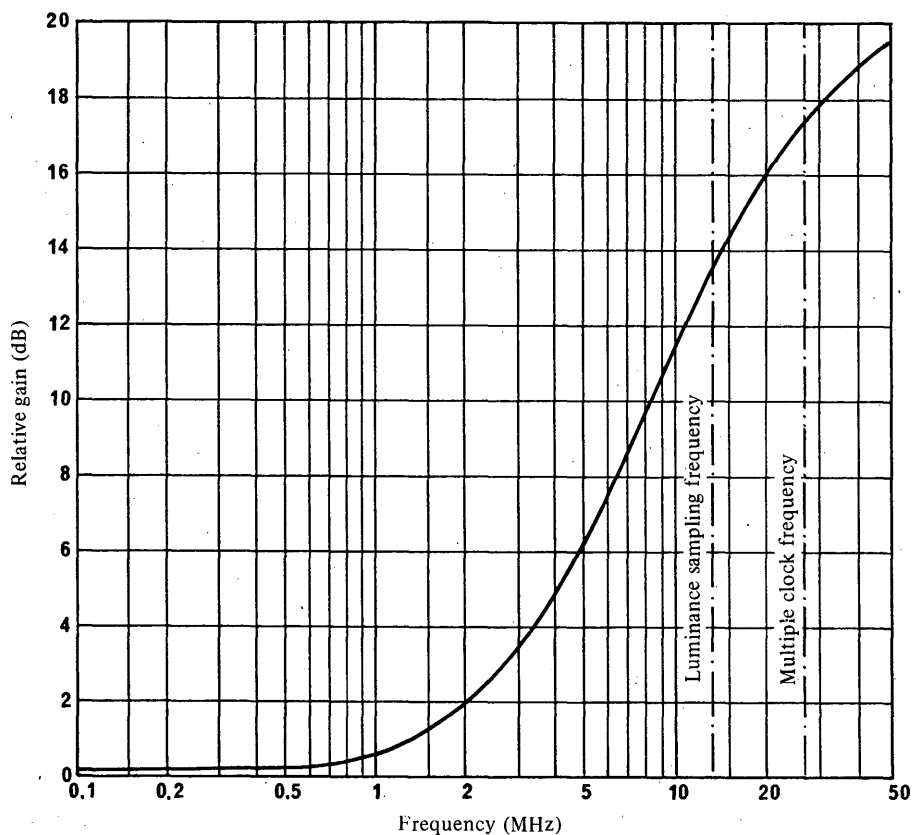


FIGURE 5 – Line receiver equalization characteristic for small signals

PART III

BIT-SERIAL INTERFACE

1. General description of the interface

The multiplexed data stream of 8-bit words (as described in Part I) is transmitted over a single channel in bit-serial form. Prior to transmission, additional coding takes place to provide spectral shaping, word synchronization and to facilitate clock recovery.

2. Coding

The 8-bit data words are encoded for transmission into 9-bit words as shown in Table VI.

For some 8-bit data words alternative 9-bit transmission words exist, as shown in columns 9B and $\overline{9B}$, each 9-bit word being the complement of the other. In such cases, the 9-bit word will be selected alternately from columns 9B and $\overline{9B}$ on each successive occasion that *any* such 8-bit word is conveyed. In the decoder, either word must be converted to the corresponding 8-bit data word.

TABLE VI – Encoding table

Input	Output	Input	Output	Input	Output	Input	Output	Input	Output	Input	Output
8B	9B 9B	8B	9B 9B	8B	9B 9B	8B	9B 9B	8B	9B 9B	8B	9B 9B
00	0FE 101	2B	053	56	097	81	0AA	AC	12C	D7	0CC
01	027	2C	1AC	57	168	82	055	AD	0D9	D8	139
02	1D8	2D	057	58	099	83	1AA	AE	126	D9	0CE
03	033	2E	1A8	59	166	84	0D5	AF	0E5	DA	133
04	1CC	2F	059	5A	09B	85	12A	B0	11A	DB	0D8
05	037	30	1A6	5B	164	86	095	B1	0E9	DC	131
06	1C8	31	05B	5C	09D	87	16A	B2	116	DD	0DC
07	039	32	05D	5D	162	88	0B5	B3	02E	DE	127
08	1C6	33	1A4	5E	0A3	89	14A	B4	1D1	DF	0E2
09	03B	34	065	5F	15C	8A	09A	B5	036	EO	123
0A	1C4	35	19A	60	0A7	8B	165	B6	1C9	E1	0E4
0B	03D	36	069	61	158	8C	0A6	B7	03A	E2	11D
0C	1C2	37	196	62	025 1DA	8D	159	B8	1C5	E3	0E6
0D	14D	38	026 1D9	63	0A1 15E	8E	0AC	B9	04E	E4	11B
0E	0B4	39	08C 173	64	029 1D6	8F	153	BA	1B1	E5	0E8
0F	14B	3A	02C 1D3	65	091 16E	90	0AE	BB	05C	E6	119
10	1A2	3B	098 167	66	045 1BA	91	151	BC	1A3	E7	0EC
11	0B6	3C	032 1CD	67	089 176	92	02A 1D5	BD	05E	E8	117
12	149	3D	0BE 141	68	049 1B6	93	092 16D	BE	1A1	E9	0F2
13	0BA	3E	034 1CB	69	085 17A	94	04A 1B5	BF	066	EA	113
14	145	3F	0C2 13D	6A	051 1AE	95	094 16B	C0	199	EB	0F4
15	0CA	40	046 1B9	6B	08A 175	96	0A8 157	C1	06C	EC	10D
16	135	41	0C4 13B	6C	0A4 15B	97	0B7 148	C2	193	ED	076
17	0D2	42	04C 1B3	6D	054 1AB	98	0F5 10A	C3	06E	EE	10B
18	12D	43	0C8 137	6E	0A2 15D	99	0BB 144	C4	191	EF	0C7
19	0D4	44	058 1A7	6F	052 1AD	9A	0ED 112	C5	072	F0	13C
1A	129	45	0B1	70	056	9B	0BD 142	C6	18D	F1	047
1B	0D6	46	14E	71	1A9	9C	0EB 114	C7	074	F2	1B8
1C	125	47	0B3	72	05A	9D	0D7 128	C8	18B	F3	067
1D	0DA	48	14C	73	1A5	9E	0DD 122	C9	07A	F4	19C
1E	115	49	0B9	74	06A	9F	0DB 124	CA	189	F5	071
1F	0EA	4A	06B	75	195	A0	146	CB	08E	F6	198
20	0B2	4B	194	76	096	A1	0C5	CC	185	F7	073
21	02B	4C	06D	77	169	A2	13A	CD	09C	F8	18E
22	1D4	4D	192	78	0A9	A3	0C9	CE	171	F9	079
23	02D	4E	075	79	156	A4	136	CF	09E	FA	18C
24	1D2	4F	18A	7A	0AB	A5	0CB	D0	163	FB	087
25	035	50	08B	7B	154	A6	134	D1	0B8	FC	186
26	1CA	51	174	7C	0A5	A7	0CD	D2	161	FD	0C3
27	04B	52	08D	7D	15A	A8	132	D3	0BC	FE	178
28	1B4	53	172	7E	0AD	A9	0D1	D4	147	FF	062 19D
29	04D	54	093	7F	152	AA	12E	D5	0C6		
2A	1B2	55	16C	80	155	AB	0D3	D6	143		

3. Order of transmission

The least significant bit of each 9-bit word shall be transmitted first.

4. Logic convention

The signal is conveyed in NRZ form. The voltage at the output terminal of the line driver shall increase on a transition from 0 to 1 (positive logic).

5. Transmission medium

The bit-serial data stream can be conveyed using either a coaxial cable (§ 6) or fibre optic bearer (§ 7).

6. Characteristics of the electrical interface

6.1 Line driver characteristics (source)

6.1.1 Output impedance

The line driver has an unbalanced output with a source impedance of 75 Ω and a return loss of at least 15 dB over a frequency range of 10 to 243 MHz.

6.1.2 Signal amplitude

The peak-to-peak signal amplitude lies between 400 mV and 700 mV measured across a 75 Ω resistive load directly connected to the output terminals without any transmission line.

6.1.3 DC offset

The DC offset with reference to the mid amplitude point of the signal lies between +1.0 V and -1.0 V.

6.1.4 Rise and fall times

The rise and fall times, determined between the 20% and 80% amplitude points and measured across a 75 Ω resistive load connected directly to the output terminals, shall lie between 0.75 and 1.50 ns and shall not differ by more than 0.40 ns.

6.1.5 Jitter

The timing of the rising edges of the data signal shall be within ± 0.10 ns of the average timing of rising edges, as determined over a period of one line.

6.2 Line receiver characteristics (destination)

6.2.1 Terminating impedance

The cable is terminated by 75 Ω with a return loss of at least 15 dB over a frequency range of 10 to 243 MHz.

6.2.2 Receiver sensitivity

The line receiver must sense correctly random binary data either when connected directly to a line driver operating at the extreme voltage limits permitted by § 6.1.2, or when connected via a cable having a loss of 40 dB at 243 MHz and a loss characteristic of $1/\sqrt{f}$.

Over the range 0 to 12 dB no equalization adjustment is required; beyond this range adjustment is permitted.

6.2.3 Interference rejection

When connected directly to a line driver operating at the lower limit specified in § 6.1.2, the line receiver must correctly sense the binary data in the presence of a superimposed interfering signal at the following levels:

d.c.	± 2.5 V
Below 1 kHz:	2.5 V peak-to-peak
1 kHz to 5 MHz:	100 mV peak-to-peak
Above 5 MHz:	40 mV peak-to-peak

6.3 *Cables and connectors*

6.3.1 *Cable*

It is recommended that the cable chosen should meet any relevant national standards on electro-magnetic radiation.

Note. — It should be noted that the ninth and eighteenth harmonics of the 13.5 MHz sampling frequency (nominal value) specified in Recommendation 601 fall at the 121.5 and 243 MHz aeronautical emergency channels. Appropriate precautions must therefore be taken in the design and operation of interfaces to ensure that no interference is caused at these frequencies. Emission levels for related equipment are given in CISPR Recommendation: "Information technology equipment — limits of interference and measuring methods" (Document CISPR/B (Central Office) 16). Nevertheless, No. 964 of the Radio Regulations prohibits any harmful interference on the emergency frequencies.

6.3.2 *Characteristic impedance*

The cable used shall have a nominal characteristic impedance of 75 Ω .

6.3.3 *Connector characteristics*

The connector shall have mechanical characteristics conforming to the standard BNC type (IEC Publication 169-8), and its electrical characteristics should permit it to be used at frequencies up to 500 MHz in 75 Ω circuits.

7. **Characteristics of the optical interface**

To be defined.

REPORT 1088

INTERFACES FOR DIGITAL VIDEO SIGNALS IN 525-LINE AND 625-LINE TELEVISION SYSTEMS

(Question 25/11)

(1986)

1. **Introduction**

CCIR Recommendation 656 specifies interfaces for digital studio equipment, in conformity with the basic parameter values contained in Recommendation 601.

This Report summarizes the contributions received on digital video interfaces which provided the basis for Recommendation 656, it includes supplementary information on the subject, and indicates areas in which further studies are required.

2. **Definitions**

Interface is a concept involving the specification of the interconnection between two items of equipment or systems. The specification includes the type, quantity and function of the interconnection circuits and the type and form of the signals to be interchanged by these circuits.

A parallel interface is an interface in which the bits of a data word are sent simultaneously via separate channels.

A serial interface is an interface in which the bits of a data word, and successive data words, are sent consecutively via a single channel.

A parallel-serial (hybrid) interface is an interface in which portions of a data word are sent consecutively via separate channels.

3. **Primary encoding format**

There are features of the basic data organization which are common to the three types of interface defined above and which are the subject of Part I of Recommendation 656. They comprise:

- the organization of the video data into words and blocks;
- the timing reference codes providing video synchronization;
- ancillary data signal structure;
- data signals during blanking intervals;
- details of the multiplexing.

3.1 *Blanking and synchronization considerations*

[CCIR, 1982-86a, b and c] agreed on the form and use of timing reference signals. Each timing reference signal consists of a four-word sequence. The first three words are a fixed preamble. The fourth word contains information defining:

- first or second field identification;
- state of field blanking;
- state of line blanking;
- error protection data.

[CCIR, 1982-86d] proposed that only one timing reference signal should be used, located at the end of each line-blanking period. This identification signal includes a clock burst (for a bit-serial interface), indication of the initial point of the data frame, field-blanking period and first and second field periods. End-of-line information will be obtained by counting clock pulses.

The EBU [CCIR, 1982-86e] suggested that additional codes be included in the data stream and that the beginning and end of the digital active line will be identified in the demultiplexed Y , C_R , C_B data streams. It further proposed that these codes be included at the 4:4:4 level for both Y , C_R , C_B and R , G , B signals in digital form.

[CCIR, 1982-86f] stated that the timing reference (digital synchronization) codes inserted into the parallel code should be easily usable in a serial code.

Proposals for 525-line and 625-line differ in their definition of digital field-blanking intervals. [CCIR, 1982-86b, c, and d] stated that only 9 lines in both fields 1 and 2 belong to the field-blanking interval. [CCIR, 1982-86a and f] specify the digital field-blanking interval of 24 lines (field 1) and 25 lines (field 2). It may be advisable to shorten the digital field-blanking interval so as to allow for complex vertical filtering, though this problem needs further study.

Amongst other considerations [CCIR, 1982-86g] drew attention to the fact that “timing reference signals” should be referred to as “timing reference codes”.

In those data words occurring during digital blanking intervals that are otherwise unspecified, the OIRT [CCIR, 1982-86e] proposed that the digital codes equivalent to blanking level for Y , C_R , C_B be included in the appropriate locations in the multiplex.

3.2 *Ancillary signals*

Provision is made for ancillary data signals to be inserted synchronously into the video multiplex during the blanking intervals. [CCIR, 1982-86d and f] contain some details concerning these signals. [CCIR, 1982-86a, b, and c] propose the ancillary data signal format. The precise location of specific ancillary data and the corresponding identification markers requires further study.

4. **Parallel interfaces**

A number of proposals [CCIR, 1982-86a, b, c, d and f] suggested using eight conductor pairs, where each should carry, in NRZ format, a multiplex stream of bits (of the same significance) of each of the component signals, namely, Y , C_R , C_B . The eight pairs should also carry timing reference information and may carry ancillary signals that are time-multiplexed into the data stream during video blanking intervals. A ninth pair would provide a synchronous clock at 27 MHz. These proposals, with [CCIR, 1982-86e], contributed to the preparation of Recommendation 656 (see also [EBU, 1983]).

The signals on the interface may be transmitted using balanced conductor pairs for a distance of up to 50 m without equalization and up to 200 m with appropriate equalization [CCIR, 1982-86a].

Appropriate coding of the clock signal, such as the use of an alternating parity (AP) coding, has been shown to extend this distance by reducing the effects of cable attenuation [CCIR, 1982-86h].

5. **Serial interfaces**

[CCIR, 1982-86d] gives an example of a data sequence using 216 Mbit/s multiplexing. Particular attention is paid to ease of clock extraction and word synchronization by the inclusion of words within the data stream which generate clock bursts.

[CCIR, 1982-86f] refers to channel coding and states that transmission should be effected via 75 Ω coaxial cables for distances up to 1 km.

[CCIR, 1982-86e] contains a detailed consideration of the special requirements for a serial interface and proposes in Annex I a draft Recommendation for a bit-serial interface for the 4:2:2 level of Recommendation 601. This contributed to the preparation of Recommendation 656 (see also [EBU, 1985]).

In [CCIR, 1982-86e] the transmission of signals is considered in both electrical form, using coaxial cable, and in optical form using an optical fibre. The special requirements for bit-serial signal transmission between studios, or between equipments in a studio are given as:

- low cost and low complexity coupled with high reliability;
- very low intrinsic error rate in the transmission due to the very short distances;
- multiple outputs for monitoring and distribution;
- rapid recovery from errors introduced by switching of the transmission path, the video source or signal interruptions;
- full compatibility with the format of the bit-parallel interface and signal code commonality of both electrical and optical implementations of the bit-serial interface;
- usable over a range of distances from zero to at least 500 m, with a minimum of adjustments and extremely low error rates;
- applicable to a range of cable types.

These requirements are confirmed in [CCIR, 1982-86i], which also points out that in the implementation of a digital video installation, preference would normally be given to the parallel interface for short connection lengths and that recourse would be made to the serial interface mainly in the case of long or complex connection paths, where the cost of the interface terminal equipment would not override the saving in the physical support of the connection itself. Coaxial cables would probably be preferred for connections of medium length, while preference would go to optical fibres for very long connection lengths.

This contribution also suggests that the code used should be structured so as to permit the redundant bits to be employed to implement a system for measuring the bit error ratio (BER) at the receiving end of the connection and thus automatically monitoring its performance.

It further suggests that in a fully integrated digital installation or system it may be useful for all interconnections to be transparent to any appropriate digital stream, irrespective of the message content. Thus, although the interface will be used to transmit a video signal, it should be "transparent" to the message content, i.e., it should not base its operation on the known structure of the message itself.

[CCIR, 1982-86e] reviews the characteristics of transmission media, including interference susceptibility and describes the proposals received for source encoding, channel encoding and error management.

Two methods of source encoding have been proposed. [CCIR, 1982-86j] suggests the use of a parallel scrambler with the addition of a parity bit for synchronization and limited error detection purposes. According to a preliminary investigation, it appears that the sending end, at least, of such an interface could be integrated in a single gate-array chip.

A second method [CCIR, 1982-86e] providing spectrum control, clock and word synchronization by an 8-bit to 9-bit adaptive mapped code, is adopted in Recommendation 656.

In relation to these methods of source encoding, two different approaches to channel encoding have been proposed. In the scrambled system the channel coding is the AMI (Alternate Mark Inversion) for coaxial cable, and NRZ for optical fibre. The AMI code restricts the required bandwidth. In the bit-mapped system the encoded bit-stream, in NRZ format, is suitable for feeding both transmission media.

6. Parallel-serial (hybrid) interfaces

[CCIR, 1982-86d and f] also discuss an alternative solution in which signals are divided into multiple channels of 108 Mbit/s each in order to reduce the bit rate per channel. This method also enables various members of the extensible family of compatible coding standards to be accommodated within a multi-channel arrangement. However, as stated in [CCIR, 1982-86k], the main advantage advocated for the hybrid interface is that it reduces the bit rate sent on each of the parallel cables, but if 2 parallel cables are used, which is the most frequent proposal, then the bit rate is halved but the new bit rate is still too high to be implemented by means of much cheaper technologies.

On the other hand, the use of a hybrid interface involves complications at the sending and receiving ends, where circuits are needed to multiplex and demultiplex the bit stream, and also to phase the bit streams received on the cables.

These complications, and the cost of the additional cable (or cables) in the hybrid interface, appear overwhelmingly to militate in favour of a fully serial interface, rather than a hybrid interface, in those cases when the parallel interface cannot be used.

7. Interference with other services

Processing and transmission of digital data, such as digital video signals, at high data rates produces a wide spectrum of energy that has the potential to cause cross-talk or interference. In particular, attention is drawn in Recommendation 656 to the fact that the ninth and eighteenth harmonics of the 13.5 MHz sampling frequency (nominal value) specified in Recommendation 601 fall at the 121.5 and 243 MHz aeronautical emergency channels. Appropriate precautions must therefore be taken in the design and operation of interfaces to ensure that no interference is caused at these frequencies. Permitted maximum levels of radiated signals from digital data processing equipment are the subject of various national and international standards, and it should be noted that emission levels for such related equipment are given in CISPR Recommendation: "Information technology equipment — Limits of interference and measuring methods" Document CISPR/B (Central Office) 16.

In the case of the bit-parallel interface [CCIR, 1982-86] states that according to studies and experiments effected at the Canadian Broadcasting Corporation (CBC), with a correct shielding of the cables, no interference problem with other services is to be expected. This contribution recommends that radiation levels should comply with the limits given in Table I [CSA, 1983]. These limits are equivalent to those of the FCC in the United States of America.

TABLE I — *Limits of spurious emissions (CSA Class A)*

Frequency (MHz)	Maximum field strength dB(μ V/m) at 30 m
30 to 88	30
88 to 216	50
216 to 1000	70

In relation to the bit-serial interface [CCIR, 1982-86e] states that transmission by optical fibres eliminates radiation generated by the cable and also prevents conducted common-mode radiation, but the performance of coaxial cable can also be made near-perfect. It is believed that the major portion of any radiation would be from the processing logic and high-power drivers common to both methods. It adds that due to the wideband, random nature of the digital signal, little is gained by frequency optimization.

8. Further studies

Further studies are required:

- on interfaces for the 4 : 4 : 4 level, and for lower members of the family of digital coding standards;
- to establish the types of ancillary signals to be carried, including their characterization and location in the data stream, and to propose international standards as necessary;
- to determine what special provisions may be necessary in relation to the associated sound channels, for example, to avoid excessive relative time delays;
- on the practical methods required to ensure acceptably low levels of radiated interference from the digital signals;
- on optical interfaces for bit-serial signals.

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REPORT 1089

BIT-RATE REDUCTION FOR DIGITAL TELEVISION SIGNALS

(Questions 3/11 and 25/11, Study Programmes 3A/11, 25J/11, 25K/11 and 25M/11)

(1986)

1. Introduction

The subject of this Report is bit-rate reduction algorithms and their performance in picture quality, processing capability, and resistance to transmission errors. Such algorithms may find application in a number of areas of broadcasting, but it is clear from contributions received that the particular application of such schemes to long-distance transmission links is of the greatest interest at the present time.

Transmission systems in general are studied by the CMTT, and therefore it is necessary for Study Group 11 to inform the CMTT of its work and, where necessary, to refer questions to the CMTT.

An analysis of potential methods of bit-rate reduction for broadcasting pictures is a formidable task, and a wide range of approaches and techniques for bit-rate reduction have been reported in contributions. An overview of the techniques used is given in § 2 of this Report.

Section 3 of this Report presents an analysis of the available information by grouping systems according to practical application.

To compare alternative systems, it is necessary to agree on the way objectives are set and the way systems should be evaluated. Section 4 describes the kinds of impairments likely to arise in bit-rate reduction schemes and their evaluation, including a reference to subjective methods.

The Report concludes in § 5 with an assessment of future studies which Study Group 11 could undertake.

2. Bit-rate reduction approaches and techniques

Pulse-code modulation (PCM) representation of video signals requires bit rates of approximately 100 Mbit/s and 216 Mbit/s for composite and component signals respectively. There are several sources of redundancies in television signals which make it possible to reduce the bit rate; these are statistical redundancy, spectral redundancy, and perceptual redundancy.

The statistical redundancy results from the high degree of spatio-temporal correlation between adjacent picture samples. Generally, the statistical redundancy can be removed or reduced by a fully reversible process, i.e., no degradations are introduced by this process.

Spectral redundancy results from over-sampling. The video signal is essentially three-dimensional (vertical, horizontal, and temporal). Orthogonal (aligned) sampling patterns are, in general, inefficient in terms of spectrum (bandwidth) utilization. With the use of appropriate sampling patterns and the three-dimensional spectral properties of the sampled signal, the effective sampling frequency can be reduced (sub-sampling). The process of sub-sampling and interpolation results in perturbation of the signal (irreversible).

Properties of the human visual system, i.e., the eye-brain mechanism, create what is known as perceptual redundancy. By exploiting these properties, visibility of impairments caused by bit-rate reduction can be minimized under normal viewing conditions. For example, the visibility of noise varies with the brightness level of the picture. Another example is the masking phenomenon where high spatio-temporal activities in the picture tend to mask coding or processing impairments.

A very important element to be considered in bit-rate reduction systems is the fidelity criterion. Picture quality requirements depend on the intended applications. It is important to recognize that picture quality requirements for display under normal viewing conditions are quite different from those needed for post-processing. Therefore, in selecting bit-rate reduction systems, techniques and parameters, it is important to take into consideration the properties of the receiver, i.e., the human visual system or processing equipment. In general, picture quality requirements for post-processing are more stringent than those for visual display.

A generic video codec for bit-rate reduction can be conceptually segmented into the following main functions:

- analogue interfaces: these perform all analogue pre- and post-processing functions. They also include the analogue-to-digital and digital-to-analogue operations. In cases where input or output signals are in digital format (e.g. conforming to Recommendation 601) they are by-passed;
- digital pre- and post-processing functions: these include operations such as noise reduction, digital pre- and post-filtering, sub-sampling, etc.;
- bit-rate reduction functions: these include the implementation of bit-rate reduction algorithms and techniques to reduce the bit rate to the desired level. The inverse of these functions is performed at the decoder to reconstruct the signals;
- peripheral functions: these include all other functions such as channel interfaces, channel encoding, multiplexing, framing, etc.

2.1 *Pre- and post-processing techniques*

Pre-processing techniques are applied to video signals in order to condition the signal for efficient encoding and minimization of signal impairments. They generally involve linear or non-linear digital filtering for reduction of aliasing prior to sub-sampling. They are also used for noise reduction. Post-processing techniques include interpolation or enhancements filtering, and in some cases, they may include noise reduction at the output.

2.1.1 *Multi-dimensional pre-filtering*

One of the techniques used in bit-rate reduction is spatio-temporal sub-sampling. This involves reducing the effective sampling frequencies spatially and/or temporally. In order to minimize the impact of aliasing, one- or multi-dimensional low-pass filters are used. Alias components affect picture quality and reduce the efficiency of bit-rate reduction systems which again translate to lower picture quality.

The design and selection of the appropriate pre-filtering technique is closely tied to the sampling pattern used. For orthogonal sampling patterns, pre-filtering is carried out in the direction of sub-sampling. This will generally require reducing the picture resolution as the alias components will coincide with the baseband components. In the case of non-orthogonal sampling patterns, e.g. line-quincunx or field-quincunx patterns, multi-dimensional pre-filtering may be required. For a carefully chosen sampling pattern, the alias components do not overlap with the baseband components. In this case they can be removed by post-filtering.

2.1.2 *Noise reduction*

Traditionally, noise reducers have been used in broadcast television in order to improve picture quality for certain types of video material. In the low bit-rate environment where large compression ratios are required, e.g. 4 : 1 or 8 : 1, noise reduction may be necessary. The benefits of using noise reduction are not limited to the improvements in picture quality but are helpful for efficient bit-rate reduction operations.

2.1.3 *Spatio-temporal interpolation*

In cases where sub-sampling techniques are utilized for bit-rate reduction, spatio-temporal interpolation is required. The design of the interpolation filters is closely tied to the specific sampling pattern used.

2.2 *Predictive coding techniques*

In predictive coding techniques, a prediction of the current picture sample is obtained using previously coded picture samples (generally referred to as DPCM). The prediction error, i.e. the difference between the current sample and prediction value, is quantized, coded and transmitted. At the receiver, the inverse of these operations is performed to reconstruct the signal.

A large body of literature dealing with predictive coding techniques already exists. A classification of the various methods is usually done according to the origin of the information used to form the prediction. They can be divided as “intrafield” techniques in which the information used to form the prediction belongs only to the current field, and as “interfield” techniques, in which information from previous fields (and possibly from the current field) is used to form the prediction.

2.2.1 *Intrafield predictive coding techniques*

Intrafield techniques can be classified as one- or two-dimensional. In one-dimensional techniques the prediction signal is formed using previously coded samples from the current line only. The simplest form is the previous element predictor where the previous sample (sometimes weighted by a factor less than unity) is used to form the prediction.

One-dimensional predictors have the advantage of simplicity of implementation. In addition, channel-error propagation is limited to the line where any error occurred. However, the achievable compression ratio is relatively moderate, unless loss of picture quality is tolerated [Systems 12, 15, 26 and 36]. (In order to provide quick cross-references, particular bit-rate reduction systems are referred to under the system numbers (applicable only in this text). These numbers are the same as the relevant Interim Working Party 11/7 contributions.)

In two-dimensional predictive coding techniques the prediction is formed using previously coded elements from current and previous lines from the same field [Systems 11, 13, 21, 30 and 42]. In general, two-dimensional techniques are more efficient than one-dimensional.

Hybrid PCM/DPCM techniques have also been reported [System 42] and [CCIR, 1982-86a]. They involve periodic transmission of PCM samples and anchoring the prediction on those transmitted PCM samples. This approach provides a certain degree of channel-error immunity.

2.2.2 *Interfield coding techniques*

While the intrafield coding techniques discussed in the previous section exploit the spatial properties of the signal, interfield techniques exploit both temporal and spatial properties. In essence, these techniques exploit the three-dimensional nature of television signals and are essential for situations where higher compression ratios are required, while maintaining good picture quality. Interfield prediction techniques can be classified into two main categories, i.e. standard interfield techniques and motion-compensated techniques.

2.2.2.1 *Standard interfield techniques*

In these techniques previous and current field elements can be used to form the prediction. The predictor configuration and prediction coefficients are fixed. They generally perform extremely well in stationary areas of the picture; however, their performance deteriorates in the moving or changing areas of the picture.

2.2.2.2 *Motion-compensated techniques*

The basic idea of motion-compensated interfield prediction techniques involves estimating the motion of different objects from one field (or frame) to the next and performing the prediction in the direction of motion [Systems 4, 7, 8 and 9].

A key element in this approach is the method of displacement (motion) estimation. Several approaches have been presented in the literature. Among these are the pattern matching approach and the picture-element (pel) recursive approach.

The displacement estimation can be carried out prior to coding in which case the displacement vectors will have to be transmitted to the receiver. Alternatively, motion estimation can be carried out based on previously coded information. In this case, the displacement estimates need not be transmitted as they can be regenerated at the receiver.

2.2.3 *Adaptive (switched) predictive coding techniques*

Any prediction process assumes a certain image model. One-dimensional (intraline) predictors assume that the image consists mostly of horizontal edges or flat areas. Two-dimensional predictors extend this model slightly to the second dimension.

Standard interfield techniques assume that images consist mostly of stationary areas. Obviously for television imagery an accurate image model does not exist. Therefore, the performance of fixed-prediction schemes will vary depending on how far the local picture properties are from the implicitly assumed properties.

In order to improve the performance of predictive coding techniques, adaptive (or switched) predictors have been used [Systems 4, 5, 14, 15, 22, 31 and 37]. In this approach, two or more predictions are formed. The predictor which gives the lowest prediction error is selected. In this way the prediction process can be adapted to local picture properties.

Predictor switching can be carried out on a pel-by-pel basis or on a group of pels. Since the receiver has to know which predictor has been used at the transmitter, the predictor-selection rule has to be conveyed explicitly or implicitly. Explicit switching rules require transmission of necessary overhead information to indicate which predictor has been used. Implicit rules are based on previously coded information and generally do not require the transmission of such overhead, at the expense of some loss of performance.

2.3 *Transform coding techniques*

In transform coding techniques, the signal is segmented into one-, two- or three-dimensional blocks. Each block is transformed using one of the known orthogonal transforms, e.g. Discrete Cosine, Hadamard, ... etc. The resulting transform coefficients are quantized, coded and transmitted. At the receiver, the inverse of the above operations is performed to reconstruct the signal [Systems 18, 20, 38, 44 and 51].

2.4 *Hybrid predictive/transform techniques*

These techniques combine both transform and predictive coding approaches. This hybrid coding process can take one of several forms. One approach is to perform a spatial two-dimensional transform on the image blocks, then code the resulting transform coefficients by an interfield predictive coding technique. A second approach involves performing an interfield predictive coding in the pel domain. The prediction error is transform encoded inside the predictive coding loop. Obviously an inverse transformation is also carried out within the feedback loop. The transform coded prediction error is transmitted to the receiver [System 27].

2.5 *Miscellaneous coding approaches*

In addition to the basic techniques described in the previous sections, other approaches have been reported in the literature. These include group coding, interpolative coding, contour coding, stored pattern transmission [System 43] and block truncation coding (BTC) [CCIR, 1982-86b].

2.6 *Techniques for bit-rate reduction*

All the methods previously described do not reduce the bit rate by themselves, but rather tend to obtain a new signal more suitable to be encoded using fewer bits per sample than the original one. However, it should be pointed out that the amount of redundancy reduction achievable, without any loss of information, is usually very small. Higher compression ratios are only obtainable by cutting out a certain amount of non-redundant signals. The way in which these techniques work is by elimination of the part of information which is less necessary to the correct reproduction of the picture, meaning that the resulting impairment is of low visibility or not visible at all.

A number of techniques which are used to achieve the actual bit-rate reduction are listed below.

2.6.1 *Synchronization and blanking intervals removal*

Removal of the highly redundant synchronization and blanking intervals gives an appreciable bit-rate saving without introducing any impairments to picture quality and is relatively easy to implement. This technique is applicable to all television coding systems.

2.6.2 *Sub-sampling*

Spatio-temporal sub-sampling is the most obvious method of bit-rate reduction. In general, loss of signal resolution results from this process. However, with the use of an appropriate sampling pattern, coupled with a corresponding pre-filtering operation, the impact of the sub-sampling process on picture quality can be minimized [Systems 4, 7, 8, 9, 13, 19, 21, 22, 36, 37] and [CCIR, 1982-86c].

Sub-sampling can be carried out over the whole picture or it can be restricted to specific areas of the picture. For example, in multi-mode coders, spatio-temporal sub-sampling can be used in higher modes of operation. Alternatively, temporal sub-sampling is applied to the stationary areas and spatial sub-sampling is applied in the moving areas. Obviously conditional sub-sampling requires accurate image characterization, e.g. segmentation into moving or stationary areas.

2.6.3 *Quantization*

Effective quantization involves reducing the number of bits representing each sample. Both uniform and non-uniform quantizers can be used. In the majority of bit rate reduction systems, several quantizers are used. The switching between quantizers can be based on which mode of operation the coder is running [Systems 4, 5, 9, 10, 11, 13, 14, 15, 28 and 42], or the switching can be based on local picture properties [Systems 21, 22 and 30].

Another approach is given by the sliding quantizer [System 36], in which the quantization law is chosen depending on the signal level. It is based on the consideration that the video signal cannot be outside a certain value range. Thus, depending on the predicted value, the prediction error is limited. Hence, the selection of the more suitable quantizer will be made from time to time on the basis of the prediction value.

The quantization process need not be carried out on a pel-by-pel basis. It can be simultaneously applied to a group of adjacent pels. Examples of this process include vector quantization and block quantization techniques.

2.6.4 *Change of thresholds and isolated pel noise suppression*

In predictive coding the prediction error falling below a given threshold is classified as insignificant and is set to zero. By changing this threshold, the number of bits needed to represent the quantized prediction error will vary. The change of threshold provides a relatively fine control over the bit rate.

In addition, isolated prediction error samples that can be classified as noise can be suppressed (set to zero) [Systems 7 and 9]. This will improve the efficiency of variable word-length, run-length, and block encoding processes that will be discussed later.

2.6.5 *Temporal filtering*

This process involves processing the prediction error signal through a linear or non-linear function. In its simplest form, the prediction error is multiplied by a value α less than unity. The result of temporal filtering is a reduction in the magnitude of prediction error. Generally, a reduction in temporal resolution and other impairments result from this process.

2.6.6 *Variable word-length encoding*

Variable word-length encoding (sometimes referred to as entropy encoding) exploits the statistical properties of the quantized prediction error signal or quantized transform coefficients. This is achieved by assigning a lower number of bits for signal values with high frequency of occurrence and a larger number of bits for signal levels with low frequency of occurrence. This results in a variable-word length representation of the signal, e.g. Huffman code representation. This leads to a reduction of the bit rate [Systems 4, 5, 10, 11, 14, 15, 19 and 28].

2.6.7 *Run-length and block encoding*

This approach involves partitioning the quantized prediction error or transform coefficients into groups of pels, i.e. either "runs" or "blocks". The behaviour or the shape of the signal is encoded and transmitted [Systems 18, 27, 38, 43 and 44].

2.7 *Multi-mode coding*

In video coders utilizing variable word-length, run-length or block encoding, video data is generated at a variable rate. Since the transmission bit rate is generally fixed, buffering of data is required. In order to prevent the buffer memory from overflowing or underflowing, multi-mode operation is required. The coder will have several modes of operation.

The modes of operation are indicated by $M_0, M_1, \dots, M_n$. Each mode represents a specific choice of coding parameters (sampling rates, quantizer levels, thresholds, etc.). R_{ij} represent mode transition rules (e.g. buffer memory occupancy changes from below T_i to above T_i). In general, most transitions are not permitted, and transitions are between adjacent, or nearly adjacent modes.

M_1 is referred to as the main mode of operation, designed for "typical" image statistics, and giving full available resolution and best picture quality. M_0 is an "underflow" mode, which ensures that the buffer does not empty, perhaps by transmitting full resolution 8-bit PCM. A refresh mode may also be considered in order to limit the propagation of channel errors. Modes $M_2, M_3, \dots, M_n$ are referred to as "overflow" modes, invoked successively in periods of increased picture quality. In order to prevent the coder from oscillating between two modes, a hysteresis is built in the mode transition rules.

The art of designing multi-mode coders involves optimization of both coding parameters and mode transition rules. This process is carried out by subjective evaluation of picture quality over a large input data base.

2.8 *Channel error management*

It is well known that channel errors caused by interference and other channel impairments will adversely affect the final picture quality. In PCM systems, channel errors do not propagate beyond the pel where they occurred. However, in systems utilizing bit-rate reduction techniques, errors propagate beyond the pel where they occurred. Generally, three techniques have been used to alleviate the impact of channel errors on picture quality. These are:

2.8.1 *Forward error correction (FEC)*

By adding a small controlled amount of redundancy to the coded information, limited protection against channel errors is provided by detecting and correcting a given number of errors per block [Systems 4, 5, and 13]. Several codes have been reported in the documents. They include BCH (239, 255) double error correcting code, Reed-Solomon (63, 59) code and Wyner Ash (15, 16) code. These codes can handle random error effectively. However, in order to deal with burst errors, interleaving techniques are used.

2.8.2 *Error detection and concealment*

This class of techniques involves error detection followed by concealment which involves replacing the corrupted picture pels by information extracted from surrounding pels. This class has been extensively used in PCM systems.

In predictive coding systems (DPCM) their use has been mainly directed to cases where one-dimensional (intraline) predictors are used. This is largely due to the error propagation properties in such systems. In the case of two-dimensional spatial predictors, errors propagate in a way that may affect the whole field. Therefore, implementation of concealment techniques may require several field memories. In the case of interfield predictors, concealment techniques may not be practical as the errors will propagate in the temporal direction.

The problem of error propagation in DPCM systems can be greatly alleviated by adding a stability constraint to the criteria of predictor design [System 13]. This can be achieved by introducing a deliberate "leak" to the prediction process (leaky predictor). Therefore, impairments caused by error propagation will decay rapidly and hence are less obtrusive.

2.8.3 *Periodic refresh*

In order to limit the propagation of channel errors, periodic PCM refresh is used. This involves periodically transmitting some of the picture samples in PCM format. This also has the effect of removing residual picture impairments caused by coding. Alternatively, in coders utilizing several predictors, periodic refresh can be achieved by enabling only the intraline predictor and disabling the remaining predictors, i.e. DPCM refresh.

In bit-rate reduction systems, the information transmitted to the decoder includes coded visual information as well as overhead and control information, e.g. line identification, field identification, mode of operation, etc. Generally, control information requires a larger degree of protection than coded visual information. This can be achieved by adding more redundancies to the control information and using the same FEC techniques used for visual information. Alternatively, a different FEC technique can be used for control and overhead information.

3. *Bit-rate reduction systems for various applications*

Table I summarizes the main features of the systems on which contributions were made in the current study period as answers to questionnaires issued by Interim Working Party 11/7 [CCIR, 1982-86d]. Certain features of these systems are outlined below.

TABLE I — Summary of bit-rate reduction systems

System No.		19	12	13	26	42	76	13	13	21	30	36	22	31	37	28	20	38	51	74	4	18	44	27	75	43	13	14	13	15	15	10	11	5	8	9	
Contributor		D	F N L	G	I	G	O I R T	G	G	D	D	F	D	D	F	D	D	F	B E L	O I R T	J	C H N	E G Y	I	O I R T	E G Y	G	J	G	J	J	J	J	J	C A N	J	
Status	Study Experimental Practical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Component	140 (155) Mbit/s 50-70 Mbit/s	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
	30-34 Mbit/s 6-20 Mbit/s									*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
PAL	68 Mbit/s 34 Mbit/s																										*	*									
NTSC	44 Mbit/s 30-32 Mbit/s 15-20 Mbit/s																												*	*		*	*	*	*	*	
Blanking removal	Line-blanking Field-blanking	(¹) (¹)		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Quantization	Linear Non-linear	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Sub-sampling	Horizontal Vertical Temporal	(¹) (¹)						*	*		*	*	*	*	*	*	*		*	*	(²) (⁴)					*		*						*	(³)		
PCM		*				*																															
DPCM	Intrafield Interfield		*	*	*	*	*	*	*	*	*	*	*		*	*					*						*	*	*	*	*			*	*	*	
	Intraframe Interframe												(⁵)	*	*	*					*		*		*						*	*		*	*		

TABLE I (cont.)

System No.		19	12	13	26	42	76	13	13	21	30	36	22	31	37	28	20	38	51	74	4	18	44	27	75	43	13	14	13	15	15	10	11	5	8	9	
Contributor		D	F N L	G	I	G	O I R T	G	G	D	D	F	D	D	F	D	D	F	B E L	O I R T	J	C H N	E G Y	I	O I R T	E G Y	G	J	G	J	J	J	J	J	J	C A N	J
Transform	2-D 3-D																*	*	*			*	*														
Entropy	Variable word-length				*					*			*			*	*				*							*		*		*	*	*	*	*	*
Miscellaneous																				*					*	*											
Adaptive control	Quantizer Predictor										*	*	*	*	*	*	*	*			*	*						*		*		*	*	*	*	*	*
	Motion-compensation Transform coefficients																			*	*	*						*		*		*	*	*	*	*	*
Error correction										*		*				*				*	*	*					*	*	*	(⁶)				*	*		
Application	Contribution Distribution Satellite	*	*		*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

⁽¹⁾ C partly, depending on sampling rate.⁽²⁾ Y and/or C partly, depending on sampling rate.⁽³⁾ Partly, depending on the mode selected.⁽⁴⁾ C only.⁽⁵⁾ In combination with intrafield prediction only.⁽⁶⁾ Optional.

3.1 *Bit-rate reduction for 4 : 2 : 2 component signals*

3.1.1 *140 Mbit/s systems*

The majority of these systems fully maintain the spatial and temporal resolution of the television signal according to Recommendation 601, hence, they meet the performance requirements of contribution links where downstream processability is required. Some general aspects on the choice of coding parameters for contribution links are given in [CCIR, 1982-86e].

Three different techniques have been applied to the coding of component signals at 140 Mbit/s: PCM coding, DPCM coding and hybrid DPCM coding.

Coding proposals for a future local-area distribution network using uniformly quantized 8-bit PCM for both luminance and colour-difference components have been reported in [System 19] and [CCIR, 1982-86f]. Bit-rate reduction is obtained using line-blanking removal combined with horizontal and/or vertical sub-sampling of the colour-difference signals.

A DPCM system is described in [System 12], in which the sampling rates are unchanged with respect to the 4 : 2 : 2 coding, while previous sample prediction is applied to both luminance and colour-difference signals using 6-bit quantization for the Y signal and 4-bit quantization for the U , V signals. [System 13] describes a non-adaptive DPCM scheme with a 9-element, two-dimensional predictor for Y and a previous sample predictor for U and V using 6 bits/sample for both luminance and colour-difference signals. A further study [System 26] for verifying optimum colour-matte performance utilizes a real-time simulator to derive the best quantization characteristics and optimum variable-length coding.

A hybrid DPCM (HDPCM) approach is reported in [System 42]. Every fourth source sample in a line-quincunx structure remains as an unmodified 8-bit PCM sample and the values of these samples are then used as a basis of two-dimensional predictor/interpolators for the intervening DPCM samples.

A further proposal is described in [CCIR, 1982-86a]. By using a folded quantizer characteristics and the hybrid coding method, picture quality degradations due to overload effects can be significantly reduced. In addition, sensitivity to transmission errors comparable to systems with PCM representation can be obtained.

3.1.2 *50-70 Mbit/s systems*

Signals with no loss of picture quality and negligible loss in colour-matte quality compared to 4 : 2 : 2 signals can be achieved at the hierarchical bit rate of 140 Mbit/s. Using the next lower standardized level, 34 Mbit/s, picture quality is generally equivalent to that of existing analogue component signals whereas the processing capability is reduced with respect to that of 4 : 2 : 2 signals. Some administrations believe that a non-hierarchical bit rate of about 68 Mbit/s may be an attractive compromise between possible link costs and available operating capabilities bearing in mind that bit rates of the order of 50 to 60 Mbit/s may also be available via future communication satellites [System 17].

A DPCM system using 5 bits/sample is described in [System 76] with an overall bit rate of 70 Mbit/s including auxiliary signals. It is based on a 4 : 1 : 1 sampling ratio with line-sequential colour-transmission together with horizontal blanking removal.

Bit-rate reduction of YUV component signals to about 52 Mbit/s using multi-element non-adaptive DPCM with a two-field prediction algorithm and a 32-level non-linear quantizing has been investigated for broadcast-quality applications in two different approaches [System 13].

In the time-division multiplex approach, the luminance sampling frequency is reduced to 10.125 MHz and colour-difference sub-sampling is involved by reducing the horizontal sampling frequency to 3.375 MHz and halving the vertical sampling frequency (line sequential colour-difference). In the frequency division multiplex approach, the colour-difference components are added to the luminance component on an out-of-band sub-carrier at half the sampling frequency of 6.75 MHz. For both cases, the picture quality was found to be comparable with, or better than, analogue composite-coded signals; some reduction in processing capability relative to the 4 : 2 : 2 source signal was introduced because of the reduced bandwidths of the colour-difference components.

3.1.3 30-34 Mbit/s systems

The data rate of 30-34 Mbit/s is of special interest for terrestrial and satellite transmission of television programmes. It has been claimed in [CCIR, 1982-86g] that a good distribution quality could be obtained at this bit rate. The quality attainable at 34 Mbit/s and its relationship with the quality required for contribution links is still to be determined.

For transmission with 34 Mbit/s various systems have been proposed which utilize non-adaptive prediction, fixed or switched quantizing together with sample-rate conversion thus introducing sub-Nyquist sampling and a ratio of 4 : 1 between the sampling frequencies for the luminance and colour-difference components.

Examples of DPCM coding schemes with fixed prediction using sampling frequencies of 9 MHz for the luminance and 2.25 MHz for the colour-difference signals are presented in [Systems 21 and 30].

A further approach [System 36] starts with an initial picture coding of 12 : 6 : 6 MHz. After line- and field-blanking removal a two-stage coding technique is provided by the use of line-quincunx sub-sampling.

In [System 22], an adaptive DPCM coding scheme using sampling frequencies of 9 MHz for luminance and 2.25 MHz for colour-difference signals is described where interframe or interfield prediction is performed when the picture content is still and intrafield prediction takes place when the content is moving.

Other approaches using adaptive predictor selection between interfield and intrafield or between interframe and intraframe have been made in which sampling rates of 10.125 MHz for the luminance and 3.375 MHz for the colour-difference signals together with alternate-line transmission of the U , V signals are used [Systems 31 and 37].

In [System 28], an interframe/intraframe DPCM codec is presented which enables transcoding between different data rates standardized for different ITU regions without prior reconstruction into the PCM level. By selecting the quantizing characteristics and the associated variable-length code words up to the capacity of the output buffer memory and by signalling predictor changes to the decoder, the concept allows the picture quality achievable in higher-rate transmission systems to be largely retained.

A DPCM method of 34 Mbit/s using variable length coding and transmission of the residual length in the horizontal blanking period is described in [CCIR, 1982-86h].

[System 4] presents a universal codec for either 525-line or 625-line systems which is applicable to the bit rates of the third PCM hierarchy levels recommended by the CCITT (32, 34 and 44 Mbit/s) without any significant modification in the hardware configuration and which has input/output interfaces conforming to Recommendations 601 and 604. This codec employs a new adaptive prediction scheme, MAP (median adaptive prediction), based on a combination of motion-compensated interframe, interfield and intrafield prediction which allows the transmission of broadcast TV programmes at 30 Mbit/s.

Transform coding has also been applied to the transmission of component signals. [System 20] proposes a coding method using a modified M -transformation for transmission at 34 Mbit/s. Here, a redundancy and irrelevance-reducing encoding is carried out in three parallel channels by processing and quantizing the spectral value, the average value and the activity of a vector which represents a block of 4×4 pels.

A further application of transform coding to the luminance component of separate component signals is described in [System 38], using a Walsh-Hadamard transform having blocks of 4 lines by 8 pels with adaptive quantization for each block.

Another 34 Mbit/s system [System 51] makes use of a Hadamard transform in combination with sub-sampling performed by two-dimensional interpolation (decimation).

Block truncation coding (group coding) has also been successfully used at 34 Mbit/s with high picture quality and having an error protection system able to withstand a bit error ratio of up to 10^{-5} [System 74] and [CCIR, 1982-86b].

3.1.4 6-20 Mbit/s systems

It may be necessary to reduce the transmission bit rate to 15-20 Mbit/s or lower in order to accommodate up to four channels per satellite transponder. Coding efficiency must be substantially improved to obtain this reduction. In this context, movement-compensated prediction, three-dimensional transform coding or hybrid DPCM/transform coding may offer promising approaches.

The codec of [System 4] is also used for the transmission of ENG programmes at 15 Mbit/s. In this 15 Mbit/s system a 2 : 1 : 0 sampling ratio is adapted.

An adaptive image transform coding using fast Hadamard transformation is described in [System 18]. The adaptivity is provided by finding so-called activity factors for each transform block and assigning more bits to the more active parts of the picture and fewer bits to the less active parts of the picture.

In [System 44], a method for achieving substantial saving in bit rate has been reported in which the correlation between consecutive frames in the form of a three-dimensional transformation is introduced. In this method, the rate distortion function is calculated for a vector of 64 pels, a square of 8×8 pels, and a cube of $4 \times 4 \times 4$ pels using in each case Karhunen-Loeve, Hadamard and Slant transformation in the one- and three-dimensional form.

First results of an investigation on a 16 Mbit/s hybrid coding scheme, a combination of predictive and transform coding, are discussed in [System 27]. The system uses a linear three-dimensional predictor which samples the previous 3 frames according to a grid of 5×5 pels surrounding the point to be predicted.

A group coding system using 4×4 pel blocks for the luminance signal and 2×4 pel blocks for the colour-difference signals is presented in [System 75]. For transmission at 18.5 Mbit/s, every other field is dropped and reconstructed by temporal linear interpolation at the receiving end.

In [System 43], a new approach called stored pattern transmission (SPT) is applied for bit-rate reduction. The SPT depends on selecting a finite number of patterns to cover the different variations normally occurring in a picture. These patterns are stored with the same addresses at both the transmitting and receiving ends. The bit rate can be reduced to 6 Mbit/s with this system.

3.2 *Bit-rate reduction systems for PAL signals*

3.2.1 *68 Mbit/s systems*

A technique involving sub-Nyquist sampling combined with non-adaptive intra/interfield DPCM is described in [System 13]. By the action of a digital comb-filter, the original $4 f_{sc}$ (see Note) sampling structure of the PAL signal is reduced to a $2 f_{sc}$ sampling structure. A fixed multi-element DPCM algorithm using several samples taken from the present and previous field in combination with a non-linear 64-level quantizer enables the difference signal so formed to be sent at a video bit rate of about 53 Mbit/s.

A coding principle based on a reversible predictive coding followed by entropy coding is reported in [System 14]. In order to generate a constant transmission rate, PCM bit truncation prior to predictive coding is introduced.

Note .— f_{sc} denotes the colour sub-carrier frequency.

3.2.2 *34 Mbit/s systems*

[System 13] describes a 34 Mbit/s DPCM coding system using a non-adaptive 14-element intra/interfield predictor and a 22-level non-linear quantizer combined with the removal of both line- and field-blanking intervals and sub-sampling at twice the colour sub-carrier frequency.

3.3 *Bit-rate reduction systems for NTSC signals*

Various studies have been carried out on bit-rate reduction of NTSC signals with bit rates in the range 30-44 Mbit/s using predictive coding techniques in fixed or adaptive form, sampling frequencies of 8.9 MHz or 10.7 MHz, and in some cases, variable word-length coding.

3.3.1 *44 Mbit/s systems*

[System 15] presents two different approaches in high-order predictive coding and describes its application to codecs encoding NTSC colour TV signals at a transmission rate of 44 Mbit/s. The first approach is based on reversible predictive coding followed by entropy coding. In the second approach, the digitized NTSC signal sampled at 8.9 MHz with 8-bit precision, is encoded into a 5-bit fixed word-length code by using a non-adaptive intrafield DPCM followed by a 31-level non-linear quantizer.

3.3.2 30-32 Mbit/s systems

For the transmission of NTSC signals within the third-order PCM hierarchy bit rate in Japan, a DPCM approach utilizing either fixed prediction schemes together with a sampling frequency of 8.9 MHz ($= 2.5f_{sc}$ or $566f_h$), or adaptive prediction schemes combined with a sampling frequency of 10.7 MHz ($= 3f_{sc}$), can provide sufficient data rate reduction.

[System 10] describes an intraframe combinational-difference coding method for use as an LSI-oriented coding algorithm in which two predictive coding circuits with identical configurations are connected in sequence and to which a quantizer is added.

The composite DPCM prediction method reported in [System 11] is based on the principle that luminance and colour-difference components are predicted individually. The composite prediction value is then determined by the sum of these two prediction values. A 4-bit and 8-bit dual word-length code assigning the 4-bit words to 15 quantizing levels which correspond to small prediction error amplitudes and the 8-bit words to 15 other quantizing levels which correspond to large prediction error amplitudes provides an average word length of 4.4 bits/sample.

A further approach to composite coding of NTSC colour TV signals using an inter/intrafield adaptive prediction method in combination with blockwise conditional replenishment control, is proposed in [System 5]. For "insignificant" blocks where the error sum does not exceed a certain threshold value, the prediction errors are assumed to be zero and only the block mode information of 2 bits transmitted, whereas the prediction errors of "significant" blocks are quantized and transmitted together with the block mode information.

3.3.3 15-20 Mbit/s systems

[System 8] presents the coding algorithms and simulation results of multi-mode movement-compensated interframe video coders operating at 15 Mbit/s and 20 Mbit/s. To reduce the bit-rates to the desired levels, various techniques such as sub-sampling from $4f_{sc}$ to $2f_{sc}$, temporal filtering, isolated pel noise suppressing, switched quantizing, block encoding, and variable word-length coding, are used in different modes which are controlled by the buffer memory status.

A second approach making adaptive use of interframe, interfield and intrafield prediction for coding of NTSC colour TV signals is presented in [System 9]. Whereas the motion-vector detection for a segment of the picture is carried out by using only the luminance signal, both the luminance signal and the two baseband components of the chrominance signal are motion-compensated in order to displace the picture segments of the previous frame according to the motion-vector which is detected.

3.4 Error protection methods

As for channel-error protection methods, several forward error correction (FEC) codes, such as Reed-Solomon (63, 59) code, Wyner Ash (15, 16) code and BCH (239, 255) code, have been applied in bit-rate reduction coding systems [Systems 4, 5, 8, 13, 14, 21, 28, 36, and 79]. As an example of a channel-error protection method employed in a codec, the BCH (239, 255) code in combination with periodic DPCM refreshing and line-reset is described in [System 79].

4. Methods of evaluation of picture quality for bit-rate reduction systems

4.1 Scope and objectives of evaluation techniques

The ultimate criteria for a bit-rate reduction system is the subjective quality of the resulting pictures, in the context of the bit rate achieved.

An overall evaluation must include the performance of the coding system itself (the basic quality), the performance after any subsequent processing has been carried out (the downstream processed quality), and the way transmission errors affect the system (the failure characteristic) and must take into account the critical nature of the test picture sequences used to evaluate the system.

In order to decide on the merits of a particular system, it is necessary to consider the relative importance of all these factors, and to establish criteria for acceptability in each case. An example of such an approach is given in [Inoue and Hishiyama, 1984].

The evidence of the current contributions to the CCIR is that predictive coding (DPCM) is likely to provide the best method for coding high-quality video with current, practically achievable, equipment. In addition, it may be noted that many proposals use sampling-frequency reduction (compared to the source 4 : 2 : 2 sampling frequencies).

4.2 *Evaluation of basic quality*

It is possible to classify the types of impairments associated with intrafield coding broadly as follows:

- slope overload (where the rise-time of the original signal cannot be matched, and therefore edges are blurred);
- edge busyness (where the precise continuity of an edge in the original signal cannot be matched, and therefore edges appear noisy);
- contouring (where the uniformity or monotonicity of the original signal cannot be matched and therefore a layering effect occurs);
- granular noise (where finely detailed portions of the picture, for example those below a threshold level, are not available, and the picture therefore has a noisy appearance).

For interframe or interfield coding, the following types of impairment may occur due to temporal prediction inaccuracy:

- temporal slope overload (where, because of the rate of movement, moving edges cannot be matched, and therefore become blurred during movement);
- granularity and edge busyness (where, for fine detailed areas in movement, the above granular noise effect and edge busyness effect occur).

For interframe or interfield coding, the following types of impairment may occur due to temporal sub-sampling:

- jerkiness (where the smoothness of movement cannot be matched and therefore there are discontinuities in moving sequences);
- temporal aliasing (where high temporal frequency components are folded back);
- loss of resolution in moving pictures (where spatial resolution is reduced during movement).

4.3 *Evaluation of downstream processed quality*

4.3.1 *Types of downstream processing to be considered*

Four types of processing operations principles need to be considered. These are as follows:

- colour matte (a process which combines colour-keying and the addition of signals to produce a single picture giving the impression that two sources (the foreground and the background) are part of the same picture);
- picture expansion and compression (a process which produces a new picture based on the original but either larger (expansion) or smaller (compression));
- successive decoding and encoding (a process of generating an analogue or digital signal in a different format, perhaps for intermediate use, before subsequent encodings, etc.);
- slow motion (reproduction of the picture signal at reduced rates of motion by repetition of frames).

4.3.2 *Types of impairment associated with bit-rate reduction systems*

4.3.2.1 *Colour matte*

- edge effects on foreground edges (where the matting becomes apparent because the transition from foreground to background has a visible halo).

4.3.2.2 *Picture expansion and compression*

- aliasing (where repeat or interference patterns manifest themselves in areas where there was originally fine detail in the picture);
- lack of picture sharpness and detail in the expanded picture.

4.3.2.3 *Successive encoding and decoding*

- a general reduction in picture quality caused by loss of frequency response, noise, etc.

4.3.2.4 *Slow motion*

- lack of picture sharpness, shape or position deformation, or position judder.

4.4 *Evaluation of failure characteristics*

The passage of the reduced bit-rate signal through the transport media, transmission line, video tape recorder, etc. may cause bit errors, which may occur independently or in bursts. The ability of a system to tolerate such errors, including either uncorrected or corrected channel errors, and the way that the resulting impairments manifest themselves, should be a part of the evaluation of a system for a given transport medium [Matsumoto *et al.*, 1985].

In general, the bit errors will manifest themselves as noise on the picture, although there could be other effects depending on the type of techniques, such as concealment, which were used. The errors can spread spatially and temporally depending on the coding technique which was used.

4.5 *Test material*

In general, intrafield systems do not limit motion portrayal, and therefore still-picture test material can be used for their assessment. (However, still-picture stores may not be sufficient because of noise effects.) For interframe coding, moving picture sequences are required.

4.6 *Subjective evaluation methods*

The bit-rate reduction schemes under consideration are likely to provide high quality pictures, therefore assessment procedures are needed which provide greatest accuracy above mid-opinion. Recommended assessment procedures are given in Recommendation 500. Annexes II and III of Report 405 give information on methods of analysis and presentation of results and Annex IV of Report 405 contains some discussions on the comparison of different test procedures.

4.7 *Quantitative evaluation methods*

Studies have been made in Japan which suggest that picture quality impairments, arising from digital coding and transmission, can be classified into several categories of disturbance which are independent of each other in terms of their effect upon subjective picture quality. [CCIR, 1978-82; Kobayashi, 1977] indicate that the physical terms to express the categories of disturbance in intrafield coding can be defined and measured using well known test signals such as the staircase and sawtooth signals. For interframe coding, [CCIR, 1982-86i; Hishiyama and Inoue, 1984] indicate that the impairment introduced can be classified into four kinds of degradation factors and the references also describe objective parameters with which they can be specified. There have been further Japanese proposals to devise analogue and digital methods of measuring distortion (the difference between the output and input signal) and in work by the BBC it has been found useful to use a visual display of the quantizing error, multiplied by a factor to make it visible.

Weston [1982] describes a digital zone plate test-signal generator for testing equipments and systems using two- and three-dimensional signal processing. As in other types of frequency-response measurements, the results are most useful qualitatively; the quantitative results may be difficult to relate to a subjective assessment using real pictures.

5. *Conclusions and future studies*

Both predictive and transform coding in combination with the removal of the line- and/or field-blanking intervals appear to be efficient coding methods for bit-rate reduction, although from a practical point of view, most of the coding equipment developed so far is based on predictive coding.

At 140 Mbit/s PCM, DPCM or hybrid DPCM techniques in combination with non-adaptive prediction schemes allow high-quality post-processing (close to that achieved with 4:2:2 signals). Component coding at 68 Mbit/s using fixed interfield prediction seems to be applicable to contribution purposes with a reduced colour-matte performance. Data rates of 30 to 44 Mbit/s which correspond to the third level of the different PCM hierarchies are of special interest for programme distribution. Conventional composite analogue picture quality can be achieved at these bit rates with present day bit-rate reduction methods.

At data rates around 30 Mbit/s or lower, the adaptive change of prediction schemes is indispensable for attaining satisfactory picture quality. Furthermore, motion-compensated prediction methods can be applied for coding systems at bit rates of 15 to 20 Mbit/s.

Administrations are encouraged to standardize component-based still picture and moving picture source material for subjective assessments of bit-rate reduction systems. If possible, these should be available on the CCIR 4 : 2 : 2 digital television tape recording format (see Recommendation 657).

It seems that a potentially achievable objective of future studies by the CCIR would be to establish standardized source coding methods for the transmission of digital television signals derived from 4 : 2 : 2 signals (Recommendation 601). Several sets of requirements need to be considered. These may include a level for contribution circuits which would preserve the quality and some or all of the processing capacity of the 4 : 2 : 2 signals, and another which would provide at least the equivalent composite signal quality for distribution circuits.

As may be noted, preliminary indications are that the former may be achieved by DPCM (60-140 Mbit/s) and the latter by adaptive DPCM (34 Mbit/s or less). However, further study is required to determine precise objectives and optimum solutions. In this connection [CCIR, 1982-86j] gives one proposal for a basis of system requirements and implementation of a bit-rate reduction coding system to be applied to distribution circuits or long-distance transmission.

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- [1978-82]: 11/83 (Japan); 11/248 (Japan); 11/277 (Germany (Federal Republic of)); 11/295 (USA); 11/296 (USA); 11/301 (Germany (Federal Republic of)).
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QUESTIONS AND STUDY PROGRAMMES, RESOLUTIONS, OPINIONS AND DECISIONS

QUESTION 1-1/11

COLOUR TELEVISION STANDARDS

(1955-1986)

The CCIR,

CONSIDERING

- (a) that standards currently used for television broadcasting in Bands I, III, IV and V are documented in Report 624;
- (b) that the 625-line, 50 fields/s video frequency characteristics of a television system to be used for international exchange of television programmes are documented in Recommendation 472;
- (c) that colorimetric standards currently used are documented in Report 476;
- (d) that system parameters for satellite broadcasting are covered by Question 2/10 and 11 and its dependent Study Programmes;
- (e) that standards for digital television systems are covered by Question 25/11 and its dependent Study Programmes;
- (f) that standards for high-definition television are covered by Question 27/11;
- (g) that standards for high-definition television are covered by Question 42/11;
- (h) that it is desirable to pursue some studies on ways to extend and improve the present terrestrial television broadcasting service,

UNANIMOUSLY DECIDES that the following question should be studied:

which steps can be taken to extend and improve the present terrestrial television broadcasting service, taking into account the provision for compatibility:

- by changes in the television synchronizing signal;
- by changes in the encoding of the picture and/or the sound information;
- by broadcasting in different frequency bands;
- by the introduction of new, compatible services such as stereoscopic television;
- by the introduction of improved receiver technology?

Note. — See Reports 476 and 624 and Recommendations 470, 471 and 472.

STUDY PROGRAMME 1C-1/11

CONSTITUTION OF A SYSTEM OF STEREOSCOPIC TELEVISION

(1958-1986)

The CCIR,

CONSIDERING

- (a) the possible future development of stereoscopic television broadcasting;
- (b) the great utility this form of television may have,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. investigation into the development of methods of providing stereoscopic television, in monochrome or colour; particularly those not requiring the use of spectacles;
2. methods of reducing the bandwidth required to broadcast stereoscopic television in order that it may be accommodated within a conventional broadcasting channel;
3. methods of ensuring that the broadcast stereoscopic television signal will be compatible with monoscopic television receivers;
4. study of the influence of noise on stereoscopic television pictures and determination of the permissible signal-to-noise ratio;
5. research into the design of receivers for the direct reproduction of stereoscopic monochrome or colour television.

Note. — See Report 312.

STUDY PROGRAMME 1D/11

RATIO OF PICTURE-SIGNAL TO SYNCHRONIZING-SIGNAL

(1970)

The CCIR,

CONSIDERING

- (a) that it is desirable that both the video and radiated signals should have the same ratio of picture-signal to synchronizing-signal;
- (b) that it is also desirable that all television systems should employ the same ratio of picture-signal to synchronizing-signal;
- (c) that modern television receivers might be able to function with a higher ratio of picture-signal to synchronizing-signal than at present used, thus improving transmitter performance,

UNANIMOUSLY DECIDES that the following studies should be carried out:

determination of a single value for the ratio of picture-signal to synchronizing-signal which could be recommended in the future for both the video and radiated signals of all television systems.

Note. — See Report 484.

STUDY PROGRAMME 1E/11

SIMPLIFICATION OF SYNCHRONIZING SIGNALS IN TELEVISION

(1970)

The CCIR

UNANIMOUSLY DECIDES that the following studies should be carried out:

the effect of a reduction of the number of equalizing pulses upon:

- the quality of field synchronization in monitoring equipment and in domestic receivers;
- the quality of interlacing in monitoring equipment and in domestic receivers;
- the vulnerability of domestic receivers to interference, especially when the frequency of the interfering signal has a precise offset from that of the wanted signal;
- the sensitivity of domestic receivers with respect to synchronization;
- the reliability of synchronization of domestic receivers when operating with an asynchronous power supply;
- the special problems that may arise in video tape recording as a result of modifications to the synchronizing signal.

Note. — See Report 626.

STUDY PROGRAMME 1G-1/11

**CHARACTERISTICS OF TELEVISION SIGNALS RADIATED IN
BAND 10 (SHF) FROM TERRESTRIAL BROADCASTING TRANSMITTERS**

(1982-1986)

The CCIR,

CONSIDERING

- (a) that the WARC-BS-77 has established for Regions 1 and 3 a frequency and orbital position Assignment Plan for the broadcasting-satellite service in the 12 GHz band shared with terrestrial broadcasting;
- (b) that the RARC BS-83 established a Plan for the broadcasting-satellite service in Region 2;
- (c) that the characteristics of the broadcasting-satellite service signals which were used for the planning purposes are given in the respective Final Acts;
- (d) that the protection ratios between AM and FM television signals are given in Report 634;
- (e) that terrestrial television signals radiated in the lower and upper parts of band 8 (VHF) and in band 9 (UHF) conform to the amplitude-modulated standards whose characteristics are given in Report 624, Table III;
- (f) that propagation factors in band 10 (SHF) will be important when considering standards for the radiation of television signals in that band from terrestrial transmitters;
- (g) that the cost of adapting the television receivers used by the public for SHF reception must be reasonable,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the type of modulation to be recommended for television broadcasting in band 10 (SHF);
2. the radio parameters necessary for planning and sharing purposes.

Note. — See Report 961.

STUDY PROGRAMME 1H/11*

**REDUCTION OF CHANNEL BANDWIDTH IN TELEVISION
BROADCASTING BY INCORPORATING THE SOUND
INFORMATION IN THE VIDEO SIGNAL**

(1986)

The CCIR,

CONSIDERING

- (a) the importance of an efficient utilization of the frequency spectrum;
- (b) that techniques are available to reduce the channel bandwidth of terrestrial television broadcasting systems by incorporating the sound information in the video signal;
- (c) that the same techniques might be used to reduce the difficulties arising from certain system parameters in satellite television broadcasting;

* Formerly Study Programme 12B-1/11 (Geneva, 1982).

- (d) that the consequent change in the television system might result in:
- an improvement in the picture quality by eliminating the need for a combining filter in transmitters and a sound trap in receivers;
 - an improvement of sound quality by eliminating the problems inherent in intercarrier sound detection;
 - the elimination of the problem of sound-to-vision intermodulation in certain transmitters and in cable distribution systems;
- (e) that there would be serious compatibility problems in introducing such techniques into existing television broadcasting services, especially for receivers,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the transmission of sound information in the video signal while maintaining compatibility with existing television broadcasting systems;
2. the required channel bandwidth and the necessary protection ratios for television broadcasting systems without a separate sound carrier.

Note. — See Report 958.

QUESTION 2-3/11

EXCHANGE OF TELEVISION PROGRAMMES

(1966–1970–1974–1986)

The CCIR,

CONSIDERING

- (a) that it is desirable to exchange television programmes between countries;
- (b) that a variety of television standards is in use;
- (c) that the number of scanning standards used throughout the world tends to be reduced to two, namely; 525-lines, 60 fields per second and 625-lines, 50 fields per second, the line frequencies of which are very close;
- (d) that other standards are being planned for new applications, such as high-definition television,

UNANIMOUSLY DECIDES that the following question should be studied:

what methods can be used to enable television programmes to be exchanged between countries in the following cases:

1. when the nominal line and field frequencies are the same;
2. when both the nominal field frequencies and the numbers of lines are different;
3. when the nominal line and field frequencies are the same but the colour television systems are different?

Note 1. — Programme exchanges should be considered:

- between different monochrome systems,
- between different colour systems,
- between monochrome and colour systems,
- between 525/625 systems and high-definition television systems.

Note 2. — See Reports 311, 630, 803 and Recommendation 472.

STUDY PROGRAMME 2A-1/11

**TRANSCODING OF COLOUR TELEVISION SIGNALS
FROM ONE SYSTEM TO ANOTHER**

(1970-1986)

The CCIR,

CONSIDERING

- (a) that, for each set of television raster scanning parameters at the source (field rate, number of lines, interlace order) several ways are used or are proposed for coding the colour-picture information;
- (b) that the need often arises to transcode between such different formats when programmes are exchanged between countries or when they are used for different applications,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. methods of transcoding from one format to another having the same scanning structure, but with different picture coding methods;
 2. tolerances required of a colour television signal to ease the problem of transcoding it into another system.
- Note.* — See Report 477.

STUDY PROGRAMME 2B/11

**CONVERSION BETWEEN DIFFERENT TELEVISION
SCANNING STANDARDS**

(1986)

The CCIR,

CONSIDERING

- (a) that different television raster scanning standards (line and field rates) are in use in different countries;
- (b) that conversion between different television scanning standards is required to permit television programme exchanges between such countries;
- (c) that other standards are being planned for new applications such as high-definition television;
- (d) that the introduction of high-definition television in programme production will generate a need for conversion between high-definition television and conventional television standards;
- (e) that careful study and a thorough understanding of standards conversion processes is required in order to achieve a conversion that will introduce the minimum possible level of impairment in the original programme material,

UNANIMOUSLY DECIDES that the following studies should be carried out:

optimization of the standards conversion methods to be respectively used for bidirectional conversion between:

1. the 625-lines/50 Hz and 525-lines/60 Hz scanning standards;
2. high-definition television and the 625-lines/50 Hz standards;
3. high-definition television and the 525-lines/60 Hz standards.

Note. — See Report 311.

QUESTION 3-2/11

**ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES
INCLUDING ALPHANUMERIC AND GRAPHIC PICTURES**

(1951-1956-1970-1982)

The CCIR,

CONSIDERING

- (a) that appreciable discrepancies may exist between assessments by different experts of the quality of the pictures given by the television systems now in use or proposed;
- (b) that these discrepancies are due to the fact that it is usually impossible to obtain simultaneous viewing of the pictures under comparison, to possible variations in quality between apparatus nominally using the same system and to alterations that may occur with time in the characteristics of the equipment used;
- (c) that, consequently, it would be eminently desirable to have some standard method of measuring picture quality, which would permit objective comparison of the results obtained in different places and would serve as a guide to the efficient and uniform working of the equipment in service;
- (d) that the quality of pictures is determined by the transmission parameters of equipment which can be measured objectively and which can be related to the subjective picture quality,

UNANIMOUSLY DECIDES that the following question should be studied:

1. what standardized methods and means of test, independent of the television standards employed, can be used to measure accurately, and whenever possible, objectively, the deterioration introduced into monochrome and colour pictures by television, taking into account the system, the equipment and the transmission processes;
2. what are the relationships between the objective parameters of television signals and the subjective assessments of displayed picture quality?

Note. — See Reports 313, 405, 959, 1082, 1083 and Recommendations 500 and 654.

STUDY PROGRAMME 3A-3/11 *

**SUBJECTIVE ASSESSMENT OF THE QUALITY
OF TELEVISION PICTURES**

(1963-1966-1978-1982-1986)

The CCIR,

CONSIDERING

- (a) that subjective methods of testing are frequently necessary to assess the relative quality of television pictures and the effect of interference and other impairments upon them;
- (b) that methods for the subjective assessment of the quality of television pictures have been agreed (see Recommendation 500);
- (c) that the results of subjective tests depend upon the conditions under which they take place, and that new techniques such as digital coding or high-definition television introduce new problems which may require more detailed or extended specification of the recommended method;
- (d) that the possible use of interfield and interframe prediction and other motion-dependent digital coding techniques will necessitate the use of moving pictures in the subjective assessment of such systems;
- (e) that the possibility of down-stream processing of component-coded digital signals is envisaged in § 12 of Annex I to Decision 18;
- (f) that it may prove necessary to compare the subjective quality and the assessment scores of television pictures provided by different television standards which have an inherently different quality capability, e.g., conventional 525 or 625-line television standards and high-definition television standards;

* This Study Programme is also of interest to the CMTT.

- (g) that the results of subjective tests can be analysed and presented in many ways;
- (h) that the results of subjective tests can be interpreted in many ways;
- (j) that it is highly desirable to increase the degree of standardization in the methods of testing, presentation and interpretation of the results of subjective tests, so that true comparisons may be made between results obtained by different workers,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. on the modifications, if any, to the specifications of the testing method covered in Recommendation 500 that may be necessary to improve the degree of standardization in the assessment of the quality of television pictures, particularly in relation to problems arising from new techniques such as digital coding or in order to take into account the special characteristics of new standards for high-definition television;
2. on the use of statistical techniques for more efficient design of experiments;
3. on the possible need for new rating scales which could be more suitable for assessing pictures provided by new television standards, such as for high-definition television, than the present scales (see Recommendation 500) but which would be simply related to them;
4. on the minimum performance specifications, and on the alignment procedures, to be recommended for picture signal sources and for picture displays used during subjective tests;
5. on the possibility of defining a comprehensive set of moving-picture sequences for the subjective assessment of motion-dependent digital coding or processing techniques;
6. on how, if at all, should the possibility of down-stream processing of component-coded signals envisaged in § 12 of Annex I to Decision 18 be taken into account in subjective assessments;
7. on the presentation of the results obtained in subjective tests;
8. on the interpretation of the results;
9. on the possible use of the methods mentioned in § 1 and 3 during international transmissions.

Note. — See Reports 405, 1082, 1083, 1089 and Recommendation 500.

STUDY PROGRAMME 3B/11

SUBJECTIVE ASSESSMENT AND OBJECTIVE MEASUREMENT OF IMPAIRMENTS TO TELEVISION PICTURES

(1978)

The CCIR,

CONSIDERING

- (a) that the subjective quality of television pictures is determined by the performance quality of each component in the overall chain, from the picture source up to and including the receiver, and on the laws of addition of the subjective effects;
- (b) that picture impairment may result from deformation or distortion of the image signal itself, as well as from the presence of unwanted signals such as background noise or interference by other radio emissions,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the establishment, in an appropriate form facilitating their application as far as possible, of the relationships between the objective parameters of television signals, which are deformed or polluted by unwanted signals, and the subjective assessment of displayed picture quality;
2. the establishment of the laws of addition of subjective effects when several causes of picture impairment are present simultaneously.

Note. — See Report 405 and Recommendations 500 and 654.

STUDY PROGRAMME 3C/11

SUBJECTIVE ASSESSMENT OF THE QUALITY OF ALPHANUMERIC
AND GRAPHIC PICTURES

(1982)

The CCIR,

CONSIDERING

- (a) that there are systems which handle graphic and alphanumeric pictures and transmit them by means of the appropriate digital codes;
- (b) that subjective tests often have to be used to assess the relative quality of the pictures and the effects produced on them by transmission errors;
- (c) that Recommendation 500 describes a method for the subjective assessment of the quality of television pictures which could be used as a guide;
- (d) that alphanumeric and graphic pictures have a specific character distinct from that of television pictures, since the mental processes involved in their subjective assessment may differ;
- (e) that there are specific methods of assessing legibility which have been used in typography;
- (f) that the results of subjective tests depend upon the conditions under which they take place and that new techniques such as digital coding introduce new problems which may require more detailed specification of the recommended method;
- (g) that the results of subjective tests can be analyzed and presented in many ways;
- (h) that the results of subjective tests can be interpreted in many ways;
- (j) that it is highly desirable to increase the degree of standardization in the methods of testing, analysis, presentation and interpretation of the results of subjective tests, so that true comparisons may be made between results obtained by different workers,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. identification of the characteristics of alphanumeric and graphic pictures, characteristics of the codes containing them, as well as their transmission, in relation to their subjective assessment;
2. examination of existing assessment methods, especially in typography, and of the possibilities of their use;
3. amendments or additions to the method of test described in Recommendation 500 that may be necessary;
4. establishment of methods of analyzing and presenting the results of subjective tests in so far as they concern alphanumeric or graphic pictures;
5. establishment of methods of interpreting the results in so far as they concern alphanumeric or graphic pictures;
6. analysis of the use of the methods referred to in § 2 and 3 above in international transmissions in so far as they concern alphanumeric or graphic pictures.

Note. — See Report 959 and Recommendation 500.

STUDY PROGRAMME 3D/11 *

**PROCESSING OF THE RESULTS OF SUBJECTIVE ASSESSMENTS
OF THE QUALITY OF TELEVISION PICTURES**

(1986)

The CCIR,

CONSIDERING

- (a) that subjective methods of testing are frequently necessary to assess the relative quality of television pictures and the effect of interference and other impairments upon them;
- (b) that the results of subjective tests can be analyzed and presented in many ways;
- (c) that the results of subjective tests can be interpreted in many ways;
- (d) that it is highly desirable to increase the degree of standardization in the methods of analysis, presentation and interpretation of the results of subjective tests, so that true comparisons may be made between results obtained by different workers,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. on the statistical analysis and presentation of the results obtained in subjective tests;
2. on the interpretation of the results.

Note. — See Report 1083.

QUESTION 4-3/11

PROTECTION RATIOS IN TELEVISION

(1955–1963–1970–1982–1986)

The CCIR,

CONSIDERING

- (a) that the satisfactory operation of a television service renders it necessary to specify the maximum field strength of interfering or unwanted signals which can be tolerated, without unduly affecting the reception of television programmes;
- (b) that the CCIR is invited by the WARC-79 to study this problem stated in its Recommendations:
 - No. 61: Technical standards for the assessment of harmful interference in the frequency bands above 28 MHz;
 - No. 64: Protection ratios and minimum field strength required,

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the protection ratio required when two or more television transmitters are operating:
 - in the same channel,
 - in adjacent channels,
 - with dissimilar but partially overlapping bandwidths,
 - in other potentially interfering channels (e.g. image channel),
 - with digital signals multiplexed in the television signal;

* This Study Programme is also of interest to the CMTT.

2. what are the protection ratios required against services other than television?

Note 1. — The reply to the question should give the protection ratios required when all the transmitters are radiating monochrome signals on the one hand, or colour signals on the other hand, and when the wanted transmitter is radiating monochrome signals and the others are radiating colour signals and *vice versa*; and it should take into account all the different signal standards that may be used and should also indicate percentage of time during which protection is desired. Separate answers may be required for various grades of service.

Note 2. — See Recommendation 655.

Note 3. — See Recommendation 565 for protection against radionavigation transmitters.

Note 4. — See Reports 481, 485 and 1084.

STUDY PROGRAMME 4A-1/11

RATIO OF THE WANTED-TO-UNWANTED SIGNAL IN TELEVISION

Use of the offset method, when there are large differences between the carrier frequencies of the interfering stations

(1959-1963-1974)

The CCIR,

CONSIDERING

(a) that, when there is partial overlapping of the channels occupied by a wanted and an unwanted signal, offset operation makes it possible to reduce the protection ratios for monochrome television and thus facilitate the planning of television networks over territories where different television standards are used (see Recommendation 418);

(b) that a similar advantage may possibly be obtained for colour television,

UNANIMOUSLY DECIDES that the following studies should be carried out:

an investigation of the extent to which offset working can be used in colour television, when there are large differences between the carrier frequencies of the wanted and unwanted signals.

Note. — See Report 481 and Recommendation 655 for information on protection ratios for colour television.

QUESTION 6/11

GHOST IMAGES IN TELEVISION

(1966)

The CCIR,

CONSIDERING

(a) that it is often necessary to locate a television transmitting antenna in the vicinity of other antenna structures;

(b) that this can result in undesirable ghost images in the received picture,

UNANIMOUSLY DECIDES that the following question should be studied:

1. what factors must be considered to ensure satisfactory ghost-free operation;

2. how can these factors be evaluated?

Note. — See Report 478.

STUDY PROGRAMME 6A/11

GHOST IMAGES IN TELEVISION

(1966)

The CCIR

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the ratio of direct-to-delayed reflected signal required for satisfactory television service, taking into account:
 - polarity of the ghost images,
 - displacement of ghost images from wanted images;
2. the methods of calculation to be used to determine the ratio and displacement of the direct and reflected signals which result from antenna structures in the vicinity of television radiators, taking into account factors such as radiation, polarization, etc.

Note. — See Report 478.

QUESTION 7-2/11**RECOMMENDED CHARACTERISTICS FOR INDIVIDUAL AND COLLECTIVE ANTENNA
SYSTEMS FOR DOMESTIC RECEPTION OF TELEVISION AND DATA BROADCASTING
SIGNALS FROM TERRESTRIAL TRANSMITTERS**

(1965-1970-1986)

The CCIR,

CONSIDERING

- (a) that the characteristics of receiving antennas have an influence on the reception performance;
- (b) that data broadcasting services (e.g. teletext) and television services with stereophonic sound are currently in operation in some countries (and that other data broadcasting services are likely to be introduced in the near future);
- (c) that the reception quality for data signals and stereophonic sound is highly dependent upon the characteristics of the receiving installation, including domestic receivers,

UNANIMOUSLY DECIDES that the following question should be studied:

what characteristics should be recommended for individual or collective domestic television antenna systems to ensure satisfactory reception of television (picture and sound) and data signals?

Note. — See Report 482.

STUDY PROGRAMME 9A-2/11 *

**DISTORTION OF TELEVISION AND DATA-BROADCASTING
SIGNALS IN EMISSION AND RECEPTION, CAUSED BY THE USE OF
VESTIGIAL-SIDEBAND TECHNIQUES**

(1956-1974-1982)

The CCIR,

CONSIDERING

- (a) that, in receivers using envelope-detection, the use of residual-sideband modulation results in overall distortion, which is a combination of:
- quadrature distortion inherent in the method,
 - distortion caused by non-uniformity of group-delay in transmitter circuits,
 - distortion caused by non-uniformity of group-delay in receiver circuits;
- (b) that synchronous detection when used in the receiver can eliminate quadrature distortion in the absence of any carrier phase-modulation introduced at the transmitter;
- (c) that the method of detection might affect some parameter tolerances at the transmitter;
- (d) that different countries using the same television system may apply different degrees of pre-correction for the group-delay characteristics of receivers;
- (e) that data broadcasting services are being brought into operation and that the influence of distortion on them is different from that on television,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. compilation of the transmitter group-delay characteristics in use;
2. influence from group-delay errors, both for television and for teletext;
3. identification of suitable methods to be adopted for correcting distortion, at the transmitter and/or in the receiver;
4. the extent to which such corrections should be introduced and, if possible, standardized internationally.

Note. — See Report 404 and Recommendation 266.

STUDY PROGRAMME 12A-2/11 *

**INSERTION OF SPECIAL SIGNALS IN THE FIELD-BLANKING
INTERVAL OF A TELEVISION SIGNAL**

(1962-1963-1966-1974-1978)

The CCIR,

CONSIDERING

- (a) that it is already current practice in a number of countries to insert special signals in the field-blanking interval of a television signal;
- (b) that such signals can be used for checking the performance of the circuits over which the television signal is transmitted;
- (c) that such signals can be used as a reference and certification tool for adjustment of the waveform characteristics of a distorted programme signal so that the original characteristics of the picture are restored;

* This Study Programme does not derive from any Question at present under study.

- (d) that such signals might also be used for various other purposes, for example:
- supervision and control,
 - transmission of information associated with the programme,
 - transmission of sound,
 - transmission of other information,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. whether special signals can be inserted in, and removed from, the field-blanking interval of the television signal, without detriment to the quality of the television picture itself;
2. the purposes for which such signals should be used internationally;
3. the points at which these signals should be inserted in the international television connection and, possibly, removed again;
4. the provisions to be made to avoid confusion between signals for national and international use;
5. the forms of special signals to be recommended for international use;
6. the position in the field-blanking interval of signals for measuring the characteristics of television networks;
7. the position in the field-blanking interval of signals associated with control functions and the transmission of operational or other information;
8. the best system of encoding for the signals referred to in § 7.

QUESTION 13-1/11 *

**MINIMUM PERFORMANCE SPECIFICATIONS FOR
LOW-COST TELEVISION RECEIVERS**

(1968-1982)

The CCIR,

CONSIDERING

- (a) Resolution No. 163 (VIII) adopted by the Economic Commission for Africa at its Eighth Session, Lagos, 13-25 February 1967;
- (b) that the CCIR is invited, by the WARC-79, to study this problem stated in Recommendation No. 502: Specifications for low-cost television receivers;
- (c) that the advantages of television should be made more easily available to the populations of the countries where at present the density of receivers is particularly low for economic, geographic or technical reasons;
- (d) that, to this end, it is desirable that efficient television receivers should be available at prices low enough to secure their wide distribution in these countries;
- (e) that general agreement on the performance of suitable television receivers would prove most useful to radio receiver manufacturers by assisting them to produce suitable receivers having an agreed adequate standard performance at the lowest possible cost,

UNANIMOUSLY DECIDES that the following question should be studied:

what performance specifications should be drawn up for one or more types of television receiver, suitable for production in large quantities at the lowest possible cost, the receivers to meet the requirements applying to the countries mentioned in § (c)?

Note. — See Report 483.

* This Question also concerns Study Group 1, the Chairman of which should be kept informed of the results obtained by Study Group 11 as they become available.

QUESTION 14-1/11

**SUBJECTIVE QUALITY TARGETS OF OVERALL
TELEVISION SYSTEMS**

(1970-1978)

The CCIR,

CONSIDERING

- (a) that, in some parts of the world, television transmission circuits much longer than 2500 km and including satellite links, either exist or are under construction;
- (b) that, with the advent of communication satellites, new types of television service are possible;
- (c) that the evaluation and planning of systems to provide these services requires a knowledge of desirable subjective quality targets,

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the desirable subjective quality targets of an overall television system, from picture source to receiver, for the various types of service;
 2. when defining these targets, what characteristics of reference receiving installations should be considered?
- Note.* — See Report 805.

STUDY PROGRAMME 14A-1/11

**SUBJECTIVE QUALITY TARGETS OF OVERALL
TELEVISION SYSTEMS AND ALLOCATION OF TOLERANCES**

(1970-1978)

The CCIR,

CONSIDERING

- (a) that the performance of a television service is determined by the performance of all the component parts of the equipment used in providing it;
- (b) that the relationship between subjective picture quality, the objective measurement of impairment and the law of addition of these effects are under study (Study Programme 3B/11);
- (c) that Study Programme 13D/CMTT, § 1, deals with the determination of the objective performance of reference chains consistent with the desirable subjective overall quality,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the quality targets that must be specified in the design of the various kinds of television services planned or in existence;
2. the typical composition of overall television systems from the picture source up to, and including, the receiver, likely to be designed for the various services;
3. the laws of addition of impairments throughout the chain;
4. the allocation of the total tolerances specified among the component parts of the chain, from the picture source up to, and including, the receiver, taking into account the statistical behaviour of departures from the nominal performance figures of the equipment.

Note. — See also Study Programme 13C/CMTT.

STUDY PROGRAMME 14B/11

SUBJECTIVE QUALITY TARGETS OF OVERALL TELEVISION SYSTEMS

Reference receiving installations

(1978)

The CCIR,

CONSIDERING

- (a) that television receiving installations are important factors in making subjective appraisals of an overall television system from picture source up to, and including, the receiver;
- (b) that the definition of a reference receiving installation would be of value,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the assembly and presentation of data, duly kept up to date, which define the principal characteristics of receivers and antennas, which together form a receiving installation, to be used in meeting the required subjective quality targets for an overall television system. Studies should take account of the relevant documents of the International Electrotechnical Commission (IEC);
2. the analysis of the data and preparation of a draft specification for a reference receiving installation.

Note. — See Report 805.

QUESTION 15/11*

AUTOMATIC MONITORING OF TELEVISION STATIONS

(1970)

The CCIR,

CONSIDERING

- (a) that the number of television broadcasting and relaying stations is constantly growing;
- (b) that the increasing demands on television stations (especially in connection with the introduction of colour television) call for higher accuracy and objectivity in monitoring;
- (c) that the considerations in § (a) and (b) above impose exacting requirements for monitoring and measuring equipment and on the qualifications of servicing staff, with the result that the operation of television stations is becoming more costly;
- (d) that the introduction of fully automated television stations necessitates the automation of monitoring and the automatic maintenance of quality parameters;
- (e) that administrations are interested in the greatest possible unification of methods and equipment used in monitoring and measurement at transmitting stations and in the video and sound channels of long distance international links,

* This Question, which is intended to cover both the picture and the associated sound transmitters, has been brought to the notice of Study Group 10.

UNANIMOUSLY DECIDES that the following question should be studied:

1. what characteristics and quality parameters of television stations must be monitored automatically during transmission;
2. what are the most effective methods of automatic monitoring;
3. what signals are best suited to automatic monitoring;
4. how should the automatic monitoring system be organized;
5. what are the basic requirements regarding equipment and the methods used for automatic monitoring;
6. what are the effects of automatic monitoring during transmission upon the extent to which routine measurements are required and the equipment required for them;
7. to what extent is it possible to unify the methods and devices for monitoring television stations with the methods and devices used in other sections of a television chain;
8. what are the most efficient ways of using monitoring results for the automatic maintenance of quality parameters and to ensure the satisfactory operational control of the station?

Note. — See Reports 628 and 804.

STUDY PROGRAMME 23G-1/11*

DIGITAL TECHNIQUES IN THE BROADCASTING-SATELLITE SERVICE (TELEVISION)

(1982)

The CCIR,

CONSIDERING

- (a) that the World Administrative Radio Conference, Geneva, 1979, allocated certain frequency bands to be shared equally by the broadcasting-satellite service and other space and terrestrial services;
- (b) that such sharing can lead to mutual interference among services and can affect the efficiency with which the geostationary orbit is utilized;
- (c) that, in planning systems for shared-frequency operation, it is necessary to specify, for each of the services involved, both the level of wanted signal (field-strength or power flux-density) necessary for satisfactory reception and the level of unwanted signal for interference that may be considered acceptable;
- (d) that particularly for community reception a digital modulation system may be economically feasible and could reduce both the radiated power from the satellite and the required bandwidth;
- (e) that technology is continually advancing in the area of digital modulation and bandwidth reduction,

* The studies may be associated with those carried out under Question 1/10 and 11. This Study Programme is analogous to Study Programme 2C/10 and 11 but refers to television only.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. to assess various digital coding methods, including those proposed for broadcasting signals in telecommunication, studio and recording installations, to determine their suitability for signals radiated by broadcasting satellites;
2. to estimate the bit-rate requirements for television signals of good broadcasting-reception quality;
3. to consider appropriate bit-rate reduction methods;
4. to evaluate error-correction coding and/or error-concealment processes and hence to deduce the optimum parameters from bandwidth and cost considerations;
5. to investigate suitable carrier modulation systems for the digital signal and the bandwidths in which the signal may be efficiently transmitted;
6. to determine what protection ratios are required between two digital signals and between a digital signal and other types of signal likely to be transmitted in the band allocated to the broadcasting-satellite service;
7. to ensure that the above studies are carried out with adequate subjective evaluation of the broadcasting signal quality, and that investigations are made relevant to practical situations with respect to noise level, interference levels and equipment limitations.

QUESTION 25-2/11 *

**STANDARDS FOR TELEVISION SYSTEMS
USING DIGITAL MODULATION**

(1972-1974-1982)

The CCIR,

CONSIDERING

- (a) that the development of digital methods of encoding, processing, recording and transmitting television signals would make it possible to benefit from the advantages of digital techniques in television;
- (b) that digital signal processing, if used in television studios, would lead to improved reliability and performance and production opportunities;
- (c) that methods for the digital coding of television signals are being studied with regard to the transmission of these signals over terrestrial and satellite channels;
- (d) that, to facilitate international exchanges of programmes and to rationalize the design of equipment, it would be desirable to standardize, as far as possible, the methods used for the digital coding of television signals,

UNANIMOUSLY DECIDES that the following question should be studied:

1. what methods could be used for the digital coding of picture signals and the associated sound signals, and what would be the resulting advantages:
 - inside the studio complex, including the recording of television signals;
 - in broadcasting from terrestrial transmitters and from satellites;

* This Question is analogous to Question 51/10. See also Decision 18.

2. what digital standard or standards should be recommended for the applications mentioned in § 1;
3. what is the simplest and most effective technique for monitoring digitally coded television and associated sound signals within the studio complex?

Note 1. — Account should be taken of studies being carried out under Question 14/CMTT and Study Programme 14A/CMTT.

Note 2. — See Reports 629, 962, 1088, 1089 and Recommendations 601 and 656.

STUDY PROGRAMME 25G/11 *

DIGITAL ENCODING OF COLOUR TELEVISION SIGNALS

(1982)

The CCIR,

CONSIDERING

- (a) that certain technical advantages may result from the use of digitally encoded television signals in the various parts of the broadcast chain from programme production to reception;
- (b) that technical, economic and other factors may lead to the existence of different standards for different purposes such as high-definition or enhanced quality television, production for conventional television, electronic news gathering, video tape recording, television broadcasting, video cassette and video disc players;
- (c) that, provided the signals are in an appropriate digitally coded form, efficient and economic forms of digital signal processing can provide effective methods for converting from one coding standard to another;
- (d) that such conversions can be made in the most effective and economic manner if the digital standards form an extensible family whose levels are simply related one to another,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the picture quality** and corresponding bit-rate requirements for various television production, post production, recording and broadcasting purposes using digitally encoded television signals, keeping in mind that for several of these applications, as exemplified in § (b), a certain amount of additional picture processing may be required;
2. the development of an extensible family of compatible digital coding standards whose levels bear simple relationships one with the other in order to facilitate conversion between them;
3. the parameters that should be common between the various coding standards, in particular, those parameters which will lead to simple algorithms for code conversion and for conversion between scanning standards;
4. the degree of compatibility to be maintained with the parameters of the present analogue television systems.

Note. — See Report 629 and Recommendation 601.

* Contributions in response to this Study Programme are of interest to the CMTT. See also Decision 18-5.

** Methods of evaluating the quality of digital television pictures are the subject of Study Programmes 3A/11, 3B/11 and 25L/11.

STUDY PROGRAMME 25H/11 *

**FILTERING AND SAMPLING FOR DIGITAL ENCODING
OF COLOUR TELEVISION SIGNALS**

(1982)

The CCIR,

CONSIDERING

- (a) that digital systems should be based upon common characteristics wherever possible and the number of different systems should be minimized;
- (b) that the signal representing a television picture can be described in terms of the two spatial dimensions and the time dimension;
- (c) that the sampling and associated filtering of the signal may be based upon one, two or all three of the dimensions outlined in § (b);
- (d) that, because filtering, sampling frequencies and sampling structures are necessarily inter-related, it is essential that these parameters be chosen with care if irreversible impairments of picture quality are to be avoided;
- (e) that the development of an extensible family of compatible digital standards is desirable in order to cover present and foreseen applications of television;
- (f) that it may prove necessary to convert digital signals between any two levels of the family,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. specification in the time and frequency domains of the characteristics of the analogue shaping filters used before the sampling process, and after digital-to-analogue conversion for colour television signals;
2. definition of the sampling frequencies and sampling structures which are most appropriate for coding colour television signals at various levels of the family of compatible coding standards;
3. definition of the filtering and interpolation processes to be applied to the luminance and colour difference signals in the digital conversion between any two levels of the family of compatible coding standards.

Note. — See Reports 629, 962 and Recommendation 601.

STUDY PROGRAMME 25J/11 **

**REDUCTION IN THE BIT RATE IN THE DIGITAL CODING
OF COLOUR TELEVISION SIGNALS**

(1982)

The CCIR,

CONSIDERING

- (a) that the large channel capacity required for the digital transmission and recording of television signals introduces problems which are both technical and economic;
- (b) that the major part of the channel capacity required for digital television is used by the encoded video signal;
- (c) that the presence of multiple digital audio channels associated with a television signal can result in the digital audio using a significant portion of the total channel capacity required for digital television transmission, particularly when bit-rate reduction techniques have been applied to the encoded video signal,

* The results obtained under this Study Programme should be brought to the attention of the CMTT. See also Decision 18.

** Contributions in response to this Study Programme are of interest to the CMTT. See also Decision 18.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the ways in which removal of redundant information, and knowledge of the visual characteristics of the human observer, can best be exploited to reduce the bit rate of the encoded video signal, without perceptible reduction in the quality of the reproduced picture;
2. the ways in which removal of redundant information can be applied to reduce the bit rate required for the digitally encoded audio channels without perceptible reduction in the quality of the programme audio.

Note 1. — See Reports 629 and 1089.

Note 2. — Studies under this Study Programme in Study Group 11 will concentrate primarily on bit-rate reduction of television signals suitable for studio and broadcasting use, and should be carried out in close collaboration with Study Group 10 and the CMTT.

STUDY PROGRAMME 25K/11 *

PROTECTION AGAINST ERRORS, JITTER AND SLIP FOR DIGITAL TELEVISION SIGNALS

(1982)

The CCIR,

CONSIDERING

that digital television signals associated with the studio complex or with direct broadcasting from terrestrial transmitters and satellites may be subject to impairments due to errors, jitter and slip,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. preferred methods whereby digital television signals may be modified, if necessary, by the addition of further digital signals, so that errors, etc. are either corrected or their effects upon the picture minimized;
2. other methods for correcting or concealing the effects of errors, jitter and slip.

Note. — See Reports 629 and 1089.

STUDY PROGRAMME 25L/11 **

DERIVING DIGITAL COMPONENT SIGNALS FROM ANALOGUE COMPOSITE SIGNALS (AND VICE VERSA)

(1982)

The CCIR,

CONSIDERING

- (a) that the signals in the television studio complex will ultimately be digitally encoded in component form;
- (b) that during a transition period the television complex will include both analogue and digital elements,

* Account should be taken of studies being carried out under Study Programme 14A/CMTT. See also Decision 18.

** Contributions in response to this Study Programme are of interest to the CMTT. See also Decision 18.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. which methods best meet the requirements of television production and broadcasting for deriving digital component signals, conforming to the digital studio interface standard, from a composite analogue signal (NTSC, PAL or SECAM) and vice versa;

2. assessment of the impairments introduced by such operations.

Note. — See Report 629.

STUDY PROGRAMME 25M/11*

QUALITY PARAMETERS AND MEASUREMENT AND MONITORING METHODS TO BE USED IN THE STUDIO COMPLEX AND IN DIRECT BROADCASTING FROM TERRESTRIAL TRANSMITTERS AND FROM SATELLITES USING DIGITAL OR ANALOGUE-AND-DIGITAL MODULATION

(1978-1982)

The CCIR,

CONSIDERING

- (a) that for the design and testing of real systems, it is essential to define objective quality parameters as well as associated measurement and monitoring methods, for the studio complex and in broadcasting from terrestrial transmitters and from satellites;
- (b) that for the use of the concept of the hypothetical reference circuit and for the testing of real systems, the CMTT is studying in Study Programmes 14B/CMTT and 16A/CMTT the quality parameters and measurement methods for digital or mixed analogue-and-digital transmission systems;
- (c) that in a digital system, picture impairments may be caused either by the coding equipments or by degradations affecting the digital signal such as: errors, jitter and slips,

UNANIMOUSLY DECIDES that the following studies should be carried out:

- 1. the objective parameters to be applied in characterizing the quality of a codec or of a digital-to-digital converter;**
- 2. the parameters to be applied in specifying the performance of digital television equipments in respect of digital signal degradation;
- 3. methods to be used for measuring and monitoring the parameters defined in § 1 and 2 for the digital television studio complex and for broadcasting from terrestrial transmitters and from satellites;
- 4. methods to be used for measuring and monitoring the parameters for television studios, terrestrial transmitters and broadcasting-satellite systems using mixed analogue and digital modulation.

Note. — See Reports 629 and 1089.

* The studies should be carried out in collaboration with the CMTT, to avoid proliferation of testing methods and equipment. See also Decision 18.

** Basic investigations into the relationships between the objectively measurable parameters of television signals and the corresponding picture quality are carried out under Study Programme 3B/11.

QUESTION 26-1/11 *

**CHARACTERISTICS OF TELEVISION RECEIVERS
AND RECEIVING ANTENNAS**

(1974-1978)

The CCIR,

CONSIDERING

- (a) the importance of certain characteristics of television receiving installations, receivers and antennas in the work of Administrative Conferences, the IFRB and other organizations concerned with establishing frequency plans;
- (b) that under the organization of the CCIR, Study Group 11 should deal with matters concerning television receiving installations, receivers and antennas;
- (c) that account should be taken of the methods of measuring characteristics specified by the International Electrotechnical Commission (IEC),

UNANIMOUSLY DECIDES that the following question should be studied:

what are the principal characteristics of television receivers and antennas for which values might be useful in frequency planning undertaken by Administrative Conferences, the IFRB and other organizations concerned?

Note. — See Report 625 and Recommendation 419.

STUDY PROGRAMME 26A-1/11 ****CHARACTERISTICS OF TELEVISION RECEIVERS
AND RECEIVING ANTENNAS**

(1974-1978)

The CCIR

UNANIMOUSLY DECIDES that the following studies should be carried out:

assembly of the necessary data, duly kept up to date, of the principal characteristics of television receiving installations, receivers and antennas, which might be useful in frequency planning work, such as that of Administrative Conferences, the IFRB and other organizations concerned, in a special section of the CCIR books. Such studies should take account of the relevant publications of the International Electrotechnical Commission (IEC).

Note. — See Report 625 and Recommendation 419.

* Contributions in response to this Question should be brought to the attention of Study Group 1.

** Contributions in response to this Study Programme should be brought to the attention of Study Group 1.

QUESTION 27-1/11

HIGH-DEFINITION TELEVISION

(1974-1986)

The CCIR,

CONSIDERING

- (a) that conventional systems for television are not ideal in respect to picture quality, for example sharpness and sense of reality;
- (b) that transmission of wideband video signals in bands for terrestrial and broadcasting-satellite systems as well as over cable systems may be possible;
- (c) that progress in the development of displays will permit the use of large-screen, high-definition television displays for domestic viewing;
- (d) that Question 14/11 does not cover all aspects of the problems presented by the introduction of high-definition television systems,

UNANIMOUSLY DECIDES that the following question should be studied:

what common standards should be recommended for high-definition television systems?

Note 1. — Account should be taken of the following factors:

- the target to be set for picture and sound quality at the next stage of development;
- the scanning standards and the resulting necessary video-frequency bandwidth;
- the principles of broadcasting transmission, including the methods of modulation and multiplexing for video, sound and data signals;
- determination of the frequency band most appropriate for this service;
- the production of reliable receivers at reasonable cost;
- conversion to existing systems of television;
- compatibility with existing systems of television;
- the possibility within the present WARC-BS planning for transmitting a wider baseband spectrum than originally envisaged;
- the possibility of stereoscopic television;
- the relationship between the studio standard which should take into account the need for production quality margin and the broadcast standard where constraints of radio spectrum apply;
- the desirability of both analogue and digital versions of the studio standard.

Note 2. — See Reports 801 and 1075; see also Question 42/11, Study Programmes 18S/11, 18T/11 and 2M/10-11-2.

STUDY PROGRAMME 27A/11

**THE COMPATIBILITY OF THE HDTV STANDARD WITH EXISTING STANDARDS
AND EXISTING BROADCAST CHANNEL ASSIGNMENTS**

(1986)

The CCIR,

CONSIDERING

that there will be, for many years, the need for the coexistence of HDTV with a number of vision standards, likely to include conventional PAL/SECAM/NTSC, digital 4 : 2 : 2, enhanced-vision systems based on components, etc.,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. ways of making the digital version of the studio HDTV standard compatible with the digital 4 : 2 : 2 studio standard (see Recommendation 601);
2. the problem of field rate compatibility with 50/60 Hz systems;

3. the compatibility with motion-picture practice, and in particular the transferability of HDTV programme material to and from motion-picture film;
4. the problems of using sources with a wider aspect ratio for reception at the existing aspect ratio;
5. methods of deriving an HDTV broadcast standard which uses one or more existing broadcast channel assignments.*

Note. — See Report 801.

STUDY PROGRAMME 27B/11

EFFECT OF DISPLAY TECHNOLOGY ON THE HDTV STANDARD

(1986)

The CCIR,

CONSIDERING

that the use and type of display technology potentially available could affect the parameters of the HDTV standard,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the types of display and associated processing which could be used for HDTV pictures including systems which make use of separate semi-conductor storage, and those that have inherent storage capacity;
2. the consequences of different types of addressing of active picture elements, for example, scanning, matrixing, etc.

Note. — See Report 801.

QUESTION 29-3/11**

BROADCASTING OF STILL PICTURES AND OTHER INFORMATION INTENDED FOR THE PUBLIC USING A TELEVISION OR NARROW-BAND CHANNEL

(1974-1978-1982-1986)

The CCIR,

CONSIDERING

- (a) that new systems for broadcasting which make use of a television or a narrow-band channel are in service or are being developed;
- (b) that these new systems, which allow broadcasting in the same channel of several kinds of information, for example still pictures, text or data, contribute to the more efficient use of the radio-frequency spectrum;
- (c) that, as a result of technological developments, particularly in the fields of storage devices and digital technology, it is possible to apply these systems to broadcasting services for the public generally, or certain categories of the public;
- (d) that to facilitate international exchange and to rationalize the design of equipment, it would be desirable to standardize, as far as possible, the methods used in these new systems;
- (e) that the degree of mutual compatibility between such services and of their compatibility with existing television broadcasting services should be defined,

* This study should be made in conjunction with Joint Working Group 10-11/S.

** Contributions in response to this Question should be brought to the attention of Study Group 10, the CMTT, and also of CCITT Study Groups VIII and XV.

UNANIMOUSLY DECIDES that the following question should be studied:

1. what types of services should be introduced;
2. what system parameters should be specified;
3. what precautions are to be taken to ensure compatibility with the reproduced sound and picture of the existing television services;
4. what are the special requirements when the signals are programme-related and may originate from different sources?

Note. — See Recommendation 653, Reports 802, 956, 1078 and 1080.

STUDY PROGRAMME 29A-2/11

BROADCASTING OF ANALOGUE TELEVISION SIGNALS FOR STILL PICTURES

(1974–1978–1982)

The CCIR,

CONSIDERING

- (a) that still-picture television signals can be broadcast more efficiently if a suitable storage device is provided at the receiver;
- (b) that this technique and other multiplexing makes it possible to broadcast still-picture television programmes consisting of still colour pictures and accompanying sound, by using a television channel exclusively, or by multiplexing with existing television signals;
- (c) that such broadcasting systems may be useful for the purpose of information and education services,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the types of services which should be introduced;
2. determination of the methods which should be used to transmit still picture signals and accompanying sound signals;
3. determination of the characteristics to be recommended for the broadcasting of still-picture signals and accompanying sound signals.

Note. — See Report 802.

STUDY PROGRAMME 29C-1/11

SPECIFICATION FOR MULTIPLEX BROADCASTING OF INFORMATION IN THE TELEVISION CHANNEL

(1978–1982)

The CCIR,

CONSIDERING

- (a) that it is possible to broadcast simultaneously (multiplex) in a television channel, a picture and sound signal and data or other information signals possibly issued from different origins and related to, or not related to, the picture and sound signals;
- (b) that the broadcasting of supplementary information or data serves a useful purpose and does so even without the simultaneous broadcasting of typical picture and sound;
- (c) that it is desirable to encourage development of compatible or possibly common multiplexing specifications in order to facilitate international exchange of programmes and to rationalize the design of equipment;
- (d) that it is important to protect the quality of the television picture and sound service,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the way in which multiplexing should be organized including the identification of the information issued from a given origin and the specification of the corresponding information transmission link;
2. the modulation and coding specifications to be used;
3. the way in which the quality of the information transmission links should be specified and measured;
4. the means of protecting the television service when the need arises;
5. for digital information, the interfaces at the originating point and at the receiver.

Note. — See Reports 802, 956 and Recommendation 653.

STUDY PROGRAMME 29G/11

INTERNATIONAL EXCHANGE OF CAPTIONING MATERIAL FOR TELEVISION PROGRAMMES

(1986)

The CCIR,

CONSIDERING

- (a) that the need for captioned programme material occurs particularly in connection with international exchange of television programmes;
- (b) that teletext provides a means for the coded transmission of captions, or several different caption services, in association with the same television programme (see Report 802);
- (c) that the use of such material is also of assistance to viewers who have a hearing impairment, and to provide captions in additional languages;
- (d) that there is a need to convey graphics as well as text;
- (e) that the use of various methods and storage media for captioning complicates the exchange and leads to duplication in the preparation of captions;
- (f) that it is therefore desirable to reduce the number of such methods and particularly to reduce the number of different storage media and recording formats in use,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the preferred formats and standards for captioning material accompanying television programmes;
2. the particular measures to be taken to facilitate the use of such material with the teletext systems recommended for international adoption (see Recommendation 653);
3. the particular measures to be taken to facilitate the use of the material to assist viewers who have a hearing impairment.

Note. — See Report 1080.

STUDY PROGRAMME 29H/11

ADDITIONAL SERVICES PROVIDED BY DATA BROADCASTING IN A TELEVISION OR NARROW-BAND CHANNEL

(1986)

The CCIR,

CONSIDERING

- (a) that data broadcasting in television or narrow-band channels already supports teletext services and facilitates the introduction of new services;
- (b) that the number of such separately identifiable services is already considerable and is increasing;
- (c) that some of these services, such as those providing software and data for various applications, are already in operation,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the essential characteristics of the services;
2. identification of the operational features required for the services;
3. identification of the various transmission means suitable for the services;
4. determination of the encoding, error protection, modulation parameters and transmission format to be adopted for the identified transmission means for the data representing the service and for access control information if required;
5. the manner in which the quality of each service should be defined and the methods of assessment to be adopted;
6. the appropriate compatibility with similar services being studied by the CCITT.

Note 1. — See Reports 802 and 956.

Note 2. — This Study Programme should be brought to the attention of Study Group 10, the CMTT and of the CCITT.

Note 3. — The assessment methods for the quality of these services differ generally from those for subjective assessment of television pictures included in Recommendation 500 and Report 405 but these should be used whenever appropriate.

QUESTION 30-1/11 *

METHODS OF REDUCING INTERFERENCE TO THE BROADCASTING SERVICE (TELEVISION) FROM OTHER SERVICES OPERATING IN ADJACENT BANDS

(1974-1982)

The CCIR,

CONSIDERING

- (a) that the number of stations in the bands adjacent to the broadcasting bands is continually increasing;
- (b) that an even more rapid growth of these services can be foreseen in the future;
- (c) that harmful interference has been recorded arising from inadequate selectivity of television receivers;
- (d) that this interference renders difficult expansion of other services in bands adjacent to the broadcasting bands;
- (e) that there is a considerable variation in the performance of television receivers made by different manufacturers with respect to protection against out-of-band signals;
- (f) that improvement of television receiver selectivity characteristics would improve frequency utilization;
- (g) that the CCIR is invited by the WARC-79 to study this problem stated in its Recommendations:
 - No. 61: Technical standards for the assessment of harmful interference in frequency bands above 28 MHz;
 - No. 70: Studies of the technical characteristics of equipment,

UNANIMOUSLY DECIDES that the following question should be studied:

to what extent should the selectivity of television receivers be improved especially for channels adjacent to the edges of the bands to increase the possibility of efficient use of frequencies in adjoining bands?

* Contributions in response to this Question should be brought to the attention of Study Groups 1 and 8.

QUESTION 31/11

**PERFORMANCE AND TESTING OF CABLED DISTRIBUTION
SYSTEMS FOR TELEVISION SIGNALS**

(1974)

The CCIR,

CONSIDERING

- (a) that, in a number of countries, the use of cables for the distribution of television programmes to the home is rapidly growing, and that this method of distribution could ultimately have a profound influence on the whole pattern of television broadcasting;
- (b) that the effect of this growing industry on receiver designs will be considerable, and it might even ultimately influence broadcasting standards;
- (c) that the International Electrotechnical Commission (IEC) is already studying methods of defining and measuring the performance of cable television distribution systems and is preparing recommended codes of practice for such systems;
- (d) that the general problems of transmission over cable, for all types of modulation, are within the technical responsibility of the CCITT,

UNANIMOUSLY DECIDES that the following question should be studied:

1. are there any matters arising from the introduction of television distribution to the home by cable that are of international significance to the efficient utilization of the radio-frequency spectrum and which should therefore be studied by the CCIR;
2. should allowances be made in the overall design of television broadcasting systems for the signal impairments introduced by cable distribution systems and should overall allocation of tolerances be made with this factor in mind?

Note. — The Director, CCIR, is requested to draw this Question to the attention of the Director, CCITT, which, for its part, may wish to study the specific problems of transmission over cable and of equipment associated with transmission over cable.

STUDY PROGRAMME 31A/11

RADIATION FROM CABLE DISTRIBUTION NETWORKS

(1978)

The CCIR,

CONSIDERING

- (a) that in a number of countries the use of cable networks for the distribution of television programmes is growing rapidly, particularly in urban areas;
- (b) that the frequency bands used for cable transmissions often lie entirely or partly outside the bands allocated to broadcasting;
- (c) that unwanted radiation from cable networks could cause interference to users of these bands,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. evaluation of the risks of interference from radiation from cable distribution networks as a function of frequency;
2. determination and evaluation of the factors affecting the radiation from cable distribution networks as a function of frequency;
3. determination of acceptable levels of radiation as a function of frequency and appropriate measurement methods;
4. precautions to be taken to restrict radiation from such networks, with respect to the design, construction and operation of equipment;
5. methods of supervising radiation from these networks.

Note. — The Director, CCIR is requested to forward this text to the Secretary General, IEC.

QUESTION 35-1/11 *

**SYNCHRONIZATION NECESSARY FOR THE SATISFACTORY RECEPTION
OF SOUND AND PICTURE SIGNALS**

(1978-1986)

The CCIR,

CONSIDERING

- (a) that in many television programme operations the sound and picture signals are recorded on separate media or processed by separate equipment, at least, at one point of the overall system;
- (b) that the sound and picture components of television programmes may be transmitted over long distances, in which the transmission time is not negligible and wherein the sound and picture signals may be transmitted by different routes or methods;
- (c) that video processing equipment can introduce significant time delay in the picture component of a television signal;
- (d) that there may therefore be an error of timing between the sound and picture signals at the receiver;
- (e) that lack of synchronism between the sound and picture signals can produce unacceptable impairment of the programme,

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the acceptable overall tolerances for the accuracy of synchronization of the sound signal with respect to the picture signal;
2. what tolerances in synchronism are required for the recording processes used;
3. what tolerances in synchronism are available for other parts of the overall system;
4. what are the preferred points at which synchronization corrections (if necessary) should be applied;
5. what method should be adopted for the addition of reference timing data in a digital sound signal to facilitate the correct time relationship between the sound and picture signals?

Note. — See Report 1081.

QUESTION 36-1/11

**POLARIZATION OF EMISSIONS IN THE TERRESTRIAL
BROADCASTING SERVICE (TELEVISION)**

Advantages of circular or elliptical polarization

(1978-1982)

The CCIR,

CONSIDERING

- (a) that emissions from terrestrial television broadcasting stations are usually transmitted with either horizontal or vertical polarization;
- (b) that multiple reflections within reception areas in rough terrain and/or in cities with high buildings can result in undesirable ghost images in the received picture;
- (c) that orthogonal polarization for television broadcasting stations operating in the same frequency channel has been used in some areas in discriminating against the reception of undesired signals;

* Studies in response to this Question are also of interest to Study Group 10 and the CMTT.

- (d) that the CCIR is invited by the WARC-79 to study this problem stated in its Resolution:
- No. 31: Application of the Final Acts of the WARC-BS-77 to take account of changes made by the WARC-79 to the Table of Frequency Allocations for the band 11.7 to 12.7 GHz in Region 2,

UNANIMOUSLY DECIDES that the following question should be studied:

1. are there advantages, both in improving the quality of the received picture where multiple reflections are present and in minimizing interference from other stations operating in the same frequency channel, in using circular or elliptical polarization for emissions from terrestrial television broadcasting stations;
2. what types of antennas can be used for transmission and reception;
3. would the use of circular or elliptical polarization be compatible with the use of horizontal and/or vertical polarization in the same reception area?

QUESTION 37/11*

SYSTEMS FOR TELEVISION WITH CONDITIONAL ACCESS

(1982)

The CCIR,

CONSIDERING

- (a) that in many countries the terrestrial television programme broadcasting networks cover practically the whole of the national territory and that broadcasting from satellites will make it possible to increase the number of programmes received in a given place;
- (b) that access to some programmes intended for the public may be conditional upon the use in the receiver of an additional signal processing circuit, which may be controlled by a "key";
- (c) that for this purpose the signal has to be processed before transmission;
- (d) that the specific processing of the signal for transmission for this purpose becomes part of the signal characteristics to be taken into account for international programme exchange and broadcasting planning,

DECIDES that the following question should be studied:

1. what methods should be used to process a television signal, picture and sound, so as to make its effective use dependent on a specific signal processing circuit in the receiver;
2. what methods should be used to process signals for additional data broadcasting services using the television channel so as to make effective use dependent on a specific signal processing circuit in the receiver;
3. what effects do signal processing and identification circuit performance have on the quality of the reconstituted signal;
4. what effect does signal processing have on the protection ratios between emissions;
5. what is the effect of impairments introduced in transmission and reception on the quality of the reconstituted signals?

Note. – See Report 1079.

* See Resolution No. COM7/6 of the Plenipotentiary Conference, Nairobi, 1982 (Annex I).

ANNEX I

RESOLUTION No. COM7/6

Opinion No. 81 of the XVth Plenary Assembly of the CCIR, Geneva, 1982

The Plenipotentiary Conference of the International Telecommunication Union (Nairobi, 1982),
having considered

Opinion No. 81 of the XVth Plenary Assembly of the CCIR, Geneva, 1982, entitled "Systems for television with conditional access";

resolves

1. that this subject is within the competence of the Union;
2. that the technical aspects of this question should be the subject of studies by the CCIR.

STUDY PROGRAMME 37A/11 *

CONDITIONAL-ACCESS BROADCASTING SYSTEMS

(1986)

The CCIR,

CONSIDERING

- (a) that there would be clear advantages for broadcasters and users in having common conditional-access systems;
- (b) that proponents of new television signal formats should take into account conditional-access technology;
- (c) that the conditional-access process comprises scrambling/descrambling and control functions, and that there is an interface between the access control and descrambling functions in the receiver;
- (d) that conditional-access systems may influence the quality and performance of the various broadcasting services in a number of ways,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the conditional-access control systems to be employed to control the descrambling process and specially their security against unauthorized access;
2. the optimum configuration for a physical interface between the conditional-access control function and the descrambling function in the receiver;
3. the particular scrambling methods to be used for vision, sound and data signals to meet the security requirements, appropriate to the broadcasters and to minimize the complexity of the home receiver;
4. the effects on picture, sound and data quality due to the scrambling and descrambling processes;
5. the susceptibility of scrambled signals and encrypted data to impairments in signal processing, in programme production, distribution and broadcasting;
6. the methods of scrambling and the use of encrypted data that are compatible with existing protection ratios and service area planning.

Note. — See Report 1079.

* This Study Programme should be brought to the attention of the CMTT and the IEC.

QUESTION 38/11 *

PROTECTION OF TELEVISION BROADCASTING STATIONS AGAINST LIGHTNING

(1982)

The CCIR,

CONSIDERING

- (a) that there are vast areas in the world where, despite the installation of protective devices against lightning, equipments are often damaged, sometimes severely, by atmospheric voltage surges;
- (b) that considerable economic and social harm is often caused by the loss of service;
- (c) that protection criteria are not yet standardized internationally;
- (d) that the IEC is studying the standardization of levels of insulation for all the electrical, electronic and telecommunications equipment present in a station and that such standardization may also be applied to broadcasting stations;
- (e) that the CCITT is studying the classification of levels of immunity of telecommunications equipment to atmospheric voltage surges;
- (f) that in its Resolution No. 64, the WARC-79 invites the CCIR in consultation with the CCITT to study this phenomenon and to formulate a Recommendation in this matter,

UNANIMOUSLY DECIDES that the following question should be studied:

what are the most suitable precautions for protection against local atmospheric discharges at terrestrial television broadcasting stations of all types, taking into account the studies in progress in the CCITT, in the IEC and in the CCIR Study Groups with a view, in particular, to defining:

1. limit values of lightning characteristics in relation to accepted risk and the probability of the station being struck by lightning;
2. criteria for evaluating the effects of lightning on stations;
3. criteria and procedure for the design of station protective equipment?

Note. — See Questions 62/1, 31/3, 32/9 and 48/10.

QUESTION 39/11 **

**FREQUENCY SHARING BETWEEN THE BROADCASTING SERVICE (TELEVISION)
AND THE FIXED AND MOBILE SERVICES BELOW 1 GHz**

(1982)

The CCIR,

CONSIDERING

- (a) that the WARC-79 increased the number of frequency bands that might be shared between the broadcasting service and the fixed and mobile services below 1 GHz;
- (b) that those bands which might be shared are given in Article 8 of the Radio Regulations;
- (c) that there are no well-established criteria for sharing the spectrum between these services;

* This Question should be brought to the attention of Study Groups 1, 3, 9 and 10. Results of studies should be brought to the attention of Study Group 1.

** This Question should be brought to the attention of Study Groups 8, 9 and 10.

(d) that the convening of a Regional Conference for the African Broadcasting Region was foreseen by the WARC-79 in Resolution No. 509 relating to the convening of a Regional Broadcasting Conference to review and revise the provisions of the Final Acts of the African VHF/UHF Broadcasting Conference (Geneva, 1963);

(e) that the CCIR was invited by the WARC-79 to study this problem as stated in its Resolution No. 702 relating to the convening of a Regional Administrative Radio Conference to establish criteria for the shared use of the VHF and UHF bands allocated to fixed, broadcasting and mobile services in Region 3,

UNANIMOUSLY DECIDES that the following question should be studied:

what planning criteria apply for the protection of the broadcasting service (television) against interference from fixed and mobile services in those parts of bands 8 and 9 that may be shared?

Note. — See Report 1087 and Recommendation 565.

QUESTION 42/11

ENHANCED QUALITY TELEVISION

(1986)

The CCIR,

CONSIDERING

(a) that the existing television systems are not ideal with respect to picture quality. For example, there are impairments due to the interlaced scanning structure and imperfect chrominance and luminance signal separation;

(b) that improved picture quality can be achieved by signal processing within the receiver, capable of reducing line structure visibility, flicker, etc.;

(c) that emission systems capable of improved picture quality, such as those using MAC-type standards, will soon be operational;

(d) that there is a clear advantage to the use of component signals in the studios, and that the CCIR has already recommended standards for digital components;

(e) that there is a need for Recommendations for analogue component signals,

UNANIMOUSLY DECIDES that the following question should be studied:

1. what common standards should be recommended for the international exchange of programmes in analogue component form;

2. what standards should be recommended for enhanced quality television systems?

Note. — See Reports 1073 and 1077.

STUDY PROGRAMME 42A/11

ANALOGUE COMPONENT SIGNALS FOR STUDIO APPLICATION*

(1986)

The CCIR,

CONSIDERING

(a) that the use of analogue component techniques may offer certain advantages over composite techniques by avoiding the defects introduced by the latter;

(b) that the use of such techniques for the production and the transmission of television programmes may be conducive to the gradual introduction of digital standards and to subsequent coexistence;

* See also Study Programme 18Q/11.

- (c) that the technology presently exists to utilize component colour signals and that equipment and systems applying these techniques are being developed for various purposes;
- (d) that to facilitate international programme exchanges and rationalize equipment design, it would be advisable to standardize the component signal format;
- (e) that it would be desirable if the methods employed were to allow for the continued use of existing infrastructures and equipments,

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of quality objectives, potential for processing and assessment of derived benefits;
2. assessment of the various methods for the implementation of analogue component signals in the television plant, and determination of the most appropriate method;
3. development of an analogue component signal exchange standard (including, in particular, time compression ratios, bandwidth, synchronization signals and other parameters);
4. study of adaptability of present analogue equipment (such as videotape recorders) to the use of component signals;
5. determination of the requirements for new equipment and testing procedures;
6. assessment of the problems of achieving compatibility with digital television (see Recommendation 601) and present analogue systems.

QUESTION 43/11

TECHNICAL BASES REQUIRED FOR PLANNING THE BROADCASTING SERVICE (TELEVISION) IN BANDS 8 AND 9

(1986)

The CCIR,

CONSIDERING

- (a) that a Regional Broadcasting Conference for the African Broadcasting Area was requested by the WARC-79 in its Resolution No. 509 to review and revise the provisions of the Final Acts of the African VHF/UHF Broadcasting Conference (Geneva, 1963);
- (b) that the CCIR is requested, in Resolution No. 509 of the WARC-79, to carry out the necessary technical studies for this Conference;
- (c) that it is important in planning to improve utilization of the radio-frequency spectrum,

UNANIMOUSLY DECIDES that the following question should be studied:

what are the technical bases required for planning which lead to efficient utilization of bands 8 and 9 for the broadcasting service (television)?

Note. — See Reports 1085, 1086 and CCIR report to the First Session of the Regional Administrative Conference to Review and Revise the Provisions of the Final Acts of the African VHF/UHF Broadcasting Conference, Geneva, 1963 (AFBC (1)).

RESOLUTION 96

**HIGH-DEFINITION TELEVISION –
EXTRAORDINARY MEETING OF STUDY GROUP 11 IN 1988**

(1986)

The CCIR,

CONSIDERING

- (a) that the XVth Plenary Assembly has decided to continue work on the HDTV system within the framework of Decision 58;
- (b) that important progress on the basic parameters of a world-wide HDTV system is likely to be reported during the Interim Meeting of Study Group 11 in November 1987,

UNANIMOUSLY DECIDES

1. that it would be appropriate to schedule an extraordinary meeting of Study Group 11, lasting not more than one week, confined to this subject, in the last quarter of 1988;
2. that this meeting will be subject to confirmation by the Director of the CCIR on the advice of Study Group 11 after evaluation during the Interim Meeting of the progress achieved in this area;
3. to ask the Director of the CCIR to make within the 1988 budget the necessary arrangements for this extraordinary meeting of Study Group 11.

OPINION 38*

**EXCHANGE OF MONOCHROME AND COLOUR TELEVISION
PROGRAMMES VIA SATELLITES**

(1970)

The CCIR,

CONSIDERING

- (a) the importance of facilitating the exchange of television programmes via satellites;
- (b) that, if this exchange is to be made between countries using the same standard or the same system, any conversion or any transcoding at intermediate points could lower the quality of the signal,

IS UNANIMOUSLY OF THE OPINION

that the attention of administrations and organizations responsible for the transmission of international television programmes should be drawn to the desirability of conserving, in the transmission over their networks, the original standard and system, to provide a better quality of service.

* This Opinion has been brought to the attention of Study Groups 4, 9 and the CMTT.

OPINION 40

**SUBJECTIVE ASSESSMENT OF THE QUALITY OF
TELEVISION PICTURES**

(1970)

The CCIR,

CONSIDERING

- (a) that it has already done considerable work on the subjective assessment of the quality of television pictures (see Report 405);
- (b) that the International Electrotechnical Commission (IEC) is also making a similar study with special reference to receivers;
- (c) that it is important to develop analogous assessment procedures to obtain consistent results,

IS UNANIMOUSLY OF THE OPINION

that the Director, CCIR, should remain in close contact with the IEC to keep it informed of the wishes of the CCIR and to obtain the results of the work of the IEC with a view to arriving at one or more common methods of assessing picture quality and preventing duplication of work.

OPINION 75

**SYSTEMS FOR SIGNAL INTERFACE CONNECTION BETWEEN
TELEVISION RECEIVERS AND ASSOCIATED EQUIPMENT**

(1982)

The CCIR,

CONSIDERING

- (a) the importance of facilitating the enhancement and greater efficiency of broadcast systems;
- (b) that the introduction of such improvements has heretofore often been delayed by the need to wait until equipment in the hands of the public has become obsolete;
- (c) that such delays could be shortened if appropriate means were provided for the connection of associated equipment,

IS UNANIMOUSLY OF THE OPINION:

that the IEC should be invited to study standards for signal interface connection between receiving equipment, recorders, teletext decoders and other associated equipment intended for use by the public.

Note. — The Director, CCIR, is requested to bring this Opinion to the attention of the CCITT and IEC. This Opinion has also been brought to the attention of Study Group 10.

OPINION 83

DATA BROADCASTING SERVICES

(1986)

The CCIR,

CONSIDERING

- (a) that some data broadcasting services have already been introduced and information is given in Recommendation 653;
- (b) that studies within the CCIR on data broadcasting generally are in progress and information is given in Reports 802 and 956;
- (c) that several administrations are providing a wide range of data services via the public telecommunication networks;
- (d) that the use of these complementary delivery facilities can increase the appeal of some of these data services;
- (e) that it is desirable to optimize the compatibility of receiving terminals for the two methods of delivery,

IS UNANIMOUSLY OF THE OPINION

that the Director, CCIR, should draw the attention of the Director, CCITT, to the CCIR documentation on data broadcasting services and invite the CCITT to take into account in its studies of data services based on the public telecommunication networks, the desirability for compatibility of the terminal equipment with data broadcasting services. Similarly, the CCIR in its studies of data broadcasting services, should take into account relevant CCITT documentation.

DECISION 42-2

PROTECTION RATIOS FOR COLOUR TELEVISION SYSTEMS

Terrestrial services

(1980-1982-1985)

CCIR Study Group 11,

CONSIDERING

- (a) that Recommendation 655 contains information on protection ratios relating to the established television systems;
- (b) that additional information is still required;
- (c) that the compatibility between new and conventional television systems is under study,

DECIDES

1. that, within the general terms of reference of Study Group 11, the Interim Working Party 11/5 be maintained;

1.1 to collect additional information and establish protection ratios applicable to:

- data signals,
- sound signals,
- out-of-channel response,
- within-channel response above the video range,
- 525-line systems,
- system B in the UHF range,
- synchronized carrier operation,

in order to complete Recommendation 655;

- 1.2 to relate protection ratios used in planning to the principal characteristics of television receivers;
- 1.3 to collect data regarding the compatibility of new systems with existing systems;
2. to invite administrations to undertake the necessary studies;
3. that, as far as possible, the work of the IWP 11/5 be conducted by correspondence; however, it may meet upon the proposal of its Chairman, following consultations with the Director of the CCIR;
4. that the IWP will consist of the Administrations, International Organizations and Recognized Private Operating Agencies shown in Annex I;
5. that the Chairman of IWP 11/5 will be a representative of the Administration of the Federal Republic of Germany.

ANNEX I

The following Administrations, International Organizations and Recognized Private Operating Agencies have indicated their participation in the work of Interim Working Party 11/5:

Administrations:

Germany (Federal Republic of)
 Australia
 Austria
 Belgium
 Benin
 Cameroon
 Canada
 Egypt
 United States of America
 Finland
 France
 Gabon
 Israel
 Italy
 Japan
 Kenya
 Netherlands
 Poland (People's Republic of)
 Portugal
 German Democratic Republic
 United Kingdom
 Swaziland
 Tanzania
 USSR
 Yugoslavia (Socialist Federal Republic of)
 Zimbabwe

International Organizations and Recognized Private Operating Agencies:

EBU

Broadcasting Corporation of New Zealand (BCNZ)
 Norddeutscher Rundfunk (NDR)

DECISION 58-1 *

HIGH-DEFINITION TELEVISION STANDARD

(1983-1986)

CCIR Study Group 11,

CONSIDERING

- (a) that high-definition television (HDTV) is a subject of intense current interest and activity in the world;
- (b) that this work is the subject of Question 27/11 and the Study Programmes which derive from it, and is detailed in Reports 630, 801 and 1075;
- (c) that it would be beneficial to HDTV broadcasters and to the public alike if the CCIR could recommend the adoption of a single, world-wide studio standard for high-definition television;
- (d) that a step to attain this goal is to define the characteristics of a single high-definition television standard to be adopted worldwide for the high-definition television studio, and for the international exchange of programmes;
- (e) that prompt action in this respect is required, to avoid the establishment of one or several *de facto* studio standards before all aspects of the problem have been adequately considered;
- (f) that the proposal for a new Recommendation given in Annex II to Report 801 defines a potential set of basic parameter values for a standard for signal generation in HDTV studios and for the international exchange of HDTV programmes;

DECIDES

1. that Interim Working Party 11/6 should continue its work within the general terms of reference of CCIR Study Group 11, taking note of Question 27/11 and the Study Programmes which derive from it and with the following specific terms of reference:
 - 1.1 to encourage administrations to participate in a coordinated way in the study of a high-definition television standard for the studio and for international programme exchange;
 - 1.2 to continue the work necessary to define a full set of relevant digital and analogue parameters for a single world-wide high-definition television standard for programme production and for the international exchange of programmes. This should take into account the implications of broadcasting requirements including the economic and operational aspects;
 - 1.3 to study simultaneously, in cooperation with JWG 10-11S, the methods for emission of HDTV signals and according to those studies to produce the specification of the baseband signal format to be used for emission;
 - 1.4 similarly, in cooperation with the CMTT, to prepare a specification for the baseband signal format to be used for the international exchange of HDTV programmes via transmission links;
 - 1.5 to prepare regularly updated draft Reports on the progress of its studies;
 - 1.6 to complete the studies as rapidly as possible and before the CCIR Final Meetings in 1989;
2. that IWP 11/6 should, as far as possible, work by correspondence; however, it may meet upon proposal of its Chairman, following consultation with the Chairman of Study Group 11 and with the Director of the CCIR;
3. that the Chairman and the composition of IWP 11/6 shall be as shown in Annex I.

* As amended by the XVIth Plenary Assembly. This Decision should be brought to the attention of the IEC.

ANNEX I

The following Administrations, International Organizations and Recognized Private Operating Agencies have indicated that they wished to participate in the work of Interim Working Party 11/6 (effective in October 1985):

Administrations:

Germany (Federal Republic of)
Australia
Canada
China (People's Republic of)
Egypt
Spain
United States of America
France
India
Italy
Japan
Netherlands
United Kingdom
Sweden
USSR
Yugoslavia (Socialist Federal Republic of)

International Organizations and Recognized Private Operating Agencies:

ABU	CBS
EBU	NHK
NANBA	RTVE
OIRT	

Chairman of Interim Working Party 11/6:

Y. TADOKORO
Japan Broadcasting Corporation (NHK)
2-2-1 Jinnan
Shibuya-ku
Tokyo 150
Japan

assisted by two Vice-Chairmen:

R. GREEN
Public Broadcasting Service
5520 Cherokee Avenue, Suite 201
Alexandria, Virginia 22312
United States of America

and

W. HABERMANN
Institut für Rundfunktechnik GMBH
Floriansmühlstrasse 60
8000 München 45
Germany (Federal Republic of)

DECISION 60-1 *

DIGITAL TELEVISION STANDARDS

(1983-1985)

CCIR Study Group 11,

CONSIDERING

- (a) that Recommendation 601 has established the basis for digital coding standards for television studios both in countries using the 525-line system and in those using the 625-line system;
- (b) that the practical implementation of Recommendation 601 requires definition of the details of various studio interfaces and the data streams traversing them;
- (c) that such interfaces should, as far as possible, have common characteristics between 525-line and 625-line versions;
- (d) that electrical interfaces in both parallel and serial form have been defined in Recommendation 656 for digital signals at the 4 : 2 : 2 encoding level;
- (e) that it is desirable for similar interfaces to be defined for the 4 : 4 : 4 level and for the lower levels of the family of encoding standards, and since transmission by optical fibre has advantages, particularly at higher bit rates and over longer distances, it is desirable for compatible optical interfaces to be defined;
- (f) that the ancillary signals provided for in Recommendation 656 need to be studied further and international standards proposed as necessary;
- (g) that digital television signals may be a potential source of interference to other services;
- (h) that further studies are required to complete the specifications in Recommendation 601 for the various members of the encoding family;
- (j) that consideration should be given to any special provisions necessary in relation to the associated sound channels;
- (k) that further studies are urgently required on bit-rate reduction so that standard methods may be chosen in the near future,

DECIDES

1. that Interim Working Party 11/7 should be maintained**, its terms of reference being to establish and submit to Study Group 11, before the end of the current study period, the following:
 - 1.1 the information necessary to extend Recommendation 601 to fully specify the 4 : 4 : 4 level, and also to include other levels if possible, including the complete specification of filter characteristics;
 - 1.2 a draft Recommendation for optical interfaces, at least for the 4 : 2 : 2 and 4 : 4 : 4 levels;
 - 1.3 a draft Recommendation for international standards, as studies may show to be desirable, for the utilization of the provision for ancillary signals in interface specifications;
 - 1.4 a draft Report, preferably with a draft Recommendation, defining any special provisions that studies show to be desirable in relation to the sound channels associated with the video signals carried by interfaces, with due regard to Recommendation 647 of Study Group 10;
 - 1.5 draft Recommendations for bit-parallel and bit-serial interfaces for the 4 : 4 : 4 level and for other levels for which the need may be established;

* This Decision should be brought to the attention of the IEC.

** Interim Working Party 11/7 was established by Decision 60 at the Interim Meeting of Study Group 11, 1983.

1.6 draft Recommendations for bit-rate reduction methods giving satisfactory picture quality and processing capability for each of the applications identified, it being necessary:

- to define each application;
- to establish objectives in respect of picture quality and processing capability for each application;
- to establish what bit-rate reduction methods will meet the objectives;
- to establish agreed test materials and test methods;

taking account of:

- available bit rates (e.g. CCITT levels);
- ease of conversion between coding schemes;
- the performance of systems, including differing systems, in cascade;
- special needs of the associated sound channels;

1.7 a draft Report defining the practical methods required to ensure acceptably low levels of radiated interference from the digital signals;

2. that liaison should be maintained with Joint IWP 10-11/4, IWP 11/6, Study Group 10 and with due regard to Decision 18, close liaison with the CMTT and its IWP CMTT/2;

3. that IWP 11/7 should, as far as possible, work by correspondence. However, it may meet upon the proposal of its Chairman, following consultation with the Chairman of Study Group 11 and the Director of the CCIR. It would be advantageous for IWP 11/7 and the CMTT IWP CMTT/2 to meet at the same place and time;

4. that the progress of work of the IWP should be reported to Study Group 11 at its Interim Meeting and its results at the final meetings of the study period 1986-1990;

5. that the Chairman, the Vice-Chairmen and composition of IWP 11/7 will be as shown in Annex I:

ANNEX I

The following Administrations, International Organizations and Recognized Private Operating Agencies have indicated their participation in the work of Interim Working Party 11/7 on digital television standards:

Administrations:

Germany (Federal Republic of)
 Australia
 Belgium
 Canada
 China (People's Republic of)
 Egypt
 United States of America
 Finland
 France
 India
 Italy
 Japan
 United Kingdom
 Sweden
 USSR
 Yugoslavia (Socialist Federal Republic of)

International Organizations and Recognized Private Operating Agencies:

EBU	CBS
NANBA	NDR
OIRT	ZDF

Chairman of Interim Working Party 11/7:

A. N. HEIGHTMAN
 Marconi Communications Systems Ltd.
 Waterhouse Lane
 Chelmsford
 Essex, CM1 2QX
 United Kingdom

assisted by two Vice-Chairmen:

K. P. DAVIES
 Canadian Broadcasting Corporation
 7925 Cote St. Luc Road
 Montréal, Québec, H4W1R5
 Canada

and

T. SAITO
 Japan Broadcasting Corporation (NHK)
 Engineering Headquarters
 2-2-1 Jinnan
 Shibuya-ku
 Tokyo 150
 Japan

DECISION 66

SUBJECTIVE ASSESSMENT OF TELEVISION PICTURE QUALITY

(1985)

CCIR Study Group 11,

CONSIDERING

- (a) that Recommendation 500 has established some methods of test for assessing the subjective quality of television systems;
- (b) that Report 405, containing 7 Annexes, gives a variety of information about testing procedures, analysis and presentation of results, while Report 1083 gives information about advanced statistical processing;
- (c) that Recommendation 654 establishes reference relationships between subjective quality and objective impairments for the more common forms of impairment in current NTSC, PAL and SECAM systems while Report 959 tabulates measured values for particular systems;
- (d) that Report 313 contains a lengthy bibliography of published work and CCIR contributions on subjective assessments;
- (e) that the introduction of new kinds of television signal processing such as digital coding and bit-rate reduction, new kinds of television signals using time-multiplexed components and, possibly, new services such as enhanced television and HDTV may require changes in the methods of making subjective assessments;
- (f) that significant progress has been made in the measurement of human perception,

DECIDES

1. that an Interim Working Party (IWP) 11/4 should be set up within the general terms of reference of Study Group 11 and with the following specific terms of reference:
 - 1.1 to review Questions 3-2/11 and 14-1/11, and their associated Study Programmes, in order to:
 - identify those tasks which have been completed; and
 - define new areas where studies are required;
 - 1.2 to review the texts in Volume IX, Part 1, of the Recommendations and Reports of the CCIR which are concerned with the subjective evaluation of picture quality with a view to:
 - the consolidation and elimination of repetitive material,
 - the improvement of clarity and brevity,
 - making them more comprehensible to non-specialists,
 - to provide a framework for the introduction of new material without reducing the clarity of the complete text;
 - 1.3 to examine current trends in television systems described in *CONSIDERING (e)* and determine what changes, if any, will be required in the methodology of subjective testing to accommodate these trends and prepare any draft revisions of Study Programmes which may be appropriate;
 - 1.4 to collect, collate and harmonize contributions to studies on the methodology of subjective testing of new systems such as those described in *CONSIDERING (e)*;
 - 1.5 to prepare regularly updated draft Reports on the progress of such studies;
 - 1.6 to submit such Reports to Study Group 11;
2. that IWP 11/4 shall keep the Chairman of Study Group 10 informed of their progress so that Study Group 10 may consider the possible application of similar methodology to the measurement of aural perception;
3. that IWP 11/4 should, as far as possible, work by correspondence; however, it may meet upon the proposal of its Chairman following consultations with the Chairman of Study Group 11 and the Director of the CCIR;
4. that the Chairman and the composition of IWP 11/4 shall be as shown in Annex I.

ANNEX I

The following Administrations, International Organizations and Recognized Private Operating Agencies* have indicated that they wished to participate in the work of Interim Working Party 11/4:

Administrations:

Australia
 China (People's Republic of)
 United States of America
 France
 Italy
 Japan
 German Democratic Republic
 United Kingdom
 USSR
 Yugoslavia (Socialist Federal Republic of)

International Organizations and Recognized Private Operating Agencies:

EBU

Broadcasting Corporation of New Zealand (BCNZ)

* Taken over from Decision 41.

Chairman of Interim Working Party 11/4:

Mr. D. WOOD
EBU Technical Centre
Avenue Albert Lancaster 32
B-1180 Bruxelles
Belgium

assisted by a Vice-Chairman:

Miss B. JONES
CBS Technology Centre
227 High Ridge Road
Stamford, CT 06905
USA

DECISION 72*

SERVICES USING DATA BROADCASTING

(1986)

CCIR Study Groups 10 and 11,

CONSIDERING

- (a) that services using data broadcasting like teletext and programme identification in television and sound broadcasting are already implemented in many countries;
- (b) that many other services have been identified and are the subject of experiments in several countries;
- (c) that terrestrial and satellite data broadcasting may share a channel with television and sound services or may occupy the full channel;
- (d) that the CCITT is studying similar services in telecommunication networks,

DECIDE

1. that a Joint Interim Working Party 10-11/5 should be set up within the general terms of reference of CCIR Study Groups 10 and 11 and with the following specific terms of reference:
 - 1.1 to carry out studies on the presentation layer requirements of some non-Latin based alphabets and non-alphabetic writing systems as indicated in Recommendation 653;
 - 1.2 to propose definitions of services using data broadcasting in television and sound broadcasting channels, whether terrestrial or satellite**;
 - 1.3 to study the data coding for these services, keeping coordination with JIWP 10-11/3, which is responsible for the accommodation of data signals in terrestrial and satellite television channels**;
 - 1.4 to define appropriate service quality criteria and assessment methods;
 - 1.5 to study the requirements for international exchange and system transcoding;
 - 1.6 to study the requirements for equipment interface standardization;
 - 1.7 to maintain contact with the CMTT, the appropriate CCITT Study Groups, the IEC and the ISO;

* The Director, CCIR, is requested to bring this Decision to the attention of the CCITT, the IEC and the ISO.

** The Study Programmes derived from Question 29-2/11, Study Programmes 44J/10, 46H/10, 47A/10 and 51D/10 as well as Study Programme 2N/10 and 11 are relevant.

2. that JIWP 10-11/5 should, as far as possible, work by correspondence; however, it may meet upon proposal of its Chairman, following consultation with the Chairmen of Study Groups 10 and 11 and the Director of the CCIR;
3. that the Chairman and the composition of JIWP 10-11/5 shall be as shown in Annex I.

ANNEX I

The following Administrations and International Organizations have indicated that they wished to participate in the work of Joint Interim Working Party 10-11/5:

Administrations:

Germany (Federal Republic of)
 Australia
 Brazil (Federative Republic of)
 Canada
 China (People's Republic of)
 Spain
 United States of America
 France
 Iran (Islamic Republic of)
 Italy
 Japan
 Netherlands
 United Kingdom
 Sweden
 USSR
 Yugoslavia (Socialist Federal Republic of)

International Organizations:

EBU
 OIRT

Chairman of Joint Interim Working Party 10-11/5:

Professor F. CAPPUCINI
 Consiglio Superiore Tecnico
 P.T.A. Ministero P.T.
 Viale Europa 160
 I-00144 Roma
 Italy

DECISION 73

CCIR STUDIES TO BE CARRIED OUT IN THE INTER-SESSIONAL PERIOD FOR SUBMISSION TO THE SECOND SESSION OF THE WARC ORB-88

(1985)

This Decision, adopted by Study Groups 1, 2, 4, 5, 8, 9, 10 and 11 at the Final Meetings in 1985, was reviewed by the Plenary Assembly and replaced by Resolution 90 which appears in Volume XIV.

ALPHABETICAL INDEX OF KEY WORDS AND TERMS OF VOLUME XI-1

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