INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

C.C.I.R.

XIIIth PLENARY ASSEMBLY

GENEVA, 1974

VOLUME XI

BROADCASTING SERVICE (TELEVISION)
(STUDY GROUP 11)

Published by the
INTERNATIONAL TELECOMMUNICATION UNION
GENEVA, 1975

COVERING NOTE

GENERAL SECRETARIAT INTERNATIONAL TELECOMMUNICATION UNION

Subject :

GENÈVE, 9 December 1977
PLACE DES NATIONS

ADDENDUM No. 2

to

VOLUME XI

XIIIth PLENARY ASSEMBLY OF THE CCIR

Geneva, 1974

Note by the Director, CCIR

Subsequent to the publication of Volume XI (Broadcasting Service (television)) of the documents of the XIIIth Plenary Assembly of the CCIR, a new text relating to the Satellite Broadcasting Service has been submitted for adoption by correspondence, in conformity with the provisions of No. 308 of the International Telecommunication Convention, Torremolinos, 1973.

It has received more than the twenty approvals necessary for its adoption by the Members of the ITU and has therefore become an official Question of the CCIR.

The text is as follows :

- Question 35/11. This Question is reproduced on the separate page 303d.

QUESTION 35/11

TRANSMITTING ANTENNAE FOR THE BROADCASTING-SATELLITE SERVICE

(1977)

The C.C.I.R.,

CONSIDERING

(a) the need for ample information on transmitting antennae for the planning of the broadcasting-satellite service;

DECIDES that the following question should be studied:

1. what are the reference patterns for the co-polar and cross-polar components of transmitting antennae for the broadcasting-satellite service for both individual and community reception;

2. what are the practicable means of achieving improved side-lobe suppression and the economic implications thereof;

3. what are the technical characteristics necessary to achieve a pointing accuracy for transmitting antennae such that:

– the deviation of the antennae beam from its normal direction shall not exceed 0·1°;

– where the transmitted antenna beam has an elliptical cross-section, the orientation of the major axis can be maintained within ±2° of the specified value?

COVERING NOTE

GENERAL SECRETARIAT INTERNATIONAL TELECOMMUNICATION UNION

Subject: Documents of the XIIIth Plenary Assembly of the CCIR Geneva, 1974

GENÈVE, 9 September 1977
PLACE DES NATIONS

ADDENDUM No. 1

to

VOLUME XI

XIIIth PLENARY ASSEMBLY OF THE CCIR

Geneva, 1974

Note by the Director, CCIR

Subsequent to the publication of Volume XI (Broadcasting Service (television)) of the documents of the XIIIth Plenary Assembly of the CCIR, a new text relating to the Satellite Broadcasting Service has been submitted for adoption by correspondence, in conformity with the provisions of No. 308 of the International Telecommunication Convention, Torremolinos, 1973.

It has received more than the twenty approvals necessary for its adoption by the Members of the ITU and has therefore become an official Question of the CCIR.

The text is as follows :

- Question 34/11. This Question is reproduced on the separate page 303 a.

QUESTION 34/11*

RADIATION OF SPURIOUS EMISSIONS FROM SPACE STATIONS IN THE BROADCASTING-SATELLITE SERVICE

(1976)

The C.C.I.R.,

CONSIDERING

(a) that the radiation of spurious emissions by space stations in the broadcasting-satellite service could cause interference to other services sharing the same frequency band or operating in other frequency bands;

(b) that spurious emissions could cause interference to other stations of the broadcasting-satellite service and might reduce the efficiency of the use made of the geostationary satellite orbit;

(c) that suppression of spurious emissions from space stations to very low levels may involve major technical problems;

(d) that the various radio services differ greatly in sensitivity to interference;

(e) that the Radio Regulations do not define limits for spurious emissions for transmitters operating on fundamental frequencies above 235 MHz;

(f) that any necessary suppression of spurious emissions must be effected prior to launching;

DECIDES that the following question should be studied:

what limits of radiation of spurious emissions from space stations of the broadcasting-satellite service are required to protect this service and other services operating in accordance with the Radio Regulations?

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* This Question should be brought to the attention of Study Groups 1, 2, 4, 7, 8 and 9.

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

C.C.I.R.

XIIIth PLENARY ASSEMBLY

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BROADCASTING SERVICE (TELEVISION)

RECOMMENDATIONS AND REPORTS

QUESTIONS AND STUDY PROGRAMMES, DECISIONS, RESOLUTIONS AND OPINIONS

(Study Group 11)

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DISTRIBUTION OF TEXTS OF THE XIIIth PLENARY ASSEMBLY OF THE C.C.I.R. IN VOLUMES I TO XIII

Volumes I to XIII, XIIIth Plenary Assembly, contain all the valid texts of the C.C.I.R. They take the place of those of the previous edition, XIIth Plenary Assembly, New Delhi, 1970.

1. Recommendations, Reports, Decisions, Resolutions, Opinions

1.1 *Numbering of these texts*

Recommendations, Reports, Resolutions 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.

While the numbering system of the C.C.I.R. texts, defined above, has not been modified, the XIIIth Plenary Assembly adopted a new category of texts known as Decisions, by which Study Groups take action, generally of an organizational nature, relative to matters within their own terms of reference, particularly the formation of (Joint) Interim Working Parties (see Resolution 24-3, Volume XIII). A certain number of Resolutions in Volumes published before 1974 have consequently become Decisions. In this case, a footnote gives the number of the Resolution which the Decision replaces.

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 XIII.

1.2 *Recommendations*

Number	Volume	Number	Volume	Number	Volume
45	VIII	310, 311	V	436	III
48, 49	X	313	VI	439	VIII
77	VIII	314	II	441	VIII
80	X	325-334	I	442, 443	I
100	I	335, 336	III	444	IX
106	III	337	I	445	I
139, 140	X	338, 339	III	446	IV
162	III	341	I	447-450	X
166	XII (CMV)	342-349	III	451	XII (CMTT)
182	I	352-354	IV	452, 453	V
205	X	355-359	IX	454-456	III
214-216	X	361	VIII	457-460	VII
218, 219	VIII	362-367	II	461	XII (CMV)
224	VIII	368-370	V	462, 463	IX
237	I	371-373	VI	464-466	IV
239	I	374-376	VII	467, 468	X
240	III	377-379	I	469-472	XI
246	III	380-393	IX	473-474	XII (CMTT)
257, 258	VIII	395-406	IX	475-478	VIII
262	X	407-416	X	479	II
265, 266	XI	417-418	XI	480	III
268	IX	419	X, XI	481-484	IV
270	IX	421	XII (CMTT)	485, 486	VII
275, 276	IX	422, 423	VIII	487-496	VIII
283	IX	427-429	VIII	497	IX
289, 290	IX	430, 431	XII (CMV)	498, 499	X
302	IX	433	I	500, 501	XI
305, 306	IX	434, 435	VI	502-505	XII (CMTT)

1.3 *Reports*

Number	Volume	Number	Volume	Number	Volume
19	III	275-282	I	424-426	V
32	X	283-289	IX	428	V
42	III	292, 293	X	429-432	VI
79	X	294	XI	433-437	III
93	VIII	298-305	X	438, 439	VII
106, 107	III	306, 307	XI	440	(1)
109	III	311, 312	XI	441	XII (CMV)
111	III	313	XII (CMTT)	443-446	IX
112	I	315	XI	448, 449	IX
122	XI	318, 319	VIII	451	IV
130	IX	321	XII (CMV)	453-455	IV
137	IX	322	(1)	456	II
176-189	I	324-330	I	457-461	X
190	X	335	XII (CMV)	463-465	X
192, 193	I	336	V	467, 468	X
195	III	338	V	469-473	XI
196	I	340	(1)	476-485	XI
197, 198	III	341-344	VI	486-488	XII (CMTT)
200, 201	III	345-357	III	490, 491	XII (CMTT)
202	I	358, 359	VIII	493	XII (CMTT)
203	III	361	VIII	495-498	XII (CMTT)
204-208	IV	362-364	VII	499-502	VIII
209	IX	366	VII	504-513	VIII
211-214	IV	367-373	I	515	VIII
215	IX	374-382	IX	516	X
216	VIII	383-385	IV	518	VII
222-224	II	386-388	IX	519-534	I
226	II	390, 391	IV	535-548	II
227-229	V	393	IX	549-551	III
233-236	V	394	VIII	552-561	IV
238, 239	V	395, 396	II	562-570	V
241	V	398-401	X	571-575	VI
245-251	VI	403	X	576-580	VII
252	(1)	404, 405	XI	581-603	VIII
253-256	VI	409	XI	604-615	IX
258-266	VI	410-412	XII (CMTT)	619-622	X
267	VII	413-415	(1)	623	X,XII (CMTT)
269-271	VII	417-420	I	624-634	XI
272, 273	I	422, 423	I	635-649	XII (CMTT)
				650	XII (CMV)

(1) Published separately.

1.4 *Decisions*

Number	Volume	Number	Volume	Number	Volume
1	I	6-11	VI	17	XI
2	IV	12-14	VII	18	XII (CMTT)
3-5	V	15	VIII	19, 20	XII (CMV)
		16	IX		

1.5 *Resolutions*

Number	Volume	Number	Volume	Number	Volume
4	VI	22, 23	XII (CMV)	43, 44	I
14	VII	24	XIII	48	VI
15, 16	I	26, 27	XIII	59	X
20	VIII	33	XIII	60, 61	XIII
		36, 39	XIII		

1.6 *Opinions*

Number	Volume	Number	Volume	Number	Volume
2	I	29, 30	I	45, 46	VI
11	I	32	I	47, 48	VII
13, 14	IX	34, 35	I	49	VIII
15, 16	X	36	VII	50	IX
22, 23	VI	38-40	XI	51, 52	X
24	VIII	41	XII (CMTT)	53, 54	XI
26-28	VII	42, 43	VIII	55	XII (CMTT)
		44	I		

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.

2.2 *Arrangement of Questions and Study Programmes*

The plan shown on page 8 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.

PLAN OF VOLUMES I TO XIII
XIIIth PLENARY ASSEMBLY OF THE C.C.I.R.

(Geneva, 1974)

Volume I	Spectrum utilization and monitoring (Study Group 1).
Volume II	Space research and radioastronomy (Study Group 2).
Volume III	Fixed service at frequencies below about 30 MHz (Study Group 3).
Volume IV	Fixed service using communication satellites (Study Group 4).
Volume V	Propagation in non-ionized media (Study Group 5).
Volume VI	Ionospheric propagation (Study Group 6).
Volume VII	Standard frequency and time-signal services (Study Group 7).
Volume VIII	Mobile services (Study Group 8).
Volume IX	Fixed service using radio-relay systems (Study Group 9). Coordination and frequency sharing between systems in the fixed satellite service and terrestrial radio-relay systems (subjects common to Study Groups 4 and 9).
Volume X	Broadcasting service (sound) including audio-recording and satellite applications (Study Group 10).
Volume XI	Broadcasting service (television) including video-recording and satellite applications (Study Group 11).
Volume XII	Transmission of sound broadcasting and television signals over long distances (CMTT). Vocabulary (CMV).
Volume XIII	Information concerning the XIIIth Plenary Assembly. Structure of the C.C.I.R. Complete list of C.C.I.R. texts.

Note. — To facilitate reference, page numbering is identical in all three versions of each Volume, that is, in English, French and Spanish.

VOLUME XI *

INDEX OF TEXTS **

BROADCASTING SERVICE (TELEVISION)

(Study Group 11)

* Although the working documents mentioned in this Volume bear the reference "Period 1970–1973" for documents published during 1971 and 1972 and "Period 1970–1974" for those published during 1973 and 1974, they are, of course, all documents of the period 1970–1974, between the Plenary Assembly of New Delhi and that of Geneva. For this reason, all references to these documents in this Volume take the form "Period 1970–1974".

** In this Volume, Recommendations and Reports dealing with the same subject are collected together. These texts are numbered in such a manner that they cannot be presented in numerical order and at the same time, in numerical sequence of pages. Consequently, this index, in numerical order of texts, does not follow the numerical sequence.

REPORTS

QUESTIONS AND STUDY PROGRAMMES

DECISIONS

OPINIONS

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BROADCASTING SERVICE (TELEVISION)

STUDY GROUP 11

Terms of reference:

1. Study of those technical aspects of the broadcasting service (television), including the use of communication satellites, which are of international importance.

2. Study of standards for motion-picture films intended for television and for all forms of television recording relevant to the international exchange of programmes.

Chairman: M. KRIVOSHEEV (U.S.S.R.)

Vice-Chairman: C.A. SIOCOS (Canada)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP 11

Study Group 11 carried out a considerable amount of work during the study period 1970–1974. Among the main results of its activities was the preparation of new Recommendations and Reports. Recommendation 500, "Method for the subjective assessment of the quality of television pictures" will make it possible to achieve world-wide unification of test conditions and methods of assessing television picture quality. Recommendation 501 "Appraisal of colour film intended for television use", setting out conditions for appraising films by means of optical projection, will help to improve telecine performance in the international exchange of programmes.

An important part in the unification of television broadcasting systems will be played by Report 624 "Characteristics of television systems", which contains the basic parameters for monochrome and colour television signals and radiated signals.

Mention should also be made of new Reports on the most recent digital television techniques, on television receivers and so forth.

A series of new Reports on satellite television comprises studies of broadcasting-satellite systems, terrestrial receiving equipment, protection ratios, frequency sharing between the terrestrial and satellite services and other such matters.

A large number of earlier Recommendations and Reports have been supplemented by the results of new studies conducted by administrations.

Participants in Study Group 11 will be faced with important tasks during the forthcoming study period. In addition to the study of traditional problems of television broadcasting techniques, research must be directed towards new areas of study and new perspectives. These areas of study are primarily concerned with problems of satellite television broadcasting and digital methods of transmitting television information.

In satellite broadcasting, the important task is to determine the optimum parameters of systems which will ensure the requisite television picture quality. Mutual interference between terrestrial and space services will have to be studied. The relevant Questions and Study Programmes, covering all the bands allocated to the television satellite services by the World Administrative Radio Conference, provide a comprehensive basis for the study of satellite broadcasting systems. The documents that Study Group 11 will prepare on the subject will play an important part in the preparation and work of the World Conference on Satellite Broadcasting in the 12 GHz band, to be held early in 1977.

Digital methods of transmitting television signals open up a wide field of study. The possibilities of sending digital television signals over any distance with practically no deterioration of picture quality, of encoding the signals of any analogue television system into a single digital form and of reducing the redundancy of television information give grounds for the expectation that digital television systems will be more and more widely used in the future.

During the forthcoming study period, basic methods and characteristics of coding television signals will be studied, together with methods of monitoring and measurement applicable to digital television.

Standards for converting the initial analogue television signals into digital form must of course be in conformity with the parameters of communication channels and other methods of television broadcasting. Accordingly, studies of digital television will be conducted in close cooperation with other Study Groups of the C.C.I.R. and C.C.I.T.T., especially the CMTT.

Another new problem to be studied during the next period is that of high-definition television, for which appropriate scanning standards and frequency band requirements must first be elaborated.

The redundancy of the analogue television signal allows for the simultaneous transmission of still-picture signals and other information by multiplexing. Study Group 11 has adopted a Question and a Study Programme concerning this problem.

The limited portion of the radio-frequency spectrum allocated to television broadcasting and the growing need to increase the number of television transmissions have aroused interest in the development of cable television, on which a Question has been prepared.

In recent years, trends have been observed and appreciable progress has been made towards the automation of television broadcasting techniques. These problems, which affect the international exchange of television programmes, have already been reflected in Reports on the automation of television transmitting stations and video recording techniques.

In addition to the topics I have mentioned, further results may be expected from work done under earlier Questions and Study Programmes.

Studies will be continued with a view to improving television standards and the standards-conversion and transcoding of colour television systems and to elaborating efficient stereoscopic television systems. Problems of protection ratios, picture quality and other matters are still under examination.

Extensive studies are foreseen under Questions and Study Programmes on film and magnetic-tape recording of television programmes. In this area, work will be continued on specifying performance characteristics, on standardizing the basic parameters of video recording, on monitoring methods and on automation of recording and reproduction processes. All this will considerably promote the ever-expanding international exchange of recorded television programmes.

Research will be continued into the technology of television reception, which is the decisive and most important link in the television chain. These studies, together with research into video recording problems, are conducted in close collaboration with the IEC.

This enumeration of topics shows that Study Group 11 is carrying on a complex study of present and future television problems of international significance which is an important prerequisite for further progress in its activities.

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

RECOMMENDATIONS AND REPORTS

Recommendations

RECOMMENDATION 470-1

TELEVISION SYSTEMS

(1970 – 1974)

The C.C.I.R.,

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 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, of the systems described in this Report, systems A, C, E and F are not recommended for a new service;

3. that, for monochrome 625-line systems, the video-frequency characteristic described in Recommendation 472-1 is to be preferred;

4. that, for a country wishing to initiate a colour television service, one of the systems defined in Report 624 or any suitable adaptation of the NTSC, PAL or SECAM systems to any one of the monochrome systems defined in this Report is to be preferred.

RECOMMENDATION 471

NOMENCLATURE OF COLOUR BAR SIGNALS

(Question 1/11)

(1970)

The C.C.I.R.,

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;

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, 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*, 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 each number:

A — the primary colour signal level during the transmission of the "white" colour bar;

B — the primary colour signal level during the transmission of the "black" colour bar;

C — the maximum level of the primary colour signal during transmission of "coloured" colour bars;

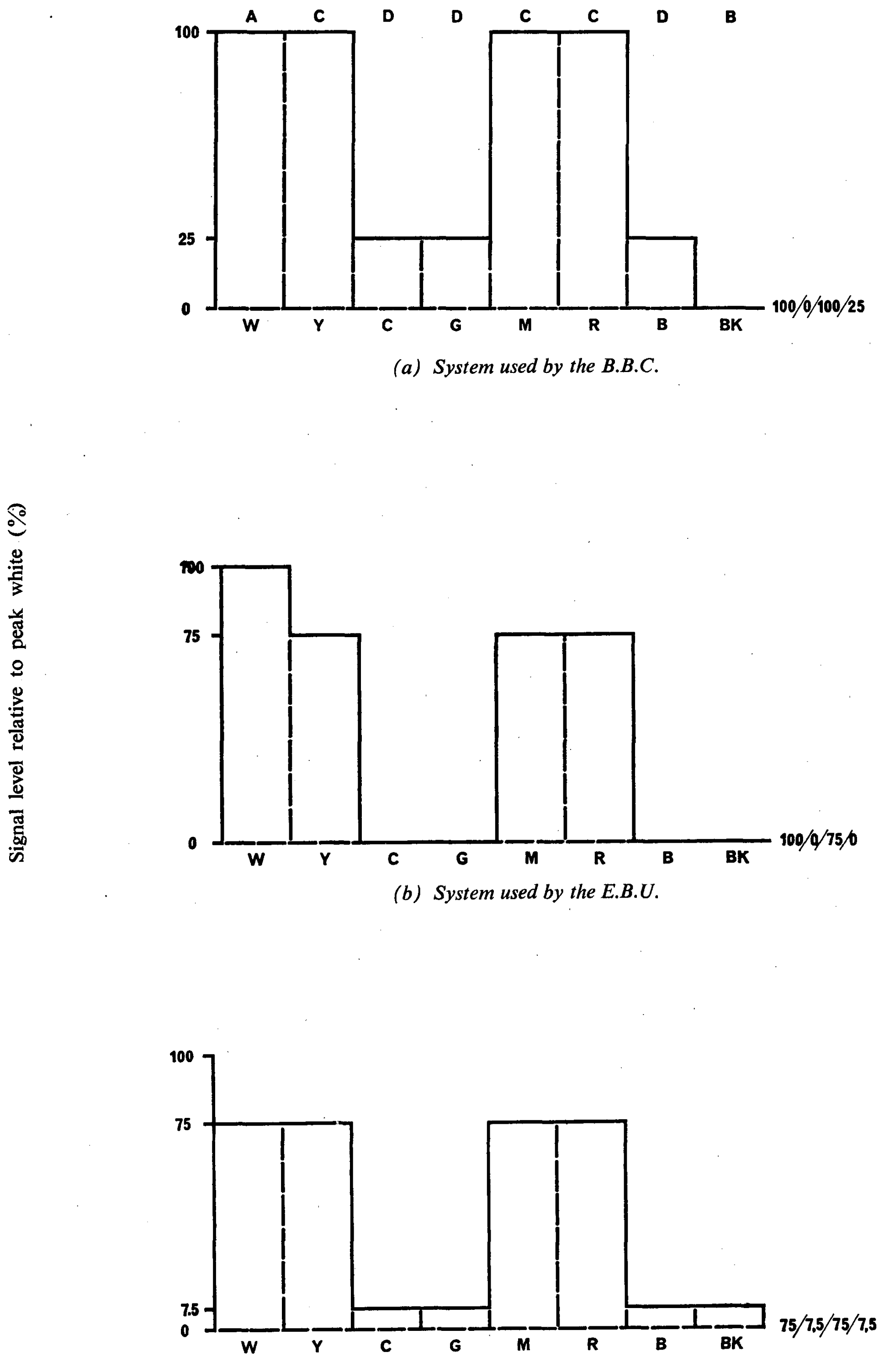
D — the minimum level of the primary colour signal during transmission of "coloured" colour bars.

Example: Referring to Fig. 1, which shows the red primary colour signal for three types of colour bar signal, this data would be expressed as follows:

Colour bars *(a)* 100 / 0 / 100 / 25
Colour bars *(b)* 100 / 0 / 75 / 0
Colour bars *(c)* 75 / 7·5 / 75 / 7·5

This nomenclature refers only to the colour bar signal and not to any other signals that may share the raster on a split screen.

* See, for example, Recommendation 451-2, part 2, § 3.3 and Report 624, Fig. 1.



(a) *System used by the B.B.C.*

(b) *System used by the E.B.U.*

(c) *System used in North America*

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

11A: *Reports*

REPORT 312-2 *

CONSTITUTION OF A SYSTEM OF STEREOSCOPIC TELEVISION

(Study Programme 1C/11)

(1963 – 1966 – 1970)

1. Methods of providing stereoscopic television have long been the subject of study in various countries. Some of these studies were made with mechanical scanning systems, ante-dating the electronic systems now in use. Several methods have been proposed to ensure that each of the two reproduced stereoscopic images reaches the proper eye of the viewer, and many of the methods are applicable to all electronic systems.

The first method was based directly on the optical stereoscope and consisted of the reproduction of two spatially separated images, one for each eye. The larger separations, to accommodate larger images, prismatic viewing devices or prismatic spectacles, could be used to produce visual registration of the two images. A second method consisted in the production of two overlapping images in complementary colours and the use of complementary colour filters, sometimes in spectacles worn by the observer, to separate the two images. A third method provides overlapping images, produced by light which is polarized in orthogonal planes for the two images, together with the use of spectacles with polarizing filters. Several methods of separating the two pictures, without the use of spectacles, have been devised. These make use of gratings or lenticular screens. Both gratings and lenticular optical systems have been applied to cathode-ray receiver displays. These methods may have more serious limitations as to permissible viewing positions than do methods employing spectacles.

2. The transmission of a stereoscopic television signal 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 colour television and the use of the transmission methods, of which study has been made for colour television, may be envisaged for stereoscopic television transmission.

3. Various solutions for reproducing the stereoscopic picture have been envisaged. Some of these solutions entail the use, for the reproduction of a stereoscopic monochrome or colour picture, of television sets designed for the reception of normal non-stereoscopic pictures.

4. Further studies should be carried out and it should be borne in mind that the problems of bandwidth and compatibility with monochrome and colour systems are of great importance.

5. Doc. XI/22, Moscow, 1958; Doc. XI/20 and Doc. XI/34, Bad Kreuznach, 1962; Doc. XI/65 and Doc. XI/66, 1963–1966, and Doc. XI/42 (U.S.S.R.), 1966–1969 and their bibliographies, contain some information on the question of stereoscopic television.

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* Adopted unanimously.

REPORT 476-1 *

COLORIMETRIC STANDARDS IN COLOUR TELEVISION

(Study Programme 1A/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:	$x = 0{\cdot}67$	$y = 0{\cdot}33$
Green:	$x = 0{\cdot}21$	$y = 0{\cdot}71$
Blue:	$x = 0{\cdot}14$	$y = 0{\cdot}08$

The reference white chosen was standard

White C: $x = 0{\cdot}310$ $y = 0{\cdot}316$

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:	$x = 0{\cdot}64$	$y = 0{\cdot}33$
Green:	$x = 0{\cdot}29$	$y = 0{\cdot}60$
Blue:	$x = 0{\cdot}15$	$y = 0{\cdot}06$

and reference white D_{65}. ***

* Adopted unanimously.

** 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.

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.

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C.C.I.R. [1970–1974] Doc. 11/63, U.S.A.
C.C.I.R. [1970–1974] Doc. 11/229, E.B.U.
C.C.I.R. [1970–1974] Doc. 11/237, U.S.A.
C.C.I.R. [1970–1974] Doc. 11/264, United Kingdom.
O.I.R.T. Doc. TK-III-830 (with Annex).

REPORT 624 *

CHARACTERISTICS OF TELEVISION SYSTEMS

(1974)

The following Tables, given for information purposes, contain details of a number of different television systems in use at the time of the XIIIth Plenary Assembly of the C.C.I.R., Geneva, 1974.

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

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, also the main parameters of systems are given in Reports 406 and 407-1, 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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* This Report, which was adopted unanimously, replaces Reports 308-2 and 407-1.

Table I

Basic characteristics of video and synchronizing signals

Item	Characteristics		System											
			A (1)	M	N	C (1)	B, G	H	I	D, K	K1	L	E (1)	Rec. 472-1 (10)
1	Number of lines per picture (frame)		405	525	625	625	625	625	625	625	625	625	819	625
2	Field frequency, nominal value (fields/second) (3)		50	60 (59·94)	50	50	50	50	50	50	50	50	50	50
3	Line frequency f_H and tolerance when operated non-synchronously (Hz) (3)		10 125	15 750 (nominal value ±0·0003 %)	15 625 ±0·15 %	15 625 ±0·02 %	15 625 (7) ±0·02 % (±0·0001 %)	15 625 ±0·02 % (±0·0001 %)	15 625 ±0·0001 % (4)	15 625 (7) ±0·02 % (±0·0001 %)	15 625 ±0·02 % (±0·0001 %)	15 625 ±0·02 % (±0·0001 %)	20 475	15 625 ±0·02 % (±0·0001 %)
3 *(a)*	Maximum variation rate of line frequency valid for monochrome transmission (8) (9) (%/s)			0·15			0·05	0·05	0·05	0·05	0·05	0·05		
4 (2)	Nominal levels of the composite video signal (%) (see Fig. 1)	blanking level (reference level)	0	0	0	0	0	0	0	0	0	0	0	
		peak-white-level	100	100	100	100	100	100	100	100	100	100	100	
		synchronizing level	−43	−40	−40	−43	−43	−43	−43	−43	−43	−43	−43	
		difference between black and blanking level	0	7·5 ± 2·5	7·5 ± 2·5	0	0	0	0	0–7	0 (colour) 0–7 (mono.)	0 (colour) 0–7 (mono.)	0–5	$0\ {}^{+5}_{-0}$
5	Assumed gamma of display device for which pre-correction of monochrome signal is made (5)		2·8	2·2	2·2	2·8								(6)
6	Nominal video bandwidth (MHz)		3	4·2	4·2	5	5	5	5·5	6	6	6	10	5·0 or 5·5 or 6·0
7	Line synchronization		see Table I-1											
8	Field synchronization		see Table I-2											

(1) These systems are given for information only. They are not recommended for adoption by countries setting up a new television service (see Recommendation 470-1).

(2) 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

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

(4) When the reference of synchronism is being changed, this may be relaxed to 15 625 ± 0·01 %.

(5) See also Annex III.

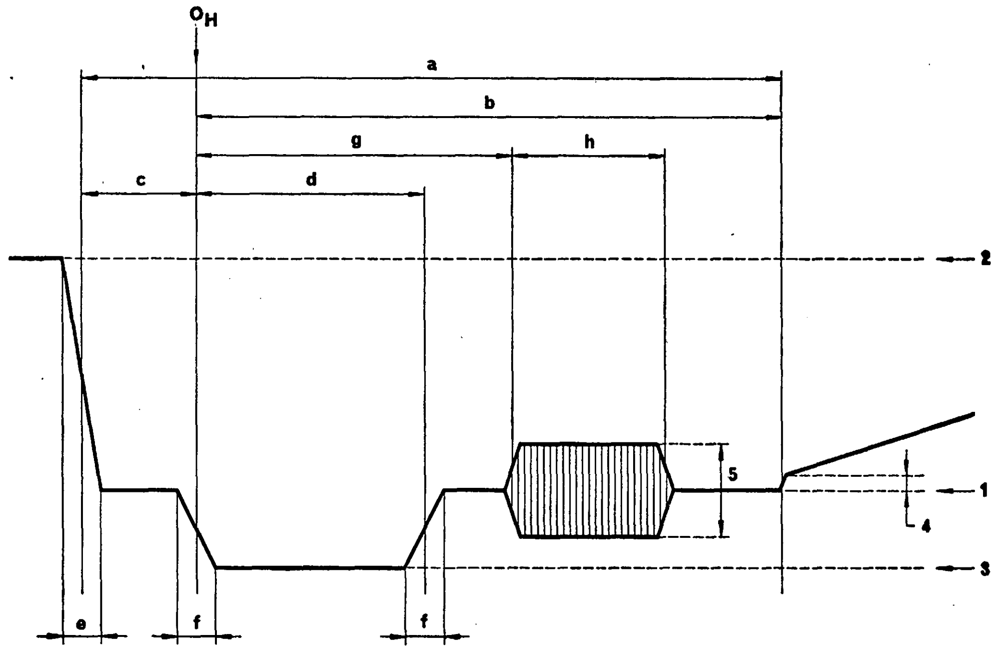
(6) In Recommendation 472-1, a gamma value for the picture signal is given as approximately 0·4.

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

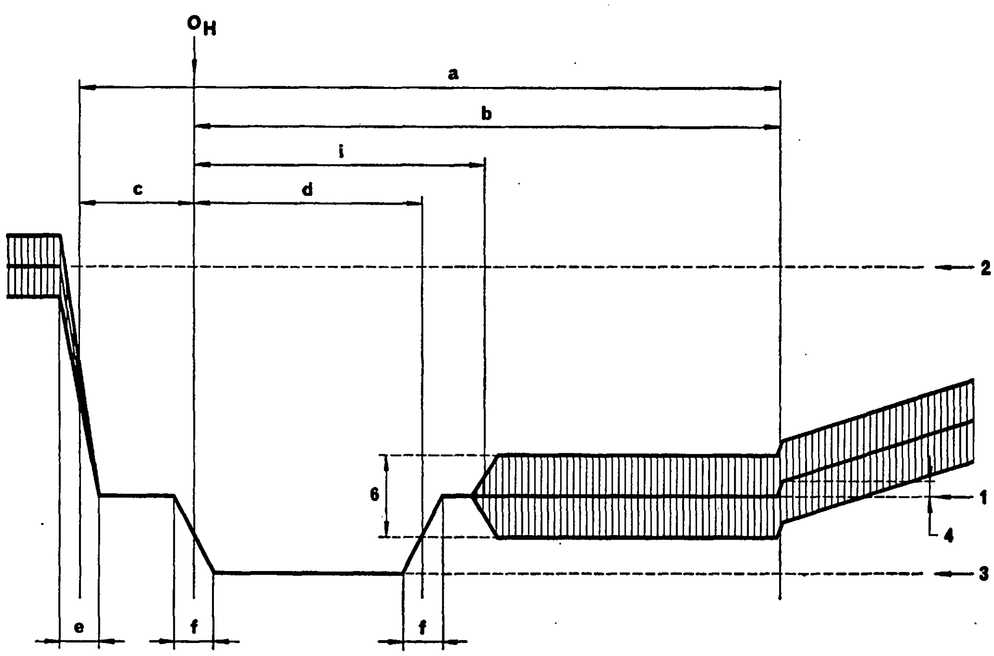
(8) These values are not valid when the reference of synchronism is being changed.

(9) Further study is required to define maximum variation rate of line frequency valid for colour transmission.

(10) Figures are given for comparison.



(a) NTSC and PAL systems



(b) SECAM system

FIGURE 1

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

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

TABLE I-1

Details of line synchronizing signals (see Fig. 1)

Durations (measured between half-amplitude points on the appropriate edges) for system

Symbol	Characteristics	A	M (1)	N	C	E	B, G, H, I, D, K, K1, L (see also Rec. 472-1)
H	Nominal line period (μs)	98·8	63·492 (63·5555)	64	64	48·84	64
a	Line-blanking interval (μs)	17·5 to 19	10·2 to 11·4 (10·5 to 11·4)	10·24 to 11·52	11·8 to 12·2	9·2 to 9·8	12 ± 0·3
b	Interval between time datum (O_H) and back edge of line-blanking signal (μs)	16 to 17	8·9 to 10·3 (9·2 to 10·3)	8·96 to 10·24	10·2 to 11	8·4 (2)	10·5 (2)
c	Front porch (μs)	1·5 to 2·0	1·27 to 2·54 (1·27 to 2·22)	1·28 to 2·56	1·2 to 1·6	1·1 ± 0·1	1·5 ± 0·3 (3)
d	Synchronizing pulse (μs)	8 to 10	4·19 to 5·71 (4·13 to 5·08)	4·22 to 5·76	4·8 to 5·2	2·4 to 2·6	4·7 ± 0·2
e	Build-up time (10 to 90%) of the edges of the line-blanking signal (μs)	0·25 to 0·5	⩽0·64 (⩽0·48)	⩽0·064	0·2 to 0·4	0·2 to 0·4	0·3 ± 0·1
f	Build-up time (10 to 90%) of the line-synchronizing pulses (μs)	⩽0·25	⩽0·25	⩽0·25	0·2 to 0·4	0·10 to 0·20	0·2 ± 0·1 (4)

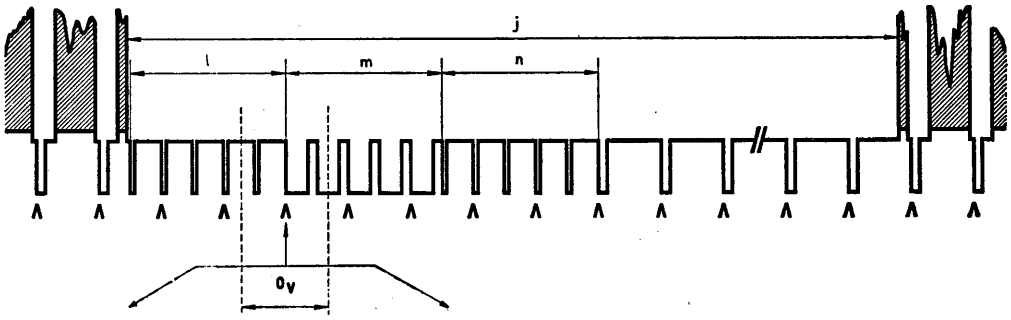
(1) Values in brackets apply to M/NTSC combination.
(2) Average calculated value, for information.
(3) For system I, the values are 1·65 ± 0·1.
(4) For system I, the values are 0·25 ± 0·05.

FIGURE 2

Details of field-synchronizing waveforms

FIGURES 2-1

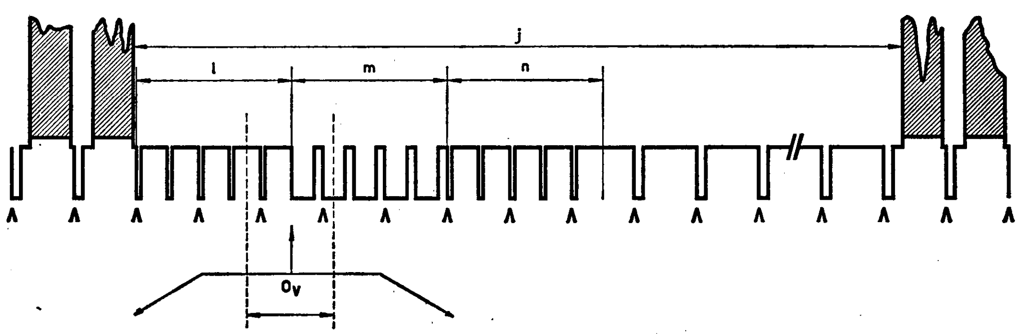
Diagrams applicable to all systems except E and M



Second field   See Fig. 2-1*c*   First field

FIGURE 2-1*a*

Signal at beginning of each first field



First field   See Fig. 2-1*c*   Second field

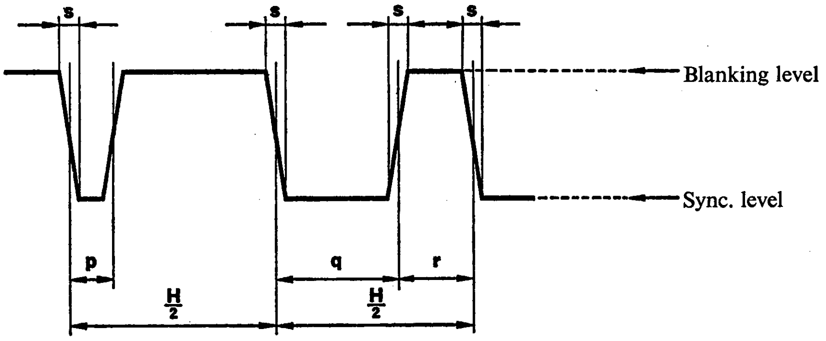
FIGURE 2-1*b*

Signal at beginning of each second field

Note 1. — ∧ ∧ ∧ 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 to the half-amplitude points on the appropriate edges)

FIGURE 2-1*c*

Details of equalizing and synchronizing pulses

FIGURE 2

Details of field-synchronizing waveforms

FIGURES 2-2

Diagrams applicable to system E

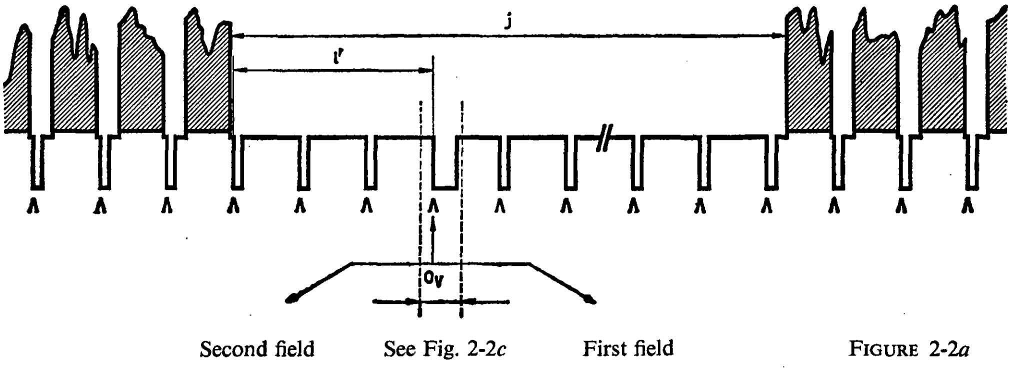


FIGURE 2-2*a*

Signal at beginning of each first field

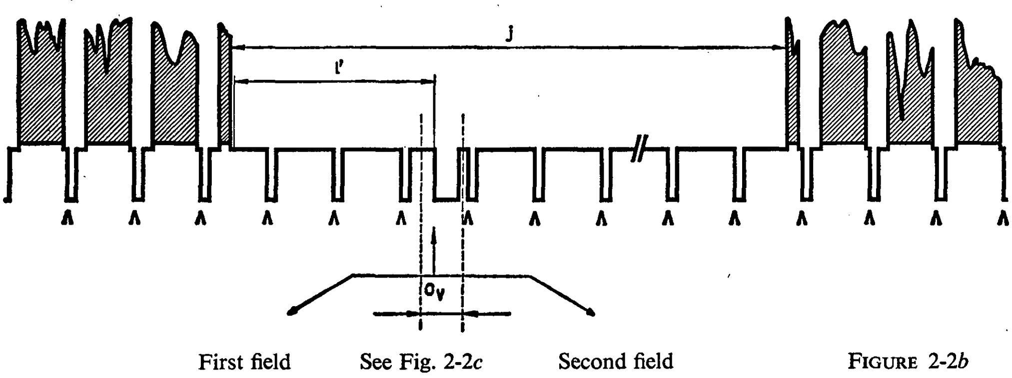


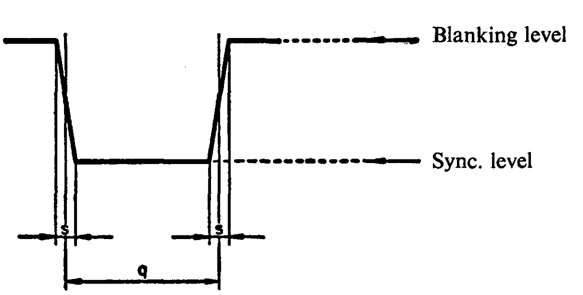
FIGURE 2-2*b*

Signal at beginning of each second field

Note 1. — ∧ ∧ ∧ 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.

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.



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

FIGURE 2-2*c*

Detail of field-synchronizing pulse

FIGURE 2

Details of field-synchronizing waveforms

FIGURES 2-3

Diagrams applicable to system M

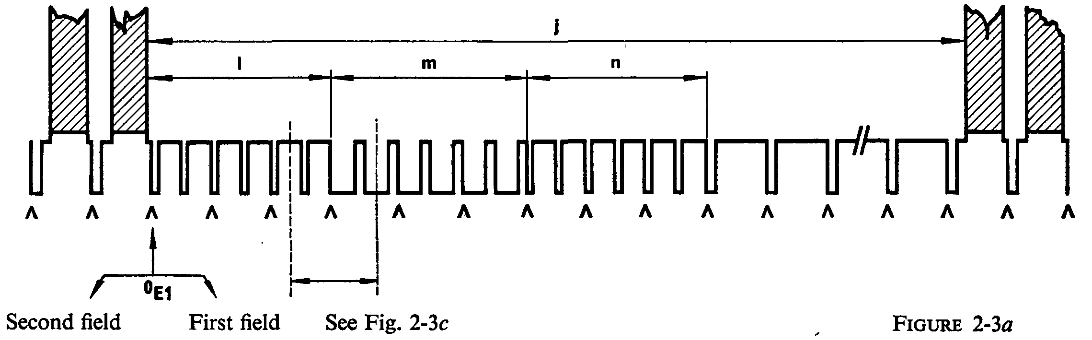


FIGURE 2-3*a*

Signal at beginning of each first field

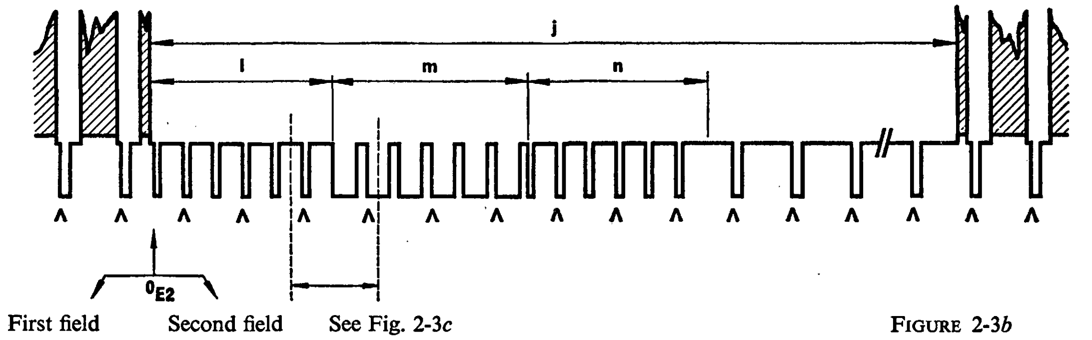


FIGURE 2-3*b*

Signal at beginning of each second field

Note 1. — ∧ 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 O_{E1} in Fig. 2-3*a*.

Note 3. — Field-two line numbers start with the second equalizing pulse in Field 2, one-half-line period after O_{E2} in Fig. 2-3*b*.

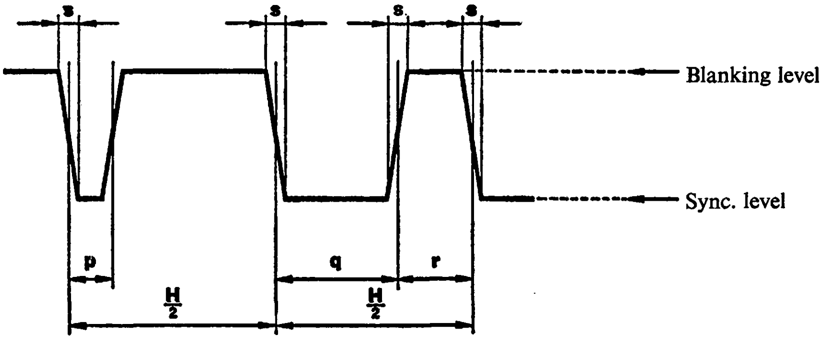


FIGURE 2-3*c*

Details of equalizing and synchronizing pulses

TABLE I-2

Details of field synchronizing signals (see Fig. 2)

Durations (measured between half-amplitude points on the appropriate edges) for system

Symbol	Characteristics	A	M	N	C	E	B, G, H, I, D, K, K1, L (see also Rec. 472-1)
v	Field period (ms)	20	16·667 (1) (16·6833)	20	20	20	20
j	Field-blanking period (for *H* and *a*, see Table I-1)	(13 to 15·5)$H + a$ (2)	(19 to 21)$H + a$	(19 to 25)$H + a$	25 $H + a$	33 $H + a$	25 $H + a$
j' (8)	Build-up time (10 to 90%) of the edges of field-blanking pulses (μs)	0·25 to 0·5	⩽6·35	⩽6·35	⩽6·4	⩽2	0·3 ± 0·1
k (8)	Interval between front edge of field-blanking interval and front edge of first equalizing pulse (μs)						3 ± 2 (3) (systems B/SECAM, G/SECAM, D, K, K1 and L only; no ref. in Rec. 472-1)
l	Duration of first sequence of equalizing pulses	(4)	3 *H*	3 *H*	2·5 *H*	(5)	2·5 *H*
m	Duration of sequence of synchronizing pulses	4 *H*	3 *H*	3 *H*	2·5 *H*		2·5 *H*
n	Duration of second sequence of equalizing pulses	(4)	3 *H*	3 *H*	2·5 *H*		2·5 *H*
p	Duration of equalizing pulse (μs)		2·29 to 2·54	2·30 to 2·56	2·3 to 2·5		2·35 ± 0·1
q	Duration of field-synchronizing pulse (μs)	38·0 to 42·0	26·4 to 28·0	26·52 to 28·16	26·8 to 27·2	19 to 21	27·3 (9) (nominal value)
r	Interval between field-synchronizing pulses (μs)	11·4 to 7·4	3·81 to 5·34	3·84 to 5·63	4·8 to 5·2		4·7 ± 0·2 (6)
s	Build-up time (10 to 90%) of synchronizing and equalizing pulses (μs)	⩽0·25	⩽0·25	⩽0·25	0·2 to 0·4	<0·2	0·2 ± 0·1 (7)

See notes page 30.

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

(2) The coefficient of H is an integral multiple of 0·5.

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

(4) In system A, there are no equalizing pulses; the field-blanking period j commences in advance of the field-synchronizing pulse sequence by an interval of from 0·015 H to 0·515 H.

(5) In system E, there are no equalizing pulses and only one field-synchronizing pulse which starts 3 H after the beginning of the field-blanking pulse (see item l' in Fig. 2-2).

(6) For system I: 4·7 ± 0·1.

(7) For system I: 0·25 ± 0·05.

(8) Not indicated in the diagram.

(9) For system I: 27·3 ± 0·1.

TABLE II

Characteristics of the video signal for colour television

Item	Characteristics	Colour television system				
		M/NTSC	M/PAL	B, G, H/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM
2.1	Assumed chromaticity coordinates (CIE 1931) for primary colours of receiver	x / y — Red 0·67 0·33; Green 0·21 0·71; Blue 0·14 0·08		x / y — Red 0·64 0·33; Green 0·29 0·60; Blue 0·15 0·06 (1)		
2.2	Chromaticity coordinates for equal primary signals $E'_R = E'_G = E'_B$	Illuminant C $x = 0·310$ $y = 0·316$ (2)		Illuminant D_{65} $x = 0·313$ $y = 0·329$ (1)		
2.3	Assumed gamma value of the receiver for which the primary signals are pre-corrected (3)	2·2	2·8			
2.4	Luminance signal	$E'_Y = 0·299\ E'_R + 0·587\ E'_G + 0·114\ E'_B$ (4) E'_R, E'_G and E'_B are gamma — pre-corrected primary signals (5)				
2.5	Chrominance signals (Colour difference)	$E'_I = -0·27(E'_B - E'_Y) + 0·74(E'_R - E'_Y)$ $E'_Q = 0·41(E'_B - E'_Y) + 0·48(E'_R - E'_Y)$	$E'_U = 0·493(E'_B - E'_Y)$ $E'_V = 0·877(E'_R - E'_Y)$			$D'_R = -1·9(E'_R - E'_Y)$ $D'_B = 1·5(E'_B - E'_Y)$
2.6	Attenuation of colour difference signals	dB MHz E'_I < 3 at 1·3; ⩾20 at 3·6 E'_Q < 2 at 0·4; < 6 at 0·5; ⩾ 6 at 0·6	dB MHz E'_U E'_V < 2 at 1·3; >20 at 3·6	dB MHz E'_U E'_V < 3 at 1·3; >20 at 4		dB MHz D'_R D'_B ⩽ 3 at 1·3; ⩾30 at 3·5 Low frequency pre-correction not taken into account (6)

See notes page 37.

TABLE II *(continued)*

Item	Characteristics	Colour television system				
		M/NTSC	M/PAL	B, G, H/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM
2.7	Low frequency pre-correction of colour difference signals					$D_R'^* = A_{BF}(f) \cdot D_R'$ $D_B'^* = A_{BF}(f) \cdot D_B'$ $A_{BF}(f) = \left\| \frac{1 + j\,(f/f_1)}{1 + j\,(f/3f_1)} \right\|$ f = signal frequency (kHz) f_1 = 85 kHz (7) (See Fig. 6)
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	$E_M = E_Y' +$ $+ E_Q' \sin(2\pi f_{sc}t + 33°) +$ $+ E_I' \cos(2\pi f_{sc}t + 33°)$ 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. 4*a*)	$E_M = E_Y' + E_U' \sin 2\pi f_{sc}t \pm E_V' \cos 2\pi f_{sc}t$ 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_V' component is the same as that of the sub-carrier burst (changing for each line) (see item 2.16 and Fig. 4*b*)			$E_M = E_Y' +$ $+ G \cos 2\pi (f_{OR} + D_R'^* \Delta f_{OR})t$ $E_M = E_Y' +$ $+ G \cos 2\pi (f_{OB} + D_B'^* \Delta f_{OB})t$ 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 page 37.

Table II *(continued)*

Item	Characteristics	Colour television system				
		M/NTSC	M/PAL	B, G, H/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM
2.11	Chrominance sub-carrier frequency *(a)* nominal value and tolerance (Hz)	3 579 545 ± 10	3 575 611·49 ± 10	4 433 618·75 ± 5	4 433 618·75 ± 1 [8] [17]	f_{OR} = 4 406 250 ± 2000 f_{OB} = 4 250 000 ± 2000 [9]
	(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} [10]
2.12	Bandwidth of chrominance sidebands (quadrature modulation of sub-carrier) (kHz) or Frequency deviation of chrominance sub-carrier (frequency modulation of sub-carrier) (kHz)	$f_{sc}\ {}^{+620}_{-1300}$	$f_{sc}\ {}^{+600}_{-1300}$	$f_{sc}\ {}^{+570}_{-1300}$	$f_{sc}\ {}^{+1070}_{-1300}$	Nominal deviation $D'^* = 1$ [12] / Maximum deviation Δf_{OR} [11]: 280 ± 9 (± 14) / +350 ± 18 (±35), −506 ± 25 (±50) Δf_{OB} [11]: 230 ± 7 (±11·5) / +506 ± 25 (±50), −350 ± 18 (±35)

See notes page 37.

TABLE II *(continued)*

Item	Characteristics	Colour television system				
		M/NTSC	M/PAL	B, G, H/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM
2.13	Amplitude of chrominance sub-carrier	$G = \sqrt{E_I'^2 + E_Q'^2}$	$G = \sqrt{E_U'^2 + E_V'^2}$			$G = M_0 \left\| \frac{1 + j\,16F}{1 + j\,1{\cdot}26F} \right\|$ where the peak-to-peak amplitude, $2M_0$, is $23 \pm 2{\cdot}5\%$ 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 $\pm$ 20 kHz. (See Fig. 7)
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. 1*a*) (µs)	4·71 to 5·71 at least 0·38 µs after the trailing edge of line synchronization signal	6·8 ± 0·1 after epoch O_H	5·6 ± 0·1 after epoch O_H [18]		
	(h) Duration of sub-carrier burst (see Fig. 1*a*) (µs)	2·23 to 3·11 minimum 8 cycles	2·52 ± 0·28 (9 ± 1 cycles)	2·25 ± 0·23 (10 ± 1 cycles)		

See notes page 37.

TABLE II *(continued)*

<table>
<tr><th rowspan="2">Item</th><th rowspan="2">Characteristics</th><th colspan="5">Colour television system</th></tr>
<tr><th>M/NTSC</th><th>M/PAL</th><th>B, G, H/PAL</th><th>I/PAL</th><th>B, D, G, H, K, K1, L/SECAM</th></tr>
<tr><td>2.15</td><td>Peak-to-peak value of chrominance sub-carrier burst (see Fig. 1*a*) (19)</td><td>4/10 of difference between blanking level and peak white-level ± 10%</td><td colspan="3">3/7 of difference between blanking level and peak white-level ± 10%
For system I, the tolerance is ± 3%</td><td></td></tr>
<tr><td>2.16</td><td>Phase of chrominance sub-carrier burst (see Fig. 1*a*)</td><td>180° relative to $(E'_B - E'_Y)$ axis (see Fig. 4*a*)</td><td colspan="3">135° relative to E'_U axis with the following sign (see Figs. 4*b* and 5*a*)
<table>
<tr><th rowspan="2">Line</th><th colspan="4">Field</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><td>even</td><td>+</td><td>+</td><td>—</td><td>—</td></tr>
<tr><td>odd</td><td>—</td><td>—</td><td>+</td><td>+</td></tr>
</table></td><td></td></tr>
<tr><td>2.17</td><td>Blanking of chrominance sub-carrier</td><td>Following each equalizing pulse and also during the broad synchronizing pulses in the field-blanking interval</td><td>11 lines of field-blanking interval:
260 to 270
522 to 7
259 to 269
523 to 8
(See Fig. 5*b*)</td><td colspan="2">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. 5*a*)</td><td>*(a)* from leading edge of line-blanking signal up to $i = 5{\cdot}6 \pm 0{\cdot}2$ (μs) after epoch O_H $(c + i)$ (See Fig. 1*b* (13))
(b) during field-blanking interval, excluding colour synchronization signals (See item 2.18)</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
</table>

See notes page 37.

TABLE II *(continued)*

Item	Characteristics	Colour television system				
		M/NTSC	M/PAL	B, G, H/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM
2.18	Synchronization of chrominance sub-carrier switching during line blanking	Does not apply to NTSC systems	By E'_V chrominance component of sub-carrier burst (See item 2.16)			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) (14) (15) (16) *Shape of identification signals:* For lines D'_R—Trapezoid with linear variation from beginning of line 15 ± 5 μs from 0 up to level +1·25 and then constant at the level +1·25 ±0·06 (±0·13) (See Fig. 8) For lines D'_B—Trapezoid with linear variation from the beginning of the line on 18 ± 6 μs (20 ± 10μs) from 0 down to level −1·52 and then constant at the level −1·52 ± 0·07 (±0·15) (see Fig. 8) (11) *Peak-to-peak amplitude of identification signals:* For lines D'_B: 500 ± 50 mV For lines D'_R: 540 $^{+40\ mV}_{-50\ mV}$

See notes page 37.

TABLE II *(continued)*

Item	Characteristics	Colour television system				
		M/NTSC	M/PAL	B, G, H/PAL	I/PAL	B, D, G, H, K, K1, L/SECAM
						if amplitude of luminance signal (between blanking level and peak white) equals 700 mV *Maximum deviation during transmission of identification signals (kHz):* For lines D'_R: + 350 ± 18 (± 35) For lines D'_B: − 350 ± 18 (± 35) (11)

(1) 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)

(2) In Japan, the chromaticity of studio monitors is adjusted to a D-white at 9300 K.

(3) The primary signals are pre-corrected so that the optimum quality is obtained with a display having the indicated value of gamma (See Annex III).

(4) In certain countries using the SECAM systems 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.

(5) 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.

(6) This value will be defined more precisely later.

(7) 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.

(8) The tolerance may be ±5 Hz for a signal originating overseas.
Maximum rate of variation of f_{sc}: 0·1 Hz/s.

(9) A reduction of the tolerance is desirable.

(10) 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.

(11) Provisionally, the tolerances may be extended up to the values given in brackets.

(12) The unity value represents the amplitude of the luminance signal between the blanking level and the peak white-level.

(13) The value of the tolerance will be defined more precisely later.

(14) Research is in progress with a view to using the chrominance signal on the line-blanking back-porch (line identification) as the colour synchronization signal both in specialized equipment and in receivers available to the public.

(15) 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 469-1.

(16) Certain countries, members of the O.I.R.T., use a switching order of the chrominance sub-carrier, such that the first field is identical with the third field shown in Fig. 9.

(17) This tolerance may not be maintained during such operational procedures as "gen-lock".

(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.

Table III

Characteristics of the radiated signals (monochrome and colour)

Item	Characteristics		A (10)	M	N	C (10)	B,G	H	I	D,K	K1	L	E (10)
1	Frequency spacing (see Fig. 10)	Nominal radio-frequency channel bandwidth (MHz)		6	6	7	B: 7 G: 8	8	8	8	8	8	14
2		Sound carrier relative to vision carrier (MHz)	−3·5	+4·5	+4·5	+5·5	+5·5 ±0·001	+5·5	+5·9996 ±0·0005	+6·5 ±0·001	+6·5	+6·5	+11·15 (13)
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	−1·25	−1·25	±2·83 (13)
4		Nominal width of main sideband (MHz)	3	4·2	4·2	5	5	5	5·5	6	6	6	10
5		Nominal width of vestigial sideband (MHz)	0·75	0·75	0·75	0·75	0·75	1·25	1·25	0·75	1·25	1·25	2
6	Minimum attenuation of vestigial side-band (dB at MHz) (1)		not specified	20 (−1·25) 42 (−3·58)	20 (−1·25) 42 (−3·5)	20 (−1·25) 20 (−3·0)	20 (−1·25) 20 (−3·0) 30 (−4·43) (2)	20 (−1·75) 20 (−3·0)	20 (−3·0) 30 (−4·43)	20 (−1·25) 30(−4·33 ±0·1) (3)	30 dB at −4·3 MHz 20 dB at −2·7 MHz ref.: 0 dB at +0·8 MHz	30 dB at −4·3 MHz 15 dB at −2·7 MHz ref.: 0 dB at +0·8 MHz	15 dB at 2·7 MHz ref.: 0 dB at +0·8 MHz
7	Type and polarity of vision modulations		A5C pos.	A5C neg.	A5C neg.	A5C pos.	A5C neg.	A5C neg.	A5C neg.	A5C neg.	A5C neg.	A5C pos.	A5C pos.
8	Levels in the radiated signal (% of peak carrier)	Synchronizing level	<3	100	100	<3	100	100	100	100	100	<6	<3
		Blanking level	30	72·5 to 77·5	72·5 to 77·5	22·5 to 27·5	75 ± 2·5	72·5 to 77·5	76 ± 2	75 ± 2·5	75 ± 2·5	30 ± 2	30 ± 2
		Difference between black level and blanking level	0 (nominal)	2·88 to 6·75	2·88 to 6·75	0 (nominal)	0 to 2 (nominal)	0 to 7	0 (nominal)	0 to 4·5	0 to 4·5	0 to 4·5	0 to 4·5
		Peak white-level	100	10 to 15	10 to 15	100	10 to 12·5	10 to 12·5	20 ± 2	12·5 (4)	10 to 12·5	100 (≈ 110) (5)	100

See notes page 39.

Table III *(continued)*

Item	Characteristics	A (10)	M	N	C (10)	B,G	H	I	D,K	K1	L	E (10)
9	Type of sound modulation	A 3	F 3	F 3	A 3	F 3	F 3	F 3	F 3	F 3	A 3	A 3
10	Frequency deviation (kHz)		±25	±25		±50	±50	±50	±50	±50		
11	Pre-emphasis for modulation (μs)		75	75	50	50	50	50	50	50		
12	Ratio of effective radiated powers of vision and sound (11)	4/1	10/1 to 5/1 (4/1) (6)	10/1 to 5/1	4/1	10/1 (7) (12)	5/1 to 10/1	5/1	10/1 to 5/1	10/1	10/1	10/1
13	Pre-correction for receiver group-delay characteristics at medium video frequencies (ns) (see also Fig. 3)	not specified	0			(9)			(8)			
14	Pre-correction for receiver group-delay characteristics at colour subcarrier frequency (ns) (see Fig. 3)	not specified	−170 (nominal)			−170 (nominal) (9)			(8)			

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

(2) For B/SECAM and G/SECAM: 30 dB at −4·33 MHz, within the limits of ±0·1 MHz.

(3) In some countries, members of the O.I.R.T., additional specifications are in use:

(a) not less than 40 dB at −4·286 MHz ± 0·5 MHz,

(b) 0 dB from −0·75 MHz to +6·0 MHz,

(c) not less than 20 dB at +6·375 MHz and higher;

Reference: 0 dB at +1·5 MHz.

(4) As the Socialist Republic of Roumania has not yet decided upon a system of colour television, the values of 10 to 12·5 for D and K monochrome television systems remain valid for this country.

(5) 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.

(6) The ratio in brackets is used in Japan.

(7) The Federal Republic of Germany proposes a ratio of 20/1 (Doc. 11/276, 1970-1974), and is prepared to begin experimental broadcasts with this power ratio. Other countries are invited to carry out similar tests.

(8) Not yet determined.

(9) In the Netherlands, the specifications of the pre-correction at the transmitter for receiver group-delay characteristics is as follows: A sine wave introduced at those terminals of the transmitter which are normally fed by the encoded (colour) video signal shall produce a radiated signal having an envelope delay, relative to the average delay between 0·05 MHz and 0·2 MHz as indicated in Fig. 3*a*, curve A. In the Federal Republic of Germany, the correction is made according to curve B in the same figure. Tolerances are shown in the table under Fig. 3*a*. From Doc. XI/170, 1966-1969, it is learned that Spain uses curve A. The O.I.R.T. countries using the B/SECAM and G/SECAM systems use a nominal pre-correction of 90 ns at medium video frequencies.

(10) These systems are given for information only. They are not recommended for adoption by countries setting up a new television service (see Recommendation 470-1).

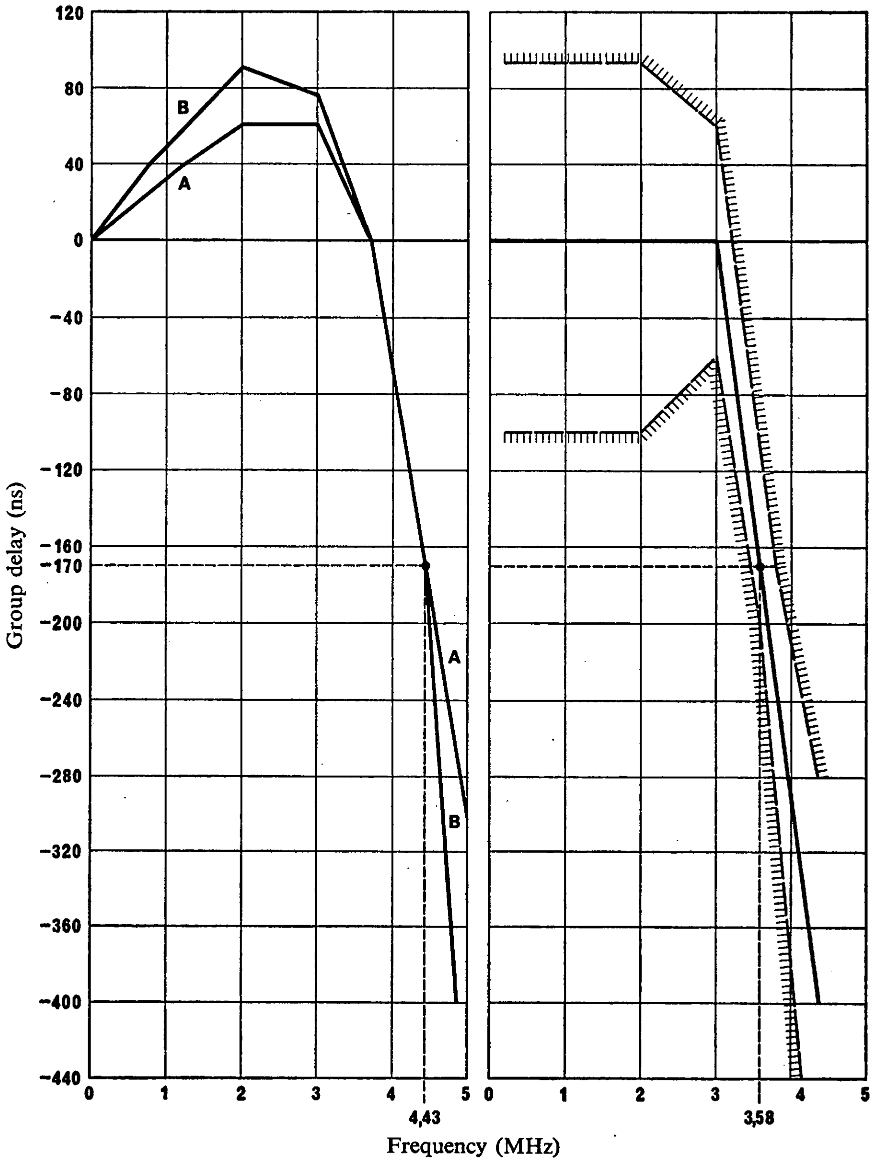
(11) The values to be considered are:

— 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 (5) above);

— the r.m.s. value of the unmodulated carrier for amplitude-modulated and frequency-modulated sound transmissions.

(12) It may be that the Austrian Administration will continue to use a 5/1 power ratio in certain cases, when necessary.

(13) This system is used both normally and reversed on the frequency scale in a tête-bêche arrangement.



(a) B/PAL and G/PAL systems (See Table III (9))

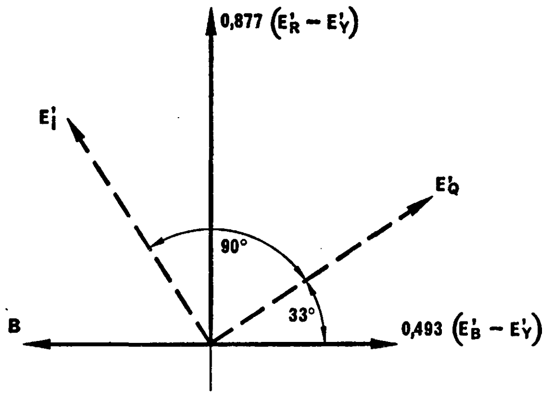
(b) M/PAL and M/NTSC systems

FIGURE 3

Curve of pre-correction for receiver group-delay characteristics

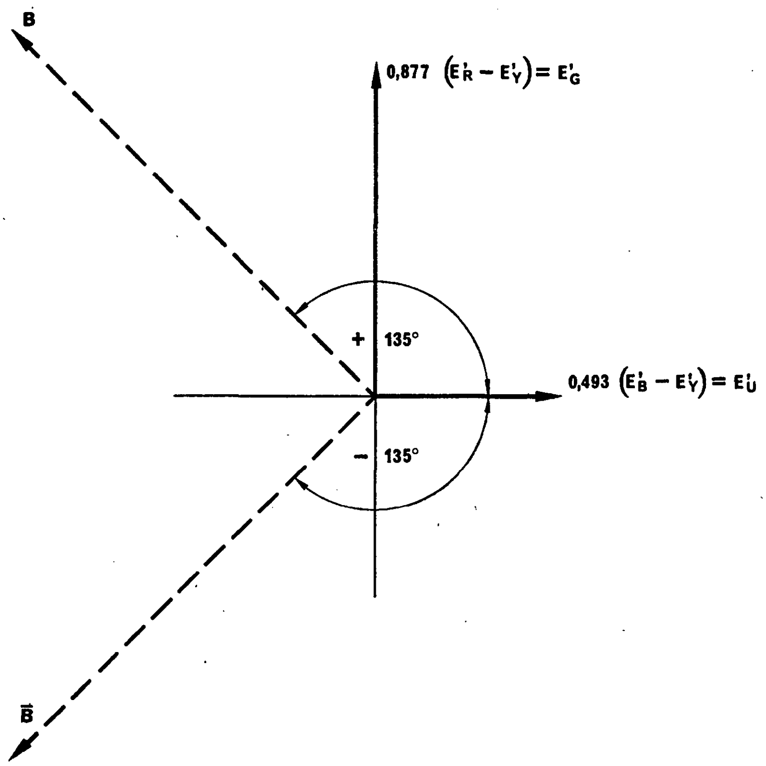
Nominal values and tolerances (ns)

Frequency (MHz)	Curve A	Curve B
0·25		+ 5 ± 0
1·00	+ 30 ± 50	+ 53 ± 40
2·00	+ 60 ± 50	+ 90 ± 40
3·00	+ 60 ± 50	+ 75 ± 40
3·75	0 ± 50	0 ± 40
4·43	−170 ± 35	−170 ± 40
4·80	−260 ± 75	−400 ± 90



B: phase of the burst

(a) NTSC system



B: phase of the burst in odd lines of the first and second fields and in even lines of the third and fourth fields

B̄: phase of the burst in even lines of the first and second fields and in odd lines of the third and fourth fields

(b) PAL system

FIGURE 4

Chrominance axes and phase of the burst

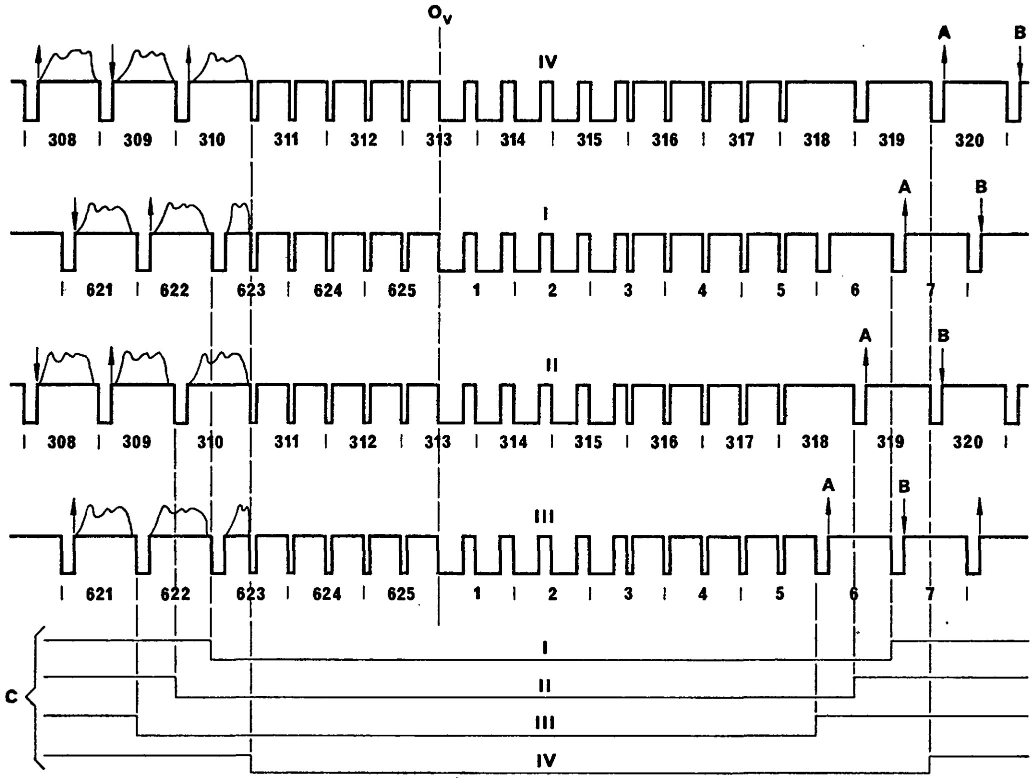


FIGURE 5*a*

Burst-blanking sequence in the B, G, H and I/PAL systems

O_V: field-synchronizing datum.
I, II, III, IV: first, second, third and fourth fields.
A: phase of burst; nominal value +135°.
B: phase of burst; nominal value −135°.
C: burst-blanking intervals.

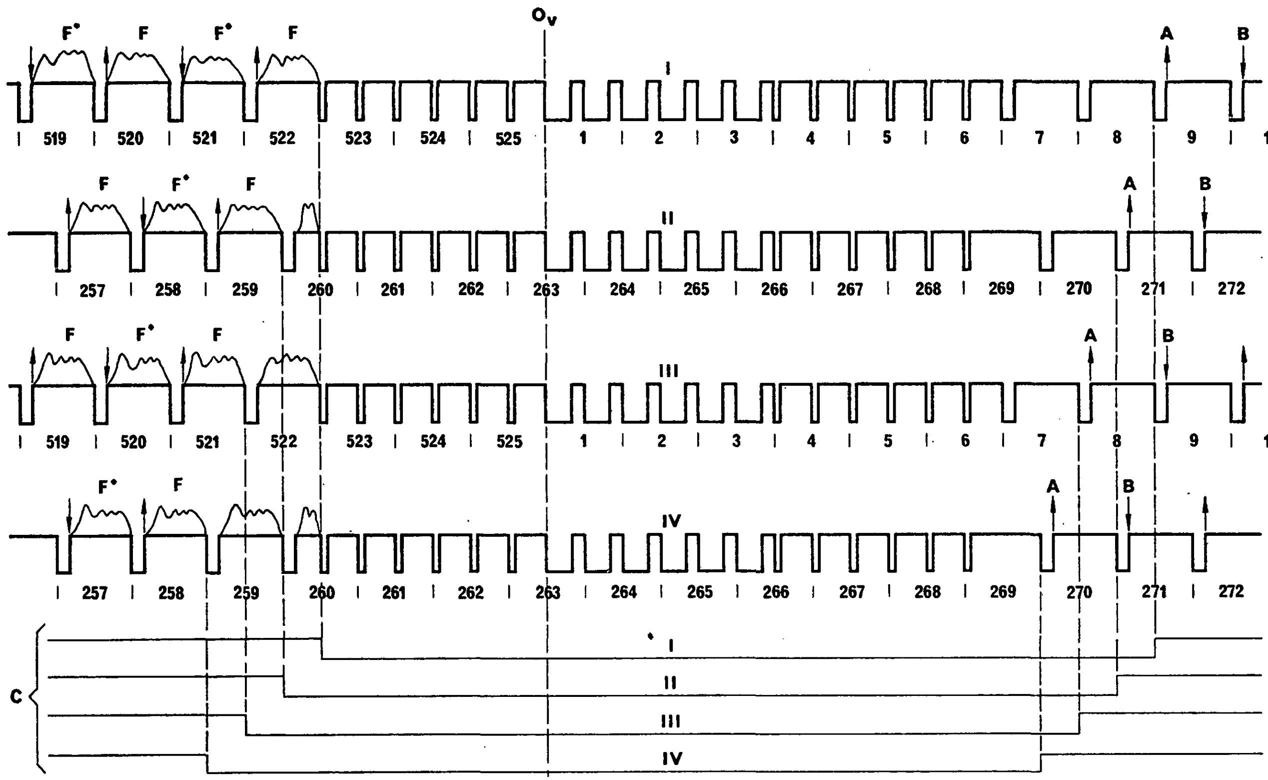


FIGURE 5b

Burst-blanking sequence in M/PAL system

O_V: field-synchronizing datum.
I, II, III, IV: first, second, third and fourth fields.
A: phase of burst; nominal value +135°.
B: phase of burst; nominal value −135°.
C: burst-blanking intervals.

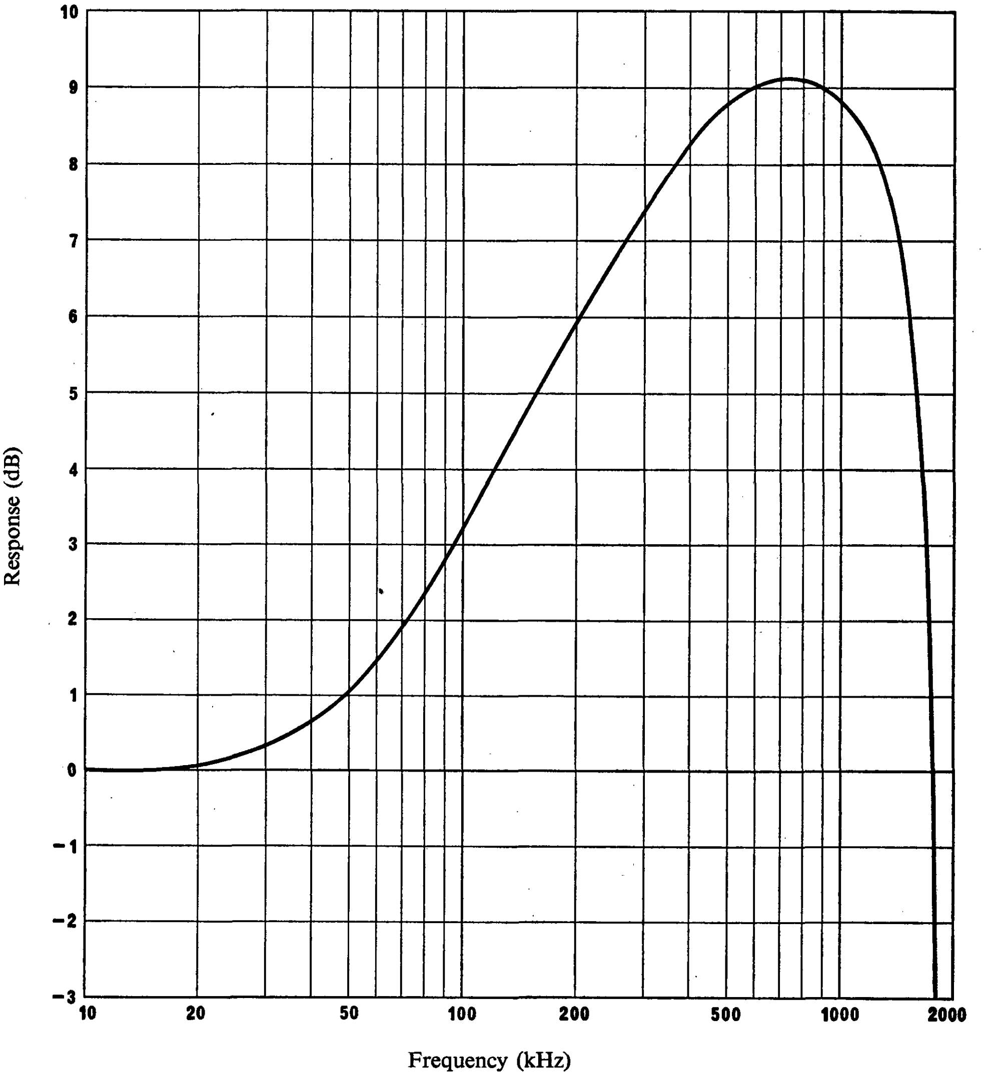


FIGURE 6

Nominal response of transfer function resulting from the video-frequency precorrection circuit $A_{BF}(f)$ and the low-pass filter (See Table II, item 2.7)

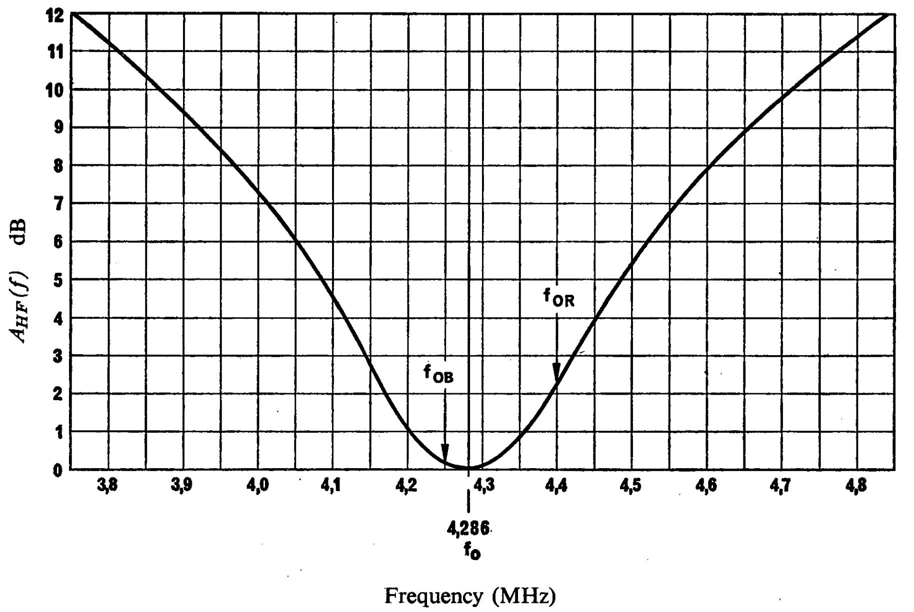


FIGURE 7

Attenuation curve of frequency correction $A_{HF}(f)$

Deviations from the nominal curve outside point f_0 must not exceed $\pm 0{\cdot}5$ dB

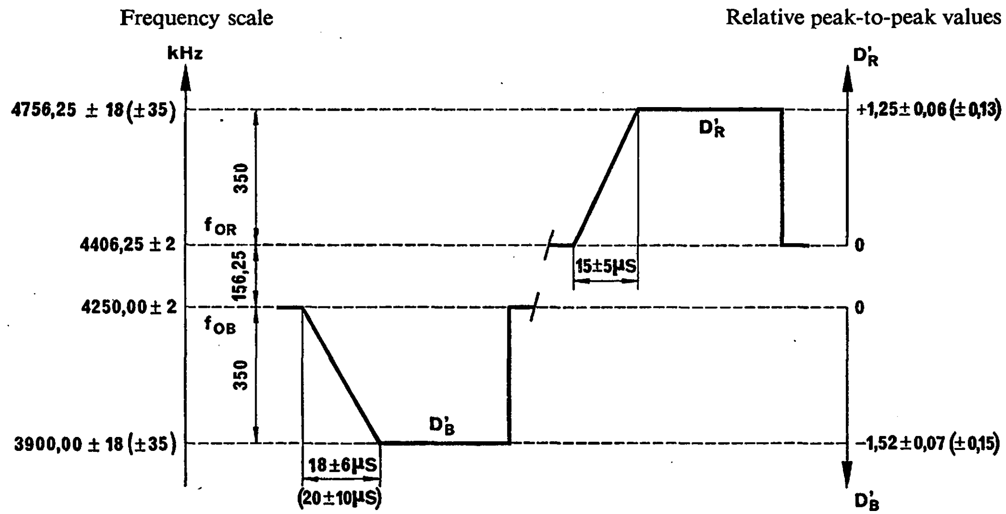


FIGURE 8

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.

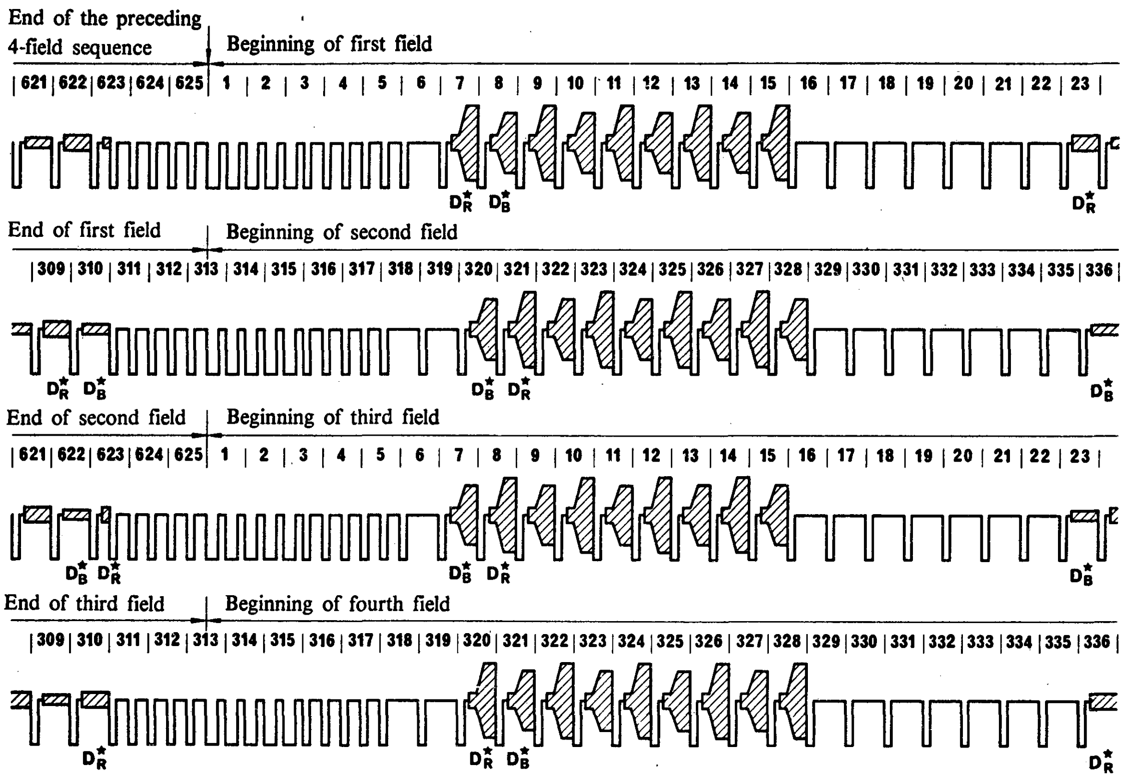


FIGURE 9

Sequence of D_R or D_B* signal over four consecutive fields*

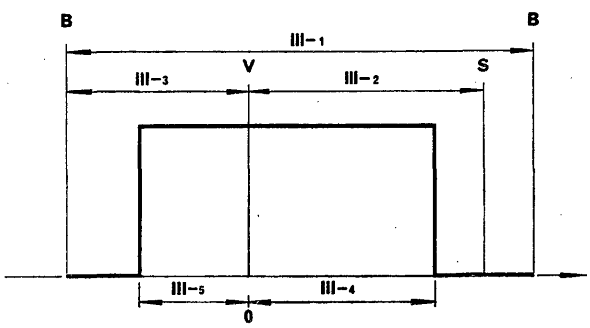


FIGURE 10

Significance of items 1 to 5 in Table III

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

ANNEX I

SYSTEMS USED IN VARIOUS COUNTRIES

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.)

Country	System used in bands:			
	I/III		IV/V	
Algeria (Algerian Democratic and Popular Republic)	B, E	(13) (16)	G*, H*	(13) (16)
Germany (Federal Republic of)	B/PAL		G/PAL	
Netherlands Antilles	M			—
Saudi Arabia (Kingdom of)	B			—
Argentine Republic	N		N	
Australia	B/PAL			—
Austria	B/PAL		G/PAL	(1)
Belgium	C, B	(17)	H	
Brazil (Federative Republic of)	M/PAL		M/PAL	
Bulgaria (People's Republic of)	D/SECAM		K/SECAM	
Burundi (Republic of)	K1*	(16)	K1*	(16)
Cameroon (United Republic of)	K1*	(15) (16)	K1*	(15) (16)
Canada	M/NTSC		M/NTSC	
Central African Republic	K1*	(16)	K1*	(16)
Cyprus (Republic of)	B		H*	(2) (18)
Colombia (Republic of)	M		M*	
Congo (People's Republic of the)	K1*	(16)	K1*	(16)
Korea (Republic of)	M			—
Ivory Coast (Republic of the)	K1*	(16)	K1*	(16)
Cuba	M		M	
Dahomey (Republic of)	K1*	(16)	K1*	(16)
Denmark	B/PAL		G*	
Egypt (Arab Republic of)	B	(16)	G*, H*	(14) (16)
Group of Territories represented by the French Overseas Post and Telecommunication Agency	K1			—
Spain	B		G*	(2)
United States of America	M/NTSC		M/NTSC	
Ethiopia	B*	(16)	G*	(16)
Finland	B/PAL		G/PAL	
France	E		L/SECAM	
Gabon Republic	K1*	(16)	K1*	(16)
Ghana	B*, G*	(16)	G*	(16)
Greece	B*		G*	(3)
Guinea (Republic of)	K1*	(15) (16)	K1*	(15) (16)
Upper Volta (Republic of)	K1*	(16)	K1*	(16)
Hungarian People's Republic	D/SECAM		K/SECAM	
India (Republic of)	B			—
Indonesia (Republic of)	B*			—
Iran	B		G	
Ireland	A, I/PAL	(4)	I*	
Iceland		—	G*	(2) (5)
Israel (State of)	B		G	(6)
Italy	B		G	
Jamaica	N			—
Japan	M/NTSC		M/NTSC	
Jordan (Hashemite Kingdom of)	B		G*	
Kenya (Republic of)	B*	(16)	G*, I*	(16)
Kuwait (State of)	B		G*	(19)
Liberia (Republic of)	B*	(8) (16)	H*	(8) (16)
Libyan Arab Republic	B*	(16)	G*	(16)
Luxembourg	C		L*	(2)
Malaysia	B		G*	

Country	System used in bands:			
	I/III		IV/V	
Malawi	B*	(10) (16)	G*	(10) (16)
Malagasy Republic	K1*	(16)	K1*	(16)
Mali (Republic of)	K1*	(16)	K1*	(16)
Morocco (Kingdom of)	B		H*	
Mauritius	B		—	
Mauritania (Islamic Republic of)	K1*	(16)	K1*	(16)
Mexico	M		—	
Monaco	E		L*	
Niger (Republic of the)	K1*	(16)	K1*	(16)
Nigeria (Federal Republic of)	B	(16)	I*	(16)
Norway	B/PAL		G*	(3)
New Zealand	B/PAL		—	
Uganda (Republic of)	B	(9) (16)	G*	(9) (16)
Pakistan	B		—	
Panama (Republic of)	M		—	
Netherlands (Kingdom of the)	B/PAL		G/PAL	(21)
Peru	M		M	
Poland (People's Republic of)	D/SECAM		K/SECAM	
Portugal	B		G	
Portuguese Oversea Provinces	I*	(16)	I*	(16)
German Democratic Republic	B/SECAM		G/SECAM	
Rhodesia	B	(10)	G*	(10)
Roumania (Socialist Republic of)	D		K*	(2)
United Kingdom of Great Britain and Northern Ireland	A		I/PAL	
Rwanda (Republic of)	K1*	(16)	K1*	(16)
Senegal (Republic of the)	K1*	(16)	K1*	(16)
Sierra Leone	B	(11) (16)	G*	(16)
Singapore (Republic of)	B		G*	(20)
Somali Democratic Republic	B*	(16)	G*	(16)
Sri Lanka (Ceylon) (Republic of)	B		—	
South Africa (Republic of)	I*	(16)	I*	(16)
Sweden	B/PAL		G/PAL	
Switzerland (Confederation of)	B/PAL		G/PAL	(7)
Surinam	M		—	
Tanzania (United Republic of)	B*, I*	(12) (16)	I*	(12) (16)
Chad (Republic of the)	K1*	(16)	K1*	(16)
Czechoslovak Socialist Republic	D/SECAM		K/SECAM	
Spanish Saharian Territory	B*	(16)	G*	(16)
Oversea Territories for the international relations of which the Government of the United Kingdom of Great Britain and Northern Ireland are responsible	B*, I*	(16)	I*	(16)
Oversea Territories of the United Kingdom in the European Broadcasting Area	—		H*	(2)
Togolese Republic	K1*	(16)	K1*	(16)
Turkey	B		G*	
Union of Soviet Socialist Republics	D/SECAM		K/SECAM	
Uruguay (Oriental Republic of)	N		—	
Venezuela (Republic of)	M		—	
Yugoslavia (Socialist Federal Republic of)	B/PAL		G/PAL	
Zaire (Republic of)	K1*	(15) (16)	K1*	(15) (16)
Zambia (Republic of)	B*	(10) (16)	G*	(10) (16)

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. — The Indications and Notes are based on indications and notes given in Chapter 2 of the "Technical data used by the European VHF/UHF Broadcasting Conference".

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. In addition, during a transition period, transmissions on system A will be made from the Dublin and Sligo stations.

Note 5. — This country does not at present intend to use Bands IV and V, but accepts the parameters given in the table under "Standard G" as television standard in Bands IV and V.

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. — Liberia accepted for planning purposes Standard B or H but reserves the right to adopt Standard M.

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. — Indications for Malawi, Rhodesia and Zambia are based on indications for Rhodesia and Nyasaland (Federation of) given in the Final Acts of the African VHF/UHF Broadcasting Conference, Geneva, 1963. Standard B is now in use in band I; no final decision is taken regarding systems to be used in bands III, IV and V.

Note 11. — Sierra Leone now uses Standard B but reserves the right to use any other standard compatible with the Plan.

Note 12. — Tanzania, the indications are based on indications for Tanganyika and Zanzibar given in the Final Acts of the African VHF/UHF Broadcasting Conference, Geneva, 1963. It is intended to use Standard B in bands I and III. Although Standard I is planned for bands IV and V, further consideration will be given to the use of Standards G and H.

Note 13.— Algeria reserves the right to change later.

Note 14. — The Arab Republic of Egypt is now studying the adoption of either Standard G or H for bands IV and V.

Note 15. — In Cameroon, Zaire and Guinea, 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 10 to 17 are based on indications and notes given in the Final Acts of the VHF/UHF African Broadcasting Conference, Geneva, 1963.

Note 17. — Belgium will use Standard C in bands I and III until November, 1976, after which Standard B will be used.

Note 18. — Cyprus is already committed to the use of Standard B in band III. Standard H is envisaged for use in bands IV and V, although further consideration will be given to the possible use of other standards when stations operating in bands IV and V are to be commissioned.

Note 19. — 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 20. — 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 21. — Some existing transmitters operate with a residual sideband up to 1·25 MHz. For the future, only transmitters with a residual sideband of 0·75 MHz are foreseen.

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:

$$E'_Y = 0{\cdot}30\ E'_R + 0{\cdot}59\ E'_G + 0{\cdot}11\ E'_B$$

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

$$D'_R = \frac{1}{1{\cdot}14}(E'_R - E'_Y)$$

$$D'_B = \frac{1}{2{\cdot}03}(E'_B - E'_Y)$$

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

$$Es_1 = \sqrt{D_R'^2 + D_B'^2} + E_p \cos [\omega_0 t + \varphi (t)]$$

Signal transmitted during the following line

$$Es_2 = \sqrt{D_R'^2 + D_B'^2} + E_p \cos (\omega_0 t + \varphi_0)$$

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

$$\sqrt{D_R'^2 + D_B'^2}$$

and where

$$\varphi (t) = \text{arc tan} (D_B'/D_R')$$

3. **Frequency of the colour sub-carrier**

The frequency of the colour sub-carrier is equal to: $f_0 = 4{\cdot}43361875$ MHz. It is related to the line sweep frequency $f_{line} = 15\,625$ Hz by the following equation:

$$f_0 = (284—1/4) f_{line} + 25 \text{ Hz.}$$

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 μs. 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 $\varphi = 90°$, and during all the odd lines $\varphi = 180°$. 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-Y}' and E_{R-Y}' at each line, a switch working to the line periodicity is used.

ANNEX III

DEFINITION OF GAMMA AND GAMMA PRE-CORRECTION

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.

Pre-correction is intended to compensate for the non-linearities of the transfer characteristics of picture tubes in a luminance range corresponding to a contrast of at least 1/40. It is assumed that the transfer characteristic of the picture tube follows a power law, the exact exponent of which is still under study.

(See Docs. 11/78, Netherlands and 11/81, Germany (Federal Republic of), 1970–1974.)

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SECTION 11B: INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES

RECOMMENDATIONS AND REPORTS

Recommendations

RECOMMENDATION 472-1

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

(1970 – 1974)

The C.C.I.R.

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 ± 0·02%
	— colour transmissions:	15 625 ± 0·0001%
2.3	Field frequency f_v (Hz):	(2/625) f_H
2.4	Picture-frame frequency f_p (Hz):	$f_H/625$
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^{+5}_{-0}

3. Details of line-blanking interval (3) (μs)

(H)	Nominal duration of a line:	$H = 64$
(a)	Line-blanking interval:	12 ± 0·3
(b)	Interval between datum (O_H) and back edge of line-blanking signal (average calculated value for information):	10·5
(c)	Front porch:	1·5 ± 0·3
(d)	Synchronizing pulse:	4·7 ± 0·2

		(μs)
(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

4. Details of the field-blanking interval

(j)	Field-blanking period:	25*H* + *a* (4)
(k)	Build-up time (10-90%) of field-blanking edges as in *(e)*:	0·3 ± 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 ± 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 ± 0·2
(s)	Build-up time (10-90%) of field-synchronizing pulses as in *(f)*:	0·2 ± 0·1

(1) When the reference of synchronism is being changed, the tolerance for colour transmissions may be increased to ± 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 Recommendations 421-3, § 2.3 and 451-2, § 3.3.

(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 Doc. XI/115 (United Kingdom) 1963–1966 and Report 626).

REPORT 311-3 *

THE PRESENT POSITION OF STANDARDS CONVERSION

(Question 2-2/11)

(1963 – 1966 – 1970 – 1974)

1. Review of image-transfer standards conversion between television signals having equal or nearly equal field frequencies

Ever since the inception of international television relays, recourse has been made to standards conversion when exchanging live monochrome television programmes. The earliest converters consisted of little more than a camera, working in accordance with the desired standards directed at a picture-monitor displaying a picture on the available standards, but over the years such "image-transfer" converters have been the subject of considerable development, although their inherent shortcomings still exist. A review of existing practice may be found in [Lord and Rout, 1962; Radio and Elect. Engr., 1971].

There are two essential features of all standards converters. In the first place, components at the line frequency of the incoming signal must be eliminated from the outgoing signal; otherwise beat patterns may result on the converted picture. At the same time, essential picture detail must be retained. The problem is like passing the signal through a filter having a suitable "vertical" frequency response. In practical converters the response of this filter must be a compromise between visibility of spurious patterns and loss of detail in a vertical sense. The converter must store the incoming information until the reading device is ready to use the information. When the conversion involves a difference in the number of lines only, the required storage time is of the same order as the scanning line duration. In interlaced systems, wherein the conversion is field by field, it must be understood that necessarily the vertical definition of the converted picture is reduced to nearly half. This is because all systems of standards conversion, where the persistence of the displayed image is short compared with the field time, must rely on interpolation between successive lines. In the light of these fundamental concepts, it is useful to examine the behaviour of existing converters.

Image-transfer converters, employing a display tube and a camera, rely on line broadening or spot wobble to reduce the component of the incoming line repetition frequency in the information which is read by the camera. The storage is provided partly by the persistence of display tube phosphor and partly by the camera. The storage time is necessarily less than a field period to avoid movement blur, and such converters are, therefore, subject to the fundamental loss of vertical definition which has been described. In addition, they are subject to flare and the signal-to-noise ratio is marginal. The use of a photoconductive camera tube improves the signal-to-noise ratio but may introduce some movement blur. Both the display and the camera are non-linear devices and the converter must operate under circumstances suitable for both. In addition, some adjustments are necessary and, under the stress of operating conditions, the best compromise is not always achieved and the picture quality may fall below the best attainable.

2. Review of image-transfer standards conversion between television signals having field frequencies that differ markedly

Conversion between monochrome television standards, having field frequencies which differ markedly from one another, requires the introduction of methods and devices, not previously considered to be necessary, for programme exchanges of the type mentioned in § 1.

In converters for such exchanges, there occurs an interference between the field frequencies which, depending upon the difference between them, can have the appearance of an annoying flicker. Although

* Adopted unanimously.

this flicker can be abated by using picture-tube screens having phosphors with long persistence, the portrayal of movement in the scene being televised becomes subject to error in the form of blurring or smearing. Various means of overcoming the flicker, without suffering excessive loss of clarity of moving pictures, have been adopted.

3. Description of image-transfer standards conversion between television signals when both the field frequencies and the numbers of lines differ in the two standards

In one method [Helsdon, 1962], the field-synchronizing waveforms of the two standards are combined to produce a suitably shaped correction signal, having a fundamental frequency equal to that of the flicker. The correction signal is used to control the gain of an amplifier through which must pass the converted signal. The point of insertion of the correction signal has recently been changed, so that pre-correction rather than post-correction is used. The variable gain amplifier is now situated in the path of the incoming, unconverted signal, before its arrival at the display cathode-ray tube. This is not an automatic system, the shape of the correcting waveform being adjusted manually for optimum results.

In another method [Benson, 1961], the correcting waveform is obtained from a peak detector, which triggers a correcting waveform generator by a signal resulting from the detection of the peak white-level of the converted signal.

In yet another method [C.C.I.R., 1962a; Sennhenn, 1961; Lord, 1960; Rout and Vigurs, 1961], a pulse is inserted into the line-blanking interval of the television signal to be converted. The pulse appears as a vertical bright bar on the picture tube and is converted to the scanning standards of the receiving authority by means of the pick-up tube. After conversion, the pulse signal which suffers from conversion flicker is gated and detected, and used to control the gain of an amplifier through which the converted signal must pass.

In a method described in Doc. XI/33 (Japan), Bad Kreuznach, 1962, use is made of a combination of systems [Helsdon, 1962; Sennhenn, 1961; C.C.I.R., 1962a] and an additional feature which relies upon gated contrast correction which is applied, in a conversion from 50-field television to 60-field television, to every sixth field of the converted signal. The field under consideration derives its picture signal from an image which has been stored for a notably longer period than preceding and subsequent images and the application of contrast correction effects a further improvement in the reduction of flicker.

Various picture tubes and pick-up tubes have been used in the above standards converters. In particular, image orthicons, orthicons and pick-up tubes with photoconductive target, have all given performances of a reasonably satisfactory nature.

4. Review of line-store standards conversion between signals of identical field frequency

Considerable attention continues to be paid to various aspects of the problems of conversion of television signals from one standard to another. In general, the work can be divided into two main categories corresponding, respectively, to Question 2-2/11, §§ 1 and 2, and the two points referred to in Study Programme 10A/11 (New Delhi).

In connection with the first item of Study Programme 10A/11 (New Delhi), mention should be made of work which has been carried out to perfect methods of conversion between television signals having identical and synchronized field frequencies, that may be locked to an electricity supply frequency (if required), but different line frequencies. This work was directed towards the development of standards converters involving no moving parts and no intermediate optical or electron-charge image. Two types of such devices, now known as "line converters" described in Doc. 266 (E.B.U.) Geneva, 1963, have been developed. Both types of instrument are based upon the concept of storing each picture element occurring along a scanning line in one of, say, 600 stores, which may consist, in the first type [Rainger, 1962 and 1964] of low-pass filters having a passband such that the response of the filter to the signal representing a given picture element in one line of a field, is dying away as the response to the signal representing the homologous picture element in the succeeding adjacent line of the field is reaching its maximum value. In this way, the component at incoming line-scanning frequency is reduced or "smoothed" in the signal output from each filter. Appropriate interpolation between the lines in the incoming signal may be achieved by suitable selection of filter characteristics. Fast-acting electronic switches select, at the correct instants, the instantaneous values of the incoming signal and apply them to the appropriate low-pass filters. A bank of similar switches samples the outputs from the filters in synchronism with the outgoing line-scanning frequency.

In the second type [Lord and Rout, June, 1962] of line converter, simple capacitors replace the low-pass filters and the appropriate interpolation between homologous picture elements on adjacent lines is obtained by generating an interpolation function $S(t)$, which is then arranged to modulate the incoming signal on the one hand, whilst on the other hand the function $1\text{-}S(t)$ is arranged to modulate the incoming signal after it has been delayed by exactly one incoming line-scan period. The two modulated signals are then added and switched, as in the first type of converter, to a bank of 600 capacitors. Both types of converter could benefit from the use of a store or delay device, having a delay-time equal to the period of one field of the incoming signal. Such a delay device would permit conversion from picture to picture instead of from field to field, and thus the maximum possible vertical resolution permitted by the lower-definition signal involved in the conversion would be approached. It is self-evident that image transfer converters are also capable of benefiting from the application of such a field store or delay device.

In the line converter of the type that uses low-pass filters as the storage elements a compound switching system is used. This arrangement greatly reduces the number of high-speed switches required. The common input or output circuit is connected to 36 high-speed switches, each of which is, in turn, connected to 16 low-speed switches (i.e. each high-speed switch serves a group of 16 stores within the full array of 576 stores). The fast switches operate at picture-element rate, but the construction is such that the slow switches need operate only at one thirty-sixth of this rate; thus the majority of the switches can be of simple design with a corresponding reduction in cost.

Both converters can be made to reverse the direction of conversion, for example, from 625 lines to 405 lines and vice versa. The converter of the type that uses simple capacitors as storage elements coupled with an interpolator that is external to the storage elements (capacitors) can be made to reverse the direction of conversion by the operation of a switch. It is also possible to construct the low-pass filter type of converter so that it, too, may reverse the direction of conversion by means of a switch.

Both designs of line converter achieve a much better picture quality than conventional converters [Rainger and Rout, 1966]. The signal-to-noise ratio, grey scale, horizontal resolution and geometrical linearity are substantially those of the incoming picture. Blurring of movement, inherent in conventional converters, is entirely absent, the static "background" pattern is almost imperceptible and there is no vignetting or loss of resolution in the corners of the picture.

The fact that no valves or cathode-ray devices are used means that the converters are available immediately after switching on and their low-power dissipation results in a high order of stability and reliability. Furthermore, the services of an operator are not required.

Recently it became apparent that a number of advantages (both technical and economic) would be obtained by replacing existing line converters by others in which the signals are processed in digital form [Lord, 1968; Lord *et al.*, 1970; Baldwin, 1970]. Accordingly the fundamental processes associated with digital line conversion have been studied and possible converter configurations devised [Lord *et al.*, 1970; Baldwin, 1970]. As in the case of analogue conversion, interpolation and time-redistribution are involved. Experimental digital line converters were built in the United Kingdom during 1970 and produced good results [Radio and Elect. Engr., 1971; R.T.S.J., 1971; Baldwin *et al.*, 1974].

5. Further work on the conversion between both monochrome and colour signals with markedly different field frequencies

In connection with the second item of Study Programme 10A/11 (New Delhi), important work is in progress, aimed at achieving conversion between television signals having markedly different field frequencies.

Basically, the problems to be solved are as follows:

— the complete incoming picture signal must be stored for at least one field period;

— the magnitudes of the signals on successive or, better, on geometrically adjacent lines must be interpolated to derive the most suitable signal magnitude for the appropriate line in the output standard. This output line will usually lie between two lines of the incoming (original) standard;

— the magnitudes of successive field signals must also be interpolated so as to maintain continuity in the portrayal of motion when a field is repeated or suppressed.

Methods involving the use of magnetic tape video recorders have been used and when both the number of lines and the number of fields differ between the two signals in question two conversions take place. The greater difficulty, which resides in the conversion of the field frequencies, is overcome by recording entire fields diagonally across the magnetic tape and ensuring that the length of the reproducing head magnetic gap is wider than that of the recording head. For conversion from 50-field to 60-field signals, for example, every third field of each group of five fields of the 50-field signal is repeated once (duplicated) and recorded on the tape adjacent to its previous position. The reproducing head, with its longer gap, is then able to read off the tape six fields (for the outgoing 60-field signal), in a time duration equal to that required by five fields of the incoming signal. To duplicate certain fields of the incoming signal as magnetic stripes on the tape, the recording disc carries two heads so that, for example, when field number three of the incoming signal is present, it can be recorded simultaneously by the two heads as adjacent magnetic stripes on the tape. The device consists of a drum around which is wound, as one turn of a helix, the video magnetic tape. Inside the drum is the disc containing, on its periphery, the two recording heads. The latter protrude through a radial slot in the drum and can, therefore, make contact with the inner side of the single-turn helix of tape.

Such a device has been constructed and performs satisfactorily [Nomura, 1961; C.C.I.R., 1962b]. Following these experiments, further studies have been carried out in Japan [C.C.I.R., 1963–1966a] and in the United Kingdom [C.C.I.R., 1963-1966b] with a view to achieving better performance in the conversion between television standards having markedly different field frequencies than is obtained with earlier forms of standards converters. These studies and experiments are in accordance with Question 2-2/11, § *(c)*, and Study Programme 10A/11, § 2 (New Delhi). In principle, a converter of the type envisaged represents an extension of the ideas incorporated in the line converter mentioned in an earlier part of § 4. The field converter thus contains no intermediate optical image and may or may not contain moving parts depending upon the availability of ultrasonic delay-lines suitable to replace delays of the type that use a rotating magnetic-recording memory disc. Delay times up to the duration of a field of the television standard to be converted are required. In particular, conversions between 60-field and 50-field standards are envisaged.

The processes involved are:

— line conversion, in order that the number of lines required for the "output" standard can be obtained from the different number of lines in the standard to be converted or "input" standard. Certain lines are omitted or duplicated;

— field conversion, in order that the number of fields required for the output standard can be obtained from the different number of fields in the input standard. Certain fields are omitted or duplicated;

— an adjustment effected to account for the different durations of the scanning lines in the input and output standards;

— interpolation between lines to make an estimate of the picture information that would have existed in between the scanning lines of the input standard and to make use of this during certain scanning lines of the output standard, when, as will occur in a cyclic manner, the latter (scanning lines of the output standard) would not have been in geometrical coincidence with the former (scanning lines of the input standard);

— interpolation between fields, to make an estimate of the picture information which should exist in each successive output field. (The smooth portrayal of motion has been interrupted as a consequence of omitting or duplicating a field);

— compensation for timing errors that occur in the waveform of the output standard.

The order in which the above processes are carried out depends upon the precise design of the field converter as well as upon the direction in which the conversion is to take place: 50 fields/s to 60 fields/s or vice versa.

In some proposals [C.C.I.R., 1963–1966b], the line and field conversions may be combined in one unit comprising many delay-lines through which the signal may be switched in accordance with a pre-arranged programme. Using such methods it is possible to convert between standards whose field frequencies are neither in an exact 5/6 (or 6/5) ratio nor in any fixed ratio; thus conversion is possible between standards whose field frequencies are not precisely related. In other proposals [C.C.I.R., 1963–1966a], conversion in the latter condition is made possible by the use of an additional timing-error compensator. Yet another proposal for a field converter is based upon a simpler concept which necessitates that the precise ratio of 6/5 (or 5/6) must be maintained between the two field-scan frequencies [Wireless World, 1967]; also no attempt is made to alter the period of each active field. This leads to a change in the size of the image with respect to the scanned raster. In Japan, a converter [C.C.I.R., 1963–1966a; C.C.I.R., 1966–1969a] which does not change the size of the image has been constructed and actual broadcasts have confirmed satisfactory conversion of 625-line signals into 525-line signals using this converter. After the above work, an effective two-way converter which can convert from a 625-line PAL or SECAM signal to 525-line NTSC signal and vice versa was completed [C.C.I.R., 1966–1969b]. Further, the modification of the above converter from the slaved-synchronizing conversion system into an independent synchronizing conversion system to make possible a non-fixed-ratio conversion has been successfully carried out [Sakata *et al.*, 1971]. This converter was used for the international exchange of programmes on magnetic tape. Recently, an improved converter to apply the conversion of live signals to international circuits via a satellite link or links has been developed [Satoh *et al.*, 1971]. This device can convert a 625-line monochrome signal into a 525-line monochrome signal and vice versa and a 625-line PAL signal into a 525-line NTSC signal and vice versa, and a 625-line PAL signal into a 625-line SECAM signal and vice versa.

As a result of work in the United Kingdom, two types of colour converter have been developed [Rout and Davies, 1969; Wireless World, 1967; Davies, 1969]. One is based upon the simpler concepts already mentioned while the other uses more advanced techniques which enable it to work with a field-frequency ratio that need not be exactly 5/6 (or 6/5), producing at its output a standard picture signal locked to local station sync. pulses and a standard colour sub-carrier frequency. Conversions by means of the simple and by means of the advanced methods have been achieved in both directions, that is, 525-lines to 625-lines and vice versa. These converters are now fully operational and have been successfully used in many international exchanges of programmes. As was predicted from feasibility studies and experiments, improved performance over optical converters has been obtained with respect to resolution, movement blur, flicker, geometric distortion and linearity of response. No adjustment by operators is required and the converters have shown a good degree of reliability.

Further work in the United Kingdom has enabled the advanced field converter [Davies, 1969; Davies *et al.*, 1971; Le Couteur and Osborne, 1970] to perform field synchronization in addition to conversion. Such a synchronizer enables a signal from a remote source, perhaps originating beyond a national boundary, to be made synchronous with locally generated signals conforming to the same nominal scanning standards, so that modern programme-assembly techniques (mixing, "split-screen" effects, etc.) can be used without difficulty.

Work in the Federal Republic of Germany [Jaeschke, 1968; Wendt, 1969] has been directed at improving the technique of optical conversion [C.C.I.R., 1966–1969c] since at the present state of development it is the simplest and cheapest method for solving the three basic requirements mentioned earlier. The colour converter designed on this principle uses two separate conversion devices, one for the luminance signal and the other for the chrominance signal. In principle, the incoming signal is divided into its luminance and chrominance components. (So-called "comb-filters" or combinations of high-pass and low-pass filters may be used for this purpose.) In the luminance part of the standards converter the luminance component is converted immediately into the new standard, if necessary after improvement of the signal by means of the crispening technique. In the chrominance part of the standards converter the chrominance carrier component is transformed into an auxiliary carrier-frequency which:

— results in a pattern of vertical stationary stripes in the displayed picture;

— is so low that, as far as contrast and horizontal positioning are concerned, the striated structure can easily be resolved by the camera of the chrominance part of the converter. Here, the contrast between the stripes is determined by the colour saturation, and the geometrical position of the stripes is determined by the hue.

For this purpose, use can be made either of a carrier frequency locked to the horizontal frequency (carrier frequency = integral multiple of the horizontal frequency) or of a start-stop oscillation of any frequency having a defined phase relationship at the beginning of each line. To define the horizontal shift of the position of the vertical stripes, a pilot signal has to be superimposed which furnishes a reference phase. After conversion of the chrominance component, the pilot signal is separated from the chrominance signal and transformed into a reference carrier to be used in a subsequent synchronous demodulation of the chrominance signal. The colour difference signals derived in this way are then remodulated with the new colour carrier by conventional technique.

The sum of the standards-converted luminance and chrominance signals yields the colour picture signal at the new standard and coding. It meets all parameters laid down in the specifications.

The techniques developed for digital line conversion (see § 4) can, with advantage, be considered for converting between signals having different line and field frequencies [Lord, 1968; Edwardson and Jones, 1971]. Several laboratories are studying the associated problems and it is expected that research and development work will ultimately provide converters whose performance is such that differences in the input and output pictures will solely be due to differences in the inherent characteristics of the two systems involved. Such digital field converters are likely to be smaller, more reliable and less costly than the equivalent equipment based upon analogue methods. Similar digital techniques are applicable to synchronizers and it is possible that, in the future, the two functions might be combined in a single unit.

Recent work in the United Kingdom has led to the successful development of a digital field converter employing stores based on dynamic shift registers [IBA, 1972 and 1973; Baldwin *et al.*, 1974], which is undoubtedly a significant step forward. Experience with this equipment has confirmed that a converter of this type can be relatively small in size, and is likely to prove very stable in service and economic in terms of running costs. In general, it includes far fewer pre-set and operational controls than corresponding analogue equipment. The performance of the equipment is noticeably better than that of previous converters and the signal-to-noise ratio at the output is not significantly different from that at the input.

6. Conclusions

In standards conversion between monochrome television signals having different line frequencies but the same or nearly the same field frequencies, a satisfactory result may be obtained by the well-known image-transfer methods. If the field frequencies are identical, however, new methods, known as line conversion, have been perfected. In these methods, no intermediate optical or electron-charge image is used and a more consistent and better quality image is achieved. Furthermore, variations in image quality, due to the human element involved in the operation of standards conversion equipment, are notably reduced by the introduction of these new techniques.

On the other hand, in converting between television signals, from one standard to another, when the field frequencies of the two standards are different, it is possible, by adopting one of the methods described in § 3, to reduce the flicker of the pictures reproduced to a hardly perceptible level, provided the adjustment of the converter is effected correctly. It has been proved that by the use of more advanced techniques the main shortcomings of former electro-optical converters such as low resolution, flickering and smearing in moving pictures can be overcome and this has led to the development in the Federal Republic of Germany of a colour standards converter with electro-optical image transfer. The prototype converter is operating with satisfactory results at the satellite earth station at Raisting.

New methods of conversion which do not require the use of the image-transfer method have been developed, and are now fully operational in the United Kingdom and in Japan. These are field converters for both monochrome and colour television and use ultrasonic delay lines as the storage medium. Recent work indicates that future converters and synchronizers are likely to be based upon digital techniques.

Operational experience with a recently developed digital field converter has shown that the impairment of picture quality, due to the conversion process, is reduced to a low level. Furthermore, the fact that the use of such equipment does not involve complex setting up is attractive operationally. Similar work in Japan on digital converters has enabled the analogue equipment [Sakata *et al.*, 1971; Satoh *et al.*, 1971] to operate with a digital memory which replaces the delay line store. A machine of this type is in operational service [C.C.I.R., 1970–1974; A.B.U., 1973]. Further studies to improve the quality of conversion using a new digital converter, which is able to reproduce one field of the output signal from three fields of the input signal, are proceeding [Kinuhata *et al.*, 1974].

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REPORT 477-1 *

TRANSCODING OF COLOUR TELEVISION SIGNALS FROM ONE COLOUR SYSTEM TO ANOTHER

(Study Programme 2-1A/11)

(1970)

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 this field of activity, a bibliography follows.

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SECTION 11C: PICTURE QUALITY AND THE PARAMETERS AFFECTING IT

RECOMMENDATIONS AND REPORTS

Recommendations

RECOMMENDATION 500

METHOD FOR THE SUBJECTIVE ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(1974)

The C.C.I.R.,

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 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-point quality and impairment scale made during the normal course of duty of 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 the Annex should be used for laboratory experiments and for operational assessments whenever possible.

ANNEX

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 [C.C.I.R., 1963–1966]. 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.

2. Details of the method

2.1 *Observers*

Observers may be either expert or non-expert.

The minimum number of non-experts should normally be twenty. The minimum number of expert observers should normally be ten. In all cases, the number and category of observers and the duration of the tests should be stated [C.C.I.R., 1970–1974].

2.2 *Grading scales*

The five-point scales are listed 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-point scale	
Quality	Impairment
5 Excellent 4 Good 3 Fair 2 Poor 1 Bad	5 Imperceptible 4 Perceptible, but not annoying 3 Slightly annoying 2 Annoying 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.

In view of the large number of documented results which have been obtained using six-point 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 with one scale into another scale, particularly in respect of the possible bias caused by the verbal cues. However, as a first approximation, the following linear relationship can be used to transform a grade, A_6, obtained in an experiment using a six-point scale (Report 405-2, notes 6 and 8) into a grade, A_5, in the corresponding five-point scale:

$$A_5 = 5{\cdot}8 - 0{\cdot}8A_6$$

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

2.3 *Test pictures*

About five test pictures should be used. These should be more critical than average pictures, although not unduly so, and where appropriate should normally include pictures derived from colour cameras viewing scenes containing bright saturated colours. Test patterns should not normally be used. The test pictures used should be identified in the presentation of 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
a	Ratio of viewing distance to picture height	6 (1)	4 to 6
b	Peak luminance on the screen (cd/m^2)	70 ± 10 (2)	70 ± 10
c	Ratio of luminance of inactive tube screen (beams cut off) to peak luminance	⩽0·02	⩽0·02
d	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	
e	Ratio of luminance of background behind picture monitor to peak luminance of picture	approximately 0·1 (3)	approximately 0·15
f	Other room illumination	low (4)	low
g	Chromaticity of background	white (5)	D_{65}
h	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) Normally (70 ± 10) cd/m^2, or (220 ± 30) asb (6), but certain tests may require luminances outside the tolerances, for example, because of flicker, defocusing, etc.

(3) If the ratio is greater than 0·1, the chromaticity has to be nearer to Illuminant D_{65} (7).

(4) The specification is loosely phrased here, since the precise value is not critical, provided it does not conflict with condition *c*.

(5) Not very critical. Any white in the region between standardized illuminants A and D_{65}. See, however, Note (3).

(6) 1 apostilb (asb) $= \frac{1}{\pi}$ candela per square metre (cd/m^2).

(7) 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 should never be presented on two successive occasions with the same or different levels of impairment.

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11C: *Reports*

REPORT 313-3 *

ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(Question 3-1/11)

(1959 – 1963 – 1966 – 1970 – 1974)

It appears that 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 it would appear that 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 3-1/11, in arriving at suitable standard methods for measuring the various kinds of picture distortion in television.

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REPORT 404-2 *

DISTORTION OF TELEVISION SIGNALS DUE TO THE USE OF VESTIGIAL-SIDEBAND EMISSIONS

(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 O.I.R.T., 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.

* Adopted unanimously.

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. These distortions 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 [C.C.I.R., 1963–1966a; Dobesch, 1966], the following conclusions can be drawn:

— the distortions increase 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 distortions 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 distortions (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 [C.C.I.R., 1963 – 1966b] that a change of the steepness of the Nyquist slope from 0·75 to 1 MHz does not lead to a perceptible decrease of distortions.

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 distortions 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 [C.C.I.R., 1963 – 1966c] have shown that transient characteristics are more useful, because they afford a result closer to the visible effect of the distortions 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 [C.C.I.R., 1963–1966c] 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 distortions have not been obtained. From theoretical calculations [C.C.I.R., 1963–1966b] 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 to use adequate tolerance masks, determining the admissible deviations of the individual characteristics from nominal responses [O.I.R.T. a]. These masks determine separately the parameters of the transmitter and those of the Nyquist demodulator [O.I.R.T. b] as well as the parameters of the entire transmitter-demodulator channel.

Theoretical calculations of T and $2T$ sine-squared pulse distortions 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 distortions 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 distortions*

Long-term investigations of the correction of television signal distortions have led to the conclusion that in this way a considerable improvement of the signal form can be obtained [C.C.I.R., 1963–1966d]. With this in view, both correction of linear distortions with the aid of phase filters and correction quadrature distortions were used on the transmitter. Measurements effected under laboratory conditions and on a number of transmitters have shown that television signal distortions 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 distortions can entirely eliminate both effects.

With the aim of confirming the measurement results of the correction of linear and quadrature distortions investigations of picture quality have been carried out on the basis of subjective tests [C.C.I.R., 1963–1966e]. 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* [C.C.I.R., 1963–1966f]. 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 [C.C.I.R., 1963–1966g]. 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 [O.I.R.T. a] that the reduction of the steepness of the Nyquist slope tends to decrease the non-uniformity of group-delay and the quadrature distortions, 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 473-1, Annex I

A complete theoretical investigation on this subject has been carried out in Italy [C.C.I.R., 1970–1974; 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 distortions which affect the elements of the insertion test signal are those summarized in Table I. As regards distortion of the white bar, 2*T* and 20*T* pulse, the theoretical results of Table I agree with results of an experimental investigation carried out in the Federal Republic of Germany [I.R.T., 1970].

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.

TABLE I

Signal element	Parameter	Values (1) for system
		B, G
White bar leading (trailing) edge (shaped by the network generating the 2*T* pulse)	Undershoot amplitude Half-amplitude delay (lead) Rise time (fall time)	3% 69 ns 240 ns
2*T* pulse (half-amplitude duration: 200 ns)	Amplitude reduction Half-amplitude duration Main negative echoes amplitude	11% 156 ns 6·7%
20*T* 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.

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REPORT 405-2 *

SUBJECTIVE ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(Study Programme 3A/11)

(1966 – 1970 – 1974)

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. Administrations are invited to provide further contributions on all aspects of this important topic.

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* Adopted unanimously.

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Table I

Conditions for laboratory assessments

Reference	U.K. [C.C.I.R., 1963-1966a]	E.B.U., O.I.R.T. [C.C.I.R., 1963-1966c and d]			Fed. Rep. of Germany [C.C.I.R., 1963-1966b]			Japan [C.C.I.R., 1963-1966e and 1966-1969a]		U.S.A. [C.C.I.R., 1963-1966f]	U.S.A. [C.C.I.R., 1966-1969b]	Italy [C.C.I.R., 1966-1969c]
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
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)
Test pictures Number	4-8	5			≥5			≥3		2-8	3-4	6
Viewing conditions Ratio of viewing distance to picture height	6	4-6			6			6-8		6-8	4	6
Peak luminance on the screen (cd/m²) (²)	50	41-54			50			Approx. 400 (monochrome) 74-84 (colour) (Note 12)		70 (Note 12)	170 (monochrome) 34 (colour) (Note 12)	50
Contrast range of the picture	Not specified				Not specified			30/1 to 50/1		Not specified		
Luminance of inactive tube screen (cd/m²)	≤0·5	0·5			≤0·5			Approx. 5 (monochrome) 0·7-2 (colour)		2		Approx. 0·5
Luminance of backcloth (cd/m²) (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

(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	O.I.R.T. [C.C.I.R., 1966-1969d]		Canada [C.C.I.R., 1966-1969e]
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	4-6		4-6
Angle of view, from a line normal to the face of the monitor			⩽30°
Luminance, on the screen, at reference white (cd/m²)			70 ± 7
Chromaticity of the screen at reference white			Illuminant *D*
Luminance of the inactive tube screen	Adapted to the ambient illumination		As low as practicable
Luminance of "light surround" (cd/m²)			10·5 ± 3·5 (Note 14)
Chromaticity of "light surround"			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

Note 6. —
+2 Much better
+1 Better

3 Different
4 Very different
5 Extremely different

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. — Doc. XI/149 (O.I.R.T.) 1963–1966, 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.

ANNEX II

ANALYSIS AND PRESENTATION OF THE RESULTS OF TELEVISION SUBJECTIVE TESTS

1. Introduction

Methods for 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 tends to make interpretation difficult.

1.3 A third method [C.C.I.R., 1966–1969] 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 Apart from the above fundamental differences, interpretation and comparison are further complicated by a number of points of detail:

1.5.1 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.

1.5.2 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.

1.5.3 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.

1.6 Recently, 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 recently 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.

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; C.C.I.R., 1970–1974a], states that if $\bar{u}_1, \bar{u}_2, \ldots\ldots \bar{u}_r \ldots\ldots \bar{u}_n$ 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:

$$\frac{1}{\bar{u}} - 1 = \sum_{r=1}^{n} \left(\frac{1}{\bar{u}_r} - 1\right) \qquad (1)$$

The above equation suggests a possible psychophysical basis for the law of addition, in terms of a multi-dimensional judgement continuum [Siocos, 1972], but essentially the matter remains one for speculation.

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 $\bar{u} = 0{\cdot}5$.

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 about which there is any possibility of doubt.

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 each 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 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 [C.C.I.R., 1970–1974a].

A preliminary study of an alternative approach to the problem of multiple simultaneous impairments has been reported [C.C.I.R., 1970–1974b]. 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.

Further contributions to the study of the evaluation of the effects of multiple simultaneous impairments are invited.

3. Statistical models of opinion distribution

In §§ 1.4 and 1.6 reference was made to models based on the binomial and normal distributions. [C.C.I.R., 1970–1974c] summarizes the binomial type models referred to in § 1.4. [C.C.I.R., 1970–1974d] summarizes, in its Annex, the data analysis method based on the normal distribution and referred to in § 1.6.

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.

4. Use of comparison scale

A contribution [C.C.I.R., 1970–1974e] 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.

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REPORT 409-1 *

BOUNDARIES OF THE TELEVISION SERVICE AREA IN RURAL DISTRICTS HAVING A LOW POPULATION DENSITY

(Recommendation 417-2)

(1966 – 1970)

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 417-2, Administrations may find it desirable to establish the appropriate median field strength for which protection against interference is planned as low as:

Band	I	III
dB (μV/m)	+46	+49

These values refer to the field strength at a height of 10 m above ground level.

In such areas, without co-channel interference, it is generally observed that the public begin to lose interest in installing television reception equipment when, in the case of Band III transmissions, the median field strength falls below + 40 dB (μV/m) at 10 m above ground level.

The values given in this Report have been obtained from field investigations of the service area limits and picture quality in rural districts of Australia (Doc. XI/168, 1963–1966).

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* Adopted unanimously.

REPORT 478 *

GHOST IMAGES IN MONOCHROME TELEVISION

Re-radiation from masts in the neighbourhood of transmitting antennae

(Study Programme 6A/11)

(1970)

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 [C.C.I.R., 1966–1969; 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 it by as much as 6 dB, or reduce it.

The Table 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.

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.

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* Adopted unanimously.

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REPORT 481 *

RATIO OF WANTED-TO-UNWANTED SIGNAL IN TELEVISION

Subjective assessment of multiple co-channel interference

(Question 4-1/11)

(1970)

1. This Report summarizes some recent 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 rth interfering signal for a given subjective impairment

and I_r = level (dB (μV/m)) of the rth interfering signal,

then P_r = $R_r + I_r$ is the protected field strength (dB (μV/m)) applicable to the rth interfering signal.

2. Unrelated interferences appear to combine according to a simple power-addition law:

$$0{\cdot}1\,P = \log_{10} \sum_{r=1}^{r=n} 10^{0{\cdot}1\,P_r}$$

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* Adopted unanimously.

3. For impairment grades near grade 3·5 (using the scale given in Note 2, Annex I, to Report 405-2) related interferences tend to follow a different law. From the limited experimental work, it appeared that a (voltage)$^{1\cdot5}$ law represented the method of combination at least as well as any other law. Such a law may be written:

$$0{\cdot}075\,P = \log_{10} \sum_{r=1}^{r=n} 10^{0\cdot075\,P_r}$$

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):

$$0{\cdot}1\,P = \log_{10} \left[10^{0\cdot1\,P_1} + 2 \sum_{r=2}^{r=n} 10^{0\cdot1\,P_r} \right]$$

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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SECTION 11D: ELEMENTS FOR PLANNING

RECOMMENDATIONS AND REPORTS

Recommendations

RECOMMENDATION 266

PHASE CORRECTION OF TELEVISION TRANSMITTERS NECESSITATED BY THE USE OF VESTIGIAL-SIDEBAND TRANSMISSION

(1959)

The C.C.I.R.,

CONSIDERING

(a) that the transmission of television signals using vestigial-sideband techniques gives rise to distortion;

(b) that this distortion consists of linear distortions (in-phase errors) and non-linear distortions (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 these linear distortions arise 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 417-2

MINIMUM FIELD STRENGTHS FOR WHICH PROTECTION MAY BE SOUGHT IN PLANNING A TELEVISION SERVICE

(1963 – 1966 – 1970)

The C.C.I.R.

UNANIMOUSLY RECOMMENDS

1. 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:

Band	I	III	IV	V
dB (μV/m)	+48	+55	+65*	+70*

These values refer to the field strength at a height of 10 m above ground level;

2. 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 (μV/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 409-1.

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.

RECOMMENDATION 418-2

RATIO OF THE WANTED-TO-UNWANTED SIGNAL IN MONOCHROME TELEVISION

(Question 4-1/11)

(1963 – 1966 – 1970)

The C.C.I.R.

UNANIMOUSLY RECOMMENDS

that the protection ratios given in the Annex should be used for planning purposes.

ANNEX

1. Introduction

The protection ratios quoted are considered to be acceptable for planning purposes for a small percentage of the time, not precisely defined, but assumed to be between 1% and 10%**. Protection ratios for just perceptible interference would be some 10 to 20 dB higher.

When making use of the protection ratios in planning, suitable allowance for fading is made by using field-strength curves appropriate to the percentage of time for which protection is desired, it being assumed that fading of the wanted signal is small, compared with that of the unwanted signal.

* The values shown for Bands IV and V should be increased by 2 dB for the 625-line (O.I.R.T.) system.

** The question of the protection necessary when interference is present for a large percentage of the time is considered in Report 479.

The protection ratios quoted refer in all cases to the ratios at the input to the receiver, no account having been taken of the effect of using directional receiving antennae or of the advantage that can be obtained by using different polarization for transmission of the wanted and unwanted signals.

The amplitude of a vision-modulated signal is defined as the r.m.s. value of the carrier at peaks of the modulation envelope, 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.

All the protection ratios quoted in this Annex refer to interference from a single interfering source.

The full advantage of offset operation can only be obtained if the carrier frequencies of the transmitters concerned are within ±500 Hz of their nominal values.

2. Interference within the same channel

2.1 *Protection ratio when the wanted and unwanted signals have the same line frequency*

2.1.1 *Carriers separated by less than 1000 Hz, but not synchronized*

Protection ratio: 45 dB *.

2.1.2 *Carriers separated by less than 50 Hz, but not synchronized*

Protection ratio reduced by 5 to 10 dB relative to the preceding case.

2.1.3 *Nominal carrier frequencies separated by 1/3, 2/3, 4/3 or 5/3 of the line frequency*

Protection ratio: — for 405-line system: 35 dB;
— for 525-line system: 28 dB;
— for 625- and 819-line systems: 30 dB.

These values may be reduced to 28 dB, 20 dB and 20 dB respectively, if a carrier separation equal to an appropriate multiple of the frame frequency can be maintained; the line frequency should be kept constant to within 5×10^{-6} and each transmitter should have a frequency tolerance of not more than ±2·5 Hz.

The 20 dB value is at present valid for the 525- and 625-line systems when there is one unwanted transmitter. Under these conditions, the ratio between the wanted and unwanted sound signals will also be 20 dB, and this is permissible only if the offset is at least 5/3 of the line frequency for frequency-modulated sound (see § 6.1), or above the audio-frequency range for amplitude-modulated sound (see § 6.2).

2.1.4 *Nominal carrier frequencies separated by 1/2 or 3/2 of the line frequency*

Protection ratio: — for 405-line system: 31 dB;
— for 525-, 625- and 819-line systems: 27 dB.

2.2 *Protection ratio for the picture signal when the wanted and unwanted signals have different line frequencies*

2.2.1 *Carriers separated by less than 1000 Hz, but not synchronized*

Protection ratio: 45 dB.

2.2.2 *Carriers separated by less than 50 Hz, but not synchronized*

Protection ratio reduced by 5 to 10 dB relative to the preceding case.

* This value may be reduced by about 20 dB for the 525-line system, if a carrier separation of a few hundred hertz is maintained at an appropriate multiple of the frame frequency with a variation in carrier-frequency difference less than 1·5 Hz.

2.2.3 *Nominal carrier frequencies separated by 6·3 kHz*

Protection ratio between a 625-line system and an 819-line system: 30 dB.

3. Adjacent-channel interference

Throughout this section, fairly conservative values have been chosen to take account of the divergence in performance between different types of television receivers and to allow for the possible introduction of colour.

3.1 *Lower * adjacent-channel interference — VHF bands*

The worst interference on the picture signal from another signal using the same standard results from the sound signal in the lower* adjacent channel. 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. The ratios are expressed in terms of the wanted and unwanted vision signals.

Protection ratio: — for frequency-modulated sound carrier (except system N): –6 dB;
— for amplitude-modulated sound carrier (system N): –10 dB;
— for amplitude-modulated sound carrier: –2 dB.

3.2 *Lower adjacent-channel interference — UHF bands*

Protection ratio: — for the 525-line system in a 6 MHz channel: –6 dB.

For the various 625-line systems proposed for use in 8 MHz channels in the UHF bands, the table below gives the protection required by a signal on any system against a lower adjacent-channel signal of the same or any of the other standards. The protection ratios quoted are those to be applied between the wanted and unwanted vision signal levels.

Interfering signal standard (See Report 624)	Protection ratio (dB) for a wanted-signal standard:					Vision/sound power ratio (dB) for interfering signal
	G	H	I	K (1)	L	
G	–6	–6	–6	–6	–6	7
H	–6	–6	–6	–6	–6	7
I	–6	–6	–6 (2)	–6	+3 (2)	7
K	–6	+16	+16	–6	+16	7
L	–4	+18	+18	–4	+18	9

(1) Administrations using system K in the VHF bands are studying the possibility of broadening the vestigial sideband to 1·25 MHz for use in the UHF bands without changing the other parameters of the systems. In this case, the protection ratios required for system K would be the same as those quoted for the 625-line system L.

(2) The values for systems I and L are different in this case, because receivers for system I will contain a sound trap giving additional rejection at the frequency of the interference.

* Upper for the 405-line standard, since the vestigial sideband lies above the vision carrier frequency.

Note. — When an interfering frequency-modulated sound signal is offset, during quiescent periods, relative to the wanted vision signal by a frequency equal to a multiple of the line frequency plus or minus about one-third line frequency, the protection ratio may be reduced by 6 dB. For an interfering amplitude-modulated sound signal with the carrier offset in a similar way the reduction may be greater.

3.3 *Upper * adjacent-channel interference — VHF and UHF bands*

Protection ratio: — for system K: 4 dB;
— for system N: −10 dB
— for all other systems: −12 dB.

4. Overlapping-channel interference

Figs. 1 to 9 give protection ratios for the 405-, 525-, 625- and 819-line systems when a CW signal of the carrier of an interfering sound or vision signal lies within the channel of the wanted transmission.

When the difference between the carrier frequencies of the wanted and unwanted signals is large and it is desired to use offset to reduce the necessary protection ratio, the line-frequency of the wanted signal must be controlled to within 5 parts in 10^6.

Where it affects the result, the ratio of vision power to sound power is assumed to be 9 dB for system L, 3 dB for system M and 7 dB for the other systems.

5. Second channel (image channel) interference

The protection ratio required depends upon the intermediate frequency used and upon the second channel rejection of the receiver. For the purpose of planning it may be assumed that the second channel rejection of receivers will not be less than 40 dB except in receivers for the O.I.R.T. systems D and K when it will not be less than 30 dB.

6. Protection ratios between sound signals

(The ratios quoted are those between wanted and unwanted sound signals.)

6.1 *Wanted and unwanted sound signals frequency-modulated*

Protection ratio:

— for carriers separated by less than 1000 Hz: 28 dB;
— for carriers separated by 5/3 of the line-frequency: 20 dB.

6.2 *Wanted and unwanted sound signals amplitude-modulated*

Protection ratio:

— for carriers separated by frequency below the audio range: 30 dB;
— for carriers separated by frequency within the audio range: 40 dB;
— for carriers separated by frequency above the audio range: 15 dB.

* Lower, for system A in the VHF bands.

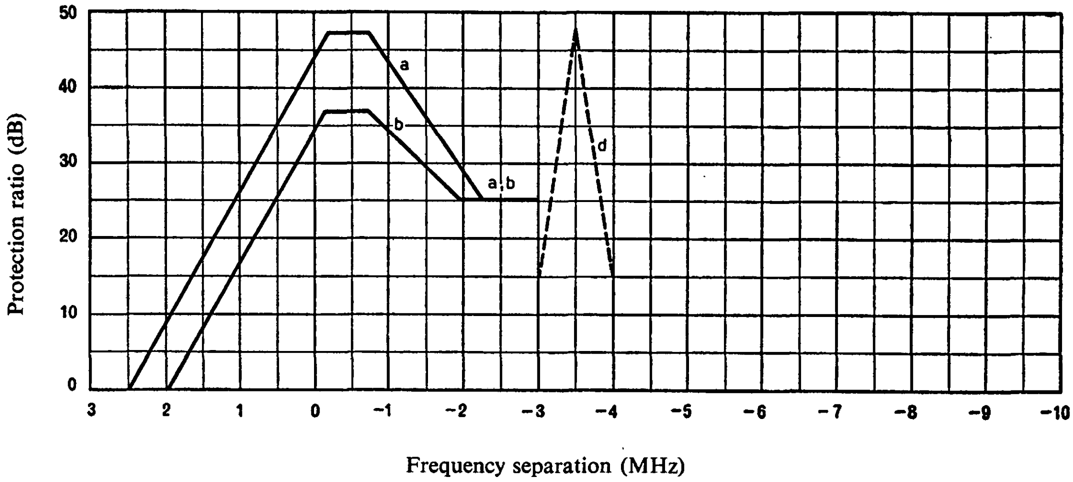

FIGURE 1

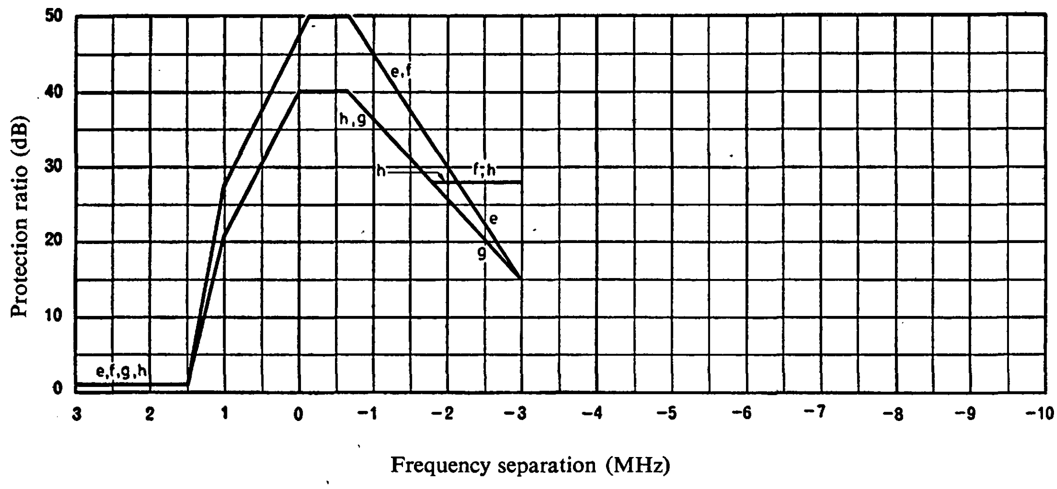

FIGURE 2

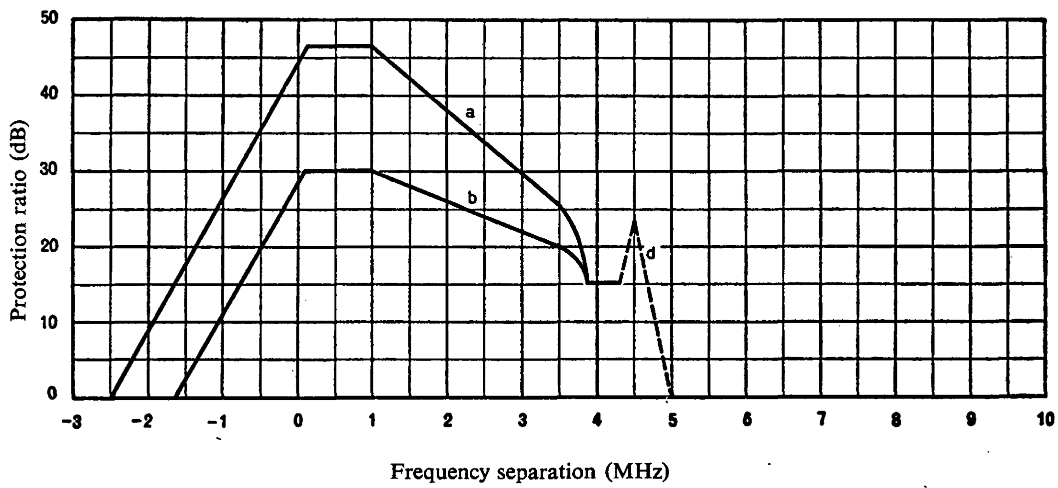

FIGURE 3

FIGURE 1

System A. Protection from vision-signal interference

In all cases in this figure, the ratios quoted are those between the wanted and the unwanted vision levels.

Curve *a* — Interference to vision from a 405-, 625-, or 819-line vision signal with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

Curve *b* — Interference to vision from a 405-, 625-, or 819-line vision signal when the nominal frequency difference between the carriers of the wanted and unwanted signals is a multiple of the line frequency (10 125 Hz) plus or minus 3 to 5 kHz. If the nominal frequency difference is 1/2 or 3/2 of the line frequency, a protection ratio of 31 dB may be accepted (see § 2.1.4).

Curve *d* — Interference to sound signal from a 450-, 625-, or 819-line vision signal.

FIGURE 2

System A. Protection from CW or sound-signal interference

In all cases in this figure, the ratios quoted are those between the wanted vision and the unwanted sound levels.

Curve *e* — Interference to vision from a CW or frequency-modulated sound signal with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

Curve *f* — Interference to vision from an amplitude-modulated sound signal with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

Curve *g* — Interference to vision from a frequency-modulated sound signal when the nominal frequency difference between the wanted-signal carrier and the interfering-sound carrier, during quiescent periods, is an odd multiple of half the line frequency, 5062·5 Hz.

Curve *h* — Interference to vision from an amplitude-modulated sound signal when the nominal frequency difference between the carriers of the wanted and unwanted signals is an odd multiple of half the line frequency, 5062·5 Hz.

FIGURE 3

System M. Protection from vision-signal interference

In all cases in this figure, the ratios quoted are those between the wanted and the unwanted vision signals.

Curve *a* — Interference to vision from another 525-line vision signal with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

Curve *b* — Interference to vision from another 525-line vision signal when the nominal frequency difference between the carriers of the wanted and unwanted signals is a multiple of the line frequency (15·75 kHz) plus or minus one-third of the line frequency (5·25 kHz).

Curve *d* — Interference to sound signal from a 525-line vision signal.

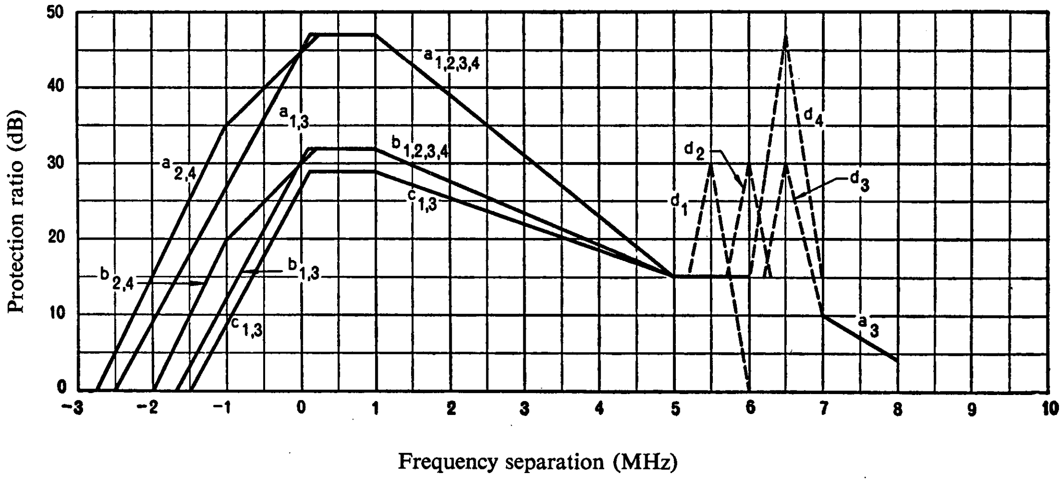

FIGURE 4

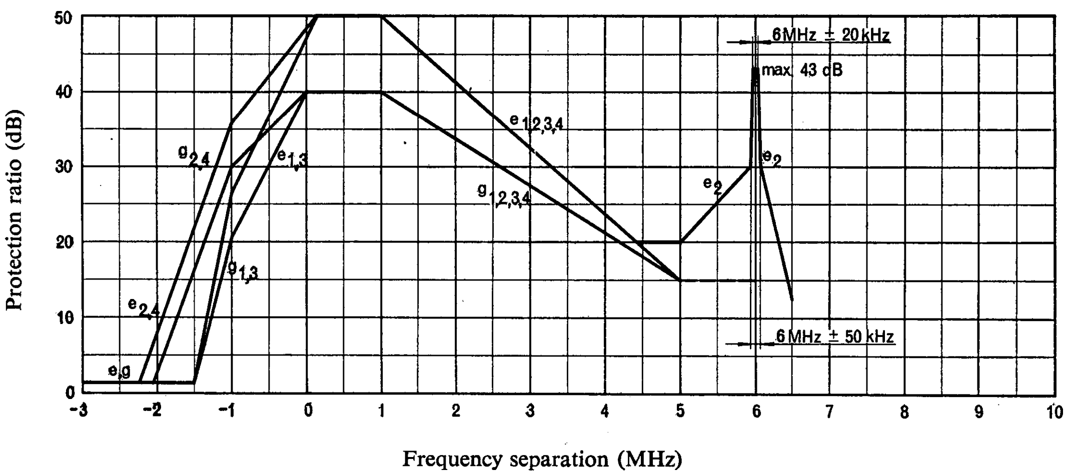

FIGURE 5

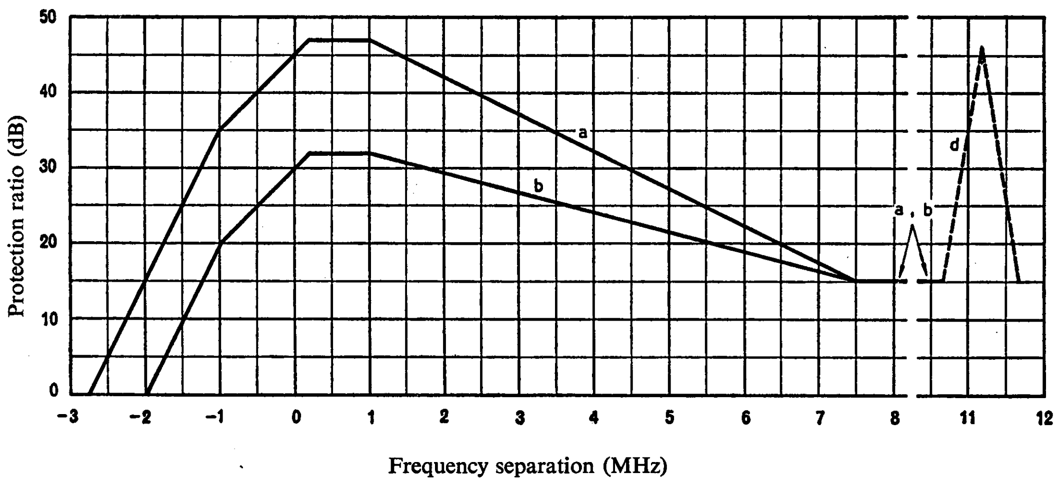

FIGURE 6

FIGURE 4

625-line system. Protection from vision-signal interference

In all cases in this figure, the ratios quoted are those between the wanted and unwanted vision levels.

The subscript numbers used on the curves indicate the various applications of the 625-line system:

1 — 625-lines; 2 — system I; 3 — system K*; 4 — system L.

Curves *a* — Interference to vision from 405-, 625-, or 819-line systems vision signal, with no special control of the nominal frequency-difference between the carriers of the wanted and unwanted signals.

Curves *b* — Interference to vision from a 625-line vision signal when the nominal frequency difference between the carriers of the wanted and unwanted signals is a multiple of the line frequency (15 625 Hz), plus or minus one-third of the line frequency (5208 Hz).

Curves *c* — Interference to vision from a 625-line vision signal when the nominal frequency difference between the carriers of the wanted and unwanted signals is an odd multiple of half the line frequency (7812·5 Hz).

Curves *d* — Interference to sound from a 625-line vision signal.

* If a vestigial sideband of 1·25 MHz is used in system K, curves a_4 and b_4 should be used instead of curves a_3 and b_3 and curve c_3 is no longer valid.

FIGURE 5

625-line system. Protection from CW or sound-signal interference

In both cases in this figure, the ratios quoted are those between the wanted vision and the unwanted sound levels.

The subscript numbers are used on the curves to indicate the variations applicable to the various 625-line systems as follows:

1 — 625-lines; 2 — system I; 3 — system K*; 4 — system L.

Curves *e* — Interference to vision from a CW or frequency-modulated sound signal, with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals. For amplitude-modulation of the interfering sound signal, the protection ratios should be increased by 4 dB.

In the case of curve e_2, for the special case of interference from sound signals that conform to the frequency limits quoted in § 6 of this Recommendation the protection ratios quoted therein apply.

Curves *g* — Interference to vision from a frequency-modulated sound signal, when the nominal frequency difference between the wanted signal carrier and the sound carrier during quiescent periods is an odd multiple of half the line frequency (7812·5 Hz).

* If a vestigial sideband of 1·25 MHz is used in system K, curves e_4 and g_4 should be used instead of curves e_3 and g_3.

FIGURE 6

System E. Protection from vision-signal interference

In all cases in this figure, the ratios quoted are those between the wanted and unwanted vision levels.

Curve *a* — Interference to vision from a 405-, 625-, or 819-line vision signal with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

Curve *b* — Interference to vision from an 819-line vision signal, when the nominal frequency difference between the wanted and unwanted signal carriers is a multiple of the line frequency (20 475 Hz), plus or minus one-third of the line frequency (6825 Hz).

Curve *d* — Interference to the sound signal from a 405-, 625- or 819-line vision signal.

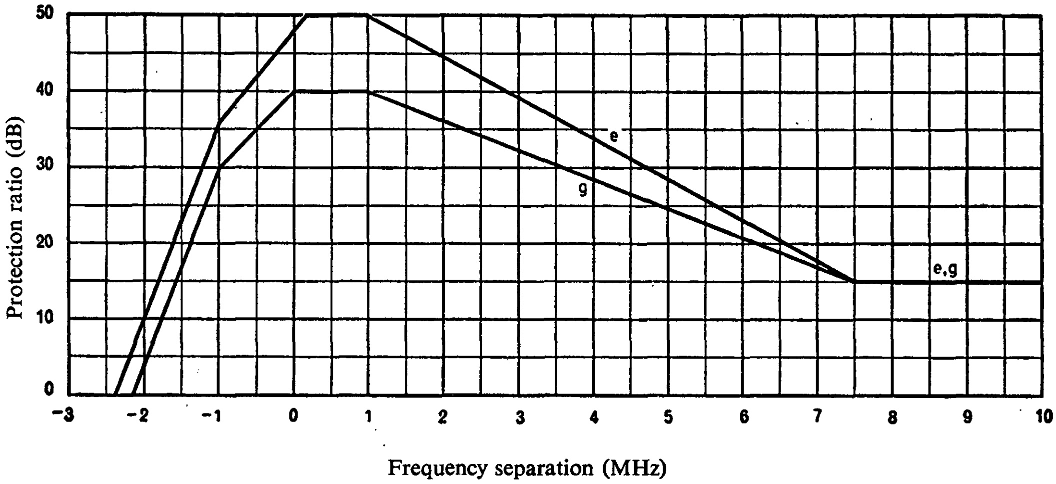

FIGURE 7

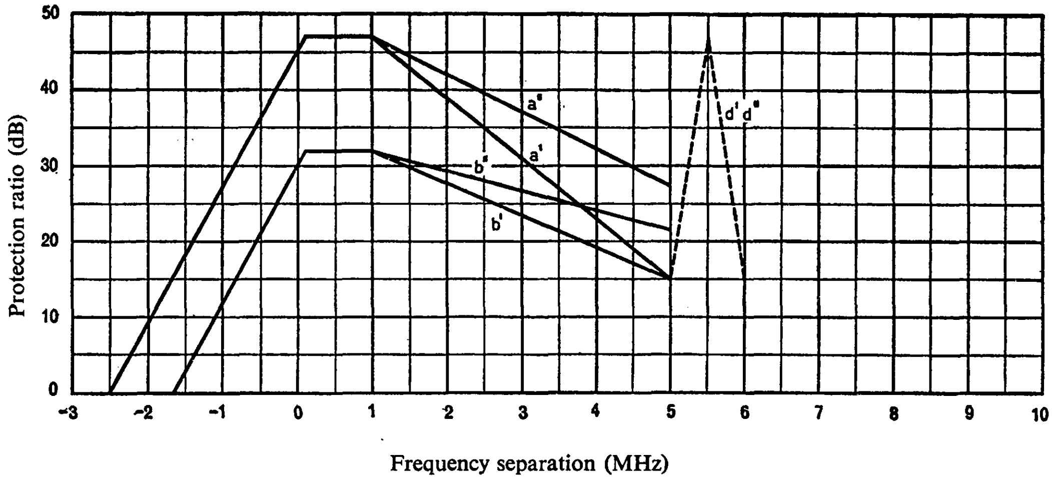

FIGURE 8

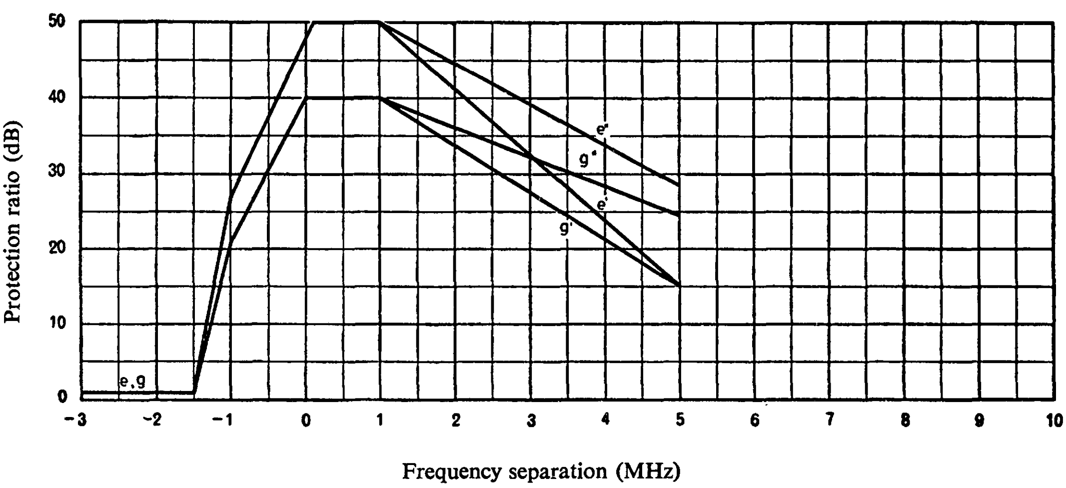

FIGURE 9

FIGURE 7

System E. Protection from CW or sound-signal interference

In both cases in this figure, the ratios quoted are those between the wanted vision and unwanted sound levels.

Curve *e* — Interference to vision from a CW or frequency-modulated sound signal, with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals. For amplitude modulation of the interfering sound signal, the protection ratios should be increased by 4 dB.

Curve *g* — Interference to vision from a frequency-modulated sound signal, when the nominal frequency difference between the wanted signal carrier and the sound carrier during quiescent periods is an odd multiple of half the line frequency (10 237·5 Hz).

FIGURE 8

Systems C and F. Protection from vision-signal interference

In all cases in this figure, the ratios quoted are those between the wanted levels of the vision and unwanted vision signals.

Letters with a single prime are used for curves applying to System C. Letters with double primes are used for curves applying to System F.

Curves *a* — Interference to vision from a 405-, 625-, or 819-line vision signal, with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

Curves *b* — Interference to vision from a vision signal, having the same number of lines when the nominal frequency difference between the carriers of the wanted and unwanted signals is a multiple of the line frequency (15 625 or 20 475 Hz), plus or minus one-third of the line frequency (5208 or 6825 Hz).

Curves *d* — Interference to the sound signal from a 405-, 625-, or 819-line vision signal.

FIGURE 9

Systems C and F. Protection from CW and sound-signal interference

In all cases in this figure, the ratios quoted are those between the levels of the wanted vision and the unwanted sound signals.

Letters with a single prime are used for curves applying to System C. Letters with double primes are used for curves applying to System F.

Curves *e* — Interference to vision signal from a CW or frequency-modulated sound signal, with no special control of the nominal frequency difference between the carriers of the wanted and unwanted signals. When the interfering sound signal is amplitude-modulated, the protection ratios should be increased by 4 dB.

Curves *g* — Interference to vision signal from a CW or frequency-modulated sound signal, when the nominal frequency difference between the carrier of the wanted signal and the sound carrier, during quiescent periods, is an odd multiple of half the line frequency (7812·5 or 10 237·5 Hz).

6.3 *Wanted-sound signal amplitude-modulated, unwanted-sound signal frequency-modulated*

Protection ratio:

- — for carriers separated by frequency below 1000 Hz: 40 dB;
- — for carriers separated by 25 kHz: 30 dB;
- — for carriers separated by 50 kHz: 12 dB.

6.4 *Wanted-sound signal frequency-modulated, unwanted-sound signal amplitude-modulated*

Protection ratio: 30 dB.

RECOMMENDATION 419

DIRECTIVITY OF ANTENNAE IN THE RECEPTION OF BROADCAST SOUND AND TELEVISION

(1963)

The C.C.I.R.

UNANIMOUSLY RECOMMENDS

that the characteristics of directivity of the receiving antennae of Fig. 1 can be used for planning broadcast sound or television service in Bands I to 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 — The Special Regional Conference, Geneva, 1960, and the European VHF/UHF Broadcasting Conference, Stockholm, 1961, did not take the directional characteristics of antennae into consideration for sound broadcasting.

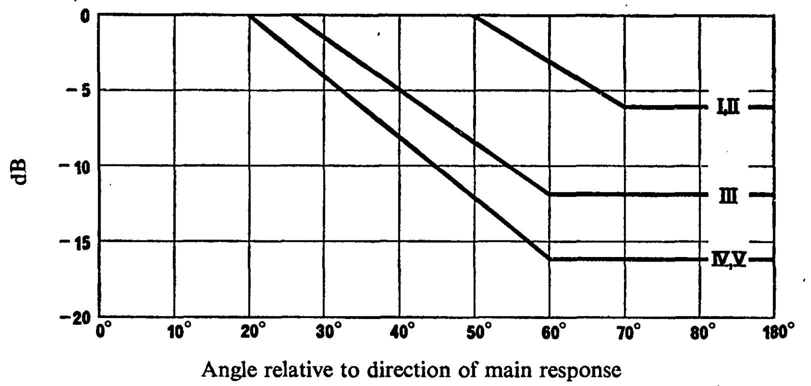

FIGURE 1

Discrimination obtained by the use of directional receiving antennae in broadcasting

(The number of the broadcasting band is shown on the curve)

REPORT 122-2 *

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)

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.

2. Band 9 (UHF)

Experiments have been conducted in the United Kingdom to determine the polarization discrimination in band 9 (UHF) of receiving antennae 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° ± 90° relative to the direction of main response, measurements confirmed that at least 20 dB

* Adopted unanimously.

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 antennae; 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.

This Report is considered to provide a sufficient answer to Question 101 for practical use, and this Question should now be concluded.

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REPORT 306-2 *

RATIO OF WANTED-TO-UNWANTED SIGNAL FOR COLOUR TELEVISION

(Question 4-1/11)

(1963 – 1966 – 1970 – 1974)

1. Introduction

The protection ratios required by amplitude-modulation vestigial-sideband colour television systems are considered in this Report. Except where otherwise stated, the standard of protection adopted throughout is that corresponding to a protection ratio of 30 dB with non-precision carrier offset of two-thirds of the line frequency, f_H, for interference between two 625-line monochrome signals. This is the standard adopted in Recommendation 418-2 and is considered acceptable for planning purposes for interference occurring between 1% and 10% of the time.

When making use of the protection ratios for planning, suitable allowance for fading should be made by using field-strength curves appropriate to the percentage of time for which protection is desired, it being assumed that the fading of the wanted signal is small, compared with that of the unwanted signal.

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* Adopted unanimously.

In all cases, the protection ratios quoted refer to the ratios at the input to the receiver, no account having been taken of the effect of using directional receiving antennae or of the advantage that can be obtained by using different polarization of transmission for the wanted and unwanted signals.

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 the case of positive modulation), 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 the purposes of planning, it may be assumed that the power in the chrominance channel at peaks of the colour modulation envelope cannot exceed a value 14 dB lower than the power in the main carrier at peaks of the modulation envelope.

All the protection ratios quoted refer to interference from a single interfering source.

2. Protection ratio conditions

2.1 *Non-controlled*

No special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

2.2 *Non-precision offset*

Difference between the nominal frequencies of the two carriers is suitably related to the line frequency; the precision of the nominal carrier frequencies being $\pm$ 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.

2.3 *Precision offset*

Difference between the nominal frequencies of the two carriers is suitably related to the line and field frequencies, but with a precision of each of the nominal carrier frequencies of the order of ± 1 Hz and a stability of the line frequencies equal to or better than 1×10^{-6}.

The protection ratios obtained through the application of precision offsets, presumes that the amplitude of the short-term instability of the carrier frequencies is maintained within acceptable limits which depend on the frequency of the deviations corresponding to the instability.

3. Co-channel interference-protection ratios for mutual interference between any of the seven systems B, D, G, I, K, K1 and L

3.1 *Carriers separated by less than 1000 Hz, but not synchronized*

Protection ratio: 45 dB.

3.2 *Nominal carrier frequencies separated by 1/3, 2/3, 4/3 or 5/3 of the line frequency*

Protection ratio: 30 dB *.

3.3 *Carriers separated by 1/2 or 3/2 of the line frequency*

Protection ratio: 27 dB *.

3.4 For systems B/PAL, G/PAL, I/PAL and L/SECAM, the protection ratios are given in decibels in Table I:

* If the wanted signal is system D, K or L, and the interfering signal is system G, the protection ratio must be increased to 35 dB to avoid interference from the unwanted sound signal.

TABLE I

Offset (multiples of 1/12 line-frequency)		0	1	2	3	4	5	6	7	8	9	10	11	12
Transmitter stability ±500 Hz (non-precision offset)	*T*	45	44	40	34	30	28	27	28	30	34	40	44	45
	C	52	51	48	43	40	36	33	36	40	43	48	51	52
	L P	60	60	57	54	50	45	42	45	50	54	57	60	60
Transmitter stability ±1 Hz (precision offset)	*T*	30	34	30	26	22	22	24	22	22	26	30	34	30
	C	36	38	34	30	27	27	30	27	27	30	34	38	36
	L P	45	44	40	36	36	39	42	39	36	36	40	44	45

T : tropospheric interference, 1% to 10% of time (reference 30 dB at 8/12 line frequency)
C : continuous interference (reference 40 dB at 8/12 line frequency)
LP : limit of perceptibility

The protection ratios given are valid up to about 50 kHz if multiples of the line frequency be added to the first line of this table.

3.5 For systems B/SECAM and G/SECAM, the protection ratios in decibels are given in Table II:

TABLE II

Offset (multiples of 1/12 line frequency)		0	1	2	3	4	5	6	7	8	9	10	11	12
Transmitter stability ±500 Hz (non-precision offset)	*A*	50	46	37	36	32	30	31	30	32	36	37	46	50
	B	42	45	42	37	31	28	25	28	31	37	42	45	42
Transmitter stability ±1 Hz (precision offset)	*A*	41	36	28	24	24	26	25	26	24	24	28	36	41
	B	36	35	32	26	23	23	24	23	23	26	32	35	36

A: unwanted PAL or SECAM modulated carrier with slightly different line frequency, $\Delta f \approx 1$ Hz.
B: unwanted SECAM modulated carrier with the same line frequency.

In addition to luminance interference, slight chrominance interference appears for frequency offsets $(5/12)f_H$ to $(7/12)f_H$.

4. Protection ratio curves

4.1 *525-line NTSC system*

The curve shown in Fig. 1 gives the protection ratio required for 525-line colour television signals using the NTSC system.

4.2 *525-line PAL system*

The curve shown in Fig. 1 also gives the protection ratio required for 525-line colour television signals using the PAL system.

4.3 *625-line SECAM system, standard L*

The curves shown in Fig. 2 give the protection ratios for the 625-line colour television signal using the SECAM system, standard L, for interference from a CW or frequency-modulated sound signal.

Curve A: non-controlled condition.

Curve B: non-precision offset condition.

Curve C: precision offset condition.

The optimum offset from the multiple nearest the line frequency is as follows:

Curve B (non-precision offset): from $(5/12) f_H$ to $(7/12) f_H$

Curve C (precision offset):

in the luminance spectrum between 0 and 3·2 MHz:

— deviation of $(2n + 1)$ 25 Hz in the vicinity of a mean deviation of $\pm$ 5·5 kHz from a multiple of the line frequency;

in the chrominance spectrum between 3·8 and 4·8 MHz:

— deviation of $\pm n \times 50$ Hz in the vicinity of the multiple of the line frequency with not too great a value of n.

4.4 *625-line SECAM system, standards B and G*

The curves shown in Fig. 3 give the protection ratio required for the 625-line colour television signal using the SECAM system, standards B and G, when the interfering signals are as follows:

4.4.1 Curve A refers to the case of a video modulated carrier, PAL or SECAM, with slightly different line frequency, $\Delta f \approx 1$ Hz.

4.4.2 Curve B refers to the case of a video modulated carrier, SECAM, with the same line frequency.

4.4.3 Curve C refers to an unmodulated or amplitude-modulated carrier (1000 Hz; 50% modulation).

4.4.4 Curve D refers to a frequency-modulated carrier (1000 Hz; 50 kHz deviation).

4.5 *625-line SECAM system, standards D and K*

Curves giving the protection ratio for television signals using the 625-line SECAM systems D and K are in course of preparation.

4.6 *625-line PAL system, standards B and G*

The curve shown in Fig. 4 gives the protection ratios for the 625-line colour television signal using the PAL system, standards B and G, for interference from a CW signal.

The curves shown in Fig. 5 give the necessary protection ratios for interference from a carrier negatively modulated by colour signals.

Curve A: non-controlled condition.

Curve B: non-precision offset condition.

Curve C: precision offset condition.

The optimum offset value depends upon the allocation of the carrier of the interfering signal in the channel of the wanted signal. There can be three different conditions with the following optimum offsets:

— interfering co-channel signal:

non-precision offset: from $+ 5/12 f_H$ to $+ 7/12 f_H$ or from $- 5/12 f_H$ to $- 7/12 f_H$
precision offset : suitable frequency near to $\pm 8/12 f_H$ or near to $\pm 7/12 f_H$

— interfering signal in the frequency band which affects the luminance signal (− 1·5 MHz to + 3·5 MHz):

offset: $\pm n f_H + 1/2 f_H$

— interfering signal in the frequency band which affects the chrominance signal (+ 3·5 MHz to + 5 MHz):

offset: $n f_H + 7/12 f_H$

4.7 *625-line PAL system, standard I*

The curve shown in Fig. 6 gives the estimated values of protection ratio for the 625-line colour television signal using the PAL system, standard I, for interference from a CW or frequency-modulation sound signal.

The curves shown in Fig. 7 give estimated values of protection ratio for interference from a television signal.

Curve A: non-controlled condition.

Curve B: non-precision offset condition.

Curve C: precision offset condition.

Curve D: standard I interfering television signal.

Curve E: standard B or G interfering television signal.

For curves B and C, it is assumed that the frequency difference between the carriers of the wanted and unwanted signal are adjusted over the range of one line frequency for minimum interference. For curve B the optimum would be an odd multiple of half the line frequency. For curve C, the optimum frequency difference up to 3·6 MHz is greater or less than a multiple of the line frequency by an amount which is in the region of one-third line frequency, but is finely adjusted to be an odd multiple of the picture frequency (25 Hz): for higher frequencies it should differ from the colour signal component by a carefully chosen frequency: for example, a line frequency harmonic plus 2631·25 Hz, which is near one sixth of the line frequency and 18·75 Hz below a harmonic of the field frequency of 50 Hz.

Also, for curves B and C, it is assumed that the vision-carrier offsets would be accompanied by suitable sound-carrier offsets as considered in § 6 of Recommendation 418-2. Otherwise greater protection ratios would be needed for frequency differences very close to zero for system I unwanted signals (or close to 0·5 MHz for standards B and G) because of interference between the sound channels.

5. Adjacent-channel interference

5.1 *Lower adjacent-channel interference*

The protection ratios are the same as those quoted for monochrome television in Recommendation 418-2, § 3.2.

5.2 *Upper adjacent-channel interference*

The protection ratios are the same as those quoted for monochrome television in Recommendation 418-2, § 3.3.

6. Protection ratios between sound signals

Protection ratios between sound signals are given in Recommendation 418-2, § 6.

Curves for the audio-frequency signal-to-noise ratio corresponding to a constant radio-frequency protection ratio of 30 dB are given in Fig. 8 as a function of the carrier-frequency offset. These curves may be assumed to be valid for all 625-line systems using frequency-modulated sound transmission.

Audio-frequency signal-to-noise ratios corresponding to other radio-frequency protection ratio values may be readily deduced because of the closely linear relationship; for example, for a 22 dB radio-frequency protection ratio (acceptable for a small percentage of the time with precision offset of 2/3 or 5/3 line frequency under tropospheric propagation conditions), the audio-frequency signal-to-noise ratio values will be 8 dB lower.

Taking into account that the audio-frequency signal-to-noise ratio will become rather poor if precision offset operation of the vision transmitters is envisaged, it is evident that 5/3 line-frequency operation is to be preferred to 2/3 line-frequency offset working.

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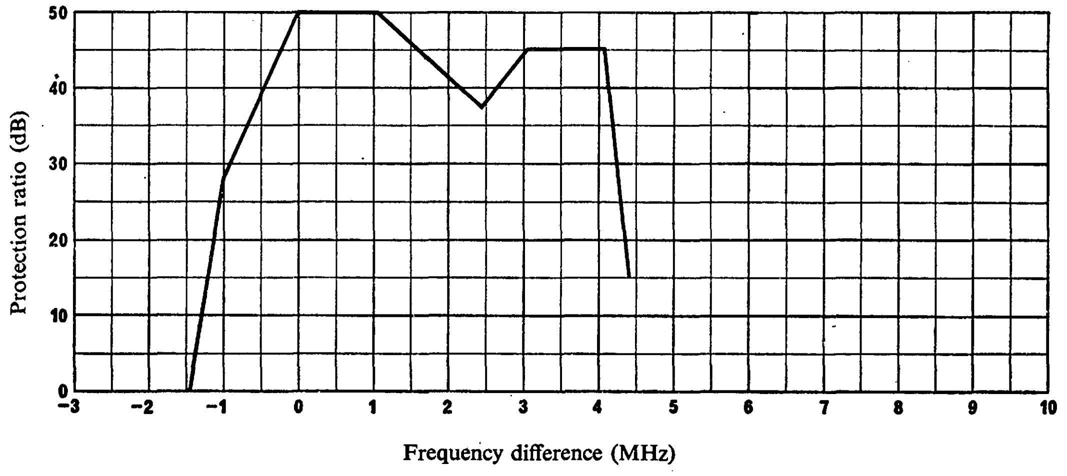

FIGURE 1

Protection ratios for the 525-line NTSC or PAL colour television system

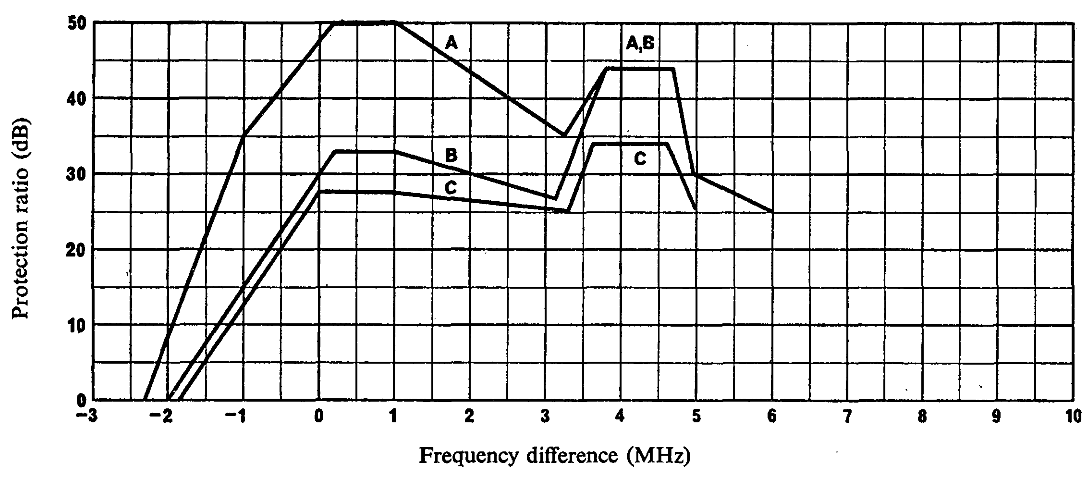

FIGURE 2

Estimated protection ratios for a SECAM (standard L) colour television system

(Interference from a CW or frequency-modulated sound signal)

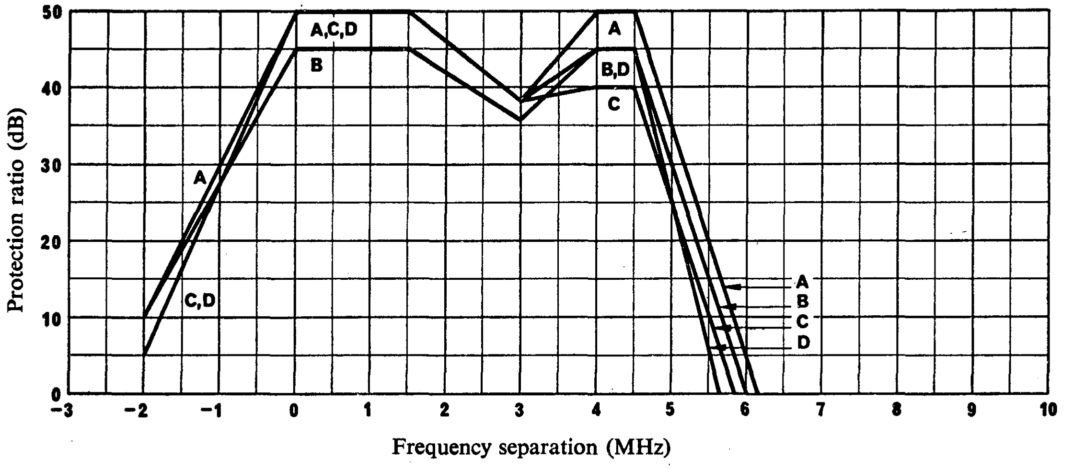

FIGURE 3

Protection ratios for a SECAM 625-line (standards B and G) colour television system

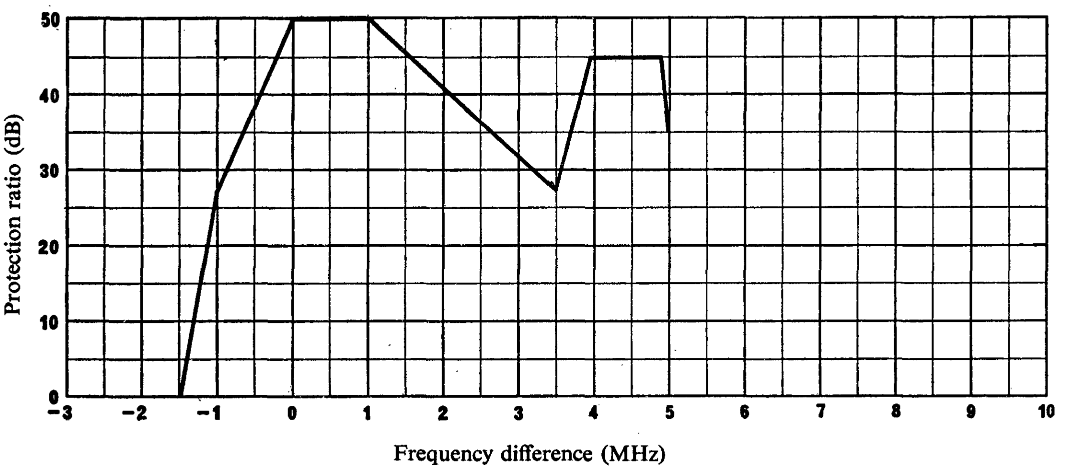

FIGURE 4

Estimated protection ratios for the 625-line PAL colour television system (standards B and G)

(Interference from a CW signal)

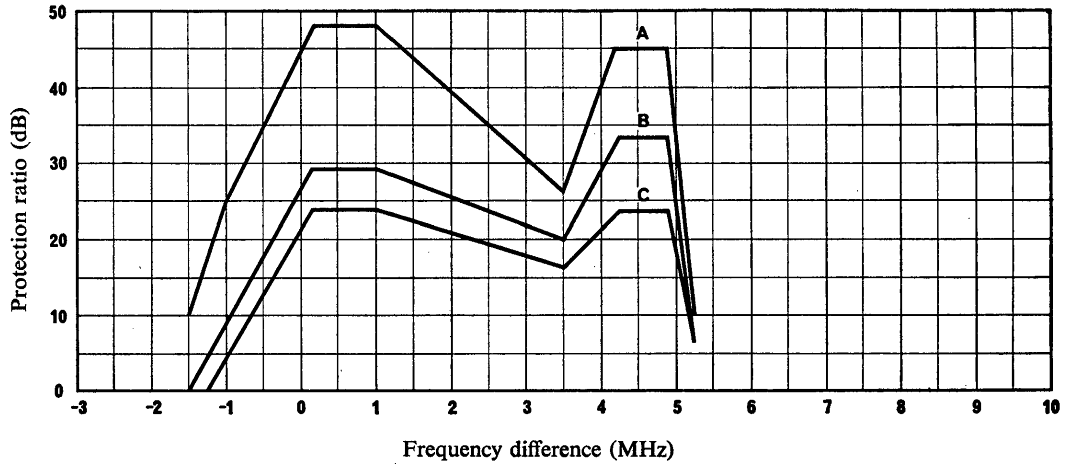

FIGURE 5

Estimated protection ratios for the 625-line PAL colour television system (standards B and G)
(Interference from a video-modulated signal)

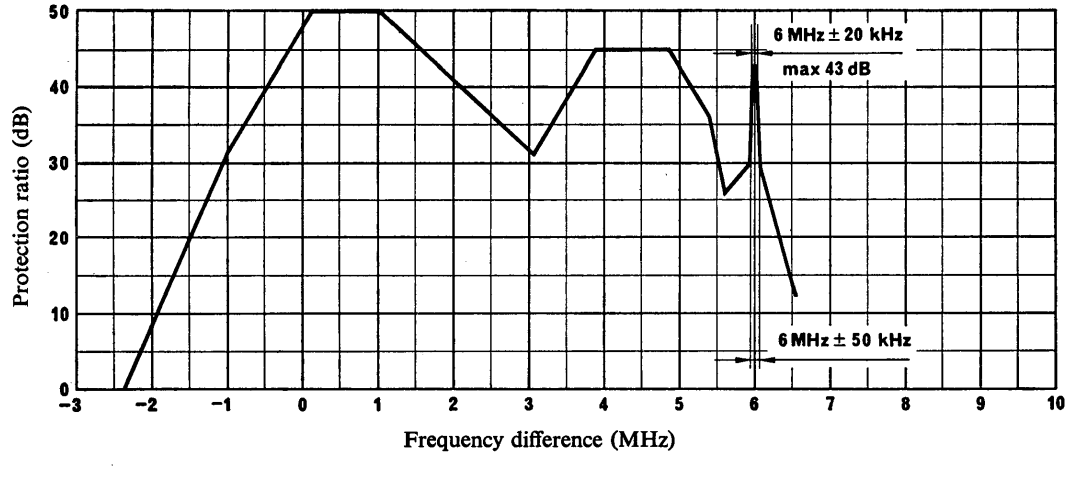

FIGURE 6

Estimated protection ratios for the 625-line PAL colour television system (standard I)
(Interference from a CW or frequency-modulated sound signal)

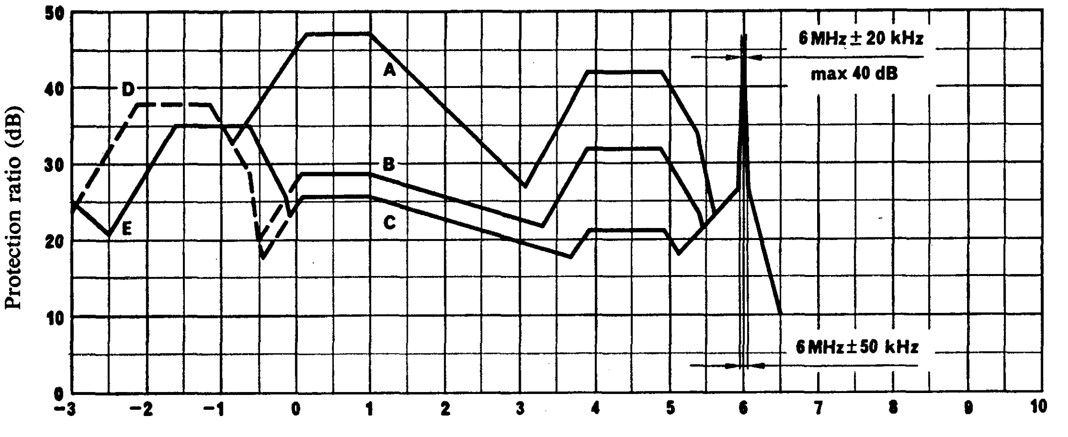

FIGURE 7

Estimated protection ratios for the 625-line PAL colour television system (standard I)

(Interference from a television transmission)

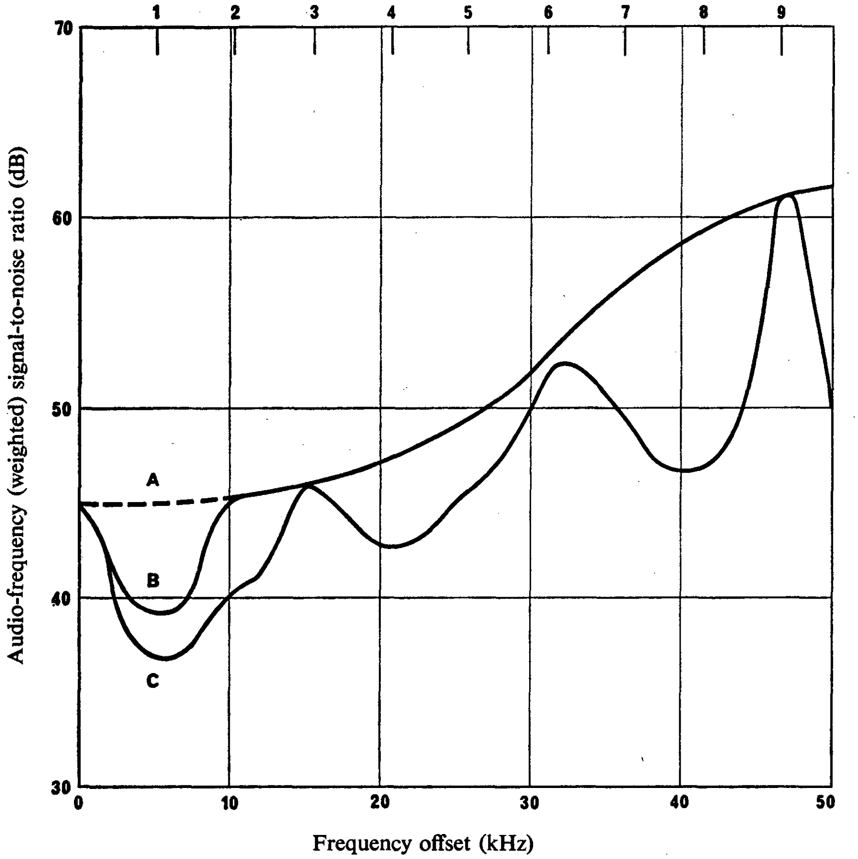

FIGURE 8

Audio-frequency signal-to-noise ratio (weighted) for a radio-frequency protection ratio of 30 dB

Wanted sound transmitter : unmodulated
Interfering sound transmitter: modulated with "coloured noise", r.m.s. deviation ±15 KHz
Curve A: split-sound demodulation
Curve B: inter-carrier demodulation (black picture)—for both wanted and interfering emissions
Curve C: inter-carrier demodulation (white picture)—for both wanted and interfering emissions

REPORT 307 *

PROTECTION RATIOS FOR TELEVISION IN THE SHARED BANDS

Protection against radionavigation transmitters operating in the band 582 to 606 MHz

(Question 4-1/11)

(1963)

1. Introduction

This Report is based on subjective tests carried out in Belgium, France and the United Kingdom. The results of some of these tests were used for planning purposes at the European VHF/UHF Broadcasting Conference, Stockholm, 1961 **, and, after some amendments, for the Special Agreement relating to the use of the band 582 to 606 MHz by the radionavigation service, Brussels, 1962.

The tests were carried out with monochrome television signals, but the results were assumed to apply also to colour television signals. Further tests, however, are needed to confirm this assumption.

It is considered that the protection ratios quoted in this Report should, in general, be afforded for at least 99% of the time.

The protection ratios quoted apply to the signal at the input of the television receiver. The level of the television signal is expressed in terms of the power at the peak of the modulation envelope and that of the radionavigation signal as the power at the peak pulse level.

2. Protection ratios required when the radionavigation signal falls within the passband of the television receiver

It has been found that, when the radionavigation signal falls within the passband of the television receiver, the required signal-to-interference ratio is:

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.

3. Protection ratios required when the radionavigation signal falls outside the passband of the television receiver

Reference should be made to Recommendation 418-2, § 5, for second-channel (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 antennae, are situated near receiving locations, especially where the television signal is weak.

* Adopted unanimously.

** However, at Stockholm, some delegates made reservations as to the prospect of fulfilling the technical criteria in the actual planning.

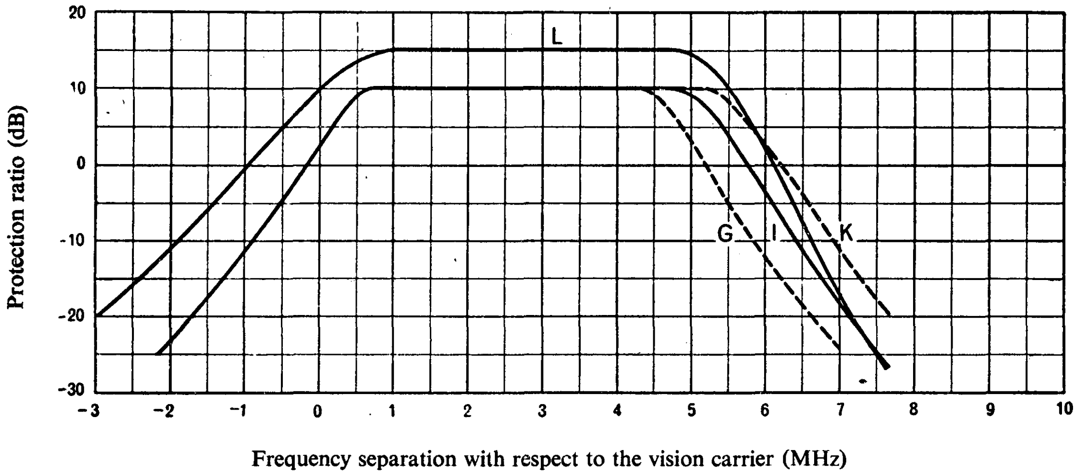

FIGURE 1

Protection ratio required by a picture signal against a radionavigation signal in the band 582 to 606 MHz

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REPORT 315-3 *

REDUCTION OF THE BANDWIDTH REQUIRED FOR THE TRANSMISSION OF A TELEVISION SIGNAL

(Study Programme 11A-1/11)

(1963 – 1966 – 1970 – 1974)

During recent years extensive studies have been carried out in the field of bandwidth reduction in television transmission. To facilitate further work in this field, it seems appropriate to give a list of documents and publications relating to this problem. The list may be extended to include subsequent work on this subject within the scope of Study Programme 11A-1/11.

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* Adopted unanimously.

REPORT 479 *

PROTECTION RATIOS FOR TELEVISION WHEN BOTH WANTED AND UNWANTED SIGNALS ARE SUBSTANTIALLY NON-FADING

(1970)

In planning networks of television transmitters it has so far been assumed, at least for Bands I and III, that interference from an unwanted co-channel television transmission will occur for only a small proportion (say up to 10%) of the time, because it has been possible to ensure adequate geographical separation between wanted and unwanted transmitters.

In spite of the use of high-power transmitters using high-gain aerials situated in elevated positions, it has been found necessary, particularly in the UHF bands, to supply a relatively large number of low-power (say less than 10 kW e.r.p.) relay stations, not only in the region just outside the service area of a main (high-power) station, but also within the nominal service area. In this way the smaller areas that may have high population density may also be adequately served.

A network of main and relay stations such as can be envisaged from the above description will need to use the same channel many times, due to the restricted number of channels available. The same channel will reappear in many different locations and several such locations may be geographically quite close together.

This Report considers the protection ratio required for a wanted emission that suffers interference from a single unwanted emission, at a receiving site which is relatively close to the latter. In this case, the interference will be almost continuous and the protection ratios given in Recommendation 418-2, based as they are upon interference that is present for only a small proportion of the time (say up to 10%), will, it is thought, be unacceptable.

This Report assumes that there must be a relationship between the percentage of time for which interference is present and the criterion of impairment that should be used when planning a television broadcasting service. Thus, if the criterion of impairment be taken as "definitely perceptible but not disturbing" for interference present for about 10% of the time, then the criterion for interference that is present for almost all the time might well be taken as "just perceptible". It is assumed that an increment of 10 dB added to the protection ratios given in Recommendation 418-2 would change the criterion from the "definitely perceptible but not disturbing" value to the "just perceptible" value. Evidence in favour of the figure of 10 dB arises from two sources. The first may be found in the first paragraph of the Introduction to the Annex to Recommendation 418-2. The second source of information was an analysis of results from co-channel interference tests that were conducted by the B.B.C. in 1962.

When planning co-channel emissions that will suffer from almost continuous interference it is essential to bear in mind that it is the *median* level of the (almost non-fading) interfering signal that the wanted (non-fading) signal level should exceed by an adequate margin. That is, the interfering signal and the wanted signal must be taken from the appropriate C.C.I.R. propagation curve for 50% of the time (Recommendation 370-2) rather than from the curves for 10% or 1% of the time.

We thus have possible rules to aid in planning. One procedure should be adopted for long-distance interference and the other for short-distance cases where fading scarcely occurs, that is, where the "fading range" of the interfering signal is less than, say, 10 dB. For these purposes, the fading range may be defined as the difference in decibels between the field strength exceeded for 1% of the time and that exceeded for 50% of the time (the median value of the field strength)**. Use of the fading range as the criterion to adopt in deciding whether the interference is long-distance or short-distance is more precise

* Adopted unanimously.

** The fading range is, of course, directly related to the standard deviation of the statistical distribution curve expressing field strength as a function of percentage of time.

than choosing a geographical distance that would take no account of the irregularity of the terrain intervening between the interfering transmitter and the service area of the wanted transmitter. Furthermore, the fading range takes account of the height of the antenna of the interfering transmitter.

The procedures may be summarized as follows:

— if the fading range is equal to or greater than 10 dB, the interference is "long-distance" and the appropriate protection ratio taken from Recommendation 418-2 must be added to the field-strength curve (from Recommendation 370-2) appropriate to the desired percentage of time for which protection is required. Note that the fading range of the wanted signal may have to be taken into account;

— if the fading range is less than 10 dB, the interference is "short-distance" and in this case it is suggested that 10 dB be added to the value of the protection ratio obtained from Recommendation 418-2 and the sum of these two quantities be then added to the median value curve for 50% of the time (from Recommendation 370-2) of the field strength curve of the interfering emission.

In addition to the non-fading signals considered in this Report, there are conditions in which the wanted signal fades and the interfering signal does not fade. Moreover, in some conditions *both* signals fade. A general procedure for planning, taking into account the presence or absence of time-fading of both signals and also of their variation in field strength from location to location, is given in Report 485.

REPORT 480 *

PROTECTION RATIOS FOR NON-PRECISION OFFSETS BETWEEN TELEVISION SIGNALS THAT ARE MULTIPLES OF ONE-TWELFTH THE LINE FREQUENCY

(Question 4-1/11)

(1970)

1. Introduction

The information given in this Report is supplementary to the technical data that were available to the European VHF/UHF Broadcasting Conference, Stockholm, 1961. Although the information given below is directly applicable to all 625-line monochrome television systems it is believed that it is also valid for all 625-line colour television systems.

2. Protection ratios for offsets that are multiples of one-twelfth the line frequency

The Table gives figures based on the assumption of transmitter stabilities of ± 500 Hz. The figures are valid at multiples of one-twelfth line frequency up to about 50 kHz.

Offset (multiples of 1/12 line frequency)	0	1	2	3	4	5	6	7	8	9	10	11	12
Protection ratio (dB)	45	44	40	34	30	28	27	28	30	34	40	44	45

Administrations concerned are invited to undertake further studies of the figures given in the Table in their television networks.

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* Adopted unanimously.

REPORT 482 *

RECOMMENDED CHARACTERISTICS FOR COLLECTIVE AND INDIVIDUAL ANTENNA SYSTEMS FOR DOMESTIC RECEPTION OF SIGNALS FROM TERRESTRIAL TRANSMITTERS

(Question 7-1/11)

(1970)

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 and 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.

It does not apply to television antennae for wired distribution systems.

2. Frequency range

The parts of bands 8 (VHF) and 9 (UHF) allocated to broadcasting and used for television.

3. Amplitude/frequency characteristic

The amplitude/frequency characteristic of the system, excluding the antenna, should be uniform within 3 dB for each channel at each individual outlet.

4. Nominal output impedance

In unbalanced systems, the nominal impedance should be 75 Ω.

In balanced systems, the nominal impedance should be 300 Ω.

5. Noise figure (see Recommendation 331-3, § 2) in particular when the system includes active elements:

— lower part of band 8 (VHF)	⩽ 9 dB
— upper part of band 8 (VHF)	⩽ 9 dB
— lower part of band 9 (UHF)	⩽ 12 dB
— upper part of band 9 (UHF)	⩽ 15 dB

unless the peak-to-peak picture signal-to-r.m.s. unweighted noise ratio at the video signal output of the receiver is greater than 37 dB.

6. Reflection coefficient

	Band 8	*Band 9*
Passive equipment	⩽ 0·25	⩽ 0·33
Couplers and filters	⩽ 0·33	⩽ 0·33
Active equipment	⩽ 0·33	⩽ 0·33

* Adopted unanimously.

7. Interference

7.1 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 (in the sense of Recommendation 418-2 or Report 306-2) with reception from the wanted transmitters, in the service area as defined by the protected field.

7.2 An echo, whether it originates outside or inside the installation will not be considered as interfering if the wanted signal/echo ratio is greater than or equal to 20 dB.

The case of multiple echoes remains to be studied.

7.3 The installation, in particular the devices for preventing interference or echoes, e.g.:

— high-gain antennae with a front-back ratio of not less than 18 dB,
— multiple antennae,
— echo correctors,

should not cause, in the channels of the transmissions normally received, discernible defects such as smear, hum, loss of synchronization, interference patterns, or interference in general.

8. Signal level at each outlet

The following are the limits within which the signal to be applied to the television receiver should lie, measured at the terminals of the appropriate resistance:

	Maximum (dBm)	*Minimum* (dBm)
— lower part of band 8 (VHF)	— 20	— 51
— upper part of band 8 (VHF)	— 20	— 51
— lower part of band 9 (UHF)	— 30	— 48
— upper part of band 9 (UHF)	— 30	— 48

9. Colour television

The system, including the antenna, should be capable of receiving broadcasts in colour made according to the C.C.I.R. system in use by the transmissions to be received. In particular, the amplitude of the sub-carrier should not differ from its nominal value by more then ± 2 dB. This value refers to the system excluding the antenna (see § 3). Particular care must be taken regarding intermodulation products between vision, sound- and colour-carrier frequencies falling into the useful radio-frequency band.

10. Oscillators and other equipment used in the system

The levels of the energy radiated and of the energy reinjected into the distribution system should be less than the values which may be specified by the C.I.S.P.R.

The total frequency drift of the oscillators should not exceed the value of ± 75 kHz for variations in the supply voltage of ± 10% and a temperature range of — 10° C to + 55° C.* This value applies to both band 8 (VHF) and band 9 (UHF).

11. Isolation between 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.

* Further information is requested.

Note. — 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.

12. Antenna characteristics

The gain shall be expressed relative to that of a half-wave dipole for each of the channels to be received.

Subject to further studies, the directivity characteristics of the antenna should meet the provisions of Recommendation 419.

The antenna gain should be uniform within $\pm$ 2 dB throughout the bandwidth of each of the channels which are indicated as being receivable by the antenna.

The impedance should be matched to the nominal impedance of the system used (see § 4).

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.

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REPORT 483-1 *

SPECIFICATIONS FOR LOW-COST MONOCHROME TELEVISION RECEIVERS

(Question 13/11)

(1970 - 1974)

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 the following documents:

Docs. XI/53 (Italy), XI/132 (United Kingdom), XI/164 (France), XI/185 (Italy) and XI/192 (India), 1966–1969, 11/112 (Italy) and 11/120 (Netherlands), 1970–1974.

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.

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* This Report, which was adopted unanimously, is also of interest to Study Group 1.

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 antennae, 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.

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 Administration concerned.

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 (1959), 106A (1962) and 107 (1960). National regulations or tests differing from these standards should be quoted.

* The IEC Publications quoted in the text are the most up-to-date issues at the time of preparation of the Report.

1.7 *Receiver tuning*

For all the measurements which follow, the receiver should be accurately tuned as described in IEC Publication 107, § 1.4.8.2 or, if this is not appropriate, in some other specified manner.

2. General specifications

		Type A	*Type B*
2.1	*Recommended size (diagonal) for the screen*	28 cm (11 in.) or larger	48 cm (19 in.) or larger
2.2	*Frequency bands*	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 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%.

3. Input characteristics

3.1	*Input impedance at the antenna terminals (Ω)*	75 or 300	75 or 300
3.2	*Toleration of surge discharges at the input circuit (IEC Publication 315-1, § 6)*		
	Energy of each discharge (μJ)	...	...
3.3	*Maximum noise figure* (dB) *(least favourable channel)*		
	Band 8 — VHF	10	8
	Band 9 — UHF	16	12
3.4	*Noise-limited sensitivity at a signal-to-noise ratio of 30 dB and standard output (IEC Publication 107, § 3.3)* (dBm)		
	Band 8 — VHF	– 50	– 60
	Band 9 — UHF	– 40	– 55

* The value is under study.

		Type A	Type B
3.5	*Characteristic of the automatic gain control (IEC Publication 107, §§ 3.6 and 3.7)*		
	(– 20 to – 50 dBm) (dB)	8	6
4.	**Output characteristics**		
4.1	*Minimum audio-frequency pass-band within 6 dB (IEC Publication 107, § 12.3)* (Hz)	150 to 5000	150 to 5000
4.2	*Minimum audio-frequency output at 10% distortion (IEC Publication 107, § 13.2.5)* (W)	0·5	2
4.3	*Minimum picture resolution* * *(IEC Publication 107, § 2.6) (lines per picture height)*		
	— 6 MHz channel systems (4·5 MHz intercarrier frequency)	225	280
	— 7 or 8 MHz channel systems (5·5, 6 or 6·5 MHz intercarrier frequency)	270	320
4.4	*Minimum brightness at white level for a black level of 3 cd/m² (IEC Publication 107, § 2.4.1)*		
	— 50 fields/s system (cd/m²)	70	120
	— 60 fields/s system (cd/m²)	70	150
4.5	*Minimum interlace ratio (IEC Publication 107, § 2.9)*	30/70	30/70
4.6	*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, § 2.3.1.1)* (%)	0·8	0·4
4.7	*Maximum relative non-linearity of scan over a complete field (IEC Publication 107, § 2.3.2)* (%)	10	6
4.8	*Maximum distortion of the picture outline (IEC Publication 107, § 2.3.3)* (%)	10	6

5. Interference

5.1 *Intermediate frequency*

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.

		Type A	Type B
5.2	*Minimum rejection of the upper adjacent picture carrier (IEC Publication 107, § 4.2)* (dB)	26	32
5.3	*Minimum rejection of the lower adjacent sound carrier (IEC Publication 107, § 4.2)* (dB)	30	35
5.4	*Minimum image rejection (IEC Publication 107, § 4.5)*		
	Band 8 — VHF (dB)	40	40
	Band 9 — UHF (dB)	20	25

* Alternatively, Administrations may wish to specify their requirements on resolution in terms of an electrical bandwidth measurement (e.g. according to IEC Publication 107, § 5.2) in which case the requirement must be negociated with the manufacturer.

** For economic reasons the number of different intermediate frequencies should be kept to a minimum (see Report 184-2).

			Type A	Type B
5.5	*Minimum intermediate-frequency rejection (IEC Publication 107, § 4.4)*			
	Band I — VHF	(dB)	20	20
	Band III — VHF, Bands, IV, V — UHF	(dB)	30	30
5.6	*Minimum crosstalk (IEC Publication 107, § 4.8.1)*			
	Vision into sound	(dB)	30	30
	Sound into vision	(dB)	40	40
5.7	*Minimum attenuation of the sound carrier relative to the vision carrier at the video detector*	(dB)	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 106/106A)* — In accordance with Recommendation No. 24/2 of the C.I.S.P.R.

Note. — Unless otherwise specified by the Administration concerned, no measurements will be made below 0·5 MHz (LF Broadcasting).

6. Stability

			Type A	Type B
6.1	*Maximum drift of the local oscillator between 2 min and 60 min after the picture appears (IEC Publication 107, § 6.1.3)*			
	VHF	(kHz)	± 300	± 300
	UHF	(kHz)	± 500	± 500
6.2	*Drift of the local oscillator due to a change of ± 10% in the supply voltage (IEC Publication 107, § 6.1.6)*	(kHz)	± 100	± 100
6.3	*Minimum range of lock-in (IEC Publication 107, § 6.2.3)*			
	Vertical, Horizontal	(%)	± 1	± 1
6.4	*Minimum range of hold (IEC Publication 107, § 6.2.3)*			
	Vertical, Horizontal	(%)	± 2	± 2

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.

	Type A	*Type B*
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. (Doc. 11/127 (U.S.S.R.), 1970–1974) are classified in four categories: 1, 2, 3 and 4.

2. The classification is based on the differences in the basic technical characteristics which to a large extent determine picture and sound quality. Basically, these characteristics determine the cost of the receivers.

3. Category 3 and 4 receivers are low-cost receivers possessing the following characteristics:

Characteristics	Typical values of characteristics (See Note 1)	
	3(*B*)	4(*A*) (See Note 2)
(1)	(2)	(3)
1. Size (diagonal) of screen (cm) not less than	47	
2. Frequency bands (See Note 3)	I, II, III, IV, V	I, II, III, IV, V
3. Noise limited sensitivity (dBm) of picture channel at a peak-to-peak video signal-to-noise ratio of 20 dB	−68	−68
4. Synchronization-limited sensitivity of picture channel (dBm)	−68	−68
5. Characteristic of the automatic gain control which maintains output-signal variations at 3 dB for input variations of the number of dB indicated	30	30
6. Minimum picture resolution (lines):		
— horizontally	400	350
— vertically	450	350
7. Maximum non-linearity of picture over a complete field (%):		
— horizontally	±10	10
— vertically	±10	10
8. Maximum geometrical distortion (%)	3	3
9. Maximum detuning of the frequency detector during warming up (kHz)	±20	±25
10. Minimum noise-limited sensitivity of the sound channel (dBm)	−68	−68
11. Minimum mean (nominal) sound pressure (N/m²)	0·4	0·2
12. Frequency characteristic of the sound channel relative to sound-pressure variations of not more than 14 dB; not worse than (Hz)	125 to 7100	150 to 5000
13. Non-linear distortion coefficient of the sound channel at a nominal value:		
— in the band 200 to 400 Hz	7	10
— above 400 Hz	5	8
14. Minimum selectivity (dB)		
band −1·5 and less	30	28
point −1·5	32	30
band +8·0 and above	34	30

Characteristics	Typical values of characteristics (See Note 1)	
	3(*B*)	4(*A*) (See Note 2)
(1)	(2)	(3)
15. Drift of local oscillator frequency due to a change of +5 to −10% (kHz) Bands I-III	±300	±300
16. Maximum admissible input signal level in dB(mW/mV) not less than	−10	−10
17. Minimum brightness (cd/m²)	100	100
18. Intermediate frequency (MHz) of:		
— picture signals	38·0	38·0
— sound signals	31·5	31·5

Note 1. — The parameters were measured in accordance with IEC Publication 107.

Note 2. — Only portable receivers are manufactured to Category 4 specifications.

Note 3. — Provision is to be made for reception of Bands IV and V by incorporating tuning units in the television receivers at a later date.

REPORT 484-1 *

RATIO OF PICTURE-SIGNAL TO SYNCHRONIZING-SIGNAL

(Question 1/11, Study Programme 1D/11)

(1970 - 1974)

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 [C.C.I.R., 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.

* Adopted unanimously.

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REPORT 485*

CONTRIBUTION TO THE PLANNING OF BROADCASTING SERVICES

Statistics of service

(Question 4-1/11)

(1970)

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 antennae are negligible in terms of determining the median values of field strength.

$$R(Q) = F_d\,(50,50) - F_u\,(50,50) + G_d - G_u - H(T) - H(L) \tag{1}$$

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;

$F(L', T')$: the level of field strength exceeded for T'% of the time in at least L'% of the locations (dB rel. 1 μV/m);

$F(50,50)$: median field strength in time and location (dB rel. 1 μV/m);

G : effective receiving antenna gain in the pertinent direction (dB);

$k(X)$: standard normal variate, tabulated in many statistical textbooks:
$k(50) = 0$; $k(70) = -0{\cdot}525$; $k(90) = -1{\cdot}282$; $k(99) = -2{\cdot}326$;

* Adopted unanimously.

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. $H(T)$ 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 [U.S.A.] 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 [U.S.A.].

$$L = \prod_{i=1}^{i=n} L_i = L_1 L_2 \ldots . L_n \tag{2}$$

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:

$$R(Q) + H(T) + H(L) = F_d(50,50) - F_u(50,50) + G_d - G_u \tag{3}$$

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 C.C.I.R. 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 $F_u(50,50)$. 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:

$$R(L,Q) = R(Q) + H(L) \approx F_d(50,50) - F_u(50,100\text{-}T) + G_d - G_u \qquad (4)$$

$$F_u(50,50) + H(T) \approx F_u(50,100\text{-}T)$$

$R(L,Q)$ 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 $F_d(50,50)$. Such would be the case for adjacent channel interference in System M, if the value of $R(Q) = -20$ dB, as proposed in Doc. XI/35 (U.S.A.), 1966–1969, is adopted. For such conditions:

$$R(L,Q) = R(Q) + H(L) \approx F_d(50,T) - F_u(50,50) + G_d - G_u \qquad (5)$$

$$F_d(50,50) - H(T) \approx F_d(50,T)$$

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 $H(L)$.

$$R(L,T,Q) = R(Q) + H(L) + H(T) \approx F_d(50,50) - F_u(50,50) + G_d - G_u \qquad (6)$$

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 I

Examples of values for H(L)

Frequency (MHz)		70	100	200	700
$\sigma_{ld} = \sigma_{lu} = \sigma_l$	(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

REFERENCE

U.S.A. Report of the *ad hoc* Committee for the evaluation of the radio propagation factors concerning the TV and FM broadcasting services in the frequency range between 50 and 250 Mc. Vols. I and II—Available from Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Vol. I PB 166696, Vol. II PB 166697.

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REPORT 625*

CHARACTERISTICS OF TELEVISION RECEIVERS AND RECEIVING ANTENNAE

(Question 26/11 and Study Programme 26A/11)

(1974)

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 C.C.I.R. 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.

In this Report, § 5 contains a table of additional characteristics which are not essential for planning purposes but indicate the technical parameters which determine quality.

By way of example, § 6 contains numerical values relating to the 1970–1974 principal and additional characteristics derived from Doc. 11/328 (Italy) and measured in accordance with IEC Publication 107.

The definition of these characteristics, the measuring method applied and the presentation of the results in Tables IV and V should be taken, where available, from IEC Doc. 12A (Secretariat) 171, and are provided purely for information purposes, since this document is provisional and still incomplete, but it is nevertheless the most recent version of the revision of Publication 107, which is now out of date. These tables will need to be brought up to date when the final version of this revision is issued.

It is important that C.C.I.R. 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.

* Adopted unanimously.

Attention is drawn to the importance of effective participation by the C.C.I.R. 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.

Apart from these characteristics, those relating to interference caused by television receivers should conform to the relevant C.I.S.P.R. recommendations.

Table III shows additional characteristics relating only to monochrome receivers. The characteristics of colour receivers will be added at a later stage.

2. Categories of receivers

2.1 A Planning Conference 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, a few references are given below in which the results of the many studies on the subject may be found:

Report 473-1;
Doc. 11/92 (France) 1970–1974;
Doc. 11/93 (France) 1970–1974;
Doc. 11/306 (Italy) 1970–1974;
Doc. 11/262 (United Kingdom) 1970–1974;
Doc. 11/315 (E.B.U.) 1970–1974.

3. Receiving antennae

The numerical values of antennae characteristics contained in Recommendation 419 and Reports 122-2 and 482 relate to antennae in situ. Only data relating to the directivity, forward gain and cross-polarization protection of antennae tested under idealized conditions in a suitable site need be recorded.

The necessary definitions and measuring methods are contained in IEC Publication 138, which is now being revised.

4. Principal characteristics required for planning

4.1 *List of characteristics*

TABLE I

Item	Characteristic	Reference IEC Doc. 12A (Secretariat) 171			Remarks
		Definition	Measuring Method	Presentation of results	
1	Noise-limited sensitivity	art. 105 and art. 109	art. 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 § 3 of Doc. 11/260 (United Kingdom) 1970–1974 and § 4.3 in this Report			
3	Rejection of adjacent picture carrier	art. 130	art. 131	art. 132	The most unfavourable value for each of the broadcasting bands
4	Rejection of adjacent sound carrier	art. 140	art. 141	art. 132	
5	Image-frequency rejection	art. 140	art. 141	art. 132	
6	Intermediate-frequency rejection	art. 138	art. 139	art. 132	
7	Oscillator position	High or low			
8	Tuning tolerance	art. 47	art. 48	art. 51	As a function of time
9	Receiver radiation	As specified in C.I.S.P.R. 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	U.K.	A	33·40 to 38·40	38·15	34·65
525	U.S.A.	M	41 to 47 (1)	41·25	45·75
525	Japan	M	22 to 28 (2) (4) 54 to 60 (2) (5)	22·25 54·25	26·75 58·75
625	Spain, Norway, Netherlands, Federal Republic of Germany, Sweden, Switzerland, Italy (2)	B, G	33·15 to 40·15	33·40	38·90
	U.S.S.R. and some O.I.R.T. 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)
	U.K.	I	33·25 to 41·25	33·50	39·50
	African countries (6)	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 radio récepteurs et téléviseurs (SCART).

(4) Television receivers (VHF).

(5) Television receivers, all channels (VHF and UHF).

(6) 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 (see Report 298-3). 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 information should be presented in the form of graphs 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.

5. Additional characteristics

TABLE III

Item	Parameter	Reference IEC Doc. 12A (Secretariat) 171			Remarks
		Definition	Measuring method	Presentation of result	
1	Passband (radio frequency and intermediate frequency) — video (MHz) — sound (kHz)	art. 130	art. 131 Under consideration	art. 132	For an attenuation of 0 dB rel. to vision carrier
2	Maximum luminance white (cd/m²)	2.4.1 (1)	2.4.1.2 (1)	2.4.1.3 (1)	For a black level of 2 cd/m². 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 (%)		art. 99		
5	Geometrical picture distortion (%)	art. 78	art. 79	art. 80	Total distortion
6	Scanning non-linearity (%)	art. 73	art. 74	art. 75	
7	Sound: amplitude/frequency response (Hz)	12.3.1 (1)	12.3.2 (1)	12.3.3 (1)	Overall electrical characteristics
8	Maximum sound output power (W)	13.2.5.1 (1)	13.2.5.2 (1)		
9	Inter-channel rejection — vision into sound (dB) — sound into vision (dB)	4.8.1 (1)	4.8.2.3 (1) 4.8.2.5 (1)		
10	Maximum usable input signal (dBm)	art. 126	art. 127		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, as indicated above, should be used as provisional references.

6. Results

6.1 The numerical values listed in Tables IV and V relate to systems B and G and are taken from Doc. 11/328 (Italy) 1970–1974. These are mean values derived from an extensive series of objective measurements.

The following tables are an example of how the numerical values of characteristics may be presented.

6.2 *Principal characteristics*

TABLE IV

Item	Characteristic	Country	IEC Publication 107: reference	Broadcasting band				Remarks
				I	III	IV/V	12 GHz	
1	Noise-limited sensitivity (dBm)		3.3.2	−60		−55		(1)
2	Protection ratio (dB)							
3	Rejection of adjacent picture carrier (dB)		4.2	−35				
4	Rejection of adjacent sound carrier (dB)		4.2	−40				
5	Image-frequency rejection (dB)		4.5.2	−40		−30		
6	Intermediate-frequency rejection (dB)	Italy	4.4.2	−30		−45		
7	Oscillator position			High				
8	Tuning tolerance (kHz)			±350				
9	Receiver radiation							(2)
10	Susceptibility of receiver to external interference							
11	Intermediate-frequency values			See Table I (item 11)				

(1) For a luminance signal-to-unweighted noise ratio of 30 dB and a normalized output level.

(2) See C.I.S.P.R. Recommendation No. 24/3.

6.3 *Additional characteristics*

TABLE V

Item	Parameter	Country	IEC Publication 107: reference	Broadcasting band				Remarks
				I	III	IV/V	12 GHz	
1	Selectivity (dB) — video — sound	Italy	4.2		— 6 −26			Attenuation for 4 MHz
2	Maximum luminance white (cd/m²)		2.4.1		100			(1)
3	Picture resolution (lines)		2.6		320			
4	Interlace ratio %		2.9		40/60			
5	Geometrical picture distortion (%)		2.3.3		3			
6	Scanning non-linearity (%)		2.3.2	5 to 8				
7	Sound: amplitude/ frequency response (Hz)		12.3	120 to 7000				(2)
8	Maximum sound output power (W)		13.2.5		1·2 2			(3) (4)
9	Inter-channel rejection — vision into sound (dB) — sound into vision (dB)		4.8.2.3 4.8.2.5		−30 −40			
10	Maximum usable input signal (dBm)				−30			

(1) For a black level of 3 cd/m² (for a picture tube without a grey filter).
(2) For ±3 dB relative to 1000 Hz.
(3) Diagonal dimension of picture tube: <51 cm (20 in.).
(4) Diagonal dimension of picture tube: $\geqslant 51$ cm (20 in.).

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REPORT 626*

SIMPLIFICATION OF SYNCHRONIZING SIGNALS IN TELEVISION

(Study Programme 1E/11)

(1974)

Proposals have been made that the television synchronizing signal should be simplified by on the one hand reducing the number of equalizing pulses [C.C.I.R., 1963–1966; 1966–1969; 1970–1974 a, b and c; Recommendation 472-1, note (5)] and on the other hand reducing the number of broad pulses [C.C.I.R., 1970–1974 a and b]. Study Programme 1E/11 requests investigation into the effect of reducing the number of equalizing pulses.

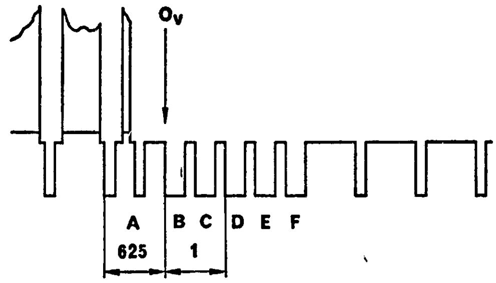
On the one hand, the simplification of the synchronizing signal leads to a simplification of synchronizing generators and, on the other hand, it makes available more line-periods of the field-blanking interval for injecting test or measuring signals, standard reference frequencies [C.C.I.R., 1970–1974d], commercial information (e.g. facsimile transmissions), auxiliary audio signals for bilingual programmes, sub-titles for the deaf, remote control and supervision of unattended centres [C.C.I.R., 1970–1974b] or for the transmission of any other information.

Studies [C.C.I.R., 1970–1974d] have been made which indicate that, in the member countries of O.I.R.T., 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 [C.C.I.R., 1970–1974c] carried out in the U.S.S.R., 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 [C.C.I.R., 1970–1974c]. In the U.S.S.R., 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 [C.C.I.R., 1970–1974 c and d].

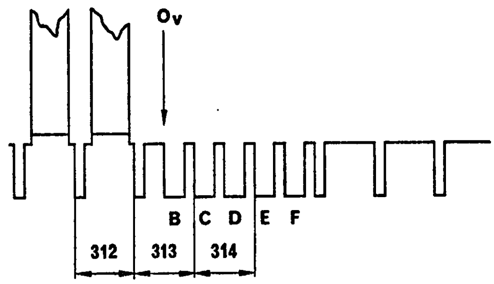
Experiments conducted in Italy [C.C.I.R., 1970–1974b] seem to indicate that one pre-equalizing pulse and no post-equalizing pulses are satisfactory for domestic receivers, provided that the single pre-equalizing pulse, situated in the middle of line number 625 (Fig. 1) has a duration of about 2·8 μs. 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 [C.C.I.R., 1970–1974a] 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 μs duration of the single pre-equalizing pulse operating upon receivers having integrators with a time-constant less than 100 μs. The reduced number of broad pulses (three) also produced a tendency for the "vertical hold" controls of some receivers to require more critical adjustment.

* Adopted unanimously.



First field



Second field

FIGURE 1

A: Single equalizing pulse at the end of each second field
B, C, D, E, F: broad pulses

Note. — Experiments mentioned in [C.C.I.R., 1970-1974 a and b] examined effect of deleting broad pulses F and E and replacing them by line sync. pulses where appropriate.

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REPORT 627 *

MINIMUM POWER FLUX-DENSITY FOR PLANNING A TERRESTRIAL TELEVISION SERVICE IN THE 12 GHz BAND (BAND VI)

(Recommendation 417-2)

(1974)

1. Introduction

In 1971 an experimental amplitude modulation terrestrial television broadcasting network in the 12 GHz band was set up in the Netherlands, using system G. The frequency converters used at the receiving points in this case have only to change the frequency from Band VI to a frequency within Bands IV and V. The converters have been mounted directly behind the parabolic reflector, giving rise to negligible feeder loss. The experiments have shown that a converter noise figure of 10 dB can be realized without excessive cost. Experience gained with the installation of the converters in different parts of the coverage area, has led to the conclusion that considering mounting facilities, beamwidth and influence of wind, an antenna diameter of 60 cm is practical.

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 Band VI.

2. Calculation of 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.

2.1 The following calculation as an example for Band VI is based on the figures mentioned in the table below.

Noise figure of converter	(dB)	F	10
Radio-frequency signal-to-noise ratio at input to television receiver	(dB)	$(S/N)_{RF}$	36
Diameter of parabolic reflector	(m)	D	0·6
Efficiency of antenna	(%)	η	50
Antenna gain	(dB rel. isotropic radiator)	G	34·5
Effective antenna area 10 log A	(m^2)	A	−8·5
10 log k $T B$	(dBW)		−137

The power flux-density Φ (dB rel. 1 W/m^2) at the receiving point is given by:

$$\Phi = F + 10 \log kTB + (S/N)_{RF} - 10 \log A \quad \text{dB rel. } 1 \text{ W/m}^2$$

This results in a minimum power flux-density for a satisfactory grade picture at the receiving antenna of −82·5 dB rel. 1 W/m^2.

* Adopted unanimously.

REPORT 628 *

AUTOMATIC MONITORING OF TELEVISION STATIONS

(Question 15/11)

(1974)

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.

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.

Report 411-2 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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* Adopted unanimously.

REPORT 629 *

TELEVISION SYSTEMS USING DIGITAL MODULATION

(Question 25-1/11, Study Programmes 25A/11 and 25B/11)

(1974)

1. Introduction

The C.C.I.T.T. is studying the transmission standards to be used for future telecommunications networks employing digital methods and is considering, among the various types of signal, the baseband signal for broadcast television.

The CMTT, which is concerned with the transmission of television and sound signals over long distances, is studying possible digital coding methods, digital standards and monitoring methods which are suitable for such purposes.

The work of Study Group 11 is directed towards the coding methods, digital standards and monitoring methods which are suitable for all the processes carried out on the picture signals and the associated sound signals within a studio complex (i.e. an area containing cameras, film scanners, video tape recorders, etc.), and for the purposes of direct broadcasting from terrestrial transmitters and from satellites.

Nevertheless circumstances may arise (e.g. during the period when long-distance transmission chains contain both analogue and digital sections), where digital coding (and possibly redundancy reduction) is carried out both in the studio complex and in the long-distance transmission chain. Under such circumstances it is considered important that close cooperation be maintained between Study Group 11 and the CMTT to ensure that adequate overall picture quality is achieved.

It is also considered important that the requirements of digital television are given due weight when the nature and performance of future integrated digital networks are being determined.

2. Basic principles

Two different approaches to the coding problem have been proposed. In one, the composite colour signal (NTSC, PAL or SECAM) is coded in its composite form, while in the other it is first separated into its luminance and chrominance components which are then coded separately and transmitted as separated bit streams time-multiplexed together.

The first method is claimed to have advantage when, as is likely to happen during the period over which digital techniques are being introduced in broadcasting, the complete chain contains several digital and analogue sections in cascade. The second method is claimed to have advantages over the first method in the cases where there are only a few digital and analogue sections in tandem and also at a later stage in the introduction of digital techniques when it becomes possible for the signal to be transmitted all the way from the source to the broadcast transmitter in digital form, the conversion to the composite colour signal taking place at the broadcast transmitter. Thus, 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 [C.C.I.R., 1970-1974a], except when different scanning standards are involved.

The concept of a reference codec operating on the separated-components principle has also been proposed for evaluation purposes [C.C.I.R., 1970–1974b].

3. Coding methods

Digital coding methods fall into three main categories. In the first category, which is known as PCM, the value of each digital "word" represents the quantized amplitude of a sample of the baseband signal, the samples being taken at a suitable rate [C.C.I.R., 1970–1974 c, d and e].

* Adopted unanimously

In the second, known as DPCM, the value of each digital word is related to the difference between the amplitude of the corresponding baseband-signal sample and either that of the preceding sample or that of a prediction based upon a set of previous samples [C.C.I.R., 1970–1974 a, c, d and e].

The third, or "transform", type of coding relies upon the concept that the digital equivalent of the baseband signal, as defined in the preceding paragraphs (or the baseband signal itself), may be transformed into another form, which may have advantages with regard to redundancy reduction or error susceptibility. The transformed signal is then passed through the digital chain and, at the output, is transformed back into the first form [C.C.I.R., 1970–1974 a and e].

The above-mentioned general forms of digital coding may in some cases be applied to the composite colour signal [C.C.I.R., 1970–1974 c and e] or may in other cases be applied separately to the luminance signal and the two colour difference signals [C.C.I.R., 1970–1974 a, b, d, e and f].

4. Examples of coding techniques

Several digital coding techniques have been proposed and these are outlined in Table I [C.C.I.R., 1970-1974 c, e and g].

Results of some experiments to assess the picture quality of the luminance component of a colour signal using various PCM and DPCM coding methods are given in Table II [C.C.I.R., 1970–1974d].

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C.C.I.R. [1970–1974f] Doc. 11/277, Germany (Federal Republic of).
C.C.I.R. [1970–1974g] Doc. CMTT/223, C.C.I.T.T.

TABLE I

Proposed digital coding techniques

Source of proposal	Type of signal	Nominal base-bandwidth (MHz)	Sampling frequency (MHz)	Digits per word, or per sample	Type of coding	Quantization distortion	Gross bit rate (Mbit/s)	Tolerable error rate
B.B.C.	PAL 625-line	0 to 5·5	13·3	9 (1)	linear PCM	52 dB weighted S/N (2)	119·7 (3)	10^{-4} (4)
I.T.T.	PAL 625-line	0 to 5·5	13·3	8 or 9	linear PCM	52 dB weighted S/N	106·4 or 119·7	10^{-8} (possibly 10^{-9}) overall
A.T.T.	NTSC 525-line	0 to 4·5	10·290	9	linear PCM		92·610	10^{-6}
F.R. of Germany	PAL 625-line	0 to 5·0	7·61	4/2 (5)	DPCM		34·270	under study
COMSAT	NTSC 525-line	0 to 4·5	Y/6·02 I/1·77 Q/0·668	Y/5 I/4 Q/4	dual range DPCM		33·4 (6)	under study
B.B.C.	PAL 625-line	0 to 5·5	13·3 (7)	7 (8)	DPCM	under study	77 (9)	under study
Japan	NTSC 525-line	0 to 4·2	10·842	9 (10)	linear PCM	54 dB weighted S/N	97·58	10^{-7}

(1) 8-bit code plus 1 parity bit per word.

(2) Ratio of signal (measured between black and white levels) to effective value of weighted noise; overall figure obtainable in practice with 4 codecs in tandem.

(3) Digit rate given includes 1 parity bit per word.

(4) Acceptable random error rate, using error detection and partial concealment based on 1 parity bit per word.

(5) 4 bits used for coding component Y, 2 bits used for coding components R-Y and B-Y.

(6) This experimental satellite system includes 4·2 Mbit/s for error correction.

(7) Exactly three times colour sub-carrier frequency.

(8) 6-bit code plus 1 parity bit per word.

(9) Assumes that only 1 μs per line is required for transmission of line-syncs, colour burst, and black level, and that the remainder of the normal line-blanking interval is used for conveying video information.

(10) Eight bits used for coding the video programme. One bit used either for coding the sound programme or for the picture synchronization.

TABLE II

(From Doc. 11/288 (Federal Republic of Germany), 1970–1974)

Luminance component encoding of colour television programme signals
Quality assessment of various coding systems

Methods for digital coding (Sampling frequency: 10 MHz)	Viewing conditions	
	According to Recommendation 500	Distance = twice the picture height; (test patterns were also used)
	Quality scale (Recommendation 500)	
PCM coding:		
8 bit linear (1)	5	5
7 bit linear (1)	5	4
6 bit linear (1)	4	4
7 bit with gamma correction	5	5
6 bit with gamma correction	4/5	4
DPCM coding with one-dimensional prediction:		
3 bit non-switched (1)	3	
4 bit non-switched (1)	4	3
5 bit non-switched	4/5	4
6 bit non-switched	5	5
4 bit with switched quantizer (1)	4/5	4
5 bit with switched quantizer (1)	5	5
DPCM coding with two-dimensional prediction:		
3 bit non-switched	4	
3 bit switched quantizer	4/5	4
4 bit switched quantizer	5	5

(1) These systems were realized physically; the other systems were simulated on a computer.

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SECTION 11E: RECORDING OF VIDEO PROGRAMMES

RECOMMENDATIONS AND REPORTS

Recommendations

RECOMMENDATION 265-3

STANDARDS FOR THE INTERNATIONAL EXCHANGE OF MONOCHROME AND COLOUR-TELEVISION PROGRAMMES ON FILM

(1956 – 1959 – 1963 – 1966 – 1970 – 1974)

The C.C.I.R.

UNANIMOUSLY RECOMMENDS

that the films used for the international exchange of television programmes should meet the following definitions and standards:

1. Definitions

The types of film referred to in this Recommendation are designated by code words as defined below. The code words should be placed on the identification leader of any film intended for international exchange of programmes and should be used in any related correspondence. The code word consists of a letter and a number (or numbers) followed by a two- or three-syllable word, for example: C 35 COMOPT.

The first letter indicates either monochrome, B, or colour, C, film type. The number, usually 16 or 35, indicates the nominal width of the film in millimetres. The first syllable indicates either a combined sound and picture recording, COM, or separate sound and picture recording, SEP. The last syllable indicates whether the sound recording is magnetic, MAG, or optical, OPT:

— 35-mm colour film with an optical track is C 35 COMOPT;

— 16-mm monochrome film with a magnetic stripe is B 16 COMMAG;

— 16-mm colour film with sound on a separate magnetic film, having one or more tracks, is C 16 SEPMAG.

1.1 For picture films without sound, the designation is MUTE, for example: B 16 MUTE.

1.2 If the picture and the sound films have the same width, this is indicated by a single number. If not, then two numbers separated by an oblique stroke are used, the first indicating the width of the picture film, for example:

— 35-mm picture film with magnetic sound track on 16-mm film is 35/16 SEPMAG.

2. Types of films recommended for international exchange of television programmes

2.1 The international exchange of recorded television programmes on monochrome and colour (types B and C) films should be effected by means of one of the following types:

1 — 35 COMOPT

2 — 16 COMOPT

3 — 16 COMMAG

4 — 16 SEPMAG (the tracks used should be specified)

5 — 35 MUTE

6 — 16 MUTE

7 — 35 COMMAG

8 — 35 SEPMAG (the tracks used should be specified)

An identification of the tracks utilized must be added after the word SEPMAG.

For example: in 35 mm film SEPMAG (tracks 1 and 2)
or SEPMAG (track 1)
or SEPMAG (tracks 1 and 3)
etc.

in 16 mm film SEPMAG (edge track)
SEPMAG (both tracks)
etc.

As indicated in § 4.3, there are at present four different sound track formats for 16 SEPMAG recording, namely:

— the 5·1 mm (0·2 in.) centre track

— the 5·1 mm (0·2 in.) edge track

— the 4 mm (0·157 in.) centre track

— the 4 mm (0·157 in.) edge track

Recordings made in conformity with any of the listed 16 SEPMAG formats may be exchanged without previous agreement.

2.2 Films of types 7 and 8 cannot be exchanged unless there is agreement between the organizations concerned.

Note. — Although the quality of sound obtainable with 16 COMOPT films is marginal, this type cannot be excluded because of its widespread use. A reduction of the number of recommended types of sound recordings appears to be impossible at present.

2.3 The fundamental technical parameters of each type listed in § 2.1 should conform to the standards given below.

3. Standards common to all types of film

3.1 Safety film must be used.

3.2 Normally the image on the film should be a photographic positive.

3.3 The picture (frame) frequency should be either 25 or 24 per second. The picture frequency should accompany any reference to programme duration.

3.4 For accurate reproduction of films in television systems some limitations should be placed on the film density range. In colour systems the colour balance of films should also be defined.

All film densities specified below are measured in singly-diffused light.

The spectral characteristic of the densitometer should conform with ISO* Recommendation R5-1955 for diffuse visual density,Type VIb.

3.4.1 For monochrome film the density corresponding to television white level should be 0·3 to 0·4 but in the case of dyed-base film the total density corresponding to television white level should not exceed 0·5.

Note. — Television white level preferably corresponds to a fully-lit object in the scene, having a reflectance of about 60%. This results in reproduction of fully-lit human faces having reflectances of about 15% to 35% at film densities between 0·2 and 0·5 greater than the density corresponding to television white level.

* ISO: International Organization for Standardization.

The maximum density of a film is determined by the scene contrast and the film transfer characteristic. The gradation in areas in the film having densities in excess of 1·6 above that corresponding to white level may be distorted or lost entirely.

3.4.2 For colour film the density corresponding to television white level should be 0·3 to 0·4.

Note 1. — Television white level preferably corresponds to a fully-lit object in the scene, having a reflectance of about 60%. This results in reproduction of fully-lit human faces having reflectances of about 15% to 35% at film densities between 0·2 and 0·5 greater than the density corresponding to television white level.

The maximum density of a film is determined by the scene contrast and the film transfer characteristic. Shadow areas, in which the reproduction of detail is not essential to the picture, may have densities in the range of 2·0 to 2·5, but it must be recognized that in such areas both image gradation and colour may be distorted or lost entirely. The density range for optimum colour reproduction is expected to be between 0·5 and 1·7.

Since the white point of colour television systems is either CIE* Illuminant C or CIE Illuminant D_{65}, adequate prints of both 35 mm and 16 mm colour films may be obtained if the print is balanced for projection by an illuminant approximating in spectral distribution to a black body of a colour temperature of 5400 K. The print, when so illuminated, should provide a pleasing reproduction of neutral grey and skin colours.

Note 2. — This neutral grey balance is very close to a metameric match with a neutral grey in the scene. (The metameric match of two colours of which the spectral compositions are different is obtained when the visual comparison of these two colours does not permit them to be distinguished by the CIE Standard Observer.)

3.4.3 Optimum viewing conditions for films intended for colour television are specified in Recommendation 501.

3.5 The dimensions of the films and images recorded thereon should conform to appropriate international standards (see ISO Recommendation R73 for 35-mm film and ISO Recommendation R359 for 16-mm film).

3.6 When films are produced for television by conventional cinematographic methods, allowances should be made for the loss of picture area that occurs both in film-scanning and in domestic receivers. The television-scanned area, the action field and the title and sub-title areas should conform with appropriate international (ISO Recommendation R1223) or equivalent national standards.

3.7 The normal position for the emulsion side of 35-mm films is internationally recognized as facing the light source when projecting on a reflecting-type screen.

For 16-mm film the position of the emulsion is dependent on the process of preparation and either emulsion-to-light source or emulsion-to-objective-lens orientations may be encountered. The actual position of the emulsion should be indicated on the leader and on the label of the film by clear statement or diagram.

3.8 Film splices should be carried out in accordance with appropriate international or national standards.

3.9 A leader for protection and identification should be attached to each film.

3.9.1 The minimum length of the protection and identification leader should be 3 m (10 ft).

* CIE: Commission internationale de l'éclairage (International Commission on Illumination).

3.9.2 The minimum information given on the identification leader should be as follows:

— name of sending organization,
— title of programme,
— code word (see § 1),
— position of emulsion (see § 3.7),
— total programme duration and picture frequency,
— total number of reels,
— reel number,
— duration or length of the film on the reel.

Further information may be given, such as: production methods used, for example, telerecording or a code word according to ISO.

3.9.3 The identification leader should have the same type of base and perforations as the film to which it is attached. Leaders should be attached to the film in such a manner that the emulsion on both leader and film is on the same side.

3.10 Films may be transported on flanged reels or on cores as specified in the appropriate international or national standards. The boxes in which films are transported should be identified with labels carrying the same information as the corresponding film leader (see § 3.9.2).

3.11 The diameter of a flanged reel or the outer diameter of the film on a core should not exceed 380 mm (15 in.). It is desirable that 16-mm films exceeding 300 m (1000 ft) in length should be on flanged reels.

3.12 Cores and reels intended for films with magnetic sound stripe should be made of non-magnetic material.

4. Special standards for certain types of film

4.1 *COMOPT types*

The preferred types of optical sound tracks are variable area, bilateral or double bilateral.

The nominal optical sound-recording characteristic for 35-mm and 16-mm film is that which produces a constant modulation of its optical transmission as a function of frequency within the given frequency range on the sound track of the film when a sine-wave signal of constant amplitude is fed into the input of the recording channel.

The corresponding nominal reproducing characteristic is that which produces a sine-wave output signal whose level is independent of frequency when reproducing a sound-track recorded with the nominal recording characteristic specified above.

Note. — The preferred method of measurement of the recording characteristic of optical sound tracks is by reference to the output signal of an ideal replay chain. (An ideal replay chain is defined as having a signal output proportional to the modulation of the optical transmission of the sound-track when this is scanned by a slit whose width is negligible in relation to the shortest recorded wavelength on the film.) This condition may be verified by measuring the modulation of the optical transmission of the film by means of a microdensitometer adjusted to have a slit-width which is negligible in relation to the shortest recorded wavelength on the film.

The preferred method of calibrating a reproducing chain is by means of a standard test film recorded with a number of audio sine-waves producing constant modulation of the optical transmission.

4.1.1 *35 COMOPT*

The location and dimensions of picture frames and sound-track should conform with appropriate international standards (ISO Recommendation R73 and ISO Recommendation R70).

The useful audio-frequency range is 40 Hz to 8000 Hz.

4.1.2 *16 COMOPT*

The location and dimensions of picture frames and sound-track should conform with appropriate international standards (ISO Recommendation R359 and ISO Recommendation R71).

The useful audio-frequency range is 50 Hz to 5000 Hz.

4.2 *16 COMMAG*

4.2.1 The dimensions and position of the magnetic sound stripes should be as given in Fig. 1.

4.2.2 The sound record should be in advance of the centre of the corresponding picture by 28 ± ½ frames.

4.2.3 The magnetic stripe should be on the side of the film that faces the light source of a projector arranged for direct projection onto a reflecting-type screen.

4.2.4 The maximum additional thickness due to the magnetic coating should be 0·02 mm (0·0008 in.).

4.2.5 If a balancing magnetic stripe is used, it should have the same thickness as the main magnetic stripe. No sound recording should be made on the balancing stripe.

4.2.6 The recording and reproducing characteristics should be those standardized by the IEC (Publication 94) for magnetic tape at a speed of 19·05 cm/s (7·5 in./s). This includes a time constant t_1 of 70 μs.

Two other standards are still in use to a decreasing extent:

— a time constant of 100 μs,

— a time constant of 50 μs.

4.3 *16 SEPMAG*

4.3.1 Three standards for SEPMAG are used:

The first (see Fig. 2) is the preferred format and consists of a centre track and an edge track both of 4·0 mm (0·158 in.) width. An optional auxiliary track of 0·7 mm (0·028 in.) width is provided which can be used for cue or control information. The 4-mm tracks are fully compatible with the other two SEPMAG formats described below in this paragraph. This leads to a single 16 SEPMAG standard which also is intended to replace these formats in the future (see Report 294-3). The second and third formats (see Fig. 3) are:

— a 5·1 mm (0·2 in.) centre track according to ISO Recommendation R890, used to a decreasing extent in Europe;

— a 5·1 mm (0·2 in.) edge track according to ISO Recommendation R891 used in the United States of America and Canada. (This type of track can, if necessary be reproduced by a magnetic head designed for 16 COMMAG.)

4.3.2 The COM and SEP types should not be combined. That is to say, if one or more sound tracks are provided on a separate film, only the SEP tracks should be used for reproduction.

4.3.3 The recording and reproducing characteristics should be those standardized by the IEC (Publication 94) for magnetic tape for a speed of 19·05 cm/s (7·5 in./s). This includes a time constant t_1 of 70 μs.

Two other standards are still in use to a decreasing extent:

— a time constant of 100 μs,

— a time constant of 50 μs.

4.4 *35 COMMAG*

4.4.1 The dimensions and position of the magnetic sound stripe should be as given in Fig. 4.

4.4.2 The sound record should be 28 ± ½ frames behind the centre of the corresponding picture.

4.4.3 The magnetic sound stripe should be on the side of the film towards the lens of a projector arranged for direct projection on to a reflecting screen.

4.4.4 If a balancing stripe is used, it should have the same thickness as the magnetic sound stripe. No sound recording should be made on the balancing stripe.

4.4.5 The recording and reproducing characteristics should be those standardized by the IEC for magnetic tape for a tape speed of 38·1 cm/s (15 in./s) having a time constant t_1 of 35 μs (see IEC Publication 94).

4.5 *35 SEPMAG*

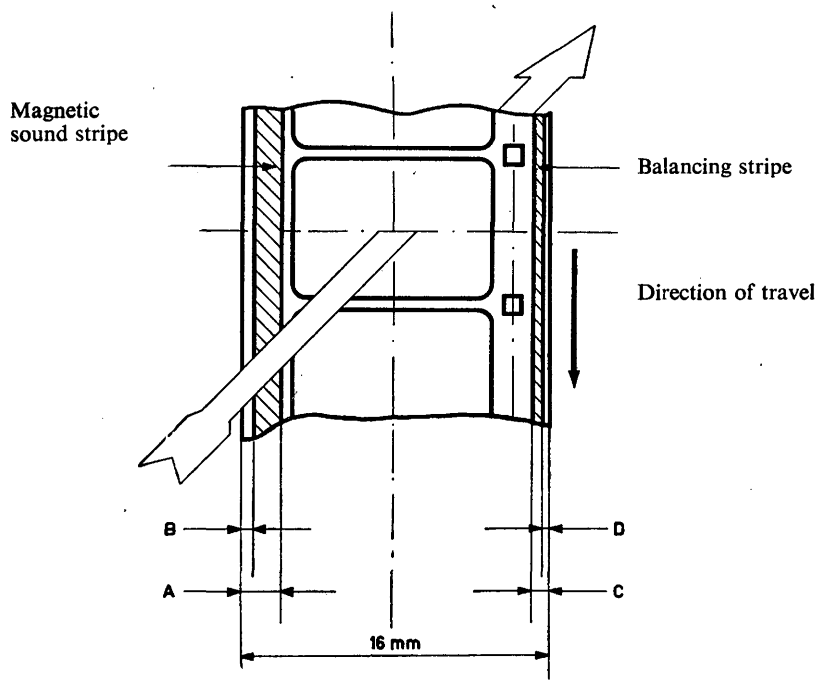
4.5.1 The second (sound) film should be a standard 35-mm magnetic film.

4.5.2 The position of the sound tracks is specified in ISO Recommendation R162. If only one sound track is used, it should be track No.1 (see Fig. 5). If a second sound track is used, it should be track No. 2.

4.5.3 The COM and SEP types should not be combined. That is to say, if one or more sound tracks are provided on a separate film, only the SEP tracks should be used for reproduction.

4.5.4 The recording and reproducing characteristics should be those standardized by the IEC for magnetic tape for a tape speed of 38·1 cm/s (15 in./s) having a time constant t_1 of 35 μs (see IEC Publication 94).

Note. — The Director, C.C.I.R., is requested to transmit this Recommendation to the ISO and the IEC, in accordance with Opinion 16-1.



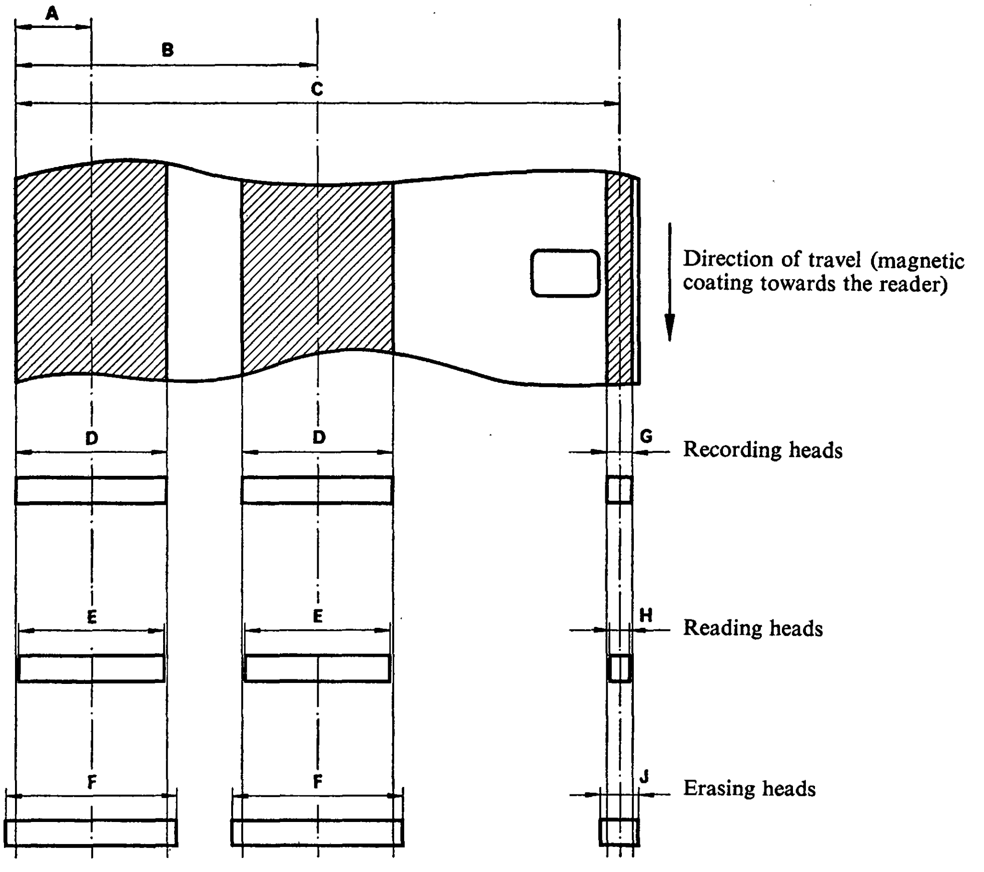
Magnetic coating towards the reader

Dimensions

	Millimetres	Inches
A	2·5 $^{+0·15}_{-0}$	0·100 $^{+0·004}_{-0·002}$
B	0·127 max.	0·005 max.
C	0·8 $^{+0}_{-0·1}$	0·031 $^{+0}_{-0·005}$
D	0·05 max.	0·002 max.

FIGURE 1

Sound recording on film type 16 COMMAG



Dimensions

	Millimetres	Inches
A	2·05 ±0·05	0·081 ±0·002
B	8.00 ±0·05	0·315 ±0·002
C	15·50 ±0·05	0·610 ±0·002
D	4·0 $^{+0·1}_{-0}$	0·157 $^{+0·004}_{-0}$
E	3·9 $^{+0}_{-0·1}$	0·154 $^{+0}_{-0·004}$
F	4·5 $^{+0·1}_{-0}$	0·177 $^{+0·004}_{-0}$
G	0·7 $^{+0·1}_{-0}$	0·028 $^{+0·004}_{-0}$
H	0·6 $^{+0}_{-0·1}$	0·024 $^{+0}_{-0·004}$
J	1·0 $^{+0·1}_{-0}$	0·039 $^{+0·004}_{-0}$

FIGURE 2

Sound recording on film type 16 SEPMAG
(Preferred format)

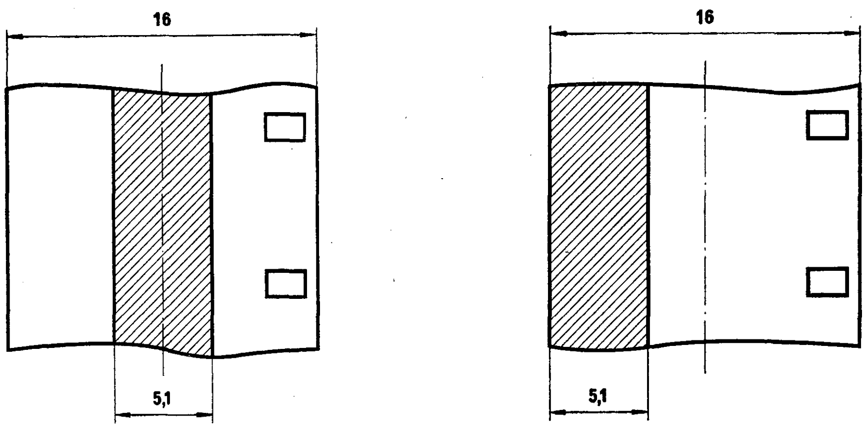
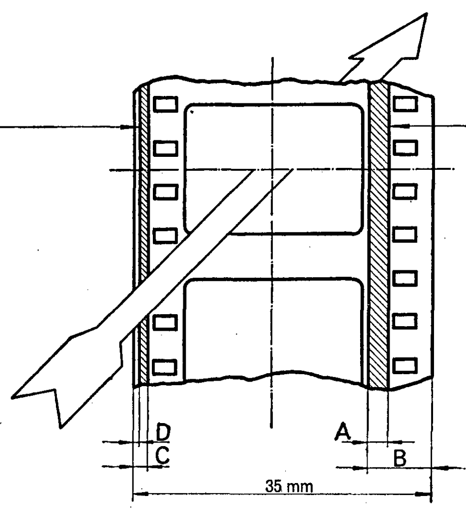


FIGURE 3

Sound recording on film type 16 SEPMAG



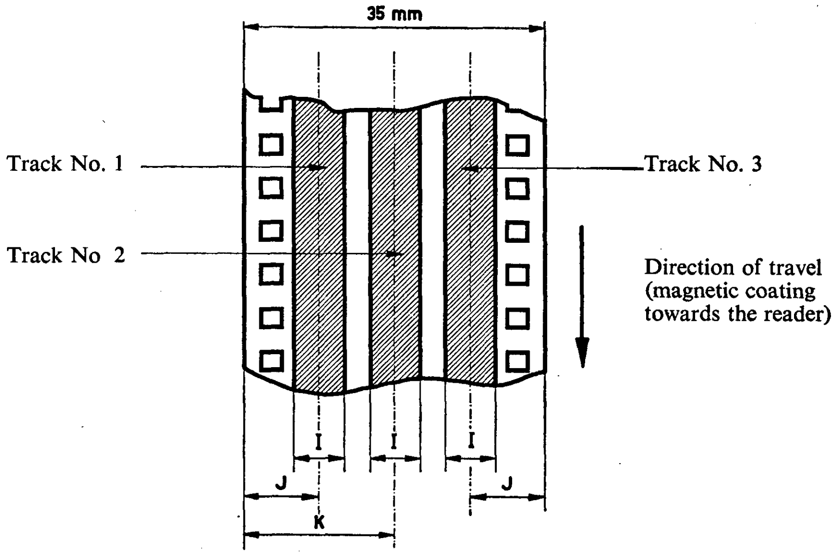
Photographic emulsion towards the reader; magnetic coating away from the reader

Dimensions

	Millimetres	Inches
A	$2{\cdot}5\ ^{+0{\cdot}1}_{-0}$	$0{\cdot}100 \pm 0{\cdot}002$
B	$7{\cdot}6\ ^{+0{\cdot}1}_{-0}$	$0{\cdot}300\ ^{+0{\cdot}002}_{-0}$
C	$1{\cdot}8\ ^{+0}_{-0{\cdot}25}$	$0{\cdot}07\ ^{+0}_{-0{\cdot}01}$
D	0·25 max.	0·01 max.

FIGURE 4

Sound recording on film type 35 COMMAG



Dimensions

	Millimetres	Inches
I	5·08 ±0·05	0·200 ±0·002
J	8·61 ±0·10	0·339 ±0·004
K	17·50 ±0·10	0·689 ±0·004

FIGURE 5

Sound recording on film type 35 SEPMAG with one or more tracks

RECOMMENDATION 469-1

STANDARDS FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES ON MAGNETIC TAPE

(1970 – 1974)

The C.C.I.R.

UNANIMOUSLY RECOMMENDS

that the magnetic recordings used for the international exchange of television programmes should meet the following standards:

1. Recording systems

Recording on magnetic tape of television programmes which are the object of international exchange should be carried out in accordance with one of the following classes of television systems:

— 625 lines; 50 fields per second
— 525 lines; 60 fields per second

(see Report 624).

The recordings should conform with the standards contained in IEC* Publication 347 with the modifications and additions detailed in this Recommendation.

2. Speed of the tape

Television programmes should be recorded at the following nominal tape speeds:

— 625-line, 50-fields/s systems: 39·7 cm/s (15·625 in./s).
— 525-line, 60-fields/s systems: 38·1 cm/s (15 in./s).

3. Position of recorded tracks

The dimensions of the recorded tracks are specified in IEC Publication 347, § 3.5.

To achieve satisfactory splicing and expeditious electronic editing of recorded tapes, dimension, J (spacing of video tracks), should be specified as

$$J = 1{\cdot}5875 \pm 0{\cdot}0015 \text{ mm } (0{\cdot}06250 \pm 0{\cdot}00006 \text{ in.})$$

and dimension, F (distance of the recorded vertical pulse from the guided edge of the tape), should be specified as

$$F = 29{\cdot}2 \pm 0{\cdot}1 \text{ mm } (1{\cdot}150 \pm 0{\cdot}004 \text{ in.}).$$

4. Specification for video recording

4.1 Recordings of colour programmes should only be made using the "high band" characteristic frequencies indicated in IEC Publication 347, § 4.2.

4.2 The most convenient way, from an operational point of view, to define a recording standard, is by means of reference tapes, which are physical embodiments of the standard. Annex I to this Recommendation contains, as an example, the current E.B.U.** specification for such reference tapes, for 625-lines, 50-fields/s television systems.

* IEC: International Electrotechnical Commission.
** E.B.U.: European Broadcasting Union

5. Specification for programme sound recording

5.1 The television programme sound shall be recorded on the audio track only.

5.2 The sound reference level shall correspond to a recorded short circuit flux of 100 ± 10 nWb/m of track width, (r.m.s.), at 1000 Hz*. Normal operational practice will result in programme peaks corresponding to a maximum short circuit flux between 250 and 310 nWb/m, (r.m.s.), i.e., about 9 dB above reference level. These maximum recorded levels correspond to the subjective overload level for television tape materials currently used for the international exchange of programmes.

Note. — When the programme peaks are measured by means of a programme meter, due account should be taken of the integration time of the instrument (see Report 292-3).

6. Specification for cue signal recording

The cue track should preferably not contain information which needs to be reproduced for programme exchanges.

Note. — The use of the cue track for purposes such as the recording of time and control information is now being studied (see Report 630).

7. Mechanical tape splices

7.1 The number of tape splices should be kept to a minimum.

7.2 The cut shall be located so as to maintain uniformity of timing of field synchronization signals and of edit pulses, and it shall be centred between two recorded tracks.

7.3 The separation between cut edges after splicing shall not exceed 0·025 mm (0·001 in.) at any point.

7.4 The longitudinal distance between corresponding points of the recorded transverse video tracks immediately preceding and following the splice shall not depart from the average distance between successive tracks by more than ± 0·013 mm (0·0005 in.).

7.5 The splicing tape shall have the following dimensions:

— nominal width: 6·35 mm (0·25 in.)

— maximum thickness: 0·018 mm (0·0007 in.)

7.6 In a finished splice, the splicing tape shall be placed symmetrically over the cut and shall not extend beyond the edges of the television tape.

7.7 The edges of the television tape on the two sides of the splice shall be on a common straight line. The tape curvature shall meet the specification of IEC Publication 347, § 3.1, when measured with the splice centred within the specified length.

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* In some countries a 400 Hz reference tone is used.

8. Composition and duration of leaders and trailers

Leader and trailer sections should be located on the tape in conformity with the sequence shown in Table I.

TABLE I

<table>
<tr><th colspan="2">Tape section</th><th>Duration (s)</th><th>Picture</th><th>Sound</th><th>Control track signal</th></tr>
<tr><td rowspan="6">Leader</td><td>Protection leader</td><td>10 (minimum)</td><td colspan="3">Blank tape</td></tr>
<tr><td>Alignment leader</td><td>60 (minimum)</td><td>Alignment signal (1)</td><td>1000 Hz at reference level (2)</td><td>Uninterrupted</td></tr>
<tr><td>Optional</td><td>5 (maximum)</td><td colspan="3">Blank tape</td></tr>
<tr><td>Identification leader</td><td>15</td><td>Programme identification</td><td>Spoken identification preferred, or silence</td><td rowspan="5">Uninterrupted</td></tr>
<tr><td rowspan="2">Cue-up leader</td><td>8</td><td>Black or cue</td><td>Silence or cue</td></tr>
<tr><td>2</td><td>Black</td><td>Silence</td></tr>
<tr><td colspan="2">Programme</td><td>Playing time of programme</td><td colspan="2">Programme</td></tr>
<tr><td colspan="2">Run-out trailer</td><td>30 (minimum)</td><td>Black</td><td>Silence</td></tr>
</table>

(1) An example of a suitable alignment signal for 625-lines, 50 fields/s systems is given in Annex I.

(2) See § 5.2.

9. Winding of the tape on the spools

9.1 The tape should be wound on the spools specified in IEC Publication 347, with the magnetic surface towards the hub of the spool.

Note. — The exchange of tapes wound on spools having a diameter exceeding 356 mm, specified in ISO Standard IS 1860, is subject to mutual agreement.

9.2 The tape must be wound in such a way as to minimize the possibility of damage during transport.

9.3 Recordings of a single programme of up to 90 min duration should preferably be on one spool.

9.4 Separate programmes shall always be on separate spools.

10. Packaging

Programme spools should be packed in containers affording protection against mechanical and environmental damage.

11. Programme identification

11.1 At least the following information should be supplied with each recorded television tape:

- name of the organization which made the recording;
- title of programme, or title, sub-title and episode number;
- total number of spools, and number of the spool in the sequence when the programme is contained on more than one spool;
- library number (reference number) of programme or of tape;
- total playing-time, and playing-time of the programme material recorded on the tape;
- line and field system (625/50 or 525/60);
- recording standard ("high band" or "low band");
- indication of the colour system, for colour recordings.

11.2 The information required in § 11.1 shall be provided in at least one of the official languages of the I.T.U.

11.3 The information required in § 11.1 shall be provided on labels conforming to the standard format exemplified in Annex II; the labels shall be affixed both to the programme spool and its container.

Bibliography

IEC [1968] Magnetic tape recording and reproducing systems: dimensions and characteristics. IEC Publication 94, Third Edition, 1968, Geneva.

IEC [1972] Transverse track recorders. IEC Publication 347, First Edition, 1972, Geneva.

IEC [1974] Time and control code for video tape recordings. IEC Publication 461, First Edition, 1974, Geneva (in preparation).

ISO [1974] Precision reels for magnetic tape used in interchange instrumentation applications. ISO/IS 1860, Geneva (in preparation).

ANNEX I

EXAMPLE OF TEST SIGNALS FOR USE IN ADJUSTING TELEVISION TAPE MACHINES

(625-line systems)

The present E.B.U. recommendation for test signals to be used in adjusting television tape machines for 625-line television systems, is shown below.

In the original E.B.U. recommendation for reference tapes, it is required that the recording be made on a specific type of television tape, which is chosen because it is representative of the tapes currently found in operation.

1. Test signals to be recorded on the leaders of television tapes

The alignment video signal on the tape leader indicated in § 8 of this Recommendation, for adjusting the reproducing machine so that the best picture quality may be obtained, should conform with the following specifications:

1.1 for monochrome television recording and SECAM colour television recordings:

— a black-level bar, a white-level bar and, if desired, a Gaussian pulse;

— a frequency "multi-burst";

— a grey-scale or a "saw-tooth" signal.

These signals should appear simultaneously. The part of the picture carrying each signal should be greater than the area scanned by one complete revolution of the head wheel:

1.2 for PAL colour television recordings:

— on the upper part (at least one third) of the picture, a conventional test pattern of colour bars;

— on the lower part (at least one third) of the picture, a uniform area having the same signal as the red bar.

Note. — The colour bar signal chosen for the leader is of the type 100/0/75/0 (according to the nomenclature of Recommendation 471). In the United Kingdom it is of the type 100/0/100/0 and may be followed by a length of dubbed colour bars.

2. Signals to be recorded on the E.B.U. reference tapes

Two types of reference tapes for television tape machines have been standardized for the member organizations of the E.B.U. They are intended to satisfy two different requirements:

— the physical embodiment of the recording standards used (see § 2.1);

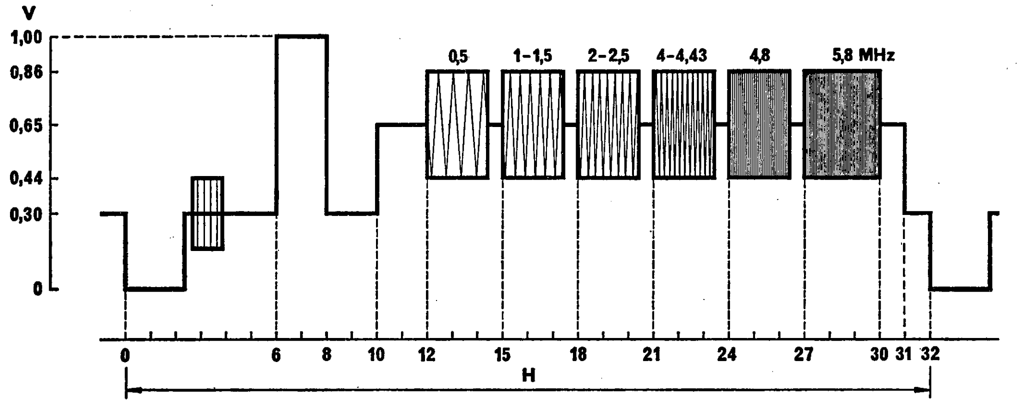
— verification of the characteristics and rapid operational alignment of television tape-machines (see § 2.2).

Tapes of these two types shall have the following characteristics:

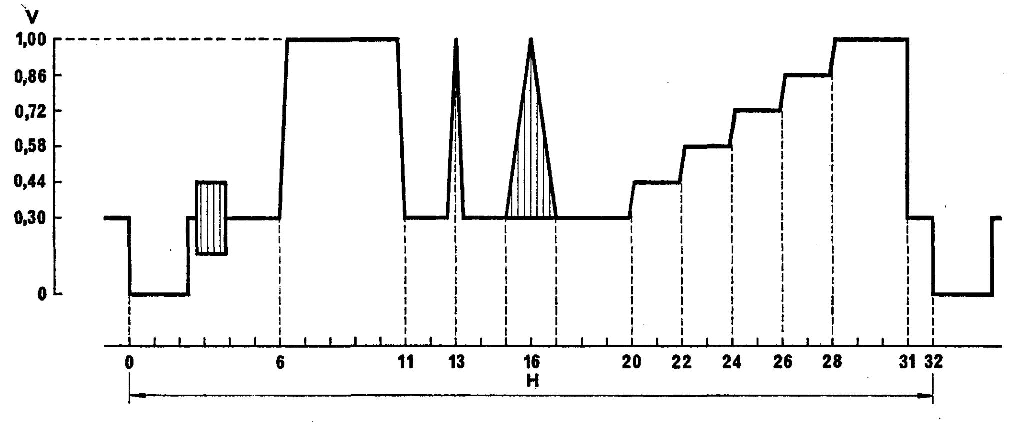
2.1 *Primary-standard reference tape*

This tape consists of five successive parts, each of them having a duration of three minutes. The different parts are recorded with the following signals occupying the full frame:

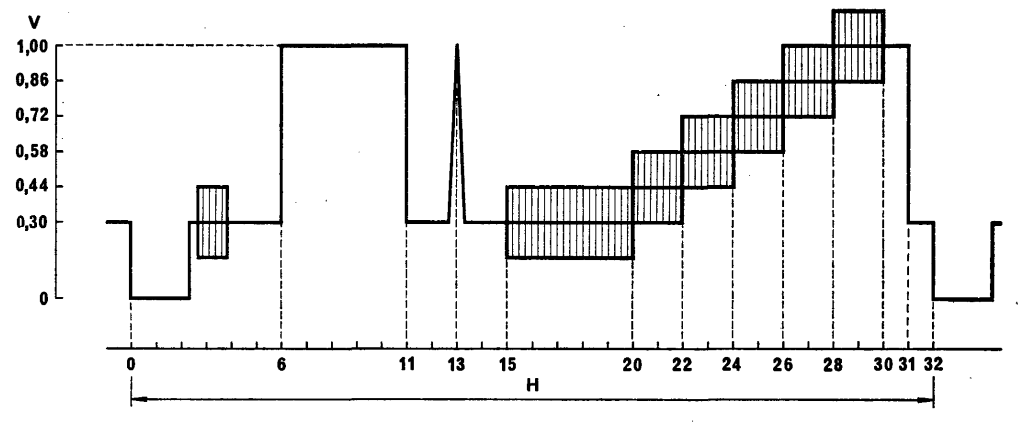
2.1.1 a multiburst signal consisting of six bursts at different frequencies, as specified by the C.C.I.R. for insertion in line 18, but preceded by a signal giving the white- and black-reference levels;



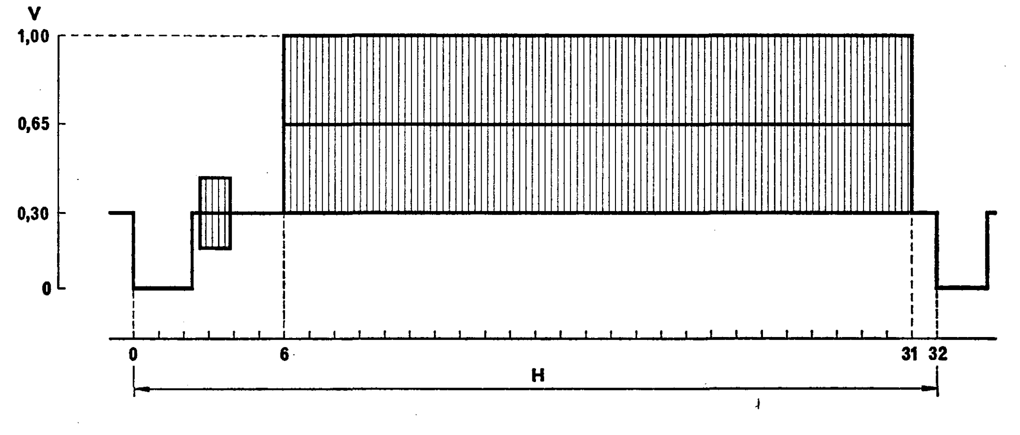
2.1.2 the signal specified by the C.C.I.R. for insertion in line 17, consisting of the following components: luminance bar, $2T$ sine-squared pulse, composite $20T$ pulse and 5-riser luminance staircase without chrominance signal;



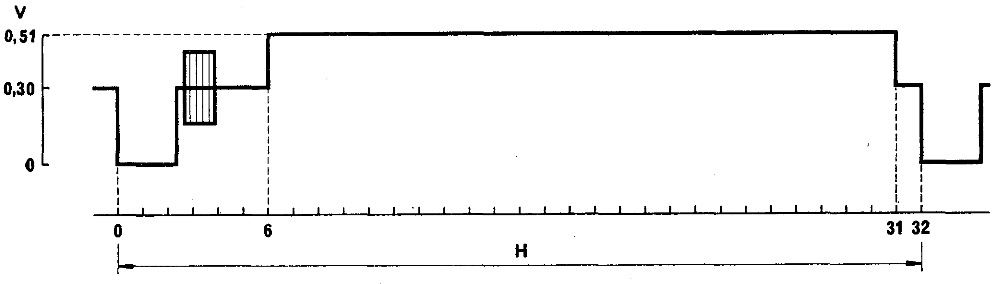
2.1.3 the signal specified by the C.C.I.R. for insertion in line 330 and consisting of the following components: luminance bar, $2T$ sine-squared pulse and 5-riser luminance staircase with superimposed sub-carrier;



2.1.4 a uniform area generated by a sub-carrier of 0·7 V (peak-to-peak) on a luminance level of 50% of the black-to-white transition extending from the beginning to the end of the line (this signal is intended for measurements of moiré and for verification of the correct reproduction of the phase of the colour sub-carrier);



2.1.5 a uniform grey area obtained with a luminance level of 30% of the black-to-white transition (this signal is intended for noise measurement).



All these signals shall include the standard PAL alternating sub-carrier burst during the line-blanking interval. The phase of the sub-carrier used in §§ 2.1.3 and 2.1.4 shall correspond to the *B–Y* axis referred to the PAL burst.

The recording of these signals shall conform to all the characteristics specified in the relevant E.B.U., C.C.I.R. and IEC documents.

The various recorded sections shall be separated by 15 s of black. The beginning and the end of the tape shall also consist of 15 s periods of black.

The cue track shall be without any recording.

The sound track shall be recorded with alternate announcements in French and English, thus: "E.B.U. reference-tape—bande-étalon de l'U.E.R.", followed by the indication of the serial number of the tape, the date of the recording and the name of the manufacturer.

2.2 *Alignment tape for quick verification of the machines*

This operational reference tape shall be recorded with a picture divided into two equal halves in the following way:

2.2.1 the upper half of the picture shall consist of the C.C.I.R. insertion signal specified for line 330 repeated on each line: luminance bar, 2*T* sine-squared pulse and 5-riser luminance staircase with superimposed sub-carrier;

2.2.2 the lower half of the picture shall consist of the type 100/0/75/0 colour-bar signal (conforming to Recommendation 471*).

Both these signals shall include the standard PAL alternating sub-carrier burst during the line-blanking interval. The phase of the sub-carrier used in § 2.2.1 shall correspond to the *B–Y* axis referred to the PAL burst.

The recording of these signals shall conform to all the characteristics specified in the relevant E.B.U., C.C.I.R. and IEC documents.

The cue track shall be without any recording.

The sound track shall be recorded with alternate announcements in French and English, thus: "E.B.U. alignment tape—bande de réglage U.E.R.", these announcements being interrupted with a few seconds of 1000 Hz tone at the reference level of 100 nWb/m as indicated in this Recommendation.

* The colour-bar signal on the tapes intended for broadcasting organizations in the United Kingdom is of the type 100/0/100/0.

ANNEX II

EXAMPLE OF A STANDARDIZED LABEL FOR TELEVISION TAPE-RECORDING

The European Broadcasting Union has drawn up a standardized design of a label containing all the information envisaged in § 11 of this Recommendation. The label has been designed to be stuck to the reel, but its size (8 × 5 cm) is such that it can be affixed to the containers in which the tapes are kept.

Below is a drawing of this label. The printed text, reading from top to bottom, indicates the following:

— the name or acronym of the originating service; the blank space to the right of the symbol of this organization is reserved for internal use by the organization which has recorded the programme;

— reference number of the programme or tape;

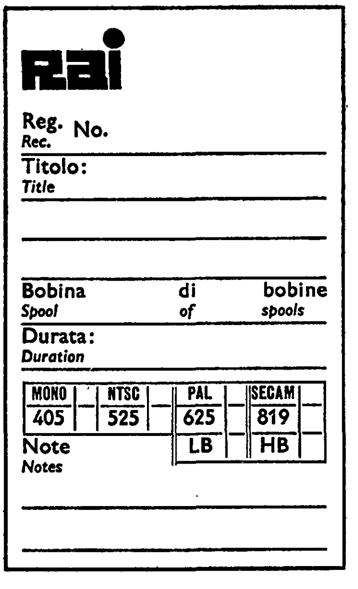
— complete title of the programme;

— total number of spools, and a number denoting the order of the spools, when the programme is recorded on more than one;

— playing-time of the programme material recorded on the tape;

— indication of standards and, if necessary, of the colour system used; this information can be conveyed simply by placing a tick in the squares relating to the various printed details;

— notes: the first line is provided for any additional information; the second line is reserved for internal use by the organization which has recorded the programme. (See Doc. X/181 (E.B.U.), 1966–1970.)



Drawing of a label conforming to the E.B.U. standard.

RECOMMENDATION 501

APPRAISAL OF COLOUR FILM INTENDED FOR TELEVISION USE

(1974)

The C.C.I.R.

UNANIMOUSLY RECOMMENDS

1. that the appraisal of films intended for the international exchange of programmes for colour television should be by means of optical projection. The optical projection arrangements must conform to standards of colour temperature and viewing conditions which are defined in § 3 (attention is drawn to the fact that the required viewing conditions are not the same as those which are conventionally accepted for the cinema theatre);

2. that broadcasting authorities should aim to provide a standard of telecine performance such that any film which appears to be of good technical quality when evaluated under the special optical viewing conditions can also be expected to appear to be of good quality when transmitted by colour television. They should not require the film to have any abnormal colour balance or special characteristic to suit a particular telecine specification;

Note. — Recommendations concerning the technical parameters of colour motion picture films intended for the international exchange of colour television programmes are contained in Recommendation 265-3. To make a reliable visual appraisal of the technical quality of a colour motion-picture film intended for television presentation, it is necessary to take into account the different circumstances under which the picture will be viewed when it is so presented.

In colour television, the displayed picture is relatively small; it has a white point corresponding to Illuminant D_{65} and is normally viewed in familiar surroundings with a considerable amount of ambient light. The field of view of the observer therefore includes not only the television screen but also other objects in the room which provide a constant reference of colour balance and this increases his sensitivity to errors in colour reproduction in the picture. There are also frequent programme changes to signals derived from television cameras and these offer comparisons with a different type of picture source.

In the cinema the environment is dark and there are no external colour references; consequently there is a tendency for the observer to adapt to whatever balance the film may have. Furthermore, it is found that when a bright object, such as the projected picture, is viewed in an otherwise dark field, the eye exercises a contrast-reducing effect upon the viewed picture and the contrast (gamma) in film for cinema presentation is desirably made substantially greater than unity. This effect is much less pronounced under normal domestic television viewing conditions and less contrast, although still greater than unity, is desirable in the television display. Hence, the appraisal of films by optical projection in an otherwise dark review theatre is not the best procedure when films are intended for television presentation.

3. that colour motion pictures intended for television presentation should be appraised in optical review theatres which have been arranged to give viewing conditions more suited to the purpose than the conventional review theatre. The projected picture should be surrounded by a relatively large illuminated area, of a standard fraction of the brightness of whites in the projected picture and a standard correlated colour temperature. The following characteristics are recommended:

3.1 the projection screen should be of such a size that the viewer is seated at a distance of between four times and six times the height of the picture. The absolute dimensions of the screen will depend upon the number of observers that it is desired to accommodate simultaneously. (The experimental results upon which this Recommendation is based are known to be valid for screens having diagonals of between 50 cm and 1·5 m. For larger review theatres, it may be necessary for the broadcaster to carry out special experiments to confirm the consistency of results.);

3.2 either front projection or back projection may be used. The display must have reflectance or transmittance over angles wide enough to ensure satisfactory uniform brightness from all viewing positions;

3.3 the illuminated surround to the projection screen should extend the illuminated field of view symmetrically to an area which is preferably not less than three times the width and three times the height of the projection screen, with the latter placed centrally in this area;

3.4 the illumination of the surround may be from the front on to a reflecting surface or from the rear to a diffusing, translucent material;

3.5 since the white point of colour television systems is either International Committee on Illumination (CIE) Illuminant C or D_{65}, the correlated colour temperature of the light reflected from, or transmitted by, the projection screen under open-gate conditions should be near to 6500 K for the most critical evaluation of television films. However, the range around 5400 K attained by Xenon projection systems will provide an acceptable white point for evaluation purposes;

3.6 the correlated colour temperature of the illumination of the surround should match that reflected from, or transmitted by, the protection screen, under open-gate conditions, to ±200 K. There should be no significant departure from the black-body locus in either case, neither should the spectral emission have very pronounced peaks;

Note. — A simple check of the accuracy of the match of colour temperature between the surrounding illumination and that of the white point of the projection system can be made in the following manner.

The light flux from the projector, *in open-gate condition, should be attenuated without changing its colour temperature* and the brightness of the projection screen should be reduced until it closely approximates to that of the surround. It will then be possible visually to judge the colour match between the light reflected from the projection screen and that from the surround. A satisfactory match may be achieved by adjustment of the colour temperature of the projector or that of the surround; any remaining difference in colour should be significantly less than that created when a 05 CC Wratten colour compensating filter of appropriate colour is placed in the light path of the projector.

3.7 for screens as described in § 3.1, and fitted with illuminated surrounds as described in §§ 3.3 and 3.4, the brightness of whites in the projected picture should lie in the range 51 cd/m² (15 fL) to 68 cd/m² (20 fL). For films made in conformity with Recommendation 265-3, this corresponds to an open-gate brightness of not less than 115 cd/m² (33·5 fL) and desirably about 140 cd/m² (41 fL);

3.8 the surround to the screen should be illuminated reasonably uniformly to approximately one third that of picture whites, for example, 14 cd/m² (4fL) to 22 cd/m² (6·5 fL);

Note. — The surround brightness is chosen as a compromise between light levels where the observer is most critical of quality and light levels where the eye suffers fatigue.

3.9 care must be taken to ensure that the characteristics of the remainder of the review room do not affect the performance of the projection system, screen and surround. The wall facing the screen should be of low reflectance and the remaining walls, floor and ceilings should not reflect light onto the screen; their total reflectance should integrate approximately to a neutral grey;

3.10 for normal appraisal purposes no ambient light should be used in the room since it would modify the standardizing effect of the surround. It may, however, be considered desirable for special test purposes to have available a controlled degree of light of appropriate colour temperature which falls on the screen, further to reduce the luminance range.

Note. — To create optical review room conditions which will give the most complete indication of the effects likely to be observed during television presentation, some users may find it desirable to cause a small amount of additional light to fall upon the screen in such a way that it simulates the effects of optical flare in the television system, and possibly that of ambient light in the room where television viewing takes place. The level of light which is intended to simulate optical flare in the television system and its colour temperature will be a function of the picture content; this can simply be produced by some mild diffusing means in the optical projection system. If also desired, the effect of ambient light falling upon the receiver could be simulated by a constant amount of light falling upon the projector screen. In either case, the precise arrangement used would be at the discretion of the user and a suitable choice would be based upon practical experience of the performance of the television system.

ANNEX I

OPTIMUM VIEWING CONDITIONS FOR THE ASSESSMENT OF FILMS INTENDED FOR COLOUR TELEVISION

The appraisal of films intended for the international exchange of programmes for colour television has frequently involved difficulties due to differing standards of performance in telecine channels. Telecine apparatus exists in a wide range of technical specifications which may vary from a highly complex design incorporating many refinements, both colorimetric and electronic, to a simple uncorrected colour analyser and many problems of film quality are ultimately found to be attributable to telecine performance. Difficulties also arise because the majority of interests involved in the production of films, particularly film-processing laboratories, do not have television apparatus and are found to carry out their quality control under very variable conditions. It is clearly desirable that where a film is a subject of international exchange, the successive appraisals of its technical characteristics should be carried out in a standard manner.

In addition to its universal availability, optical projection has many fewer variables than a colour television system and, until a world-wide standard for telecine performance can be realised, it is to be preferred for appraisal purposes.

Note. — European Broadcasting Union (E.B.U.) Technical document 3091 contains, besides the substance of this Recommendation, examples of installations at present used by members of the E.B.U.

BIBLIOGRAPHY

CTP [June, 1969] Canadian Telepractices Committee. Recommended practice CTP-1; Viewing conditions for the evaluation of color film for television use. *Journal SMPTE*, Vol. 78, 483-484.

SMPTE [1970] Color and luminance of review room screens used for 16 mm color television prints. Society of Motion Picture and Television Engineers (U.S.A.). Recommended practice RP41.

REPORT 294-3*

STANDARDS FOR THE INTERNATIONAL EXCHANGE OF MONOCHROME AND COLOUR TELEVISION PROGRAMMES ON FILM

(Recommendations 265-3 and 501)

(1970 – 1974)

1. Question 16/11 posed questions which have been largely answered in Doc. X/140 (E.B.U.) 1966–1969, and in Recommendation 265-3, § 3.4.1. It is considered that the technology of telecine design and apparatus has progressed to the point where broadcasting authorities have achieved reproducing characteristics in their monochrome telecines which give satisfactory results, taking into account the constraints imposed by the scanning standards in use (Doc. 11/41 (E.B.U.) 1970–1974). Once the recommended density range and the maximum and minimum values have been met (see the note to § 3.4.1 of Recommendation 265-3), it is considered that any additional specifications of the transfer characteristics places unnecessary constraints upon the artistic intentions of the producer (Doc. 11/60 (United Kingdom) 1970–1974). Question 16/11 has therefore been deleted in favour of Question 21-1/11 (see § 5).

2. Question 21/11 (New Delhi), referring to the reproduction of film, has been answered in part by Recommendation 265-3 incorporating contributions from Docs. 11/42 (E.B.U.), 11/43 (E.B.U.), 11/231 (Italy), 11/256 (E.B.U.) and 11/265 (United Kingdom) (1970–1974).

Those parts of the Question (§§ 1 and 3) concerning colour balance and densities of films for television have been answered in Recommendation 265-3, § 3.4.2.

One contribution (Doc. 11/29 (Japan) 1970–1974) presented a study of actual performance figures from numerous film samples (see the Annex to Doc. 11/29 (Japan) 1970–1974) which may be of interest to other broadcasters and gave information on the National Standards used in Japan. The minimum density recommended agrees with that in Recommendation 265-3, and an indication of the density range consistent with good colour reproduction has also been incorporated in this Recommendation. As for the maximum permitted density, however, other countries were reluctant to accept a tight tolerance, especially as the wording of Recommendation 265-3 has been carefully phrased to secure agreement on this subject.

3. The safe television title area and the safe television sub-title area for anamorphic films were the concern of Doc. 11/231 (Italy) 1970–1974. It is to be hoped that the ISO will produce a recommendation on this matter.**

4. The answers to § 2 of Question 21/11, New Delhi, concerning the optimum viewing conditions for the assessment of films are contained in Doc. 11/43 (E.B.U.), 1970–1974, and have been incorporated in Recommendation 501. Many countries now operate projection rooms for film review and assessment in accordance with this Recommendation. The range of colour temperature for both the balance and the assessment of colour film intended for television represents a compromise between what appears to be acceptable to film makers and processing laboratories on the one hand, and the precise normalizing white adopted by broadcasters, on the other hand.

Doc. 11/96 (France), 1970–1974, proposed that the question of an objective method for the measurement of colour balance should be studied. Several countries pointed out the difficulties inherent in such work, but it was agreed that a fairly simple objective method would be valuable for cases where inconclusive results were obtained from the recommended subjective method of appraisal.

5. In revising Question 21/11 (New Delhi) those points which have already been answered were deleted and Question 21-1/11 now refers to such matters as an objective method for the measurement of colour balance and contributions to this Question are requested.

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* Adopted unanimously.

** The Director, C.C.I.R., in accordance with Opinion 16-1, is requested to transmit this Report and Doc. 11/231 (Italy) 1970–1974 to the Director, ISO.

It has been suggested that a Study Programme should be drafted to determine the performance which may be achieved by present-day telecine equipments, and Question 21-1/11 takes account of this point.

6. Question 17-1/11, which refers to optical sound recording characteristics, takes into account Doc. 11/21 (United Kingdom), 1970–1974 and the inclusion of the new § 4.1 in Recommendation 265-3.

7. Question 19/11 refers to the pre-emphasis time-constant used in 16 mm magnetic recording. There is now widespread agreement on this matter (Docs. 11/256 (E.B.U.) and 11/265 (United Kingdom), 1970–1974) which resulted in Recommendation 265-3 (see §§ 4.2.6 and 4.3.3).

Doc. 11/97 (France) 1970–1974, proposing a new SEPMAG format compatible with both the previous standards, was adopted and was incorporated into Recommendation 265-3. It is hoped that this will lead to a reduction in the number of standards in use.

8. Cueing leaders have been actively studied. Doc. 11/257 (E.B.U.) 1970–1974 gives the E.B.U. proposals for film leaders, which are also a matter for ISO/TC 36. The E.B.U. proposals are reproduced in the Annex to this Report. It is hoped that further contributions on this subject will be received and that agreement can be reached on a leader which while being suitable for use in television broadcasting would be also acceptable for cinema use.

9. Question 22/11 and Report 468-1 deal with the synchronization of pictures and sound. The Report takes into account IEC Publication 461—Time and control code for video tape recording—as well as Doc. 11/255 (E.B.U.) and Doc. 11/336 (Netherlands) 1970–1974. Further contributions are expected on the problems of synchronizing film pictures and film sound.

10. Question 28/11 concerns the addition of data for controlling automatic television station equipment to recorded television programmes and contributions on this subject are requested.

11. Question 20/11 deals with the problem of recording colour television signals to obtain colour film programmes. Report 469-1 summarizes the systems now in use for this purpose. It has been suggested that the development of high-quality television standards-conversion equipment may reduce the importance of telerecording in the international exchange of programmes.

12. The matter of the information to be placed on the label of the film container is still of interest and some countries have been using, to their mutual advantage, a standard multi-lingual format for this label. Contributions on this topic are also requested.

ANNEX I*

UNIVERSAL FILM LEADER FOR CINEMA AND TELEVISION

1. Introduction

Many different film leaders have been designed during the history of motion picture films. Basically, the leader is a length of film attached to the head of the programme film to assist in lacing the telecine machine or cinematograph projector. If, however, it is marked with suitable visual information it may be used to ensure that the correct amount of time is allowed for the machine to run up to speed and arrive at the beginning of the programme information at a specific moment. It is also usual for the leader to bear marks which facilitate the synchronization of the reproduction of the sound record with that of the picture information. General advice on leaders is contained in Recommendation 265-3.

* This Annex is based on Doc. 11/257 (E.B.U.), 1970–1974.

The reason for the existence of many different leaders lies in the fact that the visual requirements for cinema projection tend to be different from those for television use and there is the further complication that there are some systems using 24 frames per second and others using 25 frames per second. The latter is encountered where the field rate of the television system is 50 Hz.

It is very desirable that there should be a substantial reduction in the number of leaders encountered because operational errors arise from failure to recognise the significance of certain marks (particularly marks concerned with the synchronization of the sound) when an unfamiliar leader is used. There would also be an advantage in having a leader which is suitable for use in cinematograph projectors and in telecine machines: it should also permit the synchronization of all commonly-encountered separate sound systems and give a sufficiently accurate run-up timing when used in systems having either 24 or 25 frames per second.

This Report describes a draft leader intended to fulfil these requirements.

The design incorporates a very small number of signs, and thus provides a basis for the possible development of more elaborate national leaders. The intention is that this structure should enable any operator in any country to deal with familiar images. The original leader can thus be retained with any film that is exchanged.

The draft was developed by Sub-group G3 of E.B.U. Working Party G, who based its work on various national or international proposals for leaders in order to produce a leader suitable for the maximum number of users. Copies of the leader were made by Sveriges Radio, which used them experimentally for cinema projection and showing on television. These experiments have confirmed that this leader is suitable for both applications.

2. Description of the leader

The general form of the proposal follows that of ISO Document ISO/TC 36 (October, 1968) entitled "Leaders and run-out trailers for 35 mm and 16 mm release prints". Other relevant documents are AFNOR No. Pr S 25-003, DIN 15 698 BSI document 69/5182 and ASA PH22.55-1966. The changes incorporated in this draft are those considered necessary to provide a leader which is suitable for films used in television as well as for presentation in motion picture theatres.

Leaders are normally divided into three sections:

— a protective section of blank film,

— an identification section,

— a synchronizing section.

Only the last two sections are represented in the Fig. 1 (Universal film leader) of this Report and some details concerning the design are given below.

2.1 *Identification section*

The identification section will begin at frame No. 307 (marked HEAD) and will finish at frame No. 241. It will carry information in accordance with the provisions of Recommendation 265-3, § 3.9.

Frames Nos. 288 and 264 are allocated count numbers 12 and 11, respectively, and although they fall within the identification section, they are an extrapolation of the synchronizing section for use in certain dubbing operations where a very long run-up time is necessary.

2.2. *Synchronizing section*

2.2.1 *Projection speed*

The distances between the principal marker frames (Nos. 48, 72, 96, etc.) are 24 frames, conforming to normal cinema leader practice. Thus the 'blinks' caused by the projection of the lower-density image in the marker frames will occur at intervals of one second, once the projector has run up to speed.

For part of the passage of the synchronizing section through the projector or telecine, the speed of the machine will be increasing from zero to the normal 24 or 25 frames per second and even when stability is reached, the importance of precise one-second measurements is not, as a rule, of great operational significance since the cue to start the machine must be made with a prior knowledge of its run-up characteristics.

For this reason, it is suggested that there is no substantial value in having leaders which are equally suitable for both 24 frames per second and 25 frames per second. The majority of systems function at 24 frames per second and, therefore, the leader should be based on this rate.

2.2.2 *Frame-by-frame details of the synchronizing section*

Frame 240	The synchronizing section starts at frame 240 with the count number 10 surrounded by two circles with markings for every 15°. The number and the "clock" are in black-on-white, but the minimum density is controlled to prevent overload of telecines. A triangular black pointer marks 0°.
Frames 239 to 217	Count number 10 is in white-on-black. The rate of 24 frames/s is indicated by a white pointer rotating around a centrepoint 15° every frame.
Frame 216	Count number 9. Otherwise as for frame 240.
Frames 215 to 193	Count number 9. Otherwise as for frames 239 to 217.
Frame 192	Count number 8. Otherwise as for frame 240. This frame corresponds to START of the Academy Head Leader or PICTURE START of the S.M.P.T.E. Universal leader.
Frames 191 to188	Four black frames marked COLOUR REFERENCE (printed lengthwise with the film) and intended to be replaced by four frames of colour reference picture in the leader of all master material.
Frames 187 to 173	Count number 8. Pointer indications from 75° to 285°.
Frame 172	Indicator for position of sound reproducer for 16-mm film with magnetic stripe, 16 COMMAG SYNC, printed in white letters. (Correctly spaced with respect to frame 144.)
Frame 171	Count number 8. Pointer indication 315°.
Frame 170	Indicator for position of sound reproducer for 16-mm film with an optical track, 16 COMOPT SYNC (correctly spaced with respect to frame 144).
Frame 169	Count number 8. Pointer indication 345°.
Frame 168	Count number 7. Otherwise as for frame 240.
Frames 167 to 165	Count number 7. Pointer indications from 15° to 45°.
Frame 164	Indicator for position of sound reproducer for 35-mm film with an optical track: 35 COMOPT SYNC (correctly spaced with respect to frame 144).
Frames 163 to 145	Count number 7. Pointer indications from 75° to 345°.
Frame 144	START. The reference image for synchronization of all sound tracks.
Frames 143 to 121	Count number 6. Pointer indications from 15° to 345°.
Frame 120	Count number 5. Otherwise as for frame 240.
Frames 119 to 97	Count number 5. Pointer indications from 15° to 345°.
Frame 96	Count number 4. Otherwise as for frame 240.
Frames 95 to 73	Count number 4. Pointer indications from 15° to 345°.
Frame 72	Count number 3. Otherwise as for frame 240.
Frames 71 to 49	Count number 3. Pointer indications from 15° to 345°.
Frame 48	Count number 2. Otherwise as for frame 240.

Frames 47 to 1	Black.
Frame 0	White with black text "SPLICE HERE" with a pointer which marks the junction between leader and programme, namely, between frames 1 and 0.

2.2.3 *Technical design*

2.2.3.1 The following approximate densities are suggested:
white or low density ⩾ 0·35
black or high density ⩽ 2·00

2.2.3.2 The backgrounds shall be of 4 × 3 format with a white frame line between the frames.

2.2.3.3 The START-mark and the count numbers are confined to half picture-height to allow legibility when set up as a still frame in a flying-spot telecine.

2.2.4 *Separate sound recording*

In the case of the SEPMAG system, the sound film should have a very small perforation (approximately 1 mm square) at the point in the sound recording corresponding to the START reference point on the leader. So that the user may locate this point easily, a piece of adhesive tape may be attached to the sound film in advance.

Another method for ensuring that the picture and sound coincide at the start is to use the leader described above for the sound film.

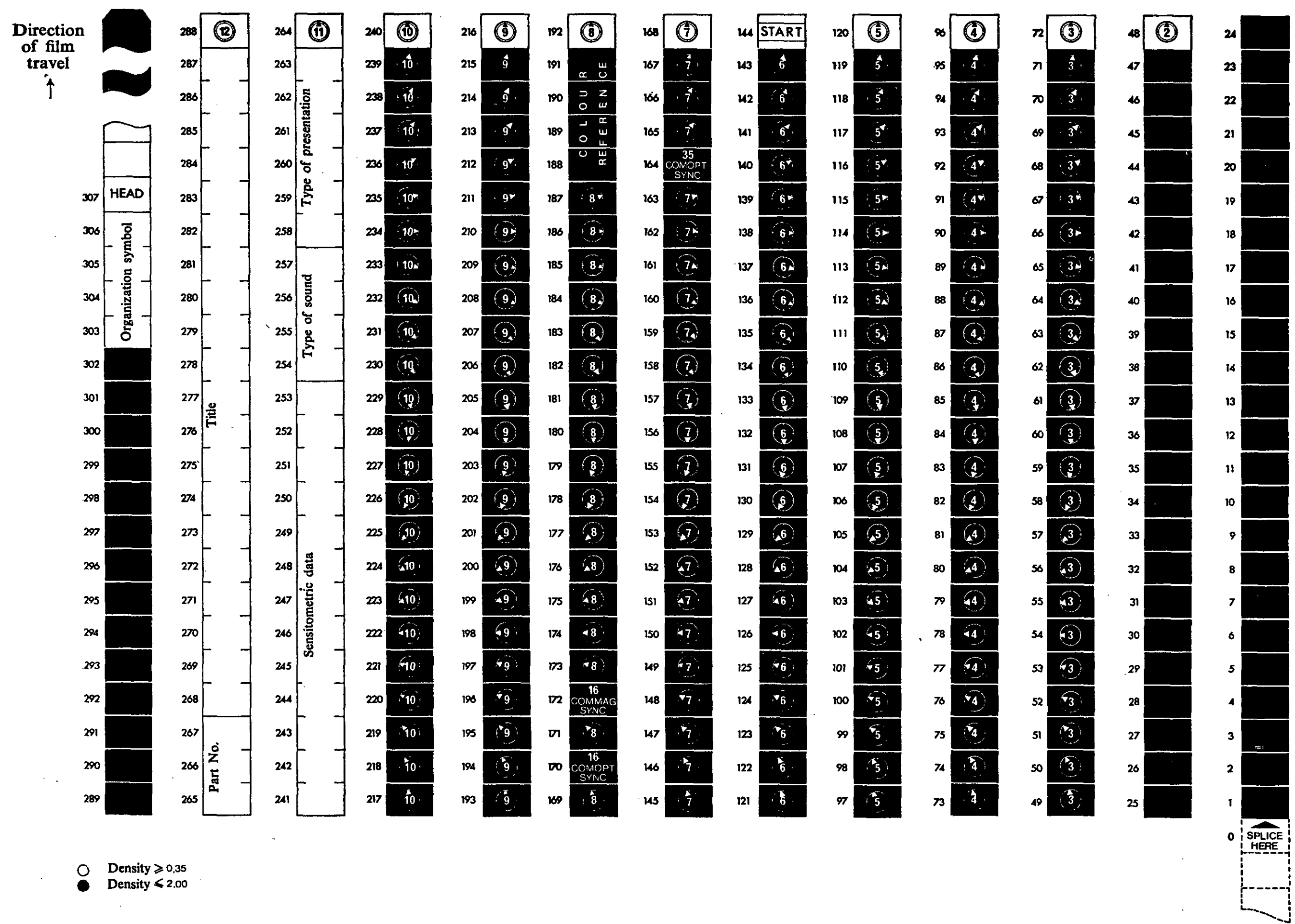

FIGURE 1

Universal film leader

REPORT 469-1*

PHOTOGRAPHIC FILM RECORDING OF COLOUR TELEVISION SIGNALS

(Question 20/11)

(1970 – 1974)

1. Introduction

A serious limitation in the international exchange of colour television programmes has been the lack of a means for transferring the electronic video-frequency signal to motion-picture film, without significant loss in quality. Although several systems are in limited commercial use at present, all rely upon some form of optical image-transducer and, in consequence, are limited by the aperture of the optical system and noise level characteristics.

Because of the limited use of the various systems, and shortcomings in the quality of recordings, it is premature to answer Question 20/11. Therefore, this Report is for information purposes only and describes practices used for photographic film recording of colour television programme material from video-frequency signals. Also noted are systems under development which use direct electron beam recording or using laser optics, which may ultimately result in significant improvement in the film recording process.

2. Present-day systems

The following is a brief description of representative film recording systems in current use and those known to be under development.

2.1 *Triniscope*

This is a three-tube picture presentation, registered optically for colour photography through a system of dichroic mirrors. Although registration is a problem, this system provides enough brightness for photography with finer grain reversal and negative-positive film systems. It has been used for several years by a few organizations.

2.2 *Shadow-mask*

More common is a single-tube presentation using conventional or special shadow-mask tubes. Signal processing is frequently done to correct for colour, sharpness or contrast errors. Conventional tubes require the higher speed, daylight-balanced 16 mm colour reversal films for adequate exposure. A special tube with a clear face-plate is used to provide just enough brightness to expose a finer-grain 16 mm colour reversal film, from which inexpensive multiple copies can be made by photographic duplication. Otherwise, multiple copies are made by repeated recording from video tape onto high-speed reversal colour films.

This latter method is used by broadcasters for distribution of television news programmes, and for recording where few copies are required. The method employing the special tube and finer-grain printing master is used primarily to obtain recordings of commercials and other promotional material.

Some limited use has been made of 35 mm negative colour film for this photography, from which either 35 mm or 16 mm prints can be derived.

2.3 *Sequential display*

One organization is providing a recording service in which red-, blue- and green-separation records are made, sequentially, from a colour video-tape recording. These separate records on black-and-white film are combined by photographic printing, to provide a photographic colour print or a master from which multiple copies can be made.

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* Adopted unanimously.

3. New systems

3.1 *Electron beam colour-film recording*

A system using electron beam equipment has been developed for use in making colour separation records.

3.2 *Colour-film recording using a laser beam*

Several organizations are investigating the use of laser beams for producing colour-film recordings. Equipment is available for producing the colour television image.

REPORT 470-1*

MEASURING METHODS FOR TELEVISION TAPE RECORDING

(Study Programme 18C/11)

(1970 - 1974)

In recent years, many studies have been conducted in various countries on the most appropriate measuring methods for television tape recordings. These studies cannot yet be considered to be concluded and it seems appropriate to give a list of documents bearing on this problem, in order to facilitate future work.

C.C.I.R. documents relevant to Study Programme 18C/11, submitted in the period 1966–1969, are:

X/2 (E.B.U.)	Test signal to be used for the adjustments of television tape recorders.
X/45 (France)	Measurement of differential phase on video-tape recorders.
X/59 (Italy)	Recording of television signals on magnetic tape.
X/168 (France)	Relative speed errors in television tape recorders.
X/170 (O.I.R.T.)	Evaluation and measurement of the most important qualitative parameters of the video frequency part of video-tape recorders.
X/182 (E.B.U.)	Definition and measurement of drop-outs in television tape recordings.
X/201 (Italy)	Recording of television signals on magnetic tape.

Documents submitted in the period 1970–1974 are:

10/33(11/39) (E.B.U.)	Measuring methods for television tape recording.
11/51 (United Kingdom)	The measurement of moiré on video tape recorders.
11/95 (France)	Measuring methods for television tape recording.

In the light of Opinion 16-1, the C.C.I.R. has decided not to continue to study the documents listed, but rather to refer them to the IEC for consideration by IEC Technical Committee 60 and their possible inclusion in future IEC Publications.

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* The Director, C.C.I.R., is requested to bring this Report, which was adopted unanimously, to the attention of the IEC.

REPORT 630*

INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES ON MAGNETIC TAPE

(1974)

1. This Report outlines some of the studies currently under way which can lead to further improving the international exchange of programmes recorded on magnetic tape.

2. Wave form of the edit-pulse record current

IEC Publication 347, § 5, Fig. 4, indicates the wave form of the record current for the edit pulse which specifies a pulse width of 60 ± 10 μs, and a minimum amplitude of 150% of the peak-to-peak amplitude of the control track sine-wave current.

In view of some difficulties experienced, the E.B.U. has proposed in Doc. 11/40 (E.B.U.) 1970–1974, that the edit-pulse wave form should be defined with greater precision by adding a specification for the rise and decay time of 15 ± 10 μs.

Final agreement could not be reached on the E.B.U. proposal; studies are in progress in the U.S.A. and elsewhere and it is hoped that further contributions will soon be submitted.

When considering the problem, attention should be paid to undesirable cross-talk which may be experienced from the control track to the cue track if the edit-pulse record current wave form has too short a rise or decay time.

3. Alignment signal to be recorded on the programme leader

Recommendation 469-1, § 8, indicates that an alignment video signal should be recorded for a minimum of 60 s, on the leader, but does not give details of the preferred alignment signal (or signals).

Studies are in progress in many organizations, and it is hoped that further contributions will soon be submitted, so that a recommendation may be formulated which would cover the (possibly different) alignment signals acceptable by all countries.

4. Standard format for the programme label

Recommendation 469-1, § 11, requests that the fundamental information necessary for identification of the recorded programme should be provided on labels conforming with the standard format exemplified in Annex II of the same Recommendation.

Annex II shows an example of a label presently in use in a Member Organization of the E.B.U., which conforms with the standard format, as was adopted within the E.B.U. some years ago.

The E.B.U. has standardized the following elements of the label:

— the dimensions of the label,

— the information provided on the label,

— the space allocated to each item of information,

— the relative position of such spaces,

— the shape and layout of the tick-box area, and the position on it of the several boxes and their captions.

In the E.B.U., the label captions are printed in two languages, one of which is the official language of the originating Organization, the other being one of the two official languages of the E.B.U. (English and French). For those E.B.U. Member Organizations whose only official language is either English or French, the captions are printed in both English and French. Apart from being used

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* Adopted unanimously. The Director, C.C.I.R., is requested to bring this Report to the attention of the IEC.

within the E.B.U. for the international exchange of recorded programmes, the same label is used by many E.B.U. Member Organizations for their own internal purposes.

The information contained in the label is often supplemented on a separate sheet or label or punched card that accompanies the recording.

It is hoped that contributions will be received suggesting a standard format for such information.

5. Standard reference audio level

Recommendation 469-1, § 5, specifies the standard reference level for television tape recordings as a short-circuit flux per track width of 100 $\pm$ 10 nWb/m, r.m.s., at 1000 Hz, and notes that the recorded programme peaks should be 9 dB above this level.

The flux level of 100 $\pm$ 10 nWb/m has been adopted as a suitable compromise between the level of 90 nWb/m used in many countries particularly in Europe, and the level of 110 nWb/m used in many other countries, including the United States of America. For the conventional, gamma-ferric-oxide television tapes, which are used at present for the international exchange of programmes, the flux level of 100 nWb/m is approximately 9 dB below the level at which perceptible distortion occurs. For this reason, it has been specified that the recorded programme peaks should exceed the reference level by 9 dB. To prevent a possible misunderstanding on the part of the operator when implementing the recommendation in practical operation, a note has been added in Recommendation 469-1, § 5, pointing out that the real level of the recorded peaks, to which the Recommendation applies, differs from the level indicated by a programme meter, by an amount which depends on the characteristics of the programme meter, and in particular on its integration time (see Report 292-3).

It is expected that it will be necessary to revise the values recommended for the reference and the maximum flux levels in Recommendation 469-1, § 5, when new tapes with a different magnetic coating having a higher coercivity start to be used for the international exchange of programmes.

6. IEC Publication 347

In June 1972, the IEC issued the first edition of Publication 347 "Transverse track recorders". In the light of Opinion 16-1, Recommendation 469-1 has been drafted, so as to make reference to Publication 347 whenever possible and appropriate.

7. Time and control code

To help locate the required sequences on the tape for the editing of programmes, and also to actuate automatic equipment, time and control information may be usefully recorded on the cue track of television tapes. For such tapes and for separate sound recording that may possibly be associated with them, a format has been standardized for a time and control code; it is described in IEC Publication 461. Work is still in progress on the detailed specifications for recording such code on the tape.

SECTION 11F: BROADCASTING SERVICE (TELEVISION) USING SATELLITES

RECOMMENDATIONS AND REPORTS

Recommendations

There are no Recommendations in this section.

Reports

REPORT 215-3*

BROADCASTING-SATELLITE SERVICE: SOUND AND TELEVISION

(Questions 34-1/10 and 23-1/11)

(1963 – 1966 – 1970 – 1974)

1. Introduction

1.1 *General*

The large coverage area possible from a satellite-borne radio transmitter raises the possibility of establishing a direct broadcasting service to the general public, despite the major technical problems that would need to be resolved. An earth-station transmitter would direct programme material to the satellite which, in turn, would broadcast this over a wide area to individual home or community receivers, by using an active repeater or transmitter.

Fixed-satellite systems used to relay programme material to Earth stations for subsequent broadcasting are not considered to be space broadcasting systems and are not, therefore discussed in this Report.

While the data presented are the most complete available, it must be stressed that they must be regarded as provisional and that future experience will undoubtedly make necessary certain modifications to these data.

In spite of their provisional nature, it is probable that results are both sufficiently accurate and wide in scope, at least as regards the technical aspects of the problem, to serve as a basis for consideration of the system to be used in the broadcasting-satellite service.

1.2 *Types of reception*

The broadcasting-satellite service was defined by the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971, in No. 84AP Spa of the Radio Regulations.

Both community and individual reception, as defined in Nos. 84APA and 84APB of the Radio Regulations, are considered in this Report.

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* Adopted unanimously.

1.3 *Educational aspects*

Several Administrations have drawn attention to the fact that, in their countries, terrestrial systems for educational purposes are in operation, and that consideration is being given to the use of satellites to extend the scope of these operations.

Systems used for educational purposes may be operated:

— by broadcasting-satellite service space stations, if intended for direct reception by the general public;

— by fixed-satellite service space stations, if not intended for reception by the general public;

— by stations in the terrestrial services.

2. Frequency considerations

2.1 *Frequency bands*

Consideration has been given to the technical possibility of using certain frequency bands in the vicinity of 700, 2600 and 12 000 MHz for the broadcasting-satellite service for television and at 12 000 MHz for sound.

2.2 *Effects of propagation*

Frequencies in the upper part of band 9 (UHF) and the lower part of band 10 (SHF) are least affected during propagation through the atmosphere. At lower frequencies, ionospheric absorption and scintillation degrade the performance of the system. At higher frequencies, absorption by atmospheric constituents, in particular, water vapour and oxygen, and attenuation due to rain, fog and clouds become important. Tropospheric scintillation will not be important for systems operating at angles of elevation greater than about 5°. Propagation through the ionosphere and troposphere are treated in detail in Chapter 10 of the Report by the Special Joint Meeting, Geneva, 1971, which shows the magnitude of variations in the signal due to various factors.

Ionospheric effects become negligible at frequencies much above band 8 (VHF), except for Faraday rotation which must be considered at frequences up to about 3 GHz. For most conditions of propagation, fading due to Faraday rotation can be avoided by the use of circular polarization either at the broadcast satellite transmitter or at the earth receiver (at the expense of an increase of 3 dB in the required power) or at both ends of the link. Multipath propagation, which could cause impairment in the quality of service, can also be reduced by the use of circular polarization.

The effective bandwidth transmissible through the ionosphere appears ample for television broadcasting transmissions (amplitude modulation) in band 9, since the group delay is small compared with the allowable delay of 0·05 μs (Recommendation 421-3), and this value may be reached at 300 MHz during the day; in band 8, partial delay equalization may be possible to meet allowable delays. The bandwidth appears ample for frequency-modulation television transmission in band 9 (and higher), but in the lower part of band 9 partial delay equalization may be desirable. The effective bandwidth appears ample for voice transmission at all frequencies of interest.

Attenuation due to precipitation and absorption is negligible at all frequencies throughout band 9. At 12 GHz, their combined effects require a substantial system power margin as illustrated below.

In Europe, the total atmospheric attenuation (including the attenuation in clear weather) in the region of 12 GHz has been measured by means of radiometers during a period of two years [Galante, 1974]. The results corresponding to 99% and 99·9% of the time during the least favourable month are given as a function of the elevation angle in Table I and the interpolation formula which follows it. These studies are still limited in their scope and they should be completed, but until more precise results are available, these figures can be used in the planning studies for satellite-broadcasting systems at 12 GHz for the European part of Region 1.

TABLE I

Atmospheric attenuation at 11·5 GHz
(Europe)

Angle of elevation (degrees)	Attenuation (dB)		Atmospheric margin (dB)
	99% of the most unfavourable month (¹)	99·9% of the most unfavourable month (¹)	Difference between the 99% and 99·9% figures
5	6·1	13·0	6·9
10	4·2	8·7	4·5
15	2·9	6·6	3·7
20	2·2	5·7	3·5
25	1·9	5·1	3·2
30	1·6	4·8	3·2
35	1·5	4·5	3·0
40	1·4	4·4	3·0

(¹) Values corresponding to time percentages equal to or higher than 99·9% are highly dependent on the length of the period to which they refer. The difference between values for a whole year and values for the most unfavourable months of that year can be several decibels. On the other hand, values corresponding to time percentages equal to or smaller than 99% are relatively independent of the lengths of the period of reference.

For any frequency f, other than 11·5 GHz, the atmospheric attenuation A_f may be calculated from the values for 11·5 GHz, $A_{11\cdot5}$, by means of the following formula, which is valid from 11·0 to 14·5 GHz:

$$A_f = A_{11\cdot5}\,[1 + 0{\cdot}2\,(f - 11{\cdot}5)] \quad \text{dB}$$

The same formula is applicable to the atmospheric margin.

Note. — The column headed "Atmospheric margin" in the above table gives a measure of the margin which must be allowed above the threshold of the demodulator, to take account of the statistical variations in the atmospheric attenuation.

2.3 *Effects of additive radio noise*

Additive radio noise* is produced from both natural and man-made sources (power lines, electrical apparatus, automobile ignition systems). Fig. 1 indicates typical noise levels associated with these sources, and shows that in the lower part of band 10 and in the greater part of band 9 a minimum of noise is introduced depending upon the conditions.

At present, limited information on the subjective aspects of impulsive noise is available [Pacini *et al.*, 1971]. There is insufficient knowledge regarding the dependence of man-made noise on the angle of arrival, polarization, frequency, height of antenna, etc., to make adequate engineering analyses of the levels likely to be present at the terminals of the receiving antenna.

In addition to the noise sources indicated in Fig. 1, a significant increase in noise level can occur for short periods when the Sun is within the antenna beam, if narrow-beam receiving antennae (beam-width less than about 5°) are used. For geostationary satellite orbits, these periods occur in the day-time for a few consecutive days in spring and autumn.

* Attention is drawn to the fact that while many measurements of noise level have been made, evaluation of this data is as yet incomplete. Therefore, the assumed noise levels must be considered as provisional.

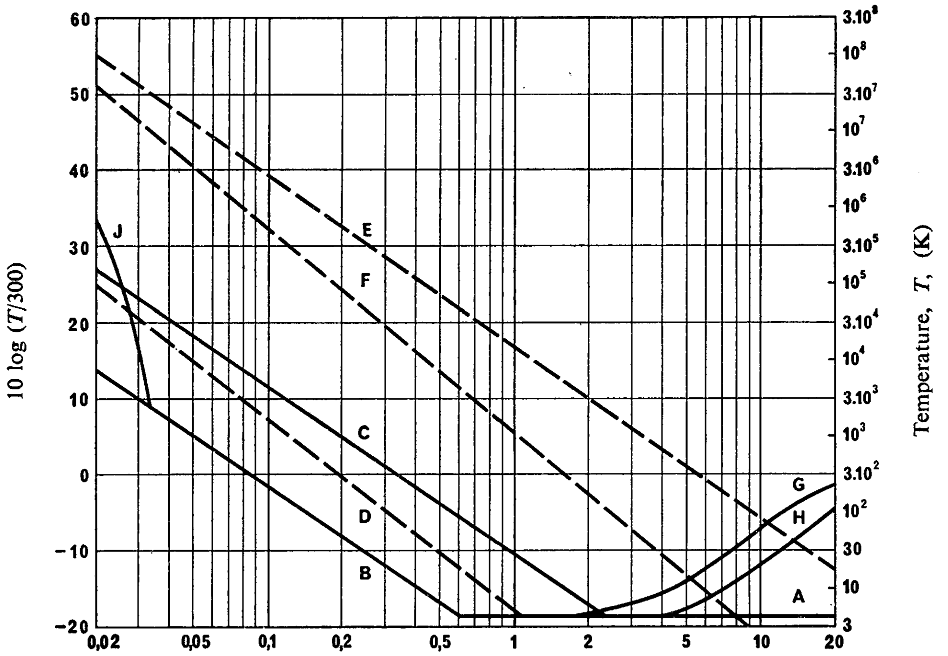


FIGURE 1

Noise temperature from natural and man-made sources

A : Cosmic noise background (Report 205-3).

B : Minimum cosmic noise (Report 205-3).

C : Maximum cosmic noise (Report 205-3).

D : Typical man-made noise in "rural" area (omnidirectional receiving antenna) [J.T.A.C., 1968].

E : Typical man-made noise in "urban" area (omnidirectional receiving antenna) [J.T.A.C., 1968].

F : "Urban" noise, adjusted for a directional antenna orientated at angles of elevation greater than 45°; noise discrimination equal to one half the gain of the antenna (in dB) is assumed with a gain of 8 dB at 20 MHz and 25 dB at 2500 MHz.

G : Typical noise due to rainfall and atmospheric absorption for 0·1% of the time: temperate latitudes: angle of elevation 30°.

H : Typical noise due to rainfall and atmospheric absorption for 1·0% of the time: temperate latitudes: angle of elevation 30°.

J : Night-time atmospheric noise (Report 322-1).

2.4 *Suitable frequency bands*

The portion of the spectrum including band 9 (Band V and above) and the lower part of band 10 is preferred for satellite broadcasting, the lower values of atmospheric attenuation, scintillation and radio noise from natural sources. The usable frequency range is wider, extending into band 7 at the lower end and approaching 20 GHz at the upper end (Report 205-3 and Report 631). For broadcasting services to urban locations, man-made noise can represent the principal limitation to reception at all frequencies throughout band 9. Because of this, the attention of administrations is drawn to the possibility of reducing this type of noise by means of regulations.

2.5 *Sharing*

Frequency sharing between the broadcasting-satellite service and terrestrial services, which is an important factor, is not discussed below, since it forms the subject of Report 631. Also, sharing between the broadcasting-satellite service and the fixed-satellite service is considered elsewhere.

3. Satellite aspects

This section provides estimates of spacecraft technology that could be available. Much of the material in this section has been derived from [C.C.I.R. 1966–1969a]. These estimates assume that programmes will be established, or continued, at a level sufficient to bring about these theoretically attainable developments.

The fraction of total spacecraft mass devoted to its several sub-systems is a function of the total spacecraft mass itself. As the mass increases, the fraction required for the "housekeeping" functions (attitude control and station keeping) and for the antenna decreases so that the fraction available for the transmitter and the power supply (and for thermal control) increases. Consequently, larger satellites represent a more efficient use of the available payload of launch vehicles.

3.1 *Factors affecting choice of orbit*

Among the factors to be considered in the selection of preferred orbits for satellite broadcasting are coverage, number of daily broadcast hours desired and antenna characteristics.

The satellite orbit for a broadcast service must provide coverage of selected regions of the Earth during desired viewing or listening hours, which may vary from several to twenty-four hours per day. For non-continuous broadcast periods, it is desirable to have these intervals occur at the same local time each day. Regardless of the duration of the broadcast period, it is desirable to have an orbit that does not require antenna tracking equipment at broadcast receiving installations.

A geostationary satellite (altitude 35 786 km above the equator) would permit a continuous broadcast service to areas as small as individual countries or as large as continents, up to about one-third of the surface of the Earth. The limitation imposed by the minimum usable angle of elevation can be determined from Fig. 1 of Report 206-3. A geostationary satellite also permits the use, if required, of a fixed receiving antenna of very high gain (and hence directivity).

A satellite in a sub-synchronous circular equatorial orbit can provide coverage at the same local time each day. The number of uninterrupted broadcast hours possible from such a satellite to a given area on the surface of the Earth is a function of the satellite altitude and the latitude of the receiving point. Representative visibility times are shown in Table II.

Because the sub-synchronous satellites in circular orbits have a lower altitude than a geostationary satellite, a stronger signal is available for a given transmitter e.i.r.p. Such satellites may therefore have an advantage when the maximum transmitting antenna gain is limited by size restrictions and when the receiving antenna can be nearly omnidirectional.

In band 8 (VHF), or at higher frequencies, a satisfactory signal-to-noise ratio can be achieved using frequency modulation with a geostationary satellite or other high-altitude satellite, so that the lower altitude satellites do not appear to present any advantage.

A satellite with a period of 12 hours, in an elliptical orbit having a plane inclined at about 63° to the equatorial plane and an apogee of 40 000 km well north of the equator, can provide a larger area of coverage in the northern hemisphere than a geostationary satellite. The use of several satellites in such orbits can provide an uninterrupted service. The times of visibility of one satellite are given in Table III for a particular latitude (60°N) of the receiving point, and a particular minimum angle of elevation (20°). In theory, because of the non-spherical shape of the Earth, an inclination of the orbit of 63·4° would ensure that the major axis does not drift in the plane of the orbit, and, therefore, that successive apogees will occur at the same terrestrial latitude.

In the example of Table III, the minor axis of the orbital ellipse is assumed to be parallel to the equatorial plane. The maximum period of visibility from a given point on the Earth at latitude 60° (10·6 hours) is then obtained when the apogee is at the same longitude as the point.

In selecting highly elliptical orbits, it is preferable to avoid passage through the van Allen belt, or to ensure that satellites pass rapidly through the radiation region in order to avoid damage to components.

For the various orbits, uninterrupted reception is possible only when the satellite remains within the beam of the receiving antenna. Therefore, assuming the antenna is fixed, it must have a sufficiently large beamwidth to ensure the desired service.

If a sub-synchronous circular orbit is used, it would not be possible to employ most of the available period of visibility, using a fixed receiving antenna, unless the antenna is of low gain (e.g. a half-power beamwidth of 110° corresponding to a maximum gain of 6 dB).

If a sub-synchronous highly elliptical orbit is used, a fixed antenna of higher gain could be used (e.g. a half-power beamwidth of about 30° corresponding to a maximum gain of 15 dB).

If a geostationary satellite is used, the antenna gain can be higher than in the examples above, but the maximum antenna gain might be limited (because of the consequent small beamwidth) either by practical considerations of the receiving installation or by the lack of stability of the position of the satellite as discussed in § 3.2.

If narrow-beam receiving antennae (beamwidth less than about 5°) are used, a significant increase in noise level can occur for periods of a few minutes when the Sun is in the antenna beam. For geostationary satellites orbits, these periods occur in the day-time for a few successive days in spring and autumn.

3.2 *Station keeping and attitude control*

The slight inequalities in the gravitational field of the Earth, together with the gravitational forces due to the Sun and Moon have perturbing effects on satellites which otherwise would remain stationary, but these can be counteracted by orbit correction or "station-keeping" techniques.

TABLE II

Visibility times for satellites in stationary and sub-synchronous circular equatorial (non-retrograde) orbits

Approximate period (h)	Altitude (km)	Passes per day over a given point	Approximate periods of visibility above the horizon per pass (h)			
			At equator	At ± 15° lat.	At ± 30° lat.	At ± 45° lat.
24 (1)	35 786	Stationary	Continuous	Continuous	Continuous	Continuous
12	20 240 (2)	1	10·1	10·0	9·9	9·3
8	13 940 (2)	2	4·8	4·7	4·6	4·2
6	10 390 (2)	3	3·0	2·9	2·8	2·5
3	4 190 (2)	7	1·0	1·0	0·9	0·6

(1) Exactly: 23 h 56 min 4 s.

(2) Approximate values.

TABLE III

Visibility times of a satellite in a typical elliptical orbit inclined at about 63·4°

Approximate period (h)	Approximate apogee (km)	Approximate perigee (km)	Approximate periods of visibility per pass (h) over a reception point at 60° latitude, with an angle of elevation of the receiving antenna greater than 20°	
			Maximum	Minimum
12	40 000	500	10·6	4·5

A geostationary satellite will experience extremely slight eastward or westward forces which change the longitudinal drift of the satellite.

Other perturbing forces tend to change the inclination of the orbital plane by approximately 0·8° per year, thereby causing the satellite to undergo corresponding daily variations in latitude.

Present station-keeping techniques develop corrective thrust to overcome the gravitational forces by the use of small propulsion jets on the satellite, operated by propellants stored on board. The extent to which correction is required depends upon the allowable displacement of the satellite.

East-West (longitudinal) station-keeping is usually essential, because the uncorrected drift may be relatively large and rapid. Fortunately, the required rate of propellant consumption is very low. North-South (latitudinal) station-keeping, to keep the orbit close to the plane of the equator, will become more important as satellites achieve longer life. Latitude station-keeping requires about ten times the amount of propellant as does longitude station-keeping.

For frequencies up to 1 GHz, where the required beamwidth of the receiving antenna is not expected to be less than 5°, a station-keeping accuracy of 1° will be sufficient to ensure that the satellite remains in the beam of receiving antennae. Above 1 GHz, accuracies of the order of 0·25° may be required. The longitudinal drift for satellites at present in the geostationary orbit can be held to 0·1° during a satellite lifetime of at least five years. Satellites now under construction will be capable of controlling the daily variation in latitude to the same accuracy. Station-keeping techniques for achieving the orbital accuracy required for a geostationary broadcasting satellite are, therefore, technically feasible.

The pointing accuracy of the satellite antenna beams is very important in satellite broadcasting to obtain the best utilization of the antenna directivity. On the other hand, solar pressure and thermal gradient are the causes of depointing of the satellite antenna beams. To maintain the pointing of the antenna, it is therefore necessary to control the attitude of the satellite with as high an accuracy as possible. This accuracy depends mainly on the type of sensor and on the system chosen for the attitude control.

The satellite antenna can be fixed to the body of the satellite or gimballed with respect to the satellite. Antennae with an electrically pointed beam are envisaged. In the case of antennae fixed to the satellite, the pointing accuracy is determined by the attitude control of the satellite that can be obtained, for example, from dual spin (spinning of a portion of the satellite while the antenna is situated on a platform fixed with respect to the Earth) which can achieve a pointing accuracy of 0·15° or from stabilization of the three orthogonal axes of the satellite, which can achieve pointing accuracies of better than 0·1°. In the case of antennae gimballed with respect to the satellite, pointing of the antennae can be obtained with a system independent from that used for the attitude control of the satellite, if, for example, use is made of the signals of a radio-frequency sensor, integrated with the antenna, controlled by a beacon transmitter on the ground; in this case, pointing accuracies of the order of 0·05° can be achieved.

3.3 *Primary power*

3.3.1 *Solar arrays*

As the projected power requirements have increased, attention has been directed to the use of light-weight sun-oriented arrays. Most of the interest is centred around photo-voltaic cells mounted on a flexible substrate which is retracted by rolling onto a drum [Ray and Winicor, 1966]. These arrays are deployed by means of extendable booms.

A 1·5 kW roll-out array has been successfully flight tested. Present estimates are that a reliable 12 kW (decreasing to 10 kW at the end of five years) roll-out array could be designed.

The mass of a broadcasting satellite in its final orbit, as a function of solar-array power, including necessary power conditioning equipment, can be approximated by the following formula, which is independent of operating frequency:

$$W \approx 250 + 110P \qquad \text{kg}$$

where P is the solar-array power (kW). As the technology for broadcasting satellites evolves, this formula may change.

A solar array does not provide power during passage in the shadow of the Earth. With a geostationary satellite there is one eclipse each day, but only within the periods of approximately 1 March to 11 April and 1 September to 11 October. Near the centre of these periods, the eclipse lasts about seventy minutes about midnight at the satellite longitude; the duration is less towards the beginning and end of the periods. In the case of longer eclipses, sufficient warm-up time must be allowed after the end of the eclipse. In the past, about half an hour has been required.

The practical consequences can be minimized by shifting the service break to late in the night, which can be done by placing the satellite to the west of its service area; batteries can also be placed on board, but this would greatly increase the weight of the satellite.

3.3.2 *Other power sources*

Nuclear reactors and fuel cells are possible sources of primary power, but additional development will be required before they will be competitive with solar arrays in terms of cost, mass and reliability.

Thermoelectric junctions and thermionic cells may also be considered as a means of converting heat from the Sun or from isotope sources into electrical energy, and offer the possibility of less total mass in the power unit for a given electrical output. Work is in progress on the development of such devices and their application to spacecraft [I.E.E., 1968].

3.4 *Radio-frequency power*

3.4.1 *Summary of radio-frequency power limits*

The final stage of the broadcast transmitter is the major consumer of power on the satellite. Solid-state transmitter modules for a frequency of about 700 MHz and at power levels of about 100 W will be available in the near future. Appreciably higher powers, particularly at higher frequencies, will require vacuum tubes. For the frequency range 2 to 20 GHz, travelling-wave tubes or klystrons might provide maximum powers in the range 1 to 7·5 kW, depending on the frequency. An efficiency of 35 to 65%, including any loss in power conditioning units, can be achieved with these systems. A 200 W travelling-wave tube with an efficiency of about 50% at 12 GHz will be used in the U.S./Canadian Communications Technology Satellite Programme.

A graphical summary of some of the factors that limit radio-frequency power is shown in Fig. 2*a*. The total output power is limited by the solar array power and the transmitter efficiency. The output power of a single tube is limited by cathode loading and beam compression. The power in a waveguide component is limited by radio-frequency breakdown and heating.

3.4.2 *Equivalent isotropically radiated power*

Combining the factors shown in Fig. 2*a* with gain limitations discussed in § 3.5, an estimate of maximum e.i.r.p. that will be technically feasible can be derived as a function of frequency (Fig. 2*b*). A 12 m antenna having been assumed, the zone of coverage obviously will decrease with increasing frequency.

For a given zone of coverage, say 2°, maximum values of e.i.r.p. of 75 dBW at 700 MHz and perhaps 70 dBW at 12 GHz can be expected with still higher powers likely to be technically feasible at a later date.

The comment at the beginning of § 3, concerning the necessity for adequate development programmes is particularly relevant to the estimates just given. Experience indicates that perhaps five years would be necessary to carry out such programmes.

3.4.3 *Thermal control*

The major problems are associated with heat rejection from the power conditioning components and from the high-power stages of the transmitter. Solid-state components lend themselves to simple passive methods of control. However, the low operating temperatures (350 K to 390 K) require a significant amount of radiator area. Other devices, such as gridded tubes and microwave tubes, have high heat dissipation densities and high temperatures. The higher operating temperatures (470 K to 500 K) minimize the radiator area requirements.

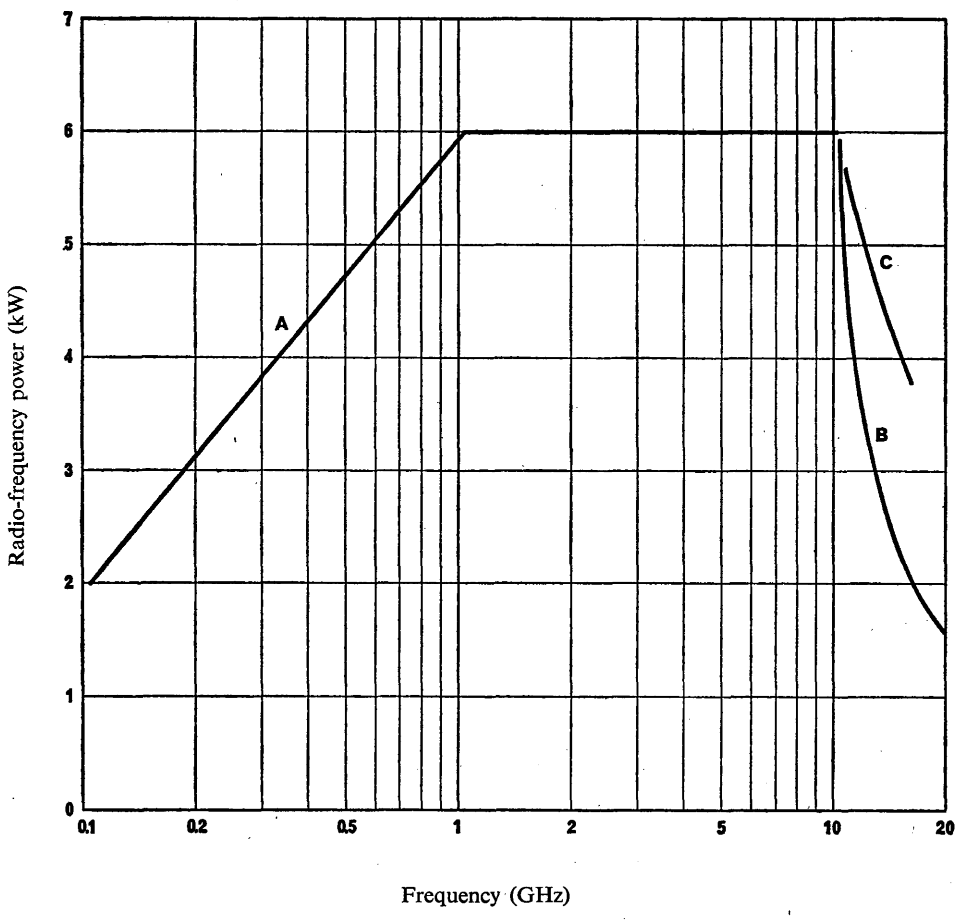


FIGURE 2*a*

Factors limiting the maximum possible radio-frequency power as a function of frequency

A: single waveguide (radio-frequency breakdown)
B: single tube (cathode loading)
C: single waveguide (heating)

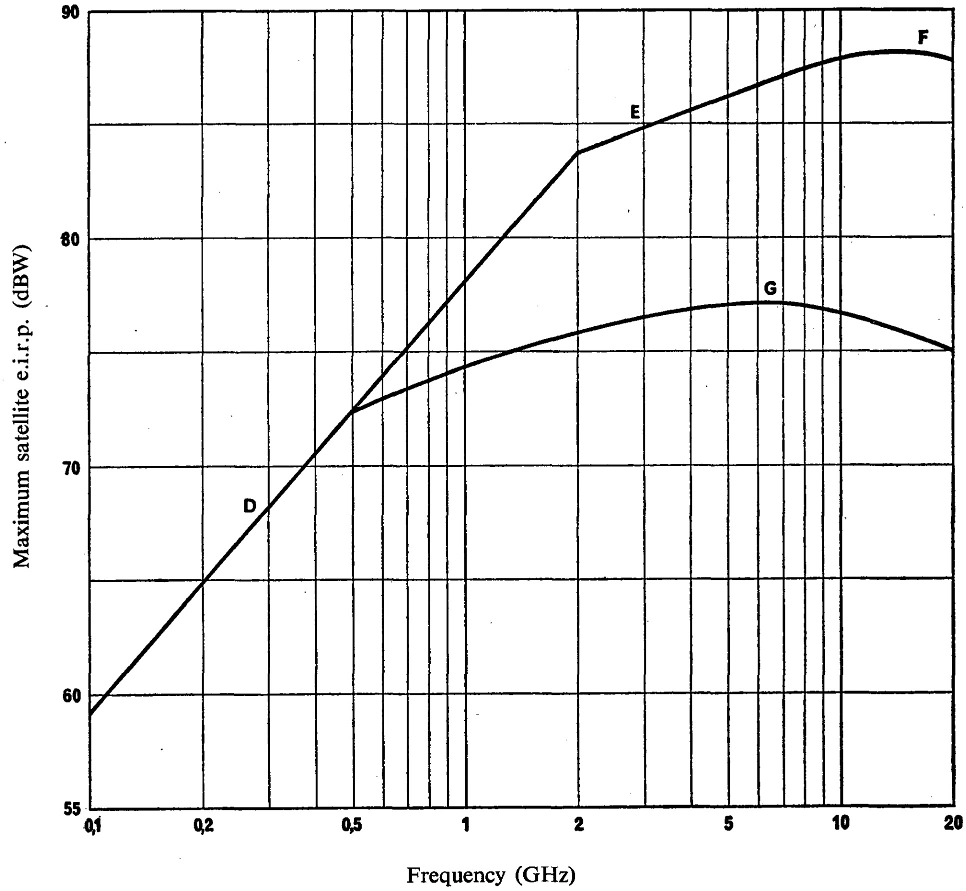


FIGURE 2*b*

Factors limiting the maximum possible e.i.r.p. as a function of frequency

D: antenna size (12 m diameter)
E: beam pointing accuracy
F: surface tolerance of reflector
G: requirement for very reduced side lobes

The development of heat pipes provides a promising method of heat transfer from the source to the radiator. Heat pipes have been used for thermal control on spacecraft [Anand, 1968] and in heat rejection from high power tubes on the ground.

3.5 *Transmitting antenna*

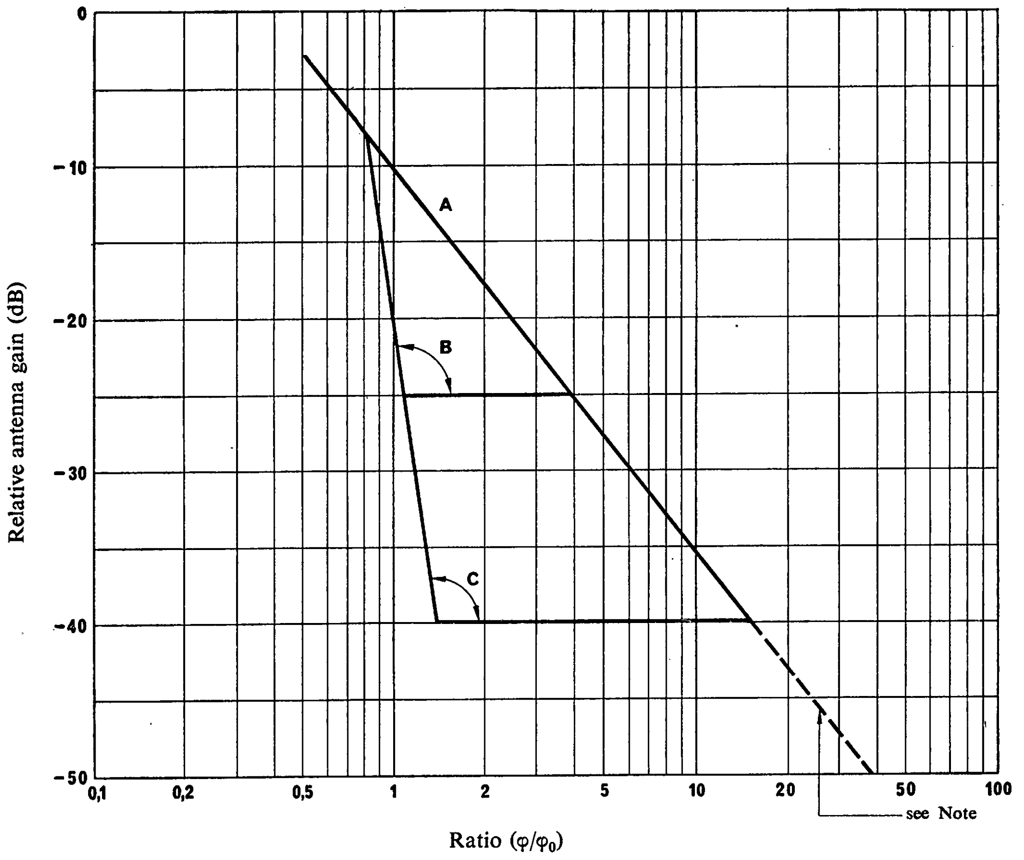
The maximum gain of an antenna and the way in which the gain decreases as a function of angle is important in interference calculations. Therefore, guide lines are required as to the probable performance of transmitting antennae for satellite broadcasting and of receiving antennae on the ground.

In view of their importance in interference control, it is considered that the side-lobe level of transmitting antennae should be carefully specified, and be held to as low a level as is consistent with the state of development. On the basis of incomplete studies carried out (Doc. 11/70 (U.S.A.) 1970–1974), Curve B of Fig. 3 is considered to be representative of desirable designs at the current state of development, although such an antenna has not yet been placed into operation. Curve C shows the limit of lobe control considered attainable with present technical resources; and Curve A shows a lobe envelope typical of antennae in which precise lobe control is not maintained.

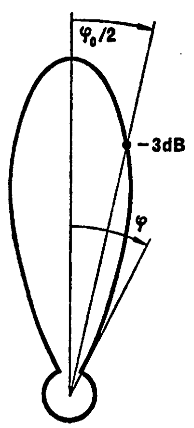
3.6 *Coverage*

The area of the Earth covered by a satellite antenna is a function of the beamwidth of the antenna which depends upon the frequency and upon the aperture of the antenna.

Fig. 4 serves to relate coverage area and ground distance at the sub-satellite point to antenna gain, assuming a synchronous satellite. The coverage area is circular at the sub-satellite point and the ground distance is the distance measured along the arc intersecting the circle and the sub-satellite point. The coverage and distance curves are based on the —3 dB beamwidth corresponding to the given antenna gain. A 55% antenna efficiency and conical beam pattern are assumed. The sub-satellite ground distance shown in Fig. 4 can be corrected to apply at angles of elevation other than 90° by applying the correction factors shown in Fig. 5. As the beam is positioned off the sub-satellite point to some chosen longitude and latitude (at a lower angle of elevation), the coverage area increases and is no longer symmetrical. Therefore, a ground-distance width and length can be defined for any given angle of elevation other than 90°. The width is perpendicular and the length is parallel to the axis of the antenna beam. A curve showing the angle of tilt is included, since it can be used to locate the —3 dB contour for the placement, the angle of elevation, etc., of the receiver. The angle of tilt is the angle subtended by the satellite at ground station.



Note. — The approximate limit of discrimination is numerically equal to the antenna gain.



A: Precise lobe control not maintained
$10{\cdot}5 + 25 \log (\varphi/\varphi_0)$ dB

B: Normal designs for lobe control

C: Limit of lobe control attainable with present technical resources

FIGURE 3

Proposed pattern for a reference transmitter antenna for satellite broadcasting

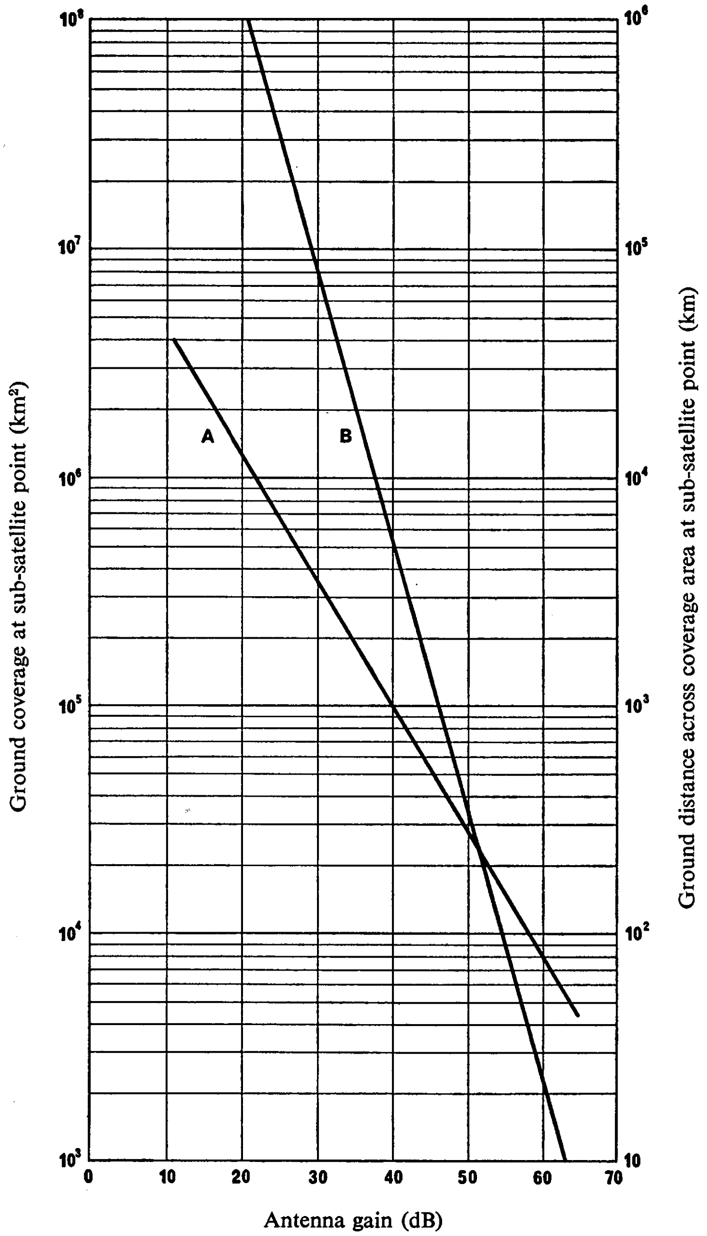


FIGURE 4

Guide to selecting antenna gain

A: Ground distance
B: Coverage area

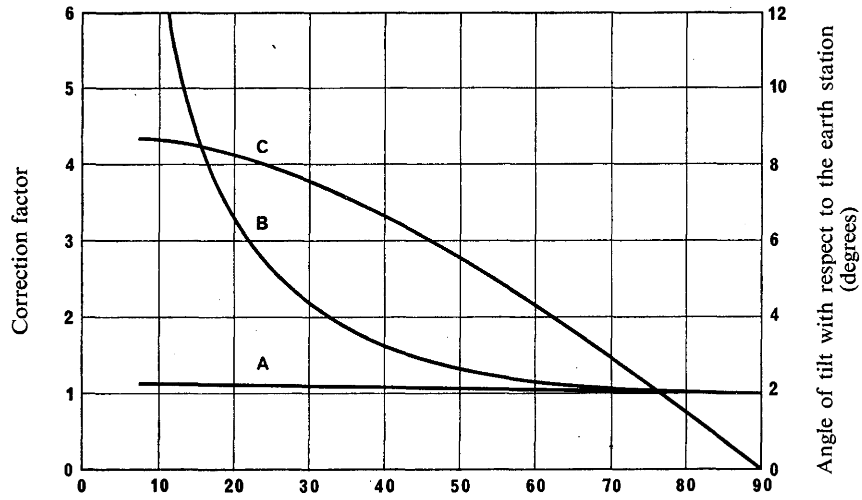


FIGURE 5

Correction factor for ground distance of Figure 3

A: width B: length C: tilt

3.7 *Lifetime*

Current system planning assumes a mean satellite life of about seven years. So far, studies and the performance of satellite systems encourage the view that a life expectancy of up to ten years can be achieved by careful design and provision of certain reserve equipments. In particular, the solar panels must be large enough to allow for the progressive deterioration that takes place in space. Fuel requirements for station-keeping and attitude stabilization may well be large, possibly of the order of 20% to 25% of the mass of the satellite if existing techniques are employed.

4. Receiving terminal aspects

4.1 *Characteristics of antennae*

The maximum gain of an antenna and the way in which the gain decreases as a function of angle is important in interference calculations. Therefore, guide lines are required as to the probable performance of receiving antennae on the ground.

Because broadcasting systems involve the use of numerous receiving antennae (whether for individual or community reception) the standards of performance that are reasonable on economic grounds will tend to be poorer for receiving antennae than for transmitting antennae, and will thus require separate discussion.

For frequencies in the vicinity of 2600 MHz and 12 GHz, it is suggested that, at an angle φ from the direction of maximum response, it may be assumed that the response of antennae for individual reception of terrestrial or broadcasting-satellite signals should differ from the maximum response by at least*:

$9 + 20 \log (\varphi/\varphi_0)$ dB, or
the isotropic gain of the antenna (dB), or
30 dB,

whichever has the lowest value. This assumption might also be applied approximately to receiving antennae for use at 700 MHz which are likely to take the form of a crossed Yagi or a helical antenna for individual reception* (see Fig. 6, curve B). Antennae for community reception may be regarded as having somewhat better side-lobe suppression as a function of φ/φ_0 than antennae for individual reception. For these antennae, it appears reasonable to approximate the discrimination by the smaller value of

$10{\cdot}5 + 25 \log (\varphi/\varphi_0)$ dB,
or the isotropic gain of the antenna (dB) (see Fig. 6, curve A).

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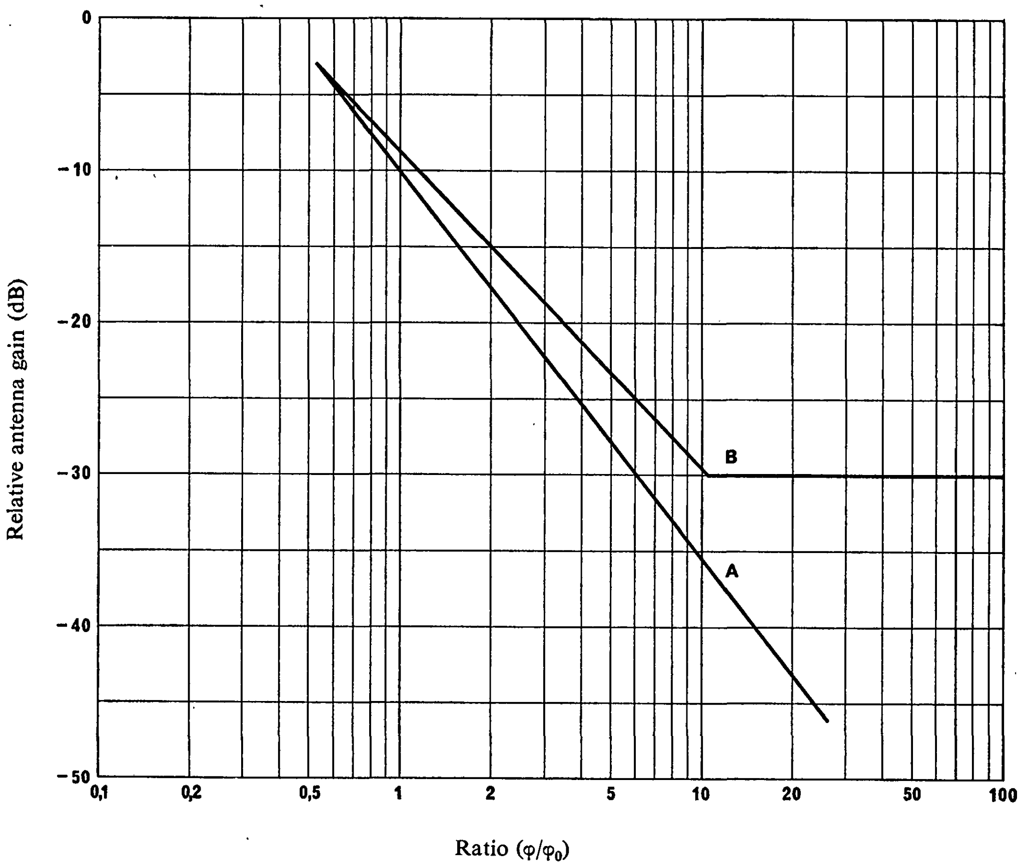
* These formulae apply only for values of φ/φ_0 greater than 0·5.



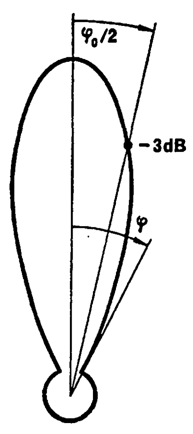


FIGURE 6

Proposed reference receiving antenna for satellite broadcasting— upper limit of gain of antenna relative to maximum

A: For community reception, $-[10{\cdot}5 + 25 \log (\varphi/\varphi_0)]$ dB

B: For individual reception, $-[9 + 20 \log (\varphi/\varphi_0)]$ dB

Note. — The approximate limit of discrimination is numerically equal to the antenna gain.

The suggested values of φ_0 to be assumed for different types of broadcasting service are given in Table IV.

TABLE IV

Half-power beamwidths, φ_0, of ground receiving antennae
(typical diameters are given in brackets)

Frequency	Satellite-broadcasting service		Terrestrial broadcasting service
	Community reception	Individual reception	
12 GHz	1·2° (1·5 m)	2·4° (0·75 m)	2·9° (0·6 m)
2600 MHz	2·7° (3 m)	8° (1 m)	
700 MHz	9° (3·4 m)	15° to 30° (2 m) (Yagi)	See Recommendation 419

Higher-gain antennae may be used in some receiving installations, for example, to obtain a better signal-to-noise ratio, but the Table is intended to indicate the values of φ_0 for the types of antenna expected to be used in the majority of receiving installations.

Attention is drawn to the fact that antennae with smaller beamwidths will require careful alignment and careful mounting to prevent degradation in reception, and that they may also call for a specification of maximum satellite motion more demanding than that of satellites for other services.

The antennae characteristics considered above do not cover the special case when the signal (from an interfering transmission) has a polarization orthogonal to that for which the antenna is designed. The amount by which the response is reduced in this case is not yet well established, but could be roughly 10 to 20 dB within the main beam, with a somewhat smaller reduction at greater angles from the axis of the main beam.

In the broadcasting-satellite service, the use of circular polarization at frequencies below about 3 GHz is to be preferred (see § 2.2 and Chapter 10 of the Report of the Special Joint Meeting, Geneva, 1971).

4.2 *Other aspects*

Report 473-1 contains additional information on ground-receiving equipment for broadcasting-satellite systems, as regards antennae, the figure of merit (G/T), the noise factor and other parameters.

5. System considerations and examples

5.1 *Quality of reception*

5.1.1 *General considerations*

The quality of the television image on the receiving screen depends on the signal-to-noise ratio, the level and nature of any interference and on the various distortions occurring in the transmission chain (studio, terrestrial link, up-link, satellite transmitter, signal path, receiver). Various methods of making subjective assessments of the quality of television pictures and the parameters involved are given in the references of Report 313-3. Scales for assessing the quality of television pictures are considered in Report 405-2. The signal-to-noise ratio is a very important parameter in calculating television systems and planning transmission networks and for this reason attention is focussed on this particular parameter. In selecting the required value of the signal-to-noise ratio, account must in many cases also be taken of other television signal distortions. In television, the signal-to-noise ratio at video frequencies is defined as the ratio, expressed in decibels, of the nominal peak-to-peak amplitude of the picture-luminance signal to the r.m.s. value of the noise in the working video frequency band (Recommendation 421-3, § 3.3, Recommendation 451-2, § 4.3).

The quality of service provided by a broadcasting-satellite system (which will be substantially uniform over the whole service area) should be higher than that recommended for the edge of a terrestrial broadcasting service area (in which the quality is very much better at the centre than at the edge). Two grades of reception quality (primary and secondary) are defined in Report 471-1.

The objectives to be aimed at for reception quality for community reception should be good, to meet the special requirements of educational programmes in television transmission and should certainly not be lower than those considered appropriate to a terrestrial broadcasting system intended for individual viewing.

The subjective effect of noise depends upon the spectral distribution of the noise energy within the video-frequency band. When measuring noise power, it is common practice to use weighting networks which take account of this fact, with the result that the weighted noise power at video frequencies is lower than the total noise power by a factor depending on the spectral distribution. For most television systems, the available weighting networks are designed so that, for various spectral distributions of the noise, the measurements more closely represent the subjective impression in monochrome pictures than do unweighted noise measurements; for colour television, the subjective effect needs special consideration.

TABLE V *

Video-frequency noise weighting-network reduction factor for monochrome television

System	Weighting (dB)	
	White noise	Triangular noise
B, C, E, F, G, H and M (Japan)	8·5	16·3
D, K, L	9·3	17·8
I	6·5	12·3
M (Canada, U.S.A.)	6·1	10·2

The weighting factors shown in Table V are not valid when a frequency-modulation system is working near the threshold, where the noise loses its gaussian characteristics and becomes impulsive. In this connection, tests have been carried out with a frequency-modulation system working near the threshold, in order to investigate the influence of the mentioned different types of noise on the picture quality. Such tests have shown that the impairment of the picture quality due to impulsive noise is greater than that due to gaussian noise, when the value of the unweighted signal-to-noise ratio is the same in both cases. See Doc. 11/116 (Italy) 1970–1974.

5.1.2 *Values of signal-to-noise ratio and distortion for various systems*

A method of calculation of signal-to-noise ratio at the input of a receiver for frequency-modulation television signals is given in Annex I.

Utilization of amplitude-modulation vestigial-sideband techniques in the broadcasting-satellite service at the present time is very unlikely because of the excessively high level of transmitter power necessary on board the satellite.

* When using pre-emphasis according to Recommendation 405-1, the combined effect of weighting and de-emphasis for triangular noise is approximately the same as that of weighting alone. More details are given in Report 637.

A broadcasting-satellite system will normally be a component part of an overall television system, from the studio to the domestic receiver. Therefore the received picture quality will depend not only upon the characteristics of the satellite system but upon those of each component part of the overall system. Furthermore the picture quality depends not only on the signal-to-noise ratio but also on the presence of distortions.

Therefore, the quality standards should be given considering the satellite circuit as a part of a complete transmission system, giving the value of all parameters intervening in determining the picture quality.

Examples of picture quality as a function of some important parameters for various systems are given below.

5.1.2.1 *525-line system/NTSC (System M: U.S.A. and Canada)*

TABLE VI

Grade (See Note 7 of Report 405-2)		Radio-frequency signal-to-noise ratio for the percentage of viewers indicated (dB) (1)	
		50%	75%
1·5	half-way between excellent and fine	39·5	42·5
2	fine	35·2	38·2
3	passable	30·0	33·0
4	marginal	25·6	28·6
5	inferior	20·4	23·4

(1) Radio-frequency r.m.s. signal during sync. peaks, no weighting, over 6 MHz bandwidth, amplitude-modulation vestigial-sideband.

Equivalent rectangular bandwidth in transmission:

— Frequency-modulation: 18 MHz

— Amplitude-modulation, vestigial-sideband: 4 MHz

Ratio of luminance signal to weighted r.m.s. noise value is 42 dB* (rated "excellent" by 50% of the viewers).

5.1.2.2 *625-line system. Colour television signal (SECAM system)*

Effective video bandwidth 5 MHz, frequency multiplexing of 5·7 MHz (approximately) frequency-modulated sub-carrier transmitting sound.

— 45 dB weighted in the luminance (weighting in accordance with Recommendation 421-3, Annex III, curve 0·33 μs);

— 33 dB in the chrominance (filter in accordance with Recommendation 451-2);

— 50 dB in the sound channel (40 to 15 000 Hz).

* Approximately 46 dB for System M (Japan).

5.1.2.3 *625-line system (System K)*

Equivalent noise band of amplitude-modulation receiver: 4·6 MHz

Three main classes of picture quality are considered:

Class I : picture of excellent quality (on a picture tube of any screen size). When the picture is viewed from a distance equal to 5 to 6 times the height of the screen, the noise is on the threshold of perception.

Class II : picture of very satisfactory quality (on picture tube of medium and small screen size). The noise is perceptible, but causes no interference to the picture and is not objectionable to the viewer.

Class III: picture still acceptable on cheap television receivers with small screens. The noise is quite noticeable and causes interference to a degree which can be accepted.

Appropriate values for the signal-to-noise ratio are given in Table VII.

TABLE VII

Class of picture quality	I	II	III
Ratio of picture signal-to-weighted r.m.s. noise value at the picture tube control electrode (dB)	46	39	32
Carrier-to-noise ratio at receiver input (dB)	44	37	30

5.1.2.4 *625-line system. Colour television signal (PAL system)*

Assuming a chain consisting of a studio, a terrestrial radio-relay link, a broadcasting-satellite system and a domestic receiver, and when all the impairments have values quoted in Table VIII, the overall subjective quality grade will be 2·6 (on the 5-point scale; see Recommendation 500). The overall grade would be 2·9 if the signal-to-noise ratio of the down-link were increased by 3 dB, the other impairments remaining at the same value.

TABLE VIII

Parameter values

Component of the chain	Parameter				
	Differential phase (degrees)	Differential gain (%)	Chrominance/luminance gain inequality (%)	Chrominance/luminance delay inequality (ns)	Signal-to-noise ratio (weighted) (dB)
Studio	± 5 (1)	± 5 (1)	± 5 (1)	± 10	48
Terrestrial circuit	± 5 (1)	±10 (1)	±10 (1)	± 50	56 (2)
Satellite system	± 5 (1)	±10 (1)	±10 (1)	± 50	
Domestic receiver	±10 (5)	±15 (5)	(3)	±100	46 (4)

(1) Statistical variable and not exceeded at least for 80% of any month.

(2) Exceeded at least for 80% of any month.

(3) It is assumed that the receiver distortion is equalized by manual chroma control.

(4) This assumes an unweighted signal-to-noise ratio of 33 dB, and a noise-weighting factor (including effect of pre-emphasis) of 13 dB. As in the example given in Table IX, the minimum performance would be achieved at the edge of the service area in the least favourable case, for 99% of the time.

(5) Studies have shown that these tolerances can be achieved in practice with simple filters without correction circuits in the receiver, when the frequency deviation is about 14 MHz/V and the −3 dB bandwidth is 27 MHz. As a first approximation, these values may be considered as constant with time.

5.2 *Influence of standards for television*

Three categories of standards may be distinguished as follows: picture standards, transmitting standards, and channel standards. The picture standard describes the scan process, line structure, etc., as set forth in Report 624. The transmitting standard describes the radio-frequency radiated signal, giving its modulation mode, the spacing between the sound carriers, etc. This standard also appears in Report 624. The channel standard gives the radio frequency and assigned bandwidth.

To provide a television broadcasting-satellite service, three approaches may be considered:

— to match exactly the existing standards as employed for terrestrial broadcasting in the geographic area of interest;

— to provide a receiving device to convert the satellite signal into one usable by a standard receiver;

— to provide a receiver designed specifically for the broadcasting-satellite service.

Factors relating to receiving converters are discussed in Report 473-1.

5.3 *Use of frequency modulation*

5.3.1 *Required margin above the frequency-modulation threshold*

It is necessary to keep the carrier-to-noise ratio above threshold for as high as possible a percentage of time (usually 99·9%) and also to achieve a given signal-to-noise ratio objective for a specific percentage of time (usually 99%). Thus it is necessary to choose a margin above threshold such that both requirements are met simultaneously. This margin should include the atmospheric loss and other terms not specifically included in the power budget. The following margins (representing the difference in decibels between the values of carrier-to-noise ratio for 99·9% and 99% of the time) seem to be required in climatic conditions typical of Europe and North America; namely, a margin of 5 dB at 700 MHz, of 4 dB at 2600 MHz and of 7 dB at 12 GHz.

5.3.2 *Television using frequency modulation: bandwidths required*

Table IX gives the equivalent rectangular bandwidth required for reception of the picture and either one, or four, sound channels and the radio-frequency channel bandwidth of the satellite transmitter for the 525-line systems. Table X provides corresponding values for the 625-line systems. In all cases it is assumed that the four sound channels are obtained by frequency multiplexing of sub-carriers modulated by these sound channels. In these evaluations, the effect of energy dispersal has not been included. The use of energy dispersal would complicate receivers and would increase the bandwidth occupied by the signal from the satellite by 1 to 2 MHz. However, it may be decided that in certain frequency bands energy dispersal should be used to facilitate sharing with other services, for example, terrestrial fixed services. Other details are given in Report 632.

In the 12 GHz band, laboratory tests discussed in Doc. 11/90 (France) 1970–1974, have shown that for frequency-modulation transmission of a 625-line colour television signal accompanied with sound transmitted by a frequency-modulation sub-carrier, a good compromise was obtained between the transmitter bandwidth and the quality of the signal for a radio-frequency bandwidth of about 25 MHz.

5.4 *Influence of the up-path*

The dimensioning of the up-path invariably affects the overall system design. Studies carried out in France [C.C.I.R., 1970–1974] have shown that in fairly low up-path frequency bands (11 and 14 GHz, for example), over-dimensioning is feasible and even desirable. In this case, the operating conditions and the modulation parameters of the system may be determined solely from the down-path data. However, for high up-path frequency bands (30 GHz, for example), it would seem necessary to strike a compromise between the ground e.i.r.p. and the satellite e.i.r.p. Here, the noise contribution and the percentage of time for which the up-path service is interrupted must be allowed for in calculating the system characteristics.

5.5 *System examples*

The tables in this section give, purely as illustrative examples*, the parameters of broadcasting-satellite systems, using a geostationary satellite of a type that might be possible in the future. It will be observed that some of the examples call for transmitter powers greater than those likely to be practicable for many years. However, the parameters of these examples might be modified to correspond to other possibilities which demand less satellite power.

TABLE IX

Required width of radio-frequency channels (MHz) for frequency-modulation television systems (525-line)

	Number of sound channels	Frequency (MHz)		
		700	2600	12 000
Equivalent rectangular bandwidth of receiver (1)	One	16–22	16–22	22–30
	Four	20–26	20–26	27–35
Radio-frequency channel width of satellite transmitter (2)	One	18–24	18–24	24–34
	Four	23–29	23–29	30–40

(1) The following equation can be used to determine the approximate video peak-to-peak deviation which is applicable:

$$B \approx 1{\cdot}1\,(D_{p-p} + 2f_b)$$

where: B : equivalent rectangular bandwidth (MHz)

D_{p-p} : video peak-to-peak deviation (MHz)

f_b : top baseband frequency including highest sound sub-carrier (MHz).

(2) Equal to the radio-frequency channel spacing.

* Examples given are for the bands allocated by the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971. Examples for other bands may be found in Doc. 11/5, 1970–1974. Attention is drawn to the fact that different assumptions are made in the various examples, particularly regarding the reception quality, the receiving installation (noise factor, antenna size) and the area served as determined by the transmitting antenna beamwidth. For this reason, caution must be exercised when comparing the transmitter powers, etc., indicated in the tables.

TABLE X

Required width of radio-frequency channels (MHz) for frequency-modulation television (625-lines systems)

	Number of sound channels	Frequency (MHz)		
		700 (3)	2600	12 000
Equivalent rectangular bandwidth of receiver (1)	One	20–22	20–22	27 (4)
	Four	24–26	24–26	
Radio-frequency channel width of satellite transmitter (2)	One	22–25	22–25	25–30 (5)
	Four	25–28	25–28	

(1) The following equation can be used to determine the approximate video peak-to-peak deviation which is applicable:

$$B \approx 1{\cdot}1\,(D_{p-p} + 2 f_b)$$

where: B : equivalent rectangular bandwidth (MHz)

D_{p-p} : peak-to-peak deviation at video-frequencies (MHz)

f_b : top baseband frequency including highest sound sub-carrier (MHz).

(2) The channel spacing may differ from the channel bandwidth, depending on the value chosen for the adjacent-channel protection ratio.

(3) These determinations are tentative and require further study.

(4) Corresponds to a frequency deviation of 13 MHz/V, and distortion introduced by the receiver equal to 10° for the differential phase and 15% for the differential gain, with a filter having a sharp cut off (6 poles), and with a sound sub-carrier producing a deviation of ±2·8 MHz of the carrier.

(5) Estimated limits for the channel spacing, with the parameters given in (4) above and with an adjacent-channel protection ratio of −6 dB.

The way in which the values given in the tables for the transmitter power in the satellite may be modified, if adjustment is made to any of the assumed parameters, is summarized below:

— assuming the use of a transmitting antenna beam of circular cross section, halving the beamwidth will permit a reduction of power by 6 dB. Doubling the beamwidth will require 6 dB more power.

— an increase in the signal-to-noise ratio, made in order to achieve better quality, will require a corresponding increase (in decibels) in the transmitter power. Similarly a decrease will permit an equivalent decrease in the power, but with frequency modulation, the deviation and radio-frequency bandwidth have to be lowered, if the region of the threshold of the discriminator is approached;

— an increase in the factor of merit of the receiving system will lead to a reduction (by an equal amount in decibels) of the transmitter power required and vice versa.

Thus the examples, modified as desired, can serve to indicate the conditions that would be required to enable the public to receive broadcast programmes whose technical quality would be comparable at all times with that of the services provided in the conventional way by a network of terrestrial transmitters.

These examples derive the field strength required for certain stated receiver characteristics. Other assumptions can be made (as for example in [C.C.I.R., 1966–1969b], which deals with colour television systems) which will result in different required field strengths, and different requirements for satellite e.i.r.p. The object of all of these examples is to establish a reasonable range of satellite power output requirements for a broadcasting-satellite service.

5.5.1 *Television broadcasting*

Table XI presents examples of satellite television systems with different frequencies and different operating and quality conditions. Columns *1*, *2*, *3* and *4* refer to television system M, the first three for community reception and the fourth for individual reception. In these examples, the sound channel has been left out of account.

Columns *5* and *6* relate to individual reception with systems G, I or L; the calculations are based on two angles of elevation (column *5*: 15° and column *6*: 40°), adopting the same value for the peak-to-peak deviation, namely 13·3 MHz for 1 V of video signal at the reference frequency of the pre-emphasis curve in Recommendation 405-1. In the example described by these two columns, the sound channel is constituted by the sub-carrier at a frequency of 6 MHz, modulated with a 50 kHz peak-to-peak deviation and producing a carrier deviation of ±2·8 MHz.

For the examples relating to system M, a value of 42 dB is assumed for the luminance signal-to-weighted r.m.s. noise ratio at the edge of beam, this value being representative of the primary reception quality; for secondary quality, a value of 35 dB could be adopted, which would require an e.i.r.p. only 1·5 dB below the value for primary quality.

For the example relating to systems G, I and L, and with the figure of merit given in Report 473-1, the signal-to-noise ratios remain respectively above the values of 33 dB (unweighted) for luminance and 50 dB (weighted) for sound for 99% of the most unfavourable month (in European climatic conditions) throughout the entire service area during the entire useful life of the satellite and the receiving installation and with the angle of elevation giving the least good result. Under the same conditions, the carrier-to-noise ratio at the receiver input remains above 10 dB for 99·9% of the most unfavourable month with the atmospheric margin defined in § 2.2 of this Report.

TABLE XI

Examples of television system parameters

Parameter (1)	Community reception			Individual reception		
	1	*2*	*3*	*4*	*5*	*6*
1. *System*						
Frequency of carrier (MHz)	700	2600	12 000	700	12 000	12 000
Type of modulation	FM	FM	FM	FM	FM	FM
Angle of elevation (degrees)					15	40
Approximate equivalent rectangular bandwidth (MHz)	19	20	17	19	27	27
Carrier-to-noise ratio before demodulation (exceeded for 99% of the time) (dB) (2)	16	15	18	16	14·1	13·3
Number of lines in system	525	525	525	525	625	625
Corresponding luminance signal-to-weighted r.m.s. noise ratio (edge of beam) (dB) (3)	42	42	42	42		
Luminance signal-to-unweighted noise ratio measured in a 5 MHz band (edge of beam) (dB) (4)					34	33
Audio-frequency signal-to-weighted noise ratio (weighting specified in Recommendation 468-1, pre-emphasis 50 μs) measured in a 15 kHz audio-frequency band (edge of beam) (dB)					51	50

Parameter (1)	Community reception			Individual reception		
	1	*2*	*3*	*4*	*5*	*6*
2. *Receiving installation*						
Figure of merit, *G/T*, (dB) (13)					4	4
System noise factor (dB) (5)	4	4	4	6		
Noise power in radio-frequency bandwidth for the above noise factor (dBW) (6)	−127	−127	−128	−125		
Carrier power required (dBW)	−111	−112	−110	−109		
Antenna diameter (m) (7)	3·4	3	1·5			
Receiving antenna gain, relative to an isotropic source (dB) (8) (9)	25	36	43	16		
Effective area of antenna, *S* (m²) 10 log *S*	7	6	0	−2		
Required flux (edge of beam) (99% of the time) (dB (W/m²))	−118	−118	−110	−107	−100·7	−101·5
Equivalent field strength (edge of beam): (dB (μV/m))	28	28	36	39	45·1	43·8
(μV/m)	25	25	63	89	180	165
Free-space attenuation between isotropic sources 39 000 km apart (dB)	181	192	206	181		
Total atmospheric attenuation exceeded for less than 1% of the time (dB) (10)	0	0	1	0		
Free-space attenuation between isotropic sources 35 786 km apart (dB)					205·1	205·1
Additional free-space attenuation (dB)					1	0·5
Additional loss equivalent to up-path noise (provisional value) (dB)					0·5	0·5
Atmospheric attenuation for 99% of the most unfavourable month (11)					3·2	1·5
Required e.i.r.p. from satellite at beam edge (dBW)	45	44	54	56	66	63
3. *Satellite transmitter*						
Antenna beamwidth at −3 dB points (degrees)	1·4	1·4	1·4	1·4	1	1
Antenna gain at the edge of service area, relative to an isotropic source (dB) (12)	38	38	38	38	41	41
Loss in feeders, filters, joints, etc. (dB)	1	1	1	1	1	1
Required satellite transmitter power: (dBW)	8	7	17	19	26	23
(W)	6·3	5	50	80	400	200

(1) In columns *1*, *2*, *3* and *4*, no account was taken of pre-emphasis. For columns *5* and *6*, the use of preemphasis as specified in Recommendation 405-1 was assumed.

(2) The carrier level considered is the r.m.s. value of the unmodulated carrier and the carrier-to-noise ratio at threshold is assumed to be 11 dB in columns *1*, *2*, *3* and *4*, and 10 dB in columns *5* and *6*. In the last two columns, the threshold is assumed to be reached for 0·1% of the most unfavourable month.

(3) These values will normally be degraded slightly (typically, by 0·5 dB) by the noise contribution of the Earth-to-satellite path. The values are derived assuming weighting according to Recommendation 421-3, Annex III.

(4) The term equivalent to the noise on the Earth-to-satellite path was explicitly introduced with a tentative value in columns *5* and *6*. In the same columns, the luminance signal-to-noise ratio is indicated as an unweighted value, particularly owing to the existence of different weighting networks in systems G, I and L. For the sound signal-to-noise ratio, the weighting is that specified in Recommendation 468-1.

(5) A pre-amplifier or frequency-changer near the antenna is assumed.

(6) The figures listed in columns *1*, *2*, *3* and *4* are valid for an antenna temperature of about 300 K.

(7) For individual reception at 700 MHz, the receiving antenna is assumed to be a crossed yagi or a helical array with a gain of 16 dB: paraboloid antennae are assumed for the other cases. For community reception at 12 GHz, the choice of a 1·5 m paraboloid antenna was to some extent dictated by beam pointing considerations and satellite positional errors.

(8) An antenna efficiency of 55% is assumed.

(9) Circularly polarized antennae are assumed at both the transmitting and receiving ends. Allowances for ellipticity losses due to imperfections in the antenna, movement of the supporting structures, etc., and perturbations in the position of the satellite have been included in the margin above threshold.

(10) These examples apply to an angle of elevation of 30° and to temperate climates, where atmospheric attenuation is negligible at 700 MHz and 2600 MHz and small at 12 GHz. In other regions, especially tropical and sub-tropical areas, atmospheric attenuation will require a higher margin.

(11) These examples apply to European climatic conditions.

(12) In the example taken for columns *1*, *2*, *3* and *4*, the beamwidth would cover an area of about 1000 km in the East-West direction and about 1000 km or more (depending on the geographical latitude) in the North-South direction. The example taken for Columns *5* and *6* may correspond to the coverage of a European country of average size. In this example, a reduction of ΔG_0 equal to 3 dB of the antenna gain at the edge of beam in relation to the maximum gain was assumed. For the same service area, the parameter ΔG_0 may be chosen arbitrarily in a range from about 3 to 6 dB. This results in a variation of the maximum antenna gain, but the required satellite transmitter power remains practically unchanged. In the case of an elevation angle of 15°, if we take, for example, $\Delta G_0 = 4{\cdot}34$ dB, which corresponds to the theoretically optimum value, the maximum antenna gain is 45·6 dB (instead of 44 dB) and the transmitter power is reduced by 0·3 dB.

(13) In accordance with the definition in the example shown in the Annex to Report 473-1.

TABLE XII

Power flux-densities required at the edge of the beam on the basis of the examples given in Table VIII (1)
(System M (U.S.A., Canada), frequency-modulation television, primary service grade)

Category of power flux density (2)	Power-flux-density (dB (W/m²)) at frequency (MHz)		
	700	2600	12 000
High	−101 (I, U)		− 99 (I, U) − 99 (I, R)
Medium	−107 (I, R)		−110 (C, U) −110 (C, R)
Low	−114 (C, U) −118 (C, R)	−118 (C, U) −118 (C, R)	

I : Individual U: Urban
C: Community R: Rural

(1) The values in dB(W/m²), are the total power flux-density as measured with an antenna that matches the polarization of the transmitter. The required flux density is about 1 dB greater for 625-line systems. The required flux density is approximately 1·5 dB less for secondary service rather than primary service. Since the values are the minimum requirements at beam edge, it should be noted that the values will be greater in other areas and when propagation conditions are favourable.

(2) These power flux-densities represent an attempt to categorize levels in accordance with Report 471-1.

Table XII is intended to illustrate a simplified form of presentation; numerical values should, of course, be revised if necessary to take into account any new contributions concerning system examples.

5.5.2 *Sound broadcasting*

Table XIII presents examples of system parameters for monophonic sound broadcasting for individual reception at 12 GHz. For stereophonic broadcasting, reference may be made to Report 632. These examples may also apply to the broadcasting of the sound component of a television programme when a separate sound carrier is used.

TABLE XIII

Examples of system parameters for monophonic sound broadcasting for individual reception

Parameter	Example 1	Example 2
1. *System*		
Frequency of carrier (MHz)	12 000 (1)	12 000
Type of modulation	FM	FM
Frequency deviation (pre-emphasis 50 μs) (kHz)	±75	±300
Audio-frequency bandwidth (kHz)	15	15
Radio-frequency bandwidth required (kHz)	180	800
Carrier-to-noise ratio before demodulation (for 99% of the time in the least favourable month) (edge of beam) (dB)	19	13·3
Corresponding audio-frequency signal-to-unweighted noise ratio (edge of beam) (dB)	51	69
Audio-frequency signal-to-weighted noise ratio (dB)	42	60
2. *Receiving installation*		
Figure of merit, G/T, of receiver (dB) (2)	4	4
Required flux (edge of beam) (99% of time in most unfavourable month) (dB(W/m²))	−117·5	−116·7
Equivalent field strength (edge of beam):		
(dB (μV/m))	28·2	29·1
(μV/m)	26	28
Free-space attenuation between isotropic sources 35 786 km apart (dB)	205·1	205·1
Additional free-space attenuation for an angle of elevation of 40° (dB)	0·5	0·5
Total atmospheric attenuation for 99% of the time in the most unfavourable month (dB) (3)	1·5	1·5
Up-path noise (provisional value) (dB)	0·5	0·5
Required e.i.r.p. from satellite at edge of beam (dBW)	47	47·7
3. *Satellite transmitter*		
Antenna beamwidth at −3 dB points (degrees)	1·4	1
Antenna gain at edge of service area relative to an isotropic source (dB) (4)	38	41
Loss in feeders, filters, joints, etc. (dB)	1	1
Required satellite transmitter power:		
(dBW)	10	7·7
(W)	10	6

(1) These examples will probably not be valid for sound broadcasting alone, unless the receiving antenna and the pre-amplifier or frequency-changer were also used for television.

(2) In accordance with the definition in the example shown in the Annex to Report 473-1.

(3) Examples valid for an angle of elevation of about 40° and European climatic conditions.

(4) An antenna efficiency of 55% is assumed.

ANNEX I

In a frequency-modulation system in which pre-emphasis is not used:

$$S/N = C/N + F_{dB} + k_w$$

where:

S/N : ratio of peak-to-peak luminance amplitude to weighted r.m.s. noise (dB)

C/N : pre-detection carrier-to-noise ratio in the radio-frequency bandwidth (dB)

F : $3\ D_{p\text{-}p}/f_v)^2 . (b/2f_v)$ (power ratio which equals F_{dB}, when expressed in dB)

$D_{p\text{-}p}$: peak-to-peak deviation by video signal (including synchronizing pulses)

f_v : highest video frequency; (e.g. 4·2 MHz in the case of System M)

b : radio-frequency bandwidth (usually taken as $d_{p\text{-}p} + 2f_v$)

k_w : weighting factor for noise in frequency-modulation systems (dB) (see Table V)

Note. — In a frequency-modulation system operating near the threshold, the use of pre-emphasis according to Recommendation 405-1 does not appreciably improve the signal-to-weighted noise ratio measured in accordance with Recommendation 421-3, assuming that the deviation at the reference frequency is kept unchanged. Therefore, for convenience, Figs. 7*a* and 8 correspond to operation without pre-emphasis. For systems operated well above the threshold, the improvement is estimated to be about 3 dB. However, a further improvement can probably be obtained with the use of "over-deviation"; further discussion is given in Report 212-3.

ANNEX II

The following relationship exists between the units of field strength and power flux-density.

The straightforward conversion between the units of field strength, E, (dB(μV/m)) and power flux density W, (dBW/m²) is:

$$W = E - 145{\cdot}8$$

— the noise power in a 1 MHz bandwidth is −144·0 dBW at a noise temperature of 290 K

— 1 μV e.m.f. in a 75Ω source corresponds to an available power of −144·8 dBW

— 1 μV e.m.f. in a 50Ω source corresponds to an available power of −143·0 dBW

The relation between the e.i.r.p. of a geostationary satellite and the power flux-density at the surface of the Earth is:

For the point on the Earth at latitude φ° and relative longitude (sub-satellite point = 0°) λ° and with $\cos\Delta = \cos\lambda \cos\varphi$, we obtain the following relationship:

Angle Δ (degrees)	spreading loss, dB (m²) *
0 (sub-satellite point)	162·1
20	162·2
40	162·5
60	162·9
80	163·4

For an angle of elevation ε, with $\tan\varepsilon = (\cos\Delta - 0{\cdot}1513)/\sin\Delta$, we obtain the following relationship:

Angle ε (degrees)	spreading loss, dB (m²) *
0	163·4
20	162·9
40	162·4
60	162·2
80	162·1

* The e.i.r.p. (dBW) minus the spreading loss in dB (m²) is equal to the power flux-density (dB (W/m²)), atmospheric loss not included.

ANNEX III

RELATIONSHIPS BETWEEN THE PARAMETERS

Figs. 7*a*, 7*b* and 7*c* show the relationships between the significant system parameters over a wide range and may be used to determine specific factors related to a proposed approach to system design. The dashed lines indicate one approach, to show how the graphs are used.

The lower part of Fig. 7*a* shows the relation between carrier-to-noise ratio (C/N) and post-detection signal-to-noise ratio (S/N) for vestigial-sideband amplitude-modulation transmission and for a range of bandwidths for frequency-modulation transmission.* Type M (U.S.A., Canada) picture standards were assumed. The upper part of the figure converts the carrier-to-noise ratio (C/N) to the carrier-to-noise-temperature ratio (C/T).

The dashed lines in Fig. 7*a* show that, for values of S/N of 34 dB and of C/N of 10 dB (corresponding to the threshold of a normal frequency-modulation detector), the bandwidth of the system is determined by the intersection of the horizontal S/N-line with the vertical C/N-line. (The short diagonal line indicates that the radio-frequency bandwidth is approximately 17 MHz in this example.) The vertical line corresponding to a value of C/N of 10 dB intersects a second diagonal line corresponding to the previously determined radio-frequency bandwidth and, moving horizontally to the left-hand edge of the diagram, the value of C/T (−146 dBW), for the example shown) is obtained.

The upper half of Fig. 7*b* converts the value C/T to the received carrier power, C, and the lower half illustrates the relationships between the receiving antenna aperture, the satellite e.i.r.p., the ground field strength, and the received carrier power. The C/T scale corresponds to that on Fig. 7*a*. Note that frequency is not a factor on these graphs.

The dashed lines in Fig. 7*b* indicate that for a value of C/T of −146 dBW and a noise temperature of 2600 K (corresponding to a noise figure of 10 dB), the receiver carrier power required is −111 dBW. A diagonal line representing this receiver carrier power intersects a vertical line corresponding to the diameter of the earth-station antenna (assumed efficiency, 55%). A horizontal line through this intersection determines the required satellite e.i.r.p. The scale at the extreme right indicates the corresponding field strength.

Fig. 7*c* pertains to the parameters of the spacecraft; the lower half converts transmitter output power and antenna gain to e.i.r.p. and ground flux density. The antenna beamwidth and half-power coverage diameter are also shown as a function of antenna gain. The e.i.r.p. scales on Figs. 7*b* and 7*c* are matched to facilitate their joint use; it is at this interface that a system margin may be inserted, in accordance with data presented in Report 205-3. No margin was used in the example indicated by the dashed lines. The upper half of the figure shows satellite antenna gain as a function of diameter for various frequencies.

In Fig. 7*c*, a horizontal line is extended from the flux density at the sub-satellite point (−111 dB(W/m^2)) until it intersects a vertical line extending upward from the available satellite transmitter output; the point of intersection will determine the required satellite antenna gain (33 dB). The antenna gain lines intersect the right-hand scale at points corresponding to the half-power beamwidth of the antenna (about 4°); the scale at the extreme right indicates the diameter of the antenna beam on the Earth at the sub-satellite point. The vertical line from the horizontal antenna-gain axis (centre of diagram) intersects the appropriate diagonal frequency line. The point of intersection determines the diameter of the satellite antenna.

Fig. 8 shows for individual reception of 12 GHz frequency-modulation television signals (antenna diameter 0·75 m, noise factor 9 dB) the variation of luminance signal-to-noise ratio with frequency deviation for various values of field strength (full-line curves). These data, based on the formula in Annex I, refer to unweighted noise in a 5 MHz band and may be applied for all standards adopted for frequency-modulation transmission. No pre-emphasis has been assumed; the extent of the advantage

* See Annex I for the derivation of the relationship between S/N and C/N in the case of frequency modulation.

of pre-emphasis is still under study. The following additional data are provided in the figure from calculation or experiment for a 625-line, System I, although they will be approximately correct for all other standards:

— the upper horizontal scale gives the approximate radio-frequency noise bandwidth, assuming that one sound sub-carrier near 6 MHz is used;

— the dashed curves give the carrier-to-noise ratio in the radio-frequency bandwidth;

— the right-hand vertical scale gives the subjective grade for colour pictures (PAL system), using the six point impairment scale of Note 8, Report 405-2.

It should be emphasized that the data in Fig. 8 take into account the noise contribution of the down-link only and allowance must be made for other contributions to the video noise (picture source, terrestrial links, up-link, etc.).

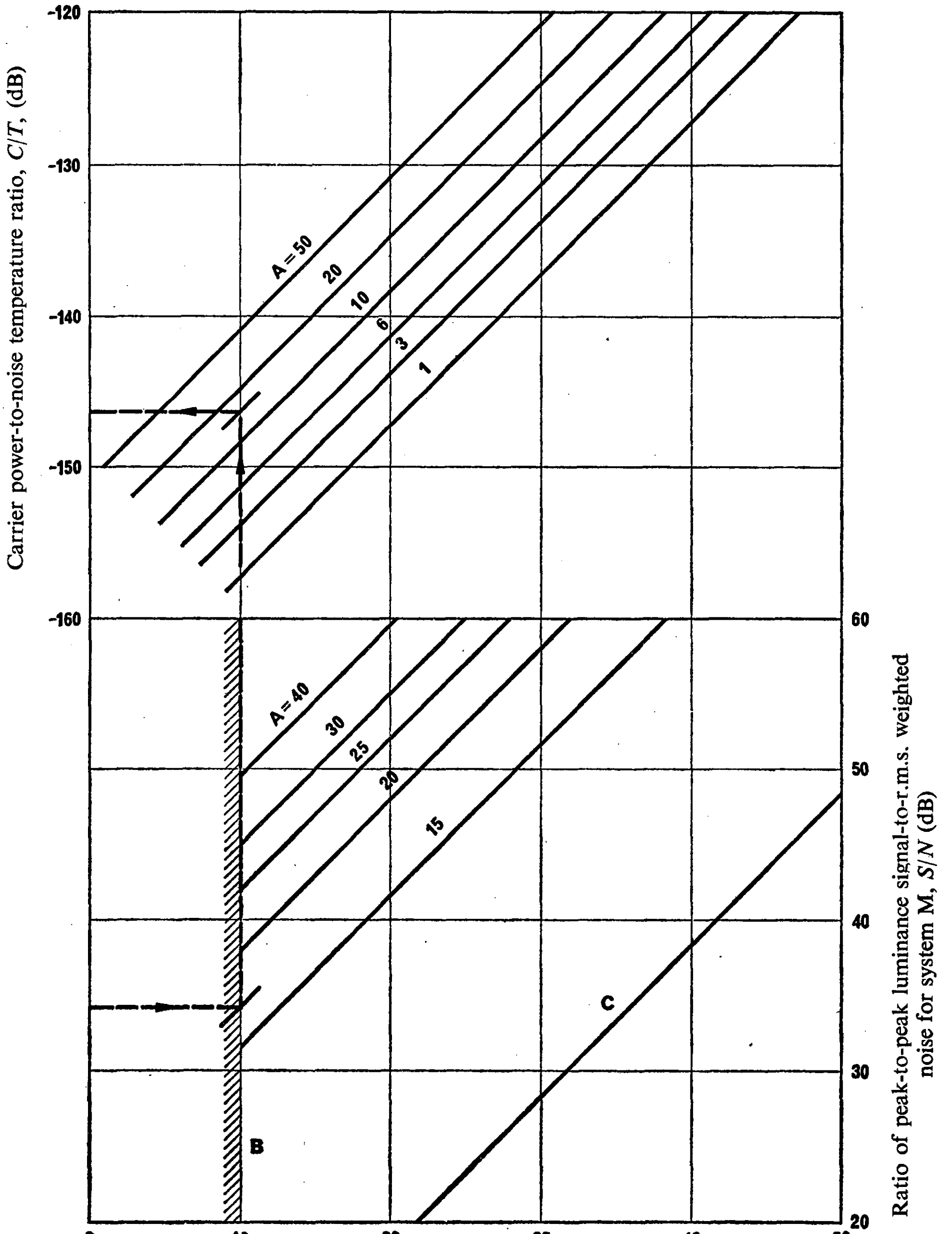


FIGURE 7*a*

A: radio-frequency bandwidth (MHz)
B: normal frequency-modulation threshold
C: vestigial-sideband amplitude-modulation

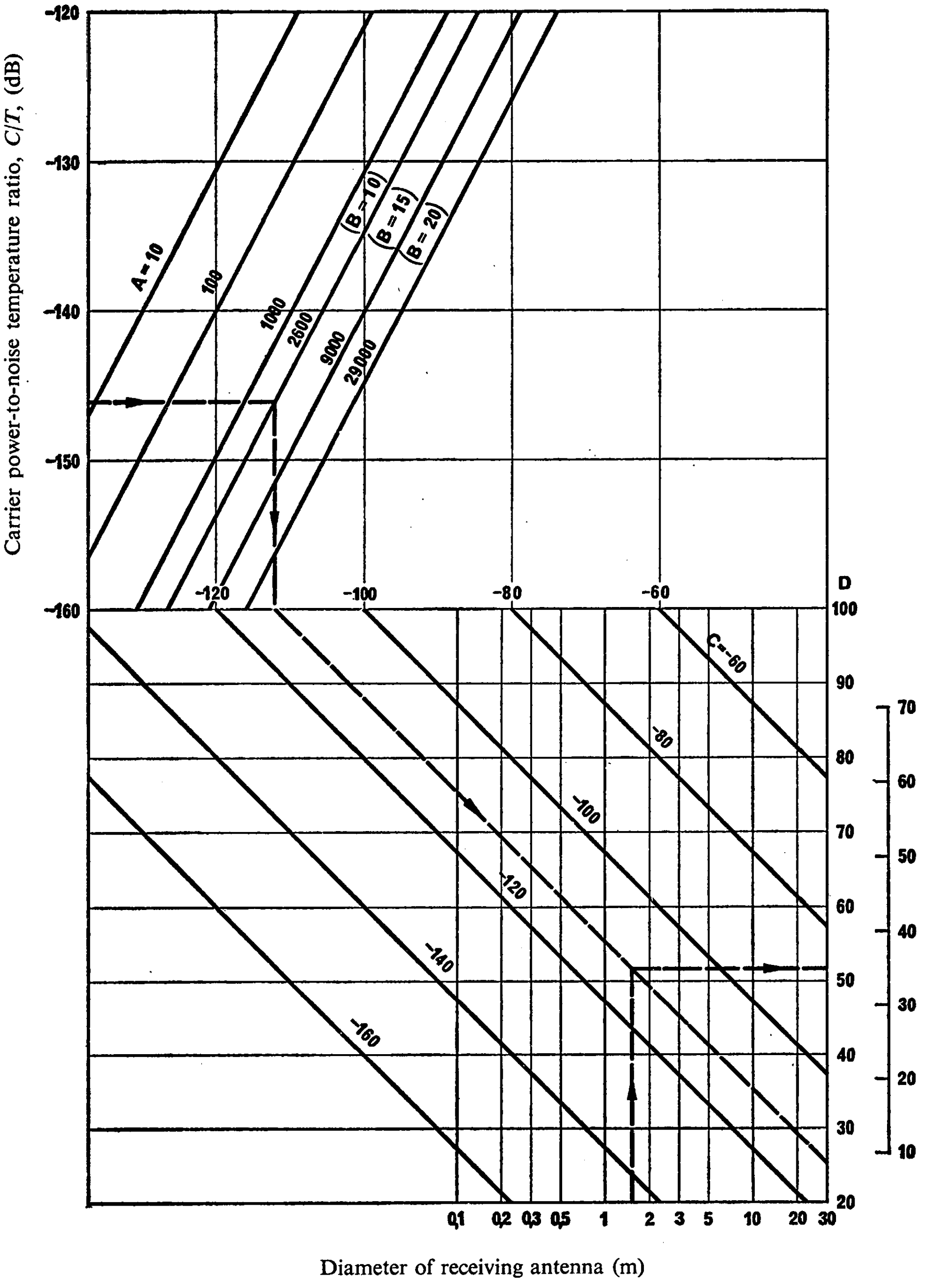


FIGURE 7b

A: noise temperature (K)

B: noise figure (dB)

C: receiver carrier power (dBW)

D: e.i.r.p. of satellite (dBW)

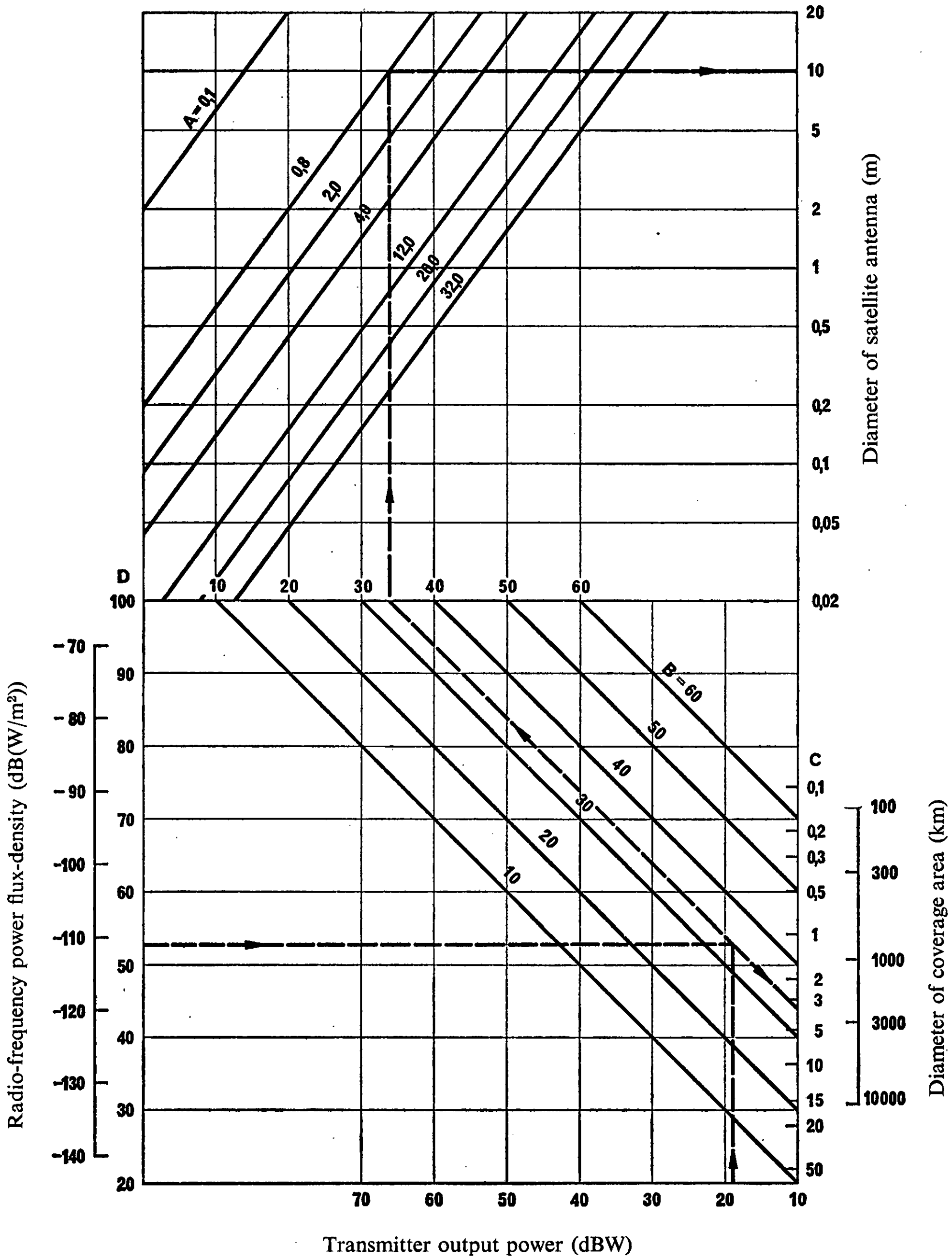


FIGURE 7*c*

A: frequency (GHz)

B: satellite antenna gain (dB)

C: half-power beamwidth (degrees)

D: e.i.r.p. (dBW)

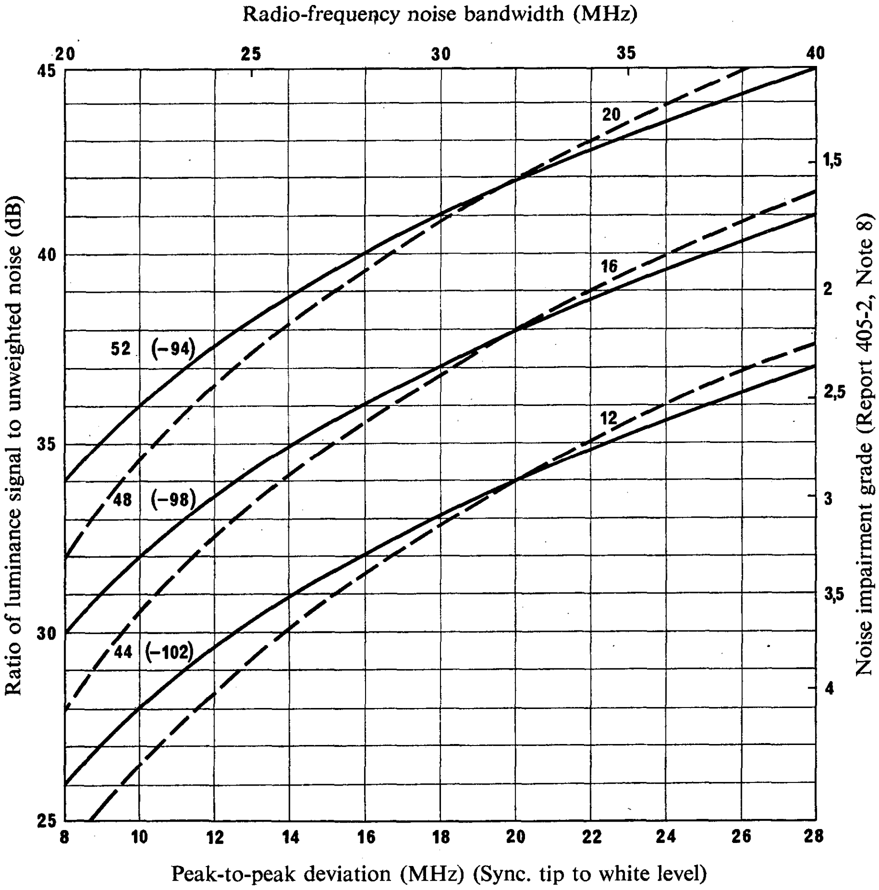


FIGURE 8

Requirements for satellite broadcasting (625-line television)

————: field strength required (dB(μV/m)) for individual reception in the 12 GHz band (power flux-density is given, in brackets, (dB(W/m²))

— — — —: carrier-to-noise ratio in the radio-frequency noise bandwidth (dB)

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REPORT 471-1 *

TERMINOLOGY RELATIVE TO THE USE OF SPACE COMMUNICATION TECHNIQUES FOR BROADCASTING

(1970 – 1974)

To facilitate the work of the C.C.I.R. the following previously defined terminology is noted and provisional new terminology is proposed:

1. Broadcasting-satellite service (1)

1.1 A radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception (2) by the general public.

1.2 *Broadcasting-satellite space station*

A space station in the broadcasting-satellite service, on an earth satellite.

1.3 *Methods of reception*

1.3.1 *Individual reception* (in the broadcasting-satellite service) (3)

The reception of emissions from a space station in the broadcasting-satellite service by simple domestic installations and in particular those possessing small antennae.

1.3.2 *Community reception* (in the broadcasting-satellite service) (4)

The reception of emissions from a space station in the broadcasting-satellite service by receiving installations, which in some cases may be complex and have antennae larger than those used for individual reception, and intended for use:

— by a group of the general public at one location, or

— through a distribution system covering a limited area.

1.4 *Reception quality*

1.4.1 *Primary grade of reception quality* (in the broadcasting-satellite service)

A quality of reception of emissions from a broadcasting-satellite space station which is subjectively comparable to that provided by a terrestrial broadcasting station in its main service area.(5)

1.4.2 *Secondary grade of reception quality* (in the broadcasting-satellite service)

A quality of reception of emissions from a broadcasting-satellite space station which is subjectively inferior to the primary grade of reception quality but is still acceptable.(6)

1.5 *Power flux-densities*

To permit individual or community reception with either grade of reception quality, broadcasting-satellite space stations may provide a high, medium or low power flux-density at the receiving site.

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* Adopted unanimously.

(1) See No. 84AP of the Radio Regulations.

(2) In the broadcasting-satellite service, the term "direct reception" shall encompass both individual reception and community reception. (See No. 84AP.1 of the Radio Regulations.)

(3) See No. 84APA of the Radio Regulations.

(4) See No. 84APB of the Radio Regulations.

(5) The main service area of a terrestrial broadcasting station is not defined but corresponds to a field strength somewhat higher than the minimum values quoted in Recommendations 411-1, 412-1, 417-2 and 448-1.

(6) See Report 409-1.

1.5.1 *High power flux-density* (in the broadcasting-satellite service)

A power flux-density which enables signals radiated by broadcasting-satellite space stations to be received by simple receiving installations with a primary grade of reception quality.

1.5.2 *Medium power flux-density* (in the broadcasting-satellite service)

A power flux-density which enables signals radiated by broadcasting-satellite space stations to be received either by simple receiving installations with a secondary grade of reception quality or by more sensitive receiving arrangements with a primary grade of reception quality.

1.5.3 *Low power flux-density* (in the broadcasting-satellite service)

A power flux-density lower than the medium power flux-density, which enables the necessary grade of reception quality to be obtained using more specialized transmission and reception techniques than those required under §§ 1.5.1 and 1.5.2.

2. Definitions concerning the use of the fixed-satellite service for the distribution of broadcasting programmes to terrestrial broadcasting stations

2.1 *Indirect distribution*

Use of a fixed-satellite service to relay broadcasting programmes from one or more points of origin to various earth stations for further distribution to the terrestrial broadcasting stations (possibly including other signals necessary for their operation).

2.2 *Direct distribution*

Use of a fixed-satellite service to relay broadcasting programmes from one or more points of origin directly to terrestrial broadcasting stations without any intermediate distribution stages (possibly including other signals necessary for their operation).

REPORT 473-1 *

CHARACTERISTICS OF GROUND RECEIVING EQUIPMENT FOR BROADCASTING-SATELLITE SYSTEMS

(Questions 5-2/11, 20-2/10, Study Programme 5F-1/11)

(1970 – 1974)

1. Introduction

The characteristics to be adopted for ground receiving equipment for broadcasting-satellite systems offer a wide range of choice. These characteristics influence the size, mass and complexity of the satellite required to provide a given quality of service because of the compromise that must be made between receiver sensitivity and the power radiated by the satellite. They themselves are affected by the broadcasting standards selected. The present report gives information about the most important of these characteristics on the basis of the results presented in the documents listed in the bibliography of this Report. Many of the contributions received relate to equipments operating in the 12 GHz frequency band.

It appears that signals broadcast from satellites could be received, not only by equipments of new design, but in some cases by existing receivers fitted with adaptive devices, provided that suitable standards were adopted for the satellite transmission.

A distinction should be made between installations intended for community reception and for individual reception.

2. Overall characteristics of receiving equipments [C.C.I.R., 1970–1974a]

It would seem desirable to specify the overall characteristics of receiving equipments by the figure of merit G/T, which is the ratio, expressed in dB, between the gain of the receiving antenna (including losses) and the total noise temperature expressed in degrees K, referred to the point of measurement of the antenna gain. There is not complete agreement on whether, for receivers in the broadcasting satellite service, this figure should include the degradation due to ageing of equipment, pointing error, and polarization effects; it is therefore important when using G/T to indicate which of the factors have been included. The advantage of introducing the figure of merit parameter is that it is no longer necessary to specify separately the performance of the various parts of the installation, such as the noise factor, coupling loss, antenna gain, etc. The latter parameters may then be chosen by the receiver manufacturers so as to obtain the required overall performance at lowest cost. A more precise definition of the figure of merit G/T and an example of how to calculate it are given in the Annex to this report.

3. Antennae [C.C.I.R., 1970–1974b, c and d]

At 12 GHz, the most probable form of antenna for individual reception is one with a parabolic reflector 0·75 to 1 m in diameter. Larger diameters, may, however, be used for community reception. Two feed arrangements are possible: either an antenna with direct illumination, or the Cassegrain assembly. The choice of diameter and of feed device may depend on economic considerations since for a given figure of merit G/T, if the antenna gain is lower, the noise factor must be lower too. The antenna may be either of aluminium or a composite moulding. A surface accuracy of about 1 mm is adequate and the mounting must be sufficiently rigid to maintain correct pointing, better than 0·5°, for example.

Receiving antenna diagrams for various frequency ranges are given in Report 215-3, indicating the upper limit of the relative gain to be assumed for planning purposes.

* Adopted unanimously.

4. Input stages [C.C.I.R., 1970–1974b]

These stages are an important part of the receiver. They should consist of a frequency down-converter which may or may not be preceded by radio-frequency amplifier stages. If they are required, the latter may be achieved by means of tunnel diodes or special transistors, or even by parametric amplifiers in the case of community receivers. The converter can use Schottky-barrier diodes. For reception at 12 GHz, the local oscillator may be a Gunn oscillator, but some care is needed to minimize frequency drift with temperature.

For community reception a noise factor of 4 dB is considered feasible in all of the frequency bands concerned. For individual reception the value 6 dB is considered feasible in the 700 MHz band only whereas 7 dB at 2600 MHz and 9 dB at 12 GHz appear more realistic. These values are valid for the immediate future, but figures as low as 4·5 dB for individual reception and 3 dB for community reception at 12 GHz have already been obtained in some cases [C.C.I.R., 1970–1974 c and d].

5. Intermediate-frequency stages

For community reception, the design will probably entail at least two frequency changes; for individual reception, installations with only one frequency change may also be feasible although in that case there is a risk of interference at the image frequency. When there are several frequency changes, the first down-converter, equipped with a fixed frequency oscillator, should be placed close to or on the antenna. For 12 GHz reception, the first intermediate-frequency signal would be between 500 and 2600 MHz. Economy in receiver design may be possible if the total frequency range containing the wanted emissions does not exceed 300 to 400 MHz. The final frequency change will select the programme required. The final intermediate frequency may be close to 35 or 70 MHz. Provision must be made for adequate image rejection [C.C.I.R., 1970–1974 b, e and f].

6. Demodulation or adapter stages

Use can be made of a frequency demodulator which will deliver the video signal (and possibly a frequency-modulation sound signal on a sub-carrier if a subcarrier is used for sound component transmission) [C.C.I.R., 1970–1974 b and d]. The video signal can directly feed a receiver at video frequency or modulate a carrier in amplitude to produce a conventional vestigial-sideband signal which then feeds an ordinary type of domestic receiver. Devices for direct conversion from frequency to amplitude modulation, without intermediate demodulation, are under study [C.C.I.R., 1970–1974 c and g].

7. Influence of cost

The relationship between cost and the overall performance of receiving equipment, measured by the figure of merit, G/T, involves other factors such as the quality of workmanship, the extent of the tests carried out after manufacture, the reliability objective, etc. Cost studies both for items of equipment and for complete installations [Knouse *et al.*, 1973] have shown substantial differences between the estimates obtained from various sources even after these estimates have been adjusted on a similar basis and for similar performance factors. The following represent examples of cost estimates taken from various sources [C.C.I.R., 1970–1974d; Knouse *et al.*, 1973].

— for a 2·6 GHz community receiving equipment with a figure of merit, G/T, of 4 dB, the estimated price varies between $2200 for a production quantity of 100 and $820 for a production quantity of 100 000. For a figure of merit, G/T, of 10 dB, these figures would be $3500 and $1200 respectively [Knouse *et al*, 1973];

— for 12 GHz equipment, assuming mass production of from 10 000 to 100 000 sets, the cost may vary in future from $120 to $300 for individual reception, depending on the value of G/T required and the number of channels that can be received and would be about $1000 for community reception [C.C.I.R., 1970–1974d].

These examples of estimates apply only to the cost of the antenna and the adapter equipment to be used with the conventional receivers.

References

C.C.I.R. [1970–1974a] Doc. 11/315, E.B.U.

C.C.I.R. [1970–1974b] Doc. 10/204 (11/262), United Kingdom.

C.C.I.R. [1970–1974c] Doc. 11/297, Japan.

C.C.I.R. [1970–1974d] Doc. 10/253 (11/306), Italy.

C.C.I.R. [1970–1974e] Doc. 11/92, France.

C.C.I.R. [1970–1974f] Doc. 11/93, France.

C.C.I.R. [1970–1974g] Doc. 11/338, France.

Knouse, G. *et al.* [April, 1973] A computer program for evaluating and synthesizing broadcast satellite systems. Final report No. 4169-011 prepared for NASA — Washington, D.C.

ANNEX

EXAMPLE OF CALCULATION OF THE FIGURE OF MERIT OF RECEIVING EQUIPMENT FOR INDIVIDUAL RECEPTION IN THE 12 GHz BAND

For the present example, the figure of merit, G/T, is defined by the following formula, which allows for pointing error, polarization effects, and ageing:

$$G/T = \frac{\alpha \, \beta \, G_r}{\alpha \, T_a + (1-\alpha) \, T_0 + (n-1) \, T_0}$$

where

α : the total coupling losses, expressed as a power ratio

β : the total losses due to the pointing error, polarization effects and ageing, expressed as a power ratio

G_r: the effective gain of the receiving antenna, expressed as a power ratio and taking account of the method of feeding and the efficiency

T_a: the effective temperature of the antenna, taken in the example below as 150 K

T_0: the reference temperature = 290 K

n : the overall noise factor of the receiver, expressed as a power ratio.

In several years time, it should be possible to produce relatively cheap receivers having figures of merit of 4 dB. An example is given in Table I in which the figure of merit of 4 dB is obtained with an antenna of 1 m diameter and a receiver noise factor of 8 dB. It is, however, possible to obtain the same result with other combinations of the parameters, and Fig. 1 shows, for example, how the antenna gain and the noise factor may have a range of values.

TABLE I

Example of the calculation of the figure of merit *

Gain of receiving antenna (1 m dia., 50% efficiency), G_r	(dB)			38·9	
Coupling loss, α	(dB)			−0·5	
Pointing and polarization losses, } β	(dB)			−1·0	
ageing degradation	(dB)			−1·0	
Net gain, G, ($\alpha\ \beta\ G_r$)	(dB)			36·4	36·4
Antenna temperature, T_a	(K)	150			
Coupling loss, α		0·891			
T_a, referred to the input, ($\alpha\ T_a$)	(K)		133·7		
Reference temperature, T_0	(K)	290			
$1-\alpha$		0·109			
Noise temperature of coupling, ($(1-\alpha)T_0$)	(K)		31·6		
T_0	(K)	290			
Receiver noise factor (8 dB) reduced by 1 (i.e., $n-1$)		5·309			
Receiver noise temperature, ($(n-1)T_0$)	(K)		1539·6		
Total effective noise temperature, T	(K)		1704·9		
$-10 \log_{10} T$					−32·3
Figure of merit, G/T *	(dB)				4·1

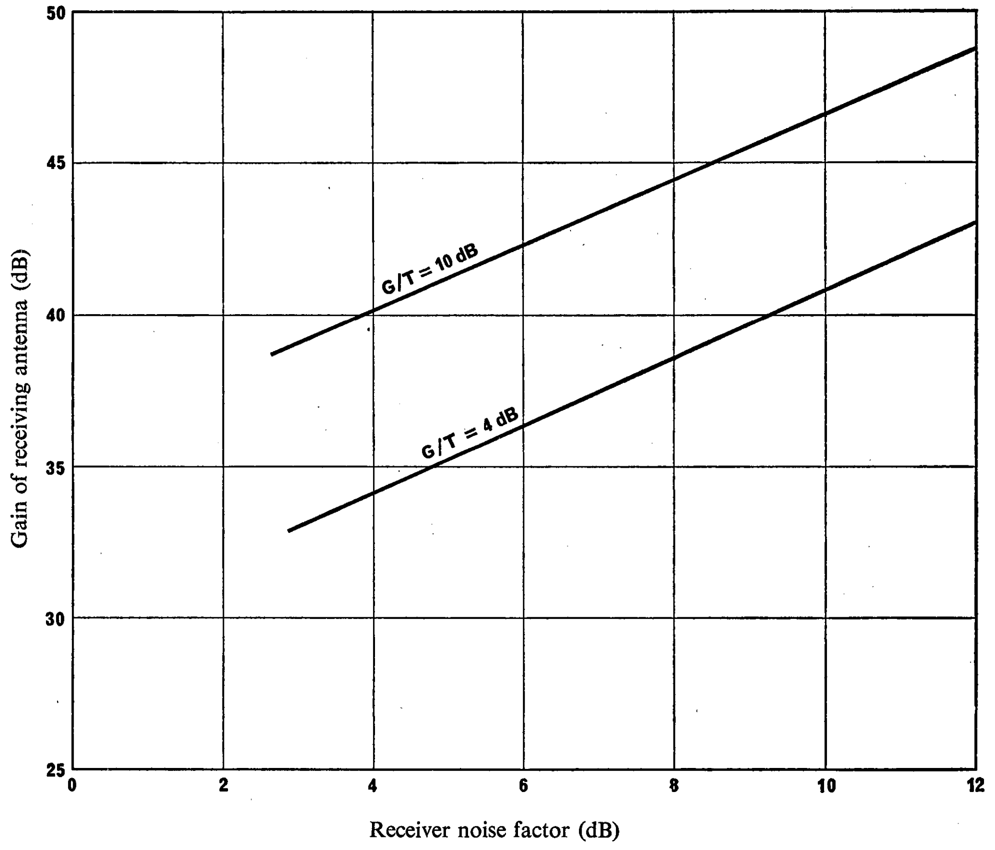

FIGURE 1

Relationship between noise factor and antenna gain for G/T = 4 dB or 10 dB losses, reference temperature and antenna temperature as in the example of Table I

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* In this example, the value of G/T would be 2 dB higher if the factor β were not included in the formula defining G/T.

REPORT 631 *

BROADCASTING-SATELLITE SERVICE: SOUND AND TELEVISION

Frequency-sharing between the broadcasting satellite service and terrestrial services

(Questions 20-2/10 and 5-2/11)

(1974)

1. Introduction

As a result of the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971, the broadcasting-satellite service has allocations or is permitted to operate under certain conditions in the following shared bands (see Article 5 of the Radio Regulations):

— 620 to 790 MHz, which is mainly used by the fixed, mobile, and terrestrial broadcasting services;

— 2500 to 2690 MHz to be shared with the fixed, fixed satellite and mobile services;

— 11·7 to 12·2 GHz (11·7 to 12·5 in Region 1) to be shared with the fixed, fixed satellite (in Region 2 only), mobile and terrestrial broadcasting services;

— 22·5 to 23 GHz in Region 3 only, where it is to be shared with the fixed and mobile services.

2. Parameters involved in frequency-sharing

For frequency-sharing between two types of service, careful consideration should be given to the order in which the assignments are made. This imposes certain limitations on the technical characteristics of each of the systems (e.g., maximum value for the power flux-density of the broadcasting satellites, inside and outside their service areas, adequate directivity for receiving earth station antennae, maximum value of the e.i.r.p. of the terrestrial service transmitters) and also certain conditions for their use (e.g., minimum distance between a terrestrial service transmitter and the boundary of the service area of a broadcasting satellite sharing all or part of the same channel). These technical or operational limitations may or may not be acceptable depending on the nature of the two systems in question.

2.1 *Sound broadcasting*

Frequency-sharing between the sound broadcasting-satellite service and terrestrial services may be feasible under one or more of the following conditions:

— considerably lower protection ratios than those contained in Recommendation 412-1 are applied;

— field strengths having values considerably lower than those required for emissions from terrestrial stations as shown in Recommendation 412-1 are utilized by the broadcasting-satellite service;

— power flux-density limitations are placed on emissions from either satellite and/or terrestrial stations within areas where interference may occur, noting that a satellite may produce interference over geographical areas of continental size;

— confinement of the potential zone of coverage for the broadcasting-satellite service to those areas where emissions from co- and adjacent-channel terrestrial stations do not exist at present and where the satellite service could be protected from interference due to terrestrial stations that might be installed in the future (primarily rural or sparsely settled areas).

The possibilities of sharing between the sound broadcasting-satellite service and terrestrial services require further study. Thus the remaining sections of this Report deal only with television broadcasting.

* This Report, which was adopted unanimously, replaces Reports 474, and 475 and furnishes a partial reply to Questions 20-2/10 and 5-2/11. It should be brought to the attention of Study Groups 4, 8 and 9.

2.2 *Television broadcasting*

2.2.1 *General equation for the limiting value of power flux-density of the unwanted signal to protect the wanted service*

As previously noted, when a broadcasting-satellite service shares frequencies with a terrestrial service, it may be necessary to impose limitations on the power flux-density produced by the unwanted signal at the receiving stations of the wanted service. A general equation for determining the limit on power flux-density is: *

$$F_s = F_{tqp} - R_q + D_d + D_p - M_r - M_i \quad (1)$$

where:

F_s : maximum power flux-density (dB(W/m²)) to be allowed at the protected station,

F_{tqp} : minimum power flux-density (dB(W/m²)) to be protected, i.e. the power flux-density which, in the face of thermal noise only, yields the output signal quality q that is to be exceeded for some specified high percentage of the time p,

R_q : protection ratio (ratio of the wanted-to-interfering signal power at the receiver input) (dB) for barely detectable interference when the output signal quality has been degraded by thermal noise to q,

D_d : discrimination (dB) against the interfering signal due to directivity of the receiving antenna,

D_p : discrimination (dB) against the interfering signal due to polarization of the receiving antenna. This factor is often combined with D_d as a single term,

M_r : margin (dB) for possible ground reflection of interfering signal,

M_i : margin (dB) for possible multiple interference entries.

The limit on power flux-density given by equation (1) insures that the output signal quality at the receiving station of the wanted signal will be equal to q even when the power flux-density of the system has faded to the level F_{tqp}. During p% of the time, the power flux-density of the system will be higher than F_{tqp} and the output signal quality will be higher than q.

If it is desired to express F_s in terms of the median value of power flux-density from the wanted system, F_{tqm}, which yields the same output quality statistics, the equation is

$$F_s = F_{tqm} - M_p - R_q + D_d + D_p - M_r - M_i \quad (2)$$

where M_p is the difference (dB) between the median value of the wanted signal level and the level exceeded p% of the time.

Equations (1) and (2) can be applied to calculate the limits on the unwanted power flux-density appropriate to any given wanted service. In the case of the terrestrial broadcasting service, the receiving station to be protected is assumed to be on the boundary of the potential service area of the terrestrial transmitter. This boundary is defined as the geographic contour within which the power flux-density from the terrestrial transmitter equals or exceeds that required to produce an output signal (television picture or sound) of acceptable quality in the absence of interference and man-made noise at 50% of the locations for at least p% of the time, where for example, p has a specified value in the range from 90% to 99%. In the terrestrial broadcasting service it is also traditional to describe the incident signal in terms of field strength in dB(μV/m) rather than in terms of power flux-density in dB(W/m²). The former can be obtained from the latter by adding 146 dB.

2.2.2 *Power flux-density requirements in the broadcasting-satellite service*

Report 215-3 discusses the required power flux-densities in some detail, and Table XII of that Report contains numerical values of such power flux-densities.

* This equation may not be valid when the satellite signal arrives near grazing incidence. In this case an additional margin must be included.

2.2.3 *Field strengths to be protected in terrestrial services*

The field strengths requiring protection in the case of terrestrial services which may share frequencies with the broadcasting-satellite service are discussed later, in the sections concerning each service.

2.2.4 *Protection ratios*

Report 634 deals with this subject in some detail and presents required values of protection ratio for different systems.

2.2.5 *Use of special techniques to meet limitations on power flux-density*

Energy dispersal techniques for frequency-modulation television could be considered to "spread" the radiated power over a wide radio frequency band to meet power flux-density limitations at the surface of the Earth. An example of the use of energy dispersal in the 2·6 GHz band is presented in Doc. 11/48 (U.S.A.) 1970–1974, which also shows calculations of the required bandwidth and corresponding signal-to-noise ratio. The conclusion is that the performance of a 2·6 GHz broadcasting-satellite system using small receiving antennae can be severely limited by the need to provide energy dispersal.

2.2.6 *Calculation of power flux-density produced by a geostationary satellite*

Several methods may be used to calculate the power flux-density at a given point on earth produced by a broadcasting satellite. One detailed method using graphs is presented in Doc. 11/73 (India) 1970–1974.

3. Sharing in the 620 to 790 MHz band

Television broadcasting from satellites using frequency modulation only is dealt with in this section.

3.1 *Sharing with the terrestrial broadcasting service*

Frequency-sharing between a broadcasting-satellite system and a terrestrial broadcasting system requires that the receivers of each system be protected against interference from the emissions of the other system. The terrestrial receivers can be protected by imposing limits on the power flux-density produced by the broadcasting satellite at points within the terrestrial service area as described in § 3.1.1. Conversely, the broadcasting-satellite system receivers can be protected against interference by requiring adequate separation between the terrestrial transmitter and the satellite receiver. An example of the separation required in a particular case is given in § 3.1.2.

3.1.1 *Protection of the terrestrial broadcasting service*

To protect the terrestrial television broadcasting service from interference from a television broadcasting satellite, it is necessary to place a limit on the power flux-density that the satellite is allowed to produce at points within the service areas of the terrestrial television broadcasting stations.

A provisional value for this limit in the band 620 to 790 MHz is given in Recommendation No. Spa2—10:

$$F_s = \begin{cases} -129 \text{ dB(W/m}^2) & \delta \leqslant 20° \\ -129 + 0{\cdot}4\,(\delta - 20) \text{ dB(W/m}^2) & 20° < \delta \leqslant 60° \\ -113 \text{ dB(W/m}^2) & 60° < \delta \leqslant 90° \end{cases}$$

where δ (degrees) is the angle of arrival of the satellite signal above the horizontal plane.

In Recommendation No. Spa2—10, the C.C.I.R. was urged to study the frequency-sharing criteria to be applied in this band and to recommend a value to be used in lieu of the provisional limit. Several administrations subsequently conducted such studies and have made their individual suggestions regarding the limit on power flux-density that should be adopted.

In each case, the limit was calculated from an equation equivalent to equation (1) or equation (2). While there was not unanimity in the suggested limits on power flux-density the differences can be understood in terms of the differences between the values assumed for the parameters in the equations. These assumptions are summarized in Table I; they will be discussed in some detail in order to illuminate the problems involved in reaching agreement on a satisfactory limit on the power flux-density.

3.1.1.1 *Minimum terrestrial power flux-density to be protected*

Recommendation 417-2 gives the values 67 and 70 dB(μV/m) for the field strengths in Band V (610 to 960 MHz) corresponding to F_{tqp} and F_{tqm} in equations (1) and (2), respectively. The Recommendation also notes that "in a practical plan, because of interference from other television transmissions, the field strengths that can be protected will generally be higher". Nevertheless, some administrations studying the question were agreed that both advances in receiver technology and practical experience with terrestrial television reception suggested that consideration should be given to protecting lower values of field strength.

In Doc. 11/331 (E.B.U.) 1970–1974, the E.B.U. suggests that in the service areas where a minimum median protected field of 70 dB(μV/m) at 50% of the locations is taken as a basis, there is often a considerable number of home receivers and relay stations providing satisfactory pictures with a lower field. It can be considered that points where the field is about 65 dB(μV/m) provide a satisfactory coverage. In many cases it is the only way of providing a service, because no other frequency is available. It is therefore necessary to protect a field of 65 dB(μV/m) against the total interference. Nevertheless, if this value is increased to 68 dB(μV/m) and if power-law addition is assumed, the field to be protected against interferences caused only by satellites should be taken as equal to 65 dB(μV/m). The minimum power flux-density to be protected for the terrestrial system is then -81 dB(W/m^2).

Table I shows examples of calculations of the limiting values of power flux-density from a broadcasting satellite required to protect the terrestrial broadcasting service. The example from the U.S.S.R. has taken into account that the values of power flux-density should be given, bearing in mind the following:

— frequency band occupied by the interfering signal;

— bandwidth of the amplitude-modulation, vestigial-sideband receiver;

— level of random noise at the output of the amplitude-modulation, vestigial-sideband receiver.

TABLE I-A

Examples of the calculation of the limiting values of power flux-density from a broadcasting satellite required to protect the terrestrial broadcasting service in the band 620 to 790 MHz

1. *Data relating to the wanted signal*					
Source documents (1970–1974)	11/58 (U.K.) 11/126 (E.B.U.) 11/331 (E.B.U.)	11/64 (U.S.A.)	11/108 (France) 11/126 (E.B.U.) 11/331 (E.B.U.)	11/126 (E.B.U.) 11/331 (E.B.U.)	11/333 (U.S.S.R.)
1.1 Television system and standard	I/PAL	M/NTSC	L/SECAM	G/PAL	K/SECAM
1.2 Quality assessment scale	6-point (1: imperceptible)		5-point (5: excellent)		
1.3 Grade of picture quality	≈ 1·6	3	4·5	4·5	Just visible interference
1.4 Picture signal-to-weighted noise ratio (dB)	>48	33	47 to 52	50	47
1.5 Minimum field strength to be protected against interference caused by satellite (dB (μV/m))	65	56 (1)	65	65	70
1.6 Minimum power flux-density, terrestrial, to be protected, F_{tqp} (dB (W/m²))	−81	−90	−81	−81	−76

(1) The assumed fading margins are those associated with an e.i.r.p. of 2 MW from an antenna at a height of 300 m in the terrestrial broadcasting service. Median field strengths of −60 dB (μV/m) and −65 dB (1 μV/m) would yield the same picture quality as above, for 90% and 99% of the time, respectively.

TABLE I-B

2. *Data relating to the protection ratio*						
Source documents (1970–1974)		11/58 (U.K.) 11/321 (E.B.U.)	11/49 (U.S.A.)	11/107 (France) 11/321 (E.B.U.)	11/126 (E.B.U.) 11/321 (E.B.U.)	11/333 (U.S.S.R.)
2.1 Picture content of wanted signal		Slides	Slides and off-the-air programmes	Slides	Slides	Electronic test chart and film
2.2 Characteristics of unwanted signal	Picture content	Colour-bars	Colour-bars and off-the-air programmes	Colour-bars	Colour-bars	Monochrome test chart
	Frequency deviation peak-to-peak (MHz)	8	18	8	8	22
	Pre-emphasis	Yes	No	Yes	Yes	No
	Dispersal	No	No	No	No	No
2.3 Protection ratio, R_q (dB)		56	35	52	57 to 60	46
3. Directivity discrimination, D_d (dB) (1)						
4. Polarization discrimination, D_p (dB)		2		2	2	
5. Reflection margin, M_r (dB)		3		3	3	2
6. Multiple interference entry margin, M_i (dB)						
7. Resultant limit on power flux-density, F_s (dB (W/m²))		−138	−125	−134	−142	−124

(1) No directivity discrimination can be assumed, since only angles of elevation less than 20° are considered.

3.1.1.2 *Protection ratio*

The values of protection ratio given in Table I were measured under different conditions. More detailed results are given in Report 634, which also discusses the various measuring conditions and system parameters which affect the assessment of protection ratio. In that Report, it is suggested that, where possible, the protection ratio should be defined for a specified combination of conditions and parameters. Corrections which may be applied for different conditions and parameters are also given in Report 634. The value of protection ratio proposed by the E.B.U. (see Table I) is based on the reference conditions.

3.1.1.3 *Directivity discrimination*

None of the examples take explicit account of the directivity of the receiving antenna; instead they consider the worst case in which the interfering satellite signal arrives from a direction close to the receiving antenna axis. However, all administrations appear to accept the idealized antenna pattern for Band V given in Recommendation 419, although the U.S.A. Administration notes that in practice, more directive antennae are likely to be used at the service area boundaries in question. In any case, using the pattern of Recommendation 419 would lead to an escalation of satellite power flux-density with angle of arrival similar to that given in the provisional limit of Recommendation No. Spa2—10.

3.1.1.4 *Polarization discrimination*

If circular polarization is used for the broadcasting satellite transmission, a discrimination of up to 3 dB may be expected from the linearly polarized terrestrial receiving antenna. Report 339-1 (New Delhi, 1970) contained data for the discrimination that will be achieved in the usual case where the satellite transmitting antenna and the terrestrial receiving antenna are not to be aligned with each other.

3.1.1.5 *Margin for ground reflections*

There is no direct experimental evidence regarding this quantity, but the United Kingdom Administration reports that extrapolation to Band V of experimentally verified theoretical predictions of reflection from irregular terrain at 230 MHz suggest that 3 dB is a reasonable value. The Administration of France and the E.B.U. agree with this assumption and cite extreme cases of near unity reflection of terrestrial signals from the sea which could enhance the interfering signal by 6 dB.

3.1.1.6 *Multiple interference margin, M_i*

In the service area of a terrestrial transmitter, a satellite can cause interference only where the receiving aerials point in a direction not very different from that of the satellite. It is therefore unnecessary to allow for interference from several satellites, if it can be assumed that there will never be more than one satellite emission at the same time on the same channel and in about the same direction.

3.1.1.7 *Summary and conclusions*

From information provided by the Administrations of the United Kingdom and France, and by the E.B U., the numerical value has been calculated for the limit which should be imposed on the power flux-density to protect terrestrial broadcasting in the band 620 to 790 MHz against the emissions from future satellites using frequency-modulation television. The results are given separately for systems I/PAL, L/SECAM and G/PAL. For these three systems, the average figure is -138 dB(W/m^2), the differences between the systems being due to the different measured values of protection ratio. This average is 9 dB lower than the provisional value recommended by the Space Conference of 1971.

The service area boundaries were defined in terms of very nearly the same minimum values of terrestrial field strength to be protected as recommended by the C.C.I.R., and possible fading of the terrestrial signal at the service area boundaries was neglected. The E.B.U. study generally supported the conclusions reached by the Administrations of the United Kingdom and France.

On the other hand, the example presented by the Administration of the U.S.A. afforded protection to a much lower terrestrial field strength, taking into account both an assumed better receiving installation, significant terrestrial signal fading, and a lower picture quality. In the U.S.A., a lower protection ratio is used which corresponds to the lower assumed picture quality and is based on a wider frequency deviation for the interfering frequency-modulation satellite signal as well as picture contents more typical of off-the-air programming. The satellite power flux-density limit in the example presented by the U.S.A. Administration was -125 dB(W/m^2), i.e. 4 dB higher than the provisional value recommended by the Space Conference of 1971.

Under the conditions presented by the Administration of the U.S.S.R. in Table I, the limit for the power flux-density was -124 dB(W/m^2), i.e. 5 dB higher than the provisional value recommended by the Space Conference of 1971. In the calculations made by the U.S.S.R. Administration a coefficient γ is introduced, which is defined as the ratio of the unwanted frequency-modulation signal total power to the portion of this power falling within the band of the amplitude-modulation, vestigial-sideband receiver. The value of γ depends on the frequency deviation of the interfering frequency-modulation signal, and on the carrier separation between the two signals. For the conditions indicated in Table I, which correspond to the worst case for carrier separation, γ is 5 dB.

Until greater agreement is reached concerning the values to be assumed for the relevant parameters, it is premature for the C.C.I.R. to recommend a single value for the satellite power flux-density limit necessary to protect terrestrial broadcasting. Indeed the possibility cannot be dismissed that it may be necessary to adopt different power flux-density limits for combinations of wanted and unwanted signals having different signal standards.

3.1.2 *Protection of the broadcasting satellite service*

Protection of the broadcasting satellite ground receiving stations is normally achieved by maintaining a minimum separation between them and the terrestrial transmitter. The minimum separation required depends on the characteristics of both the Earth receiving installation and the transmitting station in the terrestrial broadcasting system. As an example, Fig. 1 illustrates the required separation for the conditions assumed below:

Terrestrial transmitter: e.i.r.p., 1 MW, visual; vestigial-sideband amplitude modulation

Height of terrestrial antenna: 300 m above average terrain

Space service: frequency-modulation television with

$\Delta f_{p\text{-}p} = 10$ MHz (525-lines) and 13 MHz (625-lines)

Diameter of earth-station receiver antenna: 3·4 m

Antenna discrimination of earth-station receiver: $10{\cdot}5 + 25 \log (\varphi/\varphi_0)$

Protection ratio for space service: 23 dB (525-lines) and 24 dB (625-lines)

Signal-to-noise ratio for space service: 42 dB (525-lines) and 45 dB (625-lines)

Power flux-density for space service at beam edge: — 118 dB(W/m^2) (525-lines, U.S.A. and Canada)

— 117 dB(W/m^2) (625-lines)

Protection refers to 90% of the time at 50% of locations

See also Recommendation 370–2, Fig. 17*b* (25% over water).

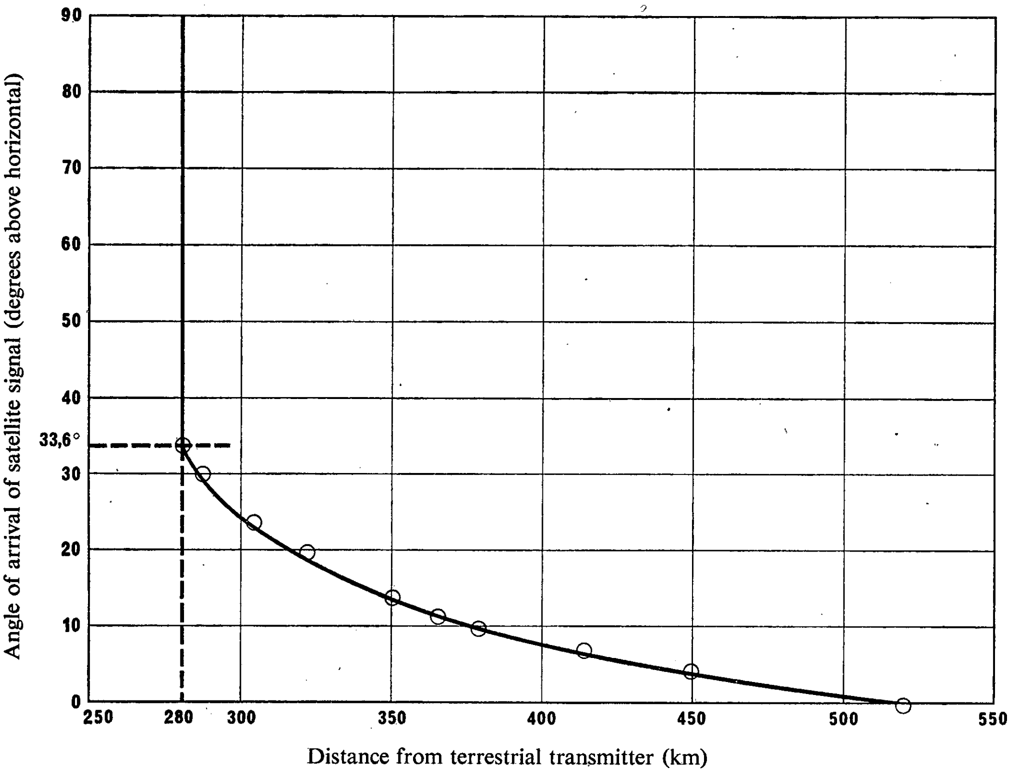

FIGURE 1

Example of separation distance between an earth receiver for community reception and a terrestrial transmitter, for just perceptible interference

3.2 *Sharing with fixed and mobile services*

Limitations on power flux-densities which would have to be imposed on the broadcasting-satellite television service to protect fixed and mobile services, including trans-horizon radio-relay systems, at present allocated the same frequency bands as the broadcasting service, may cause difficulties in such sharing. Careful consideration is, therefore, necessary before introducing the broadcasting-satellite service. Tropospheric scatter systems which point towards the geostationary orbit are particularly vulnerable. Examples of the required power flux-density limits in the case of sharing with land mobile services are given in Annex I.

4. Sharing in the band 2500 to 2690 MHz

4.1 *Sharing with the fixed service* *

The terrestrial systems in the fixed service that are considered for frequency-sharing with a broadcasting-satellite system include line-of-sight and trans-horizon radio-relay systems and a certain type of television distribution system. Conditions of sharing between the television broadcasting-satellite service and other terrestrial services are not presented owing to the absence of relevant data.

The type of broadcasting-satellite system chosen for examination was one designed for community reception. An example of the parameters of such a system is given in Table II.

* To the extent that proposed fixed satellite systems used for television distribution are technically similar to broadcasting-satellite systems, they also are subject to these considerations.

TABLE II

Example of the characteristics of a satellite television system for community reception (operating in the vicinity of 2500 MHz)

(System M, U.S.A. and Canada)
Circularly polarized emission
Frequency-modulation
Equivalent rectangular bandwidth: 20 MHz
Earth-station receiving antenna gain (3 m paraboloid: 35 dB)
Earth-station receiving antenna discrimination: $10{\cdot}5 + 25 \log (\varphi/\varphi_0)$ where: φ : angle off the main beam axis, φ_0: angle between the half-power points.
Minimum side lobe gain: 0 dB
Satellite field strength to be protected at beam edge: 28 (dB (μV/m))
Luminance signal-to-weighted r.m.s. noise: 42 dB
Required protection ratio from ITSF (1): 22 dB

(1) ITSF: Instructional Television Fixed Service.

4.1.1 *Sharing with line-of-sight radio-relay systems*

Although this case could not be studied in detail owing to lack of relevant information, it should be noted that the establishment of circuits comprising a large number of relay stations often implies the repetitive use of frequencies according to a plan occupying a continuous section of the allocated band which cannot be departed from without difficulty (see Recommendations 283-2 and 382-2).

Co-channel operation between a broadcasting-satellite system and a terrestrial radio-relay system results in a number of limitations because the presence of a transmitter of a terrestrial radio-relay system within, or in the neighbourhood of, the service area of the broadcasting-satellite system gives rise to a "hole" in the broadcasting service area. This makes planning of the radio-relay channelling very difficult.

4.1.2 *Sharing with trans-horizon radio-relay systems*

Frequency-sharing between broadcasting-satellite systems and trans-horizon radio-relay systems in the vicinity of 2500 MHz is technically feasible only to the extent that each system can accept certain technical and operational limitations required to protect it against interference from the other. (See also § 8.4.3 of the Report of the Special Joint Meeting, Geneva, 1971.)

4.1.2.1 *Protection of trans-horizon radio-relay systems*

Trans-horizon radio-relay systems are subject to geographical and frequency constraints which limit planning flexibility and could make it difficult to avoid potential interfering configurations. Sharing would involve consideration of the pointing directions of the trans-horizon system antennae, to protect the trans-horizon system receivers as well as consideration of the directivity of the satellite antenna. When the trans-horizon receiver is within the coverage area of the broadcasting-satellite and suitable protection is not available, one possible remedy would be to re-engineer the trans-horizon system to use different frequencies. Alternatively, the broadcasting-satellite system would be required to restrict its power flux-density to low values in the immediate vicinity of the trans-horizon receivers. These constraints are not likely to be acceptable to either service except under special conditions where the number of systems is small and the flexibility of placement of both the satellites and the trans-horizon stations is large. When the trans-horizon receiver lies outside the coverage area of the broadcasting satellite the problem would be eased, depending upon the system configurations in each case and the radiation pattern of the satellite antenna.

4.1.2.2 *Protection of broadcasting-satellite systems*

The receivers of the broadcasting-satellite service would be susceptible to interference from trans-horizon radio-relay transmitters within an elongated zone which extends for a considerable distance in the direction in which the trans-horizon antenna is pointed; the extent of this zone is a function of the antenna directivity and the relative directions of the trans-horizon link and the satellite. Similarly, the establishment of a satellite broadcasting coverage area would prevent the introduction of new trans-horizon systems in that area and also, nearby, if the entire area were to be protected from interference.

4.1.3 *Sharing with a certain type of fixed terrestrial television distribution*

An example of the characteristics of the type of terrestrial television distribution system in question is given in Table III. These characteristics are typical of the Instructional Television Fixed Service (ITFS) system used in parts of Region 2. Specifically, such systems utilize approximately 12 W transmitters with omnidirectional, or directional, antennae and specified receiving points (educational institutions) which employ directional parabolic receiving antennae. Thus it is considered that the type of service rendered is similar to community reception as defined for the broadcasting-satellite service.

TABLE III

Examples of characteristics for a typical ITFS system (operating in the vicinity of 2500 MHz)

Amplitude modulation, vestigial sideband, System M (U.S.A. and Canada)
E.i.r.p.: 26 dBW
Service range: approximately 50 km
Received signal to be protected: 56 dB (μV/m)
Luminance signal-to-weighted r.m.s. noise: 40 dB
Receiving antenna gain (1·8 m paraboloid): 31 dB
Receiving antenna discrimination: $9 + 20 \log (\varphi/\varphi_0)$ where: φ : angle off the main beam axis, φ_0: angle between the half-power points.
Required protection ratio from satellite signals: 40 dB

Frequency-sharing in the vicinity of 2500 MHz between a broadcasting-satellite system and an ITFS system is technically feasible under certain conditions. A limit on the power flux-density of the satellite signal would have to be specified to protect the ITFS service and a "hole" or an area of interference within the satellite service zone would be created due to interference from the ITFS operation. The size of this area of interference depends on the transmitter power and height of the transmitting antenna of the ITFS system, the angular discrimination of the earth receiving antennae of the broadcasting-satellite system, and the angle of elevation of the satellite.

4.1.3.1 *Protection of ITFS system*

The television broadcasting-satellite service using wideband frequency-modulation can share frequencies with ITFS in the 2500 MHz band provided the satellite power flux-density for each channel is limited in accordance with the values shown in Fig. 2. It may be noted that an angle of elevation for the satellite of 6·9° is the minimum angle, below which sharing is not feasible, because of insufficient antenna discrimination. The values indicated are for one satellite entry. Interference from two satellites would require 3 dB more protection and from ten satellites, up to 5 dB.

4.1.3.2 *Protection of the television broadcasting-satellite system*

An earth receiving installation for community reception can be protected from ITFS interference provided that the power flux-density of the latter is limited to a maximum of — 105 dB(W/m²). This protection is achievable at a minimum angle of elevation for the satellite of 26·6°. The necessary separation between the earth receiving installation location and the ITFS transmitter for different values of the ITFS power flux-density and angles of arrival in the range from 80 km to over 200 km is shown in Fig. 3. These values assume no site shielding.

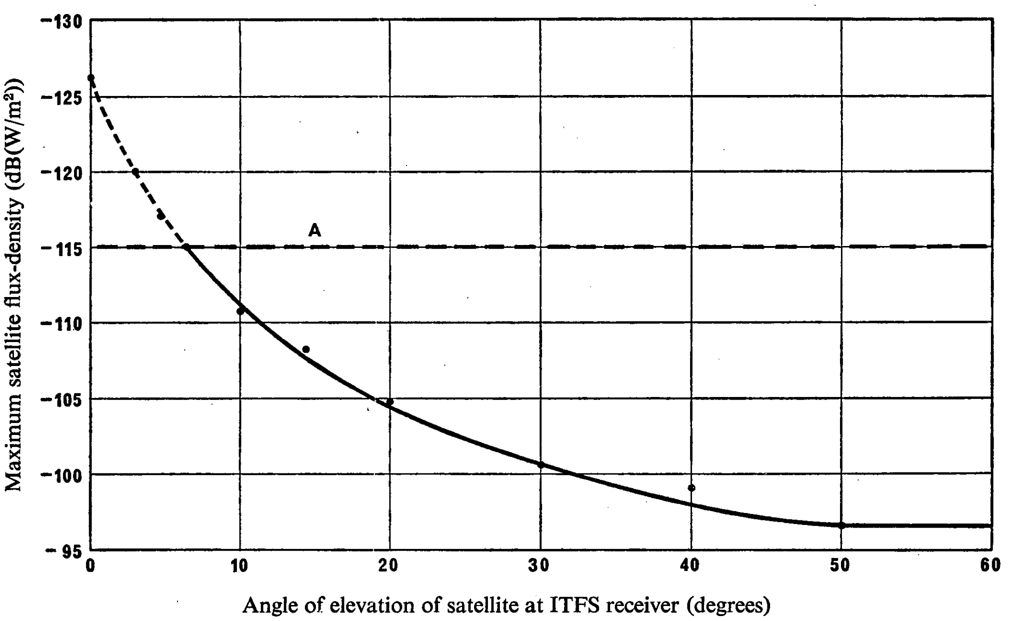

FIGURE 2

Maximum satellite flux-density as a function of angle of elevation

A : minimum required power flux-density from satellite for community reception

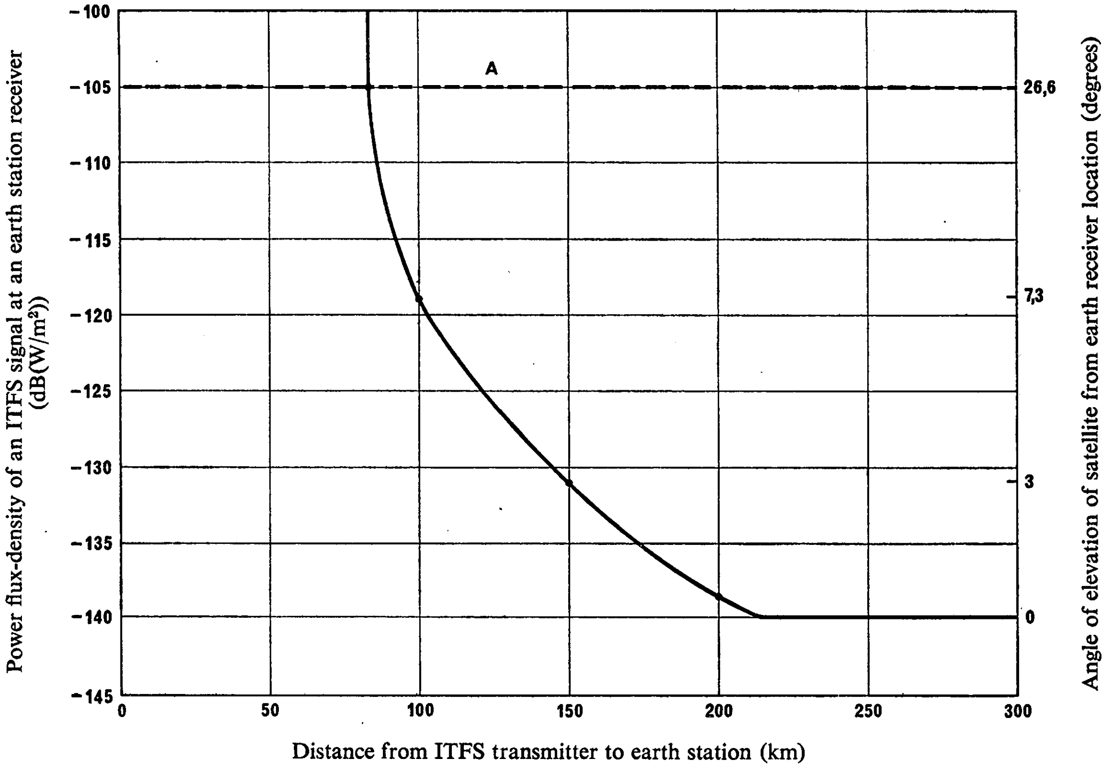

FIGURE 3

Separation distance to protect earth receivers from ITFS transmitters

A: maximum acceptable power flux-density for ITFS transmitter

4.2 *Sharing with the radioastronomy service*

Report 224-3 discusses sharing between the radioastronomy service and the broadcasting-satellite service. In the shared band, the possibilities of geographical sharing need to be explored. In making assignments, the attention of administrations is drawn to the adjacent band problems discussed in Report 224-3.

5. Sharing in the band 11·7 to 12·5 GHz

This section presents the conditions for frequency-sharing in the 12 GHz band between the broadcasting-satellite and terrestrial services. Sharing between the broadcasting-satellite service and the fixed satellite service in the band 11·7 to 12·2 GHz (applicable to Region 2) is considered in Report 561.

Rainfall attenuation in some climates may require large propagation margins if high service reliability is desired. The effect of this margin should be taken into account when considering sharing problems.

The systems and their characteristics given in Annex II are used as examples.

5.1 *Conditions for the protection of terrestrial systems against interference from broadcasting satellites*

It is useful to consider, as an example, a terrestrial broadcasting system for which the receiving antenna discrimination may be taken as

$$D_a = 9 + 20 \log (\varphi/\varphi_0) \quad \text{dB}$$

subject to a maximum of 30 dB (see Report 215-3, Fig. 6). Applying equation (1), taking a protection ratio of 36 dB and assuming values of zero for the polarization discrimination and the margin terms, the maximum acceptable satellite power flux-density may be plotted against φ/φ_0 as shown in Fig. 4. The protected power flux-density F_{tqp} is expressed as a protected field strength, and curves are drawn for values of 70, 65, 60 and 55 dB(μV/m).

For the case of interference being received from a satellite on the same azimuth as the wanted terrestrial transmission, the angle φ is simply the angle in degrees between the horizontal axis (the assumed pointing direction to the terrestrial transmitter) and the elevation to the interfering satellite. When the azimuth of the satellite is different from the direction of the wanted signal, the angle φ is given by

$$\cos \varphi = \cos \theta \cos \alpha$$

where θ is the difference in azimuth between the directions of the wanted and unwanted signals and α is the angle of elevation to the interfering satellite. This expression will not be accurate in cases where the axis of the terrestrial antenna is not horizontal.

5.2 *Conditions for the protection of the broadcasting satellite frequency-modulation television system against interference from terrestrial systems*

Equation (1) is also applicable for the case of protection for the satellite system provided that the factors are changed as necessary to represent the appropriate parameters of the satellite system.

Where the appropriate protection ratio is unknown an alternative approach may be used for the determination of the maximum interfering power flux-density at the earth station receiver, based on the effective receiver input noise power. If the maximum acceptable level of interference is limited to 10% of the effective receiver input noise power, then even under conditions of a severe fade of the wanted signal the interference will not further degrade the output signal-to-noise ratio of the receiver provided that the fade of the wanted signal does not fall below the carrier threshold level.

Fig. 5 illustrates the case for maximum tolerable interference into an earth station, i.e. a satellite broadcast receiving installation, designed for individual reception. The effective receiver input noise power was estimated to be —122·1 dBW based on the parameters given in Annex II, and an assumed antenna noise temperature of 50 K. The main beam gain of the antenna was taken as 37 dB and the off beam gain as $37 - [9 + 20 \log (\varphi/\varphi_0)]$ (Report 215-3, Fig. 6). Fig. 5 is based on a maximum acceptable interference level of —132·1 dBW at the receiver input.

The relationship between the presentations employed here and in § 5.1 may be shown by an example. If the protected field strength for a satellite broadcast service is 50 dB(μV/m), the protection ratio corresponding to Fig. 5 is 30 dB.

When the maximum acceptable power flux-density for any particular direction at the earth-station receiver has been determined from Fig. 5, then the separating distance required between an outside broadcasting link and the earth-station receiver may be determined from Fig. 6 or Fig. 7, as appropriate. Fig. 7 also gives the separating distances required for a given value of power flux-density between an earth station receiver and transmitter used on a terrestrial studio link, an amplitude-modulation terrestrial broadcast and a frequency-modulation terrestrial broadcast. The Schmeller and Ulonska propagation curve for 50% of locations and 1% of the time [Goes *et al.*, 1968] has been used in the preparation of Figs. 6 and 7.

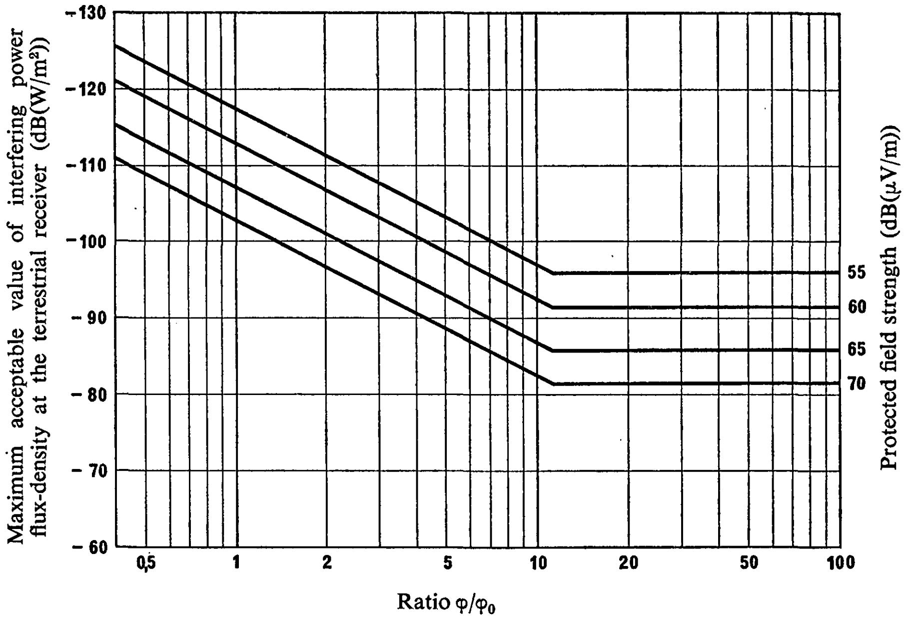

FIGURE 4

Example of maximum acceptable interfering power flux-density at a terrestrial frequency-modulation television broadcast receiver for various protected field strengths

Where:

φ : Angle of discrimination at terrestrial receiver
φ_0: Antenna, 3 dB beamwidth
Protection ratio: 36 dB
f: 12 GHz
Main beam gain, terrestrial antenna: 35 dB (0·6 m)
Terrestrial antenna discrimination: $9 + 20 \log (\varphi/\varphi_0)$

Note. — A value for φ_0 of 2·9° is proposed in Report 215-3 for a 12 GHz terrestrial broadcast receiver.

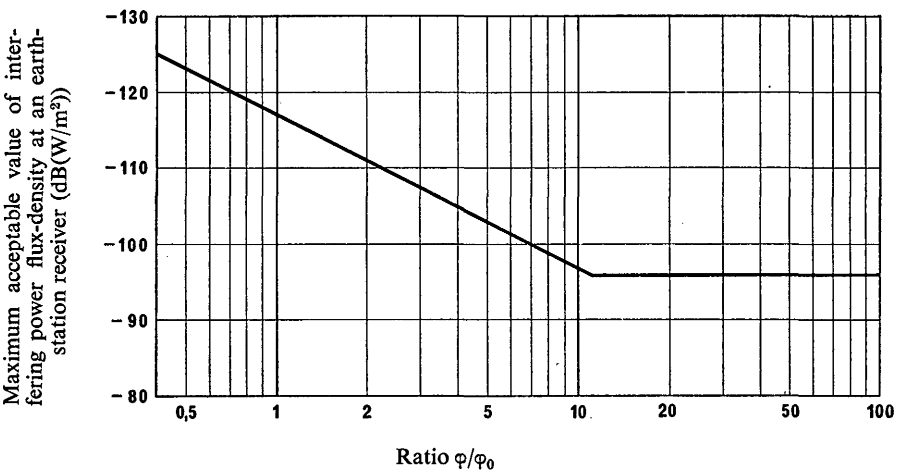

FIGURE 5

Example of maximum acceptable interfering power flux-density at an earth-station receiver (individual reception)

Where:

φ : Angle of discrimination at earth-station receiver
φ_0: Antenna, 3 dB beamwidth
Earth-station antenna off-beam gain: $28 - 20 \log (\varphi/\varphi_0)$
f: 12 GHz

Note. — A value for φ_0 of 2·4° is proposed in Report 215-3 for a 12 GHz satellite broadcasting receiver for individual reception.

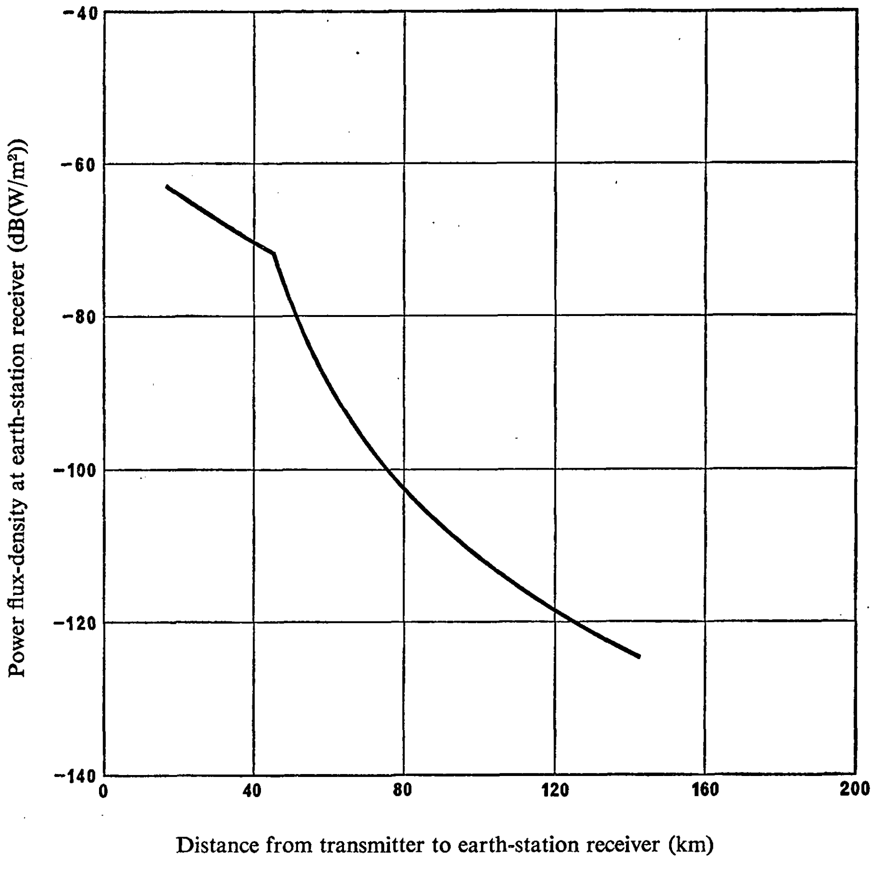

FIGURE 6

Required separation distance to protect an earth station receiver from an outside-broadcast transmitter (e.i.r.p.: 34 dBW) in the United Kingdom

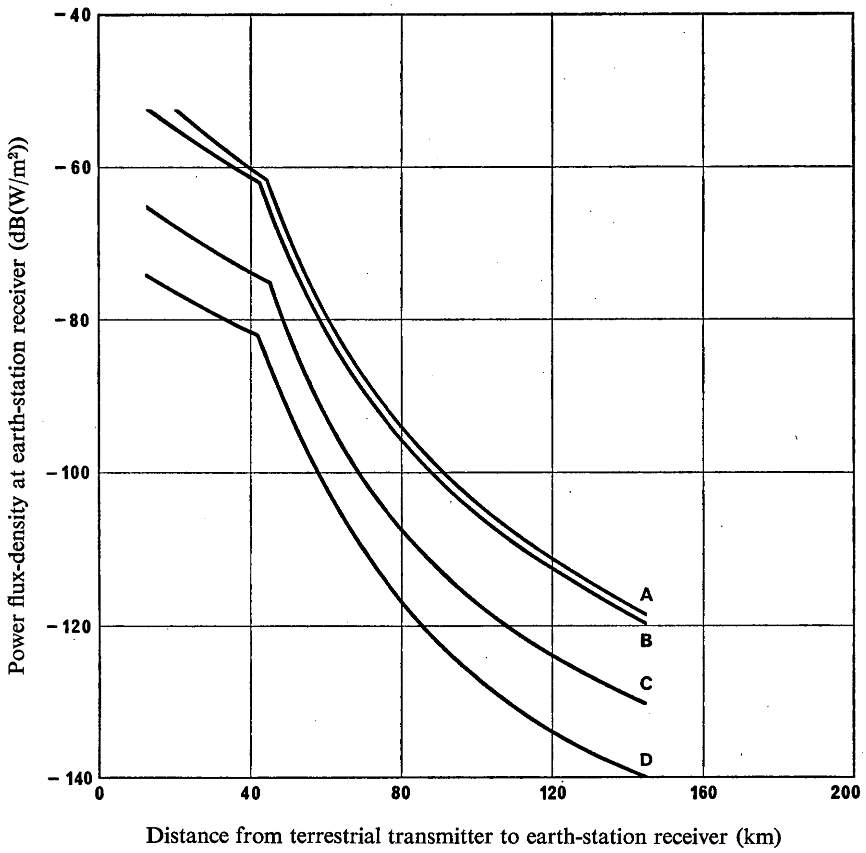

FIGURE 7

Separation distance to protect earth station receivers from terrestrial transmitters (Japan)

Power flux-density produced by:

A: Studio transmitter link (44 dBW)

B: Amplitude-modulation television broadcasting (43 dBW)

C: Outside broadcast transmitter (28 dBW)

D: Frequency-modulation television terrestrial broadcasting (21 dBW)

6. Sharing in the band 22·5 to 23 GHz

Only limited studies are available for the 23 GHz band. The maximum acceptable power flux-density from a satellite in the fixed-satellite service has been indicated in Recommendation 358-2. As a result of an examination of the effect which this Recommendation would have on a broadcasting-satellite service in the band 22·5 to 23 GHz [C.C.I.R., 1970–1974], it is considered that further study is needed concerning the power flux-density allowed for a broadcasting satellite, instead of applying the values given in Recommendation 358-2, because broadcasting-satellite transmissions would be expected to require a higher maximum power flux-density, although the transmissions would probably employ smaller beamwidths than the fixed-satellite service.

REFERENCES

C.C.I.R. [1970–1974] Doc. 10/267 (11/324), Japan.

GOES, O.W., HEINZELMANN, G. and VOGT, K. [October, 1968], Transmitter-network planning for terrestrial television broadcasting in the 11.7 to 12.7 GHz band. *E.B.U. Review, Part A*, No. 111-A, Technical.

ANNEX I

EXAMPLES OF POWER FLUX-DENSITY LIMITS REQUIRED TO PROTECT THE LAND MOBILE SERVICE AT ABOUT 800 MHz

For a single broadcasting satellite in the visible orbit, the acceptable value of power flux-density produced on the surface of the Earth by the satellite is:

— to protect a high grade service:

-133 dB(W/m^2/16 kHz) at the receiving antenna of the mobile station;

-146 dB(W/m^2/16 kHz) at the receiving antenna of the base station;

— to protect a minimum grade service:

-127 dB(W/m^2/40 kHz) at the receiving antenna of the mobile station;

-134 dB(W/m^2/40 kHz) at the receiving antenna of the base station.

These values are applicable only for the land mobile service at about 800 MHz.

The value of -146 dB(W/m^2/16 kHz) is based on currently available information and is, for example, necessary to protect a system operating in the land mobile service at about 800 MHz having the following characteristics:

— channel spacing: 25 kHz

— receiver bandwidth: 16 kHz

— receiver noise factor: 10 dB

— improvement factor: 12 dB

— antenna gain: 15 dB

— radio-frequency protection ratio: 18 dB

— polarization discrimination: 3 dB

For different or additional characteristics, the power flux-density mentioned will change accordingly. This value takes into account low elevation angles of the broadcasting-satellite.

It should be noted that if several broadcasting-satellites are in a visible orbit, the power flux-density produced by each satellite must be correspondingly lower than that quoted above.

It would be desirable to obtain more data on parameters of systems in operation or under development from other Administrations before a general value of protection to systems in the land mobile service can be arrived at. Further studies should therefore be undertaken on receipt of additional data.

At the present time it seems premature to judge whether sharing between the broadcasting-satellite service and the land mobile service is feasible at about 800 MHz.

ANNEX II

EXAMPLE OF 12 GHz SYSTEMS

	System M (Japan)					System I (United Kingdom)	
Characteristics	Studio-to-transmitter link	Outside broadcast link	Terrestrial broadcasting		Satellite (1) broadcasting	Outside broadcast link	Satellite(1) broadcasting
Type of modulation	FM	FM	AM-VSB	FM	FM	FM	FM
Approximate equivalent rectangular radio-frequency bandwidth at the picture signal (MHz)	17	17	4	16	15·4	20	27
Transmitter output power (W)	0·8	0·08	500	4	630	0·25	775
Diameter of transmitting antenna (m)	2	1	Fan beam	Fan beam	1·3	1·2	1·8
E.i.r.p. from transmitter (dBW)	44	28	43	21	65	34	72
Noise factor of receiver (dB)	9	9	9	9	9	10	8
Diameter of receiving antenna (m)	2	1	0·6	0·6	0·75	1·2	0·75
Luminance signal-to-r.m.s. weighted noise ratio (dB)	71	66	55	55	46 (2)	51·3	47 (2)
Rain margin (dB)	26	15	15	15	1	30	1·8
Percentage of time for which rain margin is not exceeded	99·95	99·95	99·9	99·9	99	99·99	99·9
Transmission distance (km)	22	11	15	15	39 000	17	39 500
Maximum power flux-density at receiving point (dB(W/m^2))	−54	−64	−52	−73	−95 (3)	−42	−91 (3)
Minimum power flux-density at receiving point (dB(W/m^2)) (4)	−80	−79	−67	−88	−99 (8)	−70	−95·8 (8)
Protection ratio against satellite interference (dB) (5) (9)	36	36	49	36		33	
Protection ratio against studio-to-transmitter link or outside broadcast link or frequency-modulation television broadcasting interference (dB) (10)					33		

	System M (Japan)					System I (United Kingdom)	
Characteristics	Studio-to-transmitter link	Outside broadcast link	Terrestrial broadcasting		Satellite (1) broadcasting	Outside broadcast link	Satellite(1) broadcasting
Type of modulation	FM	FM	AM-VSB	FM	FM	FM	FM
Protection ratio against amplitude-modulation television broadcasting interference (dB)					32		
Circular-to-linear polarization discrimination (dB) (6)	3	3	3	3		3	
Required antenna discrimination (incl. polarization discrimination for protecting the terrestrial system) (dB) (7)	18	17	18	26		9	
Off-beam angle of terrestrial antenna corresponding to above (degrees) (10)	>1·5	>2·3	>8	>20		<1·6	
Height of terrestrial transmitting antenna (m)	75	75	75	75		10	
Angle of elevation of satellite (degrees)					40		20

(1) For individual reception.

(2) This value is to be achieved at the edge of the beam (−3 dB points).

(3) to (7) The following relation exists between the values referred to in these notes:

(7) = (3) − (4) + (5) − (6).

(8) Value at the edge of the beam.

(9) See § 3.4.1.3 of the Report of the Special Joint Meeting, Geneva, 1971 for the method of calculation.

(10) The peak side lobe response of the terrestrial receiving antenna in the radio-relay system for television is 30–20 log φ, where φ is the angle off the main beam, while a terrestrial broadcasting receiving antenna has a relative gain of $[9 + 20 \log (\varphi/\varphi_0)]$ dB.

REPORT 632 *

BROADCASTING-SATELLITE SERVICE: SOUND AND TELEVISION

Technically suitable methods of modulation

(Questions 20-2/10, 5-2/11)

(1974)

1. Sound broadcasting

For the frequency bands allocated by the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971 for the broadcasting-satellite service, it seems preferable to use frequency modulation with the same standards as those used for terrestrial sound broadcasting (see Recommendations 412-1 and 450); but they could be different in certain cases. In particular, it may be desirable to use a higher deviation, to reduce the necessary satellite transmitter power, especially in the frequency bands where new receivers or additional equipment for existing receivers would in any case be required.

For stereophonic broadcasting using a frequency-modulation multiplex system (Recommendation 450), it is necessary to increase by about 20 dB the values of field strength, power flux-density, and satellite e.i.r.p. Stereophony could also use two identical channels, carrying the left and right signals, but there may be some problems for compatible monophonic reception.

2. Television

The two types of modulation best suited to the broadcasting-satellite service (television) seem to be vestigial-sideband amplitude modulation and frequency modulation. With further development pulse-code modulation techniques may also become practicable for broadcasting satellites.

For a given quality of service and a given figure of merit of the received installation, frequency modulation permits a much lower satellite transmitter power. However, in frequency bands for which there are existing terrestrial television receivers, amplitude-modulation would allow these receivers to be used without modification [C.C.I.R., 1970–1974a]. From the point of view of planning, frequency modulation requires wider channels, but the protection ratios are lower than for amplitude modulation, so either type of modulation may be advantageous, depending on the circumstances.

When frequency modulation is used, the video signal characteristics are unchanged (see Report 624), but the specifications of the transmission and channel characteristics are different (see Report 215-3, § 5). Particularly in the initial stages of development, it would be preferable to use a simple modulation converter, having an output signal conforming to the radio-frequency standard of the receiver normally used (that is, a vestigial-sideband amplitude-modulation vision signal, and a sound channel at the appropriate frequency spacing). Alternatively, dual-standard receivers or special receivers for the satellite transmissions could be used (see Report 473-1).

In frequency-modulation television, the signal bandwidth limitation arising from radio-frequency and intermediate-frequency filtering causes non-linear distortion which may significantly impair the picture quality. The most critical part of the system in this respect is the receiver; this must have cheap and simple filters, which may not be phase-corrected. In the absence of sub-carriers for the sound signals, the most critical distortions for a colour picture are the differential phase and gain of the colour sub-carrier. These distortions should be taken into account when deriving the relationship between the frequency deviation and the equivalent rectangular bandwidth of the receiver. Studies made by E.B.U. members have shown that it is possible to obtain reasonable values of the distortions, as mentioned in Table VIII of Report 215-3, with a frequency deviation of approximately 14 MHz/V at the

* Adopted unanimously.

reference frequency of the pre-emphasis characteristic, and a receiver bandwidth of 27 MHz [C.C.I.R., 1970–1974b].

3. Sound channels in television

When only a single sound channel is required, it is desirable that, after demodulation, the composite vision and sound signals should be the same as in the terrestrial service in the given geographical area; this would simplify the design of compatible receivers. This implies the use of a sub-carrier for the sound signal. However, a sub-carrier of high amplitude can cause a visible beat pattern with the colour sub-carrier, and a buzz on the sound. Experiments by E.B.U. members have shown that the receiver bandwidth need not be wider than is necessary to achieve a good quality of the picture alone, when the sound sub-carrier has an amplitude giving about 30% of the total peak-to-peak deviation of the carrier. Nevertheless, in some of these experiments the best signal-to-weighted-noise ratio which was achieved for the sound was 50 dB, as a result of buzz caused by variations in group delay of the receiver filter characteristics. If better sound quality is required (for example, with a signal-to-weighted ratio of 60 dB), it may be necessary to abandon the sub-carrier principle, and to transmit the sound by other methods. One suitable method could consist of using a separate carrier with the same modulation characteristics as those which may be used for sound broadcasting from satellites.

If several sound signals are to be broadcast with the picture, various techniques could be used. For example, digital modulation sound signals could be time multiplexed with the picture signal, as discussed in several studies (see Reports 403-2 and 488-1). This is an interesting method, especially for community reception, because high-quality signals can be transmitted without widening the radio-frequency channel. A method for providing two high-quality sound channels with the picture is described in [C.C.I.R., 1970–1974c]. Another possible method would be to use several separate carriers.

Frequency-multiplexing of one or more sub-carriers modulated by the sound signals results in a particularly economical arrangement for the receiver, at the same time needing only a moderate increase in the width of the radio-frequency channel (see Report 289-2). However, intermodulation between the picture and sound signals, and between the various sound signals, may significantly impair the quality, and more studies are necessary [C.C.I.R., 1970–1974d]. If a two-carrier sound system were adopted in terrestrial television, it would be desirable that the sub-carrier frequencies in the satellite television system should be equal to the spacings between the vision carrier and the sound carriers in terrestrial television (see Report 403-2). Other methods of providing two or more channels are discussed in [C.C.I.R., 1970–1974a]. In a terrestrial system using amplitude-modulation sound, account should be taken of this feature to determine the technical characteristics of the broadcasting satellite, in particular the bandwidth.

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REPORT 633 *

THE PLANNING OF MULTIPLE BROADCAST TRANSMISSIONS FROM SATELLITES

(Questions 20-2/10, 5-2/11)

(1974)

1. Introduction

This Report considers the conditions necessary to permit many satellite broadcast transmissions to be made simultaneously without unacceptable mutual interference; it confines itself entirely to broadcast transmissions from satellites and does not consider the problems of frequency sharing with terrestrial broadcasting services. Because the number of transmissions anticipated in the future will greatly exceed the number of frequency channels available, a large part of this Report is concerned with the results of studies on the re-use of the same channel to the maximum extent for broadcast transmissions to different areas and on the efficient use of the geostationary satellite orbit. Studies of this type will be important, in particular, for the World or Regional Administrative Conferences on plans for the broadcasting satellite service envisaged at the Space Conference of 1971 (see Resolution No. Spa2–2).

Further general points applicable to broadcasting systems are:

— it should be assumed that wherever possible, all broadcasting-satellite services covering the same area, or with largely overlapping areas, would be provided from the same geostationary orbital position (in general, on different frequency channels) to permit the use of a fixed receiving antenna. However, with future developments, it may be practicable to serve the same area from satellites in different positions with an adjustable receiving antenna, particularly in the case of community reception;

— when several interfering transmissions contribute to the total interfering signal, the protection ratio must be achieved in relation to the total interference; this may be calculated on the basis of adding the component interfering powers;

— whenever possible, the service area should be the minimum necessary to provide the required coverage;

— if it is proposed initially to operate a broadcasting satellite service for community reception, and at a later date also to operate broadcasting satellite services for individual reception in the same frequency band, both services should employ the same modulation system to facilitate frequency sharing between the services. Under such circumstances, it would also be necessary to assume sharing criteria that allow for the broadcasting services ultimately required.

Studies undertaken by several countries [C.C.I.R., 1966–1969 a and b; 1970–1974 a and b] have been presented as examples for consideration; some of these results were initially presented to the Special Joint Meeting in the preparation for the Space Conference of 1971.

These studies have been made partly of idealized systems with regularly spaced service areas of uniform size, and partly of trial assignment exercises on the provision of services to cover national territories. Emphasis will be placed on the latter studies, because they represent real possibilities, and also because the results are not greatly different from those of the idealized studies in terms of channel requirements, thus showing that the practical examples have come reasonably close to the theoretical optimum.

2. Utilization of the geostationary-satellite orbit and the radio-frequency spectrum

The discussion in this section is based on planning requirements for the down-links. The total radio-frequency spectrum required for the up-links could in principle be reduced by placing additional

* Adopted unanimously.

constraints on the down-link system, which would make the broadcast-satellite system more expensive. The use of a large number of satellites for the broadcasting service may result in less efficient use of the geostationary-satellite orbit, when the requirements of all services are taken into account; more study of this problem is required.

2.1 *12 GHz systems*

Trial assignment studies have been made for the provision of national services to about thirty to forty countries in an area about 5000 km across, assuming a receiving antenna directivity appropriate to individual reception, being equal or slightly superior to that indicated in Report 215-3. The following assumptions were made:

— the satellite should have approximately the same longitude as the centre of the service area *;

— the transmitting antenna beam should be circular or elliptical with a beamwidth not less than 0·5°;

— the maximum e.i.r.p. of all transmissions should be the same;

— the transmitter beam is chosen to include the whole area of a country, the nominal service limit being taken where the transmitting antenna gain has fallen to 3 dB below the maximum, although, in the final plan, the figure of 3 dB may be modified, to ease the problem of planning.

The results of idealized theoretical studies had shown that a spacing of the order of 2·5° to 5° for satellites operating on the same channel is feasible. The different trial assignment studies differed somewhat in the spacing of permitted satellite positions, some examples placing the satellite at the same longitude as the centre of the target area and other examples permitting only a limited number of satellite positions spaced by 5° or 15° or even more. It is, however, possible under some conditions to provide services from the same satellite (or from two satellites in the same nominal orbital position) on the same channel to two widely separated service areas. The concept of optimum satellite spacing is therefore not a clearly defined one, and in any case depends on the configuration of the service areas in the system. Further studies are required on the subject of positioning of satellites. The total number of positions used will also influence the cost of the system.

A measure of the efficiency of the system is given by the total number of radio-frequency channels required to provide one programme for each country. The results are summarized in Fig. 1 with the number of channels given as a function of the protection ratio required between co-channel transmissions.

The examples for the satellites situated at the longitude of the service area illustrate the effect of the directivity of the receiving antenna. The other examples show that fewer channels are required if the satellite position is permitted to differ from that of the service area by up to about 15°. The results, which are provisional, suggest that the 12 GHz band may be used with acceptable efficiency for individual reception. Further studies are required.

When the transmission system is established with the necessary co-channel and adjacent-channel protection ratios and the radio-frequency channel spacing corresponding to the adjacent-channel protection ratio, the total bandwidth may be found as the product of the number of channels and their spacing. Table I indicates examples for television from the Report of the Special Joint Meeting, Geneva, 1971, § 3.5.2.3, taking approximate values only for the requirements of frequency-modulation television transmissions. Because the receiving antenna was assumed to have a diameter of about 1 m in most of these studies as compared with the somewhat less directive antennae (0·75 m diameter) now considered probable for individual reception, the full-line curve in Fig. 1 was taken as a guide in preference to the other results some of which indicate a smaller number of radio-frequency channels.

This general indication, which does not depend critically on the width of the radio-frequency channel, suggests that each television programme provided on a national basis would require about

* If, as seems probable, satellites are required to be about 10° or more West in relative longitude (in order to avoid the eclipse of solar cells before local midnight (see Report 215-3, § 3.3.1, last two paragraphs), a change of position of this order could be made to all satellite positions with effect on the conclusions. Some of the studies used an initial bias to the West at the outset.

200 MHz of the frequency band. This applies to systems in which a large number of small to medium sized countries are considered. A possible system for thirty to forty countries of a continent might involve ten or more satellites spaced about 5° apart, but the cost of the system would be less in a plan for wider spacing, permitting the use of large multiple-programme satellites in each orbital position [C.C.I.R., 1970–1974c].

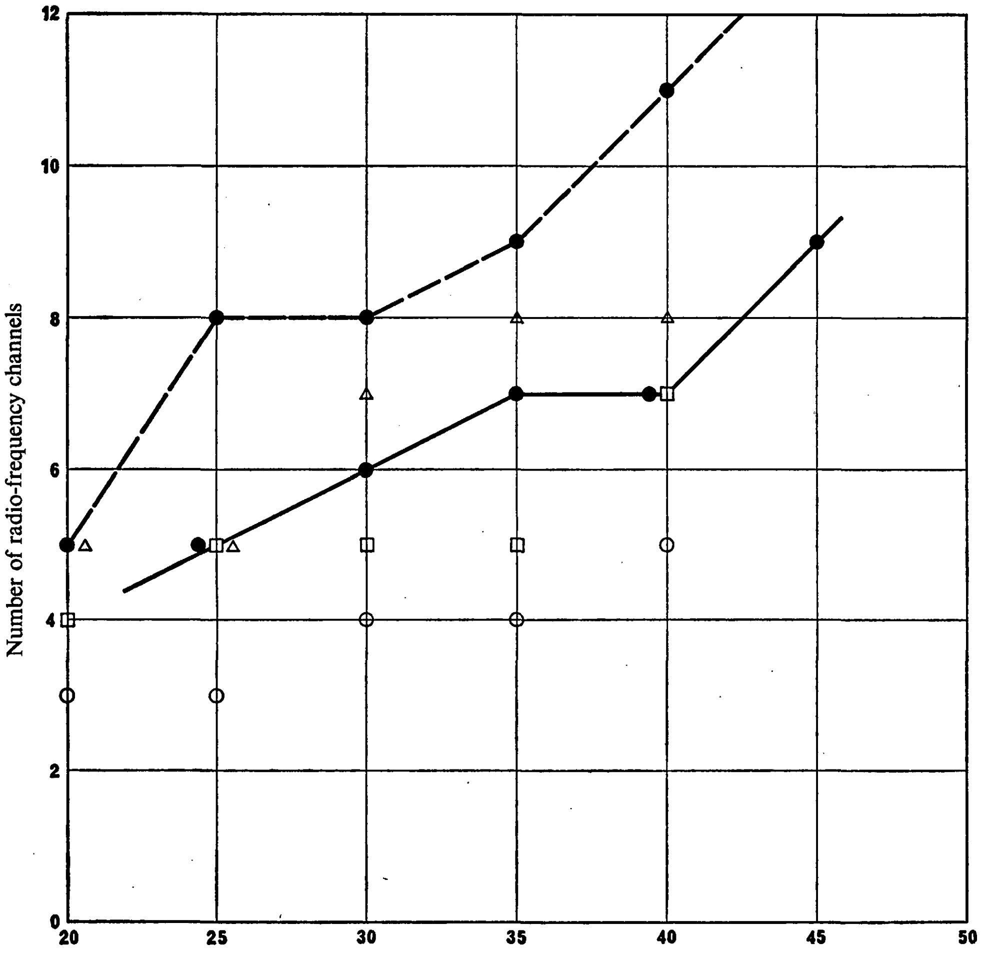

FIGURE 1

Number of radio-frequency channels required to provide one national programme to thirty to forty countries of a continent, as a function of the carrier-to-interference ratio

Frequency: 12 GHz, individual reception.

Satellite with small longitude offset from target area:

diameter of ground receiving antenna: 1 m (beamwidth, 1·8°)

△: Co-channel, satellite spacing 15° (3 satellites)

□: Co-channel, satellite spacing 5° (7 satellites)

○: Co-channel, satellite spacing 5° (9 satellites)

Satellite with same longitude as target area:

——●—— : diameter of ground receiving antenna, 1 m (beamwidth, 1·8°)

– –●– – : diameter of ground receiving antenna, 0·75 m (beamwidth, 2·5°)

TABLE I

Approximate indication of radio-frequency bandwidth requirements to provide one national programme to thirty to forty countries of a continent
(Individual reception at 12 GHz)

Channel spacing (1) (MHz)	Protection ratio (2) (dB)	Number of channels	Total bandwidth (MHz)
24	36	7	168
32	30	6	192
40	27	5	200

(1) These are approximate values based on 625-line systems covering a wider range of radio-frequency channel spacings than the preferred values given in Report 215-3.

(2) Values for a ratio of luminance (peak-to-peak)-to-weighted r.m.s. noise ⩾49 dB.

Where there are only a few large countries to be served in a continental region, fewer radio-frequency channels per national programme may be adequate; the larger satellite spacing which would be obtained under these circumstances would also allow more flexibility in satellite placement and satellite system characteristics. On the other hand, in a system where service areas are matched to countries of very different sizes within the same continent, the number of radio-frequency channels required may be greater.

It is considered that, in continents with similar longitudes, services could be provided without extra bandwidth but some coordination would be necessary, and the overall system for the two continents taken together may require satellites at closer intervals than in the typical cases studied.

Limited studies for amplitude-modulated transmissions have tended to show a similar order of magnitude for the total frequency requirements; because these studies have not assumed the values for protection ratios indicated in Recommendation 418-2 and Report 306-2 for continuous interference, the information on amplitude-modulation systems is regarded as incomplete.

In a recent study [C.C.I.R., 1970–1974b], the effects of receiving antenna side-lobe characteristics, as well as other factors, were investigated for the impact on orbit utilization of systems designed for community reception. In one example, the antenna pattern characteristics were assumed to be similar to the reference pattern proposed in Report 215-3. In another example, the side-lobe level was limited to a maximum of 26 dB below the on-axis gain. A tabulation of the results of the investigation in the case of 12 GHz is shown in Table II, Systems 3 and 4.

TABLE II

System	Frequency (GHz)	Bandwidth (MHz)	Protection ratio (dB)	Satellite spacing (degrees)	Receiving pattern
1	2·6	22	30	4	A
2	2·6	22	33	2·8	B
3	12	27	26	2	A
4	12	27	30	1	B

Pattern A: $\Delta G = 10{\cdot}5 + 25 \log (\varphi/\varphi_0)$ dB

Pattern B: $\Delta G =$ the smaller of: $10 \log [1 + (2\varphi/\varphi_0)^{6N-9}]$ or

$$3 + 10 \log [80N + (2\varphi/\varphi_0)^{N}] \quad \text{dB}$$

where: ΔG is the on-axis gain minus the gain at angle φ.

$\Delta G \leqslant 40$ dB for both patterns,

and N is the exponential rate of decay as a function of the angle of the envelope of the side lobe; for example $N = 2$ for individual reception and $N = 2{\cdot}5$ for community reception.

The results apply to a system covering a large land mass by ten satellites each with a single beam, with adjacent service areas just overlapping, and give the minimum spacing of satellites that will permit each area to be provided with a separate transmission using the same frequency channel.

A further study [C.C.I.R., 1970–1974d] has been made on the influence of antenna patterns, for individual reception, on the co-channel operation of services at 12 GHz which cover adjacent, or nearly-adjacent countries. The results show that, particularly in an area with a large number of small countries, a receiving antenna which is more directive than that proposed in Report 215-3, § 4.1, would in general permit the orbital position for each country to be nearer the optimum from the point of view of angle of elevation and the effect of solar eclipse.

2.1.1 *Optimization of a single transmitting antenna beam*

For purposes of planning the broadcasting-satellite service, it is convenient to assume that all the beams covering various countries have circular or elliptical cross-sections. The parameters to be determined for the beam covering a given country are then:

— the centre of the service area, defined as the point at which the axis of the beam cuts the surface of the Earth;

— the dimensions of the major and minor axis of the elliptical cross-section of the beam;

— the direction of the major axis of the elliptical cross-section of the beam.

These parameters can be optimized according to specified criteria. E.B.U. studies, described in [C.C.I.R., 1970–1974e] have been based on the following criteria:

— the representation of the boundaries of the countries is approximated by a polygon which should be completely covered by the beam;

— the optimization is carried out so that the ratio between the areas (measured on a projection plane perpendicular to the beam axis) of the cross-section of the beam ellipse and the projection of the polygon corresponding to a country is as close as possible to unity.

2.1.2 *Optimization of a group of beams*

If the planned system is to include a large number of satellites, it is important to standardize the equipment as much as possible, in particular the transmitting antennae. This would significantly reduce the total cost of the system, in the development and the manufacturing stages.

If the optimum beams, defined above, have sufficiently similar parameters for several countries, a single beam size could be chosen to provide nearly-optimum coverage for all those countries. Moreover, by allowing the variation in antenna gain over the service area to be slightly different for the various countries, another degree of freedom is obtained in selecting standardized antennae. Preliminary E.B.U. studies on the problem are described in Doc. 11/312 (E.B.U.), 1970–1974.

2.2 *2·6 GHz systems*

Under the provisions of the Space Conference of Geneva, 1971, the use of the 2·6 GHz band for satellite broadcasting is limited to domestic and regional systems for community reception. (See No. 361B Spa2 of the Radio Regulations).

In this Report, the results of a recent study [C.C.I.R., 1970–1974b] on the lines described in § 2.1 for community reception, are included in Table II, Systems 1 and 2, for 2·6 GHz.

2.3 *700 MHz systems*

In regard to the efficient utilization of the geostationary orbit, current studies indicate that for the broadcasting-satellite television service operating at frequencies around 700 MHz, the following criteria are appropriate for frequency modulation assuming a peak-to-peak deviation of 8 to 16 MHz:

2.3.1 For frequency sharing between areas which do not overlap and which are served from the same geostationary orbital position, the total discrimination necessary to provide the required protection ratio must be achieved by side lobe reduction of the transmitting antennae. In general, this would require a minimum separation of the service areas approximately as great as that corresponding to the first minimum of the transmitting antenna pattern. The use of orthogonal circular polarizations could help in the case of closer spaced service areas.

2.3.2 For transmitters which share the same frequency channel and are located at different orbital positions, a useful minimum separation may be approximately that corresponding to the angle between the axis of the main beam and the first minimum of the receiving antenna pattern, assumed to be the same for all receiving installations. The transmitting and receiving antennae must together provide sufficient discrimination to achieve the required protection ratio.

2.3.3 To keep propagation effects small and to conserve the geostationary orbital positions available, a broadcasting-satellite longitude should be within about 45° of the mid-longitude of its service area. Consideration should also be given to the sharing conditions with terrestrial television broadcasting services when determining the actual satellite position relative to the service area mid-longitude.

A study of the number of frequency channels required to provide services to each of about thirty countries (similar to the studies at 12 GHz) has been made [C.C.I.R., 1970–1974a] and the results are shown in Fig. 2. A receiving antenna for community reception was assumed. These are provisional results for a single example and further study is required.

2.4 *Margin of operating power required in system planning*

In planning for multiple satellite systems operating in any frequency band, the required transmitter power is calculated to provide a given quality of service considering noise and interference. In this connection an important factor is the protection ratios obtained from subjective studies, as described in Report 634. A number of practical considerations dictate that an additional term, the margin of operating power, be taken into account together with the protection ratio, when producing a plan, to provide a satisfactory system design in which the actual powers need not be exactly those calculated to provide the specified service quality.

This margin is required to account for:

— tube ageing, requiring additional power at start of life to provide necessary service quality at end of life;

— use of standardized power levels in output tubes; (the required nominal power level may not be available, so the next higher standard level must be used);

— various uncertainties in the space-to-Earth link calculations; for example, different values of atmospheric attenuation in the paths of the wanted and interfering signals, the various tolerances on the pointing accuracy of the transmitting antennae, additional path loss resulting from longitude offset, or even the use of slightly different quality standards in different countries.

The margin of operating power is a positive number, the three expressed in decibels, resulting from the statistical combination of factors cited above. The numerical value of the margin is based upon the technical characteristics of the system being considered. The approximate range of the margin is expected to be 1 to 3 dB for systems operating at 12 GHz.

3. **Dissimilar satellites**

Special problems in utilization of the orbit arise when dissimilar satellites, i.e., satellites having markedly different values of e.i.r.p. and/or different protection ratio requirements, share the same frequencies. The general effect is to reduce the number of satellites in the orbit to a value well below the number which could be used if the system were "homogeneous", i.e., all satellites having the same e.i.r.p., radio-frequency channel width, antenna directivity, etc.

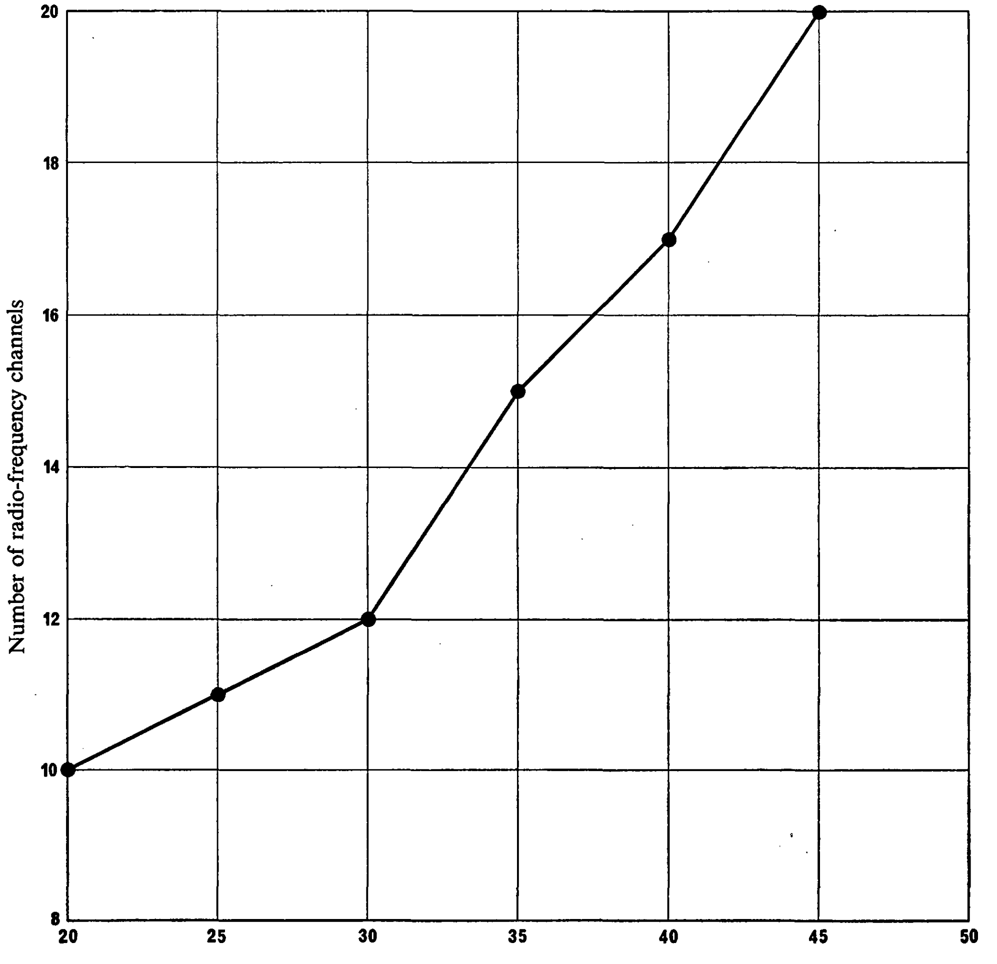

FIGURE 2

Number of radio-frequency channels required to provide one national programme to about thirty countries of a continent as a function of the carrier-to-interference ratio

(Example for a region typical of the East Asian area)

Frequency: 700 MHz, community reception.

Diameter of ground receiving antenna: approx. 3·5 m (beamwidth, 8°)

Satellite at longitude of target area

Beamwidth of satellite antenna θ: $7° > \theta \geqslant 3°$

The effects are particularly marked when dissimilar satellites alternate along the orbit, but are appreciable for any method of deployment investigated. However, it is noted that, due to the non-uniform distribution of land masses, there may be practical situations where orbit sharing of dissimilar satellites is acceptable. Except for this factor, it is considered advisable, in the interest of maximum orbit utilization, that systems sharing the same frequency band with satellites in close proximity should be reasonably homogeneous.

4. Receiver considerations affecting planning

The passband of the receivers should be limited strictly to the minimum required for good reception of the signal to improve the carrier-to-noise ratio before demodulation and to reduce the protection required from adjacent channels. The choice of transmission mode for the sound signals also has to be considered.

The necessary bandwidth for frequency modulation depends on the frequency deviation adopted, which itself depends on the signal-to-noise ratio required, margins above threshold and the nominal bandwidth of the video channel.

The bandwidth occupied by the signal from the satellite may be slightly greater than the equivalent rectangular bandwidth of the receiver if a good quality of reception is to be obtained. It will no doubt be necessary to limit it by an adequate filter so as to reduce to a minimum interference on adjacent channels.

It is also likely that, from the point of view of simplicity of design of the television broadcasting-satellite service receivers and in particular, to obtain better protection from the various types of interference from the terrestrial service in areas where the two types of service exist side-by-side, it would be advantageous for the spacing between the nominal frequencies of the satellite service channels to be a multiple of the spacing chosen for the terrestrial service.

An indication of the approximate channel widths for various systems is given in Report 215-3, Tables IX and X. A contribution by the Administration of the U.S.A. [C.C.I.R., 1970–1974f] also contains information on the effect of several values of channel width.

A constraint on the planning of multiple satellite transmission systems may arise from the image response of receivers. Depending on the intermediate frequency employed, the frequency giving rise to a spurious response may lie mainly within or mainly outside the broadcasting satellite band in which the system operates. Further details on frequency-modulation television receiver design are required before a quantitative indication of this problem can be given for frequency-modulation systems. Some discussion of constraints for both amplitude-modulation systems and frequency-modulation systems is available as a result of studies in France [C.C.I.R., 1970–1974g and h] (see also Report 473-1).

5. Up-links

Although it would ideally be preferable to provide the same total radio-frequency bandwidth for the up-link as for the down-link transmissions, the available bands are limited, and it is desirable to study the possibilities of reducing the requirements for the up-links by exploiting the greater directivity of the earth station transmitting antennae. * At present little quantitative data is available on the optimum planning of up-links for broadcasting satellites.

It is important that any up-link frequency plan should take account of the economic advantages which may arise from using a small number of orbit positions for the broadcasting satellites. Account should also be taken of the finite capacity of geostationary-satellite orbit, and the need to share the orbit between various services. Further studies are necessary on different methods of reducing the total up-link bandwidth requirements. For example, modulation methods requiring narrower frequency channels or the use of polarization discrimination might be effective, and more economic than using a greater number of satellites than the minimum required for a satisfactory down-link plan.

In this connection experimental measurements organized by ESRO [C.C.I.R., 1970–1974i] indicate that, for links operating near 12 GHz the discrimination between signals with orthogonal linear polarizations would probably be sufficient to permit frequency re-use provided a phase-shift keyed signal with digital modulation is employed.

In the planning up-links, § 7 of the Report by Interim Working Party 4/1 [C.C.I.R., 1970–1974j] indicates that it would be efficient to use the same frequency band (e.g., 10·95 to 11·2 GHz) for both the down-path in the fixed satellite service and the up-path broadcasting satellites. In this case, the

* Consideration of the up-link, which is in the fixed satellite service, is the subject of Study Programme 2J-1/4.

need to project the fixed-satellite service receiving terminals may require a large diameter earth-station antenna for the up-link transmitter in order to permit sufficient flexibility in the siting of earth stations.

For television broadcasting-satellites in the 12 GHz range using narrow-beam transmissions directed towards limited service areas, the use of the same antenna for receiving and re-transmitting signals for broadcasting may lead to considerable technological simplifications, resulting in a reduction of the space occupied by equipment, the complexity and, hence, the cost of these satellites. It is, therefore, reasonable to provide for an acceptable frequency separation between the nominal frequencies of the up-link and the down-link for each satellite. Such a frequency separation could be between a minimum of several hundred megahertz (to simplify the separation of the two frequencies) and a maximum of about 3·6 GHz (to permit a practical design of antenna to operate efficiently at both frequencies) [C.C.I.R., 1970–1974k].

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REPORT 634 *

BROADCASTING-SATELLITE SERVICE (TELEVISION)

Subjectively measured interference protection ratios for planning television broadcasting systems

(Question 5-2/11, Study Programmes 5H/11 and 5J/11)

(1974)

1. Introduction

A knowledge of interference protection ratios (the ratio of wanted-to-unwanted signal power at the receiver input) as a function of subjectively assessed picture quality is vital to the planning of television systems. Thus protection ratios for interference between two amplitude-modulation, vestigial-sideband (AM-VSB) signals have long been necessary in planning terrestrial broadcasting systems. With the allocation at the Space Conference of Geneva, 1971, of frequency bands to the broadcasting satellite

* Adopted unanimously.

service on a shared basis with various terrestrial services, the protection ratios for interference between frequency-modulation (FM) and amplitude-modulation, vestigial-sideband television signals, between two frequency-modulation television signals, and between a frequency-modulation television signal and the signals used by terrestrial services other than broadcasting have also become important. Indeed, the near future will very likely see a need for protection ratios, involving interference from and to digitally modulated television signals.

This Report summarizes the available protection ratio data for those cases in which both the wanted and the unwanted signals carry colour television signals *. These data are arranged in four sections according to the combination of wanted and unwanted signal modulations involved. Within each section, data will be given separately for the various standard television signals. In considering these data it should be noted that particular combinations of signals are not, in general, confined to a single band of frequencies. Thus the protection ratio data on frequency-modulation interference to amplitude-modulation, vestigial-sideband signals is important not only for sharing in the band 620 to 790 MHz but also for the bands 2500 to 2690 MHz and 11·7 to 12·5 GHz.

Before presenting the protection ratio data, it is useful to list the rather large number of parameters on which the values of subjectively measured protection ratios depend. Such a list is given in Table I. Only when all of these parameters are known and measurements made in accordance with agreed test procedures, can a given value of protection ratio be properly interpreted and applied.

To indicate the dependence of protection ratio on these parameters for given pairs of signals, values will normally be given for a specified "reference case" combination of parameters. The effect on the protection ratio of varying one parameter at a time from its reference case value is then given where such data is available.

TABLE I

Factors affecting subjectively measured protection ratios

Picture quality assessment scale **

Number of levels
Definition of levels (perceptibility, annoyance, quality)
Fraction of time interference effects are visible

Viewers **

Number
Expertise

Receivers

Number and types
Performance parameters (selectivity, sensitivity, overload characteristic, etc.)

Viewing conditions **

Distance to screen
Brightness of picture
Brightness of background

Wanted signal characteristics

Colour or monochrome
Television standard (M, G, L, I, ...)
Colour system (NTSC, PAL, SECAM, ...)
Picture type (still, moving) and content
Amount of detail in picture
Type of modulation (AM/VSB, FM, Digital)
Modulation index
Pre-emphasis characteristic
Energy dispersal characteristics
Fading

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* Protection ratio data for interference between an amplitude-modulation, vestigial-sideband or a frequency-modulation television signal and the types of signals used in the fixed and mobile services will be found in Report 388-2.

** See Recommendation 500.

Unwanted signal characteristics

Same as for wanted signal

Carrier frequency offset

Video signal-to-noise ratios

Receiver noise
Man-made noise
Picture source noise

Other interference and sources of picture degradation

Other interfering signals
Multipath
Receiver distortion

Although not used in the investigation described in this Report, the reference case given in Annex I has been proposed by the E.B.U. for future measurements of the protection ratio.

2. Interference between two amplitude-modulation, vestigial-sideband television signals

Values of protection ratio for this important case will be found in Report 306-2.

3. Interference to an amplitude-modulation, vestigial-sideband television signal from a frequency-modulation television signal

3.1 *525-line Standard M/NTSC*

The following data are based on the preliminary results of tests conducted in the U.S.A. [C.C.I.R., 1970–1974a]. System M was used for both the frequency-modulation and colour television signals. The protection ratios measured are for just perceptible visual interference. Audio-frequency interference was not evaluated. The picture tube diagonal was 38 cm (15 in.). Viewing distances ranged from 135 to 165 cm (4½ to 5½ feet). The centre of the viewed picture was at the viewer's eye level, and the maximum side-viewing angle was 30°. Peak white luminance was approximately 20 foot-candles (200 lux). The light from the area surrounding the picture tube measured approximately 0·1 foot-candles (1 lux).

In a series of tests, the frequency-modulation television signal was placed at the same frequencies as an amplitude-modulation, vestigial-sideband television signal. The video output of an amplitude-modulation, vestigial-sideband television receiver tuned to the amplitude-modulation, vestigial-sideband signal was evaluated for interference.

The wanted amplitude-modulation, vestigial-sideband signal carried "off-the-air" programme material. The interfering frequency-modulation signal carried various stationary test signals and used a peak-to-peak frequency deviation of 18 MHz. The modulating signal polarity was such that the deviation produced by synchronizing pulses was towards lower frequencies. No pre-emphasis was used with the frequency-modulation signal.

3.1.1 *Protection ratio as a function of carrier-frequency offset*

The amplitude-modulation, vestigial-sideband protection ratio against frequency-modulation interference is shown as a function of the carrier-frequency offset in Fig. 1, from [Miller and Myhre, 1970]. The amplitude-modulation, vestigial-sideband signal-to-random noise ratio for these tests was 49 dB (weighted). The judgments of just perceptible interference were made by a single expert observer.

The curves of Fig. 1 show that interference from still scenes is more easily perceived than interference from scenes with motion. The shaded area in Fig. 2 encompasses the data from the individual test curves and indicates the upper and lower limits on the amplitude-modulation, vestigial-sideband protection ratio. To guarantee no perceptible interference from both still and moving scenes, a protection ratio exceeding the upper boundary of the shaded area in Fig. 2 should be used.

3.1.2 *Protection ratio as a function of the signal-to-noise ratio*

The amplitude-modulation, vestigial-sideband protection ratio against just perceptible frequency-modulation interference is shown in Fig. 3 as a function of the output picture signal-to-weighted noise ratio on the amplitude-modulation, vestigial-sideband television system [Miller and Myhre, 1970]. The data used in Fig. 3 is from tests with off-the-air programming on both the amplitude- and frequency-modulation systems. For signal-to-noise ratios of less than 45 dB the average protection ratio, as shown in Fig. 3, may be expressed by:

$$R_{AM/FM} = S/N_{WTD} + 2 \quad \text{dB} \tag{1}$$

The ranges of the test data at the various signal-to-noise ratios are shown by the vertical lines through the curve in Fig. 3. Changes in programme material during the tests account for most of the variations in the test data. The interference is more easily perceived in dark-coloured areas than in light-coloured areas. Pictures having large areas of uniform colour show interference more readily than scenes with multi-coloured detail. To guarantee no perceptible interference for varied programme material on both systems, an amplitude-modulation, vestigial-sideband protection ratio exceeding the upper limits of the data should be used. In this case the protection ratio for signal-to-noise ratios less than 45 dB would be expressed by:

$$R_{AM/FM} = S/N_{WTD} + 7 \quad \text{dB} \tag{2}$$

3.1.3 *Protection ratio tests with many viewers*

The amplitude-modulation, vestigial-sideband protection ratio against just perceptible frequency-modulation interference is shown in Fig. 4 for tests with a total of 30 viewers. Each viewer witnessed a random sequence of test scenes having different ratios of wanted-to-unwanted signal power. The viewers were asked to judge only whether or not they could perceive any interference in the picture. The amplitude-modulation, vestigial-sideband picture was "off-the-air" programme material. The interfering frequency-modulation signal was either a kitchen scene, colour bars, the white window, or "off-the-air" programme material. The curve in Fig. 4 is the average of the percentage readings for the four different modulating signals on the frequency-modulation system. The ranges of the percentages over the four tests are shown by the vertical bars. At a given power ratio, the percentage of viewers perceiving no interference is a function of the amplitude-modulation, vestigial-sideband programme material. As in the tests with a single expert observer, still scenes with dark areas or with large areas of uniform colour required a greater power ratio to cause the interference to be imperceptible. Test conditions were:

AM-VSB signal-to-noise ratio: 46 dB (weighted)

Carrier-frequency offset : 0·5 MHz

Of the 30 viewers, 3 were expert viewers. There were 3 female and 27 male viewers.

On the basis of these limited tests, the amplitude-modulation, vestigial-sideband protection ratio, such that 50% of the viewers will perceive no interference, is given by the following expression:

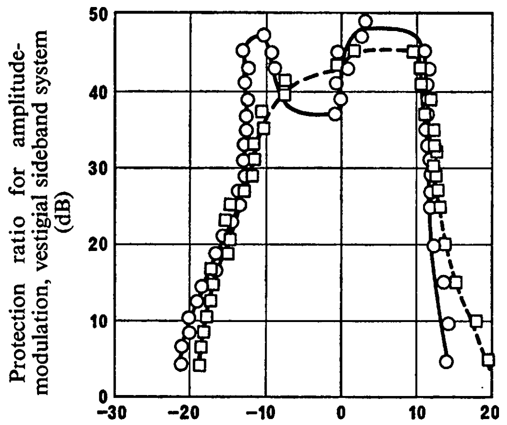
$$R_{AM/FM} = S/N_{WTD} \quad \text{dB} \tag{3}$$

The expert viewers used to obtain the barely perceptible interference test results shown in the figures were administered this same test. For these expert observers to perceive no interference, the measured amplitude-modulation, vestigial-sideband protection ratio is given by the following expression:

$$R_{AM/FM} = S/N_{WTD} + 4 \quad \text{dB} \tag{4}$$

These results indicate the expert viewers used in the other tests to be 4 dB more critical than the group of 30 viewers.

Equations (1) and (4) are based upon two different impairment criteria, and consequently are not directly comparable. Equation (1) expresses the protection ratio measured for an expert observer to notice just perceptible interference, while equation (4) expresses the protection ratio measured for expert observers to perceive no interference.

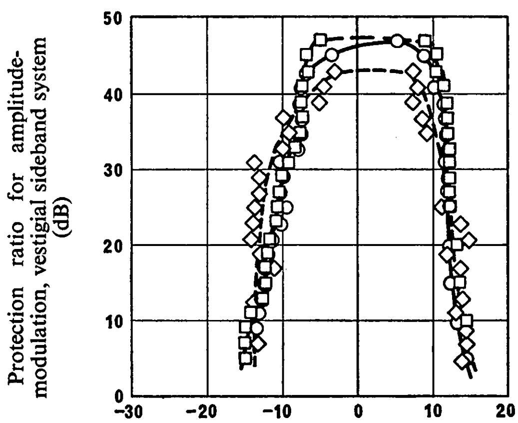


Difference between unmodulated frequency-modulation carrier and amplitude-modulation, vestigial sideband carrier (MHz)

———○——— White window on frequency-modulation system

– – –□– – – Bars on frequency-modulation system

(a) White window and colour bars on frequency modulation system



Difference between unmodulated frequency-modulation carrier and amplitude-modulation, vestigial sideband carrier (MHz)

———○——— Kitchen scene on frequency-modulation system

— —□— — Girl slide on frequency-modulation system

- - - -◇- - - - "Off-the-air" programme material on frequency-modulation system

(b) Kitchen scene, girl slide, and "off-the-air" programme material on frequency-modulation system

FIGURE 1

Protection ratio for an amplitude-modulation, vestigial sideband system as function of carrier frequency offset

$$\frac{(P_{SYNC\ PK\ AV})\ _{AM/VSB}}{(P_{AV})\ _{FM}}$$

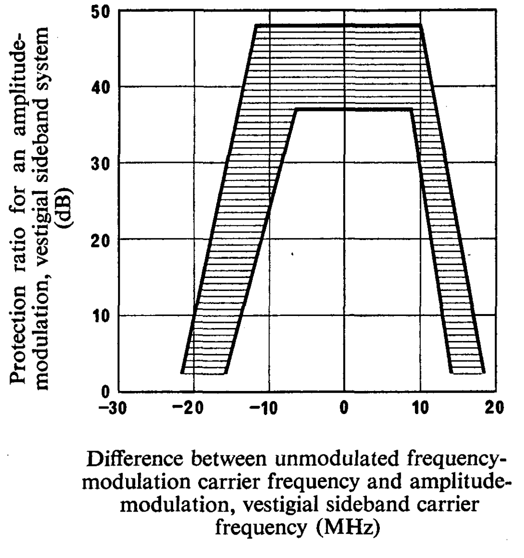
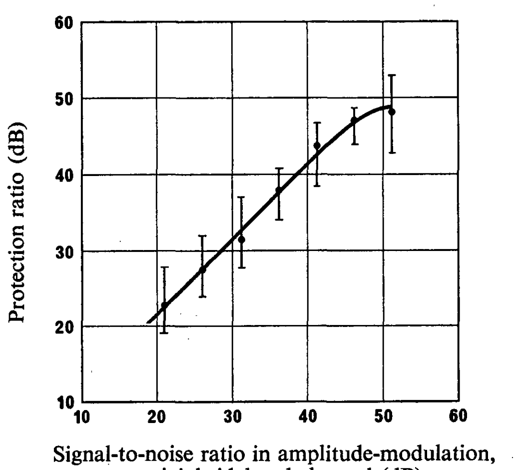


FIGURE 2

Protection ratio required for just perceptible interference in an amplitude-modulation, vestigial-sideband system subjected to interference by a frequency-modulation television system

$$\frac{(P_{SYNC\ PK\ AV})\ _{AM/VSB}}{(P_{AV})\ _{FM}}$$



Carrier frequency offset: 0·5 MHz

Peak-to-peak frequency deviation: 18 MHz

Protection ratio for just perceptible interference: 34 observations by one expert viewer, averaged at each value of signal-to-noise ratio (S/N)

$$S/N = \frac{\text{White-to-blanking voltage}}{\text{R.m.s. noise voltage in 4·2 MHz (WTD)}}$$

No pre-emphasis on frequency-modulation system

FIGURE 3

Protection ratio for an amplitude-modulation, vestigial-sideband system as a function of signal-to-noise ratio in the amplitude-modulation, vestigial-sideband channel

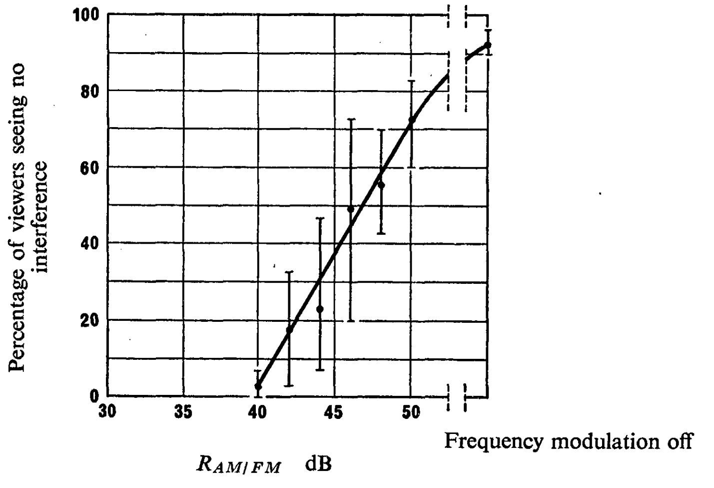


FIGURE 4

Percentage of viewers perceiving no interference, as a function of the protection ratio $R_{AM/FM}$

3.2 *625-line Standard I/PAL*

Fig. 5 gives a summary of recent subjective tests performed by the B.B.C. [C.C.I.R., 1970–1974b; Brown, 1971a]. The wanted amplitude-modulation, vestigial-sideband signal was modulated by a still picture of books, a box and silverware, and had a luminance-to-weighted-noise ratio of 43 dB. The interfering frequency-modulation signal was modulated by a colour bar using a nominal peak-to-peak deviation of 8 MHz, pre-emphasis according to curve B of Recommendation 405-1, and no energy dispersal.

Fig. 5 refers to video signal-to-unweighted-noise ratios; for weighted-noise (Standard I weighting) the numerical value is increased by 6·5 dB.

The results suggest that if the wanted signal has a signal-to-noise ratio of 36·5 dB, noise unweighted, or 43 dB noise weighted, a working protection ratio of 53 dB would cause a change of grade from less than 2·0 to about 2·5 *.

At high signal-to-noise ratios the protection ratio is 56 dB, and this value is taken as appropriate for the reference condition described in Annex I. It may be noted that from the shapes of the curves in Fig. 5, the impairment caused by interference is not significantly masked by the noise.

Reduction of this protection ratio may be permissible under the following conditions:

— no pre-emphasis: 1·5 dB reduction;

— deviation increased from 8 to 12 MHz peak-to-peak: 2 dB reduction;

— use of energy dispersal: about 2 dB reduction per MHz of peak-to-peak deviation.

On the other hand, an interfering signal modulation of black level was found to require a higher protection ratio (by about 5 dB).

* The scale used is the E.B.U. impairment scale, which is:

Interference	*Grade*
Imperceptible	1
Just perceptible	2
Definitely perceptible, but not disturbing	3
Somewhat objectionable	4
Definitely objectionable	5
Unusable	6

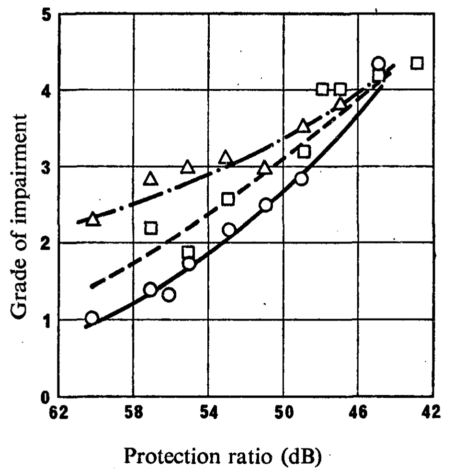


FIGURE 5

Grade of impairment caused by a combination of random noise and co-channel interference, present simultaneously

—○—	: greater than 39 dB	signal-to-unweighted noise ratio (dB)
— —□— —	: 35 to 39 dB inclusive	
·—·—△—·—·	: less than 35 dB	

3.3 *625-line Standard G/PAL*

The I.R.T. in the Federal Republic of Germany [C.C.I.R., 1970–1974c], have carried out tests on System B/PAL, which for the present purpose can be considered as equivalent to System G/PAL. The signal-to-noise ratio (weighted) was approximately 50 dB. The protection ratio was assessed for an impairment grade of 2, on the 6-point scale. At a peak-to-peak deviation of 8 MHz for the interfering signal, and with no pre-emphasis, the average value of the protection ratio was 59·7 dB. A separate series of tests suggested that, on average, pre-emphasis does not significantly affect the results. (This conclusion differs somewhat from the B.B.C. tests, which suggested that pre-emphasis may be expected to increase the protection ratio by about 1·5 dB. The difference may be due to the different picture content of the interfering signal.)

The observers in this test were all experienced, and the pictures used tended to be fairly sensitive to the effects of interference. On the other hand, it must be remembered that the impairment grade corresponded to greater impairment than the reference condition. Taking these factors into account, the protection ratio for the reference conditions may be taken as about 60 dB.

3.4 *625-line Standard L/SECAM*

The O.R.T.F., in France, [C.C.I.R., 1970–1974d and e] have investigated the case where the wanted signal is System L/SECAM, the interfering signal being PAL. In this case, the impairment grade was taken as 4, on the 5-point scale. In some separate tests, it was found that for an impairment grade of "just perceptible" (i.e., grade 2 on the 6-point scale), the protection ratio should be increased by about 5 dB. Using the conversion formula suggested in the Annex to Recommendation 500, this suggests that more than 5 dB should be added to obtain an impairment grade of 4·5 (5-point scale).

Pre-emphasis was included. The low frequency deviation was 3·8 MHz/V, so the equivalent value at the frequency of zero insertion loss (i.e. 1·5 MHz) would be 13·5 MHz peak-to-peak, and another correction is required (see § 3.5) to obtain results applicable to the reference condition of 8 MHz.

Referring to the reference conditions described in Annex I, the O.R.T.F. measurements lead to the following results:

Measured protection ratio for grade 4	:	45 dB
Allowance to refer results to grade 4·5	:	+ 5 dB
Allowance to refer results to 8 MHz deviation:		+ 2 dB

Thus, the final value of the protection ratio, applicable to the reference conditions, becomes 52 dB.

3.5 *Modified values of protection ratio for Standards I, L and G*

In Annex I, certain reference parameters related to the interfering frequency-modulated signal have been proposed. If the parameters used in a practical case are different, the protection ratio must be modified accordingly. Suitable correction factors will now be considered:

3.5.1 *Pre-emphasis*

The B.B.C. tests suggested that removing the pre-emphasis in the interfering signal tends to reduce the protection ratio required by about 1·5 dB. On the other hand, the I.R.T. found that the pre-emphasis had little effect, on average. A reasonable compromise would therefore be to assume that if pre-emphasis is not used, the protection ratio may be reduced by 1 dB.

3.5.2 *Deviation*

The B.B.C. tests showed that for deviations between about 4 and 15 MHz, the protection ratio is reduced by approximately half the number of decibels by which the deviation is increased. In the I.R.T. tests, measurements at 8, 12 and 16 MHz deviation gave identical protection ratios when pre-emphasis was used, but with no pre-emphasis the protection ratio was reduced by about 0·8 dB for each decibel by which the deviation was increased. Thus, on average, the results are consistent with those of the B.B.C.

It would therefore seem that the empirical rule "−0·5 dB in protection ratio for each +1 dB in deviation" provides a good working approximation.

3.5.3 *Energy dispersal*

The B.B.C. has carried out some tests to assess the effects of various amounts of energy-dispersal, when the normal peak-to-peak deviation is 8 MHz. The results indicated that allowance could be made for the effect of an additional energy-dispersal waveform by the empirical equality:

Reduction in protection ratio: about 2 dB per MHz of peak-to-peak deviation caused by energy dispersal.

On the other hand, tests by the O.R.T.F. indicated a benefit of only about 1 dB per MHz. As a compromise value, it is therefore suggested that the reduction in protection ratio as a result of using energy-dispersal should be taken as 1·5 dB per MHz of peak-to-peak deviation.

3.5.4 *Frequency offset*

If the frequencies of the wanted and interfering signals are spaced by a few MHz, some reduction in protection ratio is possible, the difference depending on whether the interfering signal is of a higher or a lower frequency than the wanted signal. Tests by the B.B.C., I.R.T. and O.R.T.F. all showed that the protection ratio varies only with respect to the frequency spacing. Examples are shown in Figs. 6 and 7, which show results obtained by the I.R.T. and the O.R.T.F., respectively (using deviations somewhat greater than the reference condition). Since the spacing between terrestrial channels in Systems G, I and L is 8 MHz, the best offset which could be used would be that giving equal protection ratios at ±4 MHz about the point of symmetry of the interfering spectrum. Figs 6 and 7 show that if this is done, the benefit is unlikely to exceed about 3 dB, compared with the case of using no offset.

3.5.5 *Scanning synchronization*

If the line-scanning frequencies of the wanted and unwanted transmissions are not synchronized, the protection ratio is likely to be slightly higher, but further studies are necessary.

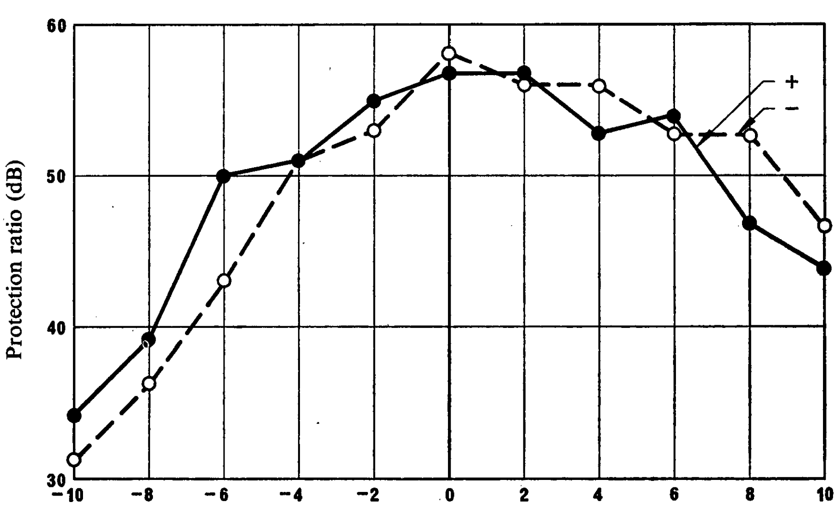
4. Interference to a frequency-modulation television signal from an amplitude-modulation vestigial-sideband television signal

4.1 *525-line Standard M/NTSC*

Some preliminary results for this case are available for 525-line Standard M. A series of tests was conducted where a frequency-modulation television signal was placed at the same frequencies as an amplitude-modulation, vestigial-sideband television signal. The video output of a frequency-modulation television receiver tuned to the frequency-modulation signal was evaluated for interference. The signals used in the tests were the same as those described in § 3.1, except that the frequency-modulation signal was now the wanted signal and the amplitude-modulation, vestigial-sideband signal was the interfering signal.

The results of the tests are shown in Fig. 8. The luminance signal-to-weighted noise ratio of the wanted picture signal used in these tests was approximately 54 dB. The judgments of just perceptible interference were made by a single expert viewer. Bandwidth of the frequency-modulation receiver was 30 MHz.

The curves of Fig. 8 show that interference from stationary scenes, having large areas of uniform colour, is more easily perceived than scenes with motion, as in most off-the-air programming. The shaded band in Fig. 9 encloses the curves of the measured protection ratios. To guarantee no perceptible interference from both still and moving scenes, a protection ratio exceeding the upper boundary of the shaded area in Fig. 9 should be used.



Difference between wanted and interfering signals, $f_{interfering} - f_{wanted}$ (MHz)

(The signs + and − refer to the two senses of modulation)

FIGURE 6

Variation of the protection ratio with respect to frequency spacing

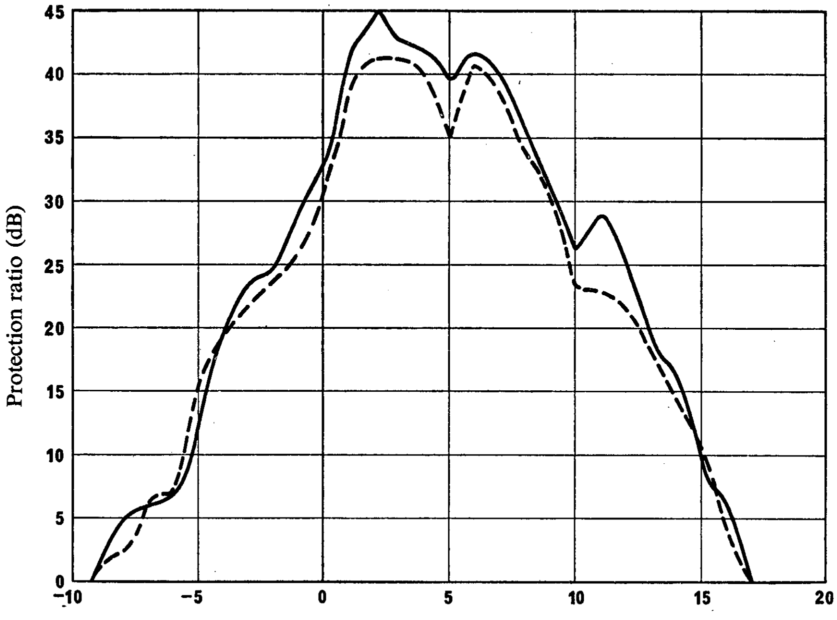


FIGURE 7

Variation of the protection ratio with respect to frequency spacing

Wanted signal : SECAM colour bars (radio-frequency level: 60 dB (1 μV/m))
Interfering signal : PAL slide, synchronized scanning.

——————— : measured without energy dispersal of the PAL signal

— — — — — : measured with energy dispersal over 2 MHz of the PAL signal

4.2 *625-line Standard K/SECAM*

Recent measurements in the U.S.S.R. [C.C.I R., 1970–1974f] determined protection ratios for frequency-modulation colour and monochrome signals against interference by CW, amplitude-modulation, vestigial-sideband, and frequency-modulation signals. To facilitate intercomparison of the results of the Standard K measurements, they are presented separately in § 6.

5. Interference between two frequency-modulation television signals

Measurements of interference between frequency-modulated television signals of the types used in the fixed-satellite service and the fixed service are presented in Report 449-1. Additional measurements for the broadcasting satellite service are given below.

5.1 *525-line Standard M/NTSC*

Tests were conducted with two frequency-modulation signals operating at carrier frequency offsets in the range from −30 MHz to +36 MHz [C.C.I.R., 1970–1974a] using an experimental arrangement similar to that described in § 3.1. The video frequency output of a frequency-modulation television receiver tuned to the wanted signal was evaluated by a single expert observer for just perceptible interference when the picture signal-to-weighted noise ratio was 50 dB. The bandwidth of the frequency-modulation receiver was 30 MHz. Fig 10 shows the measured protection ratios as functions of carrier frequency offset with off-the-air programming on the unwanted signal and various programmes on the wanted signal. The curves show that off-the-air programming, when there are scenes in motion, is less susceptible to interference than stationary scenes with large areas of uniform colour.

The shaded band in Fig. 11 encloses the individual measured protection ratios. To guarantee no perceptible interference from both still and moving scenes, a protection ratio exceeding the upper boundary of the shaded area should be used.

The foregoing results display the dependence of protection ratio on carrier frequency offset and type of programming for a frequency-modulation television signal whose output picture signal-to-weighted noise ratio was held constant at 50 dB. As previously noted, a single expert observer was used. More recently, a new series of protection ratio measurements was made [C.C.I.R., 1970–1974g] to determine the dependence of protection ratio on output picture signal-to-weighted noise ratio for specified picture quality levels, as judged by non-expert observers.

In the new measurements, peak-to-peak frequency deviation of both wanted and unwanted frequency-modulation carriers was the same as before (18 MHz), but the offset between carrier frequencies was held at nearly zero (less than 0·5 MHz) and each carrier was modulated by different off-the-air commercial colour programmes having moderate movement within the pictures. Using video tape, thirty different scenes each of 20 s duration were recorded to display all possible combinations of five levels of output picture signal-to-weighted noise (31, 40, 43, 45 and 51 dB) and six carrier-to-interference ratios (3, 7, 11, 15, 19 and ∞ dB).

To minimize the effect of the order of presentation of these scenes on the subjective evaluation of picture quality, a different random sequence of the thirty scenes was shown to each of five different groups of fifteen observers. Observers were seated at a distance equal to six times the height of the picture screen from a 48 cm diagonal consumer grade television receiver within an angle of 35° from the normal to the screen. The observers were asked to rate each scene on two different five-point scales (see Table II), one indicating only the extent to which the combined interference and noise was visually perceptible, the other, the extent to which the observers found the interference and noise annoying.

From these data, the combinations of carrier-to-interference ratio C/X, or protection ratio, and output picture signal-to-weighted noise, S/N_{WTD}, corresponding to two specific levels of picture quality of each of the two rating scales were determined. The first level was grade 2, corresponding to "barely visible" interference on the visibility scale, and "slightly annoying" on the annoyance scale. The other level was grade 4, corresponding to "quite noticeable" and "quite annoying" interference on the respective scales.

The entire experiment was conducted twice; once using high school students with an average age of 17 years as observers, and once using engineers and technicians with an average age of 40 years. The results for the tests group composed of engineers and technicians [C.C.I.R., 1970–1974g] are shown in Figs. 12 and 13. This group, though not experienced in viewing, rated the test scenes slightly lower than the group of high school students and might better be used as the basis of system design.

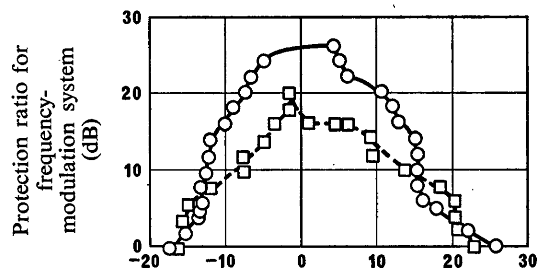
Fig. 12 shows the value of C/X associated with the selected picture grades for each of the five values of S/N_{WTD} used in the sample scenes. In this figure, each pair of points was itself determined from a separate plot [C.C.I.R., 1970–1974g] of the average subjective picture ratings versus C/X for a fixed value of S/N_{WTD}.

Fig. 13 shows the values of S/N_{WTD} associated with picture grades 2 and 4 for each of the six values of C/X used in the scenes. Here, each pair of points was determined from a separate plot [C.C.I.R., 1970–1974g] of average picture rating versus S/N_{WTD} for a given value of C/X.

Several conclusions may be drawn from an inspection of these figures. First of all, if the annoyance caused by the interference is taken as the criterion of picture quality, 1 to 3 dB lower protection ratios (1 to 3 dB higher interference levels) can be used at grade 2 than if visibility of interference is the criterion.

Another important conclusion deals with the interactive effect of interference and noise. Except for a somewhat anomalous situation at values of S/N_{WTD} exceeding 43 dB (see Fig. 12), the amount of interference that can be tolerated *at a given level of picture quality* decreases as the noise level increases. Conversely, as shown in Fig. 13, the amount of noise that can be tolerated at a given picture quality level decreases as the interference level increases. This is exactly what one would except since both noise and interference degrade picture quality, albeit to different degrees, depending on their individual natures. It in no way contradicts the previously noted conclusion (see §§ 3.1 and 6.1) that *for a given noise level*, the higher the noise level, the higher the "just perceptible" interference level.

Finally, the numerical values of the protection ratios corresponding to a grade 2 picture (slightly perceptible, or slightly annoying interference), are somewhat lower than those obtained for barely perceptible interference in the earlier frequency modulation-frequency modulation measurements (Figs. 10 and 11). This difference may be attributed largely to the fact that the more recent tests used a large group of non-expert observers while the earlier tests used only a single expert observer. Not only is the expert observer more critical in his judgment, but the protection ratios reported in Figs. 12 and 13 represent the average judgment of the non-expert viewers. The protection ratios corresponding to a picture that 90% of these viewers would rate as grade 2 or better would be in closer agreement with those of the expert viewer.

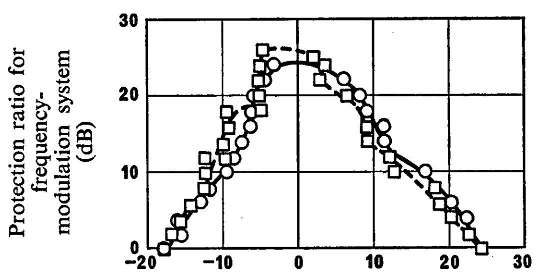


Difference between amplitude modulation, vestigial sideband carrier frequency and unmodulated frequency-modulation carrier frequency (MHz)

——o—— Colour bars on frequency-modulation system

– – –□– – – "Off-the-air" programme material on frequency-modulation system

(a) Colour bars and "off-the-air" programme material on frequency-modulation system



Difference between amplitude modulation, vestigial sideband carrier frequency and unmodulated frequency-modulation carrier frequency (MHz)

——o—— Kitchen scene on frequency-modulation system

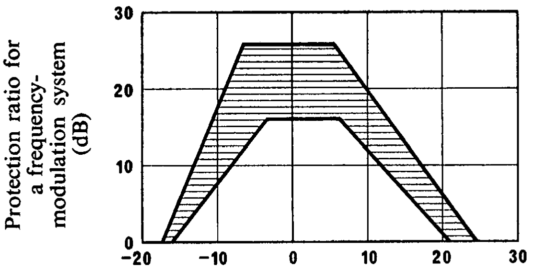
– – –□– – – Girl slide on frequency modulation system

(b) Kitchen scene and girl slide on frequency-modulation system

FIGURE 8

Protection ratio for a frequency-modulation system as a function of the carrier-frequency offset

$$\frac{(P_{AV})_{FM}}{(P_{SYNC\ PK\ AV})_{AM/VSB}}$$

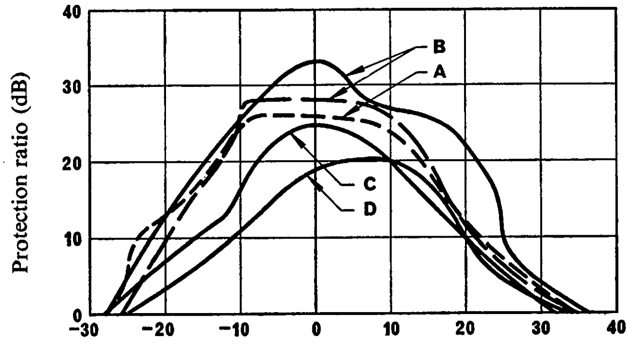


Difference between amplitude-modulation, vestigial-sideband carrier frequency and unmodulated frequency-modulation carrier frequency (MHz)

FIGURE 9

Protection ratio required for just perceptible interference in a frequency modulation television system subjected to interference by an amplitude-modulation, vestigial-sideband television system

$$\frac{(P_{AV})_{FM}}{(P_{SYNC\ PK\ AV})_{AM/VSB}}$$



Difference between unmodulated carrier frequency (Unwanted system) and unmodulated carrier frequency (Wanted system) (MHz)

	Wanted system	Unwanted system
Peak-to-peak deviation	18 MHz	18 MHz
Signal-to-noise ratio (weighted)	50 dB	
Pre- and de-emphasis	none	none

Curve	Programme material	
	Wanted signal	Unwanted signal
A	white window	off-the-air
B	colour bars	off-the-air
C	kitchen scene	off-the-air
D	off-the-air	off-the-air

FIGURE 10

Protection ratio for just perceptible interference in a frequency-modulation television system subjected to interference by frequency-modulation television

$$R_{FM/FM} = \frac{(P_{AV})_{FM}\ \text{(Wanted)}}{(P_{AV})_{FM}\ \text{(Unwanted)}}$$

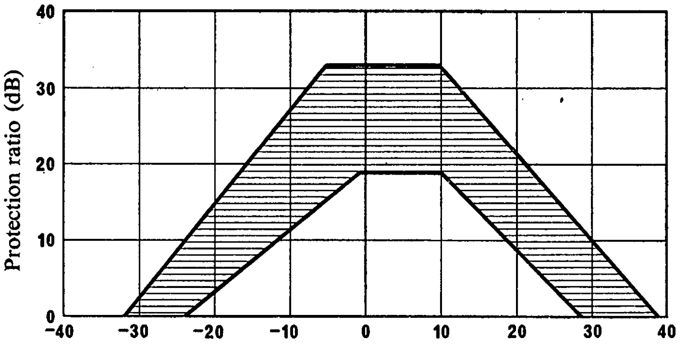


FIGURE 11

Protection ratio for just perceptible interference in a frequency-modulation television system subjected to interference by frequency-modulation television signals

	Wanted system	Unwanted system
Peak-to-peak deviation S/N (weighted) Pre- and de-emphasis	18 MHz 50 dB None	18 MHz None

TABLE II

Subjective rating scales used in measurements of interference between two frequency-modulation signals

Visibility of interference (including noise)	*Annoyance caused by the interference (including noise)*
1. Could not see any interference (clear picture)	1. Did not annoy me at all
2. Barely noticed the interference	2. Annoyed me slightly (I generally would watch it that way)
3. Definitely noticed the interference (picture somewhat unclear)	3. Definitely annoyed me (I might not watch it that way)
4. Quite noticeable interference (picture unclear)	4. Quite annoying (I would watch it that way only if it were very interesting)
5. Extremely noticeable interference (difficult to make out the picture)	5. Extremely annoying (I generally would not watch it that way)

Note. — The rating scales used are a deviation from the 5-point scale in Recommendation 500. The two rating scales separate the dimensions of visibility (perceptibility) and annoyance. Previous tests [C.C.I.R., 1970–1974g] had determined that a 5-point scale combining perceptibility and annoyance resulted in confusion of the two variables when used by non-expert viewers. The separate scales proposed and used in the United States of America [C.C.I.R., 1970–1974g] were further modified to make the word descriptions of the grade levels more understandable to non-expert observers.

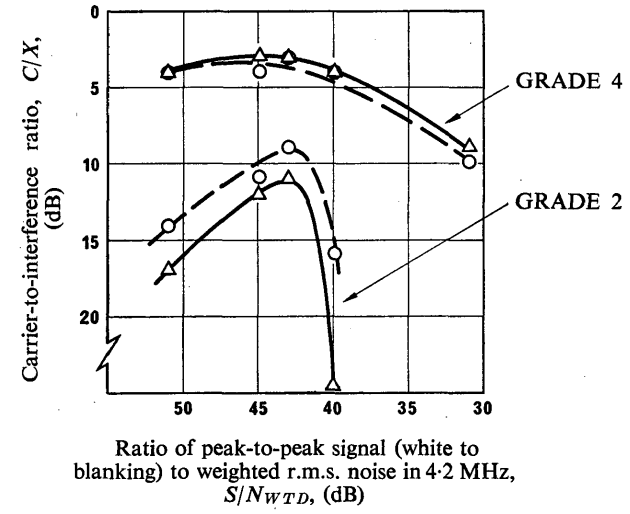


FIGURE 12

Protection ratios for picture grades 2 and 4 as functions of the output picture signal-to-weighted noise ratio

— —o— — annoyance
——△—— visibility

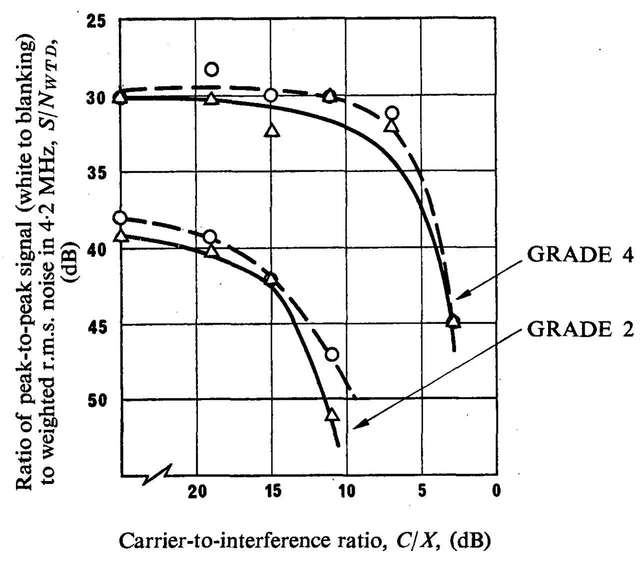


FIGURE 13

Signal-to-noise ratios for picture grades 2 and 4 as functions of carrier-to-interference ratio

— —o— — annoyance
——△—— visibility

5.2 *625-line Standard B/PAL, G/PAL, I/PAL and L/SECAM*

Measurements of protection ratio for two frequency-modulation television signals with the same value for frequency deviation have been made in the United Kingdom by the B.B.C. [Brown, 1971b] and the results are also supported by work in Italy by the R.A.I. and in the Federal Republic of Germany by the I.R.T.

The results show that the protection ratio for continuous interference can be related to the subjective impairment as follows:

$$\text{Protection ratio} = 16 - 20 \log (D_v/8) - Q + 1{\cdot}1\, Q^2$$

where Q is the impairment grade, on the 5-point scale according to Recommendation 500, and D_v is the peak-to-peak deviation (MHz) due to the composite video signal [C.C.I.R., 1970–1974h].

5.2.1 *Co-channel protection ratio between PAL and SECAM signals*

Only a few tests have been carried out to obtain results for this case. These tests were carried out by the B.B.C. It was found that when the wanted signal was SECAM, and the interfering signal PAL (both with deviation sensitivities of 13 MHz/V), very similar results were obtained to those applicable to two PAL signals. However, in the converse case of a PAL wanted signal and SECAM interfering signal, the protection ratio required was about 5 dB less. Further tests are necessary to confirm these results.

5.2.2 *Adjacent-channel protection ratio*

The value to be adopted for the adjacent-channel protection ratio depends primarily on the carrier spacing, but also upon the modulation parameters and upon the bandwidth and attenuation slope of the intermediate-frequency circuits in the receiver. Members of the E.B.U. have carried out tests with signals having a deviation sensitivity of 13 MHz/V, and with a sound sub-carrier producing a deviation of $\pm 2{\cdot}8$ MHz on the main carrier. The results of these tests indicate that when the receiver bandwidth (to the -3 dB points) is about 27 MHz, planning could be based on an adjacent-channel protection ratio of -6 dB. That is, the interfering signal could be 6 dB higher than the wanted signal. The carrier spacing would then probably be between 25 and 30 MHz.

5.2.3 *Co-channel protection ratio between wide-deviation frequency-modulation sound carriers*

In the broadcasting-satellite service it may be desirable to use a separate carrier, instead of a sub-carrier, for transmitting the television sound. In this case it may be necessary to use a deviation of about ± 300 kHz [C.C.I.R., 1970–1974i]. It is therefore important to know the co-channel protection ratio which should be specified for such signals, and also to find the minimum permissible spacing between the carriers, if several carriers were grouped together in a part of the frequency spectrum.

The B.B.C. has carried out objective measurements of the interference between two frequency-modulation sound signals. The interfering signal was modulated by a 1 kHz tone to a peak deviation of ± 300 kHz, and the resulting signal-to-noise ratio in the wanted sound channel was measured using a modified Niese noise meter* together with the recommended C.C.I.R. noise-weighting network (Recommendation 468-1).

For a signal-to-noise ratio of 50 dB, the co-channel protection ratio did not exceed 5 dB, the value depending to some extent on the exact frequency difference between the two carriers (over a range of about ± 200 kHz). For a signal-to-noise ratio of 60 dB, the protection ratio is not greater than 15 dB. The protection ratios determined for the sound signal are much lower than those for the television signal.

More tests were carried out to find suitable values for the carrier spacing (that is, the spacing between the carrier frequencies of adjacent sound channels). As in the case of television signals, it is assumed that the channel width is sufficiently large so that the adjacent-channel protection ratio is —6 dB. In this case, the tests showed that the carrier spacing should be about 0·8 MHz.

6. Protection ratios for 625-line Standard K/SECAM

Recent measurements in the U.S.S.R. [C.C.I.R., 1970–1974f] determined protection ratios for frequency-modulation signals against interference by CW, amplitude-modulation, vestigial-sideband and frequency-modulation signals.

* For noise measurements this indicates the ratio of the r.m.s signal to the r.m.s. noise.

6.1 *Measurement conditions*

Protection ratios were determined under the following conditions:

- peak deviation of the wanted frequency-modulation television signal (allowing transmission of sound component on a sub-carrier with a video signal/sound-component signal ratio of 4·5/1) was taken as ± 11 MHz;
- the ratio of the wanted signal to continuous random weighted noise at the frequency-modulation television receiver output was fixed at 57 dB (ratio of picture signal peak-to-peak amplitude, excluding synchronizing pulses, to the r.m.s. noise voltage in the frequency band from 10 kHz to the upper nominal limit of the video-frequency band). To establish this value, use was made of a low-pass filter and a weighting network with characteristics similar to those described in Recommendation 421-3, Annexes II and III for System K;
- coloured and monochrome tests charts, coloured bars and real colour pictures were used for the tests;
- a CW, an amplitude-modulation television signal, and a frequency-modulation television signal were used as interfering signals;
- the video signal of the monochrome test chart was used as modulating signal for the interfering amplitude-modulation and frequency-modulation television signal;
- a binary statement of the type "Yes-No" was used to assess picture quality;
- the test group consisted largely of non expert viewers. Expert viewers were used to determine the proposed central assessments. The test group consisted of ten to fifteen persons;
- dimensions of test picture: 475 × 375 mm;
- viewing distance: 5 to 6 times the picture height;
- the centre of the screen of the test television receiver was set at eye level of the observers;
- measurements were carried out in conditions of partial darkness;
- the level of illumination of the screen by external light sources did not exceed 0·01 of maximum screen brightness;
- sequence of changes in noise level: random, in 3 dB steps; in each measurement series, the observers were shown five values of signal-to-noise ratio. In consequence, the limits of the variation in noise level gave rise in each case to variations of ±1 grade in the assessment picture quality;
- protection ratio measurements were made without a band-pass filter at the input to the frequency modulation receiver.

6.2 *Measurement results*

The results of the protection ratio measurements as a function of detuning of the carrier frequencies (carrier-frequency offset) of the wanted and unwanted signals, for transmission in colour (colour bars, colour test-chart and real colour-picture) are shown in Figs. 14 to 16, while Fig. 17 shows the results of transmission of a monochrome picture (test chart).

Fig. 14 describes the effect of CW interference on the wanted frequency-modulation television signal, Fig. 15, the effect of interference in the form of an amplitude-modulation signal and Fig. 16, the effect of interference in the form of a frequency-modulation signal with a peak frequency deviation ±11 MHz.

Fig. 18 shows the measurement results for protection ratios as a function of the level of random noise at the output of the frequency-modulation television receiver. A colour test chart was used in recording these correlations, while the detuning between the wanted and unwanted signal carriers was fixed by the maximum perceptibility of interference on the screen of the test television receiver.

6.3 *Conclusions*

The following conclusions can be drawn from these results:

In the case of the wanted and unwanted signals in the same frequency channel (with identical mid-frequencies), the protection ratio does not exceed 30 dB, for the reception of both monochrome and colour television signals, and is virtually independent of the picture content.

If the wanted and unwanted signal mid-frequencies are detuned, the protection ratio for the reception of monochrome television signals decreases.

For the reception of colour television signals, the protection ratio with frequency detuning initially rises, reaching a maximum (40 to 42 dB) with a detuning of ± 4 to 5 MHz, and then falls. This is due to the occurrence of wanted and unwanted signal frequency beat products in the transmission of colour television signals.

The value of the protection ratio depends basically on the random noise level in the channel at ratios of less than 50 dB between the wanted signal and the weighted r.m.s. voltage at the frequency-modulation television receiver output, and is independent of the level of random noise with ratios equal to or greater than 50 dB.

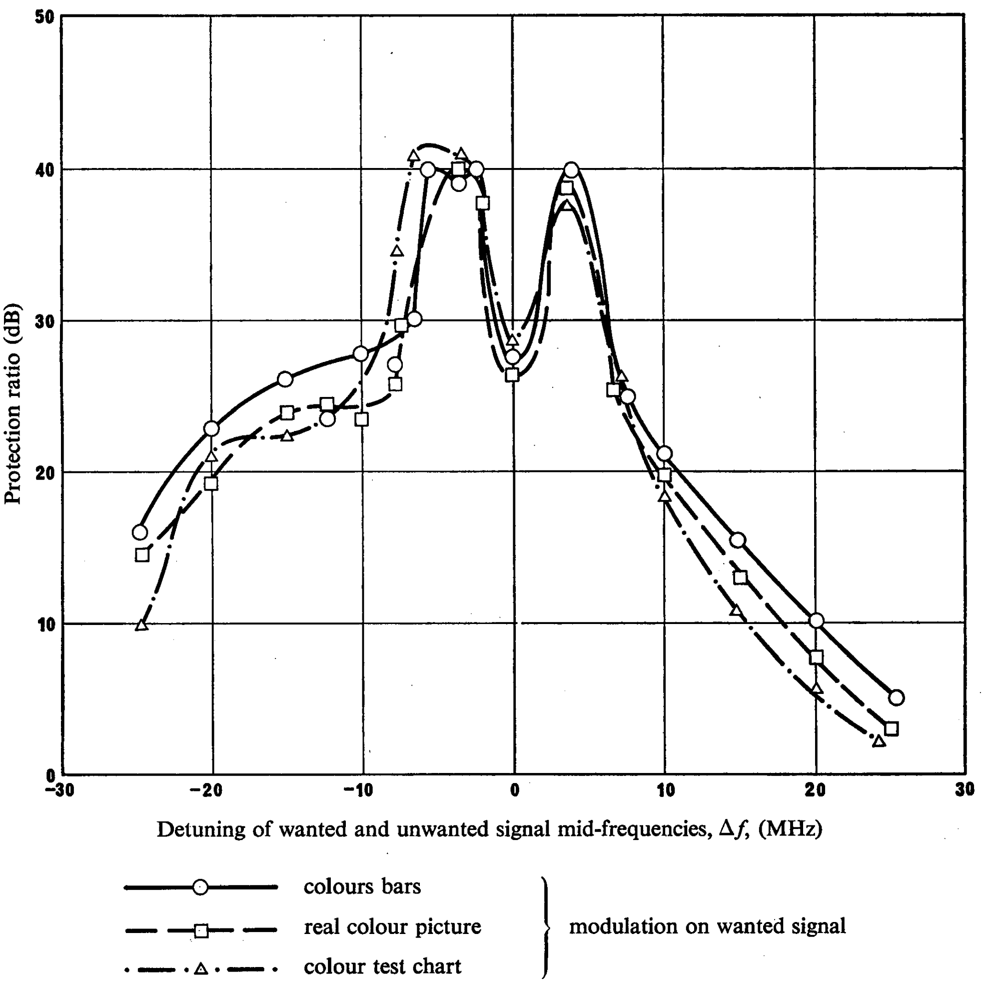


FIGURE 14

Frequency-modulation protection ratio against CW interference

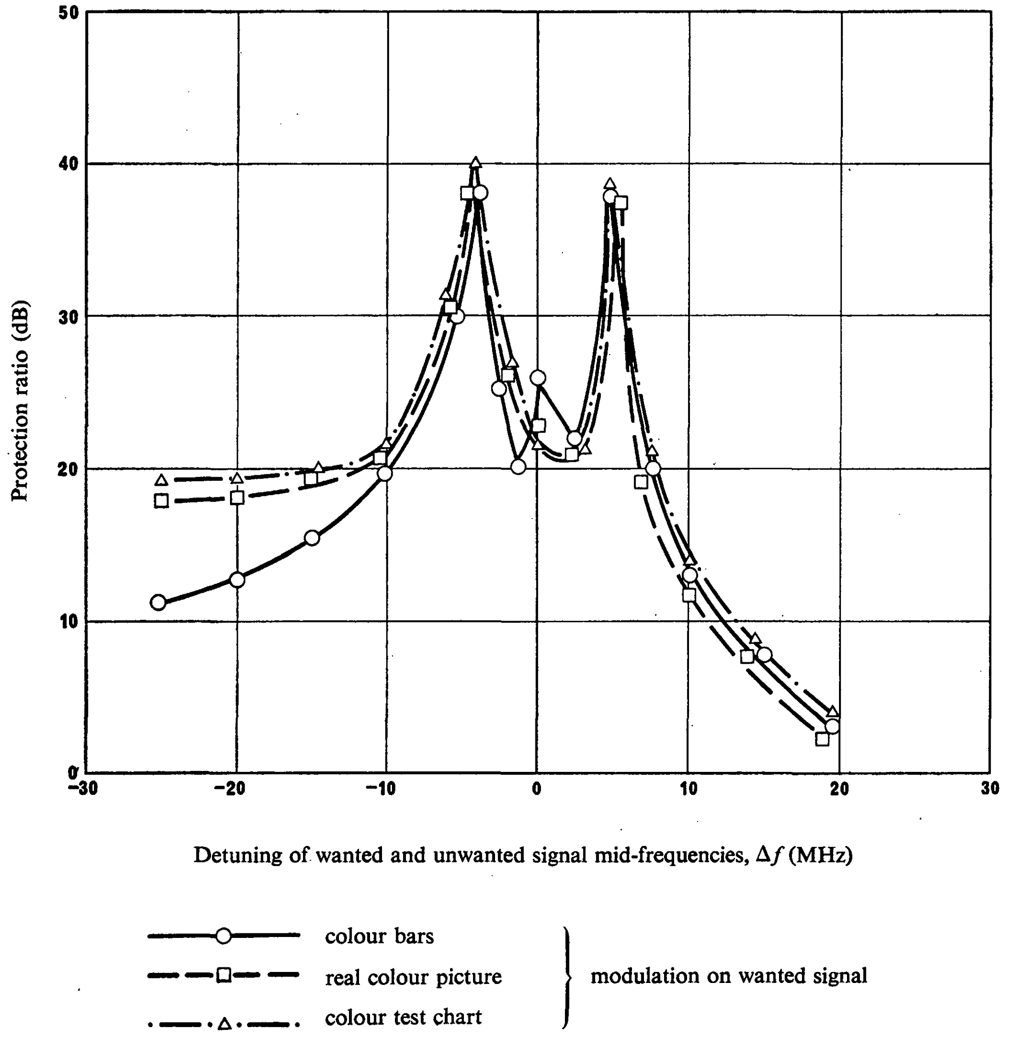


FIGURE 15

Frequency-modulation protection ratio against amplitude modulation, vestigial-sideband interference

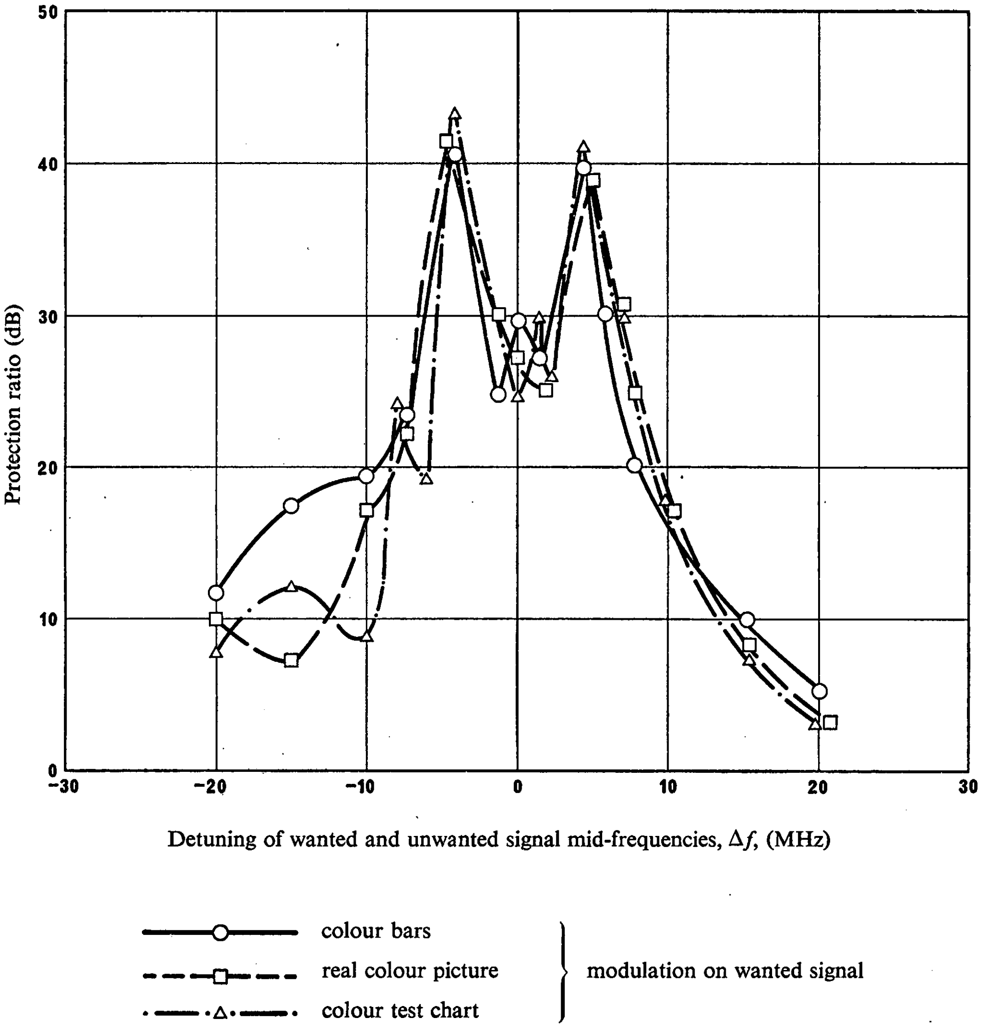


FIGURE 16

Frequency-modulation protection ratio against frequency-modulation interference

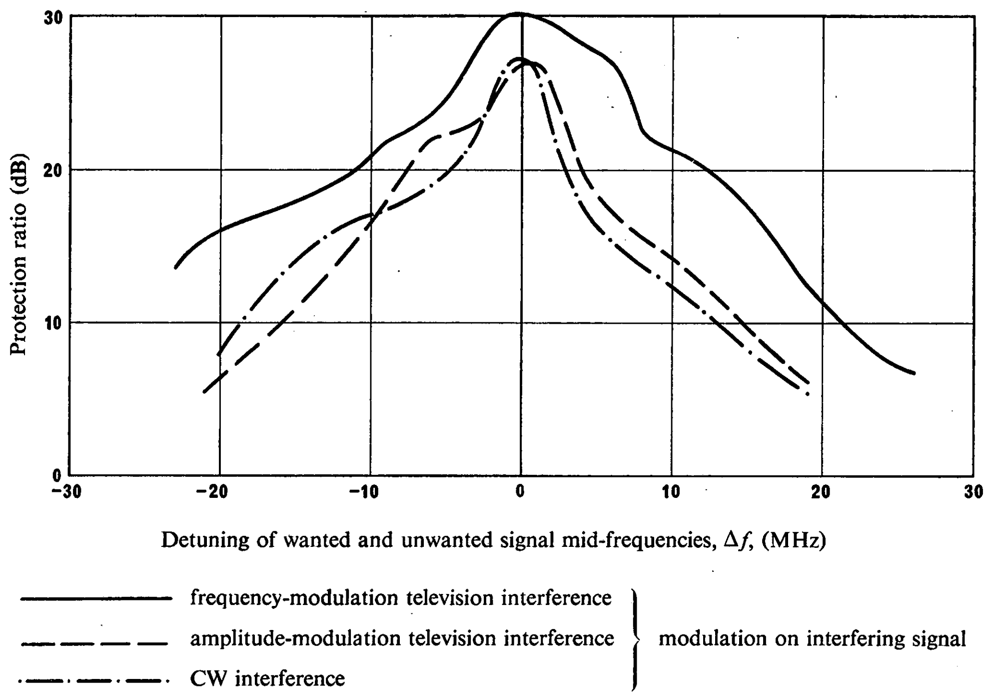


FIGURE 17

Protection ratios in the case of frequency-modulation transmission of a monochrome picture (test chart)

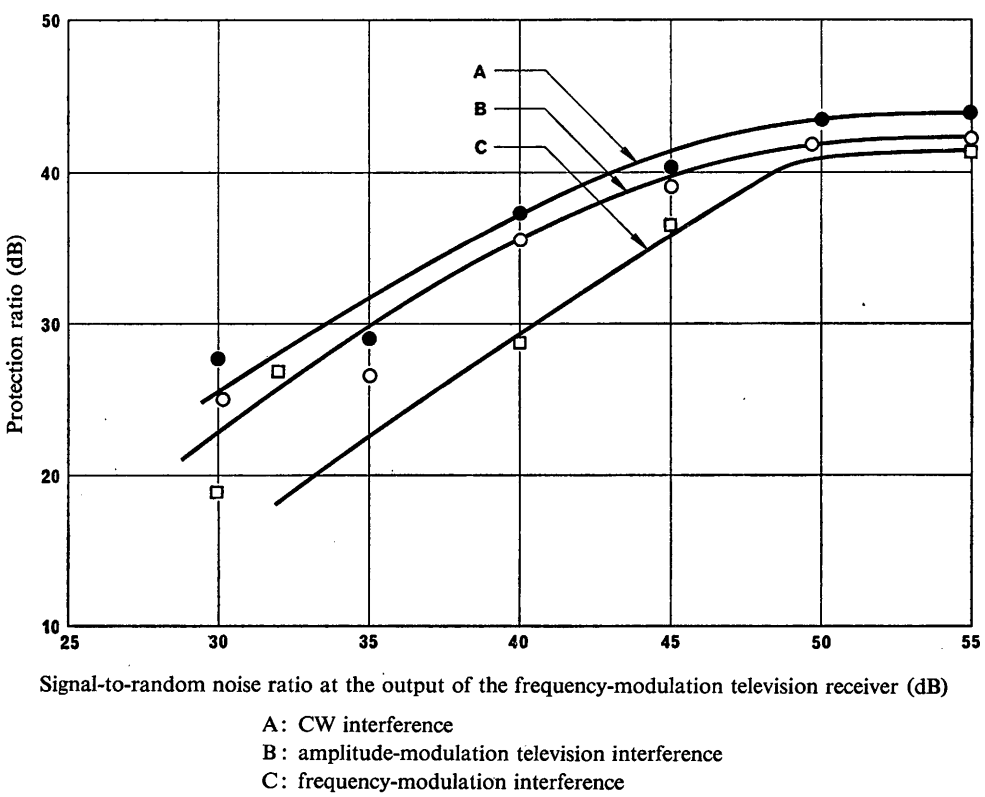


FIGURE 18

Frequency-modulation protection ratios as functions of signal-to-noise ratio

7. Discussion of the results

Comparisons of the data presented in this report are difficult because of the varying test conditions used. For some parameters in the case of interference on an amplitude-modulation, vestigial-sideband system, correction factors have been deduced to enable results to be referred to the standardized conditions proposed in Annex I. These parameters relate to:

— deviation;

— pre-emphasis;

— quality grade;

— energy dispersal.

For frequency-modulation systems some factors in determining the required protection ratio for common radio-frequency co-channel sharing are:

— quality grade of the protection ratio assessment;

— the picture signal-to-noise ratio of the wanted signal;

— the deviation of the wanted signal;

— the programme content of both wanted and unwanted signals.

The deviation and the signal-to-noise ratio for the unwanted signal have only minor effects upon the protection ratio. Over the range of deviations studied, the protection ratio decreases with increasing deviation of the wanted signal. Wanted signals which have large areas of colour or uniform luminance are more susceptible to interference; similarly unwanted signals having large single spectral components are more perceptible.

Results for 525-line Standard M/NTSC and 625-line Standard K/SECAM show that noise in the wanted signal tends to mask coherent interference by degrading the quality of the uninterfered portion of the picture and by breaking up any interference patterns. Other measurements on 625-line systems show little masking by noise. It is possible that this apparent difference in system vulnerability to interference can be explained in terms of the nature of the pictures carried by the wanted and interfering signals in the various measurements and the use of different noise-weighting when specifying the luminance-to-weighted-noise ratio in different television systems. A definitive answer must await additional test data and analysis.

A preliminary attempt to summarize the various test results in the form of empirical formulae suitable for system planning is given in Annex II.

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ANNEX I

A REFERENCE CASE FOR PROTECTION RATIO MEASUREMENTS

The following set of reference test conditions has been proposed by the E.B.U. for use in future protection ratio measurements:

1. Assessment of picture quality

Recommendation 500 defines methods and conditions for assessing picture quality or impairment, and this Recommendation should apply to tests for protection ratio. For measuring protection ratios, the 5-point impairment scale is more suitable than the corresponding quality scale.

When establishing protection ratios, it is desirable not to give too much preference to non-expert opinion, because it is possible that with technical developments such as larger screens or brighter pictures, impairments may become more noticeable to non-experts in the future. Moreover, some non-expert viewers may in the future tend to become more critical in their reactions to impairments.

2. Receivers

The receivers used in the tests should represent equipment which is fairly sensitive to the particular type of impairment being investigated. Account should be taken of domestic receivers, and the types of receiver which may be used at re-broadcast relay stations.

3. Wanted and unwanted picture characteristics

Subjective tests should be based on colour pictures, unless there is reason to suppose that monochrome pictures would result in more stringent requirements.

The protection ratios should apply to reasonably critical still pictures, as these may occur fairly frequently in practice. The value should also apply when the wanted or the interfering picture is at a nearly constant luminance.

4. Wanted and unwanted signal modulation characteristics

When either of the signals must represent emissions for which the characteristics are not yet specified, it is useful to adopt some more or less arbitrary parameters as a reference condition. For example, a frequency-modulated television signal, for which no broadcasting standard exists at present, might use the following parameters as the reference condition:

— peak-to-peak deviation caused by the video signal: 8 MHz/V;

— pre-emphasis in accordance with curve B of Recommendation 405-1. The deviation specified above is then defined in terms of a video signal of 1 V peak-to-peak at the frequency at which the pre-emphasis characteristic has zero insertion loss (i.e., 1·5 MHz);

— no energy dispersal waveform is added;

— line-scanning is synchronized between the wanted and the unwanted signals;

— the interfering carrier frequency should be chosen to correspond to the greatest subjective impairment.

When it is more convenient to use other test conditions and parameters, these should be defined, and correction factors should be given so that results applicable to the reference conditions can be deduced.

5. Video signal-to-noise ratio

As far as possible, the only noise which should be present on the picture when assessing protection ratios is that of thermal noise in the receiver. The protection ratios should be measured for pictures having a signal-to-unweighted-noise ratio of not less than 36 dB, in order that system performance should not be limited by possible masking of interference by noise.

6. Other interference and sources of picture impairment

No account should be taken of other sources of interference, etc. (except thermal noise, as mentioned above), when assessing the protection ratio. An appropriate allowance should be made for such factors when specifying the minimum field strength to be protected.

7. Impairment grade appropriate for specifying protection ratio

The protection ratio should be assessed for continuous interference, and in this case the appropriate grade on the 5-point impairment scale would be 4·5.

ANNEX II

GENERALIZATION OF RESULTS OF PROTECTION RATIO MEASUREMENTS

Further work is required to analyse the significance of the sometimes conflicting results given in this Report. Nonetheless, the empirical formulae presented in this annex are thought to provide a reasonably accurate summary for preliminary planning purposes:

1. Wanted signal, FM: unwanted signal, FM

When the modulation parameters of the wanted and unwanted signals are the same and there is no carrier frequency offset, the value, PR_0, of the protection ratio measured under the reference conditions of Annex I may be represented by a formula similar to that described in § 5.2 of this Report:

$$PR_0 = C - 20 \log (D_v/8) - Q + 1{\cdot}1Q^2 \tag{1}$$

where D_v: nominal peak-to-peak frequency deviation

Q: the impairment grade, concerning the effect of interference only, measured on the 5-point scale recommended in Recommendation 500.

C: a constant depending on the television standard which is:

16, for 625-line standards I, G, L;
22, for 625-line standard K;
18, for 525-line standard M.

2. Wanted signal, AM/VSB: unwanted signal, FM

Results obtained with standards I, G, and L as the wanted signal have given values of protection ratio, PR_0, varying between 52 and 60 dB. On the other hand, results for standard M give a typical value of 49 dB and for standard K, the corresponding value is 46 dB. This difference may arise at least partially from the different test conditions used in the measurements.

3. Wanted signal, FM: unwanted signal, AM/VSB

In this case measurements have been made for 525-line standard M and 625-line standard K as the wanted signal. There appears to be good agreement between the results.

4. Effects of noise

Some administrations feel that system planning could take account of the masking of interference by random noise. In this case, a lower value, PR_1, of protection ratio could be adopted. If the peak-to-peak luminance signal-to-r.m.s. weighted-noise ratio is S/N, results obtained for 525-line standard M suggest that

$$\left.\begin{aligned} PR_1 &= PR_0 - (49 - S/N) \qquad S/N < 49 \text{ dB} \\ PR_1 &= PR_0 \qquad\qquad\qquad\quad S/N \geqslant 49 \text{ dB} \end{aligned}\right\} \tag{2}$$

where PR_0 is the protection ratio under the reference conditions of Annex I.

5. Summarizing table

Based upon data in the Report and on the discussions in this Annex, the following values of protection ratio for just perceptible interference appear to be consistent with equations (1) and (2).

Wanted signal	*Unwanted signal*	PR_0
Amplitude-modulation vestigial-sideband	*Frequency modulation*	(dB)
625-line standards I, G, L	$D_v = 8$ MHz	56
625-line standard K	$D_v = 22$ MHz	46
525-line standard M	$D_v = 8$ MHz	49
Frequency modulation	*Amplitude-modulation vestigial-sideband*	
$D_v = 8$ MHz	525-line standard M	26
Frequency modulation	*Frequency modulation*	
$D_v = 8$ MHz	$D_v = 8$ MHz	36*
$D_v = 22$ MHz	$D_v = 22$ MHz	28*
$D_v = 16$ MHz	$D_v \geqslant 16$ MHz	30*
$D_v = 18$ MHz	$D_v \leqslant 10$ MHz	28*

* Typical result, all television standards.

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QUESTIONS AND STUDY PROGRAMMES, DECISIONS, RESOLUTIONS AND OPINIONS

QUESTION 1/11

COLOUR TELEVISION STANDARDS

(1955)

The C.C.I.R.,

CONSIDERING

(a) that Question 64 did not cover all aspects of the problems arising in the standardization of colour television;

(b) that, in Europe at least, the situation in Bands I and III differs from that in Bands IV and V, and that, in deciding on colour systems for Bands I and III, individual Administrations may find it convenient to use systems compatible with their monochrome systems already working in these bands;

(c) that, as Bands IV and V have not yet been exploited in many countries, it is desirable and theoretically possible for these countries to achieve a common standard for these bands;

(d) that, in choosing a colour system for Bands IV and V, Administrations may well be influenced by any colour systems which they may have adopted for Bands I and III, and that this possibility complicates the choice of common standards;

DECIDES that the following question should be studied:

what standards can be recommended for colour television for public broadcasting? Account should be taken of such points as:

— satisfactory picture (colour and monochrome) and sound quality;

— economical use of bandwidth;

— reliable receivers of reasonable cost;

— operation of studio, transmitting and relaying equipment;

— susceptibility to interference;

— compatibilities (see Note);

— frequency planning;

— international exchange of programmes;

— scope for development;

— the differences between Bands I and III, as compared with Bands IV and V.

Note. — A compatible colour television system is one that produces acceptable monochrome versions of the colour pictures on existing monochrome receivers. A reverse compatible colour television system is one that produces acceptable monochrome pictures on colour receivers from existing monochrome transmissions: in either case, bandwidths of the colour and monochrome systems may be the same or different.

STUDY PROGRAMME 1A/11

STANDARDS FOR VIDEO COLOUR-TELEVISION SIGNALS

(1965)

The C.C.I.R.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the preferred colorimetric parameters for representing the television picture;
2. the gamma pre-correction;
3. the scanning standards that can be recommended, e.g. sequential (field, line, dot), simultaneous or mixed;
4. comparison of the various methods of coding and decoding the colour picture information;
5. the minimum acceptable bandwidths for the signal components, corresponding to these parameters.

STUDY PROGRAMME 1B/11

STANDARDS FOR RADIATED COLOUR-TELEVISION SIGNALS

(1955)

The C.C.I.R.

DECIDES that the following studies should be carried out:

comparison of different colour television systems, in terms of the criteria listed in the text of Question 1/11. This comparison should pay particular attention to colour television systems which are either in operation, or which are, or have been, the subject of experiment.

STUDY PROGRAMME 1C/11

CONSTITUTION OF A SYSTEM OF STEREOSCOPIC TELEVISION

(1958)

The C.C.I.R.,

CONSIDERING

(a) the possible future development of stereoscopic television broadcasting;

(b) the great utility this form of television may have;

DECIDES that the following studies should be carried out:

1. Stereoscopic monochrome television

1.1 investigation into the development of methods of providing stereoscopic television, not requiring the use of spectacles;

1.2 study of the possibility of decreasing the bandwidth of stereoscopic television broadcasting, e.g., by transmitting one picture of the stereoscopic couple with the full standardized bandwidth and the other with a reduced bandwidth on a sub-carrier within the first frequency spectrum;

1.3 study of the influence of noise on stereoscopic television pictures and determination of the permissible signal-to-noise ratio;

1.4 investigation of the design of receivers with direct reproduction of stereoscopic pictures, e.g., by taking the structure of receiving-tube displays as a basis for the lay-out of the phosphorescent elements;

2. Stereoscopic colour television

2.1 the carrying out of tests, to assess the quality of colour reproduction with binocular mixing of its components, in respect of the stability of picture detail ("field-clash");

2.2 study of the possibility of decreasing the frequency band for stereoscopic colour television, e.g., by transmitting the green field of the stereoscopic couple with the full standardized band, the red and blue fields being transmitted by means of a sub-carrier within the first frequency spectrum;

2.3 research into the design of receivers for the direct reproduction of stereoscopic colour television.

STUDY PROGRAMME 1D/11

RATIO OF PICTURE-SIGNAL TO SYNCHRONIZING-SIGNAL

(1970)

The C.C.I.R.,

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.

STUDY PROGRAMME 1E/11

SIMPLIFICATION OF SYNCHRONIZING SIGNALS IN TELEVISION

(1970)

The C.C.I.R.

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.

STUDY PROGRAMME 1F/11 *

ALLOCATION OF TOLERANCES FOR COLOUR TELEVISION

(1970)

The C.C.I.R.,

CONSIDERING

(a) that the subjective quality of colour television pictures is affected by the objective performance of every component part of an overall television system from picture source up to and including the receiver;

(b) that the relationship between objective parameters of television signals and subjective assessments of displayed picture quality is under study (Study Programme 14A/11);

UNANIMOUSLY DECIDES that the following studies should be carried out:

allocation of the specified total tolerances among the component parts of an overall television system from picture source up to and including the receiver, taking into account the statistical behaviour of departures from the nominal performance figures of the equipment.

* This Study Programme is to be studied jointly with the CMTT.

QUESTION 2-2/11

EXCHANGE OF TELEVISION PROGRAMMES

(1966 – 1970 – 1974)

The C.C.I.R.,

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;

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. — Programme exchanges should be considered:
- — between different monochrome systems,
- — between different colour systems,
- — and between monochrome and colour systems.

STUDY PROGRAMME 2A/11

TRANSCODING OF COLOUR TELEVISION SIGNALS FROM ONE SYSTEM TO ANOTHER

(1970)

The C.C.I.R.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. methods of transcoding from one colour television system to another having the same nominal line and field frequencies;

2. tolerances required of a colour television signal to ease the problem of transcoding it into another system.

QUESTION 3-1/11

ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(1951 – 1956 – 1970)

The C.C.I.R.,

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 television 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 television 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?

STUDY PROGRAMME 3A/11 *

SUBJECTIVE ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(1963 – 1966)

The C.C.I.R.,

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 many different methods of subjective testing are possible;

(c) that the results of subjective tests depend on the conditions under which they are carried out;

(d) that the results of subjective tests can be interpreted in many ways;

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* This Study Programme is also of interest to the CMTT, as it relates to the transmission requirements for long-distance telephone circuits.

(e) that it is highly desirable to standardize the methods of subjective testing and the interpretation of the results, so that true comparisons may be made between results obtained at different times;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. on the methods of subjective testing best suited to the assessment of the relative quality of television pictures and of the effects of interference and other impairments upon them, taking particular account of:

— the use of full-range opinion-rating methods and the scales to be used and, alternatively, the use of comparison methods of assessment;

— the selection of test pictures;

— the viewing conditions;

— the selection and number of observers;

— the instructions to observers before tests;

2. on the analysis and presentation of the results obtained;

3. on the use of the methods described in §§ 1 and 2 during international transmissions.

QUESTION 4-1/11

RATIO OF THE WANTED-TO-UNWANTED SIGNAL IN TELEVISION

(1955 – 1963 – 1970)

The C.C.I.R.,

CONSIDERING

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;

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;

2. what is the protection ratio required against services, other than television, in the shared bands?

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 418-2 for monochrome television and Report 306-2 for colour television.

Note 3. — See Report 307 for protection against radionavigation transmitters.

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 C.C.I.R.,

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 418-2);

(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 306-2 for information on protection ratios for colour television.

QUESTION 5-2/11 *

BROADCASTING-SATELLITE SERVICE (TELEVISION)

System characteristics and protection from interference

(1965 – 1966 – 1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971, 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;

* This Question is similar to Question 20-2/10, and should be studied in connection with Questions 23-1/11 and 34-1/10. Contributions to the study of this Question should be communicated to Study Group 10 and the results arising from this study should be communicated to Study Groups 4, 8 and 9.

(d) that in the case of the broadcasting-satellite service, it would be useful to have specific numerical values for the power flux-density from space stations which would permit distinction between the requirements for "individual reception" and "community reception" (see Recommendation No. Spa2 — 15, § 2.13);

(e) that the efficiency of frequency and orbit-sharing is sensitive to a number of the technical characteristics of the systems involved, including transmission standards, modulation parameters, and the design of the transmission and reception equipment;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the preferred technical characteristics of broadcasting-satellite systems;

2. what are the values of field strength or power flux-density necessary to provide satisfactory reception of a broadcasting-satellite service for:
   - individual reception;
   - community reception;

3. what is the ratio of wanted-to-unwanted signal required for the prescribed grade of service (protection ratio) and what are the effects of interference reduction techniques such as polarization discrimination, carrier interleaving, and carrier energy-dispersal considering all relevant combinations of signal standards and modulation parameters for analogue and digital transmissions;

4. what values for the amplitude of interference caused by other terrestrial and other space radiocommunication services and its statistical distribution in time may be considered acceptable in the broadcasting-satellite service;

5. what acceptable modifications to the preferred characteristics of communication-satellite systems in other services, could assist the sharing of allocated frequency bands, taking into account typical demands for service, total system costs, and the efficient use of both the spectrum and the geostationary orbit?

STUDY PROGRAMME 5A-1/11 *

BROADCASTING-SATELLITE SERVICE

Television standards

(1966 – 1974)

The C.C.I.R.,

CONSIDERING

(a) the allocations made to the broadcasting-satellite service by the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971;

(b) that use of the wide coverage possibilities of television broadcasting from satellites may be simpler if a single standard is used within the coverage area;

(c) that a new transmission standard may be desirable;

* This Study Programme replaces Study Programme 5-1E/11, which is hereby deleted.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the preferred standards for transmission and conditions for individual and community reception, including the method of modulation which could provide high-quality monochrome and colour reception, and also acceptable monochrone reception with low-cost receivers;

2. determination of techniques for transmitting the colour information within the video spectrum of the luminance signal;

3. the number of sound channels which could be provided and the manner in which they could be transmitted;

4. determination of the values of the parameters controlling picture and sound quality (resolution, permissible contrast range and brightness, etc.) and, if these values differ from those of existing standards, the reasons for the differences.

STUDY PROGRAMME 5B/11

COMPOSITE 625-LINE SIGNAL FOR TELEVISION BROADCASTING FROM SATELLITES

(1966)

The C.C.I.R.,

CONSIDERING

(a) that television broadcasting from satellites is inherently a wide area service;

(b) that transmitting on existing television standards on bands currently used may be a method of instituting such a service;

(c) that there are numerous variations between existing standards, especially in the 625-line systems;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the possibility that satisfactory results can be obtained on receivers built to existing standards, without change, or with a minimum number of changes, when receiving a composite 625-line transmission, composed of one vision signal plus two, three or more sound signals;

2. the possibility of accomplishing any necessary changes by adapters (introduced, for example, between the picture tube and its connecting socket);

3. the increases in receiver complexity that would be incurred if dual standard receivers were to be developed for reception of an existing standard and the composite signal.

STUDY PROGRAMME 5C-1/11

BROADCASTING-SATELLITE SERVICE (TELEVISION)

Possible systems and their relative acceptability

(1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that technology has developed sufficiently that broadcasting-satellites may come into use within the next decade;

(b) that studies of the technical characteristics of broadcasting-satellite systems for television are continuing;

(c) that, to supplement these technical characteristics, the cost of such systems (covering both the capital cost and the running cost) should be taken into account;

(d) that the characteristics of the receiving equipment are of considerable importance in determining the total system cost;

(e) that these factors may influence the choice of systems;

(f) that comparative cost is not the absolute deciding factor but an important consideration to be taken into account;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. evaluation of the effects on the system cost depending on the specification and engineering design of receiving equipment, and the number of receivers required;

2. comparison between the different broadcasting-satellite systems for either individual or community television reception, taking the technical aspects and capital and running costs into account;

3. evaluation of the feasibility and possible uses of each system in the light of the technical and economic factors involved.

Note. — These studies will be carried out, taking into account detailed economic studies made by Interim Working Party PLEN/2 set up by Resolution 38. An exchange of information between Study Group 11, Interim Working Party PLEN/2 and the Technical Cooperation Department of the I.T.U. should materially assist in the execution of these studies.

STUDY PROGRAMME 5D-1/11

BROADCASTING-SATELLITE SERVICE (TELEVISION)

Technical characteristics of systems for community and individual reception

(1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that developing countries are especially interested in the study of community reception;

(b) that operating conditions and quality of reception for community reception of signals from broadcasting satellites are expected to be appreciably different from the operating conditions and quality of reception for individual reception;

(c) that this difference in operating conditions and quality of reception may enable a community television broadcasting-satellite service to be established at an early date;

(d) that in the allocated frequency bands, the parameters and standards chosen must result in interference between satellite and terrestrial transmissions exceeding an acceptable level;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the optimum characteristics of television broadcasting-satellite systems for community and individual reception to provide economical coverage of service areas within one country or a group of countries;

2. the modulation standards and video-frequency characteristics which would ensure the best service at lowest cost;

3. the power flux-densities required for community and individual reception with a view to specifying numerical values which will distinguish between these types of reception.

STUDY PROGRAMME 5F-1/11

CHARACTERISTICS OF A RECEIVING SYSTEM FOR DIRECT RECEPTION FROM BROADCASTING SATELLITES (TELEVISION)

(1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) the frequency allocations made to the broadcasting-satellite service by the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971;

(b) that the choice of frequency bands to be used and the transmission standards are of great importance in deciding the following characteristics of the receiving equipment:

— figure of merit, G/T,

— channel bandwidth,

— reliability,

— ease of control;

(c) that, particularly for community reception, which would probably be the first to be established, the frequency-modulation system for television would allow a lower radiated power from the satellite;

(d) that the standards chosen must not produce interference problems between satellite and terrestrial transmissions;

UNANIMOUSLY DECIDES that the following studies should be carried out:

determination of the characteristics of receiving equipment, for individual and for community reception, taking into account the different modulation techniques for transmitting the vision and sound signals.

STUDY PROGRAMME 5G-1/11 *

BROADCASTING-SATELLITE SERVICE (TELEVISION)

Use of the 12 GHz band

(1972 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971, allocated a band of frequencies at about 12 GHz on a primary shared basis to the broadcasting-satellite service and to other services, the requirements of which must be respected;

(b) that there may, in due course, be a very substantial demand for frequency assignments for the broadcasting-satellite and other services allocated to this band;

(c) that it is necessary to make the best possible use of the geostationary-satellite orbit and of the frequency bands allocated to the broadcasting-satellite service;

(d) that, whenever possible, the service area should be the minimum necessary to provide the required coverage;

(e) that, in view of the decision to hold a World Administrative Radio Conference for the planning of broadcasting-satellite services in the 12 GHz band not later than April, 1977 (see Resolution No. 27 of the Plenipotentiary Conference, Malaga-Torremolinos, 1973), it is necessary to prepare plans on a world-wide or regional basis for the establishment of broadcasting-satellite services;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the essential technical parameters to be recommended for the preparation of a plan assigning both geostationary-satellite positions and frequencies for the broadcasting-satellite service in the 12 GHz band;

2. determination of the necessary protection ratios affecting interference from other services allocated to this frequency band, to the broadcasting-satellite services; **

3. determination of upper limits for the signal level from transmissions of other services allocated to this frequency band, to ensure that no more than an acceptable degree of interference is caused, taking into account the necessary protection ratios as well as the directivity and polarization discrimination of the receiving antennae;

4. determination of practicable techniques for carrier energy-dispersal of broadcasting-satellite transmissions that would be expected to reduce interference to other services;

5. relationship between those sharing criteria that result from simulated laboratory tests on the one hand and the sharing criteria that result from any actual field trials on the other hand.

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* This Study Programme is similar to Study Programme 20C-1/10.

** The need for studies to determine the necessary protection ratios to prevent harmful interference from the broadcasting-satellite service to other services in the 12 GHz band should be brought to the attention of Study Groups 2, 4, 8 and 9.

STUDY PROGRAMME 5H/11

BROADCASTING-SATELLITE SERVICE (TELEVISION)

Criteria to be applied for frequency sharing between the broadcasting-satellite service and the terrestrial broadcasting service in the frequency range 620 to 790 MHz

(1974)

The C.C.I.R.,

CONSIDERING

(a) that the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971, recommended the following provisional values for the maximum power flux-density at the surface of the Earth, to provide adequate protection within the service area of a terrestrial broadcasting transmitter, by a space station in the broadcasting satellite service in the frequency range 620 to 790 MHz:

-129 dB(W/m^2)	for $\delta \leqslant 20°$
$-129 + 0{\cdot}4\ (\delta - 20)$ dB(W/m^2)	for $20° < \delta \leqslant 60°$
-113 dB(W/m^2)	for $60° < \delta \leqslant 90°$

where δ (degrees) is the angle of arrival above the horizontal plane at the terrestrial broadcasting transmitter;

(b) that these values should not be exceeded within the territory of a country without the agreement of the administration of that country;

(c) that the transmission of unmodulated carrier waves should be avoided;

(d) that, at present, insufficient data exist to permit definite values for the power flux-density to be specified;

(e) that additional information is needed on the protection ratio required from a frequency-modulation television system into a vestigial-sideband television system for both 525-line and 625-line systems;

(f) that the values for minimum field strength to be protected given in Recommendation 417-2 may require examination for currently employed terrestrial television systems;

(g) that it may be necessary to take into account the effects of ground reflections;

(h) that the values of protection ratio may be reduced if methods of carrier energy dispersal are used;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. consideration of the provisional values for power flux-density quoted in § *(a)* with a view to replacing them by definitive values;

2. determination of values of the protection ratio for 525-line and 625-line vestigial-sideband television systems for interference from a frequency-modulation television or sound signal;

3. what effect does the level of random noise have on the permissible value of the signal-to-interference ratio measured within the passband of an amplitude-modulation, vestigial-sideband receiver for various systems of television;

4. the minimum values of field strength to be protected for the terrestrial television service taking into account the current state of development;

5. the effects of ground reflection;

6. determination of the number of broadcasting satellites that may be visible from a terrestrial broadcasting receiver;

7. the effects of polarization discrimination;

8. the effects of the directivity patterns of the antennae employed;

9. the advantages, if any, to be gained from the use of carrier energy-dispersal techniques in the television broadcasting-satellite service;

10. methods of taking into account the effect of interfering signals from terrestrial broadcasting and broadcasting-satellite services that may be present simultaneously;

11. the effect of the characteristics of conventional amplitude-modulation, vestigial-sideband receivers of various television systems on the permissible value of the signal-to-interference ratio measured in the receiver;

12. how the ratio of the total power of an unwanted frequency-modulation signal to the power of that signal falling within the passband of an amplitude-modulation, vestigial-sideband receiver (for various television systems) varies as a function of the frequency deviation and the separation of the carrier frequencies of the wanted and unwanted signals;

13. the effect that the bandwidth of transmission or reception would have on the frequency sharing criteria;

14. consideration of the establishment of correlation between simulated laboratory test results and the results of any field trials;

15. the effect that synchronization, or lack of it, between the wanted and unwanted signals would have on the protection ratio.

STUDY PROGRAMME 5J/11

BROADCASTING-SATELLITE SERVICE (TELEVISION)

Criteria to be applied for frequency sharing between the broadcasting-satellite service and the terrestrial and space services in the frequency range 2500 MHz to 2690 MHz

(1974)

The C.C.I.R.,

CONSIDERING

(a) that the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971, established values for the maximum power flux-density at the surface of the Earth from a space station in the broadcasting-satellite service to provide adequate protection to the fixed and mobile service allocations in the 2500 to 2690 MHz range;

(b) that additional studies are required to determine the necessary protection ratios to prevent unacceptable interference between the broadcasting-satellite service and the fixed-satellite service allocations in this frequency range in Regions 2 and 3;*

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the necessary protection ratios for interference to the broadcasting-satellite service from the fixed-satellite service in the range 2500 to 2690 MHz;

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* The need for studies to determine the necessary protection ratios to prevent unacceptable interference from the broadcasting-satellite service to the fixed-satellite service with allocations in this frequency range in Regions 2 and 3 should be brought to the attention of Study Group 4.

2. determination of upper limits for the signal level from transmissions of the fixed-satellite service allocated to this frequency band, to ensure that no more than an acceptable degree of interference is caused, taking into account the necessary protection ratios, as well as the directivity and polarization discrimination of the receiving antennae;

3. determination of practicable techniques for carrier energy-dispersal of broadcasting-satellite transmissions that would be expected to reduce interference to other services;

4. relationship between those sharing criteria that result from simulated laboratory tests on the one hand and the sharing criteria that result from any actual field trials on the other hand.

QUESTION 6/11

GHOST IMAGES IN TELEVISION

(1966)

The C.C.I.R.,

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?

STUDY PROGRAMME 6A/11

GHOST IMAGES IN TELEVISION

(1966)

The C.C.I.R.

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.

QUESTION 7-1/11

RECOMMENDED CHARACTERISTICS FOR INDIVIDUAL OR COLLECTIVE TELEVISION ANTENNA SYSTEMS FOR DOMESTIC RECEPTION OF SIGNALS FROM TERRESTRIAL TRANSMITTERS

(1965 – 1970)

The C.C.I.R.,

CONSIDERING

(a) that the antenna and its associated components are important elements of the transmission chain;

(b) that their characteristics have an influence on the performance of receivers;

UNANIMOUSLY DECIDES that the following question should be studied:

what characteristics should be recommended for individual or collective domestic television antennae and associated equipment?

STUDY PROGRAMME 9A-1/11*

DISTORTION OF TELEVISION SIGNALS IN THE RECEPTION OF VESTIGIAL-SIDEBAND EMISSIONS

(1956 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that vestigial-sideband emission of television signals is an accepted practice in broadcasting;

(b) that this class of emission, in receivers using envelope-detection, 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;

(c) that synchronous detection when used in the receiver can eliminate quadrature distortion in the absence of any carrier phase-modulation introduced at the transmitter;

(d) that the method of detection might affect some parameter tolerances at the transmitter;

(e) that vestigial-sideband emission of television signals in several applications involves international transmissions;

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* This Study Programme does not derive from any Question at present under study.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the quantitative assessment of the respective distortion introduced in a television system using vestigial-sideband emission, when envelope-detection is used in the receiver, due to:
   - quadrature error,
   - group-delay error at the transmitter,
   - group-delay error at the receiver;
2. the quantitative assessment of distortion introduced in a television system using vestigial-sideband emission when synchronous detection is used at the receiver, with particular reference to carrier phase-modulation introduced at the transmitter;
3. suitable methods to be adopted for measuring and correcting such distortion;
4. the extent to which such corrections should be introduced at the transmitter.

STUDY PROGRAMME 11A-1/11 *

REDUCTION OF THE BANDWIDTH REQUIRED FOR A TELEVISION SIGNAL

(1958 – 1974)

The C.C.I.R.,

CONSIDERING

that the large channel bandwidth required for the transmission of television signals introduces problems which are both technical and economic;

UNANIMOUSLY DECIDES that the following studies should be carried out:

the ways in which removal of redundant information and knowledge of the visual characteristics of the human observer can be exploited to reduce the bandwidth required for transmission without perceptible reduction in the quality of the reproduced picture.

STUDY PROGRAMME 12A-1/11 *

INSERTION OF SPECIAL SIGNALS IN THE FIELD-BLANKING INTERVAL OF A TELEVISION SIGNAL

(1962 – 1963 – 1966 – 1974)

The C.C.I.R.,

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;

* This Study Programme does not derive from any Question at present under study.

(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 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 13/11 *

SPECIFICATIONS FOR LOW-COST TELEVISION RECEIVERS

(1968)

The C.C.I.R.,

CONSIDERING

(a) Resolution 163 (VIII) adopted by the Economic Commission for Africa at its Eighth Session, Lagos, 13-25 February 1967;

(b) 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;

(c) 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;

* 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.

(d) 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;

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 § *(b)*?

QUESTION 14/11

SUBJECTIVE QUALITY TARGETS OF OVERALL TELEVISION SYSTEMS

(1970)

The C.C.I.R.,

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:

what are the desirable subjective quality targets of an overall television system, from picture source to receiver, for the various types of service?

STUDY PROGRAMME 14A/11

SUBJECTIVE QUALITY TARGETS OF OVERALL TELEVISION SYSTEMS

(1970)

The C.C.I.R.,

CONSIDERING

(a) that the performance of a television service is determined by the performance of all the component equipment used in providing it;

(b) that existing methods of the assessment of the quality of television pictures are contained in Report 405-2;

(c) that Study Programme 2A-1/CMTT, § 2, is concerned with a determination of the objective performance of reference chains consistent with desirable overall subjective 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, both monochrome and colour;

2. the values to be assigned to the necessary design targets;

3. the relationships between objective parameters of television signals and subjective assessments of displayed picture quality;

4. the laws of addition of subjective effects when several causes of picture impairment are present simultaneously.

QUESTION 15/11

AUTOMATIC MONITORING OF TELEVISION STATIONS *

(1970)

The C.C.I.R.,

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;

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;

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* 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.

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?

QUESTION 17-1/11

OPTICAL SOUND RECORDING AND REPRODUCING STANDARDS FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES

(1966 – 1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that, when films intended for the international exchange of television programmes have optical sound tracks, these sound tracks do not always give satisfactory reproduction in telecine equipment;

(b) that compression of the sound signal is invariably used to obtain a satisfactory signal-to-noise ratio;

(c) that the signals reproduced from optical sound tracks have noticeably different characteristics from those originating from other programme sources;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the optimum compression characteristic for optical sound tracks, consistent with satisfactory signal-to-noise ratio;

2. is it possible, by the use of volume expansion in telecine reproducing equipment, or by other means, to reduce the difference between the sound quality obtained from optical tracks and that obtained from other programme sources?

QUESTION 18/11

RECORDING OF TELEVISION SIGNALS ON MAGNETIC TAPE

(1963 – 1970)

The C.C.I.R.,

CONSIDERING

that various types of equipment are being developed for magnetic recording of monochrome and colour television signals;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the methods of magnetic recording of television programmes which can be used by broadcasting organizations;

2. what standards should be established to enable the international exchange of such recordings to be made?

STUDY PROGRAMME 18A/11

RECORDING OF TELEVISION SIGNALS ON MAGNETIC TAPE

(1965 – 1970)

The C.C.I.R.,

CONSIDERING

(a) that there is at present a system of magnetic recording of television programmes used for the international exchange of programmes;

(b) that a study should be made of possible improvements to both the mechanical and the electronic aspects of the system;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. standards for the geometric and kinematic characteristics of the machines, with a view to improved reliability in the exchange of programmes;

2. the best methods of dealing with the video-frequency signal in relation to the overall quality of the system;

3. standards relating to the use of tracks for the recording of sound.

STUDY PROGRAMME 18B/11

STANDARDS FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES ON MAGNETIC TAPE

Helical-scan recording

(1970)

The C.C.I.R.,

CONSIDERING

(a) that the quality of helical-scan magnetic recordings obtainable with some equipment may prove acceptable for the exchange of programmes;

(b) that a variety of standards would be wasteful and impede the international exchange of programmes;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the minimum requirements necessary to specify the performance of magnetic helical-scan recorders, in order to define the standards for the international exchange of programmes;

2. the tape width, spool dimensions, and recording format.

STUDY PROGRAMME 18C/11

MEASURING METHODS FOR TELEVISION TAPE RECORDING

(1970)

The C.C.I.R.,

CONSIDERING

(a) that the interchangeability of recordings made on various television tape machines requires that strict tolerances should be applied to certain parameters;

(b) that standardized measuring methods are necessary to ensure the reproduction of tapes, intended for international exchange, without impairment of overall quality;

(c) that the measuring methods defined in existing publications are insufficient to check all essential characteristics of tapes and machines;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the recording and reproducing characteristics which affect the quality and interchangeability of tape recordings;

2. the methods of measuring these characteristics;

3. the characteristics of suitable measuring equipment.

STUDY PROGRAMME 18D/11

INTERNATIONAL EXCHANGE OF TELEVISION RECORDINGS FOR PROGRAMME EVALUATION

(1974)

The C.C.I.R.,

CONSIDERING

(a) that, for the purpose of evaluating the contents of television programmes offered for subsequent broadcasting, there is the need for the international exchange of recorded television programmes;

(b) that it may prove convenient and economical to use, for these exchanges, recordings conforming to standards which have technical characteristics inadequate for transmission, but still adequate for satisfactory viewing of the programmes (black-and-white and colour);

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the recording formats that can be used for international exchange, without prior bilateral agreement;

2. the characteristics that should be met by the recording to ensure interchangeability, within each of the chosen formats.

QUESTION 19/11

MAGNETIC SOUND RECORDING AND REPRODUCING STANDARDS FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES ON FILM

Recording and reproducing characteristics for 16 SEPMAG and 16 COMMAG

(1968 – 1970)

The C.C.I.R.,

CONSIDERING

(a) that Recommendation 265-3 specifies that for 16 COMMAG the recording and reproducing characteristics should be that standardized by the C.C.I.R. for magnetic tape for a speed of 19·05 cm/s except for the time constant which is 100 μs (see Recommendation 408-3);

(b) that this recommended standard has not been universally adopted;

(c) that the present multiplicity of standards for magnetic sound on 16 mm film recording and reproduction creates difficulties within broadcasting organizations;

UNANIMOUSLY DECIDES that the following question should be studied:

should a compromise between the ISO and S.M.P.T.E. recording and reproducing characteristics, such as the 70 μs time constant specified in Recommendation 408-3, be adopted for both 16 COMMAG and 16 SEPMAG film?

QUESTION 20/11

RECORDING OF COLOUR TELEVISION SIGNALS ON FILM

(1968 – 1970)

The C.C.I.R.,

CONSIDERING

(a) that colour films are a medium for the international exchange of colour television programmes, as stated in § 6.8 of Report 406 (New Delhi, 1970);

(b) that direct filming of programmes is not always possible for technical and economic reasons;

(c) that no simple, satisfactory system seems to be available in practice for recording colour television programmes on colour film;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what system or systems are most satisfactory for producing colour films from a live colour television programme or from one recorded on magnetic tape;

2. what are the optimum recording characteristics which would meet the standards that may be adopted for films intended for the international exchange of colour programmes?

QUESTION 21-1/11 *

STANDARDS FOR THE INTERNATIONAL EXCHANGE OF MONOCHROME AND COLOUR TELEVISION PROGRAMMES ON FILM

(1968 – 1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that the wide range of performance achieved in different telecine equipments has caused inconsistencies in the appraisal of films used for the international exchange of television programmes;

(b) that a method for appraisal by optical projection has now been agreed (see Recommendation 501);

(c) that it is also desirable to define an objective method as simple as possible of evaluating the colour balance of films when subjective assessment is inconclusive;

(d) that it is desirable to achieve optimum television reproduction of films intended for the international exchange of television programmes;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what telecine characteristics are required to give optimum reproduction of television films;

2. what telecine characteristics are obtained by typical present-day colour telecine equipment;

3. what methods of measurement and what specifications should be used to define the permissible colour deviations from the ideal colour balance for films intended for the international exchange of colour television programmes?

QUESTION 22/11

METHODS OF SYNCHRONIZING VARIOUS RECORDING AND REPRODUCING SYSTEMS

(1968 – 1970)

The C.C.I.R.,

CONSIDERING

(a) that Question 18-2/10 concerns the simultaneous transmission of two sound channels in television;

(b) that present television tape recorders provide for only one sound channel of broadcast quality;

(c) that in other cases, also, it may be necessary to synchronize a number of audio and/or video signals with each other;

(d) that no single method or system is in general use which will meet all the different possible requirements for synchronization;

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* This Question replaces Question 16/11, which is hereby cancelled.

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the required capabilities of such methods of synchronizing;

2. what methods are applicable to the synchronization of the various types of recording and reproducing devices?

STUDY PROGRAMME 22A/11

RECORDING OF CODED INFORMATION ON THE CUE TRACK OF TELEVISION MAGNETIC TAPES

(1970)

The C.C.I.R.,

CONSIDERING

(a) that the use of coded signals recorded on the cue track of television tapes for various purposes, is increasing rapidly;

(b) that such coded signals could also be useful in connection with the international exchange of television tape programmes;

(c) that for the latter purpose a unique system of coded signals should be adopted;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the type of information required to be recorded on the cue track, for the international exchange of programmes;

2. the code to be used to record this information.

QUESTION 23-1/11 *

FEASIBILITY OF DIRECT TELEVISION BROADCASTING FROM SATELLITES

(1966 – 1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971, made provision for the broadcasting-satellite service in several frequency bands;

(b) that there are many parts of the world with little or no broadcasting service;

(c) that there is considerable interest in the possibility of broadcasting from satellites;

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* This Question, which is analogous to Question 34-1/10, should be studied in connection with Questions 20-2/10 and 5-2/11. Contributions to the study of this Question should be brought to the attention of participants in the work of Study Group 10.

(d) that, in view of the extensive use of existing broadcasting bands below 1 GHz in some regions, there is particular interest in the feasibility of using frequencies above 1 GHz;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the satellite orbits most satisfactory for direct broadcasting to the general public from satellites;

2. what accuracy of positioning or station keeping can be achieved;

3. what maximum primary power is likely to be available to operate a transmitter in a satellite, and what other factors associated with the space environment operate to limit the power that could be developed in the transmitter at the various frequencies that might be used;

4. what gain, directivity and stability of orientation are attainable for satellite transmitting antennae at various frequencies;

5. what is the probable working life of a satellite, bearing in mind that failure in accurate positioning or antenna orientation may end the useful life?

QUESTION 25-1/11 *

STANDARDS FOR TELEVISION SYSTEMS USING DIGITAL MODULATION

(1972 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that the C.C.I.T.T. is studying the transmission standards to be used in future digitally coded systems for the transmission of television signals;

(b) that, in view of the development of digital methods of processing, transmitting and recording signals, it is possible that these techniques will be widely used in television;

(c) 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;

(d) 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;

(e) that digital signal processing, if used in television studios, could lead to improved reliability and performance;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what methods should 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 direct broadcasting from terrestrial transmitters and from satellites;

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* This Question is analogous to Questions 39/10 and 10-1/CMTT.

2. is there a single method of digital coding which would be suitable for all the uses described in § 1;

   Note. — Account should also be taken of studies being carried out under Question 10-1/CMTT, § 2;

3. what digital standards should be recommended for the applications mentioned in § 1;

   Note. — Account should also be taken of studies being carried out under Question 10-1/CMTT, § 3;

4. what is the simplest and most effective technique for monitoring digitally coded television and associated sound signals within the studio complex?

STUDY PROGRAMME 25A/11 *

STANDARDS FOR TELEVISION SYSTEMS USING DIGITAL MODULATION

Reduction in the bit rate in the digital coding of television signals

(1974)

The C.C.I.R.,

CONSIDERING

that the large channel capacity required for the digital transmission and recording of television signals introduces problems which are both technical and economic;

UNANIMOUSLY DECIDES that the following studies should be carried out:

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, without perceptible reduction in the quality of the reproduced picture.

STUDY PROGRAMME 25B/11 *

STANDARDS FOR TELEVISION SYSTEMS USING DIGITAL MODULATION

Encoding of colour television signals

(1974)

The C.C.I.R.

UNANIMOUSLY DECIDES that the following studies should be carried out:

comparison between the digital coding of the composite colour television signal for the system NTSC, PAL and SECAM, and the coding of the separate signal components, such as the luminance and colour-difference signals or the primary colour signals, R, G and B.

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* Contributions in response to this Study Programme are of interest to the CMTT.

QUESTION 26/11 *

CHARACTERISTICS OF TELEVISION RECEIVERS AND RECEIVING ANTENNAE

(1974)

The C.C.I.R.,

CONSIDERING

(a) the importance of certain characteristics of television receiving installations, receivers and antennae in the work of Administrative Conferences, the I.F.R.B. and other organizations concerned with establishing frequency plans;

(b) that under the organization of the C.C.I.R., Study Group 11 should deal with matters concerning television receiving installations, receivers and antennae;

(c) that in conformity with Opinion 32, account should be taken of the methods of measuring characteristics specified by the International Electrotechnical Commission (IEC);

(d) that in view of advances in technique, Recommendations 331-3, 332-3, 333 and 239-1 appear to need revision;

UNANIMOUSLY DECIDES that the following question should be studied:

what are the principal characteristics of television receivers and antennae for which values might be useful in frequency planning undertaken by Administrative Conferences, the I.F.R.B. and other organizations concerned?

STUDY PROGRAMME 26A/11 **

CHARACTERISTICS OF TELEVISION RECEIVERS AND RECEIVING ANTENNAE

(1974)

The C.C.I.R.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. assembly of the necessary data, duly brought up to date, of the principal characteristics of television receiving installations, receivers and antennae, which might be useful in frequency planning work, such as that of Administrative Conferences, the I.F.R.B. and other organizations concerned, in a special section of the C.C.I.R. books. Such studies should take account of Opinion 32 relating to the International Electrotechnical Commission (IEC), particularly Publication 107 or any other IEC document that may replace it;

2. to co-ordinate Report 483-1 concerning low-cost television receivers, and Report 473-1, concerning broadcasting-satellite reception (television) systems, with the results of the present study.

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* 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 27/11 *

HIGH-DEFINITION TELEVISION

(1974)

The C.C.I.R.,

CONSIDERING

(a) that present systems for television are not ideal in respect to picture quality, for example sharpness and reality;

(b) that transmission of wideband video signals in bands for terrestrial and broadcasting-satellite systems as well as over cable systems will be possible;

(c) that progress in the development of displays will permit the use of large-screen, high-definition television displays for domestic reception;

(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 standards should be recommended for high-definition television systems intended for broadcasting to the general public?

Note. — Account should be taken of the following factors:

— the target to be set for picture quality at the next stage of development (colour and monochrome) and for sound quality;

— the scanning standards and the resulting necessary video-frequency bandwidth;

— the transmission system, including the methods of modulation and multiplexing for both the video and the sound channels;

— determination of the frequency bands most appropriate for this service;

— the production of reliable receivers at reasonable cost;

— compatibility with existing systems of television;

— susceptibility to interference in the international exchange of programmes.

QUESTION 28/11

INTERNATIONAL EXCHANGE OF RECORDED TELEVISION PROGRAMMES

Addition to television programmes (on film or magnetic materials) of data for controlling automatic equipment

(1974)

The C.C.I.R.,

CONSIDERING

(a) that automatic programming of television broadcasting stations is in widespread use in several countries, and gaining interest in others;

* This Question is identical to Question 12/CMTT.

(b) that all relevant parameters of the controlling data, such as format, medium, signal specifications, required for the operation of automatic equipment should be standardized, in order to facilitate the international exchange of recorded television programmes;

UNANIMOUSLY DECIDES that the following question should be studied:

what information should be provided and by what means on or with television recordings, for example, tape and film programme, for the control of automatic station equipment?

QUESTION 29/11

BROADCASTING OF STILL IMAGES

(1974)

The C.C.I.R.,

CONSIDERING

(a) that information may be conveyed by still images composed of pictures and/or alpha-numeric characters;

(b) that still picture signals or digitally encoded alpha-numeric information can be transmitted extremely efficiently, if a memory or recording device is provided at the receiver, and this type of transmission is expected to contribute to an efficient use of the radio-frequency spectrum;

(c) that due to the recent development of memory and printing devices, it may be technically and economically possible to introduce such devices for home use;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what functions should be provided for the broadcasting of information;

2. what transmission standards are suitable for this type of broadcasting;

3. how should the data signal be multiplexed within an existing television broadcasting channel;

4. if no multiplexing is used, what type of television broadcasting channel should be employed;

5. what additional facilities must be incorporated in existing television receivers so that they may display the information and provide, where necessary, an interface for a printer?

STUDY PROGRAMME 29A/11

STILL-IMAGE TRANSMISSION MULTIPLEXED WITH TELEVISION

(1974)

The C.C.I.R.,

CONSIDERING

(a) that it may be desirable, for the purpose of information and/or education services, to transmit still-picture programmes or alpha-numeric information multiplexed with television signals;

(b) that it may be technically possible to transmit still-picture or alpha-numeric information signals and accompanying sound signals without any disturbance to existing television reception;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. methods to be used to multiplex still-picture or alpha-numeric information signals and/or accompanying sound signals within the existing television signals;

2. characteristics to be standardized for the transmission of still-picture or alpha-numeric information signals and/or accompanying sound signals.

QUESTION 30/11 *

METHODS OF REDUCING INTERFERENCE TO THE BROADCASTING SERVICE (TELEVISION) FROM OTHER SERVICES OPERATING IN ADJACENT BANDS

(1974)

The C.C.I.R.,

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;

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?

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* 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 WIRED DISTRIBUTION SYSTEMS FOR TELEVISION SIGNALS

(1974)

The C.C.I.R.,

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 C.C.I.T.T.;

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 C.C.I.R.;

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, C.C.I.R., is requested to draw this Question to the attention of the Director, C.C.I.T.T., which, for its part, may wish to study the specific problems of transmission over cable and of equipment associated with transmission over cable.

QUESTION 32/11 *

SUSCEPTIBILITY OF TELEVISION RECEIVERS TO AMBIENT FIELDS

(1970 - 1974)

The C.C.I.R.,

CONSIDERING

(a) that many television receivers are connected to master antenna systems or community antenna systems, instead of to individual antennae;

(b) that such receivers may respond to ambient fields in addition to the signals being carried in the distribution system;

(c) that such response to ambient fields can cause interference to reception of the wanted signals;

* This Question replaces Question 15/1.

UNANIMOUSLY DECIDES that the following question should be studied:

1. how may the susceptibility of television receivers to ambient fields be reduced;

2. what criteria should be recommended for susceptibility of television receivers to ambient fields?

Note. — The following documents of the International Electrotechnical Commission (IEC) concerning radio receivers using various classes of emission refer to methods of measurement which might be adapted to television receivers:

12A (Central Office) 40

Methods of measurement on radio receivers for amplitude-modulation, double-sideband and complete-carrier emissions.

Measurement of susceptibility to interference.

12A (Central Office) 42

Methods of measurement on radio receivers for frequency-modulation emissions.

Measurement of susceptibility to impulsive interference.

QUESTION 33/11 *

TYPICAL RECEIVERS FOR THE BROADCASTING SERVICE (TELEVISION)

(1974)

The C.C.I.R.,

CONSIDERING

(a) that receivers for television-broadcasting produced in various countries are now divided into categories with widely different costs and technical characteristics;

(b) that it appears desirable to determine specifications of certain categories of typical receivers, to be used in special conditions, for example, low cost receivers for monochrome television broadcasting for community viewing;

(c) that it is difficult to determine the specifications of typical television receivers without taking into account their division into categories;

(d) that an internationally agreed classification of receivers would greatly facilitate the preparation of detailed specifications for typical receivers;

UNANIMOUSLY DECIDES that the following question should be studied:

1. into what categories should receivers for television broadcasting be divided;

2. which tables of characteristics for such categories of television receivers should be established?

Note. — Some information and proposals connected with this Question are to be found in Docs. II/6 (C.C.I.R. Secretariat), II/23 (France), II/31 (U.S.S.R.), 1966–1969 and also in Recommendation 415. See also Report 483-1 "Specifications for low-cost television receivers", where two types of receiver are described.

* This Question, together with Question 41/10, replaces Question 17/1. Results arising from this study should be communicated to Study Group 1.

DECISION 17

PROTECTION RATIOS FOR FREQUENCY SHARING BETWEEN BROADCASTING-SATELLITE SYSTEMS AND TERRESTRIAL BROADCASTING SYSTEMS (TELEVISION)

(1974)

The C.C.I.R.,

CONSIDERING

(a) that Recommendation No. Spa2-10, § 4 of the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971 recommends "that the C.C.I.R. urgently study the sharing criteria to be applied to frequency sharing between the broadcasting-satellite service and the terrestrial broadcasting service in the band 620 to 790 MHz..." and study in particular, in § 5.1, "the required protection ratio for both 525- and 625-line systems for interference from a frequency modulation television signal into a vestigial-sideband television signal";

(b) that Recommendation No. Spa2-15, § 2.10 recommends that the C.C.I.R. study "the conditions for frequency-sharing in those bands allocated to the broadcasting-satellite service...", and that these conditions depend critically on the protection ratio requirements for television signals;

(c) that Recommendation No. Spa2-12, invites the C.C.I.R. "to study this subject (i.e. technical standards for the assessment of harmful interference) ... for the frequency bands above 28 MHz allocated to space ... and terrestrial radiocommunications";

(d) that Report 634 concludes that additional test data and analysis will be needed to resolve the apparent differences in the interference vulnerability of the various standard television systems;

(e) that several Study Programmes call for the development of sharing criteria among systems which may employ digital techniques for which there are neither measured protection ratios nor agreed test procedures;

(f) that the results of subjective measurements of the protection ratio made by different administrations are difficult to compare unless carried out under standardized test conditions;

UNANIMOUSLY DECIDES

1. that Interim Working Party (IWP) 11/2 should be continued within the general terms of reference of Study Group 11, and with the following specific terms of reference;

1.1 to agree upon and to circulate to the Member Administrations of the C.C.I.R. at the earliest possible date, a standardized set of test conditions and measurement procedures for the subjective and objective determination of protection ratios for interference between television broadcasting-satellite systems and vestigial-sideband television terrestrial broadcasting systems and among satellite television broadcasting systems, taking into account any modulation system under consideration for television broadcasting from satellites;

1.2 to apply wherever possible the recommendations of IWP 11/1 regarding the assessment of television picture quality (see Doc. 11/294 (Report, IWP 11/1) 1970-1974);

1.3 to encourage administrations to participate in a coordinated programme of measurements of protection ratio, utilizing the standardized conditions and procedures, such measurements to encompass all monochrome and colour systems, and all modulation methods likely to be involved in shared frequency operation;

1.4 to prepare draft reports and recommendations that describe the standardized test conditions and measurement procedures, and to compare and interpret the results of the protection ratio measurements for consideration at Interim Study Group Meetings in the period following the XIIIth Plenary Assembly;

2. that IWP 11/2 should as far as possible conduct its work by correspondence;

3. that the results of the work of IWP 11/2 should be reported to Study Group 11 for consideration;

4. that IWP 11/2 should be composed of representatives appointed by the Administrations of Federal Republic of Germany, Brazil, Canada, U.S.A., France, India, Italy, Japan, United Kingdom, Switzerland, U.S.S.R., Yugoslavia (Socialist Federal Republic of), and by the E.B.U.;

5. that the Chairman of the IWP 11/2 shall be a representative of the Administration of Brazil.

OPINION 38 *

EXCHANGE OF MONOCHROME AND COLOUR TELEVISION PROGRAMMES VIA SATELLITES

(1970)

The C.C.I.R.,

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.

OPINION 39-1

CHARACTERISTICS OF TELEVISION ANTENNAE FOR DOMESTIC USE

(1970 - 1974)

The C.C.I.R.,

CONSIDERING

(a) that there may be divergencies of opinion as to whether the International Electrotechnical Commission (IEC) or the C.C.I.R. is the more appropriate organization for the study of questions concerning television antennae for domestic reception;

(b) that, while the determination of definitions and methods of measurement of the various parameters can, in this particular case, be left to the IEC, after examination by the C.C.I.R., the determination of the values for these parameters and the tolerances to be applied to them for planning purposes should be left to the C.C.I.R.;

* This Opinion has been brought to the attention of Study Groups 4, 9 and the CMTT.

(c) that it is desirable that no ambiguity should remain, thus avoiding useless duplication of effort and the existence of a multiplicity of standards and the tolerances to be applied to them;

IS UNANIMOUSLY OF THE OPINION

1. that the C.C.I.R. should determine those parameters of television antennae for domestic reception which are important to its work;

2. that the Director, C.C.I.R., should:

— maintain close liaison with the IEC with a view to obtaining from the IEC appropriate definitions and methods of measurement;

— communicate to the IEC the most appropriate values for these parameters and take all necessary steps to avoid duplication of effort and the existence of a multiplicity of standards.

OPINION 40

SUBJECTIVE ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(1970)

The C.C.I.R.,

CONSIDERING

(a) that it has already done considerable work on the subjective assessment of the quality of television pictures (see Report 405-2);

(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, C.C.I.R., should remain in close contact with the IEC to keep it informed of the wishes of the C.C.I.R. 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 53

SUBJECTIVE ASSESSMENT OF THE QUALITY OF SOUND PROGRAMMES AND TELEVISION PICTURES

(1974)

The C.C.I.R.,

CONSIDERING

(a) that it has already done considerable work on the subjective assessment of the quality of television pictures (see Report 405-2);

(b) that, as a result of this work, it has produced Recommendation 501 which recommends 5-point quality and impairment scales;

(c) that identical 5-point quality and impairment scales could be used for sound programmes (see Report 623);

(d) that the C.C.I.T.T. has provisionally issued Recommendation N. 64 which recommends 5-point quality and impairment scales of which the impairment scale differs from that recommended by the C.C.I.R.;

(e) that it is essential in operational monitoring that the same quality-grading scales are used throughout a broadcasting network;

IS UNANIMOUSLY OF THE OPINION

that the Director, C.C.I.R., should draw the attention of the Director, C.C.I.T.T., to the studies which have been made in the C.C.I.R. and invite the Director, C.C.I.T.T., to consider the revision of the provisional text of Recommendation N. 64 to bring the impairment scale into line with that given in Recommendation 501.

OPINION 54 *

CLASSIFICATION BY CATEGORIES OF TELEVISION RECEIVERS

(1970 – 1974)

The C.C.I.R.,

CONSIDERING

(a) that different groups of receivers exist, e.g. table and portable receivers with a wide range of quality;

(b) that receivers are intended to give either acceptable performance at the lowest possible cost or good performance at a reasonable cost;

(c) that receivers are to be used in different climatic zones;

(d) that different criteria of reliability may be required;

(e) that a classification would clearly facilitate the free exchange of receivers between countries;

(f) that a classification should primarily concern technical criteria, which should take account of the C.C.I.R. Recommendations for the class of emission in question;

(g) that a Question 33/11 on typical television receivers has been set up;

(h) that technical parameters should be defined in accordance with the standard methods of measurements as recommended by the International Electrotechnical Commission (IEC);

(j) that the number of categories should be restricted as much as possible;

IS UNANIMOUSLY OF THE OPINION

1. that the IEC should be invited to prepare a proposal for an appropriate classification of television receivers **;

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* This Opinion, together with Opinion 52, replaces Opinion 33, which was previously published in Volume I.

** See Report 483-1, "Specifications for low-cost television receivers", where two types of receiver are described. These receiver characteristics meet the requirements of Study Group 11.

2. that close cooperation between the IEC and the C.C.I.R. should be established to achieve a common classification;

3. that Administrations and broadcasting organizations should be informed of this Opinion.

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PRINTED IN SWITZERLAND