XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

RECOMMENDATIONS OF THE CCIR, 1990

(ALSO RESOLUTIONS AND OPINIONS)

VOLUME IX – PART 1

FIXED SERVICE USING RADIO-RELAY SYSTEMS

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

Geneva, 1990

CCIR

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

2. The objectives of the CCIR are in particular:

a) to provide the technical bases for use by administrative radio conferences and radiocommunication services for efficient utilization of the radio-frequency spectrum and the geostationary-satellite orbit, bearing in mind the needs of the various radio services;

b) to recommend performance standards for radio systems and technical arrangements which assure their effective and compatible interworking in international telecommunications;

c) to collect, exchange, analyze and disseminate technical information resulting from studies by the CCIR, and other information available, for the development, planning and operation of radio systems, including any necessary special measures required to facilitate the use of such information in developing countries.

* *See also the Constitution of the ITU, Nice, 1989, Chapter 1, Art. 11, No. 84.*

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92-61-04251-1

Geneva, 1990

PLAN OF VOLUMES I TO XV
XVIIth PLENARY ASSEMBLY OF THE CCIR

(Düsseldorf, 1990)

VOLUME I (Recommendations) *Annex to Vol. I* (Reports)	Spectrum utilization and monitoring
VOLUME II (Recommendations) *Annex to Vol. II* (Reports)	Space research and radioastronomy services
VOLUME III (Recommendations) *Annex to Vol. III* (Reports)	Fixed service at frequencies below about 30 MHz
VOLUME IV-1 (Recommendations) *Annex to Vol. IV-1* (Reports)	Fixed-satellite service
VOLUMES IV/IX-2 (Recommendations) *Annex to Vols. IV/IX-2* (Reports)	Frequency sharing and coordination between systems in the fixed-satellite service and radio-relay system
VOLUME V (Recommendations) *Annex to Vol. V* (Reports)	Propagation in non-ionized media
VOLUME VI (Recommendations) *Annex to Vol. VI* (Reports)	Propagation in ionized media
VOLUME VII (Recommendations) *Annex to Vol. VII* (Reports)	Standard frequencies and time signals
VOLUME VIII (Recommendations)	Mobile, radiodetermination, amateur and related satellite services
Annex 1 to Vol. VIII (Reports)	Land mobile service – Amateur service – Amateur satellite service
Annex 2 to Vol. VIII (Reports)	Maritime mobile service
Annex 3 to Vol. VIII (Reports)	Mobile satelllite services (aeronautical, land, maritime, mobile and radiodetermination) – Aeronautical mobile service
VOLUME IX-1 (Recommendations) *Annex to Vol. IX-1* (Reports)	Fixed service using radio-relay systems
VOLUME X-1 (Recommendations) *Annex to Vol. X-1* (Reports)	Broadcasting service (sound)
VOLUMES X/XI-2 (Recommendations) *Annex to Vols. X/XI-2* (Reports)	Broadcasting-satellite service (sound and television)
VOLUMES X/XI-3 (Recommendations) *Annex to Vols. X/XI-3* (Reports)	Sound and television recording
VOLUME XI-1 (Recommendations) *Annex to Vol. XI-1* (Reports)	Broadcasting service (television)
VOLUME XII (Recommendations) *Annex to Vol. XII* (Reports)	Television and sound transmission (CMTT)
VOLUME XIII (Recommendations)	Vocabulary (CCV)
VOLUME XIV	Administrative texts of the CCIR
VOLUME XV-1 (Questions)	Study Groups 1, 12, 5, 6, 7
VOLUME XV-2 (Questions)	Study Group 8
VOLUME XV-3 (Questions)	Study Groups 10, 11, CMTT
VOLUME XV-4 (Questions)	Study Groups 4, 9

All references within the texts to CCIR Recommendations, Reports, Resolutions, Opinions, Decisions and Questions refer to the 1990 edition, unless otherwise noted; i.e., only the basic number is shown.

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DISTRIBUTION OF TEXTS OF THE XVIIth PLENARY ASSEMBLY OF THE CCIR IN VOLUMES I TO XV

Volumes and Annexes I to XV, XVIIth Plenary Assembly, contain all the valid texts of the CCIR and succeed those of the XVIth Plenary Assembly, Dubrovnik, 1986.

1. Recommendations, Resolutions, Opinions are given in Volumes I-XIV and Reports, Decisions in the Annexes to Volumes I-XII.

1.1 *Numbering of texts*

When a Recommendation, Report, Resolution or Opinion is modified, it retains its number to which is added a dash and a figure indicating how many revisions have been made. Within the text of Recommendations, Reports, Resolutions, Opinions and Decisions, however, reference is made only to the basic number (for example Recommendation 253). Such a reference should be interpreted as a reference to the latest version of the text, unless otherwise indicated.

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

1.2 *Recommendations*

Number	Volume	Number	Volume	Number	Volume
48	X-1	368-370	V	479	II
80	X-1	371-373	VI	480	III
106	III	374-376	VII	481-484	IV-1
139	X-1	377, 378	I	485, 486	VII
162	III	380-393	IX-1	487-493	VIII-2
182	I	395-405	IX-1	494	VIII-1
215, 216	X-1	406	IV/IX-2	496	VIII-2
218, 219	VIII-2	407, 408	X/XI-3	497	IX-1
239	I	411, 412	X-1	498	X-1
240	III	415	X-1	500	XI-1
246	III	417	XI-1	501	X/XI-3
257	VIII-2	419	XI-1	502, 503	XII
265	X/XI-3	428	VIII-2	505	XII
266	XI-1	430, 431	XIII	508	I
268	IX-1	433	I	509, 510	II
270	IX-1	434, 435	VI	513-517	II
275, 276	IX-1	436	III	518-520	III
283	IX-1	439	VIII-2	521-524	IV-1
290	IX-1	441	VIII-3	525-530	V
302	IX-1	443	I	531-534	VI
305, 306	IX-1	444	IX-1	535-538	VII
310, 311	V	446	IV-1	539	VIII-1
313	VI	450	X-1	540-542	VIII-2
314	II	452, 453	V	546-550	VIII-3
326	I	454-456	III	552, 553	VIII-3
328, 329	I	457, 458	VII	555-557	IX-1
331, 332	I	460	VII	558	IV/IX-2
335, 336	III	461	XIII	559-562	X-1
337	I	463	IX-1	565	XI-1
338, 339	III	464-466	IV-1	566	X/XI-2
341	V	467, 468	X-1	567-572	XII
342-349	III	469	X/XI-3	573, 574	XIII
352-354	IV-1	470-472	XI-1	575	I
355-359	IV/IX-2	473, 474	XII	576-578	II
362-364	II	475, 476	VIII-2	579, 580	IV-1
367	II	478	VIII-1	581	V

1.2 *Recommendations (cont.)*

Number	Volume	Number	Volume	Number	Volume
582, 583	VII	625-631	VIII-2	676-682	V
584	VIII-1	632, 633	VIII-3	683, 684	VI
585-589	VIII-2	634-637	IX	685, 686	VII
591	VIII-3	638-641	X-1	687	VIII-1
592-596	IX-1	642	X-1	688-693	VIII-2
597-599	X-1	643, 644	X-1	694	VIII-3
600	X/XI-2	645	X-1 + XII	695-701	IX-1
601	XI-1	646, 647	X-1	702-704	X-1
602	X/XI-3	648, 649	X/XI-3	705	X-1 (1)
603-606	XII	650-652	X/XI-2	706-708	X-1
607, 608	XIII	653-656	XI-1	709-711	XI-1
609-611	II	657	X/XI-3	712	X/XI-2
612, 613	III	658-661	XII	713-716	X/XI-3
614	IV-1	662-666	XIII	717-721	XII
615	IV/IX-2	667-669	I	722	XII
616-620	V	670-673	IV-1	723, 724	XII
622-624	VIII-1	674, 675	IV/IX-2		

1.3 *Reports*

Number	Volume	Number	Volume	Number	Volume
19	III	319	VIII-1	472	X-1
122	XI-1	322	VI (1)	473	X/XI-2
137	IX-1	324	I	476	XI-1
181	I	327	III	478	XI-1
183	III	336*	V	481-485	XI-1
195	III	338	V	488	XII
197	III	340	VI (1)	491	XII
203	III	342	VI	493	XII
208	IV-1	345	III	496, 497	XII
209	IV/IX-2	347	III	499	VIII-1
212	IV-1	349	III	500, 501	VIII-2
214	IV-1	354-357	III	509	VIII-3
215	X/XI-2	358	VIII-1	516	X-1
222	II	363, 364	VII	518	VII
224	II	371, 372	I	521, 522	I
226	II	375, 376	IX-1	525, 526	I
227*	V	378-380	IX-1	528	I
228, 229	V	382	IV/IX-2	533	I
238, 239	V	384	IV-1	535, 536	II
249-251	VI	386-388	IV/IX-2	538	II
252	VI (1)	390, 391	IV-1	540, 541	II
253-255	VI	393	IV/IX-2	543	II
258-260	VI	395	II	546	II
262, 263	VI	401	X-1	548	II
265, 266	VI	404	XI-1	549-551	III
267	VII	409	XI-1	552-558	IV-1
270, 271	VII	411, 412	XII	560, 561	IV-1
272, 273	I	430-432	VI	562-565	V
275-277	I	435-437	III	567	V
279	I	439	VII	569	V
285	IX-1	443	IX-1	571	VI
287*	IX-1	445	IX-1	574, 575	VI
289*	IX-1	448, 449	IV/IX-2	576-580	VII
292	X-1	451	IV-1	584, 585	VIII-2
294	X/XI-3	453-455	IV-1	588	VIII-2
300	X-1	456	II	607	IX-1
302-304	X-1	458	X-1	610*	IX-1
311-313	XI-1	463, 464	X-1	612-615	IX-1
314	XII	468, 469	X/XI-3	622	X/XI-3

* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3 *Reports (cont.)*

Number	Volume	Number	Volume	Number	Volume
624-626	XI-1	790-793	IV/IX-2	972-979	I
628, 629	XI-1	795	X-1	980-985	II
630	X/XI-3	798, 799	X-1	987, 988	II
631-634	X/XI-2	801, 802	XI-1	989-996	III
635-637	XII	803	X/XI-3	997-1004	IV-1
639	XII	804, 805	XI-1	1005, 1006	IV/IX-2
642, 643	XII	807-812	X/XI-2	1007-1010	V
646-648	XII	814	X/XI-2	1011, 1012	VI
651	I	815, 816	XII	1016, 1017	VII
654-656	I	818-823	XII	1018-1025	VIII-1
659	I	826-842	I	1026-1033	VIII-2
662-668	I	843-854	II	1035-1039	VIII-2
670, 671	I	857	III	1041-1044	VIII-2
672-674	II	859-865	III	1045	VIII-3
676-680	II	867-870	IV-1	1047-1051	VIII-3
682-685	II	872-875	IV-1	1052-1057	IX-1
687	II	876, 877	IV/IX-2	1058-1061	X-1
692-697	II	879, 880	V	1063-1072	X-1
699, 700	II	882-885	V	1073-1076	X/XI-2
701-704	III	886-895	VI	1077-1089	XI-1
706	IV-1	896-898	VII	1090-1092	XII
709	IV/IX-2	899-904	VIII-1	1094-1096	XII
710	IV-1	908	VIII-2	1097-1118	I
712, 713	IV-1	910, 911	VIII-2	1119-1126	II
714-724	V	913-915	VIII-2	1127-1133	III
725-729	VI	917-923	VIII-3	1134-1141	IV-1
731, 732	VII	925-927	VIII-3	1142, 1143	IV/IX-2
735, 736	VII	929	VIII-3 (1)	1144-1148	V
738	VII	930-932	IX-1	1149-1151	VI
739-742	VIII-1	934	IX-1	1152	VII
743, 744	VIII-2	936-938	IX-1	1153-1157	VIII-1
748, 749	VIII-2	940-942	IX-1	1158-1168	VIII-2
751	VIII-3	943-947	X-1	1169-1186	VIII-3
760-764	VIII-3	950	X/XI-3	1187-1197	IX-1
766	VIII-3	951-955	X/XI-2	1198	X-1 (1)
770-773	VIII-3	956	XI-1	1199-1204	X-1
774, 775	VIII-2	958, 959	XI-1	1205-1226	XI-1
778	VIII-1	961, 962	XI-1	1227, 1228	X/XI-2
780*	IX-1	963, 964	X/XI-3	1229-1233	X/XI-3
781-789	IX-1	965-970	XII	1234-1241	XII

* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3.1 *Note concerning Reports*

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

1.4 *Resolutions*

Number	Volume	Number	Volume	Number	Volume
4	VI	62	I	86, 87	XIV
14	VII	63	VI	88	I
15	I	64	X-1	89	XIII
20	VIII-1	71	I	95	XIV
23	XIII	72, 73	V	97-109	XIV
24	XIV	74	VI	110	I
33	XIV	76	X-1	111, 112	VI
39	XIV	78	XIII	113, 114	XIII
61	XIV	79-83	XIV		

1.5 *Opinions*

Number	Volume	Number	Volume	Number	Volume
2	I	45	VI	73	VIII-1
11	I	49	VIII-1	74	X-1 + X/XI-3
14	IX-1	50	IX-1	75	XI-1 + X/XI-3
15	X-1	51	X-1	77	XIV
16	X/XI-3	56	IV-1	79-81	XIV
22, 23	VI	59	X-1	82	VI
26-28	VII	63	XIV	83	XI-1
32	I	64	I	84	XIV
35	I	65	XIV	85	VI
38	XI-1	66	III	87, 88	XIV
40	XI-1	67-69	VI	89	IX-1
42	VIII-1	71-72	VII	90	X/XI-3
43	VIII-2				

1.6 *Decisions*

Number	Volume	Number	Volume	Number	Volume
2	IV-1	60	XI-1	87	IV/IX-2
4, 5	V	63	III	88, 89	IX-1
6	VI	64	IV-1	90, 91	XI-1
9	VI	65	VII	93	X/XI-2
11	VI	67, 68	XII	94	X-1
18	X-1 + XI-1 + XII	69	VIII-1	95	X-1 + XI-1
		70	IV-1	96, 97	X-1
27	I	71	VIII-3	98	X-1 + XII
42	XI-1	72	X-1 + XI-1	99	X-1
43	X/XI-2	76	IV-1 + X-1 + XI-1 + XII	100	I
51	X/XI-2			101	II
53, 54	I	77	XII	102	V
56	I	78, 79	X-1	103	VIII-3
57	VI	80	XI-1	105	XIV
58	XI-1	81	VIII-3	106	XI-1
59	X/XI-3	83-86	VI		

2. **Questions** (Vols. XV-1, XV-2, XV-3, XV-4)

2.1 *Numbering of texts*

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.

Note – The numbers of the Questions of Study Groups 7, 9 and 12 start from 101. In the case of Study Groups 7 and 9, this was caused by the need to merge the Questions of former Study Groups 2 and 7 and Study Groups 3 and 9, respectively. In the case of Study Group 12, the renumbering was due to the requirement to transfer Questions from other Study Groups.

2.2 *Assignment of Questions*

In the plan shown on page II, the relevant Volume XV in which Questions of each Study Group can be found is indicated. A summary table of all Questions, with their titles, former and new numbers is to be found in Volume XIV.

2.3 *References to Questions*

As detailed in Resolution 109, the Plenary Assembly approved the Questions and assigned them to the Study Groups for consideration. The Plenary Assembly also decided to discontinue Study Programmes. Resolution 109 therefore identifies those Study Programmes which were approved for conversion into new Questions or for amalgamation with existing Questions. It should be noted that references to Questions and Study Programmes contained in the texts of Recommendations and Reports of Volumes I to XIII are still those which were in force during the study period 1986-1990.

Where appropriate, the Questions give references to the former Study Programmes or Questions from which they have been derived. New numbers have been given to those Questions which have been derived from Study Programmes or transferred to a different Study Group.

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VOLUME IX-1

FIXED SERVICE USING RADIO-RELAY SYSTEMS

(Study Group 9)

TABLE OF CONTENTS

Page

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PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

NUMERICAL INDEX OF TEXTS

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STUDY GROUP 9

FIXED SERVICE USING RADIO-RELAY SYSTEMS

Terms of reference:

To study questions relating to line-of-sight and trans-horizon radio-relay systems operating via terrestrial stations at frequencies above about 30 MHz.

1986-1990	*Chairman:*	J. VERRÉE (France)
	Vice-Chairmen:	M. MUROTANI (Japan)
		H. WILLENBERG (Germany (Federal Republic of))

The Study Group 9 texts which take into account the work carried out during the 1986-1990 study period, are published for the last time in this Volume.

As from the next study period, in conformity with Resolution 61 adopted at the XVIIth Plenary Assembly, Düsseldorf (May-June 1990), questions relating to former Study Group 9 together with questions of the former Study Group 3 will be dealt with by a new Study Group (Study Group 9).

The scope of the work which will be undertaken and the names of the Chairman and Vice-Chairmen concerned are given below:

STUDY GROUP 9

FIXED SERVICE

Scope:

Systems and networks of the fixed service operating via terrestrial stations.

1990-1994	*Chairman:*	M. MUROTANI (Japan)
	Vice-Chairmen:	R. COLES (Canada)
		O. M. LANGER (Germany (Federal Republic of))
		V. MINKIN (USSR)
		G. HURT (United States of America)
		R. MOUMTAZ (Lebanon)

INTRODUCTION BY THE CHAIRMAN OF STUDY GROUP 9

The period 1986-1990 included preparations for and the holding of the ORB-88 Conference (Geneva, September-October 1988), the IXth CCITT Plenary Assembly (Melbourne, November 1988), which adopted Recommendations specifying the synchronous digital hierarchy, and the Plenipotentiary Conference (Nice, May-June 1989), which *inter alia* decided to convene a conference for dealing with frequency allocations in certain parts of the spectrum in 1992.

Study Group 9's work therefore tended to be organized around the above dates. The Interim Meeting in the autumn of 1987 set out the terms of reference of the Joint Interim Working Party JIWP-ORB(2), which prepared the technical bases for the ORB-88 Conference, while the Final Meeting in the autumn of 1989 began the work arising from the decisions taken by the CCITT and the Plenipotentiary Conference.

Study Group 9 extended its relations with other Study Groups:

- of the CCITT (Study Groups XV and XVIII), regarding the use of radio-relay systems in digital networks (ISDN and synchronous networks);
- of the CCIR, with regard in particular to common problems due to frequency sharing, including:
  - Study Group 2, for space research and operation;
  - Study Group 5, concerning the propagation data required for the study of system performance or frequency sharing and coordination;
  - Study Group 8, concerning terrestrial mobile and mobile-satellite services, and the use of cellular type mobile systems as fixed systems in reply to requests by the Plan Committees for Latin America (1985) and for Asia and Oceania (1986);
  - Study Groups 10 and 11, for terrestrial broadcasting and broadcasting-satellite services.

Frequency sharing between radio-relay systems and fixed-satellite service systems was studied jointly by Study Groups 4 and 9 in a Joint Working Party set up during the meetings, in accordance with long-established practice.

About 90 contributions were sent by administrations for the Interim Meeting and over 110 for the Final Meeting, to which should be added the many documents submitted by other CCITT and CCIR Study Groups and the IFRB to Study Group 9 for information or for action.

As in the past, in order to deal with this substantial workload, Study Group 9 set up five Working Groups, roughly related to the different sections of Volume IX, namely:

- performance objectives, propagation and interference effects;
- radio-frequency channel arrangements and spectrum utilization;
- characteristics, interconnection, maintenance;
- radio-relay systems for special applications;
- frequency sharing with other services.

The problems covered by Study Group 9 are considered below in that order.

1. Performance objectives, propagation and interference effects

Performance objectives for digital radio-relay systems were specified and completed on the basis of the many contributions received and information exchanged with CCITT Study Group XVIII.

A substantial amount of new information was added to Report 930, in particular concerning interference from the fixed-satellite service, the performance of real digital links, evaluation of the errored seconds objective at 64 kbit/s and criteria for determining the residual bit error ratio (RBER). For the RBER, a 15 min integration period has been provisionally adopted, although other proposals have been made (Annex II) and the problem is to be studied further.

The new Recommendations 696 and 697 deal with the medium-grade and local-grade portions of an ISDN connection; the corresponding Reports 1052 and 1053 have been changed accordingly.

We now therefore have a set of Recommendations concerning the different parts of an ISDN link (see Table I). Further details need to be worked out, however, concerning the RBER and the availability objective for the local-grade portion of an ISDN link, which depends a great deal on local conditions and on the maintenance procedures provided to re-establish the service (see Report 1053).

For the continuation of these studies, Study Group 9 has drawn up a note for CCITT Study Group XVIII (Document 9/430).

Performance and availability degradations arising from interference from other sources were considered in detail. The problem is covered in the new Report 1187, which refers to the new Report 1196 (see Section 9F) with regard to interference due to frequency sharing with other radio services on a primary basis (Questions 17/9 and 30/9); this Report includes some parts contained in the earlier Report 779, which was deleted, and in Report 937 concerning spurious emissions of radio-relay systems.

In order to clarify studies on degradations arising from interference, old Questions 23/9 and 28/9 were merged into a new draft Question 28/9, which has given rise to three new Study Programmes, with Study Programme 28C/9 taking over from Study Programme 23A/9, which has been deleted.

Some recent data on interference caused by terrain scattering had been added in Report 1054.

Report 784 on the effects of propagation on the design and operation of line-of-sight radio-relay systems has been substantially extended on the basis of the most recent data and improvements introduced in digital systems for multi-state modulation processes (such as 64-QAM).

The information needed to improve the methods of calculating digital radio performance was mentioned in a note to Study Group 5 (Document 9/453 (Rev.1)).

On the subject of availability, a new Recommendation 695 establishes objectives for real digital radio-relay links forming part of a high-grade circuit within an ISDN, on the basis of a percentage of unavailability proportional to length, for lengths between 280 and 2500 km.

2. Radio-frequency channel arrangements and spectrum utilization

2.1 *Radio-frequency channel arrangements*

Further technological developments have occurred, leading to an increase in unit channel capacity arising from the use of modulations with many significant states.

The new maximum bit rates are 70 Mbit/s in the 2 GHz band (Recommendation 283) and 140 Mbit/s or 155 Mbit/s (STM-1) in the 4 GHz band (Recommendation 382) or the lower 6 GHz bands (Recommendation 383).

A first review has been made of the use of existing radio-frequency channel arrangements for a transmission rate corresponding to the first level of the synchronous digital hierarchy defined by the CCITT in 1988 in its Recommendation G.707, namely 155.52 Mbit/s (STM-1).

All the Recommendations concerning the 2 GHz, 4 GHz, lower 6 GHz, upper 6 GHz, 11 GHz, 13 GHz, 15 GHz and 19 GHz bands are therefore adjusted accordingly.

Report 934 gives detailed information on the establishment of high capacity digital systems using 16-QAM, 64-QAM and 256-QAM modulations in frequency bands below about 10 GHz; it also mentions special conditions of use with common transmit-receive antennas.

Report 1055 on small and medium capacity systems operating in bands below about 10 GHz now includes a new § 2.3 dealing with the 2 GHz band, a new Annex IV and a reference to the new Recommendation 701 (see Section 9E).

Report 782 (11 GHz band) has been retained and extended with a new Annex III, concerning synchronous digital hierarchy signal transmission with 8-PSK modulation.

The wording of Report 607 (10.5-10.68 GHz and 11.7-15.35 GHz) has been rearranged and clarified and two new Annexes have been added describing the use of the 14.25-14.5 GHz band with channel spacings of 28 and 20 MHz respectively.

A new 17 GHz frequency limit has been adopted in relation to high-frequency radio-relay systems.

Texts on the subject have therefore had to be rearranged: Question 16/9 and its Study Programmes now relate to systems operating above about 17 GHz, while as a corollary, Questions 34/9 and 35/9 and their Study Programmes are now limited to systems operating below about 17 GHz.

Report 936, after deletion of the old § 2, now concerns only the arrangements of radio-frequency channels operating above about 17 GHz.

For television transmission using vestigial sideband amplitude modulation (AM-VSD), Report 1056 contains a new Annex IV concerning a system used in Europe in the band 12.1-12.5 GHz.

Table II lists all the texts concerning radio-frequency channel arrangements for digital radio-relay systems.

2.2 *General system characteristics*

This section contains texts concerning various technical problems which arise in the design and implementation of radio-relay systems and which have a direct or indirect effect on radio-frequency channel arrangements or spectrum utilization.

For the characteristics of digital radio-relay systems below about 17 GHz, the new version of Report 378 has been clarified and considerably developed in the light of the most recent data. It includes information on:

- 16-QAM and 256-QAM modulations and 16-TCM to 512-TCM trellis coded modulations, which provide greater spectrum efficiency;
- forward error correction (without return channel);
- evaluation of multipath fading effects (signature, waveform factor);
- available countermeasures (adaptive equalizers, multi-carrier transmission, transmitter power control, cross-polar interference cancellers).

New Report 1190 provides a first approach to the problem of inserting radio-relay systems in a synchronous digital network and reviews the subjects that need studying. The increase in the bit rate from 140 to 155 Mbit/s is great enough to raise problems with the use of existing radio channels; similarly the synchronous frame including available overhead bytes and their use for the specific requirements for the radio-relay systems is to be considered.

In view of the urgency of these studies, an Interim Working Party IWP 9/5 has been set up by Decision 88 under the chairmanship of Mr. Pietroiusti (Italy).

These studies are to be conducted in liaison with CCITT Study Groups XV and XVIII. Study Group 9 has drawn up a note for CCITT Study Group XVIII (Document 9/451(Rev.1)). It has also prepared Opinion 89 to draw the CCITT's attention to the desirability for radio-relay systems of a synchronous interface rate below the STM-1 level (e.g. 51.84 Mbit/s) better adapted to the unit bit rate transported by an individual carrier in a radio-frequency channel.

The new version of Report 783 concerning characteristics of radio-relay systems in frequency bands above about 17 GHz has been completely redrafted; it mentions in particular the need to offset economic considerations against desired availability in the choice of hop lengths; systems operating in these frequency bands are particularly well adapted to temporary or transportable links.

Report 376 concerning diversity techniques contains information on new methods of processing signals and their application to high speed modulation digital radio-relay systems.

Reference radiation patterns for radio-relay system antennas for use in coordination and interference assessment between about 1 and 40 GHz are dealt with in new Recommendation 699 for rotationally symmetrical antennas where D/λ is not greater than 100. Report 614 has been extended for D/λ ratios between 100 and 200 and gives an example of a radiation pattern for a high performance antenna.

For frequency tolerances, Report 785 contains new information on carrier sources, such as SAW devices and dielectric resonators.

Report 937 on spurious emissions of radio-relay systems has lost the sections incorporated in the new Report 1187 (see Section 9A) and now includes three new Annexes, III, IV and V, on digital radio-relay systems.

The new Report 1188 deals with transmitter power and repeater distance for systems operating in the band 1 to about 10 GHz.

3. Interconnection characteristics (baseband and intermediate frequency)

All these texts have remained practically stationary.

It may be worth mentioning the simultaneous transmission of analogue and digital signals on analogue radio-relay systems, which is still topical owing to the considerable development of existing analogue networks and the possibilities offered by the introduction of MAC-type television signals.

Report 786 contains new information on data transmission in the telephone band (1544 Mbit/s with 256-QAM modulation replacing a 60-channel supergroup) and on the use of MAC-type signals for electronic news gathering.

Obsolete Reports 284-2, 374 and 939 have been deleted.

4. Maintenance

For the supervision and protection of digital systems, Report 787 has been extended on the basis of new experience with systems in use and mentions the use of available overhead in the synchronous digital hierarchy frame as well as the problem of connecting the systems with a telecommunications management network (Q-interfaces).

The new Recommendation 700 defines the performance measurement algorithm for digital radio-relay links at the system bit rate interface. Report 613 on performance measurements for digital radio-relay systems has been extended (new § 5 and 6).

The new Study Programme 37A/9 concerns measurements on digital radio-relay systems.

5. Radio-relay systems for special applications

5.1 *Line-of-sight systems*

These are simple systems generally intended for rural areas, which are therefore of special interest to developing countries.

For subscriber telephone connections, a new table has been added to Report 380 with a summary of frequency plans for point-to-multipoint systems.

For general communications, the texts concerning point-to-multipoint systems (P-MP) have been extended.

In Report 940, Annexes I (Multipoint distribution services) and II (Packet radio systems) have been updated.

Report 1057 on point-to-multipoint systems utilizing time division multiple access (TDMA) techniques has been extended and gives 12 examples of systems operating on frequencies between 150 MHz and 26 GHz.

The new Report 1193 deals with requirements for TDMA point-to-multipoint systems used in the local grade portion of an ISDN connection; the data are still theoretical or experimental and further information has been requested (new Study Programme 27B/9).

New Recommendation 701 concerns radio-frequency channel arrangements for analogue and digital point-to-multipoint radio systems operating in frequency bands in the range 1.427-2.690 GHz; it is based on a uniform plan with 0.5 MHz spacing and applies to systems carrying of the order of 10 to 120 telephone channels or a bit rate of the order of 1 to 8 Mbit/s or the equivalent.

The new Report 1192 deals with the application of cellular type mobile radiocommunication systems for use as fixed systems; the problem has been tackled in liaison with Study Group 8, mainly Interim Working Party 8/13, and Question 38/9 has been revised.

Lastly, a new Question 142/9 has been prepared for the study of radio local area networks (RLANs), which can be used, for instance, to provide communications between computers within the workplace.

5.2 *Trans-horizon radio-relay systems*

This new sub-section contains all the texts concerning trans-horizon radio-relay systems, except for those concerning performance (Recommendations 396, 397 and 593), which have been kept close to similar texts in Section 9A.

Report 285 on propagation effects contains more details concerning diversity reception, adaptive equalization and the comparative evaluation of modems.

The new Recommendation 698 deals with preferred frequency bands for trans-horizon radio-relay systems, while the new Report 1191 considers factors which affect the choice of these bands, drawing attention in particular to the problems of frequency sharing with space radiocommunication systems and line-of-sight radio-relay systems.

Recommendation 302 on the limitation of interference from trans-horizon radio-relay systems has been brought up to date, with regard to sharing with space radiocommunication systems.

6. Frequency sharing with other services

6.1 *General*

The problems of frequency sharing with other services are very important, as they have a direct effect on the feasibility, cost and performance levels of radio-relay systems. Sharing criteria should therefore be defined in relation to the protection criteria applied to the various radio-relay systems in different frequency bands. This means defining models which can be considered as representative and using a methodology which is generally applicable.

A new Report 1196 has been prepared to that effect, which is relevant to the general problem of interference considered under Question 28/9 and in Report 1187 (see Section 9A); apart from system models, attention should be given to propagation models and path factors to assess the probability of interference.

6.2 *Sharing with terrestrial and satellite-broadcasting services*

The new Report 1189 deals with the protection of radio-relay systems against interference from the broadcasting-satellite service in the band 22.5-23 GHz. It considers a model 64-QAM digital link with a 40 MHz receiver bandwidth, as well as the effect of differential fading.

The new Report 1194 deals with sharing with the broadcasting service (television) in the band 790-862 MHz for a PAL signal and an FM radio-relay telephone system.

6.3 *Sharing with the space research service*

The new Report 1197 deals with sharing considerations near 2 GHz (2025-2210 MHz and 2200-2290 MHz in accordance with Radio Regulations 747 and 750) with near-Earth space research systems established in conformity with Article 14 of the Radio Regulations. It considers in particular the case of low-orbit satellites (300 km and 1200 km altitude) and digital radio-relay systems. Any flexibility in pfd limits would clearly depend directly on the type of system model considered.

With a view to continuing joint activities, Study Group 9 has drawn up a note for Study Group 2 (Doc. 9/427).

6.4 *Sharing with the aeronautical mobile-satellite service*

In response to Study Group 8's request regarding the bands 1.5/1.6 GHz, Study Group 9 has prepared the new Report 1195 and a Note to Study Group 8 (Doc. 9/437); it may be noted that few administrations operate the fixed service on a shared primary basis with the aeronautical mobile-satellite service in these bands.

6.5 *Sharing with the fixed-satellite service*

Frequency sharing between radio-relay systems and fixed-satellite service systems was studied by the Joint Working Party of Study Groups 4 and 9. The relevant texts are published in Part 2 of Volumes IV and IX.

Using satellites on slightly inclined geostationary orbits can lead to a saving in the fuel needed for north-south station-keeping and can substantially extend their operational life. This practice, however, has unfavourable effects on the satellite system itself and on the interference which can be caused to other radio-frequency spectrum users, especially the terrestrial services. The new Report 1142 gives an account of preliminary research into this problem, though more studies are needed regarding the system models to be used and interference reduction techniques.

The new Recommendation 674 defines power flux-density limits needed to identify administrations affected by the application of Article 14 of the Radio Regulations in the frequency band 11.7-12.2 GHz in Region 2; these limits are the ones provided in the Radio Regulations for the band 10.7-11.7 GHz. The issue is addressed in the new Report 1143.

A new Annex V dealing with the application of current power flux-density limits to digital radio-relay systems has been added to Report 387 concerning the protection of line-of-sight radio-relay systems between 1 and 23 GHz.

With regard to the protection of geostationary-satellite orbits, the interpretation of Recommendation 406 has been clarified (new Note 1). In Report 393, which deals with the geometric relations between the maximum radiation directions of radio-relay antennas and satellite orbits, new data has been supplied by Canada, Japan and the IFRB (digital formulae and analytical methods adapted to the use of computers).

For the determination of the coordination area, Report 382 has not changed, apart from two Notes drawing attention to problems raised by digital systems (with the time percentage rising to 20% and the possibility that long-term interference could become the determining criterion) and to the problems of satellites on slightly inclined orbits.

This situation is now affecting the necessary updating of Appendix 28 of the Radio Regulations, which is based on Report 382.

Study Groups 4 and 9 have therefore approved Decision 87, taking account of Study Group 5's comments, to set up a Joint Interim Working Party JIWP (2-4-5-8-9-10-11) to begin revising CCIR texts concerning Appendix 28 and to prepare a complete text within the framework of Report 382.

Report 388 on methods for determining interference in terrestrial radio-relay systems and systems in the fixed-satellite service has been considerably extended to take account of the analogue and digital modulation processes used. A new § 2.5 considers the case of a digital wanted signal and many types of modulation (such as n-QAM).

A new Recommendation 675 concerns an approximate method for the calculation of the maximum power density of a frequency-modulated FDM carrier. The corresponding text of Report 792 has been deleted.

6.6 *Organization of sharing studies*

Frequency sharing with space radiocommunication services is dealt with in Question 17/9, which has been revised and completed.

This general Question has given rise to several Study Programmes, each dealing with a specific sharing case. These include:

- Study Programme 17C/9, concerning the broadcasting-satellite service (sound), which has been enlarged and extended to the band 0.5-3 GHz in preparation for WARC-92;
- Study Programmes 17E/9, 17F/9 and the new Study Programme 17G/9, concerning the fixed-satellite service, which are to be considered in liaison with the corresponding Study Programmes of Question 32/4;
- the new Study Programme 17H/9, which considers the specific problem of fixed-satellite service systems using satellites in slightly inclined geostationary orbits;
- the new Study Programme 17J/9, concerning the mobile-satellite service in the band 0.5-3 GHz.

Question 30/9 has been redrafted and its scope extended to sharing with other terrestrial services, which makes it a general Question.

In turn it has given rise to three new Study Programmes:

- Study Programme 30A/9, concerning the use of frequencies in the band 0.5-3 GHz for radio-relay systems;
- Study Programme 30B/9, concerning the broadcasting service in the VHF and UHF bands (30-3000 MHz), which has the same wording as the old Question 30/9;
- Study Programme 30C/9, concerning sharing with the mobile services in the bands between 0.5 and 3 GHz.

It will be clear from the above that Study Group 9 has been organizing its programme in the light of the problems to be dealt with at the next World Administrative Radio Conference in 1992, for which it has already assembled technical data in its latest texts.

This work should be speeded up, however, so as to provide the Joint Interim Working Party to be set up in 1991 for the technical preparation of WARC-92 with technical data on the fixed service for the assessment of sharing problems with other services.

To this effect, in its Decision 89 Study Group 9 set up an Interim Working Party IWP 9/6 chaired by Mr. Dunk (United Kingdom), assisted by Vice-Chairmen representing each of the three regions of the Radio Regulations.

Table III shows texts concerning sharing with the fixed-satellite service, while Table IV gives references for sharing with services other than the fixed-satellite service.

7. Terminology

The new version of Recommendation 592, which heads the texts of Volume IX, has been extended with the addition of many technical terms on radio transmission, digital transmission and data transmission, currently used in Volume IX.

8. Programme of work for the next study period

By setting up IWPs 9/5 and 9/6 and through its proposal (with Study Group 4) to set up a JIWP, Study Group 9 has begun work on three priority areas:

- introduction of radio-relay systems in a synchronous digital network;
- preparation for WARC-92 with regard to the fixed service;
- revision of Radio Regulations Appendix 28 through Report 382.

Apart from these priority areas, Study Group 9 will pursue its studies in the following main fields:

- residual bit error ratio and availability objectives for the medium grade and local grade portions of an ISDN connection;
- general study of interference as part of the new version of Question 28/9 and Report 1187;
- techniques for improving the performance, increasing the capacity and reducing the cost of digital systems;
- out-of-band emission from radio-relay systems (Study Programme 19B/9);
- methods of measuring performance and availability, especially the residual bit error ratio;
- radio-relay network management and maintenance systems;
- point-to-multipoint systems for rural areas, in particular in the local grade portion of an ISDN connection;
- cellular-type fixed systems;
- radio local area networks (new Question);
- consequences of the use of satellites on slightly inclined geostationary orbits.

9. Chairmanship of Study Group 9

At the last meeting, Mr. J. Verrée (Chairman) and Mr. H. Willenberg (Vice-Chairman) announced that they would no longer be able to take part in the work of Study Group 9 after the Plenary Assembly in Düsseldorf in 1990, while Mr. Murotani (Vice-Chairman) said that he could probably continue, if authorized by his country.

The XVIIth Plenary Assembly will therefore have to appoint a new team to head Study Group 9.

In accordance with tradition, Study Group 9 preferred to draw the Plenary Assembly's attention to competent personalities with experience in the Group's work and hence qualified to lead it.

It therefore authorized the Chairman to mention the names of Messrs. Coles (Canada), Dunk (United Kingdom), Langer (Federal Republic of Germany), Minkin (USSR) and Hurt (USA) in this report for information.

10. Conclusions and thanks

In the study period 1986-1990, Study Group 9 has gathered the most up-to-date information on digital radio-relay systems and their application in different networks, as well as on frequency sharing with other services. It can thus offer the XVIIth Plenary Assembly the best possible texts on current state-of-the-art techniques. It has also made provision for future work, by setting up Interim Working Parties to begin investigations in priority areas without delay.

Study Group 9 has drawn up nine new Recommendations, thirteen new Reports, one new Question and twelve new Study Programmes; some of the new Reports give accounts of new studies on important subjects. It has also deleted four old Questions, three Study Programmes and ten Reports, accounting for 56 pages of Volume IX.

The arrangement of texts in Volume IX – similar to the last Volume – has been made as clear as possible; it has linked Recommendations with their supporting Reports, which provide the technical information required for better understanding or their practical application; this should facilitate the use of Volume IX, especially by anyone not familiar with the CCIR's work.

These achievements were made possible by the quantity and quality of contributions received from administrations, and by the contribution of participants to the success of all the meetings.

The Chairman would like once again to thank everyone involved, especially the Vice-Chairmen, Mr. H. Willenberg (Federal Republic of Germany) and Mr. M. Murotani (Japan), the Working Group Chairmen, Messrs. Coles (Canada), Fernandez (France) and Dunk (United Kingdom) and all the Chairmen of Sub-Groups and Drafting Groups.

He would also like to thank all those who provided assistance in the CCIR Secretariat, under the authority of Mr. Kirby, Director of the CCIR, as well as the general services of the ITU for their efficient help in publishing the necessary documents.

He would like to extend special thanks to the Rapporteur of Plenary Meetings and to members of the Study Group's Editorial Group, whose valuable work all too often passes unnoticed.

He would finally like to extend his very special thanks and the expression of his warm friendship to the Vice-Chairman, Mr. H. Willenberg, with whom he has worked since 1974.

TABLE I – *Hypothetical reference digital paths – Performance and availability objectives*

		Section of an ISDN			Special applications other than ISDN
		High grade	Medium grade	Local grade	
Hypothetical reference digital paths (HRDP)		Recommendation 556	Question 33/9 (Report 1052)	Question 33/9 (Report 1053)	Questions 9/9, 10/9 (Reports 379, 380)
Performance objectives	For an HRDP	Recommendation 594 (Report 930)	Recommendation 696 (Report 1052)	Recommendation 697 (Report 1053)	Questions 9/9, 10/9 (Reports 379, 380)
	For a real radio-relay link	Recommendation 634 (Report 930)			
Availability objectives	For an HRDP	Recommendation 557 (Report 445)	Recommendation 696 (Report 1052)	Question 5/9 (Report 1053)	Questions 9/9, 10/9 (Reports 379, 380)
	For a real radio-relay link	Recommendation 695 (Report 445)			

TABLE II – *Radio-frequency channel arrangements for digital radio-relay systems*

Band	High capacity	Medium capacity	Low capacity
Below 2 GHz		Recommendation 283	Recommendations 283, 701 (Report 379)
2 GHz		Recommendation 283 (Reports 934, 1055)	Recommendations 283, 701 (Reports 934, 1055)
4 GHz	Recommendations 635, 382 (Report 934)	Recommendation 382 (Report 934)	
6 GHz (lower)	Recommendation 383 (Report 934)	Question 35/9 (Report 934)	
6 GHz (upper)	Recommendation 384 (Report 934)		
7 GHz	Reports 934, 1055	Question 35/9	Question 35/9 (Report 1055)
8 GHz		Question 35/9 (Reports 934, 1055)	Question 35/9 (Report 1055)
11 GHz	Recommendation 387 (Report 782)	Recommendation 387	Recommendation 387
13 GHz	Recommendation 497 (Report 607)		
15 GHz	Recommendation 636 (Report 607)		
19 GHz	Recommendation 595 (Report 936)		
23 GHz	Recommendation 637 (Report 936)		
Above approximately 17 GHz	Question 16/9 (Report 936)		

Note 1 – Report 607 also gives information for the 10, 12 and 14 GHz bands.

Note 2 – Report 936 also gives information for analogue systems.

Note 3 – Recommendation 701 also gives information for analogue systems.

TABLE III – *Criteria for sharing with the fixed-satellite service*

	Sharing condition				Coordination	
	General principle	Maximum allowable interference	Maximum e.i.r.p.	Maximum pfd	Coordination area	Interference calculation
FS ← FSS (ES)	Recommendation 355 (Reports 209 (1), 876 (2), 1142)	Recommendations 357, 615 (3) (Report 877)	–	–	Recommendation 359 (Report 382)	Recommendation 675 (Reports 388, 448, 792)
FS ← FSS (SS)			–	Recommendations 358, 674 (Reports 387, 1143)	–	
FS → FSS (ES)		Recommendations 356, 558 (Report 793)	–	–	Recommendation 359 (Report 382)	
FS → FSS (SS)			Recommendation 406 (Reports 790, 1006)	–	–	

FS: fixed service
FSS: fixed-satellite service
(ES): earth station
(SS): space station

(1) Applicable to the frequency bands from 1 to 40 GHz.
(2) Applicable to the frequency bands above 40 GHz.
(3) Applicable to the frequency bands below 15 GHz.
Note – Recommendation 675 applies only to FDM-FM systems.

TABLE IV – *Criteria for sharing with services other than the fixed-satellite service*

General (methodology)	Space research service	Mobile-satellite service	Broadcasting-satellite service	Services in the VHF and UHF bands	
				Terrestrial broadcasting service	Terrestrial mobile services
Question 28/9 (Report 1196)	Questions 17/9, 28/9 (Report 942 (1)) Report 1197 (2)	Questions 17/9, 28/9 Report 1195 (3)	Questions 17/9, 28/9 (Reports 789 (4), 941 (5)) Report 1189 (6)	Questions 28/9, 30/9 Report 1194 (7)	Questions 28/9, 30/9

(1) Sharing with passive sensors in the frequency band 18.6-18.8 GHz.
(2) Applicable to the frequency bands 2025-2110 MHz and 2200-2290 MHz.
(3) Applicable to the aeronautical mobile-satellite service in the frequency bands 1.5/1.6 GHz.
(4) Applicable to the frequency band 11.7-12.75 GHz.
(5) Applicable to the frequency band 1427-1530 MHz (sound broadcasting).
(6) Applicable to the frequency band 22.5-23 GHz.
(7) Applicable to the frequency band 790-862 MHz.

SECTION 9T: TERMINOLOGY

RECOMMENDATION 592-2 *

TERMINOLOGY USED FOR RADIO-RELAY SYSTEMS **

(1982-1986-1990)

The CCIR

UNANIMOUSLY RECOMMENDS

that the following definitions be considered for the analysis of the texts of Study Group 9:

1. Terms relating to radio transmission

1.1 **Radio-relay system**; *Faisceau hertzien; Sistema de relevadores radioeléctricos:*

Radiocommunication system in the fixed service operating at frequencies above about 30 MHz which uses tropospheric propagation and which normally includes one or more intermediate stations.

1.2 **Trans-horizon radio-relay system**; *Faisceau hertzien transhorizon; Sistema de relevadores radioeléctricos transhorizonte:*

Radio-relay system using *trans-horizon* tropospheric *propagation*, chiefly forward scatter.

Note. – Recommendation 310 gives a definition for *trans-horizon* (tropospheric) *propagation.*

1.3 **Point-to-point communication**; *Communication point à point; Comunicación punto a punto:*

Communication provided by a link, for example, a radio-relay link between two stations located at specified fixed points.

1.4 **Point-to-multipoint communication**; *Communication point à multipoint; Comunicación punto a multipunto:*

Communication provided by links, for example, radio-relay links between a single station located at a specified fixed point and a number of stations located at specified fixed points.

1.5 **Point to area communication** ***; *Communication point à zone; Comunicación punto a zona:*

Communication provided by links between a station located at a specified fixed point and any number of stations located at non-specified points in a given area which is the *coverage area* of the station located at the fixed point.

1.6 **(Orthogonal) co-channel**; *Cocanal (orthogonal), cofréquence (orthogonal); Cocanal (ortogonal):*

Refers to an arrangement of radio channels in a radio-relay link in which the same nominal centre frequency is used on two orthogonal polarizations for the transmission of two signals which may or may not be independent.

1.7 **Alternated**; *Alternée; Alternada:*

Refers to an arrangement of radio channels in a radio-relay link in which two adjacent channels are cross-polarized.

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* The CCIR Secretariat should transmit this Recommendation to the CMV.

** Other terms, together with their definitions, relating to radiocommunications and telecommunications in general, are contained in Recommendations 573 and 662 (Volume XIII).

*** This type of communication, which is mainly used by broadcast and mobile services, is included here for comparison with terms 3 and 4.

1.8 **Interleaved**; *Intercalée; Intercalada:*

Refers to an arrangement of radio channels in a radio-relay link in which additional channels are inserted between the principal channels, the centre frequencies of the additional channels being shifted by a specified value which is a significant proportion, such as a half, of the channel bandwidth from the centre frequencies of the principal channels.

1.9 **Digital radio-relay for synchronous hierarchy (symbol: SDH-DRRS)**; *Faisceau hertzien numérique pour hiérarchie synchrone (HNS-FHN); Relevador radioeléctrico digital para jerarquías síncronas (JDS-RRD):*

A digital radio-relay system capable of carrying synchronous digital hierarchy payloads.

1.10 **Diversity reception**; *Réception en diversité; Recepción por diversidad:*

A reception method in which one resultant signal is obtained from several received radio signals which convey the same information but for which the radio path or the transmission channel differs by at least one characteristic such as frequency, polarization, or the position or orientation of antennas.

Note 1 – The quality of the resultant signal can be higher than that of the individual signals, due to the partial decorrelation of propagation conditions over the different radio paths or transmission channels.

Note 2 – The term "time diversity" is sometimes used to refer to the repetition of a signal or part of a signal over a single radio path or transmission channel.

1.11 **Order of diversity**; *Ordre de diversité; Orden de diversidad:*

The number of different radio signals used for diversity reception. For two signals, reception is said to be "double diversity", and so on.

1.12 **Space diversity reception**; *Réception en diversité d'espace; Recepción con diversidad de espacio:*

Diversity reception in which several antennas and associated receivers are used at appropriate distances from each other in a radio station.

Note – For line-of-sight radio-relay systems, separation is generally vertical, whereas for trans-horizon radio-relay systems, it is generally horizontal.

1.13 **Frequency diversity reception**; *Réception en diversité de fréquence; Recepción con diversidad de frecuencia:*

Diversity reception in which several radio channels are used with appropriate frequency separations.

Note – If the channels are situated in different frequency bands, the frequency diversity is said to be "cross-band diversity".

1.14 **Cross polarization canceller (circuit)**; *(Circuit) annuleur de transpolarisation; Circuito cancelador de transpolarización:*

Adaptive coupling circuit between two orthogonal co-frequency channels or two alternated adjacent channels, used to reduce cross-polar interference, during adverse propagation conditions.

1.15 **Digital radio concentrator (system)**; *Concentrateur en radiocommunications numériques; Sistema concentrador de radiocomunicaciones digitales:*

Point-to-multipoint radio systems using TDMA transmission between a central station and several remote stations, in which the central station allocates time intervals to each remote station according to demand.

2. Terms relating to quality in digital transmission

2.1 **Bit error ratio (symbol: BER)**; *Taux d'erreur binaire (TEB); Proporción de bits erróneos (TEB):*

For a binary digital signal, the ratio of the number of errored bits received to the total number of bits received over a given time interval.

2.2 **Residual bit error ratio (symbol: RBER)**; *Taux d'erreur binaire résiduel (TBER); Proporción residual de bits erróneos (TEBR):*

Bit error ratio in the absence of fading, including allowance for system inherent errors, environment, aging effects and long-term interference.

2.3 **Errored second (symbol: ES);** *Seconde avec erreurs, seconde entachée d'erreurs (SE); Segundo con errores (SE):*

Time interval of 1 s during which a given digital signal is received with one or more errors.

Note – According to CCITT Recommendations, an errored second is defined for each direction of a 64 kbit/s circuit-switched connection.

2.4 **Severely errored second (symbol: SES);** *Seconde gravement entachée d'erreurs (SGE); Segundo con muchos errores (SME):*

Time interval of 1 s during which a given digital is received with an error ratio greater than a specified value.

Note – According to CCITT Recommendations, a severely errored second is defined for each direction of a 64 kbit/s circuit-switched connection and the specified BER value is 10^{-3}.

2.5 **Degraded minute (symbol: DM);** *Minute dégradée; Minuto degradado:*

Time interval comprising *m* seconds, 60 of them being not severely errored seconds but for which the error ratio is greater than a specified value.

Note 1 – According to CCITT Recommendations, a degraded minute is defined for each direction of a 64 kbit/s circuit-switched connection and the specified BER value is 10^{-6}.

Note 2 – If the time interval includes *n* severely errored seconds, $m = 60 + n$.

3. Terms relating to data transmission

3.1 **Data under voice (transmission) (symbol: DUV);** *(Transmission de) données infravocales; (Transmisión de) datos en la parte inferior de la banda de base:*

A method of data transmission consisting of transmitting data within the baseband of an analogue radio system, under the frequency band occupied by a frequency division multiplex signal.

3.2 **Data above voice (transmission) (symbol: DAV);** *(Transmission de) données supravocales; (Transmisión de) datos en la parte superior de la banda de base:*

A method of data transmission consisting of transmitting data within the baseband of an analogue radio system above the frequency band occupied by a frequency division multiplex signal.

Note – Transmission is generally carried out by modulating a sub-carrier.

4. Terms relating to digital modulation

4.1 **n-state quadrature amplitude modulation (symbol: n-QAM);** *Modulation d'amplitude en quadrature à n états (MAQ-n); modulación de amplitud en cuadratura de n estados (MAQ-n):*

A type of modulation in which two carriers in phase quadrature are amplitude modulated by a digital signal, with a finite number of amplitude levels, and subsequently added to each other, the modulation effect being represented by a scatter of *n* points in an amplitude/phase diagram.

Note – In many applications, *n* is equal to 2^{2p}, *p* being an integer.

4.2 **Simple modulation;** *Modulation simple; Modulación simple:*

A digital modulation in which the RF signal can assume four or fewer values of frequency or phase or amplitude at the symbol sampling point.

4.3 **Multi-level modulation;** *Modulation multiniveaux; Modulación multiniveles:*

A digital modulation in which the RF signal can assume more than four values of frequency or phase or amplitude at the symbol sampling point.

Note – When the term "high level modulation" or "low level modulation" is used, it refers not to a modulation scheme but to the power level of the signal at the modulator input.

4.4 **Multi-state modulation;** *Modulation multiétats; Modulación multiestados:*

A digital modulation in which the RF signal can assume more than four states of phase and amplitude at the symbol sampling point.

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SECTION 9A: PERFORMANCE OBJECTIVES, PROPAGATION AND INTERFERENCE EFFECTS

RECOMMENDATION 390-4

DEFINITIONS OF TERMS AND REFERENCES CONCERNING HYPOTHETICAL REFERENCE CIRCUITS AND HYPOTHETICAL REFERENCE DIGITAL PATHS FOR RADIO-RELAY SYSTEMS

(Question 2/9, Geneva, 1982
and Study Programme 12C/9, Geneva, 1982)

(1963-1970-1974-1978-1982)

The CCIR,

UNANIMOUSLY RECOMMENDS

that the following definitions be used for defining the nature and properties of hypothetical reference circuits and hypothetical reference digital paths:

1. Analogue radio-relay systems

1.1 *Hypothetical reference circuit;* circuit fictif de référence; circuito ficticio de referencia

A hypothetical circuit of definite length, comprising a number of intermediate and terminal equipments, this number being fairly large, but not excessive.

Note 1. – The hypothetical reference circuit is a necessary element in the study of certain characteristics of long-distance circuits (e.g. noise).

Note 2. – The length of the hypothetical reference circuit does not imply that longer real circuits cannot be used.

1.2 *Hypothetical reference circuit for telephony;* circuit fictif de référence (pour la téléphonie); circuito de referencia para la telefonía

A complete telephone circuit (between an audio-frequency terminal at each end), established over a hypothetical international carrier-system of definite length. It comprises a definite number of modulations and demodulations of the groups, supergroups and mastergroups, the number of these processes being reasonably large, but not the greatest number possible.

Note 1. – Various "hypothetical reference circuits for telephony" have been determined to permit coordination between the various specifications for the constituent parts of multiplex carrier telephony systems, so that the complete telephone circuits established over these systems should satisfy the CCITT standards (see § 3.2, 3.3, 3.4 and 3.7). These various hypothetical reference circuits are all conceived for the same total length (except of course hypothetical reference circuits for satellite systems) and type of operation. They are intended as a guide only in the planning of carrier systems.

Note 2. – As a result of the introduction of three pairs of channel modulations, these hypothetical reference circuits for telephony may be used to study, not only a 2500 km circuit established over a carrier system or systems, but also an international connection having the same total length, composed of three circuits, set up on different carrier systems and interconnected in two international transit centres.

1.3 *Homogeneous section (for telephony);* section homogène (pour la téléphonie); sección homogénea (para la telefonía)

A section without either branching or modulation of any mastergroup, supergroup, group or channel, established over the system in question, with the exception of those which are defined at the end of the section.

Note 1. – All hypothetical reference circuits are built up from homogeneous sections of equal length (six or nine sections as the case may be; the number is not specified for trans-horizon systems).

Note 2. – It is assumed that, at the end of each homogeneous section, the channels, groups, supergroups and mastergroups are interconnected among themselves in a random manner.

1.4 *Hypothetical reference circuits for other types of signal*

Using the same principles, other hypothetical reference circuits and homogeneous sections have been determined for other types of signal; television, programme circuits, etc. (see § 3.5, 3.6 and 3.7).

2. Digital radio-relay systems

Hypothetical reference digital path; conduit numérique fictif de référence; trayecto digital ficticio de referencia

A hypothetical digital path of definite length, comprising a number of intermediate and terminal equipments, this number being fairly large, but not excessive.

Note 1. – The hypothetical reference digital path is a necessary element in the study of certain characteristics of long-distance digital paths (e.g. errors, jitter).

Note 2. – The design objectives recommended by the CCITT for transmission equipments are commonly expressed in terms of a maximum tolerable level of impairment arising in a hypothetical reference digital path. As far as possible, a design objective so expressed takes into account all possible uses of the system, e.g. telephony, telegraphy, data, etc.

3. References

3.1 *General definition of a hypothetical reference circuit*

CCITT Recommendation G.212.

3.2 *Hypothetical reference circuit for telephony on cable systems and on open-wire lines*

See the references in CCITT Recommendation G.212, § 2.

3.3 *Hypothetical reference circuits for telephony on line-of-sight or near line-of-sight radio-relay systems*

- using frequency-division multiplex (with a capacity of 12 to 60 telephone channels) – CCIR Recommendation 391,
- using frequency-division multiplex (for more than 60 telephone channels) – CCIR Recommendation 392.

3.4 *Hypothetical reference circuit for telephony on trans-horizon radio-relay systems*

- using frequency-division multiplex – CCIR Recommendation 396.

3.5 *Hypothetical reference circuit for television*

CCIR Recommendation 567.

3.6 *Hypothetical reference circuit for sound programme circuits*

CCIR Recommendation 502.

3.7 *Hypothetical reference circuit for fixed-satellite service systems for telephony and/or television*

CCIR Recommendation 352.

3.8 *General definition of a hypothetical reference digital path*

CCITT Recommendation G.721.

3.9 *Definitions of a digital radio section and a digital radio path*

CCITT Recommendation G.702, Nos. 9032 and 9034.

RECOMMENDATION 391*

HYPOTHETICAL REFERENCE CIRCUIT FOR RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX WITH A CAPACITY OF 12 TO 60 TELEPHONE CHANNELS

(Question 2/9, Geneva, 1982)

(1956–1959–1963)

The CCIR,

CONSIDERING

(a) that it is desired to establish hypothetical reference circuits for radio-relay systems, to afford guidance to the designers of equipment and systems for use in international telecommunication networks;

(b) that hypothetical reference circuits for radio-relay systems should, as far as possible, be in agreement with the hypothetical reference circuits specified by the CCITT for cable systems,

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for frequency-division multiplex radio-relay systems, with a capacity of 12 to 60 telephone channels per radio-frequency channel, should be 2500 km long;

2. that this circuit should include, for each direction of transmission:

– 3 sets of channel modulators,
– 6 sets of group modulators,
– 6 sets of supergroup modulators,

it being understood that a "set of modulators" comprises a modulator and a demodulator;

3. that this circuit should include, respectively, six sets of radio modulators and demodulators, for each direction of transmission, and that these should divide the circuit into six homogeneous sections of equal length.

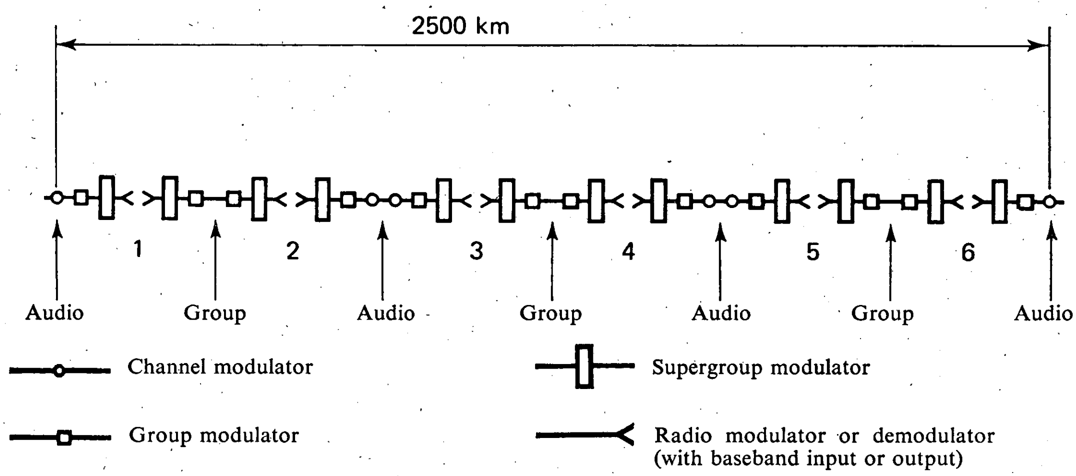

FIGURE 1

Hypothetical reference circuit for radio-relay systems using frequency-division multiplex with capacities of 12 to 60 telephone channels per radio-frequency channel

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* This Recommendation applies only to line-of-sight and near line-of-sight radio-relay systems.

RECOMMENDATION 392*

HYPOTHETICAL REFERENCE CIRCUIT FOR RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX WITH A CAPACITY OF MORE THAN 60 TELEPHONE CHANNELS

(Question 2/9, Geneva, 1982)

(1956–1959–1963)

The CCIR,

CONSIDERING

(a) that it is desired to establish hypothetical reference circuits for radio-relay systems, to afford guidance to the designers of equipment and systems for use in international telecommunication networks;

(b) that hypothetical reference circuits for radio-relay systems should, as far as possible, be in agreement with the hypothetical reference circuits specified by the CCITT for cable systems,

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for frequency-division multiplex radio-relay systems, with a capacity of more than 60 telephone channels per radio-frequency channel, should be 2500 km long;

2. that this circuit should include, for each direction of transmission:

– 3 sets of channel modulators,
– 6 sets of group modulators,
– 9 sets of supergroup modulators,

it being understood that a "set of modulators" comprises a modulator and a demodulator;

3. that this circuit should include nine sets of radio modulators and demodulators respectively, for each direction of transmission, and that these should divide the circuit into nine homogeneous sections of equal length.

* This Recommendation applies only to line-of-sight and near line-of-sight radio-relay systems.

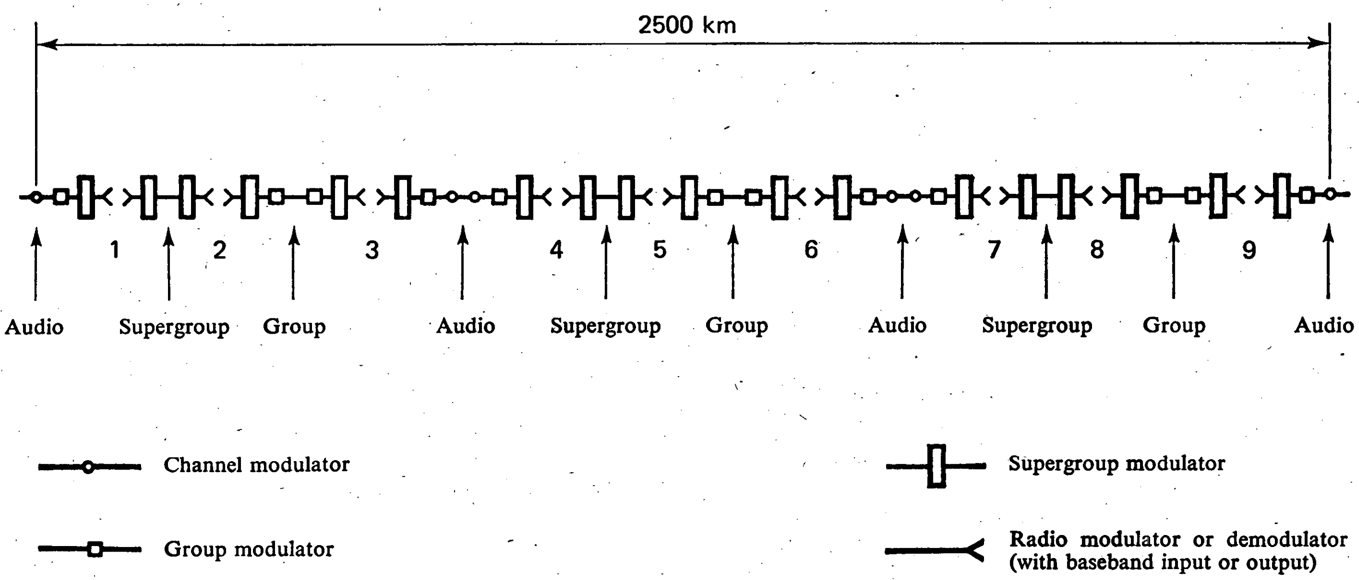

FIGURE 1

Hypothetical reference circuit for radio-relay systems using frequency-division multiplex with a capacity of more than 60 telephone channels per radio-frequency channel

RECOMMENDATION 393-4*

ALLOWABLE NOISE POWER IN THE HYPOTHETICAL REFERENCE CIRCUIT FOR RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 2/9, Geneva, 1982)

(1956-1959-1963-1966-1974-1978-1982)

The CCIR,

CONSIDERING

(a) that the hypothetical reference circuit is intended as a guide to designers and constructors of actual systems;

(b) that the total noise power in a radio-relay system is dependent on the one hand upon a number of factors concerned with equipment design, and on the other hand upon the path attenuation and the variation of path attenuation with time, which are in turn dependent upon factors such as the spacing of stations and the nature of the intervening terrain;

(c) that the total noise power in the hypothetical reference circuit should not be such as would appreciably affect conversation in a substantial number of telephone calls or the transmission of telephone signalling;

(d) that while a conventional load has been adopted for the multiplex signal (see Note 9), no conventional values have been adopted for propagation characteristics in any frequency range or in any climate;

(e) that it is desirable to prepare, for radio-relay systems, clauses which define a noise performance considered equivalent to that of cable systems;

(f) that during normal operation, periods of high noise will occur which will cause short interruptions, these interruptions being mostly caused by adverse propagation conditions (see Note 12),

UNANIMOUSLY RECOMMENDS

1. that the noise power at a point of zero relative level in any telephone channel on a 2500 km hypothetical reference circuit for frequency-division multiplex radio-relay systems should not exceed the values given below, which have been chosen to take account of adverse propagation conditions:

1.1 7500 pW0p, psophometrically weighted (Note 14) one-minute mean power (Note 15) for more than 20% of any month;

1.2 47 500 pW0p, psophometrically weighted (Note 14) one-minute mean power (Note 15) for more than 0.1% of any month;

1.3 1 000 000 pW0, unweighted (with an integrating time of 5 ms) for more than 0.01% of any month;

2. that in a part of the hypothetical reference circuit consisting of one or more of the homogeneous sections defined in Recommendation 392, the one-minute mean noise power not exceeded for 20% of the month shall be considered to be proportional to the number of sections involved;

3. that in parts of a hypothetical reference circuit consisting of one or more of the equal homogeneous sections defined in Recommendations 391 and 392, the small percentage of a month in which the one-minute mean power may exceed 47 500 pW0p and in which the noise power (with an integrating time of 5 ms) may exceed 1 000 000 pW0, should be regarded as proportional to the number of homogeneous sections involved;

* – The Recommendation relates only to "line-of-sight" radio-relay systems. Trans-horizon radio-relay systems are dealt with in Recommendation 397.
– This Recommendation should be brought to the attention of the CCITT/CCIR Joint Study Group CMBD.

4. that the following Notes should be regarded as part of the Recommendation:

Note 1. – Noise in the frequency-division multiplex equipments is excluded from the foregoing. On a 2500 km hypothetical reference circuit, the CCITT allows 2500 pW0p mean value for this noise.

Note 2. – This Recommendation relates to the hypothetical reference circuit and the indicated figures are design objectives and it is not intended that they will be quoted in specifications for equipment or used for acceptance tests. Recommendations relating to real circuits are contained in Recommendation 395.

Note 3. – The noise performance of radio-relay systems designed to the *objectives* of this Recommendation is considered equivalent to that of cable systems having noise averaging 3 pW/km over *long* circuits (noise in the frequency-division multiplex equipment is excluded).

Note 4. – It is assumed that noise surges and clicks from power supply systems and from switching apparatus are reduced to negligible proportions and will not be taken into account when calculating the noise power.

Note 5. – For the calculation of noise in hypothetical reference circuits the characteristics preferred by the CCIR and to be found in their Recommendations, should be used where appropriate; where more than one value is recommended, the designer should indicate the value chosen.

Note 6. – The requirements of the Recommendation are unlikely to be met unless the line-of-sight radio-relay system has adequate clearance over intervening terrain.

Note 7. – Designers should indicate their assumptions regarding the lengths of repeater sections, the nominal attenuation between transmitter outputs and receiver inputs, intermodulation noise in feeders and the radio path, possible interference between the radio channels of the system under consideration, precautions taken against fading (in particular, the use or not of diversity reception and protection channels) and the distribution curve of fading over short periods of time. Designers are expected to fit their noise distribution curves to fall below the figures specified in § 1.1 and 1.2.

Note 8. – It is assumed that, at junctions between the homogeneous sections of a hypothetical reference circuit, the telephone channels, groups, supergroups and mastergroups are interconnected at random; and that the noise coming from the homogeneous sections of the hypothetical reference circuit is power-additive.

Note 9. – It is assumed that, during the busy hour, the multiplex signal can be represented by a uniform-spectrum signal, the mean power absolute level of which, at a point of zero relative level is equal to $(-15 + 10 \log_{10} N)$ dBm for 240 channels or more, and $(-1 + 4 \log_{10} N)$ dBm for numbers of channels between 12 and 240 (this value is provisional for systems with a capacity of less than 60 channels), N being the total number of channels for which the radio-relay system is to be designed.

Note 10. – The requirement indicated by § 1.3 is related to the need to transmit signalling for telephony satisfactorily. It covers also the performance requirement for frequency-modulation VF telegraphy at 50 bauds over telephone channels. For amplitude-modulation VF telegraphy at 50 bauds, the CCITT has stated performance requirement in its Recommendation G.442.

Note 11. – Recommendation 357 fixes the maximum permissible value of interference caused by systems in the fixed-satellite service to a telephone channel of a radio-relay system. The values indicated in Recommendation 357 (or smaller values calculated taking account of the parameters of the radio-relay system) should, in principle, be included in the general objectives with regard to noise (see CCITT Recommendation G.222, Vol. III, Fascicle III.2). In certain cases, however, additional noise may cause the limits fixed in the general objectives to be slightly exceeded. This should not cause serious concern, provided that the provisions of CCITT Recommendation G.222, § 2.6 are met.

Note 12. – Adverse propagation conditions can result in a decrease of the wanted signal and/or an increase in the level of interfering signals.

Note 13. – This Recommendation applies only when the system is considered to be available in accordance with the non-availability criteria defined in Recommendation 557 and includes periods of high noise exceeding 1 000 000 pW0 unweighted which persist for periods of less than 10 consecutive seconds. Periods of high noise which persist for 10 consecutive seconds duration or longer are taken into account by Recommendation 557.

Note 14. – The level of uniform-spectrum noise power in a 3.1 kHz band must be reduced by 2.5 dB to obtain the psophometrically weighted noise power.

Note 15. – The one-minute mean power was chosen by CCITT Study Group XII which is responsible for all studies concerned with the quality of telephone transmission (CCITT *Red Book*, 1957 and Recommendation G.222, Vol. III, Fascicle III.2).

RECOMMENDATION 395-2 *

NOISE IN THE RADIO PORTION OF CIRCUITS TO BE ESTABLISHED OVER REAL RADIO-RELAY LINKS FOR FDM TELEPHONY **

(Question 2/9, Geneva, 1982)

(1959–1963–1966–1978)

The CCIR,

CONSIDERING

(a) that provisional maximum values for the noise in hypothetical reference circuits are given in Recommendation 393 as a guide to designers of equipment;

(b) that real circuits sometimes differ in composition from the hypothetical reference circuit (Recommendation 392) (see Fig. 1);

(c) that the hypothetical reference circuit shows a single 2500 km telephone circuit and that circuits carried over real links will share many of the component baseband sections with other telephone circuits of lesser length. While the performance requirements of these shorter circuits could safely be relaxed to ease the planning of links, the longer international circuits must not be allowed to suffer the full cumulative effect of any relaxations which are permissible for the shorter circuits;

(d) that, in some circumstances, a planned real link may comprise a larger number of baseband points than is envisaged in the hypothetical reference circuit;

(e) that equipment, which has been designed to satisfy the design objectives (Recommendation 393) for the hypothetical reference circuit (Recommendation 392), cannot be expected to give the same standard of performance when used in a circuit established over real links, the actual composition of which differs from that of the hypothetical reference circuit or its homogeneous section;

(f) that, therefore, it is necessary to give planning objectives for noise as a guide in the planning of links forming part of international circuits;

(g) that noise contributions arise from several sources; some of these contributions depend on the number of baseband equipments and others on the law of addition for intermodulation noise in a long chain of repeaters or in permanently connected group links (defined in CCITT Recommendation G.211), and that these contributions differ in different parts of the baseband-frequency spectrum,

UNANIMOUSLY RECOMMENDS

1. that, in circuits established over real links which do not differ appreciably from the hypothetical reference circuit, the psophometrically weighted *** noise power at a point of zero relative level in the telephone channels of frequency-division multiplex radio-relay systems of length L, where L is between 280 and 2500 km, should not exceed:

1.1 3 L pW one-minute mean power for more than 20% of any month;

1.2 47 500 pW one-minute mean power for more than $(L/2500) \times 0.1\%$ of any month; it is recognized that the performance achieved for very short periods of time is very difficult to measure precisely and that in a circuit carried over a real link, it may, after installation, differ from the planning objective;

* This Recommendation applies only to line-of-sight radio-relay systems suitable for use in the international telephone network.

** The term "circuit" is understood to refer to a circuit as defined in No. 02.06 of the ITU *List of Essential Telecommunication Terms*, Second Impression, Geneva, 1961, Part I. The calculations are performed between the points R' and R (see Recommendation 380) of each radio section which enters into the circuit under consideration.

*** The level of uniform-spectrum noise power in a 3.1 kHz band must be reduced by 2.5 dB to obtain the psophometrically weighted noise power.

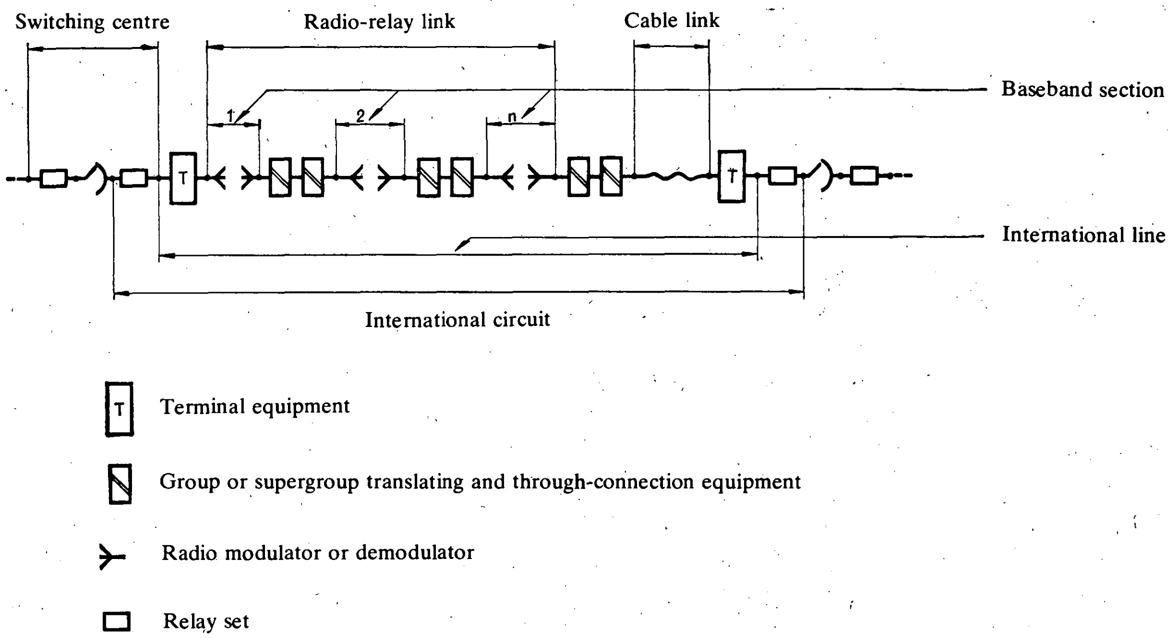

FIGURE 1 – *Constitution of an international circuit comprising real links on radio-relay and cable systems*

(The Figure is intended to illustrate the terms used in this Recommendation)

2. that circuits to be established over real links, the composition of which, for planning reasons, differs substantially from the hypothetical reference circuit, should be planned in such a way that the psophometrically weighted noise power at a point of zero relative level in a telephone channel of length L, where L is between 50 and 2500 km, carried in one or more baseband sections of frequency-division multiplex radio links, should not exceed:

2.1 for 50 km $\leqslant L \leqslant$ 840 km:

2.1.1 3 L pW + 200 pW one-minute mean power for more than 20% of any month,

2.1.2 47 500 pW one-minute mean power for more than (280/2500) × 0.1% of any month when L is less than 280 km, or more than (L/2500) × 0.1% of any month when L is greater than 280 km;

2.2 for 840 km $< L \leqslant$ 1670 km:

2.2.1 3 L pW + 400 pW one-minute mean power for more than 20% of any month,

2.2.2 47 500 pW one-minute mean power for more than (L/2500) × 0.1% of any month;

2.3 for 1670 km $< L \leqslant$ 2500 km:

2.3.1 3 L pW + 600 pW one-minute mean power for more than 20% of any month,

2.3.2 47 500 pW one-minute mean power for more than (L/2500) × 0.1% of any month;

3. that the following Notes should be regarded as part of the Recommendation:

Note 1. – Noise in the frequency-division multiplex equipment is excluded. On a 2500 km hypothetical reference circuit the CCITT allows 2500 pW mean value for this noise in any hour.

Note 2. – It is assumed that noise surges and clicks from power supply systems and from switching apparatus are reduced to negligible proportions and will not be taken into account when calculating the noise power.

Note 3. – It is permissible to assume that noise coming from individual baseband sections is power-additive, but only if the baseband spectra of adjacent baseband sections are substantially different.

Note 4. – It will be assumed that, during the busy hour, the multiplex signal can be represented by a uniform-spectrum signal, the mean power absolute level of which at a point of zero relative level, is equal to $(-15 + 10 \log_{10} N)$ dBm for 240 channels or more, and $(-1 + 4 \log_{10} N)$ dBm for numbers of channels between 12 and 240 (this value is provisional for systems the capacity of which is less than 60 channels), N being the number of channels for which the radio-relay system is designed.

RECOMMENDATION 396-1

HYPOTHETICAL REFERENCE CIRCUIT FOR TRANS-HORIZON RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 7/9)

(1963-1966)

The CCIR,

CONSIDERING

(a) that trans-horizon radio-relay systems may form part of an international connection;

(b) that the characteristics of trans-horizon systems do not allow the application of existing hypothetical reference circuits for line-of-sight radio-relay systems;

(c) that trans-horizon systems are generally limited to 120 telephone channels not utilizing supergroup through-connection;

(d) that the specific characteristics of trans-horizon systems are usually individually optimized,

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for trans-horizon radio-relay systems should be 2500 km long;

2. that the hypothetical reference circuit for trans-horizon radio-relay systems should not be divided into homogeneous sections of fixed length because these systems, as distinct from line-of-sight systems, are usually composed of long radio sections, the length of which depends on local conditions and may vary considerably (e.g. between 100 and 400 km);

3. that, if a radio section under study is L km long, the hypothetical reference circuit should be composed of $2500/L$ sections of this type in tandem, the value $2500/L$ being taken to the nearest whole number;

4. that the hypothetical reference circuit should include:

- 3 sets of channel modulators,
- 6 sets of group modulators,
- 6 sets of supergroup modulators,

for each direction of transmission, the term "set of modulators" being taken to comprise a modulator and a demodulator.

RECOMMENDATION 397-3

ALLOWABLE NOISE POWER IN THE HYPOTHETICAL REFERENCE CIRCUIT OF TRANS-HORIZON RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 7/9)

(1963–1966–1970–1978)

The CCIR,

CONSIDERING

(a) that a hypothetical reference circuit for trans-horizon radio-relay systems is established in Recommendation 396, as a guide to the designers of systems in use in international telecommunication networks;

(b) that wherever practicable, trans-horizon radio-relay systems should meet the same performance regarding noise as recommended for line-of-sight systems in Recommendation 393;

(c) that, nevertheless, the achievement of this desirable objective would sometimes result in a very high, even prohibitive cost or a power that is impractically high, or such that is likely to result in harmful interference;

(d) that this might well retard desirable extensions of the telephone network,

UNANIMOUSLY RECOMMENDS

1. that, from the point of view of performance, trans-horizon radio-relay systems be divided into two classes;

2. that, when a trans-horizon system is intended to operate between two points for which other transmission systems could be used without excessive difficulty, e.g. line-of-sight radio-relay, underground cable, etc., the hypothetical reference circuit should be established in accordance with Recommendation 396. The noise power at the end of this hypothetical reference circuit will be calculated by statistical combination of the noise power in each of its radio sections. The statistical distribution curve of the one-minute mean psophometric power, during the most unfavourable month, should then pass below the points defined in Recommendation 393, § 1.1 and 1.2;

3. that, if a trans-horizon system is to be used between points, for which other transmission systems cannot be used without excessive difficulty, and if the condition laid down in Recommendation 393 cannot be met without excessive difficulty, the following conditions will apply, once the statistical noise power distribution at the end of the hypothetical reference circuit has been calculated by the method set out in § 2:

3.1 the mean psophometric power during one minute must not exceed 25 000 pW0p for more than 20% of any month;

3.2 the mean psophometric power during one minute must not exceed 63 000 pW0p for more than 0.5% of any month;

4. that for the two classes of system defined above, the unweighted noise power (with an integration time of 5 ms) must meet Recommendation 393, § 1.3, but with the percentage of the most unfavourable month changed to 0.05%, for the systems referred to in § 3 of the present Recommendation.

Note 1. – All the values given above include the intermodulation noise in the radio part of the system. On the other hand, noise within the frequency-division multiplex equipment is excluded. On a hypothetical reference circuit 2500 km long, the CCITT authorizes a mean value of 2500 pW0p for this latter noise.

Note 2. – The method of statistical combination referred to in § 2 is described in detail in the paper "Thermal noise in multi-section radio links" by B. B. Jacobsen, IEE Monograph No. 262 R (1957).

Note 3. – The method of calculation of mean noise power in a telephone channel from the distribution of the received signal amplitude in each receiver is given in "Puissance moyenne de bruit dans les faisceaux hertziens transhorizon à modulation de fréquence" by L. Boithias and J. Battesti, *Annales des télécommunications* (May-June, 1963).

Note 4. – Systems which comply only with the terms of § 3 and 4, will be excluded from the main international and intercontinental routes; consequently in a world-wide connection, a maximum of one or two circuits of medium length will be encountered, which comply only with the terms of § 4 with a percentage of 0.05%; as far as telephone signalling is concerned, this state of affairs is acceptable. Under these conditions, the transmission of voice-frequency telegraphy is also satisfactory (see the reply by Study Group CMBD (CCITT/CCIR) to Question 1/C, annexed to Docs. IX/240 and IX/164, 1963-1966).

RECOMMENDATION 593

NOISE IN REAL CIRCUITS OF MULTI-CHANNEL TRANS-HORIZON FM RADIO-RELAY SYSTEMS OF LESS THAN 2500 km

(Question 7/9)

(1982)

The CCIR,

CONSIDERING

(a) that provisional maximum values for noise power in the hypothetical reference circuit of trans-horizon systems are given in Recommendation 397 as a guide to the designers of equipment;

(b) that in many cases the real circuits differ in both composition and length from the hypothetical reference circuit described in Recommendation 396;

(c) that recommendations governing noise in real trans-horizon radio-relay systems should be issued for guidance in the engineering of radio links,

UNANIMOUSLY RECOMMENDS

1. that in the case described in Recommendation 397, § 3, the statistical distribution of noise at a point of zero relative level in the telephone channel of a real communication system of length L km (less than 2500 km), the composition of which does not substantially differ from that of the hypothetical reference circuit, should be defined as follows:

1.1 the psophometric mean-minute noise power should not exceed 10 L pW for more than 20% of the time in any month;

1.2 the psophometric mean-minute noise power should not exceed 63,000 pW for more than (0.5 L/2500)% of the time in any month;

2. that the following Notes should be considered as part of the Recommendation:

Note 1. – Noise in the frequency-division multiplex equipments is excluded from the foregoing. On a 2500 km hypothetical reference circuit, the CCITT allows 2500 pW0p mean value for this noise.

Note 2. – It is assumed that noise surges and clicks from power supply systems and from switching apparatus are reduced to negligible proportions and will not be taken into account when calculating the noise power.

Note 3. – It is assumed that, at junctions between the homogeneous sections of a hypothetical reference circuit, the telephone channels, groups, supergroups and mastergroups are interconnected at random; and that the noise coming from the homogeneous sections of the hypothetical reference circuit is power-additive.

Note 4. – It is assumed that, during the busy hour, the multiplex signal can be represented by a uniform-spectrum signal, the mean power absolute level of which, at a point of zero relative level is equal to $(-1 + 4 \log N)$ dBm for numbers of channels between 12 and 240 (this value is provisional for systems with a capacity of less than 60 channels), N being the total number of channels for which the radio-relay system is to be designed.

RECOMMENDATION 555

PERMISSIBLE NOISE IN THE HYPOTHETICAL REFERENCE CIRCUIT OF RADIO-RELAY SYSTEMS FOR TELEVISION*

(Questions 2/9, Geneva 1982 and 3/9, Geneva, 1982)

(1978)

The CCIR,

CONSIDERING

(a) that the hypothetical reference circuit defined in Recommendation 567 is intended as a guide to designers and constructors of actual systems;

(b) that the total noise power in a radio-relay system is dependent on the one hand upon a number of factors concerned with equipment design, and on the other hand upon the path attenuation and the variation of path attenuation with time, which are in turn dependent upon factors such as the spacing of stations and the nature of the intervening terrain;

(c) that the total noise power in the hypothetical reference circuit should not be such as would appreciably affect the transmission of television signals;

(d) that the minimum signal-to-noise ratios which should be achieved are stated in § 3.2.1 of Part D of Recommendation 567; however, certain difficulties arise in the use of a noise objective relating to 1% of a month and it is therefore desirable to express the noise objective in terms of other percentages of a month;

(e) that, on radio-relay systems, it may be necessary to accept slightly lower signal-to-noise ratios for very small percentages of time;

(f) that, on radio-relay systems, it is possible to provide a better signal-to-noise ratio for the majority of the time than is required by Recommendation 567;

(g) that the relative distribution with time of noise in radio-relay systems for television or frequency-division multiplex telephony, will be similar and it is appropriate therefore to employ similar methods for specifying the noise performance;

(h) that a simple method is required for defining the noise contributions of the different sections of the hypothetical reference circuit;

(j) that to take account of the daily and seasonal variations in radio propagation conditions the period of time considered should be long, e.g. a month;

(k) that in Recommendation 567, the use of instruments with an effective time constant or integrating time of 1 s, is recommended and administrations are asked to make measurements with instruments having this time constant,

UNANIMOUSLY RECOMMENDS

1. that in the 2500 km hypothetical reference circuit for the transmission of television, the ratio expressed in decibels, of the nominal amplitude of the luminance signal to the r.m.s. amplitude of the weighted noise, measured under the conditions given in Parts B and C of Recommendation 567, should not fall below the following values,

1.1 57 dB for more than 20% of a month;
1.2 45 dB for more than 0.1% of a month;
} these values are provisional;

2. that, in a part of a hypothetical reference circuit consisting of one or two of the three identical homogeneous sections defined by Recommendation 567, Part A, the mean noise power which should not be exceeded for more than 20% of a month shall be considered to be proportional to the number of homogeneous sections involved (see Note 3);

* The Recommendation relates only to "line-of-sight" radio-relay systems. For a definition of the characteristics of television systems see Report 624.

3. that, in a part of a hypothetical reference circuit consisting of one or two of the three identical homogeneous sections defined by Recommendation 567, Part A, the small percentages of a month, during which the signal-to-noise ratio may fall below the values indicated in § 1.2 of RECOMMENDS 1, shall be regarded as proportional to the number of homogeneous sections involved (see Note 4).

Note 1. – The requirements of the Recommendation are unlikely to be met unless the line-of-sight radio-relay system has adequate clearance over intervening terrain.

Note 2. – Based on the information supplied by CMBD obtained from measurements, with a time constant of one minute, of the total noise (thermal noise and cross-talk) of telephone circuits, it is likely that signal-to-thermal noise ratio for 20% of one month and the signal-to-thermal noise ratio for 0.1% of one month will differ by about 12 dB at the most; the signal-to-thermal noise ratio obtained during at least 99% of one month, mentioned by the television specialists, is likely to be lower by about 4 dB than the signal-to-noise ratio for 20% of a month; this explains the difference between the values 57 dB and 45 dB, see § 1.1 and 1.2 of RECOMMENDS 1, these values being such, that the signal-to-noise ratio obtained during at least 99% of a month will be 53 dB, as the television specialists desire.

As mentioned in RECOMMENDS 1, these values are provisional and will, if necessary, be reviewed in the light of the tests made with a time constant of 1 s.

Note 3. – The law of proportionality given in RECOMMENDS 2, is based on the assumption that noise due to fading can be neglected for all but 20% of a month. Therefore, the value of 57 dB given in § 1.1 of RECOMMENDS 1 can be regarded as the objective for the signal-to-weighted noise ratio in the absence of fading.

Note 4. – The law of proportionality given in RECOMMENDS 3, is based on the assumption that individual fades which are of such magnitude that they occur for only very small percentages of time, and originate in different sections of a complete circuit, do not occur simultaneously. This assumption may not always be completely justifiable, but the error is small, and the approximation is regarded as acceptable.

Note 5. – This Recommendation relates to the hypothetical reference circuit. The figures given are design objectives, and it is not intended that they should be quoted in specifications of equipment or used for acceptance tests.

RECOMMENDATION 556-1

HYPOTHETICAL REFERENCE DIGITAL PATH FOR RADIO-RELAY SYSTEMS WHICH MAY FORM PART OF AN INTEGRATED SERVICES DIGITAL NETWORK WITH A CAPACITY ABOVE THE SECOND HIERARCHICAL LEVEL

(Question 33/9)

(1978–1986)

The CCIR,

CONSIDERING

(a) that it is desirable to define a hypothetical reference digital path for digital radio-relay systems, to afford guidance to the designers of equipment and systems for use in international telecommunication networks;

(b) that the hypothetical reference digital path for digital radio-relay systems should, as far as possible, be in agreement with the 2500 km hypothetical reference digital paths as specified by the CCITT;

(c) that the capacity of digital radio-relay systems should be that of a CCITT recommended hierarchical level or an integral multiple of it,

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference digital path for digital radio-relay systems, meeting the requirements of "high-grade performance" specified in CCITT Recommendation G.821 and with a capacity above the second hierarchical level, should be 2500 km long (see Note 1);

2. that this digital path should include, for each direction of transmission, nine sets of digital multiplexing equipment at the CCITT recommended hierarchical levels, it being understood that a set of digital multiplexing equipment comprises a number of associated multiplexers and demultiplexers;

3. that this digital path should include nine consecutive identical digital radio sections of equal length (see Note 2);

4. that this hypothetical reference digital path should be as represented in Fig. 1.

Note 1. – In conformity with considering *(c)* this hypothetical reference digital path also applies to systems with a capacity which is an integral multiple of the second or higher hierarchical level.

Note 2. – A digital radio section consists of two consecutive radio terminal equipments and their interconnecting transmission medium which together provide the whole of the means of transmitting and receiving between two consecutive digital distribution frames (or equivalents), a digital signal of specified rate (see CCITT Recommendation G.702). The characteristics of some radio-relay systems (for instance code conversion, insertion of justification bits, parity bits and service bits) may cause the bit rate within the digital radio section to be different from the CCITT recommended hierarchical level or an integral multiple of it.

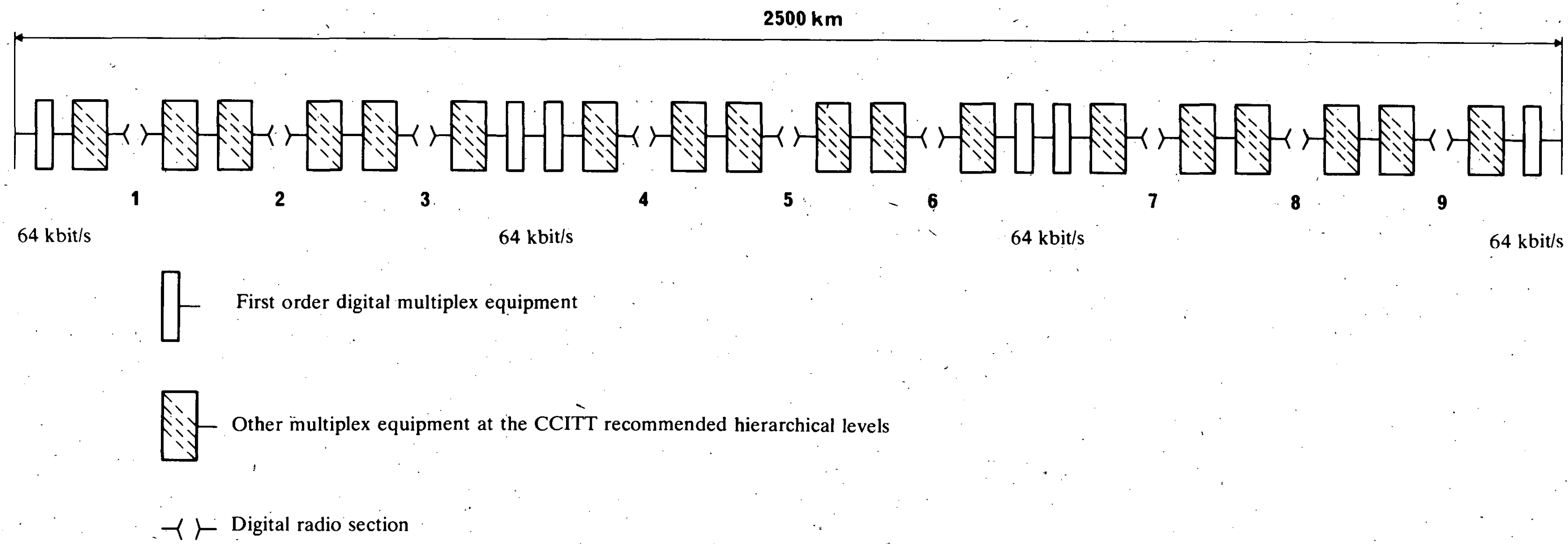

FIGURE 1 – *Hypothetical reference digital path for radio-relay systems with a capacity above the second hierarchical level*

(See Recommendation 594 and Report 930)

RECOMMENDATION 594-2

ALLOWABLE BIT ERROR RATIOS AT THE OUTPUT OF THE HYPOTHETICAL REFERENCE DIGITAL PATH FOR RADIO-RELAY SYSTEMS WHICH MAY FORM PART OF AN INTEGRATED SERVICES DIGITAL NETWORK

(Question 33/9)

(1982–1986–1990)

The CCIR,

CONSIDERING

(a) that the performance objectives of digital radio-relay systems should be defined;

(b) that the definition of the allowable bit-error performance of the hypothetical reference digital path (HRDP) is necessary for the design and construction of radio-relay systems;

(c) that propagation and other effects suggest that the bit-error performance should be stated statistically as a percentage of time;

(d) that a bit-error measurement requires a certain duration of time which depends on the magnitude of the error ratio;

(e) that the effect of error burst phenomena and jitter may need to be taken into account;

(f) that during normal operation, periods of high bit error ratio will occur which will cause short interruptions, these interruptions being mostly caused by adverse propagation conditions (see Note 7),

(g) that the performance objectives for an international digital connection forming part of an integrated services digital network (ISDN) have been specified by the CCITT (see Recommendation G.821, Malaga-Torremolinos, 1984);

(h) that the hypothetical reference digital path (HRDP) defined in Recommendation 556 corresponds to the "high-grade performance" specified in Recommendation G.821 and for which the CCITT has established a rule of apportionment of the total impairment allowance,

UNANIMOUSLY RECOMMENDS

1. that the following performance objectives are stated for each direction of the 64 kbit/s hypothetical reference digital path (HRDP) specified in Recommendation 556;

2. that fading, interference and all other sources of performance degradation are taken into account in establishing the values given below;

3. that the bit error ratio should not exceed the following values:

3.1 1×10^{-6} during more than 0.4% of any month; integration time 1 min; (minutes of degraded performance) (see Notes 10 and 11);

3.2 1×10^{-3} during more than 0.054% of any month; integration time 1 s (severely errored seconds);

4. that the total of errored seconds should not exceed 0.32% of any month (see Notes 8 and 9).

Note 1 – The limits proposed are based on the best knowledge currently available but are subject to review in the future in the light of further studies.

Note 2 – The output bit stream from a digital radio-relay system suffers from jitter. The subject requires further study and is also being considered by the CCITT.

Note 3 – This Recommendation relates to the hypothetical reference digital path (HRDP). The values given are for use by the system designer, and it is not intended that they should be quoted in specifications of equipment or used for acceptance tests.

Note 4 – Contributions from multiplex equipment are not included.

Note 5 – The Recommendation applies only when the system is considered to be available in accordance with Recommendation 557 and includes periods of high bit error ratio exceeding 10^{-3} which persist for periods of less than 10 consecutive seconds. Periods of high bit error ratio which perist for 10 consecutive seconds duration or longer are taken into account by Recommendation 557.

Note 6 – The limits given in RECOMMENDS 3.2 are based upon the 10 second non-availability criteria given in Recommendation 557, and therefore will not necessarily include all forms of degradations in performance due to adverse propagation. Degradations due to adverse propagation which persist for 10 seconds or longer will be limited by the requirements of Recommendation 557.

Note 7 – Adverse propagation conditions can result in a decrease of the wanted signal and/or an increase in the level of interfering signals.

Note 8 – The relationship between the errored seconds of a 64 kbit/s channel and the corresponding parameters which may be measured directly at the bit rate of the radio-relay system is still under study. For the time being, the errored seconds should be measured only at the 64 kbit/s interface.

Note 9 – The errored second objective described in RECOMMENDS 4 could usually be satisfied when the objectives of § 3.1 and 3.2, and the residual bit error ratio (RBER) objective for 2500 km (see Report 930) are satisfied, taking into account typical cumulative error probability distributions.

Note 10 – Measurements of BER are normally made at a much higher bit rate than 64 kbit/s, for example at the bit rate of the radio-relay system. Practical and theoretical considerations on the BER measurements are dealt with in Report 613.

Note 11 – The seconds during which the bit error ratio exceeds 1×10^{-3} should not be taken into account in the integration time.

Note 12 – The requirements are intended to meet the relevant performance objectives of Recommendations G.821 and G.921 under all normally envisaged operating conditions. Recommendation G.821 remains the overriding performance objective of the network.

RECOMMENDATION 634-1

ERROR PERFORMANCE OBJECTIVES FOR REAL DIGITAL RADIO-RELAY LINKS FORMING PART OF A HIGH-GRADE CIRCUIT WITHIN AN INTEGRATED SERVICES DIGITAL NETWORK

(Question 33/9)

(1986–1990)

The CCIR,

CONSIDERING

(a) that the error performance objectives of a high-grade 2500 km hypothetical reference digital path for digital radio-relay systems, operating above the second hierarchical level, are given in Recommendation 594, which applies to 64 kbit/s;

(b) that network performance objectives for digital sections are given in CCITT Recommendation G.921;

(c) that real paths which form part of the high-grade portion of an integrated services digital network (ISDN) sometimes differ in composition from the hypothetical reference digital path (see Recommendation 556, Fig. 1), and share radio-relay links shorter than 2500 km with other digital links;

(d) that conformity to digital radio performance Recommendations cannot be easily established by direct measurements on real systems due to the seasonal and annual variations in propagation conditions, and that practical advice on how to apply performance Recommendations is therefore necessary;

(e) that, therefore, it is necessary to give objectives for allowable bit error ratios as a guide in the design and planning of real radio-relay links forming part of the high-grade portion of an integrated services digital network,

UNANIMOUSLY RECOMMENDS

1. that when establishing real digital radio links intended to form part of a high-grade circuit within an ISDN, the following error performance criteria should be respected for a link with length, *L*, of between 280 km and 2500 km (see Notes 1, 2 and 9);

1.1 BER $\geqslant 1 \times 10^{-3}$ for no more than $(L/2500) \times 0.054\%$ of any month; integration time 1 s (see Note 3);

1.2 BER $\geqslant 1 \times 10^{-6}$ for no more than $(L/2500) \times 0.4\%$ of any month; integration time 1 min (see Notes 3, 6 and 7);

1.3 errored seconds for no more than $(L/2500) \times 0.32\%$ of any month (see Notes 3, 4 and 8);

1.4 residual bit error ratio:

$$\text{RBER} \leqslant \frac{L \times 5 \times 10^{-9}}{2500} \qquad \text{(see Note 5)}$$

2. the BER performance criteria are to be respected at the system bit rate. The errored second criterion should, for the present, be respected at the 64 kbit/s level (see Notes 4 and 7).

Note 1 – International links are sometimes composed of radio-relay systems with a capacity equal to or lower than the second hierarchical level. Real radio-relay links discussed here can include these small capacity systems.

Note 2 – Performance objectives for circuits shorter than 280 km are still under study.

Note 3 – The term "any month", as used in this Recommendation, is defined in Recommendation 581. Where measurements are used to ensure compliance with this Recommendation, then the propagation conditions also need to be assessed and related to propagation data representative of "any month" conditions.

Note 4 – The relationship between the errored seconds of a 64 kbit/s channel and the corresponding parameters which may be measured directly at the bit rate of the radio-relay system is still under study. For the time being, the errored seconds should be measured only at the 64 kbit/s interface. However, it should be noted that if the objectives given in RECOMMENDS 1.1, 1.2 and 1.4 are satisfied, then the objective given in RECOMMENDS 1.3 is usually satisfied, taking into account the typical cumulative error ratio distribution for high-grade systems.

Note 5 – The provisional method of measurement of the residual bit error ratio involves taking the BER measurements over a period of one month using a 15 min integration time, discarding the 50% of 15 min intervals which contain the worst BER measurements, and taking the worst of the remaining measurements. The RBER limits and method of measurement are under study and require verification. Report 930 discusses RBER and refers to other methods of its measurement.

Note 6 – Seconds when the BER $\geq 1 \times 10^{-3}$ should be excluded, when measuring degraded minute performance.

Note 7 – Measurements of the 10^{-6} BER criterion at the system bit rate, using different integration times, indicate that the errors occurring within a 1 min period may be clustered. The degraded minute objective may therefore become a more stringent requirement to be respected than the severely errored seconds objective (see Report 930) and possibly more stringent than the degraded minute objective at 64 kbit/s. This subject requires further study.

Note 8 – The errored second allowance includes all performance degradations other than unavailability.

Note 9 – It should be noted that this Recommendation includes allowances for all degradations to performance, additional to those caused by fading.

Note 10 – The Recommendation applies only when the system is considered to be available in accordance with Recommendation 557 and includes periods of high bit error ratio exceeding 10^{-3} which persist for periods of less than 10 consecutive seconds. Periods of high bit error ratio which persist for 10 consecutive seconds duration or longer are taken into account by Recommendation 557.

Note 11 – It should be noted that:

- the requirements of this Recommendation are intended to meet the relevant performance objectives of Recommendations G.821 and G.921 under all normally envisaged operating conditions;
- Recommendation G.821 remains the overriding performance objective of the network.

RECOMMENDATION 696

ERROR PERFORMANCE AND AVAILABILITY OBJECTIVES FOR HYPOTHETICAL REFERENCE DIGITAL SECTIONS UTILIZING DIGITAL RADIO-RELAY SYSTEMS FORMING PART OR ALL OF THE MEDIUM GRADE PORTION OF AN ISDN CONNECTION

(Question 5/9 and 33/9)

(1990)

The CCIR,

CONSIDERING

(a) that the error performance and availability objectives for digital radio-relay systems used in the medium grade portion of the network, as specified in Fig. 1 of CCITT Recommendation G.821, should be defined;

(b) that the error performance for an international digital connection forming part of an integrated services digital network (ISDN) have been specified by the CCITT in Recommendation G.821 and that this Recommendation includes the performance objectives for the medium grade portion of the network;

(c) that the error performance and availability objectives for digital radio-relay systems used in the hypothetical reference digital sections forming part of the medium grade portion should be defined;

(d) that the hypothetical reference digital section (HRDS) lengths are identified in CCITT Recommendation G.801;

(e) that network performance objectives for digital sections are given in CCITT Recommendation G.921 (Note 1);

(f) that propagation, interference, equipment failure, and other effects suggest that the performance and availability objectives should be stated statistically as a percentage of time;

(g) that digital radio-relay systems in the medium grade network may operate either below or above a frequency of about 10 GHz, and therefore several types of anomalous propagation phenomena may affect the error performance and the availability of systems (see Note 2);

(h) that a bit error ratio measurement requires a certain duration of time which depends upon the magnitude of the bit error ratio;

(j) that the occurrence of periods of unavailability due to anomalous propagation conditions, interference, equipment failure, and other effects are sufficiently variable so that it is necessary to define the objectives averaged over a long period,

UNANIMOUSLY RECOMMENDS

1. that the error performance objectives given in Table I apply to each direction and to each 64 kbit/s channel of an HRDS of quality classifications 1 to 4 utilizing digital radio-relay systems and forming part of the medium grade portion of an ISDN connection. These objectives take account of fading, short-term and long-term interference (Note 3) and all other sources of performance degradation (Note 4) during periods for which the system in considered to be available (Notes 2 and 5);

2. that the following performance objectives apply to each direction and to each 64 kbit/s channel for the total medium grade portion at each end of an HRX when this is realized entirely with digital radio-relay systems. These objectives take account of fading, short-term and long-term interference (Note 3), and all other sources of performance degradation (Note 4) during periods for which the system is considered to be available (Notes 2 and 5);

2.1 that the bit error ratio should not exceed 1×10^{-3} for more than 0.04% of any month with an integration time of 1 s (Note 6);

2.2 that the bit error ratio should not exceed 1×10^{-6} for more than 1.5% of any month with an integration time of 1 min (Notes 6 and 8);

2.3 that the total errored seconds should not exceed 1.2% of any month (Notes 6 and 9);

TABLE I – *Error performance objectives*

Performance parameter	Percentage of any month (Note 6)			
	Class 1 280 km	Class 2 280 km	Class 3 50 km	Class 4 50 km
BER > 1×10^{-3} Integration time: 1 s	0.006	0.0075	0.002 (Note 7)	0.005 (Note 7)
BER > 1×10^{-6} Integration time: 1 min (Note 8)	0.045	0.2	0.2	0.5
Errored seconds (Note 9)	0.036	0.16	0.16	0.4
RBER (Note 10)	According to Recommendation 634 5.6×10^{-10} (1)	Under study	Under study	Under study

(1) This parameter is measured in accordance with the method described in Note 5 of Recommendation 634.

3. that the total bidirectional unavailability (Notes 2 and 11) due to all causes for the HRDS classes 1 to 4 utilizing digital radio-relay systems and forming part of the medium grade portion of an ISDN connection shall not exceed the following values, the percentage being considered over a period of time sufficiently long to be statistically valid, this period is probably greater than one year; the period of time is under study:

– Class 1: 0.033%;
– Class 2: 0.05%;
– Class 3: 0.05%;
– Class 4: 0.1%.

Note 1 – If a real digital section is shorter, there will be no reduction of error performance allocation. If a real digital section is longer, the two different methods of performance allocation should be applied according to the section quality. In the case of systems in classes 2, 3, or 4, their overall allocation should correspond to that of an integer number of HRDSS (of the same quality classification) the combined length of which is at least as long as the real section length. In the case of systems in Class 1, performance objectives should be derived from a pro-rata approach in accordance with Recommendation 634.

Note 2 – The concept of unavailability of a digital radio-relay system is defined in § 3 of Recommendation 557.

Note 3 – Short-term interference, is the interference due to the existence of anomalous propagation conditions, and typically consists of very high levels of interference which only occur rarely, and exist for short periods ot time. Long-term interference, is the interference which arises from sources within line-of-sight of the victim receiver, and is typically low in level and constant in value.

Note 4 – In the design of the systems, the degradation of performance due to the sharing of the spectrum with satellite systems and other services, needs to be taken into account where appropriate, and is under study.

Note 5 – In considering specific values for the error performance objectives of the medium grade portion at each end of the HRX, administrations may wish to take account of Note 5 to Table 2 of CCITT Recommendation G.821 (allocation of a block allowance of 30% for the local and medium grade portion at each end of the HRX).

Note 6 – The term "any month" as used in this Recomendation, is defined in Recommendation 581. Where measurements are used to ensure compliance with this Recommendation, then propagation conditions also need to be assessed and related to propagation data representative of "any month" conditions.

Note 7 – In the case of the severly errored seconds an allowance for adverse propagation may be added to the given objectives for HRDS classes 3 and 4. Since the full length of the medium grade portion always belongs to a national network, the apportionment of the 0.025% allowance to the individual network parts based on the national reference network model should be a matter for the administration concerned. However, it has to be ensured that this overall objective for the medium grade portion is not exceeded.

Note 8 – Seconds when the BER 1 > 10^{-3} should be excluded, when measuring degraded minute performance.

Note 9 – The errored seconds allowance includes all performance degradations other than unavailability.

Note 10 – The residual bit error ratio (RBER) is the bit error ratio of the system in absence of fading and short-term interference, but including the presence of long-term interference. The reasons for establishing RBER objectives together with appropriate measurement methods can be found in Report 930.

Note 11 – The overall bidirectional unavailability objective for the total medium grade portion is under study (see Report 1052).

RECOMMENDATION 697

ERROR PERFORMANCE OBJECTIVES FOR THE LOCAL-GRADE PORTION AT EACH END OF AN ISDN CONNECTION UTILIZING DIGITAL RADIO-RELAY SYSTEMS

(Question 5/9 and 33/9)

(1990)

The CCIR,

CONSIDERING

(a) that the error performance objectives for digital radio systems which form all of a local-grade network, as specified in Fig. 1 of CCITT Recommendation G.821, should be defined (Notes 1 and 2);

(b) that the error performance objectives for an international digital connection forming part of an ISDN have been specified by the CCITT in Recommendation G.821 and that this Recommendation includes the performance objectives for the local-grade portion of the network;

(c) that propagation and interference effects suggest that the performance and availability objectives should be stated statistically as a percentage of time;

(d) that digital radio system in the local-grade network may operate either below or above a frequency of about 10 GHz, and therefore several types of anomalous propagation phenomena may affect the error performance;

(e) that a bit error ratio measurement requires a certain duration of time which depends upon the magnitude of the bit error ratio,

UNANIMOUSLY RECOMMENDS

1. that the following error performance objectives apply to each direction and to each 64 kbit/s channel of a digital radio system used to form all of the local-grade portion at each end of an ISDN connection (Note 2) which take account of fading, short-term and long-term interference (Note 4) and all other sources of perfomance degradation (Note 5) during periods for which the system is considered to be available (Notes 3, 6 and 9);

1.1 that the bit error ratio should not exceed 1×10^{-3} for more than 0.015% of any month with an integration time of 1 s (Note 7);

1.2 that the bit error ratio should not exceed 1×10^{-6} for more than 1.5% of any month with an integration time of 1 min (Notes 7 and 10);

1.3 that the total errored seconds should not exceed 1.2% of any month (Notes 7 and 11).

Note 1 – In accordance with Annex A of CCITT Recommendation G.801, which states that national administrations are advised to develop their own representative network models reflecting the features of their evolving national digital network in order to validate *prime facie* compliance with international standards, no hypothetical digital local-grade reference is proposed to which the performance objectives apply.

Note 2 – If the radio path consists of more than one hop and/or forms only part of the local-grade network, it is at the discretion of administrations to make and appropriate apportionment of the objectives given for the whole local-grade portion.

Note 3 – The concept of unavailability of a digital radio-relay system is defined in § 3 of Recommendation 557.

Note 4 – Short-term interference is the interference due to the existence of anomalous propagation conditions, and typically consists of very high levels of interference which only occur rarely, and exist for short periods of time. Long-term interference is interference which arises from sources within line-of-sight of the victim receiver, and is typically low in level and constant in value.

Note 5 – In the design of systems, the degradation of performance due to the sharing of the spectrum with satellite systems and other services need to be taken into account, where appropriate, and is under study (see Report 1187).

Note 6 – In considering specific values for the error performance objectives, administrations may wish to take account of Note 5 of Table 2 of CCITT Recommendation G.821 (Allocation of a block allowance of 30% for the local- and medium-grade portion at each end of the HRX).

Note 7 – The term "any month" as used in this Recommendation, is defined in Recommendation 581. Where measurements are used to ensure compliance with this Recommendation, then propagation conditions also need to be assessed and related to propagation data representative of "any month" conditions.

Note 8 – The residual bit error ratio (RBER) objective should be established. The RBER is the bit error ratio of the system in the absence of fading and short-term interference, but including the presence of long-term interference. The reasons for establishing RBER objectives together with appropriate measurement methods can be found in Report 930. The RBER criterion is respected at the system bit rate. The value of RBER objective is under study.

Note 9 – The subject of unavailability is still under study (see Report 1053).

Note 10 – Seconds when the BER $> 1 \times 10^{-3}$ should be excluded, when measuring degraded minute performance.

Note 11 – The errored seconds allowance includes all performance degradations other than unavailability.

RECOMMENDATION 557-2

AVAILABILITY OBJECTIVE FOR A HYPOTHETICAL REFERENCE CIRCUIT AND A HYPOTHETICAL REFERENCE DIGITAL PATH

(Question 5/9)

(1978-1986-1990)

The CCIR,

CONSIDERING

(a) that the hypothetical reference circuit (HRC) and the hypothetical reference digital path are intended as a guide to designers and planners;

(b) that the availability of a radio-relay system is dependent upon many factors and particularly upon: the maintenance organization (which determines the time to restore), the reliability of equipments and the system design and propagation conditions. The relative importance of these various factors may vary significantly, sometimes without possibility of control, from one area to another;

(c) that it is desirable to apply common availability objectives to both cable and radio-relay systems,

UNANIMOUSLY RECOMMENDS

1. that the availability objective appropriate to a 2500 km hypothetical reference circuit for frequency division multiplex radio-relay systems (Recommendation 392) and for a 2500 km hypothetical reference digital path for digital radio-relay systems (Recommendation 556) should be 99.7% of the time, the percentage being considered over a period of time sufficiently long to be statistically valid, this period is probably greater than one year; the period of time is under study (see Notes 1, 2 and 3);

2. that the concept of unavailability of an analogue HRC should be as follows: in at least one direction of transmission, one or both of the following conditions occur, for at least 10 consecutive seconds (Note 8):

2.1 the level of the baseband frequencies falls by 10 dB or more from reference level;

2.2 for any telephone channel the unweighted noise power with an integrating time of 5 ms is greater than 10^6 pW0 (Note 9);

3. that the concept of unavailability of a hypothetical reference digital path should be as follows:

3.1 the period of unavailable time begins when, in at least one direction of transmission, one or both of the following conditions occur for 10 consecutive seconds (Note 8):

- the digital signal is interrupted (i.e. alignment or timing is lost);
- the bit error ratio in each second is worse than 1×10^{-3} (Note 10);

these 10 seconds are considered to be unavailable time;

3.2 the period of unavailable time terminates when for both directions of transmission, both of the following conditions occur for 10 consecutive seconds:

- the digital signal is restored (i.e. alignment or timing is recovered);
- the bit error ratio in each second is better than 1×10^{-3};

these 10 seconds are considered to be available time.

4. that in the estimate of unavailability, one must include all causes which are statistically predictable, unintentional and resulting from the radio equipment*, power supplies, propagation**, interference and from auxiliary equipment and human activity. The estimate of unavailability includes consideration of the mean time to restore (see Notes 5 and 6);

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* This includes all equipment between points R and R′ defined in Recommendation 380 for analogue systems, and all equipment within a digital radio section for digital systems.

** The influence of the propagation-dependent part on the availability design objective is considered in Report 784.

5. that the following Notes should be treated as part of the Recommendation:

Note 1 – The value of 99.7% is a provisional one and it is recognized that, in practice, the objectives selected may fall into the range 99.5 to 99.9%. The choice of a specific value in this range depends on the optimum allocation of outage time among the various causes which may not be the same when local conditions are taken into account (i.e. propagation, geographical size, population distribution, organization of maintenance).

Furthermore, the availability of radio-relay systems is only one of the many aspects that ensure the acceptable grade of service of the telephony traffic; the choice of an optimum value for this particular aspect can only be done by considering all transmission systems either existing or planned in the network under study.

For these many reasons, administrations may select different values of availability objective for the use of their planning organization, the said values lying in the range shown above.

Note 2 – Availability of multiplex equipments is excluded from the foregoing. The CCITT is expected to establish availability objectives for these equipments.

Note 3 – This Recommendation relates to the hypothetical reference circuit and to the hypothetical reference digital path. Its purpose is to set an availability figure as planning objective for new radio-relay systems.

It is not intended that it will be quoted in specifications of real systems, for acceptance tests, or for operational agreements. Recommendations relating to real circuits availability have to be established.

The measured data on availability figures for real circuits shows a wide distribution, a reliable figure of the actual availability can be estimated only as an average of a large amount of data collected from many radio-relay routes for a sufficiently long period of time.

Note 4 – The sub-division of the availability objective in the high grade portion of circuits to be established over real links is given in Recommendation 695. Availability objectives for real links in the medium and local grade portions of an ISDN connection are under study.

Note 5 – Planners should indicate their assumptions concerning the mean time between failures, the mean time to restore, the precautions taken against interruptions and fading (in particular the use of protection channels and the number of hops per switching section) and the distribution of fading with a duration longer than 10 seconds.

Note 6 – The time to restore, which is the time elapsing between an interruption to traffic and its restoration, includes recognition time, travelling time as well as repair time. Differences in the time to restore will occur between administrations due to various factors such as site accessibility, weather, maintenance policy and other economic considerations.

Note 7 – This Recommendation does not take into account the improvements which could be obtained by means of re-routing traffic over other systems, e.g. cables and other radio-relay systems.

Note 8 – For interruptions with durations less than 10 seconds further study is necessary taking also into account intermittent interruptions.

Note 9 – Periods of less than 10 seconds during which the noise power in a telephone channel in frequency division multiplex systems is greater than 10^6 pW0 are taken into account in Recommendation 393.

Note 10 – Periods of less than 10 seconds during which the error ratio is greater than 10^{-3} are taken into account in Recommendation 594.

RECOMMENDATION 695

AVAILABILITY OBJECTIVES FOR REAL DIGITAL RADIO-RELAY LINKS FORMING PART OF A HIGH-GRADE CIRCUIT WITHIN AN INTEGRATED SERVICES DIGITAL NETWORK

(Question 33/9)

(1990)

The CCIR,

CONSIDERING

(a) that the availability objective of a high-grade 2500 km hypothetical reference digital path for digital radio-relay systems, operating above the second hierarchical level, is given in Recommendation 557;

(b) that real paths which form part of the high-grade portion of an integrated services digital network (ISDN) sometimes differ in composition from the hypothetical reference digital path (see Recommendation 556, Fig. 1), and share radio-relay links shorter than 2500 km with other digital links;

(c) that the availability of a radio-rely system is dependent upon many factors and particularly upon: the maintenance organization (which determines the time to restore), the reliability of equipments, the system design and propagation conditions, and that the relative importance of these various factors may vary significantly, sometimes without possibility of control, from one area to another;

(d) that it is desirable to give objectives for availability as a guide in the planning of real radio-relay links forming part of the high-grade portion of an integrated services digital network,

UNANIMOUSLY RECOMMENDS

1. that the availability objective appropriate to a real digital radio link intended to form part of a high grade circuit within an ISDN, for a link with length, L, of between 280 km and 2500 km, should be as follows:

$$A = 100 - (0.3 \times L/2500) \quad \%$$

the percentage being considered over a period of time sufficiently long to be statistically valid, this period is probably greater than one year; the period of time is under study (see Notes 1, 2 and 3);

2. that in the estimate of unavailability, one must include all causes which are statistically predictable, unintentional and resulting from the radio equipment (including all equipment within a digital radio section), power supplies, propagation (see Remark), interference and from auxiliary equipment and human activity, and that the estimate of unavailability should include consideration of the mean time to restore (see Notes 4 and 5);

Remark – The influence of the propagation-dependent part on the availability design objective is considered in Report 784.

3. that the following Notes should be treated as part of the Recommendation:

Note 1 – The value of 0.3 is a provisional one and it is recognized that, in practice, the value selected may fall into the range 0.1 to 0.5. The choice of a specific value in this range depends on the optimum allocation of outage time among the various causes which may not be the same when local conditions are taken into account (i.e. propagation, geographical size, population distribution, organization of maintenance).

Furthermore, the availability of radio-relay systems is only one of the many factors that ensure that the grade of service of the telephony traffic is acceptable, the choice of an optimum value for this particular factor can only be done by considering all transmission systems either existing or planned in the network under study. For these reasons, administrations may select different values of availability objective for use by their planning organization, the selected values lying in the range shown above.

Note 2 – Availability of multiplex equipments is excluded from the foregoing. The CCITT is expected to establish availability objectives for these equipments.

Note 3 – Availability objectives for circuits shorter than 280 km are under study.

Note 4 – Planners should indicate their assumptions concerning the mean time betwen failures, the mean time to restore, the precautions taken against interruptions and fading (in particular the use of protection channels and the number of hops per switching section) and the distribution of fading with a duration longer than 10 s.

Note 5 – The time to restore, which is the time that elapses between an interruption to traffic and its restoration, includes recognition time, travelling time as well as repair time. Differences in the time to restore will occur between administrations due to various factors such as site accessibility, weather, maintenance policy and other economic considerations.

Note 6 – This Recommendation does not take into account the improvements which could be obtained by means of re-routing traffic over other systems, e.g. cables and other radio-relay systems.

SECTION 9B: RADIO-FREQUENCY CHANNEL ARRANGEMENTS AND SPECTRUM UTILIZATION

9B1: RADIO-FREQUENCY CHANNEL ARRANGEMENTS

RECOMMENDATION 283-5 *

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR LOW AND MEDIUM CAPACITY ANALOGUE OR DIGITAL RADIO-RELAY SYSTEMS OPERATING IN THE 2 GHz BAND

(Questions 1/9 and 35/9)

(1959–1966–1970–1978–1982–1990)

The CCIR,

CONSIDERING

(a) that it is sometimes desirable to be able to interconnect radio-relay systems of 60, 120, 300 and up to 960 ** telephone channel capacity, or low and medium capacity digital systems of equivalent bandwidth, on international circuits using radio frequencies in the 2 GHz band;

(b) that, in a frequency band 200 MHz wide, it may be desirable to interconnect up to six go and six return radio-frequency channels;

(c) that economy may be achieved, if at least three go and three return channels can be interconnected between systems each of which uses a common transmit-receive antenna;

(d) that for systems up to 300 telephony channels many interfering effects can be substantially reduced by a carefully planned arrangement of the radio frequencies in radio-relay systems employing several radio-frequency channels;

(e) that for systems up to 300 telephony channels it may sometimes be desirable to interleave additional radio-frequency channels between those of the main pattern;

(f) that it is desirable for the values of the mid-frequencies of the radio-frequency channels to be the same for 60, 120, 300 and up to 960 channel telephony systems, as well as for digital systems;

(g) that the spacing between the mid-frequencies of the radio-frequency channels should be such that the systems can work with the maximum frequency deviation given in Recommendation 404 for systems up to 600 telephone channels, while for 960 telephone channel systems a lower frequency deviation should be used in order to improve the spectrum utilization,

(h) that the use of bit rates of the order of 70 Mbit/s is possible in the 2 GHz band,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to six go and six return channels, each accommodating 60, 120, 300 or a maximum of 960 ** telephone channels or digital systems up to about 70 Mbit/s, and operating within the frequency bands listed under § 6, should be as shown in Fig. 1, which is derived as follows:

Let f_0 be the frequency of the centre of a 200 MHz band of frequencies occupied (MHz);

f_n be the centre frequency of one radio-frequency channel in the lower half of this band (MHz);

f'_n be the centre frequency of one radio-frequency channel in the upper half of this band (MHz);

* This Recommendation applies only to line-of-sight and near line-of-sight radio-relay systems.

** The provision of this Recommendation for 960 channels applies only in the frequency band 2500 to 2700 MHz.

then the frequencies in MHz of individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 108.5 + 14\,n$,
upper half of the band: $f'_n = f_0 + 10.5 + 14\,n$,

where

$n = 1, 2, 3, 4, 5$ or 6;

2. that, in a section over which the international connection is arranged, all the go channels should be in one half of the band, and all the return channels should be in the other half of the band;

3. that for adjacent radio-frequency channels in the same half of the band, different polarizations should preferably be used alternately; *

4. that, when common transmit-receive antennas are used and three radio-frequency channels are accommodated on a single antenna, it is preferable that the channel frequencies be selected by either making $n = 1, 3$ and 5 in both halves of the band or making $n = 2, 4$ and 6 in both halves of the band;

5. that, when additional radio-frequency channels, interleaved between those of the main patterns, are required, the values of the centre frequencies of these radio-frequency channels should be 7 MHz above those of the corresponding main channel frequencies; **

6. that the centre frequencies should preferably be those shown below:

f_0 = 1808 MHz for the band 1700 to 1900 MHz;
f_0 = 2000 MHz for the band 1900 to 2100 MHz;
f_0 = 2203 MHz for the band 2100 to 2300 MHz (see Note 3);
f_0 = 2586 MHz for the band 2500 to 2700 MHz***.

Other centre frequencies may be used by agreement between the administrations concerned.

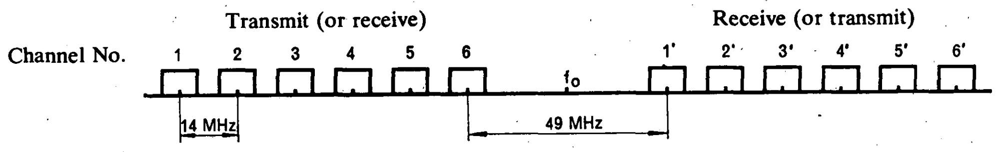

FIGURE 1 – *Radio-frequency channel arrangement for international connection of radio-relay systems operating in the 2 GHz band*

Note 1 – When the frequency band 1900 to 2300 MHz or 1700 to 2100 MHz is used for large capacity radio-relay systems and a 60, a 120 or a 300 channel system is used on the same route, the possibility of introducing mutual interference is greatly reduced if separate antennas are used for the two systems (see Fig. 1).

Note 2 – In systems for up to 300 telephony channels, operational difficulties may be experienced along a route, due to over-reach and similar problems. In such cases, additional frequencies, spaced 3.5 MHz from the allocations given above, are available for use as stagger frequencies.

Note 3 – In certain countries, particularly in Region 2, it may be preferable to have the frequencies in MHz of individual channels as expressed by the following relationships:

lower half of the band: $f_n = f_0 - 94.5 + 14\,n$,
upper half of the band: $f'_n = f_0 - 3.5 + 14\,n$,

where

$n = 1, 2, 3, 4, 5$ or 6.

* The same polarization for adjacent channels can also be used for low capacity digital systems.

** In systems for 960 telephone channels in the band 2500 to 2700 MHz, or digital systems of about 70 Mbit/s, it may not be practicable to use interleaved frequencies, because of the wide bandwidth occupied by the modulated carrier.

*** Attention is drawn to the fact that the lowest main channel frequency is below 2500 MHz and that in accordance with Article 8 of the Radio Regulations, all emissions are prohibited in the band 2690-2700 MHz except in the countries mentioned in Nos. 767 and 769 and for equipment in operation by 1 January 1985.

Interleaved channels should be 7 MHz below those of the corresponding main channels.

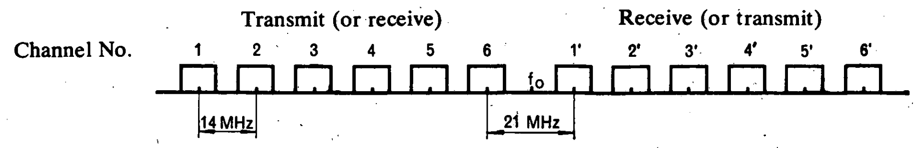

FIGURE 2 – *Radio-frequency channel arrangement referred to in Note 3*

Note 4 – When using a 960* telephone channel system, in accordance with this Recommendation, the following preferred values should be used:

– r.m.s. deviation per channel: 140 kHz,
– frequency of continuity pilot: 4715 kHz,
– r.m.s. deviation for the continuity pilot: 100 kHz.

* The provision of this Recommendation for 960 channels applies only in the frequency band 2500 to 2700 MHz.

RECOMMENDATION 382-5*

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR MEDIUM AND HIGH CAPACITY ANALOGUE RADIO-RELAY SYSTEMS OPERATING IN THE 2 AND 4 GHz BANDS, OR FOR MEDIUM AND HIGH CAPACITY DIGITAL RADIO-RELAY SYSTEMS OPERATING IN THE 4 GHz BAND

(Questions 1/9 and 35/9)

(1956-1959-1963-1966-1970-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that it is sometimes desirable to be able to interconnect radio-relay systems on international circuits at radio frequencies in the 2 and 4 GHz bands;

(b) that, in a frequency band 400 MHz wide, it may be desirable to interconnect up to six go and six return radio-frequency channels;

(c) that economy may be achieved if at least three go and three return channels can be interconnected between systems each of which uses common transmit-receive antennas;

(d) that many interfering effects can be substantially reduced by a carefully planned arrangement of the radio frequencies in radio-relay systems employing several radio-frequency channels;

(e) that it may sometimes be desirable to interleave additional radio-frequency channels between those of the main pattern;

(f) that the use of bit rates of 2 × 34 Mbit/s or 2 × 45 Mbit/s or 140 Mbit/s is possible in the 4 GHz band;

(g) that it is desirable to provide for operation of analogue and digital systems on the same path,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to six go and six return channels, each accommodating 600 to 1800 telephone channels, or the equivalent, and operating at frequencies in the 2 and 4 GHz bands or for digital radio-relay systems with a capacity of 34 to 140 Mbit/s operating in the 4 GHz band, should be as shown in Fig. 3 and should be derived as follows:

Let f_0 be the frequency of the centre of the band of frequencies occupied (MHz);
f_n be the centre frequency of one radio-frequency channel in the lower half of the band (MHz);
f'_n be the centre frequency of one radio-frequency channel in the upper half of the band (MHz);

then the frequencies in MHz of individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 208 + 29\,n,$
upper half of the band: $f'_n = f_0 + 5 + 29\,n,$

where

n = 1, 2, 3, 4, 5 or 6.

* This Recommendation applies only to line-of-sight and near line-of-sight radio-relay systems.

2. that in a section over which the international connection is arranged all the go channels should be in one half of the band, and all the return channels should be in the other half of the band;

3. that for adjacent radio-frequency channels in the same half of the band, different polarizations should preferably be used alternately; i.e. the odd numbered channels in both directions of transmission on a given section should use H(V) polarization, and the even numbered channels should use V(H) polarization, as shown in Fig. 1 below:

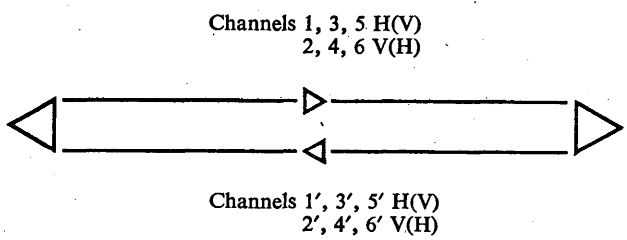

FIGURE 1

Note – When antennas for double polarization are used, the arrangement of channels shown in Fig. 2 may be used by agreement between administrations:

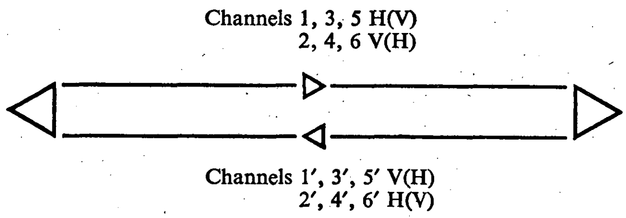

FIGURE 2

4. that, when common transmit-receive antennas are used, and not more than three radio-frequency channels are accommodated on a single antenna, it is preferred that the channel frequencies be selected by either making $n = 1$, 3 and 5 in both halves of the band or making $n = 2$, 4 and 6 in both halves of the band;

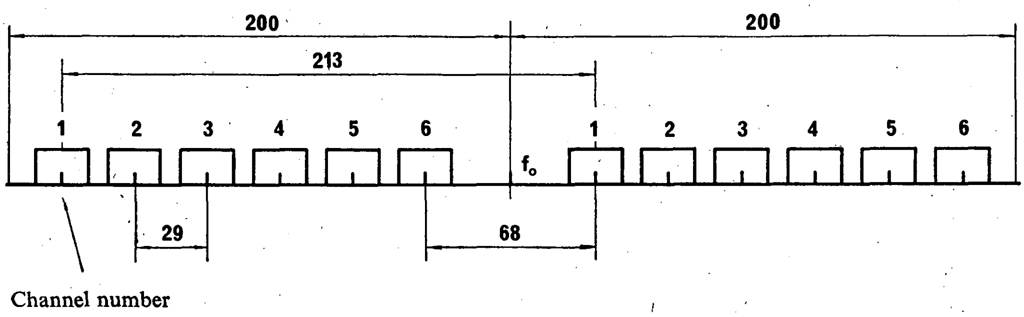

FIGURE 3 – *Radio-frequency channel arrangement for radio-relay systems with capacities from 600 to 1800 telephone channels, or the equivalent, operating in the 2 and 4 GHz bands, for use in international connections*

5. that when additional radio-frequency channels, interleaved between those of the main pattern, are required, the values of the centre frequencies of these radio-frequency channels should be 14.5 MHz below those of the corresponding main channel frequencies*;

6. that to minimize interference within a system, the centre frequency f_0 should preferably be as given below:

in the 2 GHz band, f_0 = 1903 or 2101 MHz (see Note 1);

in the 4 GHz band, f_0 = 4003.5 MHz.

Other centre frequencies may be used by agreement between the administrations concerned**;

7. that due regard be taken of the fact that in some countries, mostly in a large part of Region 2 and in certain other areas, another radio-frequency channel arrangement for 4 GHz systems is used. A description of this radio-frequency channel arrangement is given in Annex I. Attention is drawn to the problem of interconnection.

8. that if a digital transmission at 2 × 34 Mbit/s or 2 × 45 Mbit/s is established in the existing 4 GHz arrangement, there exist modulation systems which ensure compatibility on the same artery between digital and analogue radio-frequency circuits with up to 1260 analogue telephone channels, provided that the analogue and digital radio-frequency circuits are cross-polarized.

Note 1 – In certain countries, particularly in Region 2, it may be preferable to use as centre frequency:

f_0 = 1932 MHz instead of 1903 MHz, and

f_0 = 2086.5 MHz instead of 2101 MHz.

Note 2 – In the USSR, a radio-frequency channel arrangement conforming to the scheme in Fig. 1 of Recommendation 497 is used in the frequency band 3700 to 4200 MHz and for systems with a capacity of 1800 telephone channels or the equivalent, or for digital radio-relay systems with a capacity of 34 to 140 Mbit/s. The reference frequency f_0 is then 3947.5 MHz.

Note 3 – In the People's Republic of China, the frequency band from 3400 to 4200 MHz has been divided into two groups each with a frequency band 400 MHz wide. The radio-frequency channel arrangement is identical to that shown in Fig. 3 of this Recommendation, where f_0 = 3592.0 MHz and 4003.5 MHz, respectively.

ANNEX I

DESCRIPTION OF THE RADIO-FREQUENCY CHANNEL ARRANGEMENT REFERRED TO IN § 7

1. The radio-frequency channel arrangement for a band 500 MHz wide and for up to six go and six return channels (Group 1) and an interleaved pattern of six go and six return channels (Group 2), each accommodating up to 1260 telephone channels or the equivalent, or up to 2 × 45 Mbit/s, operating in the 4 GHz band, is as shown in Fig. 4 and is derived as follows:

Let f_r be the frequency of the lower edge of the band of frequencies occupied (MHz);

f_n be the centre frequency of one radio-frequency channel in the go (return) channel of the band (MHz);

f'_n be the centre frequency of one radio-frequency channel in the return (go) channel of the band (MHz);

---

* In analogue radio-relay systems for 1800 telephone channels, or the equivalent, and in radio-relay systems with digital modulation using a bit rate of 2 × 34 Mbit/s or 2 × 45 Mbit/s, it may not be practicable to use interleaved frequencies, because of the wide bandwidth occupied by the modulated carrier.

** Interference due to certain harmonics of the shift frequency, which may fall near radio-frequency channel frequencies f_n (MHz) in radio-frequency repeaters, or may fall near (f_n ± 70 MHz) in repeaters using an intermediate frequency of 70 MHz, may in certain cases be serious. Such interference may be reduced by choosing a suitable value for f_0, such as those given in § 6.

then the frequencies in MHz of individual channels are expressed by the following relationships:

Group 1

go (return) channel, $f_n = f_r - 50 + 80\ n$,
return (go) channel, $f'_n = f_r - 10 + 80\ n$,

where

n = 1, 2, 3, 4, 5 and 6.

Group 2

go (return) channel, $f_n = f_r - 70 + 80\ (n - 6)$,
return (go) channel, $f'_n = f_r - 30 + 80\ (n - 6)$,

where

n = 7, 8, 9, 10, 11 and 12.

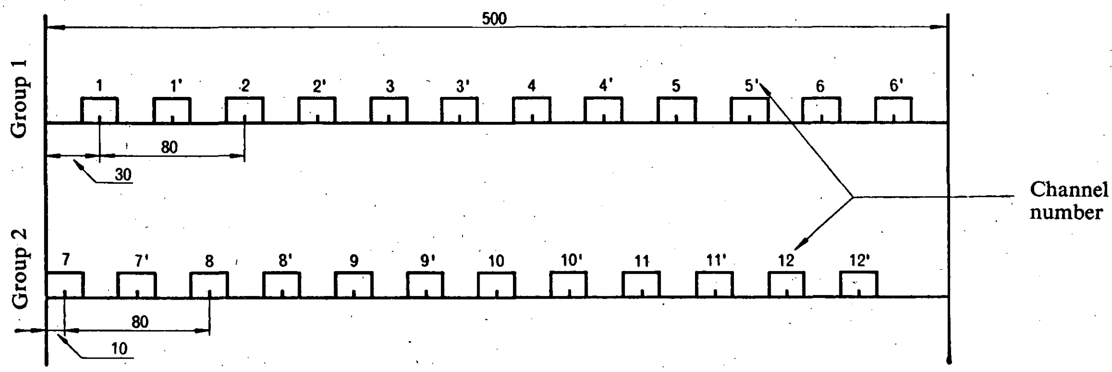

FIGURE 4 – *Radio-frequency channel arrangements described in Annex I*
(All frequencies are in MHz)

2. In a section over which international connections are arranged, the go and return channels are in the same group and are adjacent channels in that group.

3. In any section, both the go and return channels of any one group are of one polarization.

4. In any section, the channels of each group are of different polarizations.

5. In general, the value of f_r is 3700 MHz.

Note – Subject to agreement between administrations concerned, 1800 telephone channels may be accommodated on each radio-frequency channel using either Group 1 or Group 2 frequencies.

RECOMMENDATION 635-1

RADIO-FREQUENCY CHANNEL ARRANGEMENTS BASED ON A HOMOGENEOUS PATTERN FOR HIGH CAPACITY DIGITAL RADIO-RELAY SYSTEMS OPERATING IN THE 4 GHz BAND*

(Question 35/9 and Study Programme 35A/9)

(1986-1990)

The CCIR,

CONSIDERING

(a) that high-capacity digital radio-relay systems of the order of 90 Mbit/s, 140 Mbit/s or 200 Mbit/s or synchronous digital hierarchy bit rates are required in the 4 GHz radio-frequency bands;

(b) that the lower band limits of the 4 GHz radio-frequency bands are not uniform and vary internationally from 3400 to 3800 MHz;

(c) that efficient use of bands of different width can be achieved by radio-frequency channel arrangements matched to the width of the band available;

(d) that a high degree of compatibility between RF channels of different arrangements can be achieved by selecting all channel centre frequencies from a uniform basic pattern;

(e) that the centre gaps of the individual channel arrangements and the guard spacing at the edges of the band can be chosen by non-occupancy of a suitable number of RF-channel positions in a homogeneous basic pattern;

(f) that the uniform basic pattern spacing should not be unjustifiably small (i.e. the number of RF-channel positions too high) nor so large as to jeopardize efficient use of the available spectrum;

(g) that the absolute frequencies of the basic pattern should be defined by a single reference frequency,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for high-capacity digital radio-relay systems of the order of 90 Mbit/s, 140 Mbit/s or 200 Mbit/s or synchronous digital hierarchy bit rates (Note 1), operating in the 4 GHz band (Note 1), should be selected from a homogeneous pattern with the following characteristics:

Centre frequencies f_n of the radio-frequency channels within the basic pattern

$$f_n = 4200 - 10\,m \qquad \text{MHz} \qquad (1)$$

m: integral number depending on available frequency band: 1, 2, 3 . . . (Note 2);

2. that all the go channels should be in one half of the band and all the return channels should be in the other half of the band;

3. that the channel spacing XS, the centre gap YS, the guard spaces Z_1S and Z_2S at the edges of the band and the antenna polarization should be agreed between the administrations concerned;

* Frequency arrangements derived from the homogeneous pattern and general principles of RF channel arrangements for digital systems below 10 GHz are given in Report 934.

4. that the alternated or co-channel arrangement plan should be used, examples of which are shown in Fig. 1.

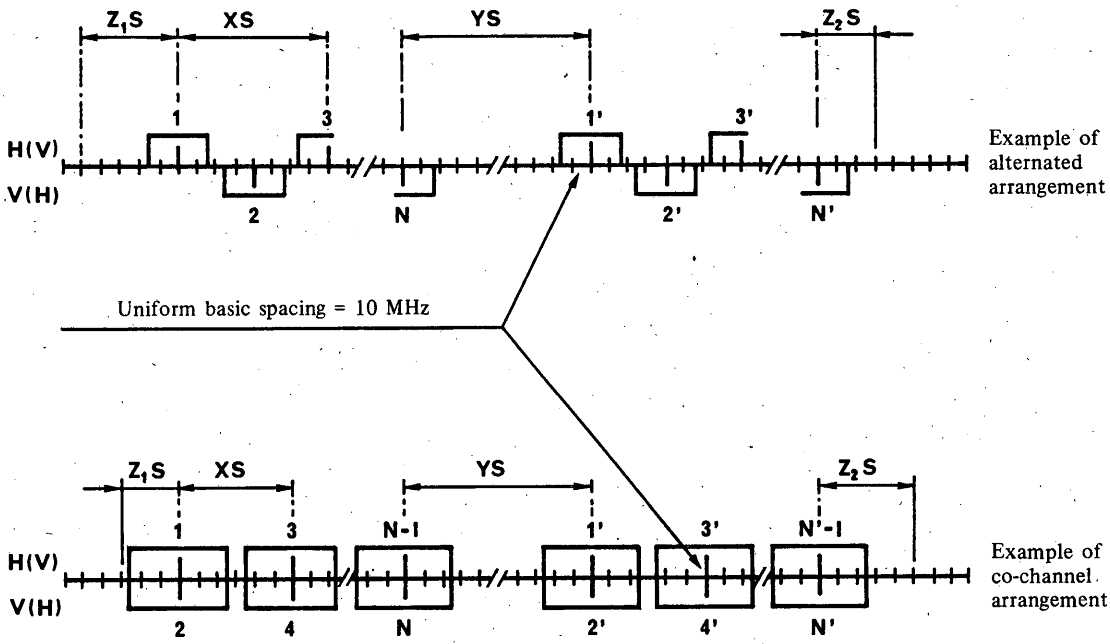

FIGURE 1 – *Examples of channel arrangements based on RECOMMENDS 1 and 2*

(For definitions of X, Y, Z and S, see Report 378)

Note 1 – Actual gross bit rates including overhead may be as much as 5% or more higher than net transmission rates.

Note 2 – Due regard should be taken of the fact that in some countries where additional radio-frequency channels interleaved between those of the main patterns are required, the values of the centre frequencies of these radio-frequency channels should be 5 MHz below those of the corresponding main channel centre frequencies as shown in the following equation (see Annex II/2 in Report 934).

$$f_n = 4195 - 10\,m$$

RECOMMENDATION 383-4*

RADIO-FREQUENCY CHANNEL ARRANGEMENTS, FOR HIGH CAPACITY ANALOGUE OR DIGITAL RADIO-RELAY SYSTEMS OPERATING IN THE LOWER 6 GHz BAND

(Questions 1/9 and 35/9)

(1959-1963-1966-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that it is sometimes desirable to be able to interconnect radio-relay systems on international circuits in the 6 GHz band at radio frequencies;

(b) that, in a frequency band 500 MHz wide, it may be desirable to interconnect up to eight go and eight return channels;

(c) that economy may be achieved if at least four go and four return channels can be interconnected between systems, each of which uses common transmit-receive antennas;

(d) that many interfering effects can be substantially reduced by a carefully planned arrangement of the radio frequencies in radio-relay systems employing several radio-frequency channels;

(e) that the use of certain types of modulation (see Report 378) permits the use of the radio-frequency channel arrangements defined for 1800 telephone channel systems for the transmission of digital channels with a bit rate of the order of 140 Mbit/s or synchronous digital hierarchy bit rates;

(f) that for these digital radio systems, further economies are possible by accommodating up to eight go and eight return channels on a single antenna;

(g) that it may sometimes be desirable to interleave additional radio-frequency channels between those of the main pattern;

(h) that there may be a desire to interconnect more than eight go and eight return radio-frequency channels, each with a capacity significantly lower than 1800 telephone channels;

(j) that it is also highly desirable to be able to operate systems using a mix of analogue and digital radio channels on the same route,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to eight go and return channels with each channel being either an analogue channel accommodating 1800 telephone channels, or the equivalent, or a digital channel with a capacity of the order of 140 Mbit/s, or synchronous digital hierarchy bit rates and operating at frequencies in the lower 6 GHz band (Note 7), should be as shown in Fig. 1 and should be derived as follows:

Let f_0 be the frequency (MHz) of the centre of the band of frequencies occupied;

f_n be the centre frequency (MHz) of one radio-frequency channel in the lower half of the band;

f'_n be the centre frequency (MHz) of one radio-frequency channel in the upper half of the band;

* This Recommendation applies only to line-of-sight and near line-of-sight radio-relay systems.

then the frequencies (MHz) of individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 259.45 + 29.65\ n$,
upper half of the band: $f'_n = f_0 - 7.41 + 29.65\ n$,

where

$n = 1, 2, 3, 4, 5, 6, 7$ or 8;

2. that, in a section over which the international connection is arranged, all the go channels should be in one half of the band, and all the return channels should be in the other half of the band;

3. that the go and return channels on a given section should preferably use polarizations as shown below:

	Go								Return							
H(V)	1		3		5		7			2′		4′		6′		8′
V(H)		2		4		6		8	1′		3′		5′		7′	

The following alternative arrangement of polarization may be used by agreement between the administrations concerned:

	Go								Return							
H(V)	1		3		5		7		1′		3′		5′		7′	
V(H)		2		4		6		8		2′		4′		6′		8′

4. that, when common transmit-receive antennas for double polarization are used and not more than four channels are accommodated on a single antenna, it is preferred that the channel frequencies be selected by either making $n = 1$, 3, 5 and 7 in both halves of the band or making $n = 2$, 4, 6 and 8 in both halves of the band (see Note 2);

5. that, when additional radio-frequency channels, interleaved between those of the main pattern, are required, the values of the centre frequencies of these radio-frequency channels should be 14.82593 MHz below those of the corresponding main channel frequencies; in systems for 1800 channels, or the equivalent, and digital high capacity digital systems, it may not be practical, because of the bandwidth of the modulated carrier, to use interleaved frequencies;

6. that up to 16 go and return radio-frequency channels, each with a capacity of up to 600 telephone channels, may be obtained on the same route if the additional radio-frequency channels are used simultaneously, with those of the main pattern. Different polarizations should be used alternately for adjacent radio-frequency channels in the same half of the band (see Note 3);

7. that the preferred centre frequency is 6175.0 MHz; other centre frequencies may be used by agreement between the administrations concerned.

Note 1 – The radio-frequency arrangement shown in Fig. 1 is suitable for use with the preferred intermediate frequency of 70 MHz (see Recommendation 403). It is also suitable for use with an intermediate frequency of 74.12965 MHz, which enables a common oscillator (14.82593 MHz) to be used for generating all the local oscillations for the system, if desired.

Note 2 – When common transmit-receive antennas are used and not more than four channels are accommodated on a single antenna, channel frequencies may be selected, by agreement between administrations, by making $n = 1$, 3, 5 and 7 in the lower half of the band, and $n = 2$, 4, 6 and 8 in the upper half of the band. If a second similar antenna is used for four further channels, the channel frequencies may be selected by making $n = 2$, 4, 6 and 8 in the lower half of the band and $n = 1$, 3, 5 and 7 in the upper half of the band, but if only three further channels are required, the channel frequencies may be selected by making $n = 2$, 4 and 6 in the lower half of the band and $n = 3$, 5 and 7 in the upper half of the band to avoid the difficulty of separating frequencies 8 and 1′.

Note 3 – The use of a single antenna working allows for seven go and seven return channels based on the preferred arrangement of polarization and eight go and eight return channels based on the alternative arrangement of polarization.

Note 4 – The primary purpose of this Recommendation is to facilitate the international interconnection of high-capacity radio-relay systems. It should therefore be noted, that the use of both the main and interleaved arrangements of radio frequencies on a route would limit the provision of systems with a capacity of 1800 telephone channels using analogue modulation or the equivalent and the provision of high capacity digital channels operating on that route.

Note 5 – In the USSR, a radio-frequency channel arrangement conforming to the scheme in Fig. 1 of Recommendation 497 is used in the frequency band 5925 to 6425 MHz and for systems with a capacity of 1800 telephone channels, or the equivalent. The reference frequency f_0 is then 6172 MHz.

Note 6 – It should be noted that one administration uses a radio-frequency channel arrangement conforming to Recommendation 635 (the reference frequency of 4200 MHz being replaced by 6425 MHz) in the frequency band 5925-6425 MHz for high capacity digital radio-relay systems with a capacity of up to about 200 Mbit/s.

Note 7 – Actual bit rates including overhead may be as much as 5% or more higher than net transmission rates.

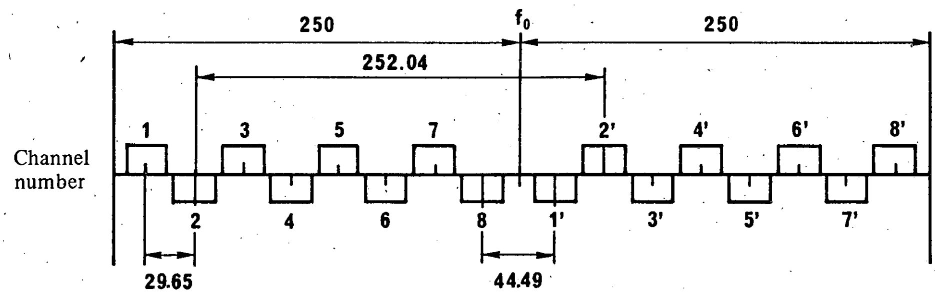

FIGURE 1 – *Radio-frequency channel arrangement for radio-relay systems operating in the 6 GHz band for use in international connections*
(All frequencies are in MHz)

RECOMMENDATION 384-5 *

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR MEDIUM AND HIGH CAPACITY ANALOGUE OR HIGH CAPACITY DIGITAL RADIO-RELAY SYSTEMS OPERATING IN THE UPPER 6 GHz BAND

(Study Programme 1A/9 and Question 35/9)

(1963-1966-1974-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that radio-relay systems with a capacity of 2700 telephone channels should prove to be feasible in the 6 GHz band, if due care is exercised in the planning of radio paths to reduce multipath effects;

(b) that it is sometimes desirable to be able to interconnect, at radio frequencies, radio-relay systems on international circuits in the 6 GHz band;

(c) that it may be desirable to interconnect up to eight go and eight return channels in a frequency band 680 MHz wide;

(d) that economy may be achieved if at least four go and four return channels can be interconnected between radio-relay systems, each of which uses common transmit-receive antennas;

(e) that a common radio-frequency channel arrangement for both up to 1260 and 2700 telephone channel radio-relay systems offers considerable advantages;

(f) that the use of certain types of digital modulation (see Report 378) permits the use of the radio-frequency channel arrangement defined for 2700 telephone channel systems for the transmission of digital channels with a bit rate of the order of 140 Mbit/s or synchronous digital hierarchy bit rates;

(g) that for these digital 140 Mbit/s radio systems, further economies are possible by accommodating up to eight go and return channels on a single antenna with suitable performance characteristics;

(h) that many interfering effects can be reduced substantially by a carefully planned arrangement of the radio frequencies in radio-relay systems employing several radio-frequency channels;

(j) that the radio-frequency channels should be so arranged that an intermediate frequency of 70 MHz may be used for up to 1260 channel systems;

(k) that the radio-frequency channels should be so arranged that an intermediate frequency of 140 MHz may be employed for 2700 channel systems,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to eight go and eight return channels, each accommodating 2700 telephone channels, or a bit rate of the order of 140 Mbit/s, or synchronous digital hierarchy bit rates (Note 3), and operating at frequencies in the upper 6 GHz band, should be derived as follows:

Let f_0 be the frequency (MHz) of the centre of the band of frequencies occupied;

f_n be the centre frequency (MHz) of one radio-frequency channel in the lower half of the band;

f'_n be the centre frequency (MHz) of one radio-frequency channel in the upper half of the band;

* This Recommendation applies only to line-of-sight and near line-of-sight radio-relay systems.

then the frequencies (MHz) of individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 350 + 40\,n,$
upper half of the band: $f'_n = f_0 - 10 + 40\,n,$

where

$n = 1, 2, 3, 4, 5, 6, 7$ or 8;

2. that, in the section over which the international connection is arranged, all the go channels should be in one half of the band, and all the return channels should be in the other half of the band;

3. that different polarizations should be used alternately for adjacent radio-frequency channels in the same half of the band;

4. that, when common transmit-receive antennas are used, and not more than four channels are accommodated on a single antenna, it is preferred that the channel frequencies be selected by making either:

$n = 1, 3, 5$ and 7 in both halves of the band

or

$n = 2, 4, 6$ and 8 in both halves of the band (Note 4);

5. that the preferred arrangement of radio-frequency polarization should be one of those shown in Fig. 1;

6. that the preferred radio-frequency channel arrangement for up to 16 go and 16 return channels, each accommodating up to 1260 telephone channels, or the equivalent, should be obtained by interleaving additional channels between those of the main pattern and should be expressed by the following relationship:

lower half of the band: $f_N = f_0 - 350 + 20\,N,$
upper half of the band: $f'_N = f_0 - 10 + 20\,N,$

where

$N = 1, 2, 3, \ldots 15, 16;$

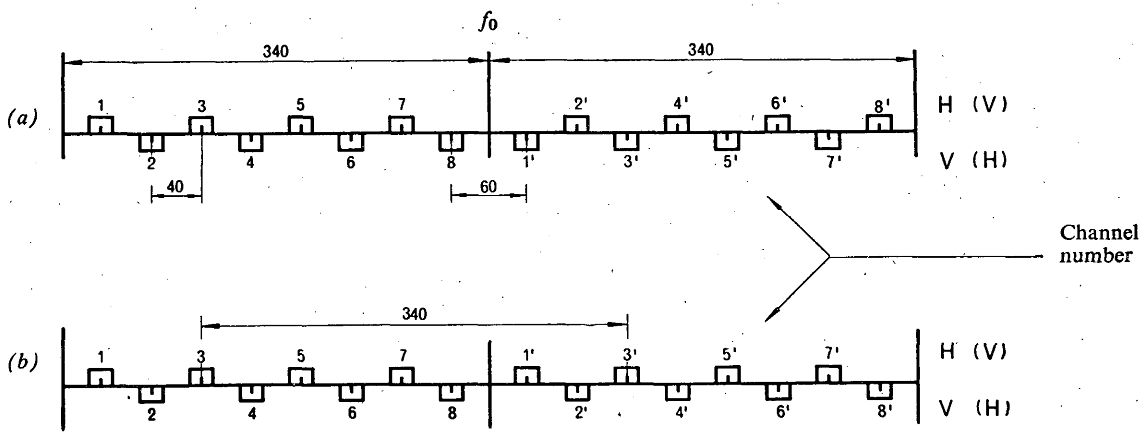

FIGURE 1

(a) Channel arrangement for antennas with double polarization (Note 4)
(b) Channel arrangement for antennas with single polarization or common Tx/Rx antenna with double polarization (Note 4)
(All frequencies are in MHz)

7. that, in the section over which international connection is arranged, all the go channels should be in one half of the band and all the return channels in the other half of the band;

8. that different polarizations should be used alternately for adjacent radio-frequency channels in the same half of the band;

9. that when common transmit-receive antennas are used, and not more than four radio-frequency channels are accommodated on a single antenna, it is preferred that the channel frequencies be selected by making either:

N = 1, 5, 9, 13 or
N = 2, 6, 10, 14 or
N = 3, 7, 11, 15 or
N = 4, 8, 12, 16,

in both halves of the bands and the preferred arrangement of radio-frequency polarization is as shown in Fig. 2;

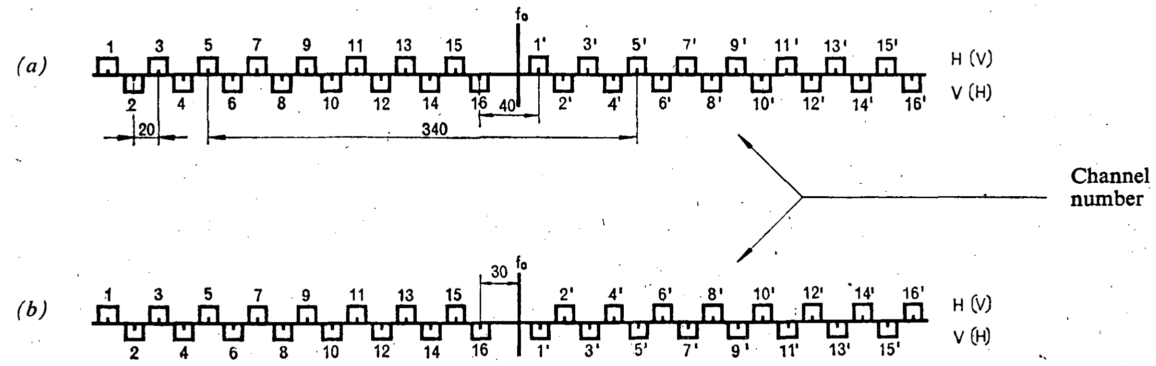

FIGURE 2

(a) Channel arrangement for antennas with single polarization
(b) Channel arrangement for antennas with double polarization
(All frequencies are in MHz)

10. that the preferred centre frequency (f_0) is 6770 MHz; other centre frequencies may be used by agreement between the administrations concerned.

Note 1 – This radio-frequency channel arrangement permits all local oscillator frequencies to be derived from a common oscillator, if desired.

Note 2 – The radio-frequency channel arrangements for systems of up to 1260-channel capacity and of 2700-channel capacity may be used on intersecting routes, as long as adequate antenna discrimination is provided.

Note 3 – Actual gross bit rates including overhead may be as much as 5% or more higher than net transmission rates.

Note 4 – The use of a single antenna working allows for seven go and return channels with the channel arrangement of Fig. 1*(a)*. The channel arrangement of Fig. 1*(b)* and suitable antenna performance gives higher isolation between transmit and receive channels, allowing the use of the eight go and return channels.

RECOMMENDATION 385-4*

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR LOW CAPACITY ANALOGUE RADIO-RELAY SYSTEMS OPERATING IN THE 7 GHz BAND**

(Question 1/9)

(1959-1963-1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that it is desirable to be able to interconnect 60, 120 and 300-channel radio-relay systems on international circuits at radio frequencies in the 7 GHz band;

(b) that frequency bands 300 MHz wide may be available for such systems;

(c) that economy may be achieved, if several go and return channels are connected to one common transmit-receive antenna;

(d) that many interfering effects can be minimized by a carefully planned arrangement of the radio frequencies in radio-relay systems employing several radio-frequency channels;

(e) that, for reasons of frequency economy, it is desirable to interleave additional radio-frequency channels between those of the main pattern;

(f) that it is desirable that the values of the mid-frequencies of the radio-frequency channels be the same for 60, 120 and 300-channel systems;

(g) that the spacing between the mid-frequencies of the radio-frequency channels should be such, that the systems can work with the maximum frequency deviation given in Recommendation 404 for such systems,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for several radio-relay systems, each accommodating 60, 120 or 300 telephone channels and operating in the 7 GHz band, should be derived as follows (see Fig. 1):

Let f_0 be the frequency of the centre of the band of frequencies occupied (MHz);

f_n be the centre frequency of one radio-frequency channel in the lower half of this band (MHz);

f'_n be the centre frequency of one radio-frequency channel in the upper half of this band (MHz);

then the frequencies (MHz) of the individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 154 + 7\,n$ (see Note 1),
upper half of the band: $f'_n = f_0 + 7 + 7\,n$ (see Note 1),

where

$n = 1, 2, 3, \ldots 20;$

2. that, in a section over which the international connection is arranged, all the go channels should be in one half of the band and all the return channels should be in the other half of the band;

* This Recommendation applies only to line-of-sight and near line-of-sight radio-relay systems.

** Subject to agreement between the administrations concerned, other higher-capacity systems using the radio-frequency channel arrangement pattern defined in this Recommendation may be accepted if necessary.

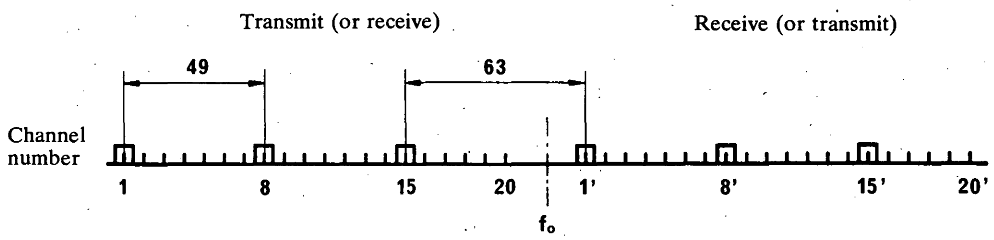

FIGURE 1 – *Radio-frequency channel arrangement for international connection of radio-relay systems for 60, 120 or 300 channels operating in the 7 GHz band*
(All frequencies are in MHz)

3. that, when common transmit-receive antennas are used and three radio-frequency channels are accommodated on a single antenna, it is preferable that the channel frequencies be selected by making:

n = 1, 8 and 15, or
n = 2, 9 and 16, or
n = 3, 10 and 17, or
n = 4, 11 and 18, or
n = 5, 12 and 19, or
n = 6, 13 and 20,

in both halves of the band;

4. that for international connections, the centre frequency should preferably be:

f_0 = 7575 MHz for the band 7425 to 7725 MHz (see Note 1);

other centre frequencies may be used in certain geographical areas by agreement between the administrations concerned, e.g.:

f_0 = 7275, 7400 or 7700 MHz (see Note 1);

5. that the channel arrangement and antenna polarization should be agreed between the administrations concerned;

6. that, when systems with 300 telephone channels are operated in a radio-frequency band, channel combinations which result in differences between channel frequencies of less than 14 MHz, should in general be avoided. If sufficient antenna discrimination is available, this precaution may be disregarded.

Note 1 – The formulae for f_n and f'_n and the values for f_0 differ from those given in Recommendation 284 (Los Angeles, 1959). This change has been made so that the "centre frequency" f_0 falls, in reality, in the centre of the band of frequencies occupied.

Note 2 - Due regard should be taken of the fact that in some countries the radio-frequency channel arrangement described in Report 934 is in use for digital systems with a capacity up to about 140 Mbit/s.

Note 3 – Due regard should also be taken of the fact that in some countries the radio-frequency channel arrangements described in Report 1055 are in use for medium and small capacity digital systems.

RECOMMENDATION 386-3

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR SYSTEMS WITH A CAPACITY OF 960 TELEPHONE CHANNELS, OR THE EQUIVALENT, OPERATING IN THE 8 GHz BAND

(Question 1/9)

(1963–1966–1982–1986)

The CCIR,

CONSIDERING

(a) that it may be desirable to be able to interconnect radio-relay systems on international circuits at radio frequencies in the 8 GHz band;

(b) that, for some administrations, a frequency band, 300 MHz wide, may be available in the 8 GHz range for such systems;

(c) that it may be desirable to interconnect in such a band up to six systems with a capacity of 960 channels, or the equivalent;

(d) that such a frequency arrangement should also be suitable for 300-channel systems;

(e) that for reasons of frequency economy, it is desirable to interleave additional radio-frequency channels between those of the main pattern;

(f) that economy may be achieved, if at least three go and three return channels can be interconnected between systems using common transmit-receive antennas;

(g) that many interfering effects can be minimized by a carefully planned frequency arrangement for systems employing several radio-frequency channels,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement in the 8 GHz band should be derived as follows:

let f_0 be the frequency of the centre of the band of frequencies occupied (MHz);

f_n be the centre frequency of one radio-frequency channel in the lower half of this band (MHz);

f'_n be the centre frequency of one radio-frequency channel in the upper half of this band (MHz);

then the frequencies of the individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 151.614 + 11.662\, n,$
upper half of the band: $f'_n = f_0 + 11.662\, n,$

where for systems with a capacity of 960 telephone channels, or the equivalent:

$n = 1, 3, 5, 7, 9$ and 11;

for systems with a capacity of 300 telephone channels:

$n = 1, 2, 3, 4, 5, \ldots 12$;

2. that, in a section over which the international connection is arranged, all the go channels should be in one half of the band, and all the return channels should be in the other half of the band;

3. that, for adjacent radio-frequency channels in the same half of the band, horizontal and vertical polarization shall be used alternately;

4. that, when common transmit-receive antennas are used and three radio-frequency channels are accommodated on a single antenna, it is preferable that for systems with a capacity of 960 telephone channels, or the equivalent, channel frequencies be selected by making:

$n = 1, 5$ and 9
or
$n = 3, 7$ and 11
} in both halves of the band;

when using systems with a capacity of 300 telephone channels it is preferable to select:

$n = 1, 5$ and 9 or
$n = 2, 6$ and 10 or
$n = 3, 7$ and 11 or
$n = 4, 8$ and 12
} in both halves of the band;

5. that, when additional radio-frequency channels are required for 960-channel systems, or the equivalent, interleaved between those of the main pattern, the frequencies of the individual channels shall be obtained by making:

$n = 2, 4, 6, 8, 10$ and 12;

6. that for international connections the centre frequency should preferably be:

$f_0 = 8350$ MHz,

this value corresponds to the band 8200-8500 MHz. Other values may be taken by agreement between the administrations concerned;

7. that due regard be taken of the fact that, in some countries, another radio-frequency channel arrangement for systems with capacities of up to 1800 telephone channels, or the equivalent, is used. A description of this radio-frequency channel arrangement is given in Annex I.

Note 1 – The radio-frequency channel arrangement described in § 1 to 6 permits all local oscillator frequencies to be derived from the common oscillator frequency 11.662 MHz. The frequency pattern allows for economical use of the frequency band, but since the intermediate frequency of 70 MHz is a multiple of the channel spacing, adequate system selectivity will have to be provided to avoid undue interference.

Note 2 – Due regard should be taken of the fact that in parts of Region 2 a different radio-frequency channel arrangement is in use for digital systems with a capacity of about 90 Mbit/s. This arrangement is described in Annex III of Report 934.

Note 3 – Due regard should be taken of the fact that in some countries the radio-frequency channel arrangement described in Report 1055 is in use for medium and low capacity digital systems operating in the band 8275 to 8500 MHz.

ANNEX I

DESCRIPTION OF THE RADIO-FREQUENCY CHANNEL ARRANGEMENT REFERRED TO IN RECOMMENDS 7

1. The radio-frequency channel arrangement, in a frequency band 250 MHz below 7975 MHz and 250 MHz above 8025 MHz for up to eight go and eight return channels, each accommodating up to 1800 telephone channels, or the equivalent, operating in the 8 GHz band, is as shown in Fig. 1 and is derived as follows:

Let f_0 be the frequency of the centre of the band of frequencies occupied (MHz);

f_n be the centre frequency of one radio-frequency channel in the lower half of this band (MHz);

f'_n be the centre frequency of one radio-frequency channel in the upper half of this band (MHz);

then the frequencies of the individual channels are expressed by the following relationships:

lower half of the band: $f_n = f_0 - 281.95 + 29.65\ n$,

upper half of the band: $f'_n = f_0 + 29.37 + 29.65\ n$,

where

$n = 1, 2, 3, 4, 5, 6, 7$ or 8.

2. That, in a section over which the international interconnection is arranged, all the go channels should be in one half of the band, and all the return channels should be in the other half of the band.

3. That the go and return channels on a given section should preferably use the polarizations shown below:

	Go	*Return*
H(V)	1 3 5 7	1′ 3′ 5′ 7′
V(H)	2 4 6 8	2′ 4′ 6′ 8′

4. That, when additional radio-frequency channels, interleaved between those of the main pattern, are required, the values of the centre frequencies of these radio-frequency channels should be 14.825 MHz below those of the corresponding main channel frequencies; in systems for 1800 channels, or the equivalent, it may not be practical, because of the bandwidth of the modulated carrier, to use interleaved frequencies.

5. That, for international connections, the centre frequency should be:

f_0 = 8000 MHz.

This value corresponds to the band 7725-7975 MHz in the lower half and 8025-8275 MHz in the upper half.

Note 1 – The radio-frequency channel arrangement for eight go and eight return channels, shown in Fig. 1, is suitable for use with the preferred intermediate frequency of 70 MHz (see Recommendation 403). It is also suitable for use with an intermediate frequency of 74.13 MHz, which enables a common oscillator (14.82 MHz) to be used for generating all the local oscillations for the system, if desired.

Note 2 – The radio-frequency channel arrangement shown in Fig. 1 overlaps that of Recommendation 386 by 75 MHz, between 8200 MHz and 8275 MHz, and that mentioned in Recommendation 385, for a centre frequency of 7700 MHz, by 125 MHz between 7725 MHz and 7850 MHz. All due precautions to avoid mutual interference must be taken by radio-relay systems using these channel arrangements.

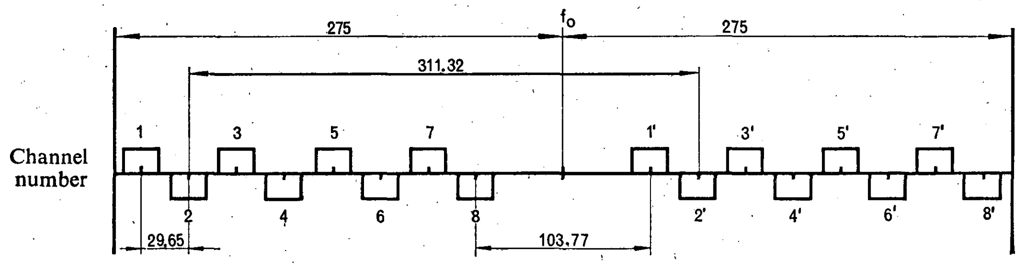

FIGURE 1 – *Radio-frequency channel arrangement, described in Annex I*
(All frequencies are in MHz)

RECOMMENDATION 387-5

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR MEDIUM AND HIGH CAPACITY ANALOGUE OR DIGITAL RADIO-RELAY SYSTEMS OPERATING IN THE 11 GHz BAND*

(Questions 1/9 and 35/9)

(1963-1970-1974-1978-1986-1990)

The CCIR,

CONSIDERING

(a) that, at 11 GHz, analogue radio-relay systems with a capacity of up to 1800 telephone channels, or the equivalent, or digital systems with a capacity of up to 140 Mbit/s or synchronous digital hierarchy bit rates seem to be feasible, subject to rainfall conditions;

(b) that repeater spacing as well as other aspects of system design in this frequency range must take due cognizance of significant meteorological factors;

(c) that it is desirable to interconnect such systems at radio frequencies on international circuits;

(d) that for analogue systems a uniform radio-frequency channel arrangement for both smaller and larger capacities offers considerable advantages;

(e) that, in a frequency band 1000 MHz wide, it may be desirable to interconnect up to twelve go and twelve return analogue channels;

(f) that economy may be achieved if up to twelve go and twelve return channels may be accommodated on a common antenna;

(g) that it may sometimes be desirable to interleave additional radio-frequency channels between those of the main pattern;

(h) that the channels should be so arranged as to enable an intermediate frequency of 70 MHz or 140 MHz to be used;

(j) that it is desirable to provide for operation of digital systems and analogue systems on the same path,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for analogue radio-relay systems with a maximum capacity of 1800 telephone channels, or the equivalent, and operating in the 11 GHz band should be derived as follows:

Let f_0 be the frequency (MHz) of the centre of the band of frequencies occupied;

f_n be the centre frequency (MHz) of one radio-frequency channel in the lower half of the band;

f'_n be the centre frequency (MHz) of one radio-frequency channel in the upper half of the band;

then the frequencies (MHz) of individual channels are expressed by the following relationship:

lower half of the band: $f_n = f_0 - 525 + 40\,n$,

upper half of the band: $f'_n = f_0 + 5 + 40\,n$,

where

$n = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11$ or 12.

* Subject to agreement between the administrations concerned, 2700 telephone channel systems employing an intermediate frequency of 140 MHz and following the main pattern of the radio frequency plan of this Recommendation, may be accommodated in the 11 GHz band when required for special cases.

The frequency arrangement is illustrated in Fig. 1;

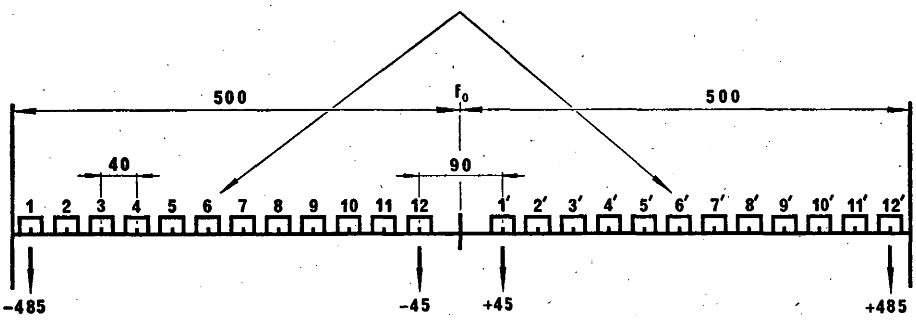

FIGURE 1 – *Radio-frequency channel arrangement for radio-relay systems operating in the 11 GHz band (Main pattern)*
(All frequencies in MHz)

2. that, when additional analogue radio-frequency channels, interleaved between those of the main pattern are required, the values of the centre frequencies of these radio-frequency channels should be 20 MHz below those of the corresponding main channel frequencies;

Note 1 – Channel 1 of the interleaved pattern in the lower half of the band is beyond the lower extremity of a 1000 MHz band and may therefore not be available for use.

Note 2 – The use of a single antenna working allows for twelve go and twelve return channels based on the channel arrangement of Fig. 1 and eleven go and eleven return channels based on the channel arrangement of Fig. 2*(a)*.

3. that, when analogue radio-frequency channels are also required for auxiliary radio-relay systems, the preferred frequencies for eleven go and eleven return channels, including two pairs of auxiliary channels in both the main and interleaved patterns should be derived by making:

n = 2, 3, 4, ... 12 in the lower half of the band,
n = 1, 2, 3, ... 11 in the upper half of the band.

The radio frequencies (MHz) for the auxiliary systems should be chosen as shown below:

	Main pattern	*Interleaved pattern*
lower half of the band	$f_0 - 485$	$f_0 - 495$
	$f_0 - 15$	$f_0 - 25$
upper half of the band	$f_0 + 15$	$f_0 + 2.5$
	$f_0 + 485$	$f_0 + 465$

The radio-frequency arrangement is illustrated in Fig. 2, which also shows a possible polarization arrangement;

4. that, in a section over which the international connection is arranged, all the go channels should be in one half of the band and all the return channels should be in the other half of the band;

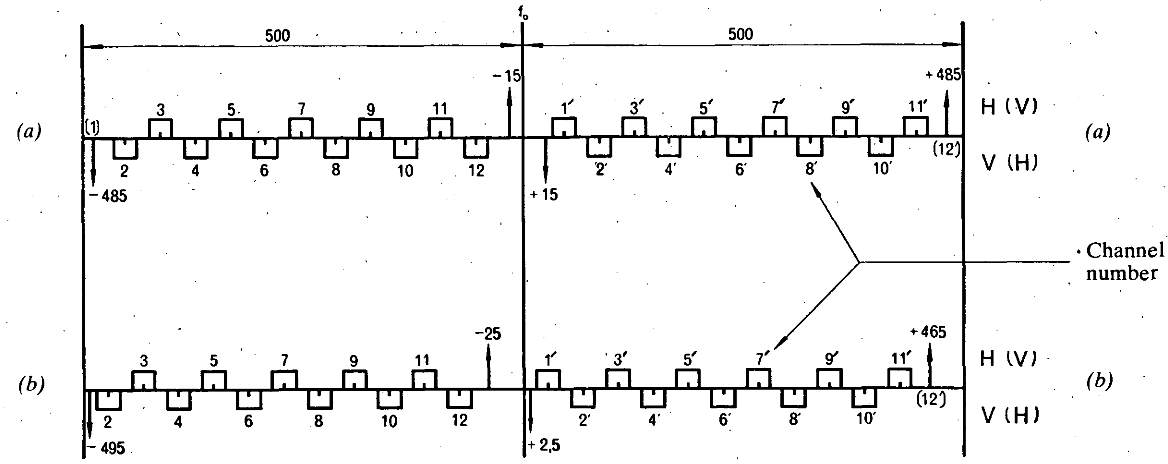

FIGURE 2 – *Radio-frequency channel arrangement for main and auxiliary radio-relay systems operating in the 11 GHz band*
(All frequencies in MHz)

(a) Main pattern
(b) Interleaved pattern

5. that if, for example, only three go and three return channels are accommodated on a common transmit-receive antenna, it is preferable that the channel frequencies (MHz) be selected by making:

n = 1, 5, 9 or
n = 2, 6, 10 or
n = 3, 7, 11 or
n = 4, 8, 12

} in both halves of the band;

6. that for adjacent analogue radio-frequency channels in the same half of the band different polarizations should preferably be used alternately;

7. that the preferred centre frequency is 11 200 MHz; other centre frequencies may be used by agreement between the administrations concerned;

8. that when digital radio-relay systems of low or medium capacity are to be used in the 11 GHz band, the radio-frequency channel arrangement should be in accordance with RECOMMENDS 1 and 2 above. A description of these channel arrangements is given in Annex I;

9. that when high-capacity digital radio-relay systems of up to 155 Mbit/s are to be used in the 11 GHz band, the radio-frequency channel arrangements should utilize the central frequencies defined in RECOMMENDS 1, 2 and 3. A description of these channel arrangements is given in Annex II.

Note 3 – It is recognized that some administrations are using alternative 140 Mbit/s channel arrangements as described in Report 782.

Note 4 – Actual gross bit rates may be as much as 5% or more higher than net transmission bit rates.

ANNEX I

DESCRIPTION OF THE RADIO-FREQUENCY CHANNEL ARRANGEMENT REFERRED TO IN RECOMMENDS 8

1. Suitable channel arrangements for low and medium-capacity digital radio-relay systems requiring channel spacings of 40 MHz can be provided by this Recommendation if co-channel assignments are made for both polarizations.

2. The preferred radio-frequency channel arrangement for digital radio-relay systems provides eleven go and eleven return channels derived as follows:

Let f_0 be the frequency (MHz) of the centre of the band of frequencies occupied;

f_n be the centre frequency (MHz) of one radio-frequency channel in the lower half of the band;

f'_n be the centre frequency (MHz) of one radio-frequency channel in the upper half of the band;

then the frequencies (MHz) of the co-channel pairs are expressed by the following relationship:

lower half of the band: $f_n = f_0 - 545 + 40\,n,$

upper half of the band: $f'_n = f_0 - 15 + 40\,n,$

where

n = 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 or 12.

3. When digital radio channels are to be added to an existing analogue system that is not fully developed, the digital channels should preferably use the interleaved plan of RECOMMENDS 2 if the analogue channels are using the main pattern of § 1 and vice versa (Fig. 3 is included as an example).

However, it is recognized that in some cases it may be possible to add digital channels in the unused portions of an existing analogue plan.

Note 1 – The general principles of compatibility between analogue and digital radio-relay systems are dealt with in Report 610.

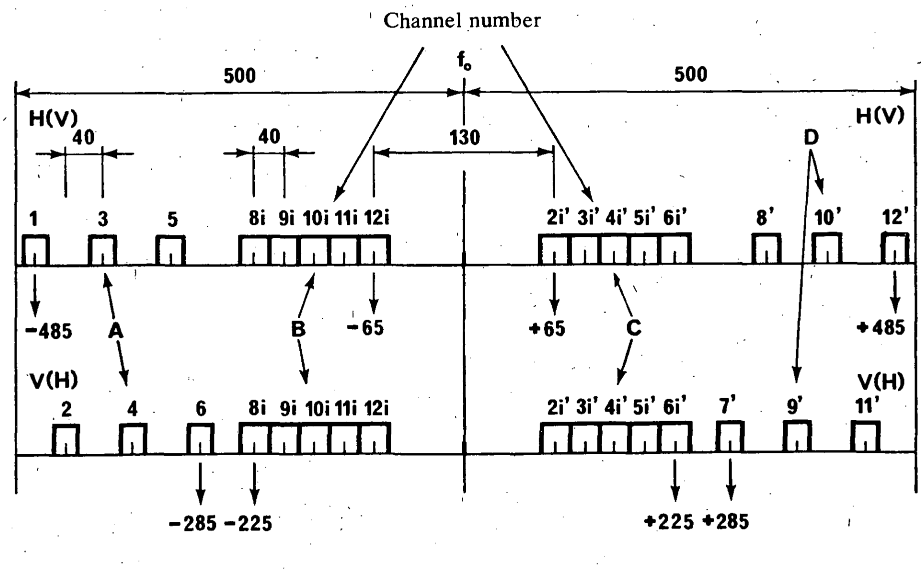

FIGURE 3 – *Example of a mixed analogue and digital radio-frequency channel arrangement for radio-relay systems operating in the 11 GHz band*

(All frequencies in MHz)

A: analogue B: digital C: interleaved pattern D: main pattern

ANNEX II

DESCRIPTION OF THE RADIO-FREQUENCY CHANNEL ARRANGEMENT REFERRED TO IN RECOMMENDS 9

1. The preferred radio-frequency channel arrangement providing 12 go and return channels based on the main pattern shown in Fig. 1 is defined by:

n = 1, 2, 3, ... 12 in the lower half of the band,

n = 1, 2, 3, ... 12 in the upper half of the band.

2. The preferred radio-frequency channel arrangement providing 11 go and return channels based on the main pattern shown in Fig. 1 is defined by:

n = 2, 3, 4, ... 12 in the lower half of the band,

n = 1, 2, 3, ... 11 in the upper half of the band.

This corresponds to the main radio-frequency channels shown in Fig. 2*(a)*.

3. The preferred radio-frequency channel arrangement providing 11 go and return channels based on the interleaved pattern shown in Fig. 2*(b)* is defined by:

n = 2, 3, 4, ... 12 in the lower half of the band,

n = 1, 2, 3, ... 11 in the upper half of the band (see Fig. 2*(b)*),

or:

n = 2, 3, 4, ... 12 in the upper half of the band (see RECOMMENDS 2).

4. The preferred radio-frequency channel arrangement providing 12 go and return channels is based on § 2 above with two additional channels as shown in Fig. 4 and defined by the following relationships:

lower half of the band: $f_n = f_0 - 505 + 40\,n$,
upper half of the band: $f'_n = f_0 - 15 + 40\,n$,

where

n = 1, 2, 3, ... 12.

Note 1 – Channels 1 and 12′ in the main pattern with a guard band of 15 MHz are generally considered unsuitable for high-capacity digital radio systems with a symbol rate of more than 25 to 30 MBd.

Note 2 – Channels 12 and 1′ in Fig. 4 with a separation of 50 MHz are generally considered to require separate antennas if operated on the same hop. Interference between channels 12 and 1′ may increase during periods of high rain rate due to back-scatter from rain. This effect should be taken into consideration in areas of the world where high rain rates are encountered.

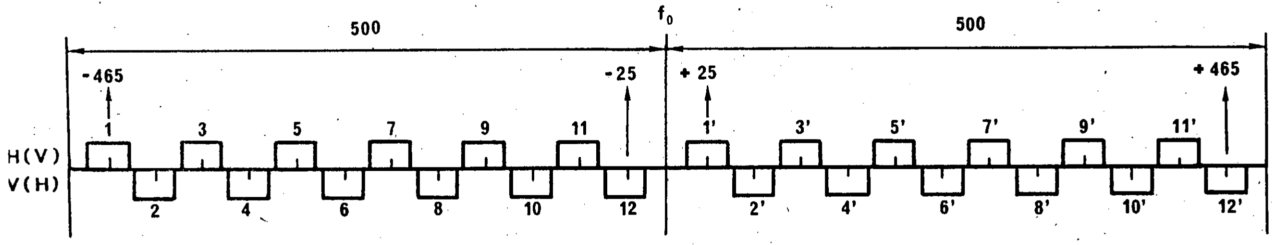

FIGURE 4 – *Radio-frequency channel arrangement for high capacity digital radio-relay systems operating in the 11 GHz band*

(All frequencies are in MHz)

RECOMMENDATION 389-2

PREFERRED CHARACTERISTICS OF AUXILIARY RADIO-RELAY SYSTEMS OPERATING IN THE 2, 4, 6 OR 11 GHz BANDS

(Study Programme 4A/9, Geneva, 1982)

(1959–1963–1970–1974)

The CCIR,

CONSIDERING

(a) that an auxiliary radio-relay system may be required for the provision of service channels for the maintenance, supervision and control of radio-relay links, using either the radio-frequency channel arrangements of Recommendations 382, 383 or 387;

(b) that, sometimes, the auxiliary radio-relay system may be required to operate with frequencies in or near the band of the main radio-relay system, and may, for reasons of economy, share the same antennas;

(c) that occasionally, a different frequency band from that of the main radio-relay system may be preferred for the auxiliary radio-relay system (Study Programme 4A/9, Geneva, 1982);

(d) that the characteristics of an auxiliary radio-relay system, sharing the same frequency band as the main radio-relay system and, in particular, the radio-frequency channel arrangement, should be such as not to cause mutual interference;

(e) that the auxiliary radio channels may employ either frequency or amplitude modulation;

(f) that two pairs of frequency allocations may be needed for the auxiliary radio-relay system, to provide either two normal service channels in each direction, or a normal service channel and a stand-by service channel in each direction, and to allow for the use of frequency diversity where this is essential and other forms of diversity are not practicable;

(g) that the numbers of the service channels to be provided and their functions have been defined in Recommendation 400,

UNANIMOUSLY RECOMMENDS

1. that, for an auxiliary radio-relay system sharing the same frequency band as the main radio-relay system, operating in the 2 or 4 GHz bands (Recommendation 382), the preferred frequencies (MHz) of the radio-frequency channels of the auxiliary system should be related to the centre frequency f_0 of the normal pattern of the main system as shown below:

Normal:

lower half of the band: $f_0 - 204.5$ and $f_0 - 12$
upper half of the band: $f_0 + 8.5$ and $f_0 + 199$

Interleaved:

lower half of the band: $f_0 - 213.5$ and $f_0 - 23$
upper half of the band: $f_0 - 2.5$ and $f_0 + 190$

The arrangement of the radio-frequency channels and the preferred polarizations are shown in Fig. 1. Other radio-frequency channel arrangements for the auxiliary radio-relay systems may be used by agreement between the administrations concerned; *

* The use of the frequency $f_0 + 199$ MHz (f_0 being 4003.5 MHz) may not be in accordance with Article 8 of the Radio Regulations. A special agreement of the administrations concerned to use this frequency is necessary, and interference must not be caused to users of the frequency in accordance with the Radio Regulations.

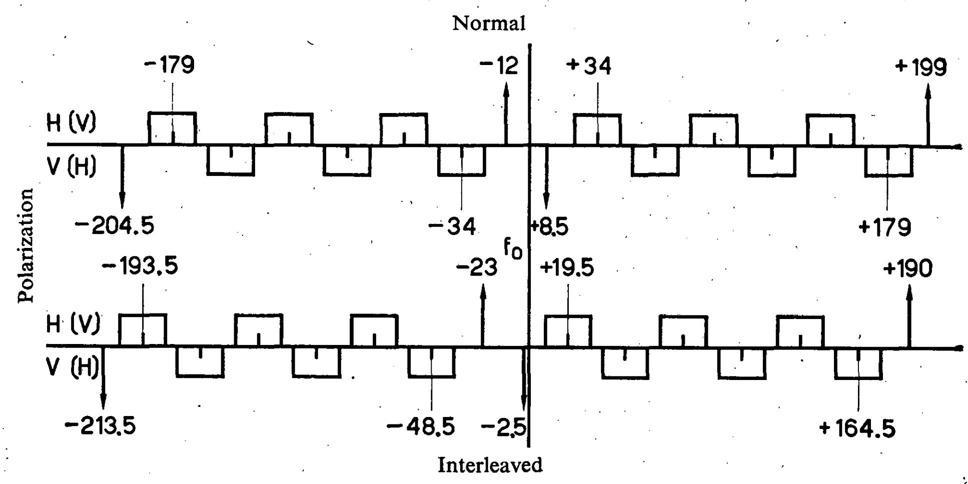

FIGURE 1 – *Radio-frequency channel arrangement for main and auxiliary radio-relay systems operating in the 2 and 4 GHz bands*

(All frequencies are in MHz)

2. that, for an auxiliary radio-relay system sharing the frequency band of the main radio-relay system, operating in the 6 GHz band (Recommendation 383), the preferred frequencies (in MHz) of the radio-frequency channels of this auxiliary system should be related to the centre frequency f_0 of the normal pattern of the main system, as shown below:

2.1 *For frequency-modulation systems**

lower half of the band: f_0 – 248.9 and f_0 – 3.1
upper half of the band: f_0 + 3.1 and f_0 + 248.9

2.2 *For amplitude-modulation or frequency-modulation systems**

lower half of the band: f_0 – 249.5 and f_0 – 2.5
upper half of the band: f_0 + 2.5 and f_0 + 249.5

The arrangement of the radio-frequency channels and the preferred polarizations are shown in Fig. 2.

If the radio-frequency channel arrangement of the main system follows the interleaved pattern of Recommendation 383, § 5, the lowest channel in each half of the band of that interleaved pattern should be left free, if the two lowest auxiliary radio-frequency channels are to be accommodated;

3. that, for an auxiliary radio-relay system sharing the frequency band of the main radio-relay system, operating in the 11 GHz band (Recommendation 387), the preferred provisions to that end, set out in § 3 of that Recommendation, should be observed;

4. that the other characteristics of the auxiliary radio-relay system should be the subject of further study and, for the present, be subject to agreement between the administrations directly concerned.

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* Apart from the type of modulation, certain other characteristics (e.g. load on main channels, frequency stability, frequency allocation plan of the adjacent bands) should be taken into account, in accordance with Study Programme 4A/9, Geneva, 1982.

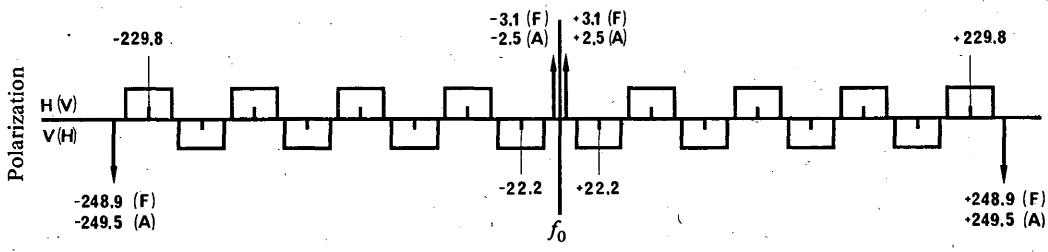


FIGURE 2 – *Radio-frequency channel arrangement for main and auxiliary radio-relay systems operating in the 6 GHz band*

(All frequencies are in MHz)

↑ or ↓ indicate the radio-frequency channels of the auxiliary radio-relay system

F: frequency modulation

A: amplitude modulation

RECOMMENDATION 497-3

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR LOW AND MEDIUM CAPACITY ANALOGUE OR MEDIUM AND HIGH CAPACITY DIGITAL RADIO-RELAY SYSTEMS OPERATING IN THE 13 GHz BAND

(Question 1/9 and Study Programme 35A/9)

(1974-1978-1982-1990)

The CCIR,

CONSIDERING

(a) that the 12.75 to 13.25 GHz band is allocated to the fixed and mobile terrestrial services;

(b) that, at these frequencies, radio-relay systems for digital or analogue transmission are feasible with repeater spacings and other features chosen according to rainfall conditions;

(c) that it may be desirable to interconnect such systems at radio frequencies on international circuits;

(d) that a uniform radio-frequency channel arrangement usable for both analogue and digital systems offers considerable advantages;

(e) that the homogeneous frequency pattern based on an interval of 14 MHz (see Report 607) is adaptable in this frequency band;

(f) that it may sometimes be desirable to interleave additional radio-frequency channels between those of the main pattern;

(g) that the radio-frequency channels should be so arranged that an intermediate frequency of 70 MHz be employed for analogue and for digital systems,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for FDM radio-relay systems with a maximum capacity of 960 telephone channels or the equivalent, and for digital radio-relay systems with a capacity of 34 Mbit/s, operating in the 13 GHz band, should be derived as follows:

Let f_0 be a reference frequency (MHz) near the centre of the 12.75 to 13.25 GHz band;

f_n be the centre frequency (MHz) of a radio-frequency channel in the lower half of the band;

f'_n be the centre frequency (MHz) of a radio-frequency channel in the upper half of the band;

then the frequencies of individual channels are expressed by the following relationship:

lower half of the band: $f_n = (f_0 - 259 + 28\,n)$ MHz

upper half of the band: $f'_n = (f_0 + 7 + 28\,n)$ MHz,

where

$n = 1, 2, 3, 4, 5, 6, 7$ or 8.

The frequency arrangement is illustrated in Fig. 1;

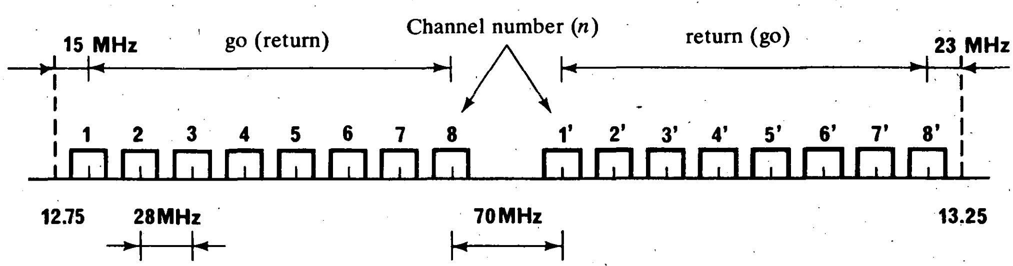


FIGURE 1 – *Radio-frequency channel arrangement for radio-relay systems operating in the 13 GHz band* (main pattern)

2. that, in the section through which an international connection is arranged to pass, all the go channels should be in one half of the band and all the return channels should be in the other half of the band;

3. that, in FDM systems, horizontal and vertical polarization shall be used alternately for adjacent radio-frequency channels in the same half of the band;

4. that, in digital systems, with a capacity of 34 Mbit/s, both horizontal and vertical polarization shall be used, where possible, for each radio-frequency channel;

5. that for digital systems with a capacity of 70 to 140 Mbit/s the same radio-frequency channel arrangement may be used utilizing the RF channels number $n = 2, 4, 6$ and 8 in the case of a co-channel arrangement or $n = 1, 2, 3, 4, 5, 6, 7$ and 8 in the case of an alternated arrangement (the possible use of the channel number 1 would depend on the radiated spectrum width) (see Note 3);

6. that, when additional radio-frequency channels with a maximum capacity of 300 FDM channels or of 240 digital channels, interleaved between those of the main pattern, are required, the values of the centre frequencies of these radio-frequency channels should be 14 MHz above those of the corresponding main channel frequencies. On the same route, it is advisable to use only systems having capacities no greater than these, when using this spacing;

7. that, when common transmit-receive antennas are used and no more than four channels are accommodated on a single antenna, it is preferred that the channel frequencies be selected by making either:

$n = 1, 3, 5$ and 7 or 2, 4, 6 and 8;

8. that, for international connections, the reference frequency should preferably be 12 996 MHz. Other values may be used by agreement between the administrations concerned;

9. that, in cases where smaller capacity radio channels having a capacity of 30 digital telephone channels (or the equivalent) are required, the following channel arrangements, (which occupy some of the bi-directional medium-capacity radio channels of the basic channel arrangement), should be used (see Note 2):

– Alternative I:

lower half of the band: $f_m = (f_0 - 276.5 + 28\,n + 7\,m)$ MHz
upper half of the band: $f'_m = (f_0 - 10.5 + 28\,n + 7\,m)$ MHz,

where

m is equal to 1, 2, 3 or 4, and n refers to the channel number of the basic channel arrangement.

When $n = 1$, the channel arrangement of Fig. 2*(a)* is obtained.

Additional channels may be obtained by choosing $n = 2$.

By agreement between the administrations concerned, n may be greater than 2.

– Alternative II:

lower half of the band: $f_m = (f_0 - 66.5 + 7\,m)$ MHz
upper half of the band: $f'_m = (f_0 + 3.5 + 7\,m)$ MHz,

where

m is preferably 3, 4, 5 or 6.

When additional channels are required, channel values of $m = 1, 2, 7$ or 8, may be used. This arrangement is illustrated in Fig. 2*(b)*;

– Alternative III:

To achieve double the number of low capacity channels using channels 1 and 1′ of the basic plan as compared with Alternative I:

lower half of the band: $f_m = (f_0 - 273 + 28\,n + 3.5\,m)$ MHz
upper half of the band: $f'_m = (f_0 - 7 + 28\,n + 3.5\,m)$ MHz,

where

m is equal to 1, 2, 3, 4, 5, 6, 7 or 8 and n refers to the number of the basic channel arrangement.

When $n = 1$, the channel arrangement of Fig. 2*(c)* is obtained.

Additional channels may be obtained by choosing $n = 2$.

By agreement between the administrations concerned, n may be greater than 2.

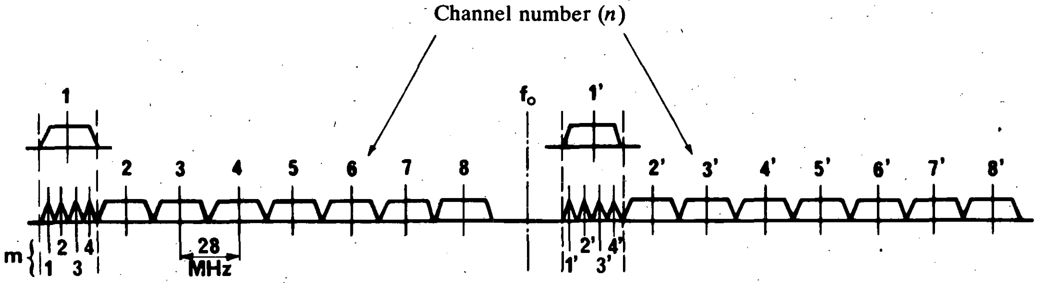
10. that due regard should be taken of the fact that a different channel arrangement for up to 960 telephone channel digital systems is also used; this arrangement is described in Annex I;

11. that Note 1 should be regarded as part of this Recommendation.

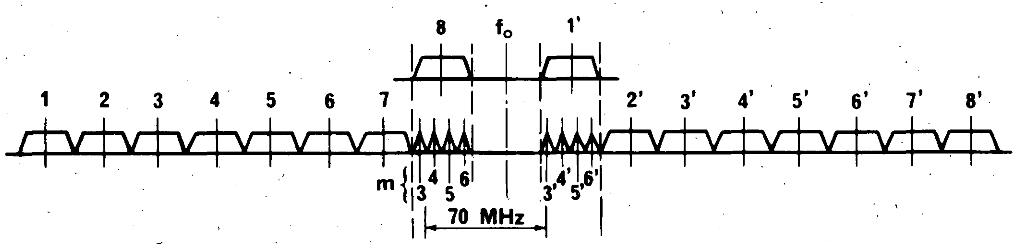
Note 1 – In some countries in Region 1, the basic channel spacing of this frequency pattern may be suitable for extension to adjacent frequency bands in the range 11.7 to 15.35 GHz, taking into account the appropriate Radio Regulations.

Note 2 – In order to reduce the possibility of an unacceptable degradation in performance occurring, care should be exercised in using mixed channel arrangements in a radio-relay network. This would especially apply if the low capacity channel arrangements described in § 9 and medium capacity radio-relay links, operating in accordance with the main channel arrangements are both present in the same network.

Note 3 – In the case of utilization with digital systems with a symbol rate of more than about 25 MBd care should be taken when using the RF channel at the lower band edge with a guard band of 15 MHz.

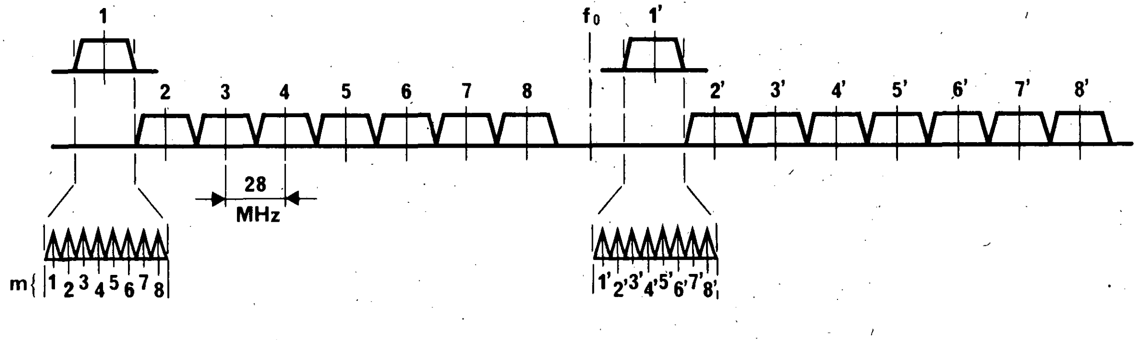


(a) Systems using channels No 1 and 1' of the basic plan



preferred values for m m = 3, 4, 5, 6
additional values m = 1, 2, 7, 8

(b) Systems having 70 MHz frequency separation between the send and receive directions



(c) Systems using channels No. 1 and 1' of the basic plan in order to achieve a more efficient use of the spectrum when compared with the arrangement in *(a)*

FIGURE 2 – *Examples of radio-frequency channel arrangements for smaller capacity digital systems*

(as described in § 9)

ANNEX I

DESCRIPTION OF THE RADIO-FREQUENCY CHANNEL ARRANGEMENT
REFERRED TO IN § 9 OF THIS RECOMMENDATION

For some digital applications with a capacity of up to 960 telephone channels, a radio-frequency arrangement having the following characteristics may be used:

lower half of the band: $f_n = (f_0 - 259 + 35\ n)$ MHz
upper half of the band: $f'_n = (f_0 + 21 + 35\ n)$ MHz,

where

$n = 1, 2, 3, 4, 5$ or 6.

The arrangement is illustrated in Fig. 3.

The preferred reference frequency f_0 is the same as that given in § 8.

All the go channels should be in one half of the band and all the return channels should be in the other half of the band. For the adjacent radio-frequency channels in the same half of the band different polarizations should preferably be used alternately.

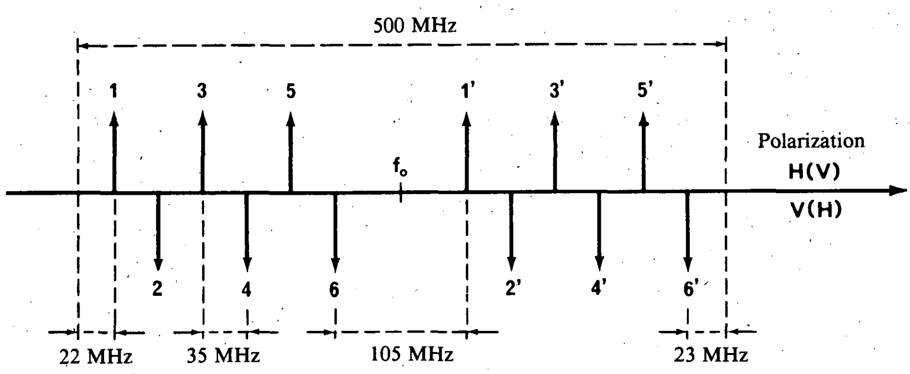


FIGURE 3 – *Radio-frequency channel arrangement for high capacity digital systems*

RECOMMENDATION 636-1

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR RADIO-RELAY SYSTEMS OPERATING IN THE 15 GHz BAND

(Question 35/9)

(1986–1990)

The CCIR,

CONSIDERING

(a) that the 14.4 to 15.35 GHz band is allocated to the fixed service and that in some countries only the 14.5 to 15.35 GHz band is used for radio-relay systems;

(b) that, at these frequencies, radio-relay systems for digital transmissions are feasible with repeater spacings and other features chosen according to rainfall conditions;

(c) that in various countries there are restrictions on the use of various portions of the whole band 14.4 to 15.35 GHz;

(d) that the homogeneous frequency pattern based on an interval of 14 MHz (see Report 607) is applicable in the band 14.4 to 15.35 GHz;

(e) that efficient use of bands of different width can be achieved by selecting all channel frequencies from this homogeneous pattern;

(f) that it may be desirable to interleave additional radio-frequency channels between those of the main pattern,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for medium-capacity digital radio-relay operating with a 28 MHz channel spacing should be derived as follows:

Let N be the number of RF channels;

then the frequencies of individual channels are expressed in MHz by the following relationships:

lower half of the band: $f_n = f_r + a + 28\ n$

upper half of the band: $f'_n = f_r + 3626 - 28\ (N - n)$

where

f_r = 11 701 MHz – the reference frequency;

a = 2688 MHz for the band 14.4 to 15.35 GHz, and

a = 2786 MHz for the band 14.5 to 15.35 GHz;

n = 1, 2, ... N, with $N \leqslant 16$ for the band 14.4 to 15.35 GHz and $N \leqslant 15$ for the band 14.5 to 15.35 GHz.

The channel arrangement with f_r = 11 701 MHz and a frequency spacing of 28 MHz is illustrated in Fig. 1;

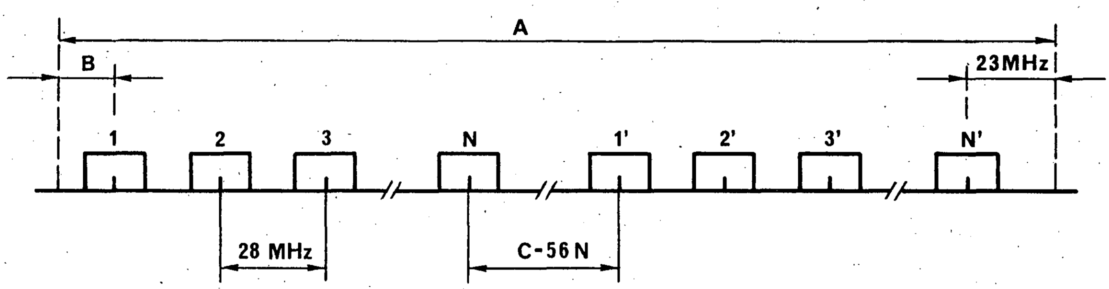


FIGURE 1 – *Radio-frequency channel arrangement for radio-relay systems operating in the 15 GHz band; 28 MHz spacing*

(for the band 14.4 to 15.35 GHz: A = 950 MHz, B = 17 MHz, C = 966 MHz
for the band 14.5 to 15.35 GHz: A = 850 MHz, B = 15 MHz, C = 868 MHz)

2. that the preferred radio-frequency channel arrangement for digital radio-relay systems operating with a 14 MHz channel spacing should be derived as follows:

lower half of the band: $f_n = f_r + a + 14\,n$ MHz

upper half of the band: $f'_n = f_r + 3640 - 14\,(N - n)$ MHz

where

f_r = 11 701 MHz – the reference frequency;

a = 2702 MHz for the band 14.4 to 15.35 GHz, and

a = 2800 MHz for the band 14.5 to 15.35 GHz;

n = 1, 2, ... N with $N \leqslant 32$ for the band 14.4 to 15.35 GHz and $N \leqslant 30$ for the band 14.5 to 15.35 GHz.

The channel arrangement with f_r = 11 701 MHz and a frequency spacing of 14 MHz is illustrated in Fig. 2;

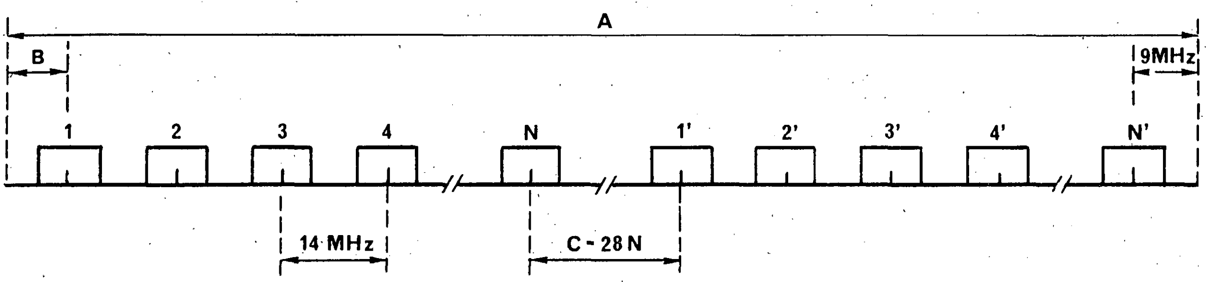


FIGURE 2 – *Radio-frequency channel arrangement for radio-relay systems operating in the 15 GHz band; 14 MHz spacing*

(for the band 14.4 to 15.35 GHz: A = 950 MHz, B = 17 MHz, C = 952 MHz
for the band 14.5 to 15.35 GHz: A = 850 MHz, B = 15 MHz, C = 854 MHz)

3. that, in cases where small-capacity radio channels are required, either the channel arrangement given in RECOMMENDS 2, in conjunction with a similar arrangement shifted by 7 MHz with respect to it, or the following channel arrangement, which occupies some of the medium capacity radio channels of the 28 MHz channel arrangement, should be used:

lower half of the band: $f_m = f_r + a + 28\,n + 7\,m$ MHz

upper half of the band: $f'_m = f_r + 3608.5 - 28\,(N - n) + 7\,m$ MHz

where

m = 1, 2, 3 or 4;

n: channel number from the basic plan which is being subdivided;

a = 2670.5 MHz for the band 14.4 to 15.35 GHz, and

a = 2768.5 MHz for the band 14.5 to 15.35 GHz;

4. that due regard be taken of the fact that in some countries, mostly in a large part of Region 2 and in certain other areas, another radio-frequency channel arrangement is used with a preferred 2.5 MHz channel spacing, or multiples thereof, derived from an homogeneous frequency pattern defined by the relationship:

$f_n = f_r + 2697.75 + 2.5\,n$

where

$1 \leqslant n \leqslant 380$ and f_r = 11 701 MHz.

A specific frequency plan, based on this pattern, is described in Report 607;

5. that, in a section through which an international connection is arranged, all the go channels should be in one half of the band and all the return channels should be in the other half of the band;

6. that both horizontal and vertical polarization shall be used, where possible, for each radio-frequency channel;

7. that for digital systems with a capacity of 70 to 140 Mbit/s the same radio-frequency channel arrangement given in RECOMMENDS 2 may be used utilizing channel numbers $n = 2$ and 6 in case of co-channel arrangement and $n = 1, 3, 5, 7$ in case of an alternated arrangement (Note 4);

8. that, when common transmit-receive antennas are used and no more than half the available channels are accommodated on a single antenna, it is preferred that the channel frequencies be either odd or even numbered;

9. that, for international connections, the reference frequency should preferably be 11 701 MHz. Other values may be used by agreement between the administrations concerned.

Note 1 – Other channel arrangements applicable to the 14.4 to 15.35 GHz frequency band are described in Report 607.

Note 2 – In order to reduce the possibility of an unacceptable degradation in performance occurring, care should be exercised in using mixed channel arrangement in a radio-relay network. This would especially apply if small-capacity radio-relay links using the channel arrangements described in RECOMMENDS 3 and medium-capacity radio-relay links operating in accordance with the main channel arrangements are both present in close geographical proximity.

Note 3 – In using the band 14.47 to 14.5 GHz, it is necessary to take all practicable steps to protect spectral line observations of the radioastronomy service from harmful interference (see No. 862 of the Radio Regulations).

Note 4 – In the case of utilization with digital systems with a symbol rate of more than about 25 MBd care should be taken when using the RF channel 1 at the lower band edge with a guard band of 15 or 17 MHz.

RECOMMENDATION 595-2

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR DIGITAL RADIO-RELAY SYSTEMS IN THE 17.7 TO 19.7 GHz FREQUENCY BAND

(Study Programme 16B/9)

(1982–1986–1990)

The CCIR,

CONSIDERING

(a) that there may be economic and operational advantages in the use of radio-relay systems for the transmission of digital signals in the frequency band 17.7 to 19.7 GHz;

(b) that it may be desirable to interconnect such systems at radio frequencies on international circuits;

(c) that a sufficient degree of compatibility between systems of different capacities should be assured,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio frequency channel arrangement for digital radio-relay systems with a capacity of the order of 280 Mbit/s, the order of 140 Mbit/s and 34 Mbit/s operating in the 17.7 to 19.7 GHz band should be derived as follows:

Let f_0 be the frequency (MHz) of the centre of the band of frequencies occupied;

f_n be the centre frequency (MHz) of a radio-frequency channel in the lower half of the band;

f'_n be the centre frequency (MHz) of a radio-frequency channel in the upper half of the band;

then the frequencies of individual channels are expressed by the following relationships:

1.1 *Co-channel arrangement*

1.1.1 for systems with a capacity of the order of 280 Mbit/s:

lower half of the band: $f_n = (f_0 - 1110 + 220\ n)$ MHz

upper half of the band: $f'_n = (f_0 + 10 + 220\ n)$ MHz,

where:

n = 1, 2, 3 or 4.

The frequency arrangement is illustrated in Fig. 1 (a);

1.1.2 for systems with a capacity of the order of 140 Mbit/s:

lower half of the band: $f_n = (f_0 - 1000 + 110\ n)$ MHz

upper half of the band: $f'_n = (f_0 + 10 + 110\ n)$ MHz,

where:

n = 1, 2, 3, 4, 5, 6, 7 or 8.

The frequency arrangement is illustrated in Fig. 1 (b);

1.1.3 for systems with a capacity of 34 Mbit/s:

lower half of the band: $f_n = (f_0 - 1000 + 27.5\ n)$ MHz

upper half of the band: $f'_n = (f_0 + 10 + 27.5\ n)$ MHz,

where:

n = 1, 2, 3, ... 35.

The frequency arrangement is illustrated in Fig. 1 (c).

1.2 *Interleaved arrangement*

1.2.1 for systems with a capacity of the order of 280 Mbit/s:

lower half of the band: $f_n = (f_0 - 1000 + 110\ n)$ MHz

upper half of the band: $f'_n = (f_0 + 120 + 110\ n)$ MHz,

where:

n = 1, 2, 3, 4, 5, 6 or 7.

The frequency arrangement is illustrated in Fig. 2 (a).

1.2.2 for systems with a capacity of the order of 140 Mbit/s:

lower half of the band: $f_n = (f_0 - 945 + 55\ n)$ MHz

upper half of the band: $f'_n = (f_0 + 65 + 55\ n)$ MHz,

where:

$n = 1, 2, 3, \ldots 15.$

The frequency arrangement is illustrated in Fig. 2 (b);

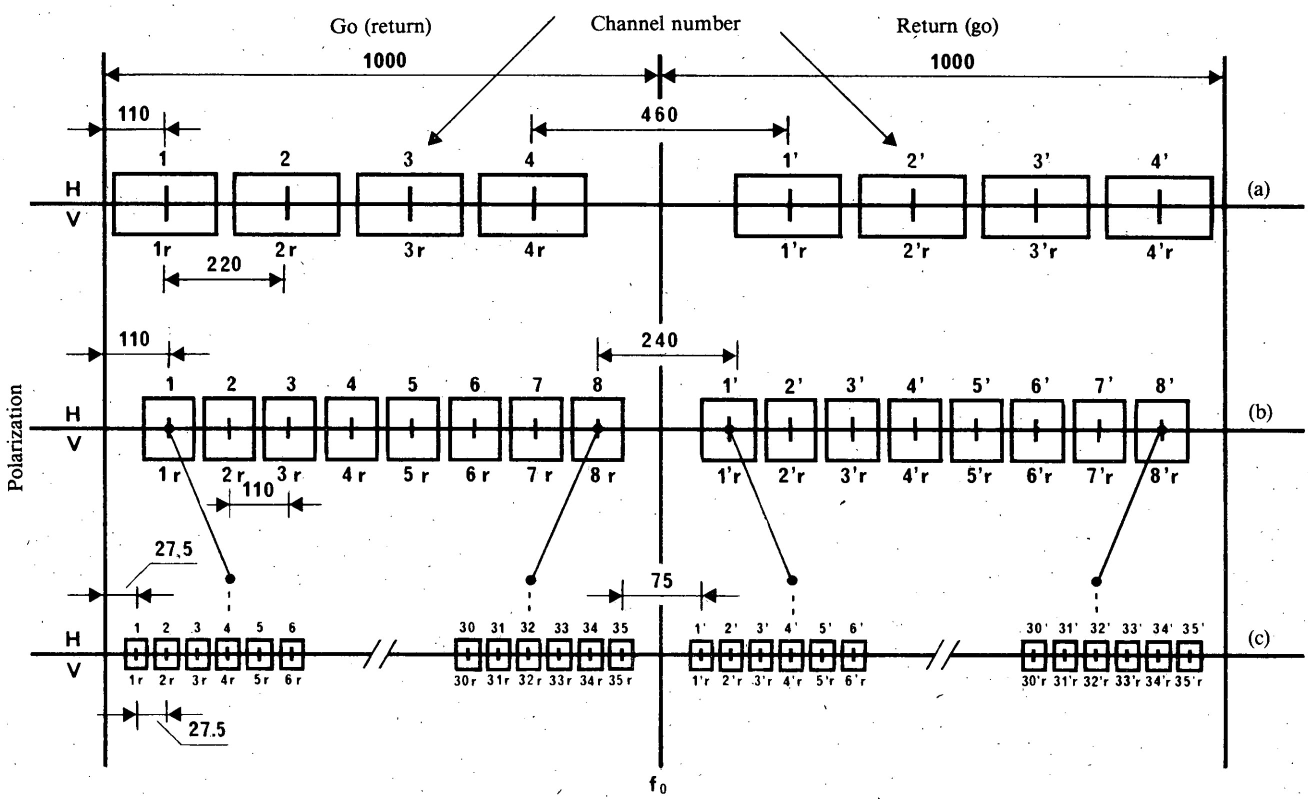


FIGURE 1 – *Radio-frequency channel arrangement for radio-relay systems operating in the 17.7 to 19.7 GHz band*

(Co-channel arrangement)

(All frequencies are in MHz)

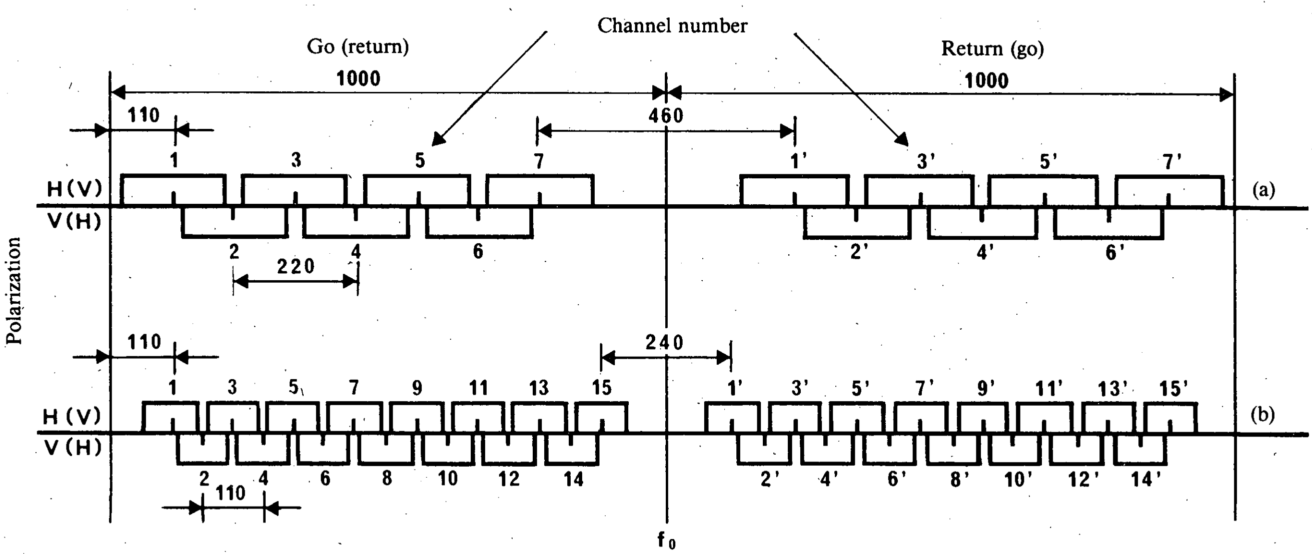


FIGURE 2 – *Radio-frequency channel arrangement for radio-relay systems operating in the 17.7 to 19.7 GHz band*

(Interleaved arrangement)

(All frequencies are in MHz)

2. that the preferred radio-frequency channel arrangement for digital radio-relay systems with a capacity of 155 Mbit/s for use in the synchronous digital hierarchy should be as given in RECOMMENDS 1.1.2 for a co-channel arrangement and RECOMMENDS 1.2.2 for an interleaved channel arrangement;

3. that, in the section through which an international connection is arranged to pass, all the go channels should be in one half of the band and all the return channels should be in the other half of the band;

4. that both horizontal and vertical polarizations should be used for each radio-frequency channel in the co-channel arrangement;

5. that the centre frequency f_0 is 18 700 MHz;

6. that for digital systems of small capacity, i.e. below about 10 Mbit/s, frequency allocations may be accommodated within any of the high-capacity channels or guard bands. Channels 1, 1′ and 8, 8′ and the guard bands of Fig. 1(b) are suitable sub-band allocations for such small-capacity utilizations. The selection of alternative allocations should not prevent the pairing of the go and return channels in the manner described in Figs. 1 and 2;

7. that for medium-capacity systems with bit rates different from that given in RECOMMENDS 1.1.3 and for small-capacity systems, administrations may adopt other RF channel arrangements in conformity with the recommended pattern for high-capacity systems;

8. that due regard be taken of the fact that in some countries another arrangement of the go and return channels which incorporates a mid-band allocation for small-capacity systems may be used, as shown in Fig. 3;

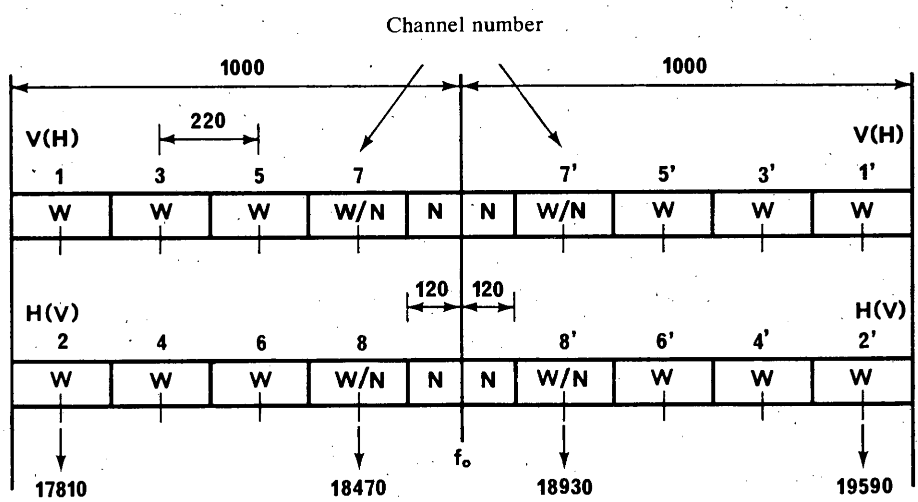


FIGURE 3 – *Co-channel radio-frequency arrangement for radio-relay systems operating in the 18 GHz band referred to in RECOMMENDS 7*

(All frequencies are in MHz)

W: wide-band channel (high-capacity of the order of 280 Mbit/s)
N: narrow-band channel (small-capacity, below 10 Mbit/s)
W/N: wide-band or narrow-band channel

9. that due regard be taken of the fact that in the countries where the band 17.7 to 21.2 GHz is available for the fixed service other channel arrangements may be used.

Note 1 – In establishing these systems, account should be taken of the need of passive sensors for earth exploration by satellite and space research in the band 18.6 to 18.8 GHz particularly in Region 2 where these services have primary status in conformity with Recommendation No. 706 and other relevant provisions (see No. 871) of the Radio Regulations (see Recommendation 515, Report 694 and Study Programme 17D/9).

Note 2 – Actual gross bit rates may be as much as 5% or more higher than net transmission rates.

RECOMMENDATION 637

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR ANALOGUE AND DIGITAL RADIO-RELAY SYSTEMS IN THE 21.2 TO 23.6 GHz FREQUENCY BAND

(Question 35/9 and Study Programme 16B/9)

(1986)

The CCIR,

CONSIDERING

(a) that the band 21.2 to 23.6 GHz is allocated to the fixed and mobile services;

(b) that both analogue and digital systems are in use in this band;

(c) that the band is used for differing applications by various administrations and that these applications may require different frequency plans;

(d) that several types of service with various capacities may be in simultaneous use in this frequency band;

(e) that the band allocated to each service or even to each administration may vary from one country to another;

(f) that the applications in this frequency band may require differing channel bandwidth;

(g) that a high degree of compatibility between RF channels of different arrangements can be achieved by selecting all channel centre frequencies from a homogeneous basic pattern,

UNANIMOUSLY RECOMMENDS

1. that frequency plans for the 21.2 to 23.6 GHz band should be based on a homogeneous pattern;

2. that the homogeneous pattern with a preferred 3.5 MHz interval be defined by the relation:

$$f_n = f_r + 3.5 + 3.5\,n$$

where:

$1 \leqslant n \leqslant 685$;

f_r: reference frequency of the homogeneous pattern;

3. that the homogeneous pattern with a preferred 2.5 MHz interval be defined by the relation:

$$f_n = f_r + 4 + 2.5\,n$$

where:

$1 \leqslant n \leqslant 959$;

f_r: reference frequency of the homogeneous pattern;

4. that the reference frequency of the homogeneous pattern for international connections should be:

$$f_r = 21\,196 \text{ MHz}$$

other reference frequencies may be agreed by the administrations concerned;

5. that all go channels should be in one half of any bi-directional band, and all return channels in the other;

6. that the channel spacings, *XS*, the centre gap, *YS*, and the distance to the lower and upper band limits, Z_1S, Z_2S, as defined in Report 378, should be agreed by the administrations concerned, dependent on the application and channel capacity envisaged.

Note – Specific channel arrangements based on this Recommendation are described in Report 936.

9B2: SYSTEM GENERAL CHARACTERISTICS

RECOMMENDATION 699*

REFERENCE RADIATION PATTERNS FOR LINE-OF-SIGHT RADIO-RELAY SYSTEM ANTENNAS FOR USE IN COORDINATION STUDIES AND INTERFERENCE ASSESSMENT IN THE FREQUENCY RANGE FROM 1 TO ABOUT 40 GHz

(Study Programme 17A/9)

(1990)

The CCIR,

CONSIDERING

(a) that, for coordination studies and for the assessment of mutual interference between line-of-sight radio-relay systems and between stations of such systems and earth stations of space radiocommunication services sharing the same frequency band, it may be necessary to use reference radiation patterns for radio-relay system antennas;

(b) that, for the above studies, radiation patterns based on the level exceeded by a small percentage of the side-lobe peaks may be appropriate;

(c) that the side-lobe patterns of antennas of different sizes are strongly influenced by the ratio of the antenna diameter to the operating wavelength;

(d) that reference radiation patterns are required for the case where information concerning the antenna diameter is not available;

(e) that, at large angles, the likelihood of local ground reflections must be considered;

(f) that the use of antennas with the best available radiation patterns will lead to the most efficient use of the radio-frequency spectrum,

UNANIMOUSLY RECOMMENDS

1. that, in the absence of particular information concerning the radiation pattern of the line-of-sight radio-relay system antenna involved (Note 1), the reference radiation pattern as stated below should be used for:

1.1 interference assessment between line-of-sight radio-relay systems;

1.2 coordination studies and interference assessment between line-of-sight radio-relay stations and stations in space radiocommunication services sharing the same frequency band;

2. that the following reference radiation pattern should be adopted for frequencies in the range 1-40 GHz, when the ratio of the diameter of the radio-relay antenna to the operating wavelength does not exceed 100:

$$G = 52 - 10 \log (D/\lambda) - 25 \log \psi \quad \text{dBi} \quad \text{for } (100\,\lambda/D)^\circ \leqslant \psi < 48^\circ$$

$$ = 10 - 10 \log (D/\lambda) \quad \text{dBi} \quad \text{for } 48^\circ \leqslant \psi < 180^\circ$$

where D and λ are the antenna diameter and the wavelength, respectively, expressed in the same units;

* This Recommendation should be brought to the attention of Study Group 4.

3. that in cases where only the maximum antenna gain is known, D/λ may be estimated from the following expression:

$$20 \log (D/\lambda) \approx G_{max} - 7.7$$

where G_{max} is the main lobe antenna gain in dBi;

4. that the following Notes should be regarded as part of the Recommendation:

Note 1 – It is essential that every effort be made to utilize the actual antenna pattern in coordination studies and interference assessment.

Note 2 – It should be noted that the radiation pattern of an actual antenna may inevitably be worse than the reference radiation pattern over a certain range of angles (see Note 3). Therefore, the reference radiation pattern in this Recommendation should not be interpreted as establishing the maximum limit for radiation patterns of existing or planned radio-relay system antennas.

Note 3 – The reference radiation pattern should be used with caution over the range of angles for which the particular feed system may give rise to relatively high levels of spill-over.

Note 4 – The reference pattern in RECOMMENDS 2 is only applicable for one polarization (horizontal or vertical). Reference patterns for two polarizations (horizontal and vertical) are under study.

Note 5 – The reference radiation pattern included in this Recommendation is only for antennas which are rotationally symmetrical. The reference radiation pattern for antennas with asymmetrical apertures requires further study. For such antennas, the above reference patterns may be considered to be provisionally valid in the horizontal plane.

Note 6 – The reference radiation pattern for antennas with D/λ greater than 100 is under study.

Note 7 – Further study is required for antennas of improved design which have better radiation patterns in the horizontal plane. Such study may lead to the establishment of an additional reference radiation pattern.

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SECTION 9C: INTERCONNECTION CHARACTERISTICS
(BASEBAND AND INTERMEDIATE FREQUENCY)

RECOMMENDATION 306

PROCEDURE FOR THE INTERNATIONAL CONNECTION OF RADIO-RELAY SYSTEMS WITH DIFFERENT CHARACTERISTICS

(Question 1/9)

(1956-1959)

The CCIR,

CONSIDERING

(a) that, to simplify interconnection across frontiers and to ensure the best transmission quality on international circuits, interconnection between systems with different characteristics should be avoided as far as possible;

(b) that, however, when such interconnection cannot be avoided, special arrangements will have to be made at the junction;

(c) that CCITT Recommendation G.352, "Interconnection of coaxial carrier systems of different types" (Vol. III, Fascicle III.2) recommends that, where different types of coaxial systems are directly connected across a frontier, each administration concerned should accept, on the receiving side, the transmission conditions normal to the incoming system,

UNANIMOUSLY RECOMMENDS

that, if different types of radio-relay systems are directly connected across a frontier, each administration concerned should accept, on the receiving side, the transmission characteristics normal to the incoming system, unless a better or more practical arrangement can be arrived at between the administrations concerned.

RECOMMENDATION 268-1

INTERCONNECTION AT AUDIO FREQUENCIES OF RADIO-RELAY SYSTEMS FOR TELEPHONY

(Question 1/9)

(1970)

The CCIR,

CONSIDERING

(a) that radio-relay systems for telephony may form part of an international circuit;

(b) that international connections between such systems, among themselves or with other radio-relay or line systems, may at times have to be made at audio frequencies;

(c) that the objective should be to comply with the relevant CCITT Recommendations in respect of overall performance measured between audio-frequency terminals;

(d) that it will be necessary to signal over telephone circuits provided by means of such systems,

UNANIMOUSLY RECOMMENDS

that, as far as is practicable, radio-relay systems for telephony providing circuits which may form part of an international connection should be such that these circuits conform with the relevant CCITT Recommendations for modern types of telephone circuit in the following respects:

1. the transmission characteristics of the circuits between audio-frequency terminals (the relevant Recommendations are contained in CCITT Vol. III, Fascicle III, 1);

2. the characteristics of the multiplex terminal equipment, where applicable (see CCITT Recommendations G.232 and G.412, Vol. III, Fascicle III.2);

3. the method of signalling over international circuits (the relevant Recommendations are contained in CCITT Vol. VI; see also CCITT Recommendation G.422, Vol. III, Fascicle III.2).

RECOMMENDATION 380-4*

INTERCONNECTION AT BASEBAND FREQUENCIES OF RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 1/9)

(1956-1963-1966-1970-1974-1986)

The CCIR,

CONSIDERING

(a) that frequency-division multiplex radio-relay systems may form part of an international circuit;

(b) that international connections between such systems, among themselves and with other radio-relay or line systems, may at times have to be made at baseband frequencies;

(c) that definitions for the points R and R' of interconnection at baseband frequencies are given in Annex I to this Recommendation and Fig. 1;

(d) that the levels of the points T and T', which are the responsibility of the CCITT (see Recommendation G.213, Vol. III, Fascicle III.2), should be known to system designers,

UNANIMOUSLY RECOMMENDS

1. that the important baseband characteristics for a frequency-division multiplex radio-relay system forming part of an international circuit are:

1.1 maximum number of telephone channels;

1.2 limits of band occupied by telephone channels;

1.3 frequency limits of the baseband, including pilots or frequencies which might be transmitted to line;

1.4 relative input and output power levels, at the points of interconnection R and R';

1.5 nominal impedance of the baseband circuits at the point of interconnection;

2. that, as far as practicable, these characteristics should conform to the preferred values given in Table I (it is recognized that in certain cases and regions it may be desirable to use baseband characteristics other than those given, by agreement between the administrations concerned);

3. the return loss at the points of interconnection should be $\geqslant$ 24 dB.

* This Recommendation applies to line-of-sight and near line-of-sight radio-relay systems, and also to trans-horizon radio-relay systems of the capacities concerned.

TABLE I

1	2	3	4	5	6	7	8
Maximum number of telephone traffic channels (Note 5)	Limits of band occupied by telephone channel (kHz)	Frequency limits of baseband (kHz) (Note 4)	Nominal impedance at baseband (Ω)	Relative power level per channel (dBr) (Notes 1, 2)			
				Radio-relay system output *R* (Note 7)	Main repeater station		Radio-relay system input *R′* (Note 7)
					T	*T′*	
24	12-108 (Notes 3, 6)	12-108 (Notes 3, 6)	150 bal.	−15	−23	−36	−45
60	12-252 60-300	12-252 60-300	150 bal. 75 unbal.	−15	−23	−36	−45
120	12-552 60-552	12-552 60-552	150 bal. 75 unbal.	−15	−23	−36	−45
300	60-1300 64-1296	60-1364	75 unbal.	−18	−23	−36	−42
600	60-2540 64-2660	60-2792	75 unbal.	−20 −23 (1)	−23 −33	−36 −33	−45 −42 (1)
960	60-4028 316-4188	60-4287	75 unbal.	−20 −23 (1)	−23 −33	−36 −33	−45 −42 (1)
1260 (2)	60-5636 60-5564 316-5564	60-5680	75 unbal.	−28	−33	−33	−37
1800	312-8204 316-8204 312-8120	300-8248	75 unbal.	−28	−33	−33	−37
2700	312-12 388 316-12 388 312-12 336	300-12 435	75 unbal.	−28	−33	−33	−37

(1) For 600 and 960 channel systems, administrations have a choice between the alternative pairs of levels shown for points *R* and *R′* which apply in the following circumstances:

a) −23 dBr at point *R*, −42 dBr at point *R′*; used when the baseband interconnection level at points *T* and *T′* is −33 dBr;

b) −20 dBr at point *R*, −45 dBr at point *R′*; used when the baseband interconnection level at point *T* is −23 dBr and at point *T′* is −36 dBr.

(2) Other limits of band occupied by telephone channels may be used by agreement between the administrations concerned.

Note 1 – The particular preferred values of the relative power level given in the Table are agreed with the CCITT. These values apply to future systems.

Note 2 – The level shown is referred to a point of zero relative level in the system, in accordance with the practice of the CCITT.

Note 3 – For 12-channel systems, either of the basic groups A (12 to 60 kHz) or B (60 to 108 kHz) recommended by the CCITT may be accommodated in the band 12 to 108 kHz.

Note 4 – Including pilots or frequencies which might be transmitted to line.

Note 5 – Larger capacity systems are not excluded by the Table.

Note 6 – A permissible alternative arrangement uses the frequency range 6 to 108 kHz. With this first alternative, it is possible to use only the noise measuring channel, situated above the baseband according to Recommendation 398. A further permissible alternative arrangement uses the frequency range 12 to 120 kHz. With this second alternative, it is possible to use only a continuity pilot situated below the baseband, according to Recommendation 381.

Note 7 – The variation with frequency, over the range of baseband frequencies, of the equivalent loss of a homogeneous section of the hypothetical reference circuit from point *R′* to point *R*, should not exceed a limit of ± 2 dB relative to the nominal value except under abnormal propagation conditions. This tolerance is similar to that accepted by the CCITT for line links by means of cable (see CCITT Recommendation M.450).

It is desirable to study the variation of loss as a function of time.

ANNEX I

DEFINITION OF THE POINTS OF INTERNATIONAL CONNECTION AT BASEBAND FREQUENCIES

The points of international interconnection at baseband frequencies, called *R'* and *R*, form the input and output of a radio-relay system, conforming to CCITT Recommendation G.423 and the present Recommendation.

At the ouput of the radio-relay system (point *R*), the following conditions are found in the baseband:

1. All the telephony groups (groups, supergroups, mastergroups, etc.), and the pilots (line regulating, frequency comparison and monitoring pilots) included in the baseband are assembled in the position in which they are transmitted, as defined in the CCITT and CCIR Recommendations mentioned above.

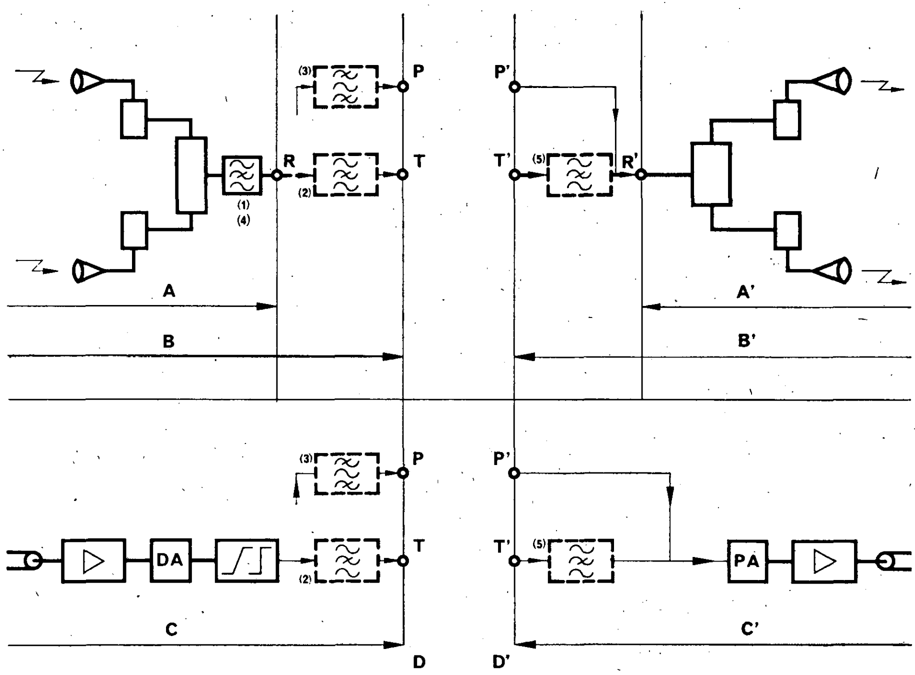


FIGURE 1

A, *A'*:	Radio-relay system
B, *B'*:	Line link by means of radio-relay system
C, *C'*:	Line link by means of cable system
D, *D'*:	Boundary of the high-frequency line equipment
R:	Radio-relay system output
R':	Radio-relay system input
Point *P'*:	Provided for possible injection of regulating pilots
Between *T* and *T'*:	Telephony translating equipment and/or direct through-connection equipment
DA:	De-emphasis network
PA:	Pre-emphasis network
(1):	Blocking of continuity pilots, and if necessary, of regulating pilots
(2):	Blocking, if necessary, of regulating pilots, and pilots that must not go beyond the line link
(3):	Through-connection filter for regulating pilots, if necessary Through-connection filter for telephone groups can, if necessary, be inserted
(4):	Blocking of unspecified pilots or supervisory signals
(5):	Filter for blocking any unwanted frequency before injecting a pilot, ensuring with (2) the requisite protection against a pilot (or other) frequency coming from another regulated line section (B or C, as the case may be)

2. All the continuity and switching pilots and other signals transmitted in a radio-relay system outside the telephony band, inherent to the radio equipment, are suppressed in accordance with Recommendation 381.

3. Any radio-relay protection switching shall be performed as part of the radio-relay system. With diversity reception, the combined output of the receivers used corresponds to point *R*.

4. Any de-emphasis networks are part of the radio equipment, so that the relative levels of the telephone channels are independent of frequency, within the limits of the tolerances stated in Note 7 of this Recommendation.

A similar point *R′* is defined for the baseband input of a radio-relay system, where similar conditions are to be met.

RECOMMENDATION 381-2*

CONDITIONS RELATING TO LINE REGULATING AND OTHER PILOTS AND TO LIMITS FOR THE RESIDUES OF SIGNALS OUTSIDE THE BASEBAND IN THE INTERCONNECTION OF RADIO-RELAY AND LINE SYSTEMS FOR TELEPHONY**

(Question 1/9)

(1953–1959–1963–1966–1970)

The CCIR,

CONSIDERING

(a) that it may be necessary to interconnect radio-relay and line systems when establishing international circuits;

(b) that a continuity pilot may be required to establish the continuity of the transmission path between the input and output terminals of a radio-relay system, independently of the frequency-division multiplex telephony being transmitted;

(c) that in addition, a line-regulating pilot may be required to measure the level stability in the baseband of a frequency-division multiplex telephony radio-relay system;

(d) that the variations of the level of the line-regulating pilot should correspond closely to the variations of the overall gain of the radio-relay system between its input and output terminals at the frequencies of the frequency-division multiplex telephony signals;

(e) that pilots are also required on line systems for gain-regulating, monitoring and frequency-comparison purposes;

(f) that the line pilots used for monitoring and frequency comparison may also be required to be transmitted over a radio-relay system;

(g) that a pilot frequency of 308 kHz is already in use by line systems for gain-regulating and other purposes, and that there is a gap in the frequency-division multiplex signal spectrum within which the pilot is located;

(h) that, in some radio-relay systems, it is permissible to place the service channels of a radio-relay system below the baseband (in certain cases, a service channel may be very near to a telephone channel in the general network);

(j) that it is essential to avoid undesirable effects, such as the interaction of the gain-regulating systems and interference or crosstalk from the pilots, when radio-relay and line systems are interconnected;

(k) that all signals transmitted on a radio-relay system, even if they cannot cause interference to either the telephone channels or the pilots of a cable system interconnected with that radio-relay system, must have a limited power to avoid overloading the cable system;

(l) that, if such interfering signals have to be eliminated by a filter incorporated in the radio equipment, that filter, the attenuation-versus-frequency characteristic of which has a finite slope, must not cause appreciable attenuation distortion on the telephone channel thus protected,

* This Recommendation applies to line-of-sight systems and near line-of-sight systems, and also where appropriate, to trans-horizon radio-relay systems.

** Attention is drawn to the fact that, for direct through-connection between two radio-relay systems, frequencies outside the baseband may pass between the points *R* and *R'*, with negligible attenuation relative to the baseband. The precautions called for to protect cable systems may, therefore, also be necessary to protect radio-relay systems. The points *R* and *R'* and the points *T* and *T'* are defined in Fig. 1 of Recommendation 380.

UNANIMOUSLY RECOMMENDS

1. that the point of interconnection between a radio-relay system and a line system forming part of an international circuit shall be considered as a junction between line-regulating sections, except when the cable system constitutes a short extension of the radio system and is then a part of the same line-regulating section; if the radio-relay link constitutes a regulated line section, the station at one end of the system would be called "the radio-link control station" and the station at the other end would be called "the radio-link sub-control station". The duties of these stations are given in the maintenance instructions in Vol. IV of the CCITT;

2. that the continuity pilot of a multi-channel telephony radio-relay system should be located outside the band of frequencies occupied by the frequency-division multiplex signal and the preferred frequencies and levels will be as shown in Recommendation 401 *;

3. that the level of the continuity pilot of a radio-relay system for telephony be suppressed below −50 dBm0 at the point of connection with a line system (point *R*);

4. that, for a line-regulating pilot on a frequency-division multiplex telephony radio-relay system with a capacity of 60 channels or more, 308 kHz ± 3 Hz be the preferred frequency and the preferred pilot level be −10 dBm0. A second line-regulating pilot situated in the upper part of the baseband may also be used, the preferred value of frequency and level of which should be those recommended by the CCITT for cable systems **;

5. that the level of the line-regulating pilot of a telephony radio-relay system be suppressed below −50 dBm0 at the point of connection with a line system, in all cases where this point is a junction between line-regulating sections (point *T* or before this point);

6. that the level of any line-regulating pilot of a line system to which a radio-relay system is connected be suppressed below −50 dBm0, before the input of the radio-relay system (point *R′*), in all cases where point *T′* is the junction between line-regulating sections, except by agreement between the administrations concerned;

7. that, when cable systems constitute short extensions of the radio system and are then part of the same line-regulating section, the same line-regulating pilots may be transmitted in the two systems;

8. that in the absence of any special agreement between administrations, the level of any pilot or supervisory signals, transmitted outside the baseband of a radio-relay system at a frequency not specified by the CCIR, should, within the radio equipment, be reduced below −50 dBm0 at point *R*;

9. that similarly, in the absence of special agreements between the administrations concerned, the levels of all pilots or supervisory signals, transmitted over the cable system and having frequencies outside the baseband of the radio-relay link, should, within the equipment of the cable system, be reduced below −50 dBm0 at point *T* (and consequently at point *R′*);

10. that, if a radio-relay system service channel, adjacent to a telephone channel in the baseband, uses the levels, frequency allocation and signalling levels corresponding to those which would be recommended by the CCITT for an ordinary telephone channel in the same position in the frequency spectrum, the channel filters are adequate to avoid the risk of cross-talk interference; if this condition is not met, an additional filter may be necessary and should be provided within the radio equipment;

---

* A continuity pilot within the baseband, possibly acting as the line-regulating pilot, may be used in systems of up to 120 channels for reasons of economy, after agreement between the administrations concerned.

** For systems up to 120 channels a line-regulating pilot of 60 kHz with a level of −10 dBm0 may be used; in this case the suppression level should conform with the provisions of CCITT Recommendation G.243, § 3.1 (Vol. III, Fascicle III.2); thus the level of the line-regulating pilot, established by the CCITT for lines, differs according to whether it concerns coaxial cables or symmetrical pairs (−10 dBm0 for coaxial cables and −15 dBm0 for symmetrical pair systems).

11. that the frequencies mentioned in § 8 and 10 must be sufficiently distant from the baseband to ensure that the filters (or other appropriate devices) required to eliminate them do not cause attenuation distortion in the passband to exceed the recommended values;

12. that, to avoid overloading the cable system, the level of any other signal outside the baseband range be less than −20 dBm0 at the point *R*; similarly, to avoid overloading the radio-relay system, the level of any other signal outside the baseband should be less than −20 dBm0 at the point *R'*;

13. that, further, the level of the total power of all the signals outside the baseband range, including thermal and intermodulation noise, be less than −17 dBm0 at the points *R* and *R'*;

14. that all other line pilots *within* the band of frequencies occupied by the frequency-division multiplex telephony signal be freely transmitted by the radio-relay system to which the line system is connected.

RECOMMENDATION 270-2

INTERCONNECTION AT VIDEO SIGNAL FREQUENCIES OF RADIO-RELAY SYSTEMS FOR TELEVISION

(Question 3/9, Geneva, 1982)

(1959–1970–1978)

The CCIR,

CONSIDERING

(a) that radio-relay systems for television may form part of an international circuit;

(b) that interconnections of such systems amongst themselves, or with other radio-relay or line systems, may at times have to be made at video signal frequencies,

UNANIMOUSLY RECOMMENDS

that radio-relay systems for television, forming part of an international circuit, should conform in their baseband characteristics to the requirements for video interconnection points given in Recommendation 567; in particular, the following characteristics are preferred:

1. the nominal impedance Z_0 at the video interconnection point should be 75 Ω unbalanced, and the return loss should not be less than 30 dB;

2. the nominal amplitude of the video signal at the input and output (excluding the chrominance sub-carriers) should be 1 V peak-to-peak (see Notes 1 and 2);

3. the nominal upper limit of the video-frequency band for different television systems should conform to the design objectives and tolerances for the various television standards as given in Report 624 and part D of Recommendation 567.

Note 1 – In the design of equipment, account should be taken of the losses in the interconnecting cables, when the video interconnection point is at some distance from the terminals of the modulating and demodulating equipment.

Note 2 – The nominal relative levels of the chrominance sub-carriers are given in Report 624 for the various television standards.

RECOMMENDATION 463-1

LIMITS FOR THE RESIDUES OF SIGNALS OUTSIDE THE BASEBAND OF RADIO-RELAY SYSTEMS FOR TELEVISION

(Question 3/9, Geneva, 1982)

(1970–1978)

The CCIR,

CONSIDERING

(a) that the interconnection of radio-relay systems and line systems, as well as the direct through-connection of radio-relay systems, may be necessary when establishing international circuits;

(b) that a continuity pilot may be required to establish the continuity of the transmission path between the input and output terminals of a radio-relay system independently of the traffic (e.g. television plus sound programme channels);

(c) that it is essential to avoid undesirable effects, such as interference or cross-talk from the pilots, when systems are interconnected;

(d) that limits should be placed on the level of any signal transmitted on a system, even if it cannot cause interference to either the traffic or the pilots of a following system, to avoid overloading that system;

(e) that if such signals have to be eliminated by a filter incorporated in the output of the equipment, the attenuation and group delay variation caused by that filter should not cause the system performance to differ from that appropriate to the system,

UNANIMOUSLY RECOMMENDS

1. that the point of interconnection between radio-relay systems or between radio-relay systems and line systems, forming part of an international connection, should be considered as a junction between line-regulating sections, except when the cable system constitutes a short extension of the radio system and is then a part of the same line-regulating section; if the radio-relay link constitutes a regulated line section, the station at one end of the link will be called "the radio-link control station" and the station at the other end of the link will be called "the radio-link sub-control station". The duties of these stations are given in the maintenance instructions in CCITT Recommendations, Series N, Vol. IV, Fascicle IV.3;

2. that the continuity pilot should be located outside the band of frequencies occupied by the television signal and any associated sound programme channels. The preferred frequencies and levels are shown in Recommendation 401;

3. that, in the absence of any special agreement between the administrations concerned, the level of any continuity pilot (Recommendation 401), sound programme sub-carrier (Report 289), service channel (Report 444), harmonic of the traffic or other unwanted signal, within prescribed limits above the television frequency band should, within the equipment, be reduced to not more than −50 dB relative to 1 V peak-to-peak (about 1 mV r.m.s.) at a point in the system corresponding to point *T* (Recommendation 380, Fig. 1) for telephony. The limits of the baseband frequency range over which this should apply are as follows: for 525-line systems the limits are 1.25 to 2.5 times the nominal upper limit of the frequency band (Report 624). For 625-line systems the limits are 1.2 times (Note 1) to twice the nominal upper limit of the frequency band (Report 624). Alternatively, the aforementioned reduction of level may be restricted to the continuity pilot and the sound programme sub-carrier;

4. that, to avoid overloading and other deleterious interference effects on the following systems such as radio-relay systems, cable systems or other interconnected systems, the level of the residue signals above 1.2 times (Note 2) the nominal upper limit of the television frequency band should be at least 30 dB (Note 3) below that of the television signal measured as the ratio of the nominal peak-to-peak amplitude of picture luminance signal to the r.m.s. amplitude of the residue signals.

Note 1 – For television systems using an upper limit of the frequency band of 6 MHz and four sound programme sub-carriers in accordance with Plan *A* (Report 289), the limits are 1.13 times to twice the nominal upper limit of the frequency band.

Note 2 – For television systems using an upper limit of the frequency band of 6 MHz and four sound programme sub-carriers, in accordance with Plan *A* (Report 289), the figure is 1.13 times the nominal upper limit of the television frequency band.

Note 3 – This is a provisional level, subject to further study.

RECOMMENDATION 402-2

THE PREFERRED CHARACTERISTICS OF A SINGLE SOUND CHANNEL SIMULTANEOUSLY TRANSMITTED WITH A TELEVISION SIGNAL ON AN ANALOGUE RADIO-RELAY SYSTEM

(Question 3/9, Geneva, 1982)

(1959-1963-1974-1978)

The CCIR,

CONSIDERING

(a) that it may be desirable for economic or operational reasons to transmit the sound signal accompanying a television signal over the same radio-relay system;

(b) that a channel suitable for the transmission of the sound signal may be provided by means of a frequency modulated sub-carrier inserted in the baseband of the radio-relay system above the video-frequency band and below the continuity pilot (see Recommendation 401);

(c) that a sound channel provided by these means may form part of an international connection,

UNANIMOUSLY RECOMMENDS

1. that the transmission performance of the sound channel should conform to the requirements of the CMTT for international sound-programme circuits (Note 1);

2. that the following transmission characteristics are preferred:

		General recommendation	French system	USSR 625-line system
2.1	*Frequency of sub-carrier (MHz)*	7.5	10	8
2.2	*Modulation characteristics of sub-carrier*			
2.2.1	Nominal input impedance of audio channel (Ω)	600 (bal.)	15 000 (bal.)	600 (bal.)
2.2.2	Maximum audio-frequency signal at a zero relative level point (dB rel. 0.775 V r.m.s.) (Note 2)	+9	+9 (in 600 Ω)	0 (input) +17 (output)
2.2.3	Audio-frequency bandwith (Hz)	30-10 000 (Note 3)	40-12 000	50-10 000
2.2.4	Deviation of sub-carrier (for a sinusoidal test tone of maximum level given in § 2.2.2)	140 kHz r.m.s.	70 kHz r.m.s (at 800 kHz)	150 kHz peak
2.2.5	Pre-emphasis of audio-frequency channel (μs) (Note 4)		50 (see Rec. 450)	nil
2.3	*Deviation of IF and RF carrier*			
	The amplitude of the unmodulated sub-carrier should be such as to produce a deviation of the IF and RF carrier of:	300 kHz r.m.s.	600 kHz r.m.s.	750 kHz peak

Note 1 – See Recommendation 504. Maintenance is dealt with in CCITT Recommendations Series N, Vol. IV, Fascicle IV.3. The conditions of measurement should be the subject of further study.

Note 2 – The input and output levels for an international programme line and for an international programme link have been defined in CCITT Recommendation J.14 (Vol. III, Fascicle III.4). It is the responsibility of the administrations concerned to choose the appropriate value for their particular use.

Note 3 – The upper limit may be increased should there be evidence of need.

Note 4 – Pre-emphasis may be used by agreement between the administrations concerned. Attention is drawn to Recommendation 450, § 1.2. The network defined in that Recommendation may also be suitable for the sound channel, but it should be studied to see if the nominal deviation of 800 Hz can remain at the value used for transmission without pre-emphasis, or if it is necessary to fix the nominal deviation at a higher frequency to avoid increase in the peak signal to the sub-carrier modulator.

RECOMMENDATION 596

INTERCONNECTION OF DIGITAL RADIO-RELAY SYSTEMS

(Question 12/9 and Study Programmes 12B/9 and 12H/9, Geneva, 1982)

(1982)

The CCIR,

CONSIDERING

(a) that the capacity of digital radio-relay systems should be that of a CCITT recommended hierarchical level or an integral multiple of it;

(b) that the signal characteristics at the interface of digital radio sections (points *TT'* in Fig. 1 of Report 938) are given in CCITT Recommendation G.703;

(c) that the characteristics of some radio-relay systems (for instance due to code conversion, insertion of justification bits, parity bits and service bits) may cause the bit rate within a digital radio section to be different from the CCITT recommended hierarchical level or an integral multiple of it;

(d) that interconnection at other points than *TT'* of Fig. 1 of Report 938, which could be included in the future as part of this Recommendation, will necessitate the standardization of many parameters of system design and service techniques;

(e) that at this time interconnections between digital radio-relay systems may only be practicable at baseband,

UNANIMOUSLY RECOMMENDS

that interconnection of digital radio-relay systems be made at points *TT'* of Fig. 1 of Report 938.

RECOMMENDATION 275-3

PRE-EMPHASIS CHARACTERISTIC FOR FREQUENCY MODULATION RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 1/9)

(1959–1966–1970–1982)

The CCIR,

CONSIDERING

(a) that the pre-emphasis characteristic should preferably be such that the effective (r.m.s.) deviation due to the frequency-division multiplex telephony signal is the same with and without pre-emphasis (Recommendation 404);

(b) that, in a frequency-modulation system for frequency-division multiplex telephony, the thermal noise is highest in the top channel and decreases with decreasing baseband frequency;

(c) that, in a phase-modulation system, or in a frequency-modulation system with pre-emphasis of 6 dB per octave, the thermal noise is constant over the whole baseband;

(d) that the thermal noise in the highest channel of a phase-modulation system is approximately 4.8 dB better than the corresponding channel of a frequency-modulation system, assuming that the two types of system are adjusted to have the same total frequency deviation;

(e) that the reduction in frequency deviation with decreasing baseband frequency in a phase-modulation system makes such a system more sensitive to low frequency interference and to the effects of non-linearity in the system;

(f) that the loss of advantage in the top channel is quite small and the effects due to non-linearity are not excessive if the range of pre-emphasis is restricted to about 8 dB;

(g) that agreement on the pre-emphasis characteristic is desirable to facilitate international connection at radio frequencies or intermediate frequencies;

(h) that the pre-emphasis network may be inserted at different places in various types of equipment,

UNANIMOUSLY RECOMMENDS

1. that, where pre-emphasis is used in radio-relay systems for frequency-division multiplex telephony, the same normalized attenuation-frequency characteristic should be used for systems with capacities up to and including 2700 channels;

2. that the preferred pre-emphasis characteristic is given by the expression:

$$\left.\begin{array}{l}\text{Relative deviation}\\ \text{produced by the}\\ \text{test-tone (dB)}\end{array}\right\} = 5 - 10 \log_{10} \left[1 + \frac{6{\cdot}90}{1 + \dfrac{5{\cdot}25}{\left(\dfrac{f_r}{f} - \dfrac{f}{f_r}\right)^2}} \right] \qquad (1)$$

where f_r (the resonant frequency of the network) = $1.25\, f_{max}$, f_{max} is the highest telephone channel baseband frequency of the system, and f is the baseband frequency.

The variation of deviation with frequency is shown in Fig. 1. Table I shows f_{max} and f_r for the frequency-division multiplex systems which are the subject of Recommendation 380 and which are mentioned in Recommendation 404.

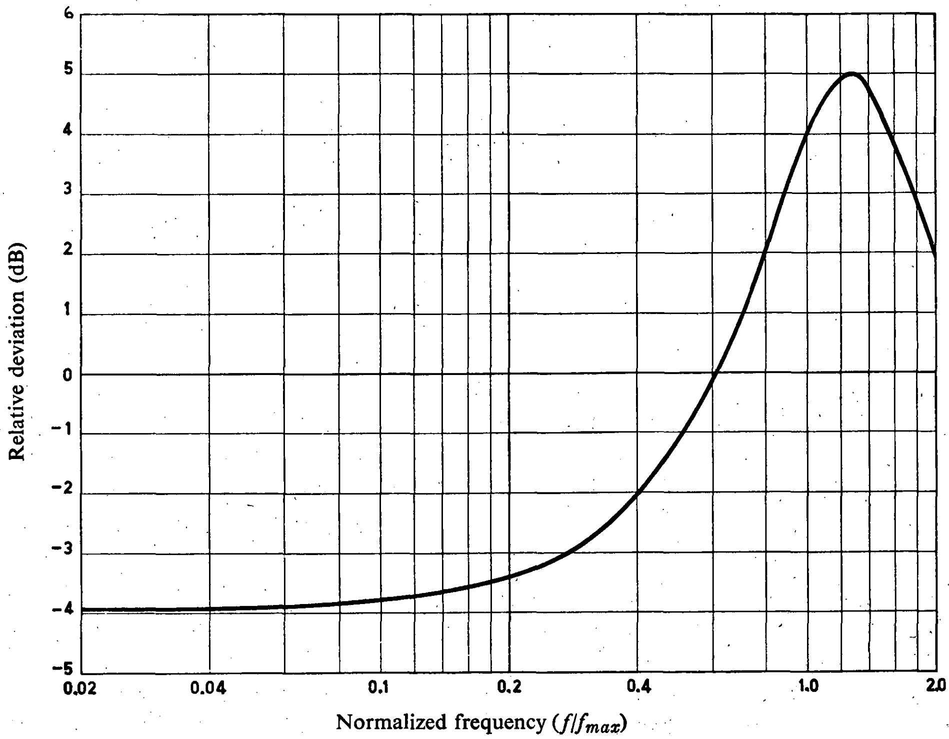


FIGURE 1

Pre-emphasis characteristic for telephony

TABLE I — *Characteristic frequencies for pre-emphasis and de-emphasis networks for the frequency-division multiplex systems which are the subject of Recommendation 380 and which are mentioned in Recommendation 404*

Maximum number of telephone traffic channels (1)	f_{max} (2) (kHz)	f_r (3) (kHz)	f_c (4) (kHz)
24	108	135	66.226
60	300	375	183.96
120	552	690	338.49
300	1 300	1 625	797.16
600	2 660	3 325	1 631.1
960	4 188	5 235	2 568.1
1 260	5 636	7 045	3 456.0
1 800	8 204	10 255	5 030.7
2 700	12 388	15 485	7 596.3

(1) This figure is the nominal maximum traffic capacity of the system and applies also when only a smaller number of telephone channels are in service.

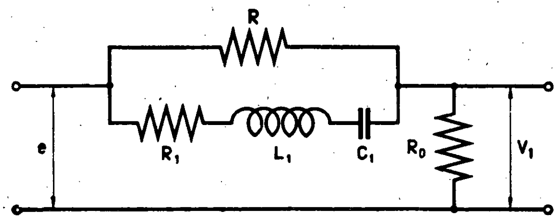
(2) Nominal maximum frequency of the band occupied by telephone channels.

(3) Nominal resonant frequency of the pre-emphasis or de-emphasis network.

(4) Cross-over frequency at which the deviations with pre-emphasis and without pre-emphasis are equal.

3. that the tolerance on the frequency response of the pre-emphasis characteristics, and also on the de-emphasis characteristics should be such that, within the nominal upper and lower limits of the baseband, the departure of the characteristic of a practical network from the theoretical characteristic should be confined within a variation of $\pm$ (0.1 + 0.05 f/f_{max}) dB, f being the baseband frequency, and f_{max} the nominal maximum frequency of the baseband. This corresponds to component tolerances of about $\pm$ 1% for resistors and about $\pm$ 0.5% for capacitors and inductors. Further, the magnitude of the departure should exhibit no rapid variations within this frequency range.

Note 1 – It is recognized that it may be desirable to achieve the pre-emphasis characteristic by inserting a network at different places in various types of equipment. An example of a pre-emphasis and de-emphasis network, to work between a constant-voltage source and an open-circuit load, is shown in Figs. 2(a) and 2(b), respectively, and to work between matched resistive input and output impedances is shown in Figs. 3(a) and 3(b), respectively.



$R = 1{\cdot}81\ R_0$

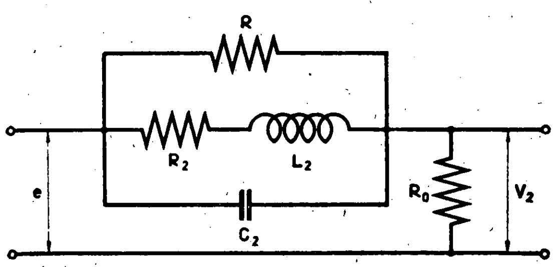
$R_1 < 0{\cdot}01\ R_0$ at f_r

$\sqrt{\frac{L_1}{C_1}} = 0{\cdot}79\ R_0$

$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_1 C_1}}$

Where f_{max} is the highest baseband frequency

(a) Pre-emphasis network



$R = 1{\cdot}81\ R_0$

$R_2 < 0{\cdot}02\ R_0$ at f_r

$\sqrt{\frac{L_2}{C_2}} = 1{\cdot}47\ R_0$

$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_2 C_2}}$

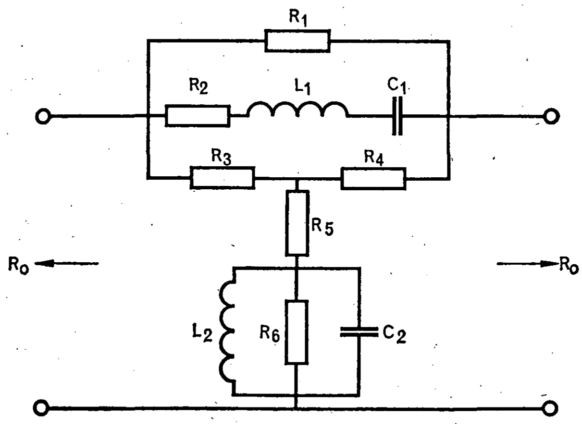
(b) De-emphasis network

FIGURE 2

Pre-emphasis and de-emphasis networks to work between a constant-voltage source and an open-circuited load

Note 2 – In the expression for the relative deviation as indicated in § 2, it should be noted that the frequency at which the deviation with pre-emphasis corresponds to that without pre-emphasis (Recommendation 404) is 0.61320 f_{max}. It may be convenient to adopt this frequency for testing the loss between baseband terminal points of systems when these are not in service.

Note 3 – It is recognized that it may sometimes be desirable to use a different pre-emphasis characteristic by agreement between the administrations concerned.



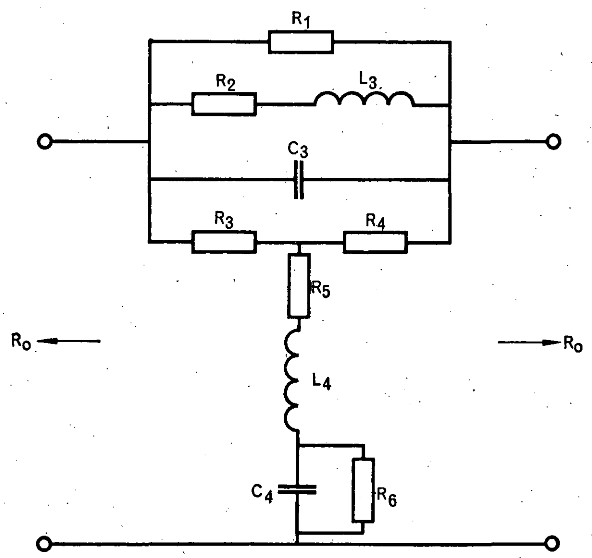
$R_1 = 1{\cdot}81\ R_0$
$R_2 < 0{\cdot}01\ R_0$
$R_3 = R_4 = R_0$
$R_5 = \frac{R_0}{1{\cdot}81}$
$R_6 > 100\ R_0$

$$f_r = 1{\cdot}25 f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_1 C_1}} = \frac{1}{2\pi}\sqrt{\frac{1}{L_2 C_2}}$$

$$\sqrt{\frac{L_1}{C_1}} = 0{\cdot}79\ R_0$$

$$\sqrt{\frac{L_2}{C_2}} = \frac{R_0}{0{\cdot}79}$$

(a) Pre-emphasis network



$R_1 = 1{\cdot}81\ R_0$
$R_2 < 0{\cdot}01\ R_0$
$R_3 = R_4 = R_0$
$R_5 = \frac{R_0}{1{\cdot}81}$
$R_6 > 100\ R_0$

$$f_r = 1{\cdot}25 f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_3 C_3}} = \frac{1}{2\pi}\sqrt{\frac{1}{L_4 C_4}}$$

$$\sqrt{\frac{L_3}{C_3}} = 1{\cdot}47\ R_0$$

$$\sqrt{\frac{L_4}{C_4}} = \frac{R_0}{1{\cdot}47}$$

(b) De-emphasis network

FIGURE 3

Pre-emphasis and de-emphasis networks to work between matched resistive input and output impedances

RECOMMENDATION 404-2*

FREQUENCY DEVIATION FOR ANALOGUE RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 1/9)

(1956–1959–1963–1966–1970)

The CCIR,

CONSIDERING

(a) that frequency-division multiplex systems for telephony using frequency modulation may form part of an international circuit;

(b) that it may at times be desirable to make international connections between such systems at intermediate or radio frequencies;

(c) that, to economize in the use of the frequency spectrum, it is desirable to use the smallest satisfactory frequency deviation;

(d) that the use of pre-emphasis allows a more uniform distribution of signal-to-noise ratio in the various channels of a multi-channel telephony system,

UNANIMOUSLY RECOMMENDS

that, as far as practicable, radio-relay systems for telephony using frequency-division multiplex forming part of an international circuit should conform to the following characteristics:

1. Frequency deviation without pre-emphasis

Maximum number of channels	R.m.s. deviation per channel (1) (kHz)
12	35
24	35
60	50, 100, 200
120	50, 100, 200
300	200
600	200
960	200
1260	140, 200
1800	140
2700	140

(1) For 1 mW, 800 Hz tone at a point of zero reference level.

Larger capacity systems are not excluded.

Note – It is recognized that it may sometimes be desirable to use other deviations by agreement between the administrations concerned. This applies in particular to trans-horizon radio-relay systems.

2. Frequency deviation with pre-emphasis

Where pre-emphasis is used, the pre-emphasis characteristic should preferably be such, that the effective (r.m.s.) deviation due to the multi-channel signal is the same with and without pre-emphasis.

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* This Recommendation applies to line-of-sight and near line-of-sight radio-relay systems and, where appropriate, to trans-horizon radio-relay systems.

RECOMMENDATION 405-1

PRE-EMPHASIS CHARACTERISTICS FOR FREQUENCY MODULATION RADIO-RELAY SYSTEMS FOR TELEVISION

(Question 3/9, Geneva, 1982)

(1959–1963–1970)

The CCIR,

CONSIDERING

(a) that it is generally preferable for the major intermediate-frequency and radio-frequency characteristics of international radio-relay systems for television to conform to those of large capacity systems for multi-channel telephony;

(b) that the flexibility of radio-relay systems would be further increased if the modulators and demodulators could be used interchangeably for either television or frequency-division multiplex telephony;

(c) that the high-level, low-frequency components in the video-frequency waveform, which are a barrier to the achievement of this flexibility, can be greatly reduced by attenuation of these components, i.e. by means of a pre-emphasis network before modulation, a corresponding de-emphasis network being inserted after demodulation;

(d) that pre-emphasis enables a simple control of the mean carrier-frequency to be used both for television and frequency-division multiplex telephony;

(e) that pre-emphasis can reduce differential gain and differential phase distortion in a radio-relay system and may be particularly advantageous if the transmission of colour television signals, or a sound channel by means of a sub-carrier, is envisaged;

(f) that, in determining the pre-emphasis characteristic, its effect on the overall weighted signal-to-noise ratio * and on adjacent-channel interference must be taken into account;

(g) that excessive attenuation of the low-frequency components of the video signal can cause difficulties due to hum and microphony;

(h) that the optimum pre-emphasis characteristics for television and frequency-division multiplex telephony will not be the same;

(j) that, to achieve readily reproducible characteristics, the pre-emphasis network, and the corresponding de-emphasis network, should be simple;

(k) that it is operationally desirable that the same shape of pre-emphasis characteristic is used for monochrome and colour television signals,

UNANIMOUSLY RECOMMENDS

1. that the use of pre-emphasis is preferred for the transmission of television signals by radio-relay systems;

2. that a minimum phase shift network should be used for pre-emphasis;

* See Recommendation 567.

3. that the idealized preferred pre-emphasis characteristic be given by the expression:

$$\text{relative deviation (dB)} = 10 \log [(1 + Cf^2)/(1 + Bf^2)] - A, \qquad (1)$$

where:

A is the attenuation (dB) at a low frequency (< 0.01 MHz),

B and C are constants which determine the shape of the pre-emphasis characteristic,

f is the frequency (MHz).

The preferred values of A, B and C for 525-, 625-, and 819-line systems are shown in Table I. The shapes of the characteristics are shown in Fig. 1;

TABLE I

Values of coefficients of pre-emphasis characteristics

Number of lines	525	625	819
A	10·0	11·0	7·0
B	1·306	0·4083	0·1021
C	28·58	10·21	2·552
Cross-over frequency (MHz)	0·7616	1·512	1·402
Deviations (peak-to-peak) at low frequencies (MHz)	2·530	2·255	3·573

4. that the tolerance on the pre-emphasis characteristics, and also on the de-emphasis characteristics referred to in Note 2, should be such that, within the frequency range of 0.01 MHz to the nominal upper limit of the video-frequency band, the departure of the characteristic of a practical network from the appropriate theoretical characteristic should be confined within a variation of $\pm (0.1 + 0.05 f/f_c)$ dB, f being the video-frequency, f_c being the nominal upper limit of the video-frequency band. This corresponds to tolerances of the network components (resistors, capacitors, inductors) of about ± 1%. Further, the magnitude of the departure should exhibit no rapid variations within this frequency range.

Note 1 – In accordance wih Recommendations 276 and 567, a peak-to-peak signal of 1 V at a point of video-frequency interconnection produces, in the absence of pre-emphasis, a peak-to-peak deviation of 8 MHz. When there is pre-emphasis, a sinusoidal wave of 1 V peak-to-peak at a video-frequency corresponding to 0 dB relative deviation (cross-over frequency) produces a peak-to-peak deviation of 8 MHz. The cross-over frequencies are shown in Table I. At a low frequency (< 0.01 MHz) the corresponding deviation is reduced in accordance with the factor A. These low frequency deviations are also shown in Table I.

Note 2 – When television signals are to be transmitted between countries with radio-relay systems designed for different numbers of lines, the administration of the country receiving the signals should provide de-emphasis networks corresponding to the pre-emphasis network of the originating country; however, if preferred, other arrangements may be adopted by agreement between the administrations concerned.

Note 3 – An example of a pre-emphasis network is shown in Table II and Fig. 2. Table III and Fig. 3 give an example of a corresponding de-emphasis network.

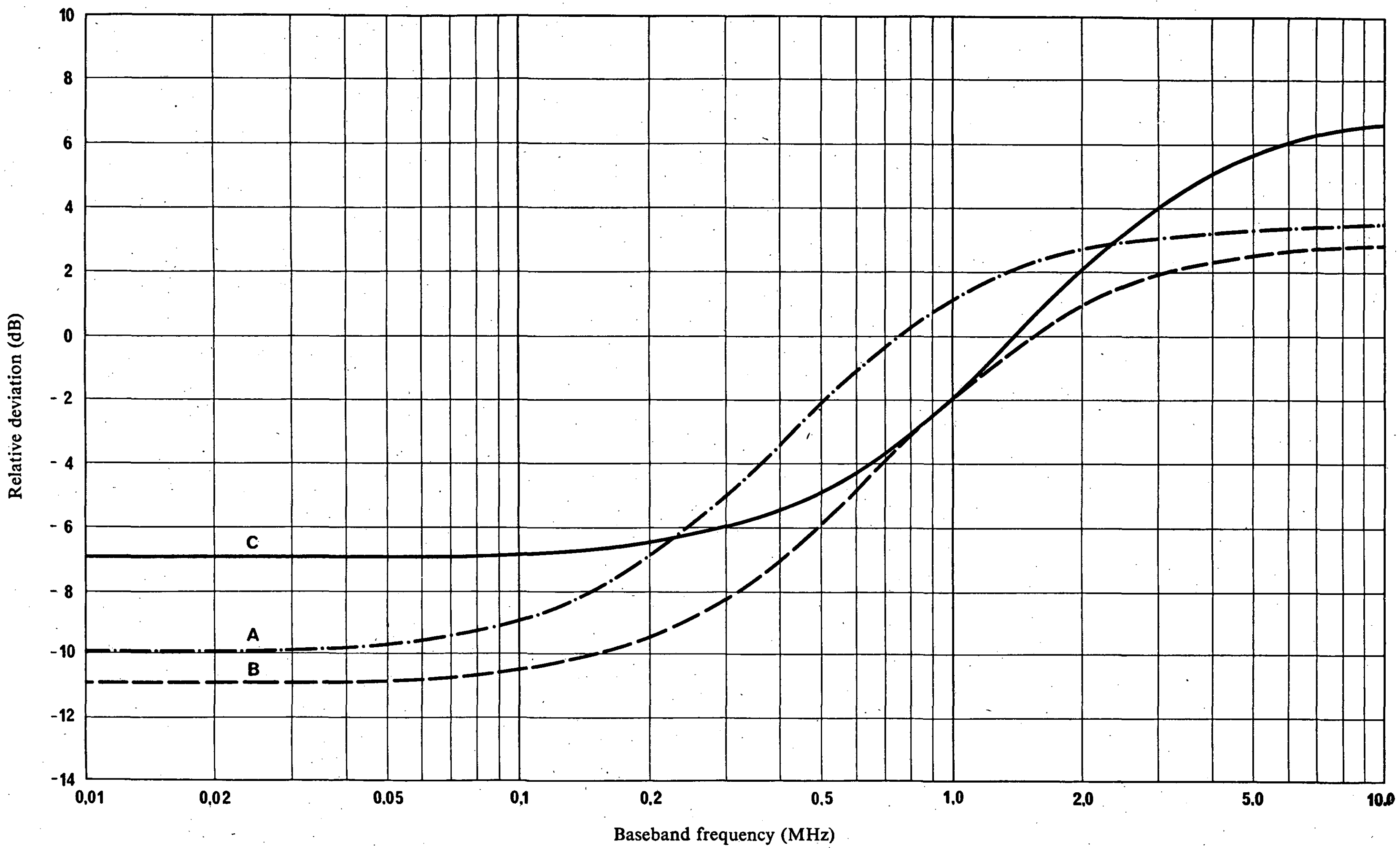

FIGURE 1

Pre-emphasis characteristic for television on 525-, 625-, and 819-line systems

Curve A: 525-line system
B: 625-line system
C: 819-line system

TABLE II

Component values of pre-emphasis network for television

Number of lines	525	625	819
L (μH)	17·35	9·54	4·77
C (pF)	3085	1695	847·5
R_1 (Ω)	275·8	300	300
R_2 (Ω)	75	75	75
R_3 (Ω)	20·4	18·75	18·75

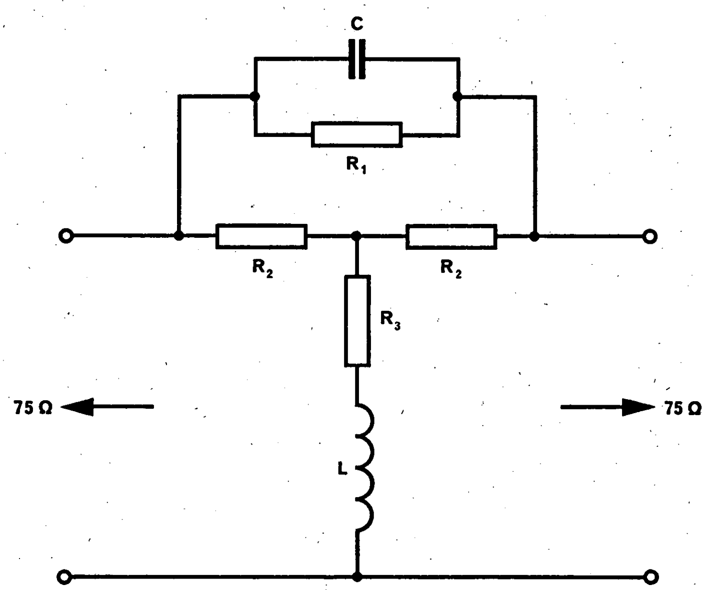

FIGURE 2

Pre-emphasis network for television

TABLE III

Component values of de-emphasis network for television

Number of lines	525	625	819
L (μH)	50·16	30·53	15·26
C (pF)	8917	5424	2712
R_1 (Ω)	275·8	300	300
R_2 (Ω)	75	75	75
R_3 (Ω)	20·4	18·75	18·75

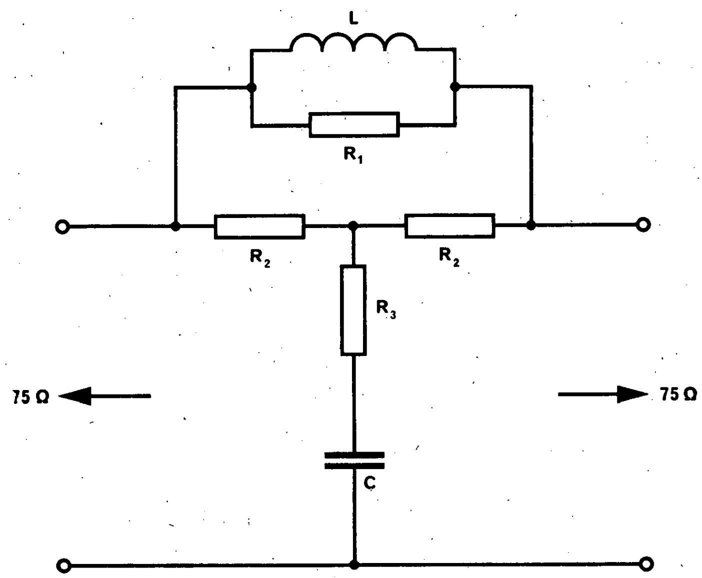

FIGURE 3

De-emphasis networks for television

RECOMMENDATION 276-2

FREQUENCY DEVIATION AND THE SENSE OF MODULATION FOR ANALOGUE RADIO-RELAY SYSTEMS FOR TELEVISION

(Question 3/9, Geneva, 1982)

(1956–1959–1970–1974)

The CCIR,

CONSIDERING

(a) that radio-relay systems for television using frequency modulation may form part of an international circuit;

(b) that international connections of such systems may at times have to be made at intermediate or radio frequencies;

(c) that the use of too large a frequency deviation results in an unnecessarily wide band of transmitted radio frequencies and should be avoided, because of the need for economy in the use of the radio frequency spectrum;

(d) that, for various reasons, the use of pre-emphasis may be desirable (see Recommendation 405),

UNANIMOUSLY RECOMMENDS

1. that the value of the frequency deviation without pre-emphasis in radio-relay systems for television should be 8 MHz peak-to-peak, referred to the nominal peak-to-peak amplitude of the video-frequency signal (see Recommendation 567);

2. that when pre-emphasis, in accordance with Recommendation 405, is used, the relative deviation of 0 dB in Fig. 2 of that Recommendation should correspond to the value of the deviation without pre-emphasis given in § 1;

Note. – This value of deviation was established for the transmission of monochrome television signals and was subsequently adopted for colour television signals.

3. that the sense of modulation at the point of international connection should be the subject of agreement between the administrations concerned.

RECOMMENDATION 403-3 *

INTERMEDIATE-FREQUENCY CHARACTERISTICS FOR THE INTERCONNECTION OF ANALOGUE RADIO-RELAY SYSTEMS

(Question 1/9)

(1956–1959–1963–1966–1970–1978)

The CCIR,

CONSIDERING

(a) that radio-relay systems for television and frequency-division multiplex telephony may form part of an international circuit;

(b) that it may at times be desirable to make international connections between such systems at intermediate frequencies;

(c) that, to facilitate international connections at intermediate frequencies, systems of the same channel capacity (independent of their radio frequencies), should preferably have the same intermediate frequency;

(d) that, to facilitate the best choice for a radio-frequency channelling arrangement, it is desirable to adopt a preferred value for the intermediate frequency;

(e) that incorrect interconnection may have harmful consequences (noise in radio-relay systems for telephony, and linear or non-linear distortion in radio-relay systems for television),

UNANIMOUSLY RECOMMENDS

that, as far as practicable, frequency-division multiplex radio-relay systems, forming part of an international circuit, should have intermediate-frequency circuits which, at a point of international connection, conform to the preferred values listed below:

1. Centre value of the intermediate frequency

Nominal centre values of intermediate frequency (MHz)	Maximum channel capacity
35 (for radio frequencies up to about 1.7 GHz) (1) 70 (for radio frequencies above about 1 GHz)	12, 24, 60, 120
70	300, 600, 960, 1260, 1800
140	2700

(1) The intermediate frequency of 70 MHz may also be used in some radio-relay systems.

The tolerance relative to the nominal centre value of the intermediate frequency may well prove to be a function of a specific system, and is the subject of further studies. Until a final recommendation can be set up, the tolerance should be agreed between the administrations concerned.

2. Output and input voltages of the intermediate-frequency signal

Nominal values	*Tolerances*
Output: 0.5 V r.m.s. (+5.2 dBm)	+1.0 dB −1.5 dB

* This Recommendation applies to line-of-sight and near line-of-sight radio-relay systems and, where appropriate, to trans-horizon radio-relay systems.

The voltage at the output of a receiver corresponds to that of nominal radio-frequency level at the receiver input.

Input: 0.3 V r.m.s. (+0.8 dBm) $\begin{matrix} +1.0 \text{ dB} \\ -1.5 \text{ dB} \end{matrix}$

Variations in levels which exceed the above range and which are either due to variations of the receive signal or to phenomena which are independent of propagation, should be the subject of agreement between the administrations concerned.

Connection between an output and an input may be made at an input voltage range of between 0.5 V r.m.s. to 0.3 V r.m.s. by agreement between the administrations concerned. Any necessary level adaptation should be made at the input point by the administration concerned.

3. Impedance of the intermediate-frequency circuit

Nominal impedance: 75 Ω (unbalanced).

Return loss: ⩾ 26 dB within a frequency band including the baseband and the continuity pilot frequency on both sides of the centre frequency, for systems with a capacity of more than 600 telephone channels, or the equivalent.

Values greater than 26 dB may be necessary depending upon the characteristics of the junction cables used, especially their length, and the bandwidth transmitted (a large number of telephone channels or television and sound broadcasting signals).

The matching conditions for systems with a capacity of 600 channels or less, remain under study.

4. Intermediate-frequency characteristics at harmonic frequencies

The generation of harmonics (particularly the second harmonic) should be controlled as these may recombine with the fundamental frequency and cause distortions which could impair the transmission quality. As an example equipment-generated harmonics propagated through a junction cable may be reflected from the cable terminations to produce intermediate-frequency signals which are delayed with respect to the main signal and so result in intermodulation distortion noise.

Administrations should consider the level of harmonics and the impedance at harmonic frequencies of the cable termination, with a view to applying appropriate remedies, pending agreement upon a Recommendation.

Note 1 – When diversity reception is used, the preferred values quoted above for impedance and output level apply to the combined output of the receivers used.

Note 2 – It is recognized that in certain cases and in certain regions, it may be desirable to use, by agreement between the administrations concerned, intermediate-frequency characteristics other than those given above.

Note 3 – The precise definition of the point of international connection is the responsibility of the administrations concerned.

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SECTION 9D: MAINTENANCE

RECOMMENDATION 290-3

MAINTENANCE MEASUREMENTS ON RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 22/9)

(1959–1970–1974–1978)

The CCIR,

CONSIDERING

that the operation of frequency-division multiplex radio-relay systems for telephony would be facilitated by maintenance procedures similar to those in existence for line networks,

UNANIMOUSLY RECOMMENDS

that the following routine maintenance measurements should be made on radio-relay regulated line sections in accordance with CCITT Recommendation M.500. These measurements should be made in the radio equipment terminal stations of the radio-relay system. Readjustment should be carried out in accordance with CCITT Recommendation M.510.

1. At intervals to be determined by agreement between the administrations concerned and based on experience of the reliability of the system:

- measurement of the loss/frequency distortion at frequencies in the baseband relative to the reference frequency* or multi-frequency check (permissible limits ± 2 dB except under abnormal propagation conditions);
- when there is no continuous recording of noise, measurement of the total noise level on the noise-measurement channels outside the baseband in accordance with Recommendation 398** this measurement can be made without causing any interference in the transmission channel;
- further measurements, e.g. group delay measurement, may be appropriate to obtain more detailed information.

2. When the measurement mentioned in § 1 gives unacceptable high noise values, or more often, when the reliability of the system makes it desirable, check the following measurements in accordance with the appropriate CCIR recommendations for the radio-relay system concerned, the radio-frequency channel being switched to the stand-by equipment. Measurement results should be compared with the results of the reference measurements required by CCITT Recommendation M.450, § 3.3:

- the deviation of the frequency at which the level is unchanged by pre-emphasis;
- the pilot-frequency deviation;
- the nominal value (control position) of the intermediate frequency in the non-modulated condition of the system;
- the level of the baseband reference frequency* where applicable (single-frequency check);
- the baseband amplitude variation with frequency relative to the reference frequency* where applicable (multi-frequency check);
- the level of individual interfering signals in the baseband in the non-modulated condition of the system.

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* The baseband reference frequency may be different from the frequency at which the level is unchanged by pre-emphasis and may be selected from one of the frequencies specified in § 3.1.2 of CCITT Recommendation M.450 for each transmitted bandwidth.

** Where a protection channel is provided, and if administrations so desire, noise measurements may be made on that channel with artificial loading, in accordance with Recommendation 399.

3. So as to enable the overall limits for the variations of transmission equivalent (see under § 1) to be met, the difference in baseband response between two systems in diversity reception or between working and protection systems should not exceed 2 dB.

Note. – The variation of ± 2 dB applies to all types of switching including baseband. The actual variation may be less for intermediate-frequency switching or for diversity switching on a single radio hop.

In order to achieve this figure consistently, it may be necessary for the amplitude/frequency response of each radio channel to be adjusted to tighter limits than those given in Recommendation 380, Note 7.

Administrations may find it advisable to adjust the transmission equivalent of all radio channels in the same switching system to close limits at a single mutually agreed reference frequency.

RECOMMENDATION 305

STAND-BY ARRANGEMENTS FOR RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

(Question 22/9)

(1956–1959)

The CCIR,

CONSIDERING

(a) that, in radio-relay systems, it is indispensable to have stand-by arrangements to decrease the time when the circuit is out of action as a result of a fault in equipment, or to facilitate periodical maintenance operations;

(b) that for this purpose, it is generally advisable to use a stand-by channel replacing the channel normally in service along the entire length of a switching section;

(c) that, for technical or operational reasons, it may be desirable to use, in certain cases, stand-by installations of a different type such as stand-by equipment with switching at each station on the same carrier frequency;

(d) that a distinction should be made according to whether the system is intended for the transmission of telephone channels, of telephone and television channels possessing very similar radio characteristics, or of telephone and television channels with differing characteristics,

UNANIMOUSLY RECOMMENDS

1. that, when several radio-frequency channels possessing the same characteristics are used for multiplex telephony, it is preferable to use a stand-by channel common to the channels in service (or several such stand-by channels, if necessary);

2. that, when some of the radio-frequency channels are utilized for multiplex telephony and others for television and all the radio channels possess very similar characteristics, it is preferable to use a stand-by channel common to the channels in service (or several such stand-by channels, if necessary);

3. that, in certain specific cases, such as when some of the radio-frequency channels are utilized for multiplex telephony and others for television and when the characteristics of such channels are substantially dissimilar, the administrations concerned may, by mutual agreement and if they so desire, use stand-by arrangements differing from those specified in §§ 1 and 2 of the present Recommendation, such as stand-by equipment operating on the same carrier frequency as the equipment in service and which can be substituted for that equipment station by station.

RECOMMENDATION 401-2 *

FREQUENCIES AND DEVIATIONS OF CONTINUITY PILOTS FOR FREQUENCY MODULATION RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

(Question 22/9)

(1956-1959-1963-1966-1970)

The CCIR,

CONSIDERING

(a) that special pilots are required on radio-relay systems to indicate the continuity of the circuit;

(b) that these pilots should be situated outside the range of frequencies occupied by the telephony or the television signals (Recommendation 381);

(c) that typically, a frequency about 10% higher than the upper limit of the transmitted baseband is desirable depending upon the necessary suppression desired (see Recommendation 381);

(d) that, in determining the upper frequency limit of continuity pilots, compatibility with radio-relay channel arrangements, and equipment passband characteristics need to be taken into account;

(e) that some administrations wish to use the same continuity pilot characteristics in various radio-relay systems for multi-channel telephony and television;

(f) that, to reduce intelligible cross-talk, the continuity pilot should, when possible, have a frequency of $(4n - 1)$ kHz, where n is an integer,

UNANIMOUSLY RECOMMENDS

1. that for frequency-division multiplex telephony and television radio-relay systems, when the continuity pilot is above the baseband, its frequency and deviation should be that shown in Table I;

2. that a continuity pilot situated below the baseband may be used after agreement between the administrations concerned;

3. that the frequency stability of the continuity pilot should be better than 5 parts in 10^5.

* This Recommendation applies to line-of-sight and near line-of-sight radio-relay systems and also, where appropriate, to trans-horizon radio-relay systems.

TABLE I

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Frequency limits of baseband (kHz) (1)	Continuity pilot frequency (kHz)	Deviation (r.m.s.) produced by the pilot (kHz) (2) (5)
24	12-108	12-108	116 or 119	20
60	12-252 60-300	12-252 60-300	304 or 331	25, 50, 100 (3)
120	12-552 60-552	12-552 60-552	607 (4)	25, 50, 100 (3)
300	60-1300	60-1364	1499, 3200 (6) or 8500 (6)	100 or 140
600	60-2540 64-2660	60-2792	3200 or 8500	140
960 900	60-4028 316-4188	60-4287	4715 or 8500	140
1260 1200	60-5636 60-5564 316-5564	60-5680	6199 8500	100 or 140 140
1800	312-8204 316-8204	300-8248	9023	100
2700	312-12 388 316-12 388	308-12 435	13 627	100
Television			8500 9023 (7)	140 100

(1) Including pilot or other frequencies which might be transmitted to line.

(2) Other values may be used by agreement between the Administrations concerned.

(3) Alternative values dependent on whether the deviation of the signal is 50, 100 or 200 kHz (Recommendation 404).

(4) Alternatively 304 kHz may be used by agreement between the Administrations concerned.

(5) This deviation does not depend on whether or not a pre-emphasis network is used in the baseband.

(6) For compatibility in the case of alternate use with 600-channel telephony systems and television systems.

(7) The frequency 9023 kHz is used for compatibility purposes between 1800 channel telephony systems and television systems, or when the establishment of multiple sound channels so indicates.

RECOMMENDATION 444-3

PREFERRED CHARACTERISTICS FOR MULTI-LINE SWITCHING ARRANGEMENTS OF ANALOGUE RADIO-RELAY SYSTEMS

(Study Programme 5A/9)

(1966–1970–1978–1982)

The CCIR,

CONSIDERING

(a) that protection arrangements for wide-band telephony and television radio-relay systems may be required to meet availability objectives;

(b) that international agreement on the major characteristics required for interconnection of such systems appears to be desirable and feasible for baseband-frequency and intermediate-frequency multi-line switching systems;

(c) that many characteristics of multi-line switching systems are still under study, while others represent areas of agreement;

(d) that an objective of multi-line switching arrangements is to facilitate compliance with Recommendations 393 and 567,

UNANIMOUSLY RECOMMENDS

that, as far as practicable, the characteristics of multi-line switching systems should conform to the following:

1. the criteria for protection switching and restoration should be based on:

1.1 the level of the continuity pilot (see Recommendation 401);

1.2 the evaluation of noise power within a frequency band in the vicinity of the pilot frequency (see Table I, Recommendation 401);

1.3 the received carrier level;

2. seizure and restoration of a protection channel should depend on the following criteria:

– § 1.1 alone
– § 1.2 alone
– § 1.3 in combination with § 1.1
– § 1.3 in combination with § 1.2
– § 1.1 in combination with § 1.2;

3. the threshold levels should be adjustable, and the actual threshold should be chosen so that switching occurs only when essential for reasons of performance and reliability;

4. in each switching section, recognition of a failure of a regular radio-frequency channel should initiate changeover to a protection radio-frequency channel *within* the section involved. Unnecessary switchover and re-set operations in other sections should be avoided;

5. the following control signals should be provided:

5.1 from the main traffic receive-end to the transmit-end, a signal for bridging or switching. This signal includes identification of the degraded channel, and, where appropriate, a preference for a particular protection channel. The signal should comprise voice frequency telegraph tones which conform in frequency with the relevant CCITT Recommendations. Other types of signal and levels may be used by agreement between the administrations concerned. A service channel should be used (see Recommendation 400) to convey this signal. A failure of the control signal information should freeze the situation as it was immediately preceding the failure. In certain cases where priority is used, it may be desirable to change the situation to some preferred configuration;

5.2 from the main traffic transmit-end to the receive-end, confirmation that bridging or switching has taken place. This may be transmitted, for instance, by suitably modulating the continuity pilot of the protection channel, or by changing its frequency, or by other means;

6. the protection channels should be made available as much as possible. If the operational requirements make it necessary, it should be possible to give priority to any regular channel;

7. the operate time of the entire automatic switching system should not exceed 40 ms. An operate time of 10 ms can be achieved by using a wide-band signalling channel;

8. the effective transfer time in most cases depends on the switching element used. Reduction of this time below 2 ms and down to 10 μs may be realized by using modern design techniques;

9. the noise allocated as a contribution by the switching equipment should generally be a small fraction of the total allowable noise of the link (see Recommendations 393 and 395);

10. conformity with CCIR Recommendations relating to interconnection and characteristics at baseband and intermediate frequencies should, in no way, be affected by the use of multi-line switching equipment.

RECOMMENDATION 398-3

MEASUREMENTS OF NOISE IN ACTUAL TRAFFIC OVER RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 22/9)

(1959-1963-1966-1970-1974)

The CCIR,

CONSIDERING

(a) that measurements by means of a generator producing white noise (according to Recommendation 399) are only possible when the radio-frequency channel is not carrying traffic and that channels used for these measurements can lie within the frequency range occupied by telephone channels*;

(b) that systems carrying multi-channel telephony cannot be withdrawn from service at will for measurement;

(c) that protection channels are not always available for maintenance purposes;

(d) that maintenance measurements of the total noise (thermal and intermodulation noise) are used for determining the quality of a system and must be made while the system is carrying traffic;

(e) that it is convenient to place the channels used for this kind of measurement outside the total bandwidth of the multiplex signal;

(f) that, when these measuring channels are located outside the total multiplex signal band, they should be positioned as near the limits of the total signal band as possible, to measure the intermodulation products due to the non-linearity of the system;

(g) that, on the other hand, to facilitate and to minimize the cost of filter construction, the measuring channels should not be positioned too near these limits;

(h) that measurements in channels above the multiplex signal band are generally more sensitive to changes of thermal and intermodulation noise in the radio-frequency and intermediate-frequency circuits of the equipment, whereas measurements in channels below this band are generally more sensitive to changes in the modulators and demodulators;

(j) that it is usually necessary to use band-stop filters at the input of a system, to minimize noise on the incoming circuit in the bands occupied by the measuring channels and that it will be necessary to specify the minimum performance of these filters, both in the stop band of these filters and at the edges of the total multiplex signal band;

(k) that the specification of frequencies, situated about 10% above the upper limit of the total multiplex signal band for continuity pilots (Recommendation 401), suggests the use of the same frequencies as centre frequencies for the measuring channels. On the other hand, measuring equipment with a heterodyne receiver, which is independent of the pilot and can also be used for measurements in accordance with Recommendation 399, will suffer interference from a pilot transmitted during the measurement, so that a shift of the measuring channel will be necessary;

(l) that the following factors have to be taken into account when the centre frequency of noise measuring channels is shifted in accordance with § *(k)*:

- the difference in frequency between the measuring channel and the total multiplex signal band should be as small as possible (§ *(f)*),
- intermodulation products between the pilot and the lower end of the baseband should not fall within the measuring channel,
- in view of spurious responses which might occur with crystal band-stop filters, the measuring channel should be shifted upwards when use is made of these;

(m) that it may be of use to combine the evaluation of the power of the continuity pilot with the measurement of the noise around it;

(n) that it may be of use to employ the measuring channels outside the multiplex signal band also for measurements with white noise, according to Recommendation 399,

* In this Recommendation the words "frequency range occupied by telephone channels" are intended to mean the part of the baseband actually transmitted, when a system is used below its maximum capacity.

UNANIMOUSLY RECOMMENDS

1. that noise occurring in radio links while actual traffic is being carried should be measured at the output of the system in relatively narrow bands situated outside (below and/or above) the total multiplex signal band;

2. that the centre frequencies of the noise measuring bands should be those shown in Table I:

– the centre frequencies given in column *(a)* should preferably be used in conjunction with the measuring equipment considered in § *(m)*;

– the centre frequencies given in column *(b)* are for use with measuring equipment similar to that described in Recommendation 399 (also considered in § *(n)*);

3. that the attenuation of the band-stop filters at the input of the system should exceed 50 dB over a minimum frequency band of $\pm$ (0.005 f + 2) kHz* (f being the centre frequency in kHz of the measuring channel). The additional attenuation, caused by the insertion of the band-stop filters at the lower and at the upper edges of the total multiplex signal band, shall not exceed 0.3 dB referred to the additional attenuation caused in the centre of the multiplex signal band;

4. that the effective bandwidth of the filters in the receiving equipment should be small enough for use with the input band-stop filter mentioned above;

5. that, in all cases where different frequency bands are used, or where there are differences between the measurement techniques, special agreements should be made.

Note. – In certain telephone channels and in combinations of them, harmonic distortion may be produced, which may make it necessary to leave these channels disconnected, e.g. if the second or third harmonics coincide with the centre frequencies of the noise measuring channels.

TABLE I

System capacity (number of channels)	Limits of band occupied by telephone channels (kHz)	Frequency limits of baseband (1) (kHz)	Centre frequencies (f) of noise measuring channels (kHz)		
			Below	Above	
				(a)	*(b)*
24 60	12–108 12–252 60–300	12–108 12–252 60–300	10 10 50	116 or 119 304 331	(2) (2) (2)
120	12–552 60–552	12–552 60–552	10 50	607 607	600 600
300	60–1300 64–1296	60–1364	50	1499	1549
600	60–2540 64–2660	60–2792	50	3200	3250
960	60–4028	60–4287	50	4715	4765
900	316–4188	60–4287	270	4715	4765
1260	60–5564 60–5636	60–5680	50	6199	6300
1200	316–5564	60–5680	270	6199	6300
1800	312–8204 316–8204	300–8248	270	9023	9073
2700	312–12 388 316–12 388	300–12 435	270	13 627	13 677

(1) Including pilots or frequencies which might be transmitted to line.

(2) These values will be indicated after more practical experience has been gained.

* Except when the centre frequency is 10 kHz; the minimum frequency band is then 10 $\pm$ 1 kHz.

RECOMMENDATION 399-3

MEASUREMENT OF NOISE USING A CONTINUOUS UNIFORM SPECTRUM SIGNAL ON FREQUENCY-DIVISION MULTIPLEX TELEPHONY RADIO-RELAY SYSTEMS

(Question 22/9)

(1956–1959–1963–1966–1974–1978)

The CCIR,

CONSIDERING

(a) that it is desirable to measure the performance of radio-relay systems for frequency-division multiplex telephony under conditions closely approaching those of actual operation;

(b) that a signal with a continuous uniform spectrum (white noise) has statistical properties similar to those of a multiplex signal, when the number of channels is not too small;

(c) that the use of a signal with a continuous uniform spectrum to measure the performance of such radio-relay systems is already widespread;

(d) that it is necessary to standardize the frequencies and bandwidths of the measuring channels to be used for such tests;

(e) that it is necessary to standardize the minimum attenuation and the bandwidth of the stop filters which may have to be used in the white-noise generator;

(f) that the CCITT has indicated, for the planning of telephone circuits, a mean value of speech power in a telephone channel to be taken into consideration during the busy hour (CCITT Recommendation G.223, Vol. III, Fascicle III.2),

UNANIMOUSLY RECOMMENDS

1. that the performance of frequency-division multiplex radio-relay systems should be measured by means of a signal of a continuous uniform spectrum in the frequency band used for the telephone channels;

2. that the nominal power level of the test signal with a uniform spectrum should be in accordance with the conventional load, specified in CCITT Recommendation G.223. If applied at the point of interconnection of the system corresponding to T′ of CCIR Recommendation 380, the absolute power levels of interest are shown in column 4 of Table I;

TABLE I

(1)	(2)	(3)	(4)
Number of telephone channels	Relative power level at point *T′* (dBr)	Level of the conventional load (dBm0)	Nominal power level of the test signal at point *T′* (dBm)
60	−36	6·1	−29·9
120	−36	7·3	−28·7
300	−36	9·8	−26·2
600	−36 −33	12·8	−23·2 −20·2
960	−36 −33	14·8	−21·2 −18·2
1260	−33	16·0	−17·0
1800	−33	17·5	−15·5
2700	−33	19·3	−13·7

2.1 that the sending equipment should be capable of providing, at the output of an inserted band-eliminating filter, a loading level at least up to +10 dB relative to the nominal power level as defined above;

2.2 that, within the bandwidth corresponding to the baseband of the system under test, the r.m.s. voltage of the white-noise spectrum measured in a band of about 2 kHz should not vary by more than ± 0.5 dB. This degree of spectrum regularity should be met in the level range up to +6 dB relative to the power level indicated in Table I, column 4. This is to ensure reliable calibration of the receiver by means of the test signal;

2.3 that the white-noise test signal should be available at the output of the sending equipment with a peak factor of about 12 dB with respect to the r.m.s. value;

3. that the nominal effective cut-off frequencies (the cut-off frequencies of hypothetical filters having ideal square cut-off characteristics and transmitting the same power as the real filters) and tolerances, for the band-limiting filters proposed for the various bandwidths of systems to be tested, should be as specified in Table II. (To reduce the number of filters required, compromises have been made between the nominal effective cut-off frequency and the system bandwidth-limiting frequency in some cases. The tolerances ensure that consequent calibration errors do not exceed ± 0.1 dB and errors in measurement of intermodulation noise do not exceed ± 0.2 dB, assuming system pre-emphasis conforming to Recommendation 275)*;

TABLE II

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Effective cut-off frequencies of band-limiting filters (kHz)		Frequencies of available measuring channels (kHz)
		High-pass	Low-pass	
60	60–300	60 ± 1	300 ± 2	70 270
120	60–552	60 ± 1	552 ± 4	70 270 534
300	60–1300 64–1296	60 ± 1	1296 ± 8	70 270 534 1248
600	60–2540 64–2660	60 ± 1	2600 ± 20	70 270 534 1248 2438
960	60–4028 64–4024	60 ± 1	4100 ± 30	70 270 534 1248 2438 3886
900	316–4188	316 ± 5	4100 ± 30	534 1248 2438 3886
1260	60–5636 60–5564	60 ± 1	5600 ± 50	70 270 534 1248 2438 3886 5340
1200	316–5564	316 ± 5	5600 ± 50	534 1248 2438 3886 5340
1800	312–8120 312–8204 316–8204	316 ± 5	8160 ± 75	534 1248 2438 3886 5340 7600
2700	312–12 336 316–12 388 312–12 388	316 ± 5	12 360 ± 100	534 1248 2438 3886 5340 7600 11700

3.1 that the discrimination of a low-pass filter should be at least 20 dB at a frequency more than 10% above nominal cut-off and at least 25 dB at frequencies more than 20% above nominal cut-off. The discrimination of a high-pass filter should be at least 25 dB at frequencies more than 20% below nominal cut-off;

3.2 that, to limit discrimination against measuring channels, the spread of losses introduced by any pair of high-pass and low-pass filters should not exceed 0.2 dB over a range of frequencies which includes the outer measuring channels;

* Study Group 9 of the CCIR has noted that the CCITT refers to a pre-emphasis of 10 dB and understands that this is valid for cable systems only.

4. that values of the provisional characteristics for the discrimination in each stop band at the output of a sending equipment are given in Table III; these characteristics are intended to apply over a temperature range from 10 °C to 40 °C;

TABLE III

Centre frequency f_c (kHz)	Bandwidth (kHz), in relation to f_c, over which the discrimination should be at least				Bandwidth (kHz), in relation to f_c, outside which the discrimination should not exceed	
	70 dB	55 dB	30 dB	3 dB	3 dB	0,5 dB
70	±1.5	± 2.2	± 3.5	—	± 12	± 18
		± 1.7	± 2.0	—	± 5	± 10
270	±1.5	± 2.3	± 2.9	—	± 8	± 24
534	±1.5	± 3.5	± 7.0	—	± 15	± 48
1248	±1.5	± 4.0	±11.0	—	± 35	±110
2438	±1.5	± 4.5	±19	—	± 60	±220
3886	±1.5	±15.0	±30.0	—	±110	±350
	±1.5	± 1.8	± 3.5	± 8.0	± 12	±100
5340	±1.5	± 2.2	± 4.0	± 8.5	± 14	±150
7600	±1.5	± 2.4	± 4.6	± 9.5	± 16	±200
11 700	±1.5	± 3.0	± 7.0	±11.0	± 20	±300

Note 1. – The discrimination values quoted are relative to the minimum attenuation of the band-stop filters within the baseband frequency range defined by high-pass and low-pass filters in Table II. This implies that a band-stop filter suitable for measurements on one system is not necessarily suitable for measurements on a system of larger bandwidth.

Note 2. – The characteristics recommended for the filters 70 kHz to 2438 kHz inclusive are based on coilcapacitor type filters. Those characteristics recommended for the filters at 5340 kHz and above are based on crystal-type filters. Optional characteristics are recommended for the 3886 kHz filter to permit a choice of design between a coil-capacitor type or crystal-type filter.

Note 3. – The design of the receiver selectivity of 3886 kHz should be related to the characteristic of the crystal-type band-stop filter.

Note 4. – Due to spurious resonances, narrow spikes of discrimination may occur in the upper passband of crystal-type band-stop filters. When resonators are operated in a higher harmonic mode, narrow spikes can also appear in the lower passband. Those spikes of about 10 dB peak attenuation within 1 to 5 kHz bandwidth are admissible because they do not affect the measuring accuracy.

5. that, when the receiving equipment is connected directly to a sending equipment provided with band-stop filters which only just meet the requirements of § 4, the ratio of the noise power indicated by the receiving equipment when the band-stop filter is by-passed, to that indicated when the filter is in circuit, should be a minimum of 67 dB; this requirement applies when a conventional load is applied. The minimum effective bandwidth of the receiver should be 1.7 kHz. The maximum reading of absolute noise power arising from leakage given by a receiver of 1.74 kHz effective bandwidth and which just meets the foregoing leakage requirement, is −85.6 dBm0p;

6. that additional measuring channels may be provided by agreement between the administrations concerned.

Note. – An overall accuracy of ± 2 dB or better, is assumed for the measurement of radio-relay systems in operation. Attention is drawn to CCITT Rec. G.228, Annex A and Annex B, which discuss the method of measurement and the measuring accuracy.

RECOMMENDATION 700

ERROR PERFORMANCE AND AVAILABILITY MEASUREMENT ALGORITHM FOR DIGITAL RADIO-RELAY LINKS AT THE SYSTEM BIT RATE INTERFACE

(Question 37/9)

(1990)

The CCIR,

CONSIDERING

(a) that the error performance objectives at the output of the hypothetical reference digital path, and sections for digital radio-relay systems which may form part of an ISDN, have been specified in Recommendation 594 and Recommendations 695, 696 and 697, in accordance with CCITT Recommendation G.821 at the 64 kbit/s interface;

(b) that CCITT Recommendation G.821 gives guidelines in its Annex B on how to measure the error performance objectives and specifies in its Annex D provisional translations of error performance measurements at primary bit rates and above into 64 kbit/s error performance parameters;

(c) that Recommendation 634 specifies error performance objectives for real digital radio-relay links forming part of a high grade circuit within an ISDN in agreement with *(b)* above;

(d) that the concept of unavailability of the hypothetical reference digital path has been defined in Recommendation 557;

(e) that it is desirable to establish performance and availability indicators for digital radio-relay links;

(f) that the standardization of bit error ratio measurement of digital radio-relay systems is desirable,

UNANIMOUSLY RECOMMENDS

that the error performance and availability measurement at the system bit rate interface, in accordance with the specifications of the above mentioned CCIR Recommendations and CCITT Recommendation G.821, should be performed by counting the number of errors at the system bit rate in each 1 s interval and then processing the results using the algorithm shown in Fig. 1 (see Note 6).

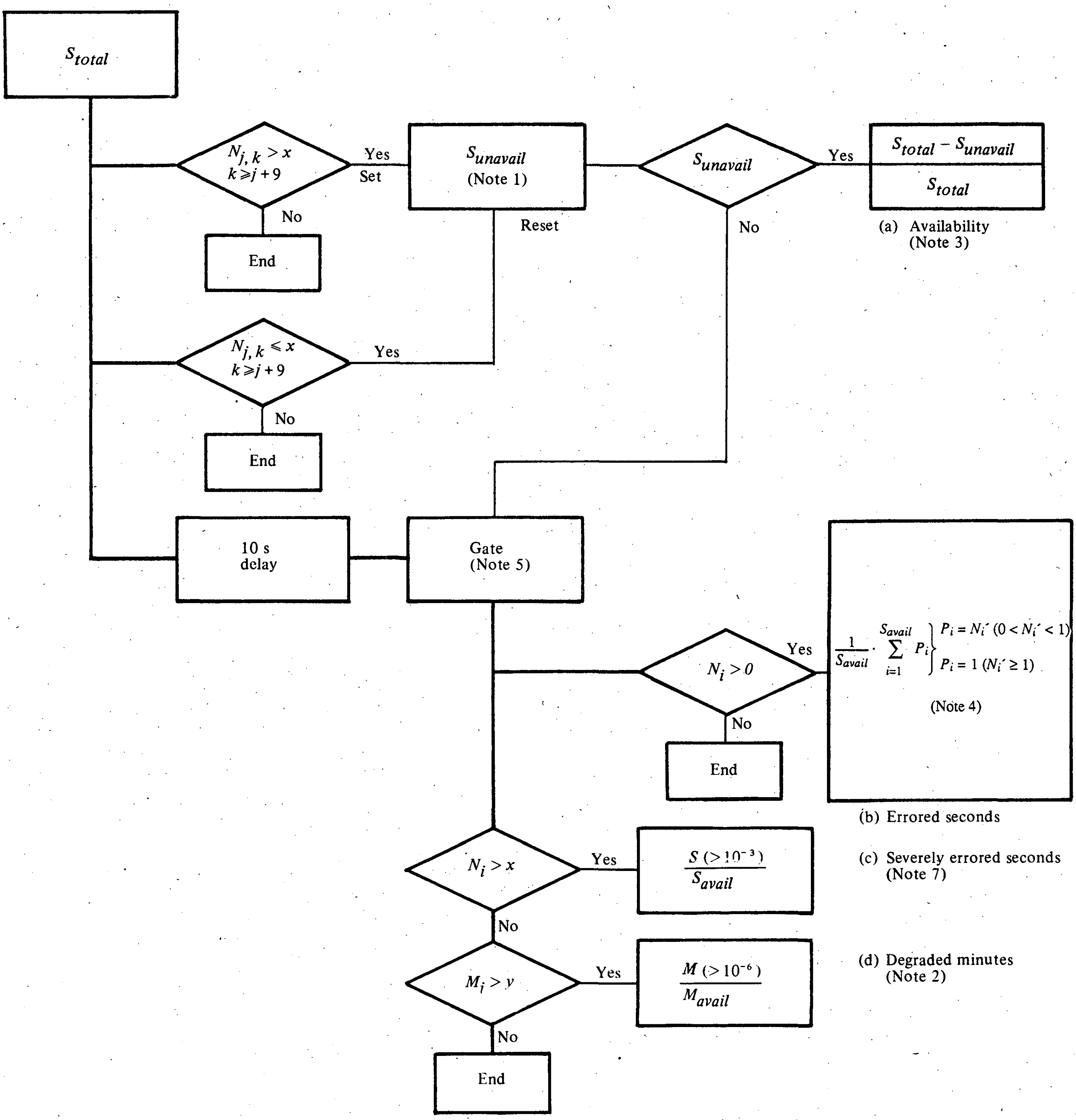

FIGURE 1 – *Measurement algorithm*

Legend of Figure 1:

▬▬▬ (thick line)	Flow of bit error measurement
——— (thin line)	Flow of logic information
S_{total} :	total measured seconds: one month
$S_{unavail}$:	unavailable time (s)
S_{avail} :	available time (s)
M_{avail} :	available time (min) $= \frac{S_{total} - S_{unavail}}{60}$ (The result is rounded off to the next higher integer)
$N_{j,k}$:	number of bit errors in each second interval at the system bit rate between *j*th second and *k*th second inclusive;
N_i :	number of bit errors in the *i*th second at the system bit rate;
N_i' :	$N_i \cdot \frac{64 \times 10^{-3}}{\text{system bit rate (Mbit/s)}}$ (number of bit errors normalized to the 64 kbit/s level);
P_i :	probability of an errored second at the 64 kbit/s level being caused by N_i bit errors at the system bit rate (see Note 4);
$S(> 10^{-3})$:	total time in seconds during which the BER exceeds 10^{-3} in each second interval;
$M(> 10^{-6})$:	total time in minutes that the BER exceeds 10^{-6}, measured in packets of 60 consecutive 1 s intervals derived by excluding any 1 s interval during which the BER exceeds 10^{-3};
M_i :	number of bit errors in the *i*th packet of 60 consecutive 1 s intervals derived by excluding any 1 s interval during which the BER exceeds 10^{-3};
x :	number of errors (rounded off to the next higher integer) corresponding to a BER of a 10^{-3} over a 1 s interval at the system bit rate ($x = 10^3 \times$ system bit rate (Mbit/s));
y :	number of errors (rounded off to the next higher integer) corresponding to a BER of 10^{-6} over 60 1 s intervals at the system bit rate ($y = 60 \times$ system bit rate (Mbit/s))

Note 1 – Available and unavailable time: a period of unavailable time begins when the bit error ratio (BER) in each second is worse than 10^{-3} for a period of 10 consecutive seconds. These 10 s are considered to be unavailable time. The period of unavailable time terminates when the BER in each second is better than 10^{-3} for a period of 10 consecutive seconds. These 10 s are considered to be available time (see Annex A to CCITT Recommendation G.821). With the algorithm shown, a small inaccuracy exists in the case where the measurement is stopped during a period of unavailability. In this case the first 10 s of the unavailability time are missing. The detailed algorithm, realized in error performance monitoring equipment, has to provide for this.

Note 2 – The last packet which may be incomplete is treated as if it were a complete packet with the same rules being applied (see Annex B to CCITT Recommendation G.821).

Note 3 – The availability figure calculated in this way refers to one transmission direction of the radio-relay link only, whereas the availability concept of Recommendation 557 specifies objectives taking into account the behaviour of both transmission directions simultaneously. To compare the results with these objectives, further processing is needed (see Report 445).

Note 4 – The translation of errored seconds at the system bit rate to errored second statistics at 64 kbit/s follows a linear law as provisionally proposed in Annex D of CCITT Recommendation G.821 and in Report 930. Alternative methods are currently under study (see Reports 613 and 930).

Note 5 – The purpose of the gate is to discount the periods of unavailable time from the calculation of errored seconds, severely errored seconds and degraded minutes.

Note 6 – The measurement of RBER is under study (see Report 930).

Note 7 – The percentage of severely errored seconds normalized to 64 kbit/s can be assessed from measurements made at the system bit rate (see Report 930).

RECOMMENDATION 400-2*

SERVICE CHANNELS TO BE PROVIDED FOR THE OPERATION AND MAINTENANCE OF RADIO-RELAY SYSTEMS

(Question 4/9, Geneva, 1982)

(1956-1959-1963-1966-1970)

The CCIR,

CONSIDERING

(a) that service channels are required for the maintenance, supervision and control of radio-relay systems;

(b) that if, for any reason, the radio-relay system itself fails to function, communication between various stations along the route, and from those stations to other points is likely to assume special importance;

(c) that agreement is desirable on the number and function of the service channels to facilitate the planning of radio-relay systems;

(d) that service channels will be used to provide:

– omnibus voice circuits,
– express voice circuits,
– supervisory circuits,
– control and operational circuits;

(e) that service channels will not be connected to the public telephone network,

UNANIMOUSLY RECOMMENDS

that, on international radio-relay systems:

1. all staffed stations should be connected directly to the public telephone network;

2. when a radio-relay link is extended by means of short cable sections, and these cable sections and the radio-relay link taken together constitute a regulated line section, the terminal stations of the radio-relay link itself should have speaker circuits to the stations at the ends of the regulated line section;

3. a telephone service channel (omnibus voice circuit) should be set up to connect together all the stations on the system, whether staffed or not;

4. a second telephone service channel (express voice circuit) should be provided for direct telephonic communication between the staffed stations receiving supervisory signals;

5. provisions for the transmission of supervisory and control signals should be subject to agreement between the administrations concerned;

6. the telephone service channels should possess, whenever possible, the characteristics (excluding noise power) recommended by the CCITT for international telephone circuits and, in particular, should be able to transmit the frequency band 300 to 3400 Hz;

7. all telephone service channels (including those used for supervisory and control circuits) up to a length of 280 km should, whenever possible, not exceed a mean noise power in any hour of 20 000 pW0p psophometrically weighted, at a point of zero relative level.

Note. – Service channels may be provided over an auxiliary radio-relay system, over the main radio-relay system, or by other unrelated means, either on a primary or stand-by basis. In the case of express voice circuits, the use of regular multiplex channels within the telephony baseband is acceptable, where this is possible.

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* This Recommendation applies to radio-relay systems which will transmit at least 60 telephone channels or a television signal and comprise two staffed terminal stations, in which the signals are demodulated to baseband, and any number of unstaffed intermediate stations. This Recommendation applies, where appropriate, to trans-horizon radio-relay systems.

SECTION 9E: RADIO-RELAY SYSTEMS FOR SPECIAL APPLICATIONS

9E1: LINE-OF-SIGHT RADIO-RELAY SYSTEMS

RECOMMENDATION 701

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR ANALOGUE AND DIGITAL POINT-TO-MULTIPOINT RADIO SYSTEMS OPERATING IN FREQUENCY BANDS IN THE RANGE 1.427 TO 2.690 GHz (1.5, 1.8, 2.0, 2.2, 2.4 AND 2.6 GHz)

(Questions 10/9, 27/9 and Study Programme 27A/9)

(1990)

The CCIR,

CONSIDERING

(a) that both analogue and digital point-to-multipoint microwave TDMA systems are now widely used to provide telephone and other telecommunication subscriber services in rural and remote areas of many countries;

(b) that the overwhelming majority of such systems are operating in a number of specific frequency bands between 1.427 and 2.690 GHz as established by administrations;

(c) that some administrations permit sharing of certain of these frequency bands between point-to-point (P-P) and point-to-multipoint (P-MP) systems;

(d) that the radio-frequency channel arrangements for point-to-point systems are given in Recommendations 283 and 382;

(e) that a number of radio-frequency channel arrangements for point-to-multipoint systems are described in Reports 380 and 1057;

(f) that certain radio-frequency channel arrangements for point-to-point systems in the 1.5 and 2.4 GHz bands are given in Reports 379 and 1055 respectively;

(g) that efficient use of bands of different width can be achieved by radio-frequency channel arrangements matched to the width of the band available;

(h) that a high degree of compatibility between RF channels of different arrangements could be achieved by selecting all channel centre frequencies from a uniform basic pattern;

(j) that the centre gaps of the individual channel arrangements and the guard spacing at the edges of the band can be chosen by non-occupancy of a suitable number of RF-channel positions in a homogeneous basic pattern;

(k) that the uniform basic pattern spacing should not be unjustifiably small (i.e. the number of RF-channel positions too high) nor so large as to jeopardize efficient use of the available spectrum;

(l) that the absolute frequencies of the basic pattern should be defined by a single reference frequency,

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for point-to-multipoint radio-relay systems carrying of the order of 10 to 120 telephone channels or a bit rate of the order of 1 to 8 Mbit/s or the equivalent and operating in the frequency bands between 1.427 and 2.690 GHz should be selected from a pattern with the following characteristics:

centre frequencies f_n of the radio-frequency channels within the basic pattern;

$$f_n = f_R - 0.5\ m \quad \text{MHz}$$

where:

m : integer whose maximum value depends on the available frequency band

f_R : reference frequency;

2. that these arrangements be applicable to the following frequency bands with the stated values of reference frequency f_R (Notes 1 and 2):

Frequency band (MHz)	f_R (MHz)	Notes
1427-1530	1530	3
1700-1900	1900	4 and 5
1900-2100	2100	4 and 5
2100-2300	2300	4 and 5
2300-2500	2500	6 and 7
2500-2690	2690	4

3. that the channel spacing C, the centre gap B, the guard spaces A_1 and A_2, and antenna polarization should preferably be chosen to allow P-MP radio systems to coexist with P-P systems operating on channel plans described in Recommendations 283 and 382 and (if applicable) Reports 379 and 1055 and should be agreed between the administrations concerned (Note 1);

4. that the alternated or co-channel arrangement plan should be used, examples of which are shown in Fig. 1.

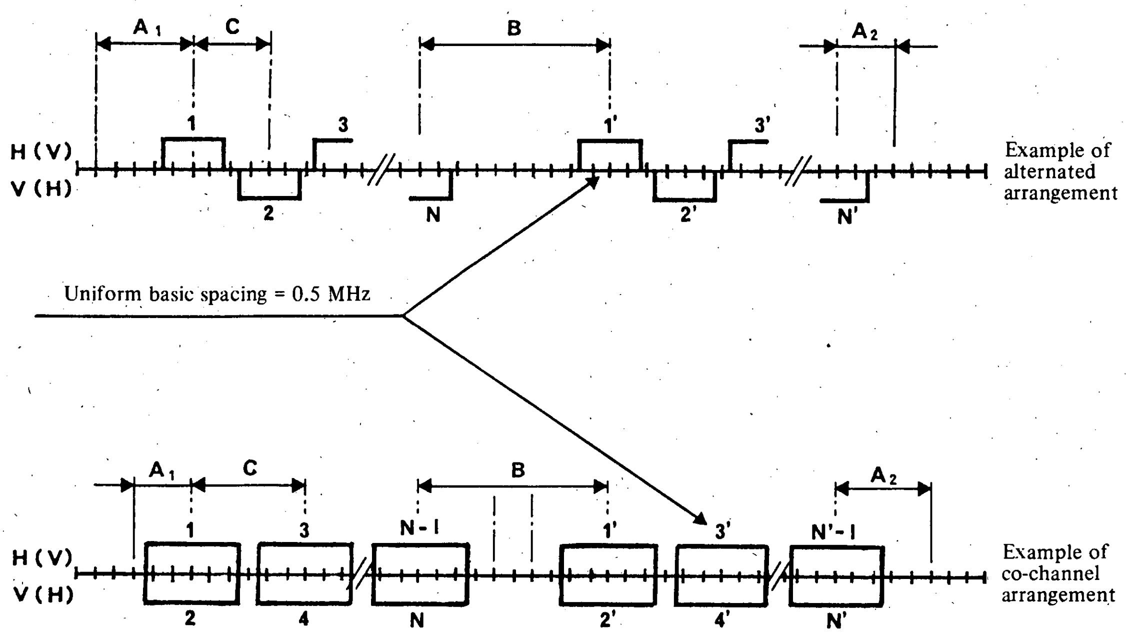

FIGURE 1 – *Examples of channel arrangements based on 1, 2 and 3*

Note 1 – It is recognized that some administrations have developed frequency channel arrangements that differ from this Recommendation in as much as A_1, A_2 and B were not always integer multiples of the channel spacing C.

Note 2 – Some administrations have selected f_R to be a frequency other than those shown in § 2.

Note 3 – A frequency channel arrangement for P-P systems in this band is described in Report 379.

Note 4 – Frequency channel arrangements for P-P systems in these bands are described in Recommendation 283 and Report 940.

Note 5 – Frequency channel arrangements for P-P systems in these bands are described in Recommendation 382.

Note 6 – A frequency channel arrangement for P-P systems in this band is described in Report 1055.

Note 7 – The band 2400-2500 MHz (centre frequency 2450 MHz) is designated for ISM applications. Radio services in this band must accept harmful interference caused by these applications.

9E2: TRANS-HORIZON RADIO-RELAY SYSTEMS

RECOMMENDATION 698

PREFERRED FREQUENCY BANDS FOR TRANS-HORIZON RADIO-RELAY SYSTEMS

(Study Programme 7F/9)

(1990)

The CCIR,

CONSIDERING

(a) that the World Administrative Radio Conference, Geneva, 1979 (WARC-79), in its Recommendation No. 100 asked the CCIR to prepare a Recommendation concerning the specific frequency bands found preferable for trans-horizon radio-relay systems, taking into account allocations to other services, particularly allocations to space services;

(b) that the WARC-79 made additional allocations of frequency bands for the space services in view of their increasing development;

(c) that Recommendation No. 100 of the WARC-79 notes that the proliferation of trans-horizon systems in all frequency bands, and particularly in those shared with the space systems, is bound to aggravate an already difficult situation;

(d) that there are optimum frequency ranges for trans-horizon radio-relay systems from the viewpoint of thermal and intermodulation noise due to propagation, depending on the distance of links;

(e) that the power limits specified in Article 27 of the Radio Regulations are applicable to transmitters of trans-horizon radio-relay systems, sharing the frequency bands with space radiocommunication services (Earth-to-space),

UNANIMOUSLY RECOMMENDS

1. that in selecting frequency bands for trans-horizon radio-relay systems, the following factors should be taken into account from the viewpoint of the total noise including thermal and intermodulation noises due to propagation:

1.1 on links of approximately 400 to 700 km relatively low frequencies below about 1 GHz with large antennas are optimum to provide adequate performance including low intermodulation noise. The transmission capacity may be small. Operation above 1 GHz may result in poor performance except for very favourably sited terminals and for very favourable propagation conditions;

1.2 on links of approximately 200 to 400 km the transmission capacity may be somewhat greater. Multipath intermodulation noise may be a major factor; frequencies about 2 GHz may be preferable to lower frequencies in order to reduce intermodulation noise;

1.3 for shorter links (approximately 100 to 200 km) operation at frequencies up to about 5 GHz is possible, resulting in low multipath intermodulation noise even with relatively small antennas. Frequencies between about 2 GHz and 3 GHz may be optimum for high transmission capacities on such links;

2. that in selecting frequency bands for trans-horizon radio-relay systems, priority should be given to bands which are not shared with space radiocommunication services;

3. that, in general, frequency bands shared with space radiocommunication services (Earth-to-space) should not be used for trans-horizon radio-relay systems (see Note 1);

4. that frequency bands shared with space radiocommunication services (space-to-Earth) may be used for trans-horizon radio-relay systems, provided that due consideration is given, on the basis of Recommendation 359, to avoiding interference from trans-horizon radio-relay systems to earth station receivers in space radiocommunication services (see Notes 2 and 3);

5. that in selecting frequency bands for trans-horizon radio-relay systems, due consideration should be given to avoiding interferences to line-of-sight radio-relay systems in accordance with Recommendation 302 (see Note 4);

6. that the following Notes should be treated as part of the Recommendation.

Note 1 – Trans-horizon radio-relay systems cannot generally operate under the power limits applicable to all systems in the fixed service shared with space radiocommunication services (Earth-to-space), as specified in Article 27 of the Radio Regulations.

Note 2 – When frequency bands shared with space radiocommunication services (space-to-Earth) are used for trans-horizon radio-relay systems, it should be confirmed that space stations in space radiocommunication services complying with Recommendation 358 (or, with Article 28 of the Radio Regulations for 1525-2500 MHz bands) do not cause unacceptable interference into trans-horizon systems. It should be taken into account that the space stations may be in geostationary or non-geostationary satellite orbits.

Note 3 – Further study is required concerning frequency sharing between trans-horizon radio-relay systems and receiving earth stations in the broadcasting-satellite service.

Note 4 – It should be also confirmed that the interferences into trans-horizon radio-relay systems caused by line-of-sight radio-relay systems are within acceptable limits.

RECOMMENDATION 388

RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR TRANS-HORIZON RADIO-RELAY SYSTEMS

(Question 7/9)

(1959–1963)

The CCIR,

CONSIDERING

(a) that trans-horizon radio-relay systems are already in service and that systems of this type will come into more extensive use in the future;

(b) that the high radiated power of trans-horizon radio-relay systems and the long range of tropospheric-scatter propagation may give rise to serious interference at distances extending beyond international boundaries, for example, 1000 km;

(c) that interference, both between and within trans-horizon radio-relay systems, could be minimized by the coordination of radio-frequency channel arrangements over a large geographical area;

(d) that many interfering effects between equipment at the same station could be minimized by a carefully planned arrangement of radio frequencies;

(e) that some technical information for the planning of such systems exists, but that the design of trans-horizon radio-relay systems is subject to change;

(f) that different methods of modulation are at present being used or proposed, among them, frequency modulation and single-sideband amplitude modulation;

(g) that, at the present time, standardization of preferred radio-frequency channel arrangements might therefore unduly restrict the future development of trans-horizon radio-relay systems;

(h) that, nevertheless, a common basis for planning such systems is desirable,

UNANIMOUSLY RECOMMENDS

1. that the radio-frequency channel arrangements for the international connection of trans-horizon radio-relay systems should be agreed between the administrations concerned;

2. that the basis of planning of the radio-frequency channel arrangements for radio-relay systems using frequency modulation given in Report 286 (Geneva, 1982) may be used, where appropriate, as a guide.

RECOMMENDATION 302-2

LIMITATION OF INTERFERENCE FROM TRANS-HORIZON RADIO-RELAY SYSTEMS

(Question 7/9)

(1959–1982–1990)

The CCIR,

CONSIDERING

(a) that trans-horizon radio-relay systems can cause interference over long distances which in many cases may extend across national boundaries;

(b) that trans-horizon radio-relay systems can cause interference to all the systems sharing the same frequency bands and particularly to space communication systems;

(c) that trans-horizon systems need some form of diversity to circumvent fading;

(d) that multiple-diversity can be provided without using additional frequencies, e.g. by employing spaced antennas, with or without cross-polarization,

UNANIMOUSLY RECOMMENDS

in planning trans-horizon radio-relay systems:

1. that account be taken of the high degree of international coordination and planning which will be involved if trans-horizon radio-relay systems of this type are to occupy the same frequency bands in nearby countries without mutual interference, and that the problem would become much more complex if, in addition, they were to occupy the same frequency bands as conventional line-of-sight systems or other services;

2. that the utmost economy in frequency should be observed;

3. that frequency-diversity should be avoided as far as possible, particularly in those parts of the world where the frequency spectrum is likely to become congested;

4. that special efforts should be made to operate such radio-relay systems at the lowest practicable level of radiated power, and in particular:

4.1 in the case of a frequency band shared with space radiocommunication services (space-to-Earth), due consideration should be given to interference from the trans-horizon radio-relay system to earth stations on the basis of the coordination area for receiving earth stations detemined in accordance with Recommendation 359;

4.2 for the range of angles for which the e.i.r.p. of the trans-horizon radio-relay systems is less than +40 dBW in a 4 kHz bandwith (see Note 1), careful consideration should be exercised, comparable to that required for coordination between line-of-sight radio-relay systems and earth stations. For the range of angles for which the directional e.i.r.p. of the trans-horizon system exceeds +40 dBW in a 4 kHz bandwith, more careful consideration is required;

5. that special efforts should be made to reduce radiation in, and reception from, undesired directions;

6. that special efforts should be made to reduce spurious emissions to the lowest practicable level.

Note 1 – This value is the maximum allowable e.i.r.p. trasmitted towards the horizon by an earth station sharing the same frequency band with the fixed service (see Article 28, No. 2541 of the Radio Regulations).

ANNEX I

Trans-horizon radio-relay systems have interference-producing capabilities and susceptibilities not unlike those encountered in line-of-sight radio-relay systems. Differences are primarily due to the usually higher transmitting powers, narrower antenna beamwidths and more sensitive receivers encountered in trans-horizon systems. This means that siting considerations are very important with trans-horizon systems.

To minimize interference from a trans-horizon radio-relay system line-of-sight situations are usually avoided, as are areas where the diffracted signal will be strong. Under some circumstances, it may be impossible to avoid occasional interference from signals due to diffraction, strong layer reflection, and especially ducting.

To estimate expected co-channel interference, it is necessary to calculate transmission loss by subtracting the path antenna gain G_p given in Fig. 1 of Report 285 from the estimated basic transmission loss. The interfering field depends on the mean long-term loss and any additional fluctuations. At UHF and higher frequencies, the lowest observed values of extra-diffraction transmission loss are the result of atmospheric focusing and ducting, either over sea or over land.

Field strength may be combined with antenna gain to yield azimuthal distance-interference patterns for various systems and combinations. In considering non-co-channel interference, account must also be taken of transmitter spectrum distribution and receiver passband characteristics. For antenna pattern considerations see Report 614.

Although it is not possible to recommend final channel arrangements, there is a need to select frequencies in an orderly manner on a regional basis. In arriving at such agreements between administrations, the guide-lines in Report 286 (Geneva, 1982) should be observed.

Polarization discrimination is also suggested to aid the use of space-diversity and the rejection of interference.

It has been general practice to engineer tropospheric-scatter systems on the high propagation attenuations exceeded only during small percentages of the time. It should be realized that under more favourable conditions, prevailing for the rest of the time, transmitter powers and antenna gains so justified can cause increased interference fields. It may be advisable under such conditions to reduce the transmitter power temporarily.

SECTION 9F: FREQUENCY SHARING WITH OTHER SERVICES

There are no Recommendations in this Section.

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OPINIONS

OPINION 14-6

PREFERRED RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR RADIO-RELAY LINKS FOR INTERNATIONAL CONNECTIONS

(1959–1963–1970–1974–1978–1982–1986–1990)

The CCIR,

CONSIDERING

(a) that line-of-sight and near line-of-sight radio-relay links have already been established by many countries for international connections and that such networks are expanding;

(b) that some countries may be considering the use of trans-horizon links for international connections;

(c) that the CCIR has recommended preferred radio-frequency channel arrangements for analogue and digital radio-relay links (see Annex I);

(d) that, for radio-frequency interconnection of links in international networks, agreement is necessary on specific radio frequencies as well as on the arrangement of radio channels within a band;

(e) that specific radio frequencies can readily be defined in terms of the centre frequency of the radio-frequency interconnection arrangement;

(f) that, for technical reasons, only certain preferred values of the centre frequency are acceptable in a given frequency band;

(g) that there are various aspects of radio-wave propagation and equipment design that lead to the choice of particular frequency bands for certain capacities and types of radio-relay system;

(h) that radio-relay links used for international connections must meet high standards of performance similar to those recommended by the CCITT for line transmission systems;

(j) that it is essential to avoid interference to radio-relay links used for international connections, either from other radio-relay links or from other radio services (including unwanted emissions), operated in the same or other countries,

IS UNANIMOUSLY OF THE OPINION

that the attention of Administrative Radio Conferences should be drawn to:

1. the technical advantages of international agreement on preferred frequency bands, within which international line-of-sight and trans-horizon radio-relay links may be established, using the radio-frequency channel arrangements recommended by the CCIR;

2. the technical advantages of preferred values for the centre frequencies of bands for line-of-sight and trans-horizon systems being established by international agreement;

3. the risk of interference between line-of-sight and trans-horizon links if these operate in the same frequency band and in the same geographical zone;

4. the need to avoid interference to radio-relay links used for international connections, from other radio services or unwanted emissions caused by them;

ANNEX I

TABLE I – *CCIR Recommendations for preferred radio-frequency channel arrangements for radio-relay systems, used for international connections* *, **

Recommendation	Frequency band (GHz)	Maximum capacity in analogue operation of each radio carrier (telephone channels or the equivalent)	Capacity of each digital channel (1)	Preferred centre frequency (2) f_0 (MHz)
701	1, 2	Various services	Small	1 530 (3) 1 900 (3) 2 100 (3) 2 300 (3) 2 500 (3) 2 690 (3)
283	2	60/120/300/960 (4)	Small, medium	1 808 2 000 2 203 2 586
382	2, 4	600/1800	Medium, high	1 903 2 101 4 003.5 (5)
635	4		Medium, high	4 200 (3)
383	6	600/1800	High	6 175
384	6	1260/2700	High	6 770
385	7	60/120/300		7 575
386	8	300/960 (6)		8 350 (6)
387	11	600/1800	Small, medium, high	11 200
497	13	960	Medium, high	12 996 (3)
636	15		Small, medium, high	11 701 (3)
595	18		Small, medium, high	18 700
637	23	Various services	Small, medium, high	21 196 (3)

* The Recommendations referred to above apply to line-of-sight and near line-of-sight systems. For trans-horizon systems, it has not yet been possible to formulate preferred radio-frequency channel arrangements, but the attention of the Administrative Radio Conference is drawn to Recommendation 388.

** Attention should also be drawn to Recommendation 389.

(1) The definition of the terms "small, medium and high capacity" digital systems is given in Report 378.

(2) Other centre frequencies may be used by agreement between administrations concerned.

(3) Reference frequency.

(4) The 960 channel capacity can only be used with the centre frequency 2586 MHz.

(5) In some countries, mostly in a large part of Region 2 and in certain others areas, a reference frequency f_r = 3700 MHz is used at the lower edge of a band 500 MHz wide (see Annex I to Recommendation 382).

(6) In some countries, a maximum capacity of 1800 telephone channels or the equivalent on each radio-frequency carrier may be used with a preferred centre frequency of 8000 MHz. The width of the radio-frequency band occupied is 500 MHz (see Recommendation 386, § 7 and Annex I).

OPINION 50

COORDINATION OF THE WORK OF THE CCIR AND THE IEC* ON MEASUREMENTS FOR THE ADJUSTMENT AND MAINTENANCE OF RADIO-RELAY SYSTEMS

(1974)

The CCIR,

CONSIDERING

(a) that it is essential to define and unify the measuring methods and the general characteristics of the measuring instruments to be used by administrations for the adjustment and maintenance of radio-relay systems;

(b) that the IEC has been working in this field;

(c) that any duplication of, or inconsistency between, the work of the CCIR and the IEC is to be avoided,

IS UNANIMOUSLY OF THE OPINION

1. that the CCIR should collaborate with the IEC in defining the measurements for the adjustment and maintenance of radio-relay systems and in determining the characteristics of the appropriate measuring instruments;

2. that the Director, CCIR, should keep in close touch with the IEC to prevent unnecessary duplication of work;

3. that the Director, CCIR, should provide the IEC with all relevant CCIR documents and invite the IEC to take account of the views expressed by the CCIR;

4. that, if necessary, the Director, CCIR, should propose a joint meeting of the CCIR and the IEC to settle any problems that cannot be settled by correspondence.

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* IEC: International Electrotechnical Commission.

OPINION 89*

REQUIREMENT OF AN ADDITIONAL INTERFACE RATE TO THE SYNCHRONOUS DIGITAL HIERARCHY

(1990)

The CCIR,

CONSIDERING

(a) that with due regard to limited radio-frequency spectrum resources it is desirable for radio-relay systems to support the synchronous digital hierarchy and to transport a bit rate below the STM-1 level;

(b) that at present the implementation of radio-relay systems with capacities intermediate between 2 Mbit/s and STM-1 level may be economically and technically desirable;

(c) that some countries are implementing** or are considering the implementation of radio-relay systems which support the synchronous digital hierarchy below the STM-1 level,

IS UNANIMOUSLY OF THE OPINION

that the CCITT be invited to consider the feasibility of defining an additional synchronous interface rate to the synchronous digital hierarchy below the STM-1 level.

Note – See Report 1190.

* The text of this Opinion should be brought to the attention of Study Group 4.

** Administrations who are implementing bit rates below the STM-1 level have submitted input Documents 9/253 and 9/335 and these are attached. The sections referencing below STM-1 level bit rates are highlighted in these documents.

ATTACHMENT 1

Documents
CCIR Study Groups
Period 1986-1990

Document 9/335-E
28 June 1989
Original: English

Received: 23 June 1989

Subject: Questions 36/9, 37/9
New Report

United States of America

DRAFT NEW REPORT

INTERCONNECTION OF DIGITAL RADIO-RELAY SYSTEMS CARRYING THE SYNCHRONOUS HIERARCHICAL BIT RATES

This draft new Report introduces the concept of synchronous hierarchical bit rates and how it may affect interconnection of digital radio relay systems. Interconnection at present is recommended at baseband points *TT'* in Recommendation 596. To be more compatible with the new synchronous network philosophy, interconnection at other points of a radio switch section may be desirable if the new synchronous digital hierarchy is transmitted. In analogy to mid-span compatibility in optical fibres consideration may be given to mid-span (RF) interconnection on radio hops. The problems posed by such a requirement may be quite severe, however. Questions of standardizing modulation formats, protection switching techniques, overhead signalling and error correction bits, etc. would have to be addressed. In comparison the questions of channelization posed by the different synchronous hierarchical bit rates are minor and can be handled by established methods.

The proposed new Report is given in Annex I.

ANNEX I

1. Introduction

In 1988, CCITT adopted a "Synchronous Digital Hierarchy Bit Rate" [CCITT, 1988], known in the United States as "SONET" [Bellcore, 1989]. Some principal features of SONET are optical mid-span compatibility, synchronous multiplexing, extensive error performance monitoring and fault location, standard interfaces for optical switches and DCS, etc.

Since optical fibre systems with the SONET standards are expected to become major transmission networks in the future and many future broadband services and signal formats will be based on SONET standards, it is important to provide for future digital radio compatible with the SONET standards [Bellcore, 1988; Cubbage, 1988].

2. SONET signals

In the United States, the basic byte format of SONET at 51.840 Mbit/s is called the "Synchronous Transport Signal – Level 1" or simply STS-1. In this new hierarchy, all rates are integer multiples of the basic rate (i.e. STS-N = N*STS-1). The higher level signal rates are obtained by synchronously multiplexing (i.e. byte interleaving) lower level signals without additional overhead or stuffing bits. The optical equivalent of the STS-N is the OC-N signal (i.e., Optical Carrier – Level N). The STS-3 level in the United States corresponds to STM-1 (i.e., Synchronous Transport Module-1) in CCITT standards.

3. Impacts of SONET on digital radio systems

The anticipated impacts of SONET on digital radio system design are:

- higher transmission bit rate for a given payload capacity within the same radio channel bandwidth;
- new baseband interfaces; and
- bitrate synchronization.

However, during the transition period, there may be transitional strategies to minimize the system costs.

3.1 *Higher transmission bit rate*

In the United States, current digital radio systems transport multiple 44.736 Mbit/s signals using the DS-3 transport protocol; i.e. the radio system must deliver a properly framed DS-3 signal with reset parity to the receiving end without further alteration. Any transport-specific overhead bits, for radio framing, forward error correction coding (FEC), orderwire, maintenance and operation are carried on top of the DS-3 signals. These radio overhead bits are not standardized nor are they delivered with the DS-3 output.

SONET Compatible Digital Radios (SCDR) will transport STS-1 signals at a bit rate about 16% higher than that of DS-3 (51.840 Mbit/s vs 44.736 Mbit/s). Furthermore, the radio systems may use additional overhead bits for functions such as forward error control (FEC), etc. The higher transmission bit rate of SCDRs will require tighter filtering or a higher number of modulation levels to accommodate the former capacity within the same radio channel. This will increase the sensitivity of the digital radio systems to various impairments such as multipath dispersive fading, radio interferences, thermal noise, timing errors, etc. With present radio technology, 64-QAM in 40 MHz radio channels and higher QAM in 30 MHz channels seem appropriate for STS-3/STM-1 rate of 155.52 Mbit/s.

3.2 *Baseband interface*

In the current DS-3 network, all terminal baseband connections are through DSX-3 cross-connects. In the mature SONET environment, the equipment interconnections will be at the standard SONET rates, such as STS-1 or STS-3/STM-1. However, during the transitional period, SCDR systems may need any or all of the following baseband interface capabilities:

- The standard DS-3 level for compatibility with the existing DS-3 network. (This requires multiplexing of DS-3 into STS-1 and *vice versa*.)
- An electrical form of STS-1.
- The standard optical interface levels, OC-N (N = 1 or 3).

3.3 *Synchronization*

By design, SONET is a synchronous network and SCDRs will be integrated into a network synchronization hierarchy [Bellcore, 1988; ANSI, 1987; Bellcore, 1986].

4. Open issues

The impact of SONET on radio is new and there are many open issues to be investigated and resolved in the future.

4.1 *Standardized overhead bits for maintenance and operation*

The SONET signal contains standardized overhead bits for operation, maintenance, and performance monitoring functions. To minimize the required transmission bit rate on radio, it may be desirable to adopt these standardized SONET overhead bits directly. However, this may increase the complexity and cost of radio repeaters. Furthermore, the SONET overhead bit structure has no provision for FEC whereas modern high capacity digital radio systems include FEC to control background transmission errors.

4.2 *Mid-air compatibility*

A major feature of the SONET optical standard is mid-fibre compatibility of optical systems produced by different manufacturers. By the same philosophy, it might be desirable to specify mid-air compatibility of SCDRs produced by different manufacturers. However, such mid-air compatibility would require standardization of many additional parameters such as the modulation method, filtering arrangements, diversity combining and protection switching methods and associated control algorithms, adaptive equalizers, overhead bit patterns, FEC, adaptive transmitter power control, etc. There are concerns that such detailed specifications and standardization may stifle future innovation.

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ATTACHMENT 2

Documents
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Japan

PROPOSED AMENDMENTS TO REPORT 938

BASEBAND INTERCONNECTION OF DIGITAL RADIO-RELAY SYSTEMS

1. Introduction

Network Node Interface (NNI) for the higher synchronous digital hierarchy has been standardized in CCITT Recommendations G.707, G.708 and G.709. Introduction of digital radio-relay systems compatible with NNI is an urgent concern. This document discusses new NNI-compatible systems and their interface bit rate and proposes amendments to Report 938.

2. NNI-compatible digital radio-relay systems and their interface bit rate

The principal parameters of new NNI-compatible systems in Japan are shown in Table I. The interface bit rate is 51.84 Mbit/s or 155.52 Mbit/s. At present the 51.84 Mbit/s rate, which is one-third of the 155.52 Mbit/s stated in CCITT Recommendation G.707, is mainly employed due to the following considerations:

- a single interface bit rate should be applicable for various modules with the NNI, such as a skip-level multiplexer and a digital cross-connecter. The 155.52 Mbit/s rate is too high for the interface in the present network, which offers mainly telephone services;
- the demand is not yet high for 155.52 Mbit/s broadband service such as for high quality video transmission.
- having an intermediate interface bit rate between 6.312 Mbit/s and 155.52 Mbit/s provides network flexibility;
- present CMOS LSI technology allows construction of a high speed 52 Mbit/s module, but the 155 Mbit/s rate will be difficult to achieve for several years.

3. Conclusion

This document therefore proposes amendments to Report 938 as shown in Annex I.

TABLE I – *Principal parameters of new NNI compatible systems*

System	4-5-6G-300M	4-5-6G-150M
Frequency bands	4, 5, 6 GHz Bands	
Modulation scheme	256 QAM	16 QAM
Interface	51.84 or 155.52 Mbit/s	
Transmission capacity per radio channel	311.04 Mbit/s	155.52 Mbit/s
Number of radio channels	27 + 1	
Number of carriers per radio channel	3 or 6	3

ANNEX I

PROPOSED AMENDMENTS TO REPORT 938

1. *Add* the following after last sentence of the second paragraph in § 1:

"The baseband characteristics for the interconnection between Network Node Interface (NNI) compatible digital radio-relay systems and other NNI systems are given in CCITT Recommendation G.707, G.708 and G.709 (see Note 2)."

2. *Add* the following at the end of § 1:

"*Note 2* – The digital bit rates at the interface points are 155.52 Mbit/s and 622.08 Mbit/s as stated in the CCITT. However, since the demand for the total capacity of the 155.52 Mbit/s service is not yet high, the digital bit rate at the interface points can be one-third of the 155.52 Mbit/s. That is, the interface bit rate of 51.84 Mbit/s is appended to the NNI interface bit rates series."

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