INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

C.C.I.R.

DOCUMENTS OF THE

XIth PLENARY ASSEMBLY

OSLO, 1966

VOLUME IV

RADIO-RELAY SYSTEMS
SPACE SYSTEMS
RADIOASTRONOMY

PART 1 : RADIO-RELAY SYSTEMS

Published by the
INTERNATIONAL TELECOMMUNICATION UNION
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ADDENDUM No. 1

to
VOLUME IV OF THE DOCUMENTS
OF THE XIth PLENARY ASSEMBLY OF THE C.C.I.R.
Oslo, 1966

Note by the Director, C.C.I.R.

1. During the Interim Meetings of the Study Groups IV (Space systems and radioastronomy) and IX (Radio-relay systems), Geneva, 1968, it was decided that, owing to the urgency of commencing study of the problems contained therein, certain new Questions and Study Programmes should be submitted for adoption by correspondence, in accordance with Article 14, § 2(1) of the International Telecommunication Convention, Montreux, 1965.

Each of these texts has received more than the twenty approvals necessary for their adoption from the Members and Associate Members of the I.T.U. and they have, in consequence, now become official Questions and Study Programmes of the C.C.I.R. (see Administrative Circulars A.C./128 of 18 December, 1968 (Study Group IV) and A.C./129 of 15 January, 1969 (Study Group IX)).

These texts are:

— *Questions 16/IX and 17/IX*, which are reproduced on separate sheets numbered 178*a* and 178*b*;
— *Question 19/IV*, which is reproduced on separate sheets numbered 580*b* and 580*c*;
— *Study Programme 3B/IX*, which is reproduced on a separate sheet numbered 165*a*;
— *Study Programmes 2H/IV, 2J/IV, 18A/IV, 19A/IV*, which are reproduced on separate sheets numbered 567*b* to 567*d* and 580*b*, 580*d* and 580*e*.

2. Two new texts concerning communication-satellite systems have been submitted by Administrations, for approval by correspondence, in accordance with Article 14, § 2(1) of the International Telecommunication Convention, Montreux, 1965.
These texts, having received more than the statutory minimum of twenty affirmative replies, have, in consequence, become an official Question and a Study Programme of the C.C.I.R. (see Administrative Circulars A.C./112 of 10 January, 1968 and A.C./114 of 9 April, 1968).

These texts are:

— *Question 18/IV*, which is reproduced on a separate sheet numbered 580*a*;
— *Study Programme 2G/IV*, which is reproduced on separate sheets numbered 567*a* and 567*b*.

3. Advantage has been taken of the issue of this Addendum to notify the following corrections to Volume IV:

Part 1

Page 96. In line 2 of " recommends ", replace " * " by " ** ".

Part 2

Page 234. In title, replace " Report 205-I " by " Report 205-1 ".

Page 280. In line 5 of § 4.2, replace " 30 dB " by " 300 dB ".

Page 295. In legend to Fig. 6, replace " C " by " S ".

Page 410. In line 2 of § 6.2, replace " space service " by " communication-satellite service ".

Page 423. Replace the legend to Fig. 2 by:

" $E = 32 - 25 \log_{10} \varphi$
Holmdal
Goonhilly
Raisting
Goldstone
Mill Village
Goonhilly (modified)
Andover
West Ford "

Page 425. Fig. 4, intervals on x-axis are incorrectly spaced.

Page 430. In Fig. 1, on abscissae, delete " Thickness of water layer (in.) ".

Page 431. In Fig. 2, on abscissae, delete " Thickness of water layer (in.) ".

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DISTRIBUTION OF THE TEXTS OF THE XIth PLENARY ASSEMBLY OF THE C.C.I.R. AMONG VOLUMES I-VI

— Volumes I to VI of the documents of the XIth Plenary Assembly contain all the C.C.I.R. texts at present in force.

— For Questions and Study Programmes, the final (Roman) numeral indicates the Study Group to which the text has been assigned. The plan on page 6 shows the Volume in which the various texts of that Study Group can be found.

— Recommendations, Reports, Opinions and Resolutions which have been amended by the XIth Plenary Assembly, have retained their original number, followed by the indication 1 (e.g. : Recommendation 326-1), which is not shown in the Table below. Further details on the numbering system appear in Volume VI.

1. Recommendations

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2. Reports

Number	Volume	Number	Volume	Number	Volume
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ARRANGEMENT OF VOLUMES I TO VI OF THE DOCUMENTS OF THE XIth PLENARY ASSEMBLY OF THE C.C.I.R.

(Oslo, 1966)

VOLUME I	Emission. Reception. Vocabulary (Sections A, B, K and Study Groups I, II and XIV).
VOLUME II	Propagation (Section G and Study Groups V and VI).
VOLUME III	Fixed and mobile services. Standard-frequencies and time-signals. International monitoring (Sections C, D, H and J and Study Groups III, XIII, VII and VIII).
VOLUME IV	Radio-relay systems. Space systems and Radioastronomy (Sections F and L and Study Groups IX and IV).
VOLUME V	Sound broadcasting and Television (Section E, Study Groups X, XI and XII and the CMTT).
VOLUME VI	List of participants. Minutes of the Plenary Meetings. Resolutions of a general nature. Reports to the Plenary Assembly. List of documents in numerical order.

Note 1. — To facilitate references, the pagination in the English and French texts is the same.

Note 2. — At the beginning of Volume VI will be found information concerning the XIth Plenary Assembly of the C.C.I.R. and the participation at this meeting, on the presentation of texts (definitions, origins, numbering, complete lists, etc.), together with general information on the organization of the C.C.I.R.

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QUESTIONS AND STUDY PROGRAMMES ASSIGNED TO STUDY GROUP IX (RADIO-RELAY SYSTEMS) : OPINIONS AND RESOLUTIONS OF INTEREST TO THIS STUDY GROUP

The following texts, which are not contained in this Volume, also concern radio-relay systems :

Text	Title	Volume
Reports 241-1, 242	Propagation data required for radio-relay systems	II
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L. 3—Direct broadcasting from satellites

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QUESTIONS AND STUDY PROGRAMMES ASSIGNED TO STUDY GROUP IV (SPACE SYSTEMS AND RADIOASTRONOMY); OPINIONS AND RESOLUTIONS OF INTEREST TO THIS STUDY GROUP

The following texts, which are not contained in this Volume, also concern space systems and radioastronomy :

Text	Title	Volume
Study Programme 5D/V	Tropospheric propagation factors affecting the sharing of the radio-frequency spectrum between radio-relay systems, including space and terrestrial telecommunications systems	II
Resolution 2	Tropospheric propagation data for broadcasting, space and point-to-point communications	II
Study Programme 5C/V	Tropospheric absorption and refraction in relation to space telecommunication systems	II
Report 263-1	Factors affecting propagation in communications with spacecraft	II
Study Programme 20A/VI	Characteristics of the ionosphere affecting space telecommunication systems	II
Question 7/VI	Effects of radio noise in space on communications with spacecraft	II
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RECOMMENDATIONS OF SECTION F (RADIO-RELAY SYSTEMS)

F. 1 : Interconnection

RECOMMENDATION 268 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Interconnection at audio frequencies

(Question 1/IX)

The C.C.I.R., (1956 — 1959)

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 or with other radio-relay or line systems, may at times have to be made at audio frequencies ;

(c) that general conformity with the relevant C.C.I.T.T. Recommendations, in respect of overall performance measured between audio-frequency terminals, is already covered by Recommendation 335-1 relating to systems operating above about 30 MHz ;

(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, frequency-division multiplex radio-relay systems forming part of an international circuit should conform with the relevant C.C.I.T.T. Recommendations for modern types of telephone circuit in the following respects :

1. the method of making international connections at audio frequencies ;

2. the characteristics of the frequency-division multiplex terminal equipment ;

3. the method of signalling over international circuits.

RECOMMENDATION 270

RADIO-RELAY SYSTEMS FOR TELEVISION

Interconnection at video signal frequencies

(Question 3/IX)

The C.C.I.R., (1959)

CONSIDERING

(a) that radio-relay systems for television may form part of an international circuit ;

* This Recommendation replaces Recommendation 188.

(b) that international connections 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 421-1, § 2 ; in particular the following characteristics are preferred :

1. nominal impedance at the point of interconnection : 75 Ω unbalanced (see Note 1) ;
2. amplitude of the video signal at input and output : 1 V peak-to-peak (see Note 2) ;
3. the nominal upper limit of the video-frequency band for different television systems should also conform with those quoted in Recommendation 421-1, as shown in the following table :

Number of lines	405	525	625	625	819	819
Nominal upper limit of the video-frequency band (MHz)	3	4	5	6	5	10

Note 1. — Details of the acceptable values of return loss are given in § 2.1 of Recommendation 421-1.

Note 2. — 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.

RECOMMENDATION 297 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION MULTIPLEX

Interconnection at audio frequencies

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that time-division multiplex radio-relay systems 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, general conformity with the relevant C.C.I.T.T. Recommendations in respect of overall performance measured between audio-frequency terminals, is already covered by Recommendation 335-1 relating to systems operating above about 30 MHz ;

(d) that it will be necessary to signal over telephone circuits provided by means of such systems ;

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* This Recommendation replaces Recommendation 186.

UNANIMOUSLY RECOMMENDS

that as far as is practicable, time-division multiplex radio-relay systems forming part of an international circuit, should conform to the relevant C.C.I.T.T. Recommendations for modern types of telephone circuit in the following respects :

1. the method of making international connections at audio frequencies ;

the method of signalling over international circuits.

RECOMMENDATION 299

RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION MULTIPLEX

Agreement on major characteristics

The C.C.I.R., (1959)

CONSIDERING

(a) that several different types of multi-channel radiotelephone systems using time-division multiplex have been developed ;

(b) that such systems are rarely installed across national boundaries ;

(c) that Recommendations 297 and 298 and Report 134 already cover certain aspects of these systems ;

UNANIMOUSLY RECOMMENDS

1. that in any international connection, the characteristics not covered by the above Recommendations and Report should be the subject of agreement between the Administrations concerned ;
2. that the study of Question 92 should be considered terminated.

RECOMMENDATION 304 *

RADIO-RELAY SYSTEMS FOR TELEPHONY

Interconnection of different systems of multiplexing

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that frequency-division multiplex, in accordance with C.C.I.T.T. Recommendations, is used widely for multi-channel telephony on line and for radio-relay systems, while time-division multiplex is used only for radio-relay systems of limited channel capacity ;

(b) that interconnections between systems employing frequency-division multiplex in accordance with C.C.I.T.T. Recommendations, can readily be made for groups of 12, supergroups of 60 and mastergroups of 300 channels, while interconnections between existing time-division multiplex systems on the one hand and frequency-division multiplex systems on the other must be made channel by channel at audio frequencies, requiring the use of additional equipment at the connection point and having disadvantages from the standpoints of economy, operation and circuit quality ;

---

* This Recommendation replaces Recommendation 183.

(c) that future time-division multiplex systems may combine small blocks of speech channels by frequency-division multiplex before multiplexing these blocks by time-division methods ;

(d) that for level stabilization, etc., some frequency-division multiplex systems transmit pilot signals which it is advantageous to transmit from one switching section to the next and that the extension of such pilot signals over a time-division multiplex system may give rise to appreciable complications ;

(e) that the interconnection of basically different types of multiplex systems would generally add to the problems of maintenance, since circuit techniques, routine measurements and fault-finding procedures would tend to differ ;

UNANIMOUSLY RECOMMENDS

1. that, where for operational reasons all international connections to a radio-relay system must be made at audio frequencies, either a time-division multiplex or a frequency-division multiplex radio-relay system may be employed and that, in such cases, interconnection should be made on a four-wire basis, in accordance with the relevant C.C.I.T.T. rules ;

2. that, where there are no operational reasons for an international connection between a new radio-relay system and an existing radio-relay or line system to be made at audio frequency, the new radio-relay system should preferably use the same form of multiplexing as the system to which it is to be connected, to permit the connection to be made at baseband, intermediate or radio frequency as may be appropriate ;

3. that, where the interconnection of time-division multiplex and frequency-division multiplex systems cannot be avoided, it should be made on a four-wire basis, in accordance with the relevant C.C.I.T.T. rules, either at audio frequencies or, if appropriate, at the baseband frequencies corresponding to the blocks of channels combined by frequency-division methods before time-division multiplexing ;

4. that, in any international connection not covered by the above, frequency-division multiplex is, in general, to be preferred.

RECOMMENDATION 306 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Procedure for the international connection of systems with different characteristics

The C.C.I.R., (1956 — 1959)

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 ;

* This Recommendation replaces Recommendation 204.

(b) that, however, when such interconnection cannot be avoided, special arrangements will have to be made at the junction;

(c) that C.C.I.T.T. Recommendation G.336 (Vol. III), "Interconnection of coaxial systems using different techniques" 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 380-1 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Interconnection at baseband frequencies

(Question 1/IX)

The C.C.I.R., (1956 — 1963 — 1966)

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 the Annex to this Recommendation and Fig. 1;

(d) that the levels of the points T and T', which are the responsibility of C.C.I.T.T., Doc. 175, Geneva, 1963, 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;

3. the return loss at the points of interconnection should be $\geqq$ 24 dB.

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* 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.

** It is recognized that in certain cases and regions it may be desirable to use baseband characteristics other than those given above, by agreement between the Administrations 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 impedence at baseband (Ω)	Relative power level per channel (dBr) (Notes 1, 2)			
				Radio equipment output R (Note 7)	Main repeater station		Radio equipment 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 (1)	−23 −33	−36 −33	−45 (1)
960	60-4028 316-4188	60-4287	75 unbal.	−20 (1)	−23 −33	−36 −33	−45 (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) Alternative levels $R = -23$ dBr and $R' = -42$ dBr can be used when the associated line transmission equipment is wholly of a type for which the C.C.I.T.T. recommends baseband interconnection levels $T = -33$ dBr and $T' = -33$ dBr (Main repeater station equipped with transistors).

(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 C.C.I.T.T. 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 C.C.I.T.T.

Note 3. — For 12-channel systems, either of the basic groups A (12-60 kHz) or B (60-108 kHz) recommended by the C.C.I.T.T. may be accommodated in the band 12-108 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 6-108 kHz. With this first alternative, it is possible to use only the noise measuring channel, situated above the baseband, according to Recommendation 293. A further permissible alternative arrangement uses the frequency range 12-120 kHz. With this second alternative, it is possible to use only a continuity pilot situated below the baseband, according to Recommendation 381-1.

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 provisional limit of $\pm$ 2 dB relative to the nominal value. This tolerance is similar to that accepted by the C.C.I.T.T. for cable systems (see C.C.I.T.T. Recommendation M.45).

The subject of variation with frequency should be studied further. It is also desirable to study the variation of loss as a function of time.

ANNEX

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 channels of radio equipment, conforming to C.C.I.T.T. Recommendation G.423 and the present Recommendation.

At the output point of the radio equipment (point *R*), the following conditions are found in the baseband of the radio-relay system :

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 C.C.I.T.T. and C.C.I.R. Recommendations mentioned above.

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 381-1.

3. Any radio stand-by switching shall be performed on the radio equipment side. 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 the radio equipment, where similar conditions are to be met.

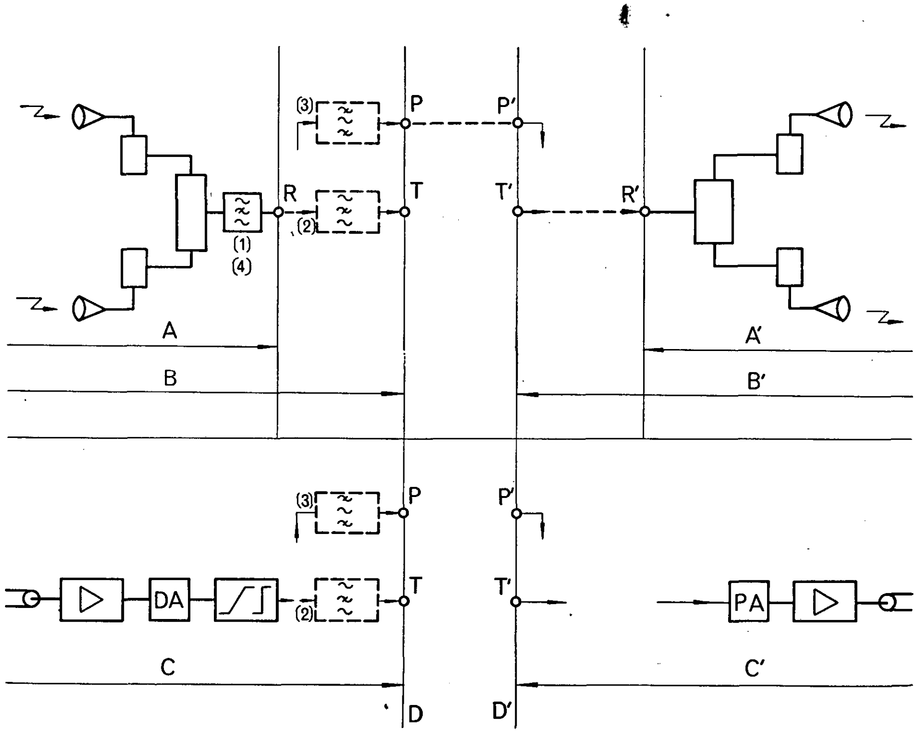

FIGURE 1

A, A′: Radio equipment.

B, B′: Radio system.

C, C′: Cable system.

D, D′: Boundary of the high-frequency line equipment.

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.

RECOMMENDATION 381-1 *

INTERCONNECTION OF RADIO-RELAY AND LINE SYSTEMS

Line regulating and other pilots
Limits for the residues of signals outside the baseband **

The C.C.I.R., (1953 — 1959 — 1963 — 1966)

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) ;

(i) 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 ;

(j) 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 ;

(k) 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 ;

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* 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 380-1.

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 Volume IV of the C.C.I.T.T. ;

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 401-1 * ;

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 $\pm$ 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 C.C.I.T.T. 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, preferably before the input terminals of the radio-relay system (point *T′*), in all cases where this 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 C.C.I.R., 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′*) ;

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* 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 C.C.I.T.T. Recommendation G.243, § A-a (Vol. III); thus the level of the line-regulating pilot, established by the C.C.I.T.T. 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).

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 C.C.I.T.T. for an ordinary telephone channel in the same position in the frequency spectrum, the channel filters are adequate to avoid the risk of crosstalk interference ; if this condition is not met, an additional filter may be necessary and should be provided within the radio equipment ;

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.

Note. — The problems raised by continuity pilots for television transmission should be the subject of a separate study.

F. 2 : Radio-frequency channel arrangements

RECOMMENDATION 279-1

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Radio-frequency channel arrangements for 300 channel systems operating in the 2 and 4 GHz bands *

(Question 1/IX)

The C.C.I.R., (1956 — 1959 — 1966)

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 it is desirable, in such cases, to use a radio-frequency arrangement for systems transmitting 300 channel telephone signals which is compatible with that for systems of 600 channels or more using the same frequency band ;

UNANIMOUSLY RECOMMENDS

1. that, the preferred radio-frequency channel arrangement for up to six go and six return radio-frequency channels, each accommodating 300 telephone channels, is the same as that given in Recommendation 382-1, § 1 ;

2. that where additional radio-frequency channels, each accommodating 300 telephone channels, are required on the same route, up to six additional pairs of channels may be interleaved between the initial channels at channel frequencies which are 14·5 MHz below those of the corresponding initial channel frequencies ;

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

4. that the initial six channels in any one half of the band should have the same polarization ;

5. that the second six channels in any one half of the band should have a polarization which differs from that of the initial six channels in the same half of the band, except by agreement between the Administrations concerned ;

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) ;

in the 4 GHz band, $f_0 = 4003{\cdot}5$ MHz ;

other centre frequencies may be used by agreement between the Administrations concerned**.

Note. — In certain countries, particularly in Region 2, it may be preferable to use a centre frequency :

$f_0 = 1932$ MHz instead of 1903 MHz, and

$f_0 = 2086{\cdot}5$ MHz instead of 2101 MHz.

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

** Interference due to certain harmonics of the shift frequency, which may fall near radio-frequency channel frequencies f_n in radio-frequency repeaters, or may fall near ($f_n \pm 70$) 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 of this Recommendation.

RECOMMENDATION 281 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred radio-frequency channel arrangements for television

(Questions 1/IX and 3/IX)

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that it is sometimes desirable to interconnect radio-relay systems at radio frequencies on international circuits;

(b) that it is desirable to use, as far as possible, the same radio-frequency arrangements for radio-relay systems for television as for the larger capacity multi-channel telephone systems;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency arrangements, for the international interconnection of radio-relay systems transmitting television signals, with any combination, either on the same radio-frequency channel or on different channels, of the following signals—television of 819 lines, television of 625 lines or less, or multi-channel telephony, are the same as those given in Recommendations 382-1 and 383-1. The choice of the particular channels for the television signals should be agreed between the Administrations concerned;

2. that, for the international connection of systems transmitting television signals (of 625 lines or less) only, the preferred radio-frequency arrangements are the same as those given in Recommendations 382-1 and 383-1;

3. that, for the international connection of systems transmitting television signals (of 819 lines only), the preferred radio-frequency channels are 1 and 4 of the frequency arrangements defined in § 1, 2 and 3 of Recommendation 382-1. Alternatively, if further channels are required, radio-frequency channels 3 and 6 of the interleaved radio-frequency channels, defined in § 5 of Recommendation 382-1, may be used by agreement between the Administrations concerned.

RECOMMENDATION 282 **

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Use of special radio-frequency channel arrangements

(Questions 1/IX and 3/IX)

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that interconnection of radio-relay systems at radio frequencies is the most common practice in international connection, and that it is desirable to define the preferred values of the characteristics for such interconnection and in particular the radio-frequency channel arrangement to be used;

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* This Recommendation, which replaces Recommendation 195, applies only to line-of-sight and near line-of-sight radio-relay systems.

** This Recommendation, which replaces Recommendation 192, applies only to line-of-sight and near line-of-sight radio-relay systems.

(b) that, in certain existing circuits, use is made of special frequency arrangements since each Administration is free to use any system of its own choice within its national territory;

(c) that Study Group IX had already indicated preferred values in a draft Report (Docs. 62-Rev. and 69-Rev., Geneva, 1954) and that certain Administrations use, in a 400 MHz band between 3800 and 4200 MHz, equipment operating in accordance with frequency arrangements as given in these documents;

UNANIMOUSLY RECOMMENDS

that international connection of radio-relay systems should preferably be carried out in conformity with Recommendations 279-1, 381-1, 382-1 and 383-1. Nevertheless, when such a course is justified to use an existing design of equipment, and provided that no harmful interference results, international connection involving the equipment and systems referred to in §§ *(b)* and *(c)*, or their possible extension, may be carried out in accordance with the particular characteristics of such installations, after agreement between the Administrations concerned.

RECOMMENDATION 283-1 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Radio-frequency channel arrangements for 60- and 120-channel telephony systems operating in the 2 GHz band

(Question 1/IX)

The C.C.I.R., (1959 — 1966)

CONSIDERING

(a) that it is sometimes desirable to be able to interconnect 60- and 120-channel radio-relay systems on international circuits at 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 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 it is desirable for the values of the mid-frequencies of the radio-frequency channels to be the same for 60- and for 120-channel telephony 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 404-1 for such systems;

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

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to six go and six return channels, each accommodating 60 or 120 telephone channels and operating within the frequency band 1700-2300 MHz, should be as shown in Fig. 1 and should be 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);

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

   lower half of band: $f_n = f_0 - 108{\cdot}5 + 14\,n$,
   upper half of band: $f'_n = f_0 + 10{\cdot}5 + 14\,n$,

   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, all the *return* channels should be in the other half of the band;

3. that, when common transmit-receive antennae 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;

4. 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;

5. that the centre frequencies for 60- and 120-channel telephony systems should preferably be those shown below:

   $f_0 = 1808$ MHz for the band 1700-1900 MHz;
   $f_0 = 2000$ MHz for the band 1900-2100 MHz;
   $f_0 = 2203$ MHz for the band 2100-2300 MHz (see Note 3);

   other centre frequencies may be used by agreement between the Administrations concerned.

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

Note 2. — When operational difficulties may be experienced along a route, due to problems of over-reach and the like, additional frequencies are available for use as stagger frequencies, spaced 3·5 MHz from the allocations given above.

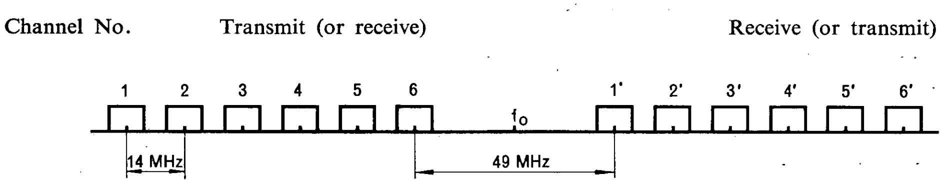

FIGURE 1

Radio-frequency channel arrangement for international connection of radio-relay systems for 60 or 120 channels operating in the 2 GHz band.

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

lower half of band : $f_n = f_0 - 94{\cdot}5 + 14\,n$,
upper half of band : $f'_n = f_0 - \ 3{\cdot}5 + 14\,n$,

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

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

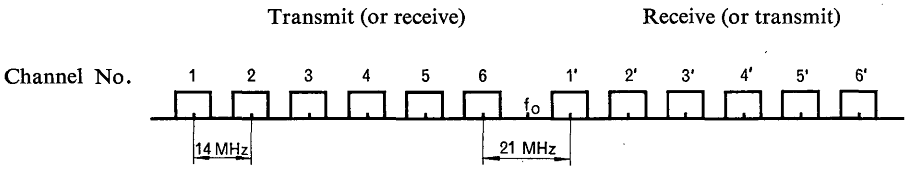

FIGURE 2

Radio-frequency channel arrangement referred to in Note 3.

RECOMMENDATION 382-1 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Radio-frequency channel arrangements for systems for 600 to 1800 telephone channels, or the equivalent, operating in the 2 and 4 GHz bands

(Question 1/IX)

The C.C.I.R., (1956 — 1959 — 1963 — 1966)

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 antennae ;

(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 ;

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

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, 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 :

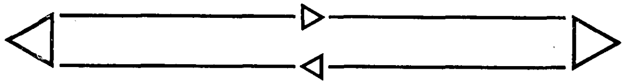
lower half of band : $f_n = f_0 - 208 + 29\,n$,
upper half of band : $f'_n = f_0 + \;\; 5 + 29\,n$,

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 ; 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 :

Channels 1, 3, 5 H(V)
2, 4, 6 V(H)

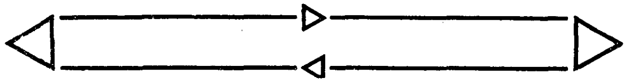


Channels 1′, 3′, 5′ H(V)
2′, 4′, 6′ V(H)

FIGURE 1

Note. — When antennae for double polarization are used, the arrangement of channels shown in Fig. 2 may be used by agreement between Administrations ;

Channels 1, 3, 5 H(V)
2, 4, 6 V(H)



Channels 1′, 3′, 5′ V(H)
2′, 4′, 6′ H(V)

FIGURE 2

4. that, when common transmit-receive antennae 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 ;

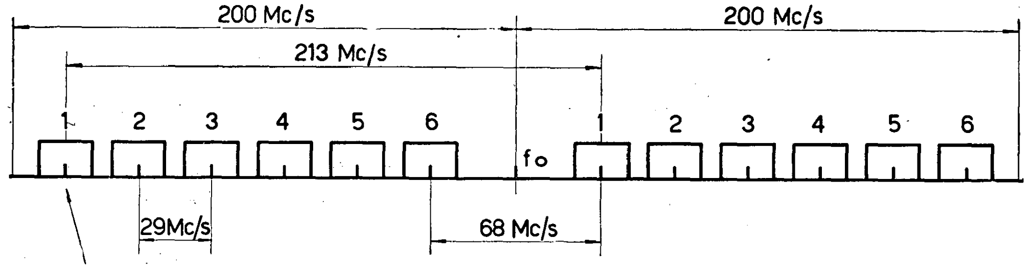


FIGURE 3

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
(All frequencies are in MHz)

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) ;

   in the 4 GHz band, $f_0 = 4003{\cdot}5$ 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 the Annex. Attention is drawn to the problem of interconnection (see Recommendation 282).

Note. — 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

$f_0 = 2086{\cdot}5$ MHz instead of 2101 MHz.

ANNEX

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

* In systems for 1800 telephone channels, or the equivalent, 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 in radio-frequency repeaters, or may fall near ($f_n \pm 70$) 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.

(group 2), each accommodating about 960 telephone channels, or the equivalent, 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) ;

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 ;

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.

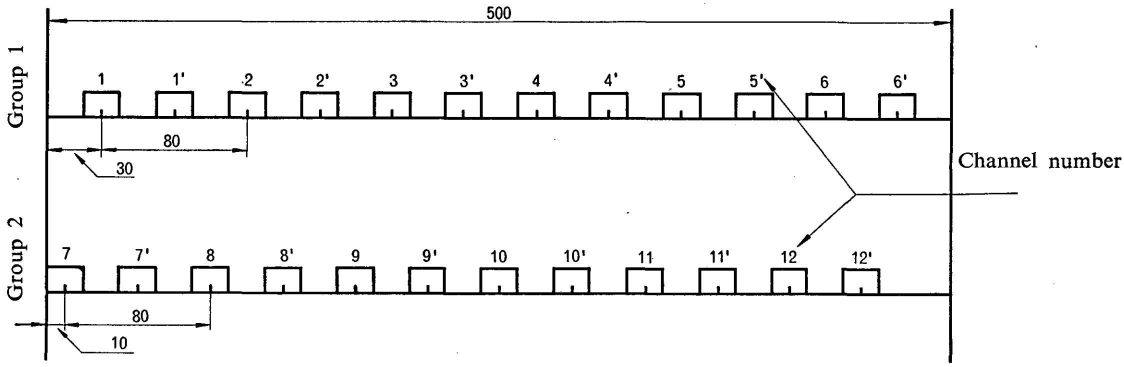


FIGURE 4

Radio-frequency channel arrangement described in the Annex
(All frequencies are in MHz)

RECOMMENDATION 383-1 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Radio-frequency channel arrangements for systems having a capacity of 1800 telephone channels, or the equivalent, operating in the 6 GHz band

(Question 1/IX)

The C.C.I.R., (1959 — 1963 — 1966)

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 antennae ;

(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 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 ;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to eight go and eight return channels, each accommodating 1800 telephone channels, or the equivalent, and operating at frequencies in the 6 GHz band, 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 ;

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

lower half of the band : $f_n = f_0 - 259{\cdot}45 + 29{\cdot}65\ n$,
upper half of the band : $f'_n = f_0 - 7{\cdot}41 + 29{\cdot}65\ n$,

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 ;

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

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 antennae 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 14·825 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;

6. that up to 16 go and 16 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 403-1). 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. — When common transmit-receive antennae 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 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, or the equivalent, on that route.

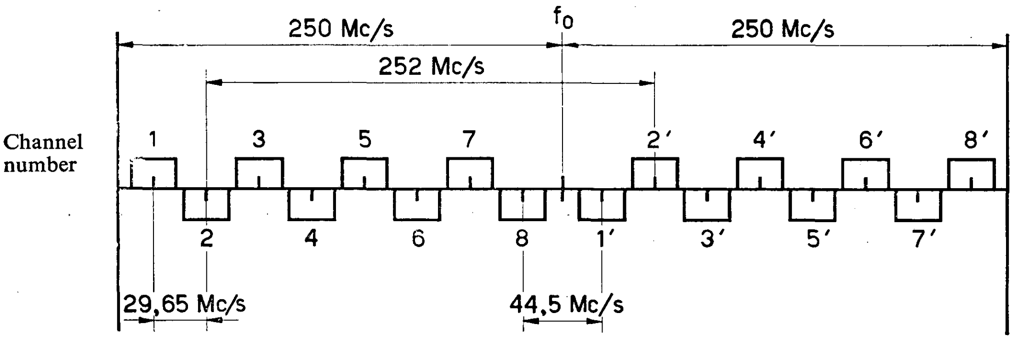


FIGURE 1

Radio-frequency channel arrangement for radio-relay systems operating in the 6 GHz band, for use in international connections (the frequencies shown are approximate)
(All frequencies are in MHz) .

RECOMMENDATION 384-1 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Radio-frequency channel arrangements for systems with a capacity of either 2700 telephone channels or 960 telephone channels, or the equivalent, operating in the 6 GHz band

(Study Programme 1A/IX)

The C.C.I.R., (1963 — 1966)

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 exercized 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 antennae ;

(e) that a common radio-frequency channel arrangement for both 960 and 2700 telephone channel radio-relay systems offers considerable advantages ;

(f) 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.

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

(g) that the radio-frequency channels should be so arranged that an intermediate frequency of 70 MHz may be used for 960-channel systems ;

(h) that the radio-frequency channels should be so arranged that an intermediate frequency of either 100 MHz or 140 MHz may be employed for 2700-channel systems, as outlined in Report 287 ;

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 the equivalent, and operating at frequencies in the 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 ;

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 antennae 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 ;

5. that the preferred arrangement of radio-frequency polarization should be one of those shown in Fig. 1, depending upon whether antennae for single or double polarization are used ;

6. that the preferred radio-frequency channel arrangement for up to 16 go and 16 return channels, each accommodating 960 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 $N = 1, 2, 3, \ldots 15, 16$;

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 antennae 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 shown in Fig. 2 ;

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 960-channel capacity and of 2700-channel capacity may be used on intersecting routes, as long as adequate antenna discrimination is provided.

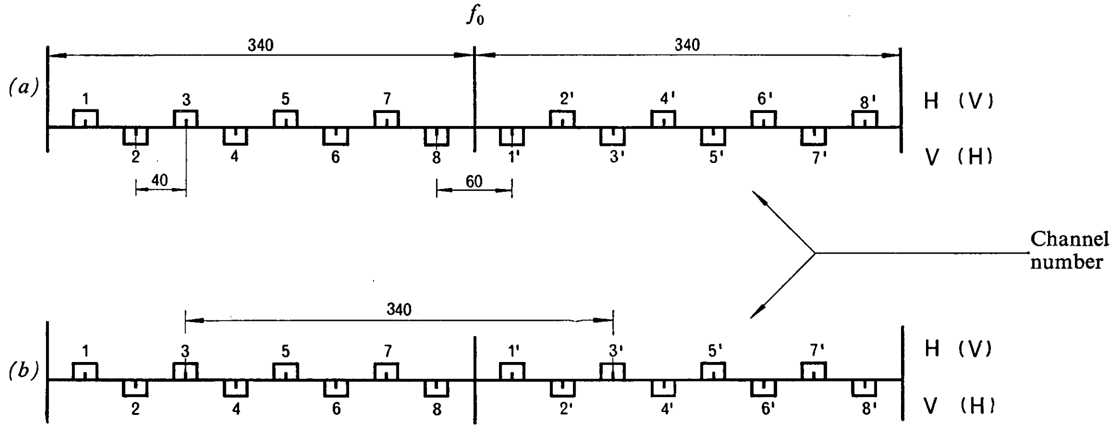

FIGURE 1

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

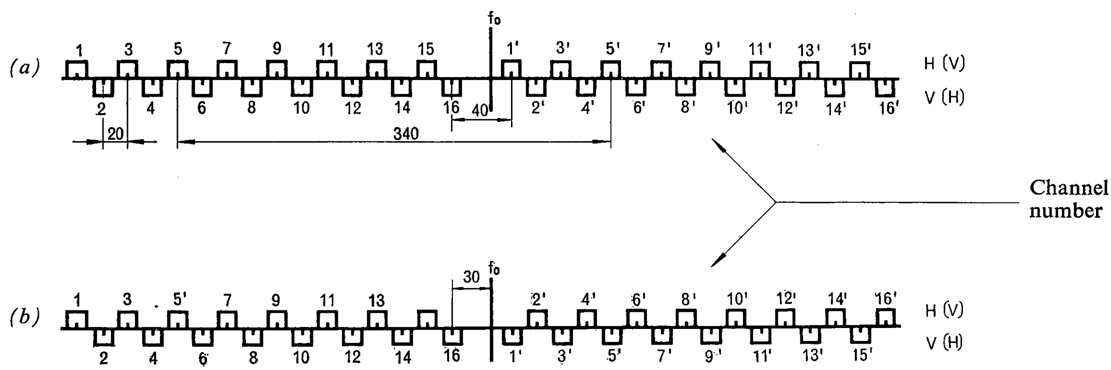

FIGURE 2

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

RECOMMENDATION 385 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Radio-frequency channel arrangements for 60-, 120- and 300-channel telephony systems operating in the 7 GHz band

(Question 1/IX)

The C.C.I.R., (1959 — 1963)

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 404-1 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 band: $f_n = f_0 - 154 + 7\,n$ (Note 1),
upper half of band: $f'_n = f_0 + 7 + 7\,n$ (Note 1),

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

* This Recommendation, which replaces Recommendation 284, 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 other half of the band;

3. that, when common transmit-receive antennae 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 7425–7725 MHz (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 (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 given above differ from those given in Recommendation 284, Los Angeles, 1959. This change, which is purely formal, has been made so that the "centre frequency" f_0 falls, in reality, in the centre of the band of frequencies occupied. No change in the individual channel frequencies will result from this modification.

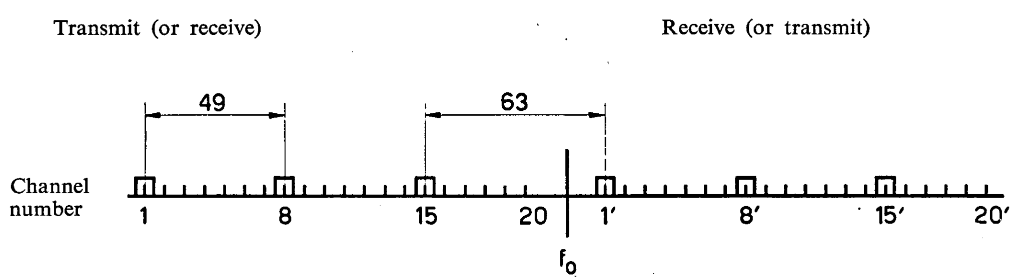

FIGURE 1

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)

RECOMMENDATION 386-1

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Radio-frequency channel arrangements for systems with a capacity of 960 telephone channels, or the equivalent, operating in the 8 GHz band

(Question 1/IX)

The C.C.I.R., (1963 — 1966)

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 antennae;

(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 band: $f_n = f_0 - 151{\cdot}614 + 11{\cdot}662\, n$,
upper half of band: $f'_n = f_0 + 11{\cdot}662\, n$,

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 alternatively;

4. that, when common transmit-receive antennae 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 } in both halves of the band;
$n = 3$, 7 and 11

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 } in both halves of the band;
$n = 3$, 7 and 11 or
$n = 4$, 8 and 12

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 the Annex.

Note. — 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.

ANNEX

DESCRIPTION OF THE RADIO-FREQUENCY CHANNEL ARRANGEMENT REFERRED TO IN § 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 band: $f_n = f_0 - 281{\cdot}95 + 29{\cdot}65\, n$,

upper half of band: $f'_n = f_0 + 29{\cdot}37 + 29{\cdot}65\, n$,

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:

$f_0 = 8$ GHz.

This value corresponds to the band 7725–7975 MHz in the lower half and 8025–8275 MHz in the upper half, thereby leaving 7975–8025 MHz for the communication-satellite service.

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 403-1). 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 386-1 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.

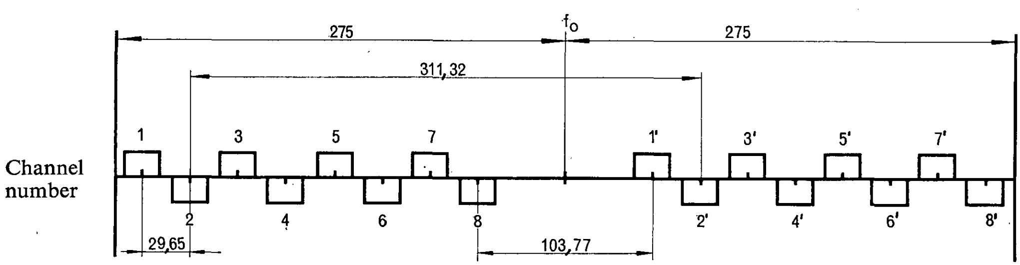

FIGURE 1

Radio-frequency channel arrangement, described in the Annex
(All frequencies are in MHz)

RECOMMENDATION 387

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Radio-frequency channel arrangements for systems with a capacity of 960 telephone channels, or the equivalent, operating in the 11 GHz band

(Question 1/IX)

The C.C.I.R., (1963)

CONSIDERING

(a) that at 11 GHz, radio-relay systems with a capacity of up to 960 telephone channels or television, seem to be feasible in many regions of the world where rainfall conditions permit, and if the repeater spacing is planned with regard to the specific climatic conditions of a country ;

(b) that it is desirable to interconnect such systems at radio-frequencies on international circuits ;

(c) that a uniform radio-frequency channel arrangement for both smaller and larger capacities offers considerable advantages ;

(d) that, in a frequency band 1000 MHz wide, it may be desirable to interconnect up to twelve go and twelve return channels ;

(e) that economy may be achieved if at least three go- and three return-channels can be accommodated on a common antenna ;

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

(g) that the channels should be so arranged as to enable an intermediate frequency of 70 MHz to be used ;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for radio-relay systems with a maximum capacity of 960 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.

The frequency arrangement is illustrated in Fig. 1 ;

2. 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 20 MHz below those of the corresponding main channel frequencies ;

Note. — 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.

3. that, when radio-frequency channels are also required for auxiliary radio-relay systems, the preferred frequencies for 11 go- and 11 return-channels, including two pairs of auxiliary channels in both the main and interleaved patterns should be derived by making:

   $n = 2, 3, 4 \ldots 12$ in the lower half of the band,
   $n = 1, 2, 3 \ldots 11$ 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;

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;

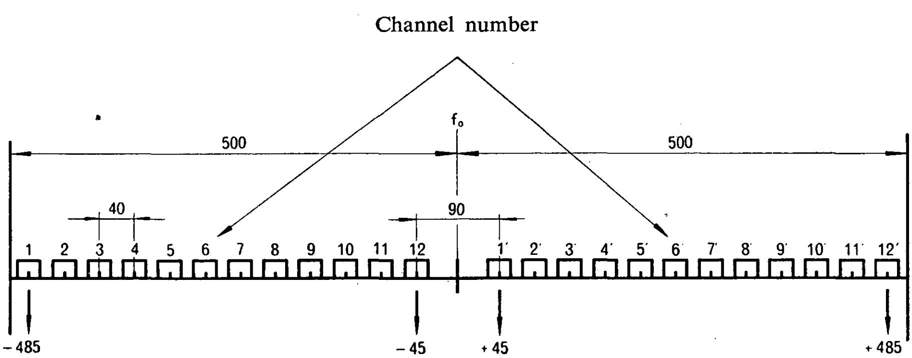

FIGURE 1

Radio-frequency channel arrangement for radio-relay systems operating in the 11 GHz band (Main pattern)
(All frequencies in MHz)

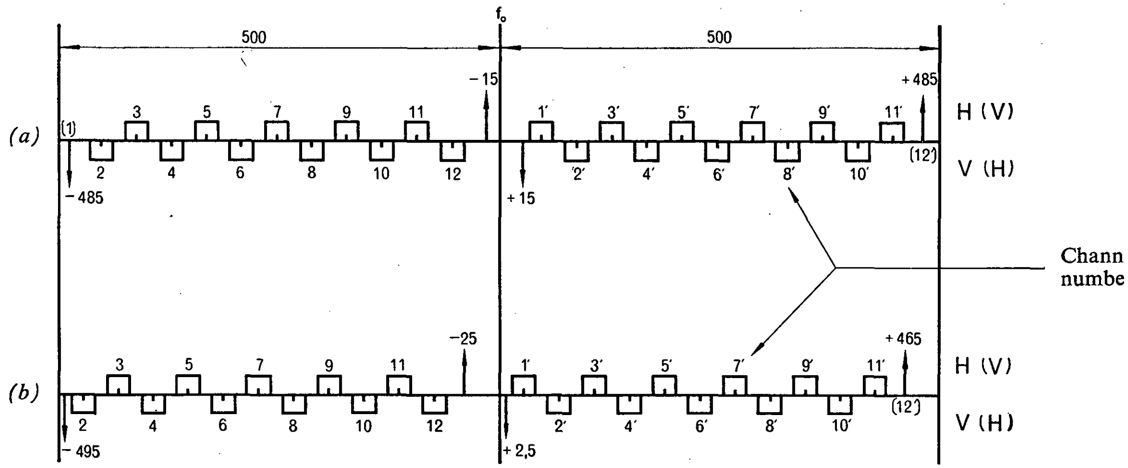

FIGURE 2

Radio-frequency channel arrangement for main and auxiliary radio-relay systems operating in the 11 GHz band
(All frequencies are in MHz)

(a) Main pattern
(b) Interleaved pattern

6. that for adjacent 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.

RECOMMENDATION 388 *

TRANS-HORIZON RADIO-RELAY SYSTEMS

Radio-frequency channel arrangements

(Question 7/IX)

The C.C.I.R., (1959 — 1963)

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 co-ordination of radio-frequency channel arrangements over a large geographical area ;

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* This Recommendation replaces Recommendation 303.

(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 may be used, where appropriate, as a guide.

RECOMMENDATION 389 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred characteristics of auxiliary radio-relay systems operating in the 2, 4, 6 or 11 GHz bands

(Question 4/IX)

The C.C.I.R., (1959 — 1963)

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 382-1, 383-1 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 antennae ;

(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/IX) ;

(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 ;

* This Recommendation replaces Recommendation 296.

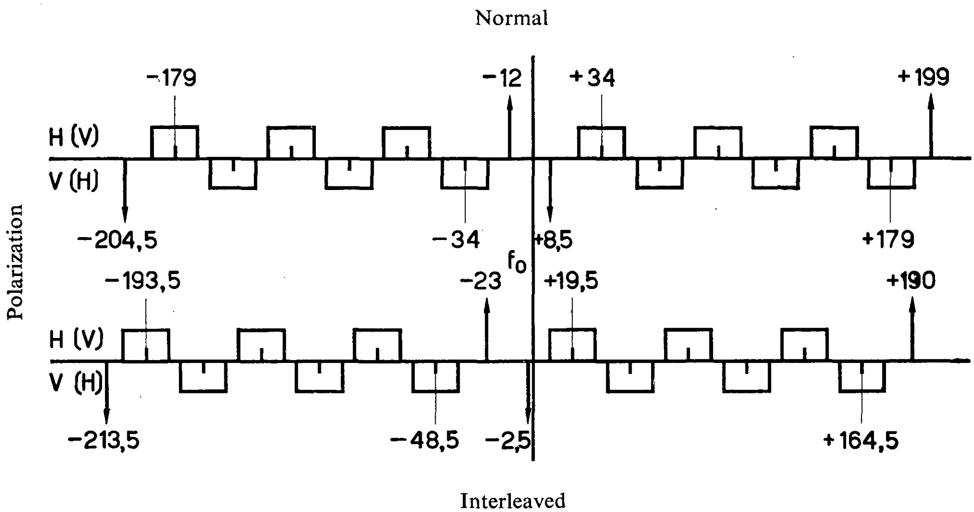

FIGURE 1

Radio-frequency channel arrangement for main and auxiliary radio-relay systems operating in the 2 and 4 GHz bands
(All frequencies are in MHz)

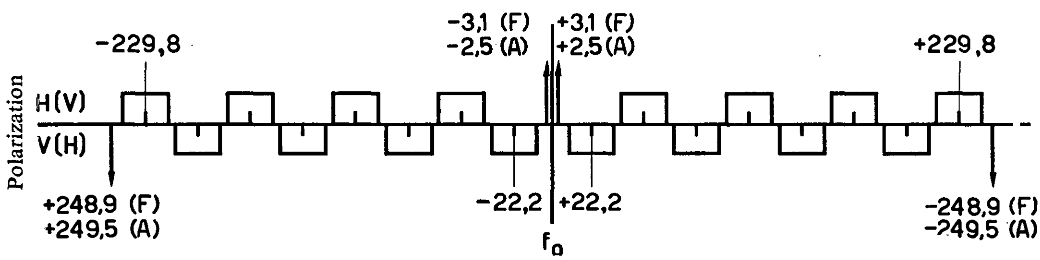

FIGURE 2

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

A : amplitude-modulation

F : frequency-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 400-1;

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 382-1), 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 band: $f_0-204{\cdot}5$ and f_0-12
upper half of band: $f_0+8{\cdot}5$ and f_0+199

Interleaved:

lower half of band: $f_0-213{\cdot}5$ and f_0-23
upper half of band: $f_0-2{\cdot}5$ 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;

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 383-1), 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-modulated systems* * *:*

lower half of band: $f_0-248{\cdot}9$ and $f_0-3{\cdot}1$,
upper half of band: $f_0+3{\cdot}1$ and $f_0+248{\cdot}9$;

2.2 *For amplitude-modulated or frequency-modulated systems* * *:*

lower half of band: $f_0-249{\cdot}5$ and $f_0-2{\cdot}5$,
upper half of band: $f_0+2{\cdot}5$ and $f_0+249{\cdot}5$.

The arrangement of the radio-frequency channels and the preferred polarizations are shown in Fig. 2;

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/IX.

F. 3 : Hypothetical reference circuits and noise

RECOMMENDATION 289

RADIO-RELAY SYSTEMS FOR MONOCHROME TELEVISION

Permissible noise in the hypothetical reference circuit

(Questions 2/IX and 3/IX)

The C.C.I.R., (1959)

CONSIDERING

(a) that the hypothetical reference circuit defined in Recommendation 421-1 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 § 3.3.1 of Recommendation 421-1 (see Note 1 below); 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 421-1;

(g) that the relative distribution with time of noise on 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;

(i) 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;

(j) that in Recommendation 421-1, 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 of the peak-to-peak signal, excluding synchronizing pulses, to the r.m.s. value of continuous random noise read on an instrument having an effective time constant (or integrating time) in terms of power of one second, and using the recommended weighting network (see Note 1), should not fall below values given below in terms of X, where X is the appropriate figure taken from the Table in Note 1 (see also Note 3):

1.1 $(X + 4)$ dB for more than 20% of any month;

1.2 $(X-8)$ dB for more than 0·1% of any month;

these values are provisional;

2. that, in a part of a hypothetical reference circuit consisting of one or two of the three equal homogeneous sections defined by Recommendation 421-1, 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 4);

3. that, in a part of a hypothetical reference circuit consisting of one or two of the three equal homogeneous sections defined by Recommendation 421-1, the small percentages of a month, during which the signal-to-noise ratio may fall below the values indicated in § 1.2 above, shall be regarded as proportional to the number of homogeneous sections involved (see Note 5).

Note 1. — The numerical values of X should be those given in Recommendation 421-1 from which the following extracts are taken:

"The signal-to-noise ratio for continuous random noise is defined as the ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal (see Fig. 2) to the r.m.s. amplitude of the noise within the range between 10 kHz and the nominal upper limit of the video frequency band, f_c. The purpose of the lower frequency limit is to enable power supply hum and microphonic noise to be excluded from practical measurements.

For the hypothetical reference circuit, the signal-to-noise ratio should not be less than the values given in Table I when measured with the appropriate low-pass filter described in Annex II, the appropriate weighting network described in Annex III, and an instrument having "effective time constant" or "integrating time" in terms of power, of 1 s (0·4 s in the U.S.A. and Canada)";

TABLE I

System (See Report 308-1)	*M* (Canada and USA)	*M* (Japan) monochrome and colour	*B, C, G, H*	*D, K, L*	*F*	*E*
Number of lines	525	525	625	625	819	819
Nominal upper limit of video frequency band f_c (MHz)	4	4	5	6	5	10
Signal-to-weighted-noise ratio X (db)	56	52	52	57	52	50

Note 2. — The Recommendation relates only to "line-of-sight" radio-relay systems with adequate clearance over intervening terrain.

Note 3. — Based on the information supplied by the joint C.C.I.T.T./C.C.I.R. Working Party on circuit noise obtained from measurements, with a time constant of one minute of the total noise (thermal noise and crosstalk) 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 at the most will differ by about 12 dB; 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 values $(X+4)$ dB and $(X-8)$ dB shown in § 1, these values being such, that the signal-to-noise ratio obtained during at least 99% of one month must be equal to X dB, as the television specialists desire.

As mentioned in § 1 above, 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 4. — The law of proportionality given in § 2, is based on the assumption that noise due to fading can be neglected for all but 20% of a month, and that the noise exceeded for 20% of a month corresponds to the mean noise in the absence of fading.

Note 5. — The law of proportionality given in § 3, is based on the assumption that individual fades which :

— are of such magnitude that they occur for only very small percentages of time,
— 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 6. — This Recommendation relates to the hypothetical reference circuit. The figures given are design objectives, but it is not intended that they should be quoted in specifications of equipment or used for acceptance tests.

RECOMMENDATION 300 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION MULTIPLEX

Hypothetical reference circuit for radio-relay systems with a capacity of 60 telephone channels or less

(Question 2/IX)

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that it is desired to define 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 time-division multiplex radio-relay systems may form a part of an international circuit ;

(c) that hypothetical reference circuits for radio-relay systems should, as far as possible, be in agreement with the hypothetical reference circuits specified by the C.C.I.T.T. for cable systems ;

UNANIMOUSLY RECOMMENDS

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

2. that this reference circuit should be constituted by six sections of equal length with voice-channel modulation and demodulation at each terminal of a section.

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* This Recommendation, which together with Recommendation 394 replaces Recommendation 201, applies only to line-of-sight and near line-of-sight radio-relay systems.

RECOMMENDATION 302

TRANS-HORIZON RADIO-RELAY SYSTEMS

Limitation of interference

(Question 196)

The C.C.I.R., (1959)

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 line-of-sight systems are far less likely to cause international interference ;

(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 antennae, 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 co-ordination 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 ;

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.

RECOMMENDATION 390

DEFINITIONS OF HYPOTHETICAL REFERENCE CIRCUITS

(Question 2/IX)

The C.C.I.R. (1963)

UNANIMOUSLY RECOMMENDS

that the following definitions be used for defining the nature and properties of hypothetical reference circuits.

1. Hypothetical reference circuit

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

It is a necessary element in the study of certain characteristics of long-distance circuits (e.g., noise).

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

2. Hypothetical reference circuit for telephony

This is 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.

Various "hypothetical reference circ uits for telephony" have been defined 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 C.C.I.T.T. standards (see §§ 5.2, 5.3, 5.4, 5.7).

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.

Moreover, 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.

3. Homogeneous section (for telephony)

This is 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.

All hypothetical reference circuits are built up from homogeneous sections of equal length (six or nine sections ** as the case may be).

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.

4. Other definitions

Using the same principles, other hypothetical reference circuits and homogeneous sections have been determined for other types of signal; television, programme circuits, etc. (see §§ 5.5, 5.6, 5.7).

5. References

5.1 *General definition* — C.C.I.T.T. Recommendation G.212, Vol. III.

5.2 *Hypothetical reference circuit for telephony* — C.C.I.T.T. Recommendation G.212, Vol. III;

— on symmetrical cable pairs — C.C.I.T.T. Recommendation G.321, Vol. III, § A. *a*,

— on coaxial cables (4 MHz systems) — C.C.I.T.T. Recommendation G.332, Vol. III, § *d*,

— on coaxial cables (12 MHz systems) — C.C.I.T.T. Recommendation G. 333, Vol. III, § *d*,

— on open-wire lines — C.C.I.T.T. Recommendation G.311, Vol. III, § *g*.

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* Except for the hypothetical reference circuit for radio-relay systems using time-division multiplex, which contain six pairs of channel modulators.

** The number is not specified for trans-horizon systems.

5.3 *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) — C.C.I.R. Recommendation 391,

— using frequency-division multiplex (for more than 60 telephone channels) — C.C.I.R. Recommendation 392,

— using time-division multiplex with a capacity of 60 telephone channels or less — C.C.I.R. Recommendation 300.

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

— using frequency-division multiplex — C.C.I.R. Recommendation 396-1.

5.5 *Hypothetical reference for television* — C.C.I.R. Recommendation 421-1, § 1.2.

5.6 *Hypothetical reference circuit for programme circuits* — C.C.I.T.T. Recommendation J.21, Vol. III.

5.7 *Hypothetical reference circuit for satellite systems* — C.C.I.R. Recommendation 352.

RECOMMENDATION 391 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Hypothetical reference circuit for radio-relay systems with a capacity of 12 to 60 telephone channels

(Question 2/IX)

The C.C.I.R., (1956 — 1959 — 1963)

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 C.C.I.T.T. 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 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.

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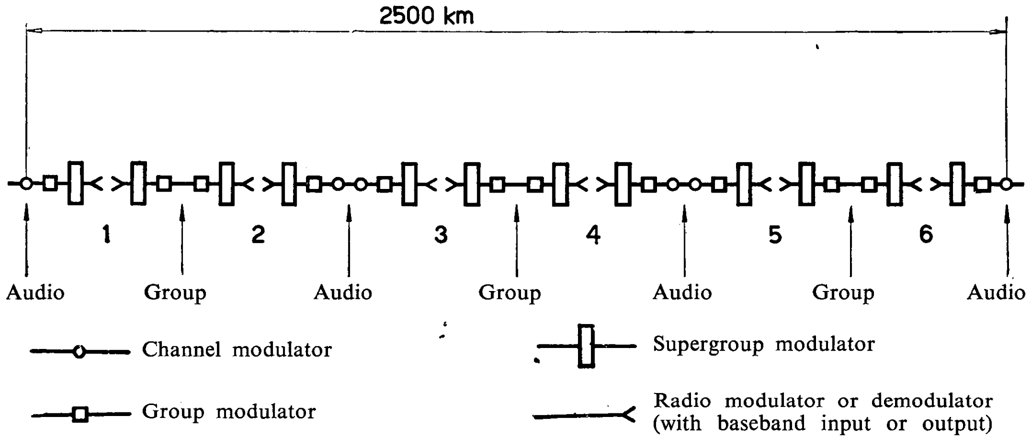
* This Recommendation, which replaces Recommendation 285, applies only to line-of-sight and near line-of-sight radio-relay systems.



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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RECOMMENDATION 392 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Hypothetical reference circuit for radio-relay systems with a capacity of more than 60 telephone channels

(Question 2/IX)

The C.C.I.R., (1956 — 1959 — 1963)

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 C.C.I.T.T. 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.

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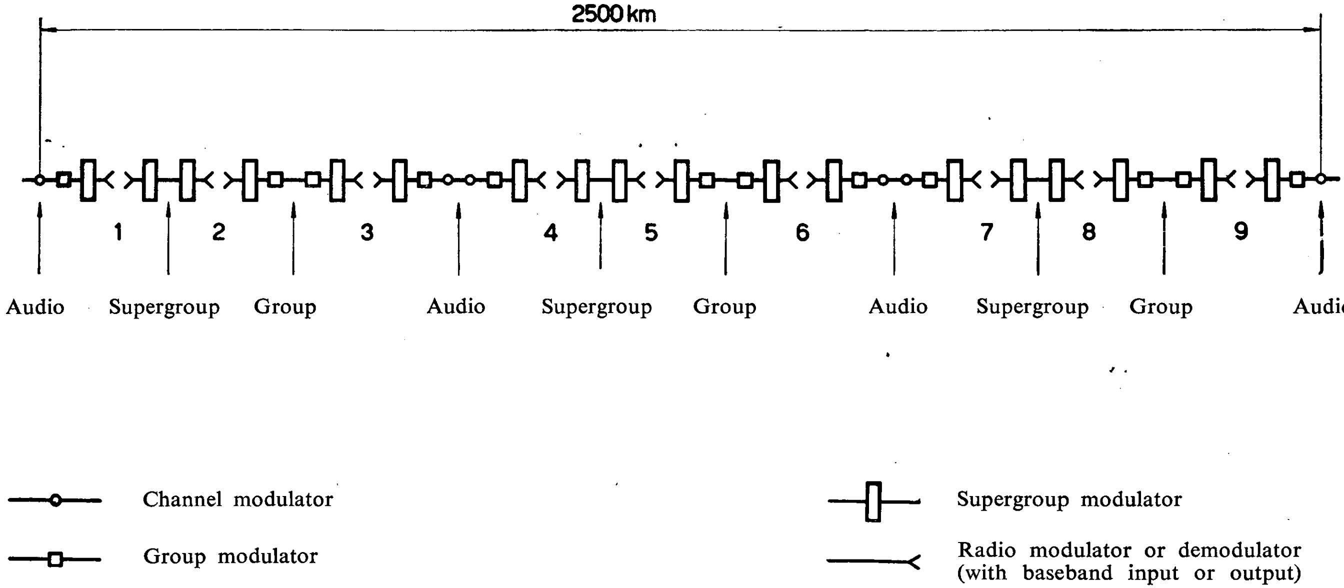
* This Recommendation, which replaces Recommendation 286, applies only to line-of-sight and near line-of-sight radio-relay systems.



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 393-1

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Allowable noise power in the hypothetical reference circuit

(Question 2/IX)

The C.C.I.R., (1956 — 1959 — 1963 — 1966)

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, in the opinion of the C.C.I.R., based on evidence so far available from the C.C.I.T.T., the typical distributions of one-minute-mean noise power in any month (given in the Annex) would not seriously affect telephone conversations ;

(e) that, if the condition given in Notes 3 and 4 of this Recommendation were met, it is unlikely that there would be large numbers of noise surges either of long or of short duration and therefore interference to telephone signalling due to such noises could be neglected ;

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 provisional values given below, which have been chosen to take account of fading :

1.1 7500 pW psophometrically weighted * mean power in any hour ** ;

1.2 7500 pW psophometrically weighted * one-minute mean power *** for more than 20% of any month ;

1.3 47 500 pW psophometrically weighted * one-minute mean power for more than 0·1% of any month ;

1.4 1 000 000 pW unweighted (with an integrating time of 5 ms) for more than 0·01% of any month ;

* 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.

** This clause, which does not give any statistical distribution in time, is well suited to cable systems, but it presents difficulties when applied to radio-relay systems. For this reason, a number of Administrations have taken no account of this clause in the design of radio-relay systems so far. Accordingly, its interpretation and practical application to radio-relay systems are under study. The hours when the noise is greatest are usually those in which the fading is most severe. These hours will sometimes be different from the busy hours.

*** The one-minute mean power was chosen by C.C.I.T.T. Study Group XII which is responsible for all studies concerned with the quality of telephone transmission (C.C.I.T.T. Red Book, 1957, Vol. I, pp. 110 and 662).

2. that in a part of the hypothetical reference circuit consisting of one or more of the equal homogeneous sections defined in Recommendations 391 and 392, the mean noise power in any hour * and the one-minute mean noise power in 20% of a month be considered to be proportional to the number of homogeneous 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 pW and in which the noise power (with an integrating time of 5 ms) may exceed 1 000 000 pW, be regarded as proportional to the number of homogeneous sections involved;

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 above. On a 2500 km hypothetical reference circuit, the C.C.I.T.T. allows 2500 pW mean value for this noise in any hour.

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 395-1.

Note 3. — The Recommendation relates only to "line-of-sight" radio-relay systems with adequate clearance over intervening terrain.

Note 4. — It is assumed that noise surges and clicks form 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 C.C.I.R., 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. — Designers should indicate their own 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. It is preferred that the predicted distribution curve of one-minute mean noise power in any month should satisfy the values recommended in §§ 1.2 and 1.3. Designers are expected to fit their distribution curves to fall below both values. That portion of the curve relating to 50% or so of the time will then give the "non-fading" noise value upon which the design is based.

Note 7. — 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 8. — 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 the capacity of which is less than 60 channels), N being the total number of channels for which the radio-relay system is to be designed.

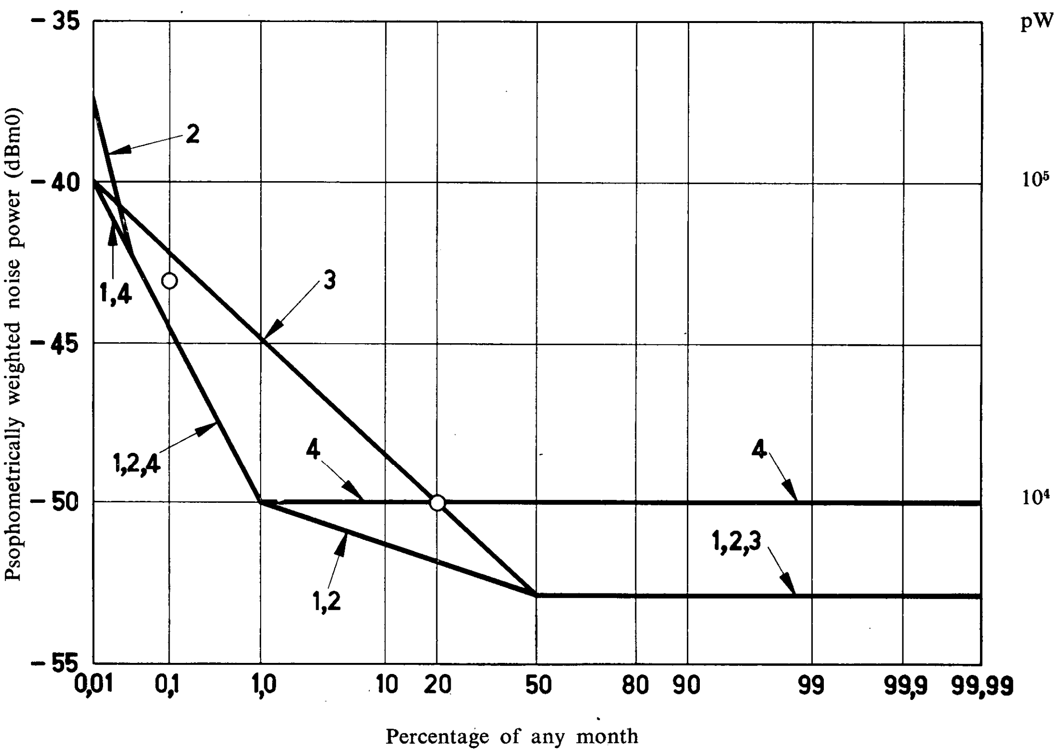
* This clause is provisional. Since, in radio-relay systems, the mean noise power in any hour varies, the subdivision of this noise objective between sections on the basis of length is inappropriate, because the worst hours of all the sections will be uncorrelated. More suitable bases for subdivision are under study.

Note 9. — The requirement indicated by § 1.4 is related to the need to transmit signalling for telephony satisfactorily. It is also related to the need for VF telegraphy at 50 bauds over telephone channels. Whereas the requirement indicated by § 1.4 is likely to be satisfactory when 50 bauds, frequency-modulation VF telegraph equipment is used, the extent to which the operation of 50 bauds, amplitude-modulation VF telegraphy systems will be satisfactory is still under study by the C.C.I.T.T.

Note 10. — Recommendation 357-1 fixes the maximum permissible value of interference caused by communication-satellite systems to a telephone channel of a radio-relay system. The values indicated in Recommendation 357-1 (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 C.C.I.T.T. Recommendation G.222 in Doc. A.P.III/51 of the IIIrd Plenary Assembly). 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 C.C.I.T.T. Recommendation G.222, § 6 are met.

ANNEX

EXAMPLES OF DISTRIBUTION CURVES FOR THE PSOPHOMETRICALLY WEIGHTED ONE-MINUTE MEAN NOISE POWER AT THE END OF THE HYPOTHETICAL REFERENCE CIRCUIT



The noise figures include 2500 pW for terminal equipment.

O Design objectives, including terminal noise.

The numbers 1 to 4 are used to distinguish the curves.

RECOMMENDATION 394 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION MULTIPLEX

Allowable noise power in the hypothetical reference circuit

(Question 2/IX)

The C.C.I.R., (1956 — 1959 — 1963)

CONSIDERING

(a) that a hypothetical reference circuit for radio-relay systems for telephony using time-division multiplex has been defined in Recommendation 300;

(b) 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;

(c) that the allowable noise power in hypothetical reference circuits for telephony radio-relay systems using time-division multiplex should conform to the values given for frequency-division multiplex (see Recommendation 393-1);

UNANIMOUSLY RECOMMENDS

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

1.1 10 000 pW, psophometrically weighted ** mean power in any hour;

1.2 10 000 pW, psophometrically weighted ** one-minute mean power for more than 20% of any month;

1.3 50 000 pW, psophometrically weighted ** one-minute mean power for more than 0·1% of any month;

1.4 1 000 000 pW, unweighted (with an integrating time of 5 ms) for more than 0·01% of any month;

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

Note 1. — The 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 or used for acceptance tests.

Note 2. — The requirement indicated by § 1.4 is related to the need to transmit signalling for telephony satisfactorily. It is also related to the need for VF telegraphy at 50 bauds over telephone channels. Whereas the requirement indicated by § 1.4 is likely to be satisfactory when 50 baud, frequency-modulation VF telegraph equipment is used, the extent to which the operation of 50 baud, amplitude-modulation VF telegraphy systems will be satisfactory is still under study by the C.C.I.T.T.

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* This Recommendation replaces Recommendation 301.

** 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.

RECOMMENDATION 395-1 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Noise in the radio portion of circuits to be established over real links **

(Question 2/IX)

The C.C.I.R., (1966)

CONSIDERING

(a) that provisional maximum values for the noise in hypothetical reference circuits are given in Recommendation 393-1 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 393-1) 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 to 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 equipment and others on the law of addition for intermodulation noise in a long chain of repeaters or in permanently connected group links (defined in C.C.I.T.T. Recommendation G.211), and that these contributions differ in different parts of the baseband-frequency spectrum;

* 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 I.T.U. List of Essential Telecommunication Terms, Second Impression, Geneva, 1961, Part I. The calculations are performed between the points *R'* and *R* (see Recommendation 380-1) of each radio section which enters into the circuit under consideration.

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 mean power in any hour ** ;

1.2 $3 L$ pW one-minute mean power for more than 20% of any month ;

1.3 47 500 pW one-minute mean power for more than $(L/2500) \times 0{\cdot}1\%$ of any month; it is recognised 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 ;

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 $50 \text{ km} \leq L \leq 840$ km :

2.1.1 $3 L$ pW + 200 pW mean power in any hour **,

2.1.2 $3 L$ pW + 200 pW one-minute mean power for more than 20% of any month,

2.1.3 47 500 pW one-minute mean power for more than $(280/2500) \times 0{\cdot}1\%$ of any month when L is less than 280 km, or more than $(L/2500) \times 0{\cdot}1\%$ of any month when L is greater than 280 km ;

2.2 for $840 \text{ km} < L \leq 1670$ km :

2.2.1 $3 L$ pW + 400 pW mean power in any hour **,

2.2.2 $3 L$ pW + 400 pW one-minute mean power for more than 20% of any month,

2.2.3 47 500 pW one-minute mean power for more than $(L/2500) \times 0{\cdot}1\%$ of any month ;

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

2.3.1 $3 L$ pW + 600 pW mean power in any hour **,

2.3.2 $3 L$ pW + 600 pW one-minute mean power for more than 20% of any month,

2.3.3 47 500 pW one-minute mean power for more than $(L/2500) \times 0{\cdot}1\%$ 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 C.C.I.T.T. allows 2500 pW mean value for this noise in any hour.

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* 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.

** The hourly mean noise power objective and its subdivision are at present under study (see Recommendation 393-1).

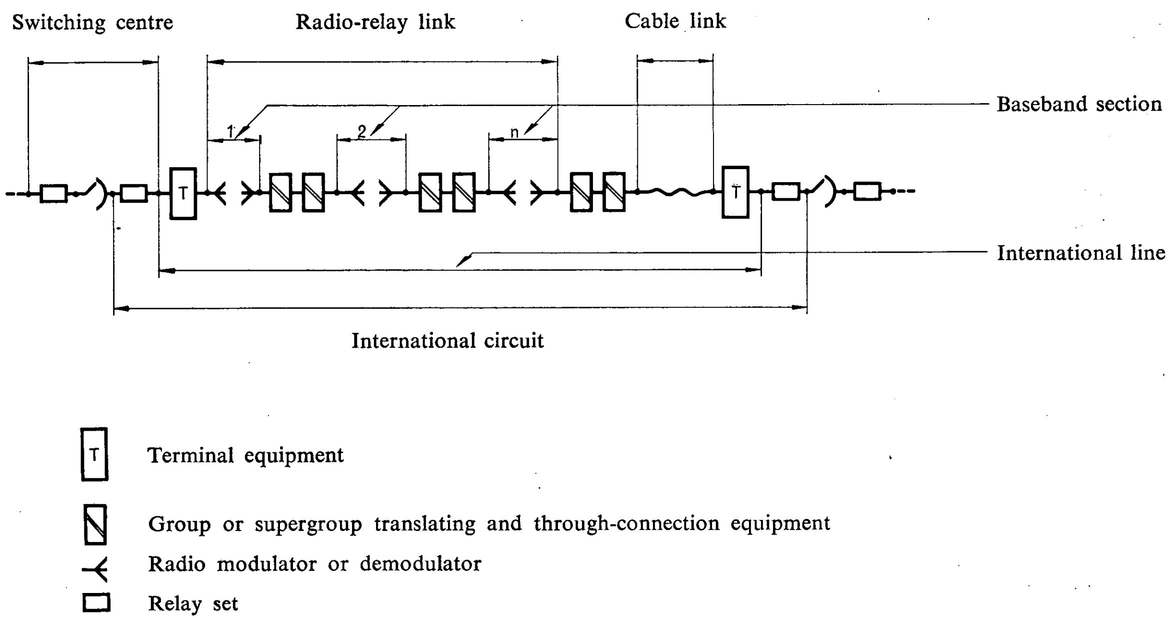

FIGURE 1

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)

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

TRANS-HORIZON RADIO-RELAY SYSTEMS

Hypothetical reference circuit for radio-relay systems for telephony using frequency-division multiplex

(Question 7/IX)

The C.C.I.R., (1963 — 1966)

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 397-1

TRANS-HORIZON RADIO-RELAY SYSTEMS

Allowable noise power in the hypothetical reference circuit for telephony transmission using frequency-division multiplex

(Question 7/IX)

The C.C.I.R., (1963 — 1966)

CONSIDERING

(a) that a hypothetical reference circuit for trans-horizon radio-relay systems is established in Recommendation 396-1, as a guide to the designers of systems in use in international telecommunication networks ;

(b) that wherever practicable and possible, trans-horizon radio-relay systems should meet the same performance regarding noise as recommended for line-of-sight systems in Recommendation 393-1 ;

(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 396-1. 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, §§ 1.2 and 1.3. Besides which, the mean psophometric power during any hour should not exceed the figure laid down in Recommendation 393-1, § 1.1 ;

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 393-1 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 pW for more than 20% of any month;

3.2 the mean psophometric power during one minute must not exceed 63 000 pW 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, § 1.4, but with the percentage of the most unfavourable month changed to 0·05%, for the systems referred to in § 3 of the present Recommendation;

5. that the conditions given in §§ 3 and 4 are provisional and should be reconsidered later.

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 C.C.I.T.T. authorizes a mean value of 2500 pW during any hour 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, I.E.E. 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 Joint Special Study Group C (C.C.I.T.T./ C.C.I.R.) to Question 1/C, annexed to Docs. IX/240, and Doc. IX/164, 1963-1966).

F. 4 : Maintenance

RECOMMENDATION 290 *

MAINTENANCE PROCEDURE FOR RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Measurements to be made

The C.C.I.R., (1959)

CONSIDERING

that the operation of frequency-division multiplex (FDM) radiotelephony relay systems would be facilitated by maintenance procedures similar to those in existence for line networks ;

UNANIMOUSLY RECOMMENDS

1. that transmission quality be checked by the following maintenance measurements :
   — stability of the net gain or loss in the baseband ;
   — total noise including crosstalk noise ;
2. that net gain or loss stability in the baseband should be measured by means of a line regulating pilot (Recommendation 381-1). Such measurements can be made during normal operation without interrupting the link and can be supplemented by a measurement of the linear attenuation distortion at the frequencies in the baseband ;
3. that total noise be measured in specially reserved measuring channels, listed in Recommendation 398-1, outside the spectrum of the FDM signal, so that noise can be measured during normal operation of the link, the load consisting of the multiplex signal. Noise can also be measured by interrupting the multiplex signal and replacing it by the uniform spectrum signal defined in Recommendation 399-1, the measurement being made either in the measurement channels referred to above or in the channels inside the telephone channel spectrum as defined in Recommendation 399-1. Noise may also be measured when the link is unloaded, so that the contribution of each noise source can be determined.

RECOMMENDATION 305 **

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Stand-by arrangements

The C.C.I.R., (1956 — 1959)

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 ;

* This Recommendation terminates the study of Question 96 for telephony.
** This Recommendation replaces Recommendation 196.

(b) that for this purpose, it is generally advisible 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 utilised 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 398-1

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Maintenance measurements in actual traffic

The C.C.I.R., (1959 — 1963 — 1966)

CONSIDERING

(a) that measurements by means of a generator producing white noise (according to Recommendation 399-1) 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 useful for determining the quality of a system and must be made while the system is carrying traffic ;

* 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.

(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;

(i) 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 range of these filters and at the edges of the total multiplex signal band;

(j) that the specification of frequencies, situated about 10% above the upper limit of the total multiplex signal band for continuity pilots (Recommendation 401-1), suggests the use of the same frequencies as centre frequencies of the measuring channels;

(k) 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;

(l) 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 399-1;

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 central frequencies of these measuring bands should be those shown in the Table below;

3. that the attenuation of the stop band 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 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 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;

6. that the design of the band stop and measuring filters should enable them to be used both for maintenance measurements according to this Recommendation and for measurements with white noise according to Recommendation 399-1.

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* Except when the centre frequency is 10 kHz; the minimum frequency band is then 10 $\pm$ 1 kHz.

Note. — In certain telephone channels and in combinations of them, harmonic distorsion 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.

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
24	12-108	12-108	10	116 or 119
60	12-252 60-300	12-252 60-300	10 50	304 331
120	12-552 60-552	12-552 60-552	10 50	607 607
300	60-1300 64-1296	60-1364	50	1499
600	60-2540 64-2660	60-2792	50	3200
960	60-4028 316-4188	60-4287	50 270	4715 4715
1260 (2)	60-5564 60-5636 316-5564	60-5680	50	6300
1800	312-8204 316-8204	300-8248	270	9023
2700 (3)	312-12 388 316-12 388	308-12 435	270	13 627

(1) Including pilots or frequencies which might be transmitted to line.

(2) Other limits of baseband occupied by telephone channels may be used by agreement between the Administrations concerned.

(3) Radio-relay systems with a capacity of 2700 channels are at present under study ; the central frequencies of the corresponding measurement channels are only given for information purposes, and the figures indicated in no way commit the future.

RECOMMENDATION 399-1

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Measurement of performance with the help of a signal consisting of a uniform spectrum

The C.C.I.R., (1956 — 1959 — 1963 — 1966)

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 C.C.I.T.T. 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 (C.C.I.T.T. Recommendation G.222, Red Book, Vol. III) ;

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 C.C.I.T.T. Recommendation G.222. If applied at the point of interconnection of the system corresponding to *T'* of C.C.I.R. Recommendation 380 the absolute power levels of interest are shown in column 4 of Table I ;

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 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 ;

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

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 bandwiths 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 275-1);

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;

3.3 that in place of the measuring-channel frequencies previously recommended (8002 and 12 150 kHz) or proposed (5450 kHz) new frequencies of 5340, 7600 and 11 700 kHz are suggested. This is to ensure the highest accuracy consistent with reasonable spacing of the measuring channels and economy of design;

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 11 700

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 of which the discrimination should not exceed	
	70 dB	55 dB	30 dB	3 dB	0·5 dB
70	± 1·5	± 2·2	± 3·5	± 12	
270	± 1·5	± 2·3	± 2·9	± 8	
534	± 1·5	± 3·5	± 7·0	± 15	
1248	± 1·5	± 4·0	± 11·0	± 35	
2438	± 1·5	± 4·5	± 19·0	± 60	
3886	± 1·5	± 15·0	± 30·0	± 110	
		± 1·8	± 3·5	± 12	± 100
5340	± 1·5	± 2·2	± 4·0	± 14	± 140
7600	± 1·5	± 2·4	± 4·6	± 16	± 200
11 700	± 1·5	± 3·0	± 7·0	± 20	± 300

Note 1. — The discrimination values quoted are relative values referred to the attenuation of the band-stop filters at the lowest baseband frequency.

Note 2. — The characteristics recommended for the filters 70 kHz to 2438 kHz inclusive are based on coil-capacitor 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.

5. that when connected directly to a transmitting equipment provided with band elimination filters which only just meet the requirements of § 4, a minimum signal-noise density ratio of 67 dB should be indicated by the receiving equipment; this requirement applies when a nominal conventional load is applied;

5.1 that the minimum effective bandwidth of the receiver should be 1·7 kHz;

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 also drawn to C.C.I.T.T. Recommendation G.228 which discusses the method of measurement.

RECOMMENDATION 400-1 *

SERVICE CHANNELS FOR RADIO-RELAY SYSTEMS

Types of service channel to be provided

(Question 4/IX)

The C.C.I.R., (1956 — 1959 — 1963 — 1966)

CONSIDERING

(a) that service channels are required for the maintenance, supervision and control of radio-relay links providing a number of radio-frequency channels for each direction of transmission ;

(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 :

- express speaker circuits,
- omnibus speaker circuits,
- supervisory and control 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 (an omnibus speaker circuit) should be set up to connect together all the stations on the system, whether staffed or not ;

4. that a second telephone service channel (a main or express speaker circuit) should be provided for direct telephonic communication between the staffed stations receiving supervisory signals ;

5. wherever possible, and after agreement between the Administrations concerned, one or two service channels should be provided in each direction for the transmission of supervisory and control signals between the stations of the system * ;

Note. — These signals may also be transmitted directly over the main radio-relay system, if it is established for telephony.

* 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.

6. one of the channels mentioned in § 5 might be used for the transmission of high speed signals associated with the switching of broadband radio channels, the other could be used for the transmission of a number of relatively low speed supervisory signals ;

Note. — It is also possible, by agreement between the Administrations concerned, to transmit the relatively slow signals in the upper part of the omnibus service channel mentioned in § 3.

7. the telephone service channels should possess, whenever possible, the characteristics (excluding noise power) recommended by the C.C.I.T.T. for international telephone circuits and, in particular, should be able to transmit the frequency band 300 to 3400 Hz ;

8. 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 pW psophometrically weighted, at a point of zero relative level ;

9. the service channels should preferably be provided either over metallic circuits or over an auxiliary radio-relay system, in the same band as the main system, or in a different band following the same route as the main system ; in special circumstances, service channels may be carried in the baseband of the main radio-relay system ;

10. the characteristics of the supervisory signals and the control signals to be transmitted between the stations of the system, should be the subject of agreement between the Administrations concerned.

Note. — Certain Administrations use the following arrangement of the baseband for auxiliary radio-relay systems, operating in a different frequency band from the main system :

- a telephone service channel (an omnibus speaker circuit), transmitted in the voice-frequency band ;
- a second telephone service channel (a main or express speaker-circuit), transmitted between 12 and 16 kHz, the sense of modulation being erect ;
- a band of frequencies situated between the two telephone service channels, used for the transmission of relatively slow supervisory signals and control signals, and, perhaps also a pilot ;
- a band of frequencies situated above the main telephone service channel, used for the transmission of telemetry signals and possible rapid control signals, the occupied band being as wide as necessary.

Other arrangements of the baseband are also used.

RECOMMENDATION 401-1 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Frequencies and deviations of continuity pilots

The C.C.I.R., (1956 — 1959 — 1963 — 1966)

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 381-1) ;

* 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.

(c) that a frequency about 10% higher than the upper limit of the frequency-division multiplex signal is convenient for such a pilot. To reduce intelligible crosstalk, the continuity pilot should, when possible, have a frequency of $(4n-1)$ kHz, where n is an integer;

(d) that some Administrations wish to use the same continuity pilot for multichannel telephony and for television signals;

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.

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)
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 64-1296	60-1364	1499, 7000 or 8500	100 or 140 (6)
600	60-2540 64-2660	60-2792	3200 or 8500	140
960	60-4028 316-4188	60-4287	4715 or 8500	140
	60-5636	60-5680 (5)	6199 or 8500	140 or 200
1260	60-5564 316-5564 (5)			
1800	312-8204 316-8204	300-8248	9023	100
2700 (7)	312-12 388 316-12 388	308-12 435	13 627	
405-line television;			8500	140
625-line television;			8500	140
Television and FDM up to 600 channels sent simultaneously			9023	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 404-1).
(4) Alternatively 304 kHz may be used by agreement between the Administrations concerned.
(5) Other limits of band occupied by telephone channels may be used by agreement between the Administrations concerned.
(6) The first value applies to frequency 1499 kHz, the second to frequency 7000 or 8500 kHz.
(7) Study is being made of 2700-channel radio-relay systems; the corresponding continuity pilot frequency is given for information only and the figures indicated in no way commit the future.

RECOMMENDATION 444

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred characteristics for multi-line switching arrangements

(Question 5/IX, Study Programme 5A/IX, Report 137-1)

The C.C.I.R., (1966)

CONSIDERING

(a) that a considerable number of wideband radio-relay systems for television and telephony operate across international frontiers;

(b) that protection arrangements for such systems are considered to be indispensable (see Recommendation 305);

(a) 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 (see Recommendation 305, § *(b)*);

UNANIMOUSLY RECOMMENDS

1. that the criteria for stand-by switching should be based on:

1.1 the level of the continuity pilot or received carrier level;

1.2 the evaluation of noise power within a frequency band in the vicinity of the pilot frequency;

2. that switching thresholds should be defined by:

2.1 a drop in pilot level or received carrier level;

2.2 a certain increase in the weighted noise power in the vicinity of the top telephone channel of a telephony system or decrease in the weighted signal-to-noise in the picture signal of a television system;

3. that, for the transmission of control signals between the terminals of a switched section, frequency coding either over a telephone channel or over a wider band auxiliary channel should be used;

Note. — It would be preferable to use the centre frequencies recommended by the C.C.I.T.T. for voice-frequency telegraph systems.

4. that the operate-time of the entire automatic switching system should not exceed 40 ms. An operate-time of 10 ms can be achieved when using a wider band auxiliary channel;

5. that the transfer-time of the switching element itself should not exceed 10 µs for switching at intermediate frequency and 2 ms for switching at baseband frequencies;

6. that the mean weighted noise introduced by the switching equipment into any telephony channel when switched from a normal to a protection radio channel should not exceed 150 pW;

7. that for a television signal the differential-phase distortion contributed by the switching equipment when switched from a normal to a protection radio channel should not exceed 0·5°;

8. that the characteristics of the protection arrangements, especially the switching thresholds and frequency coding, should be subject to further study and, for the present, be subject to agreement between the Administrations concerned.

F. 5 : Characteristics

RECOMMENDATION 275-1

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Pre-emphasis characteristic for frequency-modulation systems

(Question 1/IX)

The C.C.I.R., (1959 — 1966)

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 404-1);

(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 1800 channels;

2. that the ideal preferred pre-emphasis characteristic is given by the expression:

$$\left.\begin{array}{l}\text{Deviation (relative to} \\ \text{test-tone deviation) (dB)}\end{array}\right\} = 5 - 10 \log_{10} \left[1 + \frac{6{\cdot}90}{1 + \frac{5{\cdot}25}{\left(\frac{f_r}{f} - \frac{f}{f_r}\right)^2}} \right] \text{dB}$$

where f_r (the resonant frequency of the network) = $1{\cdot}25\, f_{max}$, where 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 described in Recommendation 380-1 ;

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 $\pm$ ($0{\cdot}1 + 0{\cdot}05\, f/f_{max}$) dB, f being the baseband frequency, f_{max} being 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.

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 404-1) is $0{\cdot}608\, f_{max}$. 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.

TABLE I

Characteristic frequencies for pre-emphasis and de-emphasis networks for the frequency-division multiplex systems of Recommendation 404-1

Maximum number of telephone traffic channels (¹)	f_{max} (kHz)	f_r (kHz)
24	108	135
60	300	375
120	552	690
300	1300	1625
600	2660	3325
960	4188	5235
1260	5636	7045
1800	8204	10 255

(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.

In the Table :
f_{max} is the nominal maximum frequency of the band occupied by telephone channels ;
f_r is the nominal resonant frequency of the pre-emphasis or de-emphasis network.

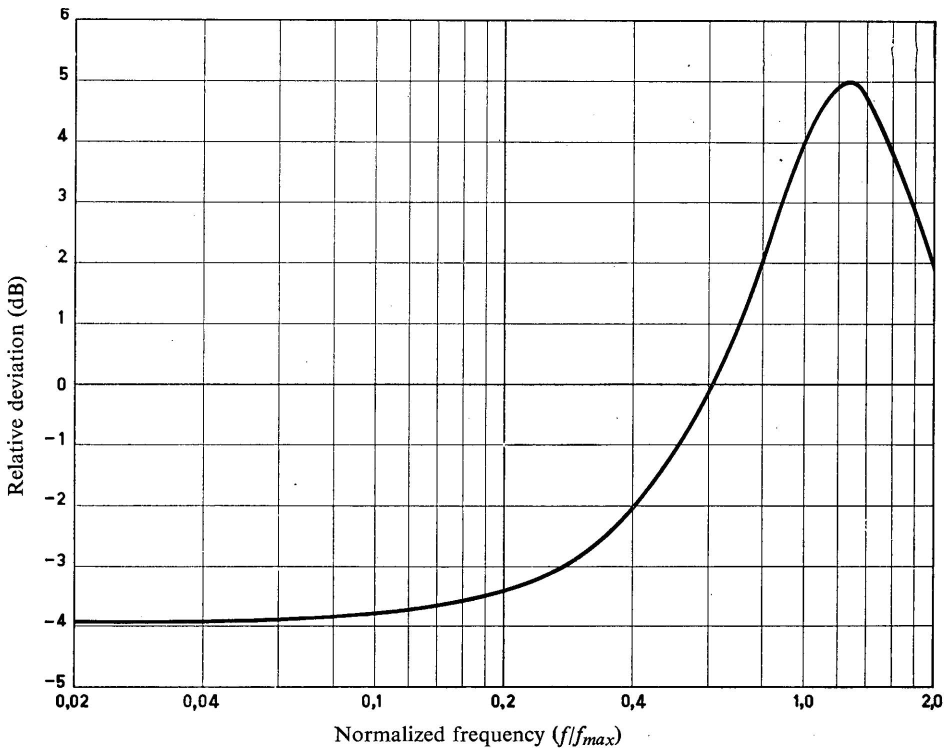
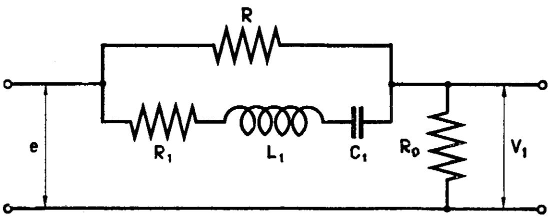


FIGURE 1

Pre-emphasis characteristic for telephony



$R = 1{\cdot}81\ R_0$

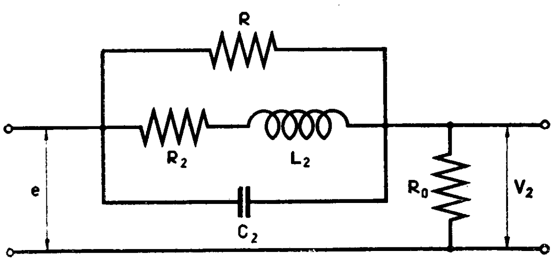
$R_1 < 0{\cdot}01\ R_0$ at f_r

$$\sqrt{\frac{L_1}{C_1}} = 0{\cdot}79\ R_0$$

$$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_1C_1}}$$

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

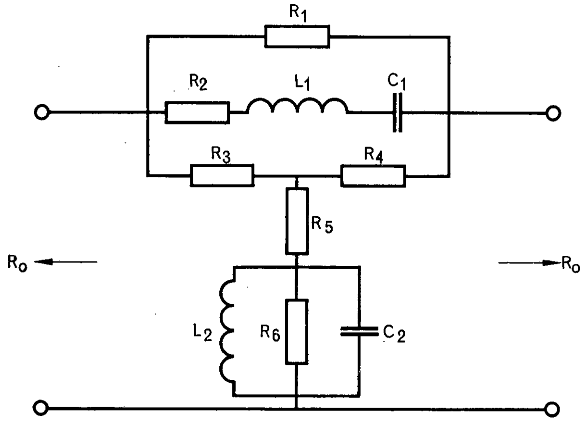
$$\sqrt{\frac{L_2}{C_2}} = 1{\cdot}47\ R_0$$

$$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_2C_2}}$$

(b) De-emphasis network

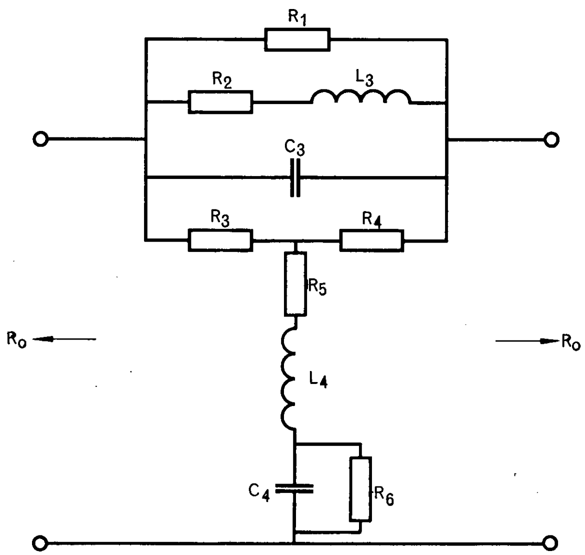
FIGURE 2

Pre-emphasis and de-emphasis networks to work between a constant-voltage source and an open-circuited load



$$R_1 = 1{\cdot}81\ R_0$$
$$R_2 < 0{\cdot}01\ R_0$$
$$R_3 = R_4 = R_0$$
$$R_5 = \frac{R_0}{1{\cdot}81}$$
$$R_6 > 100\ R_0$$
$$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_1C_1}} = \frac{1}{2\pi}\sqrt{\frac{1}{L_2C_2}}$$
$$\sqrt{\frac{L_1}{C_1}} = 0{\cdot}79\ R_0$$
$$\sqrt{\frac{L_2}{C_2}} = \frac{R_0}{0{\cdot}79}$$

(a) Pre-emphasis network



$$R_1 = 1{\cdot}81\ R_0$$
$$R_2 < 0{\cdot}01\ R_0$$
$$R_3 = R_4 = R_0$$
$$R_5 = \frac{R_0}{1{\cdot}81}$$
$$R_6 > 100\ R_0$$
$$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_3C_3}} = \frac{1}{2\pi}\sqrt{\frac{1}{L_4C_4}}$$
$$\sqrt{\frac{L_3}{C_3}} = 1{\cdot}47\ R_0$$
$$\sqrt{\frac{L_4}{C_4}} = \frac{R_0}{1{\cdot}47}$$

(b) De-emphasis network

FIGURE 3

Pre-emphasis and de-emphasis networks to work between matched resistive input and output impedances

RECOMMENDATION 276 *

RADIO-RELAY SYSTEMS FOR TELEVISION

Frequency deviation and the sense of modulation

(Question 3/IX)

The C.C.I.R., (1956 — 1959)

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 to economize in the use of the frequency spectrum;

(d) that for various reasons the use of pre-emphasis might be desirable (Recommendation 404-1);

UNANIMOUSLY RECOMMENDS

1. that the value of the frequency deviation without pre-emphasis in radio-relay systems for the transmission of television, referred to the nominal peak-to-peak amplitude of the video signal (see Recommendation 421-1, § 2.3), should be 8 MHz peak-to-peak for systems of 625 lines or less, and between 8 MHz and 12 MHz peak-to-peak for systems of 819 lines. In particular cases of international connections with 819-line television systems the value of deviation should be agreed between the Administrations concerned;

2. that, when pre-emphasis is applied according to Recommendation 404-1, the maximum frequency deviation should not exceed 8 MHz peak-to-peak for systems of 625 lines or less, or 8 MHz to 12 MHz peak-to-peak for systems of 819 lines;

3. that the sense of modulation at the point of international connection should be the subject of agreement between the Administrations concerned.

RECOMMENDATION 298 **

RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION MULTIPLEX

Preferred characteristics

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that time-division multiplex radiotelephone systems may form part of an international circuit;

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* This Recommendation, which replaces Recommendation 184, applies only to line-of-sight and near line-of-sight radio-relay systems.

** This Recommendation replaces Recommendation 185.

(*b*) that general conformity with the relevant C.C.I.T.T. Recommendations in respect of overall performance measured between audio-frequency terminals, the method of making audio-frequency connections, and the method of signalling over international connections are already covered by Recommendations 297 and 335-1 ;

(*c*) that the techniques of time-division multiplex have not yet attained stability and, while most systems in current use employ pulse-position modulation and provide not more than 24 speech channels, even the development of such systems has not yet reached the stage where general agreement is possible on all the baseband parameters necessary for interconnection at other than audio frequency (see Report 134) ;

(*d*) that certain systems, now in service or under development, provide for the transmission of several music channels or other types of service as an alternative to speech channels, or allow for more than 24 speech channels, and that such systems could become of importance ;

(*e*) that standardization of baseband parameters at the present stage might, therefore, unduly restrict the future development of time-division multiplex systems ;

UNANIMOUSLY RECOMMENDS

that, where direct interconnection is required, at other than audio-frequencies, between two time-division multiplex systems across an international boundary, the connection between the two systems should be made in accordance with Recommendation 306.

RECOMMENDATION 402 *

RADIO-RELAY SYSTEMS FOR TELEVISION

Simultaneous transmission of a monochrome television signal and a single sound channel. Preferred characteristics of the sound channel

(Question 3/IX)

The C.C.I.R., (1959 — 1963)

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 band and below the continuity pilot (see Recommendation 401-1) ;

(*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 C.C.I.T.T. for international programme circuits (Note 1) ;

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* This Recommendation replaces Recommendation 272.

2. that the following transmission characteristics are preferred:

	General Recommendation	French 819-line system	U.S.S.R. 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 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 bandwidth (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 Hz)	150 kHz peak
2.2.5 Pre-emphasis of audio-channel (μs) (Note 4)		50 (see Rec. 412)	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 C.C.I.T.T., Vol. III, Recommendation J.21. The maintenance is contained in Vol. IV, Recommendations series N. 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 Fig. 77 of C.C.I.T.T. Recommendation J.13, Vol. III. It is the responsibility of the Administrations concerned to choose the appropriate value for their special 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 412, § 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 403-1 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Intermediate-frequency characteristics

(Question 1/IX)

The C.C.I.R., (1956 — 1959 — 1963 — 1966)

CONSIDERING

(a) that multiplex 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 the intermediate frequency;

(c) that, to facilitate international connections at intermediate frequency, 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 plan, it is desirable to adopt a preferred intermediate frequency;

UNANIMOUSLY RECOMMENDS

that, as far as is 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

The nominal centre values of the intermediate frequencies are:

— 35 MHz for radio frequencies up to 1 GHz (for such radio-frequencies, the frequency of 70 MHz may also be used, for example, in larger capacity radio-relay systems);

— 70 MHz for systems of up to 1800-channel capacity employing radio-frequencies higher than 1 GHz. For systems of larger capacity, a different value of intermediate frequency may be desirable.

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 study. Until a final Recommendation can be set up, the tolerance should be agreed between the Administrations concerned.

2. Output and input voltage of the intermediate-frequency signal

Output: 0·5 V r.m.s.;
Input: 0·3 V r.m.s.

The tolerances relative to the nominal output and input levels, as a function of the frequency and the level of the radio-frequency carrier, should be the subjet of agreement between the Administrations concerned.

* This Recommendation applies to line-of-sight and near line-of-sight radio-relay systems and, where appropriate, to trans-horizon radio-relay systems.

3. Impedance of the intermediate-frequency circuit

Nominal impedance : 75 Ω (unbalanced).

Return loss : $\geqq$ 26 dB within a band covering the baseband and the continuity pilot frequency on both sides of the centre frequency, for systems having a capacity of more than 600 voice channels, or the equivalent. For low-capacity systems, this value is the subject of further study.

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 desired to use, by agreement between the Administrations concerned, intermediate-frequency characteristics other than those given above.

RECOMMENDATION 404-1 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Frequency deviation

(Question 1/IX)

The C.C.I.R., (1956 — 1959 — 1963 — 1966)

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 is practicable, frequency-division multiplex radio-relay systems for telephony forming part of an international circuit should conform to the following characteristics :

---

* This Recommendation applies to line-of-sight and near line-of-sight radio-relay systems and, where appropriate, to trans-horizon radio-relay systems.

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

[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.

RECOMMENDATION 405 *

RADIO-RELAY SYSTEMS FOR TELEVISION

Pre-emphasis characteristics for frequency-modulation systems

(Question 3/IX)

The C.C.I.R., (1959 — 1963)

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 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;

* This Recommendation replaces Recommendation 277.

(*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 ;

(*i*) that, to achieve readily reproducible characteristics, the pre-emphasis network, and the corresponding de-emphasis network, should be simple ;

UNANIMOUSLY RECOMMENDS

1. that the use of pre-emphasis is preferred for the transmission of monochrome television signals by radio-relay systems ;

2. that a minimum phase shift network should be used for pre-emphasis ;

3. that the pre-emphasis characteristic for the transmission of 405-line monochrome television signals should be derived from the basic network shown in Table I *a* and Fig. 1, the shape of the characteristic being as indicated by curve *a* in Fig. 2 ;

4. that the pre-emphasis characteristic for the transmission of 525-line monochrome television signals should be derived from the basic network shown in Table I *b* and Fig. 1, the shape of the characteristic being as indicated by curve *b* in Fig. 2 ;

5. that the pre-emphasis characteristic for the transmission of 625-line television signals should be derived from the basic network shown in Table I *c* and Fig. 1, the shape of the characteristic being as indicated by curve *c* in Fig. 2 ;

6. that the pre-emphasis characteristic for the transmission of 819-line monochrome television signals should be derived from the basic network shown in Table I *d* and Fig. 1, the shape of the characteristic being as indicated by curve *d* in Fig. 2 ;

7. that the tolerance on the pre-emphasis characteristics, and also on the de-emphasis characteristics referred to in Note 3, should be such that, within the frequency range 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 spread of $0{\cdot}1 + 0{\cdot}05\, f/f_c$ (dB), f being the video-frequency, f_c being the nominal upper limit of video-frequency band. This corresponds to tolerances of the network components (resistors, capacitors, inductors) of about $\pm$ 1%. Further, the magnitude of the departure should exhibit no rapid variations within this frequency range.

Note 1. — The total range of the network attenuation between zero and infinite frequency is 14 dB.

Note 2. — The relative deviation 0 dB corresponds to a peak-to-peak frequency deviation of 8 MHz for a sinusoidal wave of 1 V peak-to-peak applied at a point of interconnection at the input to the system (Recommendation 276).

* See Recommendation 421-1.

Note 3. — 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 4. — The attenuation of the pre-emphasis characteristic at 0·01 MHz relative to the reference deviation level given in Note 2 are: −7, −10, −11 and −12 dB for the 819, 525, 625 and 405-line characteristics respectively.

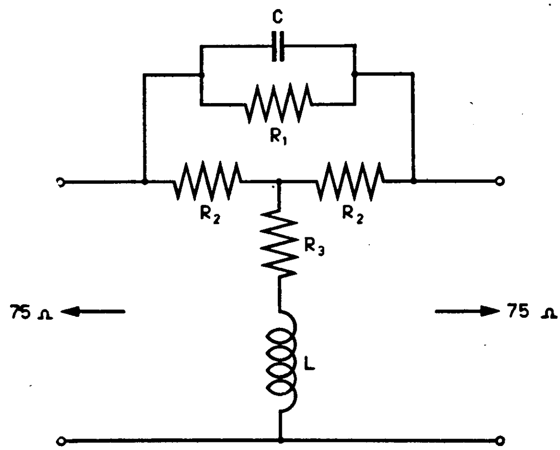

FIGURE 1

Pre-emphasis network for television

TABLE I

Component values of pre-emphasis network for television

Number of lines	405	525	625	819
Curve (Fig. 1)	*a*	*b*	*c*	*d*
L (μH)	22·22	17·35	9·54	4·77
C (pF)	3950	3085	1695	847·5
R_1 (Ω)	300	275·8	300	300
R_2 (Ω)	75	75	75	75
R_3 (Ω)	18·75	20·4	18·75	18·75

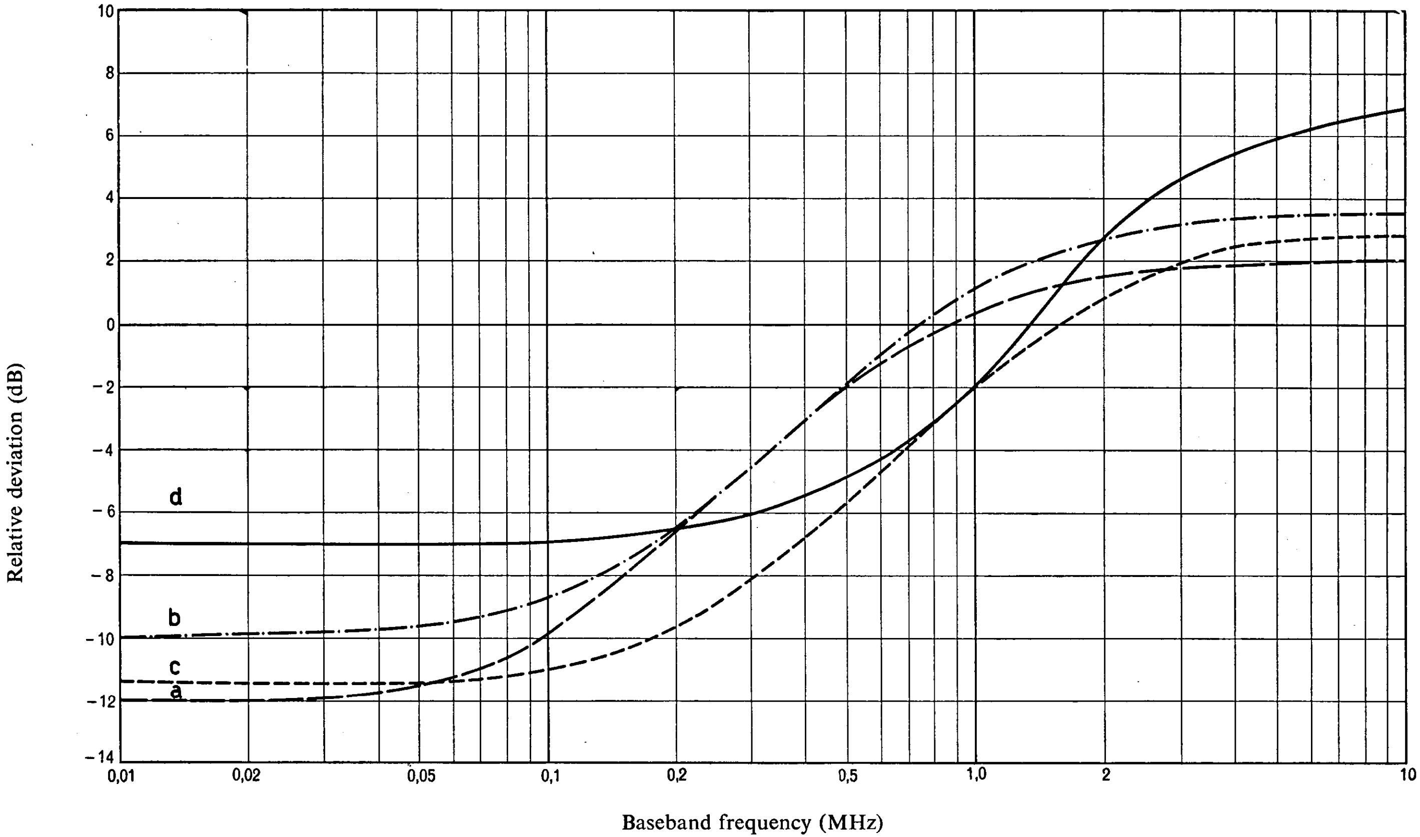

FIGURE 2

Pre-emphasis characteristics for 405, 525, 625 and 819-line television systems
(0 dB corresponds to a deviation of 8 MHz for a 1 V peak-to-peak signal (see Recommendation 276))

RECOMMENDATION 406-1 *

LINE-OF-SIGHT RADIO-RELAY SYSTEMS SHARING THE SAME FREQUENCY BANDS AS THE SPACE STATION RECEIVERS OF ACTIVE COMMUNICATION-SATELLITE SYSTEMS

Maximum equivalent isotropically radiated power of line-of-sight radio-relay system transmitters

The C.C.I.R., (1966)

CONSIDERING

(a) that communication-satellite systems and line-of-sight radio-relay systems share certain frequency bands in the range 1 to 10 GHz ;

(b) that, to avoid significant interference to reception in satellite receivers, without requiring excessive transmitter powers at the earth stations of communication-satellite systems or excessively large antennae, it is necessary to define maximum allowable values for the equivalent isotropically radiated power of line-of-sight radio-relay systems ;

(c) that the maximum allowable values of radiated power should be such as not to place undue restriction on the design of line-of-sight radio-relay systems ;

(d) that it is desirable that radio-relay systems should employ highly-directional antennae ;

(e) that it is necessary to avoid significant interference from radio-relay emissions directed at active communication satellites, and that in this respect the stationary satellite orbit is unique ;

(f) that the radio-relay system planner often has a choice in routing new systems without incurring severe economic or other penalties ;

RECOMMENDS

that in those frequency bands between 1 and 10 GHz shared between communication-satellite systems and line-of-sight radio-relay systems *, involving reception at the space station ;

1. the power delivered to the antenna input of any such radio-relay system transmitter should not exceed + 13 dBW ;

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* The Administrations of Greece, Indonesia, Iran, Pakistan, Syria and Turkey reserved their opinion on this Recommendation.

** The frequency bands concerned are given in the Final Acts of the Extraordinary Administrative Radio Conference, Geneva, 1963.

2. the maximum value of the equivalent isotropically radiated power of any such radio-relay system transmitter should, in all cases, not exceed + 55 dBW ;

3. new radio-relay routes should, wherever practicable, be so planned that the centre of the major lobe of any antenna will not be directed at less than 2° away from the stationary satellite orbit ;

3.1 if, in a particular case, this should prove impracticable, every effort should be made to comply with the following maximum values of equivalent isotropically radiated power for each transmitter :

3.1.1 47 dBW for any antenna beam directed within 0·5° of the stationary satellite orbit ;

3.1.2 47 to 55 dBW, on a linear decibel scale (8 dB per degree), for any antenna beam directed between 0·5° and 1·5° of the stationary satellite orbit ;

4. in the case of new radio-relay systems built on existing routes, the maximum values of equivalent isotropically radiated power should not, as far as possible, exceed for each transmitter :

4.1 47 dBW for any antenna beam directed within 0·5° of any location in the stationary satellite orbit, which has been internationally notified ;

4.2 47 to 55 dBW, on a linear decibel scale (8 dB per degree), for any antenna beam directed between 0·5° and 1·5° of any location in the stationary satellite orbit, which has been internationally notified.

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REPORTS OF SECTION F (RADIO-RELAY SYSTEMS)

F. 1 : Interconnection

REPORT 134 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION MULTIPLEX

Technical characteristics to be specified to enable interconnection between any two systems

(1956 — 1959)

1. General

A number of different forms of time-division multiplex (TDM) system are in use or under consideration. Of those in service, the majority use pulse-position modulation (PPM), combined with amplitude-modulation of the radio carrier (PPM-AM). However, PPM systems with frequency-modulation of the radio carrier (PPM-FM) are also used, as are systems with pulse-amplitude modulation (PAM), combined with frequency-modulation of the radio carrier (PAM-FM).

Different numbers of speech channels are provided by various systems ; other systems again provide for telegraph channels, good quality music channels or other forms of traffic, either specifically or as alternatives to speech channels. Still further systems transmit groups of speech channels by time division, which are themselves assembled by frequency-division multiplex.

Systems using pulse-code modulation are not covered by this Report.

From the point of view of international connection, TDM systems can, in this Report, be divided conveniently into those using pulse-position modulation and those using pulse-amplitude modulation. Systems of one type can be interconnected with the other, or with FDM radio-relay links or landlines, at audio frequency, and recommendations regarding this are given in Recommendation 297 and 335-1.

Interconnection at baseband (by which is meant here the sequence of modulated pulses before application to the radio-frequency carrier) at intermediate frequency or at radio frequency, requires the two systems concerned to be of the same type (both PPM or both PAM) and that the specifications of certain parameters should be co-ordinated.

Section 2 of this Report lists those parameters requiring specification for baseband interconnection, while § 3 gives the *additional* parameters for intermediate-frequency interconnection. Intermediate-frequency interconnection is not normally used for PPM-AM systems, but could be appropriate for systems using frequency-modulation of the radio carrier.

* This Report, which replaces Report 70, was adopted unanimously.

Where international connection at radio-frequency is more appropriate, it is considered that at present, the co-ordination of the necessary technical parameters should be the subject of direct agreement between the Administrations concerned.

To render unnecessary any specific agreement regarding the characteristics of the supervisory system, it is suggested that in an international connection between a TDM radio-relay system and a second telecommunication system (either similar or different), both supervisory systems should terminate at or near the international boundary, or that the method of interconnection should be the subject of agreement between the Administrations concerned.

A service channel is considered necessary as part of a TDM radio-relay system and this service channel should be accessible at all repeater stations.

2. Technical characteristics to be specified for baseband interconnection of any two TDM systems using pulse-position modulation or of any two TDM systems using pulse-amplitude modulation

A. *Characteristics applicable to both PPM and PAM systems*

2.1 Audio channel characteristics.

2.2 — maximum number of telephone traffic channels ;
— maximum number and type of traffic channels for other types of service, e.g., music, telegraphy, facsimile, groups of telephone channels assembled in FDM.

2.3 Number of equal time intervals in a sequence.

2.4 Channel sampling rate :
— for telephone traffic,
— for other types of service.

2.5 Pulse polarity at the point of interconnection.

2.6 Impedance characteristics and resulting reflection effects at the point of interconnection.

2.7 Characteristics of synchronizing signal (or marker signals, if any) at the point of interconnection.

2.8 Characteristics and position of service channel, if included in the baseband.

2.9 Characteristics of any special signals sent over the system.

2.10 Type and characteristics of compandor, if used.

2.11 Special requirements, if any, for the insertion and dropping of channels and blocks of channels.

B. *Characteristics applicable to PPM systems only*

2.12 Width and shape of channel pulses at point of interconnection.

2.13 Significant characteristics of pulse.

2.14 Peak-to-peak excursion of the channel pulse, without compandors, for standard modulation (see Note).

2.15 Input and output pulse amplitudes at the point of interconnection.

C. *Characteristics applicable to PAM systems only*

2.16 Width and shape of channel pulses at point of interconnection :

— with zero modulation,
— with standard modulation (see Note).

2.17 Input and output amplitudes of the channel pulse at the point of interconnection, with zero modulation.

2.18 Maximum and minimum amplitude of the channel pulse (without compandors) at the point of interconnection, for standard modulation (see Note).

Co-ordination of all the above parameters is necessary at stations where channels are demodulated. At those repeater stations where channels are not demodulated, it is only necessary for the following characteristics to be co-ordinated :

for PPM, the characteristics given in §§ 2.5, 2.6, 2.12 and 2.15 ;
for PAM, the characteristics given in §§ 2.5, 2.6, 2.16, 2.17 and 2.18.

Note. — Standard modulation is modulation by an 800 Hz signal of 1 mW at a point of zero relative level, or the equivalent signal for music or for other types of service.

3. Technical characteristics additional to those listed in § 2 above, to be specified for interconnection at intermediate frequency of any two TDM systems using pulse-position modulation or of any two TDM systems using pulse-amplitude modulation

3.1 Centre value of the intermediate frequency.

3.2 The frequency deviation of the carrier and, if necessary, the sense of deviation (if frequency-modulation is used), for standard modulation as defined in § 2 of this Report.

3.3 Input and output levels of the intermediate-frequency signal at the point of interconnection.

3.4 Impedance characteristics and resulting reflection effects at the point of interconnection.

4. Present position regarding the recommendation of specific values for the parameters listed in § 2

At present it has not been found possible to reach such agreement on these parameters as to make interconnection possible between any two different PPM or any two different PAM systems other than at audio frequency, and where such cases arise they should be dealt with in the manner indicated in Recommendation 306.

There has, however, been a general agreement on certains points, particularly concerning PPM systems. These agreed points are, therefore, listed below under the paragraph numbers used in § 2.

2.1 *Audio channel characteristics*

For telephone circuits reference is made to Recommendation 297.

2.2 *Maximum number of telephone traffic channels*

To achieve maximum economy in interconnection with other systems, particularly FDM radio-relay systems and line systems, it is highly desirable to provide telephone traffic channels in groups of 12.

2.4 *Channel sampling rate for telephone traffic*

The preferred value of channel sampling rate is 8 kHz with a tolerance of $\pm$ 8 Hz or better.

Unless otherwise agreed between the Administrations concerned, the pulse trains may be separately generated for the two directions of transmission.

2.5 *Pulse polarity at point of interconnection*

For PPM systems positive polarity is preferred.

2.6 *Impedance characteristics and resulting reflection effects at the point of interconnection*

The preferred nominal value of the impedance at the point of interconnection is 75 Ω.

2.12 }
2.16 } *Width and shape of channel pulses at point of interconnection*

Attention is drawn to the need to use pulse shapes requiring the minimum bandwidth consistent with the facilities given by the system.

2.16 *Grouping of channels using marker signal synchronization*

If marker signals are used, it is possible to assign to each group of 12 channels an individual marker signal as this will enable the other groups to continue to function properly when one or several groups suffer a break-down, and will also facilitate the branching-off of groups.

2.15 *Input and output pulse amplitudes at the point of interconnection in PPM systems*

The preferred value of the pulse amplitude at a point of international connection is 1·4 V at the output from receiving equipment and 0·7 V at the input to the transmitting equipment. The difference in level allows for loss in the means of interconnection.

REPORT 283 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Technical characteristics to be specified to enable interconnection between any two systems

(Question 1/IX)

(1956 — 1959 — 1963)

1. Introduction

This Report is concerned with the preferred characteristics of radio-relay systems using frequency-division multiplex (FDM) which it is proposed to specify and the reasons why such specifications are considered necessary.

The systems under consideration are those in which the input and output signals, i.e. the "baseband" signals, consist of an assembly of suppressed-carrier single-sideband telephone signals in channels spaced 4 kHz apart, using arrangements of channels recommended by the C.C.I.T.T.

* This Report, which replaces Report 131, was adopted unanimously.

It is assumed that the FDM signals themselves modulate the frequency or the phase of a radio-frequency carrier ; other possible methods exist, e.g. the modulation of a sub-carrier by the FDM signal which, in turn, modulates the radio-frequency carrier, but such methods will not be considered further in this Report.

The specification of certain preferred characteristics of FDM radio-relay systems forming part of an international circuit is necessary, to permit the ready interconnection of different radio-relay systems ; the specification of some of these characteristics is also necessary, to permit the ready interconnection of FDM radio-relay systems with FDM line systems.

2. Stages at which the interconnection of radio-relay systems among themselves or with line systems may be required

The interconnection of different radio-relay systems at national boundaries may be required at :

— baseband frequencies,
— intermediate frequencies,
— radio frequencies.

The interconnection of radio-relay systems at baseband frequencies may occasionally be essential to permit the extraction or insertion of individual channels, groups, supergroups, or mastergroups of channels, and it may also be necessary for level regulating, monitoring, supervisory or control purposes. The interconnection of radio-relay and line systems will normally be carried out at baseband frequencies, since the possibility of interconnection at intermediate or radio frequencies does not exist.

The interconnection of radio-relay systems at intermediate frequency enables the additional noise and distortion due to demodulation and remodulation to be avoided ; it also reduces the amount of equipment required as compared with interconnection at baseband frequencies. It should be noted that interconnection at the intermediate frequency requires the specification of the baseband signal as well as the modulation characteristics, i.e. the deviation of the intermediate-frequency carrier. Interconnection of two radio-relay systems at intermediate frequency is, of course, more readily carried out if the two intermediate frequencies are the same ; nevertheless, the possibility exists of translating from one intermediate frequency to another if need be, but it should be borne in mind that difficulties may arise if the two intermediate-frequency bands overlap.

However, the need for a preferred spacing between the radio-frequency channels (discussed below), makes it necessary to adopt a value for the intermediate frequency, such that interference in the working channels from the frequency-change oscillators of receivers and repeaters is avoided. This requirement, together with the need to facilitate interconnection at intermediate frequency, makes it desirable to adopt a preferred value for the intermediate frequency.

The interconnection of two radio-relay systems at radio frequencies may be needed when crossing a boundary between two countries, where the topography is such that a common frontier station is impracticable or undesirable, for example, when the boundary is located in a wide river estuary or in a sea channel between the two countries. In such cases there must be agreement on the radio-frequencies themselves, as well as on the modulation characteristics of the radio-frequency carriers and on the baseband signal. This in turn necessitates agreement on the spacings between, and the arrangements of the radio-frequency channels. The adoption of preferred values for the spacing and arrangement of the radio-frequency channels has the advantages of economizing in the use of the frequency spectrum and of minimizing interference between radio-relay systems whose routes intersect or are in close proximity.

3. Characteristics to be specified for international connections

It is assumed that overall performance of the telephone channels should, as far as possible, be in accordance with the relevant C.C.I.T.T. recommendations for modern types of telephone circuit (Recommendations 268 and 335-1).

As standardization is not yet possible, it is suggested that preferred values should be indicated for the guidance of those concerned with the specification and design of radio-relay systems.

The characteristics for which preferred values should be given are listed below, according to whether they relate to interconnection at the baseband, intermediate or radio-frequencies.

3.1 *Interconnection at baseband frequencies*

3.1.1 maximum number of telephone traffic channels ;

3.1.2 highest and lowest frequencies of telephone traffic channels, i.e. the frequency limits of the basebands according to Recommendation 380-1 : it is assumed that the arrangement of the telephone channels is in accordance with C.C.I.T.T. recommendations ;

3.1.3 nominal impedance of baseband circuits at the point of interconnection ;

3.1.4 relative input and output power levels at the points of interconnection. (The choice and precise definition of a point of interconnection are shown in Fig. 1 of Recommendation 380-1.)

In addition to the above, consideration will need to be given to the monitoring, control or supervisory signals transmitted with the traffic channels.

3.2 *Interconnection at intermediate frequencies*

For interconnection at intermediate frequencies, it will be necessary to give preferred values for the baseband characteristics given in §§ 3.1.1 and 3.1.2, in addition to the following characteristics :

3.2.1 centre value and stability of the intermediate frequency ; because of the wide range of radio frequencies and numbers of channels that may be employed, it may be necessary to give more than one preferred value for the intermediate frequency ; the number of intermediate frequencies should, however, be no more than is essential to meet the various requirements ;

Note. — For multi-channel telephony system, the centre value of the intermediate frequency corresponds to the unmodulated carrier frequency.

3.2.2 the frequency deviation of the carrier caused by a tone of 1 mW applied to a channel at a point of zero relative level in the system ; in systems with a large number of telephone channels, e.g. 600, it may be found desirable to use pre-emphasis, producing a larger deviation for the higher frequency channels to improve the signal-to-noise ratio ; if this is so, it will be necessary to specify the amount of pre-emphasis to be employed at the various channel frequencies ;

3.2.3 input and output levels of the intermediate-frequency signal at the point of interconnection ;

3.2.4 impedance of the intermediate-frequency circuit at the point of interconnection.

3.3 *Interconnection at radio-frequencies*

For interconnection at radio frequencies, it will be necessary to give preferred values for the baseband characteristics of §§ 3.1.1 and 3.1.2 and the frequency deviation of § 3.2.2, in addition to the following characteristics :

3.3.1 number and arrangement of the radio-frequency channels ;

3.3.2 wave polarization.

Interconnection at radio frequencies also requires that the frequency stability of the transmissions employed shall be within certain tolerances. Reference should be made to the valid C.C.I.R. Recommendations and to the Radio Regulations, Geneva, 1959.

REPORT 284 *

INTERCONNECTION OF AUXILIARY RADIO-RELAY SYSTEMS AT RADIO FREQUENCIES

(Study Programme 4A/IX)

(1963)

1. Frequency bands available

According to Recommendation 400-1, auxiliary radio channels can be provided either in the same band as the main system, or in a different band following the same route as the main system.

1.1 *Auxiliary systems operating in the same band as the main system*

The preferred characteristics of such auxiliary radio-relay systems are covered by Recommendation 389, which refers to systems operating in the 2, 4, 6 or 11 GHz bands. Several Administrations prefer such auxiliary channels.

1.2 *Auxiliary systems operating in a band other than that of the main system*

Frequencies are proposed in the band of 400-470 MHz and discussion showed that there would be frequencies available in the band of 2 GHz.

In the Radio Regulations, Geneva, 1959, only the bands 401-420 MHz and 450-470 MHz have been allocated to fixed (and mobile) services in all three Regions, with many restrictions set out in the appropriate footnotes. The 2 GHz band is also allocated to the fixed (and mobile) services in all three Regions, and frequencies may be available in the band 2550-2700 MHz.

Propagation conditions in the 400 MHz range are very stable, light-weight antennae and low-loss flexible coaxial cables simplify the construction of antennae, inexpensive crystal-controlled transmitters allow narrow spacing. Duplication of highly reliable transmitting tubes is feasible.

In the 2 GHz range, narrow-beam antennae are available with greater side-lobe attenuation than in the lower range. This property, and the fact that these waves are not normally propagated beyond the line of sight, reduces the number of frequency pairs necessary for a given network compared with that for the 400 MHz range.

It was stated, however, that in the latter range, a frequency offset of about 50 kHz could double the available pairs of frequencies for a given radio-frequency band.

2. Necessary number of frequencies for auxiliary systems operating in a band other than that of the main system

It was stated that the necessary number of pairs of frequencies would depend on the number of radio-relay systems crossing the border between the Administrations concerned. With regard to the changing of frequencies between adjacent hops, the minimum requirement would be one or two pairs, but the number might often be greater, for instance, six pairs for more extended networks. With a baseband of, for example, 20 kHz bandwidth, the spacing for the 400 MHz range with a frequency stability of 50×10^{-6} (Radio Regulations, Geneva, 1959), would be about 250 kHz at crossing points and about 500 kHz on parallel routes. For the 2 GHz range, a stability of 50×10^{-6} seems to be feasible (Radio Regulations, Geneva, 1959, give 300×10^{-6}) ; the corresponding figures would be about 0·5 MHz and 1 MHz respectively. For the sake of frequency conservation, the channel spacing should be reduced to the minimum practicable.

* This Report was adopted unanimously.

3. Characteristics to be specified

It was agreed that the most suitable form for transmission of the total baseband would be frequency-modulation of the carrier. (Amplitude-modulation, or a different type of modulation, may be chosen by agreement between the Administrations concerned.) Further characteristics to be specified are the frequency deviation, the pre- and de-emphasis and the polarization of radio-frequency signals.

3.1 *Frequency deviation*

In the 400 MHz range, a frequency deviation of 20 to 30 kHz r.m.s. at a modulating frequency of 1 kHz and a level of 0 dBm0 would be suitable. Information is not yet available for the other ranges.

3.2 *Pre-emphasis and de-emphasis*

In the 400 MHz range, pre-emphasis and de-emphasis corresponding to a time constant of $RC = 5$ µs would somewhat improve the signal-to-noise ratio. It was stated, however, that this point would be the subject of agreement between the Administrations concerned.

3.3 *Polarization*

If circumstances should require minimizing the interference to adjacent radio-frequency channel working in a specific station, or to co-channel working in different stations, the polarization of the radio-frequency signals should be chosen by agreement between the Administrations concerned.

REPORT 285-1 *

TRANS-HORIZON RADIO-RELAY SYSTEMS

Transmission, interconnection and interference

(Question 7/IX)

(1963 — 1966)

1. Introduction

This Report is based on consideration of systems with capacities from about 12 to 120 voice channels. Future developments may demonstrate the practicability of systems of greater capacity, but it is felt that limitations of natural phenomena and present technology prevent the compatibility of very wide-band tropospheric-scatter systems with high quality performance.

2. Transmission characteristics

Transmission characteristics can be defined in terms of the amplitude and phase properties of a received signal. Given a tropospheric-scatter path, both amplitude and phase transmission characteristics vary with frequency and time.

Amplitude variations as a function of time and frequency is affected by meteorological phenomena, terrain and other environmental conditions, and by aircraft.

Amplitude variation as a function of time is noted to consist of a rapid variation superimposed on a slow change. Rapid variations, which are basically caused by multipath phase interference phenomena, can be mitigated in many cases by diversity techniques. The effects

* This Report was adopted unanimously.

of slow variations of received power may be minimized through the use of high-power transmitting equipment, high-gain antennae, very low-noise receiving systems, low-loss feeders, adaptive message-loading techniques, and improved detection and other practices for system optimization, which are associated with the choice of radio-frequency carrier, bandwidth and modulation.

Existing trans-horizon radio-relay systems use transmitter powers which (apart from exceptional cases) are of the same order of magnitude for the different frequency ranges. The sensitivity of modern receivers (often using parametric amplifiers) is, to a large extent, independent of the frequency band used.

Variations in received power levels, as a function of carrier-frequency, depend essentially on three phenomena :

— a difference in mean signal-strength as a function of radio-frequency ; for antennae of a given diameter with free-space antenna gains realized and assuming a given total radiated power, the received power is on the average proportional to frequency ;
— the drop in antenna gain ; for an antenna of a given diameter this depends on the frequency ;
— path characteristics, antenna beamwidths and frequency selective fading.

Natural phenomena (such as multipath), causing short-term variations in phase, contribute to short-term variations in amplitude-time and amplitude-frequency as well. The variations in amplitude-time and amplitude-frequency within a narrow band can affect the choice of radio frequencies, the antenna beamwidth and gain, orders of diversity and methods of combining, adaptive message-loading techniques and modulation characteristics, as well as the choice of services to be provided.

Slow fading in adjacent sections of tropospheric scatter radio-relay links may be regarded as being statistically independent. For a single link, the slow variations of thermal noise and FM-FDM intermodulation noise due to multipath phase interference are usually well-correlated and may be regarded as synchronous (see Docs. IX/96 (U.S.S.R.) and IX/97 (U.S.S.R.), 1963-1966).

In fairly common circumstances, phase variations of many radians may be expected over short periods, introducing some frequency-modulation due to propagation alone. Over long periods, the short-term average phase may vary even more, following changes in the dominance of such propagation mechanisms as diffraction, reflection by a single elevated layer or by many layers, forward scatter by layers and by turbulence, and the focusing or defocusing of radio-wave energy by tropospheric ducts.

The higher frequencies are usually preferred for shorter paths, excepting diffraction paths, if antenna size is limited and high information rates are desired. Realization of high antenna gains at the upper frequencies can be impaired by mechanical tolerances and will be reduced somewhat whenever the path antenna gain (see Recommendation 341 and Report 112) depends upon a scatter mechanism of propagation.

The path antenna gain or total effective antenna gain over a tropospheric scatter circuit has been observed, in some experiments, to be practically independent of distance between about 150 and 500 km *. In these experiments, the total effective gain, shown in Fig. 1, may be assumed to depend only on the sum of the free-space antenna gains, without large corrections, provided that neither of the free-space antenna gains exceeds about 50 dB, and the gains of the two antennae do not differ greatly.

* Boithias, L., and Battesti, J. Etude expérimentale de la baisse de gain d'antenne dans les liaisons trans-horizon (Experimental study of the loss in antenna gain on trans-horizon links). *Annales des télécommunications* (September-October, 1964).

The effect of variations of all these three parameters, as a function of frequency for antenna diameters between 3 and 30 m, is shown in Fig. 2.

Fig. 2 represents the relative loss between the terminals of two antennae of the same diameter, located at the two ends of a tropospheric-scatter radio-relay system ; the reference loss (0 dB) is taken as that which exists under the same conditions between two antennae 10 m in diameter at 1000 MHz. As regards the length of the connection, the validity of Fig. 2 is the same as that giving the loss in antenna gain, i.e., the link under consideration is assumed to be between about 150 and 500 km in length.

It can be seen that, for an antenna of given diameter, the relative loss passes through a minimum at a particular frequency and increases on either side ; at the lower frequencies, because the relative dimensions of the antenna measured in wavelengths decrease (with a consequent decrease in free-space gain) and at the upper frequencies, because the drop in antenna gain increases as the free-space gain increases. The optimum operating frequency lies between 300 MHz for an antenna with a diameter of 30 m to 3 GHz for an antenna 3 m in diameter ; however, the minimum is very flat and a frequency departure on either side in the ratio of two is possible without substantially increasing the relative loss.

These curves can be used as a first guide in the selection of the two parameters, carrier frequency and antenna diameter, which provide an economical solution for a given distance. For the final choice, other conditions must be taken into account, for instance, the actual loss of the proposed link and the intermodulation noise power due to multipath propagation, which is assumed to be directly proportional to the fourth power of the antenna beam angle and to the eighth power of the path length (see Doc. IX/94 (U.S.S.R.), 1963-1966). For long links, for which the expected loss is very high, the relative loss should be kept as low as possible ; for this purpose, large antennae and the lower frequency ranges should be used, if there is no contradiction to the considerations of intermodulation noise mentioned above. For shorter links, however, a higher relative loss is acceptable, and smaller antennae used at higher frequencies are usually satisfactory.

The optimum frequency-deviation, corresponding to the lowest total noise power in telephone channels, depends on certain characteristics, some of which are the characteristics of equipment, the path length, the beamwidth of the antenna and the radio-frequency used. In some cases (e.g. for links using a radio-frequency of about 1 GHz or less), the intermodulation noise may be caused mainly by multipath propagation. For this reason, it may be desirable to determine the optimum value of frequency deviation separately for each hop of a trans-horizon radio-relay link (see Doc. IX/232 (U.S.S.R.), 1963-1966).

3. Interference

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, or especially ducting.

To estimate expected co-channel interference, it is necessary to circulate transmission loss by subtracting the path antenna gain G_p given in Fig. 1 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 extra-diffraction transmission loss values result from atmospheric focusing and ducting, either over sea or over land.

Antenna contributions may be analysed in terms of an idealized azimuthal or "keyhole" pattern (see Fig. 3). In this example it is assumed that the antenna gain beyond about the second set of side-lobes does not exceed the equivalent of an isotropic antenna. The two patterns shown are for 2 GHz antennae, 2 m and 15 m in diameter, which are typical sizes for line-of-sight and tropospheric-scatter systems respectively. A compilation of data on various antennae is described in Report 391.

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.

Although it is not possible to recommend final channel arrangements, there is need to select frequencies in an orderly manner on a regional basis. In arriving at such agreements between Administrations, the guide-lines in Recommendation 302 and Report 286 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.

4. Interconnection

4.1 *Interconnection at baseband frequencies*

For interconnection at baseband frequencies, application of Recommendation 380-1 is suggested.

4.2 *Interconnection at intermediate-frequency*

Where interconnection at the intermediate frequency is desired, centre frequency, passband, impedance characteristics, levels, etc. should be specified.

Interconnection at the intermediate frequency is not as appropriate in tropospheric-scatter systems as in line-of-sight radio-relay systems. This is due to the following facts :

- increasing use of frequency compression techniques ;
- limitations imposed by the use of diversity reception, particularly baseband combining ;
- due to the poor carrier-to-noise ratios usually experienced, the deviation for each system is generally chosen as the optimum for that system, rather than using a standardized deviation ; however, interconnection cannot be easily achieved unless all systems use the same deviation ;
- the intermediate-frequency bandwidths, pre-emphasis, etc., are usually chosen as a function of the number of channels actually in use and a compromise is undesirable.

Whereas the above circumstances may not prohibit intermediate-frequency interconnection, its desirability is likely to become marginal in many instances.

Nevertheless, where intermediate-frequency interconnection is desired, for frequency-modulation systems, the centre frequency, the voltage and impedance characteristics should be those specified in Recommendation 403-1.

Note. — The interconnection frequency may be attained by single heterodyning, multiple mixing, multiplication (particularly in frequency compression receivers), a combination of these or similar techniques. Considerations of receiver noise figure and selectivity may also justify using double (or higher order) mixing (see Annex).

4.3 *Interconnection at radio-frequencies*

Interconnection at radio-frequency requires the specification of the carrier frequencies employed, baseband characteristics (such as number and allocation of channels, modulation and demodulation characteristics, pre-emphasis, pilots, channel levels), order and type of diversity and polarization used, antenna characteristics (gain, bearings and polarization), radio-frequency power levels, receiver sensitivities, and system passband characteristics.

For the reasons given under § 4.2, as well as additional reasons (particularly noise, selectivity, and gain), interconnection at radio-frequency within a station is not desirable and there seems no purpose in preparing recommendations for such interconnection. Interconnection at radio-frequency over the air between two stations is nevertheless widely used.

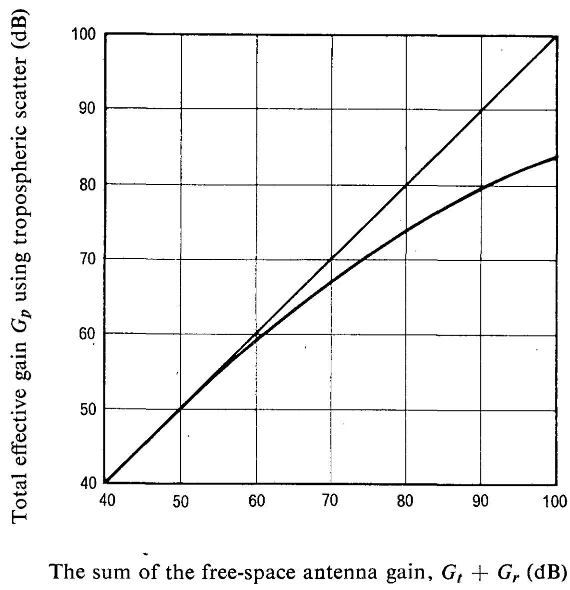

FIGURE 1

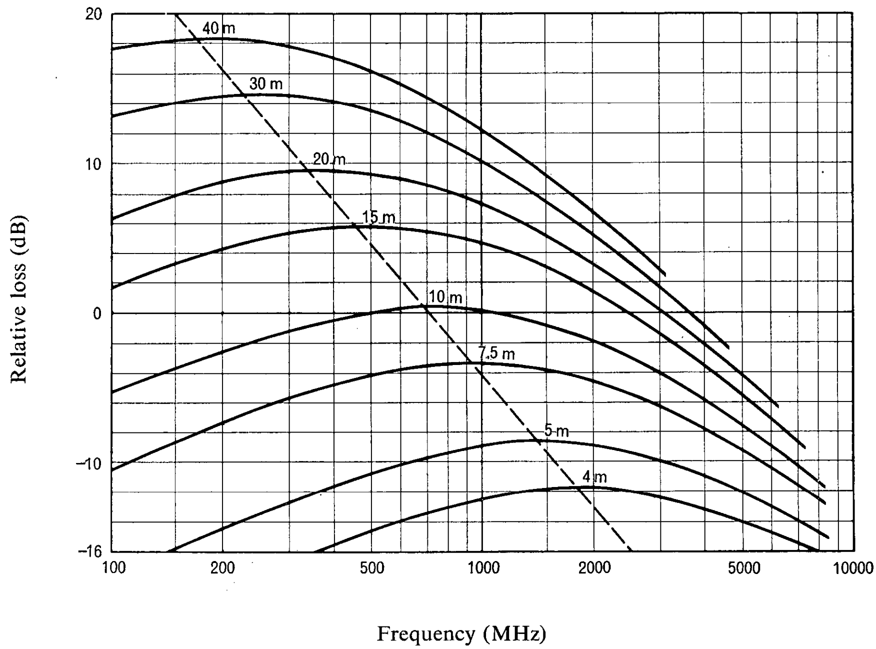

FIGURE 2

Relative loss between antennae of a given diameter

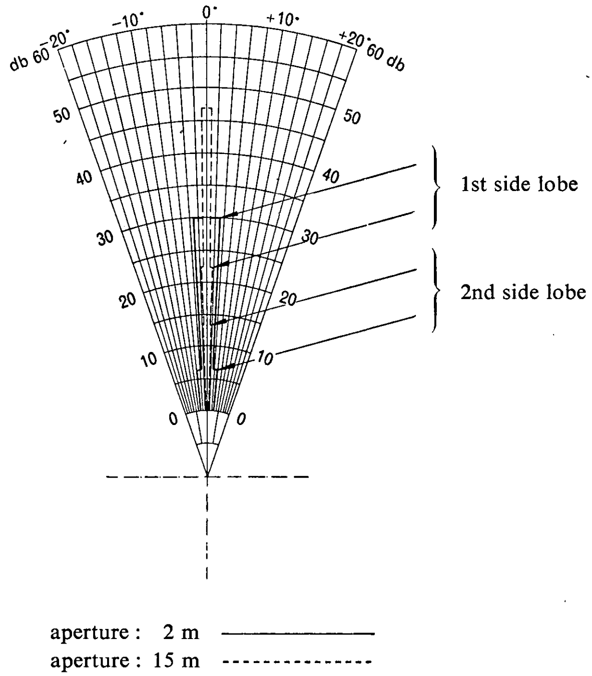

FIGURE 3

Pattern for an ideal parabolic antenna (2 GHz)

ANNEX

THE CHOICE OF INTERMEDIATE FREQUENCIES FOR TRANS-HORIZON RECEIVERS

The following notes concern the choice of intermediate frequencies for trans-horizon receivers of the angular modulation type only. For single-sideband equipment some of the considerations are different and are not considered here.

1. Choice of the first intermediate-frequency

When parametric amplifiers (or other low-noise input circuits) are used, the choice of intermediate frequency has no predominant influence on the noise factor of the receiver.

Otherwise, the choice of intermediate frequency becomes a compromise between the noise factor of the receiver and the radio-frequency filter losses. This may lead to the choice of a lower intermediate frequency than in the first case.

2. Double conversion receivers

In the interest of image rejection, as high a first intermediate-frequency as possible should be used (consistent with noise figure requirements). However, there are a number of reasons why the use of a double conversion receiver is often desirable. These include the following factors :

— the large gain needed in a tropospheric-scatter receiver is sometimes difficult to obtain with only one intermediate-frequency ;
— in a trans-horizon receiver, the intermediate-frequency bandwidth is generally less than in a line-of-sight receiver carrying the same number of channels, to obtain the best compromise between threshold and intermodulation ; hence, rather narrow intermediate-frequency bandwidths may be needed, which can be best obtained at a relatively low frequency ;
— the bandwidth at intermediate-frequency is often varied for different channel capacities to obtain the optimum compromise between threshold and intermodulation in each case. This can most economically be done by making the intermediate-frequency bandwidth suitable for the larger number of channels for which the set is to be used, and inserting a filter for lower capacities. These filters may be built more cheaply for a lower frequency.

In a receiver employing an intermediate-frequency combiner, it is necessary to have a voltage-variable oscillator in one or more of the receivers, which can be used to phase-lock the signals to one another, or to a common standard for effective combining. If this oscillator operates at a frequency below about 100 MHz, the use of relatively simple modulator techniques is possible. It can conveniently be the second local oscillator in a dual conversion receiver.

In a "compression" type of receiver, a dual intermediate-frequency is desirable, to avoid the need for duplicating the microwave local oscillators for space or angle diversity, and is necessary to avoid the application of feedback over too long a loop.

For receivers using "phase lock" detectors, it is desirable to operate the detector at as low a frequency as possible. Although operation at frequencies of the order of 70 MHz is possible, there would be advantages from the receiver design standpoint if they could be operated at lower frequencies. If compression is combined with the phase-lock detector, the use of two intermediate frequencies is mandatory to avoid trying to apply feedback over a long path.

F. 2 : Radio-frequency channel arrangements

REPORT 286 *

TRANS-HORIZON RADIO-RELAY SYSTEMS

Radio-frequency channel arrangements for systems using frequency-modulation

(Study Programme 7A/IX)

(1963)

1. Introduction

Study Programme 7A/IX asks for a study of radio-frequency channel arrangements for trans-horizon radio-relay systems. The studies carried out so far give valuable information on the problems to be taken into account for establishing such a radio-frequency channel arrangement usable over a wide geographical area. The results obtained have made it evident that it is neither possible nor even desirable to fix preferred radio-frequency arrangements for such systems. On the contrary, the maximum amount of flexibility should be maintained in the design of such systems, so that their characteristics can best be adapted to current needs (see Report 285-1).

To simplify the design of equipment and to facilitate its operation, it is, however, desirable that studies of the necessary frequency arrangements in each case should be guided by certain basic rules.

2. Considerations on which a radio-frequency channel arrangement might be based

2.1 The high radiated power of trans-horizon systems and the long range of this propagation method may give rise to serious interference at distances extending beyond national frontiers, for example 1000 km ;

2.2 interference both between and within trans-horizon systems can be minimized by the coordination of radio-frequency channel arrangements over a large geographical area ;

2.3 the presence of high-power transmitters and very sensitive receivers in the same station makes protection against local interference very difficult, and as a result it is necessary to minimize such effects by a carefully planned arrangement of radio frequencies ;

2.4 radio-frequency channel arrangements should provide for various capacities of FDM telephony (e.g. from 12 to 120 telephone channels) and perhaps also for television as appropriate ;

2.5 with the frequency deviations likely to be employed, the bandwidth of emission may range from a fraction of 1 MHz to several MHz (perhaps up to 8 MHz for television) ;

2.6 to avoid undue interference between stations, the minimum distance separating a receiving station from an interfering transmitting station operating on the same frequency, may have to be large, for example 1000 km or more, depending on the power used, the characteristics, orientations and polarizations of the antennae ;

2.7 if it is desired to make interconnections, it is recommended that use be made of the intermediate frequencies 35 and 70 MHz, in conformity with Recommendation 403-1 ; see also Report 285-1 ;

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* This Report, which replaces Report 136, was adopted unanimously.

2.8 it is important that the arrangement used be responsive to all operational requirements ;

2.9 the arrangement used should be amenable to the use of diversity reception. When the system operates in dual-diversity, the avoidance of frequency diversity is recommended, as suggested by Recommendation 302, § 3.
Where frequency diversity must nevertheless be used in each direction of transmission, the diversity frequencies can either be very close together (for example those in adjacent channels), or separated by several tens of MHz. The radio-frequency channel arrangement must be compatible with such requirements ;

2.10 the frequency bands usable by tropospheric-scatter multi-channel radio-relay systems between 100 MHz and 10 GHz have bandwidths ranging from a few MHz to more than 1 GHz. These bands are often taken from those allocated to the fixed and mobile services, according to regional and national regulations. The frequency plan must reflect this situation.

3. General indications to be followed

3.1 An appreciable reduction of the distance envisaged between stations likely to cause mutual interference can generally be realized, on condition that they can be operated on slightly different frequencies, the minimum useful frequency separation being about 0·5 to 1 MHz for narrow-band frequency-modulation systems * as well as for amplitude-modulation single-sideband systems ;

3.2 interference resulting from frequencies produced at a single station (frequencies of transmitters, local oscillators, frequency-changers) is chiefly linked to the choice of intermediate frequency. It is, therefore, not wise to set up a channel arrangement without prior consideration of the value of the intermediate frequencies used.
The most troublesome interference can usually be avoided by choosing a separation between channels, such that the intermediate frequency can never be a multiple of this separation. This rule must be respected, particularly when the effective separations between channels are chosen as appropriate multiples of the unit step between 0·5 and 1 MHz, as proposed in § 3.1 ;

3.3 to apply a single-channel arrangement to several channels of various telephone capacities, a separation between channels in a station can be used which is a multiple of a frequency module. Typically, the radio-frequency channel separation required for 60 and 120 channel systems could be respectively 3 to 5 times that required for 12 to 24 channel systems, the r.m.s. deviations used being chosen in conformity with Recommendation 404-1 ;

3.4 the first channel should be at a minimum distance from the end of the frequency band considered equal to approximately half the channel width ;

3.5 at each station, all transmitting frequencies should be in the same half of the band, and all receiving frequencies in the other half. The role of the two half-bands will be reversed in adjacent stations ;

3.6 to minimize the problem of duplexing, the minimum frequency separation between transmitted and received signals on the same antenna should be of the order of :

— 40 MHz for systems operating at frequencies below 1000 MHz ;
— 80 MHz for systems operating at frequencies above 1000 MHz.

The minimum frequency separation between transmitted and received signals at the same station, but not on the same antenna, should be of the order of :

— 25 MHz for systems operating at frequencies below 1000 MHz ;
— 35 MHz for systems operating at frequencies above 1000 MHz.

Finally, the minimum separation between two transmitting frequencies, or two receiving frequencies at the same station, could be seven times the basic unit referred to in § 3.3 ;

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* Special reference should be made to : MEDHURST, HICKS and GROSSET. Distortion in frequency-division multiplex FM systems due to an interfering carrier. *Proc. I.E.E.* **105**, Part B, 282-292 (May, 1958).

HAMER, R. and ACTON, R. A., Power spectrum of a carrier modulated in phase of frequency by white noise. *Electrical and Radio Engineer* **34**. 246-253 (July, 1957).

3.7 taking account of the great number of usable channels, the variety of situations encountered in actual practice, and to keep the maximum flexibility in the use of frequencies, precise assignment of frequencies for interconnection should be the subject of an agreement between the Administrations concerned.

REPORT 287 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Systems of capacity greater than 1800 telephone channels, or the equivalent

(Study Programme 1A/IX)

(1963)

1. The contributions to the Xth Plenary Assembly in reply to Study Programme 1A/IX, gave details of the work carried out in various countries on the problems of the transmission of very wide-band frequency-modulated radio signals. These contributions lead to the consideration of the feasibility of, and the appropriate characteristics for, radio-relay systems with a capacity of 2700 telephone channels.

The following is a resumé of the contributions submitted to the C.C.I.R. Xth Plenary Assembly.

1.1 Experimental investigations carried out in Italy have shown that radio terminal and repeater equipment of 2700 channels can be realized using well-established techniques. Field tests over a typical radio section 51 km in length over the Po Valley, have shown that distortion from multipath propagation does not appear to be a limiting factor so long as due care is taken in the choice of path length, clearance, etc. The tests indicated that a minimum radio-frequency carrier spacing of 36 MHz (about 3 times the highest baseband frequency), is required with a test-tone deviation of 140 kHz r.m.s. per channel.

1.2 In the Federal Republic of Germany, test transmissions have been carried out over two paths of 44 km and 60 km in length and of different topographical characteristics. In these tests, a 4 GHz test signal frequency-modulated by a 10 MHz sinusoid was employed and the relative phases of the separate beat signals between the upper and lower sidebands and the carrier were compared. The relative amplitudes of the two sidebands were also compared.

Although only limited quantitative data of the disturbing effects were obtained, it was considered that intermodulation noise and variations of the overall gain of a significant amount could occur, unless due care were taken in the topographical planning of radio-relay links of a very high capacity.

1.3 Experience in Japan indicated that equipment for 2700-channel capacity transmissions may be designed using principles already established for lower capacity systems.

Propagation tests have also been carried out which indicate that in such systems high noise levels may be experienced over sea paths about 70-80 km long. However, the probability of occurrence of such distortion is thought likely to be small over land paths less than 50 km in length.

1.4 Work has been carried out in the United Kingdom into the evaluation of intermediate frequency techniques for very large capacity systems. Experiments were carried out using

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* This Report was adopted unanimously.

an intermediate frequency of 210 MHz, as it was considered that the use of an intermediate frequency considerably higher than 70 MHz offered certain advantages for very high capacity systems. Tests showed that an intermediate frequency of 210 MHz was not too high to be practical for radio-relay systems and that the overall linearity of the intermediate-frequency equipment permitted a test-tone deviation of 200 kHz r.m.s. to be used for 2700-channel systems.

In the light of the foregoing, it is essential that the desirable characteristics of 2700-channel systems shall be outlined in order that international standardization shall proceed as far as is reasonable at this stage without being unduly restrictive.

2. Baseband characteristics

To facilitate interconnection of 2700-channel radio systems with 12 MHz coaxial systems, the baseband limits should be in accordance with C.C.I.T.T. Recommendation G.333. Recommendations 380-1, 398-1, 399-1 and 401-1 give provisional values for the input and output levels, baseband limits, continuity pilot frequency and white noise testing requirements for 2700 channels.

The continuity pilot deviation is undetermined, as this is related to the final choice of test-tone deviation.

3. Radio-frequency channel arrangements

Preferred characteristics for a radio-frequency channelling plan for a radio-frequency band 680 MHz wide immediately above 6425 MHz (which is the upper limit of the band planned under Recommendation 383-1), have been determined and these are given in Recommendation 384-1.

A radio-frequency channel spacing of 40 MHz has been selected for the following reasons:

— a second radio-frequency channel arrangement for lower capacity systems may be derived, with 20 MHz channel spacing, which uses the same channel frequencies, together with an interleaved set of frequencies. This second set is suitable for use with an intermediate frequency of 70 MHz, as in Recommendation 403-1, for systems of up to a capacity of 1800 channels;

— it is suitable for use with two alternative values of intermediate frequency (100 and 140 MHz), the respective merits of which are discussed in the following section on intermediate frequency;

— the possibility of interference to radio-relay systems, on parallel or crossing routes using an intermediate frequency of 70 MHz, is greatly reduced;

— the requirements for cross-polarization discrimination between adjacent radio-frequency channels are relaxed and greater freedom is permitted in the choice of test-tone deviation higher than 140 kHz r.m.s.

The preferred association of radio-frequency channels for 2700-channel systems, when common transmit-receive antennae are used, is dependent upon both the choice of relative polarizations and upon the value of intermediate frequency used. In general, it is advisable to avoid transmit-receive channel ferquencies spaced by the intermediate frequency appearing on the same antenna, but this problem has to be weighed against the difficulty of separating the two inner channel frequencies. Considering these factors, suggested polarization arrangements are shown in Fig. 1.

A frequency arrangement for lower capacity systems using a channel spacing of 20 MHz, which employs the same channel frequencies as the arrangement in Fig. 1, is shown in Fig. 2.

The need for an interleaved set of frequencies, displaced by 10 MHz from the main pattern, deserves further study. Such an arrangement might have advantages should a mixed arrangement of 960- and 2700-channel systems be used on the same route.

4. Auxiliary channels

It is customary, in devising radio-frequency channel arrangements for broadband systems, to provide for two pairs of auxiliary channel frequencies and some preliminary examination has been given to this problem. It seems likely that the values $f_0 \pm 3$ and $f_0 \pm 337$ MHz will prove to be the most suitable, although, in certain of the polarization arrangements, great difficulty may be experienced in filtering the two inner auxiliary channel frequencies. The proposed arrangement is included in Fig. 1.

An auxiliary channel arrangement with 20 MHz channel spacing is included in Fig. 2, and the suggested auxiliary channel frequencies are f_0-341, f_0-19, f_0-1 and f_0+321 MHz.

Further study is needed before preferred arrangements can be recommended.

5. Intermediate frequency

It is desirable, when devising radio-frequency channel arrangements for broadband systems, to choose an intermediate frequency which is an odd multiple of half the radio-frequency channel spacing, to minimize interference due to local oscillators. Hence, with an intermediate frequency of 70 MHz, a channel spacing of 20 MHz is satisfactory. In very wideband systems requiring the larger channel spacing of 40 MHz, intermediate frequencies of either 100 or 140 MHz are thought to be most suitable. It is not possible to establish a definite preference for one or other of the values at this stage, but factors involved in the choice are as follows :

— the lower value facilitates the early development of solid state intermediate-frequency equipment ;

— the decreased percentage bandwidth is lower at the higher frequency so that it becomes easier to attain symmetry of the intermediate-frequency passband : nevertheless, circuits are likely to be more stable at the lower frequency ;

— radio-frequency filtration problems tend to be eased when a higher value of intermediate frequency is used.

6. Deviation

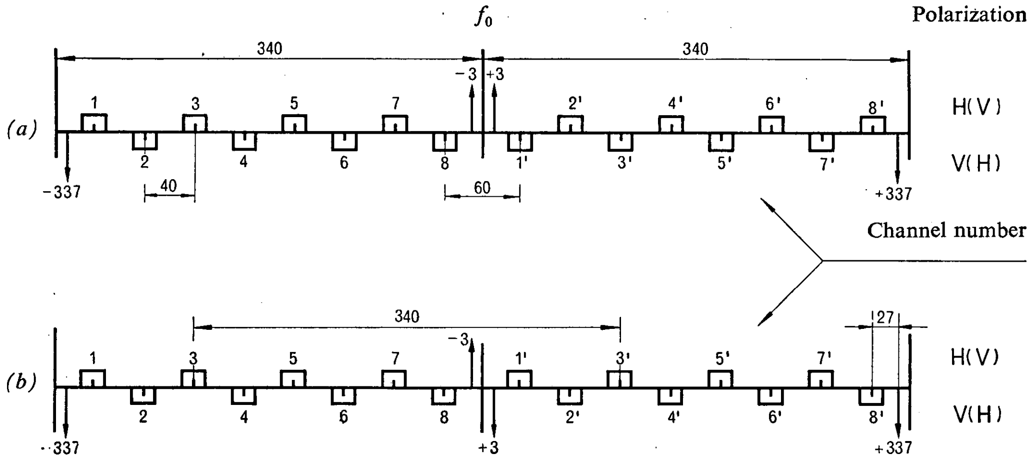
With the rapid development of circuit techniques and components and the dearth of information on the likely contribution to intermodulation distortion due to propagation, it is difficult at this stage to decide on the value of deviation that will give the best balance between thermal and intermodulation noise. It is considered that a value of test-tone deviation between 100 and 200 kHz r.m.s. will prove satisfactory ; it is considered premature to define a preferred pre-emphasis characteristic, although the curve in Recommendation 275-1 should prove a useful starting point.

7. Conclusions

It is desirable, at this stage, to delineate as far as possible the main parameters of a 2700-channel system so that, on the one hand, international standardization will be encouraged but that, on the other hand, the freedom of the designers shall not be unduly restricted. To this end, Recommendation 384 has been prepared, which defines the essential radio-frequency channel characteristics. With regard to the other system parameters, it is proposed that further study should be restricted to the following alternatives and that other values should not be chosen unless there are particularly good reasons for doing so :

— intermediate-frequency : either 100 or 140 MHz ;

— r.m.s. test-tone deviation : either 100 kHz, 140 kHz or 200 kHz.



(a) Arrangement proposed for either :

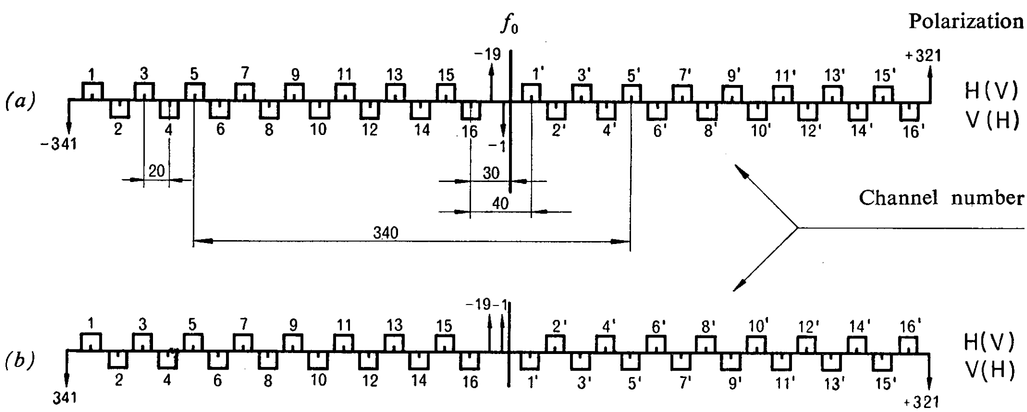
— an antenna with single polarization and an intermediate-frequency of 100 MHz, or
— an antenna with double polarization and an intermediate-frequency of 140 MHz.

(b) Arrangement proposed for either :

— an antenna with single polarization and an intermediate-frequency of 140 MHz, or
— an antenna with double polarization and an intermediate-frequency of 100 MHz.

FIGURE 1

(All frequencies are in MHz)



(a) Arrangement proposed for antennae with single polarization
(b) Arrangement proposed for antennae with double polarization

FIGURE 2

(All frequencies are in MHz)

REPORT 374 *

INTERCONNECTION OF AUXILIARY RADIO-RELAY SYSTEMS OPERATING IN THE SAME FREQUENCY BAND AS THE MAIN RADIO-RELAY SYSTEM

(Recommendation 389)

(1966)

The characteristics set out below are for angular modulation of the auxiliary carrier **.

They are applicable to auxiliary systems associated with main systems of a capacity greater than 300 telephone channels per radio-frequency channel.

1. Characteristics at baseband frequencies

1.1 *Width of baseband*

The baseband can occupy from 300 Hz to 60 kHz.

Several telephone-channels can be set up in this band, the precise arrangement of the channels being a matter for agreement between the Administrations concerned ; in particular, for practical reasons, the voice-frequency telephony channel may be omitted and the baseband can start at 4 kHz.

In accordance with Recommendation 400-1, the telephone channels can be used to provide at least one omnibus speaker circuit and one main (or express) speaker circuit.

The top part of the band can be used for supervisory or high-speed switching signals and for extra telephone channels.

1.2 *Interconnection levels*

1.2.1 *For the omnibus speaker circuit*

Input and output: between −3 and −4·3 dBr.

1.2.2 *For the 4-60 kHz band* (per telephony channel)

Input: −45 dBr;
Output: −15 dBr.

1.3 *Impedances*

1.3.1 *For the omnibus speaker circuit*

600 ohms symmetrical.

1.3.2 *For the baseband* (4-60 kHz)

150 ohms symmetrical.

2. Characteristics at radio-frequencies

2.1 *Modulation characteristics*

Frequency-modulation is used for baseband frequencies above 4 kHz.

Frequency-, phase- or intermediate angular-modulation can be used in the 0·3-4 kHz band; the conditions of interconnection will be determined by agreement between the Administrations concerned.

* This Report was adopted unanimously.

** Some Administrations also use these characteristics for below-baseband transmission on the main radio-relay system. In addition, some Administrations make use of other types of modulation of the carrier.

2.2 *Frequency deviation*

In the baseband frequencies between 4 and 60 kHz, the frequency deviation for a 1 mW signal at a point of zero relative level is 50 kHz (r.m.s.) *.

3. Quality

The mean noise power of any telephony channel up to 280 km in length, which is used for the transmission of auxiliary signals should, whenever possible, not exceed 20 000 pW psophometrically weighted at a point of zero relative level.

(In accordance with Recommendation 400-1.)

4. Continuity pilot

When it proves necessary to use a continuity pilot, its frequency deviation should be 17·5 kHz (r.m.s.).

The frequency of the pilot will be determined by agreement between the Administrations concerned. Frequencies between 4 and 5 kHz are used at present.

Note. — It may be desirable to have a high-speed pilot. Attention is drawn to the fact that there is a relationship between multi-channel switching equipment and control signal distribution.

* The frequency deviation of 35 kHz (r.m.s.) is also used.

F. 3 : Hypothetical reference circuits and noise

REPORT 130 *

RADIO-RELAY SYSTEMS FOR TELEPHONY

Noise tolerable during very short periods of time on line-of-sight systems

(Study Programme 2A/IX)

(1959)

1. Method of speculation

The maximum values of noise in telephone circuits on radio-relay systems should be specified in terms of :

— the mean psophometric noise in an hour ;

— the psophometrically-weighted noise powers, which may be exceeded only for specified small percentages of a month when the fading is severe, measured with an instrument which indicates the mean value over one minute or a quantity approximately equivalent to this value.

2. Time constant

Measurement in terms of the one-minute-mean power is favoured, to facilitate the use of the opinion-rating method of assessing telephone conversations recommended by the C.C.I.T.T. Instruments, having time constants of one minute, are acceptable even though they do not precisely measure one-minute-mean values.

3. Short noise bursts

Information on the performance of line-of-sight radio-relay links suggests, that it is not necessary to specify a limit to the number of high noise bursts of duration exceeding a given value and occurring in a given time, provided that limits are placed on the noise which may be exceeded only for small percentages of a month, and that noise, due to power supplies and switching operations, is excluded. It is desirable to stipulate, in addition, that the link should incorporate some form of diversity reception on sections in which the fading is unusually severe, e.g. due to the use of exceptionally long sections or to reflections from a water surface. The Annex gives some information on noise bursts in one country (United States of America) ; the magnitude and duration of noise bursts in other regions may be somewhat different due to the different meteorological conditions.

4. Traffic loading

It is recognized that the period of worst fading usually occurs at night, while the greatest traffic often occurs during the day. Whether advantage can be taken of this depends on the requirements that the system is intended to satisfy.

* This Report was adopted by correspondence without reservation.

5. Noise in parts of radio links

The noise power during substantial percentages of the time can, without great error, be considered proportional to the length of the circuit, for lengths exceeding about 250 km. There is some reason for assuming that intermodulation noise increases more rapidly with length than does basic noise. Nevertheless, for lengths of circuit exceeding about 250 km, the error in assuming that noise for substantial percentages of time is proportional to length is small, and it is proposed, therefore, to make use of this law of proportionality in C.C.I.R. Recommendations.

When considering very small percentages of time for which high noise values may be exceeded, these percentages can be considered as proportional to circuit length, for lengths of circuit exceeding 250 km, and for values below 0·1% or in some cases below 1%.

The two working rules given above, i.e. linear-power-addition for large percentages of time and linear-percentage-addition for small percentages of time, are somewhat inaccurate between about 0·1% and 10% where the error may in extreme cases amount to 3 or 4 dB. However, the rules are considered to be sufficiently accurate for most purposes. Greater accuracy can be obtained by detailed mathematical treatment which depends upon the particular monthly distribution curves involved. A method of approximation which can give useful accuracy in some cases has been discussed by B. B. Jacobsen (Proc. I.E.E., Part C, March, 1958).

ANNEX

RELATIONSHIP BETWEEN SHORT-TERM AND LONG-TERM NOISE PERFORMANCE IN RADIO-RELAY SYSTEMS IN THE UNITED STATES OF AMERICA

1. The distribution of the duration of deep fades (and hence the resulting noise bursts) at the frequencies used in radio-relay systems appears to be log-normal. Such a distribution may be characterized by:

— its slope or its standard deviation, and

— one point on the curve, such as the median or the average duration.

2. From several series of tests, the standard deviation is approximately $\log_{10} 2{\cdot}7$, and appears to be substantially independent of frequency. This standard deviation has been observed in tests on individual paths and on systems comprising as many as 68 paths in tandem, at different frequencies from 2 to 6 GHz and in different regions, which are subject to different fading influences and on paths with both adequate and inadequate clearance. A somewhat higher standard deviation appears to be associated with inadequate clearance, possibly because of an increased tendency towards obstruction fading.

The average duration is not as closely defined, and appears to be approximately inversely proportional to frequency. That is to say, at a given depth of fade at 2 GHz half as many fades twice as long as at 4 GHz would be expected. The total time of fading would be nearly the same, although this is only approximately true over frequency ranges greater than 2 to 1.

At 4 GHz an average duration of the order of 7 to 9 s has been observed for 30 dB fades and of the order of 4 to 5 s for 40 dB fades, in a limited series of tests on a system composed of 40 km paths.

The duration of fades is approximately inversely proportional to the length of the radio-frequency paths. The data quoted were observed on a system composed of paths approximately 40 km long in the North-eastern United States of America. In other tests on paths approximately 70 km long in the Western United States of America, durations approximately 40-70 times as long were observed.

3. From these points, it is possible to relate the number and duration of the fades to the total time that a given depth of fade is exceeded in a long period of time, such as a month.

4. As a further example, consider a 4 GHz system with parameters such that a 40 dB fade in any one section will cause the noise to exceed a given maximum level. Consider further that each section may be expected to fade 40 dB or more for n seconds during the worst month * and consider that there are N sections in tandem, without diversity, so that the total time that a 40 dB fade will be exceeded somewhere in the system is nN seconds during the worst month.

Note. — The probability that 40 dB fades will occur simultaneously in more than one of the N sections is very small. For shallower fades, such as 20 dB, the probability of simultaneous fades is greater and may be appreciable.

5. From §§ 2 and 4, the system of the example might be expected to experience $nN/4{\cdot}5$ or $0{\cdot}22\ nN$ fades exceeding 40 dB during the worst month. The duration of these fades would be as outlined in § 2.

6. Fading differs from day to day and from hour to hour. The worst day will have more fades than an average day by some variable factor, and the worst hour will have more fades than the average hour by some still more variable factor. In one series of tests on a system 450 km long including 8 paths, the first factor was 6 and the second factor was 60. There is no information for other lengths of system or other numbers of paths.

7. The system of the example might, therefore, be expected to experience

$$\left(\frac{1}{30} \times 6\right) \times 0{\cdot}22\ nN = 0{\cdot}044\ nN$$

fades during the worst day of the worst month, and

$$\left(\frac{1}{30} \times \frac{1}{24} \times 60\right) \times 0{\cdot}22\ nN = 0{\cdot}018\ nN$$

fades during the worst hour of the worst month.

8. If the performance of a specified system is predicted using the methods of the example, it may be found that the performance does not meet the requirements of Recommendation 393-1. This demonstrates the need for avoiding the effects of fading by:

— diversity operation,
— reducing the length of paths or the choice of more favourable sites,
— improving the fading margin by the use of higher power or higher gain antennae where these factors are at the disposal of the system designer.

9. The effects of deep fades may be substantially reduced by the use of some form of diversity reception, such as frequency diversity or space diversity. A limited series of tests has shown that approximately 5% of the total fading time beyond 40 dB cannot be counteracted by frequency diversity of 100 MHz or more by vertical space diversity of 15 m or more at 4 GHz The duration of the residual fades with diversity may be shorter than without diversity, by as much as 50%. No information is available on this point.

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* For the North-eastern United States and for paths about 40 km long, n may be taken as approximately 100. In other areas, and for other lengths of path, different values of n may be appropriate.

10. With the foregoing as guidance as to the probable performance of a system during the worst hour and worst day of the worst month, it is sufficient to define the system by the long-term performance, i.e. the statistical distribution of noise during the worst month.

REPORT 288-1 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Noise in circuits forming part of very long telephone connections

(Study Programme 2B/IX)

(1966)

1. Introduction

This Report is a provisional reply to Study Programme 2B/IX.

The provision of low-noise channels over large capacity systems, designed in accordance with Recommendation 393-1, has been considered in the light of information contributed to Study Group IX and summarized by Joint Special Study Group C (C.C.I.T.T./C.C.I.R).

This reply assumes that the required low-noise channels should have a noise power, excluding the noise from frequency-division multiplex equipment, not worse than one third of the noise power allowed in Recommendation 393-1.

The methods of provision correspond respectively to Study Programme 2B/IX, §§ 1 and 2:

— selection of low-noise channels;
— adaptation of a system to provide low-noise channels.

2. Selection of low-noise channels from large capacity systems designed in accordance with Recommendation 393-1

Traffic and other practical considerations indicate that channel selection should be considered worthwhile, only if at least 10% of the nominal capacity of a system can be made available as low-noise channels.

In the light of the limited documentation available up till now, the indications are that this requirement would not be met in general, but that certain systems might be capable of doing so.

3. Adaptation of large capacity systems designed in accordance with Recommendation 393-1 to provide low-noise channels

Adaptation entails removal of channels from service and/or removing or modifying pre-emphasis characteristics to increase the effective sending level of the low-noise channels.

In a number of radio-relay systems, test results indicate that in the extreme case where the maximum number of low-noise channels is to be derived, some 50%–70% of the original capacity of the system would be sacrificed. In another case, where only 10% of the capacity of a radio-relay system is required as low-noise channels, up to 50% of the original channel capacity would have to be sacrificed. In the latter case, the usable portion of the original

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* This Report was adopted unanimously.

capacity of the system would consist of the 10% low-noise channels and 40% or more as channels giving up to 3 pW/km performance. In between these extreme cases (i.e., when the maximum number of low-noise channels is needed and when 10% of low-noise channels would suffice), intermediate conditions could be realized.

The process of adaptation appears, in the light of present information, to be rather costly from the point of view of baseband utilization.

Note. — A reduction in the amount of baseband equipment used for the transmission of the low-noise circuits would not, by itself, ensure that the required low-noise performance would be met.

The above summary applies when the low-noise circuits are required to contribute not more than one third of the noise power allowed for equipment designed in accordance with Recommendation 393-1.

Study Group IX has considered C.C.I.T.T. Recommendation G.143 and has drawn the conclusion that it would be sufficient if a low-noise circuit were to produce not more than one half of the noise power allowed in Recommendation 393-1, corresponding to not more than 1·5 pW/km (averaged over a long distance). These figures are exclusive of the noise caused by frequency-division multiplex equipment.

For the noise in the multiplex equipment, Joint Special Study Group C has estimated 5000-7000 pW for the international part of the connection which is about 20 000 km long. The multiplex noise therefore would average 0·25-0·35 pW/km over long circuits.

The noise performance required in Recommendation G.143 is 1-2 pW/km, including that in the multiplex equipment and the figure of 1·5 pW/km plus the multiplex noise would result in 1·75-1·85 pW/km, which is well within the requirements of Recommendation G.143.

If this calculation is found acceptable to Joint Special Study Group C, it would appear that the conclusions in the above, regarding the number of normal channels which need to be sacrified to produce low-noise channels, should be reconsidered in terms of the 1·5 pW/km requirement rather than the 1 pW/km requirement.

4. Other ways of obtaining low-noise channels

In the following it will be assumed that a noise contribution, from a radio-relay system, of 1·5 pW/km is an acceptable objective for low-noise circuits and that this objective could be attained.

Joint Special Study Group C has suggested that a new hypothetical reference circuit, as well as new design objectives, could be envisaged for systems planned to give only low-noise channels.

C.C.I.R. Study Group IX has considered the desirability of introducing a further hypothetical reference circuit for low-noise circuits and found that many Administrations would like to avoid the creation of a further hypothetical reference circuit.

The reasons are as follows :

4.1 The performance requirement for low-noise channels differs by only 3 dB from the requirement of Recommendation 393-1 and it seems quite possible to define noise performance adequately without introducing a new hypothetical reference circuit.

4.2 If a new hypothetical reference circuit were introduced, it would lead to design of new types of equipment which would, in general, not be compatible with equipment designed to the existing hypothetical reference circuit.

4.3 It is very desirable to use the smallest possible number of types of equipment in the majority of radio stations.

4.4 It is highly desirable that low-noise systems and normal systems on a route should be capable of sharing protection and reserve circuits. This is readily attained if both systems use equipment designed in accordance with Recommendation 393-1.

In the above, compatibility implies that the two grades of circuit performance are obtainable by the use of the same station sites and antennae and that mutual interference between different radio-frequency channels in the station is not made worse, when equipment providing low-noise performance circuits is introduced. These considerations have led to a strong desire to use the same type of radio-frequency equipment for both grades of service. The low-noise grade of service may then be obtained by using equipment designed in accordance with Recommendation 393-1 at all stations, with, however, minor modifications at stations where the baseband signal is available.

These modifications would comprise:

— reduction in the quantity of circuits and in the baseband frequency range;
— re-adjustment of the frequency deviation per channel (Recommendation 404-1) to a new value to be defined later;
— provision of new pre- and de-emphasis networks appropriate to the new maximum baseband frequency (Recommendation 275-1).

5. Conclusions

In accordance with the above, Study Group IX is of the opinion that, when many low-noise telephone channels are required on a route, they could be provided by using equipment designed in accordance with Recommendation 393-1, but operated differently.

It is proposed to continue this study. This Report should be brought to the notice of Joint Special Study Group C for comment.

REPORT 375 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Noise objectives for programme circuits 2500 km long provided by means of radio-relay systems

(Study Programme 2C/IX)

(1966)

1. Introduction

This Report is a provisional reply to Study Programme 2C/IX. This Study Programme and its Annex were accepted for study by Joint Special Study Group C under its Question 10/C in 1965.

Joint Special Study Group C undertook the necessary coordination with C.C.I.T.T. Study Group XV and also the responsibility for any liaison required with broadcasting organizations.

2. The question was studied at the 1966 meeting of the Joint Study Group, with a view to providing a reply for transmission to C.C.I.R. Study Group IX and the following paragraphs are based on this reply. The noise clauses, given in §§ 4 and 5 below, are acceptable to C.C.I.R. Study Group IX and could be the subject of a future C.C.I.R. recommendation.

The explanatory clause, given in § 3, has been included to clarify the noise clauses.

* This Report was adopted unanimously.

3. Assumptions and terminology

The expression dBm0ps is used to indicate noise levels in a programme circuit, which are psophometrically weighted and measured in decibels relative to 1 mW at a point of zero relative level in that circuit. The C.C.I.T.T. practice is to quote noise level for programme circuits relative to peak programme or "maximum" voltage. The peak programme voltage is defined as the peak voltage of a sinusoidal wave having an r.m.s. value of 2·2 V (across an impedance of 600 ohms) at a point of zero relative level, i.e. a wave having an absolute level of 9 dBm at a point of zero relative level in the programme circuit. The signal-to-weighted noise ratio of 57 dB (see C.C.I.T.T. Recommendation J.21) thus corresponds to a noise level of −48 dBm0ps.

In measuring, or when calculating programme circuit noise, the transmission system should be suitably loaded.

3.1 When the programme circuit is carried on a radio-relay system for telephony, the telephone channel frequency band should be loaded conventionally (see Recommendation 393-1).

3.2 When the programme circuit is carried on a radio-relay system for television, the television channel should be loaded with a conventional signal (which, however, has not yet been defined).

(Special test signals used for the television channel may cause substantial disturbance into an associated programme channel. This might in some circumstances occur at times when the programme channel is in service.)

The problem of television test signals comes within the scope of C.C.I.R. Study Group XI and of the C.M.T.T.

4. Noise in programme circuits set up over radio-relay systems intended for telephony

When programme circuits are set up on radio-relay links in place of telephone channels which conform to the general noise objectives (Recommendation 393-1), the psophometric voltage can be expected to vary with time. The following noise values (psophometric weighting for programme transmissions), for a hypothetical reference circuit of 2500 km, can be deduced from Recommendation 393-1 by making certain assumptions :

TABLE I

	One minute mean value	
	for not more than 20% of a month	for not more than 0·1% of a month
Psophometric power (weighting for programme transmissions)	−44·5 dBm0ps	−37·5 dBm0ps

Note that the noise power is expressed as the mean over one minute and that the noise power in Table I is a consequence of the design of systems to provide telephone channels meeting the clauses in Recommendation 393-1.

The noise values in Table I are not such that the current C.C.I.T.T. noise objective for programme circuits in Recommendation J.21 (−48 dBm0ps) will be satisfied for a 2500 km circuit.

Methods of reducing the noise in this type of programme circuit established on cable circuits or on radio-relay systems, are being studied in C.C.I.T.T. Study Group XV under Questions 7/XV and 9/XV (Use of compandors and other methods).

Programme transmission channels, based on low-noise telephone channels (1·5 pW/km) rather than on normal performance channels, will be studied by Joint Special Study Group C (low-noise channels form the subject of C.C.I.R. Report 288-1).

Note. — The translation of weighted noise in a telephone channel to weighted noise in a programme channel depends on the following factors:

Conversion of telephone weighted noise to unweighted noise in 3·1 kHz bandwidth	+ 2·5 dB
Correction for actual bandwidth 10 kHz	+ 5 dB
Allowance for 1·5 dB loss between programme zero level and telephone zero level at sending end	+ 1·5 dB
Weighting effect for programme transmission	+ 5·5 dB
Improvement due to the use of pre-emphasis of the transmitted programme signals	– 9·0 dB
Total effect	+ 5·5 dB

The total effect figure must be added to the weighted noise in one telephone channel to find the weighted noise in the programme channel.

When the 1 minute mean noise power in a telephone channel is −50 dBm0p, the corresponding noise power in a programme circuit transmitted by the same carrier frequency would be −44·5 dBm0ps. (These figures are assumed each to include an allowance for multiplex equipment.) Table I has been derived on this basis.

5. Programme circuit set up on a sub-carrier of a radio-relay link for television

The noise objectives defined below are a natural extension of the objective for cable systems defined in § (e) 1 of C.C.I.T.T. Recommendation J.21.

This objective applies for programme circuits such as those defined in Recommendation 402 and Reports 289 and 290.

TABLE II

Noise objectives for a 2500 km programme circuit set up by means of a sub-carrier

Weighted noise in a programme circuit (dBm0ps) exceeded for the percentage of any month shown (One-second measurement)		
20%	1%	0·1%
−48	−44	−36

Note that in Table II the noise power is given in terms of one second average. This conforms with Recommendation 289.

F. 4 : Maintenance

REPORT 137-1 *

DURATION OF INTERRUPTIONS ON RADIO LINKS WHEN SWITCHING FROM NORMAL TO STAND-BY EQUIPMENT

(Question 5/IX)

(1959 — 1966)

1. Protection of radio-relay channels against interruptions due either to failure of equipment or to deep fading is usually supplied by automatically switched protection channels. Three main types of automatic switching arrangements are currently in use for the purpose. They are :

1.1 Multi-line switching, in which one protection channel serves two or more normal channels ;

1.2 Single-line switching, in which one protection channel serves one normal channel ;

1.3 Combining, in which the outputs of two parallel channels are combined at baseband or at intermediate frequency.

The requirements for time of operation of the three types differ ; in general, the systems are required to operate as rapidly as developments permit.

2. Two types of interruption are recognized :

2.1 the *transfer time* of the switch element itself, which while operating may introduce a short-circuit, an open-circuit or double transmission, and

2.2 the *operate time* of the entire automatic switching system, from the instant that transmission is degraded sufficiently to make switching necessary to the instant when the quality of service is restored by completion of switching to the protection channel.

The limit for the duration of an interruption of the first type is set by telegraph transmission, where interruptions of less than 1 ms will not cause errors on 50-baud AM or FM-VF (carrier) telegraphy. (It is also necessary to consider the level changes and phase changes associated with switching from one circuit to another, since these also can cause telegraph errors.) There is already a demand for data circuits which operate at much higher speed than 50-baud VF (carrier) telegraphy, and consequently, it is considered desirable to find means of reducing the switching interruption time to considerably below 1 ms.

3. There appears to be no hope of reducing the operate time of the entire switching system to 1 ms. The various components of the total operate time are, for multi-line switching :

* This Report, which was adopted unanimously, does not include interruptions due to power supply failures ; this subject should be studied separately.

3.1 Time of recognition of fade or failure, at receiving end.

3.2 Time to construct a control signal to be sent to the transmitting end.

3.3 Transmission time of control signal to transmitting end.

3.4 Recognition time at transmitting end.

3.5 Bridging time at transmitting end.

3.6 Transmission time of signals over control line to receiving end.

3.7 Time to examine signal received over control line.

3.8 Time to decide whether the switch should be operated.

3.9 Actual switch operation time.

4. By the natural laws of propagation, § 3.3 alone is usually 2 ms or more. Considering all the above items, an objective of 40 ms seems practicable and appears to fulfil the following:

4.1 A barely perceptible interruption to voice.

4.2 A tolerable interruption to television—noticeable, but very seldom causing a failure of field synchronization.

4.3 A noticeable but not severe streak on phototelegraphy.

4.4 No seizure of common equipment in toll-dialling offices.

5. The effect of failures on the operate time of the entire automatic switching system will differ from that of fades. Failures usually interrupt transmission completely and suddenly, and service is not restored until the entire operate time has elapsed. With fading, transmission quality will probably continue to deteriorate but may not completely fail after the instant that request for switching is initiated. If the operate time and the noise level which cause switching to be requested are properly proportioned to the maximum rate of increase in fading loss, it is possible to eliminate transmission errors due to fading. The maximum rate of increase in fading loss on optical paths has been taken conservatively at 100 dB per second, and if the operate time is 40 ms, the fading loss will increase 4 dB during the interval between a request for switching and the completion of switching. If there is at least 4 dB margin between the noise level causing a request for switching and the noise level that would produce transmission errors, no transmission errors will be caused by the fading, provided of course, that transmission over the protection channel is satisfactory so that switching actually takes place.

6. Single-line switching systems and combining systems operate much faster than multi-line switching systems, because the normal and protection channels can be bridged permanently at the transmitting end, so that there is no necessity to originate, transmit and recognize control signals. However, single-line switching systems cannot apparently be made fast enough to eliminate errors in 50-baud telegraph and data transmissions. For these services combining arrangements are preferable.

In some cases, stand-by equipment has been provided which can be switched to replace normal equipment which has failed. Generally, the objective is to complete switching as fast as the state of development permits.

7. In summary, the following design objectives seem feasible at present :

7.1 *Transfer time :* The transfer time of the switching element should not exceed 10 μs for switching at intermediate-frequencies and 2 ms for switching at baseband frequencies.

7.2 *Operate time :* 40 ms, which may cause errors in 50-baud telegraph transmission.

8. In conclusion, the switching systems must be such that interruptions, having the duration of the operate time, occur only in the event of :

8.1 failure of normal equipment ;

and that the duration of the interruption is limited to the transfer time in the two other cases :

8.2 failures in radio propagation ;

8.3 switching from normal to protection equipment for maintenance.

F. 5 : Characteristics

REPORT 289 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred characteristics for the simultaneous transmission of television and a maximum of four sound channels

(Study Programme 3A/IX)

(1963)

1. Introduction

This mode of operation is only intended for systems with a capacity of 1800 telephone channels. In conformity with the decisions of the C.C.I.R. Meeting of Experts, Cannes, 1961, a bandwidth of up to 6 MHz is envisaged for international television transmissions (e.g. Eurovision). As it is desired to make the separation between the highest video frequency and the sound channels sufficiently large, lest the filter necessary between the video and sound signals give rise to undue transients in the video channel, the space available in the baseband spectrum for accommodating the sound carriers is restricted approximately to the band 7 to 8·2 MHz. Only four sound channels of good quality may be accommodated in such a narrow band instead of six.

2. Baseband frequency arrangement for simultaneous transmission of television and four sound channels

2.1 *Frequency position of intermodulation products*

The sub-carriers of the four intended sound channels lie within a frequency octave, which implies they will be free from any quadratic non-linear distortion products. By careful arrangement, the third-power non-linear distortion products due to intermodulation between the sub-carriers, may be positioned off the sub-carrier frequencies, though some of them fall near the upper fringe of the video channel. Care should be taken that the third-power intermodulation product between the lowest sub-carrier and the continuity pilot is sufficiently spaced from a possible colour carrier at 4430 kHz. It is further desirable that the third-order non-linear products between the sub-carriers should not be permitted to coincide with the frequency of the continuity pilot.

2.2 Taking account of considerations of § 2.1, the nominal frequencies for the four sub-carriers might be chosen as follows : 7000, 7360, 7740 and 8140 kHz.

The third-order intermodulation products would, consequently, start at 5860 kHz, the intermodulation product between the lowest sub-carrier on 7000 kHz and the continuity pilot on 9023 kHz would be at 4977 kHz, which is well away from the colour carrier (4430 kHz).

3. Choice of the maximum frequency deviation of the sub-carriers

In § 2.2, an average spacing between the sub-carriers of 380 kHz has been proposed. A convenient choice for the maximum frequency deviation of the sub-carriers would then be ± 100 kHz.

* This Report was adopted unanimously.

4. Choice of the frequency deviation of the intermediate- and radio-frequency carriers produced by the sub-carriers

When choosing the frequency deviation of the main carrier frequency, account should be taken of the three main sources of noise :

— thermal noise,
— non-linear products falling into video channels,
— non-linear products falling into the sound channels.

As regards thermal noise, it will suffice to obtain a performance that is 12 dB better than that for telephone channels equipped for long-distance operation. The improvement can be obtained by the use of a maximum signal deviation of the sub-carriers of ± 100 kHz, as proposed in § 3. It will then be more than sufficient, if the main carrier frequency deviation due to one sub-carrier is made equal to the nominal frequency deviation of a telephone channel occupying the same position in the baseband, taking into account the use of pre-emphasis.

It seems, however, that this value of deviation would fall somewhat short in respect to the intermodulation noise into the sound channel ; this statement is based on experience with a sound channel in accordance with Recommendation 402 ; this applies still more to the present case, since the frequency deviation in § 3 above is smaller by a factor of 2 than the corresponding frequency deviation given in Recommendation 402.

In consequence, proposals for the frequency deviation of the main-carrier, would first require that values be specified for the deviation and pre-emphasis of the video signal. It has been suggested that the same pre-emphasis be used for systems designed for the simultaneous transmission of television and 600 telephone channels, or for television and several sound channels, as is used for systems loaded with 1800 telephone channels. A frequency deviation for television has been proposed which has, at the lower frequencies, the same value as that given in Recommendation 405. This results in a deviation at the highest video frequencies which is somewhat lower than that given in Recommendation 405 with pre-emphasis.

On the basis of the above assumptions, a provisional value for the main carrier-frequency deviation is proposed which is 3 dB larger than the nominal deviation for a telephone channel in the same baseband position. In this proposal, note has been taken of the fact that a system with a capacity of 1800 telephone channels must be more highly linear than a 960-channel system.

With the four sub-carriers and the television signal, the most pessimistic addition of the instantaneous peak frequency deviations gives ± 3·8 MHz, while for a 1800-channel telephone system, the corresponding figure is ± 6·2 MHz.

5. Characteristics of the multiplex equipment

The sub-carrier modulators and the network combining the sub-carriers with the video signal should be separate from the 1800 channel radio-relay equipment. The question remains to be studied, how to design the filters necessary for the separation of the video signal and the sound channels, to conform to all pertinent recommendations for television and sound channels of both the C.C.I.T.T. and the C.C.I.R.

6. Conclusions

The following transmission characteristics should be studied as preferred values :

6.1 Frequencies of the sub-carriers : 7000, 7360, 7740 and 8140 kHz.

6.2 Maximum audio signal at a point of zero relative level + 9 dB relative to 0·775 V r.m.s.

Note. — C.C.I.T.T. Recommendation J.12 (Vol. III), Fig. 77 defines the input and output levels for an international programme line and for an international programme link. It is the responsibility of the Administrations to choose the appropriate value for their special use.

6.3 Audio bandwidth : 30 to 10 000 Hz (the upper limit may be increased, should there be evidence of need).

6.4 Maximum signal deviation of sub-carrier frequency : ± 100 kHz for the level defined in § 6.2.

6.5 Pre-emphasis in the sound channel needs further study.

6.6 Main carrier-frequency deviation due to each of the four sub-carrier frequencies should be that corresponding to a power of + 3 dBm0 in a telephone channel with the same baseband position, taking into account the use of pre-emphasis.

REPORT 290 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred characteristics for the transmission of up to six sound channels

(Study Programme 3A/IX)

(1963)

1. Choice of a multiplex system for the transmission of several sound channels over a radio-relay channel

The work carried out within the scope of Study Programme 3A/IX should, for the time being, be confined to systems employing frequency-modulated sub-carriers.

2. Alternative use of a radio-relay system for the transmission of up to six sound channels

For the transmission of up to six sound channels on a radio-frequency carrier according to Study Programme 3A/IX, two different solutions have been taken into consideration, as follows :

2.1 the use of a radio-relay system with a capacity of 960 or 600 telephone channels or less ;

2.2 the use of a radio-relay system with a capacity of 1800 telephone channels, or the equivalent.

While the variant given in § 2.1 proves to be rather advantageous in respect of frequency economy, that in § 2.2 allows for a simple separation of the channels.

3. Alternative use of a radio-relay system with a capacity of 960 or 600 telephone channels or less

For the transmission of six sound channels on a radio-frequency carrier, it is not necessary to use wide-band systems with a capacity of 960 or 600 telephone channels ; a baseband approximately 1·5 MHz wide, as is found in radio-relay systems with a capacity of 300 telephone-channels, would be sufficient. An added advantage would accrue, if the sound channel sub-carriers were placed in the baseband at frequencies below 1·5 MHz, because in this case, large phase-shifts can be obtained at moderate frequency-shifts tending to a favourable signal-to-noise ratio. If it is nevertheless intended to transmit the six sound channels over a system with a capacity of 960 telephone channels, the same design parameters may be used.

* This Report was adopted unanimously.

3.1 *Channel arrangement in the baseband for the transmission of six programmes*

According to Recommendation 380-1, the baseband of a 300-channel system occupies a frequency band of 60 to 1300 kHz. The frequency of the continuity pilot is given by Recommendation 401-1 as 1499 kHz. It seems readily feasible therefore to accommodate six broadcast sound channels in the given baseband.

It is desirable to so distribute the sub-carriers in the sub-band that the quadratic and cubic harmonic distortion products fall into the gaps between the sub-carriers.

The following values are proposed when choosing sub-carriers :

90 ; 370 ; 610 ; 810 ; 1030 and 1290 kHz.

With this arrangement, we attain a minimum separation of 20 kHz between third-order interference products produced by intermodulation of the sub-carriers and a carrier, and a minimum separation of 50 kHz between second-order interference products and a carrier. These values refer to the nominal values of the sub-carriers.

3.2 *Primary deviation for the sub-carriers*

A spacing of approximately 200 kHz is proposed for the sub-carriers. The primary deviation of the sub-carriers should be :

50 $kHz_{o\text{-}p}$ for the two lower carriers and

70 $kHz_{o\text{-}p}$ for the four upper carriers.

3.3 *Secondary deviation for the sub-carriers*

The overall deviation for six sound channels should not exceed, or if possible, should be less than the peak deviation occurring when the radio-relay system is loaded with 300 telephone channels. The deviation at peak loading is 4 $MHz_{o\text{-}p}$ according to page 53 of the C.C.I.T.T. Vol. III, and the channel deviation is 200 kHz r.m.s. according to Recommendation 404-1.

It should now be examined whether it seems practicable to use the full peak deviation of 4 $MHz_{o\text{-}p}$, taking into account a deviation of 100 kHz r.m.s. for the continuity pilot (Recommendation 401-1).

Using the parameters proposed in §§ 3.1 and 3.2, calculations show that to suppress the thermal noise, an overall deviation of 1·7 MHz would suffice ; corresponding to a single sound channel deviation of 200 kHz r.m.s. By choosing low values of channel deviations, intermodulation between the six sub-carriers can be held to a minimum. Since with the sub-carriers positioned as given above, only third-power intermodulation products might give rise to trouble, these will be decreased by 2×6 dB if, as proposed above, the frequency deviation is lowered from 34 to 17 $MHz_{o\text{-}p}$.

In the calculation of the signal-to-noise ratio, it is assumed that the six sub-carriers in the baseband have all the same level and that a pre-emphasis, according to Recommendation 275-1 for 300 telephone channels, is used in the radio-relay equipment. This proposal to use the same pre-emphasis as in telephone transmission, is of advantage in that it provides for nearly the same transmission quality in the six sound channels and in that it makes at the same time for a very simple switching technique from operation to reserve channel.

As has been mentioned above, basically the same parameter may be used in systems with a capacity of 960 telephone channels. In this case it is, however, proposed to use also the pre-emphasis of these systems for telephone transmission and to choose appropriate levels of the sub-carriers in the baseband, so that the secondary frequency deviation per sub-carrier corresponds to the frequency deviation per telephone channel in the same portion of the channel frequency pattern.

From the considerations given above, the secondary mean frequency deviation for any of the six sub-carriers will be 200 kHz r.m.s., i.e. the same deviation as per telephone channel.

The transmission of broadcast sound channels requires a signal-to-noise ratio approximately 12 dB better than for telephone transmission. The necessary improvement in signal-to-noise ratio may be obtained by choosing an appropriate value for the primary frequency deviation.

The test methods for programme transmissions, according to the procedure discussed above should still be studied with a view to defining exactly the conditions on which the desired transmission quality is attainable. Study of the questions dealt with should be continued in the light of these considerations.

3.4 *Levels in the baseband of the radio-relay equipment*

Pending future decisions, the levels and impedances in the baseband should be those given in Recommendation 380-1 for systems with a capacity of 300, 600 or 960 telephone channels, even if such systems carry several broadcast sound channels instead of telephony. Thus, no difficulties would arise when switching from normal to reserve channels, at the same time making for a more uniform design of radio-relay equipment.

3.5 *Parameters for the sound channel multiplex equipment*

The translation of, say, six broadcast sound channels (audio) into the baseband, by means of six frequency-modulated sub-carriers is not a task for the radio-relay system proper, which, e.g. as regards switching technique from normal to reserve, is not affected by the addition of the multiplexing equipment. Translation into the baseband must be effected in special modulators. If the characteristics for such baseband multiplex equipment were standardized on the lines set forth above, international connection would be feasible without affecting the present recommendations for radio-relay systems as regards switching from normal to reserve channels.

At the audio side, the characteristics of the multiplex equipment should be matched to Recommendations of the C.C.I.T.T. for music lines, and at the baseband side, they should be matched to the baseband characteristics of radio-relay systems.

4. Alternative use of a radio-relay system with a capacity of 1800 telephone channels, or the equivalent

The use of a radio-relay system specialized for television, with a video bandwidth of 10 MHz in accordance with Recommendation 270, is envisaged for the transmission of six high-quality sound channels, when these channels are to be operated over the same route as one or several television channels.

The solution adopted by the French Administration in this case is explained in the following sub-paragraphs.

4.1 *Channel arrangement in the baseband for the transmission of six sound channels*

The bandwidth being sufficiently large, it will be possible to arrange the sub-carrier within a frequency octave. With this arrangement, the second-order intermodulation products fall outside the band used. Effects of third-order intermodulation products are eliminated by an appropriate arrangement of the sub-carrier frequencies.

The frequencies of the sub-carriers are chosen as :

4260, 4940, 5600, 6290, 7010 and 7760 kHz.

4.2 *Primary deviation for the sub-carriers*

The frequency spacing between the sub-carriers being 700 kHz, the large primary deviation of these sub-carriers can be chosen without regard to any interference which might arise in the adjacent channels.

A deviation of 70 kHz r.m.s. is used with a pre-emphasis which increases the relative level of the higher frequencies without noticeably decreasing the lower frequencies ; the use of such a pre-emphasis results in good protection against the different sources of noise.

To simplify matters, the pre-emphasis characteristic adopted is that used in frequency modulation on VHF broadcasting transmitters. It is defined by Recommendation 412 for an RC-circuit with a time constant of 50 μs (75 μs in Canada and the U.S.A.).

TABLE I

Characteristics	Variant § 2·1	Variant § 2·2
Modulation system	FM-FM	FM-FM
Frequency positions of the sub-carriers (kHz)	90, 370, 610, 810, 1030, 1290	4260, 4940, 5600, 6290, 7010, 7760
Nominal input impedance of the audio channel (Ω, balanced)	600	1500
Maximum audio signal (1) at a point of zero relative level (2) (dB rel. 0·775 volts r.m.s.)	+ 9	+ 9 (in 600 Ω)
Audio bandwith (Hz)	30 to 10 000 (3)	40 to 15 000
Deviation of sub-carriers (kHz r.m.s.) for a sinusoidal tone at maximum level given above	50	70 (at 800 Hz)
Pre-emphasis (μs) in the audio channel	50 (4) (75 in Canada and the U.S.A.)	50 (5) (75 in Canada and the U.S.A.)
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 carriers of : (mean value, kHz r.m.s.)	200	600

(1) The input and output levels for an international programme line and an international programme link are defined by the C.C.I.T.T. It is the responsibility of Administrations to choose the appropriate value for their special use.

(2) See C.C.I.T.T. Recommendation J. 13 (Vol. III), Fig. 77.

(3) The upper limit may be increased, should there be evidence of need.

(4) According to Recommendation 412, the reference frequency for the nominal deviation is still under study.

(5) According to Recommendation 412, the relative deviation of 0 dB corresponds to a frquency of 800 Hz.

4.3 *Secondary deviation of the main carrier for each sub-carrier*

The peak-to-peak frequency excursion being limited to about 10 MHz and taking into account the pre-emphasis in the baseband transmission (Recommendation 405), the r.m.s. value of the deviation for each sub-carrier (non-modulated) is about 600 kHz.

4.4 *Interconnection at baseband frequencies*

The characteristics for interconnection at baseband frequencies have been chosen such as to enable the multiplex signal to be transmitted over a radio-relay system in accordance with Recommendation 270. This arrangement makes for identical transmission characteristics in all channels, each of them being capable to serve as spare channel for any other without regard to baseband loading.

The multiplex equipment is foreign to the radio equipment proper : and the interconnection characteristics of the sound channel modulation conform to the C.C.I.T.T. Recommendations.

5. Comparison of the two variants

The basic characteristics of the two variants in §§ 2.1 and 2.2 are given in Table I.

REPORT 376 *

DIVERSITY TECHNIQUES FOR RADIO-RELAY SYSTEMS

(Question 13/IX)

(1966)

1. Introduction

Most radio-relay systems are affected at times by short-term rapid multipath fading characterized by amplitude-frequency, amplitude-time variations as well as by associated phase-frequency and phase-time fluctuations. It is also well known from theory as well as experiment that such fluctuations depend on the geometric properties of the path including the location of the antenna and the angle of arrival. Such fluctuations have effects on the transmitted passband, limiting both information bandwidth and quality. Most trans-horizon and some line-of-sight systems have therefore been designed to minimize the deleterious effects of such fluctuations by making use of the partially correlated properties of the transmitted signal through diversity reception and/or transmission.

2. Methods of obtaining diversity signals

2.1 *General*

The most commonly used methods have been frequency and space diversity, i.e., simultaneous transmission of the same signal over two or more channels (frequency diversity) and utilizing two (or more) antennae for reception and/or transmission (space diversity). Some operational systems have used a combination of frequency and space diversity.

Diversity reception, making use of the relatively uncorrelative properties of the direction of arrival, has been demonstrated to be beneficial in minimizing not only the rapid-fading problem, but also in lessening antenna-to-medium coupling loss [1].

Since diversity reception hinges on the reception of partially correlated signals, the necessary displacement in space (including angle of arrival) frequency and/or time to achieve such benefits, is obviously of great importance.

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* This Report was adopted unanimously.

In examining the literature, one finds that the majority of theoretical papers (particularly early ones) calculate diversity benefits predicated on completely uncorrelated (zero correlation coefficient) amplitude distributions. In practice, however, one often cannot achieve correlations of a very low order. Fortunately, to realize substantial operational benefits from diversity reception [2, 3], low orders of correlation coefficient are not required.

2.2 *Space diversity in tropospheric-scatter systems*

For space diversity, the theoretical diversity distances have been examined [4, 5], in terms of the horizontal correlation distance D_h normal to the path, the horizontal correlation distance D_a parallel to (along) the path and the vertical correlation distance D_v. D_h is the parameter most often utilized, expressed as

$$D_h = 3\,\lambda\, a/4d$$

where d is the path distance, a is the equivalent radius of the earth and λ is the wavelength. Many tropospheric-scatter systems have been installed utilizing $D_h = 100\,\lambda$.

2.3 *Frequency diversity in tropospheric-scatter systems*

The frequency correlation coefficient between the envelopes of two signals has been found theoretically [6] to be

$$\rho\,(f_2 - f_1) = \exp\,[-\,(2\,\pi\sigma)^2\,(f_2 - f_1)^2],$$

where $\sigma = 2\,l.\,\dfrac{\sin\theta/2}{c}$, where c = the velocity of light, θ = the angle of scatter, l is the standard deviation of each dimension of the scatter volume (assuming three dimensional rectangular coordinates) ; l is a function of geometric and radiometeorological parameters.

The subject of frequency correlation has received more experimental attention than space correlation. Frequency correlation is important both in assessing bandwidth capability and as a design parameter for frequency-diversity systems. The minimum necessary frequency-separation depends on the beamwidth of the antennae and the length of the path. According to [7], a frequency separation of 3 MHz was adequate to produce a correlation coefficient of 0·6 or less on 226 km and 345 km paths at either 600 or 2120 MHz, using a 10 m antenna for transmitting and a 3 m antenna for reception. This seems to be in agreement with [10], although [18] indicates considerable variance.

2.4 *Line-of-sight and diffraction paths*

Engineering methods for diversity design [32] have been developed in Japan for line-of-sight and knife-edge diffraction radio-relay systems. For atmospheric fading within the line-of-sight, space and frequency correlation coefficients were studied, the former being given by the semi-empirical formula :

$$\rho_s = \exp\left[-\;0{\cdot}0021\,\Delta h\, f \sqrt{0{\cdot}4\,d}\,\right]$$

where Δh is the vertical antenna spacing in metres, f is the frequency in GHz and d is the path length in kilometres. For knife-edge diffraction paths, system parameters are given which should enable an effective reduction of intermodulation noise due to multipath propagation, and also due to deep fading, to be achieved. These methods of design have been verified experimentally and are now in use.

2.5 *Further remarks*

The employment of time diversity hinges on the acceptability of non-real-time (such as store and forward) transmission, as well as on the fact that trans-horizon signals do indeed fade relatively rapidly. In variable information-rate systems, information to be transmitted is withheld (or rejected) during weak-signal and released (or accepted) during strong-signal conditions. The average rate then depends on the relative times of transmission and pause.

Variable information rate systems depend on having a return signalling path, hence the rapidity of switching (and thus of unmutilated data) is limited by the round-trip transmission time (plus equipment factors). Interruption time is limited by the minimum rate of fading. This type of arrangement is potentially beneficial if space and spectrum considerations limit the practicality of frequency or space diversity.

3. Methods of combining [2, 20]

3.1 *Arrangements*

Several different arrangements have been used. The most straight-forward is common with trans-horizon paths, usually involving two or four similar signals combined to form one as in Fig. 1 (*a*). For line-of-sight links, it is more common to use only one or two protection channels with four or six normal channels as in Fig. 1 (*b*). A method [32] has been reported for line-of-sight combining of four radio-frequency channels using one pilot and one combiner as in Fig. 1 (*c*).

3.2 *Operating frequency of the combiners*

Combiners are in use at radio-, intermediate- and baseband-frequencies. The radio-frequency combiner [32, 33] is usually mechanical and well-suited to the slow changes which occur over a line-of-sight sea path. Predetection combining [12, 16] has also been reported at intermediate frequency for tropospheric scatter, with enhanced carrier-to-noise ratio prior to the detection, and accompanying enhanced system availability. This is the only sort of combining that can be used at a heterodyne repeater if the through signal is to benefit. In FM systems, combining after detection is also used.

3.3 *Types of combiner*

The types of combiner operating after demodulation are, in order of decreasing efficiency, maximal-ratio, equal-gain and selector.

For maximal-ratio combining, it has been shown that for FM systems in the case of dual diversity, the mean thermal-noise power is 1·6 dB below the median without diversity, provided that the signal level for each receiver does not go below threshold more than approximately 5% of the time. With quadruple diversity, the corresponding values were 6·4 dB and 35% of the time [11].

Equal-gain combining can result in equipment and maintenance simplification over maximal-ratio combining [2], at only a modest sacrifice (approximately 1 dB for quadruple diversity) in performance. A further narrowing of this gap can be achieved by combining equal-gain with selector diversity-combiners, see Fig. 2. With equal-gain combining, if the signal levels differ greatly, a receiver in a weak signal leg can actually degrade overall performance so that normal equal-gain combining may not be preferred for television transmission. Switched off, however, an overall performance, closely approximating the ideal maximal ratio, can be demonstrated under relatively easy conditions of design tolerance.

4. Considerations of transmission bandwidth

In estimating the effects of diversity on transmission bandwidth and quality, it is convenient to characterise the transmission system by a network having amplitude/frequency and phase/frequency characteristics which vary in a random manner with time.

A theoretical evaluation of passband amplitude can be made by assuming a Rayleigh distribution of the signal amplitude, z, at the edge of the passband relative to a constant value Z. For non-diversity reception (from [13] and [14]), the probability of $z < Z$ is:

$$P(z < Z) = 1 - \left\{ (1 - Z^2) \left[(1 + Z^2)^2 - 4 r Z^2 \right]^{\frac{-1}{2}} \right\}$$

where $r = \exp - [\Delta f / \Delta f_0]^2$, the bandwidth correlation factor,

Δf = the bandwidth,

$\Delta f_0 = ac/d^2\alpha$, the correlation passband,

c = the velocity of light,

a = the effective radius of the earth,

d = the path length,

α = the beamwidth of the antenna at the half-power points.

For diversity reception of order N, the probability of $z < Z \; P_N$:

$$P_N(z < Z) = \Phi \left[(\pi N)^{\frac{1}{2}} (4 - \pi)^{\frac{-1}{2}} \right] - \Phi \left[(\pi N)^{\frac{1}{2}} (4 - \pi)^{\frac{-1}{2}} (1 - Z)(Z^2 - 2rZ + 1)^{\frac{-1}{2}} \right]$$

where $\Phi[y] = \left(2/\sqrt{2\pi}\right) \int_0^y \exp\left(-t^2/2\right) dt$, the error function.

Measurements to verify the theoretical work have been reported in [15]. In the experiment, for $\Delta f = 0{\cdot}5$ MHz, $z < 0{\cdot}7$ for 30% of the time without and 3% of the time with (dual) diversity. Higher orders of diversity are expected to demonstrate additional improvements.

For systems using frequency-division multiplex, the behaviour in the passband of the transmission path can result in the production of intermodulation noise in the transmitted telephone channels [8, 21, 35]. This noise varies with time and often results in noise spikes. It has been shown that the use of diversity can reduce the probability of occurrence of such intermodulation noise spikes.

A comparison of calculated and measured intermodulation noise caused by multipath propagation [8] showed a satisfactory agreement. The measurements were made on the tropospheric-scatter path, the length of which was 303 km with antenna beam-angle of 1°.

The r.m.s. frequency deviation per channel was 100 kHz (for 800 Hz at a point of zero relative level), pre-emphasis in accordance with Recommendation 275-1. The system was loaded with 12-252 kHz white noise in accordance with Recommendation 399-1. Dual-diversity reception with predetection combining was used as well as non-diversity reception.

The intermodulation noise power, due to multipath propagation measured in the telephone channel at 275 kHz at a point of zero relative level, exceeded the following values:

for 20% of measurement time :

3500-5500 pW (non diversity reception),
1000-2500 pW (dual diversity) ;

for 2% of measurement time :

20 000-50 000 pW (non diversity),
10 000 pW (dual diversity).

5. Performance calculations

A large number of papers have included methods and results of various types of performance calculation. In addition to those already cited, the following may be found useful :

— for partially-correlated signals [17, 28],
— for unequal signals [29, 30],
— for outages and telegraph errors [23, 24],
— for tandem-link calculation for line-of-sight systems [34],
— for tandem link calculations for tropospheric-scatter systems [36, 37, 38].

6. Conclusions

Generally, for real-time transmission, space diversity, aided if necessary by polarization discrimination, requires the least spectrum space (for tropospheric-scatter radio-relay systems see Recommendation 302, §§ 2 and 3). Frequency diversity may show advantages in economy and space.

Time diversity may be of interest when real-time transmission is not a requirement and if space and spectrum considerations are important.

Variable information rate systems (a form of time diversity) are of interest where the inquiry and return time delay (approximately 0·66 μs per km of path length for propagation only) is acceptable.

The last two methods may be applied in addition to space or frequency diversity on specific information channels.

Not only can diversity produce improvements in the reliability of trans-horizon systems, but it can also improve the passband amplitude characteristics and, in systems using frequency-division multiplex, intermodulation noise.

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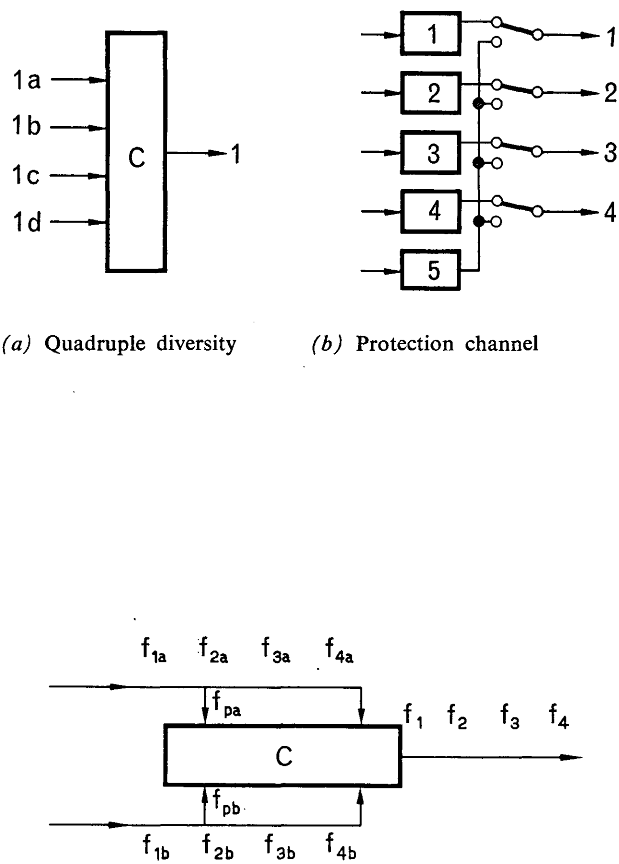

(a) Quadruple diversity *(b)* Protection channel

(c) Several radio-frequency channels on one control system

FIGURE 1

Arrangements for diversity combining

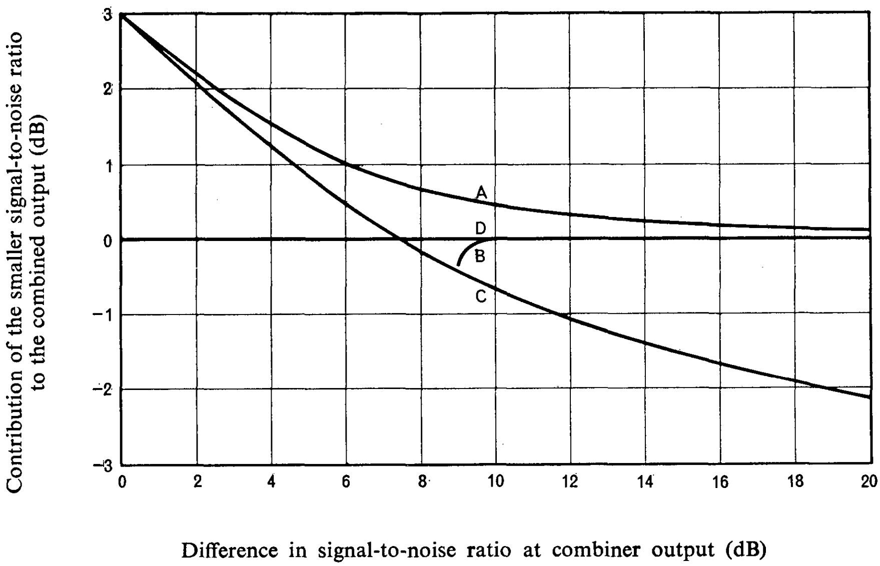

FIGURE 2

Instantaneous addition of signal and noise in dual-diversity combiner

Curve A : maximal ratio
Curve B : equal gain/switch
Curve C : equal gain
Curve D : switch

REPORT 377 *

TRANS-HORIZON RADIO-RELAY SYSTEMS

Preferred characteristics, permissible noise and signal distortion for the transmission of monochrome television signals

(Question 14/IX)

(1966)

1. Introduction

Exploitation of trans-horizon systems for the transmission of wideband channels including television, has been under extensive investigation, both theoretically and experimentally, by a number of organizations in the United States, U.S.S.R., France, etc.

The bulk of analytical study in this area relates to the base bandwidth capabilities for FDM-FM transmission of voice channels, rather than to television transmission.

This Report summarizes the contributions to the C.C.I.R. XIth Plenary Assembly on the subject of the transmission of television over trans-horizon systems, and includes a bibliography.

2. Experimental results

Experimental results indicate that successful transmission of television pictures is possible on paths about 300 km over water and about 240 km over land, using 10 kW transmitter power, 18 m diameter antennae, dual diversity and a carrier frequency in the 1 GHz range; but that performance meeting Recommendation 421-1 has not yet been achieved.

Thermal noise in the video channel and distortion of the video signal and synchronizing pulses have been studied in one experiment. Results indicate that due to the effect of multipath propagation in trans-horizon systems the wave-form distortion, as well as the signal-to-noise ratio, should be considered statistically; also that at least dual-diversity reception is required for acceptable performance.

For the transmission of the sound signal, FDM-FM transmission has been used in the past in separate radio channels but a recent experiment using TDM-FM in the same radio channel as the video signal indicates that this method may also give an acceptable performance.

3. Conclusions

Transmission of television signals and sound over trans-horizon radio-relay systems is possible over paths of length up to about 250-300 km, but the performance criteria stated in Recommendations 421-1 and 289 have not yet been achieved.

It is believed that the use of higher frequencies (4 GHz or above), larger antennae and higher orders of diversity may enable a higher quality of transmission to be achieved.

This question needs further study.

* This Report was adopted unanimously.

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REPORT 378 *

RADIO-RELAY SYSTEMS FOR THE TRANSMISSION OF PULSE-CODE MODULATION AND OTHER TYPES OF DIGITAL SIGNAL

(Question 12/IX)

(1966)

1. Study Group IX has briefly reviewed this question and two contributions which have been submitted (see Docs. IX/198 and IX/207, 1963-1966).

It is realised that, before study of this question can proceed much further, it is necessary to obtain information from the C.C.I.T.T. about certain essential parameters of any PCM systems which they have studied or will study during the next C.C.I.R. study period.

The C.C.I.R. Recommendations for radio-relay systems using frequency-division multiplex apply to baseband arrangements which have been recommended by the C.C.I.T.T. and Recommendation 380-1 deals with interconnection at baseband frequencies.

Question 12/IX, § 1 recognizes the need for study of the baseband characteristics for interconnection of radio-relay systems with cable systems designed for the transmission of PCM or other types of digital signal, and it might be expected that eventually there must be a C.C.I.R. Recommendation for digital transmission corresponding to Recommendation 380-1 which is concerned with frequency-division multiplex transmission.

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* This Report was adopted unanimously.

2. The most important information is about digital speeds. If the C.C.I.R. is to study the subject of digital transmission by radio-relay systems efficiently, the study should be confined to digital speeds for which terminal equipment will be studied by the C.C.I.T.T. At the present stage it is not essential to know the precise digital speeds required.

3. It is also important that the maximum digital error rate which could be accepted for digital transmission over 2500 km should be determined at an early date. In digital radio-relay systems, the error rate would be relatively small for a large part of the time, but for short periods of time when fading is severe the error rate would tend to rise sharply.

A useful figure would be the error rate tolerable during, for instance, 0·1% of time during any month, and perhaps also the rate for 20% of any month, in a 2500 km circuit. The fraction of time during which these error rates could be accepted may be a limiting factor. The radio-frequency noise which would cause digital errors may tend to occur in "bursts", i.e. the errors would not be randomly distributed in time but may be concentrated into "groups" of errors. These "groups of errors", furthermore, would tend to be more likely to occur at certain times of day. Thus, there are two mechanisms which would tend to concentrate high error rates.

4. It is important that further study be made of the causes of digital errors and the ability of different modulation-methods to overcome interfering effects. Some initial work has already been done (see Docs. IX/198 and IX/207, 1963-1966) but further work is necessary before any firm conclusions can be reached. For this further work to be done efficiently, information from the C.C.I.T.T. on the points raised in §§ 2 and 3 is necessary. The attention of the C.C.I.T.T. should be drawn to this Report.

This Report is a provisional statement. It is hoped that, before the next meeting, some guidance will be given by the C.C.I.T.T. and further contributions will be received, so that the Report can be extended and improved.

REPORT 379 *

CHARACTERISTICS OF SIMPLE VHF OR UHF RADIO EQUIPMENT FOR USE ON TRUNK CONNECTIONS IN THE NEW AND DEVELOPING COUNTRIES

(Question 9/IX)

(1966)

1. Introduction

Question 9/IX deals with a system for use in national networks which is normally not intended for connections across a national boundary. Such a system falls within the class of systems specified by GAS 3 in para. 2, § 1.5, Doc. GAS 3, No. 9, which are of interest to the new and developing countries and which have no equivalent among the systems to which the C.C.I.R. has Recommendations. It can, therefore, be expected that the GAS 3 Handbook will describe the system under consideration in adequate detail to provide the basis for an answer to Question 9/IX.

The following summarizes the conclusions as to the basic aspects of Question 9/IX which have been reached.

* This Report was adopted unanimously.

2. Modulation

Question 9/IX implies the use of angular modulation. Recommendation 404-1 indicates an r.m.s. frequency deviation of 35 kHz for 12 and 24 channels.

While a higher frequency deviation may be used to improve the ratio of signal-to-thermal noise under non-fading conditions, it will also raise the threshold of FM noise improvement so that, other things being equal, any gain in signal-to-noise ratio will be obtained at the expense of lower service reliability when deep fading occurs. A very large frequency deviation is likely to increase the risk of intermodulation interference. Conversely, if a lower frequency deviation is used, it will improve the fading margin at the expense of signal-to-thermal noise ratio.

While the use of angular modulation seems to be preferable at present, the use of PCM systems for national trunk connections could become practicable in the future. Studies of the characteristics of PCM systems are being actively pursued in both the C.C.I.R. and the C.C.I.T.T.

3. Choice of radio-frequency and intermediate frequency

Taking account of propagation conditions and the present state of development, the radio frequency should be chosen in one of the bands between 68 and 1690 MHz allocated to the fixed services.

The intermediate frequency may be chosen depending upon the radio frequency used since, for this equipment, interconnecting between links should preferably be performed at baseband or audio frequencies.

4. Equipment

Solid-state equipment should be employed to reduce power requirements and maintenance. Reduction in the size of the equipment is possible with solid state circuits ; however, reduction in size should not be made at the expense of reliability and the ease of maintenance.

It may be noted, however, that in certain cases (when crossing marshy land, deserts, mountainous regions or foreign territory) the use of trans-horizon radio-relay systems working in a relatively low frequency band may be advantageous, since this will avoid the provision of stations remote from important centres of population without necessitating a large installation. In these cases solid-state components might not be suitable for the transmitter power-amplifier.

5. Antennae

The antennae should be simple, sturdy and with a small surface exposed to wind. A Yagi antenna would be suitable below 470 MHz, a dipole-array, helical antenna or corner reflector in the 400 MHz band and a parabolic antenna at 900 MHz and above. The antenna should be close to the equipment-building to minimize the length of transmission line. Foam dielectric and solid dielectric cable are advantageous since they require no pressurization.

The use of the same antenna for transmission and reception is generally more economical, but in such a case a larger frequency separation must be adopted to avoid blocking the receiver (e.g. 3% to 5% of the mean frequency).

6. Power supplies

Low-power requirements may be supplied by batteries that are replenished by line chargers connected to a commercial power supply when available. Where commercial power supplies are not available the only practicable source of primary power at the present time is a motor-driven generator. For small capacity systems, dry cell batteries may also be used. The use of thermoelectric generators, solar cells, or wind-driven generators at remote sites is under study.

7. Number of initial telephone channels and ultimate increase in capacity

It is generally difficult to forecast the long-term requirements for trunk circuits in new and developing countries and it is therefore advisable to avoid an initial installation of equipment, the final capacity of which might be too great for future requirements.

The initial needs could generally be met by putting into service equipment with a capacity of 6, 12 or, at the most, 24 channels. This equipment should be relatively simple, inexpensive and easily installed. On the other hand, for a radio-relay system with a capacity of 120-240 (or 300) channels full-scale supervisory equipment would be required, together with a protection radio equipment with automatic switching or combining facilities. Such an equipment, for which C.C.I.R. Recommendations exist, is, of course, in quite a different category from the low capacity system under consideration and the basic microwave equipment for each station would cost substantially more than a low capacity VHF or UHF system.

It would seem that the most economic solution using frequency-division multiplex and angular modulation would be to choose a relatively small capacity system (24 channels or less) which is inexpensive to install. If, after several years this capacity becomes inadequate, it can be replaced by a higher capacity system which is then justified and the initial equipment recovered for use on another light-traffic route.

REPORT 380 *

SIMPLE SINGLE-CHANNEL RADIOTELEPHONY EQUIPMENT

(Question 10/IX)

(1966)

1. Introduction

Question 10/IX, proposed by the Plan Sub-Committee for Asia, relates to a radiotelephone link, which will usually constitute a subscriber's line.

Special Autonomous Working Party 3 (C.C.I.T.T./C.C.I.R.), GAS 3, is preparing a handbook that will include detailed technical characteristics of radio equipment, which is suitable for use in the new and developing countries, including the characteristics of simple single-channel radiotelephony equipment. The following summarizes the general characteristics that should be taken into account in such equipment.

2. General indications concerning the design of such subscriber lines

The variety of geographical, climatic, economic and other conditions which may be encountered makes it impracticable to give a precise list of characteristics. The following indications may, however, be of use.

2.1 *Frequency range*

With due regard to the mode of propagation and the present state of the art, the frequency should be chosen in one of the bands between 68 and 470 MHz, allocated to the fixed services. The lower bands are to be preferred mainly when propagation is by diffraction (mountainous regions) and the higher bands in cases where there is a risk of industrial interference (incoming terminal in a large town).

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* This Report was adopted unanimously.

2.2 *Frequency stability*

The tolerances should be in conformity with the Radio Regulations. This should usually be possible without the use of a thermostat.

2.3 *Type of path and equipment*

The most economical solution appears to be a line-of-sight or near line-of-sight (diffraction) path, making it possible to use transistorized equipment with transmitter powers of about 0·5 W to 5 W. A higher transmitter output power may be necessary, in certain cases.

In some cases, more complex equipment can be used at the most easily supervised terminal (telephone exchange) and simpler equipment at the other end of the circuit (subscriber station or public call box).

2.4 *Modulation*

Angular-modulation seems to be the system preferred.

2.5 *Antennae*

The antennae should be simple, sturdy and with a small surface exposed to wind. However, they should also have sufficient directional gain. Yagi antennae are in most cases a good solution, but at higher frequencies other types of antennae, such as helix or dipole array with reflector, may be used depending on required gain and bandwidth.

The use of the same antenna for transmission and reception is generally more economical, but in such cases a larger frequency separation must be adopted to avoid blocking the receiver (e.g. 3% to 5% of the mean frequency). But it is suggested that technical difficulties might arise from the adoption of too large a frequency separation because of the bandwidth limitation of some antennae.

2.6 *Signalling*

The equipment must be fitted with appropriate signalling apparatus, comprising all calling and control devices, for the modes of operation required.

2.7 *Power supply*

At the present state of development, the source of power which is easiest and most economical to install and maintain is the battery of dry-cells. It should be of sufficient capacity to operate for at least six months before replacement. With higher transmitting power and/or higher duty cycles, a secondary battery and a motor-driven generator would probably be required.

In the future, it will probably be economically possible to use other static power sources (photo-electric cells, thermo-electric cells) supplemented by storage batteries ; but dynamic sources of energy (generator sets) should, wherever possible, be ruled out owing to the amount of maintenance required. The general problem of power sources is being studied by GAS 4.

To economize in power consumption, only the receivers should operate continuously, the transmitters being switched on automatically at the start of each call.

2.8 *Installation*

The radio equipment may be placed either at the top of the pylon carrying the antennae, which reduces cable losses but makes maintenance more difficult, or at the foot of the pylon. In certain cases, where temperature fluctuations are very great (desert areas), it may be advisable to bury the equipment in cabinets.

REPORT 381 *

TWO-CHANNEL TIME-DIVERSITY TELEGRAPH SYSTEMS FOR USE ON RADIO-RELAY LINKS

(Question 278)

(1966)

The reference, in the Explanatory Note to Question 278 to "short duration interruption due to the fading of the signals and equipment interruptions .... result in mutilation of the received text", suggests that the radio-relay systems concerned are not engineered to have a performance in accordance with C.C.I.R. Recommendations. It must be emphasized that radio-relay systems designed to meet the requirements of Recommendation 395-1 are satisfactory for telegraphy transmission.

With time-delay diversity, the essential requirement is to transmit each message twice and to compare the two received messages. Either manual or automatic comparison may be adopted. With manual comparison the receiver prints two copies and the recipient corrects any discrepancies as best he can. This method is known as "slips twice" working. Alternatively, with automatic comparison, the two received messages are stored, and then compared automatically; but it might well be questioned whether it would not be more economic to improve the performance of the radio-relay system to meet C.C.I.R. Recommendations.

This Report constitutes a reply to Question 278, the study of which can hereby be terminated.

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* This Report was adopted unanimously.

STUDY GROUP IX

(Radio-relay systems)

Terms of reference :

To study all aspects of line-of-sight and trans-horizon radio-relay systems and equipment operating at frequencies above about 30 MHz, excluding those systems which utilize transmission via orbiting satellites or the ionosphere.

Chairman : Mr. E. O. DIETRICH (Federal Republic of Germany)

Vice-Chairman : Mr. T. KILVINGTON (United Kingdom)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP IX

1. The task of Study Group IX, in accordance with its terms of reference, is to study all aspects of line-of-sight and trans-horizon radio-relay systems and equipment operating at frequencies above about 30 MHz, with the aim of reaching agreement on unique values for those parameters that require international standardization.

2. Recommendations by Study Group IX applying to radio-relay systems for telephony should conform to the C.C.I.T.T. Recommendations on transmission performance. Recommendations applicable to television and sound programme channels should be in accordance with the relevant Recommendations of the CMTT.

3. Following closely the procedure adopted by the C.C.I.T.T. for cable systems, Study Group IX of the C.C.I.R. has set up, in cooperation with Joint Special Study Group C (C.C.I.T.T./C.C.I.R.), hypothetical reference circuits for radio-relay systems and has formulated Recommendations for the noise allowable in such circuits, stating the values that the noise power may attain for different percentages of the time if the operation is to meet the requirements stipulated by the C.C.I.T.T. Similar Recommendations cover the allowable noise conditions in the hypothetical reference circuit for the transmission of monochrome television signals.

4. Study Group IX has dealt with maintenance problems and has made Recommendations for the measurement of the performance of radio-relay links using a test signal having a continuous uniform spectrum. The necessary complementary Recommendations relating to the maintenance instructions for international connections fall within the competence of Study Group IV of the C.C.I.T.T.

5. Communication-satellite systems often share frequency bands with line-of-sight radio-relay systems. The problems arising from this fact demand very careful and intensive study and close cooperation between Study Groups IX and IV is indispensable.

6. The establishment of Recommendations for radio-frequency channel arrangements for trans-horizon radio-relay systems is particularly difficult. The frequencies for such systems must be very carefully chosen, lest the high radiated-power and the long range of this mode of propagation may give rise to serious interference at distances extending beyond national frontiers. Studies of this subject have to be carried out in cooperation with Study Group V.

7. Having regard to the present state of technical development, telephony transmission systems using time-division multiplex and frequency-division multiplex have both been studied. For the latter type the Recommendations are concerned with frequency-modulation only, taking account of the use of pre-emphasis.

8. One of the main interests of Study Group IX is the problem of international interconnection. Arising from this, a number of Recommendations have been established with the aim of facilitating the interconnection of systems of different origin, at radio-frequency, at intermediate-frequency and at baseband-frequency. Baseband levels, the characteristics of supervisory channels and multi-line switching arrangements have also been studied.

9. The standardization of radio-frequency channel arrangements is of great importance. Hence, channel arrangements for systems with capacities ranging from 12 to 2700 telephone channels, or the equivalent, have been laid down for the 2, 4, 6, 7, 8 and 11 GHz bands. The Final Acts of the Extraordinary Administrative Radio Conference, Geneva 1963, recording the frequency bands allocated for space radiocommunication purposes were considered and the pertinent Recommendations appropriately amended.

10. Since it has become technically feasible to transmit the related sound signal on a radio-relay system for television, the desirable characteristics for this type of operation were introduced into a number of Recommendations, taking also into account the possibility of transmitting more than one sound signal. On the other hand, systems intended for the transmission of sound programmes only are also under study.

11. The communication problems of the new and developing countries are very important. Hence Study Group IX has studied many aspects of these problems. In 1964, Special Autonomous Working Party No. 3 (GAS 3) was established by the C.C.I.T.T. and this body will be given every possible assistance by Study Group IX.

12. Problems requiring further study :

- special questions relating to trans-horizon radio-relay systems,
- preferred characteristics for the transmission of colour television signals,
- noise due to fading or interference and very high noise peaks tolerable for very short periods of time,
- characteristics of systems for 2700 telephone channels,
- characteristics of systems using pulse-code modulation (in cooperation with the C.C.I.T.T.),
- characteristics of systems which are particularly suited to the needs of the new and developing countries.

OPINION 12

RADIO-RELAY SYSTEMS FOR TELEVISION

Maintenance procedures

The C.C.I.R., (1959 — 1963)

CONSIDERING

(a) that Recommendation 290 gives the maintenance methods for radio-relay systems for telephony ;

(b) that methods different from those used for telephony may have to be used for the maintenance of television radio links ;

(c) that a joint C.C.I.R./C.C.I.T.T. Committee (CMTT) has been established to study television transmission ;

IS UNANIMOUSLY OF THE OPINION

that the maintenance procedure for television radio-relay systems, in so far as it concerns the overall transmission performance, should be referred to the CMTT, it being understood that the testing methods adopted should be the subject of agreement with the C.C.I.R.

Note. — The attention of the CMTT is drawn to the difficulties which may be produced by applying to radio-relay systems, test signals of high amplitude which can cause serious interference in adjacent radio channels.

OPINION 13

RADIO-RELAY SYSTEMS FOR TELEPHONY

C.C.I.T.T./C.C.I.R. Joint Special Study Group C on circuit noise

(Questions 2/IX and 7/IX)

The C.C.I.R., (1959 — 1963)

CONSIDERING

(a) that a Joint Study Group has been established by the C.C.I.T.T., with participation by C.C.I.R. representatives, to study circuit noise ;

(b) that certain aspects of the questions under consideration by the C.C.I.R. can usefully be studied by this Joint Study Group, that is to say :

- permissible noise power for the transmission of VF telegraphy or data (part of Question 2/IX) ;
- permissible noise power for radio-relay systems using tropospheric-scatter propagation (part of Questions 2/IX and 7/IX) ;

IS UNANIMOUSLY OF THE OPINION

1. that the working party on circuit noise established by the C.C.I.T.T. with participation by C.C.I.R. representatives be constituted as a C.C.I.T.T./C.C.I.R. Joint Study Group entitled "Joint Special Study Group C" ;

2. that this Joint Study Group be responsible for the studies indicated in § *(b)* ;

3. that the Director, C.C.I.T.T. be invited to be responsible for the convening, organization and secretariat of this Joint Study Group.

OPINION 14

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred frequency bands and centre frequencies for radio-relay links for international connections

The C.C.I.R., (1959 — 1963)

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 tropospheric-scatter links for international connections ;

(c) that the C.C.I.R. has recommended preferred radio-frequency interconnection arrangements for radio-relay links of capacity from 60 to 2700 telephone channels, or the equivalent (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 similar high standards of performance to those recommended by the C.C.I.T.T. for metallic circuits ;

(i) 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 harmonics), operated in the same or other countries ;

IS UNANIMOUSLY OF THE OPINION

that the attention of Administrative Radio Conferences be drawn to :

1. the technical advantages of international agreement on preferred frequency bands, within which international line-of-sight and tropospheric-scatter radio-relay links may be established, using the radio-frequency channel arrangements recommended by the C.C.I.R. ;

2. the technical advantages of preferred values for the centre frequencies of bands for line-of-sight and tropospheric-scatter systems being established by international agreement ;

3. the risk of interference between line-of-sight and tropospheric-scatter 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 harmonics radiated by them.

ANNEX I

C.C.I.R. RECOMMENDATIONS FOR PREFERRED RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR RADIO-RELAY SYSTEMS, USED FOR INTERNATIONAL CONNECTIONS (1) (2)

Recommendation	Maximum capacity of each radio carrier (Telephone channels or the equivalent)	Preferred centre frequency (3) f_0 (MHz)	Width of radio-frequency band occupied (MHz)
283-1	60/120	1808 2000 2203	200 200 200
385	60/120/300	7575	300
279-1 382-1	300/1800	1903 2101 4003·5 (4)	400 400 400 (4)
383-1	600/1800	6175	500
384-1	960/2700	6770	680
386-1	300/960	8350	300
387	960	11 200	1000

(1) The Recommendations referred to above apply to line-of-sight and near line-of-sight systems. For tropospheric-scatter 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 and to Report 286.

(2) The attention of the Ordinary and Extraordinary Administrative Radio Conferences should also be drawn to Recommendation 389, Study Programme 4A/IX and to Report 284.

(3) Other centre frequencies may be used by agreement between the Administrations concerned.

(4) In some countries, mostly in a large part of Region 2 and in certain other areas, a reference frequency f_r = 3700 MHz is used at the lower edge of a band 500 MHz wide (see Annex to Recommendation 382-1).

QUESTION 1/IX *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

The C.C.I.R., (1953 — 1959)

CONSIDERING

(a) that a variety of types of multi-channel radio-relay systems, operating at frequencies above about 30 MHz, use frequency-division multiplex ;

(b) that it is sometimes desirable to be able to interconnect systems of different types particularly on international circuits ;

* Formerly Question 192(IX).

UNANIMOUSLY DECIDES that the following question should be studied :

1. what are the radio, baseband or intermediate-frequency characteristics of frequency-division multiplex radio-relay systems, operating at frequencies above about 30 MHz, which it is essential to specify to enable two such systems to be interconnected ;

2. what specifications should be drawn up for such characteristics and should be recommended as standards for radio-relay systems, carrying frequency-division multiplex for use on international circuits and operating at frequencies above about 30 MHz ?

STUDY PROGRAMME 1A/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Systems of a capacity greater than 1800 telephone channels, or the equivalent

The C.C.I.R., (1959)

CONSIDERING

(a) that there may be economic and operational advantages in the use of radio-relay systems with a capacity of substantially more than 1800 telephone channels, or the equivalent, on a single radio carrier ;

(b) that very large capacity radio-relay systems may also be required in the future for the transmission of higher-definition television ;

(c) that additional information is needed to establish the practical limits of capacity of such very large capacity systems ;

UNANIMOUSLY DECIDES that the following studies be carried out :

1. the determination of optimum values for the system characteristics (including the baseband, intermediate-frequency and radio-frequency characteristics), to enable the maximum capacity in each radio-frequency carrier to be achieved ;

2. the limitation on the maximum practicable capacity of the system due to the effects of multipath propagation.

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* Formerly Study Programme 192A(IX).

QUESTION 2/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Hypothetical reference circuits and circuit noise

The C.C.I.R., (1953 — 1959)

CONSIDERING

that the noise permissible in a radio-relay system may be expected to depend to some extent on the length of the system, and that it may, therefore, be desirable for design purposes to specify hypothetical reference circuits for radio-relay systems analogous to those specified by the C.C.I.T.T. for cable systems ;

UNANIMOUSLY DECIDES that the following question should be studied :

the determination of :

— hypothetical reference circuits for the design of radio-relay systems,

— the elements appropriate to such circuits,

— the division of the permissible noise power amongst the various elements.

STUDY PROGRAMME 2A/IX **

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Noise tolerable during very short periods of time

The C.C.I.R., (1956 — 1959 — 1966)

CONSIDERING

(a) that, for radio-relay links, it is necessary to clarify how high noise levels, occurring for short periods of time, should be taken into consideration ;

(b) that consideration must be given not only to the percentage of time during which high noise levels occur, but also to the duration of each burst of noise ;

(c) that account should be taken of the fact that in radio-relay systems, high noise levels often occur at night and further, that the introduction of low night rates in certain countries and the transmission of data may produce heavy loading of the system at night ;

(d) that examples of the distribution of noise with time in radio-relay systems are given in Recommendation 393-1 and Report 130, which also contain examples of the values of noise power likely to be experienced for short periods of time ;

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* This Question, formerly Question 193(IX), also concerns trans-horizon radio-relay systems.

** Formerly Study Programme 193A(IX).

UNANIMOUSLY DECIDES that the following studies should be carried out :

1. the way in which the maximum value of noise should be specified when considering transmission on radio-relay systems ;
2. the time constant which the noise measuring apparatus should have ;
3. whether a limit should be set to the number of high noise bursts, of a duration exceeding a given value, occurring in a given time ;
4. whether account should be taken of the fact that heavy system loading may occur at night as well as in the day ;
5. the way in which the maximum tolerable noise power for a part of a radio link can be deduced from the maximum value of noise power tolerable of the complete radio link.

STUDY PROGRAMME 2B/IX *

RADIO-RELAY SYSTEMS FOR TELEPHONY

Noise in circuits forming part of very long telephone connections

The C.C.I.R., (1965 — 1966)

CONSIDERING

(a) that C.C.I.T.T. Recommendations G.143 and G.153 state that very long circuits should have, as an objective, a noise performance better than 3 pW/km ;

(b) that a hypothetical reference circuit longer than 2500 km has not been found necessary for radio-relay systems ;

(c) that radio-relay systems will be interconnected with long submarine cables or satellite systems with overall noise performance frequently better than that recommended by Recommendation 395-1 ;

(d) that very long circuits may be carried either over selected channels of radio-relay systems designed in accordance with Recommendation 393-1 or carried over radio-relay systems intended specifically for this purpose (see Questions 2/C and 3/C of Joint Special Study Group C) ;

(e) that the demand for long low-noise circuits may become so great that the selection of channels from radio-relay systems, designed in accordance with Recommendation 393-1, may not always provide sufficient capacity ;

(f) that, therefore, there may be an increasing requirement for circuits longer than 2500 km, having a noise performance better than the general noise objectives of Recommendation 393-1 ;

(g) that to provide for such circuits, it might become desirable to establish additional and better design objectives for radio-relay systems than those now stated in Recommendation 393-1 ;

(h) that the provision of long circuits with special noise requirements should not adversely affect the economy or efficiency of radio-relay systems ;

(i) that due regard should be paid to the efficient use of the radio-frequency spectrum ;

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* Formerly Study Programme 193B(IX).

UNANIMOUSLY DECIDES that the following studies should be carried out :

1. the extent to which channels, suitable for inclusion in very long circuits, may be provided by the selection of low-noise channels on radio-relay systems, designed in accordance with Recommendation 393-1 ;

2. the way in which radio-relay systems, designed in accordance with Recommendation 393-1, can be adapted to provide a better noise performance suitable for very long circuits and the extent to which this is practicable ;

3. the desirability of designing radio-relay systems especially for the purpose of providing circuits meeting low noise objectives similar to those which apply to circuits carried on long submarine cable and communication-satellite systems, and the factors involved ;

4. the improvements in the noise objectives for radio-relay systems, which might reasonably be considered without restricting the economic development of radio-relay systems, in the light of advancing technology and taking into account the studies by Joint Special Study Group C ;

5. in a general way, the characteristics of radio-relay systems providing better noise performance than that now stated in Recommendation 393-1.

STUDY PROGRAMME 2C/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Noise objectives for programme circuits 2500 km long provided by means of radio-relay systems

(1965 — 1966)

The C.C.I.R.,

CONSIDERING

(a) that programme circuits are being increasingly provided by radio-relay systems ;

(b) that the C.C.I.T.T. objective for noise in a programme circuit 2500 km long, given in C.C.I.T.T. Recommendation J.21, is drafted in a form which has been evolved for application to cable systems ;

(c) that Recommendation J.21 is unsuitable for application to programme circuits provided by means of radio-relay systems, because it makes no allowance for variation of noise with time ;

(d) that it would be desirable to have a common noise-objective applicable to all transmission systems, including radio-relay systems ;

(e) that Special Joint Study Group C is the appropriate co-ordinating body on noise objectives which are common to all transmission systems, including radio-relay systems ;

UNANIMOUSLY DECIDES that the following studies should be carried out :

determination of the noise objectives which should be recommended for programme circuits provided by means of radio-relay systems.

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* Formerly Study Programme 193C(IX).

QUESTION 3/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION

Preferred characteristics for the transmission of monochrome television

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that the study of preferred characteristics for radio-relay systems for multi-channel telephony is being pursued ;

(b) that requirements for the transmission of monochrome television over long distances are given in Recommendation 421-1 ;

(c) that Recommendation 421-1 does not, however, include a consideration of the characteristics (other than at baseband frequencies) of radio-relay systems designed for the transmission of television ;

(d) that, it is preferable for the major intermediate-frequency and radio-frequency characteristics of international radio-relay systems to conform, as far as possible, with those for multi-channel telephony ;

UNANIMOUSLY DECIDES that the following question should be studied :

what are the preferred characteristics of international radio-relay systems for television where they differ from those for telephony ?

STUDY PROGRAMME 3A/IX **

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred characteristics for the transmission of more than one sound channel

The C.C.I.R., (1959)

CONSIDERING

(a) that Recommendation 402 gives values for the preferred characteristics of a frequency-modulated sub-carrier for the transmission of a single sound channel on a radio-frequency carrier transmitting also a television signal ;

(b) that, in certain circumstances, up to six sound channels may be required over the same route as a television transmission ;

(c) that radio-relay systems with a capacity of 600 or 960 telephone channels may be used to transmit a television signal or several sound channels on each radio-frequency carrier ;

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* Formerly Question 194(IX).

** Formerly Study Programme 194A(IX).

(d) that radio-relay systems with a capacity of 1800 telephone channels, or the equivalent, may be used to transmit a television signal and several sound channels on each radio-frequency carrier;

(e) that the sound channels provided by this means should meet the requirements of the C.C.I.T.T. for music circuits;

UNANIMOUSLY DECIDES that the following studies should be carried out:

the determination of the preferred characteristics for the provision of up to six sound channels in the following cases:

1. when the radio-frequency carrier transmitting the sound channels is used alternatively for television (radio-relay systems with a capacity of 600 or 960 telephone channels);

2. when the radio-frequency carrier transmitting the sound channels is used simultaneously for television (radio-relay systems with a capacity of 1800 telephone channels, or the equivalent).

QUESTION 4/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Service channels

The C.C.I.R., (1956 — 1959)

CONSIDERING

(a) that service channels are necessary for the maintenance of radio-relay systems;

(b) that it would be desirable to define the steps to be taken for the establishment of such service channels and for facilitating their international connection;

UNANIMOUSLY DECIDES that the following question should be studied:

1. in what form and by what means should the service channels required for the maintenance of radio-relay systems be established;

2. what are the characteristics, if any, to be specified, with a view to permitting international connection of such service channels;

3 what are the preferred values of such characteristics?

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* Formerly Question 195(IX).

STUDY PROGRAMME 3B/IX

RADIO-RELAY SYSTEMS FOR TELEVISION

Residues of signals outside the baseband

(1969)

The C.C.I.R.,

CONSIDERING

(a) that it is desirable to set limits for the residues of signals outside the baseband in radio-relay systems for monochrome and colour television;

(b) that these residues may be associated with the transmission of various types of signal, such as colour and sound sub-carriers and continuity pilots;

(c) that, in suppressing these residues, it is important to avoid the introduction of excessive group-delay distortion in the baseband;

(d) that this suppression can be expressed either as an absolute level or as an attenuation;

DECIDES that the following studies should be carried out:

1. determination of the appropriate limits for monochrome and colour television, for the residues corresponding to:

1.1 signals arising from non-linear distortion within the video-frequency band, in particular, those corresponding to harmonics of the colour sub-carrier(s);

1.2 continuity and other pilots;

1.3 signals corresponding to the frequency of the sound sub-carrier(s);

1.4 any other spurious signals;

2. desirability of expressing these limits as:

— a level relative to the nominal peak-to-peak amplitude of the vision carrier,

— an attenuation.

STUDY PROGRAMME 4A/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred characteristics for auxiliary radio-relay systems for the provision of service channels

The C.C.I.R., (1959)

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 ;

(b) that this auxiliary system may be arranged by combining it with the main system, as is shown in Recommendation 389 ;

(c) that, on the other hand, it may be preferable to use an auxiliary radio-relay system quite independent of the main radio-relay system ;

(d) that the frequency band concerned and the exact frequency allocation plan must be chosen carefully, to avoid interference with the main system ;

(e) that the utmost reliability is essential for this auxiliary radio-relay system, because of the operational importance of the supervisory circuits ;

(f) that some factors affecting the bandwidth that is required for these circuits are discussed in the Annex ;

(g) that Recommendation 400-1 states the number and the function of the service channels that are required ;

(h) that economy in the use of the spectrum is important ;

UNANIMOUSLY DECIDES that the following study should be carried out :

determination of the characteristics (baseband, type of modulation and radio-frequency arrangement) for an auxiliary radio-relay system of high reliability.

ANNEX

In § *(e)*, it is pointed out that a high degree of reliability is required for service channels ; consequently, a stand-by auxiliary radio-frequency channel on each route is probably essential. These stand-by auxiliary channels could be provided on the same frequency as the main auxiliary channel or on a different frequency.

If the same frequency as the main auxiliary channel is used, the stand-by channel can be brought into circuit at any station by means of switches operated automatically by monitoring circuits on the equipment. The use of separate frequencies requires no monitoring circuits or switches and might, therefore, simplify the equipment and improve its reliability.

It sometimes occurs that a number of systems, each requiring supervisory circuits, converge at a point (including any connections with a local maintenance centre). On each route at such interconnection points, if the stand-by channel operates on a separate frequency, two pairs of frequencies in each direction of transmission will be required for the auxiliary radio-relay system. The same frequency can often be used simultaneously for two transmitters or two receivers in opposite directions, but this cannot be done at frequencies below about 1000 MHz.

* Formerly Study Programme 195A(IX).

The necessary spacing between adjacent frequency allocations at any station depends on the frequency stability of the equipment as well as on the modulation characteristics used. These factors should be considered in relation to all the frequency bands which might be used for this purpose ranging from about 8500 MHz down to 1000 MHz or even lower.

QUESTION 5/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Transmission interruptions

(Question No. 10 of the 3rd Study Group of the C.C.I.T.T., to be studied by the C.C.I.R. in cooperation with the 3rd and 4th Study Groups of the C.C.I.T.T.)

What is the duration of interruptions to transmission to be expected on radio links when switching from normal to stand-by equipment ? (See C.C.I.R. Recommendation 305.)

Note. — It is necessary to distinguish the duration of breaks in transmission corresponding to the three following causes :

(a) failure of normal equipment,

(b) fading in radio-propagation indicated by the presence of excessive noise at a switching point of a radio link,

(c) change-over of the normal and stand-by equipment for maintenance of the radio link.

STUDY PROGRAMME 5A/IX **

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred characteristics for multi-line switching arrangements

The C.C.I.R., (1965 — 1966)

CONSIDERING

(a) that Recommendation 305 states that protection arrangements are indispensable for radio-relay systems ;

(b) that such protection systems might be interconnected across international borders and this requires agreement on some major characteristics ;

(c) that so far no study of the relevant characteristics of multi-line switching arrangements is available ;

(d) that single-line switching and combiner studies are being undertaken under Question 13/IX ;

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* This Question, formerly Question 197(IX), also concerns trans-horizon radio-relay systems.

** This Study Programme, formerly Study Programme 197A(IX), applies to line-of-sight and near line-of-sight radio-relay systems.

UNANIMOUSLY DECIDES that the following studies should be carried out :

1. the preferred characteristics of multi-line switching arrangements for international interconnection of radio-relay systems ;

2. the characteristics of radio-relay systems relevant to the operation of multi-line switching arrangements ;

3. the preferred values for such characteristics.

QUESTION 6/IX *

PROTECTION RATIOS FOR THE OPERATION OF COMMUNICATION SERVICES WITHIN THE CHANNELS OF A BROADCASTING SERVICE

The C.C.I.R., (1962)

CONSIDERING

(a) that certain frequency bands may be used for television and sound broadcasting services in one country, and for communication services in another country ;

(b) that Report 77 and Recommendation 418-1 deal only with the protection requirements between broadcasting transmissions ;

DECIDES that the following question should be studied :

1. what is the protection ratio required by an amplitude-modulation or frequency-modulation communication service, as a function of its position within the frequency band occupied by a television or sound broadcasting transmission ;

2. to what extent is the protection ratio affected by variations in picture content or sound programme material of the broadcast transmission ;

3. television, pictures of certain kinds, particularly resolution-test waveforms, can result in peaks of energy higher than the energy level under normal programme conditions in portions of the occupied bandwidth. Is any allowance for this effect desirable and, if so, on what basis should it be made ?

Note 1. — The study should, in the first instance, examine the protection ratio required for multichannel frequency-modulation telephone systems, the capacity of which is normally not greater than 120 channels, sharing the television broadcast bands IV and V.

Note 2. — For the purpose of this Question, protection ratio is defined as the minimum acceptable ratio of the wanted to the unwanted signals at the input to the radio-relay system receiver.

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* This Question, formerly Question 221(IX), also includes trans-horizon systems.

QUESTION 7/IX *

TRANS-HORIZON RADIO-RELAY SYSTEMS

The C.C.I.R., (1963)

CONSIDERING

(a) that trans-horizon radio-relay systems have received acceptance and are increasingly being used operationally in many parts of the world ;

(b) that it is desirable to determine the preferred characteristics of such systems needed to facilitate their international connection ;

(c) that the frequency bands used by trans-horizon radio-relay systems are often shared with line-of-sight radio-relay systems, other fixed and mobile, or broadcasting services ;

UNANIMOUSLY DECIDES that the following question should be studied :

1. how do the characteristics of tropospheric-scatter propagation affect the design of radio-relay systems ;

2. to what extent are systems, employing this mode of propagation and operating on the same or on neighbouring frequencies, liable to interfere with each other, with systems employing different modes of propagation as well as with other services ?

STUDY PROGRAMME 7A/IX **

TRANS-HORIZON RADIO-RELAY SYSTEMS

Radio-frequency channel arrangements

The C.C.I.R., (1958)

CONSIDERING

(a) that trans-horizon radio-relay systems are already in service and that systems of this type may come into more extensive use in the future ;

(b) that such systems may use very high power (10 kW or even more) fed into high gain antennae ;

(c) that trans-horizon systems are capable of causing interference over wide areas and long distances, to systems of the same or of different type operating on the same or closely adjacent frequencies ; and that such interference could frequently extend over national boundaries ;

(d) that trans-horizon systems may be particularly susceptible to interference from systems of the same or of different type, because of the low field strengths available at the receiving terminal ;

* Formerly Question 260(IX).

** Formerly Study Programme 260A(IX).

(e) that distances between adjacent stations may vary widely, e.g. between about 100 and 400 km ;

(f) that overshoot problems are likely to be more severe than with line-of-sight systems ;

(g) that interference may be caused in directions other than that of the main beam ;

(h) that most trans-horizon systems are expected to provide not more than about 120 telephone channels ; that many smaller systems may provide only 12 or 24 channels, but certain systems may transmit wideband information such as television ;

(i) that the transmitting power used may differ considerably according to the distance to be covered, the number of channels to be transmitted, etc. ;

(j) that at present, frequency-modulation of the radio-frequency carrier is most generally used, but that other types of modulation, e.g. single-sideband, may be introduced for some systems ;

(k) that simultaneous transmission on two frequencies, to assist in the provision of quadruple diversity reception or for other reasons, while strongly deprecated in areas where the radio-frequency spectrum is likely to become congested, may be used in other areas ;

(l) that the requirements for radio-frequency channel arrangements for trans-horizon systems would seem, from the above considerations, to differ substantially from those for line-of-sight radio-relay systems or for other services ;

DECIDES that the following studies should be carried out :

1. on what basis should radio-frequency channel arrangements for trans-horizon systems be established ;

2. what basic arrangements should be proposed ?

Note. — This study should include consideration of the following points :

1. The extent to which radio-frequency channel arrangements must be considered in relation to a large geographical area rather than only to individual routes.
2. The especially difficult problem of avoiding interference to and from other systems.
3. The need to accommodate systems of differing channel capacity, power, type of modulation and type of service.
4. The transmitted bandwidths appropriate to such systems.
5. The appropriate frequency spacing, or spacings between go and return channels, on a given section of route.
6. The appropriate frequency spacing between two or more parallel channels along the same section of route.
7. The appropriate frequency spacing between systems installed in the same station for use on different routes.
8. The distances at which frequencies can be re-used without undesirable interference effects, both in the direction of the main beam and in other directions.
9. Whether the problem of radio-frequency channel arrangements might be substantially eased, if intermediate frequencies (or the first intermediate frequency if a double-frequency change receiver is used), differing from those given in Recommendation 403-1, were to be used.

STUDY PROGRAMME 7B/IX

TRANS-HORIZON RADIO-RELAY SYSTEMS

Reduction in path antenna-gain

The C.C.I.R., (1966)

CONSIDERING

(a) that determination of path antenna-gain is most important in the design of trans-horizon radio-relay systems ;

(b) that measurements in this area, though extensive, have not always been appropriately standardized and indicate significant controversy ;

(c) that the relationship between theoretical models and experimental data seem to indicate agreement with some measurements, but disagreement with others ;

(d) that particularly in long systems, errors in evaluating the characteristics or the overestimation of path antenna-gain can lead to unnecessary expense or to poor performance ;

(e) that the separation of path antenna-gain from transmission loss may be difficult ;

UNANIMOUSLY DECIDES that the following studies should be carried out :

1. the determination of the parameters that the system designer must take into consideration in estimating the reduction in path antenna-gain ;

2. the way in which these parameters (frequency, distance, elevation, antenna beamwidth, etc.) relate to the reduction in path antenna-gain ;

3. the extent to which such reduction is dependent on time, geographical, seasonal or other factors ;

4. the relationships of reduction in path antenna-gain to other system design factors, such as use of diversity (see Question 13/IX), antenna symmetry, shaping and polarization.

QUESTION 8/IX *

RADIO-RELAY SYSTEMS FOR TELEVISION

Preferred characteristics for the transmission of colour television and the simultaneous transmission of colour television and other signals

The C.C.I.R., (1963 — 1966)

CONSIDERING

(a) that the transmission of colour television signals over long distances is under study by the CMTT ;

(b) that radio-relay systems will be required for the transmission of such signals alone, or together with programme circuits ;

* Formerly Question 296(IX).

UNANIMOUSLY DECIDES that the following question should be studied :

1. what are the preferred characteristics and most critical parameters of international radio-relay systems for colour television, where they differ from those for monochrome television ;

2. what are the preferred characteristics and most critical parameters for radio-relay systems for the simultaneous transmission of colour television signals and programme circuits ;

3. in what way do these critical parameters affect the choice of route ?

Note. — In considering the preferred characteristics of mixed systems, advice is required on the following :

— the maximum level and the characteristics of the noise and the signal residues, liable to be present outside the television band offered for transmission ;
— the acceptable level of noise outside the television band, after transmission over the radio-relay system.

QUESTION 9/IX *

CHARACTERISTICS OF SIMPLE VHF OR UHF RADIO EQUIPMENT FOR USE ON TRUNK CONNECTIONS IN THE NEW AND DEVELOPING COUNTRIES

(Question No. 4 of the Regional Plan Committee for Asia, Geneva, 1963)

The Regional Plan Committee for Asia, (1963)

CONSIDERING

the expanding needs for extending communications to those areas in the new and developing countries which, due to terrain, climate or other reasons may not permit the use of land-line, wire or cable ;

REQUESTS the C.C.I.R. to study the following question :

1. what should be the broad characteristics and standards for simple and economic types of VHF or UHF equipment for trunk connections with the following basic requirements ;

1.1 low power-output, using only solid-state components ;

1.2 a small number of channels, say 6 to 12, or at the most 24 ;

1.3 low power-consumption ;

1.4 use of higher frequency deviation, to get a better noise figure to improve the signal-to-noise ratio ;

1.5 ease of installation and maintenance ;

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* Formerly Question 276(IX).

2. what changes would be required in the characteristics and what would be the estimated percentage increase in cost of the basic equipment, if it is to be capable of being extended to cater for capacities of 120 to 240 channels at a later stage?

Explanatory note. — There is a need for developing simple types of trunk radio equipment with requirements such as to meet the expanding needs of new countries for trunk communications.

QUESTION 10/IX *

SIMPLE SINGLE-CHANNEL RADIOTELEPHONY EQUIPMENT

(Question No. 5 of the Regional Plan Committee for Asia, Geneva, 1963)

The Regional Plan Committee for Asia, (1963)

REQUESTS the C.C.I.R. to study the following question:

what should be the recommendations for radio equipment that could provide, among other things, for the following:

— one speech telephone channel;
— transmitter-receivers, pole or cabinet mounted;
— low power-consumption, using solid-state components;
— independent of local power supply;
— capability of being linked to the nearest headquarters station, which may be 20 to 30 miles away (30 to 50 km);
— use the simplest possible type of antenna with an inexpensive support;
— be unattended and capable of operation by a village Postmaster;
— require a minimum of technical maintenance?

Explanatory note. — It is very important to extend telecommunication facilities to those areas of the new and developing countries where the terrain and climatic conditions do not permit such facilities to be provided by wire or cable.

There is, therefore, an urgent need for this type of equipment to connect remote areas, which have, at present, no communication whatsoever. No equipment to meet such requirements is readily available in the world's markets. Something similar to the portable transistorized broadcast receiver developed in many countries may help a great deal.

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* This Question, formerly Question 277(IX), is also of interest to C.C.I.R. Study Groups I, II, III, X and XII.

QUESTION 11/IX *

TRANSMISSION PLANNING FOR RADIO-RELAY SYSTEMS IN THE NEW AND DEVELOPING COUNTRIES

(Question No. 13 of the Regional Plan Committee for Asia, Geneva, 1963)

The Regional Plan Committee for Asia, (1963 — 1966)

REQUESTS the C.C.I.R. to study the following question :

1. what information can be given to guide developing countries in the basic transmission planning for radio-relay systems ;

2. what are the major factors to be considered in determining the broad characteristics to be specified for this type of equipment ?

Explanatory note. — Although a great deal of information has been written on this subject, it is only available through various articles, pamphlets and other miscellaneous publications. There is need for the production of a more comprehensive document, giving guidance on the basic transmission planning for cable-carrier and radio-relay systems, together with an adequate background to the fundamental questions of optimum signal levels in multi-channel systems and the planning of repeater sections to achieve specified signal-to-noise ratios.

The inclusion of a bibliography of published literature on this subject would also be valuable.

QUESTION 12/IX **

RADIO-RELAY SYSTEMS FOR THE TRANSMISSION OF PULSE-CODE MODULATION AND OTHER TYPES OF DIGITAL SIGNAL

The C.C.I.R., (1965 — 1966)

CONSIDERING

(a) that the C.C.I.T.T. has recognized the need to study pulse-code modulation (PCM) for the transmission of telephony over cables (Question 33/XV of C.C.I.T.T.) ;

(b) that PCM and other forms of digital signal may need to be transmitted over radio-relay systems ;

(c) that the transmission of PCM and other forms of digital signal may be required over international circuits ;

(d) that there may be advantages in the use of PCM and other forms of digital signal for transmission by radio-relay systems ;

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* This Question, formerly Question 279(IX), is also of interest to C.C.I.R. Study Group III. Contributions in reply to this Question should be transmitted, through the Director, C.C.I.R., to the Chairman of C.C.I.T.T./C.C.I.R. Special Autonomous Working Party No. 3, dealing with transmission systems.

** Formerly Question 297(IX).

UNANIMOUSLY DECIDES that the following question should be studied :

1. what are the preferred characteristics (including the baseband, intermediate-frequency and radio-frequency characteristics), for international interconnection of radio-relay systems with other radio-relay systems or with cable systems for the transmission of PCM or other types of digital signal ;

2. what factors need to be taken into account to minimize interference between such systems and other types of radio-relay system used for international interconnection ?

Note. — As far as possible, the same terminology should be used as in the study of C.C.I.T.T. Question 33/XV.

STUDY PROGRAMME 12A/IX

RADIO-RELAY SYSTEMS FOR THE TRANSMISSION OF PULSE-CODE MODULATION (PCM) AND OTHER TYPES OF DIGITAL SIGNAL

Calculation and measurement of the effects of propagation and interference

The C.C.I.R., (1966)

CONSIDERING

(a) that the preferred characteristics of radio-relay systems for the international transmission of pulse-code modulation (PCM), or other types of digital signal (Question 12/IX) need to be studied ;

(b) that the transmission of PCM signals over radio-relay links may be affected by propagation ;

(c) that interference from and to other radio systems, with the same or other types of modulation, should be taken into account when radio-relay systems for PCM are being designed ;

UNANIMOUSLY DECIDES that the following studies should be carried out :

1. calculation and measurement of the influence of the radio-frequency and the path length on the bit error-rate of a PCM system ;
   - under free-space propagation conditions ;
   - during severe fading caused by rain, multipath propagation, etc. ;

2. calculation and measurement of the effects of interference to radio-relay systems for PCM, caused by systems of the same or other type (expressed as the bit error-rate as a function of the ratio of interfering-to-wanted carrier) ;

3. calculation and measurement of the effects of interference to frequency-division multiplex radio systems, caused by PCM systems (expressed as noise power as a function of the ratio of interfering-to-wanted carrier) ;

4. bit error-rates attainable during certain proportions of time for preferred values of transmission performance of radio-relay systems for PCM ;

5. methods of reducing the impairments of §§ 1 to 3.

QUESTION 13/IX *

RADIO-RELAY SYSTEMS

Diversity techniques

The C.C.I.R., (1965 — 1966)

CONSIDERING

(a) that, in a radio-relay system, fading may lower the signal-to-noise ratio and impair the reliability of the system ;

(b) that these effects can, to a large extent, be mitigated by employing techniques of diversity reception ;

(c) that the optimum values of the various diversity parameters may be different for line-of-sight, diffraction, or trans-horizon radio-relay systems ;

(d) that the expression "diversity reception" should be taken in its widest sense and, in particular, should include the use of combiners, stand-by equipment or channels and certain types of coding ;

UNANIMOUSLY DECIDES that the following question should be studied :

1. under typical conditions of fading encountered in radio-relay systems, whether line-of-sight, diffraction or trans-horizon systems, what are the relative advantages of the various types of diversity ;

2. what is the optimum value of the chosen parameter for each type of diversity (antenna-spacing, frequency-spacing, time-difference, etc.) ;

3. in what way must the received signals be utilized to obtain the best possible resulting signal, due account being taken of the mechanism of propagation, the nature of the transmitted signal, the characteristics of available antennae, including adaptive arrays, the bandwidth occupied by the spectrum of the modulated wave, the complexity of the requisite equipment and its ease of operation ;

4. what influence does the use of diversity have on the transmission bandwidth and quality ;

5. what influence does the use of diversity have on interference that may be caused or suffered by the systems ?

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* Formerly Question 298(IX).

QUESTION 14/IX *

TRANS-HORIZON RADIO-RELAY SYSTEMS

Preferred characteristics, permissible noise and signal distortion for the transmission of monochrome television signals

The C.C.I.R., (1965 — 1966)

CONSIDERING

(a) that the transmission of television signals is under study by the CMTT ;

(b) that trans-horizon radio-relay systems are in operational use in many areas ;

(c) that such systems can provide up to about 120 telephone channels and have also been used for the transmission of broadband information, such as television signals ;

(d) that a hypothetical reference circuit for monochrome television transmission as in Recommendation 421-1, may also be suitable for trans-horizon radio-relay systems ;

(e) that, wherever possible and practicable, trans-horizon radio-relay systems should conform to Recommendation 421-1 or Recommendation 289 when transmitting monochrome television signals ;

(f) that, nevertheless, the complete achievement of these objectives could result in prohibitive system cost or harmful interference ;

(g) that, in many cases, the use of trans-horizon radio-relay systems is the only practicable way to transmit monochrome television signals to certain areas ;

UNANIMOUSLY DECIDES that the following question should be studied :

1. what are the preferred characteristics of trans-horizon radio-relay systems for the transmission of monochrome television signals ;

2. what are the special design considerations that need to be taken into account for the successful transmission of monochrome television signals ;

3. are the performance criteria in Recommendations 421-1 and 289 generally achievable in trans-horizon systems, or are additional recommendations desirable relating to the transmission of monochrome television signals by such systems ?

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* Formerly Question 299(IX).

QUESTION 15/IX

CHARACTERISTICS OF SIMPLE UHF RADIO EQUIPMENT FOR USE ON TRUNK CONNECTIONS IN THE NEW AND DEVELOPING COUNTRIES

(Question Addis Ababa No. 1)

The Regional Plan Committee for Africa, (1967)

CONSIDERING

the growing need to extend communications to those areas in the new and developing countries which, owing to terrain, climate or other reasons, may not permit the use of landline, wire or cable;

REQUESTS the C.C.I.R. to study the following question

1. what should be the broad characteristics and standards for simple and economic types of UHF radio equipment for trunk connections with the following basic requirements:

1.1 low power output, using only solid-state components;

1.2 a capacity of up to 60 channels;

1.3 use of frequencies below 2 GHz and preferably below 1 GHz;

1.4 low power consumption;

1.5 ease of installation and maintenance ?

Note. — The Director, C.C.I.R. is requested to send any comments or questions he may receive to Special Autonomous Working Party No. 3 (GAS 3).

Explanatory note. — Question 9/IX requests the C.C.I.R. to study the characteristics of simple and economic systems of up to 24 channels capacity in the VHF and UHF bands. Other C.C.I.R. Recommendations deal with 60- and 120- channel systems in the 2 GHz and 7 GHz bands. Nevertheless, there is a need, in new and developing countries, for a system with a capacity of about 60 channels operating at frequencies below 2 GHz. A contribution to Joint Autonomous Working Party No. 3 (GAS 3) by the East African Administration (Doc. GAS 3 — No. 4), describes this requirement in detail.

QUESTION 16/IX

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Use of frequencies above about 12 GHz

(1969)

The C.C.I.R.,

CONSIDERING

(a) that many demands may soon be made for the use of frequencies above about 12 GHz;

(b) that special propagation problems exist at frequencies above 10 GHz;

(c) that new technological developments are applicable to radio-relay systems operating at frequencies above about 12 GHz;

DECIDES that the following question should be studied:

1. what are the effects on radio-relay systems of the propagation characteristics of frequencies above about 12 GHz, operating wholly within the troposphere;

2. what are the preferred modulation techniques for use at frequencies above about 12 GHz for radio-relay systems;

3. what are the radio-frequency channel arrangements preferred for the frequency bands above about 12 GHz available for use by radio-relay systems?

QUESTION 17/IX

CRITERIA FOR FREQUENCY SHARING BETWEEN RADIO-RELAY SYSTEMS AND COMMUNICATION-SATELLITE SYSTEMS

(1969)

The C.C.I.R.,

CONSIDERING

(a) that radio-relay systems are now widely employed throughout the world and make extensive use of the radio-frequency spectrum;

(b) that the use of radio-relay systems is expected to continue to expand and that new systems are expected to operate with improved performance and make more efficient use of the radio-frequency spectrum;

(c) that the use of communication-satellite systems in the shared bands is expected to expand rapidly;

(d) that the continued development of both services is desirable;

(e) that control of mutual interference between stations of the two services is necessary;

DECIDES that the following question should be studied:

1. what levels of interference are acceptable and under what conditions do they apply to radio-relay systems in order to facilitate sharing with communication-satellite systems;

2. what limitations are acceptable to radio-relay systems to facilitate the operation of earth station and space station receivers in a shared environment?

LIST OF DOCUMENTS CONCERNING STUDY GROUP IX
(Period 1963-1966)

Doc.	Origin	Title	Reference
IX/1	Finland	Characteristics of simple VHF or UHF equipment for use of trunk connections in the new and developing countries	Q. 276
IX/2	Finland	Draft Recommendation. Simple-channel radiotelephony equipment	Q. 277
IX/3	C.C.I.R. Secretariat	List of Questions to be studied by Joint Special Study Group C in 1964-1968	Circuit noise
IX/4	C.C.I.R. Secretariat	Decisions of the IIIrd Plenary Assembly of the C.C.I.T.T. of direct concern to C.C.I.R. Study Group IX	Rec. 380
IX/5	C.C.I.R. Secretariat	Texts of the IIIrd Plenary Assembly of the C.C.I.T.T. of direct concern to the work of C.C.I.R. Study Group IX	Questions of C.C.I.T.T.
IX/6 (III/5)	C.C.I.R. Secretariat	Voice-frequency (carrier) telephony on radio circuits	Texts of the IIIrd Plenary Assembly of the C.C.I.T.T.
IX/7 (IV/14)	Canada	Sharing of radio-frequency bands. Computer study of the incidence of exposure of 4 GHz radio-relay systems in Canada to communication satellites in various orbits	Q. 236(IV) Q. 192
IX/8 (IV/15)	Canada	Frequency sharing between communication-satellite services and terrestrial radio services	Q. 235(IV) Q. 192
IX/9 and Rev. 1	Canada	Radio-relay systems for television and telephony. Radio-frequency channel arrangements for systems with a capacity of 960 telephone channels, or the equivalent, operating in the 8 GHz band	Q. 192
IX/10	Canada	Proposed modification to Rec. 275. Radio-relay systems for telephony using frequency-division multiplex. Pre-emphasis characteristic for frequency-modulation systems	Rec. 275
IX/11	Canada	Proposed modification to Rec. 383. Radio-relay-systems for television and telephony. Radio-frequency channel arrangements for systems with a capacity of 600 to 1800 telephone channels, or the equivalent, operating in the 6 GHz band	Rec. 383
IX/12	Canada	Interruptions due to protection switching	Q. 197
IX/13	Canada	Proposed modifications to Rec. 400. Service channels for radio-relay systems. Type of service channels to be provided	Rec. 400

Doc.	Origin	Title	Reference
IX/14	Canada	Radio-relay systems for telephony using frequency-division multiplex. Hypothetical reference circuit for radio-relay systems between 50 and 280 km long	Q. 193
IX/15	Canada	Radio-relay systems for telephony using frequency-division multiplex. Noise in real circuits between 50 and 280 km long	Rec. 395
IX/16	Canada	Radio-relay systems for telephony using frequency-division multiplex. Systems with a capacity of 1200 telephone channels, or the equivalent	Q. 192
IX/17	Canada	Allowable noise power in radio-relay systems using frequency-division multiplex	Recs. 393, 395
IX/18 (CMTT/2)	New Zealand	Radio-relay systems for television and telephony. Limiting parameters for the design of routes for high-capacity radio-relay systems carrying colour television and telephony	Draft Q.
IX/19	Telefonaktiebolaget L. M. Ericsson	Characteristics of simple VHF or UHF radio equipment for use on trunk connections in the new and developing countries	Q. 276
IX/20	Netherlands	Proposed modifications to Rec. 402. Radio-relay systems for television. Simultaneous transmission of a monochrome television signal and a single sound channel. Preferred characteristics of the sound channel	Rec. 402
IX/21	Netherlands	Proposed modification to Rec. 403. Radio-relay systems for television and telephony. Intermediate-frequency characteristics	Rec. 403
IX/22	Federal Republic of Germany	Proposed modifications to Rec. 385. Radio-relay systems for telephony using frequency-division multiplex. Radio-frequency channel arrangements for 60-, 120- and 300-channel telephony systems operating in the 7 GHz band	Rec. 385 Q. 192
IX/23	Federal Republic of Germany	Proposed modifications to Rec. 381. Interconnection of radio-relay and line systems. Line regulation and other pilots. Limits for the residues of signals outside the baseband	Rec. 381 S.P. 28 Q. 96
IX/24 (IV/32)	United States of America	Number of antennae of A.T. & T. Co. Radio-relay systems operating in the 4 GHz band, the beams of which intersect the orbits of stationary satellites	Q. 235(IV) S.P. 235A(IV)
IX/25	United Kingdom	Two-channel time-diversity telegraph systems for use on radio-relay links	Q. 278
IX/26	United Kingdom	Radio-relay systems for television and telephony. Radio-frequency channel arrangements for systems with capacities of 960 and 2700 telephone channels on the same route	S.P 192A

Doc.	Origin	Title	Reference
IX/27 (IV/36)	United Kingdom	Proposed modifications to Recs. 353, 355, 356 and 357	Recs. 353, 355, 356 and 357
IX/28 (IV/37)	United Kingdom	Antenna characteristics for the earth stations of communication-satellite systems. Proposals for a reference antenna radiation diagram for use in interference studies	Q. 234(IV) S.P. 235A(IV) S.P. 235C(IV)
IX/29	United States of America	Tropospheric-scatter radio-relay systems. Diversity techniques	S.P. 260B
IX/30	United States of America	Proposed revision of Rec. 396. Tropospheric-scatter radio-relay systems. Hypothetical reference circuit for radio-relay systems for telephony using frequency-division multiplex	Rec. 396
IX/31	France	Radio-relay systems for telephony using frequency-division multiplex. Radio-frequency channel arrangements for medium capacity radio-relay systems operating in the 6 GHz band	Q. 192
IX/32	France	Tropospheric-scatter radio-relay systems	Q. 260
IX/33	France	Simple VHF or UHF radio equipment for trunk connections in the new and developing countries	Q. 276
IX/34	France	Simple single-channel radiotelephony equipment	Q. 277
IX/35	United Kingdom	Characteristics of simple VHF or UHF radio equipment for use on trunk connections in the new and developing countries	Q. 276
IX/36	United Kingdom	Simple single-channel radiotelephony equipment	Q. 277
IX/37 (IV/53)	United Kingdom	Preferred reference-frequencies for communication-satellite systems sharing frequency bands with line-of-sight radio-relay systems	Q. 235(IV) S.P. 235C(IV)
IX/38	United Kingdom	Transmission planning for radio-relay systems in the new and developing countries	Q. 279
IX/39	Federal Republic of Germany	Proposed modifications to Rec. 384. Radio-relay systems for telephony using frequency-division multiplex. Systems with a capacity greater than 1800 telephone channels, or the equivalent. Radio-frequency channel arrangements for systems with a capacity of either 2700 or 960 telephone channels	Rec. 384
IX/40	Federal Republic of Germany	Proposed modifications to Rec. 399. Radio-relay systems for telephony using frequency-division multiplex. Measurement of intermodulation noise with the help of a signal consisting of white-noise	Rec. 399
IX/41	United Kingdom	Radio-relay systems for television and telephony. Preferred characteristics for auxiliary radio-relay systems for the provision of service channels	Q. 195 S.P. 195A

Doc.	Origin	Title	Reference
IX/42	United States of America	Transmission of message channels above a television signal on a 4 GHz radio-relay system	Q. 261
IX/43	United States of America	Simple single-channel radiotelephony equipment	Q. 277
IX/44	United States of America	Characteristics of simple VHF or UHF radio equipment using frequency-division multiplex on trunk connections in the new and developing countries	Q. 276
IX/45	Unites States of America	Comparison between pulse-code modulation and frequency-division multiplex from the standpoint of interference to terrestrial radio-relay systems caused by communication-satellite systems	Rec. No. 4A of the E.A.R.C., Geneva, 1963
IX/46	United States of America	Laboratory measurements of receiver transfer characteristics of terrestrial 4 GHz microwave radio receiver with respect to satellite system interference	S.P. 235A, 235B
IX/47	C.C.I.R. Secretariat	Submission of Doc. IV/17 to S.G. IX. Communication-satellite systems sharing frequency bands with line-of-sight radio-relay systems	Q. 235(IV) S.P. 235B(IV)
IX/48	United Kingdom	Protection ratios for the operation of communication services within the channels of a broadcasting service	Q. 221
IX/49	Japan	Characteristics of simple VHF or UHF radio equipment for use on trunk connections in the new and developing countries	Q. 276
IX/50	C.C.I.R. Secretariat	List of documents issued (IX/1 to IX/50)	
IX/51	Japan	Simple single-channel radiotelephony equipment	Q. 277
IX/52	Japan	Technical bibliography (Radio-relay systems)	Q. 279
IX/53	Japan	Results of field tests on distortion due to fading	Q. 192 S.P. 192A
IX/54	Japan	Proposed modifications to Rec. 400. Service channels for radio-relay systems	Q. 195 S.P. 195A
IX/55	Japan	Space diversity effects on over-the-horizon radio system using long-distance obstacle gain path	Q. 260 S.P. 260A, 260B
IX/56	Japan	Duration of interruptions on radio links when switching from normal to stand-by equipment	Q. 197

Doc.	Origin	Title	Reference
IX/57 and Add. 1	Japan	Radio-relay systems for telephony using pulse code modulation	Draft Q.
IX/58 (IV/60)	United Kingdom	Communication-satellite systems sharing the same frequency bands as line-of-sight radio-relay systems. Maximum allowable values of power flux density at the surface of the earth produced by non-stationary communication-satellites	Q. 235(IV) S.P. 235A(IV) Rec. 358
IX/59 (IV/61)	United Kingdom	Line-of-sight radio-relay systems sharing the same frequency bands as the satellite receivers of active earth-satellite communication systems. Maximum effective radiated powers of line-of-sight radio-relay system transmitters. (Non-stationary satellites)	Q. 235(IV) S.P. 235A(IV) Rec. 406
IX/60 (IV/62)	United Kingdom	Feasibility of frequency sharing between communication-satellite systems and terrestrial radio services. Interference from communication-satellite systems to radio-relay systems carrying 625-line television signals	Q. 235(IV) S.P. 235A(IV)
IX/61	Canada	Radio-relay systems for television and telephony. Proposed modifications to Recs. 279, 283, 382, 385 and 386	Recs. 279, 283, 382, 385, 386
IX/62	Canada	Tropospheric-scatter radio-relay systems. Transmission characteristics	Q. 260
IX/63	France	Radio-relay systems for telephony using frequency-division multiplex. Allowable noise power in the hypothetical reference circuit	Recs. 393, 394, 395, 397
IX/64 (IV/9)	C.C.I.R. Secretariat	Submission of Doc. IV/9 to Study Group IX. Report by Special Joint Study Group C (C.C.I.T.T./C.C.I.R.)	C.C.I.T.T. Doc. AP III/47
IX/65 (IV/20	C.C.I.R. Secretariat	Submission of Doc. IV/20 to Study Group IX. Computation of receiver transfer characteristic between two phase-modulated carriers	Q. 235(IV) S.P. 235B(IV) Rep. 209
IX/66 (IV/21)	C.C.I.R. Secretariat	Submission of Doc. IV/21 to Study Group IX. Laboratory measurements of the receiver transfer characteristic, radio-relay system to communication-satellite system	Q. 235(IV) S.P. 235B(IV) Rep. 209
IX/67 (IV/22)	C.C.I.R. Secretariat	Submission of Doc. IV/22 to Study Group IX. An example of interference to radio-relay systems from a multiple-access set of frequency-modulated carriers, as compared with interference from a single frequency-modulated carrier	Q. 235(IV) S.P. 235B(IV)
IX/68 (IV/23)	C C.I.R. Secretariat	Submission of Doc. IV/23 to Study Group IX. Active communication-satellite systems for frequency-division multiplex telephony. Frequency deviation	Q. 235(IV) S.P. 235D(IV)

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IX/69 (IV/49)	C.C.I.R. Secretariat	Submission of Doc. IV/49 to Study Group IX. Proposed modifications to Recommendation 360. Criteria for selection of preferred reference frequencies for communication-satellite systems sharing frequency bands with line-of-sight radio-relay systems	Rec. 360
IX/70	United Kingdom	Radio-relay systems for television and telephony. Noise objectives for 2500 km programme circuits provided by means of radio-relay systems	Draft Q.
IX/71 (IV/65)	United Kingdom	Feasibility of frequency sharing between communication-satellite and terrestrial radio services. Interference between stationary communication-satellite systems and line-of-sight radio-relay systems	Q. 235(IV) S.P. 235A(IV) Recs. 358, 406
IX/72	Federal Republic of Germany	Radio-relay systems for telephony using frequency-division multiplex. Measurement of intermodulation noise with the help of a signal consisting of white noise. Investigation of the accuracy of measurement	Op. 12 Rec. 399
IX/73	Federal Republic of Germany	Draft Recommendation and Study Programme. Radio-relay systems for television and telephony. Transmission interruptions. Stand-by arrangements	Q. 197 Rep. 137
IX/74	Federal Republic of Germany	Proposed modifications to Rec. 403. Radio-relay systems for television and telephony. Intermediate-frequency characteristics	Q. 192 Rec. 403
IX/75	Federal Republic of Germany	Characteristics of simple VHF or UHF radio equipment for use on trunk connections in the new and developing countries	Q. 276
IX/76 (IV/69)	Federal Republic of Germany	Technical characteristics of communication-satellite systems	Q. 235(IV) § 5, Q. 192
IX/77 and Add. 1	Chairman, Study Group IX	Interim report by the Chairman, Study Group IX — Radio-relay systems	
IX/78 (V/8)	Belgium	Tropospheric-scatter radio-relay systems — Drop in antenna gain	Q. 260
IX/79	Italy	Symbols for inscriptions on panels and racks of radio-relay systems	Res. 23
IX/80	Italy	Radio-relay systems for television. Proposed pre-emphasis characteristic for the transmission of 625-line colour television signals	Q. 261 and 121 (CMTT)
IX/81 (IV/84)	United States of America	Communication-satellite systems and line-of-sight radio-relay systems sharing the same frequency bands — maximum allowable value of power flux-density at the surface of the earth produced by communication-satellites	Rec. 358
IX/82 (IV/85)	United States of America	Communication-satellite systems — Frequency sharing between communication-satellite systems and terrestrial services	Rep. 209

Doc.	Origin	Title	Reference
IX/83 (IV/86)	United States of America	Determination of power flux-density required by communication-satellite systems	Q. 235(IV)
IX/84	Federal Republic of Germany	Preferred characteristics for auxiliary radio-relay systems for the provision of service channels	Q. 195 S.P. 195A
IX/85	Federal Republic of Germany	Radio-relay systems for telephony using frequency-division multiplex — Noise in real circuits	Rec. 395
IX/86	C.C.I.R. Secretariat	Submission of Doc. IV/81 to Study Group IX — Sharing frequency bands between communication-satellite systems and tropospheric-scatter terrestrial radio-relay systems	Q. 235(IV)
IX/87	C.C.I.R. Secretariat	Submission of Doc. IV/87 to Study Group IX — Interference at communication satellite caused by terrestrial line-of-sight radio-relay system transmitter	S.P. 235B(IV)
IX/88	C.C.I.R. Secretariat	Submission of Doc. IV/91 to Study Group IX — Corrigenda to Recs. 356, 357, 358, 359 and 360 relating to communication-satellite systems and radio-relay systems sharing the same frequency bands	Q. 235A(IV) S.P. 235A(IV) Recs. 356, 357, 358, 359 and 360
IX/89	C.C.I.R. Secretariat	Submission of Doc. IV/92 to Study Group IX — Power limits of earth stations in the communication-satellite service	Rep. 209
IX/90	C.C.I.R. Secretariat	Submission of Doc. IV/93 to Study Group IX — Communication-satellite systems — Feasibility of frequency sharing between communication-satellite systems and terrestrial radio services	S.P. 235A(IV)
IX/91 (V/12)	United States of America	Tropospheric radio-relay diversity techniques	Draft Q.
IX/92	Working Group IX-D	Report — Sharing problems	
IX/93	U.S.S.R.	Tropospheric-scatter radio-relay systems — Widening of the passband with diversity reception	S.P. 260B
IX/94	U.S.S.R.	Tropospheric-scatter radio-relay systems — Intermodulation noise caused by multipath propagation	Q. 260
IX/95	U.S.S.R.	Tropospheric-scatter radio-relay systems — Preferred characteristics of tropospheric-scatter radio-relay systems, permissible values of signal form distortions and of signal-to-noise ratio for television signal transmission	Draft S.P.
IX/96	U.S.S.R.	Tropospheric-scatter radio-relay systems — The correlation between slow fadings in adjacent sections of tropospheric-scatter radio-relay links	Q. 260
IX/97	U.S.S.R.	Tropospheric-scatter radio-relay systems — The correlation between the slow variations of thermal and non-linear noise	Q. 260
IX/98	F.S.R. of Yugoslavia	Bibliography from developing countries	Q. 279

Doc.	Origin	Title	Reference
IX/99 (IV/120) (Rev.)	Working Group IX-D Working Group IV-B	Proposed revision of Study Programme 235A(IV)	
IX/100	C.C.I.R. Secretariat	List of documents issued (IX/51 to IX/100)	
IX/101	Italy	Interconnection of radio-relay and line systems — Line regulating and other pilots — Limits for the residues of signals outside the baseband	Rec. 381 S.P. 28 Q. 96
IX/102	Study Group IX	Summary record of the opening meeting	
IX/103 (IV/154)	Working Group IX-B	Proposed modification to Doc. IV/105(Rev. 2)	
IX/104	Working Group IX-C	Summary record of the first meeting	
IX/105 and Rev. 1	Working Group IX-C	Draft amendment of Question 261(IX)	
IX/106	Working Group IX-C	Summary record of the second meeting	
IX/107	Working Group IX-A	Draft amendment to Rec. 380	
IX/108	Working Group IX-A	Draft amendment to Rec. 381	
IX/109	Study Group IX	Summary record of the second meeting	
IX/110	Sub-Group IX-B	Tropospheric-scatter radio-relay systems for telephony using frequency-division multiplex	Rec. 396 Q. 260(IX)
IX/111	Working Party IX-C-4	Report by the Chairman	
IX/112 and Rev. 1	Working Group IX-E	Summary record of the first meeting	
IX/113	Working Group IX-A	Radio-relay systems for television and telephony — Systems with a capacity of 1200 telephone channels, or the equivalent	Draft S.P.
IX/114	Working Group IX-A	Draft amendments to Recs. 279, 283, 382 and 385	
IX/115	Working Group IX-A	Proposed modifications to Rec. 384	
IX/116	Working Group IX-A	Report	
IX/117	Study Group IX	Resignation of the Vice-Chairman of Study Group IX	
IX/118	Working Group IX-B	Report	
IX/119	Working Group IX-C	Draft amendment to Rec. 400	
IX/120 Rev. 1, and Corr. 1	Working Party IX-B-1	Tropospheric-scatter radio-relay systems — Diversity techniques	

Doc.	Origin	Title	Reference
IX/121	Working Group IX-C	Cancellation of C.C.I.R. Rec. 271	
IX/122	Working Group IX-C	Summary record of the third meeting	
IX/123	Working Group IX-D	Report (2nd Part) sharing problems	
IX/124	Working Group IX-B	Draft Revision of Rec. 393	
IX/125	Working Group IX-C	Amendment to Rec. 403	
IX/126	Working Group IX-E	Two-channel time-diversity telegraph systems for use on radio-relay links	Draft R. Q. 278
IX/127 and Rev. 1	Working Group IX-C	Radio-relay systems — Diversity techniques	Draft Q.
IX/128 and Rev. 1	Working Group IX-E	Simple single-channel radio-telephony equipment	Draft Rep. Q. 277
IX/129 and Rev. 1	Working Group IX-B	Radio-relay systems for telephony — Noise in circuits forming part of very long telephone connections	Draft S.P.
IX/130	Working Group IX-B	Radio-relay systems for television and telephony — Noise objectives for 2500 km programme circuits provided by means of radio-relay systems	Draft S.P.
IX/131 and Rev. 1 Rev. 2	Working Group IX-B	Tropospheric-scatter radio-relay systems — Transmission, interference and interconnection	R. 285 Q. 260
IX/132 and Rev. 1	Working Group IX-A	Proposed amendments to Rec. 383	
IX/133	Study Group IX	Radio-relay systems for telephony using frequency-division multiplex — Noise in real circuits	Rec. 395 Q. 193
IX/134	Study Group IX	Hourly mean noise power	
IX/135	Study Group IX	Summary record of the third meeting	
IX/136 and Corr. 1	Working Group IX-A	Radio-frequency channel arrangements for radio-relay systems operating in the 8 GHz band	
IX/137 and Rev. 1	Working Group IX-B	Second Report	
IX/138	Working Group IX-E	Characteristics of simple VHF or UHF radio equipment using frequency-division multiplex on trunk connections in the new and developing countries	Draft Rep.
IX/139	Working Party IX-B-1	Tropospheric-scatter radio-relay systems — Preferred characteristics, permissible noise and signal distortion for monochrome television transmission	Draft Q.

Doc.	Origin	Title	Reference
IX/140	Working Party IX-B-1	Report by the Chairman — Tropospheric-scatter radio-relay systems — Telephone and telegraph transmission	
IX/141	Working Party IX-B-1	Report by the Chairman — Diversity techniques on diffraction paths	
IX/142	Working Group IX-C	Radio-relay systems for television and telephony — Preferred characteristics for multi-line switching arrangements	Draft S.P. Q. 197
IX/143	Working Group IX-C	Radio-relay systems for the transmission of PCM and other types of digital signal	Draft Q.
IX/144	Working Group IX-C	Radio-relay systems for the transmission of PCM and other types of digital signal	
IX/145	Working Group IX-C	Radio-relay systems for telephony using frequency-division multiplex — Measurement of performance with the help of a signal consisting of a uniform spectrum	
IX/146	Working Group IX-C	Measurement of performance with the help of a signal consisting of a uniform spectrum	
IX/147	Working Group IX-C	Summary record of the fourth meeting	
IX/148	Working Group IX-C	Final report	
IX/149	Working Group IX-E	Transmission planning for radio-relay systems in the new and developing countries	Proposed mod. to Q. 279
IX/150	C.C.I.R. Secretariat	List of documents issued (IX/101 to IX/150)	
IX/151	Working Group IX-E	Questions 276(IX), 277(IX), 278(IX) and 279(IX)	Q. 276, 277, 278, 279
IX/152	Working Group IX-A	Recapitulation of documents	
IX/153	Study Group IX	Number of antennae of A.T. & T. Co. radio-relay systems operating in the 4 GHz band, the beams of which intersect the orbits of stationary satellites	Doc. IX/24
IX/154	Study Group IX	Noise in real circuits	Rec. 395
IX/155	Working Group IX-B	Final report	
IX/156	Study Group IX	Summary record of the fourth meeting	
IX/157	Study Group IX	Summary record of the fifth meeting	
IX/158	Study Group IX	Summary record of the sixth meeting	
IX/159 (IV/166) (VII/57) (VIII/67)	C.C.I.R. Secretariat	List of participants — Interim meetings (Monte Carlo, 1965)	
IX/160	C.C.I.R. Secretariat	List of documents issued (IX/151 to IX/160)	

Doc.	Origin	Title	Reference
IX/161	C.C.I.R. Secretariat	Submission of page 29 of CCITT Doc. COM XV — No. 10	
IX/162	C.C.I.R. Secretariat	Submission of Doc. V/74	
IX/163	C.C.I.R. Secretariat	Submission of Doc. CCITT COM Sp.C-No. 20 (Circuit noise)	
IX/164	C.C.I.R. Secretariat	Tropospheric-scatter radio-relay systems	Q. 260
IX/165	United Kingdom	Summary of the results of some measurements of noise in a 960-telephone channel-capacity radio-relay system under various conditions of traffic loading	S.P. 193B
IX/166	United Kingdom	Proposed amendments to Recommendations 275, 380 and 401 — Radio-relay systems for television and telephony — Systems with a capacity of 1200 telephone channels or the equivalent	Recs. 275, 380 and 401 S.P. 192B
IX/167	Chairman, Study Group IX	Report by the Chairman, Study Group IX	
IX/168	United States of America	Tropospheric-scatter radio-relay systems — Transmission of monochrome television signals	Q. 299
IX/169	United States of America	Draft Study Programme — Tropospheric-scatter radio-relay systems — Loss in path antenna gain	
IX/170	United States of America	Characteristics of simple VHF or UHF radio equipment for use on trunk connections in the new and developing countries	Q. 276
IX/171	United States of America	Transmission planning for radio-relay systems in the new and developing countries — Radio-relay bibliography	Q. 279
IX/172	United States of America	Radio-relay systems for television and telephony — Systems with a capacity of 1200 telephone channels, or the equivalent	S.P. 192B
IX/173	United States of America	Proposed modification to Recommendation 380 (F.1.a) — Radio-relay systems for telephony using frequency-division multiplex — Interconnection at baseband frequencies	Draft Rec.
IX/174	United States of America	Proposed modification to Recommendation 398 — Radio-relay systems for telephony using frequency-division multiplex	Rec. 398
IX/175	United States of America	Proposed modification to Recommendation 399 (F.4.a(IX)) — Radio-relay systems for telephony using frequency-division multiplex — Measurement for performance with the help of a signal consisting of a continuous uniform spectrum	Draft Rec.
IX/176	United States of America	Proposed modification to Recommendation 401 — Radio-relay systems for television and telephony — Frequencies and deviations of continuity pilots	Rec. 401

Doc.	Origin	Title	Reference
IX/177	United States of America	Proposed modification to Recommendation 275 (F.5.a(IX)) — Radio-relay systems for telephony using frequency-division multiplex — Pre-emphasis characteristics for frequency-modulation systems	Draft Rec.
IX/178	United States of America	Proposed modification to Recommendation 404 — Radio-relay systems for telephony using frequency-division multiplex — Frequency deviation	Rec. 404
IX/179 (IV/172)	United States of America	Proposed modification to Recommendation 355 — Active communication-satellite systems — Feasibility of sharing bands with terrestrial radio services	Q. 235(IV) S.P. 235A(IV)
IX/180 (IV/173)	United States of America	Proposed modification to Draft Recommendation L.2.b(IV) — Communication-satellite systems sharing the same frequency bands as line-of-sight radio-relay systems	Q. 235(IV) S.P. 235A(IV)
IX/181 (IV/174)	United States of America	Proposed modification to Draft Recommendation L.2.c(IV) — Communication-satellite systems sharing the same frequency bands with line-of-sight radio-relay systems	Q. 235(IV) S.P. 235A(IV)
IX/182 (IV/175) (V/115)	United States of America	Proposed modification to Recommendation 360 — Criteria for selection or preferred reference frequencies for communication-satellite systems sharing frequency bands with line-of-sight radio-relay systems	Q. 235(IV) S.P. 235A(IV)
IX/183 (IV/176)	United States of America	Proposed modification to Draft Recommendation F.5.c(IX) — Line-of-sight radio-relay systems sharing the same frequency bands as the satellite receivers of active earth-satellite communication systems	Draft Rec.
IX/184 (IV/177)	United States of America	Proposed modification to Draft Recommendation L.2.d(IV) — Communication-satellite systems and line-of-sight radio-relay systems sharing the same frequency bands — Maximum allowable values of power flux-density at the surface of the earth produced by communication-satellites	Q. 235(IV) S.P. 235A(IV)
IX/185	United Kingdom	Draft Resolution — Radio-relay systems — Technical characteristics and radio-frequency channelling plans	
IX/186 (IV/190)	United Kingdom	Feasibility of frequency sharing between communication-satellite systems and terrestrial radio services — Intersection of the beams of the antennae of radio-relay system stations in the U.K. with the stationary satellite orbit	Q. 235(IV) S.P. 235A(IV)
IX/187 (IV/191)	United Kingdom	Feasibility of frequency sharing between communication-satellite systems and terrestrial radio services — Determination of the power per 4 kHz which may be radiated in the horizontal plane by communication-satellite earth stations	S.P. 234F(IV)
IX/188 (IV/192)	United Kingdom	Revision of Draft Report L.2.o(IV) and Draft Recommendation L.2.d(IV) — Power flux-density at the surface of the earth from communication-satellites	Draft Rep. Draft Rec.

Doc.	Origin	Title	Reference
IX/189 (IV/201)	United States of America	Proposed modification to Draft Report L.2.g (IV) — Frequency sharing between communication-satellite systems and terrestrial services	Q. 235(IV), 285(IV) S.P. 235B(IV), 311E(IV) Draft Rep.
IX/190	Australia	Sense of modulation at IF in radio-relay systems for television	Rec. 276 Q. 194 Draft. Rec.
IX/191 (IV/209)	United Kingdom	Proposed amendment to Draft Recommendation F.5.c(IX) — Interference from terrestrial line-of-sight radio-relay systems to communication-satellite systems	Q. 235(IV) S.P. 235A(IV)
IX/192	Italy	Radio-relay systems for telephony using pulse-code modulation	Q. 279
IX/193	Federal Republic of Germany	Radio-relay systems for television and telephony — Systems with a capacity of 1200 telephone channels, or the equivalent	Q. 192 S.P. 192B
IX/194	Federal Republic of Germany	Radio-relay systems for television and telephony — Intermediate-frequency characteristics	Q. 192, Draft Rep. 283
IX/195	Federal Republic of Germany	Radio-relay systems for telephony — Noise in circuits forming part of very long telephone connections	Q. 193 S.P. 193B Q. 3/C
IX/196	Federal Republic of Germany	Radio-relay systems for telephony using frequency-division multiplex — Noise in real circuits	Q. 193 Rec. 395 Q. 9/C
IX/197	Federal Republic of Germany	Radio-relay systems for television and telephony — Characteristics for multi-line switching arrangements	Q. 197 S.P. 197A Rep. 137
IX/198	Federal Republic of Germany	Radio-relay systems for telephony — Radio-relay systems for the transmission of multi-channel telephony using pulse-code modulation (PCM)	Q. 297
IX/199	Federal Republic of Germany	Radio-relay systems for television and telephony — Characteristics for auxiliary radio-relay systems for the provision of service channels	Q. 195 S.P. 195A
IX/200	C.C.I.R. Secretariat	List of documents issued (IX/161 to IX/200)	
IX/201	Federal Republic of Germany	Measurement of performance with help of a signal consisting of a uniform spectrum — Position of the centre frequencies of the upper out-of-band measuring channel	Draft Rec.
IX/202	United Kingdom	Special Autonomous Working Party No. 3 (GAS 3) — Economic and technical comparison of transmission systems — Note by the Interim Director, C.C.I.R.	Q. 279
IX/203 and Corr. 1	Japan	Proposed modifications to Draft Recommendation F.2.b(IX)	Draft Rec.
IX/204	Japan	Radio-relay systems for telephony and television — Systems of a capacity greater than 1800 telephone channels, or the equivalent — Preferable characteristics for systems of 2700 channel capacity	Recs. 403, 404 Draft Rec.
IX/205	Japan	New rule for subdivision of hourly-mean noise	Q. 193 Q. 4/C
IX/206	Japan	Low noise channels for very long circuits	S.P. 193B Q. 3/C

Doc.	Origin	Title	Reference
IX/207	Japan	Radio-relay systems for the transmission of pulse-code modulation (PCM) and other types of digital signal — Fundamental characteristics of radio-relay systems using pulse-code modulation	Q. 297
IX/208	Japan	Radio-relay systems for television and telephony Multi-line switching system and switching time	Q. 197 S.P. 197A
IX/209	France	Radio-relay systems for television and telephony — Preferred characteristics for auxiliary radio-relay systems for the provision of service channels	Q. 195 S.P. 195A
IX/210 (II/59) (V/106	Italy	Propagation on line-of-sight paths	Q. 311(V), 298
IX/211 (IV/217)	Federal Republic of Germany	Technical characteristics of communication-satellite systems	Q. 235(IV), § 4
IX/212 (IV/218)	Federal Republic of Germany	Frequency sharing between communication-satellite systems and terrestrial services	Q. 235(IV) Draft Rep.
IX/213 (V/94)	United Kingdom	Proposed modifications to Question 311(V), Study Programmes 311A(V) and 311E(V) — Propagation data required for radio-relay systems, including communication-satellite systems	Q. 311(V) S.P. 311A and 311E(V)
IX/214 (IV/228)	Canada	Frequency sharing between communication-satellite systems and terrestrial radio services — Visibility of antennae of Canadian radio-relay systems in the 4 and 6 GHz bands to the stationary orbit and the longitudinal distribution of the intersecting points	Q. 235(IV) S.P. 235F(IV)
IX/215 (IV/229)	Canada	Frequency sharing between communication-satellite systems and terrestrial radio services — Power flux-density at the surface of the earth from communications-satellites	Q. 235(IV) S.P. 235F(IV) Draft Rec.
IX/216 (IV/230) and Corr. 1	Canada	Frequency sharing between communication-satellite systems and terrestrial radio services — Calculation of co-ordination and separation distances	Q. 235(IV) S.P. 235F(IV) Draft Rep.
IX/217 (IV/231)	Canada	Line-of-sight radio-relay systems sharing the same frequency bands as the satellite receivers of active earth-satellite communication systems — Maximum effective radiated powers of line-of-sight radio-relay system transmitters (6 GHz band)	Draft Rec.
IX/218 (IV/232)	Canada	Proposed modifications to Draft Recommendation L.2.b(IV) — Maximum allowable values of interference in a telephone channel of a communication-satellite system, and to Draft Recommendation L.2.c(IV) — Maximum allowable values of interference in a telephone channel of a radio-relay system	Draft Rec.

Doc.	Origin	Title	Reference
IX/219 (IV/233)	Canada	Frequency sharing between communication-satellite systems and terrestrial radio-relay systems — Principles of sharing	Q. 235(IV) Draft Rep.
IX/220 (IV/234)	Australia	Exposure study of radio-relay systems in Australia	Q. 235(IV) Draft Rec.
IX/221 (V/109)	New Zealand	Propagation data required for line-of-sight radio-relay systems — Rapid variations in path length of transmissions at SHF due to multipath propagation	S.P. 311A(V)
IX/222 (V/111)	New Zealand	Propagation data required for line-of-sight radio-relay systems — Time distribution of path attenuation at 6 GHz	S.P. 311A(V)
IX/223	Canada	Proposed modifications to Recommendation 386 — Radio-relay systems for television and telephony — Radio-frequency channel arrangements for systems with a capacity of 960 telephone channels, or the equivalent, operating in the 8 GHz band	Rec. 386
IX/224	Canada	Radio-relay systems for telephony using frequency-division multiplex—Hypothetical reference circuit 5000 km long, and allowable noise power for radio-relay systems with a capacity of more than 60 telephone channels	S.P. 193B, Rec. 392, Draft Rec.
IX/225	Canada	Radio-relay systems for telephony using frequency-division multiplex — Noise performance of very long radio-relay systems	S.P. 193B
IX/226	Canada	Proposed modifications to Study Programme 193A(IX) — Radio-relay systems for television and telephony — Noise tolerable during very short periods of time	S.P. 193A
IX/227	Canada	Radio-relay systems for telephony — Noise in circuits forming part of very long telephone connections	S.P. 193B
IX/228 and Rev. 1	Canada	Radio-relay systems for telephony using frequency-division multiplex — Systems with a capacity of 1200 telephone channels, or the equivalent	Recs. 275, 380, 398, 399, 401 and 404
IX/229 (IV/237)	United States of America	Communication-satellite systems sharing the same frequency bands as line-of-sight radio-relay systems — Detailed analysis of interference relations between stationary communication-satellites and a long east-west radio-relay system	Q. 235(IV) S.P. 235F(IV) Draft Rec.
IX/230	U.S.S.R.	Transmission of a television sound signal over the same link as the video signals by time-division multiplex on tropospheric-scatter radio-relay systems	Draft Q.
IX/231	U.S.S.R.	Admissible signal noise and distortion in television transmission on tropospheric radio-relay links	Q. 299

Doc.	Origin	Title	Reference
IX/232	U.S.S.R.	Tropospheric-scatter radio-relay systems — Determination of the optimum frequency deviation	Q. 260
IX/233	Japan	Radio-relay systems for telephony using frequency-division multiplex — Radio-relay systems with a capacity of 960 to 1800 telephone channels, or the equivalent, operating in the 14 GHz band	Q. 192
IX/234	Japan	Radio-relay systems — Diversity techniques	Q. 298
IX/235 and Corr. 1	Japan	Characteristics of simple VHF or UHF radio equipment for use on trunk connections in the new and developing countries — (Comment on Draft Report F.5.e(IX))	Q. 276 Draft Rep.
IX/236	Japan	Simple single-channel radiotelephony equipment — (Comment on Draft Report F.5.f(IX))	Q. 277 Draft Rep.
IX/237	C.C.I.R. Secretariat	Radio-relay systems for television and telephony — Noise tolerable during very short periods of time	S.P. 193A
IX/238	C.C.I.R. Secretariat	Note by the Director *a. i.*, C.C.I.R.	Q. 297
IX/239	C.C.I.R. Secretariat	Note by the Director *a. i.*, C.C.I.R.	Rec. 290
IX/240 (IV/247)	C.C.I.R. Secretariat	Report by Joint Special Study Group C (C.C.I.T.T./C.C.I.R.)	
IX/241	Italy	Determination of optimum values for the system characteristics required to achieve the maximum capacity in each radio-frequency channel	S.P. 192A Rep. 287 Draft Rec. Rec. 404
IX/242	India	Proposed modifications to Recommendation 406 — Line-of-sight radio-relay systems sharing the same frequency bands as the satellite receivers of active earth-satellite communication-systems — Maximum effective radiated powers of line-of-sight radio-relay system transmitters	Rec. 406
IX/243	Italy	Draft Question (IX) — Radio-relay systems for the transmission of sound-broadcasting signals	Draft New Q.
IX/244	Japan	Radio-relay systems for telephony using frequency-division multiplex	Recs. 275, 380, 398, 399, 401 and 404
IX/245	C.C.I.R. Secretariat	Report of the first meeting of GAS 3, Rabat, 1966	Q. 279 Rep. GAS 3
IX/246	Italy	Preferred characteristics for auxiliary radio-relay systems assigned to service channels — Proposals for an extended definition	Q. 195 S.P. 195A
IX/247 (IV/245)	Joint Working Group IV/IX	Summary record of the first meeting	
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IX/249	Working Group IX-C	Draft Recommendation — Radio-relay systems for telephony using frequency-division multiplex — Allowable noise power in the hypothetical reference circuit	Q. 193
IX/250	C.C.I.R. Secretariat	List of documents issued (IX/201 to IX/250)	
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IX/261	Study Group IX	Proposed modification to the terms of reference of Study Group IX	
IX/262 and Rev. 1	Working Group IX-C	Draft Report — Radio-relay systems for telephony using frequency-division multiplex — Noise in circuits forming part of very long telephone connections	S.P. 193B
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IX/269	Working Group IX-A	Draft Report — Interconnection of auxiliary radio-relay systems operating in the same frequency band as the main radio-relay system	Rec. 389
IX/270	Study Group IX	Summary record of the second meeting	
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IX/274 (IV/276) (XIV/15) and Corr. 1 and Corr. 2	Terminology Working Group of Study Group IV	Draft letter from the Chairman of Study Group IV to the Chairman of Study Group XIV	
IX/275 and Rev. 1	Working Group IX-C	Draft Recommendation — Radio-relay systems for telephony using frequency-division multiplex — Noise in the radio portion of circuits to be established over real links	
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IX/283 (IV/286)	Joint Working Group IV/IX	Draft Recommendation — Frequency sharing between active communication-satellite systems and terrestrial radio services in the same frequency bands	Q. 235(IV)
IX/284 (IV/288)	Joint Working Group IV/IX	Draft Recommendation — Communication-satellite systems and line-of-sight radio-relay systems sharing the same frequency bands — Maximum allowable values of power flux-density at the surface of the earth produced by communication satellites	Q. 235(IV)
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IX/286 (IV/294)	Joint Working Group IV/IX	Draft Report — Feasibility of frequency sharing between communication-satellite systems and terrestrial radio services — Maximum power in any 4 kHz band which may need to be radiated in the horizontal plane by active communication-satellite earth stations	S.P. 235F(IV)
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IX/291 (IV/297) and Rev. 1	Joint Working Group IV/IX-A	Draft Recommendation — Line-of-sight radio-relay systems sharing the same frequency bands as the space station receivers of active satellite-communication systems — Maximum directional radiated power of line-of-sight radio-relay system transmitters	
IX/292 (X/216) (CMTT/80)	Joint Working Group IX/X/CMTT	Transmission of sound modulation channels — Report by the Chairman	
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IX/297 (IV/302) and Corr. 1	Joint Working Group IV/IX	Proposed modification to Recommendation 360 — Criteria for selection of preferred reference frequencies for communication-satellite systems sharing frequency bands with line-of-sight radio-relay systems	
IX/298	Study Group IX	Report — Radio-relay systems for the transmission of pulse-code modulation and other types of digital signal	Q. 297
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IX/301 (IV/311)	Joint Working Group IV/IX-C	Draft amendment to Recommendation L.2.e (IV)	
IX/302 (IV/313)	Working Group IV/IX-D	Draft modifications to Report L.2.g(IV) — Frequency sharing between communication-satellite systems and terrestrial services	Q. 235(IV)
IX/303 (IV/314)	Joint Working Group IV/IX	Draft Report — Exposures of radio-relay antennae to communication satellites	Q. 235(IV)
IX/304 (IV/316)	Joint Working Group IV/IX	Summary record of the third meeting	
IX/305 (IV/326)	Joint Working Group IV/IX	Modifications to Draft Recommendation L.2.c(IV) — Communication-satellite systems and line-of-sight radio-relay systems sharing the same frequency bands — Maximum allowable values of interference in a telephone channel of a radio-relay system	
IX/306 (IV/327)	Joint Working Group IV/IX	Proposed modification to Draft Recommendation L.2.b(IV) — Communication-satellite systems and line-of-sight radio-relay systems sharing the same frequency bands — Maximum allowable values of interference in a telephone channel of a communication-satellite system	
IX/307 (IV/303) and Rev. 1	Working Group IV/IX-C	Draft Report — Determination of coordination distance	
IX/308 (IV/328)	Joint Study Group IV/IX	Summary record of the fourth meeting	
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IX/1011	Radio-relay systems for telephony using frequency-division multiplex — Radio-frequency channel arrangements for 300 channel systems operating in the 2 and 4 GHz bands	Rec. 279-1
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IX/1025	Radio-relay systems for television and telephony — Preferred characteristics for multi-line switching arrangements	Rec. 444
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