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INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

C.C.I.R.

DOCUMENTS OF THE
IXth PLENARY ASSEMBLY

LOS ANGELES, 1959

VOLUME I

RECOMMENDATIONS



Published by the
INTERNATIONAL TELECOMMUNICATION UNION
GENEVA, 1959

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE



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VOLUME I

RECOMMENDATIONS



Published by the
INTERNATIONAL TELECOMMUNICATION UNION
GENEVA, 1959

April, 1960

Corrigendum to Volume I - issued in April 1960

Volume I

p. 12 Paragraph 4

Replace " VIIIth. Plenary Assembly (Warsaw, 1956) " by " IXth Plenary Assembly (Los Angeles, 1959) ".

p. 109 Rec. 40, title

Replace " calls " by " circuits ".

p. 109 Rec. 244, title

Replace " telex " by " metallic ".

p. 131 Rec. 242, Annex I

Replace " 173 " by " 132 ".

p. 132 Rec. 242, Table I, col. 2, line 15.

Replace " AAAZA " by " AAZZ ".

p. 161 Rec. 252, § (a), line 3.

Replace " 8463 " by " 8364 ".

May, 1961

Corrigendum to Volume I - issued in May 1961

Volume I

Page 29, Rec. 228, Table, Section A3, Column 4, (b), delete "1 to 1·8" substitute "1 to 1·08".

Page 286, Rec. 307, § 4, last line, delete " $\varepsilon = 4 \times 10^{-13}$ " substitute " $\varepsilon = 4 \times 10^{-11}$ ".

**RESOLUTION AND RECOMMENDATIONS
OF THE ADMINISTRATIVE RADIO CONFERENCE, GENEVA, 1959
WHICH CONCERN THE C.C.I.R.**

RESOLUTION No. 7

Relating to Radio Emissions from Artificial Satellites and Other Space Vehicles

(See Question No. 208 (IV) below)

RECOMMENDATION No. 1

to the C.C.I.R. Relating to the Frequency Tolerances of Transmitters

(See Study Programme No. 169 (I) below)

RECOMMENDATION No. 2

Relating to the Technical Standards of the I.F.R.B.

The Administrative Radio Conference, Geneva, 1959,

recognizing

that the Technical Standards of the International Frequency Registration Board (I.F.R.B.) are in daily use in the technical examination of frequency assignment notices,

urges the C.C.I.R.

to expedite all phases of the programme of studies which will assist the I.F.R.B. in the further refinement of its Technical Standards,

and invites the administrations

in their participation in the work of the C.C.I.R. and its study groups, to give special priority to those studies.

RECOMMENDATION No. 3

**to the C.C.I.R. Relating to Signal to Interference Protection
Ratios and Minimum Field Strength Requirements ***

The Administrative Radio Conference, Geneva, 1959,

recognizing

that the available information on signal to interference protection ratios and minimum field strengths required for each one of the services needs further refinement in order to permit the most efficient planning of the use of the radio frequency spectrum;

* See Study Programme No. 128(III).

invites the C.C.I.R.

1. to continue to study signal to interference protection ratios which define the threshold of harmful interference for the several services;
2. to continue to study the signal to noise ratios and the minimum field strengths required for satisfactory reception of the different classes of emission in the several services;
3. to continue the study of fading allowances for the several services;
4. to give particular attention to those studies which will assist in the further refinement of the technical standards used by the International Frequency Registration Board.

RECOMMENDATION No. 4

to the C.C.I.R. Relating to Studies of Radio Propagation and Radio Noise

The Administrative Radio Conference, Geneva, 1959,

considering

- a) that the efficient utilization of radio frequencies depends upon the use of the most reliable technical data and standards, especially in those parts of the radio frequency spectrum which are most congested;
- b) that the satisfaction of new frequency requirements and the development of radio services can be facilitated by improvements, where these are necessary, in the technical standards at present used by the I.F.R.B.;
- c) that, in accordance with Appendix A, administrations will endeavour to promote further studies on radio propagation and radio noise through the medium of the C.C.I.R.;
- d) that the C.C.I.R. has adopted a programme of studies covering many of these problems;

invites the C.C.I.R.

1. to continue the studies of radio propagation and radio noise and to take measures for the co-ordination of the results of these studies carried out in different countries;
2. to give particular attention to those studies which will assist in the further refinement of the technical standards used by the I.F.R.B.;
3. to report regularly on these matters, even if the studies have not been completed;
4. to continue regular consultation with other organizations undertaking studies of propagation such as the International Scientific Radio Union, in order to attain the maximum possible degree of co-ordination.

RECOMMENDATION No. 5

**to the C.C.I.R. and to Administrations Relating to International Monitoring
in the Bands Below 28 000 kc/s**

The Administrative Radio Conference, Geneva, 1959,

considering

- a) the desirability of achieving a more effective use of the radio spectrum in order to assist administrations to satisfy their frequency requirements, and, to that end, the desirability of taking

Addendum issued in April 1960

steps to make the International Frequency List reflect more accurately the actual use being made of the radio spectrum;

- b) the provisions of the Radio Regulations, Geneva, 1959, under which the International Frequency Registration Board shall review the entries in the Master International Frequency Register with a view to bringing them into conformity, to the maximum extent practicable, with the actual use being made of the radio spectrum;
- c) that monitoring information should assist the Board in discharging that function;

recognizing

- a) that an international monitoring system cannot be fully effective unless it covers all areas of the world;
- b) that, at present, in certain areas of the world, monitoring facilities are either non-existent or insufficient to provide effective coverage;

invites the C.C.I.R.

in collaboration with the Board, to study and make technical recommendations concerning the additional facilities required to provide adequate coverage in all areas of the world for the purposes of Articles 8, 9 and 13 of the Radio Regulations, and

invites Administrations

1. to make every effort to develop monitoring facilities as envisaged in Article 13 of the Radio Regulations bearing in mind the means which may be made available through the appropriate technical assistance organs of the United Nations;
2. to inform the Board of the extent to which they are prepared to co-operate in such monitoring programmes as may be requested by the Board.

RECOMMENDATION No. 6

to the C.C.I.R. Relating to Studies of the Technical Characteristics of Equipment

The Administrative Radio Conference, Geneva, 1959,

recognizing

that the available technical information concerning the various types of apparatus used for the reception of the different classes of emission in the several services needs to be more complete and more precise in order to permit the most efficient planning of the use of the radio frequency spectrum;

invites the C.C.I.R.

1. to continue to study, and to make recommendations for the bandwidth, selectivity, sensitivity and stability characteristics of various types of apparatus used for the reception of the different classes of emission in the several services;
2. to continue to study practical methods of achieving the recommended characteristics;
3. to study the minimum practicable spacing between adjacent channels for the different classes of emission for the several services in the various bands; *

* See Study Programme No. 128 (III).

4. to study other desirable conditions to be fulfilled by the complete systems employed by the different services in order to determine the required technical performance of the equipment, including the station terminal apparatus and the antennae; *
5. to study methods for determining whether the equipment satisfies the recommended requirements; *
6. to give particular attention to those studies which will assist in the further refinement of the technical standards used by the International Frequency Registration Board.

RECOMMENDATION No. 7

Relating to Specifications of Broadcasting Receivers at Low Cost

(See Study Programme No. 170 (XII) below)

RECOMMENDATION No. 8

Relating to the Classification of Emissions

(See Question No. 207 (I) below)

RECOMMENDATION No. 9

Relating to the Use of the Rationalized M.K.S. System of Units **

The Administrative Radio Conference, Geneva, 1959,

recognizing

the wide use of the Rationalized M.K.S. system of units (also known as the rationalized Giorgi system) by radio engineers and authors of radio publications, and its wide use in the C.C.I.R. and other permanent organs of the Union;

recommends

that administrations shall endeavour to adopt that system gradually in their relations with the Union and its permanent organs.

* See the various texts of Study Groups Nos. I, II and III.

** See Recommendation No. 143 of the C.C.I.R.

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**Section J: Monitoring
of Transmissions**

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Section K: Vocabulary

K

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INTRODUCTION

The International Radio Consultative Committee (C.C.I.R.) held its IXth Plenary Assembly in Los Angeles from 2 April to 29 April, 1959. It was attended about 425 delegates, representatives, experts and observers from some 42 different countries, Members of the I.T.U., 17 recognized private operating agencies, 9 international organizations and 11 scientific or industrial organizations.

At the same time all the fourteen Study Groups of the C.C.I.R. held meetings in Los Angeles and the Plenary Assembly adopted 96 Recommendations, 38 Reports * and 28 Resolutions put forward by the Study Groups.

The programme of work for the next three years was also studied. The programme of work consists of 80 Questions and 70 Study Programmes dealing with all aspects of radio communication, including problems of the transmission, propagation and reception of electromagnetic waves which arise in the operation of all radio services.

Volumes I, II and III contain all the texts adopted at Los Angeles, as well as those which were adopted during the four preceding Plenary Assemblies and still remain valid. Hence they form an up to date collection of the texts of the C.C.I.R.

The four preceding Plenary Assemblies of the C.C.I.R. took place in Stockholm in July 1948 (Vth C.C.I.R. Plenary Assembly), Geneva in June/July 1951 (VIth C.C.I.R. Plenary Assembly), London in September/October, 1953 (VIIth C.C.I.R. Plenary Assembly) and Warsaw in August/September, 1956 (VIIIth C.C.I.R. Plenary Assembly) respectively.

During its final meeting, the IXth Plenary Assembly of the C.C.I.R. accepted unanimously and with acclamation an invitation from the Administration of the Republic of India to hold the Xth Plenary Assembly of the C.C.I.R. in New Delhi.

* A further 39 Reports were examined by the Drafting Committee after adoption by the Study Groups but were not published in their final form for adoption by the Plenary Assembly.

“The duties of the International Radio Consultative Committee (C.C.I.R.) shall be to study technical radio questions and operating questions, the solution of which depends principally on considerations of a technical radio character and to issue recommendations on them.”

— *Extract from Article 7, paragraph 1 of the International Telecommunication Convention (Buenos Aires, 1952).*

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VOLUME III Reports of the C.C.I.R.	
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List of delegates.	
Numerical list of documents.	
List of documents classified by Study Groups.	
VOLUME V Minutes of the Plenary Meetings.	

Note. — For ease of reference, the page numbering in the English and French editions has been made the same.

LIST OF PARTICIPANTS IN THE IXth PLENARY ASSEMBLY

Administrations

Argentina (Republic of)	New Zealand
Australia	Pakistan
Austria	Netherlands
Belgium	Poland (People's Republic of)
Bielorussian Soviet Socialist Republic	Portugal
Bulgaria (People's Republic of) *	Federal German Republic
Canada	Federal People's Republic of Yugoslavia
China	Ukrainian Soviet Socialist Republic
Denmark	Roumanian People's Republic
Ecuador	United Kingdom of Great Britain and Northern Ireland
Spain	Ireland
United States of America	Sweden
Finland	Switzerland (Confederation)
France	Czechoslovakia
Guatemala	Overseas Territories of the French Republic
India	Turkey
Ireland	Union of South Africa
Italy	Union of Soviet Socialist Republics
Japan	Venezuela (United States of)
Monaco	
Norway	

Private Operating Agencies

American Telephone & Telegraph Co.	Nippon Hoso Kyokai (N.H.K.)
British Broadcasting Corporation (B.B.C.)	Nippon Telegraph & Telephone Public Corporation (N.T.T.)
Cables & Wireless Ltd.	Radio Austria A.G.
Compagnie générale de Télégraphie sans Fil	Radio Corporation of America (R.C.A.)
Companhia Portuguesa Radio Marconi	Radio Suisse
Independent Television Authority	Radiotelevisione Italiana (RAI)
International Marine Radio Co. Ltd. (I.M.R.C.)	Radiojäst A.B.
Kokusai Denshin Denwa Co. Ltd. (K.D.D.)	South African Broadcasting Corporation (S.A.B.C.)
Marconi International Marine Communication Co., Ltd. (M.I.M.C.C.)	

International Organizations

International Astronautical Federation (I.A.F.)	International Special Committee on Radio Interference (C.I.S.P.R.)
International Astronomical Union	International Broadcasting Organization (I.B.O.)
International Radio Maritime Committee (C.I.R.M.)	International Scientific Radio Union (U.R.S.I.)
International Chamber of Shipping (I.C.S.)	European Broadcasting Union (E.B.U.)

* Represented by Czechoslovakia

Scientific and Industrial Organizations

Brown, Boveri & Co., Ltd.
Electronic Industries Association (E.I.A.)
Face Standard
Siemens & Halske A.G.

Telfonaktiebolaget L. M. Ericsson
Telefunken G.m.b.H.
West Coast Electronics Manufacturers Association (W.C.E.M.A.)

Specialised Agencies of the United Nations

International Civil Aviation Organization
(I.C.A.O.)

World Meteorological Organization (W.M.O.)

LAYOUT OF VOLUMES I, II AND III

(Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R.)

General

The Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R., the texts of which appear in Volumes I, II and III, are those which have been approved by the IXth Plenary Assembly of the C.C.I.R., together with those which, approved by the Vth, VIth, VIIth and VIIIth Plenary Assemblies, have been retained.

The Recommendations, Reports and Resolutions of a general nature are arranged in numerical order.

The Questions and Study Programmes are grouped together and arranged in the numerical order of the Study Groups. For each Study Group the Questions are laid out in numerical order, each being followed by the Resolution(s) and Study Programme(s) to which they are related. Study Programmes which are not the result of a Question are indicated by a note.

Questions submitted to the C.C.I.T.T. form the subject of a separate chapter.

References to the texts, if any, forming the basis of Recommendations, Reports, Resolutions, Questions and Study Programmes are given below the title. On the right under this reference is shown the Plenary Assembly or Assemblies which have approved or subsequently modified the text.

Mention is made in a footnote, when the occasion arises, of the texts or text which have been replaced by the text in question; in the case of a Question, the Study Programmes are shown which arise from it; and in the case of Study Programmes, mention has been made where necessary of the Questions to which they refer.

To facilitate reference to a desired document, and to reduce the bulk of the bound edition, the previous Volume I has been divided into three:

Volume I : Recommendations of the C.C.I.R.

Volume II : Resolutions, Questions and Study Programmes of the C.C.I.R.

Volume III: Reports of the C.C.I.R.

Further to facilitate the tracing of a desired document, the Recommendations and Reports of the C.C.I.R., while retaining their serial numbering, have been grouped into ten sections designated by capital letters:

A. Transmission	F. Radio-relay systems
B. Reception	G. Propagation
C. Fixed services	H. Standard-frequencies and time signals
D. Mobile services and space-systems	J. International monitoring
E. Sound broadcasting and television	K. Vocabulary

Definitions of Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R.

The following definitions of Recommendations, Resolutions and Questions are those which appear in Doc. No. 272 of Geneva (Drafting Committee). The definition given for Study Programmes is that which appears in Doc. No. 630 of London (Drafting Committee). The definition given for Reports is that which appears in Doc. No. 731 of London (U.S.A.) modified by the addition of the words "by a Study Group".

Recommendation	Statement issued when the study of a Question, or part of a Question, has been concluded.
Report	Statement for information on the studies carried out by a Study Group on a given subject.
Resolution	Statement of an opinion of the C.C.I.R. on a non-technical subject.
Question	Statement of a technical problem which the C.C.I.R. is to consider.
Study Programme	Text describing the work to be done on a given technical problem forming the subject of a Question.

Origin of certain documents referred to in these volumes

The documents referred to in these volumes as "Stockholm", "Geneva", "London", "Warsaw" and "Los Angeles" are respectively the documents of the Vth, VIth, VIIth, VIIIth and IXth Plenary Assemblies of the C.C.I.R. held in Stockholm in 1948, Geneva in 1951, London in 1953, Warsaw in 1956 and Los Angeles in 1959.

The documents referred to in these volumes as of "Mexico" and "Florence/Rapallo", are respectively those of the High-Frequency Broadcasting Conferences of Mexico City in 1948-49 and of Florence/Rapallo in 1950.

Other documents referred to in these volumes are the documents of the meetings of certain Study Groups of the C.C.I.R. The following list of the meetings of these Study Groups is given for information:

Zurich (July 1949)	Study Group No. XI
Washington (March 1950)	Study Groups Nos. VI and X
London (May 1950)	Study Group No. XI
Geneva (July 1950)	Sub-Group Gerber of Study Group No. XI
The Hague (April 1952)	Study Groups Nos. I and III
Stockholm (May 1952)	Study Groups Nos. V, VI and XI
Geneva (August 1952)	Study Group No. X
Geneva (September 1952)	Study Group No. IX
Brussels (March-April 1955)	Study Groups Nos. I and XI
Paris (July 1957)	C.M.T.T. (Joint Study Group for television transmission)
Geneva (December 1957)	Sub-Group Lépéchinsky
Moscow (May-June 1958)	Study Group No. XI
Geneva (July-August 1958)	Study Groups Nos. I, II, III, IV, V, VI, VII & IX
Monte-Carlo (October 1958)	C.M.T.T.

Numbering of the Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R.

The Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R. are numbered consecutively in five series, each starting at No. 1.

The series of Recommendations, Questions and Resolutions were started at the Vth Plenary Assembly (Stockholm, 1948).

The series of Reports and Study Programmes were started at the VIth Plenary Assembly (Geneva 1951).

Questions and Study Programmes remaining for study after the VIIIth Plenary Assembly (Warsaw, 1956) carry in Roman figures after the serial number, the number of the Study Group to which they have been submitted.

The following table serves as a guide to the numbering of C.C.I.R. documents:

Plenary Assembly of C.C.I.R.	Recommendation No.	Report No.	Resolution No.	Question No.	Study Programme No.
Vth Stockholm (1948)	1 to 35	Nil	1 & 2	1 to 33*	Nil
VIth Geneva (1951)	36 to 85**	1 to 15	3 to 9	46 to 73	1 to 38
VIIth London (1953)	87 to 144	16 to 37	10 to 19	74 to 112***	39 to 78***
VIIIth Warsaw (1956)	145 to 227	38 to 95	20 to 38	123 to 164****	82 to 115****
IXth Los Angeles (1959)	228 to 324	96 to 174	39 to 67	171 to 206	124 to 168

* Questions Nos. 34 to 45 were submitted to the C.C.I.R. between the Vth and VIth Plenary Assemblies.

** Recommendation No. 86 was issued after the meeting of Study Group X of the C.C.I.R. held at Geneva 1952.

*** Questions Nos. 113 to 122 and Study Programmes Nos. 79 to 81 were submitted to the C.C.I.R. between the VIIth and VIIIth Plenary Assemblies.

**** Questions Nos. 165 to 170 and Study Programmes Nos. 116-123 were submitted to the C.C.I.R. between the VIIIth and IXth Plenary Assemblies.

COMPLETE LIST OF RECOMMENDATIONS OF THE C.C.I.R.

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1	<i>Replaced together with Recommendation No. 43, by Recommendation No. 97.</i>	
2	<i>Replaced successively by Recommendations Nos. 41, 94, 154 and 234.</i>	
3	<i>Replaced successively by Recommendations Nos. 36, 87, 145 and 230.</i>	
4	<i>Replaced successively by Recommendations Nos. 42, 95, 155 and 235.</i>	
5	<i>Cancelled.</i>	
6	<i>Cancelled.</i>	
7	<i>Cancelled.</i>	
8	<i>Cancelled.</i>	
9	<i>Cancelled.</i>	
10	<i>Cancelled.</i>	
11	<i>Cancelled.</i>	
12	<i>Cancelled.</i>	
13	<i>Cancelled.</i>	
14	<i>Cancelled.</i>	
15	<i>Cancelled.</i>	
16	<i>Cancelled.</i>	
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20	<i>Replaced successively by Recommendations Nos. 180 and 322.</i>	
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25	<i>Reclassified as Question No. 58 which no longer remains for study.</i>	
26	<i>Cancelled.</i>	
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28	<i>Replaced by Report No. 173.</i>	
29	<i>Reclassified as Question No. 64 which no longer remains for study.</i>	
30	<i>Cancelled.</i>	
31	<i>Cancelled.</i>	
32	<i>Cancelled.</i>	
33	<i>Replaced successively by Resolutions Nos. 36 and 67.</i>	
34	<i>Cancelled.</i>	
35	<i>Cancelled.</i>	
36	<i>Replaced successively by Recommendations Nos. 87, 145 and 230.</i>	
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51	<i>Replaced successively by Recommendations Nos. 109, 169 and 308.</i>	
52	<i>Replaced by Recommendation No. 307.</i>	
53	<i>Cancelled.</i>	
54	<i>Replaced by Recommendation No. 310.</i>	
55	<i>Replaced successively by Recommendations Nos. 111 and 312.</i>	
56	<i>Cancelled.</i>	
57	<i>Cancelled.</i>	
58	<i>Cancelled.</i>	
59	<i>Replaced by Recommendation No. 313.</i>	
60	<i>Replaced by Report No. 138.</i>	
61	<i>Replaced by Report No. 138.</i>	
62	<i>Replaced successively by Recommendation No. 112 and Report No. 138.</i>	
63	<i>Replaced by Report No. 138.</i>	
64	<i>Replaced successively by Recommendation No. 113 and Report No. 138.</i>	
65	<i>Replaced by Report No. 138.</i>	
66	<i>Replaced successively by Recommendations Nos. 114 and 171 and Report No. 138.</i>	
67	<i>Replaced, together with Recommendation No. 120, successively by Recommendations Nos. 175 and 315.</i>	
68	<i>Replaced successively by Recommendations Nos. 105 and 164.</i>	
69	<i>Replaced successively by Recommendations Nos. 117 and 172.</i>	
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88	<i>Replaced by Recommendation No. 229.</i>	
89	<i>Replaced successively by Recommendations Nos. 147 and 232.</i>	
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The following Recommendations which have been classified in other sections also concern Transmission:

Rec. No.	Section
100	C
139	E
182	J
205	E
214	E
215	E
248	C
249	C
255	D
262	E
266	E
322	J

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RECOMMENDATION No. 83 *

**DISTURBANCES IN TELEVISION RECEIVERS
RESULTING FROM HARMONICS
AND OTHER NON-ESSENTIAL RADIATIONS FROM RADIO TRANSMITTERS**
(Question No. 26)

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that Study Programme No. 2 (I) relating to Question 1 (I) *b*, covers the general problem of harmonic radiation from transmitters;
- (b) that the general study of the interference to other services by those harmonic radiations will include that caused to television reception;

RECOMMENDS

that the administrations should collect all possible data relating to such interference with broadcasting (television) in order to assist the Study Group concerned with transmitter questions.

RECOMMENDATION No. 129

**METHODS OF SPECIFYING THE POWER SUPPLIED TO AN ANTENNA
BY A RADIO TRANSMITTER**
(Question No. 60)

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that the Radio Regulations, Atlantic City, 1947, Art. 1, Section IV, Nos. 60 to 64, call for the use of peak power in specifying the power of a radio transmitter, but permit the use of mean power in cases where the peak power specification is not satisfactory or adequate;
- (b) that in some cases the power of the unmodulated carrier may be a preferable method of rating the power of a transmitter with regard to monitoring and interference producing capabilities;
- (c) that, although the two alternatives provided in the Radio Regulations may not always be adequate for all the uses made of transmitter power ratings, there is no satisfactory alternative form of specification immediately available;
- (d) that there is no good reason for not specifying the power of a radio transmitter in a number of ways simultaneously, as long as each way can be shown to be necessary;

* This Recommendation concludes the study of Question No. 26.

UNANIMOUSLY RECOMMENDS

1. that, for the time being the provisions of the Radio Regulations, Atlantic City, 1947, Art. 1, Section IV, Nos. 60 to 74 need not be altered;
2. that other methods of specifying and measuring the power of radio transmitters should be included when this is justified.

RECOMMENDATION No. 130 *

POWER RELATIONSHIPS FOR MODULATED EMISSIONS

(Question No. 59)

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that the modulated signals likely to be used for field-strength measurements can be divided into two classes;
 - Class 1: where the radiated power is wholly or largely independent of the degree of modulation;
 - Class 2: where the radiated power is largely dependent on the degree of modulation.
- (b) that for modulation by speech, music or conversation, or by certain other forms of intelligence, the power relationships of the modulating signal are variable;

UNANIMOUSLY RECOMMENDS

1. that for signals of Class 1 it should suffice, for most field-strength measurements, to specify the unmodulated carrier power;
2. that for signals of Class 2, when it is necessary to make field-strength measurements of high precision, it appears desirable for the two terminals to co-operate, either by recording the transmitter output power with an instrument having similar characteristics to those of the field-strength recorder or by the transmission of special signals.

RECOMMENDATION No. 131 **

INTERFERENCE TO RADIO SERVICES ***

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that the study of certain aspects of interference, affecting sound and television broadcasting, especially from industrial sources, is already entrusted to the International Special Committee on Radio Interference (C.I.S.P.R.) administered by the International Electrotechnical Commission (I.E.C.);

* This Recommendation completes the study of Question No. 59.

** France reserved its opinion on this Recommendation.

*** See Buenos Aires Resolution No. 5.



- (b) that the C.C.I.R. in accordance with Recommendation No. 27 of the Vth Plenary Assembly (Stockholm, 1948) maintains regular contact with the C.I.S.P.R.;
- (c) that the harmonious co-existence of radio services with industrial installations producing radio oscillations involves close collaboration between organisations representing the manufacturers and users of these installations on the one hand, and the radio services on the other, for which the existing collaboration between the C.C.I.R. and the C.I.S.P.R. provides;
- (d) that the C.I.S.P.R. has already studied and is continuing to study extensively the permissible signal-to-interference ratios for sound and television broadcasting, but has not yet made equivalent studies for other radio services;

RECOMMENDS

1. that the existing collaboration between the C.C.I.R. and the C.I.S.P.R. should be actively maintained and extended;
2. that in the course of such collaboration the C.C.I.R. should bring to the notice of the C.I.S.P.R. those aspects of the work that are of the greatest urgency, so far as the C.C.I.R. is concerned, so that the results of their work can be used in future by the C.C.I.R.;
3. that the study of interference to radio services, required by Resolution No. 5 annexed to the International Telecommunication Convention, Buenos Aires, 1952, should be carried out by the C.C.I.R., the latter continuing to study the maximum interference levels (including radiation from industrial scientific and medical equipment) tolerable in various radio systems, while avoiding duplication of the work already in progress in the C.I.S.P.R., and that the C.C.I.R. should transmit its findings to the C.I.S.P.R. to facilitate the latter's study of radio interference problems;
4. that the C.C.I.R. should continue to take cognisance of those aspects of this work which relate specifically to the study and establishment of conditions necessary to ensure the avoidance of harmful interference between services whose operation is covered by the Radio Regulations.

RECOMMENDATION No. 228 *

STUDY OF RELATIONSHIPS BETWEEN PEAK POWER AND MEAN POWER

(Question No. 22)

The C.C.I.R.,

(Geneva, 1951 — Los Angeles, 1959)

CONSIDERING

- (a) that the Radio Regulations, Atlantic City, 1947, Art. 1, Section IV, Nos. 60 to 64, call for the use of "peak power" in specifying the power of a radio transmitter, but allow the additional use of "mean power" in cases where the peak power specification is not satisfactory or adequate;
- (b) that in many cases it will be possible to measure the peak power directly and in others it will be possible to derive the peak power from measurements made under suitably arranged tests conditions;
- (c) that a specification of radiated power is advantageous for use in calculations of radio propagation, channel spacing, signal-to-interference ratios and signal-to-noise ratios involved in radio communications;

* This Recommendation replaces Recommendation No. 73.

- (d) that for administrative purposes or for the calculations in (c), the specification of peak power as defined in the Radio Regulations, Atlantic City, 1947, is not sufficient to evaluate adequately the interference-producing capabilities of a signal;
- (e) that in monitoring of field-intensity recording of the strength of radio signals the use of automatic recorders frequently involves measurements of average rather than peak field strength; for some types of modulated signal, the mean field intensity is not affected by the modulation;
- (f) that consequently it is necessary for the field strength as measured by use of monitoring equipment to be interpreted consistently in terms of the rated power of the transmitter;
- (g) that information on transmitter power expressed in terms of peak or mean power alone, as defined in the Radio Regulations, Atlantic City, 1947, is adequate only for certain types of emission and for certain uses of the information; in many cases it is desirable to use power ratings expressed otherwise;

UNANIMOUSLY RECOMMENDS

that the table attached in the Annex, which presents, for each type of emission specified in the Radio Regulations, Atlantic City, 1947, the relationships between peak power and mean power, and also the power under conditions of no modulation, should wherever practicable, supersede the Annex to Question No. 22.

ANNEX

CONVERSION TABLE FOR RELATIONSHIPS BETWEEN PEAK POWER AND MEAN POWER

1. In the following table the symbols P_p and P_m indicate peak power and mean power, respectively, as defined in Art. 1 of the Radio Regulations, Atlantic City, 1947, which states that:
 - 1.1 the peak power of a radio transmitter is the mean power supplied to the antenna during one radio-frequency cycle at the highest crest of the modulation envelope, taken under conditions of normal operation;
 - 1.2 the mean power of a radio transmitter is the power supplied to the antenna during normal operation, averaged over a time sufficiently long compared with the period corresponding to the lowest frequency encountered in actual modulation (in general, a time of 1/10 second, during which the mean power is a maximum, will be selected).
2. In the following table the average power which a transmitter supplies to its antenna during one radio-frequency cycle under conditions of no modulation is considered to have a value of unity. Conditions of no modulation are specified in the table. With these conditions as a reference, relative values of P_m and P_p for various modulated emissions are indicated by conversion factors under the columns P_m and P_p , where applicable.
3. Specification of modulating wave form is essential for conversions between peak power ratings and power ratings of other types. Accordingly, one or more "characteristic modulations" are assumed and described for each class of emission evaluated in the following table. To permit proper evaluation of potential geographical interference ranges, these "characteristic modulations" are chosen, as far as possible, to give maximum ratios of P_p to P_m .



Type of modulated emission	Characteristic modulation	Condition of no modulation	Conversion factors (See § 2 of this Annex)	
			P_m	P_p
<i>Amplitude modulation</i>				
A1 (On-off telegraphy)	Series of rectangular dots; equal marks and spaces; zero space amplitude	Key down	0.5 (Note 1)	1
A2 (Telegraphy with keying of audio-frequency modulating tone, or of modulated emission)	Series of rectangular dots; equal marks and spaces; single sine-wave audio-frequency modulating tone; 100% modulation (a) Modulating tone keyed (b) Modulated emission keyed	(a) Key up (tone removed) (b) Key down (tone removed)	(a) 1.25 (b) 0.75	(a) 4 (b) 4
A3 (Double-sideband telephony, full carrier)	(a) Single sine-wave audio-frequency modulating tone; 100% modulation (b) Smoothly read text	(a) Carrier only (Note 2) (b) Carrier only (Note 2)	(a) 1.5 (b) 1 to 1.8	(a) 4 (b) 4
A3a (Single-sideband, reduced carrier)	See Supplementary Table I and Note 3			
A3b (Two independent sidebands, reduced carrier)	See Supplementary Table II and Note 3			
A4 (Facsimile)	Black and white chequerboard picture giving square modulating wave; 100% modulation	Full carrier amplitude	0.5 (Note 6)	1 (Note 6)
A5 (Television)	(See Note 4)			
<i>Frequency or phase modulation</i>				
F1	(For all types of frequency or phase-modulated transmissions the modulation changes the distribution of power in the frequency band of the emissions while leaving the total power of the emissions unchanged)		1	1
F2			1	1
F3			1	1
F4			1	1
F5			1	1
F6			1	1
F9			1	1
<i>Pulse modulation</i>				
P1 (Simple telegraphy)	Pulse train keyed on and off; mark and space equal; rectangular pulses, constant amplitude and duty cycle	Key down (Note 5)	0.5 (Note 5)	1/duty cycle

Type of modulated emission	Characteristic modulation	Condition of no modulation	Conversion factors (See § 2 of this Annex)	
			P_m	P_p
	Audio-frequency tone-modulated telegraphy. Series of equal rectangular marks and spaces; single sine-wave audio-frequency modulating tone; 100% modulation			
P2d (Pulses, amplitude-modulated; constant duty cycle)	(a) Modulating tone keyed	(a) Key up (tone removed) (Note 5)	(a) 1.25	(a) 4/duty cycle
	(b) Modulated emission keyed	(b) Key down (tone removed) (Note 5)	(b) 0.75	(b) 4/duty cycle
P2e (Pulses, width or duration modulated; constant amplitude)	(a) Modulating tone keyed	(a) Key up (tone removed) (Note 5)	(a) 1	(a) 1/average duty cycle
	(b) Modulated emission keyed	(b) Key down (tone removed) (Note 5)	(b) 0.5	(b) 1/average duty cycle
P2f (Pulses, position or phase modulated; constant amplitude)	(a) Modulating tone keyed	(a) Key up (tone removed) (Note 5)	(a) 1	(a) 1/average duty cycle
	(b) Modulated emission keyed	(b) Key down (tone removed) (Note 5)	(b) 0.5	(b) 1/average duty cycle
P3d (Pulses, amplitude-modulated; constant duty cycle)	Telephony			
	(a) Single sine-wave audio-frequency modulating tone; 100% modulation	(a) Pulse carrier only (Note 5)	(a) 1.5	(a) 4/duty cycle
	(b) Smoothly read text	(b) Pulse carrier only (Note 5)	(b) 1 to 1.08	(b) 4/duty cycle
P3e (Pulses, width or duration modulated; constant amplitude)	Single sine-wave audio-frequency modulating tone; 100% modulation; rectangular pulses	Pulse carrier only (Note 5)	1	1/average duty cycle
P3f (Pulses, position or phase modulated; constant amplitude)		Pulse carrier only (Note 5)	1	1/average duty cycle

Note 1. — For Morse: $P_m = 0.49 P_p$.

For International Alphabet No. 2: $P_m = 0.58 P_p$.

Note 2. — The peak power of double-sideband transmitters is nominally four times the power of the unmodulated carrier. To determine the proper level for applying speech, two tones are employed, as in the single-sideband case described in Note 3. In a well-constructed transmitter, this should result in reasonably high percentages of modulation.

SUPPLEMENTARY TABLE I
Ratio of P_m to P_p for A3a emission

Condition of no modulation	Characteristic modulation		
Carrier level, referred to peak power of sideband (db)	† Single sine-wave audio-frequency modulating tone; transmitter fully loaded	†† Smoothly-read text, transmitter fully loaded	††† "Other" programme material; transmitter fully loaded
—10	0.636 (—1.97 db)	0.149 (—8.27 db)	0.115 (—9.39 db)
—20	0.835 (—0.78 db)	0.139 (—8.57 db)	0.091 (—10.4 db)
—30	0.940 (—0.27 db)	0.150 (—8.24 db)	0.095 (—10.2 db)
—∞ (fully suppressed)	1.000 (0 db)	0.158 (—8.00 db)	0.100 (—10.0 db)

SUPPLEMENTARY TABLE II
Ratio of P_m to P_p for A3b emission

Condition of no modulation	Characteristic modulation			
Carrier level, referred to peak power of either sideband (db)	† Single sine-wave audio-frequency modulating tone on each sideband; transmitter fully loaded	†† Each sideband fully loaded by smoothly-read text; transmitter fully loaded	††† Each sideband fully loaded by "other" programme material; transmitter fully loaded	Sideband 1 smoothly-read text and sideband 2 "other" programme material
—10	0.392 (—4.07 db)	0.078 (—11.1 db)	0.056 (—12.5 db)	0.067 (—11.8 db)
—20	0.456 (—3.41 db)	0.074 (—11.3 db)	0.048 (—13.2 db)	0.061 (—12.1 db)
—30	0.485 (—3.14 db)	0.077 (—11.1 db)	0.049 (—13.1 db)	0.063 (—12.0 db)
—∞ (fully suppressed)	0.500 (—3.01 db)	0.079 (—11.0 db)	0.050 (—13.0 db)	0.065 (—11.9 db)

† For a single sine-wave audio-frequency modulating tone, the mean radio-frequency power of each sideband is equal to its peak radio-frequency power (Atlantic City definition), but is 3 db below its maximum instantaneous radio-frequency power: this 3 db difference corresponds to the 3 db difference between the mean and the instantaneous peak audio-frequency power levels of the impressed modulation.

†† For smoothly-read text, it is assumed that the mean radio-frequency power of each sideband is 8 db below its peak radio-frequency power (Atlantic City definition), or 11 db below its maximum instantaneous radio-frequency power; the corresponding underlying assumption of an 11 db difference between the mean and equivalent instantaneous peak audio-frequency power levels of the impressed modulation is made in accordance with the most recent information available.

††† For conversational speech and certain programme material other than smoothly-read text, it is assumed that the mean radio-frequency power of each sideband is 10 db below its peak radio-frequency power (Atlantic City definition), or 13 db below its maximum instantaneous radio-frequency power: the corresponding underlying assumption of a 13 db difference between the mean and equivalent peak radio-frequency power levels of the impressed modulation is made in accordance with the most recent information available.

It has been found in connection with smoothly-read text that a reading of 2 (VU * meter readings) corresponds to a mean power of zero dbm ** measured in the audio-frequency band, nominally up to 3000 or 4000 c/s.

Note 3. — The two-tone method of rating the power of single-sideband radiotelephone transmitters consists in setting the level of each of two equal tones applied to the audio-frequency input so that the resulting cross-modulation term ($2f_1 - f_2$) is 25 db below the level of either tone, measured in the r.f. output of the transmitter; the peak power rating of the transmitter is taken as four times the r.f. power output, after removal of one of the two tones. Single channel speech is applied at the audio-frequency input at a VU level equal numerically to the mean dbm level of one of the two aforementioned tones. For multichannel single-sideband transmission, the level of each channel is reduced 0.5 ($N - 1$) db, where N is the number of channels, up to a total of about four.

Note 4. — Depending on the standards used, the condition of no modulation may not apply. For any particular case, the ratio of mean power to peak power can be calculated, for the extreme conditions of all-black and all-white pictures, by taking into account the relative amplitudes and durations of blanking signals, synchronising pulses and picture signals. As examples, in the 525-line, 60-field system used at present in the United States, this results in a ratio of P_m to P_p of 0.164 for an all-white picture and 0.608 for an all-black picture; in the 405 line, 50-field system now used in the United Kingdom, the ratios are 0.800 for an all-white picture and 0.080 for an all-black picture.

Note 5. — The average power which a pulse transmitter supplies to its antenna during one pulse period of an unmodulated pulse train (P_o conditions) is considered to have a value of unity.

Note 6. — The values listed here are based upon direct facsimile scanner modulation of the main radio-frequency carrier. When the output of the facsimile scanner modulates a subcarrier and this sub-carrier is then applied as amplitude or frequency modulation of the main carrier, the resultant emission has A3, A3a, A3b, or F3 characteristics and the appropriate power relationships, therefore, must be sought in the corresponding section of the table.

RECOMMENDATION No. 229 ***

MEASUREMENT OF SPECTRA AND BANDWIDTHS OF EMISSION

The C.C.I.R.,

(Geneva, 1951 — London, 1953 — Los Angeles, 1959)

CONSIDERING

- (a) that accurate determination of bandwidths actually occupied by emissions is of increasing importance;
- (b) that Question No. 1 (I) (a) § 2, speaks of "practical methods of measuring the bandwidths actually occupied by emissions";
- (c) that new methods of measurements are proposed;
- (d) that important progress has been made in the design of measuring apparatus;
- (e) that it is now possible to present some tentative values of the degree of accuracy to be attained;

* This refers to readings of a VU meter, which is a volume indicating device having certain specific dynamic characteristics, and which is described in *Proc. I.R.E.*, 28, 1 (January 1940). Such a device reads zero for a 1000 c/s tone delivering 1 mW to a load impedance of 600 ohms. When speech volume is measured by it according to I.R.E. standards, a reading of zero corresponds to zero VU.

** dbm defined as "power in decibels referred to one milliwatt".

*** This Recommendation replaces Recommendation No. 88.

- (f) that a practical basis must be furnished for the final determination of the bandwidth necessary for a service of appropriate quality;

UNANIMOUSLY RECOMMENDS

that attention should be paid to the following:

1. Method of measurement on frequencies below 30 Mc/s

Three main methods are at present in use.

- 1.1 The first one consists in analysing the spectrum of the transmission completely by means of a narrow band filter of fixed frequency, the frequency of each component being made to coincide with the central filter frequency by frequency transposition on the superheterodyne principle either manually or automatically.

- 1.2 The second method consists in measuring directly the ratio of the total power to the part remaining outside of the bandwidth being measured.

Two variants of this method have been described.

In the first variant, the frequency components of the rectified signal are selected by means of high pass filter, the cut-off frequency of which is progressively increased (Doc. No. 128 (Japan) London, 1953).

The second variant uses two identical fixed high pass filters for the independent selection of the upper and lower out-of-band components of the signal; two frequency converters are used, the oscillators of which are automatically and independently adjusted so that each of the two filters selects the pre-determined proportion of the power (Doc. No. I/40 (Poland), of Geneva, 1958).

- 1.3 The third method consists in dividing the occupied band into narrow bands of say 100 c/s, for each of which a pass-band filter is provided, the output of each of these filters is connected either individually and permanently to a measuring device, or successively and automatically to a single measuring device. This method seems to be especially suitable for the examination of non-periodic signals such as telephone transmissions; equipments based on this method are described in Doc. 79 (USA) and 274 (Austria), of London, 1953.

2. Accuracies required for bandwidth measurement

2.1 Periodic signals of Class A1

2.1.1 Apparatus using the method described in § 1.1

- 2.1.1.1 *Laboratory apparatus.* This apparatus requires that the signals under test shall give rise to a spectrum the components of which should be stable in amplitude and in frequency. Amplitudes are measured by means of a calibrated attenuator with reference to a constant level; frequencies are measured by means of a frequency meter.

If the stability conditions referred to above are satisfied, the accuracy of the measurement depends only of the accuracy of calibration of the attenuator and of the frequency meter. An accuracy of $\pm 1\%$ in the measurement of the amplitude is obtainable, but an accuracy of $\pm 5\%$ is sufficient for most practical purposes.

- 2.1.1.2 *Automatic sweep apparatus.* Provided the frequency exploration speed is sufficiently slow to take full advantage of the high selectivity of the filter, the amplitudes of the components adjacent to the carrier can be measured with an accuracy of ± 2 db, but greater inaccuracy must be expected for the amplitudes of the remote components, especially with narrow spectra and/or slow telegraph speeds.

The accuracy of measurement of frequency deviations depends on the linearity of the sweep and on the width of the explored band. Nevertheless in the case of periodic signals, the frequency deviations between successive components are generally known by the value of the telegraph speed.

2.1.2 *Apparatus using the method described in § 1.2*

The accuracy of this measuring equipment depends on the accuracy of the measurement of power ratio, and on the steepness of the attenuation curve of the high-pass filter.

The accuracy of the measurement of power ratio should be of the order of $\pm 0.1\%$ but the errors due to the attenuation characteristics of the filter will of course depend on the type of filter employed.

2.1.3 *Apparatus using the method described in § 1.3*

When the component frequencies of the signal correspond approximately to the mid-band frequencies of the filters, accuracies of $\pm 1\%$ should be obtained.

2.2 *Periodic signals of Class F1:*

2.2.1 *Apparatus using the method described in § 1.1*

If it is possible to form periodic F1 signals for which there are corresponding components stable in amplitude and in frequency, the same accuracies as those mentioned in 2.1.1.1 and 2.1.1.2 for periodic signals of type A1 can be achieved. It is pointed out that of course, in the present case, the components which can be measured with an accuracy of ± 2 db with automatic sweep apparatus, are those adjacent to the mark and space frequencies.

It is important to point out that for F1 signals it is generally difficult, in practice, to comply with the above mentioned conditions of stability. It is then necessary to consider the envelope of several spectra observed successively, but it is not yet possible to give a satisfactory physical significance to this envelope.

2.2.2 *Apparatus using the method described in § 1.2 (see 2.1.2).*

2.2.3 *Apparatus using the method described in § 1.3 (see 2.1.3).*

2.3 *Actual traffic signals:*

No data were presented in respect of such signals, which would allow the determination of the significance of the results given by the apparatus described above. It is thus not yet possible to propose any value of the accuracy to be recommended for such signals.

ANNEX I

CHARACTERISTICS OF MEASURING EQUIPMENT WITH AUTOMATIC FREQUENCY SWEEP

That equipment suitable for use in analysing the spectrum of transmitters operating in the medium and high frequency range would in general possess the following characteristics.

Filter bandwidth

The filter bandwidth depends essentially on the characteristics of the signal to be studied. It should be small in comparison with the width of the spectrum to be measured, and whilst in the present state of the art it is inappropriate to specify a single bandwidth to the exclusion of others, it is desirable that the static bandwidth of the filter should not exceed 25 c/s. Its attenuation-frequency characteristic should be steep-sided down to the region of 60 db.

Scanning speed

Although rather high scanning speeds might prove to be useful for preliminary adjustments, when it is desired to take full advantage of the resolving power of the filter for fine analysis, the scanning speed must be sufficiently slow for the response curve of the filter to be as near as possible to the steady state selectivity curve. The admissible value of the scanning speed depends essentially on the filter characteristics and should be determined experimentally in each case.

For information purposes only it can be said that for filters having a bandwidth of 10 c/s or so at -3 db, the scanning speed admissible is generally lower than 100 c/s per second.

ANNEX II

Principal characteristics of the frequency spectrum analysers presented before the C.C.I.R. VIIth Plenary Assembly

Administration	Doc. No.	Exploration			Filter				Amplitude range (db)	Measuring instrument		Measurement of the component frequency
		Type	Sweep duration	Freq. band explored (kc/s)	Type	Bandwidth		Freq. (kc/s)		Observations	Recording	
						at -3 db	at other level					
Japan	127	auto.	1 min. 5 min.	6 and 20	crystal		50 c/s at -25 db	55	55	voltmeter	record. on paper	
Netherlands	136	auto.	20 s. 2 min. 6-7 min.	1; 5; 25	Selective feed back amplifier	Adjustable between 8 and 40 c/s		40	0-20 20-40 40-60	oscillo- scope	recorder	
United Kingdom	168*	auto.	0-1; 0-3; 1; 3; 10; 30 s.	0 to 30	crystal	6 c/s 30 c/s 150 c/s		60	0-30 30-60	oscillo- scope	photo.	
Switzerland	191	auto. and man.	0-1 to 60 s.	20; 60 in 3 steps	electro- mechn.		80 c/s at -43.5 db	3		oscilloscope or peak voltmeter	photo.	marks each 1 kc/s
Italcable	199	man.			LF		50 c/s at -80 db	1	calibrated attenuator	voltmeter		frequency- meter
France	349	auto.	6 and 36 s.	2 and 6	crystal		6 or 30 c/s below 80 db	70	60	oscillo- scope	photo.	
Belgium	**	auto.	6; 20; 45 s.	0-5 to 30	crystal	9 c/s		195	20 db lin. scale 60 db log. scale	oscillo- scope	photo.	marks 0-5 or 1 kc/s

* This apparatus has been demonstrated before S.G. No. I.

** This apparatus has been demonstrated before S.G. No. I, but was not described in a C.C.I.R. document.

Scanning range

The scanning range shall be adequate to include the outermost significant sideband components likely to be encountered. A top limit of 30 kc/s total sweep should normally be adequate. For investigating narrow band transmissions, the range should be adjustable down to 1 kc/s.

Suppression of automatic sweep

Provision should be made for the possibility of stopping the automatic sweep to enable manual scanning to be used in certain cases.

Form of display

For direct observation the display may take the form of a cathode ray tube, but other means such as recording meters may be used.

Amplitude range

The range of amplitudes displayed should be such that it is possible to measure components differing in amplitude by at least 60 db. The amplitude scale of the display instrument may be linear or logarithmic. It may be desirable to measure the major and minor components separately and by stages such as may be obtained through the use of a calibrated attenuator or calibrated scale applied to the oscilloscope screen.

Frequency stability

The frequency stability of the various beating oscillators must be such that the drift during the course of a measurement is small compared with the effective resolving power of the filter.

RECOMMENDATION No. 230 *

SPECTRA AND BANDWIDTHS OF EMISSIONS

(Question No. 1 (I))

(Stockholm, 1948 — Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

The C.C.I.R.,

CONSIDERING

- (a) that it is of the utmost importance to ensure economy of the radio spectrum by reducing the spacing between assigned frequencies;
- (b) that, to this end, it is necessary to reduce the spectrum space occupied by each emission, in compliance with the rules of Art. 13, § 4 of the Radio Regulations; that moreover, the Radio Regulations have prescribed in Art. 17, § 2, that the bandwidths mentioned in App. 5 must be considered as a guide, until more recent recommendations of the C.C.I.R. are published;
- (c) that for the determination of a spectrum of minimum width, the whole transmission circuit as well as all its technical working conditions, and particularly, propagation phenomena, must be taken into account;
- (d) that one cannot, strictly speaking, mention bandwidth without having previously adopted quantitative definitions of the various bandwidths by fixing well determined points on the complete spectrum;
- (e) that the definition of the bandwidth occupied, being the only definition mentioned in the Radio Regulations and satisfying the previous conditions, is useful to specify a given emission;

* This Recommendation replaces Recommendation No. 145.



- (f) that, however, this definition does not suffice when consideration of the complete problem is involved; and that one should be in a position to establish general rules limiting, on the one hand, the bandwidth occupied to the value strictly necessary in each case and, on the other hand, the amplitudes of the emitted components in that part of the spectrum which could interfere with adjacent channels;
- (g) that one can thus realize the usefulness of three concepts:
 - the necessary bandwidth;
 - the bandwidth occupied;
 - the emitted spectrum outside the necessary bandwidth;
 which may be defined and applied according to the following principles;
- (ga) the necessary bandwidth should be established at the smallest value possible, while including the spectrum components useful to a good receiver to ensure communication with the quality required by the two correspondents (that is to say, for example, maintaining the telephone quality laid down, or the percentage of errors admitted in telegraphy), in the presence of given technical conditions;
- (gb) the bandwidth occupied, as defined in the Radio Regulations, enables the operating agencies, and the national and international organisations to carry out measurements of the bandwidth actually occupied by a given emission and so to ascertain, by comparison with the necessary bandwidth that such an emission does not occupy an excessive bandwidth in view of the service to be provided, and is, therefore, not likely to create harmful interference beyond the limits laid down for this class of emission. The use of this concept appears then to be a useful way of requiring the operating agencies to restrict the emitted energy outside the necessary bandwidth;
- (gc) the emitted spectrum outside the necessary bandwidth must be determined by reconciling the following requirements:
 - the necessity to limit to a strict minimum the interference caused to the adjacent channels;
 - the technical and practical possibilities of transmitter design;
 - the limitation to a permissible value of the shaping or distortion of the signal;
- (h) that, however, one must always bear in mind the fact that the three concepts are not independent and that given a specific emission, the knowledge of each one provides partial information on the emitted spectrum; the emission is completely determined only by its entire spectrum;

UNANIMOUSLY RECOMMENDS

1. Definitions

- 1.0 that the following definitions and explanatory notes should be employed as convenient conventions to facilitate and clarify the consideration of bandwidth problems.
- 1.1 *Bandwidth occupied by an emission*
the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to one half percent of the total mean power radiated by the emission (see Note 5).
- 1.2 *Necessary bandwidth*
for a given class of emission, the minimum value of the frequency bandwidth such that, below its lower and above its upper frequency limits the mean powers radiated, are each equal to one half per cent of the total mean radiated power, this minimum value being sufficient to ensure the transmission of information at the rate and with the quality required for the system employed, under specified conditions (see Note 5).
- 1.3 *Out-of-band radiation of an emission*
the power radiated by an emission outside the necessary bandwidth (see Note 1). The out-of-band radiation does not include emissions on remote frequencies such as spurious emissions (see Notes 2, 3 and 4).

1.4 *Build-up time of the signal*

the time during which the telegraphic current passes from one tenth to nine tenths (or vice versa) of the value reached at the steady state (see Note 6).

- 1.5 *Note 1.* — Such radiation useful for the good functioning of the receiving equipment, as for example, the radiation corresponding to the carrier of reduced-carrier systems should be included in the necessary bandwidth, and not in the out-of-band radiation.

Note 2. — It is not intended that radiation on frequencies remote from the useful part of the emission, such as radio-frequency harmonics, be included in the defined out-of-band radiation, as these are covered by separate regulations (see App. 4, Radio Regulations).

Note 3. — The bandwidth occupied by an emission which would be considered as perfect from the standpoint of bandwidth economy equals the necessary bandwidth, in this case the total power of the out-of-band radiation equals 1% of the total radiated power. If the bandwidth occupied is larger than the necessary bandwidth, this percentage is higher.

Note 4. — The concept of out-of-band radiation gives a convenient means to indicate the relative imperfection of an emission. However, a complete description of the spectrum of the out-of-band radiation is indispensable for the determination of interference caused on adjacent channels.

Note 5. — In some cases, e.g. (radiotelephony and frequency division multiplex especially for microwave systems) the percentage of power of 0.5% chosen may lead to certain difficulties in the practical application of the definitions of occupied and necessary bandwidths. In such cases a different figure may prove useful.

Note 6. — In the case of asymmetric signals, two different values corresponding to this definition can exist, representing the build-up times at the beginning and end of the signal.

2. *Limitations of the emitted spectra*

- 2.0 that, since some present emissions (particularly class A1 emissions) occupy an unduly wide bandwidth, administrations should endeavour, with the minimum practicable delay, to limit the emitted spectra to those shown below for various classes of emission.

2.0.1 The telegraph speed in bauds B used in the following text is the maximum speed used by the corresponding transmitter. In the case of a transmitter operating at a speed lower than this maximum speed, the build-up time should be increased to keep the occupied bandwidth at a minimum in order comply with Art. 17, § 2 (No. 398) of the Radio Regulations.

2.1 *Class A1 emissions with fluctuations*

2.1.0 Under conditions where large short-period variations of the received field are present the specifications given below for single-channel, amplitude-modulated, continuous-wave telegraphy (class A1) represent desirable performance that can be obtained from transmitters with adequate input filters and sufficiently linear amplifiers, following that in which keying takes place.

2.1.1 *Necessary bandwidth*

The necessary bandwidth is equal to five times the telegraph speed in Bauds with an attenuation of the components at the edges of the band equal to at least 3 db, in comparison with the level of the same components of the spectrum representing a series of equal rectangular dots and spaces at the same telegraph speed. This relative level of -3 db corresponds to an absolute level of 27 db below the level of a continuous mark.

2.1.2 *Spectrum of the out-of-band radiation*

Outside the bandwidth defined above, the envelope of the spectrum should lie below a curve starting at the point $(\pm 5B/2, -27 \text{ db})$ defined above, and presenting



a slope of 30 db per octave and extending over at least one octave out of the points ($-5B$, -57 db). From these points onward, the level of all the components emitted should be below -57 db.

2.1.3 *Build-up time of the signal*

The build-up time of the transmitted signal depends essentially on the shape of the signal at the input of the transmitter, on the exact structure of the filters to which this signal is applied, on filtering and non-linear effects which may take place in the transmitter itself (assuming that the antenna has no influence on the shape of the signal). As a first approximation it can be accepted that a spectrum curve close to the limiting spectrum defined in § 2.1.1 and 2.1.2, corresponds to a build-up-time of about 20% of the initial duration of the telegraph dot, i.e. of the order of $1/(5B)$.

2.2 *Class A1 emissions, without fluctuations*

For amplitude-modulated, continuous-wave telegraphy, in conditions where short-period variations of the receiver field strength do not affect transmission quality, the necessary bandwidth can be reduced to three times the keying speed in bauds.

2.3 *Class A2 emissions*

2.3.0 For single-channel modulated telegraphy keyed on both the carrier and the modulating frequency, the percentage of modulation being 100% or less and the modulation frequency higher than twice the keying frequency ($F > B$), the specifications given below represent desirable performance that can be obtained from transmitters with fairly simple input filters and approximately linear stages.

2.3.1 *Spectrum*

Outside a band with a width equal to twice the modulating frequency F plus five times the telegraph speed in bauds, the envelope of the spectrum should lie below a curve starting at the points of abscissae $\pm (F + 5B/2)$ and ordinates -24 db, presenting a slope of 12 db per octave, and extending over at least one octave, that is out to the points of abscissae $\pm (F + 5B)$ and ordinate -36 db.

From these points onward the level of all the components emitted should be below -36 db.

The reference level is the carrier level during a steady dash.

2.3.2 *Modulation depth*

With a view to reducing the components due to the harmonics of the modulating frequency it is recommended that, in general, the depth of modulation should not exceed 80%.

2.3.3 *Necessary bandwidth*

The necessary bandwidth depends on the telegraph speed, on the frequency and depth of modulation and on non-linear effects. It must, therefore, be determined for each specific case.

2.4 *Class A3 emissions*

The limitations given below for radiotelephone emissions have been deduced from measurements made by different methods. In one of these methods two pure audio-frequency tones of equal amplitude are applied to the input of the transmitter and the amplitude of modulation products outside the normal bandwidth of the transmitter is measured at the output. In other methods, the output voltage from a recording of conversational speech, or a white noise voltage, is substituted for the two audio-frequency tones. These fundamentally different methods do not lead to the same result; however, the known results of measurements are within the limiting spectra specified below. In the curves defined in § 2.4.1 and 2.4.2, the ordinates represent the energy intercepted by a receiver of a bandwidth practically equal to 3 kc/s, the central frequency of which is tuned to the frequency plotted on the abscissa, as compared with the energy which would be intercepted by the same receiver, if it were tuned to the central frequency of the occupied band. Note 5 of

§ 1.5 should be applied to the emissions of this class. A percentage of power slightly higher than 99% would probably give necessary and occupied bandwidth figures near to the currently accepted figures for necessary bandwidth, as defined by a spectrum component level criterion.

2.4.1 *Class A3 emissions, double-sideband*

2.4.1.1 *Necessary bandwidth*

The necessary bandwidth is in practice equal to twice the highest audio frequency M which it is desired to transmit with a specified small attenuation.

2.4.1.2 *Power within the necessary band*

To estimate the distribution of power within the necessary band statistically, when no privacy equipment is connected with the transmitter, the distribution shown by the C.C.I.F. for the "commercial circuit psophometer" can be used (Recommendation No. 5, 16th Plenary Assembly, Volume VI); in addition, the relative power level of speech frequencies should be taken into account. In cases where the transmitter is used in connection with a frequency inversion privacy equipment the same data can be used with appropriate frequency inversion of the resulting spectrum.

If a band-splitting privacy equipment is used, it has to be assumed that the statistical distribution of power is uniform within the frequency band.

2.4.1.3 *Power outside the necessary band*

If $2M$ is the necessary bandwidth and if a logarithmic abscissa frequency scale and an ordinate amplitude scale in decibels are used, the distribution curve of power outside the necessary band should lie below two straight lines starting from the points $(\pm M, 0 \text{ db})$ to the points $(\pm 1.4 M, -20 \text{ db})$. Beyond these points, and down to the level of -60 db , this curve should lie below two straight lines starting from the latter points and presenting a slope of 12 db per octave. Thereafter, the same curve should lie below the level -60 db .

The reference level corresponds to the level of a single pure tone which, when applied to the input of the transmitter, gives the peak modulation of the transmitter.

2.4.2 *Class A3a, A3b, etc., emissions, independent-sidebands and reduced-carrier*

2.4.2.1 *Necessary bandwidth*

The necessary bandwidth $2F$ is in practice equal to the difference of the two radio frequencies defining the limits of the necessary band. These two frequencies correspond to the extreme modulating frequencies which it is desired to transmit with a specified small attenuation in the outer channels of the emission.

2.4.2.2 *Power within the necessary band*

The distribution of power within the necessary band is determined as for double-sideband transmitters. However, one must consider that independent sideband transmitters are, in general, used with a band-splitting privacy equipment; it has then to be assumed that power distribution is, in general, statistically uniform within each of the sidebands.

2.4.2.3 *Power outside the necessary band*

The power outside the necessary band is dependent on the number and position of the active channels. The curves described below are appropriate when all channels are active simultaneously. When some channels are idle the power outside the necessary band is less. $2F$ being the necessary bandwidth,



if a logarithmic abscissa frequency scale and an ordinate amplitude scale in decibels are used, the distribution curve of power outside the necessary band should lie below two straight lines starting from the points $(\pm F, 0 \text{ db})$ to the points $(\pm 1.4 F, -30 \text{ db})$.

Beyond these points, and down to the level of -60 db , this curve should lie below two straight lines starting from the latter points and presenting a slope of 12 db per octave . Thereafter, the same curve should lie below the level -60 db . The reference level corresponds to the level of a single pure tone which, when applied to the input of one of the transmitter sidebands, gives the peak power of the transmitter.

2.5 Class F1 emissions

For Class F1, frequency-shift telegraphy, with or without fluctuations:

2.5.1 Necessary bandwidth

The frequency shift, or difference between mark and space frequencies being $2D$ and m being the modulation index $2D/B$, the necessary bandwidth is given by one of the following formulae, the choice depending on the value of m :

$$\begin{aligned} &2.6 D + 0.55 B \text{ within } 10\% \text{ for } 1.5 < m < 5.5 \\ &2.1 D + 1.9 B \text{ within } 2\% \text{ for } 5.5 \leq m \leq 20 \end{aligned}$$

2.5.2 Spectrum of the out-of-band radiation

Outside the bandwidth defined above, the envelope of the spectrum should lie below a curve of constant slope in db per octave starting from points situated at the limiting frequencies for the necessary bandwidth. The curve extends to the level of -60 db . The levels are indicated by comparison with a zero level corresponding to the amplitude of the emission. The starting ordinates of the curve and its slopes are given in the following table, the entry depending on the modulation index:

Modulation index	Starting ordinates (db)	Slope (db per octave)
$1.5 \leq m < 6$	-15	$13 + 1.8 m$
$6 \leq m < 8$	-18	$19 + 0.8 m$
$8 \leq m \leq 20$	-20	$19 + 0.8 m$

On the frequencies more remote from the median frequency than those where the curve reaches the -60 db level, the level of all emitted components should lie below -60 db .

2.5.3 Build-up time of the signal

A spectrum curve close to the limiting spectrum described in § 2.5.1 and 2.5.2 corresponds to a build-up time equal to about 8% of the duration of the initial telegraph dot, i.e. about $1/(12 B)$ provided that an adequate filter is used for signal shaping.

2.5.4 Bandwidth occupied, in the case of unshaped signals

For comparison purposes only, with the formulae above, it may be mentioned that for a sequence of equal and rectangular (zero build-up time) mark and space signals, the occupied bandwidth is given by the following formulae:

$$\begin{aligned} &2.6 D + 1.4 B \text{ within } 2\% \text{ for } 2 \leq m \leq 8 \\ &2.2 D + 3.1 B \text{ within } 2\% \text{ for } 8 \leq m \leq 20 \end{aligned}$$

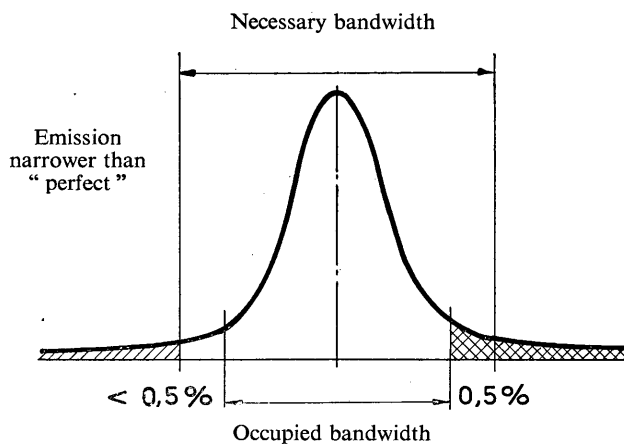
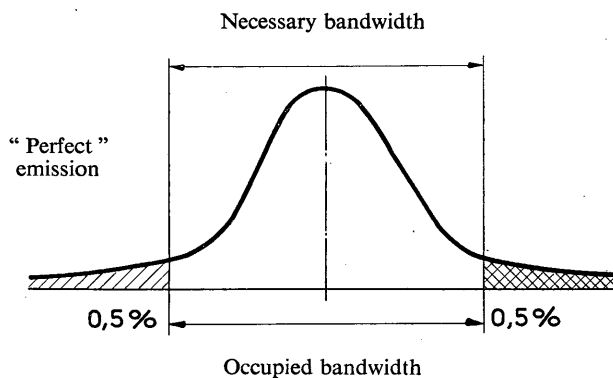
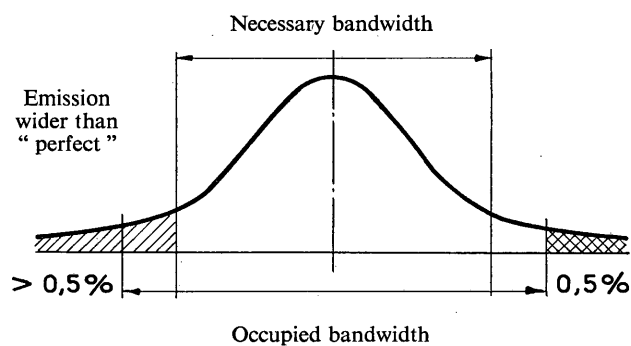
ANNEX

Examples of spectra illustrating the definition of necessary bandwidth

Abcissae: frequencies

Ordinates: power per unit frequency

The spectra are assumed to be symmetrical



Hatched areas represent the out-of-band radiation (see definition 1.3)
 Cross-hatched areas represent radiation outside the occupied band (see definition 1.1)



RECOMMENDATION No. 231 *

DEFINITION OF BANDWIDTH OCCUPIED BY AN EMISSION

(Study Programme No. 126 (I))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the criterion of the power contained in the band is the one likely to provide results which will be well correlated even if traffic and measurement conditions vary;
- (b) that the ratio of the power outside the occupied band to the total radiated power gives an estimate of the upper limit of the interference;
- (c) that satisfactory methods of direct measurement of bandwidth occupied exist;
- (d) that no existing measuring method takes account of any discrete component outside the band comprising 99% of the power;

UNANIMOUSLY RECOMMENDS

- 1. that the bandwidth occupied by an emission be defined as the band of frequencies comprising 99% of the total radiated power;
- 2. that the bandwidth occupied by an emission should in general leave 0.5% of the power below its lower limit and 0.5% above its upper limit;
- 3. that where a more complete description of the emitted spectrum is necessary, the bandwidth corresponding to percentages of power different from 99%, in particular to the percentages of 98% and 99.5%, be indicated;
- 4. that any new definition should exclude reference to the discrete components;
- 5. that the following draft definition be submitted to the next Administrative Radio Conference:

Bandwidth occupied by an emission:

The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to one half per cent of the total mean power radiated by the emission.

- 6. that the following draft definition be submitted to the same Conference for the purpose of making it possible, whenever necessary, to place with exactitude a given emission in the spectrum of the radio frequencies:

Frequency band occupied by an emission:

The frequency band in the radio frequency spectrum such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to one half per cent of the total mean power radiated by the emission.

- 7. that in some cases (e.g. radiotelephony and frequency-division multiplex, especially for microwave systems), the percentage of power of 0.5% chosen may lead to certain difficulties in the practical application of the definitions of occupied and necessary bandwidth. In such cases a different figure may prove useful.

* This Recommendation replaces Recommendation No. 146.

8. that the Administrative Radio Conference examine the preceding proposals in relation with the other proposed definitions submitted to it:
- in Recommendation No. 230, § 1.2 (Necessary bandwidth);
 - in Recommendation No. 233, § 1 (Frequency band assigned to a station, assigned frequency, characteristic frequency of an emission, reference frequency, frequency tolerance).

RECOMMENDATION No. 232 *

SPURIOUS EMISSIONS

(Question No. 1 (I), para. A.b)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Waraw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that Appendix 4 of the Radio Regulations 1947 specifies the maximum level of harmonics and parasitic emissions of all transmitters (except those mentioned in Note 1 of this Appendix) operating in the frequency band 10 to 30 000 kc/s in terms of power supplied to the antenna on the frequency of the harmonic, or of the parasitic, emission;
- (b) that Article 17, § 2 (398), of the Radio Regulations, states that:
 - “ the bandwidths of emissions, level of radio-frequency harmonics, and non-essential emissions must be kept at the lowest value which the state of technique and the nature of the service permit. Appendices 4 and 5 must be considered as a guide in this respect, until more recent recommendations of the C.C.I.R. are published ”;
- (c) that measurements of the amount of power at frequencies other than the fundamental frequencies supplied to a transmitting antenna or to a dummy load are useful in the analysis of transmitter performance with reference to purity of emissions under specific conditions, and that such measurements will encourage the use of certain means of reducing spurious emissions;
- (d) that the relation between the power of the spurious emission supplied to a transmitting antenna and the field-strength of the corresponding signals at locations away from the transmitter may differ greatly due to such factors as the horizontal and vertical antenna directivity at the unwanted frequencies, propagation over various paths and radiation from parts of the transmitting apparatus other than the antenna proper;
- (e) that field-strength measurements of spurious emissions at locations distant from the transmitter are recognized as the direct means of expressing the intensities of interfering signals due to such radiations;
- (f) that in dealing with emissions on the fundamental frequencies, administrations customarily establish the power supplied to the antenna, and measure the strength at a distance to aid in determining when an emission is causing interference with another authorized emission; that a similar procedure would be helpful in dealing with spurious emissions (see Article 13, No. 376, of the Radio Regulations);
- (g) that for the most economic use of the frequency spectrum it is necessary to lay down general maximum values of spurious emissions while recognizing that specific services may need tighter tolerances for technical and operational reasons;

* This Recommendation replaces Recommendation No. 147. France reserved its opinion on this Recommendation.

RECOMMENDS

A

1. Terminology and definitions :

that the following terms and definitions be used to designate what are regarded as spurious emissions;

1.1 *Spurious emission*

emission on a frequency or frequencies outside the necessary band, the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions and intermodulation products, but exclude emissions in the immediate vicinity of the necessary band, which are a result of the modulation process for the transmission of information;

1.2 *Harmonic emission*

spurious emission on frequencies which are whole multiples of those comprised in the band occupied;

1.3 *Parasitic emission*

spurious emission accidentally generated at frequencies which are independent both of the fundamental frequencies and of frequencies appearing in the course of generation of the fundamental frequencies;

1.4 *Intermodulation products and emissions other than harmonic and parasitic*

1.4.1 spurious emission at frequencies resulting from intermodulation between the fundamental frequencies or the harmonic frequencies of an emission and the fundamental frequencies or the harmonic frequencies of one or several other emissions originating from the same or different stations;

1.4.2 spurious emission at frequencies resulting from intermodulation between several frequencies appearing in the course of generation of the fundamental frequencies of one or several emissions, which is not covered by the definition in 1.4.1 above;

1.4.3 spurious emission at frequencies or the harmonics of frequencies used in the course of generation of a fundamental frequency.

2. Application of tolerances

2.1 that the tolerances for spurious emissions continue to be expressed by the power supplied to the antenna at the frequencies of the spurious emission considered;

2.2 that in the event of the standards of performance in § 3 below being adopted by an Administrative Radio Conference as revised tolerances for Appendix 4 of the Radio Regulations, a period of at least 3 years from the coming into force of the revised Regulations might be necessary to enable all Administrations to achieve these tolerances for new transmitters.

3. Tolerances for the intensity of spurious emissions (see Notes 1 and 2)

3.1 that the following tolerances are realizable on new transmitters with fundamental frequencies between 10 kc/s and 30 000 kc/s:

for any spurious emission the mean power supplied to the antenna should be at least 40 db below the power of the fundamental, without exceeding the value of 50 mW (see Notes 3, 4 and 5);

3.2 that the following tolerances are realizable on new transmitters with fundamental frequencies between 30 Mc/s and 235 Mc/s;

3.2.1 *Stations with output power at the fundamental frequencies greater than 25 W*

for any spurious emission, the mean power supplied to the antenna should be at least 60 db below the power of the fundamental without exceeding the value of 1 mW (see Note 6);

3.2.2 Stations with output power at the fundamental frequencies less than 25 W

for any spurious emission, the mean power supplied to the antenna should be at least 40 db below the power of the fundamental without exceeding the value of 25 μ W:

- 3.3 that the tolerances adopted by the Administrative Radio Conference should also be shown in the Radio Regulations in the form of a graph as indicated in Fig. 1:

- 3.4 *Note 1.* — It is recognised that specific services may need tighter tolerances for technical and operational reasons.

Note 2. — These tolerances are not applicable to lifeboats, survival craft, and aeronautical and maritime emergency (reserve) transmitters.

Note 3. — For transmitters which can operate on two or more frequencies, covering a frequency range approaching an octave or more, it may not always be practicable to achieve a suppression greater than 60 db.

Note 4. — For some hand-portable equipments of power less than 5 W, it may not be practicable to achieve a suppression of 40 db, in which case a suppression of 30 db should apply.

Note 5. — A limit of 50 mW may not be practicable for mobile transmitters, in which case the spurious emission should be at least 40 db below the fundamental without exceeding the value of 200 mW.

Note 6. — In some areas where the interference problem is not serious a limit of 10 mW may be sufficient.

4. Methods of measurement of spurious emissions by measurement of power supplied to the antenna

that, together with other known methods of measuring the power of spurious emissions, either the substitution method, or a direct power measuring method should be used, when the transmitter is operated under normal conditions and when connected to its normal antenna or to a dummy load; *

4.1 Substitution method

In the substitution method an auxiliary generator the output power of which can be varied is employed and its frequency is adjusted to be equal to the mean frequency of the spurious emission in question. This auxiliary generator is used as follows: the generator is substituted for the radio transmitter and is adjusted in power output and internal impedance until it produces the same field on the spurious emission frequency as was produced by the radio transmitter, both as to intensity and polarization. This field is measured by means of a radio receiver tuned to the spurious emission and located at a distance of several wavelengths from the transmitting antenna. The power supplied by the generator is then equal to the power ordinarily supplied by the transmitter itself, on condition that non-linearity of the radiating system does not introduce harmonic radiation. In order to obtain the same conditions with the generator, account must be taken of any stray coupling from the original transmitter to the radiating system and of any direct radiation from the transmitter as from feeder lines or other apparatus that may become excited by direct coupling. It is also necessary to take into account the possibility of the power of a spurious emission being supplied in a push-pull or push-push mode or combination of both. More than one generator may be necessary when the method of excitation is complex. It is also necessary to determine the impedance of the feeder input circuit at the spurious frequencies in order that the power supplied to the antenna may be accurately measured. It is advisable that several sets of measurements be made when using different receiver locations;

When a dummy load is used, an indicator coupled to the load is required.

* Relevant documents are: Docs. 65, 80, 101, 124, 130 and 340 of London, 1953; Doc. 313 of Warsaw, 1956; and Docs. I/22, I/28 and I/34 of Geneva, 1958.



4.2 Direct methods of power measurement

The two following direct methods of measurement can be used:

First method: the voltage, current and power factor are determined at one point on the feeder using a test probe and a selective radio receiver tuned to the mean frequency of the spurious emission concerned.

Second method: the forward and reflected powers are determined using a directional coupler and a selective radio receiver tuned to the mean frequency of the spurious emission concerned. The difference between these two powers gives the spurious power supplied to the antenna on their frequencies of the spurious emission.

5. Radiation from parts of the transmitting system, other than the antenna

that spurious radiation from any part of the system other than the antenna should not have an effect greater than that due to radiation from the antenna when the mean power supplied to the antenna at the spurious frequency is the maximum specified;

6. Further improvements

that Administrations and private operating agencies should continue to improve the degree of suppression of spurious emissions where this is economically possible in order to reduce interference to other services to a greater extent than that provided for in the Table of Tolerances in App. 4 of the Radio Regulations, by, for example:

- the use of low-pass or other output filters;
- suitable coupling circuits;
- screening of various stages in transmitters, filters and other parts of the equipment, which otherwise might emit spurious radiations directly or by coupling.

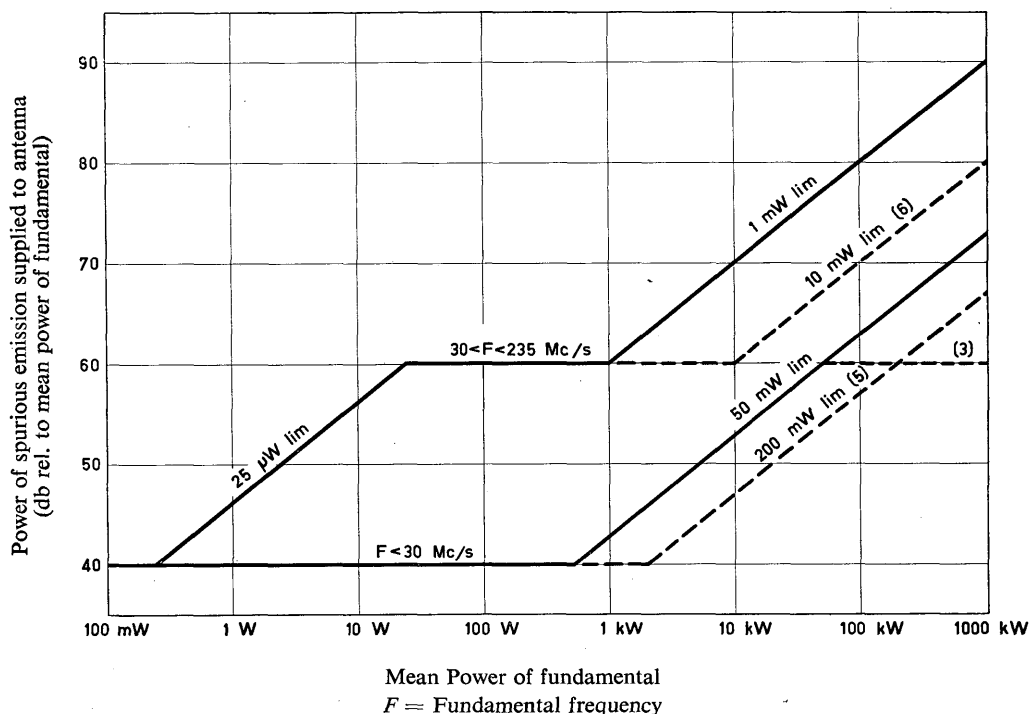


FIGURE 1

Level of the spurious emissions (see § 3.3) (Mean power supplied to the antenna)
(3), (5) and (6) (see § 3.4)

RECOMMENDATION No. 233 *

FREQUENCY STABILIZATION OF TRANSMITTERS

(Question No. 1 (I) (c))

The C.C.I.R.,

(London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that in certain frequency bands a large number of transmitters at present in use are more stable than is required by Appendix 3 of the Radio Regulations, Atlantic City, 1947;
- (b) that it seems possible and desirable that new transmitters for these frequency bands should comply with more stringent tolerances;
- (c) that the additional cost of ensuring that these new transmitters comply with the new tolerances is small compared with the total cost and operating expenses of the equipment;
- (d) that certain paragraphs in the Radio Regulations, especially No. 271 and No. 274 (a) of Article 9, and the heading of the table of tolerances, are likely to deprive the frequency tolerances of all practical significance;

RECOMMENDS

1. Terminology and definitions

that the following terms and definitions be used when dealing with questions of frequency assignment and frequency tolerances:

1.1 *Assigned frequency*

The centre of the frequency band assigned to a station.

1.2 *Frequency band assigned to a station*

The frequency band, the centre of which coincides with the frequency assigned to the station, and the width of which equals the necessary bandwidth, plus twice the absolute value of the frequency tolerance.

1.3 *Characteristic frequency of an emission*

A frequency which can be easily identified and measured in a given emission.

1.4 *Reference frequency*

A frequency having a fixed and specified position with respect to the assigned frequency. The displacement of this frequency with respect to the assigned frequency has the same absolute value and sign that the displacement of the characteristic frequency has with respect to the centre of the frequency band occupied by the emission.

Note 1. — The idea of a reference frequency is made necessary by the fact that the centre frequency of certain classes of emission is not easily identified and measured.

Note 2. — For certain classes of emission it is necessary to specify the value of one or more reference frequencies as well as the assigned frequency. For example, in the case of television broadcast stations, the characteristic frequencies are those of the vision and sound carriers, and the figures for the corresponding reference frequencies should be specified.

1.5 *Frequency tolerance*

The maximum permissible deviation, with respect to the frequency assigned to a station, of the centre frequency of the frequency band occupied by the corresponding emission, or

* This Recommendation replaces Recommendation No. 148. India reserved its opinion on this Recommendation.

with respect to the reference frequency, of the characteristic frequency of the emission. The frequency tolerance is expressed in c/s or as a fractional value of the assigned frequency;

2. that the next Administrative Radio Conference consider revision or deletion of No. 271 and No. 274 (a) of Article 9 in the Radio Regulations;
3. that the frequency tolerances shown in the following table are technically realisable on new transmitters and should be considered by the next Administrative Radio Conference revising the Regulations.
4. that in the table of frequency tolerances the frequency bands be designated only by the figures corresponding to the limits of these bands, and that other lettering or numbering be avoided.
5. that a period of three years from the coming into force of the new Regulations might be necessary to enable all administrations to achieve these tolerances for new transmitters.

Table of frequency tolerances

Frequency tolerances are expressed in parts in 10^6 or in cycles per second

Frequency bands and classes of station ⁽¹⁾	Tolerances adopted at Atlantic City 1947	Tolerances recommended for the future, the effective date to be determined by the Administrative Radio Conference ⁽²⁾
(1)	(2)	(3)
Band: 10 to 535 kc/s		
1. <i>Fixed stations</i> :		
— 10 to 50 kc/s	1000	1000
— from 50 kc/s to end of band	200	200
2. <i>Land stations</i> :		
(a) <i>coast stations</i>		
— power 200 W or less	500	500
— power above 200 W	200	200
(b) <i>aeronautical stations</i>	200	100
3. <i>Mobile stations</i> :		
(a) <i>ship stations</i>	1000	1000
(b) <i>emergency (reserve) transmitters on ships, and life-boat, life raft and survival craft transmitters</i>	5000	5000
(c) <i>aircraft stations</i>	500	500
4. <i>Radionavigation stations</i>	200	100
5. <i>Broadcasting stations</i>	20 c/s	10 c/s
Band: 535 to 1605 kc/s		
<i>Broadcasting stations</i>	20 c/s	10 c/s ⁽³⁾
Band: 1605 to 4000 kc/s		
1. <i>Fixed stations</i> :		
— power 200 W or less	100	100
— power above 200 W	50	50

Frequency bands and classes of station ⁽¹⁾	Tolerances adopted at Atlantic City 1947	Tolerances recommended for the future, the effective date to be determined by the Administrative Radio Conference ⁽²⁾
(1)	(2)	(3)
2. Land stations : — power 200 W or less — power above 200 W	100 50	100 50
3. Mobile stations : (a) ship stations (b) transmitters aboard lifeboats, life rafts and survival craft (c) land mobile stations (d) aircraft stations	200 200 200	200 500 200 100
4. Radionavigation stations : — power 200 W or less — power above 200 W	100 50	100 50
5. Broadcasting stations	50	20
Band: 4000 to 29 700 kc/s		
1. Fixed Stations — power 500 W or less — power above 500 W	100 30	50 15
2. Land stations : (a) coast stations — power 0.5 kW or less — power above 0.5 kW and below 5 kW — power 5 kW and above (b) aeronautical stations — power 0.5 kW or less — power above 0.5 kW (c) base stations — power 0.5 kW or less — power above 0.5 kW	50 50 50 100 50 100 50	50 30 15 100 50 100 50
3. Mobile stations : (a) ship stations: (i) Class A1 emission (ii) emissions other than Class A1 — power 50 W or less — power above 50 W (b) transmitters aboard lifeboats, life rafts and survival craft (c) aircraft stations (d) land mobile stations	200 50 200 200 200	200 100 ^(*) 50 200 100 200
4. Broadcasting stations	30	15
Band: 29.7 to 100 Mc/s		
1. Fixed stations — power 200 W or less — power above 200 W	200 200	50 30

Frequency bands and classes of station ⁽¹⁾	Tolerances adopted at Atlantic City 1947	Tolerances recommended for the future, the effective date to be determined by the Administrative Radio Conference ⁽²⁾
(1)	(2)	(3)
2. Land stations : — power 15 W or less — power above 15 W	200 200	50 20
3. Mobile stations : — power 5 W or less — power above 5 W	200 200	100 50
4. Radionavigation stations	200	200
5. Broadcasting stations (other than television): — power 50 W or less — power above 50 W	30	50 20
6. Broadcasting stations (television sound and vision): — power 50 W or less — power above 50 W	30	100 1000 c/s ⁽¹⁰⁾
Band : 100 to 470 Mc/s		
1. Fixed stations : — power 50 W or less — power above 50 W	100 100	50 20
2. Land stations : (a) coast stations (a) aeronautical stations (c) base stations — power 5 W or less — power above 5 W	100 100 100 100	20 50 50 20
3. Mobile stations : (a) ship stations and transmitters aboard lifeboats, life rafts and survival craft: — 156–174 Mc/s ⁽⁹⁾ — outside this band (b) aircraft stations (c) land mobile stations — power 5 W or less — power above 5 W	100 100 100 100 100	20 50 ⁽⁶⁾ 50 50 20
4. Radionavigation stations	200	50 ⁽⁷⁾
5. Broadcasting stations (other than television)	30	20
6. Broadcasting stations (television: sound and vision): — power 100 W or less — power above 100 W	30	100 1000 c/s ⁽¹⁰⁾
Band : 470 to 2450 Mc/s		
1. Fixed stations : — power 100 W or less — power above 100 W	7500 7500	300 ⁽⁹⁾ 100 ⁽⁸⁾

Frequency bands and classes of station ⁽¹⁾	Tolerances adopted at Atlantic City 1947	Tolerances recommended for the future, the effective date to be determined by the Administrative Radio Conference ⁽²⁾
(1)	(2)	(3)
2. <i>Land stations</i>	7500	300
3. <i>Mobile stations</i>	7500	300
4. <i>Radionavigation stations</i>	7500	500 ⁽⁷⁾
5. <i>Broadcasting stations</i> (other than television)	7500	100
6. <i>Broadcasting stations</i> (television, sound and vision): 470-960 Mc/s		
— power 100 W or less	7500	100
— power above 100 W	7500	1000 c/s ⁽¹⁰⁾
<i>Band: 2450 to 10 500 Mc/s</i>		
1. <i>Fixed stations</i> :		
— power 100 W or less	7500	300 ⁽⁹⁾
— power above 100 W	7500	100 ⁽⁸⁾
2. <i>Land stations</i>	7500	300
3. <i>Mobile stations</i>	7500	300
4. <i>Radionavigation stations</i>	7500	2000 ⁽⁷⁾
<i>Band: frequencies above 10 500 Mc/s</i>		
<i>Fixed stations</i>		500

⁽¹⁾ The power shown for the various classes of stations is the mean power as defined in Article 1 of Radio Regulations.

⁽²⁾ It is recognised that certain services may need tighter tolerances for technical and operational reasons.

⁽³⁾ It is recognized that in the area covered by the North American Regional Broadcasting Agreement (N.A.R.B.A.), it may be desirable to continue the tolerance of 20 c/s.

⁽⁴⁾ For certain ship transmitters using only frequencies below 13 Mc/s in tropical regions, the tolerance of 100 can be increased to 200. These transmitters are sometimes used in these parts of the world in the same circumstances as those of the band 1605 to 4000 kc/s.

⁽⁵⁾ The limits of the band 156-174 Mc/s shown are in accordance with the Agreement of the International Maritime VHF Radiotelephone Conference, The Hague, 1957, for use in Europe. The limits of the corresponding band may be different in other regions.

⁽⁶⁾ This tolerance is not applicable to the frequency 243 Mc/s where a special guard band is proposed.

⁽⁷⁾ Where specific frequencies are not assigned to radar stations the bandwidth occupied by the emission shall be maintained wholly within the band allocated to the service and the indicated tolerance does not apply.

⁽⁸⁾ This tolerance applies only to such emissions for which the maximum bandwidth is 3 Mc/s; for larger bandwidth emissions tolerance of 300 applies.

⁽⁹⁾ For certain transmitters using time division multiplex the tolerance of 300 may be increased to 500.

⁽¹⁰⁾ Certain administrations desire to adopt a tolerance of 500 c/s for the vision transmitters while retaining the tolerance of 1000 c/s for the sound transmitters.

SECTION B RECEPTION



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The following Recommendations which have been classified in other sections also concern Reception:

Rec. No.	Section
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140	E

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RECOMMENDATION No. 27

**METHODS OF MEASUREMENT AND LIMITS OF TOLERANCES
FOR INTERFERENCE CAUSED TO BROADCASTING
BY ELECTRICAL INSTALLATIONS**

The C.C.I.R.,

(Stockholm, 1948)

CONSIDERING

- (a) that there is no need to resume the study of methods of measurement within the C.C.I.R. since this question has already been entrusted to the Special International Committee on Radio Interference (C.I.S.P.R.), founded under the auspices of the International Electro-technical Commission (I.E.C.);
- (b) that the C.C.I.R. should keep in regular contact with the C.I.S.P.R. and send a representative to the meetings of this latter Committee;
- (c) that in view of the importance of the work undertaken by various countries since the last meeting of the C.I.S.P.R. which still remains unpublished, a detailed study of the results obtained by that Committee cannot be usefully carried out at this meeting;
- (d) that the measuring equipment designed by the C.I.S.P.R. may prove useful for the study of disturbances other than those caused by electrical apparatus, for example by atmospherics;
- (e) that the measurements should be extended to disturbances affecting all types of receivers, especially television, constructed according to modern transmission technique;
- (f) that Bucharest Recommendation No. 88 should be extended to all disturbances due to causes other than signals produced by transmitters;
- (g) that in this respect, the most urgent problem relates to the disturbances affecting television receivers and caused particularly by other radio receivers, electrical ignition systems, industrial, scientific and medical equipment producing hertzian radiations;
- (h) that, in consequence, the means of measurement is to be extended to all the frequency bands used for sound and visual broadcasting;
- (i) that the work of the C.I.S.P.R. is directed according to the four preceding paragraphs;
- (j) that, with regard to the precautions to be taken for electrical apparatus and installations and radio equipment, collaboration is essential between the administrations and the organisations representing electrical industry on the one hand, and broadcasting on the other hand;

RECOMMENDS

1. that the C.I.S.P.R. maintain regular contact with the C.C.I.R. and admit a representative of the C.C.I.R. to its meetings;
 2. that, if necessary, the C.I.S.P.R. take into consideration the suggestions by the C.C.I.R. regarding the relative urgency of the work carried out in various fields;
 3. that, in particular, C.I.S.P.R. pursue actively its work on interference caused to television receivers by other receivers, ignition systems, and industrial, scientific and medical equipment producing hertzian radiations.
-

RECOMMENDATION No. 159

**RESPONSE OF BROADCAST AND TELEVISION RECEIVERS *
TO QUASI-IMPULSIVE INTERFERENCE**

(Question No. 175 (II))

The C.C.I.R.,

(Warsaw, 1956)

CONSIDERING

- (a) that many types of interference—e.g. from atmospheric phenomena, ignition systems and electrical equipment—cannot be considered as random noise or as simple isolated impulses, but may be regarded as “quasi-impulsive” **;
- (b) that the work of the C.I.S.P.R. has led to agreement on the performance specification of a measuring receiver designed to evaluate the importance of quasi-impulsive interference to broadcast sound reception in the frequency range 150 kc/s to 25 Mc/s;
- (c) that the C.I.S.P.R. is studying the performance specification of a measuring receiver designed to evaluate the effect of quasi-impulsive interference on frequency modulation and television reception in the frequency range 25 Mc/s to 300 Mc/s;
- (d) that the C.I.S.P.R. has reached partial agreement on and is further studying standard methods for measuring conducted and radiated interference;

UNANIMOUSLY RECOMMENDS

1. that the C.C.I.R. be guided provisionally by the methods and adopt the specifications of measuring receivers of the C.I.S.P.R.;
2. that the C.I.S.P.R. radio-interference measuring sets be used as a guide in evaluating the parameters of quasi-impulsive interference, affecting broadcast sound and television reception.

RECOMMENDATION No. 234 ***

NOISE AND SENSIVITY OF RECEIVES

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the sensitivity of a receiver is a measure of its ability to receive weak signals and to produce an output having usable strength and acceptable quality; in many cases in order to assess the quality of the output it might be necessary to take into consideration the receiving equipment as a whole, including the parts giving the information in a printed, aural or visual form;

* See also Recommendation No. 27, Questions Nos. 84 (I) and 175 (II) and Report No. 99.

** If a very large number of impulses occurs in a random sequence per second the effect is that of random noise. Impulse generators usually give a regular sequence of equal impulses. In interference problems the form and sequence of the impulses is irregular and their number is not high enough to give the effect of random noise. The name “quasi-impulsive” was therefore introduced.

*** This Recommendation replaces Recommendation No. 154.

- (b) that the following parameters, which are determined by the particular service for which the receiver is used, are of special importance in relation to sensitivity;
 - necessary output level,
 - necessary overall signal bandwidth,
 - necessary signal-to-noise ratio at the output;
- (c) that the following parameters relating to the internal noise of the receiver, which are determined by the receiver design, are also of importance in relation to the sensitivity of the receiver:
 - the level of the internal noise, as defined, for example, by the noise factor,
 - the width of the effective overall noise band, which is not necessarily identical with the width of the signal band (see Recommendation No. 235);
- (d) that, in many cases, in order to economize in transmitted power, it is desirable that the sensitivity shall be as great as economic and technical considerations permit and is justified by the external noise level;
- (e) that the conditions for obtaining high sensitivity, viz., the ability of the receiver to receive weak signals of the desired transmission, should be considered in connection with those for obtaining good protection against interfering signals (see Recommendation No. 235);
- (f) that Question No. 172 (II) asks for additional data on noise factor and sensitivity for the various types of receivers used for reception of different classes of emission in the different services;
- (g) that, for the purpose of presenting, comparing, and using data on the sensitivity of receivers, it is desirable to define the following terms:
 - maximum usable (noise-limited) sensitivity;
 - maximum usable (gain-limited) sensitivity;
 - reference sensitivity;
 - noise factor;
- (h) that often, values for noise factor are particularly useful, since they are more uniform than values of maximum usable sensitivity for the various types of receivers used for the reception of different classes of emission in the different services, and other factors remaining unchanged, indicate the degree of improvement in maximum usable sensitivity which is theoretically possible.
- (i) that the noise factor is useful only for a linear receiver or for the linear part of a receiver, since in a non-linear receiver the noise factor is dependent on the signal input level;
- (j) that reference sensitivity is chiefly of value in comparing linear receivers;
- (k) that it is desirable to define a "linear" receiver;
- (l) that, for radiotelegraphy receivers:
 - the use of a non-linear detector, discriminator or telegraph shaping circuit or the use of narrow band filters changes the effect of noise from an amplitude variation into a variation of the duration of the telegraph signal elements at the output of the receiver (signal distortion);
 - noise may cause mutilation of the signals by splits or extras;
 - signal distortion and signal mutilation may cause erroneous characters in the reproduced text;
 - the foregoing considerations make it desirable to define receiver sensitivity with reference to signal distortion and mutilation or character errors in the reproduced text;
- (m) that for sound broadcast and television receivers, it is desirable to define sensitivity not only for a reasonably good output signal, but also for any usable output signal;

UNANIMOUSLY RECOMMENDS

1. that a *linear* receiver should be defined as one operating in such a manner that the signal-to-noise ratio at the output is proportional to the signal level at the input, and to the degree of modulation;
2. that the *noise factor* should be defined as follows: the noise factor is the ratio of noise power measured at the output of the receiver to the noise power which would be present at the output if the thermal noise due to the resistive component of the source impedance were the only source of noise in the system;
3. that the width of the *effective overall noise band* should be defined as the width of a rectangular frequency response curve having a height equal to the maximum height of the receiver frequency response curve and corresponding to the same total noise power *;
4. that the *maximum usable sensitivity* should be defined as the larger of the minimum input signal levels (expressed as the e.m.f. of the carrier) ** which must be applied in series with the specified source impedance (dummy antenna) to the input of the receiver to produce at the output:

(a) the signal level or (b) the signal-to-noise ratio	}	necessary for normal operation

when the normal degree of modulation *** is applied to the carrier. If the gain is sufficient to enable both conditions to be satisfied simultaneously, the maximum usable sensitivity is described as "noise-limited". Otherwise, the gain being insufficient, the maximum usable sensitivity is described as "gain-limited"; in this case the gain, being adjusted to a maximum, enables condition (a) (necessary output level) to be satisfied without regard to the output noise level (condition (b));
5. that, for the purpose of presenting and comparing data for particular classes of receivers and classes of emission for the different services (normally noise-limited), and for a particular frequency range the *reference sensitivity* should be defined as the maximum usable sensitivity for specified values of:
 - signal-to-noise ratio,
 - receiver bandwidth,
 - degree of modulation,
 - source impedance (dummy antenna).

Within the linear range the maximum usable sensitivity for any of these conditions should be derived from the reference sensitivity (the noise factor being considered as constant), and vice versa (see Ann. II);
6. that in case of uncertainty with regard to terms of the formulae relating noise factor and reference sensitivity (see Ann. II) e.g. the width of the effective overall noise band, independently measured values for these two quantities should be given;
7. that values for the maximum usable sensitivity and for the reference sensitivity should be considered in connection with the values for the single signal and multiple signal selectivity****;
8. that, since the reference sensitivity is of particular value for a receiver working in a linear condition, for the markedly non-linear condition only the maximum usable sensitivity and the noise factor for the normal operating conditions should be given;
9. that, although radiotelegraph receivers for aural reception can be operated linearly, those for automatic operation, in which non-linearity usually occurs, must be given separate consideration;

* See Doc. No. 3 of Geneva, 1951.

** For frequencies above about 30 Mc/s the input signal strength is usually taken as the available power from the source.

*** Class A1 modulation is considered 100% modulated.

**** See Recommendation No. 235.

- 9.1 *maximum usable sensitivity* should be defined as the minimum input signal (expressed as the e.m.f. of the carrier) which must be applied in series with the specified source impedance (dummy antenna), to the input of the receiver in order to obtain at the output the desired signal level and the amount of signal distortion or mutilation permissible in normal operation; the maximum usable sensitivity as defined above should be described as “distortion limited” or “mutilation limited”;
- 9.2 *maximum usable sensitivity, including the reproducing equipment* should be defined as the minimum input signal (expressed as the e.m.f. of the carrier), which must be applied in series with the specified source impedance (dummy antenna), to the input of the receiver in order to obtain a specified character error rate in the reproduced text;
- 9.3* defined methods for measuring signal distortion, signal mutilation and character error rates should be used;
- 9.4** for the purpose of comparing and presenting data the maximum usable sensitivity should be given for specified values of:
- the amount of signal distortion and signal mutilation at the receiver output with a specified probability of occurrence (see 9.1 and Annex II, 5.4); or the character error rate in the reproduced texts (see § 9.2 and Annex II, § 5.5); and the receiver predetector and post-detector signal bandwidth;
 - the frequency shift for F1 transmissions;
 - the source impedance (dummy antenna);
- 9.5 the performance of the receiving equipment in terms of signal distortion, signal mutilation or character error rate, instead of being defined by the maximum usable sensitivity, is often described by the *signal-to-noise* power ratio value in the receiver, just prior to the non-linear part; in this case it is convenient to use a parameter called the “Normalized signal-to-noise ratio” which is defined as the signal-to-noise power ratio per baud per unit bandwidth; * in Annex II, § 6, a formula is given relating the normalized signal-to-noise ratio to the e.m.f. of the carrier at the receiver input (in series with the sources equivalent resistance)
10. that for sound broadcast and television receivers:
- 10.1 a *maximum sensitivity* should be defined as the minimum input signal applied, in series with the specified source impedance (dummy antenna), to the input of the receiver for which any usable signal with a specified output level can be obtained;
- 10.2 measurements of sensitivity be made in conformity with Recommendations Nos. 157 and 158;
11. that since measured characteristics vary widely from one receiver to another, measurements should be made as far as possible on several receivers of the same type, and the values given for the type of receiver under consideration should be stated statistically (mean value, standard deviation);
12. that, when a psophometric weighting network is used for sensitivity measurements, this fact should be stated and the response curve given.

Note. — The Annexes listed below give for reference purposes the noise and sensitivity values obtained for several types of receiver in current use in certain countries, based on data and information given in Recommendation No. 154, and Docs. II/3, II/21 and II/32 of Geneva, 1958. The data were collected as part of the studies required by Question No. 172 (II).

Annex I: Classification of receivers.

* Doc. 227 of Warsaw, 1956, Doc. II/3, II/11 and II/23 of Geneva, 1958.

** See Annex II, clause 5.

*** The normalized signal-to-noise ratio is an energy ratio and it can be expressed in db. (See Report No. 105).

Annex II: Formulae relating noise factor and sensitivity of linear receivers. Measurement of and formulae relating to sensitivity and normalized signal-to-noise ratio of radiotelegraphy receivers for automatic reception.

Annex III: General considerations relating to the noise factor of receivers.

Annex IV: Representative values for the noise factor and reference sensitivity of receivers (excluding television receivers and radiotelegraphy receivers for automatic reception).

Annex V: Representative values for the noise factor and sensitivity of radiotelegraphy receivers for automatic reception.

Annex VI: Representative values for maximum sensitivity of sound-broadcasting receivers.

Annex VII: Representative values for the sensitivity and noise factor of television receivers.

ANNEX I

CLASSIFICATION OF RECEIVERS

Type of Service	Frequency sub-division
1. <i>Telegraphy (aural reception)</i> A1 general purpose A2 mobile service <i>Telegraphy (automatic reception)</i> A1 } A2 } Fixed service F1 }	{ 30 – 600 kc/s 1 600 – 30 000 kc/s 30 – 300 Mc/s
2. <i>Telephony</i> A3 { Fixed service General purpose Mobile service A3b Fixed service F3 { Fixed service General purpose Mobile service	{ 30 – 600 kc/s 1 600 – 30 000 kc/s 30 – 300 Mc/s
3. <i>Sound broadcasting</i> A3 F3	{ 150 – 300 kc/s 500 – 1 600 kc/s 1 600 – 30 000 kc/s { 30 – 100 Mc/s 100 – 300 Mc/s 300 – 1 000 Mc/s
4. <i>Television</i> A5 Vision A3 } F3 } Sound	{ 30 – 100 Mc/s 100 – 300 Mc/s 300 – 1 000 Mc/s

ANNEX II

FORMULAE RELATING NOISE FACTOR AND SENSITIVITY OF LINEAR RECEIVERS.
MEASUREMENT OF AND FORMULAE RELATING SENSITIVITY AND NORMALIZED
SIGNAL-TO-NOISE RATIO OF RADIOTELEGRAPHY RECEIVERS
FOR AUTOMATIC RECEPTION

1. *A1, A2, A3 emissions (amplitude modulation)*

$$E^2 = 8kT \frac{BRn}{m^2} F \times 10^{12} \quad (1)$$

where:

E = e.m.f. of the carrier in series with the equivalent series resistance of the source, measured in microvolts;

F = noise factor (power ratio);

R = equivalent resistance of source (dummy antenna) in ohms;

n = signal-to-noise power ratio at the output;

m = degree of modulation (modulation considered sinusoidal). For A1 emissions, take $m = 1$;

k = Boltzmann constant = 1.37×10^{-23} Joules/degree K;

T = absolute temperature in degrees K (T is commonly taken as 293° K, then $kT \approx 400 \times 10^{-23}$ Joules);

B = width of the effective overall noise band in c/s, taken as the smaller of the two following quantities;

(a) the post-detection bandwidth;

(b) half the pre-detection bandwidth (see Note 1).

2. *A3b emissions (single-sideband amplitude-modulation).*

$$E^2 = 4kTBRnF \times 10^{12} \quad (2)$$

where:

E = e.m.f. of the sideband component in series with the equivalent series resistance of the source, measured in microvolts;

F , R , n , k and T are as defined in § 1;

B = width of the effective overall noise band in c/s taken as the smaller of the two following quantities;

(a) the post-detection bandwidth;

(b) the full pre-detection bandwidth (see Note 1).

3. *F3 emissions (frequency-modulation)*

$$E^2 = 8kT \frac{BRn}{q^2} F \times 10^{12} \quad (3)$$

where:

$$q^2 = 3 \frac{D^2}{B^2}$$

E , F , R , n , k , and T are as defined in § 1;

$2D$ = peak-to-peak value of the frequency deviations in telephony (modulation considered sinusoidal);

B = width of the effective overall post-detection noise band.

Note 1. — In some cases, it may be sufficient to approximate the bandwidth by taking limiting responses 6 db below the maximum response; if a more accurate measurement of bandwidth is required, the width of the effective overall noise band may be determined in each case, as explained in § 3 of this Recommendation. It is, however, recommended that a psophometer be used (see § 12 above), since the bandwidth will be known from the psophometer characteristics; this is an advantage since the bandwidth enters the formula to the third power.

Note 2. — Formula (3) is applicable only to a receiver of perfect design working under idealized conditions, that is with:

- (a) *perfect limiting*, in which case no amplitude modulation remains and the signal-to-noise ratio at the output is proportional to that of the input;
- (b) *receiver noise* mainly produced in the early stages of the receiver.

Formula (3) should not be used to calculate the noise factor from the reference sensitivity and vice-versa, unless the conditions under (a) and (b) are satisfied.

4. *Reference sensitivity (see para. 5 of this Recommendation)*

The reference sensitivity may be calculated from the noise factor (see Ann. III) by means of formulae (1) to (3) above or the simplified formula (4) given below:

$$E^2 = C F \quad (4)$$

Typical reference values for B , R , n , m and D are given in Table I below, together with the corresponding values of the multiplying factor C used in formula (4). For ease of computation the values of C given in the table are in decibels.

While formulae (1) to (4) can also be used to calculate the noise factor from the measured sensitivity, this procedure must be employed with caution because possible uncertainties in the various parameters (e.g. the effective overall noise band) may lead to less precise values for F than can be obtained by direct measurement (see Ann. IV para. 1.2).

5. *Measurement of maximum usable sensitivity and normalized signal-to-noise ratio of telegraph receivers for automatic reception **

- 5.1 The input signal should be modulated by a square wave at a frequency suitable for the receiver, a frequency corresponding to 50 bauds being used where appropriate;
- 5.2 the recommended values for the frequency shift for F1 transmissions are 400 c/s, 200 c/s and 100 c/s; the receiver bandwidth just prior to the non-linear part of the receiver and that of the post-detector low-pass filter should be chosen in conformity with those given in:
Recommendation No. 230, § 2.1, 2.2 and 2.5;
Recommendation No. 101, § 1.1 and 1.2;
- 5.3 the source resistance should be taken as 75 ohms.
- 5.4 the amount of distortion or mutilation in the receiver should be taken as that one of the following which requires the greater signal input:
— 20% distortion with a probability of 1 in 1000;
— one split or extra in 1000 elements (see 9.1);
- 5.5 the character error rate in the reproduced text should be taken as 1 in 1000 (see § 9.2).

An indication of the critical input level for distortion or mutilation limited sensitivity can be obtained by observing the shape of the signal at the receiver output on an oscilloscope or on a recording apparatus or by observing the appearance of wrong characters in the reproduced text on a printing apparatus. As this procedure is found to be fairly critical, a useful criterion can thus be obtained in a simple way.

6. *Formulae relating "normalized signal-to-noise ratio" and sensitivity*

6.1 $E^2 = 4 k T R B_i n_i F \cdot 10^{12}$

E , F , R , k , T are as defined in Annex II, § 1

B_i = receiver bandwidth, just prior to the non-linear part

n_i = signal-to-noise power ratio, just prior to the non-linear part

$n_i = n_c S/B_i$;

n_c being the normalized signal-to-noise ratio

S = keying speed (bauds)

* See Doc. 227 of Warsaw 1956, Doc. II/3, II/11, II/21 and II/23 of Geneva, 1958.

$$6.2 \quad E^2 = 4 \, kTR \cdot 10^{12} \cdot F \cdot n_c \cdot S$$

If $R = 75$ ohms

$$E^2 = C_1 \cdot F \cdot n_c \cdot S$$

$$C_1 = -59.2 \text{ db}$$

$$6.3 \quad E^2 = C_2 \cdot F \cdot n_c$$

$$C_2 = -42.2 \text{ db for 50 bauds}$$

$$= -39.2 \text{ for 100 bauds}$$

TABLE I

Typical reference values for parameters used in calculating and measuring reference sensitivity

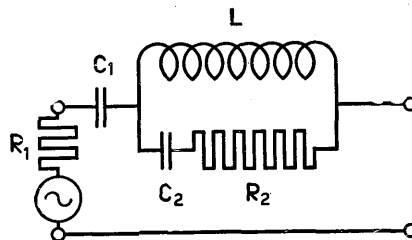
Class of emission	Service	Effective overall noise band B (c/s)	Source resistance R (ohms)	Output-signal-to-noise power ratio n (db)	Degree of modulation m	Frequency shift for F1 peak deviation for F3 (c/s)	$10 \log C$ (db)
A1	General purpose	1000	75	20	1		— 6.2
	Mobile	1000	75	20	1		— 6.2
A2	General purpose	1000	75	20	0.3		+4.3 ⁽¹⁾ —6.2 ⁽²⁾
	Mobile	1000	75	20	0.3		+4.3 ⁽¹⁾ —6.2 ⁽²⁾
A3	Fixed General purpose Mobile	3000	75	20	0.3		+ 9.1
	Sound-broadcast (MF) domestic use	5000	dummy antenna ⁽³⁾	20	0.3		
	Sound-broadcast (HF)	domestic use	5000	dummy antenna ⁽³⁾	20	0.3	+18.3
		professional use	5000	75	20	0.3	+11.1
A3b	Fixed	3000	75	20			— 4.4
F3	Fixed General purpose Mobile	3000	75	20		± 4500 ⁽⁴⁾	— 9.7
	Sound-broadcast	5000	75	20		± 22500 ⁽⁴⁾	—17.0

⁽¹⁾ Without IF oscillator.

⁽²⁾ With IF oscillator.

⁽³⁾ The values of the elements of the dummy antenna are shown in Fig. 1.

⁽⁴⁾ 30% of reference peak deviation
— telephony 15 kc/s.
— sound broadcasting 75 kc/s.



$$\begin{aligned} C_1 &= 125 \text{ pF} \\ C_2 &= 400 \text{ pF} \\ L &= 20 \text{ } \mu\text{H} \\ R_1 &= 80 \text{ } \Omega \\ R_2 &= 320 \text{ } \Omega \\ Q_L &> 15 \text{ (at 1 Mc/s)} \end{aligned}$$

FIGURE 1 - *Dummy Antenna*

ANNEX III

GENERAL CONSIDERATIONS RELATING TO THE NOISE FACTOR OF RECEIVERS

In a well designed receiver, noise originating in the receiver is mainly due to the random voltages (thermal and shot-noise) generated in the early stages of the receiver, including that portion of the antenna circuit contained within the receiver.

Representative values of noise factor for good modern receivers, which are especially designed to have low noise factors, are given below:

TABLE II

Frequency (Mc/s)	Noise Factor	
	Power Ratio	db
up to 100	2.5	4.0
200	3.5	5.4
500	5.5	7.4
1 000	8.0	9.0
2 000	11.2	10.5
5 000	18.0	12.5
10 000	25.0	14.0

When, however, either the external noise level or the input signal level is high, the receiver noise factor becomes less important. For this reason, some receivers (e.g., many broadcast receivers) are not designed to have the best possible values of reference sensitivity or of noise factor (see § 4 of this Recommendation).

The measurement of noise factor is generally best carried out by means of the noise-generator method (particularly for frequencies above 30 Mc/s) (see Doc. 117, London, 1953).

When the receiver contains a non-linear element (e.g., a detector, limiter or discriminator), it is desirable that overall measurements of noise factor be made under conditions of linear operation, such as may be obtained by simultaneous injection of a carrier at an appropriate frequency and level (see Docs. 197 and 235, London, 1953).

ANNEX IV

REPRESENTATIVE VALUES FOR THE NOISE FACTOR AND REFERENCE SENSITIVITY OF RECEIVERS

(EXCLUDING TELEVISION RECEIVERS)

1. Introduction

- 1.1 In the following tables an attempt has been made to present in a systematic way representative data for noise and sensitivity characteristics of the various classes of receivers. In order to facilitate the use of these data and at the same time to reduce the amount of data presented, in general only three figures (called for convenience "maximum", "mean", and "minimum" values) have been given for each characteristic for a number of similar receivers in each class. The terms *maximum*, *mean* and *minimum* refer to values expressed in decibels for sensitivity or noise factor according to the column. It is important to note therefore, that for a given case, the *maximum value* in the sensitivity column indicates a poorer *sensitivity* than that of the *minimum value*. For some medium-frequency sound broadcasting receivers, statistical values (mean values and standard deviation) are given.

- 1.2 It was found that the values for maximum usable sensitivity, reference sensitivity and noise factor, obtained from the different sources, were not always consistent with formulae (1) to (4) in Ann. II. As the values for noise factor were considered more reliable in such cases, these were taken as the basic information, and the values for reference sensitivity given in the tables in Ann. IV were derived from those for the noise factor by the use of formula (4) in Ann. II.

2. Notes on Tables III to V

Column No.

- (1), (2), *Receivers* are tabulated in terms of the class of emission, service and frequency range, respectively.
- (4) See § 1.1 of this Annex.
- (5) *Reference sensitivity.* See § 5 and Ann. II, § 4 of this Recommendation; the values for the reference sensitivity given in the tables assume the reference values for overall noise-band, source resistance, output signal-to-noise ratio and degree of modulation (frequency-shift or deviation in frequency-modulation receivers), given in Table I of Ann. II.
- (6) *Noise Factor.* See § 2 and Ann. II and III of this Recommendation.
- (7) *Reference bandwidth.* See Ann. II, Table I of this Recommendation.
- (8) *Remarks.* This column contains information on the number of receivers on which the representative values for noise and sensitivity are based and, when possible, some indication of the spread of the data.

TABLE III

*Reference sensitivity and noise factor for radiotelegraphy receivers (aural reception) **

Class of emission	Service	Frequency range (Mc/s)		Reference sensitivity (db rel. to 1 μ V)	Noise factor (db)	Reference bandwidth (c/s)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A1	General purpose	1.6–30	Max. Mean Min.	+ 7.8 + 2.8 – 1.2	14 9 5	1000	Several receivers tested
	Mobile	1.6–30	Max. Mean Min.	+11.3 + 5.8 + 0.3	17.5 12 6.5	1000	Few receivers tested

* See Annex IV of Recommendation No. 154.

TABLE IV
Reference sensitivity and noise factor for radiotelephony receivers *

Class of emission	Service	Frequency range (Mc/s)		Reference sensitivity (db rel. to 1 μ V)	Noise factor (db)	Reference bandwidth (c/s)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A3	Fixed	1.6–30	Max. Mean Min.	+19.1 +16.1 +11.1	10 7 2	3000	Several receivers tested
	General purpose	1.6–30	Max. Mean Min.	+23.1 +17.1 +11.1	14 8 2	3000	Several receivers tested
	General purpose	30–300	Max. Mean Min.	+29.1 +18.6 +11.1	20 9.5 2	3000	Few receivers tested Frequency range = 20–155 Mc/s
	Mobile	30–300	Max. Mean Min.	+22.6 +18.5 +15.1	13.5 9.4 6	3000	Several receivers tested
A3b	Fixed	1.6–30	Max. Mean Min.	+ 5.6 + 2.6 – 0.4	10 7 4	3000	Several receivers tested
F3	Fixed	30–300	Max. Mean Min.	+ 5.3 + 1.3 – 1.7	15 11 8	3000	Few receivers tested Frequency range = 80–200 Mc/s
	General purpose	30–300	Max. Mean Min.	+ 1.8 – 2.1 – 5.4	11.5 7.6 4.3	3000	3 receivers tested of the same type. Freq. range = 24–184 Mc/s
	Mobile**	30–300	Max. Mean Min.	+ 7.3 + 0.8 – 3.7	17 10.5 6	3000	Many receivers tested Frequency range = 60–200 Mc/s

* See annex IV of Recommendation No. 154 and Doc. II/32 of Geneva, 1958.

** See also Doc. No. 445 of Warsaw, 1956.

TABLE V

*Reference sensitivity and noise factor for sound-broadcast receivers **

Class of emission	Service	Frequency range		Reference sensitivity (rel. to 1 μ V)	Noise factor (db)	Reference bandwidth (c/s)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A3	Sound broadcasting	500–1600 kc/s	Mean	+35.5	24	5000	Mass-produced receivers** Standard deviation = 3.5 db Source impedance = dummy antenna
		1600–30 000 kc/s	Mean	+38.7	20.4	5000	Mass-produced receivers** Source impedance=dummy antenna (400 ohms)
		1600–30 000 kc/s	Max. Mean Min.	+32.1 +25 +17.1	21 13.9 6	5000	Several receivers tested, one RF stage Source impedance=75 ohms
		30–300 Mc/s	Mean	+19.1	8	5000	
F3	Sound broadcasting	88–100 Mc/s	Mean	0	17	5000	Many receivers tested. Standard deviation=6 db***

* See Annex IV of Recommendation 154.

** See Doc. 398 of Warsaw, 1956.

*** See Docs. Nos. 7, and 199 of Warsaw, 1956, and Doc. II/3 of Geneva, 1958.

ANNEX V

REPRESENTATIVE VALUES FOR THE NOISE FACTOR AND SENSITIVITY OF RADIOTELEGRAPHY RECEIVERS
FOR THE FIXED SERVICES*(automatic reception)*1. *Introduction*

In the following tables an attempt has been made to present in a systematic way representative data for noise and sensitivity characteristics of radiotelegraphy receivers for A1 and F1 emissions and for the fixed services (automatic reception).

In the following tables an attempt has been made to present in a systematic way representative data for noise and sensitivity characteristics of radiotelegraphy receivers for A1 and F1 emissions and for the fixed services (automatic reception).

2. *Notes on Tables VI to IX*

In *Table VI* information of a general character, pertaining to the *Tables VII to IX* has been given, including figures for the noise factor (maximum, mean and minimum values) of A1 and F1 receivers for the fixed services.

Column No. *Tables VII to IX*

(6) *Sensitivity criterion.* It has been indicated, whether the sensitivity should be considered as "distortion limited (D)" or "mutilation limited (M)".

(7) *Normalized signal-to-noise ratio* (see § 9.5).

(8) *Noise factor.* Only the mean value taken from the noise factor figures contained in *Table VI* has been used in these tables.

(9) *Sensitivity.* The data are given in conformity with the recommended measurement characteristics described in Annex II, § 5 above.

Note. — In view of the small number of receivers tested the data for normalized signal-to-noise ratio and sensitivity should be considered as provisional.

The relation between normalized signal-to-noise ratio, sensitivity and noise factor is given in Annex II, § 6, above.

TABLE VI *

Noise factor of A1 and F1 receivers for the fixed services

Class of emission	Service	Frequency range (Mc/s)		Noise factor (db)
(1)	(2)	(3)	(4)	(5)
A1 } F1 }	Fixed	1.6–30	Max. Mean Min.	10 7 4

* See Annex IV of Recommendation No. 154, and Docs. II/3, II/21 and II/32 of Geneva, 1958.

TABLE VII

*Sensitivity of radiotelegraphy receivers (automatic reception) **
(Signal distortion and signal mutilation)

A1

Class of Emission	Frequency range (Mc/s)	Frequency shift (c/s)	Keying speed (bauds)	Filter Bandwidth (c/s)		Sensitivity criterion M = mutilation D = distortion	Normalized signal-to-noise ratio (db)	Assumed Noise factor (db)	Sensitivity for 1 failure in 1000 elements (db rel. to 1 μ V)	Remarks
				Pre-det.	Post-det.					
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)	(10)
A1 (Fixed services)	1.6-30		50	1000	75	M	27.7	7	- 7.5	Three receivers tested
				1000	120	M	26.2	7	- 9	
				1000	250	M	20.2	7	-15	
			100	1000	120	D	24.7	7	- 7.5	
				1000	250	D	22.2	7	-10	

Source impedance = 75 Ω

* Calculated from data given in Doc. II/21 of Geneva, 1958 according to Annex II, § 6, above.

TABLE VIII
*Sensitivity of radiotelegraphy receivers (automatic reception) **
 (Signal distortion and signal mutilation)

F1

Class of Emission	Frequency range (Mc/s)	Frequency shift (c/s)	Keying speed (bauds)	Filter Bandwidth (c/s)		Sensitivity criterion M = mutilation D = distortion	Normalized signal-to-noise ratio (db)	Assumed Noise factor (db)	Sensitivity for 1 failure in 1000 elements (db rel. to 1 μ V)	Remarks
				Pre-det.	Post-det.					
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)	(10)
F1 (Fixed services)	1.6–30	400	50	1000	75	M	16.7	7	–18.5	Four receivers tested
				1000 or 1500	120	M	20.7	7	–14.5	
				1000	250	M	18.2	7	–17	
			100	1000	120	D	14.2	7	–18	
				1000	250	D	17.7	7	–14.5	
				1000	75	M	16.7	7	–18.5	
		200	50	1500	120	M	19.2	7	–16	
				1000	250	M	21.2	7	–14	
				1000 or 1500	120	D	16.7	7	–15.5	
			100	1000	250	D	22.7	7	– 9.5	

Source impedance = 75 Ω

* Calculated from data given in Docs. II/31 and II/21 of Geneva, 1958 according to Annex II, § 6, above.

TABLE IX

*Sensitivity of radiotelegraphy receivers (automatic reception) **

(Character error rate)

F1

Class of Emission	Frequency range (Mc/s)	Frequency shift (c/s)	Keying speed (bauds)	Filter Bandwidth (c/s)		Sensitivity criterion M = mutilation D = distortion	Normalized signal-to-noise ratio (db)	Noise factor (db)	Sensitivity for 1 failure in 1000 elements (db rel. to 1 μ V)	Remarks
				Pre-det.	Post-det.					
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)	(10)
F1 (Fixed services)	1.6-30	400	50	**	45		17	7	-18.2	Two receivers tested
		400	50	**	90		19	7	-16.2	
		400	50	**	180		23	7	-12.2	
		200	50	**	100		19.2	7	-16	

Source impedance = 75 Ω

* Docs. II/3, II/11 and II/23 of Geneva, 1958; Doc. 2 of Warsaw, 1956.

** Pre-detector bandwidth unknown.

ANNEX VI

Table X contains data for the maximum sensitivity of sound broadcasting receivers (see § 10.1 of the Recommendation for the definition of maximum sensitivity).

TABLE X

*Maximum sensitivity for sound broadcasting receivers **

Class of emission	Service	Frequency range (Mc/s)	Effective overall noise band (c/s)		Maximum sensitivity (db rel. to 1 μ V)	Remarks
F3	Sound broadcast	86-100	6400	Max.	36	Superheterodyne. Battery receiver with 3 I.F. stages and ratio detector. Two receivers tested
				Min.	14	
			4300	Max.	25	Mains receiver Two receivers tested
				Min.	6	
			10 400	Max.	20	Mains receiver Two receivers tested.
				Min.	3	

Source impedance = 75 Ω

Deviation = ± 22.5 kc/s

Output level = 50 mW

ANNEX VII

REPRESENTATIVE VALUES FOR THE SENSITIVITY AND
NOISE FACTOR OF TELEVISION RECEIVERS

1. *Introduction*

- 1.1 The methods of test of television receivers have not, as yet, been fully standardized in the various countries and the data given in this Annex and the relevant documents must be regarded as tentative until such standardization is more complete **.
- 1.2 The Tables given below contain representative values for the sensitivity of the vision and sound channels of typical television receivers, as required by Question No. 172 (II). The data given in the Tables are deduced from information contained in Documents 116 and 118 of London, 1953 Doc. 199, 215 and 398 of Warsaw, 1956 and Docs. II/3 and II/21 of Geneva, 1958.

2. *Notes on Table XI (405-line system)*

Column No.

(1) (2) (3) The significance of these columns is the same as for the columns with corresponding titles in Ann. IV.

(4) The sensitivity of the vision channel has been taken as the larger of the input signal levels required to produce at the output:

(a) a vision signal output level of 20 V (peak-to-peak, black-to-white picture signal).

or

(b) a vision signal-to-noise ratio of 30 db (peak-to-peak values of vision signal and r.m.s. values for noise).

* See Doc. II/21 of Geneva, 1958.

** See Recommendation No. 158 of Warsaw, 1956.

If the gain is insufficient to enable (a) and (b) to be satisfied simultaneously, the receiver is referred to as gain-limited; otherwise it is noise-limited. If, on the other hand, (a) being satisfied, (b) is the signal-to-noise ratio for any usable picture, the sensitivity should be described as "maximum sensitivity".

The sensitivity is stated as the r.m.s. value of the input carrier corresponding to peak white modulation (positive modulation system); for test purposes a carrier sinusoidally modulated to a depth of 50% corresponding to a black to white picture signal in a system with 70/30 picture/synchronizing-pulse ratio, is assumed.

The following values are also assumed:

Source resistance = 75 Ω

Width of overall effective noise band = 3 Mc/s

The reference values for the output signal/noise ratio of the sound channel, the width of the overall effective noise band and the modulation of the test signal are the same as for sound broadcasting receivers (see Annex II, Note 1 and Table I).

3. Notes on Tables XII and XIII (625-line system)

Column No.

(1) (2) (3) The significance of these columns is the same as for the columns with corresponding titles in Annex IV.

(4) The sensitivity of the vision channel has been taken as the input signal required to produce at the output:

(a) a vision signal output level of 20 V (peak-to-peak, black-to-white picture signal) (Table XII), or standard image of maximum subjective brightness of white = 20 nits (6 ft. lamberts) and contrast = 10 (Table XIII);

(b) a vision signal-to-noise ratio of approximately 38 db (peak-to-peak values of vision signal and r.m.s. values for noise), a 38 db signal-to-noise ratio being considered as a value for a good picture.

If the gain is insufficient to enable (a) and (b) to be satisfied simultaneously, the receiver is referred to as "gain-limited", otherwise it is "noise-limited".

On the other hand, if (a) is satisfied and if the signal-to-noise ratio defined in (b) refers to "any usable" picture, the sensitivity should be described as "maximum sensitivity".*

The sensitivity is stated as the r.m.s. value of the input carrier, modulated sinusoidally to a depth of approximately 85%. The following reference values are assumed:

Source impedance = 75 Ω

Width of the effective noise band = 4.6 Mc/s for 625 lines

The reference values for the output signal-to-noise ratio of the sound channel, the width of the effective overall noise band, the degree of modulation and, for frequency modulation, the deviation, are the same as for A3 or F3 sound broadcast receivers. (See Annex II, Note 1 and Table I).

4. Notes on Table XIV (619-line system)

Column No.

(1) (2) (3) The significance of these columns is the same as for the columns with corresponding titles in Annex IV.

(4) See § 3 of Annex VII with:

(a) a vision signal output level of 33.3 V (peak-to-peak);

(b) a vision signal-to-noise ratio of 32 db (peak-to-peak values of signal and r.m.s. values for noise).

The sensitivity is stated as the r.m.s. value of the input carrier, square-modulated to a depth of 100% at 5000 c/s.

* See Doc. 398 of Warsaw, 1956 and Doc. 11/3 of Geneva, 1958.

TABLES XI TO XIV

Sensitivity and noise factor for television receivers

Frequency range (Mc/s)	Class of emission		Maximum usable sensitivity noise-limited	Maximum usable sensitivity gain-limited	Maximum sensitivity	Noise factor (db)	Remarks
			(db relative to 1 μV)				
(1)	(2)	(3)	(4)			(5)	(6)
TABLE XI (405-line system)							
41-68	A5 (vision)	Max.	56	57		14	10 receivers tested (8 noise-limited, 2 gain-limited); maximum sensitivity for 1 receiver only
		Mean	46	54	23	8	
		Min.	42	51		5	
	A3 (sound)	Max.	28	35		13	10 receivers tested (5 noise-limited, 5 gain-limited)
		Mean	21	27	4	9	
		Min.	8	20		6	
174-216	A5(vision)		48		26		One receiver tested
	A3(sound)		12		9		
TABLE XII * (625-line system, 5 Mc/s video band)							
41-68	A5 (vision)	Max. Mean Min.	43		36	11.8 8 6	Mass production receivers; noise factor for 10 receivers tested
	F3 (sound)	Max. Mean Min.	34.5				
174-216	A5 (vision)	Max. Mean Min.	49		44	11.8 8 6	
	F3 (sound)	Max. Mean Min.	40.5				
TABLE XIII (625-line system, 6 Mc/s video band) **							
41-68	A5 (vision)	Mean	56	50			Few receivers tested. Receivers of different type and design
TABLE XIV (819-line system)							
162-216	A5 (vision)	Mean	43	57	33	8	

* See Doc. No. 398 of Warsaw, 1956 and Doc. II/3 of Geneva, 1958.

** See Doc. No. 215 of Warsaw, 1956.

RECOMMENDATION No. 235 *

SELECTIVITY OF RECEIVERS

The C.C.I.R.,

(London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the selectivity of a receiver is a measure of its ability to discriminate between a desired signal to which the receiver is tuned and undesired signals;
- (b) that economy in the use of the radio spectrum requires the maximum selectivity compatible with the technical and economic considerations relating to the particular class of receiver;
- (c) that the single-signal selectivity method is used to express the performance of certain characteristics of the receiver. The measurements are made with sufficiently low levels of input to avoid non-linearity (e.g. overloading) affecting the results; automatic gain control, automatic frequency control, etc., being rendered inoperative;
- (d) that measurement of selectivity with more than one signal should be the general method for measuring the selectivity. Sometimes the non-linear effects are numerous, then it will be necessary to select the most representative cases in order to simplify the measurements;
- (e) that defined methods of single-signal and multiple-signal selectivity measurements are desirable to permit comparison of receivers;

UNANIMOUSLY RECOMMENDS

- 1. that the pass-band of the receiver shall be no wider than is essential for the transmission of the necessary modulation of the desired signal without significant distortion (see § 1.2 of Recommendation No. 230), together with an allowance for the unavoidable instabilities of the frequencies of the transmitter and of the receiver;
- 2. in establishing the selectivity of a receiver account should be taken of:
 - 2.1 the unavoidable spread of the spectrum of signals in adjacent channels (see § 2 of Recommendation No. 230);
 - 2.2 the limitations of the selectivity of the receiver by unavoidable amplitude non-linearity, e.g. cross-modulation;
 - 2.3 the fact that an excessively large attenuation-slope may lead to serious distortion of the phase/frequency characteristic in the pass-band;
- 3. that the filters which determine the selectivity shall be included as near as possible to the receiver input, and the amplifying stages preceding the filters shall be sufficiently linear, in order to avoid significant loss of selectivity, e.g. by cross-modulation of the desired signal by strong undesired signals;
- 4. that for the purpose of studying single-signal selectivity, the following definitions are recommended:
 - 4.1 *pass-band*: the pass-band is the band of frequencies limited by the two frequencies for which the attenuation exceeds that of the most favoured frequency by some agreed value; in general this value is 6 db, except for high-quality radiotelephony receivers where the value is 2 db;
 - 4.2 *attenuation-slope*: the attenuation-slope on each side of the pass-band is the ratio:
 - of the difference in the attenuations corresponding to two different frequencies beyond the pass-band;

* This Recommendation replaces Recommendation No. 155.

— to the difference between these frequencies;

4.3 *image-response ratio* : the image-response ratio is the ratio:

- of the input signal level at the image frequency required to produce a specified output from the receiver,
- to the level of the desired signal required to produce the same output.

The image frequency is the desired signal frequency plus or minus twice the intermediate frequency, according to whether the frequency-change oscillator is respectively higher or lower in frequency than the desired signal frequency.

If the receiver incorporates more than one frequency change there will be more than one image frequency, and for each of these there will be a corresponding image-response ratio;

4.4 *intermediate-frequency response ratio* : the intermediate-frequency response ratio is the ratio:

- of the level of a signal at the intermediate frequency applied to the receiver input and which produces a specified output from the receiver,
- to the level of the desired signal required to produce the same output;

4.5 other spurious responses can occur when the intermediate frequency arises as the sum or the difference of the frequency of an interfering signal and a harmonic of the local oscillator frequency, etc.,

spurious-response ratio : the spurious-response ratio is the ratio:

- of the input level at the interfering frequency required to produce a specified output from the receiver,
- to the level of the desired signal to produce the same output;

5. that single-signal measurements be made of the pass-band, the attenuation slope, the image-response, the intermediate-frequency response and other spurious-response ratios as defined above.

For the attenuation-slope, sufficient indication is generally obtained by considering the frequency difference corresponding to attenuations of 20, 40, 60 and if possible 80 db, reckoned from the limit frequencies of the pass-band. When the values thus obtained are essentially equal for the two sides of the pass-band it is sufficient to give mean values.

For some purposes it is of interest to know the bandwidth at fixed levels corresponding to the above-mentioned attenuations. These figures can easily be deduced from the pass-band and the attenuation-slopes at the different levels (see Fig. 1).

The two methods of the presentation of the single-signal selectivity are very similar and there seems no good reason for preference of one over the other. After the introduction of the method of presentation by the attenuation slope (Geneva, 1951) this method was used for Tables I, II and III of the Annex.

Since, when plotted in decibels to a logarithmic scale of frequency, the sides of the selectivity characteristics are often almost straight beyond a certain frequency difference relative to the mid-band frequency, the attenuation outside the pass-band can also be expressed as the slope of the attenuation/frequency characteristic, in decibels per octave of the frequency difference (see Fig. 1 Recommendation No. 95, London, page 107). The frequency and attenuation at the starting point of such a slope, relative to the mid-band frequency, should be stated;

6. that for the purpose of studying the selectivity in the non-linear region with *two or more input signals* the following definitions are recommended:

6.1 *effective selectivity* : the effective selectivity is the ability of the receiver to discriminate between the desired signal (to which the receiver is tuned) and undesired signals (having frequencies generally outside the pass-band) the level of which is such as to produce non-linear effects, the desired and undesired signals acting simultaneously. The effective selectivity can be investigated by measuring blocking, cross-modulation and inter-modulation as follows:

6.2 *blocking* : blocking is measured by the level of an undesired signal on a near-by frequency, e.g. in an adjacent channel, which results in a given change (generally a reduction), e.g. 3 db,

in the output due to a modulated * desired signal of specified level applied to the receiver input;

- 6.3 *cross-modulation*: crossmodulation is measured by the level of a modulated undesired signal on a frequency near to an unmodulated desired signal (e.g. in an adjacent channel), which results in an output from the receiver of a specified amount, (e.g. 20 db **), below that which would be obtained if the desired signal were modulated;
- 6.4 *intermodulation*: inter-modulation is measured as the levels of two undesired signals which, when applied together, produce at the receiver output a given level (e.g. 20 db **) below that due to the normal input signal, when the frequencies F_n' and F_n'' of these two undesired signals have:
- 6.4.1 a sum equal to the intermediate frequency ($F_{if} = F_n' + F_n''$), in which case tests should be made with frequencies such that the undesired signals will have frequencies close to, but not equal to, half the intermediate frequency;
 - 6.4.2 a difference equal to the intermediate frequency ($F_{if} = F_n' - F_n''$) in which case tests should be made with frequencies such that the undesired signal having the lower frequency should have a frequency near to that of the desired signal, e.g., in an adjacent channel;
 - 6.4.3 a sum equal to the frequency of the desired signal ($F_d = F_n' + F_n''$), in which case the undesired signals should have frequencies close to but not equal to half of the desired signal;
 - 6.4.4 a difference equal to the frequency of the desired signal ($F_d = F_n' - F_n''$), in which case the undesired signal having the lower frequency should have a frequency near to that of the desired signal, e.g., in an adjacent channel;
 - 6.4.5 a sum equal to the image frequency ($F_{im} = F_n' + F_n''$), in which case the undesired signals should have frequencies close to but not equal to half of the image frequency;
 - 6.4.6 a difference equal to that between the desired signal and one undesired signal, the intermodulation product being of the third order $F_d = 2F_n' - F_n''$, in which case the nearer undesired signal should have a frequency near to that of the desired signal, e.g., in an adjacent channel.

Other orders of intermodulation products may occur; those selected are generally sufficient to describe the performance in respect of intermodulation.

The frequency of one of the undesired signals should be adjusted to make the interference a maximum, and that of both should be such that the receiver output is negligible when only one undesired signal is applied and modulated.

To determine the severity of intermodulation for a range of values of the strength of the desired signal, a third signal (the desired signal) should be applied at the frequency to which the receiver is tuned; suitable input levels may be + 20 db, + 40 db, + 60 db and + 80 db relative to 1 μ V. (See Note 2.)

The undesired signals should be equal in level; in receivers for A3 they should be unmodulated because the interference resulting from the beat between the intermodulation product and the carrier of the desired signal is more severe than that due to any modulation; in receivers for A3b they should also be unmodulated and the frequency of one undesired signal should be adjusted to make the output of the receiver have a frequency equal to that of the modulation initially applied to the desired signal.

7. that to express the selectivity in the non-linear region, it is desirable that measurements be made of the effective selectivity in terms of the blocking, cross-modulation and intermodulation characteristics as defined above.

Note 1. — The application of multiple-signal tests of effective selectivity to receivers for A1, A2, F1 and F3 signals is the subject of further study (Question No. 178 (II)).

Note 2. — To enable the measurements to be made with two signal generators, the sensitivity of the receiver can be adjusted by the use of a suitable potential applied to the automatic-gain-

* Except for A1 signals when an unmodulated carrier is used.

** Other values may be desirable for certain special classes of receivers.



control circuit, to correspond to the input signals recommended. In this case, one of the undesired signals should be modulated. A correction should be made for the depth of modulation.

Note 3. — Annex I gives representative values for the selectivity of a limited number of receivers (excluding television receivers) and is based on data and information given in the Annex to Recommendation No. 95 and of Docs. Nos. 137, 318, 398 and 488 of Warsaw, 1956 and II/4, II/12, II/16, II/17, II/25 of Geneva, 1958 and 89 of Los Angeles, 1959.

Annex II gives representative values for the selectivity of television receivers and is based on data given in the Annex to Recommendation No. 95 and Docs. Nos. 137, 398 and 488 of Warsaw, 1956 and II/25 and II/29 of Geneva, 1958. The data given in Annexes I and II were collected as part of studies required by Study Programme No. 42.

Annex III gives representative values for the two-signal selectivity of FM broadcast receivers and is based on Doc. No. II/14 and II/15 of Geneva, 1958.

Annex IV gives representative values for time-delay/frequency characteristics of high-frequency radiotelegraphy receivers and is based on data and information given in Docs. Nos. II/14 and II/15 of Geneva, 1958.

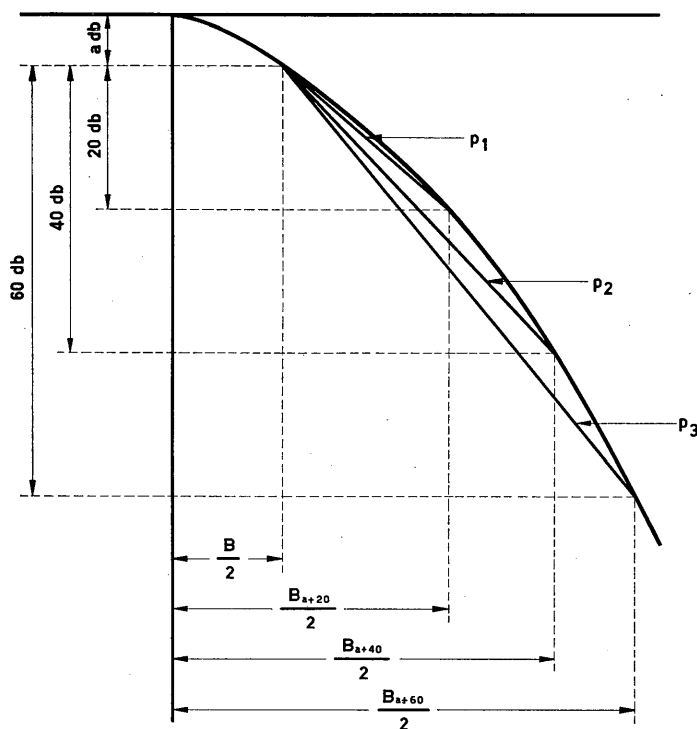


FIGURE 1

Conversion between methods of presentation of single-signal selectivity

The formula: $B_{a+20n} = B + 20(2n/p_n)$

can be used to convert from the figures given in the tables to bandwidths at specified levels, where

a = the attenuation at the edge of the passband

B_{a+20n} = the bandwidth at a level $(a + 20n)$ db from the middle of the passband in kc/s

B = the bandwidth of the passband in kc/s as given in column (5) of Tables I, II and III

p_n = slope of the attenuation in db/kc/s as given in column (6) for n = an integer (1, 2, 3 or 4)

ANNEX I

SELECTIVITY OF RECEIVERS, EXCLUDING TELEVISION RECEIVERS

1. *General*

In the following tables an attempt has been made to present representative data for the selectivity characteristics of the various classes of receiver in a systematic way. In order to facilitate the use of these data and at the same time to reduce the amount of data presented, only three figures (called for convenience “maximum”, “mean” and “minimum” values) have been given for each characteristic for a number of similar receivers of each class. This means, that the mean value is taken as a result of figures given either for a larger number of receivers of the same type or for different types of receivers and for different frequencies within the indicated range (Col. 3). In most cases, however, the actual frequency range is less than the full indicated range. It should be noted, however, that in many cases, because of the small number of receivers (indicated in the “Remarks” columns of the tables), these figures have no precise statistical significance.

For certain classes of receiver, only limited data, and in some cases no data, were available. Nevertheless, it is hoped that the incomplete data given in the tables will be of value to users and that it will be possible to add to these in the future.

2. *Notes to the tables*2.1 *Single-signal selectivity* (See Tables I, II and III)

Column No.

- (1) (2) (3) Receivers are tabulated in terms of the class of emission, class of receiver and frequency range respectively, according to the “Classification Scheme for Receivers”, contained in Annex I of Recommendation No. 234.
- (4) See § 1 above (General).
- (5) See § 4.1 of this Recommendation.
- (6) See § 4.2 and 5 of this Recommendation.
- (7) See § 5 and Fig. 1 of this Recommendation. The “ultimate slope” is the value, generally constant, that the attenuation slope attains at frequencies remote from the pass-band. The frequency and attenuation at the starting point of such a slope, relative to the mid-band frequency, should be stated.
- (8) See § 4.3 of this Recommendation.
- (9) See § 4.4 of this Recommendation.
- (10) This column shows the number of receivers on which the representative values for the single-signal selectivity are based, and, when possible, some indication of the spread of the data.

2.2 *Two-signal selectivity (except inter-modulation)* (See Tables IV/1, V/1 and VI/1)

Column No.

- (1) (2) (3) See § 2.1 above.
- (4) Frequency difference between the desired signal (F_d) and the undesired signal (F_n).
- (5) See § 1 above (General).
- (6) See § 6.2 of this Recommendation.
- (7) See § 6.3 of this Recommendation.
- (8) This column shows the number of receivers on which representative values for the two-signal selectivity are based, and the values for the ratios of the desired to the undesired signal at the receiver output (in cross-modulation tests) when these differ from those suggested in § 6.3 of this Recommendation.

2.3 *Multiple-signal selectivity* (See Table IV/2, V/2 and VI/2)

Column No.

- (1) (2) (3) See § 2.1 above.
- (4) Desired frequency.
- (5) See § 1 above (General).
- (6) See § 6.4 of this Recommendation.
- (7) This column shows the number of receivers on which the representative values are based.

ANNEX II

SELECTIVITY OF TELEVISION RECEIVERS

General

The methods of test of television receivers have not, as yet, been fully standardized in the various countries and the data given in this Annex and the relevant documents must be regarded as tentative until such standardization is more complete (see Table VII).

Table VII contains representative values for the single-signal selectivity of the vision and sound channels of typical television receivers (405 and 625 line systems only).

Some results of delay-time-measurements of television receivers are given in Doc. 203 of Los Angeles, 1959.

ANNEX III

General

In Table VIII representative figures of the two-signal selectivity of FM (F3)-broadcast receivers are shown. The measurements were made in the manner adopted by the I.E.C. in which the ratio of "unwanted-to-wanted signal strength" required to give an interference output 30 db below the wanted output with 30% modulation for various frequency separations including zero is measured. (See also Recommendations Nos. 237 and 238.)

ANNEX IV

GROUP DELAY CHARACTERISTICS OF RADIOTELEGRAPHY RECEIVERS

1. *General*

Table IX shows values of "group-delay" characteristics of bandpass filters, which are used as IF filters in telegraphy receivers. A short description of the measuring method is given in Report No. 104.

2. *Notes to the table*

Column No.

(1) (2) (3) Classification and single signal selectivity of receivers tested are shown.

(4)

(5) Group-delay time in milliseconds at the centre frequency (f_0) of the IF filters.

(6) (7) (8) Maximum positive and negative deviations of group-delay time within the

(9) (10) (11) specified bandwidths limited by two frequencies at which the attenuations exceed from that at f_0 by 3, 6 and 12 db respectively.

(12) Remarks on the design of receivers.

ANNEX I

TABLE I

Single-signal selectivity of radiotelegraphy receivers

Class of emission	Service	Frequency range (Mc/s)		RF and IF passband (kc/s)	Attenuation slope from edge of passband (db/kc/s)				Ultimate slope (db/octave)	Image response ratio (db)	IF response ratio (db)	Remarks
					26 db	46 db	66 db	86 db				
(1)	(2)	(3)	(4)	(5)	(6)				(7)	(8)	(9)	(10)
A1	Fixed	1.6-30		1.1	165	200	200	200		113/83		1 receiver tested
		1.6-30		0.4 1.2	108 130	135 165	144 183	130 210		100 100	100 100	
		3-24		0.4	200	350	425					
				1.0	300	625	950			95-131	64-127	$2f_o + f_{if} : 137 \text{ db}$ $2f_o + f_{if} : 123 \text{ db}$ $f_o + \frac{1}{2} f_{if} : 139 \text{ db}$
				1.2	100	200	260	360		88-118	106-126	
	General purpose	1.6-30	Max. Mean Min.	4.7 1.4 0.2	28 16 10	28 15 10	28 15 8			119/53 73/28 41/7	110 90 80	6 receivers tested
		0.03-30	Max. Mean Min.	3.8 3.2 2.4	10.5 8.9 6.7	10.0 7.4 6.5				100 31	110 52	3 receivers tested (different types)
F1	Fixed	3-30		0.6 *	77 *	77 *	77 *					Triple frequency-change receiver
	General purpose	3-30		1 *	24	24	24					Average type of receiver with 8-10 tubes
				1 *	32	32	32					Double frequency-change receiver, 20 tubes

* At 3 db down and therefore at 23/43/63 db instead of 26/46/66 db (in column 6).

TABLE II
Single-signal selectivity of radiotelephony receivers

Class of emission	Service	Frequency range (Mc/s)		RF and IF passband (kc/s)	Attenuation slope from edge of passband (db/kc/s)				Ultimate slope (db/octave)	Image response ratio (db)	IF response ratio (db)	Remarks
					26 db	46 db	66 db	86 db				
(1)	(2)	(3)	(4)	(5)	(6)				(7)	(8)	(9)	(10)
A3	Fixed	1-6-30		6	22	23	26.5	28		> 70	> 100	
	General purpose	1-6-30	Max. Mean Min.	6.8 5.3 4.0	12 8.5 5	11 8 4	11 8 4			119/53 73/28 41/7	> 110 > 90 > 80	7 receivers tested
		0.0-330	Max. Mean Min.	9.4 6.1 4.3	10.5 9.1 7.1	10.7 9.3 6.5				> 100 30	> 100 81	4 receivers (of different types) tested
		30-300	Max. Mean Min.	52 34 16.5	1.25 1.1 0.84	1.5 1.2 0.9	1.5 0.9	1.5 0.9		100 63 22	100 90 82	3 groups of 2 receivers (of different types) tested
	Mobile	30-300	Max. Mean Min.	65 37 22	5 3.2 1.5	4.4 2.7 1.1	3.6 2.3 1.5	3 1.4 1.1		100 60	109 90	3 groups of 4 receivers (of different types) tested
	Aeron. mobile	225-400		100						> 80	> 80	Double freq. change
A3b	Fixed	1-6-30	Max. Mean Min.	6.4 6.15 6.0	240 100 12	240 114 12	240 118 12	100 70 10		115/85 112/84 110/82	> 110 > 95 > 80	4 receivers tested for cols. (5) & (6); 3 for (8) & (9)
		1-6-30	Max. Mean Min.	7.3 6.9 6.1	45 13.3					115 61	126 60	23 receivers tested of 4 different types
		2.5-21		6	50	55	70	37		> 90	> 75	$f_o - f_{if2} : > 78 \text{ db}$

TABLE I (continued)

(1)	(2)	(3)	(4)	(5)	(6)				(7)	(8)	(9)	(10)
F3	Fixed	30-300 30-300		900 2100	0.35 0.02	0.35 0.02	0.35		200	60 58	80 > 100	20 receivers (same type) tested; designed for 24 channel system.
		170 **		1500	0.03	0.03				70	140	$2f_o + f_{if}$: > 130 db
	General purpose	30-300		40	0.8	0.8				90/44	> 100	
		65-175		28 *	1.5 *	1.5 *	1.5 *	1.5 *		> 70	> 100	Receiver with continuous tuning. Single frequency change
	Mobile	30-300	Max. Mean Min.	52 33 21	5.2 2.5 1.4	5.2 2.8 1.7	5.2 3.1 1.1	5.2 3.3 1.1	53 ***	96 92 76	100 ***	13 receivers tested (of different types) ***
		30-300		55	1.2	1.2	1.2	1.1	118 *** 47	70	80	Portable rec. 25 recs. tested (of 2 types)
		68-87.5		30 *	3 *	3 *	3 *	3 *		> 70		Fixed frequency rec., double freq. change
		31.7-41 67-71 76-88 156-174		30 *	2.3 *	2.3 *	2.3 *	2.3 *		> 70		Portable receiver
		405-475		40						> 80	> 80	Triple freq. change
P	Fixed	2100-2300		5000	0.009	0.009	0.009	0.009	22	50	100	1 receiver tested (prototype of 24-channel PPM-system)

* At 3 db down and therefore at 23/43/63/83 db.

** Measurements made at the single frequency shown.

*** See also Doc. No. 446 (Warsaw).

TABLE III
Single-signal selectivity of sound-broadcast receivers

Class of emission	Service	Frequency range (Mc/s)		RF and IF passband (kc/s)	Attenuation slope from edge of passband (db/kc/s)				Ultimate slope (db/octave)	Image response ratio (db)	IF response ratio (db)	Remarks
					26 db	46 db	66 db	86 db				
(1)	(2)	(3)	(4)	(5)	(6)				(7)	(8)	(9)	(10)
A3	Sound broadcasting	1.6-3.0	Max. Mean Min.	13.3 8.05 4.0	4.5 3.6 2.5	3.75 3.1 2.1				44 25 9	120 90 57	10 receivers tested
		0.5-3.0	Max. Mean Min.	15.0 7.3 4.0	8.9 3.3 1.2	6.7 3.4 1.8	6.3 3.1 2.0			78 * 28 * 22 *	100 * 96 * 68 *	169 receivers of about 20 types tested
		0.5-3.0	Max. Mean Min.	5.8 5.5 5.3	4.5	4.2	3.4					Mean value (taken from a curve); 356 receivers tested)
		1 **		6	3.3	1.3				38	36	$2f_o + f_{if}$: 63 db $f_o + \frac{1}{2}f_{if}$: 96 db
		0.5-10	Mean	10.0	4.3	6.1						Low price receiver of 1 type (24 000 tested)
F3	Sound broadcasting	861-00								20 37 21 13	32 42 51 28	FM/AM battery receiver FM/AM receiver FM/AM receiver FM/AM battery receiver
		90 **		125 ***	0.19 ***	0.17 ***				23	68	FM tuner. Switched with A.F.C. Cheap broadcast receivers
		881-00		165 ***	0.28 ***	0.27 ***						High-quality broadcast receivers

* 3 receivers of different types tested.

** Measurements made at the single frequency shown.

*** At 3 db down and, therefore, at 23/43 db (in column 6).

TABLE IV/1

Two-signal selectivity of radiotelegraphy receivers

Class of emission	Service	Frequency range (Mc/s)	Signal separation $F_d - F_n$ (kc/s)		Blocking Level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Cross-modulation Level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Remarks
					+20	+40	+60	+80	+20	+40	+60	+80	
(1)	(2)	(3)	(4)	(5)	(6)				(7)				(8)
A1	Fixed	1-6-30	10		90	105	115	120					1 receiver tested
	Fixed	1-6-30	20	Max. Mean Min.	72 69 66	80 77 73	88 85 80	93 91 87	69 64 63	77 73 71	84 81 79	89 87 85	3 receivers tested
A1	General purpose	0-03-30	10	Max. Mean Min.		106 81 70	115 101 86	123 115 104		90 77 59	101 91 83	113 104 100	3 receivers of different types tested at 2 frequencies
F1	Fixed	1-6-30	20	Max. Mean Min.	102 94 85	113 102 88	> 120 > 111 94	> 120 > 115 102	96 89 87	> 120 > 120 > 120	> 120 > 120 > 120	> 120 > 120 > 120	9 receivers tested
A1 A2	Fixed	3-24	5	Max. Min.	83 80	104 102	111 108						
			2	Max. Min.	72 72	93 92	113 111						

TABLE IV/2
Multiple signal selectivity of radiotelegraphy-receivers

Class of emission	Service	Frequency range (Mc/s)	F _d Mc/s		Intermodulation																		Remarks		
					Level of undesired signals (db relative to 1 μV) for the levels of the desired signal given below																				
					F _n ' ± F _n " = F _{if} cf. para. 6.4.1 and 6.4.2					F _n ' ± F _n " = F _d cf. para. 6.4.3 and 6.4.4					F _n ' + F _n " = F _{im} cf. para. 6.4.5					2F _n ' - F _n " = F _d cf. para. 6.4.6					
					a *	20	40	60	80	b *	20	40	60	80	c *	20	40	60	80	d *	20	40		60	80
(1)	(2)	(3)	(4)	(5)	(6)																		(7)		
A1	Fixed	1-6-30	10	Max. Mean Min.	(—)		> 120 > 110 101			(—)		97 90 85											3 receivers tested		
				Max. Mean Min.					(+)		115 110 104														
	General purpose	0-03-30	1-10	Max. Mean Min.	(—)	100 79 64				(—)	90 81 72												3 receivers tested		
				Max. Mean Min.					(+)	100 87 80															
F1	Fixed	1-6-30	10	Max. Mean Min.	(—)		> 120 > 107 101			(—)		91 86 80											9 receivers tested		
				Max. Mean Min.					(+)		104 95 86														
A1 A2	Fixed	3-24	3-24	Max. Min.	(—)	94 56				(—)	70 60								(—)	60 43					
				Max. Min.					(+)	90 76															

* In these columns the values inserted are those for the frequencies given by the following:

(a) for (+): $(F_n' + F_d)$; for (—): $(F_n' - F_d)$; (c) $(F_n' - \frac{1}{2}F_{im})$; (b) for (+): $(F_n' + \frac{1}{2}F_d)$; for (—): $(F_n' - \frac{1}{2}F_d)$ (d) $(F_n' - F_d)$.

TABLE V/1

Two-signal selectivity of radiotelephony receivers

Class of emission	Service	Frequency range (Mc/s)	Signal separation $F_d - F_n$ (kc/s)		Blocking Level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Cross-modulation Level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Remarks
					+20	+40	+60	+80	+20	+40	+60	+80	
(1)	(2)	(3)	(4)	(5)	(6)				(7)				(8)
A3	Fixed	1.6-30	18	Max. Mean Min.	92 87 74	96 93 88	101 97 94	106 101 96	60 57 54	74 64 56	81 68 60	89 76 68	4 receivers tested
			36	Max. Mean Min.	98 97 94	102 99 96	105 103 100	112 107 102	62 60 56	80 68 60	88 72 65	86 77 72	
	General purpose	1.6-30	10	Max. Mean Min.	86 75 66	> 120 95 78	> 120 108 94	> 120 117 111		93 81 61	106 94 79	115 101 78	6 receivers tested
			10	Max. Mean Min.		119 87 61	126 107 90	126 120 108		109 86 72	115 93 79	121 97 85	4 receivers tested, of different types, at 2 frequencies
		30-300	30			39	67	108		36	51	66	1 receiver tested
			50			62	84	102		48	75	84	1 receiver tested
			300		> 100	> 100	> 100		92	> 100	> 100		1 receiver tested
	Mobile	0.03-0.6	10		102	112	127			77	109 89	114	1 receiver tested
		0.03-30	10										2 receivers tested
		30-300	50				100						2 receivers tested
			1000								100 *		

* Output level 40 db below the standard value.

TABLE V/1 (cont.)

Class of emission	Service	Frequency range (Mc/s)	Signal separation $F_d - F_n$ (kc/s)		Blocking Level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Cross-modulation Level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Remarks
					+20	+40	+60	+80	+20	+40	+60	+80	
(1)	(2)	(3)	(4)	(5)	(6)				(7)				(8)
A3b	Fixed	1.6-30	10	Max. Mean Min.	72 70 69	90 89 86	110 105 104	110 105 100	76 72 64	92 87 84	105 101 97	115 105 96	3 receivers tested (measured at 3 frequencies)
		1.6-30	10	Max. Mean Min.	78 70 62	103 90 77	118 110 102	116 111 105	91 74 60	94 84 75	106 101 93	110 102 95	23 receivers tested (4 different types, measured at 4 frequencies)
		1.6-30	18	Max. Mean Min.	94 88 68	105 99 79	113 107 95	120 113 108	73 64 53	84 76 66	89 82 74	94 82 72	7 receivers tested
		1.6-30	36	Max. Mean Min.	107 99 82	114 106 91	120 112 108	120 116 111	86 78 67	94 87 83	95 86 74	96 86 74	
		2.5 *	10	Mean	88		117	115	68		99	102	
		4-28	20	Max. Mean Min.					100 90 80	108 100 95			

* Measurements made at the single frequency shown.

TABLE V/2

Multiple-signal selectivity of radiotelephony receivers

Class of emission	Service	Frequency range (Mc/s)	F_d (Mc/s)		Intermodulation																			Remarks	
					Level of undesired signals (db relative to 1 μ V) for the levels of the desired signal given below																				
					$F_n' \pm F_n'' = F_{if}$ cf. para. 6.4.1 and 6.4.2					$F_n' \pm F_n'' = F_d$ cf. para. 6.4.3 and 6.4.4					$F_n' + F_n'' = F_{im}$ cf. para. 6.4.5					$2F_n' - F_n'' = F_d$ cf. para. 6.4.6					
					a^*	20	40	60	80	b^*	20	40	60	80	c^*	20	40	60	80	d^*	20	40	60		80
(1)	(2)	(3)	(4)	(5)	(6)																			(7)	
A3	Fixed	1-6-30	10	Max.	(-)	91	> 104	> 104	> 104	(-)	84	93	99	103										4 receivers tested	
				Mean	0.5	84	> 94	> 101	> 100	15.1	80	86	95	101											
			Min.		79	81	90	87		79	81	93	97												
			Max.						(+)	96	96	> 104	> 104												
	Mean						11.0	85	91	> 100	> 103														
	Min.							84	83	> 99	> 99														
	General purpose	0-03-30	10	Max.	(-)	100				(-)	90													Receivers of different types	
				Mean		85					77														
			Min.		63					65															
			Max.						(+)	100															
		Mean							93																
		Min.							80																
30-300		30		(-)	82				(-)	84															
									(+)	90															
	50		(-)	90				(-)	81																
								(+)	96																

* In these columns, the values inserted are those for the frequencies given by the following:

(a) for (+): $(F_n' + F_d)$; for (-): $(F_n' - F_d)$; (b) for (+): $(F_n' + \frac{1}{2}F_d)$; for (-): $(F_n' - \frac{1}{2}F_d)$; (c) $(F_n' - \frac{1}{2}F_{im})$; (d) $(F_n' - F_d)$.

TABLE V/2 (cont.)

Class of emission	Service	Frequency range (Mc/s)	F _d Mc/s		Intermodulation																				Remarks
					Level of undesired signals (db relative to 1 μV) for the levels of the desired signal given below																				
					F _{n'} ± F _{n''} = F _{if} cf. para. 6.4.1 and 6.4.2					F _{n'} ± F _{n''} = F _d cf. para. 6.4.3 and 6.4.4					F _{n'} + F _{n''} = F _{im} cf. para. 6.4.5					2F _{n'} - F _{n''} = F _d cf. para. 6.4.6					
a *	20	40	60	80	b *	20	40	60	80	c *	20	40	60	80	d *	20	40	60	80						
(1)	(2)	(3)	(4)	(5)	(6)																				(7)
A3b	Fixed	1-6-30	10	Max. Mean Min.	(-)	> 94 > 92 89					(-)	94 90 88												23 receivers tested	
				Max. Mean Min.						(+)	> 96 > 94 > 94														
				Max. Mean Min.	(-)	106 95 75					(-)	109 93 90													
				Max. Mean Min.							(+)	103 93 88													
				Max. Mean Min.	0.5 (-)	> 104 > 90 68	> 104 > 98 79	> 104 > 102 92	> 104 > 103 98	15.1 (-)	80 73 69	90 83 79	99 92 88	> 104 > 100 96											
				Max. Mean Min.						11 (+)	91 89 77	101 94 90	> 104 > 102 94	> 104 > 104 > 104											
F3	Fixed	30-300	160		(-)	> 94					(+) (+)	> 94 > 94											1 receiver tested		
	Mobile	30-300	77.4		(-)	96					(-) (-)	87 81													

* In these columns, the values inserted are those for the frequencies given by the following:

a) for (+): ($F_{n'} + F_d$); for (-): ($F_{n'} - F_d$); (b) for (+): ($F_{n'} + \frac{1}{2}F_d$); for (-): ($F_{n'} - \frac{1}{2}F_d$); (c) ($F_{n'} - \frac{1}{2}F_{im}$); (d) ($F_{n'} - F_d$).

TABLE VI/1

Two-signal selectivity of sound broadcast-receivers

Class of emission	Service	Frequency range (Mc/s)	Signal separation $F_d - F_n$ (kc/s)		Blocking level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Cross-modulation level of undesired signal (db rel. to 1 μ V) for level of desired signal (db rel. to 1 μ V) of:				Remarks
					+20	+40	+60	+80	+20	+40	+60	+80	
(1)	(2)	(3)	(4)	(5)	(6)				(7)				(8)
A3	Sound broadcasting	0.5-1.6	10	Max.		72	88	107		61	85	115	3 receivers tested
				Mean		67	86	104		55	79	101	
				Min.		64	86	102		50	73	93	
		0.5-30	10	Max.		79	96	114		76	99	115	3 receivers tested of different types at 3 frequencies; output signal-to-noise ratio 20 db
				Mean		64	83	102		68	86	104	
				Min.		50	68	85		54	72	94	
F3	Sound broadcasting	0.5-1.6	20						94		114		Ordinary broadcast receiver *
			20						109		124		"Narrow" bandwidth } High-qual. b'cast rec.
			20						102		124		
		30-300	300						46	65	80	90	Several receivers tested
		30-300	300						40	52	60	80	Several receivers tested; output level of undesired signal 40 db below level of desired signal
		88-100	300					37					Ordinary broadcast receiver
		88-100	300					43					High quality broadcast receiver

* Output level of undesired signal 30 db less than level of desired signal.

TABLE VI/2

Multiple signal selectivity of sound-broadcast receivers

Class of emission	Service	Frequency range (Mc/s)	F_d Mc/s		Intermodulation																		Remarks		
					Level of undesired signals (db relative to 1 μ V) for the levels of the desired signal given below																				
					$F_n' \pm F_n'' = F_{if}$ 6.4.2 cf. para. 6.4.1 and 2					$F_n' \pm F_n'' = F_d$ 6.4.4 cf. para. 6.4.3 and 4					$F_n' + F_n'' = F_{im}$ cf. para. 6.4.5					$2F_n' - F_n'' = F_d$ cf. para. 6.4.6					
					a^*	20	40	60	80	b^*	20	40	60	80	c^*	20	40	60	80	d^*	20	40		60	80
(1)	(2)	(3)	(4)	(5)	(6)																		(7)		
A3	Sound broadcast- ing	0.5-1.6	1	Max.	(-)	> 90					(-)	> 90												7 receivers tested	
				Mean		78					72														
		Min.		58					53																
		Max.						(+)	> 90																
Mean							76																		
Min.							61																		
0.5-30	1	Max.	(-)	90					(-)	78													3 receivers tested		
		Mean		70					70																
Min.		51							63																
Max.					(+)	90				90															
Mean						82				82															
Min.						70				70															

* In these columns, the values inserted are those for the frequencies given by the following:

(a) for (+): $(F_n' + F_d)$; for (-): $(F_n' - F_d)$; (b) for (+): $(F_n' + \frac{1}{2}F_d)$; for (-): $(F_n' - \frac{1}{2}F_d)$; (c) $(F_n' - \frac{1}{2}F_{im})$; (d) $(F_n' - F_d)$.

ANNEX II

TABLE VII

Single-signal selectivity of television receivers

Class of emission	Frequency range (Mc/s)		Attenuation in decibels, relative to maximum response, at the frequency shown below in (Mc/s,) relative to vision carrier frequency *															Remarks	
			-7	-6.5	-6	-5.5	-5	-4.5	-4	-3.5	-3	-2.5	-2	-1	0	+0.5	+1		+1.5
(1)	(3)	(5)	(6)															(10)	
(a) 405-line system																			
A5 (vision)	30-100	Max. Mean Min.					>60 >60 40	>60 >60 18	>60 >60 32	>54 40 36	20 15 10	5 3 1	1 0 0	0 0 0	9 6 4	27 23 20	46 41 37		4 receivers tested
	30-300	Max. Mean Min.					>50 >40 26	>50 >40 26	>50 >37 25	>60 >50 45	46 24 6	24 9 1	6 2 0	2 1 0	6 4 0	18 13 6	40 30 17		5 receivers tested
		Max. Mean Min.					42 37 35	36 29 25	35 28 25	>50 >50 >50	29 20 8	13 8 1	4 1 0	4 2 0	2 2 0	15 10 6	23 21 17		3 receivers tested
		56.75					41	29	26	58		2	0	0	3	14	20	48	
	A3 (sound)	53.25					43	25	14	0		28	33.5	42	42	48	50	>52	
(b) 625-line system																			
			Adjacent vision carrier		Sound carrier				Vision carrier				Adjacent sound carrier						
A5 (vision)	100-300	Max. Mean Min.	58 43 33	38 31 27	36 25 12	40 23 15	12 7.7 5		5 1.2 0		3 0.7 0		1.4 0.7 0	2.5 0.9 0	6	21 14 10		45 40 32	4 receivers (of different types) tested
	30-300	Mean	40	23	26	28	16		0.5		0		0	1.5	7.5	16		28	20 receivers tested, each on 5 channels (figs. taken from a curve)
		Mean	+37			+24	+14		-1	-3		-4	-4	-4	0	+7	+17	+22	

* In the case of the 625-line system, the sign of the frequency difference must be changed, since the vision carrier is lower in frequency than its accompanying sound carrier.



ANNEX III

TABLE VIII

Two-signal F.M. (F3) broadcast receiver selectivity

Service	Frequency of desired signal (Mc/s)	Input level of desired signal (db(mW))	Undesired-to-desired signal input ratio (db) for a desired-to-undesired output ratio of 30 db with frequency separations (kc/s) of								Remarks <i>All new receivers and not realigned before test</i>	
			0	± 100		± 200		± 300		± 400		
(1)	(2)	(3)	(4)	(5)		(6)		(7)		(8)		(9)
				− 100	+ 100	− 200	+ 200	− 300	+ 300	− 400	+ 400	
F3	94	−80 −60 −40		− 10 − 11.5 − 10	− 9.5 − 5.5 − 11	+ 1 − 9.5 − 9.5	− 9.5 + 4 − 8.5	+ 15.5 − 4.5 − 6	− 5.5 + 16.5 + 2.5	+ 26 + 4.5 − 1	+ 5 + 27 + 20	1 r.f. 2 i.f. ratio detector
	94	−80 −60 −40		− 5 − 6 + 0.5	− 10 − 13 − 1	− 1.5 − 0.5 + 4	− 9.5 − 13 + 0.5	+ 4.5 + 6 + 8	− 7.5 − 14 + 2	+ 12 + 13 + 15	− 4 − 10 + 6	1 r.f. 2 i.f. ratio detector
	92	−80 −60 −40		+ 2.5 − 10.5 − 12	+ 1 − 8 − 10	+ 3.5 − 7 − 7.5	+ 12 + 0.5 − 4	+ 14 + 2.5 − 0.5	+ 24 + 13 + 4.5	+ 32.5 + 14 + 8	+ 36 + 27.5 + 7.5	1 r.f. 2 i.f. ratio detector
	94	−80 −60 −40		− 10.5 − 10.5 − 11.5	− 6.5 − 6.5 − 11	+ 1 0 + 4.5	+ 4 + 3 − 6	+ 35 + 25 −	+ 36 + 21.5 + 11	+ 44 + 33 −	+ 48 + 33 −	3 i.f. ratio detectors. Battery operated
	94	−80 −60 −40		0 − 13.5 − 13.5	− 8 − 1.5 − 11	− 3 − 14.5 − 13	+ 6 + 6 + 0.5	− 3.5 − 10.5 − 12.5	+ 20 + 16 + 14	+ 11 + 5.5 + 2.5	+ 32 + 24.5 −	1 r.f. 1 i.f. 1 limiter. Foster Seeley Discriminator
	92	−80 −60 −40		− 3 − 3 − 10	− 4 − 3.5 − 10	− 2.5 − 1.5 + 0.5	+ 3 + 4 − 8	+ 5.5 + 3.5 − 17.5	+ 13 + 15 − 5.5	+ 13 + 13 − 15	+ 24 + 22.5 + 1	1 r.f. 2 i.f. ratio detector
	94	−80 −60 −40		− 7 − 6.5 − 17.5	− 6.5 − 5.5 − 20.5	+ 7.5 + 10 − 4	− 5 − 10 − 21.5	+ 25 + 27.5 + 12.5	+ 9 − 2 − 15	+ 40 −	+ 23 + 15.5 + 2.5	1 r.f. 3 i.f. ratio detector
	92	−80 −60 −40		− 7.5 + 1.5 − 7.5	− 5.5 − 7.5 − 11	− 7 − 3.5 + 2	+ 0.5 − 2 − 6.5	+ 1 + 5 −	+ 8.5 + 5.5 − 11	+ 16 + 19.5 −	+ 18 + 15 − 3.5	1 r.f. 2 i.f. ratio detector
	94	−80 −60 −40	−13 −12 −16	− 9.5 − 3.5 − 8	− 6 − 9.5 − 13.5	0 + 20 + 15	+ 10.5 + 1.5 − 10	+ 24.5 + 33 −	+ 32 + 18 + 9	+ 45.5 −	+ 48 −	3 i.f. ratio detector. Battery operated

ANNEX IV

TABLE IX

Group-delay characteristics of radiotelegraphy receivers

Classification *	Passband (c/s)	Attenuation slope (db/100 c/s)		Group-delay time at centre frequency f_0 (20 kc/s) (ms)	Maximum deviation of group-delay time within the specified bandwidths by attenuations of 3,6 and 12 db. The value at f_0 is taken as a reference (ms)						Remarks
					3 db		6 db		12 db		
		26 db	46 db		+	—	+	—	+	—	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1-A	570	7.9	10.3	1.9	0.2	0	0.3	0	0.4	0	Designed for shift width of 400 c/s
2-A	570	8.7	10.5	1.9	0.1	0	0.1	0.1	0.1	0.3	
3-A	656	8.4	11.4	1.8	0.2	0.2	0.2	0.2	0.3	0.2	
4-B	700	18.8	23.0	2.0	2.1	0.1	2.3	0.1			
5-B	700	18.8	23.0	2.3	2.0	0.1	2.0	0.1			
6-A	1070	4.0	4.9	1.2	0	0.3	0	0.5	0	0.5	Designed for shift width of 800 c/s
7-A	1060	4.2	5.4	1.2	0.1	0	0	0.1	0	0.2	
8-A	1092	3.5	5.1	1.2	0.1	0.2	0.1	0.2	0.1	0.2	
9-B	1560	12.2	8.4	0.9	1.3	0.1	1.7	0.1			
10-B	1500	12.2	8.4	1.0	1.2	0.1	1.2	0.1			

* In the receivers classified A, the filters used were designed to have flat group-delay/frequency characteristics, whereas for B, they were designed by conventional methods.

RECOMMENDATION No. 236 *

FREQUENCY STABILITY OF RECEIVERS

The C.C.I.R.,

(London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that, in practice, the pass-band of receivers (§ 1 of Recommendation No. 230) is often increased beyond that essential for the transmission of the modulation of the desired signal without significant distortion;
- (b) that the reasons for this increase in the pass-band width, in the most usual order of importance, are:
 - frequency instability of the receiver frequency-change oscillators,
 - inaccuracies in resetting these oscillators to a desired frequency,
 - instability of the receiver filters,
 - instability of the frequency of received signals;
- (c) that, to achieve the greatest economy in the use of the radio spectrum, it is desirable to keep to a minimum the increase of pass-band necessitated by the foregoing causes;

UNANIMOUSLY RECOMMENDS

1. that, in cases where economic considerations prevent the use of more effective frequency stabilizing devices, e.g. in some general-purpose communication receivers and broadcast receivers, attention should, as far as possible, be given to:
 - the stability of the inductors and capacitors against temperature variations and mechanical shock,
 - the stability of the oscillator circuit,
 - the use of temperature-compensating components (e.g. negative temperature-coefficient capacitors),
 - the protection of the frequency-controlling components from the effects of humidity (e.g., by means of protective coatings),
 - the protection of the frequency-controlling components against excessive temperature rise by adequate natural ventilation and suitable positioning of the components,
 - the reduction of the thermal time-constant in the case of receivers that are frequently switched on and off;
2. that, in cases where operation over a frequency band is required with a better degree of stability than that afforded by the methods referred to in § 1 (e.g., in good quality communication receivers), consideration may be given to the use of variable-frequency oscillators contained in constant-temperature compartments, hermetically sealed to avoid frequency instability which would be caused by changes of humidity or by chemical action of the atmosphere;
3. that, in cases where a still better degree of stability is required, it is advantageous to age the frequency-controlling components (especially inductors and capacitors) by subjecting them to repeated temperature cycles;
4. that, in cases where operation over a frequency band with a high degree of stability is required, it is desirable to consider frequency-synthesis methods (e.g., methods whereby the frequency-change oscillation is derived from the combination of two frequencies, one being a harmonic

* This Recommendation replaces Recommendation No. 156.

of a quartz-crystal oscillator and the other being a variable frequency (interpolating) oscillator of limited range); noting, however, that special care may have to be taken to avoid undesired responses in the receiver from unwanted frequency components present with the frequency-change oscillations;

5. that, where fixed-frequency operation (with its resulting simplicity) is required together with the highest degree of stability (i.e. for high-grade communication services), high stability frequency-controlling components such as quartz crystals should be employed using, if necessary, the constant-temperature hermetically-sealed compartments referred to in § 2;
6. that, to minimize the effect of other circuits on the stability of the oscillator, it is desirable to use a separate valve for the oscillator rather than a dual-purpose valve;
7. that, to obtain the highest frequency stability from the frequency-change oscillator, it is desirable that the HT and heater supplies to this valve should be stabilized separately;
8. that, where the instability of the frequency-change oscillator would otherwise be such as to require an appreciable percentage increase in the width of the receiver pass-band, automatic frequency control is desirable to reduce the frequency variation of the intermediate-frequency signal to a sufficiently small fraction of the width of the pass-band;
9. that, where a high degree of synchronization is required (e.g., systems employing a partially suppressed pilot-carrier), it is desirable to use a more accurate automatic frequency control capable of correcting the frequency of a local oscillator in the receiver so that the intermediate-frequency carrier is within a few cycles per second of the frequency of another oscillator used to demodulate the signal;
10. that, particularly in single-sideband receivers where sudden jumps of the oscillator frequency can cause failure of the automatic frequency control, it is desirable to prevent such jumps. These jumps may be due to creeping of an inductor winding relative to its supporting former, and it is therefore desirable to take such steps as, for example, to use rigid self-supporting coils or windings consisting of metal deposited on a ceramic former;
11. that consideration be given to reducing to a minimum the frequency instability, caused by changes of humidity and temperature, of the receiver filters (electrical or mechanical) by applying methods similar to those referred to in § 1 and 2, by the use of high-stability components such as quartz crystal resonators where technical and economic considerations permit, and of various methods existing at the present time, such as those mentioned in Tables VI and VII of the Annex.
12. that, to reduce to a minimum frequency variations due to mechanical shock and vibration, due attention should be paid to the mechanical design of the receiver oscillators and filters and, in the case of variable-frequency oscillators, to the resetting accuracy of the variable capacitors or inductors and the frequency-range changeover switches employed;
13. that, because in multiband receivers the frequency-range changeover switches associated with the oscillating circuits often introduce frequency instability, it is desirable to avoid the use of such switches by employing a single-range oscillator followed by frequency multiplying circuits.

Note. — The Annex gives the typical stability values obtained for various types of receivers in certain countries, based on data given in Recommendation No. 96, together with additional information contained in Docs. Nos. 3 (Federal Republic of Germany), 119 (Czechoslovakia), 158 (United Kingdom), 159 (United Kingdom), 160 (United Kingdom), 394 (France), 398 (Italy) of Warsaw 1956, in Docs. Nos. II/2 (Federal Republic of Germany), II/6 (Italy), II/24 (United Kingdom) and II/31 (Czechoslovakia) of Geneva 1958, and in Doc. No. 122 (U.S.S.R.) of Los Angeles 1959. The assembly of this information constitutes a partial reply to Question No. 173 (II).

ANNEX

1. *General*

In the following tables an attempt has been made to present in a systematic way representative data for the frequency instability (generally of the frequency-change oscillators) for various classes of receiver. In order to facilitate the use of these data and at the same time to reduce the amount of data presented, only three figures have been given for each characteristic for a number of similar receivers in each class:

- a “ minimum ” value corresponding to the lowest value obtained during the measurements;
- a “ mean ” value, corresponding to the arithmetical mean of the values obtained during the measurements;
- a “ maximum ” value, corresponding to the highest value obtained during the measurements (it might be possible to lower this maximum value should subsequent results reveal a systematic improvement).

It should be noted, however, that in some instances, because of the small number of receivers tested (as indicated in the Remarks column) the figures for the mean value have no precise statistical significance.

Only limited data are available for certain classes of receiver, particularly television receivers and other receivers for frequencies above about 30 Mc/s approximately.

The following general conclusions may be drawn from the data so far obtained:

- 1.1 there is a very wide variation in the figures obtained, even for the same type of receiver;
- 1.2 most receivers reach their working temperature within one hour after switching on, although the use of a thermostatically controlled compartment may prolong the period needed for warming-up.

Tables I to V show representative data for various classes of traffic receiver and other receivers in current use;

Tables VI and VII contain instability values for specially high-grade receivers;

Table VI . — Receivers with compensating capacitors;

Table VII. — Receivers using combined systems (automatic correction or crystal controlled first oscillator);

- 1.3 little information is available on the instability due to a 20% mains voltage variation or to wide ranges of temperature variation.

2. *Notes on the Tables*

Column No.

- (1) The suffix (L) signifies that the information was extracted from the documents of London (1953); (W) that it was extracted from the documents of Warsaw (1956). Where the information is a combination of that from both sources, the suffix (L W) is used.
- (2) (3) The class of emission and type of service are quoted in accordance with Annex I of Recommendation No. 234.
- (4) The frequency range quoted is that covering the data given in the appropriate documents but does not in all cases correspond to the preferred ranges quoted in Annex I of Recommendation No. 234.
- (5) This column indicates the type of frequency-change oscillator(s) used in the receiver, e.g. LC-controlled, quartz crystal controlled, frequency synthesizer, double frequency changer, etc., In many cases, sufficient information regarding this point was not available.
- (6) See § 1 of this Annex.
- (7) Relative frequency-drift during the warming-up period is indicated, without regard to sign, at 1, 10, 30, 60 and 120 minutes after switching on, the value at 60 minutes

being used as the reference datum. These figures are given as being of the greatest importance when considering permissible channel spacings. A knowledge of the sign of the drift would be of interest to the designers of receivers since a change of sign during the warming-up period would indicate some measure of self-compensation in the receiver, different parts of the receiver having different thermal time-constants. The inclusion of this information would, however, make the Table too complicated and is considered unnecessary for the purposes of the C.C.I.R.

- (8) The relative frequency variation is the largest of the variations obtained when the power supply voltage varies:
 - $\pm 10\%$ for AC mains supply
 - $\pm 20\%$ for battery supply
- (9) The relative frequency variation is:
 - either that due to 1°C variation near the normal ambient temperature, especially where thermostatic control is used,
 - or that due to variations of temperature over the range shown in the tables.
- (10) The relative frequency variation indicated resulting from light mechanical shock, e.g. due to striking the front of the receiver lightly with the hand. In certain cases, e.g., mobile service receivers, more comprehensive vibration and shock tests are desirable.
- (11) This column contains information on the number of receivers used for the determination of the representative values for the frequency drift and variation including, when possible, some indication on the spread of the data; information on the vibration and shock tests referred to under Column (10) above is also to be included in this column.

TABLE I
Radiotelegraphy receivers

Ref.	Class of emission	Service	Frequency range (Mc/s)	Crystal-controlled frequency changer used		Relative frequency drift ($\times 10^{-6}$) at the following times (in minutes) after switching on					Relative frequency variation ($\times 10^{-6}$) due to supply voltage variation of:		Relative frequency variation ($\times 10^{-6}$) due to temperature variation of:		Relative frequency variation ($\times 10^{-6}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1(L)	A1 } A2 }	Fixed	1.6-30	No	Max. Mean Min.		33 17 3	20 9 0	0 0 0	8 4 1	10		17 7 0			Col. (7): 6 receivers tested Col. (8): 1 receiver tested Col. (9): 7 receivers tested
2(W)	A1 A2 F1	Fixed and mobile	1.5-28	No	Mean	{ 125 109 190	105 42 42	50 26 26	0 0 0	35 4 5	10 1.3 0.8		11 6.4 1.3			$f_{osc} = 2$ Mc/s $f_{osc} = 16$ Mc/s $f_{osc} = 27$ Mc/s
3(W)	A1 A2 F1	Fixed	3-30	Yes *	Mean	{ 323 122 17	237 66 6	186 19 2	0 0 0	42 13 1	2.9 1.3 3.2					$f_{osc} = 7$ Mc/s $f_{osc} = 16$ Mc/s $f_{osc} = 24$ Mc/s
4(W)	A1 A2 A3 F1	Fixed	2-30	Yes	Max. Mean Min.			110 50 20	0 0 0				2 1 0.4			Several receivers tested
5(L)	A2	Mobile	100-1000	No	Max. Mean Min.						4 3.3 2.6		1.7 1.1 0.4			1 receiver tested

* Frequency synthesis employed.

TABLE II
Radiotelephony receivers

Ref.	Class of emission	Service	Frequency range (Mc/s)	Crystal-controlled frequency-changer used		Relative frequency drift ($\times 10^{-6}$) at the following times (in minutes) after switching on					Relative frequency variation ($\times 10^{-6}$) due to supply voltage variation of:		Relative frequency variation ($\times 10^{-6}$) due to temperature variation of:		Relative frequency variation ($\times 10^{-6}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1(L)	A3	Fixed	1.6-30	No	Max. Mean Min.		33 17 3	20 9 0	0 0 0	8 4 1	<10		17 7 0			Col. (7): 6 receivers tested Col. (8): 1 receiver tested Col. (9): 7 receivers tested
2(LW)	A3b	Fixed	1.6-30	No	Max. Mean Min.		468 184 10.2	176 84 2.1	0 0 0	95 43 12.9	36 1.5		5.5		10 0	Col. (7): 23 receivers tested Cols. (8), (9) and (10): Only a few receivers tested
3(W)	A3b	Fixed	18.4	No	Mean		34	16	0		127				12	Adjustable temperature compensating capacitor used
4(W)	A3 A3b	Fixed	4-28	Yes	Max. Mean Min.						1 0.5 0.2		7 5 3			Several receivers tested
5(W)	F3	Fixed	41-68	No	Max. Mean Min.	640	185	16	0		10 *		13 10 5.5			24 channel radio-relay link receivers. Only a few receivers tested.
6(W)	F3	Fixed	185	No	Mean		5	21	0	21	320				1	Multi-channel receiver, AFC on Osc. 1 with thermostatic control of discrim. Crystal Osc. 2 I.F. bandwidth 200 kc/s
7(W)	F3	Fixed	163.5	Yes	Mean		19	11	0		3.6				3.5	I.F. bandwidth 35 kc/s
8(W)	A3 F3	Mobile	70-200	Yes	Max. Mean Min.	8.5	5.5	2	0	0.9	150 17 1.8	4	0.8 0.5	50 } 0°C to 10 } 60°	<1	Only a few receivers tested
9(L)	A3	Mobile	100-1000	No	Max. Mean Min.						4 3.3 2.6		1.7 1.1 0.4			1 receiver tested

* For 5% supply voltage variation.

TABLE III
General purpose receivers

Ref.	Class of emission	Service	Frequency range (Mc/s)	Crystal-controlled frequency-changer used		Relative frequency drift- ($\times 10^{-6}$) at the following times (in minutes) after switching on					Relative frequency variation ($\times 10^{-6}$) due to supply voltage variation of:		Relative frequency variation ($\times 10^{-6}$) due to temperature variation of:		Relative frequency variation ($\times 10^{-6}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1(LW)	A1 A2 A3	General purpose	1.6-30	No	Max. Mean Min.		390 180 4	223 85 2	0 0 0		176 52 6.5				140 26 1	13 receivers tested
2(LW)	A1 A2 A3	General purpose	1.6-30	Yes	Max. Mean Min.		235 124 5	130 41 1	0 0 0	86 20 1	0.6		3 2 1.5		<1 <1 <1	11 receivers tested
3(LW)	A1 A2 A3 F3	General purpose	100	No	Max. Mean Min.		135 47	39 35	0 0		10	114 3.6			14 3.5	

TABLE IV
Sound-broadcast receivers

Ref.	Class of emission	Service	Frequency range (Mc/s)	Crystal-controlled frequency-changer used		Relative frequency drift ($\times 10^{-6}$) at the following times (in minutes) after switching on					Relative frequency variation ($\times 10^{-6}$) due to supply voltage variation of:		Relative frequency variation ($\times 10^{-6}$) due to temperature variation of:		Relative frequency variation ($\times 10^{-6}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1(LW)	A3	Sound broadcast	0.5-1.6	No	Max. Mean Min.	1000 700 60	830 263 7	470 115 0	0 0 0	234 91 0	1100 107 30				150 38 0	Col. (7): 52 receivers tested Col. (8): 48 receivers tested Col. (10): 6 receivers tested
2(LW)	A3	Sound broadcast	1.6-30	No	Max. Mean Min.		770 241 20	320 118 3	0 0 0	575 159 57	475 89 0.6				142 30 0	Col. (7): 17 receivers tested Col. (8): 13 receivers tested Col. (10): 15 receivers tested
3(LW)	A3 F3	Sound broadcast	30-100	No	Max. Mean Min.	857 250 26	958 226 0	335 33 0	0 0 0	150 50 0	403 130 1					Col. (7): 25 receivers tested Col. (8): 32 receivers tested



TABLE V
Television receivers

Ref.	Class of emission	Service	Frequency range (Mc/s)	Crystal-controlled frequency-changer used		Relative frequency drift ($\times 10^{-9}$) at the following times (in minutes) after switching on					Relative frequency variation ($\times 10^{-9}$) due to supply voltage variation of:		Relative frequency variation ($\times 10^{-9}$) due to temperature variation of:		Relative frequency variation ($\times 10^{-9}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1(LW)	A5 F3	Television	100-300	No	Max. Mean Min.	2200 555 200	360 180 80	300 113 0	0 0 0	660 300 0	1000 600 200		12 *		350 *	Only a few receivers tested

* Approximate values.

TABLE VI
General purpose high stability receiver with compensating capacitor

Ref.	Class of emission	Service	Frequency range (Mc/s)	Crystal-controlled frequency-changer used		Relative frequency drift ($\times 10^{-9}$) at the following times (in minutes) after switching on					Relative frequency variation ($\times 10^{-9}$) due to supply voltage variation of 10%	Relative frequency variation ($\times 10^{-9}$) due to temperature variation:	Relative frequency variation ($\times 10^{-9}$) due to mechanical shock	Remarks
						1	10	30	60	120		1°C for range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)	(9)	(10)	(11)
1	A1	General purpose	24-184	No	Max.	100	83	45	0	30	24	11	4 receivers tested	
	70					50	30	0	20	16	5.5			
	15					12	7	0	6	7	1.5			
	F1													
	F3				Min.									

TABLE VII
High stability traffic receivers using combined systems

Ref.	Class of emission	Service	Frequency range	Type of frequency changer used		Relative frequency drift ($\times 10^{-6}$) at the end of the following times in hours			Relative frequency variation ($\times 10^{-6}$) due to supply voltage variation of 10%		Relative frequency variation ($\times 10^{-6}$) due to mechanical shock
						1	6	12			
(1)	(2)	(3)	(4)	(5)	(6)	(7)			(8)	(9)	(10)
1		General purpose	Tested at 20 Mc/s	Automatic correction		25.3 *			1.8		3.5
2		General purpose	Tested at 20 Mc/s	Automatic correction					1.8		3
3		General purpose	Tested at 20 Mc/s	1st ** crystal oscillator		11 ***			<0.3		
4		General purpose	Tested at 20 Mc/s	1st ** crystal oscillator		24 *			0.3		0.9

* Measurement started 5 minutes after switching on.

** Double frequency-change receiver: first frequency change by very stable crystal controlled oscillator; second frequency change on a much lower frequency (see Doc. No. II/24, Geneva, 1958).

*** Measurement started 60 minutes after switching on (including thermostat).

RECOMMENDATION No. 237 *

**SENSITIVITY, SELECTIVITY AND STABILITY OF AMPLITUDE
MODULATION AND FREQUENCY-MODULATION SOUND-BROADCAST
RECEIVERS**

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that Recommendation No. 234 gives general recommendations on receiver sensitivity;
- (b) that Recommendation No. 235 gives general recommendations on receiver selectivity;
- (c) that Recommendation No. 236 gives general recommendations on receiver stability;
- (d) that Publications 69 and 91 of the I.E.C. give definitions concerning the sensitivity, selectivity and stability of amplitude-modulation and frequency-modulation sound-broadcasting receivers and the methods of measuring these properties;
- (e) that the I.E.C. is contemplating periodical revision of these definitions and measurement methods:

UNANIMOUSLY RECOMMENDS

- 1. that, for measuring the sensitivity, selectivity and stability of amplitude modulation and frequency-modulation sound-broadcasting receivers, the C.C.I.R. shall provisionally adopt the definitions and measurement methods contained in I.E.C. Publications 69 and 91 **;
- 2. that, to the same end, the amendments that the I.E.C. might make to these definitions and measurement methods from time to time be used as a guide by the C.C.I.R.

RECOMMENDATION No. 238 ***

**SENSITIVITY, SELECTIVITY AND STABILITY OF TELEVISION
RECEIVERS**

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that Recommendation No. 234 gives general recommendations on receiver sensitivity;
- (b) that Recommendation No. 235 gives general recommendations on receiver selectivity;
- (c) that Recommendation No. 236 gives general recommendations on receiver stability;
- (d) that the I.E.C. has circulated, for final approval, a document giving definitions of the sensitivity, selectivity and stability of television receivers and methods of measuring these properties;
- (e) that the I.E.C. is contemplating periodical revision of these definitions and measurement methods;

* This Recommendation in conjunction with Recommendation No. 238 replaces Recommendations Nos. 157 and 158.

** Available at the Central Office of the I.E.C. in Geneva.

*** This Recommendation in conjunction with Recommendation No. 237 replaces Recommendations Nos. 157 and 158.

UNANIMOUSLY RECOMMENDS

1. that, for measuring the sensitivity, selectivity and stability of television receivers, the definitions and measurement methods contained in Publication No. 107 of the I.E.C.*, be used as a guide by the C.C.I.R.;
2. that, to the same end, the amendments that the I.E.C. might make to these definitions and measurement methods from time to time be used as a guide by the C.C.I.R.



RECOMMENDATION No. 239 **

SPURIOUS EMISSIONS FROM BROADCAST AND TELEVISION RECEIVERS

(Question No. 176 (II))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that many receivers produce undesired emissions, due e.g. to local oscillators or to IF radiation and, in the case of television receivers, to time-base circuits;
- (b) that these radiations may emanate from the aerial circuits, the mains supply leads or the receiver chassis and may interfere with many services;
- (c) that considerable progress has been made in national methods of measurement and techniques of reducing undesired emissions, both of which are particularly useful in the design of receivers (see Docs. Nos. 181, 302 and 449 of Warsaw);
- (d) that considerable data concerning these radiations have been obtained recently;
- (e) that limiting values for such undesired emissions have been established, based on different methods, by several Administrations;
- (f) that international standardization of measuring methods and limiting values is very desirable;
- (g) that the I.E.C. has published a work *** on the methods of measuring spurious emissions from broadcast and television receivers up to 300 Mc/s, while an extension of the band up to 1000 Mc/s is being studied;
- (h) that the C.I.S.P.R. is studying the level of emissions from such receivers with a view to establishing tolerable limits;

UNANIMOUSLY RECOMMENDS

1. that the C.C.I.R. be guided by the methods established by the I.E.C. for all types of broadcast and television receivers;
2. that the C.C.I.R. confirm to the C.I.S.P.R. its interest in knowing the level of emissions from receivers and ask to be kept informed of the progress in establishing tolerable limits for such emissions;
3. that all possible means compatible with economy should be employed in the construction of receivers to reduce such undesired emissions.

* Available at the Central Office of the I.E.C. in Geneva.

** This Recommendation replaces Recommendation No. 160.

*** Publication No. 106 of the I.E.C.

ANNEX

A considerable amount of data has been produced by different administrations, as representative of the radiation figures of frequency-modulation and television receivers manufactured during recent years (see Docs. Nos. 8, 136, 181, 398 and 449 of Warsaw, and 107 of Los Angeles).

However, due to the fact that these data were taken by different methods and that a considerable improvement has recently been achieved in reducing receiver radiations, no data have been included here.

Nevertheless, useful information on "conversion factors" from one method to another and on limits that are now accepted for the various methods have been brought to the attention of the C.C.I.R.* Subjective measurements have confirmed the practical value of the methods mentioned above **.

* J. MEYER DE STADELHOFEN. *Mesures du rayonnement parasite de récepteurs F.M. exécutées en Suisse par un groupe d'experts du sous-comité 12-1 (Radiocommunications — S.C. Mesure) de la C.E.I.* — Bulletin Technique des P.T.T., 1956.

** C. EGIDI. *Confronto di apparecchiature normalizzate per la misura delle irradiazioni parassite* — Eletttronica, 1956.

Section C

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The following Recommendations which have been classified in other sections also concern the Fixed Services:

Rec. No.	Section
168	G
216	E
268 to 306	F
323	J

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RECOMMENDATION No. 40

INTERCONTINENTAL RADIOTELEPHONE SYSTEMS AND USE OF
RADIO LINKS IN INTERNATIONAL TELEPHONE CIRCUITS

(Questions Nos. 29 and 41)

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that radiotelephone systems connecting the various continents at the present time usually employ carrier frequencies under about 30 Mc/s *;
- (b) that the use of such a radio link in a long-distance telephone circuit implies certain special conditions which introduce particular difficulties not encountered when purely metallic connections are used;
- (c) that such a radiotelephone circuit differs from a metallic circuit in the following ways:
 - c.a such a radiotelephone circuit is subject to attenuation variation with the special difficulty of fading;
 - c.b such a radiotelephone circuit suffers from noise caused by atmospherics whose intensity may reach, or even exceed, a value comparable with that of the signal which it is desired to receive;
 - c.c special precautions are necessary in the setting up and maintenance of such a radiotelephone circuit so as to avoid disturbance of the radio receiver by any radio transmitter and especially by its own radio transmitter;
 - c.d so as to maintain the radiotelephone link in the best condition from a point of view of transmission performance, it is necessary to take special measures to ensure that the radio transmitter always operates so far as is possible under conditions of full loading whatever may be the nature and the attenuation of the telephone system connected to the radiotelephone circuit;
 - c.e it is necessary to take measures to avoid or correct abnormal oscillation or crosstalk conditions;
 - c.f although the effectively transmitted frequency band recommended for international landline circuits has been determined by a study of the requirements of the human ear, this band (in the case of a radiotelephone circuit operating at a frequency below 30 Mc/s) may be limited by the necessity of obtaining the maximum number of telephone channels in this part of the radio-frequency spectrum and in order that each telephone channel does not occupy a radio-frequency band larger than necessary;
 - c.g in general, such a radiotelephone circuit is a long distance intercontinental circuit giving telephone service between two extended networks, and this fact is of great importance from two points of view:
 - c.g.a on the one hand, intercontinental conversations, in general, are of great importance to the subscribers and, on the other hand, they are made in languages which are not always their mother tongue so that high quality reception is particularly important;
 - c.g.b the public should not be deprived of a very useful service under the pretext that it does not always satisfy the degree of excellence desirable for long distance communication from the point of view of transmission quality;

* Further reference to "30 Mc/s" in this Recommendation means "about 30 Mc/s".



UNANIMOUSLY RECOMMENDS

1. Circuits above 30 Mc/s.

that between fixed points, telephone communications should be effected wherever possible by means of metallic conductors or radio links using frequencies above 30 Mc/s so as to make the allocation of radio frequencies less difficult, and where this can be realised, the objective should be to attain the transmission performance recommended by the C.C.I.T.T. for international telephone circuits on metallic conductors.

2. Circuits below 30 Mc/s.

- 2.1 that, since it becomes necessary to economize in the use of the frequency spectrum when considering intercontinental circuits which consist mainly of single long-distance radio links operating on frequencies less than 30 Mc/s, it is desirable to use single-sideband transmission to the maximum extent possible, to employ a transmitted band less than the 300 to 3400 c/s recommended by the C.C.I.T.T. for land-line circuits and preferably to reduce the upper frequency to less than 3000 c/s, but not below 2600 c/s except in special circumstances;
- 2.2 that, although it will be necessary to tolerate large variations in noise level on such a radiotelephone circuit, every possible effort should be made to obtain minimum disturbance to the circuit from noise and fading by the use of such techniques as full transmitter modulation, directional antennae and single-sideband operation; with present technical development, it is not yet practicable to recommend either a minimum value for the signal-to-noise ratio or a method of measuring the disturbing noise;
- 2.3 that during the time that such a radiotelephone circuit is connected to an extension circuit equipped with echo suppressors the intensity of disturbing currents should not be sufficient to operate the echo suppressor frequently;
- 2.4 that such a radiotelephone circuit should be provided with a reaction suppressor (voice-operated switching device) so as to avoid singing or echo disturbance on the complete circuit;
- 2.5 that such a radiotelephone circuit should be equipped with automatic gain control so as to compensate automatically, as far as possible, for the phenomenon of fading;
- 2.6 that the terminal equipments of such a radiotelephone circuit should be such that it may be connected, in the same way as any other circuit, with any other type of circuit;
- 2.7 that, where privacy equipment is used, this equipment should not appreciably affect the quality of telephone transmission;
- 2.8 that, when suitable automatic devices are not provided, the circuit should be controlled as often as necessary by an operator in order to ensure optimum adjustment of transmitter loading, received volume and the operating conditions of the reaction suppressor.

Note. — Although the requirements contained in Part 2 of the Recommendation are much less severe than those imposed on international land-line circuits, the ideal remains to attain the same standards of telephone transmission in all cases. In view of this, it is desirable that the telephone systems connected to a radiotelephone circuit should conform to C.C.I.T.T. recommendations referring to the general conditions to be met by international circuits used for land-line telephony especially in respect of equivalent, distortion, noise, echoes and transient phenomena.

Bearing in mind the recommendations contained in Parts 1 and 2 above, it is desirable that in each particular case, administrations and private companies concerned should first reach agreement on how far the standards usually employed for international land-line circuits may be attained in the case considered. If the technique of Part 1 of the recommendation can be used, the objective should be to obtain, as far as possible, the characteristics recommended by the C.C.I.T.T. for international land-line circuits. Otherwise, the administrations and private companies concerned should study the best solution from the point of view of both technique and economy.

RECOMMENDATION No. 74

PRINCIPLES OF THE DEVICES USED FOR ACHIEVING PRIVACY
OF RADIOTELEPHONE CONVERSATIONS

(Question No. 30)

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that the devices referred to are intended for achieving *privacy* rather than *secrecy* of radiotelephone conversations;
- (b) that in the interest of maximum privacy, the details of the systems employed and of their performance should be agreed upon between the administrations and private enterprises concerned;

UNANIMOUSLY RECOMMENDS

1. that the following statement of principles and characteristics of the devices concludes the study of Question No. 30 for radio circuits operating on frequencies less than about 30 Mc/s*.

- 1.1 *Principles of the devices*

Two general types of systems are used for achieving "privacy" or "relative secrecy" of radiotelephone circuits operating on frequencies less than about 30 Mc/s as follows:

- 1.1.1 *For double-sideband systems*

inverter systems with or without wobbling of the carrier (i.e. rapid cyclic variation of the carrier frequency over a few hundred c/s), the speech band being inverted about a fixed frequency;

- 1.1.2 *For single-sideband systems*

band-splitting systems in which the speech band is subdivided into equal frequency bands, the speech components in the sub-bands being interchanged, with or without frequency inversion, and according to a prearranged repetitive sequence, to give "scrambled" speech. The process is reversed at the receiving terminal to reform the speech signals. Accurate synchronization of the switching processes at the two terminals is required;

- 1.2 *Characteristics of the devices*

- 1.2.1 the band-splitting system provides privacy superior to that obtained with the inverter system, but for satisfactory operation it can tolerate less radio distortion than for example, is caused by selective fading on the radio link;
 - 1.2.2 the apparatus is designed to reduce attenuation distortion and the levels of unwanted products of modulation and of carrier signals to a minimum. The extent of the permissible distortion due to the presence of the privacy devices is, in general, dependent on the type of privacy and is usually agreed between the administrations or private enterprises concerned;

* Information regarding this matter may be found in Docs. Nos. 47 and 48 of Geneva, 1951.



1.3 *Location of the devices*

to facilitate control and maintenance and on the grounds of economy, the privacy apparatus is normally located at the point where the transmitting and receiving channels of a radio-telephone circuit are combined;

2. that for frequencies above about 30 Mc/s the details of the systems to be employed and of their performance should be agreed upon between the administrations or private enterprises concerned.

RECOMMENDATION No. 75

**CLASSIFICATION AND ESSENTIAL CHARACTERISTICS
OF FEED-BACK SUPPRESSORS**

(Question No. 31)

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

that the feed-back suppressors now generally used are of a type whose operation is sufficiently independent of the characteristics of those at the opposite end of the circuit;

UNANIMOUSLY RECOMMENDS

that no classification of types nor terminology be adopted.

Essential characteristics

(§ (b) of Question No. 31)

The essential characteristics of the feed-back suppressors used on radiotelephone circuits in the United Kingdom and in the United States of America for fixed services are described respectively in Docs. Nos. 49 and 51 of Geneva, 1951. These are in substantial accord with the characteristics described in C.C.I.F., 1950-1951, 5th Study Group, Doc. No. 7. Question No. 2.

RECOMMENDATION No. 97 *

CHANNEL SEPARATION

The C.C.I.R.,

(Stockholm, 1948 — Geneva, 1951 — London, 1953)

CONSIDERING

- (a) that, in the more usual cases, the primary factors which determine frequency separation between channels include:
- the signal power required by the receiver;
 - the interference power intercepted by the receiver including that from interfering signals and from noise;

* This Recommendation replaces Recommendations Nos. 1 and 43.

- (b) that transmitters in general emit radiations outside the frequency bandwidth necessarily occupied by the emission;
- (c) that many factors are involved, among which are the properties of the transmission medium (which are variable in character and difficult to determine), the characteristics of the receiver and, in the case of aural reception, the discriminating properties of the human ear;

UNANIMOUSLY RECOMMENDS

1. that the required separation between channels be calculated by the following method:
 - determine the signal power intercepted by the receiver;
 - determine the interfering power intercepted, including both noise and interfering signal;
 - determine from these data the degree of frequency separation that produces acceptable ratios of signal power to interfering power, for an acceptable percentage of the time. Account should be taken of the fluctuating nature both of the signal and of the interference, and whenever appropriate, the discriminating properties of the human ear;
2. that at every stage of the calculation, comparison should be made, as far as possible, with data obtained under controlled representative operating conditions, especially in connection with the final figure arrived at for the channel separation;
3. that the study of the problem should be undertaken in connection with Question No. 3 (III).

RECOMMENDATION No. 98

CHANNEL SEPARATION ACHIEVED IN PRACTICE

(Question No. 3 (III))

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that it is not yet possible to give a full answer to Question No. 3 (III);
- (b) that in the case of telegraphy using A1 and F1 emissions, a large number of machine telegraph circuits are operating successfully with nominal separations of 2.5 kc/s, particularly in the frequency range below 12 Mc/s;
- (c) that there is evidence (in particular Doc. No. 457 of Geneva, 1951) that, with reception of F1 at a speed of 50 bauds, a separation of about 1.5 kc/s is satisfactory when the two signals have the same median value at the input to the receiver, and that in certain cases a separation of about 2 kc/s provides fairly satisfactory operation when the median value of the wanted signal is 6 db below that of the unwanted signal *;
- (d) that, when allowance is made for frequency tolerance, this evidence suggests the possibility of a separation of about 2.5 kc/s between emissions under the particular conditions of the test;
- (e) that, while due regard must be paid to the frequency tolerances provided for in the Radio Regulations, 1947, App. 3, a higher degree of frequency stability is possible and is actually achieved in practice;

* These tests are related to separate emissions without common control of the respective frequencies radiated.

RECOMMENDS

1. that administrations should:
 - 1.1 collect data relating to transmitters at present working in adjacent channels, indicating:
 - the channel separations observed in practice;
 - the field strengths of the signals on adjacent channels received at the same location;
 - the effect of interference due to signals on adjacent channels (see Study Programme No. 128 (III) for the method of expressing the effect of interference);
 - 1.2 carry out tests similar to those described in Doc. No. 457 of Geneva, 1951;
2. that administrations who have made these tests should submit the result to the Director of the C.C.I.R., as early as possible.

RECOMMENDATION No. 100

**REDUCTION OF OCCUPIED BANDWIDTH
AND TRANSMITTER POWER IN RADIO TELEPHONY**

(Question No. 3 (III))

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) the urgent need for improved utilization of the radio spectrum, particularly in the range below 30 Mc/s;
- (b) that a very great improvement in the utilization of the spectrum will arise from the replacement of double-sideband by single-sideband technique (see Recommendation No. 40, § 2.1 and 2.2);
- (c) that improvements can be obtained by the use of noise reducers and devices enabling the average percentage of modulation to be maintained at a high level, e.g. peak-clipping devices (see Recommendation No. 161);

RECOMMENDS

1. that administrations should, whenever possible, make use of single-sideband systems in preference to double-sideband systems *;
2. that noise reducers should be employed at the receiving terminal of all circuits where an improvement in signal-to-noise ratio can be obtained **;
3. that devices should be employed at the transmitting terminal of all circuits to enable the average percentage of modulation to be maintained at a high level (for example, peak-clipping devices). With the use of these devices adequate precautions must be taken to prevent radiation outside the necessary bandwidth (for example, by the use of an adequate low-pass filter after the device) ***.

* Improvement of signal-to-noise ratio or a reduction in power of at least 9 db is obtained by the use of single-sideband systems instead of double-sideband systems.

** The improvement which may be obtained in practice by the use of a noise reducer is dependent upon the signal-to-noise ratio at the input to the noise reducer (for example, an improvement of the order of 10 db may be obtained on radiotelephone circuits of good commercial quality).

*** The improvement which may be obtained in practice is dependant upon the original average percentage modulation of the transmitter. Improvement up to 6 db may be obtained in practice.

RECOMMENDATION No. 101

**BANDWIDTH REQUIRED AT A TELEGRAPH OR TELEPHONE
RECEIVER OUTPUT**

(Question No. 3 (III))

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) the urgent need to determine the minimum separation between frequency assignments of stations operating on adjacent channels, in the range 10 kc/s to 30 000 kc/s;
- (b) that the width of the frequency band which is necessary at the output of the receiver is one of the factors which determine the band of frequencies required for the overall system;
- (c) that, in the case of telegraphy the permissible degree of distortion is not yet defined;
- (d) that, in the case of telephony the bandwidth may depend among other factors upon the type of privacy equipment in use;

RECOMMENDS

- 1. that in the case of telegraphy a provisional value for the bandwidth necessary at the output of the receiver, under average practical conditions, should be as follows:
 - 1.1 for A1 emissions, the bandwidth in cycles per second, after the final detector stage, should be equal to 2.5 times the signalling speed in bauds;
 - 1.2 for F1 emissions, the bandwidth in cycles per second after the discriminator should be equal to 1.4 times the signalling speed in bauds.

The extent to which these values can be applied to permit closer spacing of adjacent channels, depends upon the degree and speed of amplitude variations due to fading and upon the differential fading of the mark and space frequencies;

- 2. that, in the case of telephony, as a compromise between intelligibility and economy of bandwidth, the bandwidth necessary for each speech channel at the output of the receiver should be as follows:
 - 2.1 in accordance with Recommendation No. 40 the upper limit frequency should be reduced to 3000 c/s or less but not lower than 2600 c/s;
 - 2.2 for systems employing privacy equipment the necessary bandwidth for satisfactory service may require the use of an upper limit frequency greater than 2600 c/s (e.g. in five-band privacy equipment the necessary bandwidth is 2750 c/s, the upper limit being 3000 c/s).

RECOMMENDATION No. 102 *

DIRECTIVITY OF ANTENNAE AT GREAT DISTANCES

The C.C.I.R.,

(Geneva, 1951 — London, 1953)

CONSIDERING

- (a) that the study of the directivity of antennae at great distances concerns chiefly radio communication on frequencies between 3000 and 30 000 kc/s;

* This Recommendation replaces Recommendation No. 46.

- (b) that in certain cases the phenomena of ionospheric propagation may be such as to modify appreciably both the theoretical directivity diagram and the practical diagram drawn up for measurements at short distances;
- (c) that it would be very useful for operators to have the most accurate idea possible of the directional discrimination that can be expected of the antennae they are using;

RECOMMENDS

1. that all administrations in a position to do so should undertake systematic measurements on frequencies that can be used for long-distance circuits;
2. that the method used for the study of § (c) could be either the statistical method described in Doc. No. 23 of Geneva, 1951 (see also Doc. No. 206 of London) or any other appropriate method;
3. that members of the C.C.I.R. who are able to provide either transmitting or receiving installations which could take part in the programme of studies proposed above should communicate full details of their installations to the Director of the C.C.I.R. as soon as possible, so that the latter may send them on to such other members of the C.C.I.R. as express a wish to receive them.

RECOMMENDATION No. 106

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Question No. 43 (III))

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that diversity reception on radiotelegraphy circuits is not general practice;
- (b) that, in the case where voice-frequency equipment is used on radio circuits at frequencies lower than about 30 Mc/s, the quality of these circuits will in general be insufficient when no means of diversity reception is provided;
- (c) that, in the presence of fading, space diversity or frequency diversity give comparable improvement to the quality of reception of telegraph signals transmitted on radio channels;
- (d) that for adequate frequency diversity it appears necessary that the frequencies which are used in combination to obtain this diversity should differ by at least 400 c/s;
- (e) that space diversity needs only half the bandwidth and less power for each telegraph channel when compared with the case of frequency diversity but, in general, requires more equipment;

UNANIMOUSLY RECOMMENDS

1. that, when voice-frequency telegraph systems are used on radio circuits at frequencies lower than about 30 Mc/s, diversity reception should be used on the individual voice-frequency channels;
2. that, whenever practicable, space diversity should be used in preference to frequency diversity;
3. that, in the case of frequency diversity, the channel frequencies used in combination should have a separation of at least 400 c/s so that adequate diversity effects may be obtained.

RECOMMENDATION No. 161 *

**BANDWIDTHS AND SIGNAL-TO-NOISE RATIOS
IN COMPLETE SYSTEMS**

(Question No. 3 (III))

The C.C.I.R.,

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

that it is not yet possible to give a full and accurate answer to Question No. 3 (III) but that in order that such an answer may be given it is desirable to classify the important points with which future study will have to deal;

RECOMMENDS

1. that meanwhile, the values given in the table in Ann. I should be adopted as provisional values for the signal-to-noise ratio required for the types of service concerned;
2. that in further study relating to the minimum separation between frequencies of stations operating on adjacent channels, the factors detailed in Ann. II should be taken into consideration.

ANNEX I

Note 1. — Measured as the ratio of r.m.s. signal corresponding to peak output of the transmitter and r.m.s. noise in a 6 kc/s band, assuming stable conditions.

Note 2. — Carrier keyed. Beat-frequency oscillator used.

Note 3. — For A3 telephony the figures in this column represent the ratio of the audio signal, as measured on a standard VU-meter, to r.m.s. noise for a bandwidth of 3 kc/s. (The corresponding peak signal power, i.e., when the transmitter is 100% tone-modulated, is assumed to be 6 db higher.)

Note 4. — For 90% intelligibility of unrelated words.

Note 5. — When connected to the public service network.

Note 6. — These values are based on Washington Doc. No. 138, Doc. No. 112 of Geneva, 1951, and The Hague Doc. No. 11.

* This Recommendation replaces Recommendation No. 99. The Bielorussian S.S.R., the Hungarian P.R., the Ukrainian S.S.R. the Roumanian P.R., Czechoslovakia, and the U.S.S.R. reserved their opinions on this Recommendation.

Signal-to-noise ratios required
(Stable conditions) (Note 6)

Type of service	Receiver audio bandwidth (kc/s)	Audio signal-to-noise ratio (db)	Receiver bandwidth (kc/s)	Ratio of peak RF signal-noise in 6 kc/s band (Note 1) (db)
<i>A1 telegraphy</i>				
8 baud low grade	1.5	—4	3	—7
24 baud	1.5	11	3	8
120 baud recorder	0.6	10	0.6	0
50 baud printer	0.25	16	0.25	2
<i>A2 telegraphy</i>				
8 baud low grade	1.5	—4	3	—3 (Note 2)
24 baud	1.5	11	3	12 (Note 2)
<i>F1 frequency-shift telegraphy</i>				
120 baud recorder	0.25	4	1.5	2
50 baud printer	0.10	10	1.5	—2
<i>Phototelegraphy F4</i>				
Sub-carrier frequency-modulation single side-band emission	3	15	3	12
<i>Hellschreiber</i>				
Frequency-shift	1.5	6	3	3
<i>A3 telephony</i>		(Note 3)		
Double-sideband, just usable quality, operator to operator (Note 4)	3	6	6	18
Double-sideband, marginally commercial (Note 5)	3	15	6	27
Double-sideband, good commercial quality (Note 5)	3	33	6	35*
Single-sideband, 1 channel	3	33	3	26*
2 channels	3	33	3**	28*
3 channels	3	33	3**	29*
4 channels	3	33	3**	30*
<i>Broadcasting</i>	5	33	10	47

* Assuming 10 db improvement due to the use of noise reducers.

** Per channel.

ANNEX II

FACTORS TO BE TAKEN INTO ACCOUNT FOR VARIOUS SERVICES IN DETERMINING THE MINIMUM SEPARATION BETWEEN THE FREQUENCIES OF STATIONS OPERATING ON ADJACENT CHANNELS

1. Required signal-to-interference ratios.
2. Necessary bandwidth for required intelligence.
3. Transmitters:
 - out-of-band radiation.
 - frequency instability.
4. Propagation:
 - allowances for fluctuations due to absorption and fading.
5. Receivers:
 - necessary bandwidth.
 - attenuation slope.
 - frequency instability.
6. Effect of:
 - inequalities of received field strength on desired and adjacent channels
 - antenna directivity at transmitter and receiver.

RECOMMENDATION No. 162 *

USE OF DIRECTIONAL ANTENNAE

(Question No. 3 (III) — Study Programme No. 45)

The C.C.I.R.,

(London, 1953 — Warsaw, 1956)

CONSIDERING

- (a) the urgent need to determine the minimum separation between frequencies of stations operating on adjacent channels, below 30 Mc/s;
- (b) that the improvement in the signal-to-noise ratio and signal-to-interference ratio to be obtained by the use of directional receiving antennae is an important means of reducing the necessary channel spacing to a minimum;
- (c) that the use of directional transmitting antennae considerably reduces the level of interference by:
 - providing at the receiver the necessary field strength with reduced transmitted power,
 - reducing the field strength received at stations situated outside the principal lobe of the transmitting antennae;
- (d) that, in addition, the use of a directional antenna can contribute an improvement by reducing echo and multipath effects;
- (e) that, using known techniques, highly directional antennae can be constructed;
- (f) that, despite the non-homogeneous nature of the transmission medium, it is possible to employ transmitting and receiving antennae with appreciably greater directivity than that of antennae in general use;
- (g) that it is not yet possible to give full and precise answers to the questions posed in Study Programme No. 45, § 1.1.9 and 1.2.9.

* This Recommendation replaces Recommendation No. 103.

UNANIMOUSLY RECOMMENDS

- that the characteristics which might reasonably be expected in practice for rhombic antennae at present in use for point-to-point circuits be considered in three main arcs as shown in Figure 1, i.e.:
 - (M) the main arc including only the main lobe
 - (A) consisting of two arcs A_1 and A_2 on either side of the main arc
 - (B) the remaining arc from the limits of the arcs A_1 and A_2 and including the whole of the backward arc.
- that the gains in the correct azimuthal direction and the gains for the arcs A and B as shown in the Annex should be adopted for distances of 3000–10 000 km.

ANNEX

Frequency range (Mc/s)	Median value of gain relative to optimum gain for half-wave dipole at the same height (db)			Azimuthal range (degrees)		
	In the correct azimuthal direction	In arc A	In arc B	Half of main arc	Arc $A_1=A_2$	Half of arc B
4	6	0	−3	30	35	115
6	8	0	−3	25	30	125
8	10	0	−4	20	25	135
11	12	1	−5	15	22	143
15	14	2	−6	10	20	150
22	15	3	−6	8	18	154

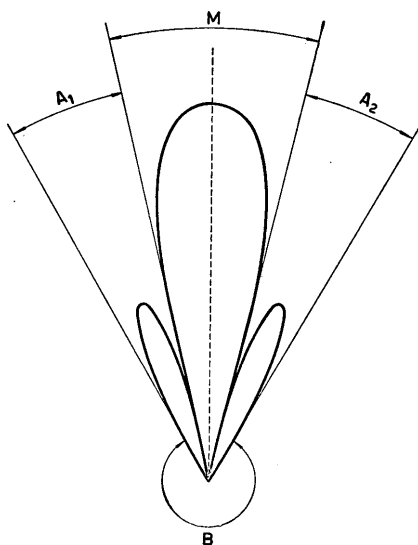


FIGURE 1

RECOMMENDATION No. 164 *

FADING ALLOWANCES FOR THE VARIOUS CLASSES
OF SERVICE

(Question No. 3 (III) — Study Programme No. 128 (III))

The C.C.I.R.,

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

- (a) that Annex I to Recommendation No. 161 is a provisional partial reply to Question No. 3 (III) for stable conditions;
- (b) that there is a need for figures which take fading and field intensity fluctuation into account;
- (c) that it is not yet possible to give a full answer to Study Programme No. 128 (III);
- (d) that, however, the documents received relative to Question No. 52 and Study Programme No. 24 give some results from which can be derived provisional data on fading allowances;

RECOMMENDS

- 1. that the studies in connection with Recommendation No. 161 and Study Programme No. 128 (III) should be continued in conjunction with those of Study Programme No. 148 (VI), for the purpose of determining whether the provisional values given in the Annex may be accepted or should be modified;
- 2. that meanwhile, the values given in the Annex may be regarded as provisional total fading allowances (combined fading safety factors and intensity fluctuation factors);
- 3. that meanwhile, these values may be used as a guide in conjunction with the values for signal-to-noise ratios required for stable conditions given in Recommendation No. 161, Ann. I, to estimate monthly median values of hourly median field intensity necessary for the various types and grade of service; similarly, the fading allowances may be used as a guide in conjunction with the values for signal-to-interference ratios (for stable conditions) appropriate to the various services.

ANNEX

Note 1. — The allowance for day-to-day fluctuation (intensity fluctuation factor) for the signal, against steady noise, is 10 db, estimated to give protection for 90% of the days. The intensity fluctuation of atmospheric noise is also taken to be 10 db for 90% of the days. Assuming that there is no correlation between the intensity fluctuations of noise and of signal (the worst condition likely to exist), a good estimate of the combined signal and noise factor is:

$$\sqrt{10^2 + 10^2} = 14 \text{ db}$$

* This Recommendation replaces Recommendation No. 105. The Bielorussian S.S.R., the Hungarian P.R., the Ukrainian S.S.R., the Roumanian P.R., Czechoslovakia and the U.S.S.R. reserved their opinions on this Recommendation.

*Provisional total fading allowances **

Type of service **	For the protection of a fading signal against:	
	atmospheric noise subject to day-to-day intensity fluctuation (subtract 4 db for protection against steady noise or steady interfering signal) (see Note 1)	interfering sign 1 subject to fading and day-to-day intensity fluctuation (see Note 2)
	db relative to ratios of monthly median values of hourly median field strength	
<i>A1 telegraphy</i>		
8 baud, low grade (Note 3)	21	17
24 baud (Note 4)	25	20
120 baud recorder (Note 6)	25	20
50 baud printer (Notes 5, 6)	32	27
<i>A2 telegraphy</i>		
8 baud, low grade (Notes 3, 7)	17	13
24 baud (Notes 4, 7)	20	17
<i>F1 telegraphy</i>		
120 baud recorder (Note 6)	25	20
50 baud printer (Notes 5, 6)	32	27
automatic repetition printer (ARQ) (Notes 6, 8)	17	12
<i>Phototelegraphy F4</i>		
sub-carrier frequency-modulation single-sideband emission .	23	20
<i>Hellschreiber frequency-shift</i> (Note 9)	23	20
<i>A3 telephony</i>		
DSB just usable quality, operator to operator (Note 10)	17	11
DSB marginally commercial (Note 11)	19	14
DSB good commercial quality (Note 12)	21	17
SSB 1 channel	21	17
2 channel		
3 channel		
4 channel		
(Note 12)		
<i>Broadcasting</i>	21	17

* Combined fading safety factor and intensity fluctuation allowances.

** From Annex I, Recommendation No. 161.

This figure has been added to the fading safety factor applied to each type of service to obtain the combined fading allowance in column 1. Subtraction of 4 db reduces the intensity fluctuation allowance to 10 db, which is the value for the signal alone; the net allowance would then be appropriate for the protection of a fading signal against a steady (non-fluctuating) noise or a steady (non-fading or fluctuating) interfering signal.

Note 2.—The probability distribution of the ratio of two signals fading independently has been used as given in London Doc. No. 443. The combined intensity fluctuation allowance for two signals has been taken as 7 db, which represents a compromise between the 0 db allowance appropriate in the case of perfectly correlated intensity fluctuations of the two signals, and the 14 db allowance appropriate (see Note 1) for uncorrelated intensity fluctuations of the two signals.

General Note.—In calculating the fading safety factor for rapid or short period fading, log-normal amplitude distribution of the received fading signal (using 7 db for the ratio of median level to level exceeded for 10% or 90% of the time) has been used, except in the case of high-speed automatic telegraphy services, where the protection has been calculated on the basis of Rayleigh distribution. The following notes refer to protection against rapid or short-period fading.

Note 3.—For protection 90% of the time.

Note 4.—For protection 98% of the time.

Note 5.—For protection 99.99% of the time.

Note 6.—Minimum of 2-element diversity assumed.

Note 7.—Total sideband power combined with keyed carrier is assumed to give partial (two-element) diversity effect. 4 db allowed for the case of 90% protection (8 baud) and 6 db allowed for the case of 98% protection.

Note 8.—Based on 90% traffic efficiency.

Note 9.—Based on 95% protection.

Note 10.—Based on 70% protection.

Note 11.—Based on 80% protection.

Note 12.—Based on 90% protection.

RECOMMENDATION No. 165 *

COMMUNICATION THEORY

(Question No. 133 (III))

The C.C.I.R.,

(London, 1953 — Warsaw, 1956)

CONSIDERING

- (a) that the study of both the practical and theoretical aspects of communication theory is of interest to the I.T.U.;
- (b) that the bibliography on this subject and the documentation on the characteristics of various transmission systems in practical use, published by the Secretariat of the C.C.I.R. are useful for this study;
- (c) that the U.R.S.I. is willing to take part in the preparation of this bibliography, in particular through the help of its Netherlands Committee;

* This Recommendation replaces Recommendation No. 107.



UNANIMOUSLY RECOMMENDS

1. that other administrations should co-operate in the preparation of the bibliography by sending to the Netherlands Administration a yearly list of papers on communication theory published in their country, where possible with an abstract;
2. that the Secretariat of the C.C.I.R. should continue the publication and dissemination of periodic supplements to the bibliography and to the documentation mentioned in § (b).

RECOMMENDATION No. 166

UNIT OF QUANTITY OF INFORMATION

The C.C.I.R.,

(Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

the following definition of the unit of quantity of information:

“ the unit of quantity of information corresponds to a ‘ message unit ’ consisting of a random choice between two equally probable signals ” (Xth General Assembly of U.R.S.I., Sydney, 1952). This unit may be designated by the word “ bit ”.

Note. — The U.R.S.I. (The Hague, 1954) has drawn attention to the fact that the quantity of information in a message cannot be measured by a simple instrument. In most cases only a statistical estimate of an upper limit for the received quantity of information can be computed.

It is doubtful whether the construction of a computer for this purpose would serve a useful end, since such statistical estimates can also be made indirectly.

RECOMMENDATION No. 240 *

SIGNAL-TO-INTERFERENCE PROTECTION RATIOS

(Question No. 3 (III), Study Programme No. 128 (III))

The C.C.I.R.,

(London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

that a knowledge of the signal-to-interference protection ratios for various types of service is needed;

RECOMMENDS

1. that the values of signal-to-interference ratios for stable conditions below which harmful interference occurs can be used in conjunction with the fading allowances in the Annex to Recommendation No. 164;
2. that the values shown in the table below are appropriate to emissions indicated.

* This Recommendation replaces Recommendation No. 163. The R.P. of Bulgaria, the Ukrainian S.S.R., Czechoslovakia and the U.S.S.R. reserved their opinion on this Recommendation.

TABLE
Minimum protection ratios and frequency separations required under stable conditions

Wanted signal	Interfering signal																			
Type of service	A1 50 bauds (1)				A1 100 bauds				F1 50 bauds 2D=280 c/s (1)				F1 100 bauds 2D=400 c/s				Broadcast (5)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	(db)	(kc/s)			(db)	(kc/s)			(db)	(kc/s)			(db)	(kc/s)			(db)	(kc/s)		
A1-50 baud teleprinter B=500 c/s	11	0.36	0.44	1.14	(2) 12	(2) 0.25	(2) 0.35		13	0.46	0.54	1.24	(2) 3	(2) 0.40	(2) 0.55					
F1-50 baud teleprinter 2D=280 c/s, B=500 c/s	1	0.2	0.28	0.6					7	0.32	0.39	0.67								
F1-50 baud teleprinter 2D=280 c/s, B=3000 c/s																	(3) 18	(3) 3	(3) 4.5	(3) 7.5
F1-50 baud teleprinter 2D=400 c/s, B=500 c/s					(2) 3	(2) 0.35	(2) 0.50						(2) 2	(2) 0.45	(2) 0.60					
F1-171 baud ARQ system 2D=400 c/s, B=500 c/s					(4) 4	(4) 0.40	(4) 0.55						(4) 4	(4) 0.50	(4) 0.70					
F4-phototelegraphy, 60 r.p.m. B=1000 c/s					15	1.00	1.20						15	1.10	1.20					

In the column "Type of Service" B represents the Receiver Bandwidth and 2D represents the total frequency shift. Columns numbered 1 give the limiting values of signal-to-interference ratio (db) in the cases when the occupied band of the interfering emission either falls entirely within the pass-band of the receiver, or covers it completely. Columns numbered 2, 3 and 4 indicate the frequency separation necessary between a wanted and an interfering signal when the latter is 0, 6 or 30 db higher than the wanted signal.

Notes. — (1) Bandwidth of interfering signals limited to 500 c/s;
(2) For a character error rate of 1/10 000;
(3) For a character error rate of 1/1000;
(4) For a traffic efficiency of 90 %;
(5) Average modulation degree of 40%; for this test the sideband components extended to ± 9 kc/s.



RECOMMENDATION No. 241

THE CONCEPT OF TRANSMISSION LOSS IN RADIO SYSTEMS STUDIES

(Question No. 81 and Study Programme No. 130 (III))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that the radio frequency signal power, p_a , available * at the terminals of a receiving antenna for a given power input, p_t , to the terminals of a transmitting antenna provides a measure which is useful in determining at the terminals of the receiving antenna the service from or the interference produced by a radio system involving a transmitting antenna, a receiving antenna, and the intervening propagation medium;
- (b) that the ratio, p_t/p_a , which will be called the system loss, is a convenient dimensionless form for expressing this measure of the combined radio propagation and the circuit loss characteristics of such a system;
- (c) that the available power at the terminals of the receiving antenna is sometimes a simpler and more directly useful concept than that of the effective field strength, especially where the effective field is the resultant of a large number of received field components corresponding to several modes of propagation arriving at the receiving antenna with different angles and possibly with different polarizations;
- (d) that the relationship between the system loss and the conditions in the neighbourhood of the receiving antenna does not depend solely on the received field strength because the impedance of the antenna is itself dependant upon the conditions in its neighbourhood;
- (e) that the power P_t' radiated from the transmitting antenna required for satisfactory reception in the presence of noise is precisely determined for a system with transmission loss L by the simple relation: $P_t' = L + P$; P is the minimum signal power that is required to provide satisfactory reception (as defined in Report No. 65), available from an equivalent lossless receiving antenna.
- (f) that it is desirable to standardize terminology and notation for describing system loss and its various components;

UNANIMOUSLY RECOMMENDS

that the terminology and notation given in the Annex be adopted for use by the C.C.I.R., in accordance with the further discussion of the use of these terms given in Report No. 112.

ANNEX

1. *System Loss (L_s)*

The system loss of a radio circuit consisting of a transmitting antenna, receiving antenna, and the intervening propagation medium is defined as the ratio, p_t/p_a , where p_t is the radio frequency power input to the terminals of the transmitting antenna and p_a is the

* The available power p_a is the power which would go to the load if it were matched to the antenna impedance.

resultant radio frequency signal power available at the terminals of the receiving antenna. Both p_t and p_a are expressed in watts. The system loss is usually expressed in decibels: *

$$L_s = 10 \log_{10} (p_t/p_a) = P_t - P_a$$

Note that the system loss, as above defined, excludes any transmitting or receiving antenna transmission line losses since it is considered that such losses are readily measurable. On the other hand, the system loss includes all of the losses in the transmitting and receiving antenna circuits, including not only the transmission loss due to radiation from the transmitting antenna and re-radiation from the receiving antenna, but also any ground losses, dielectric losses, antenna loading coil losses, terminating resistor losses in rhombic antennae, etc. The inclusion of all of the antenna circuit losses in the definition of system loss provides a quantity which can always be accurately measured and which is directly applicable to the solution of radio system problems.

2. *Transmission Loss (L)*

The transmission loss of a radio circuit consisting of a transmitting antenna, receiving antenna, and the intervening propagation medium is defined as the dimensionless ratio, p_t'/p_a' , where p_t' is the radio frequency power radiated from the transmitting antenna, and p_a' is the resultant radio frequency signal power which would be available from the receiving antenna if there were no circuit losses other than those associated with its radiation resistance. The transmission loss is usually expressed in decibels:

$$L = 10 \log_{10} (p_t'/p_a') = L_s - L_{tc} - L_{rc}$$

where L_{tc} and L_{rc} are the losses, expressed in decibels, in the transmitting and receiving antennae circuits respectively, excluding the losses associated with the antennae radiation resistances; i.e., the definitions of L_{tc} and L_{rc} are $10 \log_{10}(r'/r)$ where r' is the resistive component of the antenna circuit and r is the radiation resistance.

3. *Basic Transmission Loss (L_b)*

The basic transmission loss (sometimes called path loss) of a radio circuit is the transmission loss expected between ideal, loss-free, isotropic, transmitting and receiving antennae at the same locations as the actual transmitting and receiving antennae.

4. *Path Antenna Directivity Gain (G_p)*

The path antenna directivity gain is equal to the increase in the transmission loss when lossless, isotropic, antennae are used at the same locations as the actual antennae:

$$G_p = L_b - L$$

5. *Path Antenna Power Gain (G_{pp})*

The path antenna power gain is equal to the increase in the system loss when lossless isotropic antennae are used at the same locations as the actual antennae:

$$G_{pp} = L_b - L_s = G_p - L_{tc} - L_{rc}$$

Note that G_{pp} will be negative when the antenna circuit losses exceed the path antenna directivity gain.

In some idealized situations the path antenna power gain, G_{pp} , is simply the sum ($G_{tp} + G_{rp}$) of the free space power gains, G_{tp} and G_{rp} , of the transmitting and receiving antennae relative to lossless isotropic antennae. However, in most practical situations G_{pp} is less than ($G_{tp} + G_{rp}$) because of the complex nature of the received field. The path antenna power gain may be measured by determining the increase in the system loss when

* Throughout this Recommendation, capital letters are used to denote the ratios, expressed in decibels, of the corresponding quantities designated with lower-case type; e.g., $P_t = 10 \log_{10} p_t$. P_t is the input power to the transmitting antenna expressed in decibels above one watt.

both the transmitting and receiving antennae are replaced *simultaneously* by simple standard antennae such as short electric or magnetic dipoles, and then adding the calculated path antenna power gain corresponding to the use of the standard antennae. In the case of ionospheric or tropospheric scatter propagation, the path antenna power gain is sometimes substantially smaller than the sum of the free space power gains ($G_{tp} + G_{rp}$); in such cases the path antenna power gain cannot be defined by the sum of the effective power gains of the transmitting and receiving antennae (as determined by replacing first one antenna and then the other successively by a standard antenna) since such effective power gains depend upon the gain of the antenna used at the other terminal.

In the case of ionospheric or tropospheric propagation, the transmission loss L , the basic transmission loss L_b , and the path antenna gain G_p , are all random variables with respect to time, and tend to be normally distributed about their expected values. Typically, L and G_p are negatively correlated with each other, and thus the variance of L_b is usually substantially less than the sum of the variances of L and of G_p ; for this reason it will often be more practical simply to measure the system loss with the particular antennae intended for use rather than attempt to calculate the expected system loss and its variance with time in terms of the measured or calculated values of the basic transmission loss, the path antenna gain, and the losses L_{tc} and L_{tr} .

Note also that the path antenna gain may actually be negative. For example, the path antenna gain will usually be negative for ground wave or tropospheric wave propagation between a vertically polarized and a horizontally polarized antenna, and the concept of path antenna gain should prove to be useful for expressing the results of such cross polarization measurements.

6. Propagation Loss (L_p)

The propagation loss is the system loss expected if the antennae gains and circuit resistances were the same as if the antennae were located in free space:

$$L_p = L_s - L_t - L_r$$

L_t and L_r are defined by $10 \log_{10}(r'/r_f)$ where r' is the actual antenna resistance and r_f is the resistance the antenna would have if it were in free space and there were no losses other than radiation losses.

RECOMMENDATION No. 242 *

THE USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

(Question No. 129)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that is essential to be able to interconnect terminal start-stop apparatus employing the International Telegraph Alphabet No. 2 by means of radiotelegraph circuits;
- (b) that radiotelegraph circuits are required to operate under varying conditions of radio propagation, atmospheric noise and interference which introduce varying degrees of distortion which may at times exceed the margin of the receiving apparatus;

* This Recommendation replaces Recommendation No. 167.

- (c) that in consequence, the transmission of 5-unit code signals over radio circuits is liable to errors and that such errors are not automatically detectable by the receiving apparatus;
- (d) that an effective means of reducing the number of wrongly printed characters is the use of codes permitting the correction of errors, either by their intrinsic constitution or by detecting the errors and automatically causing repetition;
- (e) that the methods using automatic repetition (ARQ) are well known at present;
- (f) that in certain cases there is a need to subdivide one or more channels in order to provide a number of services at a proportionately reduced character rate;

UNANIMOUSLY RECOMMENDS

1. that when the direct use of a 5-unit code on a radio circuit gives an intolerable error rate and there is a return circuit, a 7-unit ARQ system be considered. In such a case the 7-unit system described in the Annex should be adopted as a preferred system.
2. that studies be continued in order to devise a method of unambiguous phasing under all circumstances. (See for example Report No. 108.)

ANNEXES

I. TABLE OF CODE CONVERSION (see page 173)

II. CHANNEL ARRANGEMENTS

1. *Two channels*

channels A and B consecutive
(A—normally direct keying,
B—normally reversed keying) *

2. *Four channels*

channels A and B consecutive
channel C interlaced with channel A
channel D interlaced with channel B
(A and D—normally direct keying
B and C—normally reversed keying) *

III. SUB-CHANNEL ARRANGEMENTS

1. the speed of the fundamental sub-channel should be a quarter of the standard speed and multiples of quarter-speed channels may be used;
2. sub-channels should be numbered 1, 2, 3 and 4 consecutively.
In order to ensure the automatic phasing of the sub-channels in the case of a four character cycle, the polarity of the signalling of sub-channel No. 1 should always be inverted as shown below:
direct keying: A2, A3, A4, B1, C1, D2, D3, D4
reversed keying: A1, B2, B3, B4, C2, C3, C4, D1
3. in the case when sub-channels of half-speed, or three-quarter-speed are provided, combinations of the fundamental sub-channels should be arranged as shown in Table II.

* See Report No. 108.



TABLE 1
Table of code conversion

	International code No. 2	7-unit code
A	ZZAAA	AAZZAZA
B	ZAAZZ	AAZZAAZ
C	AZZZA	ZAAZZAA
D	ZAAZA	AAZZZAA
E	ZAAAA	AZZZZAA
F	ZAZZA	AAZAAZZ
G	AZAAZ	ZZAAAAZ
H	AAZAZ	ZAZAAZA
I	AZZAA	ZZZAAAA
J	ZZAZA	AZAAAZZ
K	ZZZZA	AAAZAZZ
L	AZAAZ	ZZAAAZA
M	AAZZZ	ZAZAAAZ
N	AAZZA	ZAZAZAA
O	AAAAZ	ZAAAZZA
P	AZZAZ	ZAAZAZA
Q	ZZZAZ	AAAZZZA
R	AZAZA	ZZAAZAA
S	ZAZAA	AZAZAZA
T	AAAAZ	ZAAAZAZ
U	ZZZAA	AZZAAZA
V	AZZZZ	ZAAZAAZ
W	ZZAAZ	AZAAZAZ
X	ZAZZZ	AAZAZZA
Y	ZAZAZ	AAZAZAZ
Z	ZAAAZ	AZZAAAZ
carriage return	AAAZA	ZAAAAZZ
line feed	AZAAA	ZAZZAAA
figures	ZZAAZ	AZAAZZA
letters	ZZZZZ	AAAZZZA
space	AAZAA	ZZAZAAA
unperforated tape	AAAAA	AAAAZZZ
signal repetition		AZZAZAA
signal α		AZAZAAZ
signal β		AZAZZAA

TABLE II

Proportion of channel operating speed	Combination of fundamental sub-channels
(1) quarter (2) quarter (3) half	No. 1 No. 3 Nos. 2 and 4
(1) half (2) half	Nos. 1 and 3 Nos. 2 and 4
(1) quarter (2) three-quarters	No. 1 Nos. 2, 3 and 4

IV. REPETITION CYCLES

1. Four characters for normal circuits which are not subject to excessive propagation time.
2. Five characters on circuits for which the four-character repetition cycle is inadequate, provided sub-channelling is not required.
3. Eight characters on circuits for which the four-character repetition cycle is inadequate and sub-channelling is required. The cycle should comprise one repetition signal, three signals β and four stored characters, or one repetition signal and seven stored characters.

- V. C.C.I.T. Recommendation No. C. 23 recommends that the interval between the beginning of successive start elements of the signals transmitted into the landline network be at least 144 ms. Therefore the duration of the transmission cycle on the radio circuit and also the keying speed must be chosen correspondingly if interconnection to the network is wanted.

Practical values for the keying speed in bauds and the duration of the transmission cycle which enable synchronization to be effected by means of one single oscillator for all three cases are:

Transmission cycle (ms)	Keying speed (bauds)
$163\frac{1}{3}$	$171\frac{3}{7}$
$145\frac{5}{6}$	192
140	200

The transmission cycle of $163\frac{1}{3}$ ms is suitable for connecting to 45 baud networks.

The transmission cycle of $145\frac{5}{6}$ ms may be used for connection to 50 baud networks.

The transmission cycle of 140 ms is suitable for radio links without direct connection to a landline network.

- VI. C.C.I.T. Recommendation No. E. 6 has given the signalling conditions to be used when telex communication is to be established by means of such radio circuits.

RECOMMENDATION No. 243 *

FACSIMILE TRANSMISSION OF METEOROLOGICAL CHARTS
OVER RADIO CIRCUITS

(Questions Nos. 94 (III) and 130 (III))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that increasing use is being made of facsimile telegraphy for the transmission of meteorological charts for reception on direct-recording apparatus;
- (b) that it is desirable to standardize certain characteristics of the radio circuits for this purpose;

* This Recommendation replaces Recommendation No. 226.

UNANIMOUSLY RECOMMENDS

1. that when frequency modulation of the sub-carrier is employed for the facsimile transmission of meteorological charts over radio circuits, the following characteristics should be used:

centre frequency	1900 c/s
frequency corresponding to black	1500 c/s
frequency corresponding to white	2300 c/s
2. that when direct frequency modulation is employed on radio circuits the following characteristics should provisionally be used:

centre frequency (corresponding to assigned frequency) :	f_o
frequency corresponding to black:	$f_o - 400$ c/s,
frequency corresponding to white:	$f_o + 400$ c/s;

In special cases, for example on lower frequency circuits, a smaller deviation may be used, but it is too early to fix any standard shift.

Note. — The normal index of cooperation is 576 associated with a speed of 60 r.p.m. The same index of cooperation is also used in association with speeds of 90 and 120 r.p.m. It is to be observed that whereas with the drum speed of 60 r.p.m. satisfactory reception can usually be expected, the quality of the recording may be impaired at higher drum speeds, depending upon the composition of the circuit and the presentation of the original document.

RECOMMENDATION No. 244 *

STANDARDIZATION OF PHOTOTELEGRAPH SYSTEMS FOR USE ON
COMBINED RADIO AND METALLIC CIRCUITS

The C.C.I.R., (Stockholm, 1948 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that in order to facilitate interworking it is desirable to standardize the characteristics of systems employed for phototelegraph transmission over long-distance HF (decametric) circuits;
- (b) that it is desirable to standardize certain characteristics of the systems in such a way as to make them equally suitable for transmission over metallic circuits;
- (c) that the transmission system using direct amplitude modulation is generally unsatisfactory over HF (decametric) radio circuits because of the intolerable fading ratio usually encountered;
- (d) that the time-modulation system gives insufficiently good definition;
- (e) that the system of sub-carrier frequency modulation has proved satisfactory but requires standardization in respect of the centre frequency and shift frequencies, taking into account the values of the picture-modulation frequencies to be transmitted;
- (f) that, when a direct frequency modulation system is employed, the terminal equipment as normal to sub-carrier modulation system should be usable without serious modifications;

* This Recommendation replaces Recommendation No. 227.

- (g) that, taking into account the degree of distortion that is tolerable, the effect of multipath echoes on long-distance HF (decametric) radio circuits normally limits the maximum admissible picture-modulation frequency to approximately 600 c/s;
- (h) that a Joint Study Group of the C.C.I.T. and the C.C.I.R. under the direction of the C.C.I.T. was formed to study certain aspects of the subject of "Transmission of half-tone pictures over combined radio and metallic circuits", and at the proposal of the Joint Study Group, the VIIIth Plenary Assembly of the C.C.I.T. has accepted a new Recommendation No. D. 4;
- (i) that the C.C.I.F. has approved the conditions under which frequency modulation may be used for phototelegraphy over international telephone circuits;

UNANIMOUSLY RECOMMENDS

1. that over the radio path:
 - 1.1 when sub-carrier frequency modulation system is used, the following characteristics should be observed:

centre frequency 1900 c/s
 frequency corresponding to white 1500 c/s
 frequency corresponding to black 2300 c/s
 (the 1500 c/s frequency is also used for the phasing frequency)

- 1.2 when a direct frequency modulation system is employed, the following characteristics should provisionally be observed:

centre frequency (corresponding to assigned frequency): f_o ,
 frequency corresponding to white: $f_o - 400$ c/s,
 frequency corresponding to black: $f_o + 400$ c/s;

- 1.3 in both systems the stability of frequencies should be such that the variations are less than:

instantaneous 8 c/s,
 during 15 minutes 16 c/s;

2. that, for the present, the following alternative characteristics should be used:

	a	b	
index of cooperation	352	264	
speed of rotation of drum in r.p.m.	60	90 or 45	(The lower speed is for use when the radio propagation conditions demand it)

3. that frequency modulation or amplitude modulation may be used in the metallic portions of the combined circuit. When conversion from amplitude modulation to frequency modulation (or vice versa) is required, the conversion should be such that the deviation of the frequency-modulated carrier varies linearly with the amplitude of the amplitude-modulated carrier.

The standards for both amplitude-modulated and frequency-modulated transmissions will be found in C.C.I.T. Recommendations Nos. D.1 and D.3. Recommendation No. D.3 applies only to the metallic portion of the combined circuit.

Each Administration will decide, when the question arises, on the location of modulation converters. They will be placed either at the terminal phototelegraph station or at the control station associated with the radio station, so as to facilitate speech on the circuit used for phototelegraphy, if the radio channel will carry speech.

Note. — The provisions of § 2 above do not imply the imposition of such standards on private users who use their own equipment for the transmission of pictures over private circuits.

RECOMMENDATION No. 245 *

TELEGRAPHIC DISTORTION

(Question No. 18)

The C.C.I.R.,

(London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

that the definitions applying to telegraphic distortion and to the mutilation of telegraphic signals which appear in Section 33, Part I, of the "List of Definitions of Essential Telecommunication Terms" published by the International Telecommunication Union give an answer to Question 18, which required a general definition of telegraphic distortion capable of being usefully applied to the case of radiotelegraphy,

UNANIMOUSLY RECOMMENDS

that the following definitions contained in Section 33 of the above-mentioned "List of Definitions of essential Telecommunication Terms" should be applied to radiotelegraphy:

Perfect modulation (or restitution)

Modulation (or restitution) such that all the significant intervals are associated with correct significant conditions and conform accurately to their theoretical durations.

*Incorrect modulation (or restitution)**Defective modulation (or restitution)*

Modulation (or restitution) containing one or more elements, the significant condition of which differs from that corresponding to the kind prescribed by the code.

Telegraph distortion (of a modulation or a restitution)

A modulation (or restitution) suffers from telegraph distortion when the significant intervals have not all exactly their theoretical durations.

Degree of individual distortion of a particular significant instant (of a modulation or of a restitution)

Ratio to the unit interval of the displacement, expressed algebraically, of this significant instant from an ideal instant.

This displacement is considered positive when the significant instant occurs after the ideal instant.

The degree of individual distortion is usually expressed as a percentage.

Degree of isochronous distortion

Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and the theoretical intervals separating any two significant instants of modulation (or of restitution), these instants being not necessarily consecutive.

The degree of distortion (of an isochronous modulation or restitution) is usually expressed as a percentage.

Note. — The result of the measurement should be completed by an indication of the period, usually limited, of the observation.

For a prolonged modulation (or restitution) it will be appropriate to consider the probability that an assigned value of the degree of distortion will be exceeded.

* This Recommendation replaces Recommendation No. 151.

Degree of start-stop distortion

Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and theoretical intervals separating any significant instant of modulation (or of restitution) from the significant instant of the start element immediately preceding it.

The degree of distortion of a start-stop modulation (or restitution) is usually expressed as a percentage.

Note. — As for the degree of isochronous distortion.

Degree of gross start-stop distortion

Degree of distortion determined when the unit interval and the theoretical intervals assumed are exactly those appropriate to the standardized modulation rate.

Note. — As for the isochronous distortion.

Degree of synchronous start-stop distortion (i.e. at the actual mean modulation rate)

Degree of distortion determined when the unit interval and the theoretical intervals assumed are those appropriate to the actual mean rate of modulation (or of restitution).

Note 1. — As for the isochronous distortion.

Note 2. — For the determination of the actual mean modulation rate, account is only taken of those significant instants of modulation (or of restitution) which correspond to a change of condition in the same sense as that occurring at the beginning of the start element.

Characteristic distortion

Distortion caused by transients which, as a result of the modulation, are present in the transmission channel and depend on its transmission qualities.

Fortuitous distortion

Distortion resulting from causes generally subject to random laws (accidental irregularities in the operating of the apparatus and of the moving parts, disturbances affecting the transmission channel, etc.).

*Asymmetrical distortion**Bias distortion*

Distortion affecting a two-condition (or binary) modulation (or restitution) in which all the significant intervals corresponding to one of the two significant conditions have longer or shorter durations than the corresponding theoretical durations.

Error rate of a telegraph communication

Ratio of the number of alphabetic signals of a message incorrectly received (after automatic translation, where applicable) to the number of alphabetic signals of the message, the keying being correct.

Note 1. — A telegraph communication may have a different error rate for the two directions of transmission.

Note 2. — The notion of error rate could be applied to any operation taking place in a telegraph communication (e.g. keying, translation, etc.).

Note 3. — The statement of the error rate will be accompanied by that of the time interval, generally limited, during which the observation was made. For a communication established for a sufficiently long time, the probability of exceeding an assigned value of error rate could be considered.

Quality index of a channel or of a telegraph apparatus

— The probability of exceeding an assigned value:

- (a) of the degree of inherent distortion of a channel, or of a section of a channel, or of a telegraph repeater, etc.,
- (b) of the degree of distortion of the modulation produced by an apparatus.

— The probability of the effective margin of a receiving apparatus being less than its nominal margin (or less than a value assigned for the apparatus).

Efficiency factor in time (of a telegraph communication with automatic repetition for the correction of errors)

Ratio of the time necessary to transmit a text automatically without repetition, at a specified modulation rate, to the time actually taken to receive the same text with a given error rate.

Note 1. — The whole of the apparatus comprising the communication is assumed to be in the normal conditions of adjustment and operation.

Note 2. — A telegraph communication may have a different efficiency factor in time for the two directions of transmission.

Note 3. — The actual conditions in which the measurement is made should be specified, in particular the duration of the measurement.

Mutilation

A transmission defect in which a signal element becomes changed from one significant condition to another.

Transposition

A transmission defect in which, during one character period, one or more signal elements are changed from one significant condition to the other, and an equal number of elements are changed in the opposite sense.

RECOMMENDATION No. 246 *

FREQUENCY-SHIFT KEYING

(Question No. 183 (III))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that frequency-shift keying is employed in radio telegraphy in the fixed service and that its use has also been extended to the mobile service;
- (b) that it is desirable to adapt the frequency shift used to the telegraph speed;
- (c) that traffic interruptions should be reduced to a minimum by avoiding frequent changes of the shift employed;
- (d) that it is often necessary to employ the same radio transmitter to work with more than one receiving station;
- (e) that it is desirable to standardize the main operating characteristics of systems employing frequency shift keying;
- (f) that various technical factors influence the choice of operating characteristics in such systems, in particular:
 - the economy of bandwidth and the consequent need to control the shape of the transmitted signals;
 - the signal distortion due to propagation conditions;
 - the instability of the characteristics of certain transmitter and receiver elements (such as oscillators, filters or discriminators); this instability being one of the reasons for the relatively large shift employed in many existing equipments;
- (g) that difficulties can arise from the use of terms "mark" and "space" in the case of teletype circuits and also that the C.C.I.T., at its VIIth Plenary Assembly, issued Recommendation

* This Recommendation replaces Recommendation No. 150.

No. 1.4 introducing new terms; these terms have been published by the I.T.U. in the "List of Definitions of Essential Telecommunication Terms", Part I, June 1957;

UNANIMOUSLY RECOMMENDS

1. that it is too early to standardize the actual values of frequency shift, but that every effort should be made to achieve this as quickly as possible for emissions using only two frequencies; that to assist in this, the characteristics shown below should be used as far as possible;
2. that the value of the frequency shift employed should be the lowest compatible with the maximum telegraph speed regularly used, the propagation conditions and the equipment stability;
3. that for frequency-shift systems working on two conditions only (i.e. single-channel and time-division multiplex systems) and operating between about 3 Mc/s and 30 Mc/s the preferred values of frequency shift are 200 c/s, 400 c/s and 500 c/s *;
4. that the values 140 c/s, 280 c/s and 560 c/s may be used provisionally but 560 c/s should not be adopted for new systems;
5. that the value of the frequency shift should, if possible, be maintained within $\pm 3\%$ of its nominal value and, in any case, within $\pm 10\%$;
6. that for circuits using the Morse code, the higher frequency should correspond to the Mark signal, and the lower frequency should correspond to the Space signal;
- 7.** that for circuits using the International Alphabet No. 2 code with start-stop apparatus, the higher frequency should correspond to the start signal (position A) and the lower frequency to the stop signal (position Z);
- 8.** that, for telex circuits using the International Alphabet No. 2 code directly on the radio circuit, the higher frequency should correspond to the C.C.I.T.T. "free circuit condition" (position A) and the lower frequency to the C.C.I.T.T. "idle-circuit condition" (position Z).
- 9.** that for channels of a 7-unit automatic repetition system, which are referred to in the Annex to Recommendation No. 167 as directly keyed channels (e.g., channel A of a two-channel system), the higher frequency should correspond to the code elements shown as letter A and the lower frequency to the code elements shown as letter Z. For the channels which are to have reversed keying (e.g. channel B of a two-channel system) the higher frequency should correspond to the code elements shown as letter Z and the lower frequency to the code elements shown as letter A.

* For long-distance communication see Question No. 181 (III).

** In those cases where modification of equipment is required, it is recognized that it may take some time before the recommendations of those paragraphs can be implemented on circuits between different Administrations.

RECOMMENDATION No. 247 *

FOUR-FREQUENCY DIPLEX SYSTEMS

(Question No. 183 (III))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that there are in use, in the fixed radiotelegraph services operating between 2 Mc/s and 27 Mc/s, four-frequency diplex (or twinplex) systems in which each of four frequencies is used to transmit one of the four possible combinations of signals corresponding to two telegraph channels; it being understood that either one, or both of the two telegraph channels may be sub-channelled by time-division methods and that the use of such systems may be extended;
- (b) that it is desirable to standardize the main characteristics of four-frequency diplex systems;
- (c) that it may sometimes be necessary to employ the same radio transmitter to work with more than one receiving station;
- (d) that circuit interruptions should be reduced to a minimum by avoiding frequent changes of the spacing between adjacent frequencies and of the correspondence between the frequencies and the significant conditions of the channels;
- (e) that various technical factors influence the choice of operating characteristics in such systems, in particular:
 - economy of bandwidth and the consequent need to control the shape of the transmitted signals;
 - a relatively wide spacing between adjacent frequencies may be necessary for high telegraph speeds;
 - the signal distortion due to propagation conditions;
 - the instability of the characteristics of certain receiver and transmitter elements such as oscillators, filters or discriminators;
- (f) that many existing four-frequency diplex systems each use one of four values of spacing between adjacent frequencies with corresponding telegraph speeds;
- (g) that it is desirable to use only one coding system, the simpler the better.

UNANIMOUSLY RECOMMEND:

1. that the following preferred values shall be adopted for the spacing between adjacent frequencies:

Spacing between adjacent frequencies (c/s)	Nominal telegraph speed of each channel (bauds)
1000	over 300
500 **	200 to 300
400 **	100 to 200
200 or 250	below 100

* This Recommendation replaces Recommendation No. 152.

** Lower telegraph speeds may be used with both these spacings at present.

2. that the following coding system should be adopted: *

Frequency of emission	Channel 1		Channel 2	
	Teleprinter	Morse	Teleprinter	Morse
f_4 (highest frequency)	A	Mark	A	Mark
f_3	A	Mark	Z	Space
f_2	Z	Space	A	Mark
f_1 (lowest frequency)	Z	Space	Z	Space

where f_1, f_2, f_3, f_4 designate the frequencies of the emissions; the spacings between adjacent frequencies, $(f_4 - f_3), (f_3 - f_2), (f_2 - f_1)$ being equal.

A represents the start signal of the teleprinter.

Z represents the stop signal of the teleprinter.

3. that the value of the frequency separation between adjacent frequencies employed should be the lowest of the preferred values compatible with the maximum telegraph speeds regularly used, the propagation conditions and the equipment stability;
4. that in cases where the two channels are not synchronised it is desirable to limit the maximum rate of change of frequency in order to minimise the bandwidth of the emission;
5. that in order to designate this type of emission, the classification F6 may be used provisionally.

RECOMMENDATION No. 248 **

CLASSIFICATION OF MULTICHANNEL RADIO-TELEGRAPH SYSTEMS FOR LONG-RANGE CIRCUITS OPERATING ON FREQUENCIES BELOW 30 Mc/s AND DESIGNATION OF THE CHANNELS IN THESE SYSTEMS

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that there exists a large number of long-range multichannel radiotelegraph systems using frequencies below about 30 Mc/s and that it is desirable to classify them in categories;
- (b) that the lack of uniformity in the arrangement and designation of the channels in these systems may give rise to certain difficulties when one transmitting station has to work with several receiving stations;
- (c) that the increasing use of multichannel telegraph systems makes it desirable to adopt a uniform designation of channels in such systems;

* In those cases where modification of equipment is required, it is recognized that it may take some time before the coding systems indicated in this paragraph can be implemented on circuits between different Administrations.

** This Recommendation replaces Recommendation No. 153 and Report No. 39.

UNANIMOUSLY RECOMMENDS

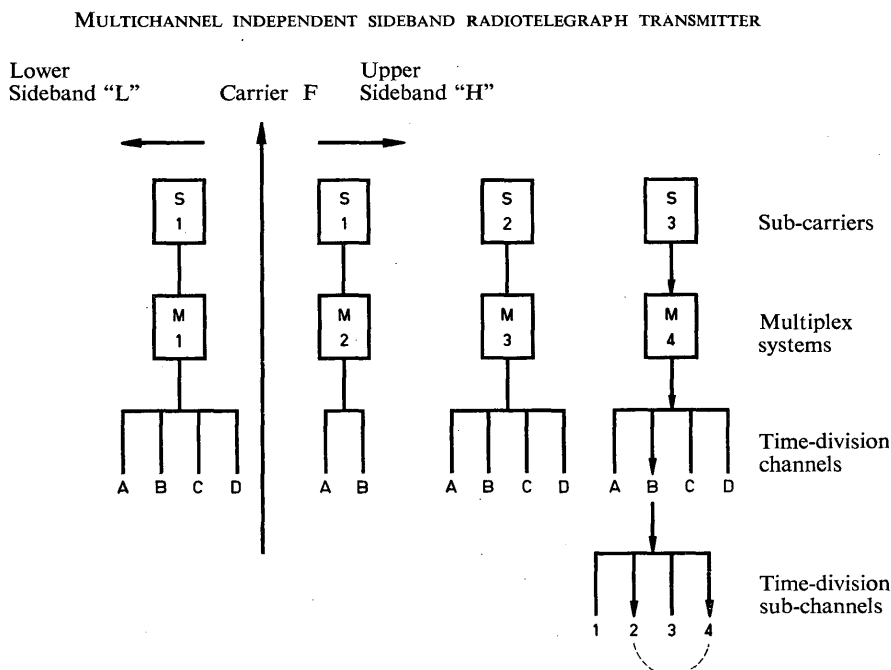
1. that the systems should be classified, and the different categories designated by letters, as follows:
 - 1.1 Time-division multiplex systems: Capital letter T
(For example, synchronous systems, such as Baudot, RCA and TOR Multiplex and Double current cable code)
 - 1.2 *Frequency-division multiplex systems*:
 - 1.2.1 Systems with *constant* frequency arrangements of significant conditions: Capital letter U
(For example: Voice frequency multiplex with frequency shift)
 - 1.2.2 Systems with *variable* frequency arrangements of significant conditions: Capital letter V
(For example: Four-frequency diplex)
 - 1.3 *Multichannel systems using a combination of these processes*:
 - 1.3.1 Frequency-division systems, with constant frequency arrangement, combined with a time-division multiplex combination of the above-mentioned letters (always beginning with the frequency division letters U or V)
 - 1.3.2 Four-frequency diplex system combined with a time-division multiplex system
2. when a multichannel telegraph signal is applied to a multichannel telephone transmitter the designation of the telephone channel should come first in the sequence and should be in accordance with Recommendation No. 249;
3. when a multichannel telegraph signal is applied to an independent sideband transmitter used solely for telegraphy, the designation of the sideband should come first in the sequence. The letter H shall denote the upper sideband, and the letter L the lower sideband;
4. that in time-division systems the telegraph channels should be designated by capital letters A, B, C, D, etc.; in the case of sub-division, the sub-channels should be designated by A1, A2, A3, A4, B1, B2, B3, B4, etc.;
5. that in frequency-division systems the telegraph channels should be designated by figures;
6. that in a combination of multichannel processes the telegraph channels should be designated by a letter and figure sequence.

For example :

When using a frequency-division system with constant frequency arrangement of significant conditions (letter U), and modulating the 3rd channel of this latter system with a time-division multiplex (letter T), channel B of this latter system would be indicated by "U3TB";

- where channel B of the time-division system is sub-divided and sub-channel 2 is in use, the designation would be "U3TB2";
- if the above-mentioned system is applied to channel B of an independent-sideband telephone transmitter, the corresponding designation would be "BU3TB" or "BU3TB2";
- if the above-mentioned system is applied to the upper sideband of an independent sideband multichannel transmitter used solely for telegraphy, the corresponding designations would be "HU3TB" or "HU3TB2";
- where additional information is required, the multiplex system may be identified by a number inserted between the letters T and B, and where two sub-channels (quarter-channels) are linker together to form a half-speed sub-channel (half-channel), each

quarter-speed sub-channel component may be designated by the use of numbers separated by an oblique stroke. The full designation "HU3T4B2/4" would be applicable to the arrangement shown diagrammatically by the arrows on the right of the figure below.



Note. — Sub-carriers are numbered sequentially in both upper and lower sidebands, starting with the number 1, adjacent to the carrier (radiated or suppressed).

RECOMMENDATION No. 249 *

ARRANGEMENT OF CHANNELS IN MULTI-CHANNEL RADIOTELEPHONE TRANSMITTERS FOR LONG-RANGE CIRCUITS OPERATING ON FREQUENCIES BELOW ABOUT 30 Mc/s

(Question No. 74 (III))

The C.C.I.R.,

(London, 1953 — Warsaw, 1956)

CONSIDERING

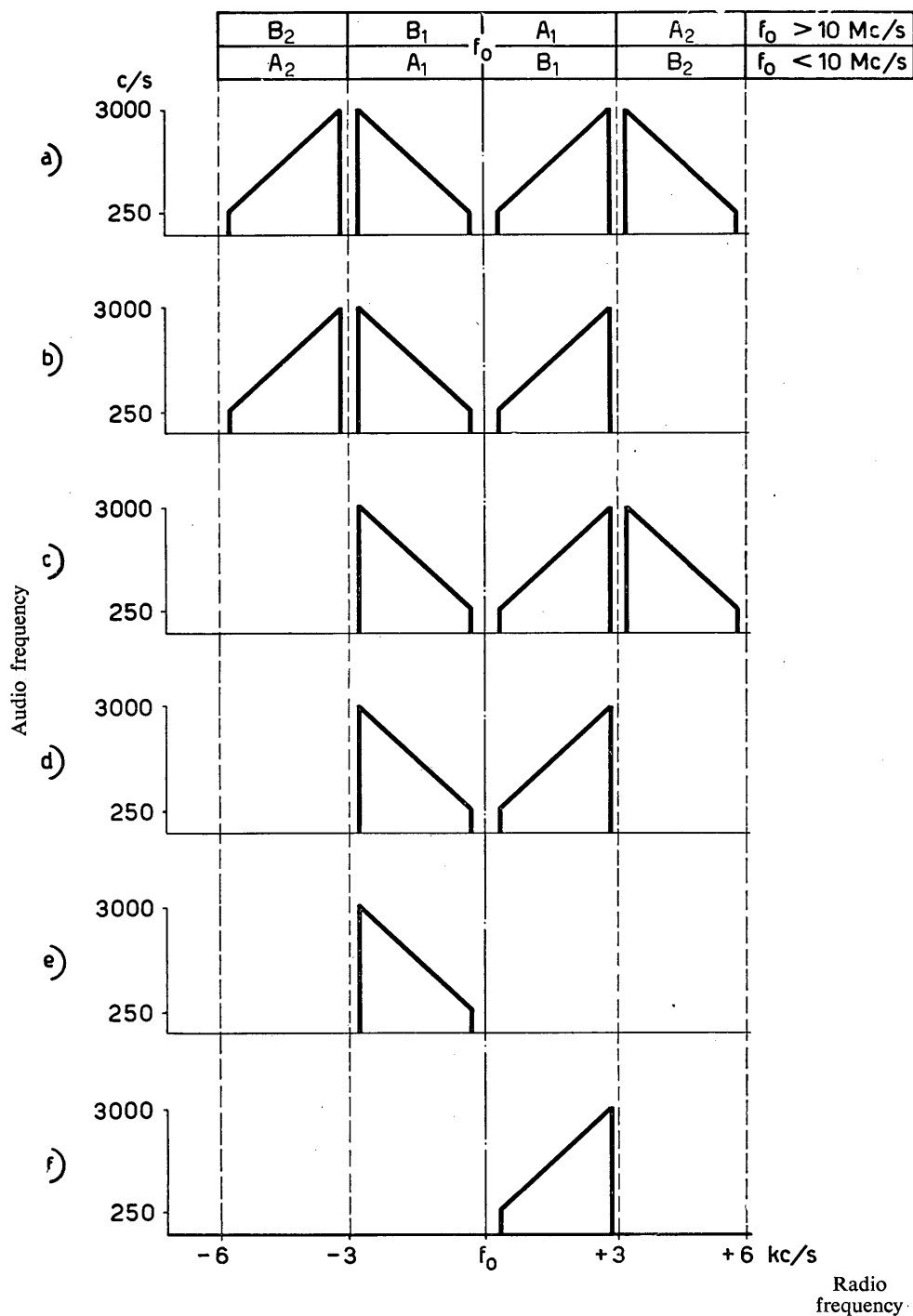
- (a) that the lack of uniformity in the arrangement and designation of the channels in multi-channel transmitters for long-range circuits operating on frequencies below about 30 Mc/s may give rise to certain difficulties when one transmitting station has to work with several receiving stations;

* This Recommendation replaces Recommendation No. 149.

- (b) that, since it is necessary to economize in the use of the radio spectrum when considering inter-continental circuits consisting mainly of single long-distance radio links operating on frequencies less than 30 Mc/s, it is desirable:
 - to use independent-sideband transmissions to the maximum extent possible;
 - to transmit a band less than the 300 to 3400 c/s recommended by the C.C.I.F. for land-line circuits;
 - to reduce the upper frequency to 3000 c/s or less but not below 2600 c/s, except in special circumstances;
- (c) that there are already in operation international multichannel radiotelephone circuits in which the bandwidth allocated to each channel is 3000 c/s actually transmitting a speech band of 250 to 3000 c/s;
- (d) that, in general, the outer channels are liable to cause and receive more interference to and from stations operating on adjacent assigned frequencies; the outer channels being those located furthest from the assigned frequency;
- (e) that there are numerous transmitters in service which, when operated on a twin-channel basis, give rise to excessive cross-talk unless one of the channels is placed away from the carrier;
- (f) that there are transmitters in service which permit the addition of a third channel when it is desired to provide additional traffic capacity;
- (g) that there may be advantages in adopting channel arrangements which are the same in all parts of the frequency range from 3 to 30 Mc/s.

UNANIMOUSLY RECOMMENDS

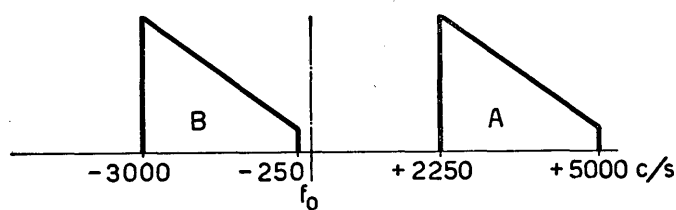
1. that standard channel arrangements should be adopted for multi-channel radiotelephone systems;
2. that the effective speech channel allocation should be 3000 c/s;
3. that the transmitted band in each speech channel should be from 250 to 3000 c/s;
4. that in four-channel systems the channel arrangement should be as shown in Fig. 1 (a);
5. that in four-channel systems the channel designation should be as shown in the upper part of the Table when the reference frequency f_o corresponding to the reduced carrier is above 10 Mc/s and in the lower part when f_o is below 10 Mc/s. The same table should be used when less than four channels are employed;
6. that when less than four channels are used the channels nearest to the carrier should be selected according to the arrangements shown in Figs. 1 (b), (c), (d), (e) or (f);
7. that with some transmitters in service, which do not give satisfactory operation with the arrangement shown in Fig. 1 (d), a channelling arrangement such as that shown in Fig. 2 may be used to minimize cross-talk;
8. that with some transmitters in service, which do not give satisfactory operation with the arrangements shown in Figs. 1 (b) or 1 (c), a third channel may be provided as shown in Fig. 3;
9. that, wherever practicable, new transmitters should be designed to maintain the same channel arrangements throughout their frequency range.



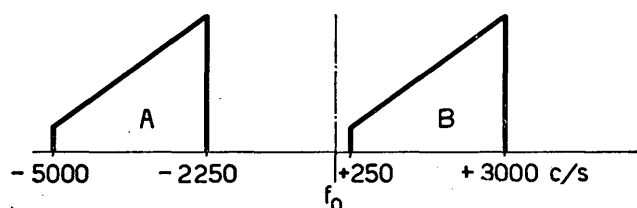
These figures represent the relationship between the audio frequencies and the radio frequencies for the various channel arrangements

FIGURE 1

C

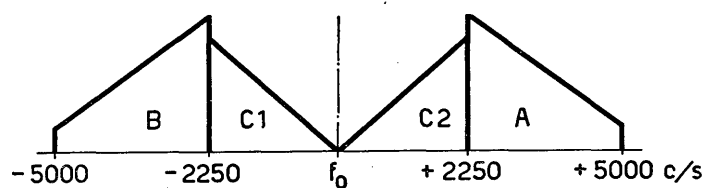


Reference frequency above 10 Mc/s

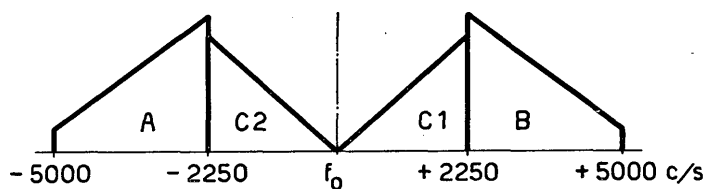


Reference frequency below 10 Mc/s

FIGURE 2



Reference frequency above 10 Mc/s



Reference frequency below 10 Mc/s

It is necessary that the subdivision of channel C into two parts C1 and C2 as well as the arrangement of these parts should be agreed upon by operating organizations

FIGURE 3

Section D

MOBILE SERVICES AND SPACE SYSTEMS

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The following Recommendation, which has been classified in another section also concerns Mobile Services:

Rec. No.	Section
323	J



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RECOMMENDATION No. 45

**AVOIDANCE OF INTERFERENCE FROM SHIPS' RADAR
TO OTHER RADIOCOMMUNICATION APPARATUS ON BOARD**

(Question No. 35)

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that experience has proved that with well-designed and properly installed radar the possibility of interference occurring in practice is very remote;
- (b) that the possibility of interference to radio reception and to direction finding on a vessel other than that upon which the radar is located is exceedingly remote and that no instances of such interference have been reported.
- (c) that in the unlikely case where radar interference might result to radio reception aboard a radar equipped vessel, the presence of such interference may be readily detected and identified by listening on the radio receiver or direction finder;
- (d) that where interference has occurred to radio reception aboard ships equipped with well designed radar, in each case the cause of the interference has been faulty initial installation and has been removed by correcting the installation;

UNANIMOUSLY RECOMMENDS

1. that administrations shall see to it that radar equipments placed aboard ships are well designed and properly installed so as not to cause interference to radio reception aboard the radar equipped vessel. In this regard, particular attention shall be paid to shielding, bonding and to fitting line filters, especially in the modulator circuits, for the conductors which are routed between the major components of the installation;
2. that the absence of interference shall be assured either by test procedures of prototypes or by installation inspection procedures whereby an investigation is made to determine whether or not there exists any noticeable interference to ships' radio receivers or direction finders under practical conditions of installation and operation.

RECOMMENDATION No. 76

**VOICE-OPERATED DEVICES FOR SHIP STATIONS
AND CARRIER-OPERATED DEVICES FOR SHORE STATIONS**

(Question No. 32)

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that the essential characteristics of the devices controlled by voice currents and acting on the carrier wave in radiotelephone stations on board ships and of the carrier-operated devices in receivers of coast stations are their "operate" and "release" times;

- (b) that the operate times of the devices should be short to minimize clipping, and their release times should be sufficiently long to enable the devices to remain operated in the intervals between words in normal speech;

UNANIMOUSLY RECOMMENDS

1. that the operate and release times of the voice-operated carrier switching unit on the ship should be as follows:

Input level (Note 1)	Net operate time (Note 2)	Net release time (Note 3)
—30 db	less than 25 ms	between 75 and 170 ms
—20 db	less than 15 ms	between 75 and 170 ms

2. that the operate time (Note 4) of the carrier-operated device in the coast station receiver should be as short as practicable to allow somewhat longer operate times in the ship's apparatus and should not exceed 5 milliseconds when the carrier level at the input to the receiver is more than 1 db above the level just necessary to operate the device. The required value of release time (Note 5) is dependent on several factors, including the time constants of the automatic gain control of the radio receiver and a value between 10 and 50 milliseconds is generally suitable.

Note 1. — *Input level* refers to the level of a test sinusoidal signal of frequency corresponding to the middle of the voice-frequency range relative to that producing 100% modulation.

Note 2. — *Net operate time* is the time which elapses between the instant the test signal is applied to the input to the modulator of the transmitter, and the instant when the carrier reaches 50% of its maximum amplitude.

Note 3. — *Net release time* is the time which elapses between the instant when the test signal is disconnected and the instant the carrier is reduced to within 5 db of the maximum carrier suppression achieved.

Note 4. — *Operate time* of the carrier-operated device is the time which elapses between the sudden application of a test signal simulating the carrier wave from the ship and the instant of opening of the receiving channel (the instant when the attenuation of the receiving channel is within 5 db of the final value of attenuation for the receiving condition).

Note 5. — *Release time* of the carrier-operated device is the time which elapses between the cessation of a test signal simulating the carrier wave from the ship and the instant of blocking of the receiving channel (the instant when the attenuation of the receiving channel is within 5 db of the final value of attenuation in the blocked condition).

RECOMMENDATION No. 77 *

**CONDITIONS NECESSARY FOR INTERCONNECTION
OF MOBILE RADIOTELEPHONE STATIONS
(FOR INSTANCE, AUTOMOBILES, AIRCRAFT AND SHIPS)
AND INTERNATIONAL TELEPHONE LINES**

(Question No. 33)

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that the conditions concerning which international agreement is necessary appear to be few in number;

* The Roumanian P.R. reserved its opinion on its Recommendation.

- (b) that these conditions, if met, would permit suitable interconnection between mobile radiotelephone stations and international telephone lines;

RECOMMENDS

1. that mobile radiotelephone circuits, intended for connection to international telephone systems, should terminate (on a two-wire basis, for the present at least) in such a way that they may be connected to international lines in the same manner as other land-line connections;
2. that the mobile radiotelephone circuits should accept from and deliver to the land-line system, speech volumes conforming, as far as possible, to the C.C.I.R. and C.C.I.T.T. standards for connections to international circuits;
3. that the attenuation-frequency characteristics of the radio system (including the land-lines to the radio receiver and radio transmitter) should be such that the grade of transmission is not unduly affected; and in particular, the effectively transmitted band should be not less than 300 to 2600 c/s;
4. that the noise from a radio circuit connected to an international circuit should not be unduly great and should be insufficient to operate echo suppressors or other devices on domestic or international circuits frequently;
5. that for mobile radiotelephone stations which may have to communicate with land stations in more than one country, consideration be given to the necessity for agreement as to a method of signalling for use between the land mobile stations.

D

RECOMMENDATION No. 124 *

WATCH ON THE RADIOTELEPHONY DISTRESS FREQUENCY OF 2182 kc/s

(Questions Nos. 56 & 57)

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that, according to Atlantic City Radio Regulations No. 815, the frequency of 2182 kc/s may be used for calls and replies, and is the frequency to be used for the distress call and traffic, as well as for urgency and safety signals and messages;
- (b) that there is, as yet, little experience of the world-wide use of a common frequency for calling and distress in the MF (hectometric) maritime radiotelephony service;
- (c) that in certain area distress calls at times suffer interference from traffic calls and replies;
- (d) that certain countries use frequencies other than 2182 kc/s, especially working frequencies, for normal traffic calling and replies, in accordance with Radio Regulations No. 817;
- (e) that, nevertheless, the exclusive use of the frequency of 2182 kc/s for distress purposes would militate against extensive watch-keeping on this frequency by ships;

* This Recommendation concludes the study of Question No. 57.

- (f) that the use of an alarm signal with strongly distinctive characteristics would facilitate the reception of distress calls in ships and coast stations carrying out aural watch as well as in those stations fitted with automatic alarms;
- (g) that a loudspeaker distress watch in ships not fitted with automatic alarms would increase the efficiency of the distress watch;

UNANIMOUSLY RECOMMENDS

1. that an alarm signal of the type specified in Recommendation No. 219 should be adopted by all administrations and brought into use at an early date;
2. that administrations should encourage the keeping of a loudspeaker watch on the calling and distress frequency of 2182 kc/s on board those of their ships which are not fitted with automatic alarm receiving equipment for that frequency; nevertheless the automatic or aural watch for the alarm signal on the distress frequency of 2182 kc/s need be encouraged only on ships not fitted with radiotelegraph equipment in the 500 kc/s band;
3. that administrations should take special steps to enforce respect for the Radio Regulations (especially Nos. 815 and 816) regarding the use of the calling and distress frequency of 2182 kc/s;
4. that administrations should maintain observations over a sufficient period to determine whether there is a need to change the Radio Regulations regarding the use of the international calling and distress frequency of 2182 kc/s;
5. that the results of such observations should be submitted directly by administrations to an appropriate administrative conference.

RECOMMENDATION No. 126 *

PULSE TRANSMISSION FOR RADIO DIRECTION FINDING

(Question No. 61)

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that certain studies, extending over many years, of the errors of direction finders show that, under ideal conditions of site, equipment and operation, the use of pulse transmissions offers only a slight improvement in accuracy over the use of continuous-wave transmissions;
- (b) that, in practice, unavoidable departures from the ideal conditions referred to in (a) would tend to reduce this improvement in accuracy;
- (c) that, for reasons of interference, their wide bandwidths make the use of pulse transmissions on frequencies below 20 000 kc/s generally undesirable;

UNANIMOUSLY RECOMMENDS

that the foregoing considerations should be brought to the notice of the administrations and other organisations concerned.

* This Recommendation completes the study of Question No. 61.

ANNEX

The following errors in high-frequency direction finding can occur:

1. observational errors introduced by the operator;
2. instrumental errors, including polarization errors and those due to deficiencies of the direction-finder site;
3. errors due to radiation scattered from topographical features many wavelengths distant from the direction finder;
4. errors due to lateral deviation in the ionosphere;
5. errors due to wave interference caused by convergence of rays and by different modes of propagation.

The advantage of a pulse emission over a continuous-wave emission lies in its ability to allow signals arriving over different paths to be separated, and so to reduce errors arising from sources 4 and 5 above.

The degree of accuracy to be expected from the use of pulse emissions for radio direction finding has been studied, and it is estimated that in most favourable circumstances, for a frequency of about 8000 kc/s, the standard deviation of a single rapidly observed bearing might be about 3 degrees for a continuous-wave emission and about 2 degrees for a pulse emission. The corresponding figures for the mean of ten such bearings taken in a period of five minutes are: continuous-wave 2.5 degrees, pulse 1.7 degrees.

RECOMMENDATION No. 218 *

PREVENTION OF INTERFERENCE TO RADIO RECEPTION ON SHIPS **

(Question No. 34)

The C.C.I.R.,

(Geneva, 1951 — Warsaw, 1956)

CONSIDERING

- (a) that the Maritime Regional Radio Conference, Copenhagen (1948), recommended that the C.C.I.R. study the question of interference to radio reception caused by electrical installations on board ship;
- (b) that the Safety of Life at Sea Conference, London (1948), requested that all steps be taken to eliminate as far as possible the causes of radio interference from electrical and other apparatus on board ship;
- (c) that electrical interference is caused by the unwanted excitation of the radio receiving equipment, including the aerial, by fluctuating electromagnetic fields set up by other electrical installations;
- (d) that the fluctuation of electromagnetic fields which gives rise to interference is caused by abrupt changes in current in the source of interference, and by abrupt changes in the resistance of conductors situated in electromagnetic fields;
- (e) that electrical interference may be transmitted by direct radiation and induction from the source of interference itself, and also by re-radiation and induction from conductors which carry interfering currents;

* This Recommendation replaces Recommendation No. 78.

** Interference from radar and other electronic equipment has not been specifically considered in framing this Recommendation. The prevention of radar interference is covered by Recommendation No. 45.

UNANIMOUSLY RECOMMENDS

1. that the design, construction and installation of electrical equipment in ships should be such that interference is minimised at its source;
2. that electrical equipment installed in ships should be efficiently maintained to prevent any increase in the level of interference which it causes;
3. that aerials used for transmission or reception should be erected as far above and as far away as possible from electrical machinery and from parts of the ship's structure such as funnels, stays and shrouds;
4. that the down-leads of aerials which are used exclusively for reception should be screened; that the screen should extend continuously from the receiver to a point which is as high as practicable above the ship's structure, and that the screen should be effectively connected to the earth terminal of the receiver;
5. that frame or loop aerials used for direction finding should be effectively screened against electrostatic interference;
6. that the radio receiving room should be effectively screened and situated as high as practicable in the ship;
7. that power converting plant within the radio receiving room should be housed in a separate screened enclosure, unless the plant is self-screened;
8. that the radio receiving equipment should be designed so that it is effectively screened;
9. that suppressor filters to prevent the propagation of interference should be fitted at the sources of interference, preferably built into the interference-producing equipment, and that in particular:
 - 9.1 The electrical ignition systems of internal combustion engines, including those which may be installed in lifeboats, should be fitted with suppressors;
 - 9.2 The navigational instruments and associated equipment which are installed in the neighbourhood of the receiving aerials or the radio receiving room should, if necessary, be fitted with suppressors, be screened, and the screen effectively earthed;
10. that cables in the vicinity of the receiving aerials or the radio receiving room, and cables within the radio room, should be screened by enclosing them in metal conduits, unless the cables themselves are effectively screened;
11. that twin cables should be used wherever possible: if single-core cable is necessary, the "lead" and "return" conductors should be fixed as close to one another as possible to avoid the formation of loops;
12. that suppressors should be fitted to cables at their point of entry into the radio receiving room, unless they terminate close to the point of entry in equipment which itself provides adequate screening and suppression;
13. that cables, ducts and pipes which do not terminate in the radio receiving room, should preferably not be installed in the radio receiving room; if it is essential for them to pass through the radio receiving room, the ducts and pipes and the screening of the cables should be effectively earthed;
14. that a copper earth-busbar should be fixed along the bulkheads and bonded at several points to the ship's structure and to the metal structure or screening of the radio receiving room; the screens of cables within and near to the radio receiving room, as well as the screens of apparatus in the radio receiving room, should be effectively connected to the busbar;
15. that rigging should be either insulated from or bonded to the ship's structure (stays that are subject to considerable tension can more conveniently be bonded);
16. that in the case of smaller vessels and those constructed of wood the principles recommended should be applied as far as is practicable;

17. that particular care should be taken to minimize interference on the frequency bands used for distress, safety and direction finding in the maritime service;
18. that administrations should bring the above recommendations to the attention of naval architects, shipbuilders and those responsible for the manufacture, installation and maintenance of electrical equipment.

RECOMMENDATION No. 219 *

ALARM SIGNAL FOR USE ON THE MARITIME RADIOTELEPHONY DISTRESS FREQUENCY OF 2182 kc/s

The C.C.I.R.,

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

- (a) that it is desirable and practicable to establish an internationally agreed alarm signal for use on the calling and distress frequency of 2182 kc/s;
- (b) that the alarm signal should be such as to:
 - provide reliable operation of automatic alarm equipment;
 - provide a distinctive signal which is readily recognised aurally when received on a loud-speaker or headphones;
 - be capable of being received through interference from speech transmissions, through other kinds of interference, and through noise;
 - avoid false responses when received either aurally or by automatic means;
 - be capable of being produced by a simple manual device, as well as by automatic means;
- (c) that the alarm signal should be such as to permit the construction of an alarm equipment which is rugged, dependable, stable in performance, of low cost, of easy production, of long life with a minimum of maintenance, and which can be used with existing maritime radio-telephone equipment;
- (d) that to help in clearing the calling and distress frequency channel of emissions from other stations the alarm signal and detecting device should be effective beyond the range at which speech transmission is satisfactory;
- (e) that the automatic alarm equipment should be capable of operating in as short a time as possible, consistent with the avoidance of false responses;
- (f) that the results of the further examination of this problem by the administrations which participated in Study Programme No. 29 (Geneva, 1951) are sufficiently conclusive to determine the essential characteristics of the signal including tolerances that should be recommended for international adoption;
- (g) that it is possible to specify the minimum performance standards for automatic alarm equipment, for both transmission and reception, to such an extent that future progress and development are not hampered;
- (h) that it is undesirable that the specification of performance standards for automatic alarm equipment should exceed in scope the requirements already established by international

* This Recommendation replaces Recommendation No. 125.

agreement for automatic alarm devices intended for the reception of the international alarm signal or the international distress signal in radio telegraphy, normally transmitted on the frequency 500 kc/s (Art. 37, § 31, 32, 33, International Radio Regulations, Atlantic City, 1947; and Chap. IV, Regulation 11, Convention for Safety of Life at Sea, London, 1948);

UNANIMOUSLY RECOMMENDS

1. that the alarm signal described below should be adopted internationally for use on the maritime radiotelephony calling and distress frequency of 2182 kc/s;
 - 1.1 the alarm signal shall consist of two substantially sinusoidal audio-frequency tones, transmitted alternately for a minimum period of 6 seconds. One tone shall have a frequency of 2200 c/s and the other a frequency of 1300 c/s. The duration of each tone shall be 250 milliseconds;
 - 1.2 the tolerance of the frequency of each tone shall be $\pm 1.5\%$; the tolerance on the duration of each tone shall be ± 50 milliseconds; the interval between successive tones shall not exceed 50 milliseconds; the ratio of the amplitude of the stronger tone to that of the weaker shall be within the range 1 to 1.2;
 - 1.3 when generated by automatic means, the alarm signal shall be sent continuously for a period of at least 30 seconds but not exceeding one minute; when generated by other means, the signal shall be sent as continuously as practicable over a period of approximately one minute;
 2. that the automatic devices intended for the reception of the alarm signal in question should fulfill the following conditions:
 - 2.1 the frequencies of maximum response of the tuned circuits, and other tone-selecting devices, shall be subject to a tolerance of $\pm 1.5\%$ in each instance; and the response shall not fall below 50% of the maximum response for frequencies within 3% of the frequency of maximum response;
 - 2.2 in the absence of noise and interference, the automatic receiving equipment shall be capable of operating from the alarm signal in a period of not less than four and not more than six seconds;
 - 2.3 the automatic receiving equipment shall respond to the alarm signal under conditions of intermittent interference caused by atmospherics and powerful signals other than the alarm signal, preferably without any manual adjustment being required during any period of watch maintained by the equipment;
 - 2.4 the equipment shall not be actuated by atmospherics or by strong signals other than the alarm signal;
 3. that the automatic alarm equipments, for both transmission and reception on the calling and distress frequency of 2182 kc/s, shall fulfill the following conditions:
 - 3.1 the equipment shall be effective beyond the range at which speech transmission is satisfactory;
 - 3.2 the equipments shall be capable of withstanding vibration, humidity, changes of temperature and variations in power supply voltage equivalent to the severe conditions experienced on board ships at sea, and shall continue to operate under such conditions;
 - 3.3 the equipment should as far as practicable give warning of faults that would prevent the apparatus from performing its normal functions during watch hours;
 4. that before any type of automatic alarm equipment for transmission and reception on the calling and distress frequency of 2182 kc/s is approved for use on ships, the administrations having jurisdiction over those ships should be satisfied by practical tests, made under operating conditions equivalent to those obtaining in practice, that the equipment complies with the provisions of § 1, 2 and 3 of this Recommendation.
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RECOMMENDATION No. 222

INTER-SHIP RADAR IDENTIFICATION

(Question No. 158 (XIII))

The C.C.I.R.,

(Warsaw, 1956)

CONSIDERING

- (a) that the operational requirements to be met by any inter-ship radar identification device should be formulated by the responsible shipping and administrative authorities;
- (b) that no internationally agreed requirement was indicated by the last Safety of Life at Sea conference, London, 1948, nor by the last international meeting on Radio Aids to Marine Navigation, New York, 1947;
- (c) that, before a final recommendation can be made by the C.C.I.R. it is most desirable for the operational requirements to be agreed internationally;
- (d) that it may be of assistance to the shipping and administrative authorities concerned to be advised of the work that has been done on this form of identification by the C.C.I.R.;
- (e) that the operational uses which may be made of these identification devices may have repercussions on the current Regulations for Preventing Collisions at Sea and may also raise new legal problems;

UNANIMOUSLY RECOMMENDS

1. that administrations should consult their responsible shipping and administrative authorities to determine whether there is an operational need for the development of inter-ship radar identification devices; that if there is such a need, then steps should be taken to reach international agreement on the navigational requirements that should be met by inter-ship radar identification devices; and that the responsible authorities should be informed of the work that has already been carried out by the C.C.I.R. and which is described in Documents No. 53 and No. 71 (Warsaw) and summarised in Report No. 92;
2. that in the interval the general study of marine radar identification should be continued (see Question No. 158 (XIII)), subject to review after the international navigational requirement has been clarified.

RECOMMENDATION No. 224 *

**TESTING OF 500 kc/s RADIOTELEGRAPH AUTO-ALARM
RECEIVING EQUIPMENT ON BOARD SHIPS**

(Question No. 108)

The C.C.I.R.,

(Warsaw, 1956)

CONSIDERING

that it is important for the safety of life at sea that radiotelegraph auto-alarm receiving installations (including the aerial) are always in good working order on board ships at sea;

* This Recommendation concludes the study of Question No. 108.

UNANIMOUSLY RECOMMENDS

in addition to the requirements of chapter IV of the International Convention for the Safety of Life at Sea (London, 1948):

1. that all radiotelegraph auto-alarm receiving equipments for use on the international calling and distress frequency of 500 kc/s should, wherever practicable, be provided specifically with means for automatic warning of the following:
 - 1.1 failure of any valve filament, whether the cathode is directly or indirectly heated;
 - 1.2 major variation or sustained failure of any source of voltage which is used for supplying valve elements where this would seriously affect the proper functioning of the apparatus as laid down in Chapter IV, Regulation No. 11 of the said Convention;
 - 1.3 any drop in voltage, or complete failure, of the main power supply to the auto-alarm equipment that would seriously affect the proper functioning of the equipment and where such warning is not already given by other means;
2. that provision should be made for listening to the output of the auto-alarm receiver;
3. that the proper functioning of auto-alarm installations should be checked periodically by listening to signals on the auto-alarm receiver, with its normal aerial connected, and by observing similar signals received on 500 kc/s on the ship's main receiving installations;
4. that measures should be taken to ensure that the auto-alarm aerial is always in good condition;
5. that the design of auto-alarm equipment should be as simple as possible consistent with reliable and efficient operation;
6. that wherever practicable, measures should be taken to permit reception on the auto-alarm installation when the radio direction finder is being used;
7. that live test transmissions of the radiotelegraph auto-alarm signal should *not* be made.

RECOMMENDATION No. 250 *

SIGNALS "MAYDAY" AND "PAN"

The C.C.I.R.,

(Stockholm, 1948 — Los Angeles, 1959)

CONSIDERING

that the results of further tests carried out by administrations and the discussions thereon relating to the question of changing the radio telephone distress signal MAYDAY and the radio telephone urgency signal PAN indicate that insufficient advantage would result from the proposed use of SOS instead of MAYDAY and URGENT instead of PAN to justify making a change to the Radio Regulations;

UNANIMOUSLY RECOMMENDS

that the present radio telephone distress signal MAYDAY and the radio telephone urgency signal PAN be retained.

* This Recommendation replaces Recommendation No. 23.

RECOMMENDATION No. 251 *

ADDITION TO APPENDIX 9 OF THE RADIO REGULATIONS

(Question No. 28)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that a code should not be inserted in the Radio Regulations unless it provides a sufficiently accurate assessment of the quality of transmissions;
- (b) that it would be advisable for all the administrations to use the same codes, and that the number of officially recognised codes must consequently be as restricted as possible;
- (c) that the abbreviations in the Q code are in general inadequate for obtaining a clear idea of the quality of a transmission;
- (d) that the SINPO code has been used for several years by some administrations;
- (e) that the FRAME and RAFISBENQO codes have been used for a long time but:
 - the SINPO code gives a more accurate description of the transmission quality than the FRAME code and is easier to use;
 - the SINPFEMO code is derived from the SINPO code by adding three letters relating to special features of telephone transmissions and is easier to use than the RAFISBENQO or RISAFMONE code;
- (f) that the information which is not included in the SINPO or SINPFEMO code may be transmitted satisfactorily by service message;

UNANIMOUSLY RECOMMENDS

1. that the SINPO and SINPFEMO codes described in the Annex should be included in the Radio Regulations;
2. that, in the meantime, these signal codes may be placed in service by interested operating agencies or administrations at the earliest time that may be mutually arranged between them. In this respect, the Secretary General is asked to circularise all administrations to know if they are prepared to apply these codes by 1st January, 1952.

Special remarks

- A signal report shall consist of the code word SINPO or SINPFEMO followed by a five or eight figure group respectively rating the five or eight characteristics of the signal code.
- The letter X shall be used instead of a numeral for characteristics not rated.
- Although the code word SINPFEMO is intended for telephony, either code word may be used for telegraphy or telephony as may be desired.
- The overall rating for telegraphy shall be as indicated in tables I and II.

Note. — It is recommended that the figure P appearing in the Table in the Annex should be used only if it is quite certain that the insufficient intensity of the signal has been caused by a propagation disturbance in the circuit for which the quality report is being made. This could apply, for example, in the following cases:

- for a circuit which is operated every day at a given time, if it is noted that the receiving and transmitting apparatus is in normal condition and that for normal ionospheric conditions, the transmission frequency does not exceed the maximum usable frequency (MUF) or is not close to the lowest usable high frequency (LUHF).

* This Recommendation replaces Recommendation No. 221.

D

In this case, it is desirable to assess the degree of disturbance by the decrease in signal strength as compared with normal propagation conditions.

- for a single observation of a circuit, if it is quite certain that, at a given moment in a given place, there is ionospheric propagation disturbance affecting all circuits in the frequency range which also contains the transmission frequency.

In this case, it is desirable to assess the degree of disturbance by the decrease in signal strength with respect to normal propagation on a regularly observed circuit following the same path approximately.

A report on ionospheric propagation disturbance should not be formulated simply because the disturbance information service has predicted a disturbance for the period in question, or because a disturbance has been noted on another circuit or in a different frequency range. In this case, the letter X is used.

TABLE I

	Mechanised Operation
5 Excellent	4-channel time-division multiplex
4 Good	2-channel time-division multiplex
3 Fair	Marginal single start-stop printer
2 Poor	BK's, XQ's and call signs readable
1 Unusable	Unreadable

TABLE II

	Morse Operation
5 Excellent	High speed
4 Good	100 wpm
3 Fair	50 wpm
2 Poor	BK's, XQ's and call signs readable
1 Unusable	Unreadable

- The overall rating for telephony shall be as indicated in Table III.

TABLE III

	Operating condition	Quality
5 Excellent	Signal quality unaffected	} Commercial
4 Good	Signal quality slightly affected	
3 Fair	Signal quality seriously affected. Channel usable by operators or by experienced subscribers	} Marginally commercial
2 Poor	Channel just usable by operators	
1 Unusable	Channel unusable by operators	} Not commercial

ANNEX
SINPO SIGNAL REPORTING CODE

Rating scale	S	I	N	P	O
	Signal strength	Degrading effect of			Overall readability (QRK)
		Interference (QRM)	Noise (QRN)	Propagation disturbance	
5	Excellent	Nil	Nil	Nil	Excellent
4	Good	Slight	Slight	Slight	Good
3	Fair	Moderate	Moderate	Moderate	Fair
2	Poor	Severe	Severe	Severe	Poor
1	Barely audible	Extreme	Extreme	Extreme	Unusable

SINPFEMO SIGNAL REPORTING CODE

Rating scale	S	I	N	P	F	E	M	O
	Signal strength	Degrading effect of			Frequency of fading	Modulation		Overall rating
		Interference (QRM)	Noise (QRN)	Propagation disturbance		Quality	Depth	
5	Excellent	Nil	Nil	Nil	Nil	Excellent	Maximum	Excellent
4	Good	Slight	Slight	Slight	Slow	Good	Good	Good
3	Fair	Moderate	Moderate	Moderate	Moderate	Fair	Fair	Fair
2	Poor	Severe	Severe	Severe	Fast	Poor	Poor or nil	Poor
1	Barely audible	Extreme	Extreme	Extreme	Very fast	Very poor	Continuously over-modulated	Unusable

RECOMMENDATION No. 252 *

USE OF 8364 kc/s FOR RADIO DIRECTION FINDING

(Question No. 21)

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the International Radio Conference of Atlantic City (1947) in No. 780 of the Radio Regulations states that

“ The frequency 8463 kc/s must be used by lifeboats, liferafts and other survival craft, if they are equipped to transmit on frequencies between 4000 and 23 000 kc/s, and if

* This Recommendation replaces Recommendation No. 217. The P.R. of Poland reserved its opinion on this Recommendation.

they desire to establish with stations of the maritime mobile service communications relating to search and rescue operations (see No. 600) ” *;

- (b) that land stations will, when the appropriate portions of Art. 33 of the Atlantic City Radio Regulations become effective, keep watch during their service hours on the band 8356 kc/s to 8372 kc/s; of which 8364 kc/s is the centre;
- (c) that Regulations 13 and 14 of Chapter IV of the Safety of Life at Sea Convention (1948) indicate minimum specifications for automatic distress transmitters;
- (d) that tests and operational experience have shown that radio direction finding on 8364 kc/s may be a valuable aid (in conjunction with direction finding on 500 kc/s), in finding the position of both aircraft and ships in distress and survival craft;
- (e) that complete coverage cannot be obtained with direction finding on only one frequency in the HF (decametric) band because of the limitations caused by radio propagation conditions;
- (f) that HF (decametric) radio direction finding requires apparatus as free as possible from local site error and polarisation error;
- (g) that the accuracy of the bearing will depend upon the field strength of the signal and the signal/noise ratio;
- (h) that in view of the rapid variation of the apparent azimuth of the bearing which is frequently observed in HF (decametric) radio direction finding, measurements should be made over several minutes to obtain a more accurate mean bearing; and that the bearing and fix may be improved subsequently by a further series of measurements;
- (i) that standardized distress transmissions are desirable;
- (j) that it is essential to have a means of rapid communication between the watch-keeping station and the direction-finding stations;

RECOMMENDS

1. that the site of the HF (decametric) radio direction-finding station should be, as far as possible:
 - 1.1 flat and horizontal for a radius preferably of at least 200 metres, with the surrounding neighbourhood flat and free from obstruction;
 - 1.2 of high and uniform ground conductivity;
 - 1.3 free from large metallic masses and objects likely to resonate at frequencies near to 8364 kc/s;
2. that the aerial system should be as free as possible from wave polarization error (e.g. Adcock systems and spaced-loop systems);
3. that the bandwidth of the direction-finding receiver used when bearings are taken should be as narrow as possible, compatible with the modulation and frequency stability of the signal on 8364 kc/s, and that a broader bandwidth position should also be incorporated in the receiver for watch-keeping purposes;
4. that the sensitivity of the direction-finding equipment should be such that it operates satisfactorily with a field strength as low as $5 \mu\text{V/m}$;
5. that the bearing should be determined by an aural-null method or by any other method of comparable or better accuracy;
6. that the direction-finding equipment should be adjusted, balanced and calibrated at frequent intervals on the frequency of 8364 kc/s;
7. that the signal radiated by survival craft should be as strong as possible and stable in frequency to ensure the greatest accuracy in determining the bearings;

* The use of 8364 kc/s for this purpose depends upon the implementation of the appropriate portion of the Atlantic City Table of Frequency Allocation.

8. that the signals transmitted by survival craft should preferably include long dashes sent over a period of not less than five minutes for direction-finding purposes. The attention of administrations should be drawn to the precise form and content of such signals proposed by France, U.S.A. and U.K., given in Doc. Nos. 39 (France), 43 and 99 (U.S.A.) and 44 (U.K.) of Geneva, 1951, and to the question of whether it would be desirable to use a common form of signal for both 500 kc/s and 8463 kc/s;
9. that, in order to give as great accuracy of fix as possible, several widely-spaced and inter-connected direction-finding stations should be employed (see Annex);
10. that the attention of administrations concerned should be drawn to the advantage of their studying further:
 - 10.1 the most suitable type of network for providing rapid communication between direction-finding stations and plotting centres;
 - 10.2 the most suitable way in which information should be exchanged between different stations or networks (e.g. use of "Q" code);
 - 10.3 the best way to evaluate the most probable fix (position) from bearings supplied by the direction-finding stations;
11. that the attention of administrations should also be drawn to the fact that world-wide direction-finding coverage cannot be obtained with only one frequency in the HF (decametric) band.

ANNEX

ACCURACY OF BEARINGS ON 8364 kc/s

At distances greater than about 1200 km the root-mean-square (r.m.s.) bearing error to be expected with a modern HF (decametric) direction-finding system is of the order of 3 to 5 degrees.

At distances less than 1200 km the error progressively increases with decrease of distance to values of the order of 5 to 10 degrees; at small distances, less than about 100 km, the error may be even greater than 10 degrees.

The above figures refer to the arithmetic mean of bearings spread over an interval of not more than about 10 minutes.

RECOMMENDATION No. 253 *

BEARING AND POSITION CLASSIFICATION FOR DIRECTION-FINDING

(Question No. 159)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that the procedure specified in Appendix 15, Sections 5 and 6, of the Radio Regulations, Atlantic City, 1947, applies to direction-finding bearings and positions in the 500 kc/s frequency band;
- (b) that there would be advantages in adopting an internationally agreed system for classifying the accuracy of bearings and positions for all frequency bands;
- (c) that there would be advantages in adopting an internationally agreed type of signal for direction-finding purposes;

* This Recommendation terminates the study of Question No. 159.

UNANIMOUSLY RECOMMENDS

1. that a common system of classification of bearings and positions should be used in all frequency bands;
2. that the accuracy of bearings should be classified as follows:
 - “ Class A ”: Probability of less than 1 in 20 that the error exceeds 2 degrees;
 - “ Class B ”: Probability of less than 1 in 20 that the error exceeds 5 degrees;
 - “ Class C ”: Probability of less than 1 in 20 that the error exceeds 10 degrees;
 - “ Class D ”: Bearings whose accuracy is less than Class C;
3. that the accuracy of positions determined from direction-finding bearings should be expressed as Class *N*, where *N* is the error, or amount of uncertainty, in nautical miles, such that the chance that *N* is exceeded is 1 in 20;
4. that Report No. 93, and the references below, should be used as a guide in determining the accuracy of bearings and positions by the objective (statistical) method and the subjective (observational) method, and the Annex to the Report should be used as a guide to the accuracy of bearings to be expected from HF Adcock direction-finders;
5. that signals for direction-finding purposes should include long dashes, each of at least 5 seconds duration, but, where necessary, the direction-finding station should also be permitted to specify the type and duration of the signal.

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RECOMMENDATION No. 254 *

**TECHNICAL CHARACTERISTICS OF FREQUENCY-MODULATED VHF
(METRIC) MARITIME EQUIPMENTS**

(Question No. 107, 161 (XIII) and 164)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the Radio Regulations, Atlantic City, Chapter XIII, Article 34, Nos. 830 to 834, stipulate the general procedure for the worldwide use by the maritime mobile service of the frequency 156.8 Mc/s and neighbouring frequencies;
- (b) that the use of VHF (metric) equipments in the maritime mobile service could reduce the use of MF (hectometric) maritime bands and thus tend to reduce congestion in these heavily loaded bands;

* This Recommendation which terminates the study of Question No. 107 replaces Recommendation No. 223. Belgium, France, the P.R. of Poland and the P.R. of Rumania and the F.P.R. of Yugoslavia reserved their opinion on this Recommendation.

- (c) that the early introduction of the world-wide use of equipments operating on the frequency of 156.8 Mc/s and neighbouring frequencies could contribute to the safety of life at sea;
- (d) that it would be desirable to reach agreement upon essential technical characteristics for frequency-modulated VHF (metric) radiotelephone equipments for use in international maritime services in order to expedite the international use of such equipments;
- (e) that, in the informal agreement on standardization of VHF (metric) channels for international maritime radiotelephone services that was reached among certain countries during the Baltic and North Sea Radiotelephone Conference, 1955 (see I.T.U. circular letter 1683/55/R, dated 13 December 1955), it was considered that the equipment should employ frequency modulation and be capable of operating ultimately with a frequency spacing of 50 kc/s;
- (f) that, without some further measure of agreement on channel allocations, it is not possible to decide all the technical characteristics needed to facilitate the design of equipment for international VHF (metric) maritime mobile services;
- (g) that the International Maritime VHF Radiotelephone Conference (The Hague, 1957), had agreed among other matters, upon a frequency allocation table using 4.6 Mc/s separation for duplex operation in the VHF international maritime mobile radiotelephone service;

RECOMMENDS

1. that the following characteristics for frequency-modulated VHF (metric) radiotelephone equipments for the international maritime mobile services operating on 156.8 Mc/s and neighbouring frequencies should be adopted by administrations;
 - 1.1 at present the frequency deviation should not be greater than ± 15 kc/s and the maximum deviation should be reviewed later if it is found in practice that unacceptable adjacent channel interference occurs, particularly as the loading of the channels increases;
 - 1.2 all receivers should be capable of receiving satisfactorily emissions having a maximum deviation of ± 15 kc/s;
2. vertical polarization should be used;
3. in the absence of fading and local screening, the protection ratio for common-channel operation should be such that the desired signal level exceeds the interfering signal level by at least 10 db. Each administration should provide for a further allowance, where appropriate, for fading and for fluctuations of a local nature (for instance, reflections from the terrain, sea, ships, docks, etc.);
4. the equipment should be designed for a frequency separation between adjacent channels of 50 kc/s;
5. the frequency separation between the transmitting and receiving frequencies for duplex working should be 4.5 Mc/s;
6. further study is required of means of selective calling. For this purpose reference is made to Question No. 160 (XIII);
7. other essential parameters:
 - 7.1 frequency modulation with a pre-emphasis of 6 db/octave should be used (phase modulation) with subsequent de-emphasis in the receiver;
 - 7.2 the output power of the ships' transmitters should generally not exceed 20 watts except in special circumstances to be determined by individual administrations;
 - 7.3 Spurious emissions:
 - 7.3.1 The power of spurious emissions due to harmonics of the carrier frequency should not exceed 25 μ W measured at the antenna terminals of the transmitter when loaded with a resistance equal to the nominal antenna impedance.

- 7.3.2 The power of spurious emissions falling in any other International VHF Maritime Mobile channel due to products of modulation should not exceed $10 \mu\text{W}$, measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance.
- 7.3.3 The power output of any other spurious emission on any discrete frequency within the International VHF Maritime Mobile Band should not exceed $2.5 \mu\text{W}$, measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance.
- 7.3.4 In cases where Administrations permit exceptionally the use of higher powered transmitters, proportionate increases in the level of these spurious emissions may be permitted.
- 7.4 the audio-frequency bandwidth should be limited to 3000 c/s;
- 7.5 the frequency tolerance of the transmitter should not exceed 0.002 %;
- 7.6 to minimize interference, special attention should be paid to the following receiver characteristics:
- stability;
 - selectivity;
 - receiver radiation;
 - intermodulation;
8. equipments should be designed so that frequency changes between assigned channels can be carried out rapidly, e.g., within a few seconds.

RECOMMENDATION No. 255 *

**SPURIOUS EMISSIONS FROM FREQUENCY-MODULATED VHF
(METRIC) MARITIME MOBILE EQUIPMENT**

(Question No. 161 (XIII))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that spurious emissions originating from frequency-modulated VHF Maritime Mobile equipment are likely to cause interference in the VHF International Maritime Mobile Radio-telephone bands if they are not adequately suppressed;
- (b) that Report No. 113 gives a statement about the study of the nature of such spurious emissions;
- (c) that it would be advisable to limit the spurious emissions generated in frequency-modulated VHF mobile maritime transmitting and receiving equipment as far as practicable;

RECOMMENDS

- 1. that the study of the nature of such spurious emissions, falling within the band of frequencies used by the VHF maritime mobile services, be continued. Attention is drawn to Report No. 113;

* The P.R. of Poland reserved its opinion on this Recommendation.

2. that for transmitters of the order of 20 watts:
- 2.1 any spurious emission due to products of modulation and falling in any international VHF maritime mobile channel other than the channel of the fundamental emission, should not exceed $10 \mu\text{W}$, measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance;
- 2.2 the output of any other spurious emission on any discrete frequency within the international VHF maritime mobile bands should not exceed $2.5 \mu\text{W}$, measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance.
3. that in those cases where Administrations permit exceptionally the use of higher powered transmitters, proportionate increases in the level of these spurious emissions may be permitted.

RECOMMENDATION No. 256 *

**INTERFERENCE DUE TO INTERMODULATION PRODUCTS IN THE
VHF (METRIC) MARITIME MOBILE RADIOTELEPHONE SERVICE**

(Question No. 164)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that intermodulation products may cause serious interference in the operation of the VHF mobile maritime radiotelephone service;
- (b) that intermodulation products may be generated and radiated at receiving stations and transmitting stations, in the radio equipment itself or at external points (such as aerial systems) where there is electrical non-linearity;
- (c) that practical measures can be taken to minimize the generation of such intermodulation products and to mitigate their harmful effects;

UNANIMOUSLY RECOMMENDS

1. that Recommendation No. 218, particularly parts 3, 4 and 15, should be followed for the purpose of minimizing the generation of intermodulation products at points on ships external to the receiver;
2. that aerials, rigging, stays and structures likely to cause intermodulation products should be maintained in such condition as to minimize the generation of intermodulation products;
3. that care should be taken, in the design and development of receivers, to minimize the possibility of interference due to the generation of intermodulation products in the receivers themselves;
4. that the range of interference due to radiated intermodulation products should be limited to sea areas that are not normally navigated by ships and to shore areas that are clear of coast receiving stations;
5. that the siting of coast stations should take into account the factors mentioned in § 4 above;

* This Recommendation terminates the study of Question No. 164.

6. that frequency assignments in the VHF mobile maritime radiotelephone band should, as far as possible, take into account the possibility of interference from intermodulation products;
7. that where the service area permits, coast stations should use directive aerials;
8. that care should be taken in the use of the single-frequency channels to minimize interference, due to intermodulation products, to the common calling and safety channel of 156.80 Mc/s; and to the high-priority channels of The Hague VHF Maritime Radiotelephone Frequency Plan;
9. that frequency assignments to other services should, as far as possible, take into account the possibility of interference to the VHF mobile maritime radiotelephone service due to the generation of intermodulation products; in particular, powerful emissions from stations near coastal areas and with frequencies differing by about 4.6 Mc/s from one another, should be avoided if possible.

RECOMMENDATION No. 257

**SELECTIVE CALLING DEVICES FOR USE IN THE INTERNATIONAL VHF
(METRIC) MARITIME MOBILE RADIOTELEPHONE SERVICE**

(Question No. 160 (XIII))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that selective calling from coast stations to ship stations would expedite handling of traffic particularly in public correspondence services;
- (b) that a selective calling system is faster and more positive than calling by voice;
- (c) that it overcomes the disadvantage and annoyance caused by vessels being required to listen to all calls;
- (d) that it permits concentration of aural watches on the safety and calling channel 156.80 Mc/s;
- (e) that a selective calling system is not subject to language difficulties;

UNANIMOUSLY RECOMMENDS

1. that a selective calling system for the international VHF maritime mobile radiotelephone service be standardized as soon as possible;
2. that this selective calling system should have an international numbering system for such public correspondence services;
3. that the system and the numbering plan should be capable of providing a sufficient number of individual non-conflicting codes;
4. that the bandwidth required for the transmission of the code signals should not exceed the maximum permissible emission bandwidth specified by regulations governing the maritime services;
5. that the time required to select and transmit the code signal should be of the shortest possible duration consistent with reliable operation;

6. that the system should be capable of satisfactory operation with signal-to-noise ratios at least equivalent to the minimum acceptable for satisfactory two-way speech transmission;
7. that the individual signalling combinations must be sufficient for adequately identifying ships using selective signalling, considering that it might be possible to repeat codes in sufficiently separated geographic areas, taking into account ships' itineraries;
8. that the selective signalling at any given coast station should not be limited to vessels regularly using that coast station. The numbering system should be planned so as to make this unnecessary;
9. that the number code assigned to a ship should be distinctive and should be permanently associated with that ship;
10. that the call should not be prefixed by a long dash or other special signal, in order to attract attention of vessels not fitted with a selective calling device, as such calls should be made, preferably, on the frequency of the common calling and safety channel 156.80 Mc/s;
11. that the attention of Administrations should be drawn to the desirability of their reaching agreement upon the channel that should be used for selective calling. Attention should also be drawn to Note 8 of Annex 1 of the Agreement on the international VHF maritime mobile radiotelephone service (The Hague, 1957).

D

RECOMMENDATION No. 258 *

SINGLE SIDEBAND AERONAUTICAL AND MARITIME MOBILE RADIOTELEPHONE EQUIPMENTS

(Question No. 162)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that the main advantages of single-sideband working (SBB, i.e. A3a) compared with double-sideband (DSB, i.e. A3) for mobile radio telephony are as follows:
 - a.a reduction of bandwidth required per channel;
 - a.b increase in signal-to-noise ratio or, alternatively, reduction in transmitter power (and hence antenna voltage) for the same signal-to-noise ratio, improvements dependent upon the degree of carrier suppression;
 - a.c reduction of the type of distortion that is due to selective fading;
 - a.d reduction of interference, particularly that due to beat notes between carriers dependent on the degree of carrier suppression;
 - a.e reduction of interference, due to cross-modulation between adjacent channel transmissions;
- (b) that the disadvantages of SSB compared with DSB for mobile radio telephony are as follows:
 - b.a more rigorous requirements for transmitter and receiver frequency stability;
 - b.b greater complexity of apparatus;

* This Recommendation terminates the study of Question No. 162. The P.R. of Poland and the U.S.S.R. reserved their opinion on this Recommendation.

- b.c* higher prices of the equipment;
- b.d* higher maintenance costs for the equipment;
- b.e* impracticability of conversion of existing mobile DSB equipments for SSB operation;
- b.f* Doppler effects that are significant for very high speed mobile units;
- (c)* that the MF-Radiotelephony bands used in the maritime services (i.e. worldwide 1605 to 2850 kc/s and additionally in Region 1–3155 to 3800 kc/s):
 - c.a* include the international calling and distress frequency 2182 kc/s;
 - c.b* are shared with fixed services;
 - c.c* are used by many low tonnage ships, some compulsorily and others voluntarily fitted exclusively with DSB MF-Radiotelephone equipments;
- (d)* that the parts of the HF bands (i.e. 4000 kc/s and 23 000 kc/s for mobile maritime and 2850 kc/s to 24 000 kc/s for aeronautical use) allocated to the respective services:
 - d.a* do not include any international distress frequency;
 - d.b* are exclusively allocated to these services;
- (e)* that in the maritime mobile services the advantages of SSB operation predominate over the disadvantages to a greater extent in the HF than in the MF band;
- (f)* that, in the maritime mobile services, in the interests of safety of life at sea, the introduction of SSB operation should not be allowed to discourage the extension of voluntary fitting of DSB MF-Radiotelephony equipment;

RECOMMENDS

1. for the maritime mobile services:
 - 1.1 that SSB operation be introduced as far as operationally required in the MF and HF Radiotelephony bands;
 - 1.2 that coast stations be prepared to communicate with DSB and SSB shipborne equipment;
 - 1.3 that for SSB equipment the following technical characteristics be employed:
 - 1.3.1 for an interim period the degree of carrier reduction should be 16–26 db below peak envelope power and every endeavour should be made to achieve a carrier suppression of at least 40 db as soon as possible;
 - 1.3.2 the carrier frequency of the transmitters should be maintained within the following tolerances:
 - 1.3.2.1 for coast stations ± 20 c/s;
 - 1.3.2.2 for ship stations the short term limits (of the order of 15 minutes) should be ± 40 c/s;
 - 1.3.2.3 for ship stations long term limits of ± 350 c/s (in the 8, 12, 16 and 22 Mc/s bands and ± 100 c/s in the 2 and 4 Mc/s bands) should be permitted for an interim period and every endeavour should be made to achieve limits of ± 100 c/s as soon as possible in all bands;
 - 1.3.3 the carrier frequency stability of SSB receivers should be maintained within the following tolerances:
 - 1.3.3.1 for coast stations ± 20 c/s;
 - 1.3.3.2 for ship stations the short term limits should be ± 40 c/s *;

* This value may be maintained either manually or by other means.

- 1.3.3.3 if spot frequency (i.e. fixed frequency pre-tuned) shipborne receivers are used, long term limits of ± 350 c/s should be permitted for an interim period and every endeavour should be made to achieve limits of ± 100 c/s as soon as possible;
- 1.3.4 the upper sideband should be used *;
- 1.3.5 the channel arrangements should be such that two SSB channels are accommodated within each existing DSB channel and the bandwidth of the SSB emissions should be kept within such limits as will permit this to be done (it is proposed that the precise arrangement of these SSB channels should be further discussed at the Administrative Radio Conference);
- 1.3.6 the transmitter audio frequency band should be 350 to 2700 c/s with a permitted amplitude variation of 6 db;
- 1.3.7 the unwanted frequency modulation of the SSB carrier should be sufficiently low to prevent harmful distortion;
- 1.3.8 in the MF maritime mobile Radiotelephony bands SSB ship stations should be able to insert a carrier at a level sufficient to permit satisfactory reception by DSB receivers when communicating with DSB stations;
- 1.3.9 in the particular case of transmissions on the radiotelephone calling and distress frequency 2182 kc/s all transmissions should be made either by DSB, or by SSB with carrier insertion sufficient to permit satisfactory reception by DSB receivers;
- 1.4 that the attention of Administrations should be drawn to the fact that there would be technical and operational advantages in designating certain frequencies for international common use for ship-shore and inter-ship working;
- 2. that for the aeronautical mobile service, the Director of the C.C.I.R. should:
 - 2.1 formally acquaint the I.C.A.O. of the interest of the C.C.I.R. in the study of SSB working in the aeronautical and maritime mobile services;
 - 2.2 invite the I.C.A.O. to advise the C.C.I.R. of any technical or operational problems on which they would like the assistance of the C.C.I.R.;
 - 2.3 offer to keep the I.C.A.O. informed of progress made by the C.C.I.R. in the study of the application of SSB working in the maritime mobile services;
 - 2.4 request the I.C.A.O. to keep the C.C.I.R. informed of progress made by the I.C.A.O. in the study of the application of SSB working in the aeronautical mobile services.



* Exceptionally, in the 4-23 Mc/s bands independent sideband (ISB) may be used by special arrangement between administrations.

RECOMMENDATION No. 259

**SELECTION OF FREQUENCIES USED IN TELECOMMUNICATION WITH
AND BETWEEN ARTIFICIAL
EARTH SATELLITES AND OTHER SPACE VEHICLES**

(Questions No. 168 and 169)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that transmission of radio signals between the earth and artificial earth satellites and other space objects is now an established fact;
- (b) that such extraterrestrial objects may well be consecutively above different countries of the world, thus necessitating international collaboration;
- (c) that radiocommunication between extraterrestrial objects and the earth and among extraterrestrial objects will be of importance;
- (d) that such radiocommunication will be affected by the terrestrial troposphere and ionosphere, and by ionization, radio-frequency noise, and man-made interference in space, as well as by relative velocities;
- (e) that the study of the effects of the ionosphere on such communications may be facilitated by comparison of HF signals with VHF or UHF signals since the ionospheric effects are larger on the lower frequencies;
- (f) that while frequencies for communication with objects in extraterrestrial space are being selected at present on the basis of particular communication requirements and technological capabilities, the inevitable increase in this type of communication is likely to lead to a chaotic situation in the radio spectrum;
- (g) that no provision for such communication was made in the Table of Frequency Allocations (Atlantic City);
- (h) that Report No. 115 presents a treatment of the technical factors affecting the selection of frequencies for telecommunication with and between space vehicles;

UNANIMOUSLY RECOMMENDS

1. that consideration be given to the provision of a number of small frequency-bands well spaced throughout the HF and higher bands for telecommunication services with and between space vehicles;
 2. that for services involving communication among space vehicles in interplanetary space, additional consideration be given to the use of frequencies which do not significantly penetrate the terrestrial ionosphere or troposphere (roughly below 1 Mc/s or above 50 000 Mc/s respectively);
 3. that special and particular consideration be given to the provision of at least two narrow frequency bands between 19 and 54 Mc/s to permit study of the effects of the ionosphere on communications passing through it;
 4. that in determining the widths of allocated bands particular account be taken of Doppler shifts in frequency associated with high relative velocities.
-

SECTION E

SOUND BROADCASTING AND TELEVISION

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The following Recommendations, which have been classified in other sections also concern Sound Broadcasting and Television:

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27	B
83	A
159	B
237	B
238	B
239	B
270	F
271	F
272	F
276	F
289	F



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RECOMMENDATION No. 48

**CHOICE OF FREQUENCY TO AVOID INTERFERENCE IN THE BANDS
SHARED WITH TROPICAL BROADCASTING**

(Question No. 102 (XII))

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that an audible interfering beat note may occur irrespective of the position of the frequencies used by other services between two adjacent broadcasting carriers in the shared bands;
- (b) that the minimum tolerable field-strength ratio of the wanted to unwanted signal depends primarily upon the frequency separation between the carrier waves;
- (c) that it is extremely important that all stations operate with the best frequency stability obtainable;
- (d) that transmitters of poor frequency stability may be capable of causing harmful interference to tropical broadcasting when operated in the shared bands;
- (e) that mobile stations, due to their lower frequency stability and variable location, are likely to cause more interference than fixed stations to tropical broadcasting when operated within the shared bands, particularly when using A3 emissions;

RECOMMENDS

1. that it is not necessary for frequencies of other services sharing frequency bands with broadcasting in the tropical zone to be assigned only midway between the broadcasting frequencies. When mid-spaced frequencies are not assigned, however, it is desirable that the same frequencies be assigned for other services as for broadcasting. The use of frequencies midway between broadcasting station carriers would have the advantage that less stringent tolerances would be required to maintain the required degree of protection than would be the case when frequencies of other services are assigned indiscriminately between adjacent broadcasting frequencies;
 2. that administrations should attempt to improve, as soon as possible, the frequency stability of fixed stations and, more generally, of all stations operating in the shared bands to the values specified in App. 3, Col. 3, Radio Regulations, 1947. Administrations should arrange for transmitters which do not meet this requirement to operate only on frequencies outside the shared bands, unless there is little possibility of interference to tropical broadcasting services;
 3. that, wherever possible, administrations should avoid the operation of mobile stations in the tropical zone within the bands shared with broadcasting, particularly as regards the use of A3 emissions by such mobile stations.
-

RECOMMENDATION No. 49

CHOICE OF SITE OF STATIONS AND TYPE OF ANTENNA TO AVOID INTERFERENCE IN THE BANDS SHARED WITH TROPICAL BROADCASTING

(Question No. 102 (XII))

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) the provisions of Art. 13, § 3, Radio Regulations, 1947;
- (b) that all possible sources of interference to broadcasting should be minimized;

RECOMMENDS

1. that administrations should make every effort to comply, as soon as possible, with the regulations with regard to the siting of stations and the use of directional antennae when the nature of the service permits;
2. that administrations should take steps to ensure that all interference to broadcasting and other radio services in the tropical zone produced by radiation, such as key-clicks, sideband spread, etc., be kept to a minimum;
3. that the broadcasting services in the tropical zone should, for their part, reciprocally take similar precautions to facilitate the operation of other services working in other zones in the shared bands.

RECOMMENDATION No. 80

HIGH-FREQUENCY BROADCASTING. DIRECTIONAL ANTENNAE

(Question No. 23 (X))

The C.C.I.R.,

(Geneva, 1951)

CONSIDERING

- (a) that the formation of strong subsidiary lobes of radiation can be avoided by the multiple feeding of, and appropriate current distribution in, appropriately spaced radiation elements;
- (b) that, by this means, it is theoretically possible to reduce the subsidiary lobes to a small value for a limited angle of slew of the main beam, provided the working frequency does not materially differ from the frequency for which an array is designed;
- (c) that the realization of these conditions is, however, not considered to be practicable on grounds of complexity of installation, difficulty of operation and maintenance of designed performances;

RECOMMENDS

that in practical operating conditions, for purposes of calculating interference, the field strength in directions other than that of the main lobe cannot be assumed to be less than 222 mV/m at a distance of one kilometre for one kilowatt of power supplied to the antenna *.

* R refer to statement of Specialised Secretariat of the C.C.I.R. on the subject *The gain, directivity and protection ratio of a directional antenna or antenna array*, Doc. No. 24 of Washington as reproduced in Geneva, 1951.

RECOMMENDATION No. 136

SINGLE-SIDEBAND SOUND BROADCASTING

(Question No. 62)

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that the results of a series of laboratory experiments (see London Doc. No. 305) on the use of SSB or ASB transmissions for HF (decametric) broadcasting indicate that:
 - with present types of HF (decametric) broadcast receivers no economy in the radio spectrum can be obtained by changing from double-sideband (DSB) to SSB or ASB transmission;
 - a relatively small saving (about 7%) might be obtained by the use of SSB transmissions if substantial improvements were made in the selectivity of receivers, but the modifications could not be applied to receivers already manufactured;
 - a greater saving (about 14%) might be obtained by the use of SSB with a “ tête-bêche ” system of channelling but this would necessitate elaboration in the design of receivers, which could not be applied to receivers already manufactured;
 - closer carrier spacing might be possible if low-pass audio-frequency filters could be added to present receivers, but this would be almost equally true whether applied to the reception of SSB or of DSB transmissions;
- (b) that the use of SSB or ASB transmissions for medium-frequency broadcasting would also necessitate considerable modifications to the receivers and, in addition, would reduce the range obtainable for an acceptable distortion from a transmitter of given power;

UNANIMOUSLY RECOMMENDS

that these results be accepted as a conclusive answer to Question No. 62.

RECOMMENDATION No. 139

DESIGN OF TRANSMITTING ANTENNAE FOR TROPICAL BROADCASTING

(Question No. 70, § 1)

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that it is desirable to use transmitting antennae for tropical broadcasting that cause, outside the service area, a minimum of interference;
- (b) that the antennae should be economical in design and simple in operation;
- (c) that Report No. 86 gives the principles on which antennae for tropical broadcasting should be designed and constructed;
- (d) that it is desirable to obtain as much operational data as possible on tropical broadcasting using antennae designed on these principles;

RECOMMENDS

1. that administrations and organisations operating tropical broadcasting services should use antenna systems so designed that:
 - the power radiated is as large as possible at the high angles of elevation required for the needs of the service area;
 - a sufficient value of radiation should be maintained at angles of elevation necessary to serve the fringe of the service area;
 - the power radiated at angles of elevation lower than those used to serve the fringe of the service area is as low as possible;
2. that administrations and organisations should forward to the C.C.I.R. reports on the operation of such antennae so that an addendum can be issued to Report No. 86 giving practical operational data concerning these antennae. The data and information should be forwarded in the following form:
 - type of antenna system used and its physical dimensions in relation to the frequency of operation;
 - electrical characteristics—polar diagram in the vertical and the horizontal planes;
 - power radiated by the antenna;
 - siting of the antenna with respect to the geographical configuration of the area to be served and the orientation of the antenna with respect to North;
 - hourly averages of field strength measured, whenever practicable every 100 or 200 km, up to a maximum distance of 2000 km in all directions;
 - fading characteristics of the received signal;
 - influence, if any, of the orientation of the antenna with respect to the magnetic meridian;
 - ground conductivity in the vicinity of the antenna system;
 - any other information considered useful in respect of this Recommendation.

RECOMMENDATION No. 140

DESIGN OF RECEIVING ANTENNAE FOR TROPICAL BROADCASTING

(Question No. 70, § 3)

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that for the great majority of domestic tropical broadcast listeners, only simple antennae are practicable;
- (b) that the antenna has to be both cheap and simple to install and it has to be used on a number of frequencies with fields at varying angles of incidence;

RECOMMENDS

1. that the directivity of receiving antennae cannot be relied upon to improve the signal-to-noise ratio;
2. that it appears reasonable to assume that the antenna of the average listener cannot be better than that given in the Report of the Geneva Planning Committee (1948) which consisted of an "L" type aerial with horizontal and vertical limbs, each 16 feet in length (4.80 metres).

RECOMMENDATION No. 205 *

**USE OF SYNCHRONIZED TRANSMITTERS IN HF (DECAMETRIC)
BROADCASTING**

The C.C.I.R.,

(London, 1953 — Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

that two synchronized transmitters at the same site, driven by a common oscillator and modulated by the same programme in the correct phase, may be considered not to introduce any appreciable deterioration in reception

1. for non-overlapping service areas;
2. for overlapping service areas provided that due consideration is given to:
 - the shape and size of the reception area;
 - the availability of suitable antennae with similar transmission characteristics;
 - the propagation conditions over the two transmission paths, corresponding to the two antennae.

These considerations become more critical as the transmission distance increases.

RECOMMENDATION No. 210

**MEASUREMENT OF WOW AND FLUTTER IN EQUIPMENT
FOR SOUND RECORDING AND REPRODUCTION**

(Study Programme No. 161 (X))

The C.C.I.R.,

(Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

1. that the tone to be recorded for the measurement of wow and flutter should preferably be 3000 c/s;
2. that the equipment used should measure wow and flutter within a minimum frequency range of 0-200 c/s.

RECOMMENDATION No. 212 **

TELEVISION STANDARDS

The C.C.I.R.,

(Geneva, 1951 — Warsaw, 1956)

CONSIDERING

that a study of television standards was recommended by the C.C.I.R. at its Vth Plenary Assembly, to facilitate the interchange of programmes and to coordinate the design of receivers;

E

* This Recommendation replaces Recommendation No. 137.

** This Recommendation replaces Recommendation No. 82.

UNANIMOUSLY RECOMMENDS

1. that television systems should be capable of operating independently of the frequency of the power supply;
2. that the aspect ratio of the picture should be 4/3;
3. that line interlacing should be used in the ratio 2/1;
4. that the scanning of the picture viewed during active periods should be from left to right and top to bottom;
5. that the vision carrier should be modulated in amplitude;
6. that receivers should be designed for the reception of vestigial-sideband transmissions and that the vision carrier should be attenuated in the receiver;
7. that transmitters should be designed to attenuate the lower or the upper sideband without attenuating the carrier;
8. that the vision and sound carriers should be located within the channel, the vision carrier being 1.25 Mc/s from one edge and the sound carrier being 0.25 Mc/s from the other edge;
9. that the unwanted sideband should be attenuated so that the radiated field is reduced by at least 20-db at that edge of the channel which is 1.25 Mc/s away from the vision carrier;
10. that the black level should be a definite carrier level independent of the picture content;
11. that the gamma characteristic of the radiated signal should be lower than unity in order to take account of the signal/brightness characteristic of the average receiving picture tube;
12. that there is no necessity to standardize the polarization of the transmitted wave.

Note. — In those countries where transmitters are already operating on a regular basis administrations are free to use their discretion as to the extent to which the provisions of § 6, 7, 8 and 9 of this recommendation may be implemented in the case of these transmitters, taking into account the modifications to existing receivers that might be necessary.

RECOMMENDATION No. 214 *

**LIMITATION OF THE POWER OF TRANSMITTERS
IN THE TROPICAL ZONE TO AVOID INTERFERENCE IN THE BANDS
SHARED WITH TROPICAL BROADCASTING**

(Question No. 102 (XII))

The C.C.I.R.,

(Geneva, 1951 — Warsaw, 1956)

CONSIDERING

- (a) that the power of transmitters for radio services in the tropical zone operating within the bands shared with tropical broadcasting (Art. 9, § 244, Radio Regulations, 1947) should be determined so as to ensure full protection to broadcasting in the tropical zone;

* This Recommendation replaces Recommendation No. 47.

- (b) that it is preferable to exploit the possibilities of "time sharing" between broadcasting services in the tropical zone and radiotelegraph services operating within the shared bands;
- (c) that, at sunspot minimum, when certain frequencies become useless for tropical broadcasting, such frequencies could be used by other services;
- (d) that Recommendation No. 215 recommends provisional power limitations for broadcasting stations in the tropical zone;
- (e) that the maximum power of radiotelegraph stations can best be determined in the light of the permissible "repetition distance" (geographical sharing *);
- (f) that the protection ratio to be considered in the determination of the "repetition distance" will be that set forth in Recommendation No. 216 read with Report No. 89;
- (g) that the factors governing the limitation of power for A3 emissions by services other than broadcasting within the shared bands are similar to those for radiotelegraphy;

RECOMMENDS

1. that, for the particular cases not involving simultaneous operation of broadcasting and other services, no limitations be imposed on the power of radiotelegraph stations operating within the shared bands other than those necessary to comply with the provisions of Section I, Art. 13, Radio Regulations, 1947;
2. that, for the general case involving simultaneous operation of broadcasting and radiotelegraph services within the shared bands, the limitation to be imposed on the power of radiotelegraph stations in the tropical zone should be only that required to provide adequate protection for the broadcasting services;
3. that the limitations for fixed service stations in the tropical zone employing A3 emissions and operating within the shared bands should be similar to those for radiotelegraph stations operating under like conditions.

E

RECOMMENDATION No. 215 **

MAXIMUM POWER FOR SHORT-DISTANCE HIGH-FREQUENCY BROADCASTING IN THE TROPICAL ZONE ***

(Questions Nos. 27 and 102 (XII), Study Programme No. 112 (XII),
Recommendation No. 214)

The C.C.I.R.,

(Warsaw, 1956)

CONSIDERING

- (a) that the prolonged observations and studies which have been carried out confirm the existence of high noise levels in tropical zones;
- (b) that good quality service pre-supposes the maintenance of a satisfactory value of signal-to-noise ratio in the entire service zone which the provisional power limits mentioned in Recommendation No. 84 cannot ensure with appropriate coverage up to 800 km;

* See P.F.B. Doc. No. 712, dated 14th February, 1950.

** This Recommendation replaces Recommendation No. 84. France, the United Kingdom (for § 1.3), the Overseas Territories of the French Republic, Turkey (for § 1.3) and the Union of South Africa reserved their opinions on this Recommendation.

*** As defined in the "considerations" of Question No. 27, given in the Annex to Study Programme No. 112 (XII), for this service.

- (c) that the high value of noise level observed in tropical regions during certain hours of the day and certain periods of the year, together with the need for signal-to-noise ratios such as to ensure a satisfactory service for practically all listeners within the specified service area tends to suggest the use of a high transmitter power for tropical broadcasting services. It is therefore advisable when evaluating the powers to be used to assume reasonable values for the average noise level and signal-to-noise ratio in order to reach practical values of transmitter powers, ensuring at the limit of the service area acceptable conditions of reception for a suitable percentage of transmission time;
- (d) that when the service zone is limited to 400 km, vertical incidence antennae may effectively be used in order to concentrate the energy in the service zone and to reduce radiation beyond this zone;
- (e) that for greater distances it appears necessary to use types of antenna with low gain, such as a simple dipole, in order to obtain the desired field strength at a distance of 800 km. Nevertheless this type of antenna radiates at low angles of elevation and may give rise to interference at great distances;
- (f) that it is advisable to make a judicious choice of transmitting frequencies which, for a tropical broadcasting programme, may be located in the shared bands whose upper limit is 5060 kc/s and in the HF (decametric) broadcast bands above 5060 kc/s;

RECOMMENDS

1. that the upper power limit for the unmodulated carrier wave of short-distance high-frequency broadcast transmitters employing double-sideband emission, operating in the tropical zones should be determined as follows;
 - 1.1 for a service area limited to 400 km the nominal power of the transmitter should not exceed 10 kW,
 - 1.2 for a service area limited to 800 km the nominal power of the transmitter should not exceed 30 kW,
the powers mentioned in § 1.1 and 1.2 are for frequencies below 5060 kc/s used in tropical broadcasting for such ranges;
 - 1.3 for frequencies above 5060 kc/s, where tropical broadcasting services use the same frequency bands as the high-frequency broadcasting services, the same power limit as recommended by the Mexico City Conference (1949) shall apply;
 2. that, within the above limits, administrations should use, as far as possible, lower powers, if these will assure satisfactory service throughout the reception area;
 3. that the frequency used should always be as near as possible to the optimum working frequency (provided that the frequency employed is within one of the permissible broadcasting bands), in order to provide as good a received signal-to-noise ratio as possible;
 4. that, in conformity with the provisions of Recommendation No. 139, and in order to make the best possible use of the frequency bands which have been allocated, administrations should use appropriate antennae, so that radiations at low angles be reduced to a minimum to avoid all harmful interference outside the service zone.
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RECOMMENDATION No. 216 *

**MINIMUM PERMISSIBLE PROTECTION RATIO TO AVOID INTERFERENCE
IN THE BANDS SHARED WITH TROPICAL BROADCASTING ****

(Question No. 102 (XII))

The C.C.I.R.,

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

- (a) that it is necessary to establish, as soon as possible, a value for the minimum permissible protection ratio for broadcasting within the shared bands in the tropical zone;
- (b) that the operation of broadcasting transmitters with 10 kc/s separation makes it difficult to measure the protection ratio with a receiver having an audio-frequency cut-off in excess of 5 kc/s;
- (c) that, in the absence of sufficient information concerning noise values in various parts of the tropical zone, it is difficult to state a value of minimum field strength to which the minimum permissible protection ratio should be maintained; however, this minimum field strength should provide satisfactory reception at the limit of the broadcast station service area as provided by Art. 9, No. 243, Radio Regulations, 1947;

RECOMMENDS

1. that, for the present and wherever practicable in the tropical zone, the ratio of median wanted broadcasting carrier to median unwanted carrier shall be 40 db, to provide a signal-to-interference ratio of not less than 23 db for 90% of the hours and 90% of the days (ref: Mexico City 1948/49, Doc. No. 635, § 13) ***;
2. that the protection ratio thus defined should be measured at the output of a receiver provided with a filter having an audio-frequency cut-off of 5.0 kc/s ****;
3. that, for the present, the protection ratio, as defined in § 1 above, should be maintained throughout the broadcast service area in the tropical zone to a minimum field strength of 200 microvolts/metre or any lower value consistent with satisfactory reception;
4. that the conditions of operation required for broadcasting in the tropical zone should be compatible with the protection ratio required for other services outside the tropical zone, in accordance with Art. 3, No. 90, § 5, of the Radio Regulations, 1947.

* This Recommendation replaces Recommendation No. 138.

** See Report No. 89.

*** Doc. No. 43 of Washington refers in particular to the effect of long and short term fading.

**** Practical consideration of the frequency separation of adjacent channels requires the use of an audio-frequency cut-off of 5kc/s in the measurement in preference to 6.4kc/s, appropriate corrections being applied, if considered necessary, to correspond to an audio-frequency cut-off of 6.4 kc/s.



RECOMMENDATION No. 260 *

SOUND RECORDING FOR THE INTERNATIONAL
EXCHANGE OF PROGRAMMES

(Questions Nos. 42 and 63)

The C.C.I.R.

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

that the international exchange of recorded sound programmes between broadcasting agencies should be by means of:

1. single track magnetic recording on tape as specified in Recommendation No. 261;
2. lateral cut transcription disc recording for professional use as specified in I.E.C. (Publication 98).

RECOMMENDATION No. 261 **

STANDARDS OF SOUND RECORDING
FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES

Single track recording on magnetic tape

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

UNANIMOUSLY RECOMMENDS

that single track recording on magnetic tape should be in accordance with the following technical standards:

1. *Speed of tape*

Primary speeds: $\left\{ \begin{array}{ll} 15 \text{ in/s. (38.1 cm/s) nominal value} \\ 7\frac{1}{2} \text{ in/s. (19.05 cm/s) } & \text{ " } & \text{ " } \end{array} \right.$
 Secondary speed: 30 in/s. (76.2 cm/s) " " ***

The actual value of tape speed should be as close as possible to the nominal value.
 A tolerance of not more than $\pm 0.5\%$ is considered desirable.

2. *Width of tape*

0.246 ± 0.002 in (6.25 ± 0.05 mm) ****

3. *Strength of tape*

The tape should be suitable for use on a machine exerting a maximum (transient) stress of 2.2 pounds (1 kg).

* This Recommendation replaces Recommendation No. 207.

** This Recommendation replaces Recommendation No. 209.

*** The secondary speed should only be used by prior agreement.

**** This modification implies the deletion of Report No. 80 and Resolution No. 30.

4. *Direction of winding*

If the top surface of a spool is distinguished by markings, by a label or by other means (especially if the hub is asymmetrical), then the tape should be wound in such a way that during reproduction it may be unwound in an counterclockwise direction.

5. *Tape spools*

Two types of hub are accepted for international programme exchange:

Fig. 1 gives the principal dimensions of the type more generally used in Europe;

Fig. 2 gives the dimensions of the hub more generally used in the United States and of the accompanying flange;

Fig. 3 gives the main dimensions of a typical machine fitting to receive the hub of Fig. 1.

Fig. 4 gives the main dimensions of an adapter to enable the machine fitting of Fig. 3 to receive the hub of Fig. 2.

Whenever the exchange of recorded programmes has to be effected by cine-type flanged spools, the spools must conform to the standards established in Publication 94 of the International Electrotechnical Commission.

As far as possible, for the exchange of recorded programmes only flanged spools or spool hubs with flanges should be used.

6. *Maximum diameter of a full spool*

for the hub shown in Fig. 1: 290 mm *

for the hub shown in Fig. 2: 267.5 mm

7. *Tape leader*

A non-magnetic identification strip at least one metre long should be placed at the beginning of the tape giving at least the number of the spool and the reference number (see § 8 below). This information should be given on the side of the leader continuous with the unrecorded side of the tape.

Note. — It is recommended that whenever possible the unrecorded side of the tape should be identified by some form of marking continuous throughout the length of the tape.

8. *Programme identification*

A label giving the following information should accompany each reel:

- broadcasting organisation,
- programme title,
- reel number,
- total number of reels,
- reference number,
- total playing time of programme,
- speed of tape (marked as prominently as possible).

9. *Reproducing characteristics*

A Standard Replay Chain is specified and recordings for programme interchange should give a response within the tolerances stated below when reproduced on this Standard Replay Chain:

9.1 *Nominal characteristic*

The Standard Replay Chain is defined as one having the same response as that of an "ideal" reproducing head, the open-circuit voltage of which is amplified in an amplifier with a response curve as specified below:

For tape speeds of 15 in/s (38.1 cm/s) and 30 in/s (76.2 cm/s), the specified frequency response curve falls with increasing frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of 35 μ s. This curve is shown in Fig. 6.

* In France, the maximum diameter is 270 mm.

For a tape speed of $7\frac{1}{2}$ in/s (19.05 cm/s) the specified frequency response curve falls with increasing frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of 100 μ s. This curve is shown in Fig. 7.

9.2 Tolerances

Tapes for international programme interchange should be recorded so that, when reproduced on a Standard Replay Chain the response falls between upper and lower limits defined as follows for tape speeds of 15 in/s (38.1 cm/s) and 30 in/s (76.2 cm/s):

upper limit

- from 50 c/s to 100 c/s falling regularly by 1 db,
- from 100 c/s to 5 000 c/s flat,
- from 5 000 c/s to 10 000 c/s rising regularly by 1 db,
- from 10 000 c/s to 15 000 c/s flat;

lower limit

- from 50 c/s to 100 c/s rising regularly by 3 db,
- from 100 c/s to 7 500 c/s flat,
- from 7 500 c/s to 15 000 c/s falling regularly by 3 db.

From 100 to 5000 c/s the flat portions of the upper and lower limits are 2 db apart. These limits are shown in Fig. 8.

For a tape speed of $7\frac{1}{2}$ in/s (19.05 cm/s), the response should fall within limits defined as follows:

upper limit

- from 50 c/s to 10 000 c/s flat;

lower limit

- from 50 c/s to 100 c/s rising regularly by 3 db,
- from 100 c/s to 5 000 c/s flat,
- from 5 000 c/s to 10 000 c/s falling regularly by 3 db.

From 100 to 5000 c/s the flat portions of the upper and lower limits are 2 db apart. These limits are shown in Fig. 9.

Note 1. — An “ideal” reproducing head is defined as a ferromagnetic reproducing head, the losses of which are negligible. Normally this means that the gap is short, that the arc of contact with the tape is long compared with the relevant wavelengths on the tape and that the losses in the material of the head are small.

With the reproducing heads used in practice, compensation for the head losses must be added to the replay amplifier.

With good replay heads a mean value of this equalization may be used for the two higher speeds and even for the three speeds.

Note 2. — The open circuit voltage developed in a ferromagnetic reproducing head depends on the surface induction * on the tape while it is in contact with the head. It has been found that, provided a coated high-coercivity tape is used, the surface induction in free space will be altered, when the tape is placed in contact with the head, by an approximately constant factor over the whole range of wavelengths. Under these circumstances the relative surface inductions at different frequencies can be measured by at least three methods that are described in the Annex. From such measurements the departure of the response of a reproducing head from the “ideal” can be defined, and consequently a Standard Replay Chain can be established as a primary standard. Test tapes can then be made which can serve as secondary standards for use in normal operations.

Note on use of reproducing characteristics. — A different Standard Replay Chain has been adopted in the U.S.A. for 15 in/s (38.1 cm/s). The difference between the nominal characteristics of the Standard Replay Chain of the U.S.A. and that of the C.C.I.R. is less than the tolerance in § 9.

Furthermore a different characteristic is used in France for 30 in/s (76.2 cm/s).

* In this Recommendation and in the Annex the term “surface induction” means the normal surface induction, that is to say the flux density at right-angles to the surface of the tape.

ANNEX

1. Methods of measuring the magnetization of a tape

There are two general ways in which the surface induction/frequency characteristics of a tape may be determined:

- 1.1 by means which do not affect the surface induction. This implies the use of a non-magnetic reproducing device. For example, reproduction by means of a simple non-magnetic conductor placed in the field at the surface of the moving tape is practicable as a laboratory method and may therefore be used to establish a primary standard. This can be used to determine the relative change of surface induction with wavelength created by the presence of a magnetic head;
- 1.2 by means of a magnetic reproducing device, which necessarily affects the surface induction of the tape in a manner dependent on recorded wavelength. In this category there are two ways in which conventional magnetic heads have been used, one method involving heads with a short gap, the other involving heads with a long gap. In both cases the gap in the reproducing head must be sufficiently accurate, magnetically, to give well-defined minima of reproduced level, one in the short gap method or several in the long gap method. In order to ensure that the same results will be obtained with both magnetic and non-magnetic reproducing devices, a coated high-coercivity tape must be used.

Steps must be taken to ensure that the arc of the tape in contact with the head is long enough in relation to the longest wavelengths recorded. If this is not so, it may be found that output level at the lower frequencies is slightly higher than that given by an ideal head and that the deviation increases as the frequency decreases while remaining as a general rule within the tolerances defined above. The error may be reduced by using bigger reproducing heads for the very low frequencies.*

1.2.1 The "short gap" method

The longest wavelength at which a minimum of reproduced level occurs is called the effective gap length d . The necessary correction for the gap length is calculated on the assumption that the output is proportional to

$$\frac{\sin \frac{\pi d}{\lambda}}{\frac{\pi d}{\lambda}}$$

This correction must not exceed 5 db at the shortest wavelength considered. Any necessary correction for eddy current losses must also be determined, for example, by comparing outputs at various tape speeds or by the use of an inducing loop. Once these corrections are known and applied, the head may be used as an "ideal" head to measure relative surface inductions on the tape over the wavelength range considered.

1.2.2 The "long gap" method

In this method a head is used with a gap some 50 times longer than that of the normal reproducing head. In practice an erase head can usually be adapted for the purpose. The response of such a head should show a series of well defined maxima and minima as shown in Fig. 10.

A curve through the successive maxima is a measure of the relative surface induction on the tape, when the necessary correction for the eddy current losses of the head has been made. This curve falls approximately 4 db/octave compared with the curve of surface induction/frequency in air as determined by a non-magnetic reproducing device, or by a "short gap" head. This correction must therefore be applied.

The precise steps by which the procedures of 1.2.1 and 1.2.2 may be applied in practice are outlined in the following.

* See Report No. 79.

2. Standardization by the short magnetic head

Using the short gap method a recording equipment is set to the standard condition in the following way:

- 2.1 A "gliding tone" is recorded on a tape and reproduced by means of the head to be used for the measurements. The longest wavelength at which the output disappears is noted. This wavelength will be equal to the effective gap length, from which the gap correction may be deduced. If this correction exceeds 5 db the head is unsuitable for this measurement.

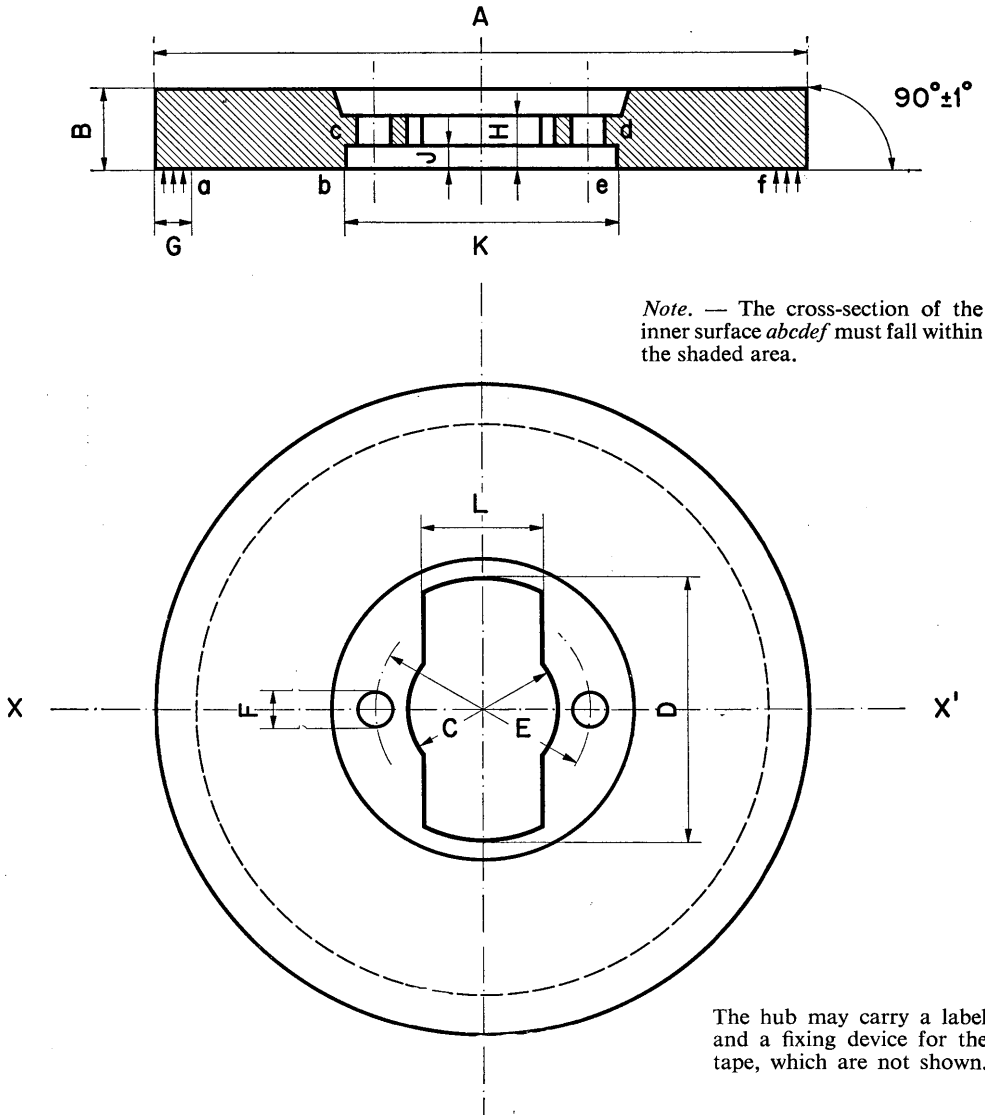
Since the measurement must take place at a very short recorded wavelength, a high-coercivity tape should be used, and a certain amount of pre-emphasis will be found useful. In order to avoid making the measurements at an unnecessarily high frequency the lowest tape speed available should be used.

- 2.2 The tape with the gliding tone is reproduced at two different speeds and the output curves are compared. If the curves can be brought to coincidence by displacing one frequency scale so that equal wavelength coincide, it may be assumed that frequency-dependent losses are negligible. If not, these losses may be deduced from the two curves mentioned or, alternatively, from a measurement with an inducing loop.
- 2.3 The frequency response of the reproducing chain is now adjusted to be that specified in § 9.1 of this Recommendation together with the gap correction noted in § 1 and the compensation for frequency dependent losses noted in § 2 above.
- 2.4 The recording equalisation is then adjusted so that a flat overall response is obtained.

3. Standardization by the long gap magnetic head

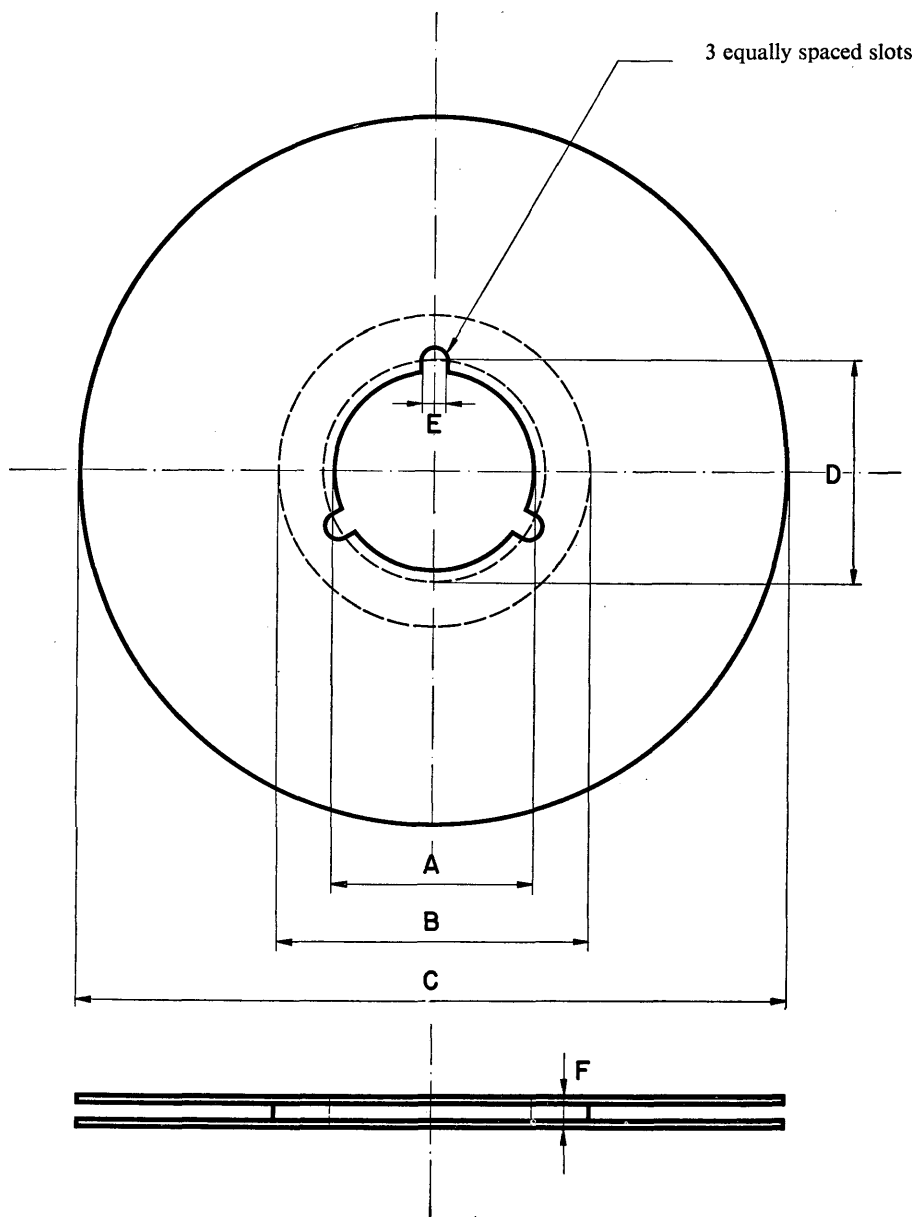
Using the long gap method a recording equipment is set to the standard condition in the following way:

- 3.1 The reproducing head used has a well-defined gap long enough to give successive maxima of response at intervals of 1 kc/s, or less, in the audio-frequency range (with a tape speed of 30 in/s (76.2 cm/s) the gap length required would be about 800 microns). If the successive minima in the response curve are not equally well defined the head is not suitable for this measurement. A short preliminary experiment is carried out to determine the exact frequencies at which successive maxima occur at the relevant tape speed.
- 3.2 A "gliding tone" test tape of the audio frequencies of maximum level is then recorded with constant voltage input to the recording chain and the tape is reproduced using the long gap head. The open circuit voltage of the head around these frequencies is then plotted against frequency, and a smooth curve is drawn through the successive maxima.
- 3.3 The tape with the gliding tone is reproduced at two different speeds using the long gap head and the output curves are compared. If the curves can be brought to coincidence by displacing one frequency scale so that equal wavelengths coincide it may be assumed that frequency-dependent losses are negligible. If not, these losses may be deduced from the two curves mentioned or, alternatively, from a measurement with an inducing loop.
- 3.4 When the curve drawn in § 2 has been corrected by a 6 db/octave rise with increasing frequency together with the correction for frequency-dependent losses and a correction of 2 db/octave falling with increase of frequency, the result defines the relative surface inductions on the tape.
- 3.5 The equalization of the recording amplifier is now altered to obtain a characteristic of surface induction/frequency that is the inverse of the equalization specified for the reproducing chain (without allowance for the replay head losses).
- 3.6 The reproducing amplifier equalization is then adjusted so that a flat overall response is obtained when using a normal reproducing head.



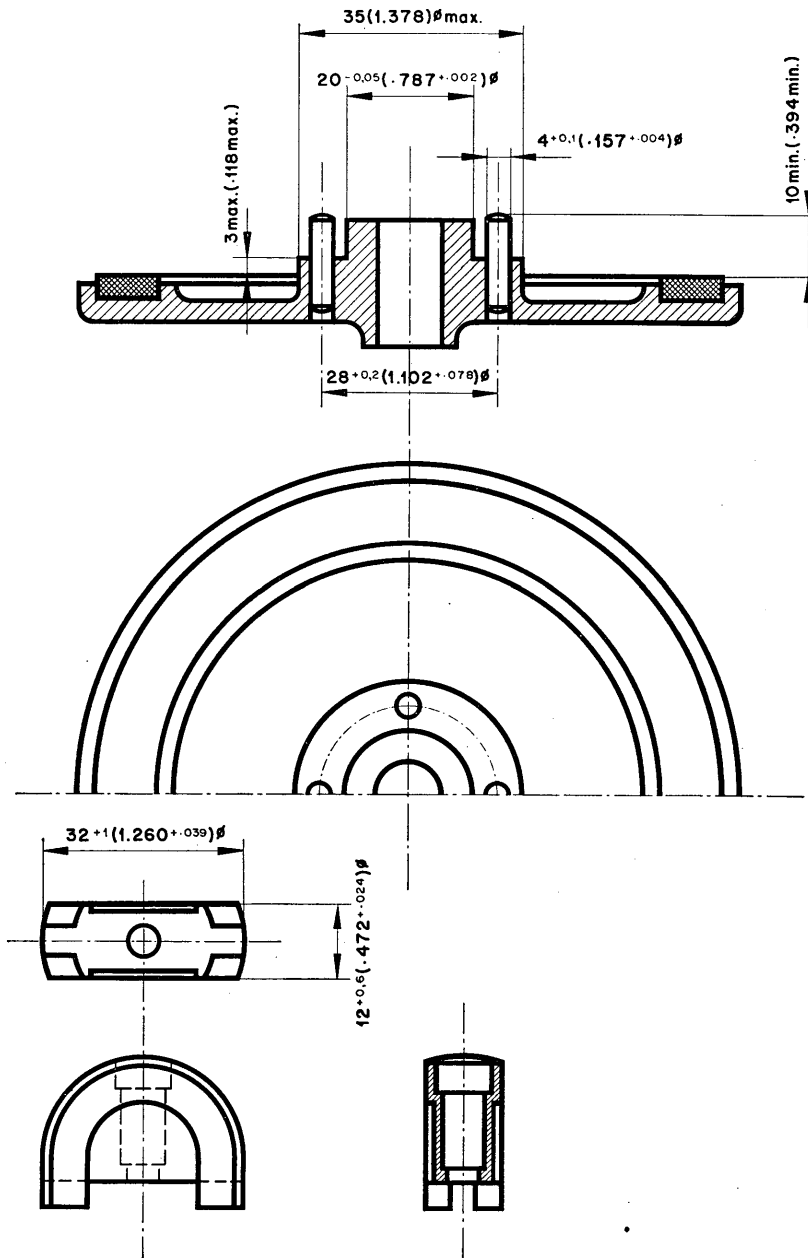
Dimensions	Millimetres	Inches	Dimensions	Millimetres	Inches
A	58 - 100	2.28 - 3.95	G	4	0.157
B	11 ⁺⁰ / _{-0.2}	0.433 ⁺⁰ / _{-0.008}	H	7 ⁺⁰ / ₋₁	0.275 ⁺⁰ / _{-0.04}
C	20.1 ^{+0.1} / ₋₀	0.791 ^{+0.004} / ₋₀	J	3.5 min.	0.138 min.
D	35 ^{+0.2} / ₋₀	1.378 ^{+0.008} / ₋₀	K	36 min.	1.417 min.
E	28 ^{+0.2} / ₋₀	1.102 ^{+0.008} / ₋₀	L	16 ^{+0.02} / ₋₀	0.63 ^{+0.008} / ₋₀
F	5 ^{+0.2} / ₋₀	0.197 ^{+0.008} / ₋₀			

FIGURE 1
European standards
Spool hub for magnetic tape recording



Dimensions	Inches		Millimetres	
	Minimum	Maximum	Minimum	Maximum
A	3.000	3.004	76.20	76.30
B	4.490	4.510	114.05	114.55
C	10.50	10.52	267.0	267.5
D	3.248	3.252	82.45	82.55
E	0.219	0.225	5.60	5.75
F	0.447	0.457	11.35	11.60

FIGURE 2
U.S.A. type of spool for magnetic tape recording



E

FIGURE 3
European standards
Machine fitting to receive spool hub

Note. — Unless otherwise indicated, all dimensions are in millimetres, with corresponding figures in inches in parenthesis.

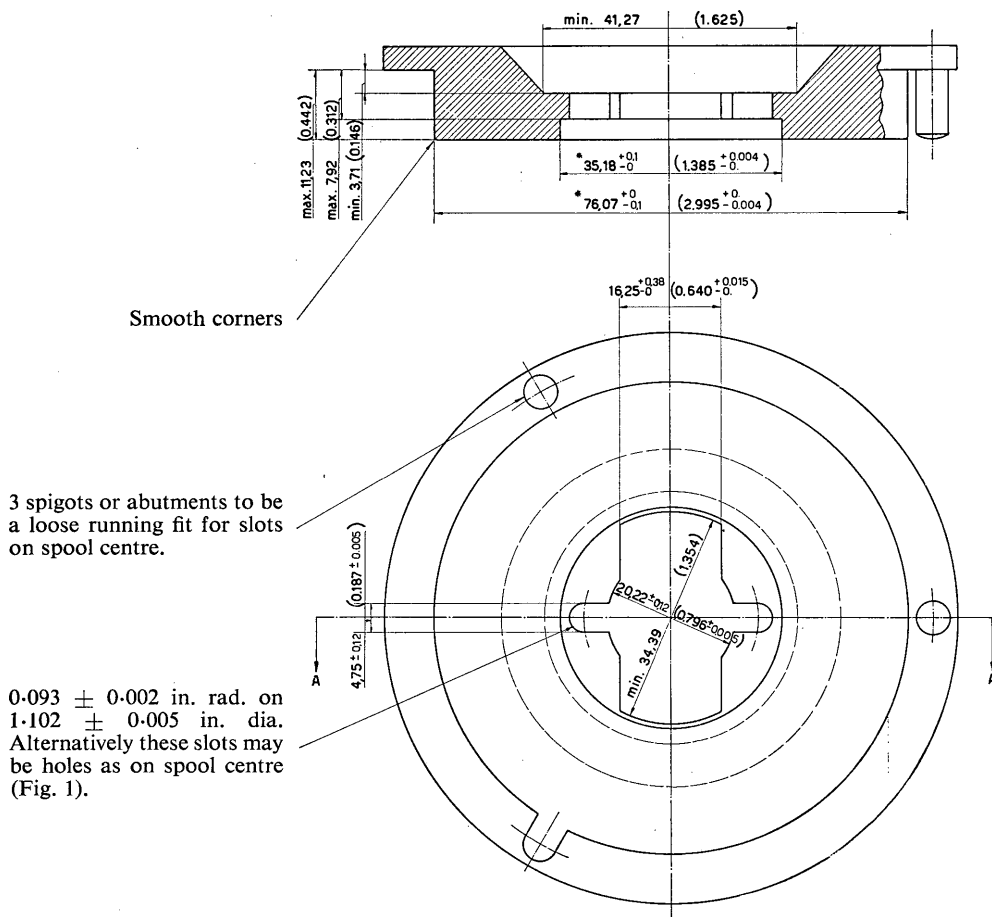
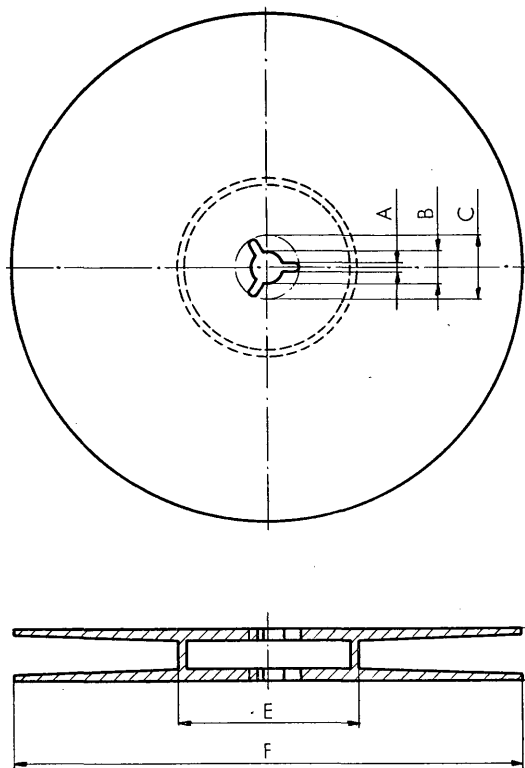


FIGURE 4

Typical adapter to enable the European type of machine fitting to receive the hub of Figure 2

Note. — Diameters marked thus * to be concentric within 0.003 in. Unless otherwise indicated, all dimensions are in millimetres, with corresponding figures in inches in parenthesis.



Not to scale

The millimetre dimensions are derived from the original inch dimensions

Third angle projection

Ref.	Millimetres			Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.524		1.651	0.060		0.065
B	8.027		8.102	0.316		0.319
C	16.01			0.63		
D	12.75		13.512	0.502		0.532

Nominal capacity		F* Nominal diameter		E Minimum core diameter	
m	ft	mm	in	mm	in
50	150	76	3	35	1 3/8
100	300	101.5	4	35	1 3/8
200	600	127	5	44.5	1 3/4
400	1200	178	7	57.1	2 1/4

* Tolerances on F
-0.00 in. (-0 mm)
+0.08 in. (+2 mm)

FIGURE 5
Cine type Spool

E

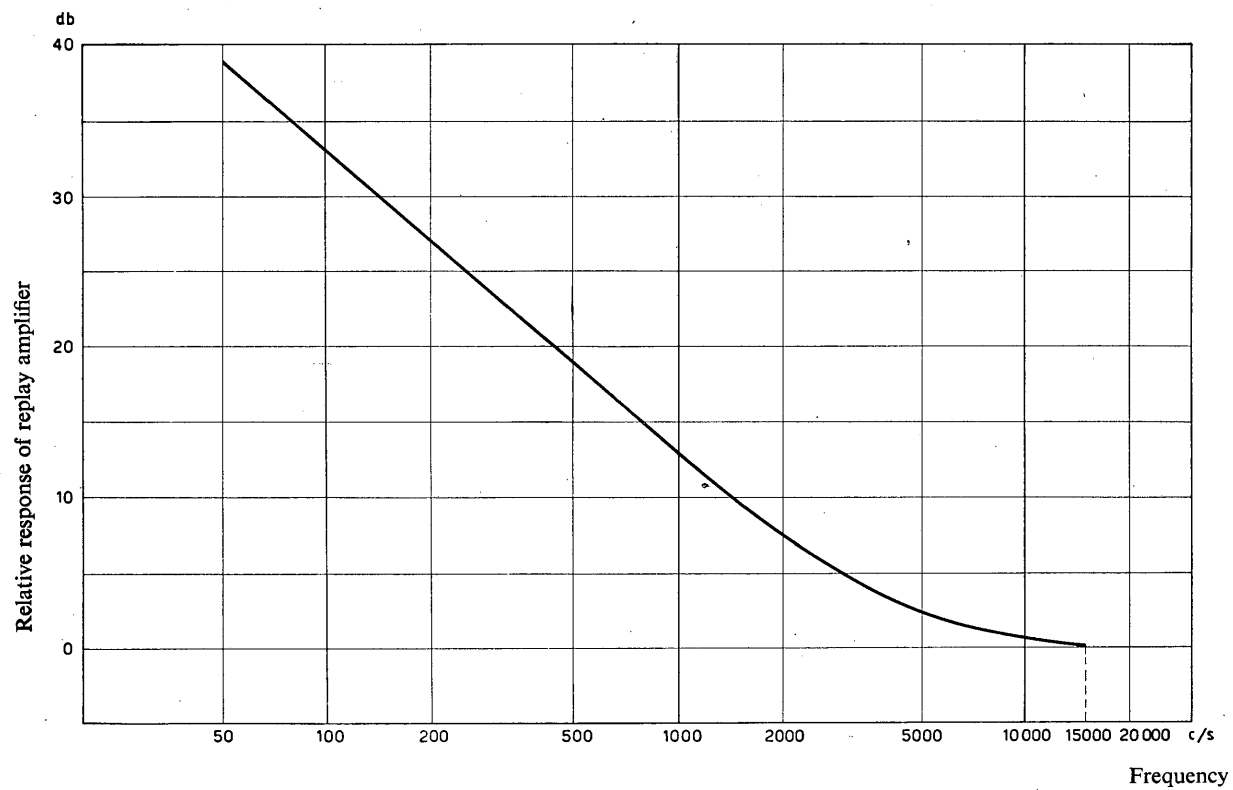


FIGURE 6

Nominal reproducing characteristic for magnetic tape at 15 in/s and 30 in/s

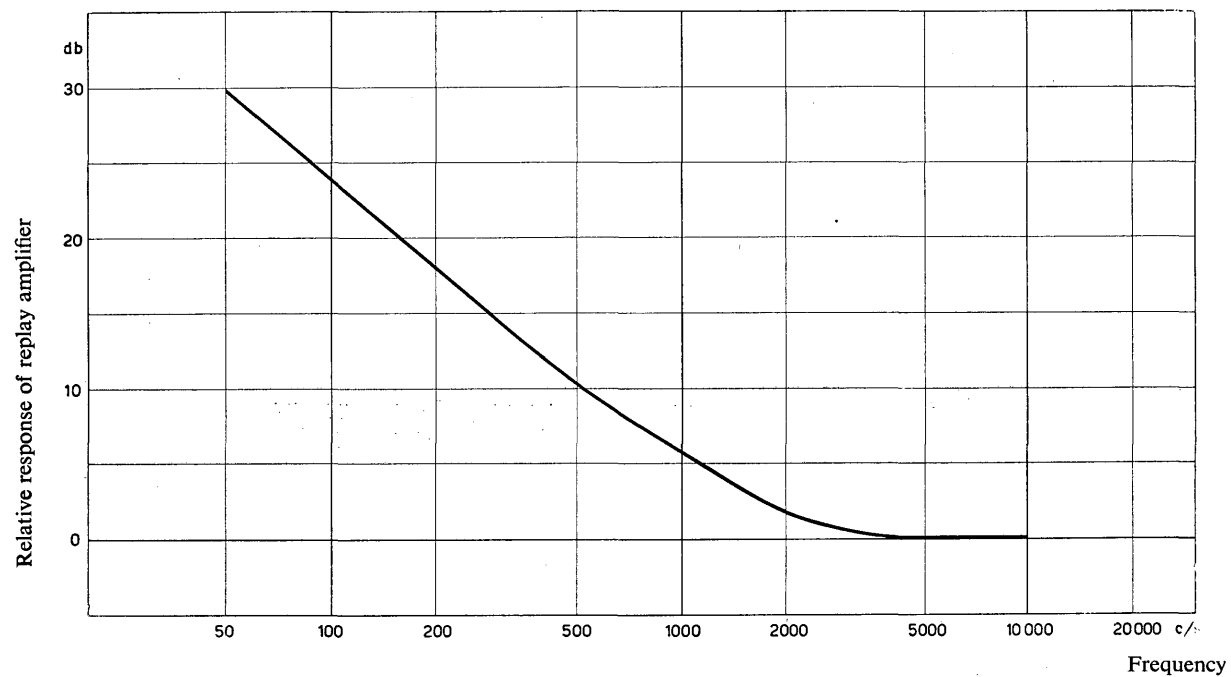


FIGURE 7

Nominal reproducing characteristic for magnetic tape at 7½ in/s

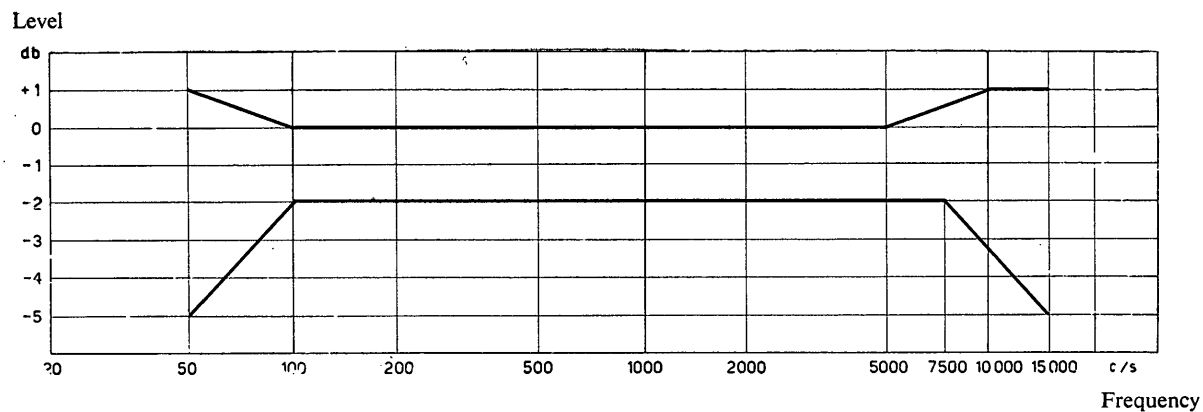


FIGURE 8

Recording tolerance for the speed of 15 and 30 in/s. Limits within which the response should lie when reproduction is carried out on the Standard Replay Chain

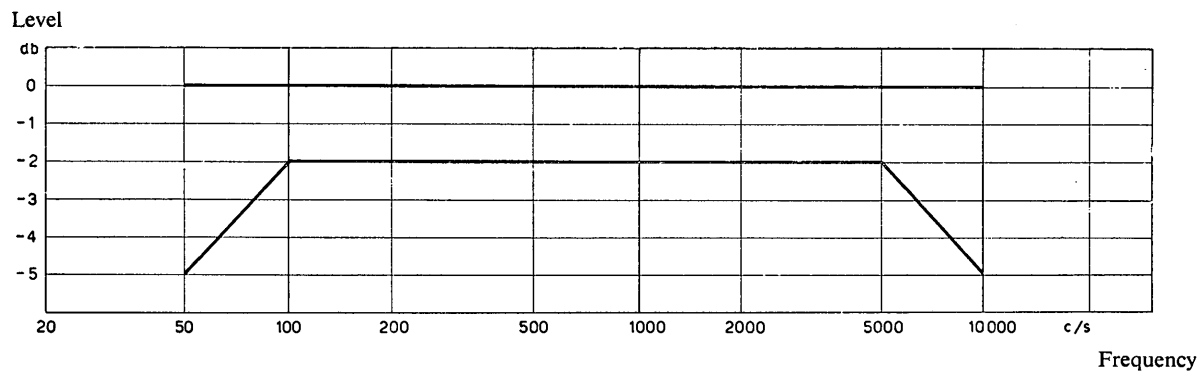


FIGURE 9

Recording tolerance for the speed of 7 1/2 in/s. Limits within which the response should lie when reproduction is carried out on the Standard Replay Chain

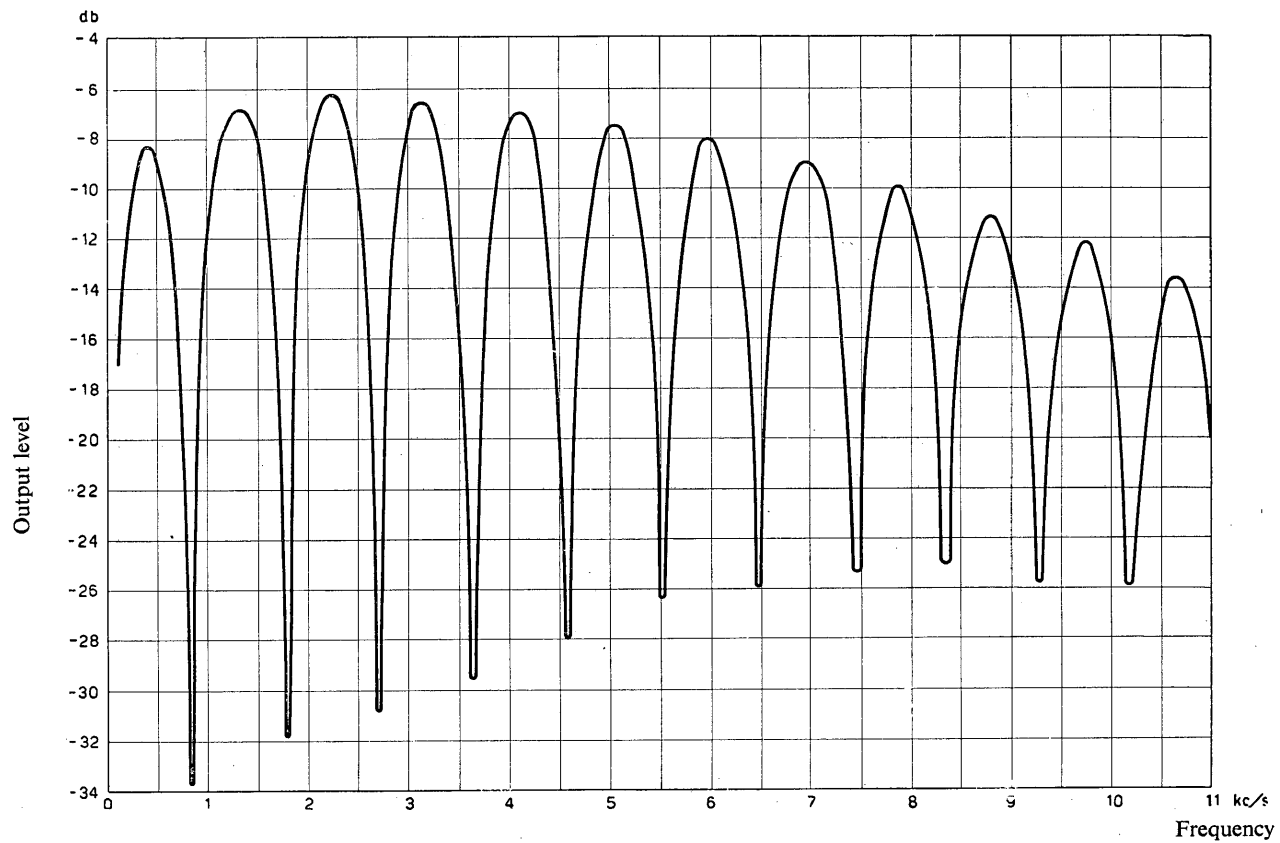


FIGURE 10
Typical response curve of a "long gap" reproducing head

RECOMMENDATION No. 262

H.F. BROADCASTING
Effects of Closer Spacing Between Carriers
(Question No. 203 (X))

The C.C.I.R.,

(Los Angeles, 1959)

UNANIMOUSLY RECOMMENDS:

that at least with the majority of receivers in use, the ratio of the wanted to unwanted field-strengths to give satisfactory reception (see Note) when two transmitters use carrier frequencies 5 kc/s apart should not be considered to be less than when the transmitters use the same frequency (within 50 c/s).

Note. — Satisfactory reception is defined here as a condition when the interference from the unwanted signal can be deemed tolerable.

RECOMMENDATION No. 263 *

STANDARDS FOR FREQUENCY-MODULATION SOUND BROADCASTING
IN THE VHF (METRIC) BAND

(Question No. 150 (X))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

RECOMMENDS

that for frequency-modulation sound broadcasting:

1. the maximum frequency deviation should be either ± 75 kc/s or ± 50 kc/s;
2. the pre-emphasis characteristic should be defined as a curve rising with frequency in conformity with the admittance of a parallel combination of a capacitance and a resistance having a time constant of 50 microseconds;
3. in the absence of interference from industrial and domestic equipment a minimum field strength ** of 50 μ V/m can be considered to give an acceptable service;
4. in the presence of such interference a satisfactory service requires a minimum median field strength ** of
 - 0.25 mV/m in rural areas,
 - 1 mV/m in urban areas,
 - 3 mV/m in large cities;
5. the protection ratios required to give satisfactory reception for 99% of the time are as given below, in terms of the spacing between carrier frequencies and for a maximum frequency deviation of ± 75 kc/s:
 - 28 db for co-channel working
 - 12 db for carriers spaced at 100 kc/s.
 - 6 db for carriers spaced at 200 kc/s.
 - 7 db for carriers spaced at 300 kc/s.

* This Recommendation replaces Recommendation No. 206. Canada and the U.S.A. reserved their opinions on this Recommendation.

** The field-strength as measured 10 metres above ground level.

The above figures apply when the interference results from tropospheric propagation; for steady interference about 8 db extra protection is required;

6. an added protection can be obtained by carrier offsetting of 20 kc/s or more, but the gain in protection depends on the types of receivers mainly used in each country. Carrier offsets to give 8 db added protection can vary from 20 kc/s to 60 kc/s.

Note. — Further consideration of Question No. 150 (X) may lead to modification of the figures given in paragraphs 5 and 6.

RECOMMENDATION No. 264 *

RECORDING STANDARDS FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES

(Question No. 100)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

UNANIMOUSLY RECOMMENDS

that the international exchange of recorded television programmes should be effected by means of one of the following:

- (1) film 35 COMOPT
- (2) film 16 COMOPT
- (3) film 16 COMMAG
- (4) films 16 SEPMAG
- (5) films 35 SEPMAG

in accordance with the definitions and standards given in Recommendation No. 265.

Film type 5 is a secondary standard and cannot be exchanged until there is agreement between the organizations concerned.

RECOMMENDATION No. 265 **

RECORDING STANDARDS FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES

Film Recording

(Question No. 100)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

UNANIMOUSLY RECOMMENDS

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

* This Recommendation, together with Recommendation No. 265 replaces Recommendation No. 211.

** This Recommendation together with Recommendation No. 264 replaces Recommendation No. 211.

1. Definitions

The types of films are designated by code words defined below. The code words should be placed on the identification leader of any film used for programme exchange and should also be used for any correspondence concerning these films.

Any form of picture and sound recording is specified by a number (or numbers) in conjunction with a two or three syllable code word: for example, 35 COMOPT.

The number, usually 16 or 35, indicates the gauge of the film in millimetres. The first syllable of the code word indicates either a combined sound and picture recording by the letters COM or separate sound and picture by the letters SEP. The second syllable of the code word indicates whether the sound recording is magnetic or optical by the letters MAG or OPT. Thus,

- 35-mm film with an optical sound track is 35 COMOPT
- 16-mm film with a magnetic stripe is 16 COMMAG
- 35-mm film with separate ("unmarried") magnetic sound is 35 SEPMAG.

- 1.1 If the sound and picture films are of the same gauge, this is indicated by a single number. If not, then two numbers separated by a stroke are used, the first indicating the gauge of the picture film. For example:

- 35-mm picture film with magnetic sound track on 16-mm film is 35/16 SEPMAG
- 16-mm picture film with optical sound track on 35-mm film is 16/35 SEPOPT

If the sound is carried on a $\frac{1}{4}$ -inch (unperforated) tape the second gauge number is replaced by the letter T. Thus,

- 16-mm picture film with sound or magnetic tape is 16/T SEPMAG

- 1.2 If the sound is on a separate film using two, three or four tracks, then the syllable DU for two tracks, TRI for three tracks or QUAD for four tracks is inserted between the two code-word syllables. Thus,

- 16-mm film with magnetic stripe is 16 COMMAG
- 16-mm picture film with single magnetic sound track on a separate 16-mm film is 16 SEPMAG
- 16-mm picture film with two magnetic sound tracks on a separate 16-mm film is 16 SEPDMAG
- 16-mm picture film with three magnetic sound tracks on a separate 35-mm film is 16/35 SEPTRIMAG
- 35-mm picture film with four magnetic sound tracks on a separate 35-mm film is 35 SEPQUADMAG

- 1.3 In the case of picture film without sound, the designation is 16 MUTE or 35 MUTE.

2. Standards common to all films

- 2.1 Safety film should be used.
- 2.2 The film should normally be photographic positive.
- 2.3 The picture (frame) frequency should be either 25 or 24 pictures (frames) per second.
- 2.4 Splicing of the film should be carried out according to ASA PH 22.24 for 16 mm.
- 2.5 The leader attached to a film sent to another organization should end in a frame line of the general form indicated in Fig. 1.

When joined on to a combined sound and picture film, the leader should be spliced on so that the dotted line is one frame ahead of picture start or sound start, whichever is the earlier in time sequence.

When used with separate sound and picture films, the dotted frame line of one leader should be joined one frame ahead of picture or sound start, whichever is the earlier in time sequence; the other leader should be joined to the other film so that the dotted line indicates a point that is synchronous with the dotted frame line on the first, a blank length of film being inserted if necessary.

- 2.6 The minimum length of the protection and identification leader should be 3 metres.
- 2.7 The minimum information given on the identification leader should be as follows:
 - Name of sending organization
 - Code word (see § 1)
 - Picture frequency
 - Title of film
 - Number of reel
- 2.8 The films should be either on flanged reels as described in ASA specification PH 22.11 for the 16-mm films, or on flangeless hubs as described in ASA specification PH 22.37 for the 35-mm films and ASA specification PH 22.38 for the 16-mm film.*
- 2.9 Flanges and hubs for films with magnetic sound recording should be of non-magnetic material.
- 2.10 The diameter of a flanged reel or the outer diameter of the film on a flangeless hub should not exceed 15 in. (380 mm).

3. Special standards for certain types of film

3.1 35 COMOPT

ASA specifications: PH 22.36 PH 22.58
 PH 22.59 PH 22.40

3.2 16 COMOPT

ASA specifications: PH 22.12 Z 22.8
 Z 22.7 Z 22.41

3.3 16 COMMAG

- 3.3.1 The dimensions and position of the magnetic stripe should be as given in Fig. 2.
- 3.3.2 The sound record should be in advance of the picture by $28 \pm \frac{1}{2}$ frames.
- 3.3.3 The magnetic stripe should be on the side of the film that faces the light source of a projector arranged for direct projection on to a reflecting type screen.
- 3.3.4 The maximum additional thickness due to the magnetic stripe should be 0.0008 in. (20 microns).
- 3.3.5 If a balancing magnetic stripe is used outside the sprocket holes, it should have the same composition and thickness as the main magnetic stripe. The dimensions and position of the magnetic stripe should be as given in Fig. 2.
- 3.3.6 No recording should be made on the balancing stripe.
- 3.3.7 The recording characteristic should be that standardized by the C.C.I.R. for magnetic tape for a tape speed of $7\frac{1}{2}$ in/s (19.05 cm/s) (Recommendation No. 209 amended).

3.4 16 SEPMAG

- 3.4.1 The second film should be a standard 16-mm film with single perforation intended to run at the same mean speed as the picture film.**
- 3.4.2 Either one or two sound tracks may be provided. Track No. 1 is nominally 0.2 in. (5 mm) wide and in the centre of the film; track No. 2 is nominally 0.1 in. (2.5 mm) wide at the unperforated edge. See Fig. 3.
- 3.4.3 If there is only one sound track, it should be in the centre (track No. 1).
- 3.4.4 If two tracks are used, they should be placed synchronously on the film.

* It should be noted that in some cases film coming from France may be received on a of hub different design.

** It is to be noted in this connection that France may send out double perforated film for some time.

- 3.4.5 The COM and SEP forms should not be combined, that is to say, if a sound track or tracks are provided on a separate film, only these tracks should be used for reproduction.
- 3.4.6 The code word 16 SEPMAG or 16 SEPDUMAG should always be marked on the identification leaders of both films to indicate whether one or two sound tracks are provided.
- 3.4.7 The recording characteristic should be that standardized by the C.C.I.R. for magnetic tape for a tape speed of $7\frac{1}{2}$ in/s (19.05 cm/s) (Recommendation No. 209 amended).
- 3.5 35 SEPMAG
- 3.5.1 The second film should be a standard 35-mm double-perforated film intended to run at the same mean speed as the picture film.
- 3.5.2 Up to three sound tracks may be provided, their positions and dimensions being as described in ASA specification PH 22.86, i.e. three tracks nominally 0.2 inches (5 mm) wide. See Fig. 4.
- 3.5.3 The tracks should be designated as follows: Track No. 1 is the left-hand track, No. 2 the central track and No. 3 the right-hand track as seen on a film hanging vertically with the start end downwards and with the magnetic coating towards the observer.
- 3.5.4 If only one sound track is used, it should be track No. 1.
- 3.5.5 If a second track is used, it should be track No. 2.
- 3.5.6 If two or three sound tracks are provided, they should be placed synchronously on the film.
- 3.5.7 The COM and SEP forms should not be combined, that is to say, if one or more sound tracks are provided on a separate film, only these tracks should be used for reproduction.
- 3.5.8 The code word 35 SEPMAG, 35 SEPDUMAG, or 35 SEPTRIMAG should always be marked on the leaders of both films to indicate whether one, two or three sound tracks are provided.
- 3.5.9 The recording characteristic should be that standardized by the C.C.I.R. for magnetic tape for a tape speed of 15 in/s (38.1 cm/s) (Recommendation No. 261).

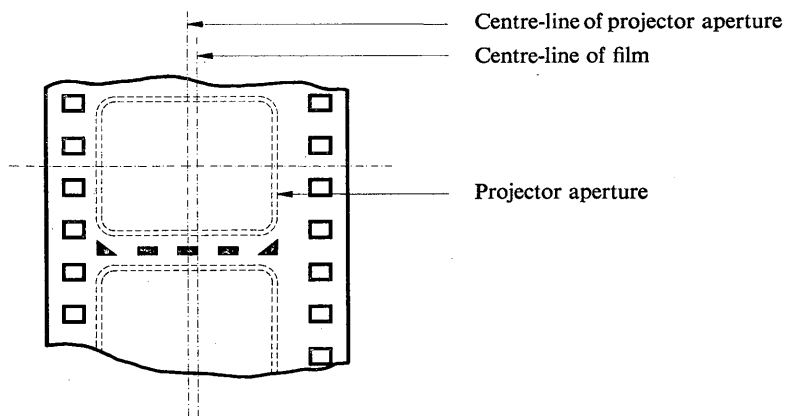
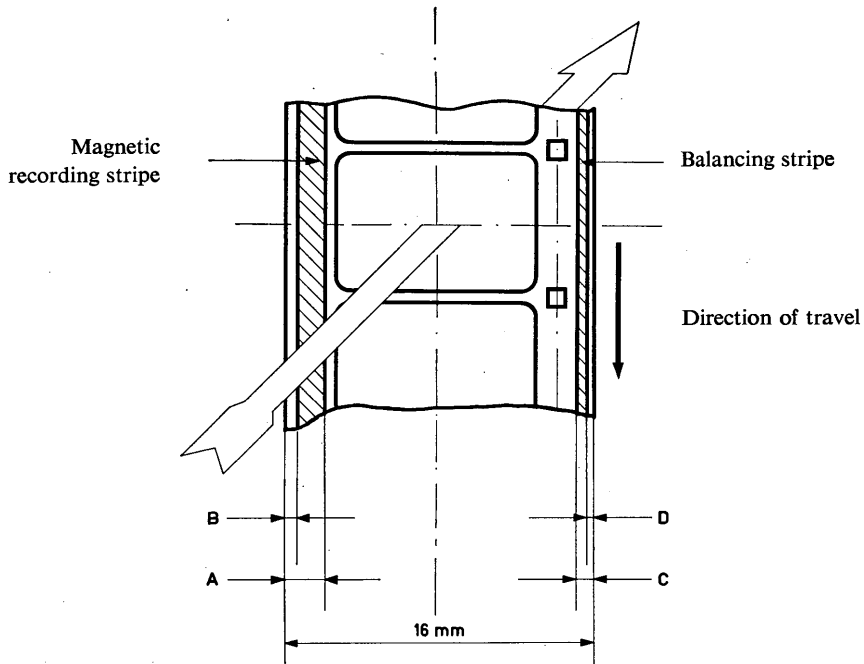


FIGURE 1

End of the identification leader

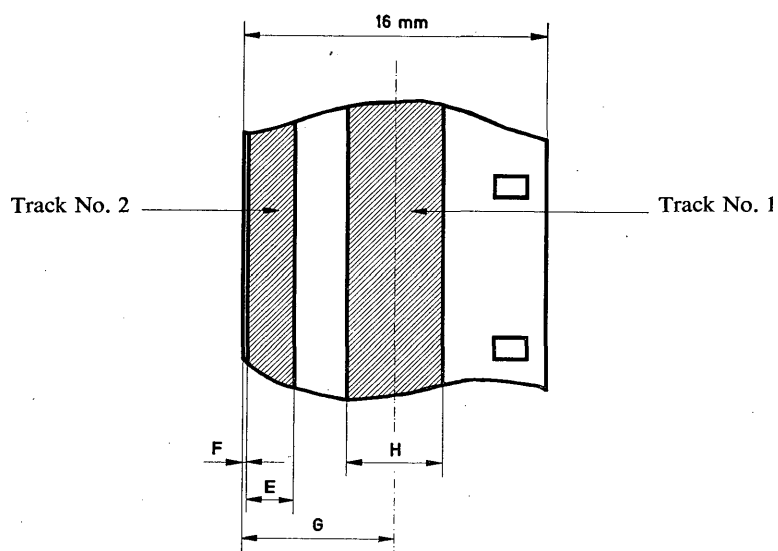


Dimensions

	Inches	Millimetres
A	0.100 $\begin{smallmatrix} +0.004 \\ -0.002 \end{smallmatrix}$	2.5 $\begin{smallmatrix} +0.15 \\ -0 \end{smallmatrix}$
B	0.005 max.	0.15 max.
C	0.031 $\begin{smallmatrix} +0 \\ -0.005 \end{smallmatrix}$	0.8 $\begin{smallmatrix} +0 \\ -0.1 \end{smallmatrix}$
D	0.002 max.	0.05 max.

FIGURE 2

Sound recording on film type 16 COMMAG

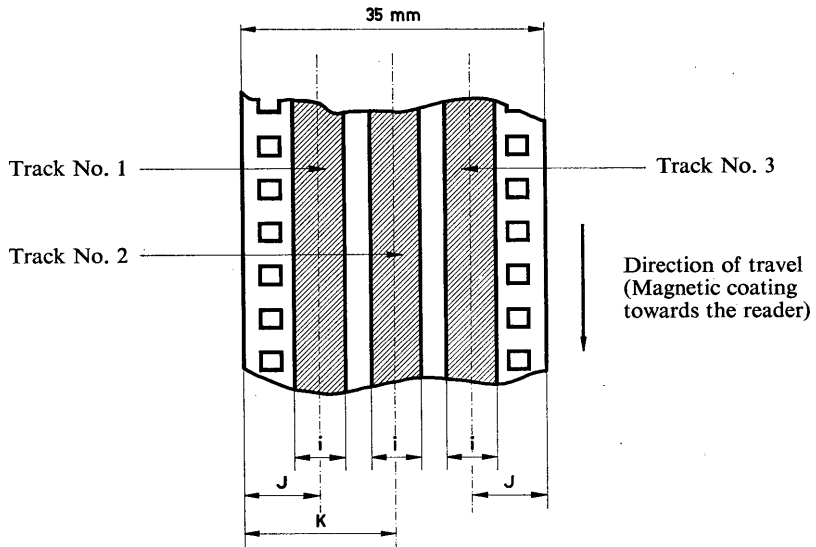


Dimensions

	Inches	Millimetres
E	0.100 $+0.005$ -0.000	2.54 $+0.127$ -0.000
F	0.005 $+0.000$ -0.005	0.127 $+0.000$ -0.127
G	0.315 ± 0.004	8.00 ± 0.10
H	0.200 ± 0.002	5.08 ± 0.05

FIGURE 3

Sound recording on film type 16 SEPDUMAG



Dimensions

	Inches	Millimetres
i	0.200 ± 0.002	5.08 ± 0.05
J	0.339 ± 0.004	8.61 ± 0.10
K	0.689 ± 0.004	17.50 ± 0.10

FIGURE 4

Sound recording on film type 35 SEPTRIMAG

RECOMMENDATION No. 266

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

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that the transmission of television signals using the vestigial sideband techniques gives rise to distortion;
- (b) that this distortion consists of linear distortions (in-phase errors) and non-linear distortions (quadrature errors);
- (c) that with average pictures the depths of modulation are low and thus the non-linear distortion is less visible than the linear distortion;
- (d) that these linear distortions arise partly from the transmitter and partly in the receiver;
- (e) that due regard has to be paid for future design and development of television receivers as well as to the differing degrees of phase errors in existing receivers;

UNANIMOUSLY RECOMMENDS

- 1. that linear precorrection shall be introduced into the television picture transmitter so as to compensate for that part of the linear distortion arising from the errors in the radiated signal;
- 2. that the television picture transmitter may also introduce a correction to compensate for linear distortions arising in the receiver, but this correction shall not exceed one half of that necessary to compensate a receiver using normal minimum phase shift networks and with an amplitude characteristic corresponding to the television standard concerned;
- 3. that the precorrection allowed in § 2, applies only to frequencies between zero and up to approximately half the video bandwidth.

RECOMMENDATION No. 267

REQUIREMENTS FOR THE TRANSMISSION OF MONOCHROME TELEVISION SIGNALS OVER LONG DISTANCES

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

the agreement reached by the Joint C.C.I.R./C.C.I.T.T. Committee for television transmissions (C.M.T.T.) on a draft recommendation concerning television transmissions over long distances, common to the C.C.I.R. and the C.C.I.T.T.,

UNANIMOUSLY RECOMMENDS

that, taking account of the definitions in § 1, monochrome television transmissions over long distances should satisfy the requirements laid down in § 2 and 3 below and their Annexes.

1. Definitions

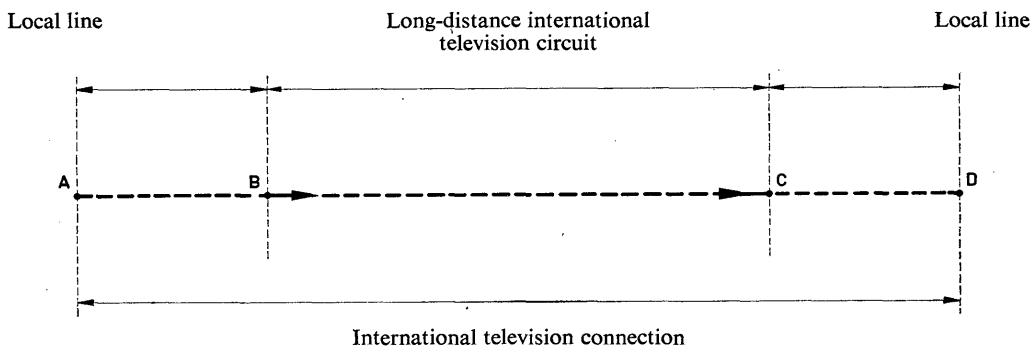


FIGURE 1

1.1 Definition of a long-distance international television connection (see Fig. 1)

- 1.1.1 The point *A*, to be considered as the sending end of the international television connection, may be the point at which the programme originates (studio or outside location), a switching centre, or the location of a standards converter.
- 1.1.2 The point *D*, to be considered as the receiving end of the international television connection, may be a programme mixing or recording centre, a broadcasting station, a switching centre or the location of a standards converter.
- 1.1.3 The local line *AB* connects the point *A* to the sending terminal station, point *B*, of the international television circuit.
- 1.1.4 The long-distance international television circuit, *BC*, comprises a chain of national and international television links. The precise locations (e.g. within buildings) to be regarded as the points *B* and *C* will be nominated by the authorities concerned.
- 1.1.5 The local line *CD* connects point *C*, the receiving terminal station of the international television circuit, to the point *D*.
- 1.1.6 The combination *AD* of the long-distance international television circuit *BC* and the local lines *AB* and *CD* constitutes the "international television connection".

The requirements given in sections 2 and 3 hereafter refer to the performance of long-distance international television circuits only; no requirements have been laid down for the local lines, *AB* and *CD*.

1.2 Definition of the hypothetical reference circuit

The main features of the television hypothetical reference circuit, which is an example of a long-distance international television circuit (*BC* in Fig. 1) and which may be of either radio or coaxial-cable type, are:

- the overall length between video terminal points is 2500 km (1,600 miles approx.),
- two intermediate video points divide the circuit into three sections of equal length,
- the three sections are lined up individually and then interconnected without any form of overall adjustment or correction;
- the circuit does not contain a standards converter or synchronizing-pulse regenerator.

Note. — The purpose of the hypothetical reference circuit concept is to provide a basis for the planning and design of transmission systems. Such a circuit has a length which is reasonably but not excessively long and, in the case of a television circuit, a defined number of video-to-video sections. It is appreciated that at the present time international television circuits generally contain more than three video-to-video links in a 2500 km length but it is expected that the number will be reduced in the course of time.

2. Requirements at video interconnection points

In this section the requirements apply at the video terminals of any long-distance television circuit whatever its length.

2.1 Impedance

At video interconnection points, the input and output impedance of each circuit should be unbalanced to earth with a nominal value of 75 ohms resistive and a return loss of at least 24 db relative to 75 ohms *.

2.2 Polarity and d.c. component

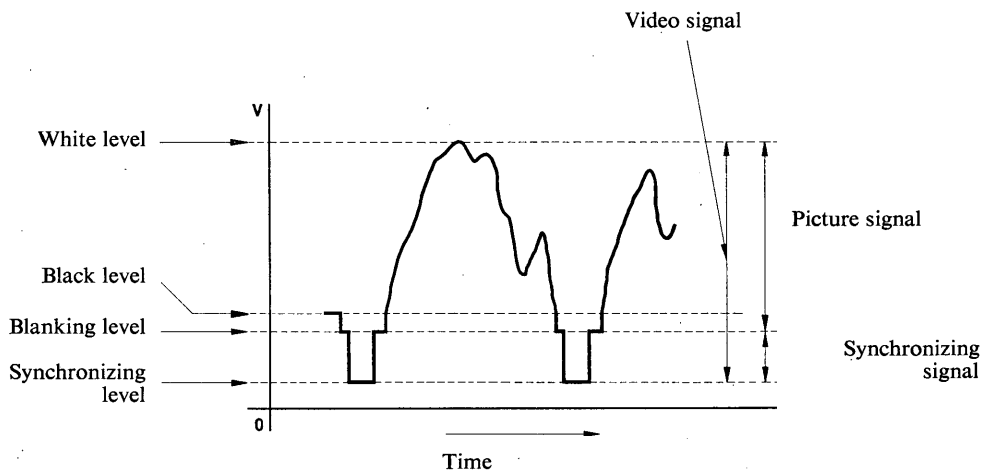
At video interconnection points, the polarity of the signal should be "positive", i.e. such that black-to-white transitions are positive-going.

The useful d.c. component, which is related to the average luminance of the picture, may or may not be contained in the video signal and need not be transmitted, or delivered at the output.

Any non-useful d.c. component unrelated to the video signal (e.g. the component due to d.c. valve supplies) should not cause more than 0.5 watt to be dissipated in the 75-ohm load impedance. If the load impedance is disconnected, the voltage of this component should not exceed 60 volts.

2.3 Signal amplitude

At video interconnection points, the blanking level taken as the reference level, the nominal amplitude of the picture signal, measured from the blanking level to the white level should be 0.7 volt, while the nominal amplitude of the synchronizing signal, measured from the blanking level to the tips of the synchronizing pulses should be 0.3 volt, so that the nominal peak-to-peak amplitude of the video signal should be 1.0 volt (see Fig. 2).



V = Difference in potential between the terminal (not at earth potential) of the input (or output) impedance and earth (difference of potential positive in an upward direction).

FIGURE 2

Theoretically, the amplitude should be measured with the useful d.c. component of the video signal restored but in practice this is not necessary.

Note 1. — In the design of equipment, account should be taken of the losses in interconnecting cables when the video interconnection points are at some distance from the terminals of the modulating and demodulating equipment.

* The return loss, relative to 75 ohms, of an impedance Z is

$$20 \log_{10} \left| \frac{75 + Z}{75 - Z} \right| \text{ decibels.}$$

Note 2. — In the 525-line system used in Japan the nominal amplitude of the picture signal is 1.0 volt and that of the synchronizing signal 0.4 volt.

3. Transmission performance of the hypothetical reference circuit

In this section the performance requirements are to be taken as design objectives applying to the hypothetical reference circuit as defined in section 1.2.

It should be emphasized that the material of this section constitutes only a first step towards the solution of the general problem of determining methods of measuring and specifying the performance of television circuits of any length or degree of complexity.

3.1 Insertion gain

A long-distance international circuit having the form of the hypothetical reference circuit should, at the time of setting up, have an insertion gain of $0 \text{ db} \pm 1 \text{ db}$.

The insertion gain should be measured using Test-Signal No. 2 (described in Annex I) and is defined as the ratio, expressed in decibels, of the amplitude of the bar (from black level to white level) at the output to the nominal amplitude of the bar at the input.

The measurement should be made under the following conditions:

A generator producing Test Signal No. 2, and having an internal impedance of 75 ohms (resistive), is adjusted so that if connected directly to a 75-ohm resistance, it would produce a line-synchronizing signal of 0.3 volt combined with a picture signal of 0.7 * volt which may include 0.05 volt of pedestal. At the receiving end, the voltage between the black level and white level (bar amplitude) is measured, using an oscilloscope connected across a 75-ohm resistance. The ratio of this voltage to 0.65 volt if pedestal is used, or 0.7 volt if it is not, expressed in decibels, is the insertion gain of the television circuit.

3.2 Insertion gain variations

For the hypothetical reference circuit, the variations of insertion gain with time should not exceed the following limits:

- short-period (e.g. 1 second) variations: $\pm 0.3 \text{ db}$
- medium-period (e.g. 1 hour) variations: $\pm 1.0 \text{ db}$

3.3 Noise

3.3.1 Continuous random noise

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 kc/s and the nominal upper limit of the video frequency band of the system, 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 ratios should be not less than the values X given in the following table when measured with the appropriate low-pass filter described in Annex II, the appropriate weighting network described in Annex III, and an instrument having an “effective time constant” or “integrating time” in terms of power of 1 second.

System	Lines	405	525	625	625	819	819
	Nominal upper limit of video frequency band f_c (Mc/s), ...	3	4	5	6	5	10
Signal-to-weighted-noise ratio X (db)		50		52	57		50

* 1 volt for the 525-line system used in Japan.

** Administrations measuring the quasi-peak-to-peak amplitude of the noise are asked to establish the crest factor appropriate to their method of measurement and to express the results in terms of r.m.s. noise.

Note 1. — To obtain satisfactory transmission performance, television specialists believe that the signal-to-weighted-noise ratio should neither fall below X db for more than 1% of any month, nor below $(X - 4)$ db for more than 0.1% of any month. This latter ratio might be reduced to $(X - 8)$ db if desired by C.C.I.R. Study Group IX,* but any proposal for a greater reduction would need to be studied carefully.

Note 2. — One possible device for measuring signal-to-weighted-noise ratio is described in Doc. No. XI/25 (Moscow, 1958) and Doc. C.M.T.T./23 (Monte-Carlo, 1958) of the U.S.S.R.

3.3.2 Periodic noise

The signal-to-noise ratio for periodic noise is defined as the ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal (see Fig. 2) to the peak-to-peak amplitude of the noise.

Note. — This definition has so far been used in specification clauses dealing with single-frequency noise and with power-supply hum (including the fundamental frequency and lower-order harmonics), but it may prove to be useful also for any case in which two or more sinusoidal components are in harmonic relationship.

For the hypothetical reference circuit, the signal-to-noise ratio should not be less than the value given in the following table:

System	No. of lines	405	525	625	625	819	819
	Nominal upper limit of video frequency band f_c (Mc/s)	3	4	5	6	5	10
	Signal-to-noise ratio (db) for power-supply hum (including the fundamental frequency and lower-order harmonics) **	30		30	30	30	30
	Signal-to-noise ratio (db) for single-frequency noise between 1 kc/s and 1 Mc/s	50		50	50	50	50***
	Value (db) to which the signal-to-noise ratio for single-frequency noise may decrease linearly between 1 Mc/s and f_c	25		30	30	30	30****

3.3.3 Impulsive noise

The signal-to-noise ratio for impulsive noise is defined as the ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal (see Fig. 2) to the peak-to-peak amplitude of the noise.

Provisionally, for the hypothetical reference circuit, a minimum signal-to-noise ratio of 25 db for impulsive noise of a sporadic or infrequently occurring nature has been proposed for all systems, except the 525-line system, on which no information is available.

3.4 Non-linearity distortion

Non-linearity distortion affects both the picture signal and the synchronizing signal.

* This value was adopted at the IXth Plenary Assembly of the C.C.I.R. (see Recommendation No. 289).

** These figures apply only to hum added to the signal and not to hum which in transmission has modulated the amplitude of the signal and cannot be removed by clamping. The measurement should be made without clamping.

*** In the case of the 819-line system (10 Mc/s video bandwidth) for frequencies below 1 kc/s excluding power-supply hum (including both the fundamental frequency and lower-order harmonics) the signal-to-noise ratio may decrease linearly between the values 50 db at 1 kc/s and 45 db at 100 c/s, and between the values 45 db at 100 c/s and 30 db at 50 c/s.

**** In the case of the 819-line (10 Mc/s video bandwidth) system, this figure is reached at a frequency of 7 Mc/s and remains constant between 7 Mc/s and f_c (10 Mc/s).

Non-linearity distortions of the picture signal may be classified under three headings *, namely:

- field-time non-linearity distortion,
- line-time non-linearity distortion,
- short-time non-linearity distortion.

3.4.1 *Field-time non-linearity distortion of the picture signal*

This matter is still under study.

3.4.2 *Line-time non-linearity distortion of the picture signal*

Non-linearity of the picture signal is measured with Test Signal No. 3 (described in Annex I) ** using a superimposed sine-wave of frequency $0.2 f_c$.

The magnitude of the distortion is indicated by the ratio of the minimum peak-to-peak amplitude of the sine-wave to the maximum amplitude along the sawtooth.

The sine-wave may be displayed on an oscilloscope with the time base running at line frequency by using a band-pass filter to separate the sine-wave from the rest of the signal. The display then has the form indicated in Fig. 3 and the line-time non-linearity distortion is indicated by changes in amplitude across the display.

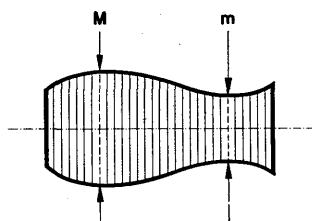


FIGURE 3

For the hypothetical reference circuit, the ratio m/M should not be less than 0.80 whether the intermediate lines are at black or white level.

3.4.3 *Short-time non-linearity distortion of the picture signal*

This matter is still under study ***.

3.4.4 *Non-linearity distortion of the synchronizing signal*

For the hypothetical reference circuit, when the gain of the circuit is 0 db, the amplitude (S) of the line synchronizing signal, measured with Test Signal No. 3, should lie between the limits of 0.21 V and 0.33 V irrespective of whether the intermediate lines are at black level (S_a) or at white level (S_b).

The ratio S_a/S_b therefore lies within the limits 0.64–1.57.

3.5 *Linear waveform distortion*

3.5.1 *Field-time waveform distortion—405-line, 625-line and 819-line systems*

For the hypothetical reference circuit, using Test Signal No. 1 (described in Annex I) the received waveform displayed on an oscilloscope should lie within the limits **** of the mask shown in Fig. 4, provided that the oscilloscope is adjusted so that the half-amplitude points of the bar transitions coincide with M_1 and M_2 , and the mid-points of the 10-ms “black” and “white” portions coincide with A and B respectively.

* The corresponding terms in French are respectively: distorsion non-linéaire aux fréquences très basses, aux fréquences moyennes, et aux fréquences élevées.

** Although this signal is agreed for international use, the United Kingdom proposes to use a “staircase” signal for testing its national television links.

*** In several countries such measurements are currently being carried out using Test Signal No. 3 with a higher value than $0.2 f_c$ for the frequency of the superimposed sine-wave (see Doc. C.M.T.T. No. 41 – Chairman’s report).

**** These limits correspond, for the 405-line system, to a rating factor (K) of 5% ($K=0.05$) as defined in Appendix IV.

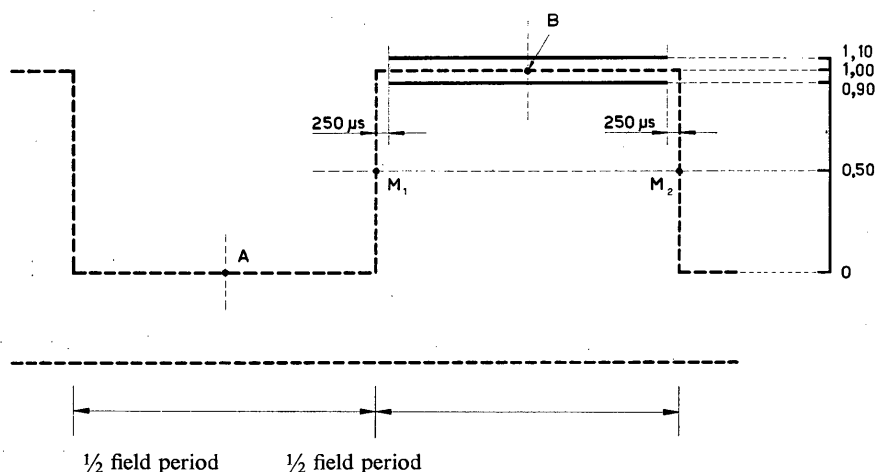


FIGURE 4

*Waveform response to Test Signal No. 1***3.5.2 Line-time waveform distortion 405-line system**

For the hypothetical reference circuit, using Test Signal No. 2 (described in Annex I) with a rise time of $2T$ ($0.33 \mu\text{s}$) and with an interval of $0.1H$ between the bar and the succeeding synchronizing pulse, the received waveform displayed on an oscilloscope should lie within the limits * of the corresponding mask shown in Fig. 5 provided

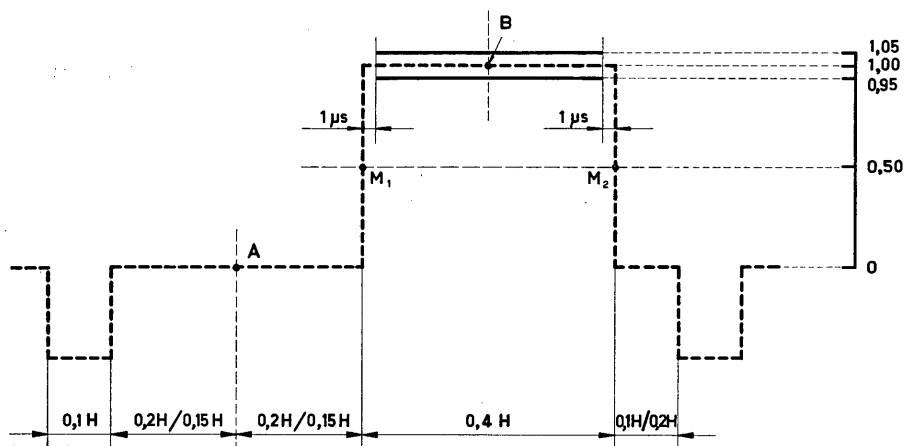


FIGURE 5

Waveform response to Test Signal No. 2

that the oscilloscope is adjusted so that the half-amplitude points of the bar transitions coincide with M_1 and M_2 , and the mid-points of the "black" and "white" portions coincide with A and B respectively.

525-line system

Information not available.

* These limits correspond, for the 405-line system, to a rating factor (K) of 5% ($K=0.05$) as defined in Appendix IV.

625-line and 819-line systems

For the hypothetical reference circuit, using Test Signal No. 2 (described in Annex I) with a rise time of T^* the receiving waveform displayed on an oscilloscope should lie within the limits of the mask shown in Fig. 5, provided that the oscilloscope is adjusted so that the half-amplitude points of the bar transitions coincide with M_1 and M_2 and the mid-points of the "black" and "white" portions coincide with A and B respectively.

3.5.3 Short-time waveform distortion

405-line system

For the hypothetical reference circuit, the rating factor (K) as defined in Annex IV should not exceed 5% ($K = 0.05$). For this measurement, Test Signal No. 2 (described in Annex I) should be used with an interval of 0.1 H between the bar and the succeeding synchronizing pulse and with a sine-squared pulse of half amplitude duration T (0.17 μ s). inserted in the interval "A".

525-line system

Information not available.

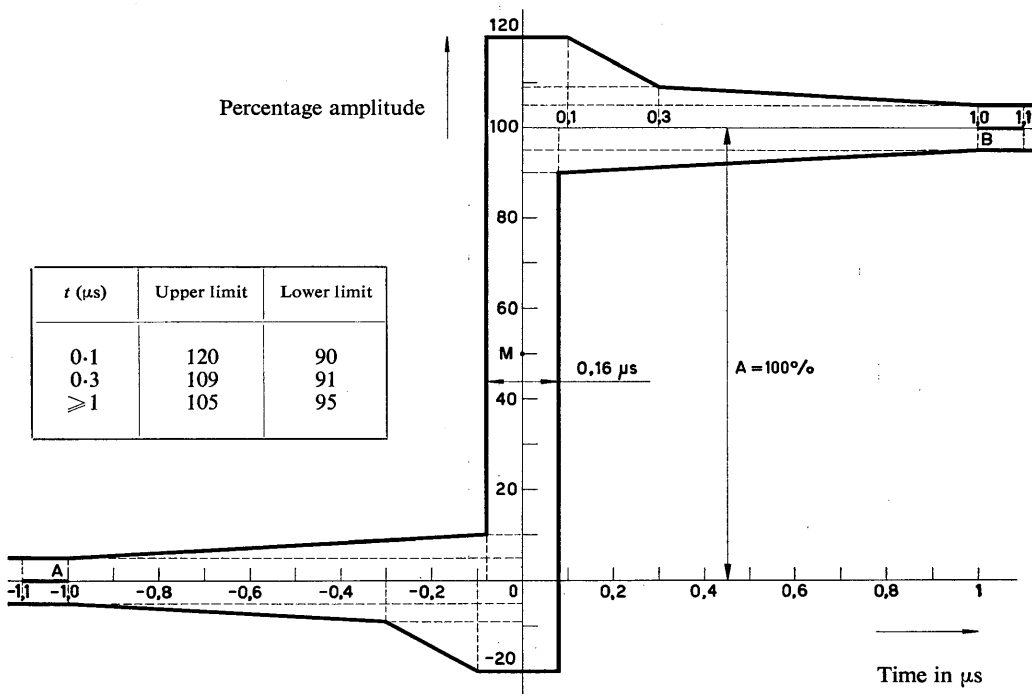


FIGURE 6

Mask for waveform response, using Test Signal No. 2,
for the 625-line and 819-line Belgian system

* For circuits which cut off sharply close to the nominal upper video frequency limit, it may be necessary to use a rise time of $2T$.

625-line systems and 819-line systems

Test Signal No. 2 is used, with a rise-time of $T = 1/(2f_c)$.

The response is observed by means of one of the masks shown in Figs. 6, 7 and 8, the oscilloscope being adjusted so that M coincides with the middle of the rise and the black and white levels coincide with the segments A and B .

If ringing is present in the regions A and B , the peaks of the oscillations should be set symmetrically with respect to A and B .

For the hypothetical reference circuit the response should lie within the limits of the appropriate mask as follows:

- Fig. 6 for the Belgian 625-line system ($f_c = 5$ Mc/s), and the Belgian 819-line system ($f_c = 5$ Mc/s),
- Fig. 7 for the 625-line system ($f_c = 6$ Mc/s),
- Fig. 8 for the other 625-line system ($f_c = 5$ Mc/s) and the 819-line system ($f_c = 5$ Mc/s) and the 819-line system ($f_c = 10$ Mc/s).

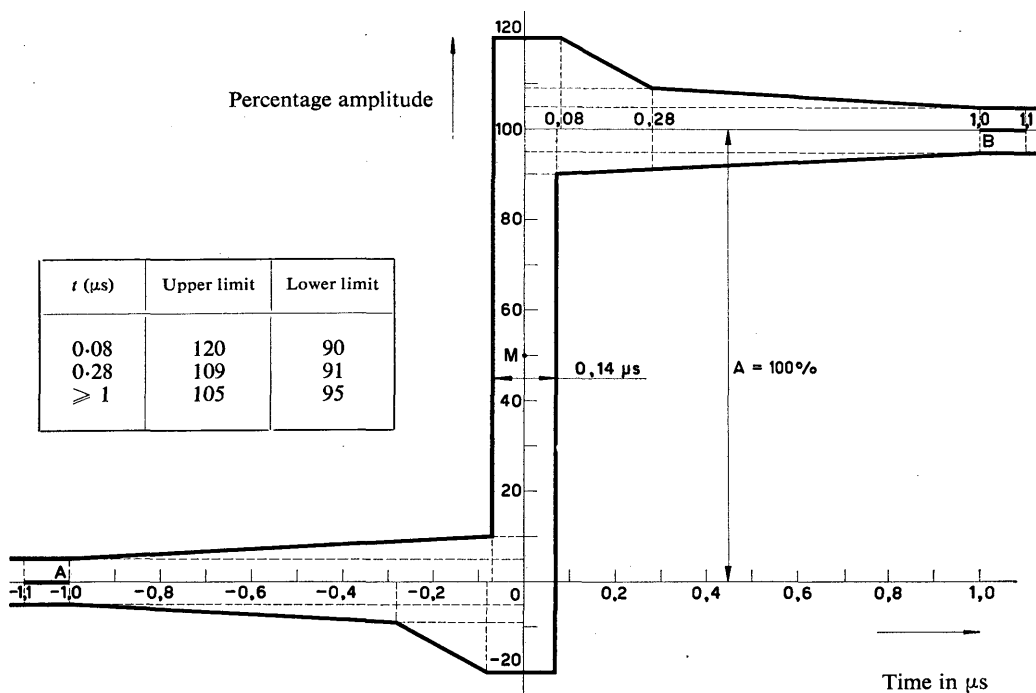


FIGURE 7

Mask for waveform response to Test Signal No. 2, for the 625-line system, in a 8 Mc/s radio channel

Mask formed by a part of the curve defined by:
 $\pm e = 1/8a + 0.025$
 within the limits:
 $e = +0.2$ and $e = -0.1$
 on the one hand, and
 $e = \pm 0.05$ up to $t = 1 \mu s$ on the other hand

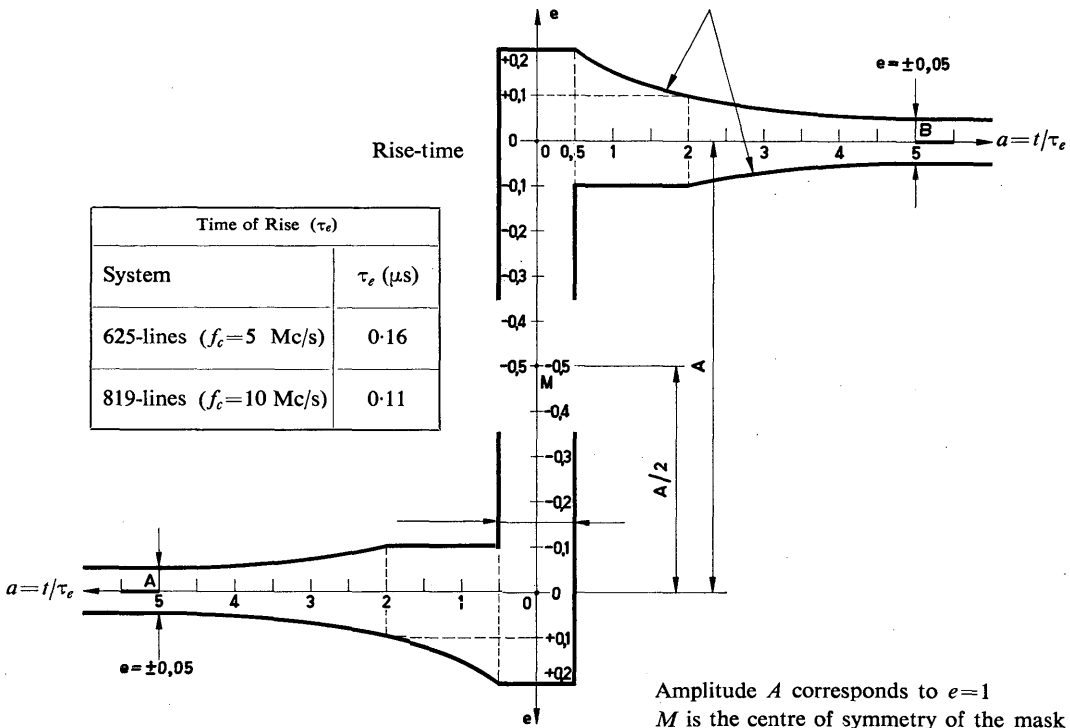


FIGURE 8

Mask for waveform response to Test Signal No. 2 of the
 625-lines ($f_c = 5$ Mc/s) and 819-lines ($f_c = 10$ Mc/s) systems

3.6 Steady-state characteristics

3.6.1 405-line system

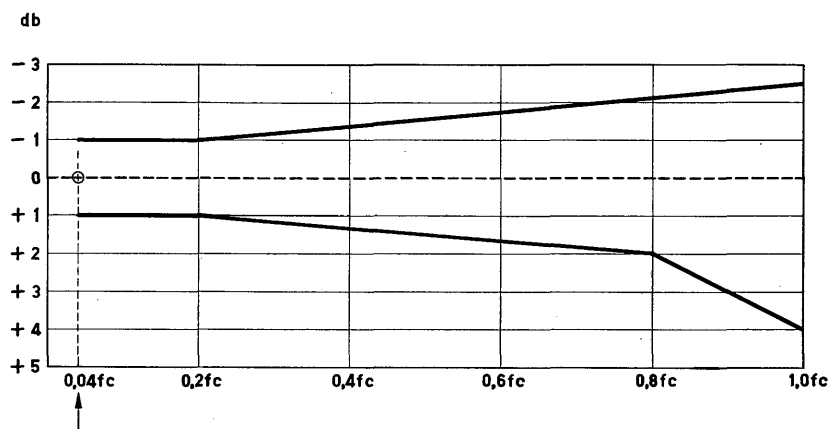
For the hypothetical reference circuit, as a precaution against possible overloading effects, the insertion gain at any frequency between the field-repetition frequency (50 c/s) and the nominal upper limit of the video-frequency band (3 Mc/s) should not exceed the gain at the line-repetition frequency (10 kc/s) by more than 5 db.

3.6.2 525-line system

Information not available.

3.6.3 625-line and 819-line systems

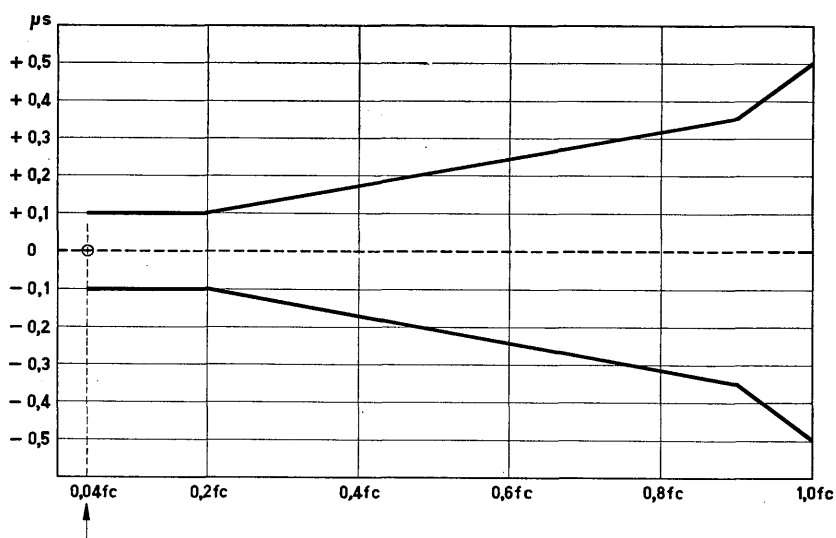
For the hypothetical reference circuit the limits of the attenuation/frequency and envelope-delay/frequency characteristics given in Figs. 9 and 10 may be found useful by designers. In these figures the abscissae show a single parameter which is the ratio between the frequency and the nominal upper video frequency, f_c , of the system considered (normalized frequency).



Reference frequency

FIGURE 9

Limits for the attenuation/normalized frequency characteristic for television systems with nominal upper limits of the frequency band $f_c = 5.6$ and 10 Mc/s respectively



Reference frequency

FIGURE 10

Limits for the envelope-delay/normalized frequency characteristic for television systems with nominal upper limits of the video frequency band $f_c = 5.6$ and 10 Mc/s respectively

ANNEX I

TEST SIGNALS

Test Signal No. 1

Test Signal No. 1 is used in the measurement of field-time wave-form distortion. As shown in Fig. 11 below, it comprises a square wave of field frequency superimposed upon line-synchronizing and blanking pulses. If desired, a field synchronizing signal may be included and the pedestal may be omitted.

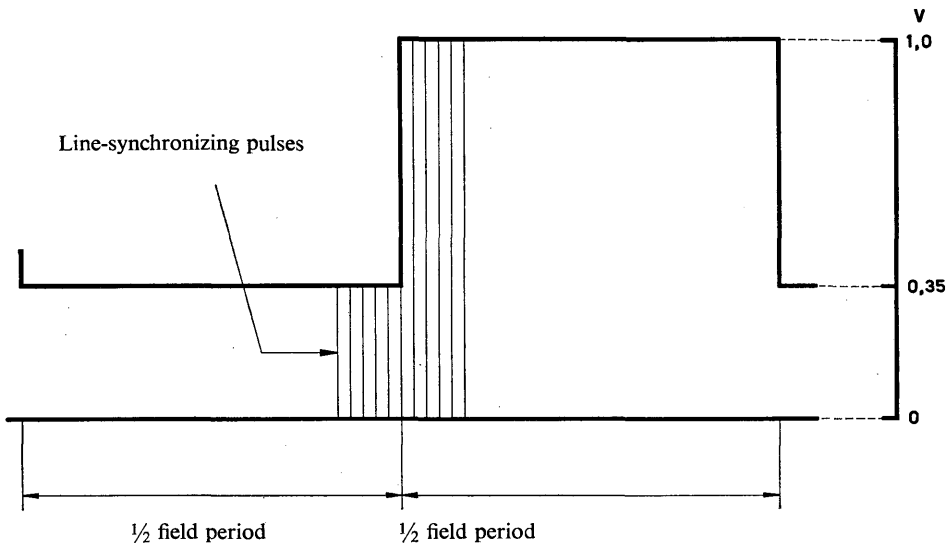


FIGURE 11

*Test Signal No. 1**Test Signal No. 2*

Test Signal No. 2 is used in the measurement of insertion gain, line-time waveform-distortion and short-time waveform-distortion. As shown in Fig. 12, it comprises a half-line bar associated with line-synchronizing pulses. If desired, a field-synchronizing signal may be included. The interval between the half-line bar and the succeeding synchronizing pulse may be either $0.1H$ or $0.2H$, where H is the line period. The pedestal may be omitted if desired.

The precise shape and rise-time of each transition of the half-line bar may be determined by means of a shaping network, the design of which is based on "Solution 3" in a paper by W. E. Thomson (Proc. I.E.E., Part III, 1952, Vol. 99, p. 373). Two alternative networks may be used giving rise-times of T and $2T$, where $T = 1/2 f_c$, f_c being the nominal upper video-frequency limit of the system. (Design details of suitable networks are given in Annex IV).

If desired, an additional feature such as a sine-squared pulse of shape and half-amplitude duration determined by the above-mentioned shaping networks, or a high-frequency burst can be added in the space marked "A".

Test Signal No. 3

Test Signal No. 3 is used in the measurement of non-linearity distortion. As shown in Fig. 13 it is a signal in which the "picture" portion of every fourth line consists of a sine-wave

of 0.1-volt peak-to-peak amplitude superimposed on a sawtooth, the three intermediate lines being set either to black level or to white level by means of a switch at the sending end. If desired, a field-synchronizing signal may be included and the pedestal may be omitted.

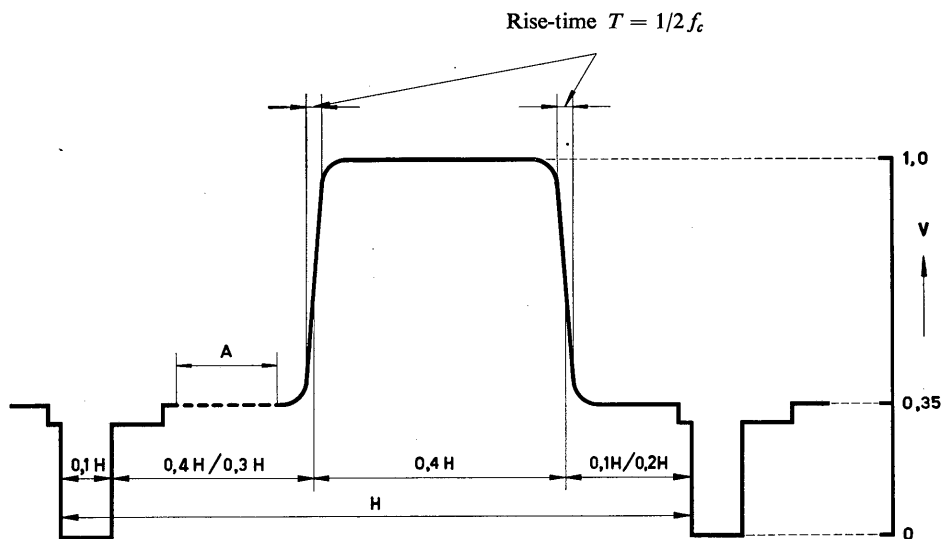


FIGURE 12
Test Signal No. 2

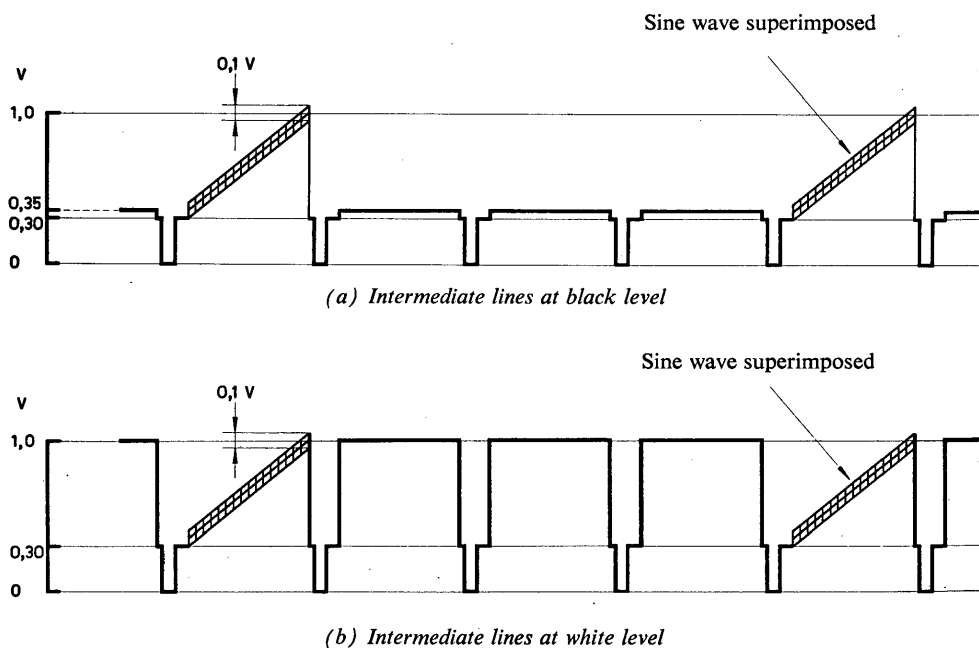


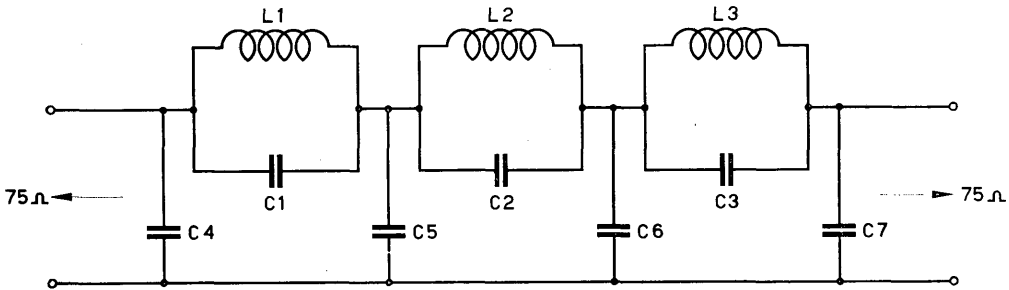
FIGURE 13
Test Signal No. 3

For measuring line-time non-linearity distortion the frequency of the superimposed sine wave is $0.2 f_c$.

At the receiving end of a circuit, any variation of the sine-wave amplitude over the duration of the sawtooth is taken as indicative of non-linearity distortion.

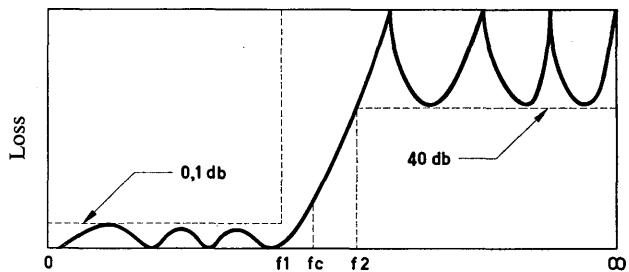
ANNEX II

LOW-PASS FILTER FOR USE IN MEASUREMENTS OF CONTINUOUS RANDOM NOISE



	Nominal upper video-frequency limit f_c (Mc/s)		
	L (μ H)	C (pF)	f (Mc/s)
1	$14.38/f_c$	$497.6/f_c$	$1.8816/f_c$
2	$7.673/f_c$	$2723/f_c$	$1.1011/f_c$
3	$8.600/f_c$	$1950/f_c$	$1.2290/f_c$
4		$2139/f_c$	
5		$2815/f_c$	
6		$2315/f_c$	
7		$1297/f_c$	

f/f_c	db	f/f_c	db
0.98	0.1	1.04	14.8
0.99	0.5	1.05	18.8
1.00	1.8	1.06	23.0
1.01	4.2	1.07	27.7
1.02	7.3	1.08	33.3
1.03	10.9	1.09	41.0



Theoretical insertion loss

$$f_1 = 0.9 f_2 \text{ by design}$$

$$\text{Ringing frequency} = f_c \text{ by design}$$

$$f_1 = 0.9807 f_c$$

$$f_2 = 1.0897 f_c$$

Note 1. — Each capacitance quoted is the total value, including all relevant stray capacitances and should be correct to $\pm 2\%$.

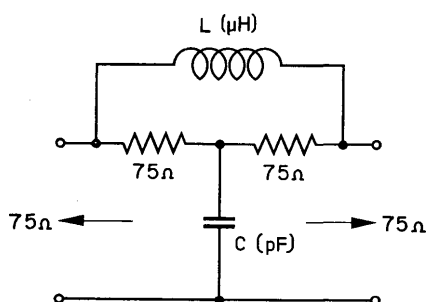
Note 2. — Each inductor should be adjusted to make the insertion loss a maximum at the appropriate indicated frequency, f (Mc/s).

Note 3. — The Q of each inductor measured at the frequency f_c should be between 80 and 125.

Note 4. — Limits for the insertion-loss/frequency characteristic are specified indirectly by the indicated tolerances on the component values.

ANNEX III

CONTINUOUS-RANDOM-NOISE WEIGHTING NETWORKS



$$L(\mu\text{H}) = 75\tau(\mu\text{s}); \quad C(\text{pF}) = \frac{\tau(\mu\text{s})}{75} \cdot 10^6$$

$$\text{Insertion loss (db)} = 10 \log (1 + \omega^2 \tau^2)$$

Number of lines	f_c (Mc/s)	τ (μs)	τf_c	Theoretical weighting, (db), for:	
				"White" noise	"Triangular" noise
405	3	0.33	1.0	6.5	12.3
525	4				
625	5	0.33	1.66	8.5	16.3
625	6	0.33	2.0	9.3	17.8
819	5				
819	10	0.166	1.66	8.5	16.3

f_c is the nominal upper video-frequency limit of the system (Mc/s)

ANNEX IV

SPECIFICATION OF LINEAR WAVEFORM-TRANSMISSION PERFORMANCE
FOR THE 405-LINE SYSTEM1. *Scope*

This Annex describes two complementary methods of specifying the linear waveform-transmission performance, between video input and output terminals, of television links and equipment intended for use with the 405-line 3-Mc/s monochrome system.

2. *General*

The present limitations of available waveform-measuring equipment make it necessary to distinguish two complementary methods of testing performance. The first, or “routine-test”, method is rapid but less precise because it relies on direct oscilloscopic observations of the responses to prescribed test signals, and because the spectrum of one of these signals unavoidably extends beyond the 3 Mc/s limit of interest. The second, or “acceptance-test”, method is slow but more precise because a computational process applied to a series of waveform ordinates (measured by travelling microscope on a photographic record, or by other means) enables irrelevant information to be eliminated and certain measuring-equipment errors to be corrected.

The routine-test method may be used for:

- checking the performance of a batch of items when type-approval has been given after a full acceptance test on one item;
- detecting gross distortion during the initial tests of a new item;
- checking the performance of temporary links and similar items when conditions do not permit a full acceptance test.

The performance limits are given in terms of a rating factor K , for which numerical values are assigned in the individual specifications for links and equipment. Rating factors may range from several per cent for a complex system down to less than $\frac{1}{2}\%$ ($K = 0.005$) for a single video amplifier. The basis of reference of the rating-factor method, is distortion consisting only of a single long-term echo, the rating factor then being numerically equal to the relative amplitude of the echo.

3. *Test-Signal waveforms*3.1 *Pulse-and-bar test signal*

The composite pulse-and-bar test signal consists of a sine-squared pulse and a smoothed half-line bar associated with line-synchronizing pulses as shown in Fig. 14.

The sine-squared pulse should have alternative half-amplitude durations of $0.17\ \mu\text{s}$ (a half-period of 3 Mc/s) and $0.33\ \mu\text{s}$ (a whole period of 3 Mc/s), distinguished by the terms “ T -pulse” and “ $2T$ -pulse” respectively. The T -pulse is used in both the routine-test and acceptance-test methods, but the $2T$ -pulse is used only in the routine-test method. The precise shapes and durations of the pulses are determined by the pulse-shaping networks detailed in Fig. 19, operated under the indicated conditions or their equivalent.

For both the routine-test and acceptance-test methods, each of the bar transitions should have an integrated sine-squared shape with a 10–90% rise time of $0.33\ \mu\text{s}$. These transitions are determined by a pulse-shaping network identical with that used for the $2T$ -pulse, the input waveform being specified to have transitions with 10–90% rise times not exceeding $0.07\ \mu\text{s}$.

3.2 *50-c/s square-wave test signal*

This consists of a 50-c/s square wave associated with line-synchronizing pulses as shown in Fig. 15.

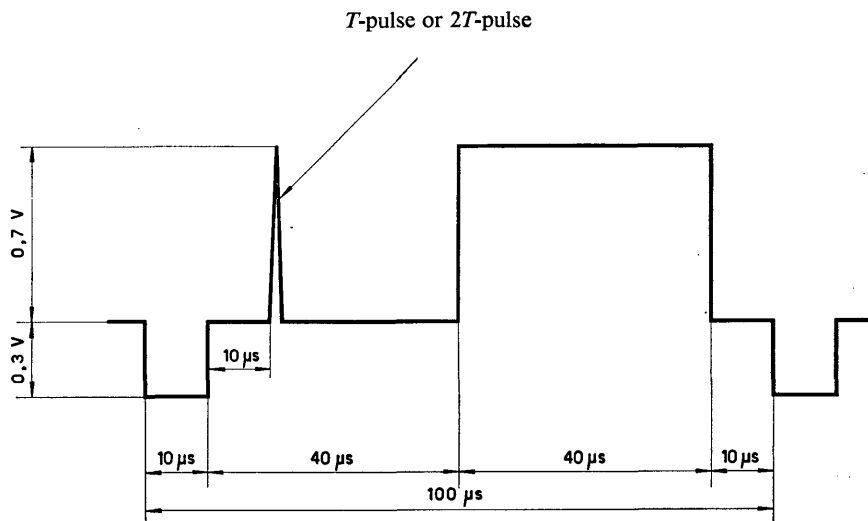


FIGURE 14

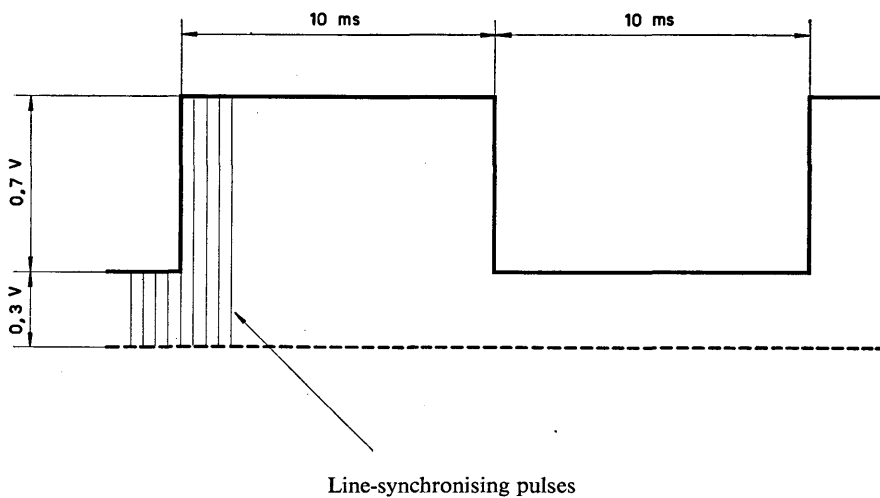
Pulse-and-bar test signal

FIGURE 15

50 c/s square-wave test signal

4. Routine-test method

To meet a specified rating factor K , the responses to the test signals should fall within the limits stated in the following sub-sections.

4.1 Bar response

The limits are indicated by the oscilloscope mask shown in Fig. 16. The oscilloscope is to be adjusted so that the half-amplitude points of the bar transitions coincide with M_1

and M_2 , and the mid-points of the 40- μ s “black” and “white” portions coincide with A and B respectively. The response should then fall within the $\pm K$ limits indicated by the full lines, which extend to 1 μ s from each transition.

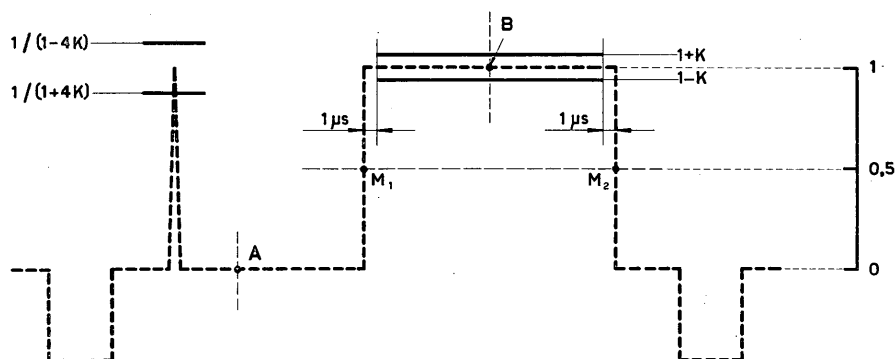


FIGURE 16

Limits of bar response

4.2 2T-pulse response

The limits are indicated by the oscilloscope mask shown in Fig. 17. The oscilloscope is to be adjusted so that:

- the sweep velocity corresponds with the time scale indicated;
- the “black” level of the response coincides with the horizontal axis;
- the peak of the response falls on the unit-amplitude line;
- the half-amplitude points of the response are symmetrically disposed about the vertical axis.

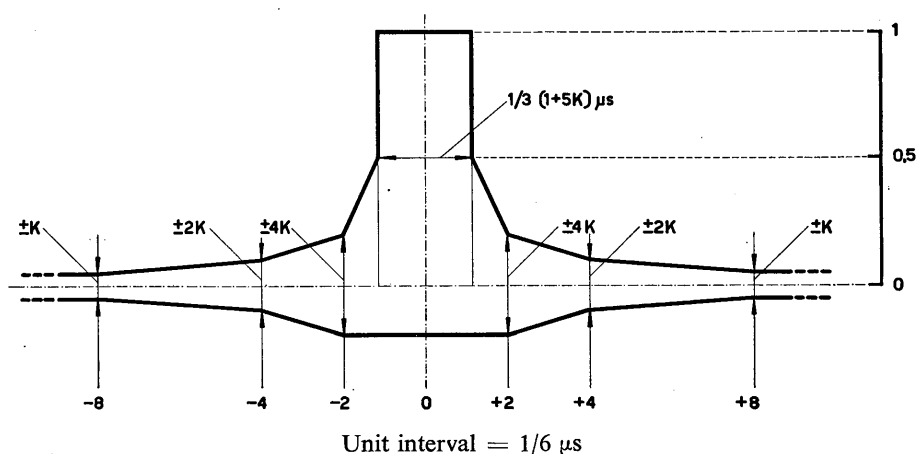


FIGURE 17

Limits of 2T-pulse response

4.3 Bar/pulse ratio

The ratio of the amplitude of the bar response to the amplitude of the 2T-pulse response should fall within the limits $(1 \pm 4 K)$. The amplitude of the bar is taken as the amplitude-difference between the points *A* and *B* already defined; the amplitude of the pulse is the difference between the “black” level and the peak of the response. These limits are also shown in Fig. 17.

4.4 T-pulse response

In the routine-test method, only a few features of the *T*-pulse response need to be specified. For long-distance links which cut off relatively sharply close to 3 Mc/s, typical limits are given in the following table:

Features	Rating factors					
	1%	2%	3%	4%	5%	6%
Half-amplitude duration maximum, (μ s)	0.245	0.250	0.255	0.260	0.265	0.270
Ringing frequency, minimum (Mc/s)	3	3	3	3	3	3
First lobe (negative), leading or trailing, maximum, (%)	10	12	14	16	18	20
Second lobe (positive), leading or trailing, maximum, (%)	6	8	9	10	11	12

Because the *T*-pulse has a frequency spectrum with appreciable components above 3 Mc/s, the response of links or equipment depend to some extent upon their upper cut-off characteristics. For this reason, link or equipment specifications permitting the use of the routine-test method may in some cases call for limits different from those given above.

4.5 50-c/s square-wave response

The limits are indicated by the oscilloscope mask shown in Fig. 18. As for the bar response, the oscilloscope is to be adjusted so that the wave-form passes through the four marked points, the synchronizing pulses being ignored.

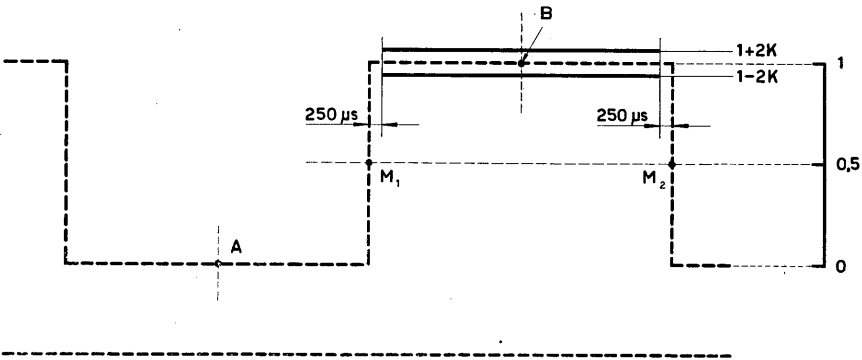


FIGURE 18

Limits of 50 c/s square-wave response

5. *Acceptance-test method*5.1 *Bar response*

The limits are identical with those given in § 4.1 for the routine-test method.

5.2 *T-pulse response*

From the measured *T*-pulse response and the measured or assumed responses of the measuring equipment itself, the “filtered impulse response” is derived and expressed in the form of a normalized time series. The “main” term of this series represents the ideal or non-distorting part of the transmission properties of the item under test, while the “echo” terms represent the distorting part. To meet a specified rating factor, *K*, the amplitudes of the echo terms should be such that each of the following four conditions is met.

Let the time series representing the filtered impulse response be

$$B(rT) = \dots\dots\dots B_{-r} \dots\dots\dots B_{-1} B_0 B_{+1} \dots\dots\dots B_{+r} \dots\dots\dots$$

and assume that this has already been normalized so that $B_0 = 1$.

Let the serial product of $B(rT)$ and the series $(\frac{1}{2}, 1, \frac{1}{2})$ be

$$C(rT) = \dots\dots\dots C_{-r} \dots\dots\dots C_{-1} C_0 C_{+1} \dots\dots\dots C_{+r} \dots\dots\dots$$

where $C_r = \frac{1}{2}B_{r-1} + B_r + \frac{1}{2}B_{r+1}$

The first condition is:

$$\frac{1}{8} \left| \frac{C_r}{C_0} - \frac{1}{2} \right| \leq K \quad r = +1$$

and

$$\frac{1}{8} \left| r \frac{C_r}{C_0} \right| \leq K \quad \begin{cases} -8 \leq r \leq -2 \\ +2 \leq r \leq +8 \end{cases}$$

and

$$\left| \frac{C_r}{C_0} \right| \leq K \quad \begin{cases} r \leq -8 \\ +8 \leq r \end{cases}$$

The second condition is:

$$\frac{1}{4} \left| \frac{1}{C_0} \left(\sum_{-8}^{+8} B_r \right) - 1 \right| \leq K$$

The third condition is:

$$\frac{1}{6} \left| \sum_{-8}^{+8} B_r - 1 \right| \leq K$$

The fourth condition is:

$$\frac{1}{20} \left(\sum_{-8}^{+8} |B_r| - 1 \right) \leq K.$$

The series $C(rT)$ represents fairly closely the response to a 2-*T* pulse. The first condition corresponds approximately to the limits indicated in Fig. 17 for the 2-*T* response in the routine test method.

The second condition corresponds to the limits placed on the bar/pulse ratio in the routine test method.

The third condition corresponds to limits placed on the bar/pulse ratio of the response of a hypothetical pulse-and-bar test signal in which the pulse is an ideal filtered impulse.

The fourth condition is an upper limit placed on the average amplitude, ignoring signs, of the 16 central echo terms.

5.3 *50 c/s square-wave response*

The limits are identical with those given in § 4.5 for the routine test method.

SINE-SQUARED PULSE-SHAPING NETWORK

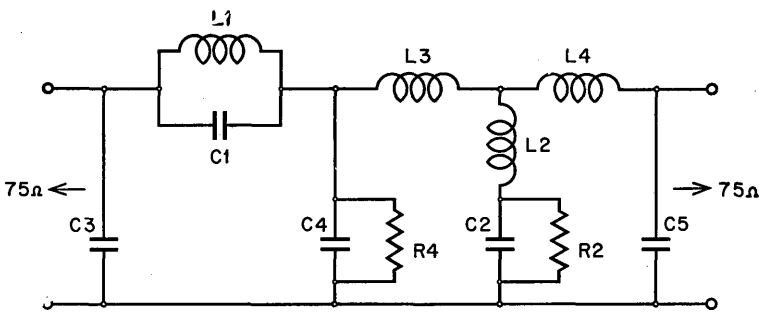


FIGURE 19

Component	Value (see Note 7)		Tolerance ($\pm$ %)	Q (Note 3)
	H.A.D. = $1/6 \mu s$	H.A.D. = $1/3 \mu s$		
L_1	1.580	3.150	1	≥ 70
L_2	0.308	0.617	(Note 2)	≥ 40
L_3	3.091	6.182	1	≥ 100
L_4	3.035	6.069	1	≥ 100
C_1	79.22	158.4	2	
C_2	2168	4335	0.5	
C_3	75.92	151.8	2	
C_4	566.4	1133	0.5	
C_5	166.4	332.9	2	
R_2	1300	1300	5	
R_4	5100	5100	5	

Note 1. — Inductances are given in μH , capacitances in pF, resistances in ohms.

Note 2. — Inductor L_2 should be adjusted to make the insertion loss a maximum at 6.156 Mc/s for the $1/6 \mu s$ network, and at 3.078 Mc/s for the $1/3 \mu s$ network.

Note 3. — The values of Q should be measured at 4 Mc/s for the $1/6 \mu s$ network, and at 2 Mc/s for the $1/3 \mu s$ network.

Note 4. — The network should, if necessary, be connected between masking pads designed to present impedances of $75 \text{ ohms} \pm 1\%$ to the network under operating conditions.

Note 5. — An allowance for stray capacitance should be made in the value of any capacitor.

Note 6. — The design is from "solution 3" given by W. E. Thomson "The synthesis of a network to have a sine-squared impulse response" proc. I.E.E., Vol. 99, part III, p. 373, 1952.

Note 7. — The half-amplitude durations (H.A.D) of the input pulses should not exceed $0.035 \mu s$ and $0.07 \mu s$ for the $1/6 \mu s$ and $1/3 \mu s$ networks respectively.

SECTION F

RADIO-RELAY SYSTEMS

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The following Recommendation which have been classified in other sections, also concern Radio-Relay Systems:

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40	C
267	E

RECOMMENDATION No. 268 *

**RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION
MULTIPLEX**

Interconnection at audio frequencies

(Question No. 192 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 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 conformance with the relevant C.C.I.T.T. recommendations in respect of overall performance measured between audio-frequency terminals is already covered by Recommendation No. 40 relating to systems operating above about 30 Mc/s;
- (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 No. 269 **

**RADIO RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION
MULTIPLEX**

Interconnection at baseband frequencies ***

(Question No. 192 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that frequency-division multiplex radio relay systems may form part of an international circuit;

* This Recommendation replaces Recommendation No. 188.

** This Recommendation replaces Recommendation No. 189.

*** This Recommendation applies to line-of-sight and near line-of-sight radio relay systems, and also to tropospheric scatter systems of the capacities concerned.

- (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;

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 nominal impedance of the baseband circuits at the point of interconnection;
 - 1.5 relative input and output power level, at the point of interconnection *;
2. that as far as is practicable these characteristics should conform to the preferred values given in the Table ** below.

Maximum number of telephone traffic channels (6)	Limits of band occupied by telephone channels (kc/s)	Frequency limits of baseband (kc/s) (5)	Nominal impedance at baseband (Ω) (4)	Relative power level per channel (1) (2) (4)	
				input (db)	output (db)
24	12-108 (3)	12-108 (3)	150 balanced	-45	+ 4.5
60	12-252 60-300	12-252 60-300	150 balanced 75 unbalanced	-45 -45	+ 1.75 -15
120	12-552 60-552	12-552 60-552	150 balanced 75 unbalanced	-45 -45	+ 1.75 -15
300	60-1300 64-1296	60-1364	75 unbalanced	-45	-15
600	60-2540 64-2660	60-2792	75 unbalanced	-45	-20
960	60-4028 316-4188	60-4287	75 unbalanced	-45	-20
1800	312-8204 316-8204	300-8248	75 unbalanced	-40	-25

- (1) The particular preferred values for the relative power level given in the table are still to be agreed with the C.C.I.T.T. These values apply to future systems.
- (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.
- (3) For 12-channel systems either of the basic groups *A* (12-60 kc/s) or *B* (60-108 kc/s) recommended by the C.C.I.T.T. may be accommodated in the band 12-108 kc/s.
- (4) In the case where diversity reception is used the preferred values quoted in the table for nominal impedance and relative power levels apply to the combined outputs of the receivers used.
- (5) Including pilots or frequencies which might be transmitted to line.
- (6) Larger capacity systems are not excluded by the table.

* The choice and precise definition of a point of international interconnection is a subject for agreement between Administrations 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.

RECOMMENDATION No 270

RADIO RELAY SYSTEMS FOR TELEVISION

Interconnection at video signal frequencies

(Question No. 194 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that radio-relay systems for television may form part of an international circuit;
- (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 with the requirements for video interconnection points given in Section 2 of Recommendation No. 267; 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 volt 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 No. 267, as shown in the following table:

Number of lines	405	525	625	625	819	819
Nominal upper limit of the video frequency band, (Mc/s)	3	4	5	6	5	10

Note 1. — Details of the acceptable values of return loss are given in Recommendation No. 267 (§ 2.1).

Note 2. — In the design of equipment account should be taken of the losses in the inter-connecting cables, when the video interconnection point is at some distance from the terminals of the modulating and demodulating equipment.

RECOMMENDATION No. 271

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Simultaneous transmission by the same radio-frequency carrier.

Baseband arrangements

(Question No. 194 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

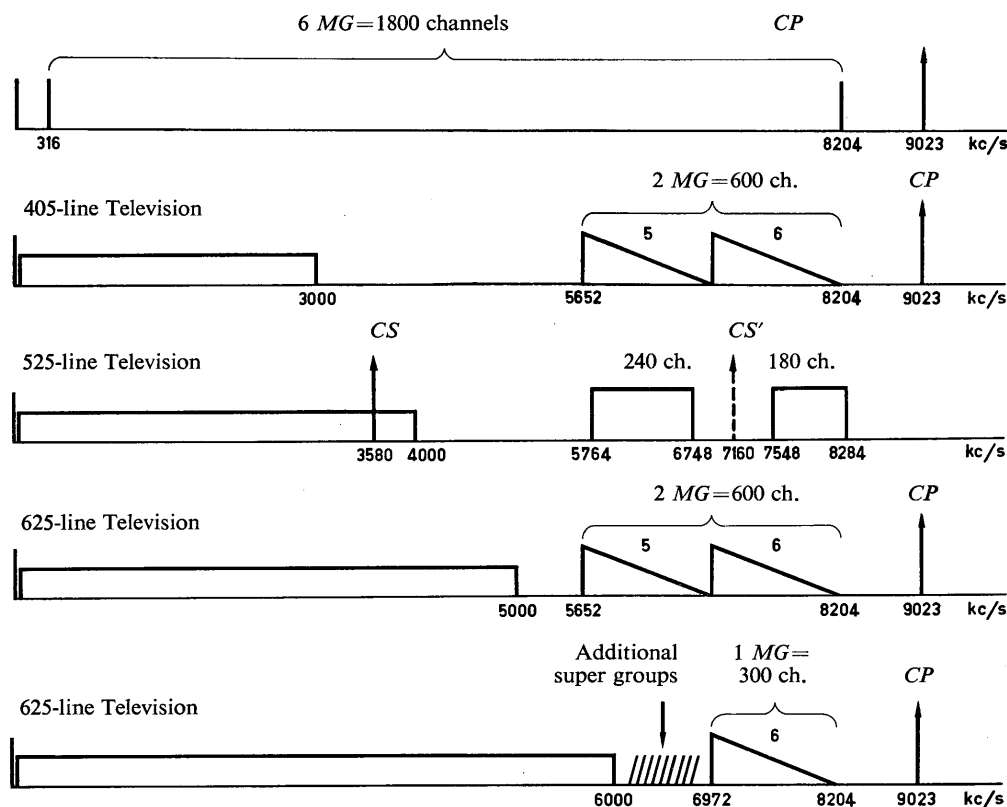
- (a) that radio-relay systems for the simultaneous transmission of television and telephony on the same radio-frequency carrier may be established;
- (b) that international interconnection of such systems at baseband frequencies may be required;

F

- (c) that there are substantial advantages in respect of signal-to-noise ratio and distortion if the television signal is transmitted as a video signal in the lower part of the baseband rather than as a vestigial sideband signal;

UNANIMOUSLY RECOMMENDS

1. that in radio-relay systems for the simultaneous transmission of telephony and television on the same radio-frequency carrier, the television signal should be transmitted as a video signal in the lower part of the baseband;
2. that in such radio-relay systems, the telephony signals should be transmitted in the upper part of the baseband;
3. that the preferred arrangement of telephone channels in the baseband should be a subject for further study and agreement with the C.C.I.T.T.; various possible arrangements under consideration are given in Fig. 1;
4. that in the case of television systems in which a colour sub-carrier is transmitted, consideration be given to the omission of certain blocks of telephone channels in order to avoid interference from the second harmonic of the colour sub-carrier.



The mastergroup numbers shown in the diagrams are those proposed by the C.C.I.T.T.

MG = mastergroup of 300 telephone channels

CP = continuity pilot (see Recommendation No. 292)

CS = colour sub-carrier

CS' = second harmonic of *CS*

FIGURE 1

Examples of alternative baseband arrangements for radio-relay systems transmitting television and telephony simultaneously on the same radio-frequency carrier.

RECOMMENDATION No. 272

RADIO RELAY SYSTEMS FOR TELEVISION
Simultaneous transmission of a monochrome television signal
and a single sound channel
Preferred characteristics of the sound channel
(Question No. 194 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that it may be desirable for economical 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 (Recommendation No. 292);
- (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 music circuits *;
- 2. that the following transmission characteristics are preferred **;
- 2.1 *Frequency of sub-carrier*
Nominal frequency of sub-carrier: 7.5 Mc/s.
- 2.2 *Modulation characteristics of the sub-carrier*
 - 2.2.1 Nominal deviation of sub-carrier: ± 140 kc/s r.m.s.
 - 2.2.2 Audio bandwidth: 30 c/s to 10 kc/s (the upper limit may be increased to 15 kc/s, should this be recommended by the C.C.I.T.T.);
 - 2.2.3 Audio level and impedance: + 9 dbm (corresponding to a deviation of ± 140 kc/s r.m.s.) in a circuit of 600 ohms, balanced;
 - 2.2.4 It is provisionally recommended that no pre-emphasis be used ***;
- 2.3 *Deviation of IF and RF carriers*

The amplitude of the unmodulated sub-carrier should be such as to produce a deviation of the IF and RF carriers of ± 300 kc/s r.m.s.

* See pages 233-238, Green Book, Vol. III bis of the C.C.I.F. The conditions under which measurements are to be made should be the subject of further study.

** Where desired, other characteristics may be used by agreement between the Administrations concerned, in particular, in France the frequency of the sub-carrier is 10 Mc/s.

*** Further study of the use of a pre-emphasis is required.



RECOMMENDATION No. 273 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Intermediate Frequency Characteristics **

(Question No. 192 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that multiplex radio-relay systems for television and FDM telephony may form part of an international circuit;
- (b) that it may at times be desirable to make international connections between such systems at intermediate frequency;
- (c) that it is desirable to adopt a preferred intermediate frequency to facilitate the optimum choice of a radio-frequency channelling plan;

UNANIMOUSLY RECOMMENDS

that as far as is practicable frequency-division multiplex radio-relay systems forming part of an international circuit and with maximum capacities of up to 1800 telephone channels or the equivalent, should have intermediate frequency circuits which at a point of international connection conform to the preferred values listed below:

1. *Centre value voltage of the intermediate frequency*

The nominal centre values of the intermediate frequencies are:

- 35 Mc/s for radio frequencies up to 1000 Mc/s (for radio frequencies up to 1000 Mc/s the frequency of 70 Mc/s may also be used, for example, in larger capacity radio-relay systems);
- 70 Mc/s for radio frequencies from 1000 to 8500 Mc/s ***. The tolerance relative to the nominal centre value of the intermediate frequency should be agreed between the Administrations concerned.

2. *Input and output voltage of the intermediate-frequency signal*

Output: 0.5 volt r.m.s.

Input: 0.3 volt r.m.s.

3. *Impedance of the intermediate-frequency circuit*

Nominal impedance: 75 ohms unbalanced.

In frequency division multiplex systems, the amount of intermodulation noise due to mismatch of the intermediate frequency circuits at a point of international interconnection should not be excessive in relation to the overall noise requirements of the hypothetical reference circuit for such systems.

Similarly, in television systems, the amount of echo distortion due to impedance mismatch of the intermediate frequency circuits at a point of international interconnection should not be excessive in relation to the overall performance requirements of the hypothetical reference circuit for such systems.

* This Recommendation replaces Recommendations Nos. 187 and 190.

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

*** 8500 Mc/s is the highest frequency allocated at present by the International Radio Regulations to systems of this type.

The amount of intermodulation noise and the television echo distortion in particular cases should be the subject of agreement between the Administrations concerned.

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 No. 274 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX **

Frequency Deviation

(Question No. 192 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

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:

1. *Frequency deviation without pre-emphasis*

Maximum number of channels	r.m.s. deviation per channel *** (kc/s)
24	35
60	50, 100, 200
120	50, 100, 200
300	200
600	200
960	200
1800	140 ****

Larger capacity systems are not excluded.

* This Recommendation replaces Recommendation No. 191.

** This Recommendation applies to line-of-sight and near line-of-sight radio relay systems; corresponding characteristics for tropospheric scatter systems require further study.

*** For 1 mW, 800 c/s tone at a point of zero reference level.

**** Provisional value (assuming pre-emphasis is used).

F

Note. — It is recognized that in certain cases it may be desirable to use other deviations by agreement between the Administrations concerned.

2. *Frequency deviation with pre-emphasis*

Where pre-emphasis is to be 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 No. 275

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Pre-emphasis characteristic for frequency modulation systems

(Question 192 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

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 (Rec. 274);
- (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 at 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 in order to facilitate international interconnection at radio frequencies or intermediate frequencies;

UNANIMOUSLY RECOMMENDS

- 1. that where pre-emphasis is used for frequency division multiplex telephony radio-relay systems the same normalized attenuation-frequency characteristic should be used for systems up to and including 960 channels, and provisionally also for systems of 1800 channels;
- 2. that the preferred pre-emphasis characteristic is that obtained by using a network with insertion loss given by:

$$20 \log_{10} \frac{e}{v_1} = 10 \log_{10} \left[1 + \frac{6.90}{1 + \frac{5.25}{\left(\frac{fr}{f} - \frac{f}{fr} \right)^2}} \right] \text{ db.}$$

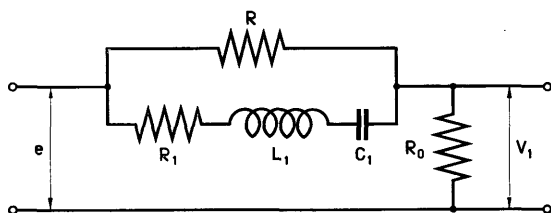
where f_r (the resonant frequency of the network) = $1.25 f_{max}$, where f_{max} is the highest telephone channel baseband frequency of the system.

Table 1 shows f_{max} and f_r for the frequency division multiplex systems of Recommendation No. 269;

3. that the pre-emphasis network should be derived from the basic network shown in Fig. 1 and that the de-emphasis network should be derived from the basic network in Fig. 2;
4. that the tolerances should not exceed those shown in association with Figs. 1 and 2.

Note 1. — The frequency at which the deviation should correspond to that without pre-emphasis (Rec. 274) is $0.608 f_{max}$; it may be convenient to adopt this frequency for testing the loss between baseband terminal points of systems when these are not in service. The variation of deviation with frequency is shown in Fig. 3.

Note 2. — It is recognized that in certain cases it may be desirable to use a different pre-emphasis characteristic by agreement between the Administrations concerned.



$$R = 1.81 R_0$$

$$R_1 < 0.01 R_0 \text{ at } f_r$$

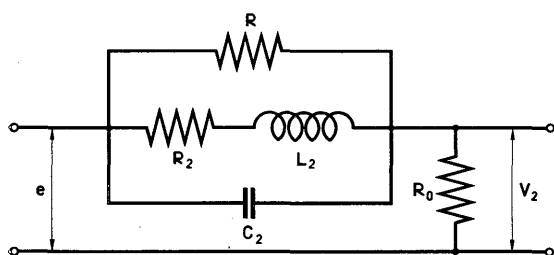
$$\sqrt{\frac{L_1}{C_1}} = 0.79 R_0$$

$$f_r = 1.25 f_{max} = \frac{1}{2\pi} \sqrt{\frac{1}{L_1 C_1}}$$

where f_{max} is the highest baseband frequency

FIGURE 1

Basic pre-emphasis network.



$$R = 1.81 R_0$$

$$R_2 < 0.02 R_0 \text{ at } f_r$$

$$\sqrt{\frac{L_2}{C_2}} = 1.47 R_0$$

$$f_r = 1.25 f_{max} = \frac{1}{2} \sqrt{\frac{1}{L_2 C_2}}$$

FIGURE 2

Basic de-emphasis network.

Note. — Tolerances for both networks

Resistors $\pm 1\%$

Capacitors $\pm 0.5\%$

f_r $\pm 0.5\%$ (L resonating with C)

TABLE I
Characteristic Frequencies for Pre- and De-emphasis Networks for the F.D.M. Systems
of Recommendation No. 269

Maximum number of telephone traffic channels *	f_{max} (kc/s)	f_r (kc/s)
24	108	135
60	300	375
120	552	690
300	1300	1625
600	2660	3325
960	4188	5237
1800 **	8204	10255

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- or de-emphasis network.

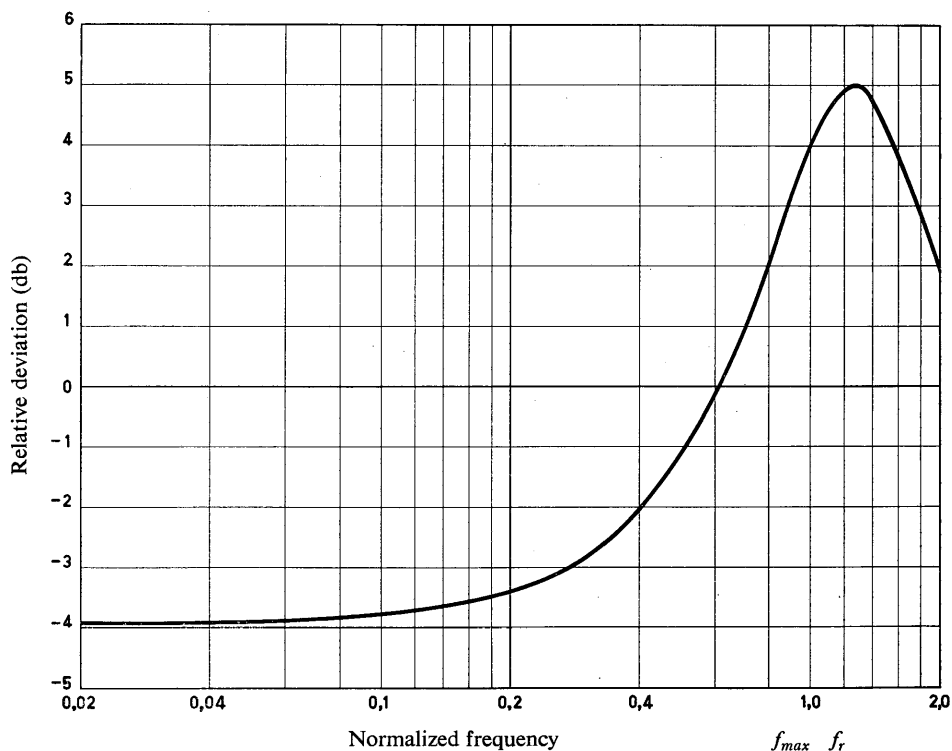


FIGURE 3

Pre-emphasis characteristic for telephony.

* 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 case of 1800 channel systems this Recommendation is provisional in respect of both the networks used and the characteristic frequencies.

RECOMMENDATION No. 276 *

RADIO-RELAY SYSTEMS FOR TELEVISION

Frequency deviation and the sense of modulation **

(Question No. 194 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 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 (Rec. 277),

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 Rec. 267, § 2.3), should be 8 Mc/s peak-to-peak for systems of 625 lines or less, and between 8 Mc/s and 12 Mc/s 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 No. 277 the maximum frequency deviation should not exceed 8 Mc/s peak-to-peak for systems of 625 lines or less, or 8 Mc/s to 12 Mc/s peak-to-peak for systems of 819 lines;
3. that the sense of modulation at the point of international interconnection should be the subject of agreement between the Administrations concerned.

RECOMMENDATION No. 277

RADIO-RELAY SYSTEMS FOR TELEVISION

Pre-emphasis characteristics for frequency modulation systems

(Question No. 194 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

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 multichannel telephony;

* This Recommendation replaces Recommendation No. 184.

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



- (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 FDM 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;
- (d) that pre-emphasis enables a simple control of the mean carrier frequency to be used both for television and FDM 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 the pre-emphasis network, and the corresponding de-emphasis network; should be simple in order to achieve readily reproducible characteristics;

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. 2, the shape of the characteristic being as indicated by curve (a) in Fig. 1;
4. that the pre-emphasis characteristic for the transmission of 625-line monochrome television signals should be derived from the basic network shown in Table I (b) and Fig. 2, the shape of the characteristic being as indicated by curve (b) in Fig. 1;
5. that the pre-emphasis characteristic for the transmission of 525-line television signals should be derived from the basic network shown in Table I (c) and Fig. 2, the shape of the characteristic being as indicated by curve (c) in Fig. 1;
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. 2, the shape of the characteristic being as indicated by curve (d) in Fig. 1.

Note 1. — The total range of the network attenuation is about 14 db between zero and infinite frequency in cases (a), (b) and (c), and 9.5 db in case (d).

Note 2. — The relative deviation 0 db corresponds to a peak-to-peak frequency deviation of 8 Mc/s for a sinusoidal wave of 1 volt peak-to-peak applied at a point of interconnection at the input to the system (Recommendation No. 276).

Note 3. — When television signals are to be transmitted between countries with systems having 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. — For the time being, the tolerance on the pre-emphasis and de-emphasis characteristics for television is the subject for further study.

* See Recommendation No. 267.

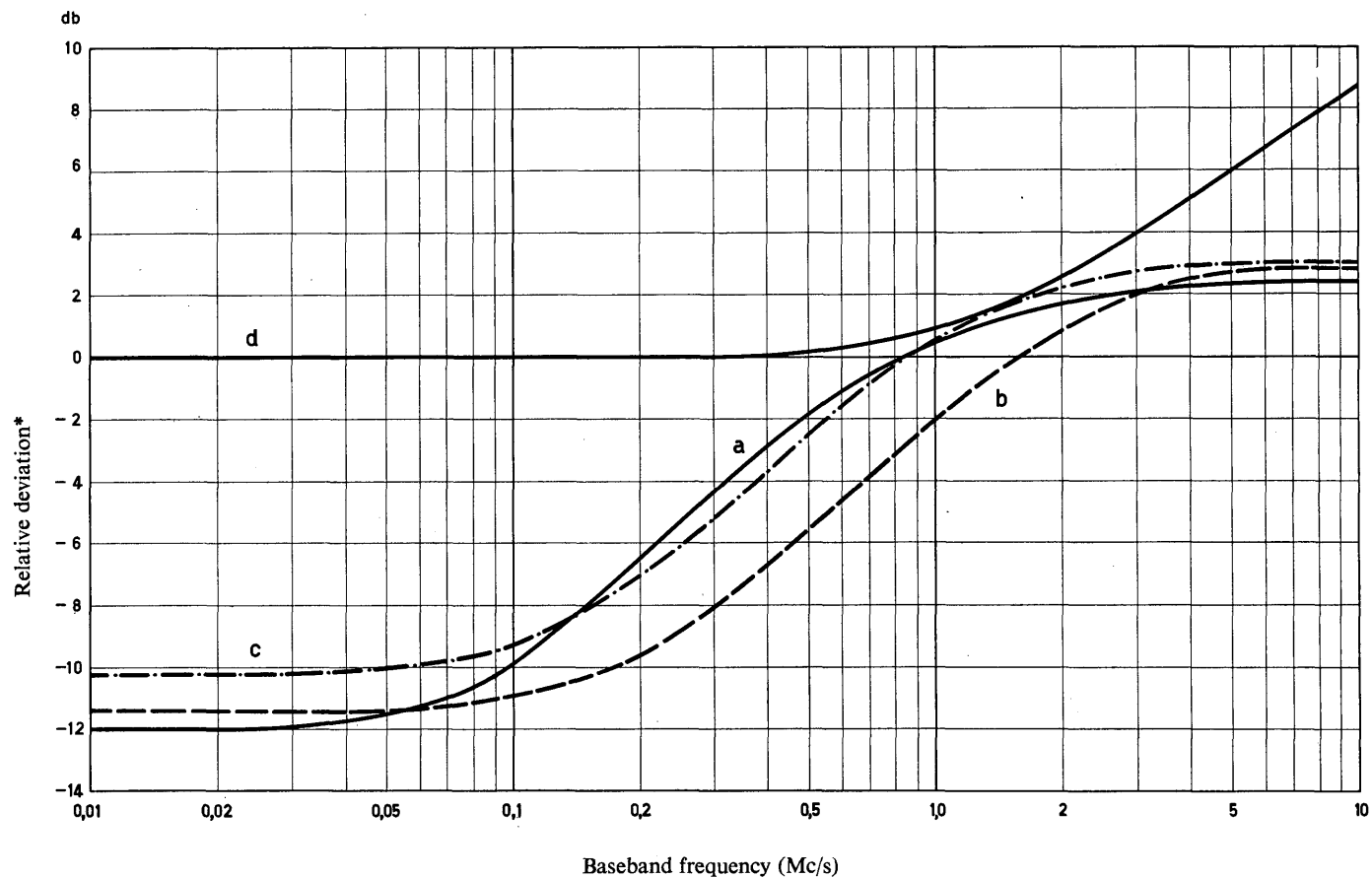


FIGURE 1

Television pre-emphasis characteristics, 405, 525, 625 and 819-line systems.

* 0 db corresponds to a deviation of 8 Mc/s for 1 volt peak-to-peak sinusoidal signal. (Recommendation No. 276.)

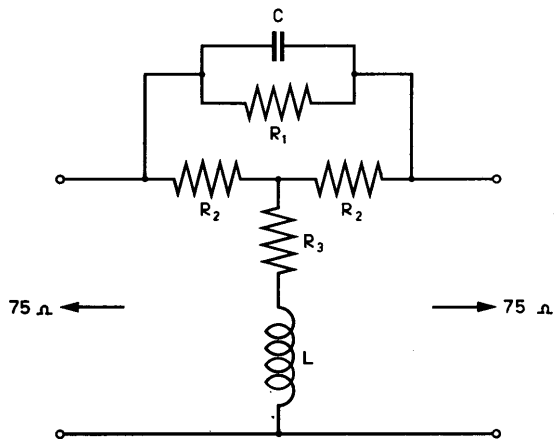


FIGURE 2
Television pre-emphasis network.

TABLE I
Component values for television pre-emphasis network.

No. of lines	405	625	525	819
Curve (Fig. 1)	(a)	(b)	(c)	(d)
L_1 (μ H)	22.25	9.54	15	3.313
C_1 (pF)	3950	1695	3085	589
R_1 (Ω)	300	300	∞	121.3
R_2 (Ω)	75	75	48.7	75
R_3 (Ω)	18.75	18.75	33.2	46.38

RECOMMENDATION No. 278 *

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 2000 and 4000 Mc/s bands

(Question No. 192 (IX) and Study Programme No. 121)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that in certain cases it is desirable to be able to interconnect radio relay systems on international circuits at radio frequencies in the 2000 and 4000 Mc/s bands;
- (b) that in a frequency band 400 Mc/s wide it may be desirable to interconnect up to six go and six return radio-frequency channels;
- (c) the economies may be achieved if at least three go and three return channels can be interconnected between systems each of which uses common transmit-receive aerials;
- (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 in certain cases it may be desirable to interleave additional radio-frequency channels between those of the main pattern;

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 2000 and 4000 Mc/s bands, should be as shown in Fig. 2 and should be derived as follows:

Let f_o be the frequency of the centre of the band of frequencies occupied (Mc/s);

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

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

then the frequencies in Mc/s of individual channels are expressed by the following relationships:

lower half of band, $f_n = f_o - 208 + 29 n$

upper half of band, $f'_n = f_o + 5 + 29 n$

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

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 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 direc-

* This Recommendation replaces Recommendations Nos 187 and 194; it applies only to line-of-sight and near line-of-sight radio relay systems. Italy reserved its opinion on this Recommendation.

tions of transmission on a given section should use H(V) polarization, and the even numbered channels should use V(H) polarization, as shown in Fig. 1 below:

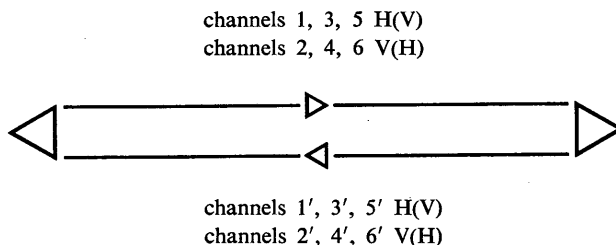
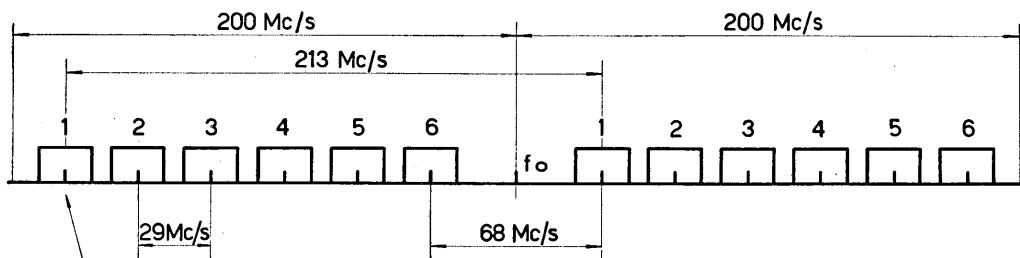


FIGURE 1

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;



Channel number

FIGURE 2

Radio-frequency channel arrangement for radio-relay systems with capacities from 600 to 1800 telephone channels or equivalent operating in the 2000 and 4000 Mc/s bands, for use in international connections

5. that when additional radio-frequency channels, interleaved between those of the main pattern, are required, the values of the centre frequencies of these radio-frequency channels should be 14.5 Mc/s below those of the corresponding main channel frequencies; *
6. that in order to minimize interference within a system, the centre frequency f_0 should preferably be as given below:
- in the 2000 Mc/s band, $f_0 = 1903$ or 2101 Mc/s,
in the 4000 Mc/s band, $f_0 = 4003.5$ Mc/s.

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

* In the case of systems for 1800 telephone channels, or the equivalent, it may not be practicable, because of the wide bandwidth occupied by the modulated carrier, to use interleaved frequencies.

** Interference due to certain harmonics of the shift frequency, which may fall near radio-frequency channel frequencies f_n in the case of radio-frequency repeaters, or may fall near $(f_n \pm 70)$ Mc/s in the case of repeaters using an intermediate frequency of 60 Mc/s, 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 above.

Note. — In the case of radio-relay systems of 600 telephone channels operating in the 4000 Mc/s band in Regions 2 and 3, the alternative radio frequency channel arrangement shown in Fig. 3 may be employed. The frequencies used for transmission in a given direction from a station are in either of two groups 1, 2, and are separated by 80 Mc/s centre-to-centre. The received frequencies are also separated from each other by 80 Mc/s and are located midway between the transmitting frequencies. Both groups 1 and 2 may be used on the same route if desired, with suitable arrangements. The radio-frequency channel arrangement shown in Fig. 3 is suitable for use with the preferred intermediate frequency of 70 Mc/s.

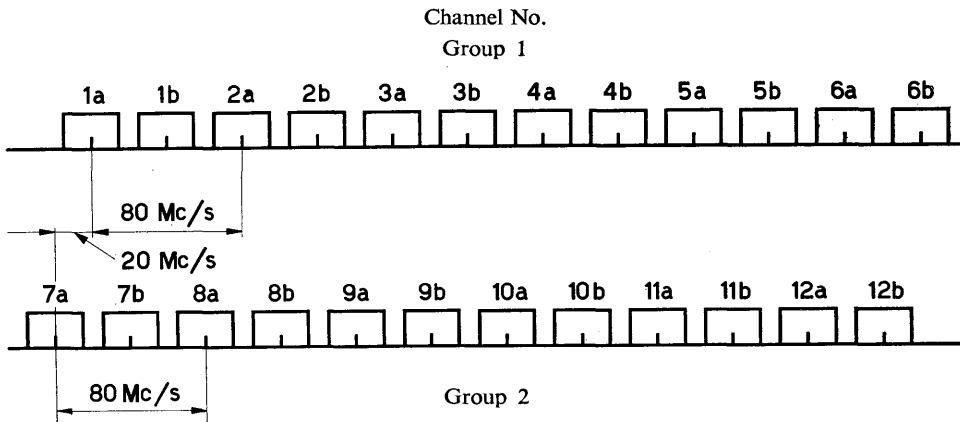


FIGURE 3

Alternative radio-frequency channel arrangement for 600-channel telephony system used in the 4000 Mc/s band in Regions 2 and 3.

RECOMMENDATION No. 279 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Radio-frequency channel arrangements for 300 channel systems operating in the 2000 and 4000 Mc/s band **

(Question No. 192 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that in certain cases it is desirable to be able to interconnect radio relay systems on international circuits at radio frequencies in the 2000 and 4000 Mc/s bands;
- (b) that it is desirable in such cases to use a radio-frequency arrangement for systems transmitting 300 channel telephony signals which is compatible with that for systems of 600 channels or more using the same frequency band;

* This Recommendation replaces Recommendation No. 193.

** 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 radio-frequency channels, each accomodating 300 telephony channels is the same as that given in § 1 of Recommendation No. 278;
2. that where additional radio-frequency channels, each accomodating 300 telephony 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 Mc/s below those of the corresponding 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 in order to minimize interference within a system, the centre frequency f_o should preferably be as given below:
 - in the 2000 Mc/s band, $f_o = 1903$ or 2101 Mc/s,
 - in the 4000 Mc/s band, $f_o = 4003.5$ Mc/s;
 other centre frequencies may be used agreement between the Administrations concerned *.

RECOMMENDATION No. 280

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 6000 Mc/s band **

(Question No. 192 (IX) and Study Programme No. 121)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that in certain cases it is desirable to be able to interconnect radio-relay systems on international circuits in the 6000 Mc/s band at radio frequencies;
- (b) that in a frequency band 500 Mc/s wide it may be desirable to interconnect up to eight go and eight return channels;
- (c) that economies may be achieved if at least four go and four return channels can be inter-connected 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;

* Interference due to certain harmonics of the shift frequency, which may fall near radio-frequency channel frequencies f_n in the case of radio-frequency repeaters, or may fall near $(f_n \pm 70)$ Mc/s in the case of repeaters using an intermediate frequency of 70 Mc/s, may in certain cases be serious. Such interference may be reduced by choosing a suitable value for f_o , such as those given in § 6 of this Recommendation.

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

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

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to eight go and eight return channels, each accommodating 600 to 1800 telephone channels or the equivalent, and operating at frequencies in the 6000 Mc/s band, should be as shown in the attached figure and should be derived as follows:

Let f_o be the frequency, (Mc/s) of the centre of the band of frequencies occupied;
 f_n be the centre frequency, (Mc/s) of one radio-frequency channel in the lower half of the band;
 f'_n be the centre frequency, (Mc/s) of one radio-frequency channel in the upper half of the band.

Then the frequencies, in Mc/s, of individual channels are expressed by the following relationships:

lower half of the band, $f_n = f_o - 259.45 + 29.65 n$

upper half of the band $f'_n = f_o - 7.41 + 29.65 n$

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

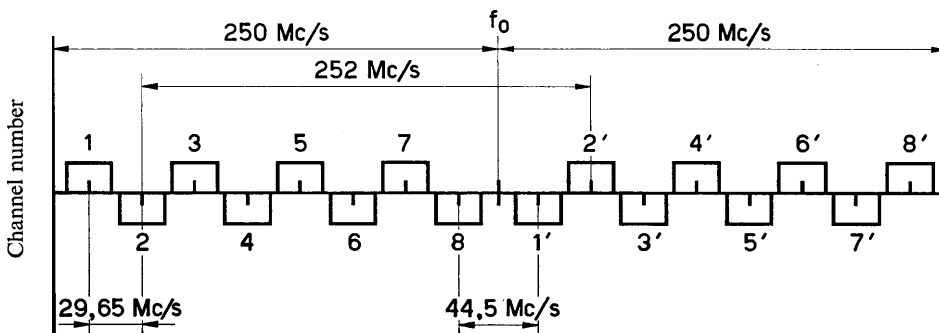
2. that in a section over which the international interconnection is arranged, all the go channels should be in one half of the band, and all the return channels should be in the other half of the band;
3. that the go and return channels on a given section should preferably use polarizations as shown below:

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

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

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

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



Radio-frequency channel arrangement for radio-relay systems operating in the 6000 Mc/s band, for use in international connections (the frequencies shown are approximate).

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 Mc/s below those of the corresponding main channel frequencies; in the case of 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 the preferred centre frequency is 6175·0 Mc/s; other centre frequencies may be used by agreement between the Administrations concerned.

Note 1. — The radio-frequency arrangement shown above is suitable for use with the preferred intermediate frequency of 70 Mc/s (see Recommendation No. 273). It is also suitable for use with an intermediate frequency of 74·13 Mc/s, which enables a common oscillator (14·82 Mc/s) to be used for generating all the local oscillations for the system, if desired.

Note 2. — If an antenna for single polarization is used the channel frequencies may be selected 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 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.

RECOMMENDATION No. 281 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred radio-frequency channel arrangements for Television **

(Questions Nos. 192 (IX) and 194 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that in certain cases it is 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 television relay systems as for the larger capacity multichannel telephony systems;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency arrangements for the international interconnection of relay systems transmitting television signals with any combination, either on the same radio channel or on different channels, of the following signals—television of 819-lines, television of 625-lines or less or multichannel telephony are the same as that given in Recommendations Nos. 278 and 280. The choice of the particular channels for the television signals should be agreed between the administrations concerned;
2. that, for the international interconnection of systems transmitting television signals (of 625 lines or less) only, the preferred radio-frequency arrangements are the same as those given in Recommendations Nos. 278 and 280);

* This Recommendation replaces Recommendation No. 195.

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

3. that, for the international interconnection 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 No. 278. Alternatively, if further channels are required radio-frequency channels 3 and 6 of the interleaved radio-frequency channels, defined in § 5 of Recommendation No. 278 may be used by agreement between the administrations concerned.

RECOMMENDATION No. 282 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Use of special radio-frequency channel arrangements **

(Questions Nos. 192 (IX) and 194 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that interconnection of radio relay systems at radio frequencies is the most common practice in international interconnection, and that it is desirable to define the preferred values of the characteristics for such interconnection and in particular the frequency plan to be used;
- (b) that, in the case of 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 No. IX had already indicated preferred values in a draft report (Docs. 62-Rev. and 69-Rev. of Geneva, 1954) and that certain administrations utilize, in a 400 Mc/s band between 3800 and 4200 Mc/s, equipments operating in accordance with frequency plans as given in these documents;

UNANIMOUSLY RECOMMENDS

that international connection of radio relay systems should preferably be carried out in conformity with Recommendations Nos. 278, 279, 280 and 281. Nevertheless, in cases where such a course is justified, in order to utilize an existing design of equipment, and provided that no harmful interference results, international interconnection involving the equipment and systems referred to in considering (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.

F

* This Recommendation replaces Recommendation No. 192.

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

RECOMMENDATION No. 283 *

**RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION
MULTIPLEX****Radio-frequency channel arrangement for 60- and 120-channel
telephony systems operating in the 2000 Mc/s band**

(Question No. 192 (IX) — Study Programme No. 104 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that in certain cases it is desirable to be able to interconnect 60- and 120-channel radio-relay systems on international circuits at radio frequencies in the 2000 Mc/s band;
- (b) that in a frequency band 200 Mc/s wide it may be desirable to interconnect up to six go and six return radio-frequency channels;
- (c) that economies may be achieved if at least three go and three return channels can be inter-connected 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 in certain cases it may 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 No. 274 for such systems;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to six go and six return channels, each accomodating 60- or 120-telephone channels and operating within the frequency band 1700-2300 Mc/s, should be as shown in the attached figure and should be derived as follows:

Let f_o be the frequency of the centre of a 200 Mc/s band of frequencies occupied (Mc/s);

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

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

then the frequencies in Mc/s of individual channels are expressed by the following relationships:

lower half of band, $f_n = f_o - 108.5 + 14n$,

upper half of band, $f'_n = f_o + 10.5 + 14n$,

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

2. that in a section over which the international interconnection 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;

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

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 Mc/s above those of the corresponding main channel frequencies;
5. that the centre frequencies for 60- and 120-channel telephony systems should preferable be those shown below:

$f_o = 1808$ Mc/s for the band 1700–1900 Mc/s,

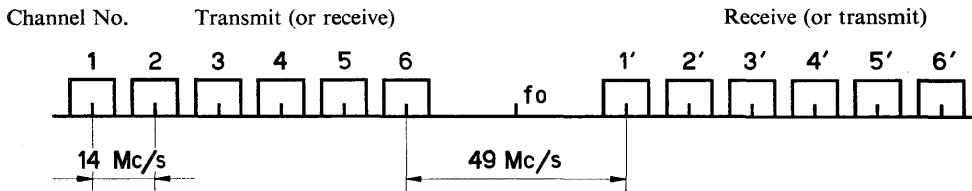
$f_o = 2000$ Mc/s for the band 1900–2100 Mc/s,

$f_o = 2203$ Mc/s for the band 2100–2300 Mc/s.

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

Note 1. — When the frequency band 1900–2300 Mc/s or 1700–2100 Mc/s 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. — In cases where 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 Mc/s from the allocations given above.



Radio-frequency channel arrangement for international interconnection of radio-relay systems for 60 or 120 channels operating in the 2000 Mc/s band.

RECOMMENDATION No. 284

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY DIVISION MULTIPLEX

Radio-frequency channel arrangement for 60 and 120 channel telephony systems operating in the 7000 Mc/s band *

(Question No. 192 (IX), Study Programme No. 120)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that it is desirable to be able to interconnect 60- and 120-channel radio-relay systems on international circuits at radio frequencies in the 7000 Mc/s band;

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

- (b) that frequency bands 300 Mc/s wide may be available for such systems;
- (c) that economies 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 minimised 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 for the values of the mid-frequencies of the radio-frequency channels to be the same for 60- and for 120-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 No. 274 for such systems;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for several systems of three go and three return channels, each accommodating 60 or 120 telephone channels, and operating in the 7000 Mc/s band, should be as shown in the attached figure and should be derived as follows:

Let f_o be the frequency of the centre of the band of frequencies occupied (Mc/s);

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

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

then the frequencies in Mc/s of the individual channels are expressed by the following relationships:

lower half of band: $f_n = f_o - 136.5 + 7n$

upper half of band: $f'_n = f_o + 24.5 + 7n$

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

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 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:

$f_o = 7558.5$ Mc/s for the band 7425–7725 Mc/s.

* Subsequent to the Plenary Assembly it was brought to the notice of the Secretariat that the four centre frequencies cited above were incorrect. The corrections to be made to Recommendation 4 are:—

Replace 7558.5 Mc/s by 7557.5 Mc/s.

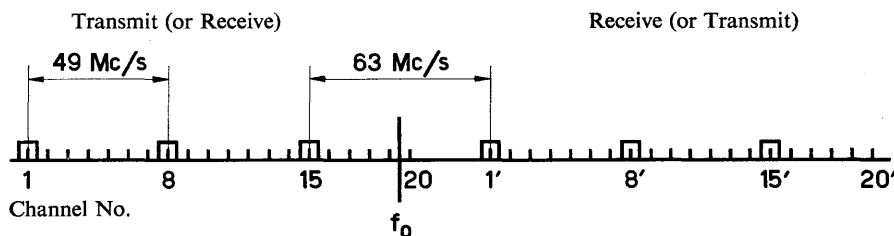
Replace 7258.5 Mc/s by 7257.5 Mc/s.

Replace 7400 Mc/s by 7382.5 Mc/s.

Replace 7700 Mc/s by 7682.5 Mc/s.

Other centre frequencies may be used in certain geographical areas by agreement between the Administrations concerned; (e.g.):

$$f_0 = 7258.5 \text{ Mc/s, } 7400 \text{ or } 7700 \text{ Mc/s.}$$



Radio-frequency channel arrangement for international interconnection of radio-relay systems for 60 or 120 channels operating in the 7000 Mc/s band.

RECOMMENDATION No. 285 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

**Hypothetical reference circuit for radio relay systems
with capacity of 12 to 120 telephone channels ****

(Question No. 193 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that it is desired to establish hypothetical reference circuits for radio relay systems in order 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;

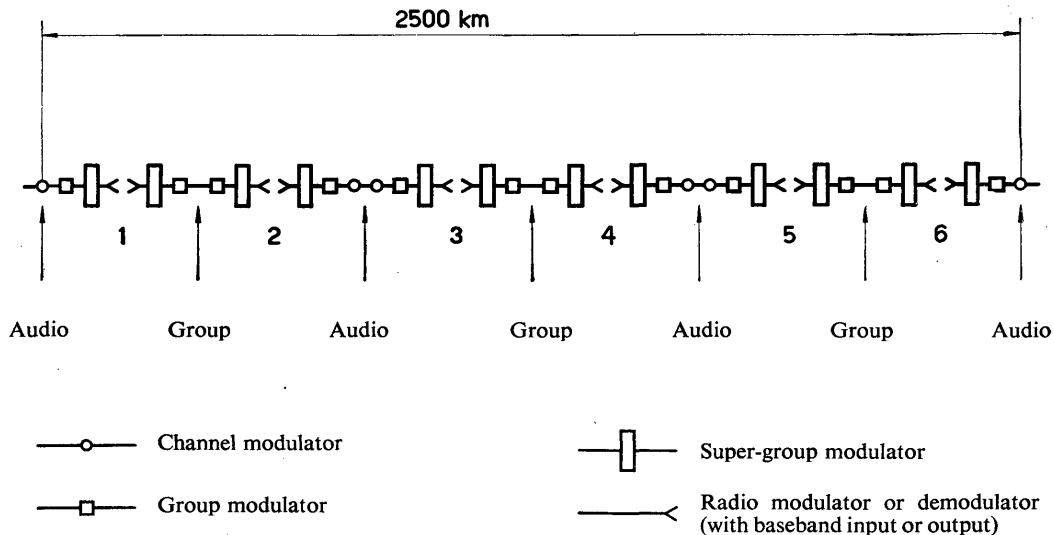
UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for frequency-division multiplex radio relay systems with a capacity of 12 to 120 telephone channels per radio channel should be 2500 km long;
2. that this circuit should include, for each direction of transmission:
 - 3 sets of channel modulators,
 - 6 sets of group modulators,
 - 6 sets of supergroup modulators,
 it being understood that a "set of modulators" comprises a modulator and a demodulator;

* This Recommendation replaces Recommendation No. 202.

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

3. that this circuit should include respectively 6 sets of radio modulators and demodulators, for each direction of transmission and that these should divide the circuit into 6 homogeneous sections of equal length.



Hypothetical reference circuit for FDM radio relay systems with capacity of 12 to 120 telephone channels per radio-frequency channel

RECOMMENDATION No. 286 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

**Hypothetical reference circuit for radio-relay systems
with capacity of more than 120 telephone channels ****

(Question No. 193 (IX))

The C.C.I.R.,

(Warsaw, 1956 — London, 1959)

CONSIDERING

- (a) that it is desired to establish hypothetical reference circuits for radio relay systems in order 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:

* This Recommendation replaces Recommendation No. 203.

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

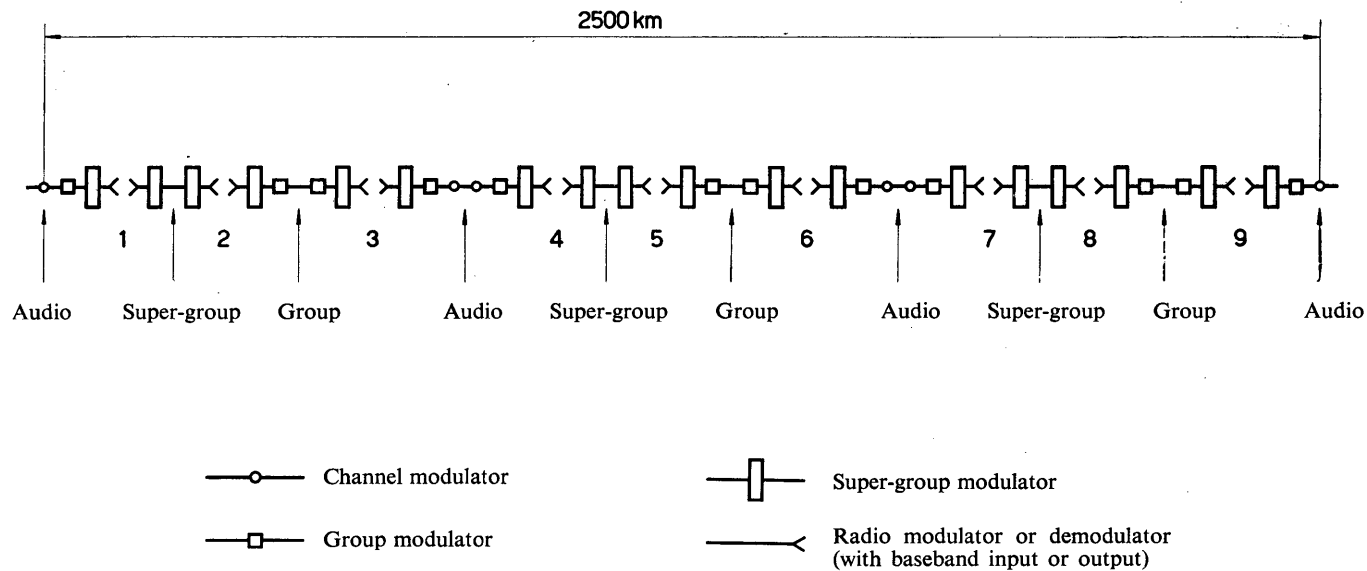


FIGURE 1

Hypothetical reference circuit for FDM radio relay systems with capacity of more than 120 telephone channels per radio-frequency channel

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for frequency-division multiplex radio relay systems with a capacity of more than 120 telephone channels per radio 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 9 sets of radio modulators and demodulators respectively, for each direction of transmission, and that these should divide the circuit into 9 homogeneous sections of equal length.

RECOMMENDATION No. 287 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION
MULTIPLEX

Allowable noise power in the hypothetical reference circuit

(Question No. 193 (IX) and Study Programme No. 158 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

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 figure attached would be unlikely to hinder telephone conversations appreciably;
- (e) that if the conditions 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 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 kilometre hypothetical reference circuit for frequency-division-multiplex radio-relay systems should not exceed the provisional values given below:

* This Recommendation replaces Recommendation No. 200.

- 1.1 7500 pW psophometrically weighted * mean value in any hour **;
- 1.2 7500 pW psophometrically weighted * one-minute mean power for more than 20% of a month when the fading is severe;
- 1.3 47 500 pW psophometrically weighted * one-minute mean power for more than 0.1% of a month when the fading is severe;
- 1.4 1 000 000 pW unweighted (with an integrating time of 5 ms) for more than 0.01% of a month when the fading is severe;
2. that in a part of hypothetical reference circuit consisting of one or more of the equal homogeneous sections defined in Recs. Nos. 285 and 286, the mean noise power in any hour, and the one-minute mean noise power in 20% of a month shall 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 Nos. 285 and 286, the small percentages of a month in which the one-minute mean power may exceed 47500 pW and in which the 5 ms noise power may exceed 1 000 000 pW shall 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 circuits 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 No. 288.

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 from power supply systems and from switching apparatus are reduced to negligible proportions, and will not be taken into account when calculating the noise power.

Note 5. — For the calculation of noise in hypothetical reference circuits the characteristics preferred by the 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, inter-modulation noise in feeders and the radio path, precautions taken against fading, in particular the use or otherwise 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 in a month when the fading is severe should satisfy the values recommended in 1.2 and 1.3 above. 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 then “non-fading” noise value upon which the design is based.

Note 7. — It should be assumed that at junctions between the homogeneous sections of a hypothetical reference circuit the telephone channels, groups and super-groups are interconnected at random; in particular it should be assumed that the noise coming from the homogeneous sections of the hypothetical reference circuit is power-additive.

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

** 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.

Note 8. — 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, N being the total number of channels for which the radio-relay system is to be designed.*

Note 9. — The requirement indicated by paragraph 1.4 is related to the need to transmit signalling for telephony satisfactorily. It is not yet possible to make firm recommendations regarding any additional requirements to be met if VF telegraph and data transmission are required over telephone channels on a radio-relay system.

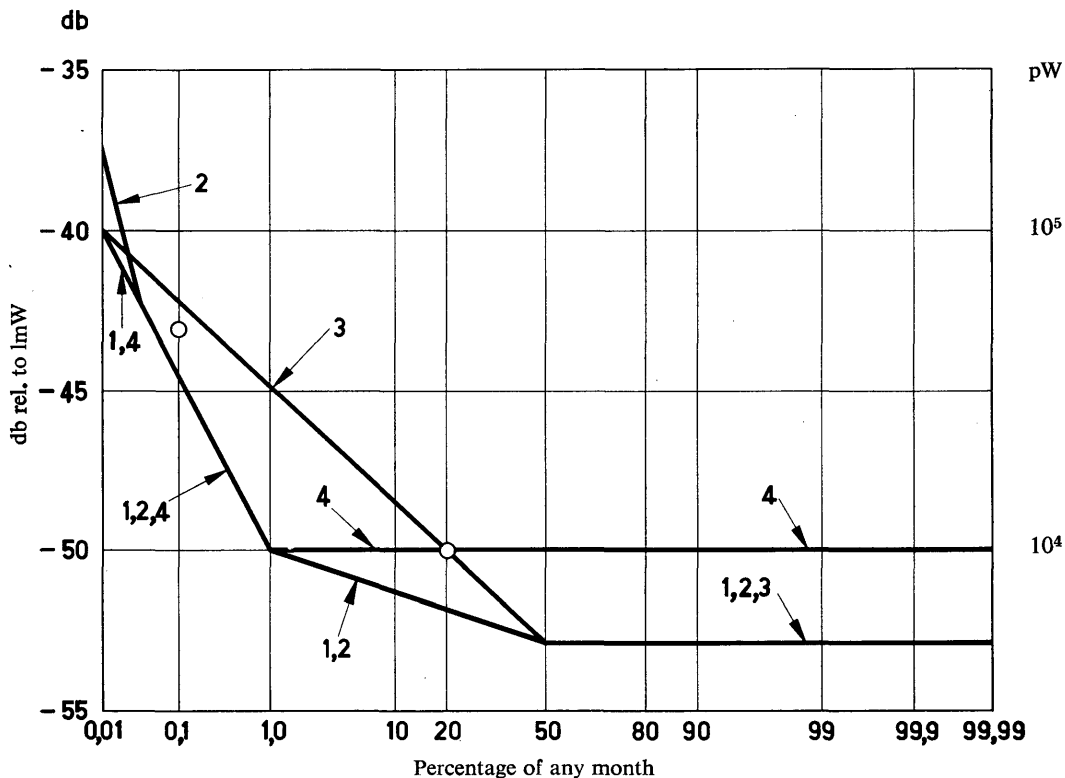


FIGURE 1

*Typical distribution curves of weighted one-minute mean noise power ** at the end of a 2500 km telephone circuit.*

Notes. ○ Design objectives.

The numbers 1, 2 etc. distinguish one curve from another.

The noise figures include 2500 pW for terminal equipments.

* This value is provisional for systems with less than 60 channels.

** Measured at a point of zero relative level.

RECOMMENDATION No. 288

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

Noise in Real Circuits *

(Question No. 193 (IX), Study Programme No. 158 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that provisional maximum values of noise in hypothetical reference circuits are given in Recommendation No. 287 as a guide to designers of equipment;
- (b) that each designer of a radio-relay equipment must make his own assumptions including those regarding the length of repeater sections, the extent of fading and any precautions taken, for example, the use of necessary of diversity reception and of protection channels;
- (c) that if the composition of a real circuit is similar to the hypothetical reference circuit, and if the design assumptions made are those corresponding to the real circuit, it is expected that the levels of noise on the real circuit will be of the same order as those predicted for the hypothetical reference circuit;
- (d) that in some cases real circuits will be different in composition from the hypothetical reference circuit;
- (e) that the differences between the conditions assumed at the design stage and those in a real circuit may have an effect on the noise power;

UNANIMOUSLY RECOMMENDS

1. that the psophometrically-weighted ** noise power at a point of zero relative level in the telephone channels of a real FDM radio-relay system of length L km, where L is between 250 and 2500 km, and whose composition does not differ appreciably from the hypothetical reference circuit, should not:
 - 1.1 exceed $3L$ pW mean value in any hour;
 - 1.2 exceed $3L$ pW one-minute-mean power for more than 20% of any month;
2. that, as planning objective, and recognising that the performance achieved for very short periods of time by real circuits when installed may differ from the planning objective and is difficult to measure precisely, the psophometrically-weighted noise power at a point of zero relative level in the telephone channels of such a real system as is considered in (1) above, should not exceed 47500 pW one-minute-mean power for more than $(L/2500) \times 0.1\%$ of any month;
3. that, because it is not possible at the present time to adopt permissible noise powers for systems the composition of which differs considerably from that of the hypothetical reference circuit, or for systems of less than 250 km, the problems should be further investigated;
4. that the following notes should be regarded as part of the Recommendation.

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

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



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;

Note 2. — The recommendation relates only to “line-of-sight” radio-relay systems with adequate clearance over intervening terrain;

Note 3. — 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 4. — It is assumed in planning systems that at the demodulation points of the real circuit the telephone channels, groups and supergroups are interconnected at random; in particular it is assumed that the noise coming from the different sections is power-additive;

Note 5. — 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 $(\frac{1}{2} 15 + 10 \log_{10} N)$ dbm for 240 channels or more, and $(\frac{1}{2} 1 + 4 \log_{10} N)$ dbm * for numbers of channels between 12 and 240, N being the total number of channels for which the radio-relay system is designed.

RECOMMENDATION No. 289

RADIO-RELAY SYSTEMS FOR MONOCHROME TELEVISION

Permissible noise in the hypothetical reference circuit

(Questions Nos. 193 (IX) and 194 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that the hypothetical reference circuit defined in Recommendation No. 267 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 No. 267 (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 than is required by Recommendation No. 267 for the majority of the time;
- (g) that the relative distribution with time of noise on radio-relay systems for television or FDM telephony will be similar and it is appropriate therefore to employ similar methods for specifying the noise performance;

* This value is provisional for systems with less than 60 channels.

- (h) that a simple method is required of 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 No. 267 the use of instruments with an effective time constant or integrating time of 1 sec. 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 peak-to-peak signal, excluding synchronising 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 a month when the fading is severe;
 - 1.2 $(X - 8)$ db for more than 0.1 % of a month when fading is severe; these values are provisional;
2. that in part of a hypothetical reference circuit consisting of one or two of the three equal homogeneous sections defined by Recommendation No. 267 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 No. 267 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 No. 267 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, Recommendation No. 267) to the r.m.s. amplitude of the noise within the range between 10 kc/s 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 when measured with the appropriate low-pass filter described in Annex II of Recommendation No. 267, the appropriate weighting network described in Annex III of the same document, and an instrument having an ‘ effective time constant ’ or ‘ integrating time ’ in terms of power, of 1 second, given in the following table : ”

System	No. of lines	405	525	625	625	819	819
	Nominal upper limit of video frequency band, f_c (Mc/s)	3	4	5	6	5	10
Signal-to-weighted-noise ratio X (db)		50		52	57		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 cross-talk) of telephone circuits, it is likely that signal-to-thermal noise

ratio for 20% of one month and the signal-to-thermal-noise ratio for 0.1% of one month 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 second.

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 of such magnitude that they only occur for very small percentages of time, and originating in different sections of a complete circuit are not coincident in time. 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 No. 290 *

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

Measurements to be made

(Question No. 96)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

that the operation of 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 base band;
 - total noise including cross-talk noise;
2. that net gain or loss stability in the baseband should be measured by means of a line regulating pilot (Recommendation No. 291). 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;

* This Recommendation terminates the study of Question No. 96 for telephony.

3. that total noise be measured in specially reserved measuring channels, listed in Recommendation No. 293, 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 No. 294, 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 No. 294. Noise may also be measured when the link is unloaded so that the contribution of each noise source can be determined.

RECOMMENDATION No. 291 *

INTERCONNECTION OF RADIO-RELAY AND LINE SYSTEMS

Line-regulating and other Pilots **

(Study Programme No. 28 and Question No. 96)

The C.C.I.R.,

(London, 1953 — Los Angeles, 1959)

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;
- (f) 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;
- (d) 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 kc/s 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 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;

UNANIMOUSLY RECOMMENDS

1. that the point of interconnection between radio-relay 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 will be called the radio link control station and the station

* This Recommendation replaces Recommendation No. 128.

** This Recommendation applies to line-of-sight systems and near line-of-sight systems, and also where appropriate, to tropospheric scatter systems.

at the other end will be called the radio link sub-control station. The duties of these stations are given in the maintenance instructions on pages 236 and 237 of Volume 3 of the C.C.I.F. Green Book.

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 No.292 *.
3. that the level of the continuity pilot of a radio-relay system for telephony be suppressed to at least — 50 dbmo at the point of connection with a line system;
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 kc/s $\pm$ 3 c/s is the preferred frequency and the preferred pilot level is — 10 dbmo. A second line regulating pilot situated in the upper part of the baseband can 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 shall be suppressed at least to — 50 dbmo at the point of connection with a line system in all cases when this point is a junction between line regulating sections;
6. that the level of any line regulating pilot of a line system to which a radio-relay system is connected be suppressed at least to — 50 dbmo, preferably before the input terminals of the radio-relay system 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 can be transmitted in the two systems;
8. that all other line pilots *within* the band of frequencies occupied by the frequency-division-multiplex telephony signal shall be freely transmitted by the radio-relay system to which the line system is connected.

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

RECOMMENDATION No. 292 ***

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Frequencies and deviations of continuity pilots ****

(Question No. 96)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that special pilots are required on radio systems to indicate the continuity of the circuit;

* A continuity pilot within the baseband, possibly acting as the line regulating pilot, may be used, in the case of systems of up to 120 channels for reasons of economy, after agreement between the Administrations concerned.

** In the case of low capacity systems (up to 120 channels) a line regulating pilot of 60 kc/s with a level of —10 dbmo may be used; in this case the suppression level should conform with the provisions of the C.C.I.T.T. (Green Book of the C.C.I.F. Volume III bis page 106); 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 dbmo for coaxial cables and —15 dbmo for symmetrical pair systems).

*** This Recommendation replaces Recommendations Nos. 198 and 199.

**** This Recommendation applies to line-of-sight and near line-of-sight radio-relay systems and also, where appropriate, to tropospheric scatter systems.

- (b) that these pilots should be situated outside the range of frequencies occupied by the telephony or the television signals (Recommendation No. 291);
- (c) that a frequency about 10% higher than the upper limit of the frequency-division multiplex signal is convenient for such a pilot. In order to reduce intelligible crosstalk the continuity pilot should, when possible, have a frequency of $(4n - 1)$ kc/s; 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 systems, when the continuity pilot is above the baseband, its frequency and deviation should be that shown in the following table:

TABLE

System capacity	Limits of band occupied by telephone channels (kc/s)	Frequency limits of baseband ⁽¹⁾ (kc/s)	Continuity pilot frequency (kc/s)	Deviation (r.m.s.) produced by the pilot (kc/s) ⁽²⁾
24 channels	12–108	12–108	116 or 119	20
60 channels	{ 12–252 60–300	{ 12–252 60–300	304 or 331	25, 50, 100 ⁽³⁾
120 channels	{ 12–552 60–552	{ 12–552 60–552	607 ⁽⁴⁾	25, 50, 100 ⁽³⁾
300 channels	{ 60–1300 64–1296	60–1364	1499, 7000 or 8500	100 or 140 ⁽⁵⁾
600 channels	{ 60–2540 64–2660	60–2792	3200 or 8500	140
960 channels	{ 60–4028 316–4188	60–4287	4715 or 8500	140
1800 channels	{ 312–8204 316–8204	300–8248	9023	100
405-line TV			8500	140
625-line TV			8500	140
TV and FDM up to 600 channels sent simultaneously			9023	100

⁽¹⁾ Including pilot or 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 kc/s (Recommendation No. 274).

⁽⁴⁾ Alternatively 304 kc/s may be used by agreement between the Administrations concerned.

⁽⁵⁾ The first figure applies to frequency 1499 kc/s, the second to frequency 7000 or 8500 kc/s.

2. that a continuity pilot situated below the baseband can 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 .

RECOMMENDATION No. 293

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION
MULTIPLEX

Maintenance Measurements in Actual Traffic

(Question No. 96)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that measurements by means of a generator producing white noise (according to Recommendation No. 294 are only possible when the RF channel is not carrying traffic and that the measuring channels used for this kind of measurement *can* lie within the frequency range occupied by telephone channels *;
- (b) that systems carrying multichannel telephony cannot be withdrawn from service at will for measurement;
- (c) that standby-channels are not always available for maintenance purposes;
- (d) that maintenance measurements of the total noise (thermal and intermodulation noise) are of use to determine the quality of a system and *must* be made during the traffic;
- (e) that it is convenient to place the channels used for this kind of measurement outside the total bandwidth of the multiplex signal;
- (f) that, in the case where 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, in order to measure the intermodulation products due to the non-linearity of the system;
- (g) that on the other hand, in order to facilitate and to cheapen 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 RF and IF parts of the equipment, whereas measurements in channels below this band are 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 No. 292, Doc. 358) suggests the use of the same frequencies as central 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 No. 294.

UNANIMOUSLY RECOMMENDS

1. that noise in radio links should be measured during actual traffic at the output of the system in relatively narrow bands situated outside (below and/or above) the total multiplex signal band;

* In this Recommendation, the words "frequency range occupied by telephone channels" are intended to mean the part of the baseband actually transmitted (in cases where a system is used below its maximum capacity).

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 $\pm (0.005 f + 2)$ kc/s *, f being the centre frequency in kc/s of the measuring channel. The additional attenuation caused by the insertion of the stop filters at the lower edge and at the upper edge 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 No. 294.

Note. — In certain telephone channels and in combinations of them harmonic distortion may be produced, which may make it necessary to leave these channels disconnected, e.g. if the second or third harmonics coincide with the central frequencies of the noise measuring channels.

TABLE

System capacity (channels)	Limits of band occupied by telephone channels (kc/s)	Frequency limits of baseband ** (kc/s)	Central frequencies (f) of noise measuring channels (kc/s)	
			Below	Above
24	12–108	12–108	10	116 or 119
60	{ 12–252	12–252	10	304
	{ 60–300	60–300	50	331
120	{ 12–552	12–552	10	607
	{ 60–552	60–552	50	607
300	{ 60–1300	60–1364	50	1499
	{ 64–1296			
600	{ 60–2540	60–2792	50	3200
	{ 64–2660			
960	{ 60–4028	60–4287	50	4715
	{ 316–4188		270	4715
1800	{ 312–8204	300–8248	270	9023
	{ 316–8204			

F

* Except when the central frequency is 10 kc/s; the minimum frequency band is then ± 1 kc/s.

** Including pilots or frequencies which might be transmitted to line.

RECOMMENDATION No. 294 *

RADIO-RELAY SYSTEMS FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX**Measurements of the performance with the help
of a signal consisting of a continuous uniform spectrum**

(Study Programme No. 28 and Question No. 96)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that it is desirable to measure the performance of radio relay systems for frequency division multiplex (FDM) 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 multi-channel 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 as soon as possible the frequencies and bandwidths of the measuring channels to be used for such tests;
- (e) that it is necessary to standardize as soon as possible 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.F. 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.F. Green Book, Vol. III bis, Geneva 1956, p. 53);

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 power level of the signal with a uniform continuous spectrum should, for radio channels with at least 240 telephone channels, be equal to $(-15 + 10 \log_{10} N)$ db, relative to one milliwatt, at a point of zero relative level, N being the total number of channels in the circuit;
3. that the power level of this signal with a uniform continuous spectrum for radio channels with a capacity of at least 12 not more than 240 telephone channels should be equal to $(-1 + 4 \log_{10} N)$ db ** relative to 1 milliwatt at a point of zero relative level and N being the total number of channels in the circuit;
4. that intermodulation noise measurements should be performed:
 - either in the noise measuring channels used during actual traffic (Recommendation No. 293).
 - or in noise measuring channels used in conjunction with a white noise spectrum.

The use of these measuring channels seems preferable for special tests, e.g. acceptance tests, calibration or tests on very wide band systems. They can be positioned either within the multichannel signal band or outside.

* This Recommendation replaces Recommendation No. 197.

** This value is provisional for systems of less than 60 channels.

5. that the frequencies of the measuring channels should be those shown in the following table.

System capacity (channels)	Bandwidth ⁽¹⁾ of white noise spectrum (kc/s)	Centre-frequencies of measurement channels (kc/s)				
		Lower channel ⁽²⁾		Centre channel	Upper channel ⁽²⁾	
60	60–300	50	70		270	331
120	60–552	50	70	270	534	607
300	60–1300	50	70	534	1248	1499
600	60–2660	50	70	1248	2438	3200
960	{ 60–4038	50	70	2438	3886	4715
	{ 316–4188	270	534	2438	3886	4715
1800	316–8204	270	534	3886	8002	9023

⁽¹⁾ Within this band the r.m.s. noise voltage levels measured with a narrow bandwidth of about 2 kc/s shall not vary by more than 1 db. Outside this band the power must drop sharply and be more than 25 db down at all frequencies greater than 10% above and 20% below the band.

⁽²⁾ Either of the two frequencies indicated in this column may be used.

6. that the attenuation of noise in each stop band at the output of the sending equipment should exceed 80 db over a band at least 3 kc/s wide, and should exceed 3 db at frequencies of $\pm (0.02 f + 4)$ kc/s with respect to the centre frequency, f being in kc/s. The shape of the filter characteristics should be such that, when all three band stop filters are simultaneously brought into circuit, the errors * in measurement as compared with a measurement carried out with a perfectly uniform source and an indefinitely narrow stop band should not exceed 1 db.
7. that the effective bandwidth of the filters in the receiving equipment should be small enough for use with a transmitter stop band having 3 db attenuation at frequencies $\pm (0.02 f + 4)$ kc/s with respect to the centre frequency f of the stop band.
8. that additional or alternative measuring channels may be provided by agreement between the Administrations concerned.

Note. — The attention of the C.C.I.T.T. is drawn to this Recommendation with a view to possible adoption of the same preferred values of test frequencies for both radio-relay and coaxial cable systems; in the case of 12 Mc/s bandwidth coaxial cable systems, the C.C.I.T.T. is invited to consider the adoption of an additional stop band centered on 12 150 kc/s and lower and upper limits of white noise of 312 and 12 388 kc/s respectively.

* The "error" is due to the loss by the insertion of filters, to the changes in the spectral distribution of thermal and inter-modulation noise produced by this insertion and to other causes.

RECOMMENDATION No. 295 *

SERVICE CHANNELS FOR RADIO RELAY SYSTEMS **

Type of service channels to be provided

(Question No. 195 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING that

- (a) service channels are required for the maintenance, supervision and control of radio-relay links providing a number of RF channels for each direction of transmission;
- (b) if for any reason the radio-relay system itself fails to function, communications between various stations along the route, and from those stations to other points is likely to assume special importance;
- (c) agreement is desirable on the number and function of the service channels to facilitate the planning of radio-relay systems;

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 when 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. one telephone service channel (a main or express speaker circuit) should be provided for telephonic communication directly between the staffed stations receiving supervisory signals;
4. a second telephone service channel (an omnibus speaker circuit) should be provided for telephone communication linking together all stations, both staffed and unstaffed, of the system;
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;
6. one of the channels mentioned in recommends 5 might be used for the transmission of high speed signals associated with the switching of broad-band radio channels, the other could be used for the transmission of a number of relatively low speed supervisory signals ***;
7. whenever possible all service channels should provide the bandwidth recommended by the C.C.I.T.T. for international telephone circuits, namely, 300 to 3400 c/s;
8. the service channels should 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 (see, for example, Recommendation No. 296) following the same route as the main system ****;

* This Recommendation replaces Report No. 72.

** The radio-relay systems which are the subject of this Recommendation are those that will transmit at least 60 telephone channels or a television signal and comprising two staffed terminal stations in which the signals are demodulated to base-band and any number of unstaffed intermediate stations.

*** 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 paragraph 4.

**** For low capacity systems (maximum 300 channels) and for economic reasons the service channels can be placed in the band of frequencies below the band occupied by the multiplex signals after agreement between the Administrations concerned.

9. the remaining terminal characteristics of the service channels and of the signals to be transmitted over them should be the subject of further study and consultation as necessary with the C.C.I.T.T. Meanwhile they should be the subject of agreement between the Administrations concerned.

RECOMMENDATION No. 296

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Preferred Characteristics of Auxiliary Radio-Relay Systems

Operating in the 2000, 4000 or 6000 Mc/s Bands

(Question No. 195 (IX))

The C.C.I.R.,

(Los Angeles, 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 using either the radio-frequency channel arrangement of Recommendation No. 278 or the arrangement of Recommendation No. 280.
- (b) that in some cases 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 in other cases a different frequency band from that of the main radio-relay system may be preferred for the auxiliary radio-relay system (Study Programme No. 160 (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 two pairs of frequency allocations may be needed for the auxiliary radio-relay system in order to provide either two normal service channels in each direction, or a normal service channel and a standby 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;
- (f) that the numbers of the service channels to be provided and their functions have been defined in Recommendation No. 295;

UNANIMOUSLY RECOMMENDS

1. that in the case of an auxiliary radio-relay system sharing the same frequency band as the main radio-relay system, operating in the 2000 or 4000 Mc/s bands (Recommendation No. 278), the preferred frequencies (in Mc/s) of the radio-frequency channels of the auxiliary system should be related to the centre frequency f_o of the normal pattern of the main system as shown below:

Normal, lower half of band: $f_o - 204.5$ and $f_o - 12$
upper half of band: $f_o + 8.5$ and $f_o + 199$

Interleaved, lower half of band: $f_o - 213.5$ and $f_o - 23$
upper half of band: $f_o - 2.5$ and $f_o + 190$

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 in the case of an auxiliary radio-relay system sharing the frequency band of the main radio-relay system, operating in the 6000 Mc/s band (Recommendation No. 280), the preferred frequencies (in Mc/s) of the auxiliary system radio-frequency channels should provisionally be related to the centre-frequency f_0 of the normal pattern of the main system, as shown below:

Lower half of band: $f_0 - 248.9$ and $f_0 - 3.1$

Upper half of band: $f_0 + 3.1$ and $f_0 + 248.9$

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

3. that the other characteristics of the auxiliary radio-relay system should be the subject for further study and, for the present, be the subject of agreement between the Administrations directly concerned.

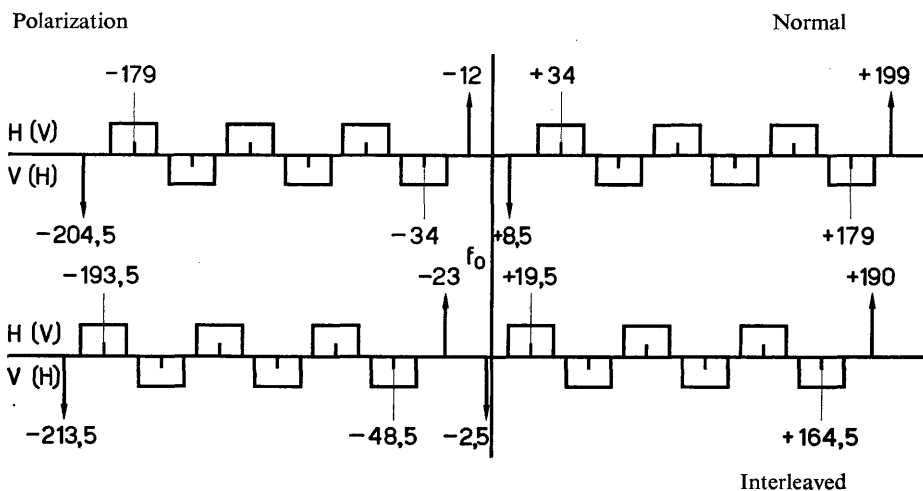


FIGURE 1

Radio-frequency channel arrangement for main and auxiliary radio-relay systems operating in the 2000 and 4000 Mc/s bands

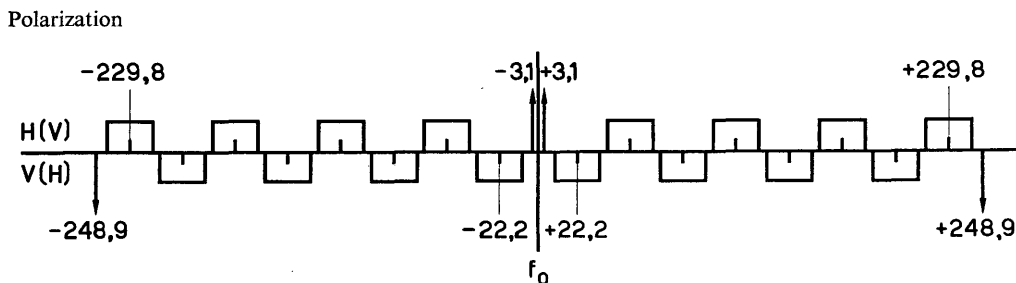


FIGURE 2

Radio-frequency channel arrangement for main and auxiliary radio-relay systems operating in the 6000 Mc/s band.

All frequencies are in Mc/s

↑ indicates auxiliary channel frequencies H(V)

↓ indicates auxiliary channel frequencies V(H)

RECOMMENDATION No. 297 *

**RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION
MULTIPLEX**

Interconnection at audio frequencies

(Question No. 92)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 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 conformance to the relevant C.C.I.T.T. recommendations in respect of overall performance measured between audio-frequency terminals is already covered by Recommendation No. 40 relating to systems operating above about 30 Mc/s;
- (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, 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;
2. the method of signalling over international circuits.

RECOMMENDATION No. 298 *

**RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION
MULTIPLEX**

Preferred characteristics

(Question No. 92)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

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

* This Recommendation replaces Recommendation No. 186.

* This Recommendation replaces Recommendation No. 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 Nos. 40 and 297);
- (c) that the art of time-division multiplex is still fluid 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 No. 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 No. 306.

RECOMMENDATION No. 299

**RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION
MULTIPLEX**

Agreement on major characteristics

(Question No. 92)

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that several different types of multi-channel radio-telephone systems using time-division-multiplex have been developed;
- (b) that such systems are rarely installed across national boundaries;
- (c) that C.C.I.R. Recommendations Nos. 297 and 298 and Report No. 134 already cover certain aspects of these systems;

UNANIMOUSLY RECOMMENDS

1. that in any case of international interconnection the characteristics not covered by the above recommendations and report be the subject of agreement between the Administrations concerned.
 2. the study of Question No. 92 should be considered as terminated.
-

RECOMMENDATION No. 300 *

**RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION
MULTIPLEX**

**Hypothetical Reference Circuit for Radio-Relay Systems
with Capacity of 60 Telephone Channels or Less ****

(Question No. 193 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that it is desired to define hypothetical reference circuits for radio-relay systems in order to offer guidance to the designers of equipment and systems for use in international telecommunication networks;
- (b) that time-division 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 channel should be 2500 km long;
- 2. that this reference circuit should be constituted by 6 sections of equal length with voice-channel modulation and demodulation at each terminal of a section.

RECOMMENDATION No. 301 ***

**RADIO-RELAY SYSTEMS FOR TELEPHONY USING TIME-DIVISION
MULTIPLEX**

Allowable noise power in the hypothetical reference circuit

(Question No. 193 ,Study Programme No. 158 (IX))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that a hypothetical reference circuit for radio-relay systems for telephony using time-division multiplex has been defined in Recommendation No. 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;

* This Recommendation together with Recommendation No. 301 replaces Recommendation No. 201.

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

*** This Recommendation together with Recommendation No. 300 replaces Recommendation No. 201.

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- (c) that the allowable noise power in hypothetical reference circuits for telephony radio-relay systems using time-division multiplex should conform to that for frequency-division multiplex which is the subject of Recommendation No. 287;

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, under conditions equivalent to those in normal service:
 - 1.1 10 000 pW psophometrically weighted * mean value in any hour **;
 - 1.2 10 000 pW psophometrically weighted * one-minute mean power for more than 20% of a month when the fading is severe;
 - 1.3 50 000 pW psophometrically weighted * one-minute mean power for more than 0.1% of a month when the fading is severe;
 - 1.4 1 000 000 pW, unweighted (with an integrating time of 5 ms) for more than 0.01% of a month when the fading is severe.

2. that the following Notes should be regarded as part of this 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 satisfactorily to transmit signalling for telephony. It is not yet possible to make firm recommendations regarding any additional requirements to be met if VF telegraph and data transmission are required over telephone channels on a radio-relay system.

RECOMMENDATION No. 302

RADIO-RELAY SYSTEMS EMPLOYING TROPOSPHERIC-SCATTER PROPAGATION

Limitation of interference

(Question No. 196 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that tropospheric-scatter radio-relay systems can cause interference over large 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 tropospheric-scatter 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;

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

** The hours when the noise is greatest may be those in which the fading is most severe; noise due to unintelligible crosstalk from other channels must also be considered.

UNANIMOUSLY RECOMMENDS

in planning tropospheric-scatter radio-relay systems:

1. that account be taken of the high degree of international co-ordination and planning which will be involved if tropospheric-scatter 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 frequency-economy 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 No. 303

RADIO-RELAY SYSTEMS USING TROPOSPHERIC-SCATTER PROPAGATION

Radio-frequency channel arrangements

(Study Programme No. 122 (IX) and Question No. 196 (IX))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that radio-relay systems using tropospheric scatter propagation 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 tropospheric scatter 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 tropospheric scatter systems could be minimized by the co-ordination of radio-frequency channel arrangements over a large geographical area;
- (d) that many interfering effects between equipments 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 tropospheric scatter 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 present no definite frequency bands are allocated to tropospheric scatter radio relay systems;

- (h) that at the present time standardization of preferred radio-frequency channel arrangements might therefore unduly restrict the future development of tropospheric scatter radio-relay systems;
- (i) that nevertheless a common basis for planning such systems is desirable;

UNANIMOUSLY RECOMMENDS

1. that the radio-frequency channel arrangements for international interconnection of tropospheric scatter 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 No. 136 may be used, where appropriate, as a guide.

RECOMMENDATION No. 304 *

RADIO-RELAY SYSTEMS FOR TELEPHONY**Interconnection of differing multiplex systems**

(Question No. 90)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 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 master groups 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;
- (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 multi-

* This Recommendation replaces Recommendation No. 183.

plex 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, in order 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 case of international interconnection not covered by the above, frequency-division multiplex is in general to be preferred.

RECOMMENDATION No. 305 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

Standby arrangements

(Question No. 96)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that in radio-relay systems it is indispensable to have standby arrangements to decrease the time when the circuit is out of action as a result of a fault in equipment or to facilitate periodical maintenance operations;
- (b) that it is generally advisable to utilize for this purpose a standby 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, standby installations of a different type such as standby 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 channels possessing the same characteristics are used for multiplex telephony, it is preferable to use a standby channel common to the channels in service (or several such standby channels, if necessary);
2. that when some of the radio channels are utilized for multiplex telephony and others for television and all the radio channels possess very similar characteristics, it is preferable to use a standby channel common to the channels in service (or several such standby channels, if necessary);

* This Recommendation replaces Recommendation No. 196.

3. that in certain specific cases such as when some of the radio 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 standby arrangements differing from those specified in § 1 and 2 of the present Recommendation, such as for example, standby equipment operating on the same carrier frequency as the equipment in service and which can be substituted for that equipment station by station.

RECOMMENDATION No. 306 *

RADIO-RELAY SYSTEMS FOR TELEVISION AND TELEPHONY

**Procedure for international connection between systems
with differing characteristics**

(Question No. 113)

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that, in order to simplify interconnection across frontiers and to ensure the best transmission quality on international circuits, interconnection between systems with different characteristics should be avoided as far as possible;
- (b) that, however, when such interconnection cannot be avoided, special arrangements will have to be made at the junction;
- (c) that the C.C.I.T.T. 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.

* This Recommendation replaces Recommendation No. 204.

** Green Book of the C.C.I.F. — Geneva, 1956, Volume III, bis — paragraph 346 “ Interconnection of coaxial carrier systems using different techniques ”.

SECTION G PROPAGATION

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The following Recommendations which have been classified in other sections also concern Propagation:

Rec. no	Section
22	J
130	A
181	J
241	C



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RECOMMENDATION No. 116 *

PRESENTATION OF BASIC PROPAGATION PREDICTION CHARTS

The C.C.I.R.,

(London, 1953)

CONSIDERING

- (a) that basic propagation prediction charts produced by different organisations are not of uniform presentation;
- (b) that the use of such charts for routine predictions, and their intercomparison, would be facilitated by the standardization of the scales employed;

UNANIMOUSLY RECOMMENDS

that, keeping their present form, the charts should be made with a uniform scale using a centimetre grid on which one centimetre represents 10 degrees of latitude and 15 degrees of longitude or one hour of time.

RECOMMENDATION No. 168 *

PRESENTATION OF ANTENNA RADIATION DATA

(Question No. 49)

The C.C.I.R.,

(London, 1953 — Warsaw, 1956)

CONSIDERING

- (a) that the aims pursued by the I.T.U. require a knowledge of the radiation in free space in all directions from the antennae used in international radiocommunication;
- (b) that antenna radiation is well represented by diagrams showing the field strength or the power radiated in every direction of space;
- (c) that, alternatively, the antenna radiation can be represented by the vectorial specific cymomotive force F in every direction in space (See Note);

UNANIMOUSLY RECOMMENDS

1. that, in diagrams of antenna radiation, contours representing the radiation in free space in all directions be labelled in terms of relative radiated power or field strength;
2. that an alternate method of presentation may also be employed consisting of diagrams of contours representing the radiation in all directions of space in terms of the vectorial specific cymomotive force F ;
3. that the Director of the C.C.I.R. should take account of the above considerations, when antenna diagrams are being drawn;

* This Recommendation replaces Recommendation No. 53.

* This Recommendation replaces Recommendation No. 108.



Note. — Specific cymomotive force F is a vector expressed in volts and is defined as the product $E \cdot d$, where E is the vectorial free-space field radiated by the antenna in a particular direction at a distance d from the centre of radiation of the antenna when the total radiated power is 1 kW.

In cases where the antenna dimensions are not negligible in relation to the wave-length, or to the distance at which the measurements are made, the limit of the product $E \cdot d$ as d approaches infinity, is regarded as the c.m.f. In order to measure the c.m.f. in these instances, the field measured at a finite distance must be modified by an appropriate correction factor *.

The radiated power W and the cymomotive force F are related by the equation $F^2 = 366 W$, where F is expressed in volts and W is expressed in watts per unit solid angle in the direction considered.

In cases where the polarization of the electric field is elliptical, the c.m.f. may be shown as the magnitude and direction of the two main axes of the polarization ellipse.

RECOMMENDATION No. 172 **

PREDICTION OF SOLAR INDEX

The C.C.I.R.,

(London, 1953 — Warsaw, 1956)

CONSIDERING

- (a) that it is desirable to have an internationally agreed prediction of smoothed relative sunspot numbers for about six months in advance;
- (b) that it is impracticable at present to obtain complete agreement on methods of prediction;
- (c) that the methods studied by the Director of the C.C.I.R. based on autocorrelation techniques, have not led to a completely satisfactory method of prediction of solar index;

UNANIMOUSLY RECOMMENDS

- 1. that the Director of the C.C.I.R. should continue the studies on this subject;
- 2. that apart from objective autocorrelation methods, subjective methods, such as cycle matching, might also be used;
- 3. that as soon as practicable, predictions should be published by the Director of the C.C.I.R. with an indication of an estimated probable error;
- 4. that these predictions should be published in the "Telecommunication Journal" and should be made available monthly to all administrations and other interested parties by an inexpensive postcard subscription service utilizing air mail;
- 5. that the Director of the C.C.I.R. and the various administrations should present to the next Plenary Assembly of the C.C.I.R. their comments on these predictions, stressing in particular:
 - the usefulness of 12-month smoothed averages,
 - the usefulness of predictions 6 months in advance,
 - the applicability of these predictions to their communication problems.

* See e.g. "Carlo Micheletta - Sulla determinazione della forza cymomotrice di emittitori con antenne a paraboloide" - Piccolle Note-Recensioni e Notizie - I.S.P.T. No. 1, 1956, page 13.

** This Recommendation replaces Recommendation No. 117.

RECOMMENDATION No. 307 *

GROUND-WAVE PROPAGATION CURVES BELOW 10 Mc/s

(Question No. 184 (V))

The C.C.I.R.,

(Geneva, 1951 — Los Angeles, 1959)

CONSIDERING

- (a) that ground-wave propagation curves for an extended range of frequencies are of continued importance for all types of radio communication including navigational aids;
- (b) that such curves for a range of land conductivities are needed for the varying conditions along the land paths met with in practice;

UNANIMOUSLY RECOMMENDS

- 1. that the curves in the Annex hereto be used for the determination of groundwave field strength on frequencies below 10 Mc/s under the conditions stated;
- 2. that these curves supersede the existing C.C.I.R. (1937) curves for frequencies below 10 Mc/s.

ANNEX

The attached curves apply to propagation on frequencies below 10 Mc/s.

The following points are to be especially noted with regard to them:

- 1. they refer to a smooth homogeneous earth, as in the corresponding C.C.I.R. (1937) curves;
- 2. no account is taken of tropospheric effects on these frequencies, i.e. they are calculated for the actual radius of the earth. It is realised that the troposphere exerts some influence below 10 Mc/s, but experimental evidence suggests that on medium frequencies the $4/3$ earth's radius usually assumed over-estimates the effect of normal refraction in the troposphere. Moreover, mathematical analysis shows that with decreasing wavelength the concept of an effective earth's radius is no longer strictly valid as the necessary transformation involves not only the frequency used, but also the conductivity of the earth. It was therefore decided to retain the use of the actual earth's radius as in the case of the C.C.I.R. (1937) curves, and the consideration of the effect of the troposphere is accordingly made the subject of Study Programme No. 87 (IV);
- 3. the frequency range has been extended down to 10 kc/s in view of the suggested use of very low frequencies for navigational aids;

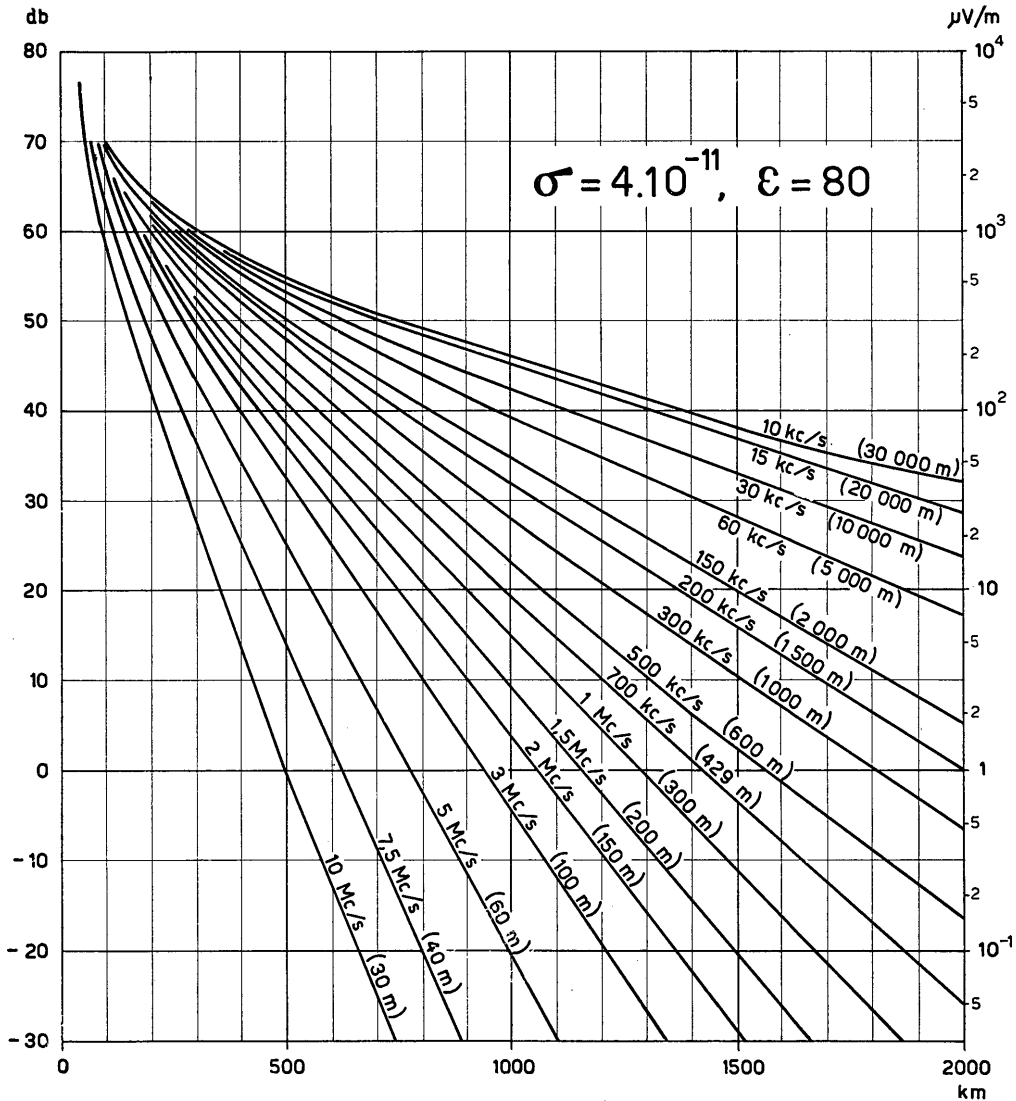
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* This Recommendation replaces Recommendation No. 52.

4. in order to cater more adequately for the differences of land conductivity met with in practice, the curves for the value 10^{-13} e.m.u. of the conductivity σ have been supplemented by curves for the further values of $10^{-12.5}$, $10^{-13.5}$ and 10^{-14} e.m.u. The value of the permittivity assumed is $\epsilon = 4$ as in the C.C.I.R. (1937) curves, but it may be stated that the precise value assumed is not of practical significance for the frequency range under consideration. For the sea curves, the value $\epsilon = 4 \times 10^{-13}$ e.m.u. and $\sigma = 80$ have been retained;
 5. it should be pointed out that the sea curves and the land curves for $\sigma = 10^{-13}$ e.m.u. differ from the C.C.I.R. (1937) curves only in the extension of the frequency range and in the slightly modified method of presentation, as they are based on the same rigid analysis of the problem given by van der Pol and Bremmer;
 6. the presentation is given in two forms:
 - 6.1 with a linear scale of distance out to 2000 km as abscissa and an ordinate scale which is linear in decibels relative to a field strength of $1 \mu\text{V/m}$. A subsidiary scale reading directly in $\mu\text{V/m}$ is added on the right-hand side. The linear distance scale has been retained to exhibit the linear aspect of the curves in the diffraction region where the field strength is attenuated approximately exponentially with distance. The linear scale in decibels replaces the logarithmic scale for $\mu\text{V/m}$ used in the C.C.I.R. (1937) curves in view of its greater convenience in most engineering applications;
 - 6.2 with a logarithmic distance scale for distances up to 10 000 km. This has been done to make the curves more useful in the neighbourhood of the transmitter where they are very steep when the linear distance scale is used. It should be noted that at the shorter distance it is not practicable to include all the curves down to 10 kc/s where they differ very little from one another and from the unattenuated inversed distance curve;
 7. the curves are no longer referred to a radiated power of 1 kW, but to what has been called an unattenuated field strength of $3 \times 10^5/D$ in $\mu\text{V/m}$ where D is the distance from the transmitter in kilometres. This field would actually correspond to the case of a vertical antenna, shorter than one quarter wavelength, radiating 1 kW when placed on the surface of a perfectly conducting plane earth. In a given practical case, the engineer should regard the determination of the appropriate value of the unattenuated field and the value of the necessary multiplier as an auxiliary problem;
 8. the transmitter and receiver are both assumed to be on the ground. In most practical cases in the frequency range concerned, the height-gain effects with elevated antennae would not be significant. Although height-gain curves exist which refer to this frequency range, their restriction to the diffraction region makes them of very limited use, and it was decided not to include them;
 9. the curves should, in general, be used to determine field strength only when it is known that ionospheric reflections of the frequency under consideration will be negligible in amplitude — for example, propagation in daylight between 150 kc/s and 2 Mc/s and for distances of less than about 2000 km. However, under conditions where the sky wave is comparable with, or even greater than, the ground wave, the curves are still applicable when the effect of the ground wave can be separated from that of the sky wave by the use of pulse transmissions, as in some forms of direction-finding systems and navigational aids.
-

Propagation curves

Ground wave corresponding to an unattenuated field of:
 $3 \times 10^8 / D_{\text{km}} \text{ } \mu\text{V/m}$

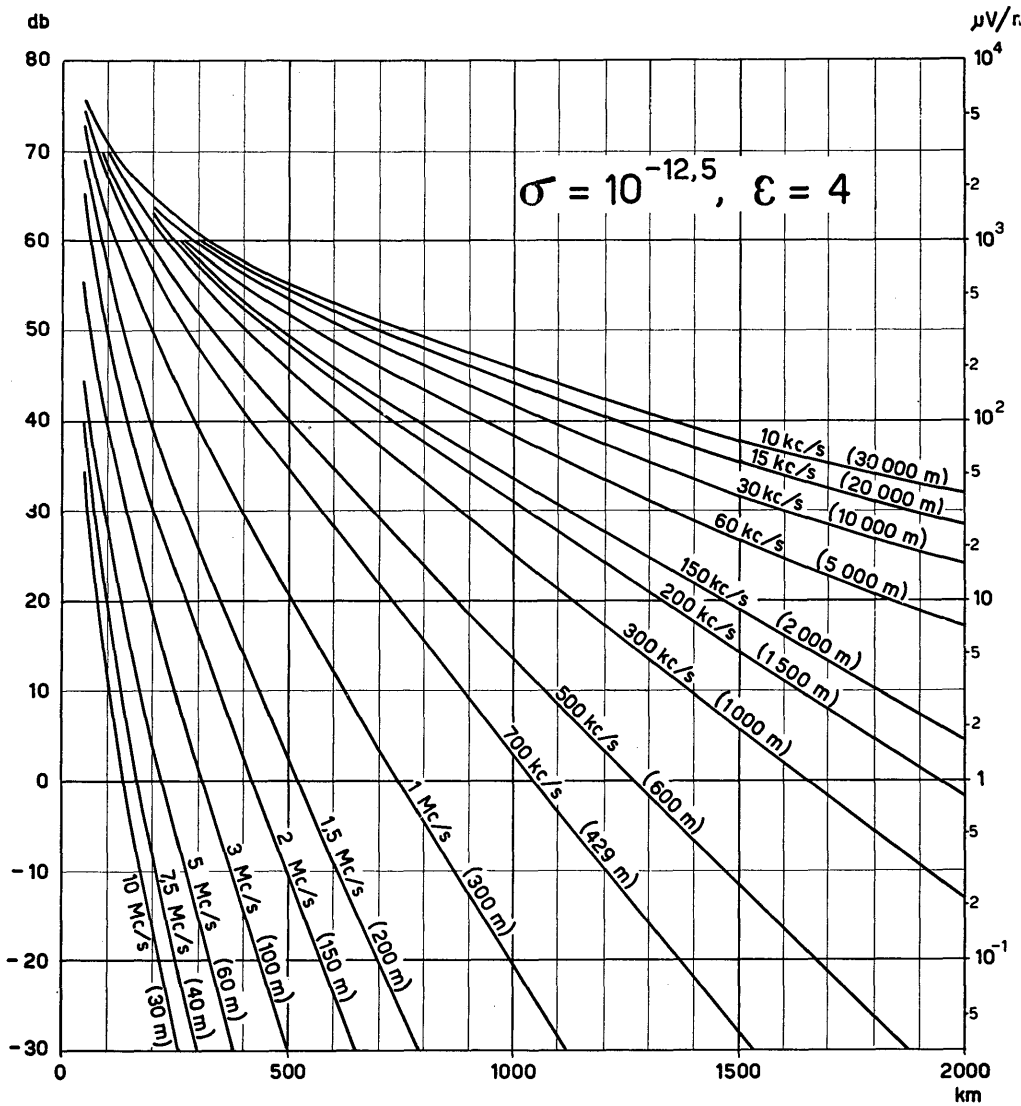


Propagation over sea (conductivity $\sigma = 4 \times 10^{-11}$ e.m.u., dielectric constant $\epsilon = 80$).

FIGURE 1

Propagation curves

Ground wave corresponding to an unattenuated field of:
 $3 \times 10^6 / D_{\text{km}} \text{ } \mu\text{V/m}$

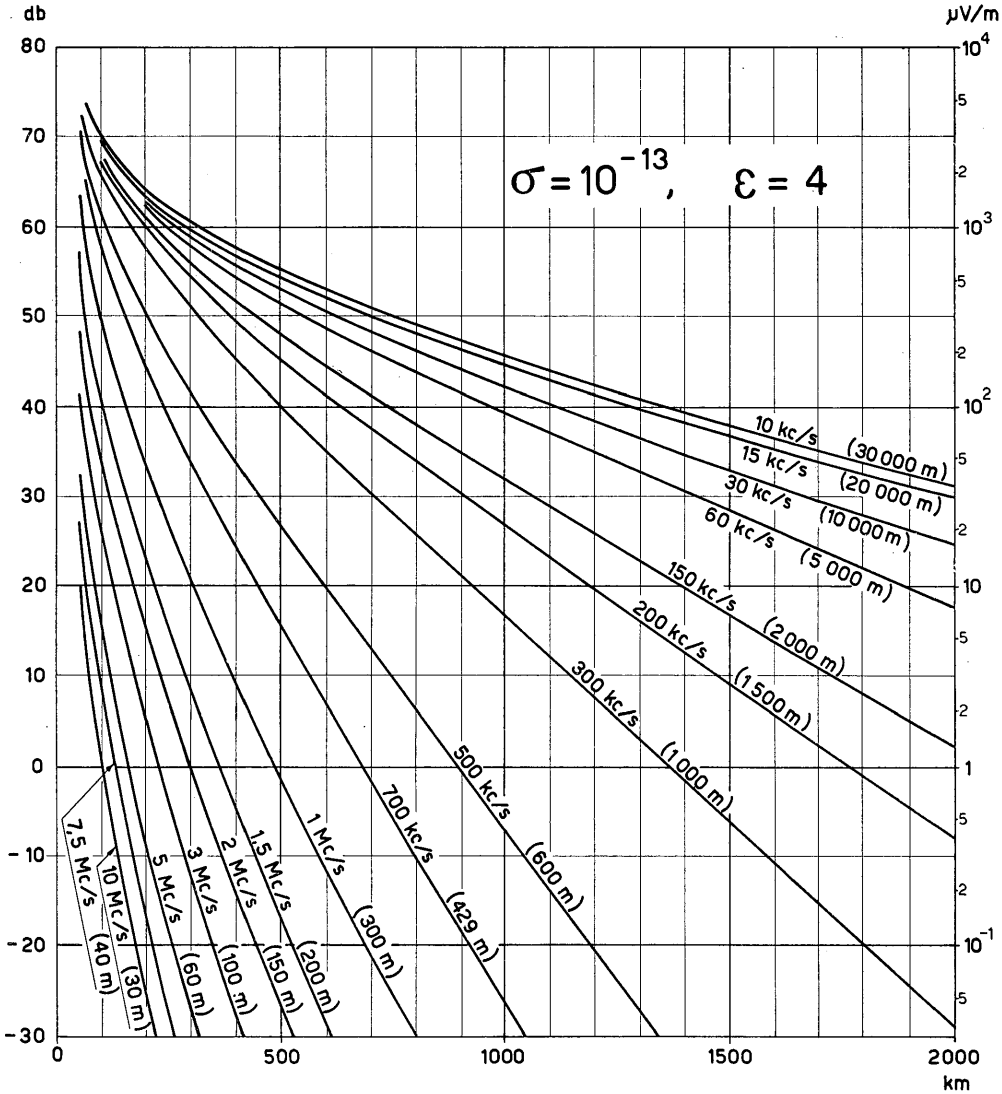


Propagation over land (conductivity $\sigma = 10^{-12.5}$ e.m.u., dielectric constant $\epsilon = 4$).

FIGURE 2

Propagation curves

Ground wave corresponding to an unattenuated field of:
 $3 \times 10^5 / D_{\text{km}} \text{ } \mu\text{V/m}$

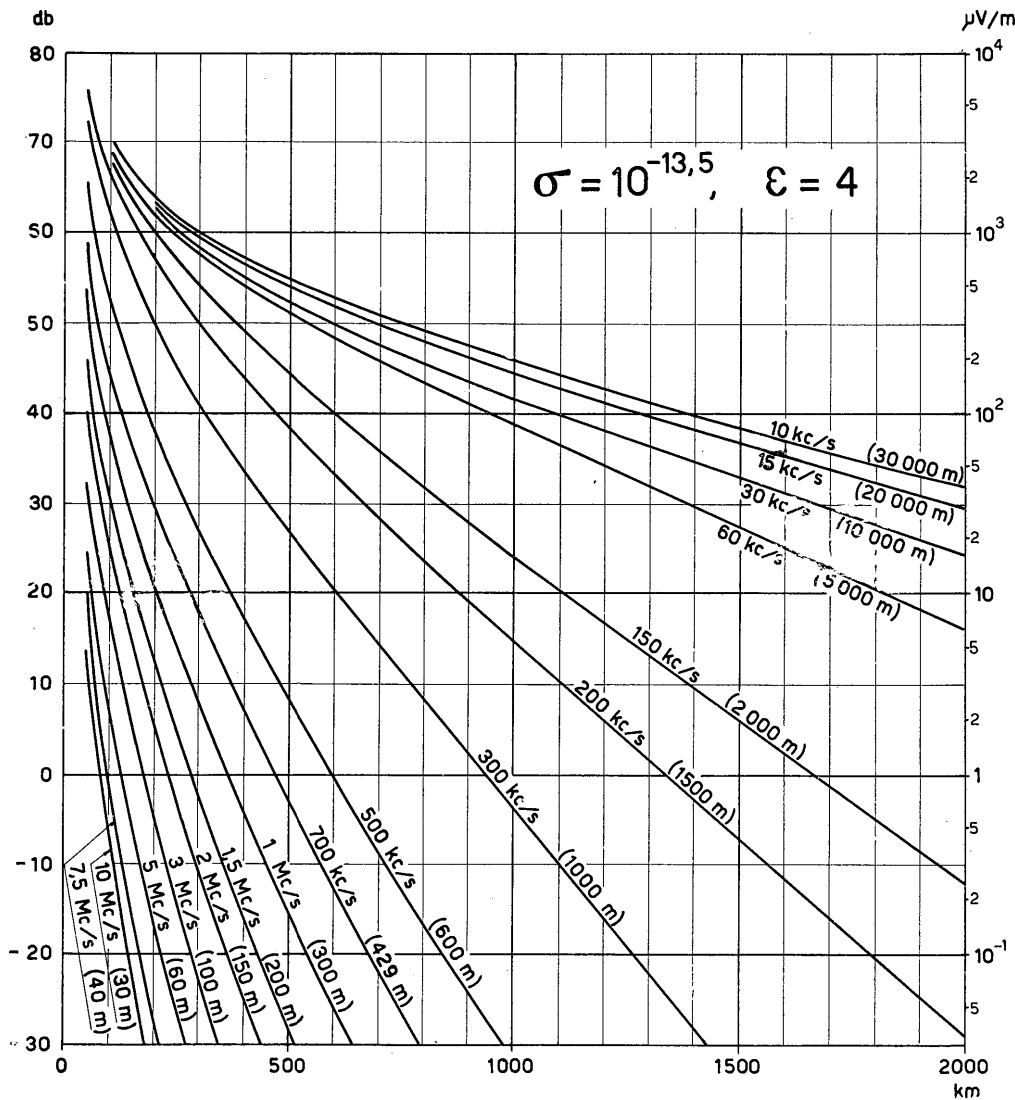


Propagation over land (conductivity $\sigma = 10^{-13}$ e.m.u., dielectric constant $\epsilon = 4$).

FIGURE 3

Propagation curves

Ground wave corresponding to an unattenuated field of:
 $3 \times 10^8 / D_{\text{km}} \text{ } \mu\text{V/m}$

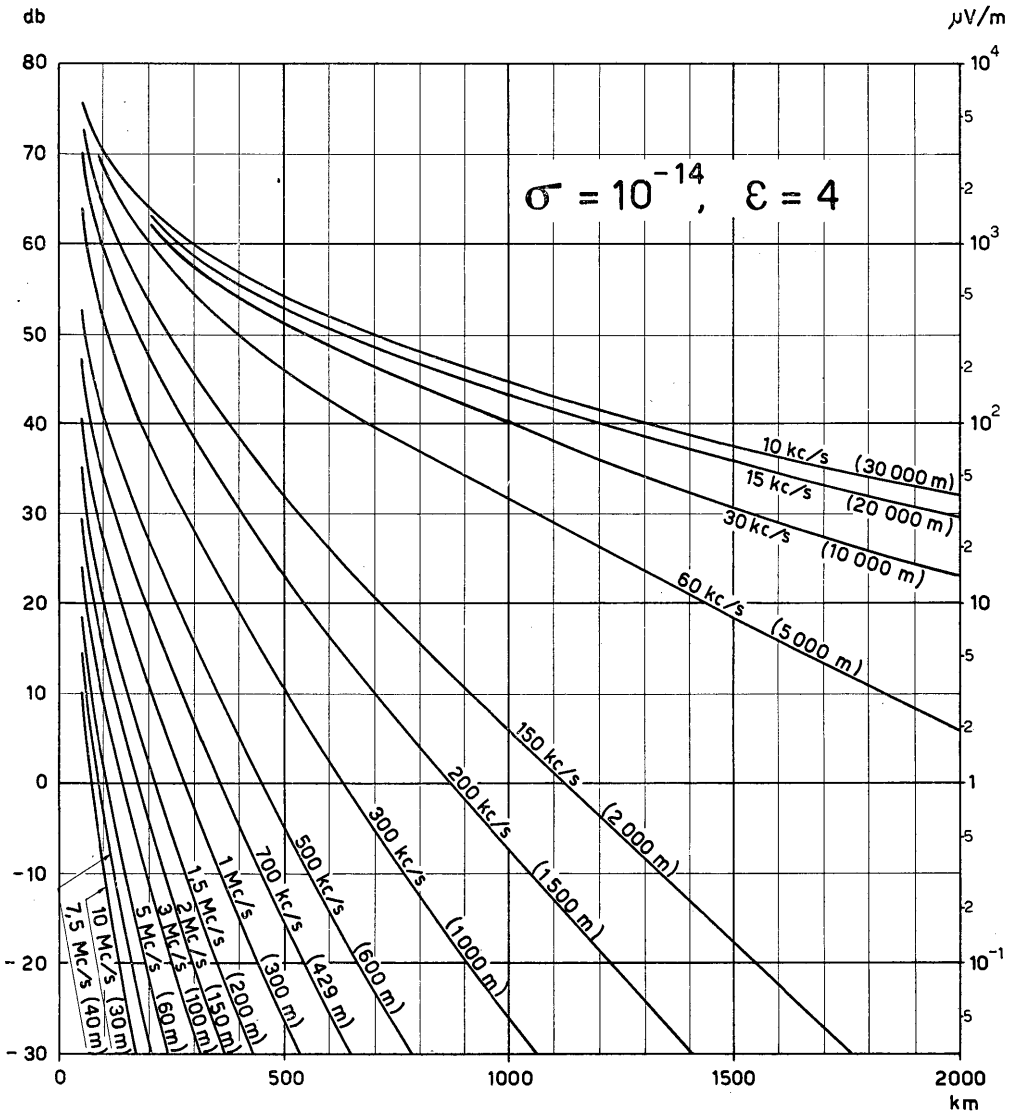


Propagation over land (conductivity $\sigma = 10^{-13.5}$ e.m.u., dielectric constant $\epsilon = 4$).

FIGURE 4

Propagation curves

Ground wave corresponding to an unattenuated field of:
 $3 \times 10^5 / D_{\text{km}} \text{ } \mu\text{V/m}$



Propagation over land (conductivity $\sigma = 10^{-14}$ e.m.u., dielectric constant $\epsilon = 4$).

FIGURE 5

G

$$\sigma = 4 \cdot 10^{-11}, \epsilon = 80.$$

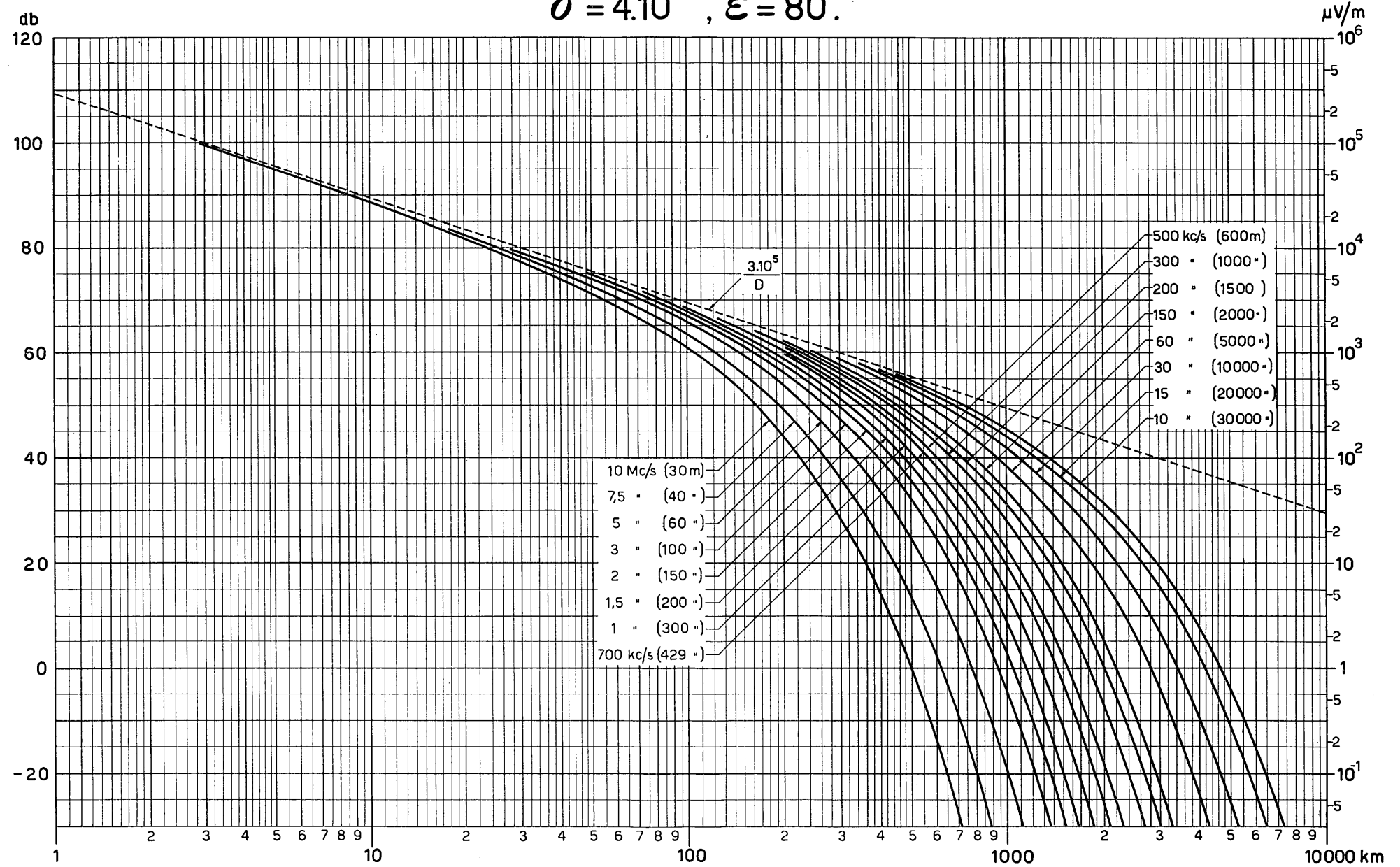


FIGURE 6

$$\sigma = 10^{-12,5}, \epsilon = 4.$$

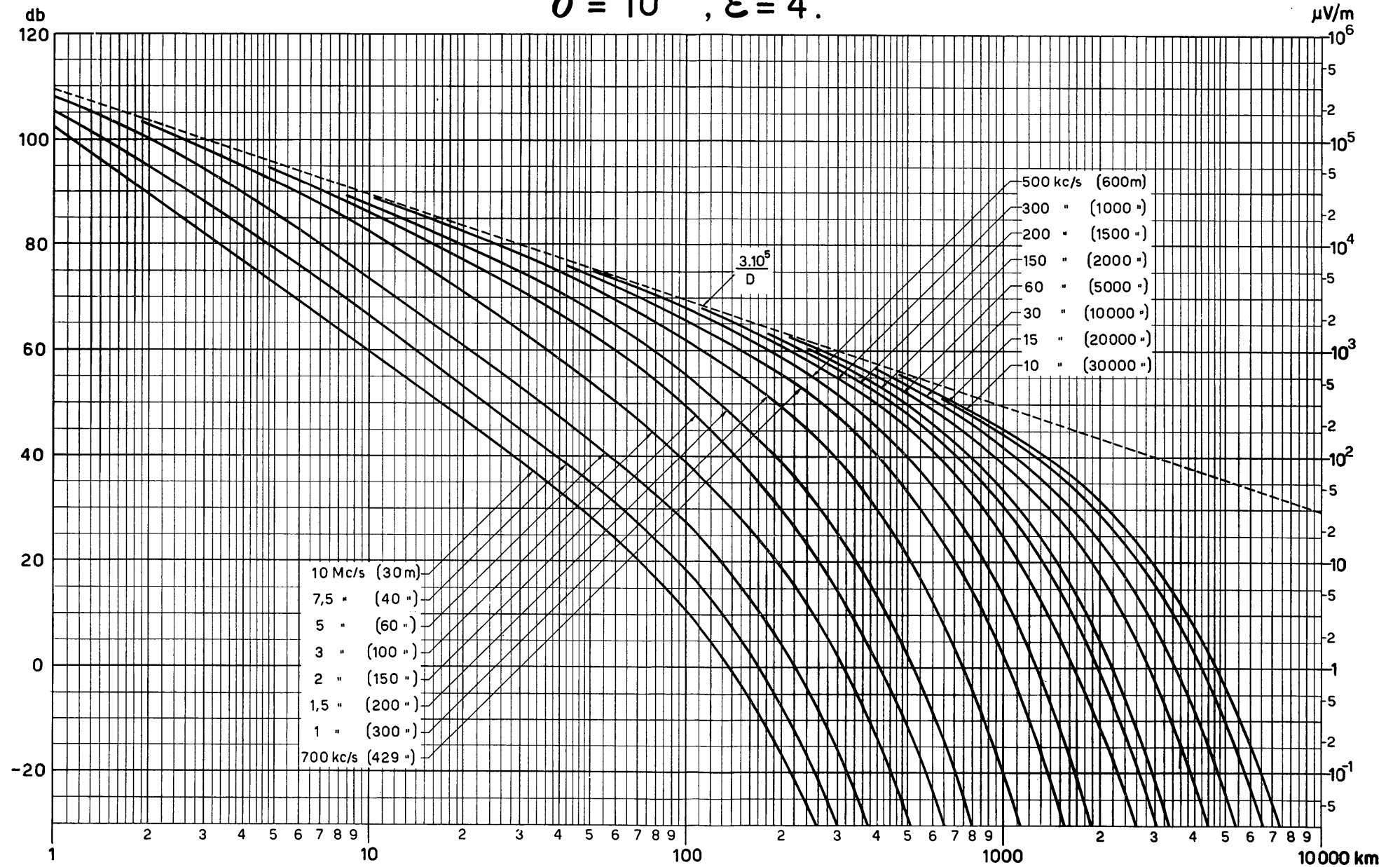


FIGURE 7

$$\sigma = 10^{-13}, \quad \epsilon = 4.$$

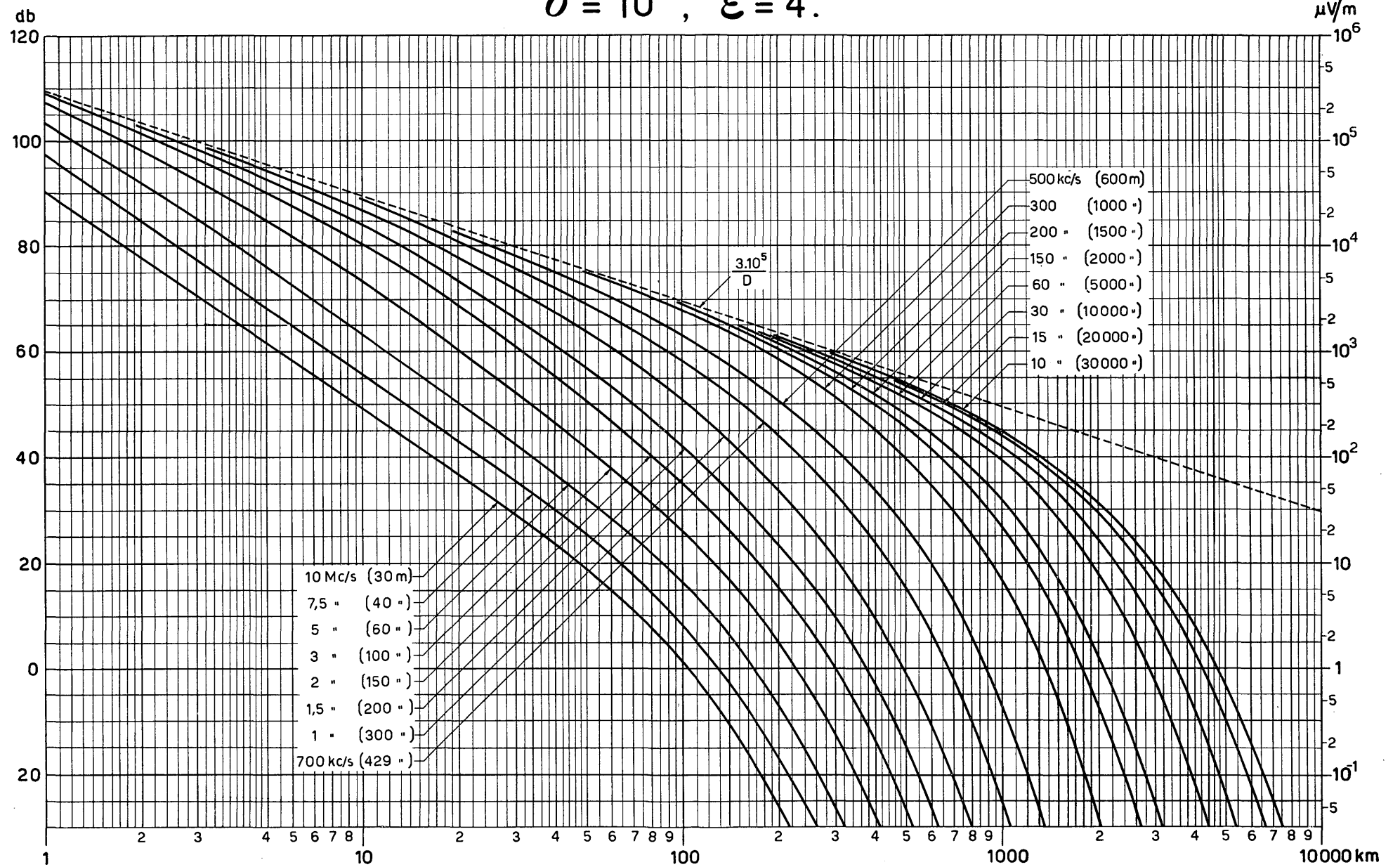


FIGURE 8

$$\sigma = 10^{-13,5}, \epsilon = 4.$$

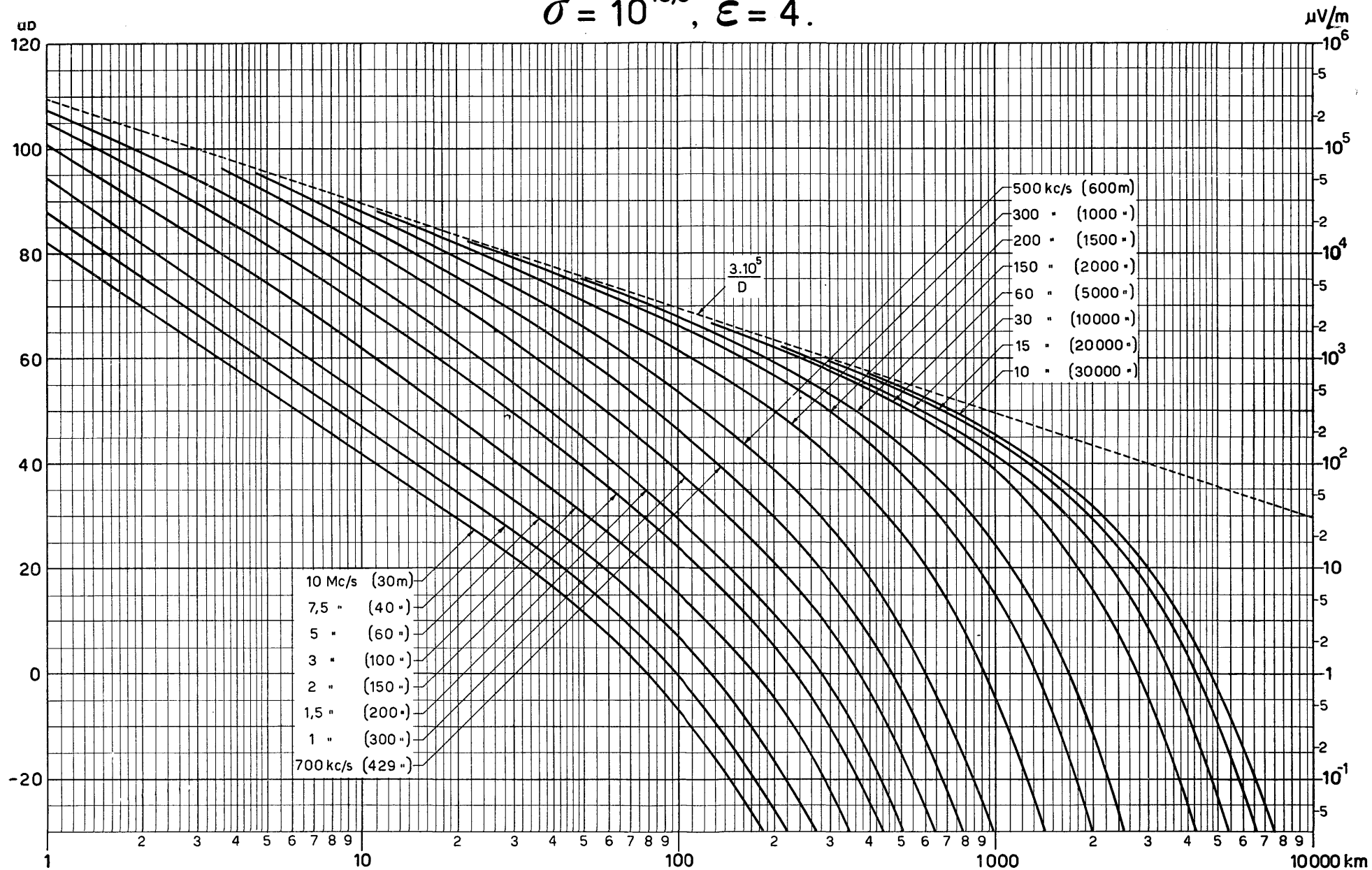


FIGURE 9

$$\sigma = 10^{-14}, \quad \epsilon = 4.$$

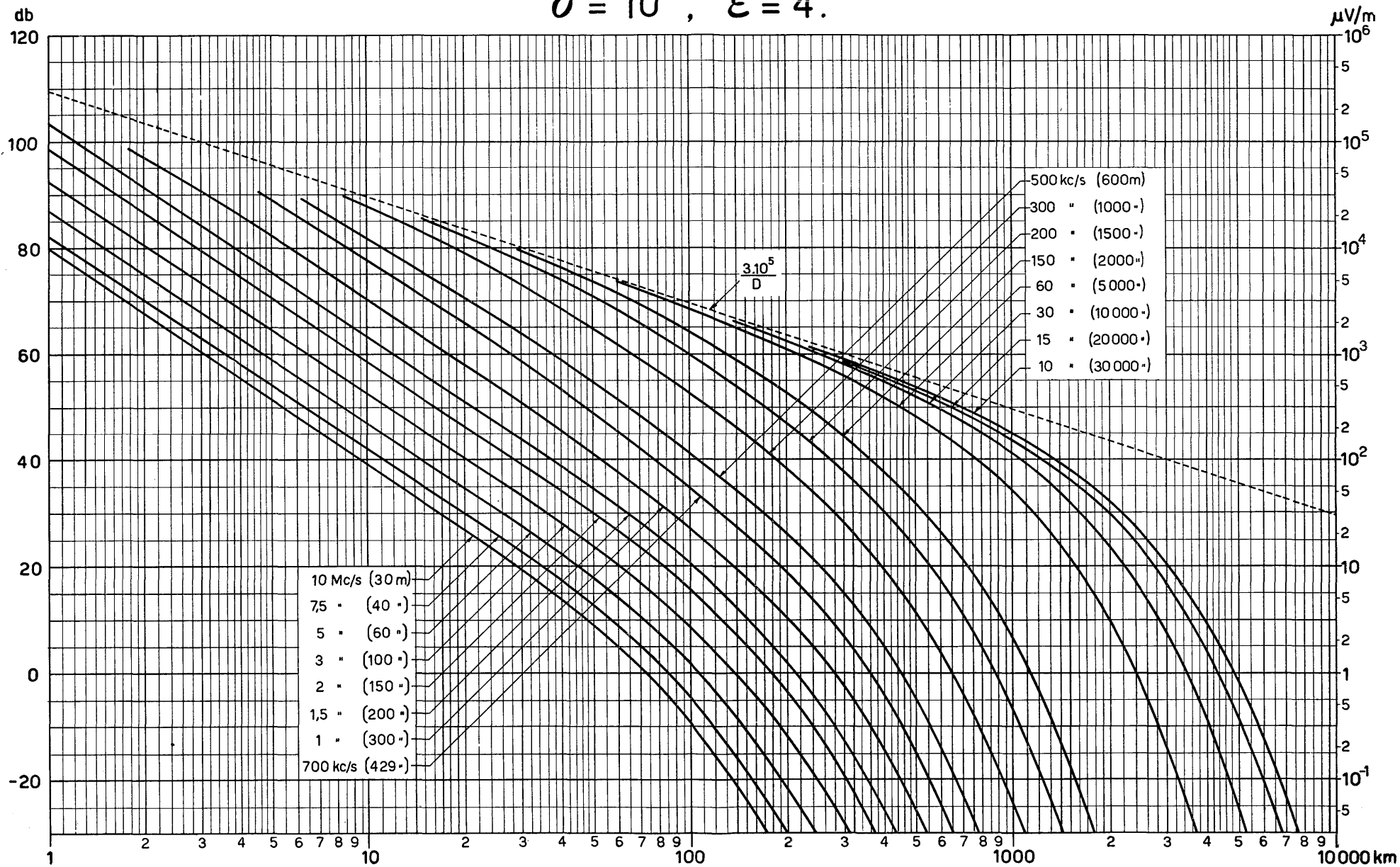


FIGURE 10

RECOMMENDATION No. 308 *

GROUND-WAVE PROPAGATION OVER INHOMOGENEOUS EARTH

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the calculation of ground-wave field-strengths and phases for propagation over inhomogeneous earth, such as part land and part sea, is a matter of great importance in determining the service areas of radio transmitters and in the use of medium and low frequencies for navigational aids;
- (b) that the mathematical analysis has now been reduced in some special cases of well-defined homogeneous sections to a graphical form convenient for use in the solution of practical problems (see section E of the Bibliography in Report No. 141);
- (c) that the influence of a gradual transition between two homogeneous sections has in some special cases been investigated theoretically (see references C.1 and A.16 of the Bibliography in Report No. 141);
- (d) that the closely related problem of propagation over a surface with small undulations has been analysed by an analogous mathematical technique (see section C of the Bibliography in Report No. 141);
- (e) that, nevertheless, for the general case, calculations based on a rigid mathematical analysis are laborious;
- (f) that, in many cases, the variations in the electrical constants in both horizontal and vertical directions result in changes of the equivalent surface impedance of the ground which are gradual, ill-defined or imperfectly known;
- (g) that computations made from the mathematical analysis confirm the results of well-defined experiments;
- (h) that the semi-empirical methods which are in use (see section F of the Bibliography in Report No. 141) give good agreement within the range of their application with a rigorous theoretical analysis and field-strength measurements made under well-defined conditions;

UNANIMOUSLY RECOMMENDS

- 1. that for cases for which the mathematical analysis has been reduced to a convenient form for practical application such methods should be used;
- 2. that, for other cases, the semi-empirical methods should be employed with due regard to the limitations of their use.

RECOMMENDATION No. 309

DEFINITION OF A BASIC REFERENCE ATMOSPHERE

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) the need of radio engineers to represent the mean variations of refractive index with height by a non-linear law;
- (b) the impossibility of formulating these variations by a universal law;

* This Recommendation replaces Recommendation No. 169.



- (c) that the dependence upon the height h of refractive index n of the atmosphere at radio frequencies is well expressed by the law

$$n(h) = 1 + (a.e^{-bh})$$

where a and b are constants that can be determined statistically for different climates. (See Report No. 146);

UNANIMOUSLY RECOMMENDS

that the basic reference atmosphere be defined by the relationship

$$n(h) = 1 + \{289 \times 10^{-6}.e^{-(0.136h)}\}$$

where h is the height above sea level in kilometres.

Note. — The refractive index in the first kilometre of the basic reference atmosphere is very nearly equal to that in an atmosphere corresponding to an earth of effective radius of $4/3$ the real radius.

RECOMMENDATION No. 310 *

DEFINITION OF TERMS RELATING TO PROPAGATION IN THE TROPOSPHERE

The C.C.I.R.,

(Geneva, 1951 — Los Angeles, 1959)

CONSIDERING

that it is well known that the propagation of waves of frequencies greater than 30 Mc/s is greatly influenced by meteorological conditions in the troposphere;

UNANIMOUSLY RECOMMENDS

that the list of definitions annexed hereto be adopted for incorporation in the vocabulary in accordance with Resolution No. 5.

VOCABULARY OF TERMS USED IN RADIO PROPAGATION THROUGH THE TROPOSPHERE

Term	Definition
1. <i>Troposphere</i>	The lower part of the earth's atmosphere extending upwards from the earth's surface, in which temperature decreases with height except in local layers of temperature inversion.
2. <i>Tropopause</i>	The upper boundary of the troposphere, above which the temperature increases slightly with respect to height, or remains constant.
3. <i>Temperature inversion</i>	In the troposphere: an increase in temperature with height.
4. <i>Modified refractive index</i>	For a given height above sea level: the sum of the refractive index of the air at this height and the ratio of this height to the radius of the earth.
5. <i>Refractive modulus</i>	One million times the amount by which the modified refractive index exceeds unity.
6. <i>M unit</i>	A unit in terms of which refractive modulus is expressed in accordance with the preceding definition.

* This Recommendation replaces Recommendation No. 54.

Term	Definition
7. <i>M curve</i>	A curve showing the relationship between refractive modulus and height above the earth's surface.
8. <i>Standard refractive modulus gradient</i>	That uniform variation of refractive modulus with height above the earth's surface which is regarded as a standard for comparison. The gradient considered as normal. has a value of 0.12 M-units per metre (3.6 M-units per hundred feet).
9. <i>Standard radio atmosphere</i>	For tropospheric propagation: an atmosphere having the standard refractive modulus gradient.
10. <i>Basic reference atmosphere</i>	An atmosphere defined by the relationship: $n(h) = 1 + \{289 \times 10^{-6} \cdot e^{-(0.136h)}\}$ where h is the height above sea-level in kilometres. <i>Note.</i> — The refractive index in the first kilometre of the basic reference atmosphere is very nearly equal to that in an atmosphere corresponding to an earth of effective radius of 4/3 the real radius.
11. <i>Standard refraction</i>	The refraction which would occur in a standard radio atmosphere (see Fig. 1).
12. <i>Super-refraction</i>	Refraction greater than standard refraction (see Fig. 1).
13. <i>Sub-refraction</i>	Refraction less than standard refraction (see Fig. 1).
14. <i>Standard propagation</i>	The propagation of radio waves over a smooth spherical earth of uniform electrical characteristics under conditions of standard refraction in the atmosphere.
15. <i>Tangential wave path</i>	In radio-wave propagation over the earth: a path of propagation of direct wave, which is tangential to the surface of the earth. The tangential wave path is curved by atmospheric refraction.
16. <i>Radio horizon</i>	The locus of points at which direct rays from the transmitter become tangential to the earth's surface.
17. <i>Effective radius of the earth</i>	The radius of a hypothetical earth for which the distance to the radio horizon assuming rectilinear propagation is the same as that for the actual earth with an assumed uniform vertical gradient of refractive index. (For the standard atmosphere, the effective radius is 4/3 that of the actual earth.)
18. <i>Tropospheric radio duct</i>	A stratum of the troposphere within which an abnormally large proportion of any radiation of sufficiently high frequency is confined and over part or all of which there exists a negative gradient of refractive modulus. The upper bounding surface is determined by a local minimum value of the refractive modulus. The lower bounding surface is either the surface of the earth or a surface parallel to the local stratification of refractive properties at which the refractive modulus has the same values as that at the local minimum value of the refractive modulus (see Fig. 2, 3 and 4).
19. <i>Surface duct</i> <i>Ground-based duct</i>	A tropospheric radio duct having the earth as its lower boundary and in which the modified refractive index is everywhere greater than the value at the upper boundary (see Fig. 2 and 3).
20. <i>Elevated duct</i>	A tropospheric radio duct of which the lower boundary is an elevated surface at which the modified refractive index has the same value as at the upper boundary (see Fig. 4).
21. <i>Duct thickness</i> <i>Duct width</i>	The difference in height between the upper and lower boundaries of a tropospheric radio duct.
22. <i>Duct height</i>	The height above the surface of the earth of the lower boundary of an elevated duct (see Fig. 4).

Term	Definition
23. <i>Tropospheric mode</i>	Any one of the possible modes of propagation in the troposphere.
24. <i>Trapped mode</i>	A mode of propagation in which the energy is substantially confined within a tropospheric radio duct.
25. <i>Mixing ratio</i>	The ratio of the mass (in grammes) of water vapour in a given volume of the atmosphere to the mass (in kilogrammes) of the dry air in the same volume.

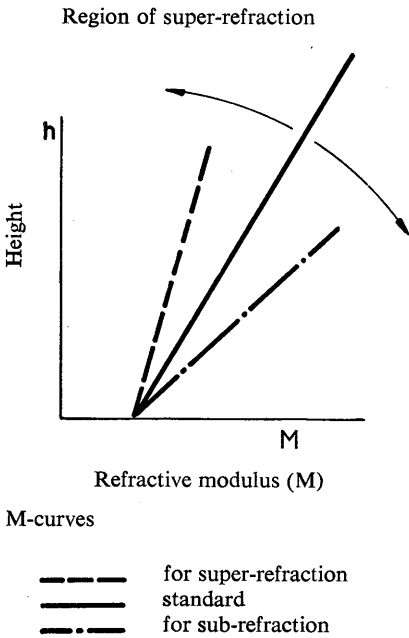


FIGURE 1

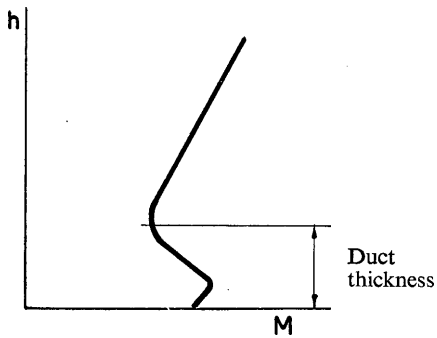


FIGURE 2

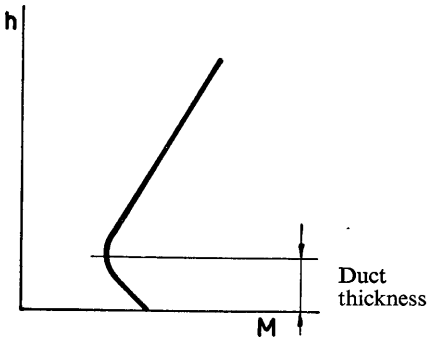


FIGURE 3

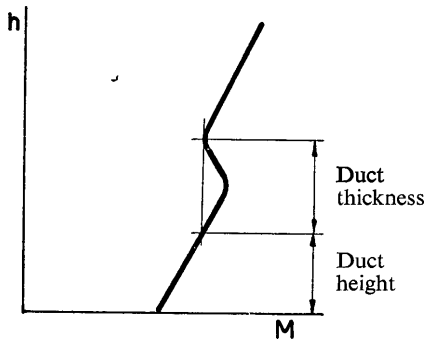


FIGURE 4

RECOMMENDATION No. 311 *

PRESENTATION OF DATA IN STUDIES
OF TROPOSPHERIC-WAVE PROPAGATION

The C.C.I.R.,

(London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that there is an urgent need for guidance to be given to engineers in the planning of broadcasting, television and fixed link services in the frequency band 30–4000 Mc/s;
- (b) that it is important to determine how the field strength in this frequency band depends on meteorological conditions and upon the nature of the terrain at locations both within and beyond the horizon;
- (c) that to facilitate the comparison of results, it is desirable that administrations and operating agencies should present field-strength data in a uniform manner;
- (d) that it is not yet possible finally to establish a method of presenting results and a system of statistical analysis best suited to the requirements expressed in § (a) and (b);

UNANIMOUSLY RECOMMENDS

1. that the field strengths exceeded for 0.1 %, 1 %, 10 %, 50 %, 90 %, 99 % and 99.9 % of the overall time should, whenever possible, be determined for all locations at which measurements are made;
2. that in the case of broadcasting and television the median values of field strength exceeded at 10 %, 50 % and 90 % of the locations should be determined;
3. that it is desirable to amplify these overall statistics by a more detailed and precise analysis; for this purpose the methods proposed in Annex I of the present Recommendation, or in Doc. 172 (France) of Warsaw, 1956, or in Doc. V/58 (France) of Geneva, 1958 might be taken as a basis;
4. that the statistical results of field-strength measurements should be displayed on probability paper. The field strength should be plotted along the ordinate and expressed in decibels relative to 1 microvolt per metre, the values of field strength increasing, moving up the ordinate. The percentage of total valid recording time, or percentage of locations should be plotted along the abscissa, with a scale following the Gaussian probability law, percentages increasing from left to right. An example of a log-normal distribution plotted on probability paper is given in Annex II;
5. that all measured values of field strength should be normalized to correspond to those that would be obtained with a vertical half-wave dipole, or with a similar horizontal dipole placed broadside to the direction of the receiving point, the dipole in each case being at least several wavelengths above the ground and radiating 1 kW;
6. that in the case of broadcasting and television, and whenever possible, all measurements should be referred to a receiving aerial 10 metres above the ground and this aerial should not be highly directive in the vertical plane.

* This Recommendation replaces Recommendation No. 170.

ANNEX I

It should be noted that the recommendations given above refer particularly to the propagation of waves over long distances (especially in connection with interference problems in sound and television broadcasting) and also to propagation characteristics within the service areas of sound and television broadcasting stations. While in these cases the first interest lies in ascertaining those values of field strength exceeded for various percentages of the overall time at varying distances, for a more detailed analysis it might, however, be useful to analyse measurements within unit periods of 1 hour. This latter procedure would permit studies to be made of diurnal variations, while similarly seasonal variations could conveniently be studied by grouping the values obtained at specified hours of the day for a whole month and examining the change of field strength distributions from month to month. Presentation of the results in this form would, moreover, permit later correlation of radio measurements with meteorological data.

For the study of propagation over fixed line-of-sight links in the VHF (metric), UHF (decimetric) or SHF (centimetric) bands, a more precise correlation between received field strength and prevailing atmospheric conditions might be required. For this and other reasons it is considered that results should be capable of being presented separately for each hour of the day of each month during which tests are being conducted. At the same time, overall distribution curves for periods of one month will be required to permit a study of seasonal variations; overall distribution curves for even longer periods will also, no doubt, be required by the planning engineer. It is generally convenient to refer results to the free space value for the distance and other conditions concerned.

Although it will usually be necessary to preserve, for reference, the original charts upon which the field-strength variations are recorded, it is essential that some much simpler and more conveniently accessible means of displaying the essential data be employed. One method is to plot the maximum, median and minimum field strengths for each hour on linear graph paper, the spread of results within the hour being shown by a vertical line. In addition, by determining the hourly median value or value over some other percentage of the time, it is possible to obtain for any given hour of the day, the statistical distribution of these values for a month (or any other desired period of time).

ANNEX II

The Gaussian probability scale is defined by

$$P(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-\frac{1}{2}\xi^2} d\xi$$

For abscissae $x = 0$, $x \rightarrow \infty$ and $x \rightarrow -\infty$, the corresponding values of the probability $P(x)$ are 50%, 0% and 100%.

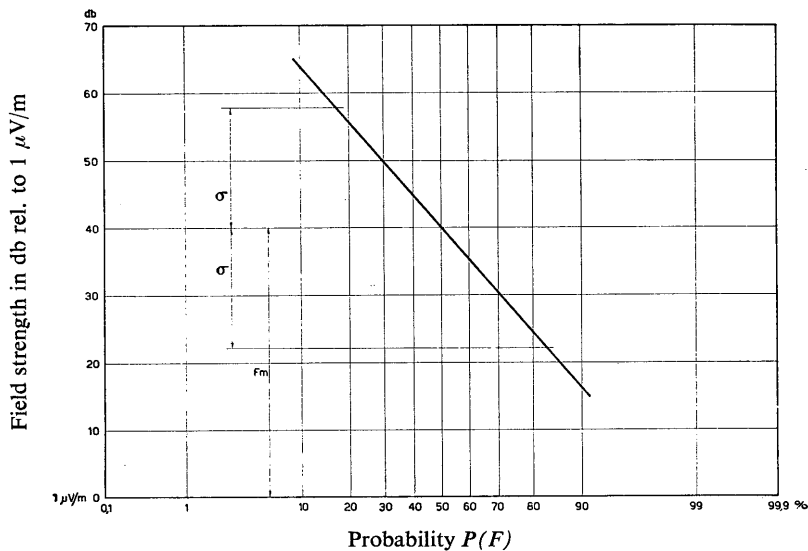
An amplitude Gaussian distribution for a field strength F measured in db (log-normal distribution) is given by:

$$P(F) = \frac{1}{\sigma\sqrt{2\pi}} \int_F^\infty e^{-\frac{1}{2}\left(\frac{f-F_m}{\sigma}\right)^2} df$$

$P(F)$ is the probability (percentage of time or locations) that the field strength E expressed in db above $1 \mu\text{V/m}$ ($F = 20 \log E$) will exceed the level F . F_m is the median value of F , i.e. that which is exceeded for 50% of the time or locations. σ is the standard deviation, so that $P(F_m - \sigma) \approx 84\%$ and $P(F_m + \sigma) \approx 16\%$.

It is often of interest to know the field strength exceeded for 1% or 10% of the time; when the distribution is log-normal, the distribution curve is a straight line, the corresponding deviations are given by 2.32σ and 1.28σ .

The accompanying graph illustrates the presentation of log-normal distribution.



Graph showing log-normal distribution of field-strength measurements.

RECOMMENDATION No. 312 *

TROPOSPHERIC WAVE PROPAGATION CURVES **

The C.C.I.R.,

(Geneva, 1951 — London, 1953 — Los Angeles, 1959)

CONSIDERING

- (a) that there is a need to give a guide to engineers in the planning of services in the VHF and UHF bands, in particular for television and other broadcasting in these bands;
- (b) that in the case of stations working in the same or adjacent frequency channels the determination of the minimum geographical distance of separation required to avoid intolerable interference due to long-distance tropospheric transmission is a matter of great importance;
- (c) that the annexed curves are based on the statistical analysis of a considerable amount of experimental data (see Report No. 145);

UNANIMOUSLY RECOMMENDS

that the revised curves given in Annex II be adopted for provisional use, subject to the conditions stated in Annex I.

ANNEX I

1. The curves of Annex II were prepared from data obtained mainly in the United States of America and Western Europe; many more measurements have been made for distances up to about 400 kilometres than for greater distances, and the curves have their greatest reliability up to, say, 500 kilometres;

* This Recommendation replaces Recommendation No. 111.

** It must be emphasized that the curves of this Recommendation are intended for use in the planning of broadcasting services for the solution of interference problems over an extended area; they should not be used for point-to-point communication links, for which systems the actual terrain profile may be determined and methods of field strength prediction of higher accuracy may be used.

2. the curves are expressed in db rel. to $1 \mu\text{V/m}$ for 1 kW effective power radiated from a half-wave dipole, either vertical or horizontal;
3. the curves of Annex II refer specifically to propagation over land paths which are not mountainous in character;
4. all of the curves of Annex II are to some extent dependent upon frequency. It is, however, difficult to assess this dependence quantitatively since it is influenced by the nature of the terrain, climatic conditions and antenna height. From the data so far available it has not been possible to determine a definite variation of the field strength at various distances with frequency, and the curves are intended to apply at all frequencies between 40 and 600 Mc/s; but it must be emphasized that further data for frequencies exceeding 300 Mc/s may ultimately require a frequency dependence to be shown;
5. it is probable that the curves will give too low field strengths for very smooth paths such as those which are entirely over sea, especially if the terminals are on clear open sites. There are indications that, in such circumstances, field strengths exceeding those given in the curves by as much as 10 db may occur;
6. it is probable that many of the field strength measurements used to determine the curves were made under relatively favourable receiving conditions; and there is some evidence that in typical conditions of domestic reception somewhat lower field strengths, perhaps by several decibels, could be obtained. Until further information is available on this point, however, it is inadvisable to apply a correction to the curves;
7. the curves may be taken to apply to a receiving antenna height of 10 metres above ground at the receiving location, and to a transmitting antenna height of 300 metres: the transmitting antenna height being somewhat arbitrarily defined as the height of the antenna above the average level of the ground between distances of 3 km and 15 km from the transmitter, over the sector in which it is required to know the magnitude of the interfering fields. From the data available it is not considered possible to give a precise indication of the effect of changing the transmitter height, but, as a first approximation, for transmitter heights differing significantly from 300 metres a correction may be applied on the following basis. To obtain the field strength at a distance of x km for a transmitting aerial height of h meters, the curves should be read for the distance $(x + 70 - 4.1\sqrt{h})$ km. This correction should not be applied, however, if the receiving point is visible from or near the horizon of the transmitter.
8. the curves of Fig. 1 show, the field strengths exceeded for 1%, 10% and 50% of the time for at least 50% of the receiving locations within the sector of interest, as a function of distance, for any frequency in the band 40 to 600 Mc/s, subject to the reservation given in § 6;
9. Fig. 2 relates the field strength exceeded at 50% of receiving locations to that exceeded at any other required percentage of receiving locations. From the data at present available, it appears that the same curve may be used to obtain approximate results for all of the frequencies, and distances covered by Fig. 1. The curve corresponds to an average standard deviation of 8 db; but in practice the standard deviation may vary from 5 to 11 db, depending on the degree of roughness of the terrain;
10. it is known that the median field strength varies in different climatic regions, and data for a wide range of such conditions in the United States of America and Western Europe show that it is possible to correlate the observed median fields with the refractive index gradient in the first 1000 metres of the atmosphere above ground level. If n_s and n_{1000} are the refractive indices at the surface and at a height of 1000 metres respectively and if ΔN is defined as $(n_{1000} - n_s) \cdot 10^6$, then in a standard atmosphere, $\Delta N \simeq -40$, and the median curve of Fig. 1 refers to this case. If the mean value of ΔN in a given region is appreciably different from -40 , a correction factor of $-0.5 (\Delta N + 40)$ db should be applied to the curves to give the appropriate median field strengths for all distances. If ΔN is not known, but

information concerning the mean value of N_s is available, where $N_s = 10^6(n_s - 1)$, an alternative correction which may be used at least for temperate climates, is $0.2(N_s - 310)$ db. Whilst these corrections have so far only been established for the geographical areas referred to above, they may serve as an approximate guide to the corrections which may be necessary in other geographical areas. The extent to which it is reliable to apply similar corrections to the curves for field strengths exceeded 1% and 10% of the time is not known. It is expected, however, that a larger correction will be required for the 1% and 10% values in regions where super-refraction is prevalent for an appreciable part of the time.

ANNEX II

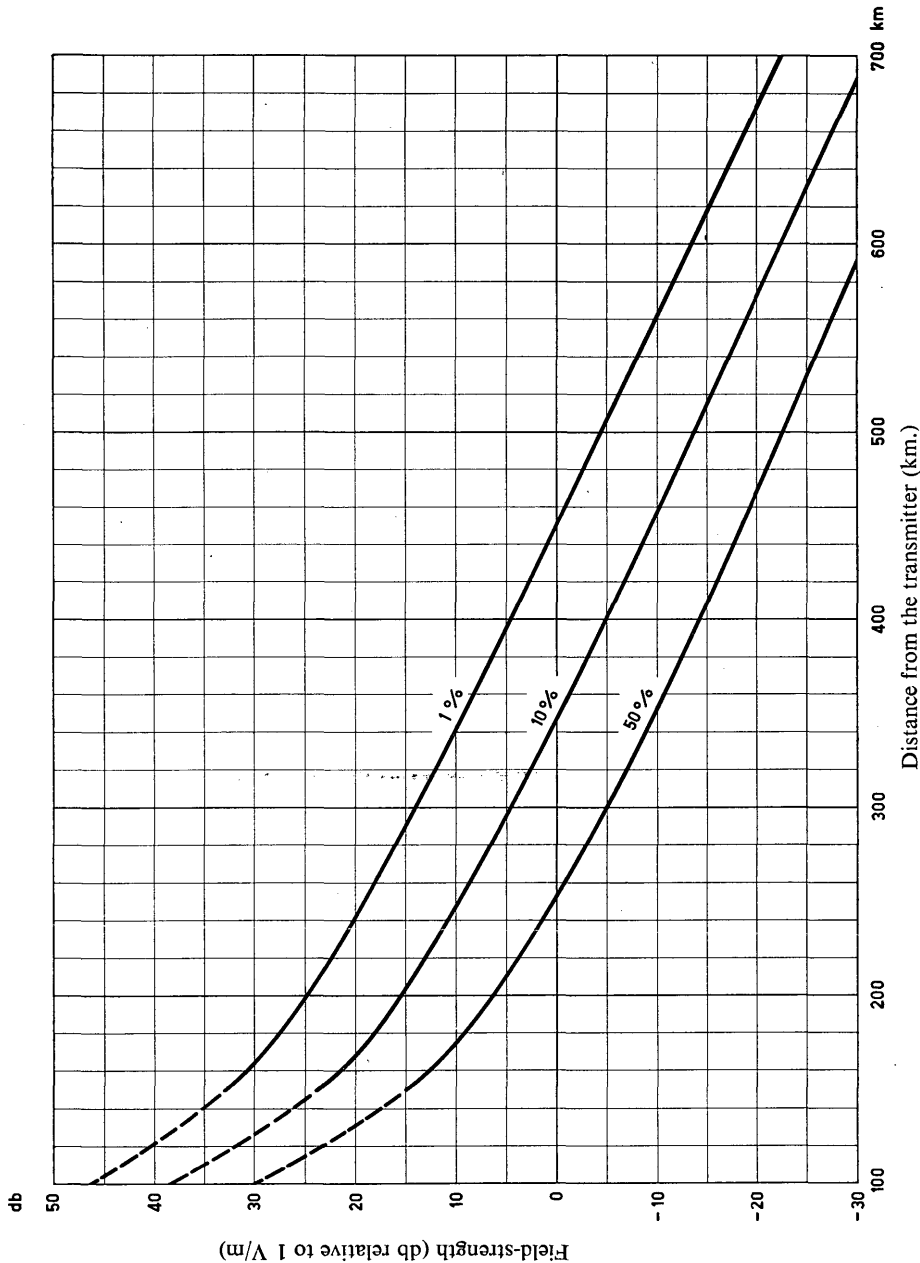


FIGURE 1

Frequency range: 40 to 600 Mc/s. Values of field-strength for 50% of locations for 1 kW radiated power by a half-wave dipole with vertical or horizontal polarization exceeded for 1%, 10%, and 50% of the time. (The dashed portions of the curves are less reliable than the portions shown in full lines.)

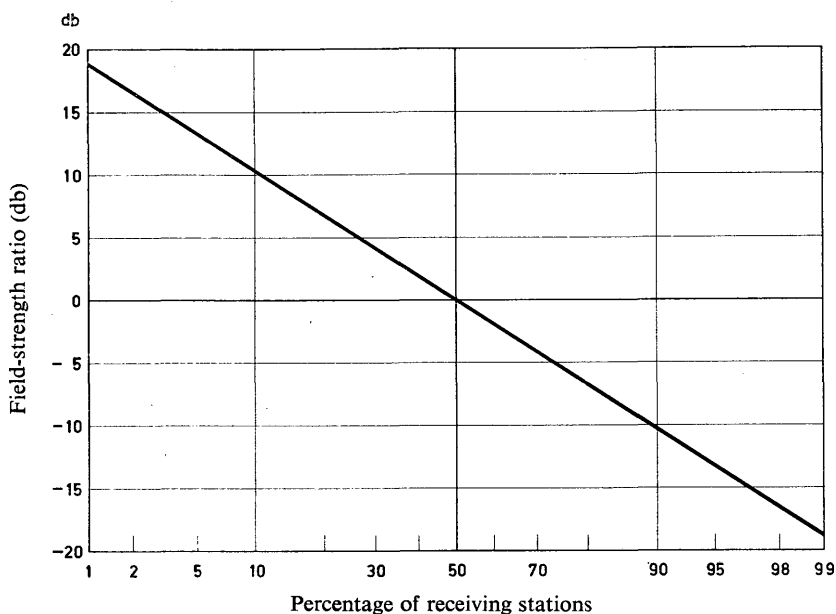


FIGURE 2

Ratios of the field-strengths exceeded at the stated percentages of receiving locations to that exceeded at 50% of the locations.

RECOMMENDATION No. 313 *

EXCHANGE OF INFORMATION FOR THE PREPARATION OF SHORT-TERM FORECASTS AND THE TRANSMISSION OF IONOSPHERIC DISTURBANCE WARNINGS

The C.C.I.R.,

(Geneva, 1951 — Los Angeles, 1959)

CONSIDERING

- (a) that it is important to give Administrations and operating services (navigation and other services) using ionosphere-propagated waves the earliest possible warning of the onset of disturbances to ionospheric propagation conditions, so that they may arrange their traffic schedules accordingly;
- (b) that it is desirable to find an easier method of drawing up a plan for the rational use of frequencies in place of the system based on long-term mean values when the latter is temporarily unsatisfactory on account of ionospheric disturbances;
- (c) that it would therefore be advisable for all organizations publishing ionospheric forecasts to study the technique of forecasting disturbances;
- (d) that it is of great importance to take steps to secure the greatest possible accuracy of such forecasts and the maximum of speed in their dissemination;

* This Recommendation replaces Recommendation No. 59.

- (e) that, for the exchange and dissemination of propagation information, there are three categories of users: those who make forecasts, those who make operational use of propagation information and those who require the information for scientific research or other purposes; and that, to meet these different requirements, it is desirable to use the most appropriate methods of exchange in each case;
- (f) that effective collaboration has been arranged, particularly for the I.G.Y. programme, between some Administrations, operating services and the organizations studying the characteristics of the ionosphere and deducing forecasts therefrom;
- (g) that provisional codes, prepared by the International Radio Scientific Union (U.R.S.I.) such as the code used in French Ursigrams, or due to organizations such as the Central Radio Propagation Laboratory (C.R.P.L.), the Arbeits-Gemeinschaft Ionosphäre, the Japanese Central Propagation Laboratory and others, have proved their usefulness in the dissemination of information for the preparation of short-term forecasts;

UNANIMOUSLY RECOMMENDS

1. that each country participating in radio propagation research should designate an official agency for the reception, coordination and exchange of such data and for liaison with corresponding agencies in other countries;
2. that the information required for the preparation of short-term forecasts should be centralised by the agencies mentioned in § 1, as far as possible by the most direct means of telecommunication between the centralizing agency and the various scientific institutes for solar, magnetic and other observations;
3. that, of the data thus assembled, those which are of use for forecasting within 48 hours should be disseminated in accordance with the U.R.S.I. decisions by suitable available communication channels;
4. that the other data, of use for the improvement of forecasting technique in general and for other purposes, should be disseminated by ordinary post or airmail; if they deem it of use for the organization of regional forecasts or for scientific research, interested Administrations may organize alone or preferably collectively after centralization of information, the dissemination of detailed information by radio;
5. that certain short but regular transmissions, giving short-term warnings of ionospheric disturbances, should be effected by long-range radio stations;
6. that the attention of the U.R.S.I. should be drawn to the advantages of the fullest possible standardization of the codes to be used either for the short warnings mentioned in § 5, or for the exchange of the limited information mentioned in § 3 or the general information mentioned in § 4;
7. that Administrations should be invited to conform to the resulting codes and to make them known to their operating services;
8. that Administrations should invite these services, together with operating agencies, to study the accuracy of the forecasts, to submit records and to make any suggestions which might assist the studies undertaken to improve the methods used;
9. that special attention should be paid to the comparison between the forecasts and the actual behaviour of radio circuits; it is particularly desirable that Administrations should adopt identical methods of assessing the quality of the circuits by using a suitable classification;
10. that it is also desirable that a common method should be adopted to describe ionospheric perturbations, taking account of such factors as the starting time, zone affected, duration and importance of the perturbation;
11. that where Administrations have provided facilities for the rapid exchange of information for the preparation of short term forecasts of radio propagation, in connection with the I.G.Y. these facilities should be maintained, and if necessary extended in the future.

RECOMMENDATION No. 314 *

PROTECTION OF FREQUENCIES USED FOR
RADIO ASTRONOMICAL MEASUREMENTS

The C.C.I.R.,

(London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the development of radio astronomy has already led to major technological advances, particularly in receiving techniques, and to improved knowledge of fundamental radio noise limitations of great importance to radio communication, and promises further important results;
- (b) that protection from interference on certain frequencies is absolutely essential to the advancement of radio astronomy and the associated measurements;
- (c) that, for the observation of known spectral lines, certain bands at specific frequencies are of particular importance;
- (d) that account should be taken of the Doppler shifts of the lines, resulting from the motion of the sources which are in general receding from the observer;
- (e) that for other types of radio astronomical observations a certain number of frequency bands are in use, the exact positions of which in the spectrum are not of critical importance;
- (f) that the sensitivity of radio astronomical receiving equipment, which is still steadily improving, greatly exceeds the sensitivity of communications and radar equipment;
- (g) that a considerable degree of protection can be achieved by appropriate frequency assignments on a national rather than an international basis;
- (h) that, nevertheless, it is impracticable to afford adequate protection without some international agreement;

UNANIMOUSLY RECOMMENDS

- 1. that radio astronomers should be encouraged to choose sites as free as possible from interference;
- 2. that Administrations should afford all practicable protection to the frequencies used by radio astronomers in their own and neighbouring countries;
- 3. that particular care should be taken to give complete international protection from interference to observations of emissions known or thought to occur in the following bands:

Line	Line frequency (Mc/s)	Band to be protected (Mc/s)
Deuterium	327.4	322–329
Hydrogen	1420.4	1400–1427
OH	1667	1645–1675

- 4. that the bands allocated for standard frequency and time signal emissions at 2.5, 5.0, 10.0 and 20.0 Mc/s should not include anything other than the standard frequency and time signal emissions, thus permitting their use for reception in radio astronomy;

* This Recommendation replaces Recommendation No. 173.

5. that consideration be given to securing adequate international protection of a number of narrow frequency bands throughout the spectrum above 30 Mc/s for the purpose of reception in radio astronomy (see Note);
6. that Administrations, in seeking to afford protection to particular radio astronomical observations, should take all practical steps to reduce to the absolute minimum amplitude harmonic radiations falling within the band of the frequencies to be protected for radio astronomy.

Note. — Radio astronomers in a number of countries have indicated their desire to use for this purpose one frequency band at each of the following approximate positions (not necessarily in harmonic relation):

Frequency (Mc/s)	Bandwidth (Mc/s)
40	$\pm$ 0.75
80	$\pm$ 1.0
160	$\pm$ 2.0
640	$\pm$ 2.5
2560	$\pm$ 5.0
5120	$\pm$ 10.0
10240	$\pm$ 10.0

RECOMMENDATION No. 315 *

ATMOSPHERIC NOISE DATA

(Study Programme No. 154 (VI))

The C.C.I.R.,

(Geneva, 1951 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the information in Report No. 65 is now available for provisional use;
- (b) that there will be a continuing need for revision of this information;
- (c) that improved equipment now in operation should greatly increase the data available for such revision;
- (d) that there is a need for coordination of these data before any further revision of Report No. 65 can be carried out;
- (e) that new data should make possible an extension of the scope, as well as improvement in the accuracy of Report No. 65;

UNANIMOUSLY RECOMMENDS

1. that in assessing the level of atmospheric radio noise throughout the world the information contained in Report No. 65 should be used with some caution, until sufficient new data to justify a revision have been accumulated and made available;
2. that the Chairman of Study Group VI should designate a continuing working group to make arrangements by correspondence for the collection of data relevant to Report No. 65 from all sources;

* This Recommendation replaces Recommendation No. 175.



3. that material submitted to the working group should be in a form which facilitates comparison with Report No. 65. More specifically such data should include values of noise power and should show whether:
 - 3.1 the relative noise levels at different locations suggest that the noise contours should be amended;
 - 3.2 the relative noise levels at different frequencies suggest that the frequency curves should be amended;
 - 3.3 the ratios of upper and lower decile values to the median value should be amended;
4. that the working group should keep the data under continual review and should formulate proposals for a revision of Report No. 65 when it appears desirable;
5. that the working group should also consider means for including new statistical data on atmospheric noise in any future revision of Report No. 65.

Note. — Administrations participating in this work are invited to take particular note of the data obtained during the I.G.Y. and collected in the World Data Centres.

RECOMMENDATION No. 316 *

BASIC PREDICTION INFORMATION FOR IONOSPHERIC PROPAGATION

(Study Programme No. 149 (VI))

The C.C.I.R.,

(Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the objectives of Study Programme No. 60 have not yet been attained;
- (b) that the I.F.R.B. has made known its urgent need for the most reliable median F2 MUF data which are available at the present time, for application on a world-wide scale, as well as for information which will assist in determining those circuits for which operational results differ appreciably from MUF predictions;

UNANIMOUSLY RECOMMENDS

1. that Study Group No. VI should study by correspondence the improvements that could be obtained by adopting forms of presentation other than zonal charts, and that the Chairman of this Study Group should send the results of this study, through the Director of the C.C.I.R., to the I.F.R.B.;
2. that interested Administrations may make available to the I.F.R.B. by way of information, or for purposes of consultation, operational data on circuits, especially those for which it appears, from operational experience or from monitoring observations for instance, that divergences of practical importance exist between basic predictions and operational results. These data should comprise statistics of fade-in and fade-out times and should indicate the effects of factors other than propagation conditions (for example, frequency changes made for operational reasons). In principle, all relevant details of the working conditions should be stated;
3. that the information be transmitted through the Chairman of Study Group No. VI and the Director of the C.C.I.R., and that in the most important cases the I.F.R.B. or the Administration concerned may request the Director of the C.C.I.R. to consult the Working Group charged with Resolution No. 48.

* This Recommendation replaces Recommendation No. 176.

RECOMMENDATION No. 317 *

**SYSTEMATIC SKY-WAVE FIELD STRENGTH MEASUREMENTS ON
FREQUENCIES BETWEEN THE APPROXIMATE LIMITS OF 1.5 AND 40 Mc/s**

The C.C.I.R.

(Los Angeles, 1959)

CONSIDERING

- (a) that the Working Group for Resolution No. 48 has at its disposal only a restricted number of data on field strength values, as well as on the radiation pattern of transmitting antennae;
- (b) that in order to carry out its task it should have available a great number of reliable field strength measurements, referring to widely different conditions;
- (c) that, in the vast task undertaken within the framework of the I.G.Y. programme as to the physics of the ionosphere, insufficient attention has been given to the question of field strength measurements;

UNANIMOUSLY RECOMMENDS

- 1. that absolute field strength measurements, as accurate and systematic as possible, should be carried out in receiving stations in order to determine as a final objective the median hourly-monthly field strength values;
- 2. that these measurements should be carried out for circuits:
 - operating on different frequencies
 - of various lengths up to at least 12 000 km (measurements on the longest of these are most urgent)
 - in various geographical directions (for example N-S and E-W)
 - on which, preferably, the emission is almost continuous; and the radiated power is almost constant;
- 3. that these measurements should be carried out over as long a period as possible, and at least for one month of each season, during the times of the day most useful for the problem;
- 4. that these measurements should be carried out within a coordinated programme and that their results should be comparable (same units, same scale of diagrams, etc.); and to this end the Administrations should exchange information on their calibration procedures;
- 5. that for this purpose it is necessary to create a small but reliable network of key measuring stations; wherever possible determinations of the angle of incidence should be made at these measuring stations;
- 6. whenever possible the measurement programme outlined in § (4) above should include measurements of the directivity at great distance of the antennae used in accordance with Study Programme No. 130 (III);
- 7. that the measuring equipment now in the possession of the C.C.I.R. Specialized Secretariat should be utilized as soon as possible for regular recording of a certain number of HF (decametric) field strength values;
- 8. that Administrations, members of the C.C.I.R., should be requested to designate some transmitters for the field strength measurements. The Administrations should make precise measurements of the radiation characteristics of these transmitters in order to evaluate

* See Report No. 142.



accurately the field strength at a distance of 1 km from the antenna at all relevant values of angle of elevation and azimuth. During the measuring period the overall radiated power should be controlled. If such measurements prove to be impossible, precise measurements of the power supplied to the antenna should be made and the antenna gain and pattern should be indicated. The antenna should be maintained in good technical condition;

9. that a joint programme of measurements, for which the basic suggestions are described in the annex to this document, should be worked out in the near future by correspondence, in accordance with the possibilities of individual countries;
10. that the resolution of observations should be done at the measuring stations according to the programme set up; the corresponding monthly Tables or graphs should be sent at appropriate intervals to the Working Group;
11. that the final data obtained, and their practical results, should be published in an appropriate form.

ANNEX

SYSTEMATIC FIELD STRENGTH MEASUREMENTS ON FREQUENCIES BETWEEN THE APPROXIMATE LIMITS OF 1.5 AND 40 Mc/s

A comprehensive programme for coordinated measurement of field strength should be established, by means of correspondence followed by a special consultation. Some basic suggestions in the form of a preparatory document are given below:

1. All countries taking part, whether concerned with transmission or reception, should designate the circuits, typical for various propagation conditions over which the measurements are to be made, and should take into account any proposals regarding such circuits which may be made by the Working Group. The number of circuits should not be too great.
2. All countries taking part should designate transmitters with suitably directed antennae. The transmitter-antenna installation must provide adequate radiated power. The antenna patterns (both vertical and horizontal) must be calculated in the most thorough way possible, and the power fed to the antenna must be measured, and the vertical and horizontal radiation patterns described in detail.
3. The choice of frequencies on which the measurements are to be made should be governed by the programme for different levels of solar activity, time of year or day, etc. The frequencies transmitted by standard frequency stations must, in any case, be included.
4. Every effort including relevant agreements should be made to provide protection of the selected frequencies.
5. It is recommended that accurate measurements, checked at frequent intervals, be made with a small number of key stations in different countries.

As auxiliary stations, it would be advisable to make use also of stations possessing fairly simple equipment giving less accurate measurements than those obtained by key stations.

6. Such key stations should record the field strengths by means of automatic recording equipment over a period of time long enough to reveal the characteristic trend of the field.

Auxiliary stations may carry out measurements over shorter periods and without making use of automatic recording equipment.

A proposed time table should be established at a later date, depending on the means available to the individual countries and the general organization of the work.

7. Uniform recording speeds, scales, etc., should be established for the key stations so that the recordings can be compared.
8. A uniform method should be established for compiling the data obtained and presenting the final results.
9. The measurement programme worked out may be altered in the light of experience and by agreement between those taking part in the work.

10. The precision required for the measurements obtained must be established on the basis of the measurement means available and the accuracy of knowledge concerning the radiated power and antenna patterns.
11. When selecting the circuits on which the measurements are to be made, account must be taken of any ionospheric vertical sounding stations.
12. All countries, members of the C.C.I.R., should be called upon to continue and extend any work undertaken in accordance with the I.G.Y. programme likely to be of assistance in the present task (vertical and oblique sounding, measurement of absorption, etc.).

RECOMMENDATION No. 318 *

MEANING OF " MUF "

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that experience has shown that transmission is often possible above the MUF (maximum usable frequency) * expected for waves propagated solely by ionospheric refraction (i.e. without the influence of ionospheric or ground scatter);
- (b) that some prediction services are using empirical correction factors to take account of this experience in predictions of median MUF;
- (c) that the World-Wide Soundings Committee of the U.R.S.I. has recommended the use of a standard transmission curve for rapid analysis of ionograms;
- (b) that lateral deviations from the great circle path have been observed, especially with propagation involving ionospheric and/or ground scatter;
- (e) that means for describing and evaluating the highest useful frequency for specified long distance high-frequency services are of great importance operationally and for frequency allocation;
- (f) that the term " MUF " is used with different meanings in the literature;

UNANIMOUSLY RECOMMENDS

1. that the term " classical MUF " should be used to designate the highest frequency transmittable by ionospheric refraction alone. For the approximation to this value obtained by application of a standard transmission curve (1) or distance factor (2) the term " standard MUF " may be used **. If used without reference to a particular mode of propagation, the term " classical MUF " should imply the highest of the classical MUFs of the individual modes;
2. that the term " operational MUF " should denote the highest frequency permitting operation at a given time between given points under specified working conditions. The operational MUF may be higher than the classical MUF as a result of effects such as ionospheric and/or ground scatter. If known, the modes of propagation involved, including those involving ionospheric and/or ground scatter, should be specified;

* This Recommendation is primarily concerned with the instantaneous MUF for a given path.

** For the results of theoretical calculations the term " theoretical MUF " seems to be adequate, and similarly the term " experimental MUF " might be used for the results of special experiments.



3. that working conditions should be stated as precisely as possible in connection with the operational MUF; in principle, all pertinent details of the actual system should be given, including class of emission and information rate;
4. that for any MUF prediction it should be clearly stated whether it was intended to predict the classical MUF or the operational MUF, and, if appropriate, which mode of propagation;
5. that the ratio of the classical MUF to the operational MUF under different combinations of working conditions and ionospheric conditions should be determined by a combination of experience and theoretical studies.

REFERENCES

- (1) *Annals of the I.G.Y.* Volume 3, 1, 61.
 - (2) See, for example, *Circular No. 462 of the U.S.A. National Bureau of Standards*, 82.
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SECTION H

STANDARD FREQUENCIES AND TIME SIGNALS

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RECOMMENDATION No. 319 *

STANDARD FREQUENCY TRANSMISSIONS AND TIME SIGNALS

(Question No. 140 (VII))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

- (a) that the Administrative Radio Conference, Atlantic City, 1947, allocated the frequency bands $2.5 \text{ Mc/s} \pm 5 \text{ kc/s}$ ($2.5 \text{ Mc/s} \pm 2 \text{ kc/s}$ in Region 1), $5 \text{ Mc/s} \pm 5 \text{ kc/s}$, $10 \text{ Mc/s} \pm 5 \text{ kc/s}$, $15 \text{ Mc/s} \pm 10 \text{ kc/s}$, $20 \text{ Mc/s} \pm 10 \text{ kc/s}$, and $25 \text{ Mc/s} \pm 10 \text{ kc/s}$, requesting the C.C.I.R. to study the question of establishing and operating a world-wide standard-frequency and time service;
- (b) that the operation of 15 standard-frequency and time signal stations, 5 of which were put into operation since the VIIIth Plenary Assembly (Warsaw, 1956), has allowed the collection of considerable data on their performance;
- (c) that atomic (and molecular) standards of frequency with improved accuracy have come into general use, and that the first determination of the characteristic frequency of caesium with respect to Ephemeris time has been made;

UNANIMOUSLY RECOMMENDS

1. that a standard-frequency transmission on 5, 10 and 15 Mc/s should preferably comprise a standard carrier-frequency, modulated by time signals only;
2. that if desired, transmissions on 2.5, 20 and 25 Mc/s may be modulated by one audio frequency at a time chosen preferably from 440, 600 or 1000 c/s;
3. that the time signals should consist of impulses repeated at intervals of one second and maintained within 50 ms of Universal Time, UT2 **;
4. that the impulses should consist preferably of m cycles of $200 m \text{ c/s}$ tone, where m is an integral number limited by the bandwidths allotted for standard-frequency transmissions and time signals;
5. that the first impulse of each minute be modified so as to be easily identified;
6. that preferably the time signals should be transmitted without any other modulation for periods of one or several minutes totalling at least 10 minutes per hour;
7. that the Chairman of Study Group No. VII, in cooperation with the Director of the C.C.I.R. and the administrations concerned shall study the problem of reducing mutual interference in the existing standard-frequency and time signals bands, e.g. by time sharing and frequency offsetting.
8. that atomic standards should be used to maintain the transmitted frequency within the stated limits and to provide correction;
9. that transmitted frequencies should
 - correspond approximately to UT2 and differ from Ephemeris time by as constant an amount as possible;
 - remain constant throughout any one year to $\pm 5 \text{ parts in } 10^9$;

* This Recommendation replaces Recommendation No. 179.

** Provisional Uniform Universal Time No. 2 as adopted by the I.A.U. (Dublin, 1955).

10. that a transmitted time interval of n seconds duration should be given with a tolerance of $\pm (5n \cdot 10^{-9} + 10^{-6})$ seconds;
11. that each administration should publish promptly:
 - the provisional measured values of frequencies and time signals for each day at a specific time or for each group of 5 days, at a specified time, beginning on a day whose Julian number is divisible by 5;
 - the date, time and magnitude of adjustments of the time signal;
 - the date, time and magnitude of step adjustments to the frequency;
 - the assumed value of the atomic standard when used as a frequency reference, in cycles per second; *
12. that each administration should send to the Director of the C.C.I.R. for collation and distribution the results specified in § 11 for the period of each calendar year;
13. that each administration should coordinate with the Chairman and Vice-Chairman of Study Group No. VII any new standard-frequency broadcasts or any changes in existing standard-frequency broadcasts;
14. that each administration should send all pertinent new information on standard-frequency broadcasting stations to the Chairman and Vice-Chairman of Study Group No. VII for forwarding to the Telecommunication Journal of the I.T.U. for publication in that Journal;
15. that no new transmitting station, operating in the standard-frequency bands, shall be notified to the I.F.R.B. until experimental investigations and coordination have been completed in accordance with Recommendation No. 2 to the C.C.I.R. in the Radio Regulations;
16. that any station operating within the framework of this Recommendation and found to be causing harmful interference within the service areas of other established standard frequency stations should eliminate such interference;
17. that cooperation with the B.I.H. and the U.R.S.I. should continue.

RECOMMENDATION No. 320

STANDARD-FREQUENCY TRANSMISSIONS AND TIME SIGNALS IN ADDITIONAL FREQUENCY BANDS

(Question No. 142 (VII))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that Recommendation No. 319 refers only to the transmissions of standard-frequency and time signals allocated by the Radio Regulations, Atlantic City 1947, centered on the frequencies 2.5, 5, 10, 15, 20 and 25 Mc/s;
- (b) that propagation characteristics, interference and noise considerably degrade the short term accuracy obtainable in these frequency bands;
- (c) that in communications, research and industry, there is an increasing need for high accuracy of frequency and time measurements in a short period of time;
- (f) that measurements on controlled stations in Band 4 have demonstrated that a precision of frequency comparison of 1 part in 10^{10} can be achieved in a period of a few hours during

* The second being the unit of time adopted in 1956, at Sèvres, by the International Committee of Weights and Measures.

daylight at a range of 5000 km,* at great ranges the precision decreases, but is still much greater than that obtainable in Bands 6 and 7;

- (e) that, therefore, the possibility exists of achieving a world-wide frequency reference of high precision in Band 4 between 15 and 25 kc/s by means of a single station or at most two or three transmitters operating on different frequencies;
- (f) that it may be possible by specialized techniques to provide a highly precise world-wide time reference by emissions in Band 4;
- (g) that studies employing highly stabilized transmissions in Band 4 provide valuable information regarding ionospheric and propagation conditions which is useful in scientific studies and in the design of long range navigation systems;

UNANIMOUSLY RECOMMENDS

1. that as many stations as possible already in operation in Band 4 should be controlled with sufficient stability to permit an extension of present measurements of path phase stability;
2. that phase measurements in Band 4 at great distances, for example near the antipodal points, be continued and refined to yield further information on the behaviour of such standard-frequency transmissions at extreme distances;
3. that the techniques for transmission and reception of standard-frequency and time signals in Band 4 be investigated with a view of avoiding interference in the distribution of such a service;
4. that a band of 100 c/s in the neighbourhood of 20 kc/s (15 to 25 kc/s) would appear to be a suitable channel for an effective standard-frequency and time signals service;
5. that appropriate existing stations in Bands 5 and 6 be employed as much as possible for distribution of standard-frequency by precisely controlling their carrier frequency;
6. that existing broadcasting stations in Band 8, such as FM and television, be employed as much as possible for distribution of standard-frequency and time signals which can be added to the existing present modulation, without interference to the normal programme;
7. that any administration contemplating transmissions in accordance with the above proposals should first communicate the details to the Chairman and Vice-Chairman of Study Group No. VII.

RECOMMENDATION No. 321

**AVOIDANCE OF EXTERNAL INTERFERENCE WITH TRANSMISSIONS
OF THE STANDARD-FREQUENCY SERVICE
IN THE BANDS ALLOCATED TO THAT SERVICE**

(Question No. 140 (VII))

The C.C.I.R.,

(Los Angeles, 1959)

CONSIDERING

- (a) that standard-frequency transmissions and time signals in the allocated bands are very useful for all administrations to synchronize their own services either by frequency or by time;

* See Annex II to Report No. 166 "Observations of a standard frequency service on 16 kc/s".



- (b) that the transmissions in the standard-frequency bands are very important for communications, technology and science;
- (c) that interference reduces the usefulness of the standard-frequency and time signal service to a very high degree;
- (d) that the efforts made by administrations and the I.F.R.B. to clear other users from the standard-frequency bands have made progress and that only a few other registered users remain in these bands;
- (e) that there are many unnotified, some probably mobile or portable, transmitters in these bands, which cause more or less strong intermittent interference;
- (f) that there are gaps in the standard-frequency bands where no transmissions should be made as these gaps are used for measuring noise;
- (g) that it is highly desirable that administrations and, if necessary, the I.F.R.B. should continue their efforts in clearing the standard-frequency bands in order to avoid external interference;
- (h) that sometimes it is possible neither for the users of the standard-frequency transmissions nor for the monitoring service to identify the unnotified interfering station;
- (i) that to attain the objective of clearing the standard-frequency bands it is desirable to have all possible information concerning the interfering stations;

UNANIMOUSLY RECOMMENDS

1. that each administration make every effort to prevent all users of the radio frequency spectrum from operating, in the territory under its jurisdiction, and in the standard-frequency bands, stations other than standard-frequency stations, capable of causing harmful interference to the standard-frequency service;
 2. that the national monitoring stations should carry out a regular search for external interfering stations in the standard-frequency bands and should make every effort to identify each interfering stations, if necessary with international cooperation;
 3. that the users of standard-frequency transmissions in each case of external interference request the monitoring service of their own country to identify the interfering station;
 4. that in cases of external interference with the standard-frequency service, the administrations should apply the provisions of Article 14 of the Radio Regulations, and, if desired, send a copy of relevant correspondence to the I.F.R.B.;
 5. that the representatives of the administrations to Study Group VII of the C.C.I.R. exchange information from users of standard-frequency broadcasts and time signals and from the monitoring service concerning transmissions and interference in the standard-frequency bands even if the interference is not definitively identified, in order to collect such measurements and information as may, at a later time, enable the interfering station to be identified.
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SECTION J
MONITORING OF TRANSMISSIONS

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RECOMMENDATION No. 19 *

ORGANISATION OF AN INTERNATIONAL MONITORING SERVICE

The C.C.I.R.,

(Stockholm, 1948)

CONSIDERING

- (a) that the rapid supply of accurate monitoring information, on a world-wide scale, is essential to the I.F.R.B. in the efficient performance of its duties, and to administrations in the effective control of their radio services;
- (b) that such monitoring information will be essentially required in respect of a vast number of radio stations of many types including those operating short-range services on low power; and that, in such circumstances, a large number of monitoring stations spread throughout the world is necessary if the required measurements are to be quickly and accurately made;
- (c) that the information at the disposal of the C.C.I.R. shows that large and important areas of the world are not at present provided with monitoring stations; and that, in consequence, the I.F.R.B. will have great difficulty in obtaining full and proper information from these areas, and especially from the tropical regions where, on account of the high levels of atmospheric noise and the large number of low-power services in operation, the effective coverage of any individual monitoring station is likely to be small;
- (d) that in Art. 18 and App. C of the Radio Regulations of Atlantic City (1947), it is recognised that certain stations may not participate in the whole field of monitoring but may operate only within a limited part of that field;
- (e) that owing to the different characteristics of transmitters and the different techniques and operating procedures employed in the various types of radio services, it would be advantageous for the I.F.R.B. to receive regularly the results of measurements by specialised monitoring stations operated by personnel experienced in the type of service concerned;
- (f) that, in particular, the radio stations of the mobile services, due to the special character of their exploitation and to the vital importance of certain categories of these stations for the safety of life at sea and in the air, should be systematically monitored and the results of the measurements transmitted to the I.F.R.B.;
- (g) that the exchange of requests for, and the results of measurements would be greatly facilitated if a single national centralizing office were designated in each country participating in a world-wide service of monitoring, in conformity with the provisions of Art. 18 of the Radio Regulations of Atlantic City (1947); that on the one hand a uniform distribution, between the monitoring stations of any country, of requests emanating from the I.F.R.B. and from administrations and of actual measurements, and on the other hand the distribution of actual measurements to the I.F.R.B. and to those administrations, would be facilitated through the agency of a single national centralizing office, thereby reducing the possibility of overloading certain monitoring stations and thus affording the possibility of expediting the clearance of harmful interference;

RECOMMENDS

1. that administrations, recognized private operating agencies, and international organisations should participate forthwith in the establishment of a coordinated, world-wide, monitoring service;
2. that administrations, recognized private operating agencies, and international organisations in the regions of the world where few, or no, monitoring stations at present exist, particularly in the tropical regions, should endeavour, as far as they are able and as soon as possible,

* The P.R. of Bulgaria, the P.R. of Roumania and the P.R. of Czechoslovakia reserved their opinions on this Recommendation.

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to establish such stations in order to ensure efficient monitoring not only of long-distance but of short-distance transmissions and with a view to the operation of not less than six monitoring stations suitably distributed in each continent;

3. that some monitoring stations be principally devoted to the monitoring of mobile service transmissions and that their locations be chosen within the regions of the world where the density of such transmissions is the greatest and where harmful interference is most likely to be experienced;
4. that the administrations of each country should designate, as far as they deem it possible and at an early date, a single national centralizing office for the exchange of all requests and information relating to the monitoring service;
5. that the attention of the administrations is drawn to the need for rapid communications between the I.F.R.B. and the centralizing offices, between centralizing offices and between individual centralizing offices and the individual monitoring stations under their control.

RECOMMENDATION No. 22

FORM OF REPORT FOR FREQUENCY AND FIELD-STRENGTH MEASUREMENTS MADE AT MONITORING STATIONS

The C.C.I.R.,

(Stockholm, 1948)

CONSIDERING

the desirability of uniformity in furnishing monitoring data;

UNANIMOUSLY RECOMMENDS

1. that the form used in reporting frequency measurements should contain, at least, the following data:
 - (a) serial number;
 - (b) identification of the monitoring station (administration or organization and location);
 - (c) date;
 - (d) time (G.M.T.);
 - (e) call letters and/or other means of identification of the measured station;
 - (f) classification of emission;
 - (g) assigned frequency or reference frequency;
 - (h) frequency tolerance;
 - (i) measured frequency;
 - (j) accuracy of measurement;
 - (k) deviation from assigned or reference frequency;
 - (l) additional observations (e.g. period covered by measurement, drift of measured frequency during that period, quality of signal and conditions of reception, etc.);
 - (m) remarks;
 - (n) signature of responsible official of the administration or organization;
2. that the form used in reporting field-strength measurements should contain, at least, the following data:
 - (a) serial number;
 - (b) identification of the monitoring station (administration, organization, location);

- (c) date;
 - (d) time (G.M.T.);
 - (e) call letters and/or other means of identification of the measured station;
 - (f) classification of emission;
 - (g) assigned frequency;
 - (h) value of measured field;
 - (i) estimated accuracy of measurement;
 - (j) polarization component;
 - (k) other elements or characteristics of the measurement;
 - (l) remarks;
 - (m) signature of responsible official of the administration or organization;
3. that the I.F.R.B. should study the forms to be universally used in furnishing the foregoing data.

RECOMMENDATION No. 181 *

ACCURACY OF FIELD-STRENGTH MEASUREMENTS BY MONITORING STATIONS

(Question No. 55)

The C.C.I.R.,

(London, 1953—Warsaw, 1956)

CONSIDERING

- (a) that field intensity measurements are being made by monitoring stations in the frequency range from 15 kc/s to 300 Mc/s;
- (b) that the order to accuracy of such measurements would make them suitable for use in connection with the international registration and assignment of frequencies;
- (c) that the publication of such data by monitoring stations is therefore desirable;

UNANIMOUSLY RECOMMENDS

1. that, to obtain the accuracy specified in the table below, the field-strength measuring equipment at monitoring stations should be installed, calibrated and operated in accordance with the terms contained in the Annex to this Recommendation;
2. that, except where there are limitations due to receiver noise level, atmospheric noise or external interference, the accuracy to be expected in field-strength measurements at intensities above $1 \mu\text{V/m}$ is as shown in the following table.

Frequency band	Accuracy of measurement
Below 3000 kc/s	± 1.5 db
3000 to 30 000 kc/s	± 2.0 db
30 to 300 Mc/s	± 3.0 db

* This Recommendation replaces Recommendation No. 123.

The accuracy specified in the table is obtainable with apparatus either manually operated or used with automatic recorders, provided that the time constant of the combined equipment is 0.1 second or less, when measuring unmodulated carriers, modulated emissions of all types except A1, A2, P and emissions with suppressed or reduced carriers;

3. that when, because of interference, signal instability or for other reasons, accuracy within these limits is not obtainable, the measurements should nevertheless receive due consideration if their accuracy is indicated;
4. that studies of methods and equipment for field-strength measurements at monitoring stations should be continued;
5. that further studies are not necessary at this time to improve the accuracy of the calibration of signal generators for field-strength measurements by the use of various secondary voltage standards or other means.

ANNEX

1. ANTENNA INSTALLATION

1.1 *Frequencies of 30 Mc/s and below.*

It is recommended that, for frequencies of 30 Mc/s and below, vertical antennae three-eighths wavelength or less in height should be used, with ground systems consisting of buried radial conductors at least half wavelength long or of an equivalent ground screen near the earth.

The radial conductors should be spaced 10 degrees or less apart. It is necessary to ensure that no significant distortion of the field being measured is caused by obstructions, buildings, buried pipes, etc.

Vertical antennae as described above, are recommended as standard for field-strength measurement by monitoring stations, for ionospheric signals on frequencies of 30 Mc/s and below for the following reasons:

- 1.1.1 It is generally accepted that random variations in polarization of ionospheric waves are such that the vertically polarized component is, in general, substantially equal to the horizontal component.
- 1.1.2 The effective height of a vertical stub-antenna is substantially independent of wavelength.
- 1.1.3 The disadvantage of using a horizontal antenna is that its gain depends on its elevation above the ground and on its orientation.

1.2 *Frequencies above 30 Mc/s.*

Antennae for field-strength measurement on frequencies above 30 Mc/s are recommended to conform to the following conditions:

- 1.2.1 The receiving antenna must have the same polarization as the transmitting antenna. For these frequencies stub-antennae, or half-wave dipoles can be used, as appropriate.
- 1.2.2 VHF (metric) antennae should be located at a standard height above ground, representative of average receiving conditions, and a height of 10 metres is recommended.
- 1.2.3 There should be a clearance of at least 100 feet (30 metres) from other structures.

1.3 *Antenna factor.*

For frequencies below 30 Mc/s, the error in the determination of the antenna factor should be kept within ± 1 db and for frequencies from 30 Mc/s to 300 Mc/s it should be within ± 2 db. The antenna factor includes coupling or mismatch losses between antenna and receiver in the parts not common to the measuring and calibrating circuits.

2. RECEIVER

The receiver should have high inherent stability with respect to gain, frequency, bandwidth and attenuation calibrations. Particular attention is drawn to the desirability of using voltage regulators and crystal controlled oscillators to limit the effect of the receiver on the overall accuracy of field-strength measurements. Nevertheless, the frequent use of a signal generator for calibration of the field-strength measuring equipment is recommended. With current designs using recording equipment, calibration should be carried out at least daily.

3. SIGNAL GENERATOR

The attainable accuracy of standard signal generators in the voltage range above $1\text{ }\mu\text{V}$ is $\pm 1\text{ db}$.

This accuracy can be obtained using a bolometer secondary voltage standard or other recognised methods of comparable precision. However it should be noted that there is now available an improved device capable of greater accuracy, namely the micro-potentiometer.

The calibration of the signal generator should be checked frequently by means of such standards in order to maintain the desired accuracy of measurement.

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RECOMMENDATION No. 182

AUTOMATIC MONITORING OF OCCUPANCY OF THE RADIO-FREQUENCY SPECTRUM

(Question No. 143 (VIII))

The C.C.I.R.,

(Warsaw, 1956)

CONSIDERING

- (a) that the increasing demand for radio services requires the most efficient use of the radio-frequency spectrum;
- (b) that the most efficient use of the spectrum can be arranged only when the distribution in time, magnitude and direction of the signals occupying it is known;
- (c) that automatic monitoring equipment is now in use by administrations and that further development in automatic observation is foreseen, including methods for the analysis of records;
- (d) that by the use of automatic monitoring equipment a number of parameters can be evaluated which are of considerable value in enabling more efficient utilization of the spectrum;

UNANIMOUSLY RECOMMENDS

1. that, although automatic monitoring equipment will not completely replace manual observations, it is a valuable aid. Administrations should be encouraged to undertake the use and further development of such equipment;

2. that, although further study is needed to enable administrations, and frequency, planning authorities to derive the greatest benefit from the records produced, it is desirable that equipment should possess the following principal characteristics:
- total frequency range minimum 2 to 30 Mc/s; desirable 10 kc/s to 30 Mc/s or more;
 - swept frequency range variable, typical range 100 to 1000 kc/s;
 - number of sweeps per hour variable, 30 to 180;
 - maximum rates of sweeping variable; dependent on the desired frequency resolution for the band being swept and the class or classes of emission being recorded;
 - sensitivity 1 μ V/m or better;
 - resolving power variable; approximately 100 to 1000 c/s;
 - signal characteristics recorded — carrier frequency,
 — bandwidth,
 — field strength,
 — duration of occupancy;
 - size of records paper chart 20 cm $\times$ 32 cm for twenty-four hours; calibration at intervals of 1, 10 or 100 kc/s as appropriate.
3. that it is desirable that the records should also contain, if possible, the following information:
- name and location of monitoring station;
 - date and period of recording;
 - frequency band;
 - signal identification, as appropriate;
 - class of emission, as appropriate;
 - direction of signal;
 - noise level.

RECOMMENDATION No. 322 *

ACCURACY OF FREQUENCY MEASUREMENTS AT MONITORING STATIONS

The C.C.I.R.,

(Stockholm, 1948—Warsaw, 1956—Los Angeles, 1959)

CONSIDERING

- (a) the requirements of the Administrations, of international organizations carrying out monitoring Observations and of the I.F.R.B., in respect of the necessary frequency measurements for the efficient performance of their duties;
- (b) the general availability of suitable monitoring equipments for frequency measurements;
- (c) the desirability that the error of frequency measurement shall be several times better than the tolerance used in practice and shall not exceed one-tenth of the tolerance specified in the table of frequency tolerances of the Radio Regulations;

* This Recommendation replaces Recommendation No. 180.

UNANIMOUSLY RECOMMENDS

that monitoring equipments and procedures used shall be such that frequency measurements shall be made with an accuracy equal to or better than that specified in the following table:

Type of measurement	Accuracy
Measurements, at fixed monitoring stations, of the frequencies of stations, excluding broadcasting stations, operating in the band 10 kc/s–4000 kc/s	± 5 parts in 10^6 (or, where this would be less than ± 2 c/s, to an accuracy within ± 2 c/s)
Measurements, at fixed monitoring stations, of the frequencies of broadcasting stations operating in the band 10 kc/s–4000 kc/s	± 1 c/s
Measurements, at fixed or mobile monitoring stations, of the frequencies of amplitude modulated stations, excluding “standard” television stations *, operating in the band 4000 kc/s–500 Mc/s	± 2 parts in 10^6
Measurements, at fixed or mobile monitoring stations, of the frequencies of frequency modulated stations operating in the band 4000 kc/s–50 Mc/s	± 2 parts in 10^6
Measurements, at fixed or mobile monitoring stations, of the frequencies of frequency modulated stations operating in the band 50 Mc/s–1000 Mc/s	± 200 c/s (Note 1)
Measurements, at fixed or mobile monitoring stations, of amplitude modulated stations, excluding “standard” television stations *, operating in the bands above 500 Mc/s	± 1 part in 10^5
Measurements, at fixed or mobile monitoring stations, of the frequencies of “standard” television stations *, operating in the band 30 Mc/s–1000 Mc/s	± 100 c/s (Note 2)

Note 1. — An accuracy of ± 200 c/s at 300 Mc/s is equivalent to ± 1 part in 10^6 , which can be obtained without difficulty at fixed or mobile monitoring stations. At higher frequencies, since the error of standard frequency transmissions received over skywave paths may exceed 1 part in 10^7 , the achievement of a higher accuracy must depend on the availability of a more accurate means of calibrating the secondary frequency standard used at the monitoring station than is provided by the usual methods of using skywave standard frequency transmissions.

Note 2. — This accuracy is necessary since in Europe the offset frequency of a vision carrier must be accurate to within ± 500 c/s. The use of “precision offset” will in future demand a much higher accuracy of measurement of the frequencies of television stations.

* By “standard” television stations are meant stations operating in the appropriate television broadcasting bands.

RECOMMENDATION No. 323 *

IDENTIFICATION OF RADIO STATIONS

(Question No. 187 (VIII))

The C.C.I.R., (Geneva, 1951—London, 1953— Warsaw, 1956—Los Angeles, 1959)

CONSIDERING

- (a) that, in order to carry out an efficient monitoring service of radio stations, it is necessary for these stations to be identified as regularly as possible during their transmissions;
- (b) that in some types of radio systems the identification procedure used at present is satisfactory to operating agencies, regulating Administrations and monitoring services, as in the case of single-channel low-speed telegraphy;
- (c) that the Atlantic City Radio Regulations (Article 13, section V, para. 10) set forth requirements for transmissions of radio call signs and state that each radio station provided with a call sign from the international series must, unless the Atlantic City Radio Regulations provide otherwise, transmit this call sign during the course of their transmission as frequently as is practicable and reasonable;
- (d) that certain types of radio stations are exempted from the necessity of having an international call sign, for example, stations which are easily identified by other means and whose signals of identification, or characteristics of emission, are published in international documents;
- (e) that satisfactory methods for identifying some multi-channel types of transmission have been evolved;
- (f) that the requirement of transmitting an identifying signal frequently by interrupting the traffic imposes difficulties on the operating agencies by reducing the operating time of a circuit, particularly where heavily loaded multi-channel or high-speed machine operation is employed;
- (g) that, when an identifying signal is transmitted simultaneously with traffic, it is desirable, for ease of identification, to transmit a appropriate signal from the International Q-Code to indicate that the identifying signal which follows is superimposed on another emission;

RECOMMENDS

- 1. 1.1 that each radio station required to have an identifying signal under the provisions of the Atlantic City Radio Regulations, Article 19, should send such signal at the beginning and the end of a transmission, and as often as practicable and reasonable during such transmissions;
- 1.2 that, when a number of stations work simultaneously in a common circuit, either as relay stations, or in parallel on different frequencies, each station shall as far as is practicable and reasonable, transmit its own identifying signal; alternatively, each station should transmit the identifying signal or signals of all stations working as a group;
- 2. that for the purpose of identification, one of the following means should normally be used:
 - 2.1 International Morse code using class A1, A2, F1, or F2 emission, and transmitted preferably at hand speed;

* This Recommendation replaces Recommendation No. 220. The Belorussian S.S.R., the P.R. of Bulgaria, the P.R. of Roumania, the Ukrainian S.S.R., Czechoslovakia and the U.S.S.R. reserved their opinion on this Recommendation.

- 2.2 Five-Unit Code (International Telegraph Alphabet No. 2) using class A1, A2, or F1 emission, at a speed appropriate to single-channel working and preferably at the standardized speed of 50 bauds;
- 2.3 speech in clear;
3. that the identifying signal should be transmitted non-simultaneously with the traffic and using one of the means in § 2 above, or simultaneously with the traffic using the following methods:
 - 3.1 for class F1 emissions, particularly for high-speed or multichannel working, the superposition of the identifying signal in International Morse code by an additional frequency or phase modulation of the carrier;
 - 3.2 for single-sideband emissions, by amplitude keying of the reduced carrier or of some other pilot frequency;
 - 3.2.1 keying of the reduced carrier with a difference in level of 5 db gives a satisfactory compromise between the acceptable distortion of the traffic signals and the suitability for identification purposes, especially if the identifying signal is repeated;
 - 3.3 for facsimile transmission employing class A4 emissions, by amplitude modulation, at a frequency below the lowest used for the facsimile modulation. Where single-sideband transmission is used, amplitude keying, as in § 3.2, may be used;
4. for the transmission of the identifying signal simultaneously with traffic, as covered in § 3 or in other ways, the signal sent to indicate that the identifying signal which follows is superimposed on another transmission, should be sent in the same manner as the identifying signal, and the letters QTT should be used and incorporated in the International Q-Code (Radio Regulations, Atlantic City, 1947, App. 9) for this purpose;
5. that, in order to avoid additional complexity in the equipment and operating of transmitting stations, every reasonable effort should be made to provide monitoring stations, every reasonable effort should be made to provide monitoring stations with equipment suitable for the reception of identifying signals of all stations;
6. that, if the identifying signal cannot be transmitted frequently or continuously, it would facilitate the work of monitoring stations if the identifying signal were transmitted in the period from 10 minutes before to 10 minutes after the hour (G.M.T.), but not necessarily continuously during that 20-minute period;
7. that administrations be encouraged to co-operate directly with one another in carrying out tests of identification methods. Administrations are also invited to inform the I.F.R.B. in advance of such tests of new methods of identification in order to facilitate cooperative observations and also to afford other administrations the opportunity to become acquainted with such new methods for the identification of radio stations.

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SECTION K

VOCABULARY

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The following Recommendations which have been classified in other sections, also concern the Vocabulary:

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233	A
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318	G

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RECOMMENDATION No. 143

UNIT SYSTEMS

(Resolution No. 6)

The C.C.I.R.,

(London, 1953)

CONSIDERING

that the use of the rationalised M.K.S. system (also known as the rationalised Giorgi system) has been recommended by the International Electrotechnical Commission (Technical Committee No. 24 meeting, held in Paris on 17th and 18th July, 1950) and that it is now very widely used by radio engineers and by the authors of radio publications;

RECOMMENDS

that administrations and private operating agencies should be encouraged gradually to adopt, in their relations with the I.T.U. and its permanent organs, the rationalised M.K.S. system also known as the rationalised Giorgi system).

RECOMMENDATION No. 324 *

NOMENCLATURE OF THE FREQUENCY AND WAVELENGTH BANDS
USED IN RADIOCOMMUNICATIONS

(Question No. 73)

The C.C.I.R.,

(London, 1953—Warsaw, 1956—Los Angeles, 1959)

CONSIDERING

- (a) that it is appropriate to retain the subdivision of frequencies and of wavelengths adopted by the Administrative Radio Conference of Atlantic City (Radio Regulations Article 2, para. 10), which has been shown to be of considerable practical value, since it is in fair agreement with the criterion of grouping together frequencies with common physical and propagation properties as well as a uniform equipment constructional technique;
- (b) that the merits of Heinrich Hertz (1857–1897) as a research worker on the basic phenomena of radio waves are universally recognized, as was confirmed at the centenary of his birth, and that as early as 1937 the I.E.C. adopted the Hertz (symbol: Hz) as a name for the unit of frequency (see, inter alia, the International Electrotechnical Vocabulary, publication 50/05, 1954 edition: 05–35–055, page 44, and 05–35–110, page 47);
- (c) that the C.C.I.T.T. also uses the Hertz (cf. Red Book, French version);
- (d) that in this Recommendation the table should be as synoptic as possible and that the expression of frequencies should be as concise as possible;

UNANIMOUSLY RECOMMENDS

1. that the Hertz (Hz) be accepted for use alternatively, with cycles per second (c/s) as a name for the unit of frequency;

* This Recommendation replaces Recommendation No. 225.

2. that it is proper to characterize bands by means of progressive whole numbers in accordance with the following table, intended to be substituted, at a later conference of the I.T.U., for Article 2, § 10 of the Radio Regulations of Atlantic City.

Band number	Frequency range (lower limit exclusive, upper limit inclusive)	Metric subdivision
4	3 to 30 kc/s or kHz	Myriametric waves
5	30 to 300 kc/s or kHz	Kilometric waves
6	300 to 3000 kc/s or kHz	Hectometric waves
7	3 to 30 Mc/s or MHz	Decametric waves
8	30 to 300 Mc/s or MHz	Metric waves
9	300 to 3000 Mc/s or MHz	Decimetric waves
10	3 to 30 Gc/s or GHz	Centimetric waves
11	30 to 300 Gc/s or GHz	Millimetric waves
12	300 to 3000 Gc/s or GHz (or 3 Tc/s or THz)	Decimillimetric waves

Note 1. — “Band N ” extends from 0.3×10^N to 3×10^N c/s (Hz).

Note 2. — When a service adopts a reference number or letter to designate a specific frequency band allocated to it and situated, wholly or for the most part, in “Band N ” of the above nomenclature, the prefix N should normally precede the reference in question. For example, for the 41 to 48 Mc/s (MHz) band, to which broadcast users give the reference “I”, the appropriate designation is “broadcast band 8-I”, since it refers to a part of “Band 8”. This practice, applicable in the drafting of C.C.I.R. documents, is generally recommended for all cases where such a definition would obviate the risk of confusion in designating the numerous frequency bands and sub-bands.

Note 3. — Abbreviations:

k = kilo (10^3)
M = Mega (10^6)
G = Giga (10^9)
T = Tera (10^{12})

Note 4. — Abbreviations for adjectival band designations:

Band 4 = VLF	Band 7 = HF	Band 10 = SHF
Band 5 = LF	Band 8 = VHF	Band 11 = EHF
Band 6 = MF	Band 9 = UHF	

