XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

RECOMMENDATIONS OF THE CCIR, 1990

(ALSO RESOLUTIONS AND OPINIONS)

VOLUME I

SPECTRUM UTILIZATION AND MONITORING

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

Geneva, 1990

CCIR

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

2. The objectives of the CCIR are in particular:

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

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

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

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

XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

RECOMMENDATIONS OF THE CCIR, 1990

(ALSO RESOLUTIONS AND OPINIONS)

VOLUME I

SPECTRUM UTILIZATION AND MONITORING

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

92-61-04161-2

Geneva, 1990

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

(Düsseldorf, 1990)

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

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

1990
Printed in Belgium

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

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

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

1.1 *Numbering of texts*

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

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

1.2 *Recommendations*

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

1.2 *Recommendations (cont.)*

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

1.3 *Reports*

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

* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3 *Reports (cont.)*

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

* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3.1 *Note concerning Reports*

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

1.4 *Resolutions*

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

1.5 *Opinions*

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

1.6 *Decisions*

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

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

2.1 *Numbering of texts*

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

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

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

2.2 *Assignment of Questions*

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

2.3 *References to Questions*

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

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

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

VOLUME I

SPECTRUM UTILIZATION AND MONITORING

(Study Group 1)

TABLE OF CONTENTS

Page

Resolutions and Opinions

NUMERICAL INDEX OF TEXTS

Note – Resolutions and Opinions which already appear in numerical order in the table of contents, are not reproduced in this index.

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

STUDY GROUP 1

SPECTRUM UTILIZATION AND MONITORING

Terms of reference:

1. To study principles and general applications relating to the efficient use of the radio frequency spectrum;

2. To study principles and to develop techniques for spectrum management, including electromagnetic compatibility (EMC) prediction models and computer-aided techniques for frequency assignment, and to develop, in cooperation with the Study Groups concerned, general methods for solving sharing and interference problems;

3. To study principles for classifying emissions.

4. To develop means of specifiyng and measuring the characteristics of emissions and other forms of radiation including man-made radio noise from individual sources likely to give rise to harmful interference.

5. To study techniques for spectrum monitoring and for measuring at a distance the parameters of emissions and spectrum occupancy; to devise means for identifying emissions and for locating sources of harmful interference; and to improve, in collaboration with the IFRB, procedures for presenting the corresponding reports.

1986-1990	*Chairman:*	M. J. HUNT (Canada)
	Vice-Chairmen:	R. N. AGARWAL (India) T. BOE (Norway) R. MAYHER (United States of America)

As from the next study period, in conformity with Resolution 61 adopted at the XVIIth Plenary Assembly, Düsseldorf (May-June 1990), the scope of the work which will be undertaken and the names of the Chairman and Vice-Chairmen are as follows.

STUDY GROUP 1

SPECTRUM MANAGEMENT TECHNIQUES

Spectrum engineering, planning, sharing, monitoring and utilization

Scope:

Development of principles and techniques for effective spectrum management, methods for solving spectrum sharing problems, techniques for spectrum monitoring and general spectrum utilization applications.

1990-1994	*Chairman:*	M. J. HUNT (Canada)
	Vice-Chairmen:	R. N. AGARWAL (India) T. BOE (Norway) R. MAYHER (United States of America) K. J. B. YAO (Cote d'Ivoire)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP 1

1. General

The Interim Meeting of Study Group 1 took place from 13-26 April 1988 and the Final Meeting from 26 October to 8 November 1989. Both meetings were held in Geneva under the chairmanship of Mr. M. J. Hunt.

The Study Group 1 (Spectrum utilization and monitoring) develops techniques for effective spectrum management which includes computer-aided techniques for frequency assignment, electromagnetic compatibility analysis, methods of solving frequency sharing problems in cooperation with other Study Groups, planning for effective spectrum management, spectrum monitoring, improvements in methods of spectrum utilization and spectrum matters of concern to other Study Groups. During the past study period considerable effort has been given to the examination of the focus and efficiency of the work of Study Group 1 and changes made to incorporate the results of this examination. To this end the following sections discuss these aspects in more detail.

2. Refocus of Study Group 1 activities to meet future requirements

Attention has been given during the past study period to focusing Study Group 1 activities to ensure the results meet the future requirements for spectrum managers. To this end, the Study Group formed an ad hoc Planning Group at the Interim Meeting to define a number of steps that should be taken to achieve these requirements.

As a result of this work, the Study Group approved at the Final Meeting a restructuring of the activities into a different set of Working Groups. This was viewed as a more effective organization of work to achieve the objectives of the Study Group. As an integral part of this process the terms of reference of the Study Group were reviewed and recommendations for modifications will be put forward to the Plenary Assembly. The thrust of this change is to emphasize the central role of the Study Group in spectrum management activities. Consequently, a greater emphasis is placed on the practical elements of spectrum management and this is reflected in the proposed new title and elements describing the Study Group.

The ad hoc Planning Group also identified areas where additional information was necessary to progress specified studies. Prior to the Final Meeting, contributions on specific subjects were invited to address the areas of particular concern to the Study Group.

3. Results of the past Study Group period

As a part of the refocus of the activities of the Study Group, two new Reports were developed to specifically describe the functions of spectrum management. Two Recommendations related to this matter were also created. The first deals with methods of exchanging computer programs and data for spectrum management purposes and the second recommending a standard for data elements for specifying frequency assignments and notification data. A related new Report describes frequency management data systems using small computers. Several new Reports were developed to provide spectrum managers with better methodology for establishing EMC parameter limits for mobile services in an interference environment, and analysing EMC for spread spectrum systems.

New Reports were also added that will assist in the planning function of spectrum management. New Reports were also developed that enable a determination of the density of spectrum usage in a frequency band as well as a method of estimating the efficiency of spectrum usage of radio-relay systems. Another Report was added that provides information on the criteria that can be applied to determine how the utilization of the frequency spectrum can be improved by frequency reassignment.

Further work was done in cooperation with other Study Groups, on frequency sharing matters. A new Report was developed which tentatively deals with frequency sharing between the land mobile and broadcasting service. Further work on this matter is expected through the coming study period.

In keeping with the focus of the Study Group on the related functions for spectrum management, two new Reports were developed that define the radio monitoring functions and techniques relevant to spectrum management. A new Report has also been added that describes the techniques for radio monitoring from airborne platforms. Many of the existing Reports and Recommendations on spectrum monitoring were revised to update techniques and practices.

Considerable effort was spent during the past study period in addressing the matter of the possibility of interference to the COSPAS/SARSAT satellite system from MAC/packet decoder systems. Several Reports were also created or modified dealing with the potential interference to communication devices from radiation from various sources. The matter of limitation of radiation from ISM devices is discussed in § 5 with regard to Interim Working Party 1/4. A new Report was prepared that studies the reduction of radio noise near electric power substations. A new Report was also created predicting the electric field strength in the near field zone of high power LF/MF antennas.

4. Joint Interim Working Parties

JIWP/VHF-UHF

This JIWP was created at the 1986 Plenary Assembly to prepare technical information for the Regional Administrative Radio Conference to establish criteria for the shared use of the VHF and UHF bands allocated to the fixed, broadcasting and mobile services in Region 3 and countries concerned in Region 1 (CARR-3). This is in response to ITU Resolution No. 702 (WARC-9) and CCIR Resolution 94. This work was co-ordinated by Study Group 1 and Mr. J. McKendry was appointed Chairman.

The terms of reference for the JIWP are:

1) to identify situations where frequency sharing between different services in the VHF/UHF bands may be necessary in Region 3;
2) to study the various aspects of compatibility between the different services and to determine the conditions under which sharing may be practicable;
3) to examine the relevant technical information already available in the texts of Study Groups 1, 5, 6, 8, 9, 10 and 11 in conjunction with any new information contributed by administrations and other participants;
4) to develop calculation methods for interference assessment, particularly in the case of multiple interfering sources;
5) to propose sharing criteria and related technical parameters appropriate to the needs identified above.

This JIWP developed a Report which was approved at the Final Meeting of Study Group 1 in October 1989. Upon approval of the JIWP report by the CCIR, it is recommended that the Administrative Council takes account of the existence of the report in its future deliberations on the matter of this Regional Conference.

JIWP - ORB(2)

Study Group 1 forwarded material to this JIWP related to the matter of spurious emissions from stations of the space service. The JIWP noted that studies should continue on spurious emissions from space stations of the fixed-satellite service.

5. Interim Working Parties

Interim Working Party 1/2 under the chairmanship of Mr. R. Mayher, identified the following tasks for examination during the past study period:

- computer software development and review of new spectrum management programs;
- computer hardware development;
- spectrum management functional requirements;
- data file requirements and standards;
- automated spectrum management system implementation procedures;
- electromagnetic compatibility analysis models;
- methods of data exchange.

Through work by correspondence and several meetings, extensive new material for the Handbook on Spectrum Management and Computer-Aided Techniques was added. A computer program catalogue for spectrum management functions was developed and new computer programs approved for inclusion. Several draft Recommendations and Reports were developed and submitted to Study Group 1 for approval.

IWP 1/4, chaired by Mr. G. Lehning, is charged with the determination of limits on radiation from ISM devices. This task stems from Resolution No. 63 of the WARC-79. More than 140 input documents have been considered during this period of time and an extensive Report 1104 has been developed to indicate levels of ISM radiation necessary to protect radio communication services. This work has been done in collaboration with IEC/CISPR. The IWP has been unable to gain agreement on a Recommendation on ISM radiation limits to this point of time.

IWP 1/5 is charged with updating the Handbook for Monitoring Stations and certain other tasks on monitoring. Under the chairmanship of Mr. R. Lefort, the IWP finalized the revision of the Handbook and saw its publication in October 1989.

6. Technical cooperation

Study Group 1 participated actively in the second meeting on National Frequency Management held in September 1987. The purpose of this meeting, in accordance with Resolution No. 7 of the WARC-79, was to characterize the type of national frequency management units suitable for developing countries.

One recommendation of this meeting was that the CCIR, through its Study Group 1, continue needed efforts on national frequency management, particularly with regard to the use of computer-aided spectrum management. During its Interim Meeting, Study Group 1 developed a Resolution that resolves to take special note of these requirements in the regular meetings of the Study Group and its IWPs. At the Final Meeting, a Resolution was prepared concerning the improvement of national radio spectrum management practices and techniques.

7. Future activities

Study Group 1 will continue its efforts to provide the practices and criteria necessary to carry out the functions of spectrum management. The ad hoc Planning Group of Study Group 1 will bring further proposals to the Interim Meeting indicating the priority items that should be addressed by the Study Group.

SECTION 1A: SPECTRUM ENGINEERING AND COMPUTER-AIDED PRINCIPLES AND TECHNIQUES

RECOMMENDATION 329-6

SPURIOUS EMISSIONS*

(Question 55/1)

(1951-1953-1956-1959-1963-1966-1970-1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that Recommendation 328 distinguishes between out-of-band emissions and spurious emissions, and specifies limits for out-of-band emissions;

(b) that Appendix 8 to the Radio Regulations, specifies the maximum permitted level of spurious emissions in terms of the mean power supplied by a transmitter to the antenna transmission line at the frequency, or frequencies, of each spurious emission;

(c) that Article 5, (Nos. 304 to 306), of the Radio Regulations stipulates that stations must conform to the tolerances specified in Appendix 8 for spurious emissions; that, moreover, every effort should be made to keep spurious emissions and out-of-band emissions at the lowest values which the state of the technique and the nature of the service permit;

(d) that measurements of power, at frequencies other than the fundamental frequencies supplied to a transmitting antenna or to a test load, are useful in the analysis of transmitter performance as regards purity of emissions under specific conditions, and that such measurements will encourage the use of certain means of reducing spurious emissions;

(e) 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 frequencies of the spurious emissions, propagation over various paths and radiation from parts of the transmitting apparatus other than the antenna itself;

(f) 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 emissions;

(g) that, in dealing with emissions on the fundamental frequencies, administrations customarily establish the power supplied to the antenna transmission line, and measure the field 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 18, No. 1813, of the Radio Regulations);

(h) that for the most economical use of the frequency spectrum, it is necessary to lay down general maximum limits of spurious emissions, while recognizing that specific services may need lower limits for technical and operational reasons,

* *Note by the Editorial Committee.* – The terminology used in Recommendation 329 is in conformity, in the three working languages, with that of Article 1 of the Radio Regulations (No. 139), namely:

– French: *Rayonnement non essentiel*
– English: *Spurious emission*
– Spanish: *Emisión no esencial.*

UNANIMOUSLY RECOMMENDS

1. Terminology and definitions

that the following terms and definitions should be used to designate emissions that are regarded as spurious:

1.1 *Spurious emission* (Article 1, No. 139 of the Radio Regulations)

emission on a frequency, or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out-of-band emissions;

1.2 *Harmonic emissions*

spurious emissions at frequencies which are whole multiples of those contained in the frequency band occupied by an emission;

1.3 *Spurious intermodulation products*

spurious intermodulation products are intermodulation products at frequencies resulting from:

1.3.1 intermodulation between:

- the oscillations at the carrier, characteristic, or harmonic frequencies of an emission, or the oscillations resulting from the generation of the carrier or characteristic frequency, and
- oscillations of the same nature, of one or several other emissions, originating from the same transmitting system or from other transmitters or transmitting systems, and

1.3.2 intermodulation between any oscillation generated to produce the carrier or characteristic frequency of an emission;

1.4 *Spurious frequency conversion products*

spurious emissions, not including harmonic emissions, at the frequencies, or whole multiples thereof, of any oscillations generated to produce the carrier or characteristic frequency of an emission;

1.5 *Parasitic emissions*

spurious emissions, accidentally generated at frequencies which are independent both of the carrier or characteristic frequency of an emission and of frequencies of oscillations resulting from the generation of the carrier or characteristic frequency.

Note – Non-linearity in amplitude modulated transmitters (including single sideband transmitters) may result in out-of-band emissions which are immediately adjacent to the necessary bandwidth, due to odd order intermodulation products.

Recommendation 328 distinguishes between out-of-band emissions and spurious emissions. Whereas the limits for spurious emissions are specified below, the limits applicable to out-of-band emissions due to intermodulation are specified in Recommendation 326.

2. Application of limits

2.1 that, as the limits for out-of-band emissions are covered by Recommendation 328, the limits given for spurious emissions given below should apply only for spurious emissions in accordance with the definition;

2.2 that for the time being, the maximum permitted levels of spurious emissions continue to be expressed in terms of the mean power supplied by the transmitter to the antenna feeder at the frequencies of the spurious emission concerned;

2.3 that spurious emission from any part of the installation, other than the antenna system, i.e. the antenna and its feeder, shall not have an effect greater than would occur if this antenna system were supplied with the maximum permissible power at that spurious emission frequency;

2.4 that, in the event that the standards of performance in § 3 below are adopted by an Administrative Radio Conference as revised limits for Appendix 8 to 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 attain these limits for new transmitters;

2.5 that, where a transmitting system comprises more than one transmitter, the application of the limits specified in § 3 should apply with all transmitters operating normally in accordance with Appendix 8 to the Radio Regulations.

3. Limits for the power of spurious emissions (see Notes 1 to 15)

3.1 that the following limits are applicable to transmitters with fundamental frequencies between 9 kHz and 30 000 kHz (from Radio Regulations Appendix 8, Table, Columns A and/or B):

For any spurious emission, the mean power supplied to the antenna transmission line should be at least 40 dB below the power of the fundamental emission, without exceeding the value of 50 mW (for exceptions see Notes 2, 3, 4, 7 and 8);

3.2 that the following limits are applicable to transmitters having fundamental frequencies between 30 MHz and 235 MHz (see Radio Regulations, Appendix 8, Table, Columns A and/or B):

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

For any spurious emission, the mean power supplied to the antenna transmission line should be at least 60 dB below the power of the fundamental emission, without exceeding the value of 1 mW (for exceptions, see Notes 5 and 9);

3.2.2 *Transmitters with output power 25 W or less at the fundamental frequencies*

For any spurious emission, the mean power supplied to the antenna transmission line should be at least 40 dB below the power of the fundamental emission, without exceeding the value of 25 μW (for exceptions, see Notes 5 and 6);

3.3 that the following limits are realizable for new transmitters with fundamental frequencies between 235 MHz and 960 MHz (see Radio Regulations, Appendix 8, Table, Column B):

3.3.1 *Transmitters with output power greater than 25 W at the fundamental frequencies*

For any spurious emission, the mean power supplied to the antenna transmission line should be at least 60 dB below the power of the fundamental emission, without exceeding the value of 20 mW (for exceptions, see Notes 10 and 11);

3.3.2 *Transmitters with output power 25 W or less at the fundamental frequencies*

For any spurious emission the mean power supplied to the antenna transmission line should be at least 40 dB below the power of the fundamental emission, without exceeding the value of 25 μW (for exceptions, see Notes 10 and 11);

3.4 that the following limits are realizable for new transmitters with fundamental frequencies between 960 MHz and 17.3 GHz:

3.4.1 *Transmitters with output power greater than 10 W at the fundamental frequencies*

For any spurious emission, the mean power supplied to the antenna transmission line should be at least 50 dB below the power of the fundamental emission, without exceeding the value of 100 mW (for exceptions, see Notes 10, 11, 12 and 13);

3.4.2 *Transmitters with output power 10 W or less at the fundamental frequencies*

For any spurious emission, the mean power supplied to the antenna transmission line should not exceed the value of 100 μW (for exceptions, see Notes 10, 11, 12 and 13).

3.5 that the limits adopted by the World Administrative Radio Conference, Geneva, 1979, should also be shown in the Radio Regulations, in the form of a graph as indicated in Fig. 1.

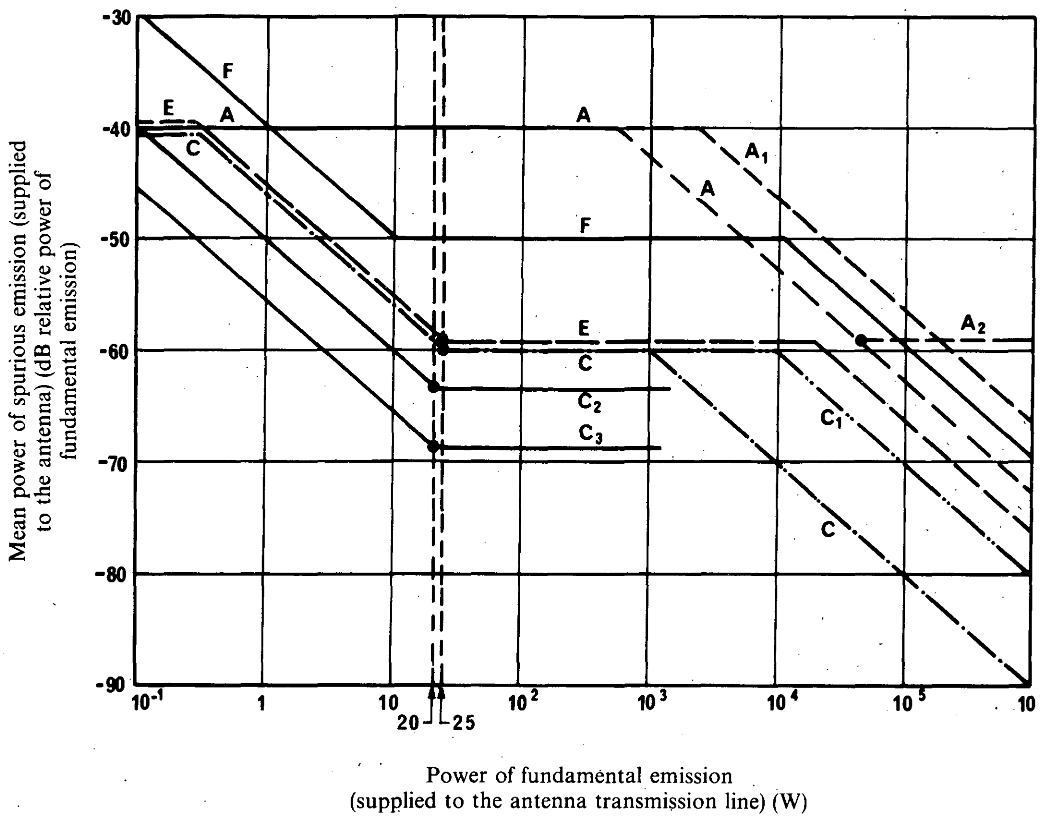


FIGURE 1

Curves A
A_1 (see § 3.5, Note 4) } 9 kHz $\leqslant f <$ 30 MHz
A_2 (see § 3.5, Notes 2 and 7)

C } 30 MHz $\leqslant f <$ 235 MHz
C_1 (see § 3.5, Note 9)

C_2 (see § 3.5, Note 5.1)
C_3 (see § 3.5, Note 5.2)

E: 235 MHz $\leqslant f <$ 960 MHz

F (see § 3.5, Notes 10, 11, 12 and 13): 960 MHz $\leqslant f \leqslant$ 17.3 GHz

(f: fundamental frequency)

Note 1 – When checking compliance with the provisions of the Table, it shall be verified that the bandwidth of the measuring equipment is sufficiently wide to accept all significant components of the spurious emission concerned.

Note 2 – For transmitters of mean power exceeding 50 kW and which operate below 30 MHz over a frequency range approaching an octave or more, a reduction below 50 mW is not mandatory, but a minimum attenuation of 60 dB shall be provided and every effort should be made to comply with the level of 50 mW.

Note 3 – For hand-portable equipment of mean power less than 5 W which operates below 30 MHz, the attenuation shall be at least 30 dB but every effort should be made to attain 40 dB attenuation.

Note 4 – For mobile transmitters which operate below 30 MHz any spurious component shall have an attenuation of at least 40 dB without exceeding the value of 200 mW but every effort should be made to comply with the level of 50 mW wherever practicable.

Note 5.1 – For frequency modulated maritime mobile radiotelephone equipment which operates above 30 MHz, the mean power of any spurious emission falling in any other international maritime mobile channel, due to products of modulation, shall not exceed a level of 10 µW. In addition, where, exceptionally, transmitters of mean power above 20 W are employed, these levels may be increased in proportion to the mean power of the transmitter.

Note 5.2 – The mean power of any other spurious emission on any discrete frequency within the international maritime mobile band shall not exceed a level of 2.5 µW. Where, exceptionally, transmitters of mean power above 20 W are employed, these levels may be increased in proportion to the mean power of the transmitter.

Note 6 – For transmitters having a mean power of less than 100 mW it is not mandatory to comply with an attenuation of 40 dB provided that the mean power level does not exceed 10 µW.

Note 7 – For transmitters of a mean power exceeding 50 kW which can operate on two or more frequencies covering a frequency range approaching an octave or more, whilst a reduction below 50 mW is not mandatory, a minimum attenuation of 60 dB shall be provided.

Note 8 – For hand-portable equipment of mean power less than 5 W the attenuation shall be 30 dB but every practicable effort should be made to attain 40 dB attenuation.

Note 9 – Administrations may adopt a level of 10 mW provided that harmful interference is not caused.

Note 10 – Where several transmitters feed a common antenna or closely spaced antennas on neighbouring frequencies, every practicable effort should be made to comply with the levels specified.

Note 11 – Since these levels may not provide adequate protection for receiving stations in the radioastronomy and space services, more stringent levels might be considered in each individual case in the light of the geographical position of the stations concerned.

Note 12 – These levels are not applicable to systems using digital modulation techniques, but may be used as a guide. Values for these systems may be provided by the relevant CCIR Recommendations, when available (see Recommendation No. 66 of the WARC-79 and Appendix 8 to the Radio Regulations).

Note 13 – Intermodulation emissions and thermal noise from earth and space stations in the space services occurring outside the frequency band allocated by the Radio Regulations and referenced to a 4 kHz bandwidth or a 1 MHz bandwidth, as appropriate and consistent, shall be at least 30 dB below the saturated transmitter output power (or, in the case of a solid-state amplifier, the rated output power) as produced by a single unmodulated carrier. All other spurious emissions, excluding thermal noise, from stations in the space services outside the assigned frequency band and referenced to a 4 kHz bandwidth or a 1 MHz bandwidth, as appropriate and consistent, shall be at least 50 dB below the power of the fundamental. The 100 mW and 100 µW limits in § 3.4 shall not apply, as these require further study by the CCIR.

Note 14 – It is recognized that specific services may need lower limits for technical and operational reasons.

Note 15 – For radiodetermination stations, until acceptable methods of measurement exist, the lowest practicable power of spurious emission should be achieved. Single-sideband maritime mobile limits are listed in Appendix 17, and pertinent aeronautical mobile service information is found in Appendix 27 and Appendix 27 Aer2-1 to the Radio Regulations.

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

that, together with other known methods of measuring the power of spurious emission, 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 test load. When the measurements are performed with the transmitter connected to a test load, the power of the spurious oscillations supplied to the test load might differ considerably from the spurious emission supplied to the antenna used for actual transmission;

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 until it produces the same field at the mean frequency of the spurious emission as was produced by the radio transmitter (in 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 originally supplied by the transmitter itself, on condition that non-linearity of the radiating system does not introduce harmonic emission. 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 and 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 measured accurately. It is necessary that several sets of measurements be made using different receiver locations.

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

4.2 *Direct methods*

That the following three direct methods of measurement can be used:

4.2.1 *First method.* (See [CCIR, 1953e].) The voltage, current and power factor are determined at one point on the feeder using a selective radio receiver tuned to the mean frequency of the spurious emission concerned, and coupled to the desired point of the feeder.

4.2.2 *Second method.* (See [CCIR, 1962a].) The forward and reflected powers are determined by using a pair of inverse directional couplers, inserted directly in the feeder line or the test load; a selective power-measuring device is switched alternatively to the couplers and tuned to the mean frequency of the spurious emission concerned. The difference between these two measured powers gives the power supplied to the antenna at the frequencies of the spurious emission.

The voltages or power from the directional couplers can be measured using a comparison-method with the aid of a receiver and a signal generator. The principle of this method and a formula for determining the possible error of the measuring result are contained in [CCIR, 1966-69].

For coaxial lines a directional coupler may consist of a conductor (linear antenna), arranged within the feeder, parallel to its axis, and provided at one of its ends with a reflectionless termination relative to the external conductor. A voltage appears at the open end that is due entirely to the voltage wave in the feeder, which extends from the open end of the linear antenna to the closed end. The dimensions and spacing between the conductors of the coupler and the external wall depend on the maximum permissible input level and on the input impedance of the measuring set to be connected.

The method enables the power of spurious emission transferred from a transmitter to the antenna to be measured, regardless of whether it is generated directly in the transmitter concerned or in a secondary manner, e.g. by interaction with other transmitters.

For balanced feeder lines (see [CCIR, 1963-66b]), a directional coupler may consist of a pair of parallel conductors (symmetrical linear antenna) arranged symmetrically near the feeder in a plane parallel to the plane containing the feeder. The directional coupler is provided with a reflectionless termination at one end.

---

* Relevant documents are: [CCIR, 1953a, b, c, d, e and f; 1956; 1958a, b and c; 1962a, b and c; 1963-66a].

A voltage, balanced relative to ground, appears at the open end due entirely to the push-pull mode of the wave on the feeder. For selective measurement of the voltage it is preferable to transform it from balance to unbalance by a transformer.

If the couplers are arranged as mentioned above, the push-push mode of the wave on the feeder has a negligible influence on the measurement. The extent of this influence depends on the balance of the transformer used.

The spacing between the coupler and the feeder and the distance between the two conductors of the coupler depend on the maximum permissible input level of the selective level meter to be connected and the transformation ratio of the transformer used.

When power components of substantial magnitude transferred in a push-push mode can be expected, these components should be measured separately by using another appropriate method.

Another measuring equipment suitable for balanced feeder lines (see [CCIR, 1963-66c]) uses two coaxial feeder sections, each of which is fitted with two directional couplers. Thus the forward and reflected powers can be determined separately for each of the two conductors.

The sum of the forward powers is equal to the total power transferred to the transmission line. The method does not, however, distinguish between the power in the push-pull and push-push modes.

A special type of directional coupler can be used for measuring the power of spurious emissions over a wide range of frequencies.

4.2.3 *Third method.* (See [CCIR, 1962c].) Measurement is made of electromotive force values at the points of a node and anti-node on a symmetrical open-wire feeder and these values are converted into power values of the spurious emission at the frequency to be measured. The electromotive force values are measured by means of a coupling element and a selective radio receiver tuned to the mean frequency of the spurious emission concerned. The coupling element is a screened loop placed symmetrically between the feeder conductors and moved at will along the feeder to locate the nodes and anti-nodes. By changing the position of the plane of the loop in relation to the plane of the feeder conductors, it is possible to measure the power of the push-pull and push-push modes of the spurious emission.

The coefficient used for conversion of the measured values into power values is found from a graph plotted previously, at the time of calibration of the device.

4.3 *Measurements of spurious emission at frequencies close to the fundamental frequencies* [CCIR, 1962b]

4.3.1 In view of the difficulty of measuring spurious emissions which are relatively close to the necessary band, it may not be possible to ensure that the limitations set forth in § 3 are met in such cases (see Question 55/1).

4.3.2 In many cases, adequate suppression of oscillations which unduly disturb the measurement of spurious emissions on nearby frequencies can be effected by the insertion of suitable band-pass filters. Additional selective suppression of the carrier oscillation, for instance when measuring spurious emission on nearby frequencies, can be realized by cancelling the carrier in the monitoring receiver with an unmodulated carrier in antiphase, obtained from a low power stage (see [CCIR, 1963-66d]).

4.3.3 When several transmitters work on nearby frequencies in the same station, and may even be feeding the same antenna, as may happen, for instance, in sound broadcasting stations using frequency modulation at the frequencies in band 8, intermodulation products may be found with a frequency separation less than 1 MHz from the carrier frequencies in use.

4.3.3.1 In such cases measurements can be made using a directional coupler and a tuned filter. The principle of the measuring equipment is shown in [CCIR, 1966-69]. With this method a filter is used which is tuned to attenuate the more distant of the fundamental signals contributing to the generation of the spurious component to be measured. This prevents the generation of additional spurious components in the receiver.

The errors from overloading the receiver by the remaining fundamental signals can be overcome by measuring the level of the spurious component in the presence of the fundamental signals using the comparison method. The signal generator will be adjusted to increase the power output of the receiver by a factor of two. In this case the power of the spurious component and of the comparison signal are equal.

4.3.3.2 In some cases, the methods of measurement described above may be somewhat difficult to apply. It may then be preferable to measure the field strength on the spurious frequency and on a nearby carrier frequency at a convenient distance (a few, or a few tens of kilometres), with a sufficiently selective measuring instrument. If all the signals are radiated by the same antenna and share similar radiation patterns then the power of the spurious components can be determined by measurement of the field strengths. If the powers of the fundamental signals cannot be measured separately the sum of these powers can be used to calculate the power of the unknown spurious component by using the ratio of the squared value of field strength of the spurious component to the sum of the squared values of field strength for the fundamental signals. This ratio will be equal to the ratio of the power of the spurious component to the sum of the powers of the fundamental signals.

5. Further improvements

that administrations and private operating agencies should continue to improve the degree of suppression of spurious emission, where this is economically possible, to reduce interference to other services to a greater extent than that given in § 3. Guidance on the means of reducing the level of spurious emission from transmitters is given in Report 838.

6. Radioastronomy

that radioastronomy, because of its unique, passive, and sensitive nature, needs special consideration in so far as spurious emissions are concerned; radioastronomers frequently encounter signal-to-noise ratios of −30 dB and in extreme cases as low as −60 dB using long integration intervals. Administrations are urged, as far as practicable, to take into consideration the need to avoid spurious emissions which could cause harmful interference to radioastronomy operating in accordance with Article 36 of the Radio Regulations. For the purpose of resolving interference from spurious emissions, radioastronomy should be treated as a radiocommunication service and given protection to the extent radiocommunications services afford each other protection.

7. Space service

that information regarding spurious emissions from space services transmitters, located both at earth and space stations, should contain intermodulation and general spurious emission limits. These spurious emission limits should apply up to a frequency of 17.3 GHz, excluding the 100 mW and 100 μW limits specified in § 3.4. Administrations should also endeavour to reduce spurious emission levels from such transmitters above 17.3 GHz to the lowest possible values, compatible with technical and economic constraints of the space transmitters used.

8. Amplitude modulated sound broadcast transmitters which employ pulse width modulation techniques

that particular attention should be paid to spurious emissions which may be produced at multiples of the switching frequency on either side of the carrier as the result of the pulse width modulation technique;

that the switching frequency should be a multiple of the channel spacing in order to reduce interference within the broadcasting bands.

REFERENCES

CCIR Documents

[1953]: London, **a.** 65; **b.** 80; **c.** 101; **d.** 124; **e.** 130; **f.** 340.

[1956]: Warsaw, 313.

[1958]: Geneva, **a.** I/22; **b.** I/28; **c.** I/34.

[1962]: Geneva, **a.** I/1; **b.** I/17, **c.** I/23.

[1963-66]: **a.** I/54 (OIRT); **b.** I/1 (Federal Republic of Germany); **c.** I/40 (USSR); **d.** I/55 (OIRT).

[1966-69]: I/67 (USSR).

RECOMMENDATION 326-6

DETERMINATION AND MEASUREMENT OF THE POWER OF RADIO TRANSMITTERS

(Question 59/1)

(1951-1959-1963-1966-1974-1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that Article 1 of the Radio Regulations contains definitions of different expressions of power;

(b) that Article 1, No. 150 of the Radio Regulations lays down that, whenever the power of a radio transmitter is referred to, it shall be expressed in one of the following forms according to the class of emission using the arbitrary symbols indicated:

- peak envelope power (PX or pX);
- mean power (PY or pY);
- carrier power (PZ or pZ);

but that indication of one only of these powers is adequate only for certain classes of emission and for certain uses, whereas in many cases it is desirable to express the transmitter power in other forms (see Appendix 1 to the Radio Regulations).

For use in formulae, the symbol p denotes power expressed in watts and P denotes power expressed in decibels relative to a reference level;

(c) that the direct measurement of each of these powers, or the deduction of one of them from a measurement of another, can only be effected under very precisely defined operating conditions,

UNANIMOUSLY RECOMMENDS

1. that the determination and measurement of the power of an amplitude-modulated radio transmitter should be made on the basis of the following considerations and methods:

1.1 *General considerations*

For amplitude-modulated transmitters, it is not always possible to measure directly the peak envelope power. For an ideal, perfectly linear transmitter this can be calculated theoretically from measurement of the mean power or of the carrier power of the emission, but the difference between the actual peak envelope power and the value thus calculated depends primarily on the degree of non-linearity of an actual transmitter.

Moreover, the coincidence of the measurements of the ratio of the mean power to the carrier power with the theoretical values is not a sure criterion of the linearity of the transmitter because of the distortion which may, as a function of the input level, increase the mean power linearly without proportionally increasing the peak envelope power.

The peak envelope power of a perfectly linear, double-sideband transmitter with full carrier (A2A, A2B, A3C or A3E), modulated at 100% would be four times greater than the carrier power. But all transmitters are to some extent non-linear, and this defect produces signal distortion and also an increase in out-of-band radiation. To keep these undesirable effects to the minimum, it is necessary to limit the peak envelope power to a useful value which, for a double-sideband transmitter with full carrier, is equivalent to limiting the modulation depth to less than 100%.

The peak envelope power is limited by the acceptable intermodulation distortion. The method recommended for defining and measuring the peak envelope power of a single-sideband or independent-sideband transmitter (R3E, B8E, etc. emissions) is described below. The same method may also be used for double-sideband transmitters (A3E emission).

1.2 *Intermodulation*

1.2.1 *Principle for the measurement of intermodulation distortion*

The imperfect linearity of amplitude-modulated radio transmitters can be expressed as a function of the level of the intermodulation products. To determine that level, it is convenient to measure separately the amplitude of each intermodulation oscillation resulting from the application, at the input of the transmitter, of two periodic modulating sinusoidal oscillations with frequencies f_1 and f_2.

For the sinusoidal exciting oscillations at frequencies f_1 and f_2, the frequency of the intermodulation component at the output of the transmitter is given by the formula:

$$F = p(F_0 \pm f_1) \pm q(F_0 \pm f_2) \text{ with } p, q = 1, 2, 3, \ldots \quad (1)$$

where F_0 is the carrier frequency, f_1 and f_2 the frequencies of the exciting oscillations.

The positive sign between the two terms of the sum corresponds to much higher frequency oscillations with, as a general rule, very low amplitudes; this case is of minor interest for the purpose of this Recommendation.

1.2.2 *Choice of frequencies for modulating oscillations*

To measure the amplitude of the intermodulation products, it is desirable to use modulating oscillations having frequencies near the limits of the audio-frequency passband. The audio-frequency passband to be considered here is the band at the input of the transmitter which corresponds at the output, to the whole of a sideband of an emission.

Harmonics and intermodulation components, mainly of even order, may originate in the low-frequency equipment at the input of the transmitter or during the processes of modulation. To prevent these coinciding or interfering at the output of the transmitter with the intermodulation components of the third and the fifth order to be measured, the modulating frequencies f_1 and f_2 should be chosen carefully.

A harmonic relation between the modulating frequencies f_1 and f_2 should be avoided, as well as a ratio f_1/f_2 having a value in the neighbourhood of 2/3, 2/5, 2/7, 3/4, 3/5, 3/7 and 4/5. With respect to the latter condition it is assumed that for most practical purposes intermodulation components of orders higher than the fifth may be neglected.

In an audio-frequency passband between 300 and 3000 Hz, for example, a value in the neighbourhood of 700 or 1100 Hz may be chosen for f_1, and in the neighbourhood of 1700 Hz or 2500 Hz for f_2, in which case the requirements stated above are satisfied.

1.2.3 *Acceptable intermodulation level*

The intermodulation level considered here is expressed in terms of the ratio, generally in decibels, between the powers of the largest intermodulation component at radio frequency $p(F_0 \pm f_1) - q(F_0 \pm f_2)$ and the power of the fundamental component at radio frequency ($F_0 \pm f_1$ or $F_0 \pm f_2$) produced by either of the two f_1 and f_2 modulating oscillations applied simultaneously at the input of the transmitter, the amplitudes of which are adjusted as indicated above (§ 1.2.1 2nd paragraph).

The intermodulation level that can be regarded as acceptable depends on the class of emission and the service for which the transmitter is intended. From this aspect, three main categories of emissions can be considered:

First category

– Single-sideband single-channel radiotelephone emissions (R3E, J3E, H3E) without a privacy device.

For these classes of emission, the major part of the energy of the modulating signal is concentrated in the part of the spectrum containing relatively low audio frequencies. If, after modulation, the high power components remain near to the carrier in frequency, fairly high levels of intermodulation can be tolerated without serious increase in out-of-band radiation or noticeable distortion.

The acceptable intermodulation level can be taken as -25 dB or less.

If an emission of the same class is used with a privacy device which may transpose the high power components to any position in the necessary band, the preceding condition is not met, and the emission must be transferred to the second category.

Second category

– Independent-sideband radiotelephone emissions (B8E).
– Multi-channel voice-frequency telegraph emissions (R7B and B7B).
– Independent-sideband multiplex emissions (B7W).
– Single-sideband or double-sideband single-channel radiotelephone emissions (A3E, R3E, J3E, H3E) with a privacy device.

For these classes of emission, intermodulation products cause interference between channels or undesirable out-of-band radiation. Their level must be more strictly limited.

The acceptable intermodulation level may be taken as −35 dB or less.

Third category

– Double-sideband amplitude-modulated emissions.

The peak envelope power of double-sideband transmitters may also be measured by means of the method recommended in § 1.3. This is mainly of use in determining the out-of-band radiation characteristics of the transmitter.

Some administrations prefer to use the harmonic distortion method of measurement using a single sinusoidal modulating oscillation. For acceptable performance the modulation depth does not normally exceed 90%.

1.3 *Methods for measuring the peak envelope power*

It results from the foregoing that, because of non-linearity in the transmitters, the measurement of the peak envelope power must take into consideration the accepted intermodulation level for the transmitter in question, and that different measuring methods may give results which do not agree.

Hence it is desirable to adopt a single measuring method which is as simple and certain as possible.

The following method is recommended:

1.3.1 *Single- or independent-sideband amplitude-modulated transmitters with reduced or suppressed carrier*

1.3.1.1 The transmitter output is connected to the antenna feeder line or to a test load with the proper terminal impedance.

Provisions should be made to measure the mean power. Any instrument suitable for measurement of mean power of a sinusoidal radio-frequency oscillation of constant amplitude may be used for this purpose.

1.3.1.2 A selective measuring device, e.g. a selective radiofrequency voltmeter or a spectrum analyzer, and an instrument responding to the peak amplitude of the modulated signal, e.g. an oscilloscope, are coupled to the terminal load.

The selective measuring device is used to measure the relative amplitudes of the spectral components of the radiofrequency signal. The peak value of the envelope of this signal is determined by the peak responding instrument.

1.3.1.3 The carrier control switch or attenuator of the transmitter is set to the position corresponding to the required carrier level.

This carrier level is preferably:

– for suppressed carrier emissions: −40 dB or less
– for reduced carrier emissions: between −16 dB to −26 dB
– for full carrier emissions: −6 dB

relative to the level of a sinusoidal reference oscillation. The level of this oscillation (0 dB) is called the reference level.

1.3.1.4 The deflection of the peak responding instrument, corresponding to the reference level is initially determined by setting the carrier control switch or attenuator to 0 dB*.

1.3.1.5 Once the deflection corresponding to the reference level is known and the carrier control switch has been set to the position indicated in § 1.3.1.3 the transmitter is modulated by two sinusoidal oscillations, the frequencies of which are chosen as indicated in § 1.2.2.

1.3.1.6 The input levels of the two modulating oscillations are adjusted so that, at the output:

– the radio-frequency oscillations corresponding to the modulation signal have fundamental components which are of equal amplitude, and simultaneously,
– the deflection of the peak responding instrument resulting from the composite radio-frequency signal is equal to the deflection corresponding to the reference oscillation, as obtained in § 1.3.1.4.

1.3.1.7 Next, the level of the complete signal, including the carrier, is adjusted so that, at the output, the largest intermodulation component as measured with the selective measuring device reaches the acceptable intermodulation level, as defined in § 1.2.3.

1.3.1.8 The deflection of the peak responding instrument, resulting from the signal mentioned in § 1.3.1.7, is recorded.

---

* The measurement procedure is applicable to equipment provided with a carrier control switch. If the equipment is not so fitted, or if the fitted control does not allow a 0 dB setting, the procedure is still applicable if the attenuation of the carrier with respect to the reference level is known and appropriate allowances are made.

1.3.1.9 This last instrument is calibrated in terms of peak envelope power by using a single sinusoidal oscillation.

This may be accomplished either:

– by replacing the two modulating oscillations by a single sinusoidal oscillation and by suppressing the carrier or, if this is not possible,

– by suppressing the two modulating oscillations and by increasing the carrier. The modulation input level or the carrier level, whichever is applicable, is adjusted to obtain an arbitrary deflection of the peak responding instrument, which, for purposes of optimum overall measurement accuracy, preferably should be equal to the deflection obtained in § 1.3.1.8 above.

The deflection is recorded and the corresponding mean power is measured.

1.3.1.10 The peak envelope power is calculated from the formula:

$$\text{peak envelope power} = \text{mean power} \times \left[\frac{\begin{array}{c}\text{deflection}\\ \text{obtained in § 1.3.1.8}\\ \text{with two}\\ \text{oscillations}\end{array}}{\begin{array}{c}\text{deflection}\\ \text{obtained in § 1.3.1.9}\\ \text{with one}\\ \text{oscillation}\end{array}} \right]^2 \tag{2}$$

1.3.2 *Single-sideband or double-sideband amplitude-modulated transmitters with full carrier*

If the transmitter is capable of being operated also with suppressed or reduced carrier and is provided with a carrier control switch, it is preferable to follow the same procedure as outlined in § 1.3.1.

If the transmitter is suitable only for operation with full carrier, the measurement is performed as follows:

1.3.2.1 same as in § 1.3.1,

1.3.2.2 same as in § 1.3.1,

1.3.2.3 The transmitter is modulated by two sinusoidal oscillations, the frequencies of which are chosen as indicated in § 1.2.2.

1.3.2.4 The input levels of the two modulating oscillations are adjusted so that, at the output:

– the radio-frequency oscillations corresponding to the modulating signal have fundamental components which are of equal amplitude, and simultaneously,

– the level of the largest intermodulation component as measured by the selective measuring device, reaches acceptable intermodulating level as defined in § 1.2.3.

1.3.2.5 The deflection of the peak responding instrument, resulting from the signal mentioned in § 1.3.2.4, is recorded.

1.3.2.6 Next, the modulating signal is suppressed; the carrier power is measured, and the corresponding deflection of the peak responding instrument is recorded.

1.3.2.7 The peak envelope power is calculated from the formula:

$$\text{peak envelope power} = \text{carrier power} \times \left[\frac{\begin{array}{c}\text{deflection}\\ \text{obtainable in § 1.3.2.5}\\ \text{with two}\\ \text{oscillations}\end{array}}{\begin{array}{c}\text{deflection}\\ \text{obtainable in § 1.3.2.6}\\ \text{corresponding to the}\\ \text{carrier amplitude}\end{array}} \right]^2 \tag{3}$$

Note – [CCIR, 1970-74] describes in general a method for measuring the peak envelope power of transmitters utilizing the conversion factors contained in Table I of this Recommendation. This method is applicable strictly in the ideal case of insignificant intermodulation distortion, but, additionally, may be utilized to give results with less than approximately 5% error for transmitters when intermodulation levels are −40 dB or less relative to the level of either fundamental component of the radio-frequency signal.

2. that the relationships between the peak envelope power, the mean power and the carrier power of a radio transmitter should be calculated using the conversion factors given in Annex I.

REFERENCE

CCIR Documents

[1970-74]: 1/116 (Canada).

ANNEX I

CONVERSION FACTORS BETWEEN THE PEAK ENVELOPE POWER, THE MEAN POWER AND THE CARRIER POWER OF A RADIO TRANSMITTER

The conversion factors are calculated on the basis of certain assumptions; these assumptions are explained in the notes of § 3 of the Annex.

1. Conversion factors with respect to the peak envelope power

1.1 Table I gives the conversion factors applicable when the peak envelope power is taken as unity.

1.2 Column 5 gives the theoretical values of the mean power which would be obtained, with linear transmitters for amplitude modulation. In practice, the imperfect linearity of the transmitter and other causes may increase the mean power above the figures shown in the Table.

1.3 As the conversion factors depend on the modulating signal, one or more examples described in Column 2 have been chosen to enable representative values for the factors in Column 5 to be determined.

1.4 Similarly, Column 4 gives the theoretical carrier power in the specific conditions of no-modulation described in Column 3, and chosen so as to make that carrier power easily measurable.

1.5 Unless otherwise specified, the expression "sinusoidal oscillation" in this Recommendation means an audio-frequency periodic sinusoidal oscillation.

2. Conversion factors with respect to the carrier power

2.1 Table II gives the conversion factors applicable when the carrier power is taken as the unit, as is the common practice at least for the two classes of amplitude-modulated emissions A2A, A2B and A3E.

2.2 Column 5 gives the theoretical mean power obtained with the modulating signals described in Column 2, with practically linear transmitters. The conversion factors shown are the quotients of the corresponding factors in Columns 5 and 4 of Table I.

2.3 Similarly, Column 4 gives the theoretical peak envelope power. The conversion factors shown are the reciprocals of the corresponding factors in Column 4 of Table I.

2.4 Column 3 gives the conditions of no-modulation from which the carrier power chosen as the unit can be determined and measured.

TABLE I

Class of emission (1)	Modulating signal (2)	Condition of no-modulation (3)	Conversion factor: Carrier power / Peak envelope power (4)	Conversion factor: Mean power / Peak envelope power (5)
Amplitude-modulation Double-sideband				
A1A, A1B Telegraphy without modulation by a periodic oscillation	Series of rectangular dots; equal alternating marks and spaces; no emission during space periods (Note 1)	Continuous emission	1	0.500 (−3.0 dB) (Note 1)
D2A, D2B Telegraphy with on-off keying of carrier frequency-modulated by a low-frequency periodic oscillation	Series of rectangular dots; equal alternating marks and spaces; single sinusoidal oscillation modulating the main carrier; no emission during space periods (Note 1)	Continuous emission	1	0.500 (−3.0 dB) (Note 1)
A2A, A2B Telegraphy with on-off keying of one or more low-frequency periodic oscillations amplitude-modulating the carrier, or with keying of the carrier modulated by those oscillations (see Table II)	Series of rectangular dots; equal alternating marks and spaces; single sinusoidal oscillation modulating the carrier at 100%			
	(a) modulating oscillation keyed	Continuous emission, modulating oscillation suppressed (carrier only)	0.250 (−6.0 dB)	0.312 (−5.1 dB)
	(b) modulated carrier keyed (Note 1)	Continuous emission with modulating oscillation	0.250 (−6.0 dB)	0.187 (−7.3 dB) (Note 1)
A2N Continuous signal of carrier amplitude-modulated by low-frequency periodic oscillation (Example: some radio beacons)	Single sinusoidal oscillation modulating the carrier to 100%; no keying	Continuous emission, modulating oscillation suppressed (carrier only)	0.250 (−6.0 dB)	0.375 (−4.3 dB)
A3E Double-sideband telephony, full carrier (see Table II)	(a) single sinusoidal oscillation modulating the carrier at 100%	Carrier only	0.250 (−6.0 dB)	0.375 (−4.3 dB)
	(b) smoothly read text (Note 2)	Carrier only	0.250 (−6.0 dB)	0.262 (−5.8 dB)
Amplitude-modulation Single-sideband				
H2N Continuous signal of carrier amplitude-modulated by periodic oscillation, full carrier	Single sinusoidal oscillation modulating the carrier at 100%; no keying	Modulating oscillation suppressed (carrier only)	0.250 (−6.0 dB)	0.500 (−3.0 dB)

TABLE I *(continued)*

Class of emission (1)	Modulating signal (2)	Condition of no-modulation (3)	Conversion factor: Carrier power / Peak envelope power (4)	Conversion factor: Mean power / Peak envelope power (5)
R3E Single-sideband telephony, reduced carrier	(a) two sinusoidal oscillations modulating transmitter to peak envelope power	Reduced carrier only	0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.379 (−4.2 dB) 0.454 (−3.4 dB)
	(b) smoothly read text (Note 2)	Reduced carrier only	0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.096 (−10.2 dB) 0.093 (−10.3 dB)
H3E Single-sideband telephony, full carrier	(a) single sinusoidal oscillation modulating carrier at 100%	Carrier only	0.250 (−6.0 dB)	0.500 (−3.0 dB)
	(b) smoothly read text (Note 2)	Carrier only	0.250 (−6.0 dB)	0.275 (−5.6 dB)
J3E Single-sideband telephony, suppressed carrier	(a) two sinusoidal oscillations modulating transmitter to peak envelope power	Suppressed carrier	<0.0001 (< −40 dB)	0.500 (−3.0 dB)
	(b) smoothly read text (Note 2)	Suppressed carrier	<0.0001 (< −40 dB)	0.100 (−10 dB)
Amplitude-modulation Independent-sideband B8E Two independent telephony sidebands, carrier reduced or suppressed	(a) single sinusoidal oscillation on each sideband, modulating the transmitter to peak envelope power, both bands being modulated to the same level	Reduced carrier only	0.025 (−16 dB) 0.0025 (−26 dB)	0.379 (−4.2 dB) 0.454 (−3.4 dB)
		Suppressed carrier	<0.0001 (< −40 dB)	0.500 (−3.0 dB)
	(b) smoothly read text on each of two sidebands simultaneously (one channel per sideband) (Notes 2 and 3)	Reduced carrier only	0.025 (−16 dB) 0.0025 (−26 dB)	0.061 (−12.1 dB) 0.048 (−13.2 dB)
		Suppressed carrier	<0.0001 (< −40 dB)	0.050 (−13 dB)
	(c) smoothly read text on each of the four channels simultaneously (two per sideband) (Notes 2 and 3)	Reduced carrier only	0.025 (−16 dB) 0.0025 (−26 dB)	0.096 (−10.2 dB) 0.093 (−10.4 dB)
		Suppressed carrier	<0.0001 (< −40 dB)	0.100 −10 dB)

TABLE I *(continued)*

Class of emission	Modulating signal	Condition of no-modulation	Conversion factor	
			Carrier power	Mean power
			Peak envelope power	Peak envelope power
(1)	(2)	(3)	(4)	(5)
Amplitude-modulation Facsimile				
A1C Facsimile: direct modulation of the main carrier by the picture signal	Black and white chessboard picture giving square wave; modulating the carrier as for A1B	Continuous emission	1	0.500 (−3.0 dB)
A3C Facsimile: sub-carrier frequency-modulated by the picture signal, and amplitude-modulating the main carrier	Any picture, 100% amplitude-modulation of main carrier (the conversion factors are independent of the form of the picture signal)	Main carrier only	0.250 (−6.0 dB)	0.375 (−4.3 dB)
R3C Facsimile: sub-carrier frequency-modulated by the picture signal and amplitude-modulating the main carrier, single-sideband, reduced carrier	For this class of emission, the modulation by the picture signal alters the power distribution within the occupied bandwidth without affecting the total power	Reduced carrier only	0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.733 (−1.3 dB) 0.905 (−0.4 dB)
J3C Facsimile: sub-carrier frequency-modulated by the picture signal and amplitude-modulating the main carrier, single-sideband, suppressed carrier	For this class of emission, the modulation by the picture signal alters the power distribution within the occupied bandwidth without affecting the total power	Suppressed carrier	<0.0001 (< −40 dB)	1
Amplitude-modulation Television				
C3F Television, vestigial sideband, picture only	(a) *All white*			
	– 405 lines, 50 fields, positive modulation	(Note 4)		0.800 (−1.0 dB)
	– 525 lines, 60 fields, negative modulation			0.164 (−7.9 dB)
	– 625 lines, 50 fields, negative modulation			0.177 (−7.5 dB)
	– 819 lines, 50 fields, positive modulation			0.742 (−1.3 dB)
	(b) *All black*			
	– 405 lines, 50 fields, positive modulation	(Note 4)		0.080 (−11.0 dB)
	– 525 lines, 60 fields, negative modulation			0.608 (−2.2 dB)
	– 625 lines, 50 fields, negative modulation			0.542 (−2.7 dB)
	– 819 lines, 50 fields, positive modulation			0.085 (−10.7 dB)

TABLE I *(continued)*

Class of emission	Modulating signal	Condition of no-modulation	Conversion factor	
			Carrier power	Mean power
			Peak envelope power	Peak envelope power
(1)	(2)	(3)	(4)	(5)
Multichannel Telegraphy R7B and B7B (Note 5) Multichannel voice-frequency telegraphy, single or independent-sideband, reduced carrier	Frequency-shift or 2-tone voice-frequency channel telegraphy:	Reduced carrier only		
	2 channels		0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.379 (−4.2 dB) 0.454 (−3.4 dB)
	3 channels		0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.261 (−5.8 dB) 0.302 (−5.2 dB)
	4 or more channels (Note 6)		0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.202 (−6.9 dB) 0.228 (−6.4 dB)
J7B Multichannel voice-frequency telegraphy, single-sideband, suppressed carrier	Frequency-shift or 2-tone voice-frequency channel telegraphy	Suppressed carrier		
	2 channels		<0.0001 (< −40 dB)	0.500 (−3.0 dB)
	3 channels		<0.0001 (< −40 dB)	0.333 (−4.8 dB)
	4 or more channels (Note 6)		<0.0001 (< −40 dB)	0.250 (−6.0 dB)
B9W (Note 5) Combination of speech and multichannel telegraphy, independent-sideband, reduced or suppressed carrier	Smoothly read text on one channel and one group of multichannel telegraph signals; 4 or more channels (Notes 6 and 7)	Reduced carrier only	0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.132 (−8.8 dB) 0.138 (−8.6 dB)
		Suppressed carrier	<0.0001 (< −40 dB)	0.151 (−8.2 dB)
	Smoothly read text on two channels and one group of multichannel telegraph signals; 4 or more channels (Notes 6 and 7)	Reduced carrier only	0.025 (−16.0 dB) 0.0025 (−26.0 dB)	0.105 (−9.8 dB) 0.105 (−9.8 dB)
		Suppressed carrier	<0.0001 (< −40 dB)	0.113 (−9.5 dB)

TABLE I *(continued)*

Class of emission (1)	Modulating signal (2)	Condition of no-modulation (3)	Conversion factor: Carrier power / Peak envelope power (4)	Conversion factor: Mean power / Peak envelope power (5)
Frequency or phase modulation				
F1B, G1B F2B, G2B (frequency displacement on modulating oscillation) F3E, G3E F3C F3F F7BDX FXX, GXX	For these classes of emission the modulation changes the distribution of power in the frequency spectrum while leaving the total power unchanged	Various	1 1 1 1 1 1 1	1 1 1 1 1 1 1
Pulse modulation				
P0N Continuous emission of a series of periodic pulses for radiodetermination. (See Note 8 for the definition of *d*)	Periodic series of identical non-modulated pulses: amplitude, width (duration), repetition frequency of pulses are constant	Without change	*d*	*d*
Telegraphy with on-off keying of a periodic oscillation which modulates a series of periodic pulses. (See Note 8 for the definition of *d*)	Series of rectangular dots; equal alternating marks and spaces; a single sinusoidal oscillation modulating the pulses			
K2B Periodic oscillation modulating the amplitude of the pulses	Amplitude of pulses modulated by sinusoidal oscillation at 100% (a) modulating oscillation keyed	Continuous periodic series of pulses, modulating oscillation suppressed	0.250d (−6.0+ 10 log d) dB	0.312d (−5.1+ 10 log d) dB
	(b) modulated emission keyed (Note 1)	Continuous series of pulses with modulating oscillation	0.250d (−6.0+ 10 log d) dB	0.187d (−7.3+ 10 log d) dB (Note 1)
L2B Periodic oscillation modulating the width (duration) of pulses to constant mean width (duration)	(a) modulating oscillation keyed	Continuous periodic series of pulses with modulating oscillation suppressed	*d*	*d*
	(b) modulated emission keyed (Note 1)	Continuous series of pulses with modulating oscillation	*d*	0.500d (−3.0+ 10 log d) dB (Note 1)

TABLE I *(continued)*

Class of emission (1)	Modulating signal (2)	Condition of no-modulation (3)	Conversion factor: Carrier power / Peak envelope power (4)	Conversion factor: Mean power / Peak envelope power (5)
M2B Periodic oscillation modulating the phase or position of the pulses to constant mean spacing	(a) modulating oscillation keyed	Continuous periodic series of pulses with modulating oscillation suppressed	*d*	*d*
	(b) modulated emission keyed	Continuous series of pulses with modulating oscillation	*d*	0.500*d* (−3.0+ 10 log *d*) dB
Pulse modulation *Telephony* K3E Pulses amplitude-modulated by telephone signal	(a) single sinusoidal oscillation modulating pulses at 100%	Periodic series of non-modulated pulses	0.250*d* (−6.0+ 10 log *d*) dB	0.375*d* (−4.3+ 10 log *d*) dB
	(b) smoothly read text (Note 2)	Periodic series of non-modulated pulses	0.250*d* (−6.0+ 10 log *d*) dB	0.262*d* (−5.8+ 10 log *d*) dB
L3E Pulses width (duration) modulated to constant mean width (duration) by telephone signal	The mean width (or duration) and spacing being constant, the conversion factors are independent of the modulating signal	Periodic series of non-modulated pulses	*d*	*d*
M3E Pulses phase (or position) modulated to constant mean spacing by telephone signal	The mean width (or duration) and spacing being constant, the conversion factors are independent of the modulating signal	Periodic series of non-modulated pulses	*d*	*d*

TABLE II

Class of emission	Modulating signal	Condition of no-modulation	Conversion factor	
			Peak envelope power / Carrier power	Mean power / Carrier power
(1)	(2)	(3)	(4)	(5)
A2A, A2B Telegraphy with on-off keying of one or more periodic oscillations amplitude-modulating the carrier, or with keying of the carrier modulated by those oscillations	Series of rectangular dots; equal alternating marks and spaces; single sinusoidal oscillation modulating the carrier at 100% (a) modulating oscillation keyed	Continuous emission, modulating oscillation suppressed (carrier only)	4 (+6.0 dB)	1.25 (+1.0 dB)
	(b) modulated carrier keyed (Note 1)	Continuous emission with modulating oscillation	4 (+6.0 dB)	0.75 (−1.3 dB) (Note 1)
A3E Double-sideband telephony, full carrier	(a) single sinusoidal oscillation modulating carrier at 100%	Carrier only	4 (+6.0 dB)	1.5 (+1.8 dB)
	(b) smoothly read text (Note 2)	Carrier only	4 (+6.0 dB)	1.05 (+0.2 dB)

3. Explanatory notes

Note 1 – When the modulating signal, instead of consisting of a series of alternating marks and spaces, is coded with the help of a telegraph alphabet, the conversion factors in Column 5 should be multiplied by the following coefficients:

Morse alphabet: 0.49/0.50 = 0.98 (−0.1 dB)

International telegraph alphabet No. 2: 0.58/0.50 = 1.16 (+0.6 dB)

Seven-unit alphabet as in Recommendation 342: 0.5/0.5 = 1.

Note 2 – It is assumed that for smoothly read text the mean power level of the speech signal is 10 dB lower than the power level of a reference sinusoidal oscillation. The conversion factors in Column 5 are based on this ratio which can be considered as a practical value for telephony except for sound transmissions in the broadcasting service.

For the classes of emission to which this note applies, the reference level of this sinusoidal oscillation is determined as follows:

- A3E, H3E and K3E emissions: the level of a sinusoidal oscillation which would modulate the transmitter to a modulation factor of 100%;
- single-channel R3E and J3E emissions: the level of a sinusoidal oscillation which would modulate the transmitter to its peak envelope power;
- multi-channel R3E, B8E and J3E emissions: the level of a sinusoidal oscillation which would modulate the transmitter to one quarter (−6 dB) of its peak envelope power.

Although these assumptions do not in all cases correspond to the practice adopted by some administrations, they result in practical average values in Column 5.

Note 3 – For independent-sideband emissions (B8E) of 3 or 4 channels, it is assumed that independent modulating signals are applied to each channel.

Note 4 – The condition of no-modulation cannot be defined exactly because of the highly complex and asymmetric nature of the modulation; the figures given in Column 5 are average figures which may vary according to the tolerance in width of the synchronizing pulses and of the black level.

Note 5 – The power relationships in multi-channel voice-frequency telegraphy depend on the number of channels and not on the bandwidth they occupy. Therefore, either one or both sidebands can be occupied, and there is no distinction to be made here between R7W and B7W emissions.

Telegraph signals can occupy all the channels of an emission as in R7W and B7W telegraphy, or can occupy one or more channels of a composite (B9W) emission. It is therefore convenient to regard the group of voice-frequency telegraph channels as equivalent to one or more normal speech channels.

Note 6 – The ratios given in Table I are based on the conditions mentioned below which are considered typical of present practice.

– When one to four telegraph channels are used, the mean power of each channel is determined on the basis of voltage addition. Thus, if n is the number of channels of identical level, the mean power of each channel is given by:

$$\frac{\textit{Peak envelope power allocated to the group of channels}}{n^2}, \text{ when } n = 1, 2, 3 \text{ or } 4. \quad (4)$$

– When more than four telegraph channels are used it is normal practice to increase the level of each channel above that for which the peak envelope power allocated to the group of channels would never be exceeded. Since it may be assumed that the phases of the different sub-carriers are randomly distributed, the mean power of the emission may thus be increased without this peak envelope power being exceeded for more than a specified small fraction of the time.

In this case, the mean power of each channel is given by:

$$\frac{\textit{Peak envelope power allocated to the group of channels}}{4n}, \text{ when } n > 4. \quad (5)$$

Under this condition, the peak envelope power allocated to the group of channels is not exceeded for more than about 1% to 2% of the time.

Note 7 – For composite emissions, the mean levels in speech channels are assumed to be adjusted to the values set out in Note 2 for B8E emissions. To avoid interference from the group of telegraph channels, the level of this group is assumed to be reduced, relative to the level as set out in Note 6, by 3 dB when one channel is used for speech and by 6 dB when more than one channel is used.

Note 8 – For pulse emissions, it is assumed that the pulses are rectangular and that the peak envelope power is unity. The duty cycle d is the ratio of pulse duration to pulse repetition period, and is a constant for amplitude-modulated pulses. Where the duty cycle is variable, as with position or width modulated pulses, d is to be taken as the average value.

RECOMMENDATION 331-4

NOISE AND SENSITIVITY OF RECEIVERS

(Question 57/1)

(1951-1953-1956-1959-1963-1966-1970-1974-1978)

The CCIR,

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, 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;

(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 332);

(d) that, in many cases, to economize in transmitted power, it is desirable that the sensitivity shall be as great as economic and technical considerations permit and 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 332);

(f) that Question 57/1 (Geneva, 1982) asks for additional data on noise factor and noise temperature for the various types of receiver 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 or noise temperature;

(h) that often values for noise factor or noise temperature are particularly useful, since they are more uniform than values of maximum usable sensitivity for the various types of receiver 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;

(j) that the noise factor or noise temperature 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;

(k) that reference sensitivity is chiefly of value in comparing linear receivers;

(l) that it is desirable to define a "linear" receiver;

(m) that, for radiotelegraphy receivers for automatic reception:

- the use of a non-linear demodulator, 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;

(n) 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/or 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; both noise powers are determined at an absolute temperature of the source equal to T = 293 K;

2.1 that the *noise temperature* be defined as the value by which the temperature of the resistive component of the source impedance should be increased, if it were the only source of noise in the system, to cause the noise power at the output of the receiver to be the same as in the real 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 (see [CCIR, 1951]);

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:

4.1 – the signal level
4.2 – 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 the condition of § 4.1 (necessary output level) to be satisfied without regard to the output noise level (condition of § 4.2);

4.3 – the ratio of (signal + noise + distortion) to (noise + distortion) necessary for normal operation; or

4.4 – the signal distortion or mutilation just acceptable for normal operation;

5. that, for the purpose of presenting and comparing data for particular classes of linear 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 Annex I);

6. that in case of uncertainty with regard to terms of the formulae relating noise factor and reference sensitivity (see Annex I), 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 reference sensitivity should be considered in connection with the values for the single signal and multiple signal selectivity (see Recommendation 332);

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;

---

* For frequencies above about 30 MHz, the input signal strength is sometimes taken as the available power from the source.

** Classes of emission A1A and A1B are considered 100% modulated.

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;

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 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 to obtain a specified character error ratio in the reproduced text;

9.3 defined methods for measuring signal distortion, signal mutilation, element error ratios and character error ratios should be used (see [CCIR, 1956; 1958a, b, c and CCIR, 1966-69a and b]);

9.4 for the purpose of comparing and presenting data (see Annex I, § 5), 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 I, § 5.4); or the character error rate in the reproduced texts (see § 9.2 and Annex I, § 5.5) and the receiver pre-detector and post-detector signal bandwidth;
- the frequency shift for F1B emissions;
- 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 I, § 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 equivalent source 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 237-1 and 330 (Geneva, 1974);

11. that for receivers for single channel frequency-modulation for telephony (class of emission F3EJN) other than those used for sound broadcasting:

11.1 the maximum usable 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 a specified value of

$$\frac{\text{signal} + \text{noise} + \text{distortion}}{\text{noise} + \text{distortion}}$$

can be obtained at the output;

11.2 the measurement of (noise + distortion) should be made with the wanted modulation present, the output due to this modulation being removed by a filter;

11.3 this method of measurement is in accordance with the IEC proposals;

Note. – The characteristics of the filter used to remove the wanted modulation shall be such that, at the point at which the output meter used for sensitivity measurement is connected, the relative attenuation of the 1 kHz signal shall be at least equal to the specified

$$\frac{\text{signal} + \text{noise} + \text{distortion}}{\text{noise} + \text{distortion}}$$

ratio plus 20 dB, and that at 2 kHz it shall not exceed 0.6 dB. Moreover, in the absence of the modulating frequency, the filter shall not cause more than 1 dB attenuation of the total noise signal power occurring within the specified receiver bandpass;

---

* The normalized signal-to-noise ratio is an energy ratio and it can be expressed in dB (see Report 195).

12. that for receivers for amplitude-modulation, other than those used for sound broadcasting, as an alternative to the signal-to-noise ratio, the ratio

$$\frac{\text{signal} + \text{noise} + \text{distortion}}{\text{noise} + \text{distortion}}$$

may be measured as indicated in § 11.1 and 11.2;*

13. 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);

14. that, when a psophometric weighting network is used for sensitivity measurements, this fact should be stated and the response curve given;

15. that, with a view to the ultimate statistical treatment of the presented data, Administrations should be encouraged to provide results of measurements made on receivers of recent design, in accordance with the provisions of this Recommendation.

REFERENCES

CCIR Documents

[1951]: Geneva, 3.

[1956]: Warsaw, 227.

[1958] Geneva: **a.** II/3; **b.** II/11; **c.** II/23.

[1966-69]: **a.** II/29 (Rev.1); **b.** II/30 (Rev.1).

ANNEX I

EQUATIONS RELATING NOISE FACTOR AND SENSITIVITY OF LINEAR RECEIVERS, MEASUREMENT OF, AND EQUATIONS RELATING TO THE SENSITIVITY AND NORMALIZED SIGNAL-TO-NOISE RATIO OF RADIOTELEGRAPH RECEIVERS FOR AUTOMATIC RECEPTION

1. A1A, A1B, A2A, A2B, A3E emissions (amplitude modulation)

$$E^2 = 8k\,(T_S + T_N)\,\frac{BRn}{m^2} \times 10^{12} \qquad (1)$$

where:

T_S: noise temperature of signal source (antenna) in K;

T_N: receiver noise temperature in K (see Note 1);

when $T_S = T$ or $F \gg 1$, equation (2) can be used:

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

where:

E: e.m.f. of the carrier in series with the equivalent series resistance of the source (μV);

F: noise factor (power ratio);

R: equivalent resistance of source (dummy antenna) (Ω);

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

m: degree of modulation (modulation considered sinusoidal). For A1A and A1B emissions, take $m = 1$;

* Certain Administrations do not agree with the method of measurement described in § 12, but Study Group 1 is awaiting results from the IEC before deciding whether or not to amend this Recommendation.

k: Boltzmann's constant (1.37×10^{-23} J/K);

T: absolute temperature (K);
(T is commonly taken as 293 K, then $kT \approx 400 \times 10^{-23}$ J);

B: width of the effective overall noise band (Hz), taken as the smaller of the following two quantities:
- the post-demodulation bandwidth;
- half the pre-demodulation bandwidth (see Note 2).

Note 1 – The noise temperature T_N is related to the noise factor by the following equation:

$$T_N = T(F - 1)$$

2. B8E emissions (independent-sideband amplitude-modulation)

$$E^2 = 4k(T_S + T_N)\, BRn \times 10^{12} \tag{3}$$

When $T_S = T$ or $F \gg 1$, equation (4) can be used:

$$E^2 = 4\, kTBRnF \times 10^{12} \tag{4}$$

where:

E: e.m.f. of the sideband component in series with the equivalent series resistance of the source (μV);

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

B: width of the effective overall noise band (Hz), taken as the smaller of the following two quantities:
- the post-demodulation bandwidth;
- the full pre-demodulation bandwidth (see Note 2).

3. F3E emissions (frequency modulation)

$$E^2 = 8k(T_S + T_N)\frac{BRn}{q^2} \times 10^{12} \tag{5}$$

when $T_S = T$ or $F \gg 1$, equation (6) may be used:

$$E^2 = 8kT\frac{BRn}{q^2}\, F \times 10^{12} \tag{6}$$

where:

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

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

$2D$: peak-to-peak value of the reference frequency deviation in telephony (modulation considered sinusoidal);

B: width of the effective overall post-demodulation noise band.

Note 2 – 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 § 14 of this Recommendation), since the bandwidth will be known from the psophometer characteristics; this is an advantage since the bandwidth enters the equation to the third power.

Note 3 – Equations (5) and (6) are applicable only to a receiver of perfect design working under idealized conditions, that is with:

- *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;
- *receiver noise* mainly produced in the early stages of the receiver.

Equations (5) and (6) should not be used to calculate the noise factor from the reference sensitivity and vice versa, unless the conditions above are satisfied.

Note 4 – The study (see [CCIR, 1966-69a and b and CCIR, 1970-74]) shows that equation 6 is applicable only above the F3E receiver threshold. The threshold may be defined by the 1 dB departure from linear input-output noise characteristic of the receiver. The threshold value of pre-demodulation signal-to-noise ratio n_i may be expressed by the equation:

$$n_i\,(\text{threshold}) = 4.25 + 2.6 \log \frac{B_i\,D}{B_o^2}$$

where:

B_i : effective pre-demodulation bandwidth;

B_o : effective post-demodulation bandwidth;

D : peak frequency deviation with sinusoidal modulation.

Accordingly, equation (6) cannot be applied to sensitivity calculations when the system parameters lead to a signal-to-noise ratio below threshold. This applies also to most of the data in Tables I and II below, concerning F3E emissions [CCIR, 1970-74].

Note 5 – Equations (1) to (6) are valid when the signal source output is matched with the receiver input.

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

The reference sensitivity may be calculated from the receiver noise temperature or noise factor (see Annex II) by means of equations (1) to (6) or the following simplified equations:

$$E^2 = C'\,(T_S + T_N),\ C' \text{ being a factor of proportionality} \tag{7}$$

when $T_S = T$ or $F \gg 1$:

$$E^2 = CF, \text{ with } C = C'T \tag{8}$$

Typical reference values for B, R, n, m, and D are given in Table I, together with the corresponding values of the multiplying factor C used in equation (8). For ease of computation the values of C given in the table are in decibels.

While equations (1) to (8) can also be used to calculate the receiver noise temperature or 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 T_N or F than can be obtained by direct measurement.

5. **Measurement of maximum usable sensitivity and normalized signal-to-noise ratio of telegraph receivers for automatic reception** (see [CCIR, 1956; 1963 a, b, c and d]).

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 F1B transmissions are 400 Hz, 200 Hz and 100 Hz; the receiver bandwidth just prior to the non-linear part of the receiver and that of the post-demodulator low-pass filter should be chosen in conformity with those given in:

Recommendation 328, § 3.1 and 3.6,
Recommendation 338, § 1.1 and 1.2;

5.3 the source resistance should be taken as 75 Ω;

5.4 the amount of distortion or mutilation in the receiver should be taken as either of the following two conditions:

– 20% distortion with an element error ratio of 10^{-3};

– one split or extra in 1000 elements (see § 9.1);

TABLE I – *Typical reference values for parameters used in calculating and measuring reference sensitivity*

Class of emission	Service	Effective overall noise band B (Hz)	Source resistance R (Ω)	Output signal-to-noise power ratio n (dB)	Degree of modulation: factor m	Degree of modulation: (kHz)	Peak system deviation for F3E D (kHz)	10 log C (dB)
A1A, A1B	General purpose	1000	75	20	1			−6.2
	Mobile	1000	75	20	1			−6.2
A2A, A2B	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)
A3E	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
	Sound broadcast (HF): profes-sional use	5000	75	20	0.3			+11.1
B8E	Fixed	3000	75	20				−4.4
F3E	Fixed General purpose Mobile	3000	75	20	0.3	±4.5 (5)	±15	−9.7
	Sound-broadcasting	5000	75	20 (4)	0.3	±22.5 (5)	±75	−17.0
		5000	75	40	0.3	±22.5 (5)	±75	+3
		5000	75	20 (4)	0.3	±15 (5)	±50	−13.8
				40	0.3	±15 (5)	±50	+6.2
		5000	300	20 (4)	0.3	±15 (5)	±50	−7.8
				40	0.3	±15 (5)	±50	+12.2

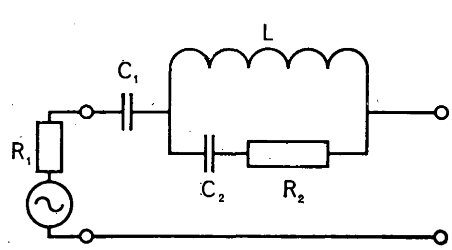
(1) Without IF oscillator.

(2) With IF oscillator.

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

(4) For future measurements, a signal-to-noise ratio of 40 dB should be used in place of the 20 dB value indicated.

(5) This number represents 30% of reference peak deviation (telephony 15 kHz; sound broadcasting 75 and 50 kHz)



$C_1 = 125$ pF
$C_2 = 400$ pF
$L = 20$ μH
$R_1 = 80$ Ω
$R_2 = 320$ Ω
$Q_L > 15$ (at 1 MHz)

FIGURE 1 — *Dummy antenna*

TABLE II — *Typical values for parameters used for non-linear receivers measured according to § 11 of this Recommendation*

Class of emission	Service	Effective overall noise band B (Hz)	Source resistance R (Ω)	Output signal-to-noise-power ratio n (dB)	Degree of modulation factor m	Degree of modulation (kHz)	Peak system deviation for F3E D (kHz)
A3E	Mobile	3000	75	12	0·3		
F3E	Mobile	3000	75	12	0·6 0·6	±9 ±3	±15 ± 5

5.5 the character error ratio 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. **Equations relating "normalized signal-to-noise ratio" and sensitivity** (see Report 195)

6.1
$$E^2 = 4\ kTRB_in_iF \times 10^{12}$$

E, F, R, k, T are defined in § 1 of this Annex;

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 (dB):

$$n_i = n_c \frac{S}{B_i},$$

n_c: normalized signal-to-noise ratio (dB);

S: keying speed (bauds).

6.2
$$E^2 = 4\ kTRn_c\ FS \times 10^{12}$$

If $R = 75\Omega$

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

$C_1 = -59.2$ dB

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

$C_2 = -42.2$ dB for 50 bauds,
or -39.2 for 100 bauds.

7. **Influence of mismatch of the input on receiver sensitivity**

Receiver sensitivity depends on the extent to which the receiver input is matched with the signal source output. Mismatching results in incomplete transfer of signal and noise power from the signal source to the receiver input, and in a difference in measured receiver noise as compared with matching conditions of the receiver input.

Equations characterizing the influence of mismatching on receiver sensitivity are given in [CCIR, 1974-78].

When the reflection coefficient of the receiver input and/or the signal source output is $\leqslant 0.2$, the relative difference between the power required from the signal source and the power calculated from formulae shown in

[CCIR, 1974-78], to give an equivalent sensitivity value, may range over the values +25% to −25%. Such a difference may occur with sensitive receivers where there is close correlation between the input and output noise of the receiver. With the reflection coefficient equal to 0.2, and in the absence of correlation, where the relative difference is always equal to or greater than zero, such difference may be as great as +8%.

Where there is no correlation of internal receiver noise, the noise is at a minimum and, correspondingly, there is maximum sensitivity with matching at the receiver input.

Where there is correlation of internal noise, there may be maximum sensitivity with some mismatching between the receiver and the signal source.

REFERENCES

CCIR Documents

[1956]: Warsaw, 227.

[1963] Geneva: **a.** II/3; **b.** II/11; **c.** II/21; **d.** II/23.

[1966-69]: **a.** II/20 (People's Republic of Poland); **b.** II/86 (People's Republic of Poland).

[1970-74]: 1/135 (People's Republic of Poland).

[1974-78]: 1/54 (USSR).

ANNEX II

GENERAL CONSIDERATIONS RELATING TO THE NOISE FACTOR AND THE NOISE TEMPERATURE OF RECEIVERS

In a well-designed receiver, noise originating in the receiver is mainly due to random processes (thermal, shot and flicker noise) generated in the early stages of the receiver.

For the quantitative estimation of internal receiver noise, the noise factor F or the noise temperature T_N are used.

In the case of highly sensitive receivers, where $F = 1.05$ to 2 or $T_N = 15$ to 293 K (see definitions of F and T_N in § 1 of Annex I), it is preferable to measure the noise temperature rather than the noise factor.

For medium- or low-sensitivity receivers, either the noise factor or the noise temperature may be used.

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

Special methods have been developed for measuring noise temperatures and noise factors. A number of indirect measurement methods (double reading methods) are described in Report 534. It is often preferable to use direct reading methods – the most commonly used of which is the direct-reading modulation method – in the tuning and operation of receivers.

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 Report 534 (Dubrovnik, 1986)).

RECOMMENDATION 332-4

SELECTIVITY OF RECEIVERS

(Question 57/1)

(1953–1956–1959–1963–1966–1970–1974–1978)

The CCIR,

CONSIDERING

(a) that the selectivity of a receiver is a measure of its ability to discriminate between a wanted signal to which the receiver is tuned and unwanted 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 method of single-signal selectivity 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 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 bandwidth of the receiver shall be no wider than is essential for the transmission of the necessary modulation of the wanted signal without significant distortion (see also Recommendation 328 § 1.1);

2. that 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 Recommendation 328, § 3);

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 passband;

2.4 the fact that *selectivity* and *protection ratios* are different characteristics, the first being a property of the receiver only, the second being an agreed minimum value, taking into account characteristics of the emission, propagation and reception;

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, to avoid significant loss of selectivity, e.g. by cross-modulation of the wanted signal by strong unwanted signals;

4. that, for the purpose of studying bandwidth or single-signal selectivity, the following definitions are used:

4.1 for amplitude-modulated signals (including single-sideband and independent-sideband emissions), the *passband* is the band of radio frequencies accepted by the receiver and measured at the detector input, 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 for frequency- or phase-modulated signals, the modulation acceptance *bandwidth* of a receiver, other than those used for broadcast reception, is twice the frequency deviation of an input signal which, when applied at a level 6 dB higher than the maximum usable sensitivity level, and measured in accordance with Recommendation 331, § 11, will produce a

$$\frac{\text{Signal + noise + distortion}}{\text{noise + distortion}}$$

ratio equal to that specified for the maximum usable sensitivity level. This is an indication of the frequency deviation which the receiver will accept without excessive degradation of the ratio

$$\frac{\text{Signal + noise + distortion}}{\text{noise + distortion}}$$

4.3 *attenuation-slope:* the attenuation-slope on each side of the passband is the ratio:

– of the difference in the attenuations corresponding to two different frequencies beyond the passband,
– to the difference between these frequencies;

4.4 *image-rejection ratio:* the image-rejection ratio is the ratio:

– of the input signal level at the image frequency required to produce a specified output power from the receiver,
– to the level of the wanted signal required to produce the same output power.

The image frequency is the wanted 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 wanted signal-frequency.

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

4.5 *intermediate-frequency rejection ratio:* the intermediate-frequency rejection 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 power from the receiver,
– to the level of the wanted signal required to produce the same output power;

4.6 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 rejection ratio: the spurious-response rejection ratio is the ratio:

– of the input level at the interfering frequency required to produce a specified output power from the receiver,
– to the level of the wanted signal to produce the same output power;

5. that single-signal measurements be made of the passband, the attenuation slope, the image response, the intermediate-frequency rejection and other spurious-response rejection ratios as defined above and also, in frequency-modulation receivers, the modulation acceptance-bandwidth.

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 passband. When the values thus obtained are essentially equal for the two sides of the passband, 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 passband and the attenuation-slopes at the different levels (see Fig. 1).

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 passband can also be expressed as the slope of the attenuation/frequency characteristic, in decibels per octave of the frequency difference. 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 used:

6.1 *effective selectivity:* the effective selectivity is the ability of the receiver to discriminate between the wanted signal (to which the receiver is tuned) and unwanted signals (having frequencies generally outside the passband), the level of which is such as to produce non-linear effects, the wanted and unwanted signals acting simultaneously. The effective selectivity can be investigated by measuring blocking, adjacent-signal selectivity (or adjacent-channel selectivity, if there is regular channelling) and radio-frequency intermodulation, as follows:

6.2 *blocking:* blocking is measured by the level of an unwanted signal on a nearby frequency, e.g., in an adjacent channel, which results in a given change (generally a reduction) e.g., 3 dB, in the output power due to a modulated* wanted signal of specified level applied to the receiver input;

6.3 *adjacent signal selectivity:* one of two following principles of measurement is used:

6.3.1 The adjacent-signal selectivity is measured by the level of an unwanted modulated signal at a frequency near to that of the wanted signal which results in an output power from the receiver (sum of the power of all unwanted components) of a specified amount (e.g., 20 dB) below the power due to the modulation of the wanted signal (adjacent-signal selectivity type A).

---

* Except for class of emissions A1A and A1B when an unmodulated carrier is used.

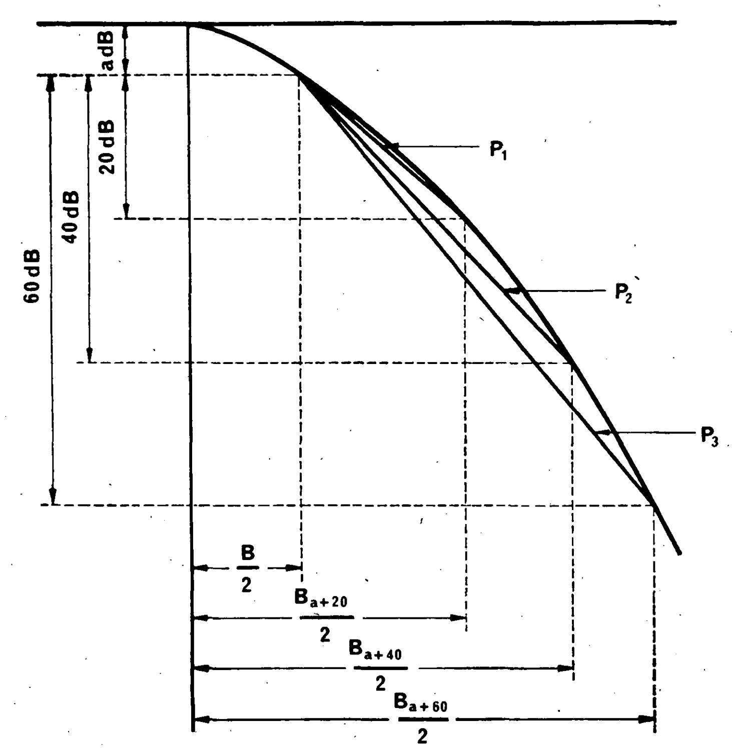


FIGURE 1 — *Conversion between methods of presentation of single-signal selectivity*

The formula: $B_{a+20n} = B + 20\ (2n/P_n)$ can be used to convert 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 kHz

B: the bandwidth of the passband in kHz

P_n: slope of the attenuation in dB/kHz

n: an integer (1, 2, 3 or 4)

The measurement of the level of the unwanted signal may be made with the modulation of the wanted signal removed. In the case that the modulation is not removed, the output power due to the modulation shall be excluded from the measurement by adequate audio-frequency filtering or a wave analyzer shall be used to measure the unwanted components.

With receivers for amplitude-modulated classes of emission with reduced or suppressed carrier, the wanted signal shall be modulated.

6.3.2 The adjacent-signal selectivity is measured by the level of an unwanted signal* at a frequency near to that of the wanted signal which results in a degradation of the wanted modulated signal at the output of the receiver either**:

– by a specified change in the ratio:

$$\frac{\text{Signal + noise + distortion}}{\text{noise + distortion}}$$

(e.g., of 6 dB) when measured at the maximum usable level of sensitivity (adjacent-signal selectivity type B1),

– or to a specified value (e.g., 12 dB) when measured at values above the maximum usable level of sensitivity (adjacent-signal selectivity type B2).

---

* The unwanted signal shall be modulated, except in those cases in which the modulation does not affect the result.

** Certain Administrations do not agree with the method of measurement described in § 6.3.2, but Study Group 1 is awaiting results from the International Electrotechnical Commission (IEC) before deciding whether or not to amend this Recommendation.

The measurement of adjacent-signal selectivity includes the effects of cross-modulation and inadequate intermediate-frequency filtering.

The method given in § 6.3.2 is to be preferred for frequency-modulation receivers in the mobile services (class of emission F3E) *.

Note. – For single-sideband and independent-sideband emissions, a modulated signal is deemed to comprise a reduced carrier (if applicable) and one sinusoidal component in only one of its sidebands.

6.4 *intermodulation:* intermodulation is measured in terms of the levels of two unwanted signals which, when applied together, produce at the receiver output either **:

– a given level of intermodulation (e.g., 20 dB ***) below the level produced by a wanted input signal (intermodulation type A), or

– a specified degradation in the ratio

$$\frac{\text{Signal} + \text{noise} + \text{distortion}}{\text{noise} + \text{distortion}}$$

(e.g., of 6 dB) if measured at the maximum usable sensitivity level (intermodulation type B1), or

– a degradation of the ratio

$$\frac{\text{Signal} + \text{noise} + \text{distortion}}{\text{noise} + \text{distortion}}$$

to a specified value (e.g., 12 dB), when measured with signal levels in excess of the maximum usable sensitivity level (intermodulation type B2); when the frequencies F'_n and F''_n of these unwanted signals have:

6.4.1 a sum equal to the intermediate frequency ($F_{if1} = F'_n + F''_n$), in which case, tests should be made with frequencies such that the unwanted signals will have frequencies close to, but not equal to, half the intermediate frequency;

6.4.2 a difference equal to the intermediate frequency ($F_{if2} = F'_n + F''_n$), in which case, tests should be made with frequencies such that the unwanted signal at the lower frequency should have a frequency near to that of the wanted signal, e.g., in an adjacent channel;

6.4.3 a sum equal to the frequency of the wanted signal ($F_{d1} = F'_n + F''_n$), in which case, the unwanted signals should have frequencies close to, but not equal to, half the wanted signal;

6.4.4 a difference equal to the frequency of the wanted signal ($F_{d2} = F'_n + F''_n$), in which case, the unwanted signal having the lower frequency should have a frequency near to that of the wanted 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 unwanted signals should have frequencies close to, but not equal to, half the image frequency;

6.4.6 a difference equal to that between the wanted signal and the nearer unwanted signal intermodulation product being of the third order ($F_{d3} = 2F'_n - F''_n$), in which case, the nearer unwanted signal should have a frequency near to that of the wanted signal, e.g., in an adjacent channel.

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

The products that are most significant differ with receivers for different services.

---

* When there is regular channelling, the value of the adjacent-signal selectivity measured for a frequency separation equivalent to the channel spacing is termed adjacent-channel selectivity.

** Certain Administrations do not agree with the method of measurement described in § 6.4 concerning intermodulation types B1 and B2, but Study Group 1 is awaiting results from the IEC before deciding whether or not to amend the Recommendation.

*** Other values may be desirable for certain classes of receiver.

Fifth and higher order intermodulation products may be significant in certain services, e.g., VHF land-mobile.

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

To determine the severity of intermodulation for a range of values of the strength of the wanted signal, a third signal (the wanted 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 μV, or the maximum usable sensitivity level (see Note 2).

The unwanted signals should be equal in level; in receivers for A3E, they should be unmodulated, because the interference, resulting from the beat between the intermodulation product and the carrier of the wanted signal, is more severe than that due to any modulation; in receivers for R3E, B8E, J3E, F1B and F3E in the mobile services, they should also be unmodulated and the frequency of one unwanted signal should be adjusted to make the output power of the receiver have a frequency equal to or, if the signal is filtered out, near to that of the modulation initially applied to the wanted 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, adjacent-signal selectivity and radio frequency intermodulation characteristics as defined above.

8. that, with a view to the ultimate statistical treatment of the presented data, Administrations should be encouraged to provide results of measurements made on receivers of recent design, in accordance with the provisions of this Recommendation.

Note 1 – The application of multiple-signal tests of effective selectivity to receivers for A1A, A1B, A2A, A2B and F1B signals is the subject of further study (Question 57/1 (Geneva, 1982)).

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

RECOMMENDATION 239-2*

SPURIOUS EMISSIONS FROM SOUND AND TELEVISION BROADCAST RECEIVERS

(Question 57/1)

(1956-1959-1974-1978)

The CCIR,

CONSIDERING

(a) that many receivers produce spurious emissions, due, for example, to local oscillators or to intermediate-frequency radiation and, in television receivers, to time-base circuits;

(b) that these emissions may emanate from antenna circuits, the mains supply leads or the receiver chassis and may interfere with many services;

(c) that limiting values for such spurious emissions have been established, based on different methods, by several Administrations;

(d) that international standardization of measuring methods and limiting values is very desirable;

(e) that the International Electrotechnical Commission (IEC) has published a Standard (IEC Publication 106, Second edition, 1974) on methods of measuring radiated and conducted interference from receivers for amplitude-modulation, frequency-modulation and television broadcast transmissions;

(f) that the International Special Committee on Radio Interference (CISPR) is studying the level of spurious emissions from such receivers, with a view to establishing tolerable limits,

UNANIMOUSLY RECOMMENDS

1. that the CCIR be guided by the methods established by the IEC for measuring spurious emission for all types of sound and television broadcast receivers;

2. that the CCIR should take note of the limits for spurious emission from frequency-modulation sound broadcast receivers and television broadcast receivers laid down by CISPR in Recommendation No. 24/3**;

3. that the CCIR confirm to the CISPR its interest in knowing the level of emissions from broadcast receivers other than those mentioned in § 2 above, and ask to be informed of any progress in establishing tolerable limits for such emissions;

4. that all possible means, compatible with economy, should be employed in the construction of receivers to reduce such spurious emissions.

---

* This Recommendation is brought to the attention of Study Groups 10 and 11.

** Contained in Amendment No. 1 (1973) to CISPR Publication 7 (Second edition, 1969). This publication may be purchased from the IEC Central Office, Geneva.

RECOMMENDATION 328-7

SPECTRA AND BANDWIDTH OF EMISSIONS

(Study Programme 60A/1)

(1948-1951-1953-1956-1959-1963-1966-1970-1974-1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that in the interest of an efficient use of the radio spectrum, it is essential to establish for each class of emission rules governing the spectrum emitted by a transmitting station and to lay down methods of measurement for verifying the spectral properties of the emission;

(b) that, for the determination of an emitted spectrum of optimum width, the whole transmission circuit as well as all its technical working conditions, including other circuits and radio services sharing the band, and particularly propagation phenomena, must be taken into account;

(c) that the concepts of "necessary bandwidth" and "occupied bandwidth" defined in Article 1, Nos. 146 and 147 of the Radio Regulations, are useful for specifying the spectral properties of a given emission, or class of emission, in the simplest possible manner;

(d) that, however, these definitions do not suffice when consideration of the complete problem of radio spectrum economy and efficiency is involved; and that an endeavour should be made to establish rules limiting, on the one hand, the bandwidth occupied by an emission to the most efficient value in each case and, on the other hand, the amplitudes of the components emitted in the outer parts of the spectrum so as to decrease interference to adjacent channels;

(e) that with regard to the efficient use of the radio-frequency spectrum necessary bandwidths for individual classes of emission must be known, that in some cases the formulae listed in Appendix 6, Part B, to the Radio Regulations can only be used as a guide and that the necessary bandwidth for certain classes of emissions is to be evaluated corresponding to a specified transmission standard and a quality requirement;

(f) that the occupied bandwidth and the x dB bandwidth enable operating agencies, national and international organizations, to carry out measurements of the bandwidth actually occupied by a given emission and thus to ascertain, by comparison with the necessary bandwidth, that such an emission does not occupy an excessive bandwidth for the service to be provided and is, therefore, not likely to create interference beyond the limits laid down for this class of emission;

(g) that, in addition to limiting the bandwidth occupied by an emission to the most efficient value in each case, rules should be established to limit the amplitudes of the components emitted in the outer parts of the spectrum by reconciling the following requirements:

- the necessity for limiting the interference caused to adjacent channels to a strict minimum;
- the technical and practical possibilities of transmitter and receiver design, and modulation technique;
- the limitation of shaping or distortion of the signal to a permissible value;

(h) that, although some problems of spacing between channels or interference can be dealt with in an approximate but simple manner, merely by use of the data for the necessary bandwidth (for a given class of emission), the occupied bandwidth or the x dB bandwidth (for a given emission), and the spectrum emitted outside the necessary bandwidth, interference problems can be dealt with accurately only if complete knowledge is available, either of the Fourier transform of the signal or of the function representing its energy spectrum for all frequencies in the radio-frequency spectrum;

(j) that in several cases, the use of systems employing necessary bandwidths much greater than the baseband bandwidth (e.g. systems which employ high modulation index FM, bandwidth expansion techniques) potentially increase the number of users sharing a band, because the susceptibility of receivers to interference may be reduced sufficiently, to more than compensate for the reduction in the number of channels available, thus increasing the efficiency of radio spectrum use as defined in Report 662,

UNANIMOUSLY RECOMMENDS

1. Definitions

that the following definitions and explanatory notes should be used when dealing with bandwidth, channel spacing and interference problems:

1.1 *Baseband*

The band of frequencies occupied by one signal, or a number of multiplexed signals, which is intended to be conveyed by a line or a radio transmission system.

Note. – In the case of radiocommunication, the baseband signal constitutes the signal modulating the transmitter.

1.2 *Baseband bandwidth*

The width of the band of frequencies occupied by one signal, or a number of multiplexed signals, which is intended to be conveyed by a line or a radio transmission system.

1.3 *Necessary bandwidth*

For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions (Article 1, No. 146 of the Radio Regulations).

1.4 *Bandwidth expansion ratio*

The ratio of the necessary bandwidth to baseband bandwidth.

1.5 *Out-of-band spectrum (of an emission)*

The part of the power density spectrum (or the power spectrum when the spectrum consists of discrete components) of an emission which is outside the necessary bandwidth and which results from the modulation process, with the exception of spurious emissions.

1.6 *Out-of-band emission*

Emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions (Article 1, No. 138 of the Radio Regulations).

Note – Non linearity in amplitude modulated transmitters (including single sideband transmitters) may result in out-of-band emissions which are immediately adjacent to the necessary bandwidth, due to odd order intermodulation products. The acceptable levels of intermodulation distortion are specified in Recommendation 326.

1.7 *Spurious emission*

Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions (Article 1, No. 139 of the Radio Regulations).

1.8 *Unwanted emissions*

Consist of spurious emissions and out-of-band emissions (Article 1, No. 140 of the Radio Regulations).

1.9 The terms associated with the definitions given in § 1.6, 1.7 and 1.8 above are expressed in the working languages as shown in Table I.

1.10 *Permissible out-of-band spectrum (of an emission)*

For a given class of emission, the permissible level of the power density (or the power of discrete components) at frequencies above and below the limits of the necessary bandwidth.

Note – The permissible power density (or power) may be specified in the form of a limiting curve giving the power density (or power), expressed in decibels relative to the specified reference level, for frequencies outside the necessary bandwidth. The abscissa of the initial point of the limiting curve should coincide with the limiting frequencies of the necessary bandwidth. Descriptions of limiting curves for various classes of emissions are given in § 3 below.

TABLE I

English	French	Spanish
Out-of-band emissions	Emission hors bande	Emisión fuera de banda
Spurious emission	Rayonnement non essentiel	Emisión no esencial
Unwanted emissions	Rayonnements non désirés	Emisiones no deseadas

1.11 *Out-of-band power (of an emission)*

The total power emitted at the frequencies of the out-of-band spectrum.

1.12 *Permissible out-of-band power*

For a given class of emission, the permissible level of mean power emitted at frequencies above and below the limits of necessary bandwidth.

Note – The permissible level of out-of-band power should be determined for each class of emission and specified as a percentage β of total mean power radiated derived from the limiting curve fixed individually for each class of emission.

1.13 *Occupied bandwidth*

The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage β/2 of the total mean power of a given emission.

Unless otherwise specified by the CCIR for the appropriate class of emission, the value of β/2 should be taken as 0.5% (Article 1, No. 147 of the Radio Regulations).

Note – The value of β could be determined by calculating the sum of the percentages of the total mean power above and below the necessary bandwidth. The occupied bandwidth is optimum when it equals the necessary bandwidth.

1.14 *x dB bandwidth*

The width of a frequency band such that beyond its lower and upper limits any discrete spectrum component or continuous spectral power density is at least x dB lower than a predetermined zero dB reference level.

Note – The x dB values for some classes of emission and various methods of establishing zero levels are described in Report 275; Report 324 also describes an evaluation of bandwidth using x dB values.

1.15 *Assigned frequency band*

The frequency band within which the emission of a station is authorized; the width of the band equals the necessary bandwidth plus twice the absolute value of the frequency tolerance. Where space stations are concerned, the assigned frequency band includes twice the maximum Doppler shift that may occur in relation to any point of the Earth's surface (Article 1, No. 141 of the Radio Regulations).

1.16 *Assigned frequency*

The centre of the frequency band assigned to a station (Article 1, No. 142 of the Radio Regulations).

1.17 *Characteristic frequency*

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

A carrier frequency may, for example, be designated as the characteristic frequency (Article 1, No. 143 of the Radio Regulations).

1.18 *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 (Article 1, No. 144 of the Radio Regulations).

1.19 *Frequency tolerance*

The maximum permissible departure by the centre frequency of the frequency band occupied by an emission from the assigned frequency or, by the characteristic frequency of an emission from the reference frequency.

The frequency tolerance is expressed in parts in 10^6 or in hertz (Article 1; No. 145 of the Radio Regulations).

1.20 *Build-up time of a telegraph signal*

The time during which the telegraph current passes from one-tenth to nine-tenths (or vice versa) of the value reached in the steady state; for assymetric signals, the build-up times at the beginning and end of a signal can be different.

1.21 *Relative build-up time of a telegraph signal*

Ratio of the build-up time of a telegraph signal defined in § 1.20 to the half-amplitude pulse duration.

2. Emission of a transmitter, optimum from the standpoint of spectrum economy

that an emission should be considered optimum from the standpoint of spectrum economy when its occupied bandwidth coincides with the necessary bandwidth for the class of emission concerned and when the out-of-band spectrum envelope is inscribed within the appropriate limiting curve given in § 3 below for various classes of emission.

To facilitate monitoring, an emission optimum from the standpoint of spectrum economy may be regarded as an emission whose x dB bandwidth stands in a fixed relationship to the necessary bandwidth for the corresponding class of emission, this relationship being determined by the x dB level and the parameters of the limiting curve for the out-of-band spectrum. A number of x dB levels and the required relationships between the corresponding values of the x dB bandwidths and the necessary bandwidths are given in Reports 275 and 324 (see also the examples given in Annex I).

An optimum bandwidth from the standpoint of spectrum economy may not be optimum from the standpoint of spectrum efficiency in a sharing situation.

3. Limitations of the emitted spectra

that administrations should endeavour, with the minimum practicable delay, to limit the emitted spectra to those shown below for various classes of emission.

Note – The modulation rate in bauds, *B*, used in the following text is the maximum speed used by the corresponding transmitter. For 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, to comply with Article 5, No. 307, of the Radio Regulations.

3.1 *Classes of emission A1A and A1B with fluctuations*

When large short-period variations of the received field are present, the specifications given below for single-channel, amplitude-modulated, continuous-wave telegraphy (Class A1A and A1B), represent the desirable performance obtainable from a transmitter with an adequate input filter and sufficiently linear amplifiers following the stage in which keying occurs.

3.1.1 *Necessary bandwidth*

The necessary bandwidth is equal to five times the modulation rate in bauds. Components at the edges of the band shall be at least 3 dB below the levels of the same components of a spectrum representing a series of equal rectangular dots and spaces at the same modulation rate.

This relative level of -3 dB corresponds to an absolute level of 27 dB below the mean power of the continuous emission (see Recommendation 326, Table I).

3.1.2 *Out-of-band spectrum*

If frequency is plotted as the abscissa in logarithmic units and if the power densities are plotted as ordinates, in decibels, the curve representing the out-of-band spectrum should lie below two straight lines starting at point $(+5B/2, -27$ dB$)$ or at point $(-5B/2, -27$ dB$)$ defined above, with a slope of 30 dB per octave and finishing at point $(+5B, -57$ dB$)$ or $(-5B, -57$ dB$)$, respectively. Thereafter, the same curve should lie below the level -57 dB.

The permissible amounts of out-of-band power, above and below the frequency limits of the necessary bandwidth, are each approximately 0.5% of the total mean power radiated.

3.1.3 *Build-up time of the signal*

The build-up time of the emitted signal depends essentially on the shape of the signal at the input to the transmitter, on the characteristics of the filter to which the signal is applied, and on any linear or 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 may be assumed that an out-of-band spectrum close to the limiting curve defined in § 3.1.2 corresponds to a build-up time of about 20% of the initial duration of the telegraph dot, i.e. about $1/5B$.

3.2 *Classes of emission A1A and A1B without fluctuations*

For amplitude-modulated, continuous-wave telegraphy, when short-period variations of the received field strength do not affect transmission quality, the necessary bandwidth can be reduced to three times the modulation rate in bauds.

3.3 *Classes of emission A2A and A2B*

For single-channel telegraphy, in which both the carrier frequency and the modulating oscillations are keyed, the percentage of modulation not exceeding 100% and the modulation frequency being higher than the modulation rate ($f > B$), the specifications given below represent the desirable performance that can be obtained from a transmitter with a fairly simple input filter and approximately linear stages.

3.3.1 *Necessary bandwidth*

The necessary bandwidth is equal to twice the modulating frequency f plus five times the modulation rate in bauds.

3.3.2 *Out-of-band spectrum*

If the frequency is plotted as the abscissa in logarithmic units and the power densities are plotted as ordinates, in decibels, the curve representing the out-of-band spectrum should lie below two straight lines starting at point $[+(f + 5B/2), -24$ dB$]$ or at point $[-(f + 5B/2), -24$ dB$]$, with a slope of 12 dB per octave, and finishing at point $[+(f + 5B), -36$ dB$]$ or $[-(f + 5B), -36$ dB$]$, respectively. Thereafter, the same curve should be below the level -36 dB.

The reference level, 0 dB, corresponds to that of the carrier in a continuous emission with modulating oscillation.

The permissible amounts of out-of-band power above and below the frequency limits of the necessary bandwidth, are each approximately 0.5% of the total mean power radiated.

3.4 *Amplitude-modulated radiotelephone emission, excluding emissions for sound broadcasting*

The spectrum limits described in this section for radiotelephone emissions have been deduced from various measurements. The peak envelope power of the transmitter is first determined using the method described in Recommendation 326, § 3.1.3, and the transmitter is adjusted for an acceptable distortion for the class of service.

Measurements have been made using several different modulating signals substituted for the two audio tones. It has been found that white or weighted noise, with the bandwidth limited by filtering to the desired bandwidth of the information to be transmitted in normal service, is a satisfactory substitute for a speech signal in making practical measurements.

In the curves defined in § 3.4.1 and 3.4.2 the ordinates represent the energy intercepted by a receiver of 3 kHz bandwidth, the central frequency of which is tuned to the frequency plotted on the abscissa, normalized to the energy which is intercepted by the same receiver when tuned to the central frequency of the occupied band.

However, a receiver with 3 kHz bandwidth cannot provide detailed information in the frequency region close to the edge of the occupied band. It has been found that point-by-point measurements with a receiver having an effective bandwidth of 100 to 250 Hz or with a spectrum analyzer with similar filter bandwidth are more useful in analyzing the fine structure of the spectrum.

To make these measurements, the attenuation-frequency characteristics of the filter limiting the transmitted bandwidth should first be determined. The transmitter is then supplied with a source of white noise or weighted noise, limited to a bandwidth somewhat larger than the filter bandwidth.

In applying the input signal to transmitter, care should be taken that, at the output, the peaks of the signal do not exceed the peak envelope power of the transmitter or the level corresponding to a modulation factor of 100%, whichever is applicable, for more than a specific small percentage of time. This percentage will depend on the class of emission, and in this connection, reference is made to Part D, § 2.1 of Report 977.

3.4.1 *Class of emission A3E double-sideband telephony*

3.4.1.1 *Necessary bandwidth*

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

3.4.1.2 *Power within the necessary band*

The statistical distribution of power within the necessary band is determined by the relative power level of the different speech frequency components applied at the input to the transmitter or, when more than one telephony channel is used, by the number of active channels and the relative power level of the speech frequency components, applied at the input to each channel.

When no privacy equipment is connected to the transmitter, the power distribution of the different speech frequency components in each channel may be assumed to correspond to the curve given in CCITT Recommendation G.227 (see Annex II). This curve is not applicable to sound broadcasting.

If 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 may be assumed that the statistical distribution of power is uniform within the frequency band.

3.4.1.3 *Out-of-band spectrum*

If frequency is plotted as the abscissa in logarithmic units and if the power densities are plotted as ordinates, in decibels, the curve representing the out-of-band spectrum should lie below two straight lines starting at point ($+0.5F$, 0 dB) or at point ($-0.5F$, 0 dB), and finishing at point ($+0.7F$, -20 dB) or ($-0.7F$, -20 dB), respectively. Beyond these points and down to the level -60 dB, this curve should lie below two straight lines starting from the latter points and having a slope of 12 dB per octave. Thereafter, the same curve should lie below the level -60 dB.

The reference level, 0 dB, corresponds to the power density that would exist if the total power, excluding the power of the carrier, were distributed uniformly over the necessary bandwidth (see also Part D, § 2.2, of Report 977).

3.4.2 *Single-sideband, classes of emission R3E, H3E and J3E (reduced, full or suppressed carrier) and independent-sideband, class of emission B8E*

3.4.2.1 *Necessary bandwidth*

3.4.2.1.1 For classes of emission R3E and H3E, the necessary bandwidth F is, in practice, equal to the value of the highest audio frequency f_2, which it is desired to transmit with a specified small attenuation.

3.4.2.1.2 For class of emission J3E, the necessary bandwidth F is, in practice, equal to the difference between the highest f_2 and lowest f_1 of the audio frequencies which it is desired to transmit with a specified small attenuation.

3.4.2.1.3 For class of emission B8E, the necessary bandwidth F is, in practice, equal to the difference between the two radio frequencies most remote from the assigned frequency, which correspond to the two extreme audio frequencies to be transmitted with a specified small attenuation in the two outer channels of the emission.

3.4.2.2 *Power within the necessary band*

For considerations with regard to the power in the necessary band, reference is made to § 3.4.1.2.

3.4.2.3 *Out-of-band spectrum for class of emission B8E; four telephony channels simultaneously active*

The out-of-band power is dependent on the number and position of the active channels. The curves described below are only appropriate when four telephone channels are active simultaneously. When some channels are idle, the out-of-band power is less.

If frequency is plotted as the abscissa in logarithmic units, the reference frequency being supposed to coincide with the centre of the necessary band, and if the power densities are plotted as ordinates, in decibels, the curve representing the out-of-band spectrum should lie below two straight lines starting at point ($+0.5F$, 0 dB), or at point ($-0.5F$, 0 dB), and finishing at point ($+0.7F$, -30 dB) or ($-0.7F$, -30 dB), respectively. Beyond the latter points and down to the level -60 dB, this curve should lie below two straight lines starting from the latter points and having a slope of 12 dB per octave. Thereafter, the same curve should lie below the level -60 dB.

The reference level, 0 dB, corresponds to the power density that would exist if the total power, excluding the power of the reduced carrier, were distributed uniformly over the necessary bandwidth.

3.5 *Amplitude-modulated emissions for sound broadcasting*

The spectrum limits described in this section for amplitude-modulated emissions for sound broadcasting have been deduced from measurements performed on transmitters which were modulated by weighted noise to an r.m.s. modulation factor of 35% in the absence of any dynamic compression of the signal amplitudes (see Part D, § 3.1, of Report 977).

3.5.1 *Class of emission A3E, double-sideband sound broadcasting*

3.5.1.1 *Necessary bandwidth*

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

3.5.1.2 *Power within the necessary band*

The statistical distribution of power within the necessary band is determined by the relative power level of the different audio-frequency components applied at the input to the transmitter.

The power distribution in the audio-frequency band of an average broadcast programme can be assumed to correspond to the curve given in Recommendation 559. In practice, this curve will not be exceeded for more than 5% to 10% of the programme transmission time.

3.5.1.3 *Out-of-band spectrum*

If frequency is plotted as the abscissa in logarithmic units and if the power densities are plotted as ordinates, in decibels, the curve representing the out-of-band spectrum should lie below two straight lines starting at point ($+0.5F$, 0 dB) or at point ($-0.5F$, 0 dB), and finishing at point ($+0.7F$, -35 dB) or ($-0.7F$, -35 dB), respectively. 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 having a slope of 12 dB per octave. Thereafter, the same curve should lie below the level -60 dB.

The reference level, 0 dB, corresponds to the power density that would exist if the total power, excluding the power of the carrier, were distributed uniformly over the necessary bandwidth (see also Part D, § 3.2, of Report 977).

The ordinate of the curve so defined represents the average power intercepted by an analyzer with an r.m.s. noise bandwidth of 100 Hz, the frequency of which is tuned to the frequency plotted on the abscissa.

3.6 *Class of emission F1B*

For class of emission F1B, frequency-shift telegraphy, with or without fluctuations due to propagation:

3.6.1 *Necessary bandwidth*

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

$2.6D + 0.55B$ within 10% for $1.5 < m < 5.5$,

$2.1D + 1.9\,B$ within 2% for $5.5 \leq m \leq 20$.

3.6.2 *Out-of-band spectrum*

If frequency is plotted as the abscissa in logarithmic units and if the power densities are plotted as ordinates, in decibels, the curve representing the out-of-band spectrum should lie below two straight lines of constant slope in decibels per octave, starting from the two points situated at the frequencies limiting the necessary bandwidth, and finishing at the level -60 dB. Thereafter, the same curve should lie below the level -60 dB. The starting ordinates of the two straight lines and their slopes are given in Table II, as a function of the modulation index, m:

TABLE II

Modulation index	Starting ordinates (dB)	Slope (dB per octave)
$1{\cdot}5 \leqslant m < 6$	-15	$13 + 1{\cdot}8\ m$
$6 \leqslant m < 8$	-18	$19 + 0{\cdot}8\ m$
$8 \leqslant m \leqslant 20$	-20	$19 + 0{\cdot}8\ m$

The reference level, 0 dB, corresponds to the mean power of the emission.

The permissible amounts of out-of-band power, above and below the frequency limits of the necessary bandwidth, are each approximately 0.5% of the total mean power radiated.

3.6.3 *Build-up time of the signal*

An out-of-band spectrum close to the limiting curve described in § 3.6.2 corresponds to a build-up time equal to about 8% of the initial duration of the telegraph dot, i.e. about $1/12B$, provided that an adequate filter is used for signal shaping.

3.6.4 *Bandwidth occupied, for unshaped signals*

For the purpose of comparison with the above formulae, 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:

$2.6D + 1.4B$ within 2% for $2 \leqslant m \leqslant 8$,

$2.2D + 3.1B$ within 2% for $8 \leqslant m \leqslant 20$.

3.7 *Frequency-modulated emissions for sound broadcasting*

3.7.1 *Class of emission F3E, monophonic sound broadcasting*

3.7.1.1 *Necessary bandwidth*

The necessary bandwidth can be calculated by the formula, provided in Appendix 6 to the Radio Regulations:

$$B_n = 2\ M + 2\ DK$$

where:

B_n: necessary bandwidth,

M: highest modulation frequency,

D: maximum deviation of the RF carrier,

K: factor, equals 1 if the condition $D \gg M$ is met.

3.7.2 *Classes of emission F8E and F9E, stereophonic sound broadcasting*

3.7.2.1 *Necessary bandwidth*

Since generally the condition that $D \gg M$ is not met, sufficient information for the determination of the factor K is not available and the formula mentioned in § 3.7.1.1 is recommended as a guide.

Measurement results have shown that the RF bandwidth of stereophonic FM sound-broadcast emissions are smaller than one would expect from calculations using the formula with a factor $K = 1$.

Although Recommendation No. 63 of WARC-79 states in its considerings that sufficient information is not available for the determination of a reliable formula and that for reasons of simplification and international uniformity it is desirable that measurements for determining the necessary bandwidth be made as seldom as possible.

For the present, the necessary bandwidth for F8E and F9E emissions should be determined by measurement, taking into consideration the requirement that transmission and quality standards must be specified.

4. Measurement of spectra and bandwidths of emissions

that attention should be paid to the following methods of measurement:

4.1 *Direct methods of measuring the x dB bandwidth and the out-of-band spectrum*

The methods described below are designed to obtain, in various ways, the spectrum of the signal from which the x dB bandwidth may be derived by direct reading. Various characteristics of the out-of-band spectra such as the initial starting point levels and the decay rates may also be derived. A description of the method of establishing the "0 dB" reference levels for determining the x dB bandwidth and the values of x dB levels for various classes of emission is given in Reports 275, 324 and 420 (Dubrovnik, 1986).

By determining, by means of integration, the power in the two outer parts of the spectrum relative to the power of the complete spectrum and by using the appropriate value of the power ratio $\beta/2$, it is possible to determine also the occupied bandwidth.

The following methods of spectrum analysis may be used:

4.1.1 *Methods with single bandpass filter (sequential spectrum analysis)*

This method consists in completely analyzing the spectrum of the emission by means of a narrow-band filter of fixed frequency and bandwidth, the frequency of each component being made sequentially to coincide with the central frequency of the filter by an appropriate frequency conversion which is controlled either manually or automatically.

Measuring equipment employing this technique may have been designed for analyzing the spectrum of either periodic signals (voltage spectrum analyzers) or non-periodic signals (power spectrum analyzers). For the characteristics of both types of equipment, see Annex IV. See also § 4.4 for the use of this equipment for the measurement under actual traffic conditions.

4.1.2 *Method with multiple bandpass filters (simultaneous spectrum analysis)*

This method consists in dividing the occupied band into narrow-bands for each of which a bandpass filter is provided; the output of each filter is connected either individually and permanently to its own measuring device, or successively and automatically to a single measuring device. This method seems especially suitable for the examination of non-periodic signals, such as radiotelephone emissions.

4.1.3 *Other methods of spectrum analysis*

These methods employ conversion from time domain to frequency domain and include various new techniques of spectrum analysis based either on the use of special measuring equipment (for example for time dispersion and signal compression in time) or on mathematical analysis (e.g., the analysis of the signal spectrum by "fast Fourier transform" by means of a computer).

4.2 *Direct methods of determining occupied bandwidth by measurement of the power ratio β/2*

The methods described below compare the total power of the emission with the power remaining after filtering. Alternatively, the relevant power constituents can be determined by evaluating the power spectrum as obtained by a spectrum analyzer.

4.2.1 *Method using a single high-pass filter*

With this method, use is made of a single fixed high-pass filter. By means of the variable-frequency oscillator of a frequency converter, two cut-off frequencies are determined such that, above the first frequency and below the second, the powers at the output of the filter are $\beta/2$ in % of the total power at the input. The bandwidth occupied is given by the difference between the two cut-off frequencies.

The measuring procedure can be simplified by using an adjustable oscillator, working alternately at two frequencies of constant mean value, their difference being adjusted by a single control the dial of which is calibrated in terms of bandwidth.

If the spectral distribution is substantially symmetrical, a simpler method can be used, in which the frequency components of the rectified signal are selected by means of a high-pass filter, the cut-off frequency of which is progressively increased.

4.2.2 *Method using two high-pass filters*

With this method, use is made of 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 filter selects β/2% of the total power.

4.2.3 *Method using a high-pass and a low-pass filter*

With this method, a low-pass filter and a high-pass filter with the same cut-off frequency are used to select the upper and lower out-of-band components independently.

Two frequency converters are used. The frequencies of the two oscillators are automatically and independently adjusted, so that each of the two filters selects β/2 in % of the total power. The frequency difference between these two oscillators is equal to the occupied bandwidth and is measured by means of a frequency measuring device which directly indicates the frequency difference.

4.2.4 *Method using a spectrum analyzer*

With this method [CCIR, 1982-86] the frequency limits above and below at which the powers are β/2 in per cent of the total power are determined by evaluating the power spectrum of an emission as obtained by spectrum analysis. The relevant power values are determined by the summation of the powers of the individual spectral components.

This assumes a line spectrum which exists only for periodic signals. The spectrum of actual traffic signals, however, is a continuous spectrum. Nevertheless, this method can also be applied in the latter case, because it is sufficient for the determination of the occupied bandwidth to select samples of the spectrum with equidistant frequency separation. This frequency separation must only be chosen in such a way that the samples reproduce the envelope of the spectrum sufficiently well. Since a conventional spectrum analyzer performs a sequential and not a real-time analysis of the spectrum, it is advisable to make a number of scans in mode of operation "maximum hold".

Although this method theoretically requires a power spectrum analyzer whereas the majority of analyzers available are voltage spectrum analyzers, the latter may be used taking account of the limitations indicated in § 4.4. Thus, this method is particularly suited for determining the occupied bandwidth of signals containing digital or quantized information with their quasi-periodic spectra, e.g. telegraphy, data and radar signals.

Using modern spectrum analyzers with a digital memory, this method is especially suitable for computerizing.

4.3 *Indirect methods of determining occupied bandwidth*

The methods described below are based on the relationship between the occupied bandwidth and other parameters, such as the out-of-band spectrum decay rate, the telegraph signal build-up time, the r.m.s. value of the frequency deviation, etc. In some cases, for example in the case of noise or interference, or when measurements are carried out on signals under actual traffic conditions, these parameters can often be measured with greater accuracy than the actual occupied bandwidth itself.

4.3.1 *Method based on the measurement of the decay rate of the out-of-band spectrum*

The method consists in calculating the spectral power density levels at the limits of the occupied bandwidth, using the known value β/2 in per cent and the measured decay rate of the out-of-band spectrum for a given law of spectral power density distribution within the limits of the out-of-band spectrum, and in subsequent measuring of the bandwidth at these levels. A description of the method is given in Report 324, § 2.2.1, and Report 275, § 11.1.

4.3.2 *Method based on the measurement of the relative pulse build-up time*

For telegraph classes of emission, the occupied bandwidth depends on the relative pulse build-up time defined in § 1.21 and may be calculated from the measured values of the relative pulse build-up time of the shortest pulse.

For A1A, A1B and F1B emissions, the formulae, given in § 1.2 of Part B and Part A respectively of Report 977, can be used.

4.3.3 *Method for frequency modulated emissions, using the r.m.s. value of the frequency deviation*

This method, based on the relationship between the occupied bandwidth of frequency-modulated single-channel radiotelephone emissions and the r.m.s. frequency deviation, is described in Report 324, § 2.2.2.

4.4 *Measurements under actual traffic conditions*

The spectra of actual traffic signals cannot generally be analyzed accurately enough for practical purposes with sequential spectrum analyzers (§ 4.1.1) designed for analyzing the spectra of periodic signals and equipped with detectors having a short time-constant. Spectrum analysis of actual traffic signals with fairly intense channel loading and without appreciable interruptions should preferably be carried out by power spectrum analyzers with post-detection averaging devices having a sufficiently long integrating time (see also Annex IV).

Spectrum analysis of a number of telegraph classes of emission – A1A, A1B, F1B, H2B, J2B and F7BDX – on actual traffic signals may be carried out by means of analyzers for periodic signals (voltage spectrum analyzers) if the bandwidth of the analyzing filter is approximately equal to the modulation rate. Under these conditions, the envelopes of the reproduced spectra, except for relatively narrow sectors contiguous to the carrier, the mark and space frequencies or the nominal transmitted frequencies, whichever is applicable, coincide with the spectrum envelope of these classes of emission when transmitting telegraph signals with equal marks and spaces. In these narrow sectors, the maximum response may reach the level of the unmodulated carrier (unmodulated nominal transmitted frequencies).

The spectra of actual traffic signals measured in this way differ in detail from actual power spectra, since their structure is not reproduced, but their envelopes are smoothed out. Nevertheless, the method can be used to measure occupied bandwidths according to § 4.2.4, x dB bandwidths and the decay rates of out-of-band spectra, since for the purposes of such measurements the envelope of a spectrum is of greater interest than its details.

5. Accuracies required for bandwidth measurements

that Annex III should be consulted for the accuracies required for bandwidth measurements.

REFERENCES

CCIR Documents

[1982-86]: 1/119 (Germany (Federal Republic of)).

ANNEX I

Examples of spectra illustrating the definitions of out-of-band power, necessary bandwidth and x dB bandwidth.

Abscissae: frequency

Ordinates: power per unit frequency.

Note 1 – Symmetrical spectra are assumed.

Note 2 – The dotted lines denote the permissible limiting curve for the out-of-band spectrum.

Emission wider than "optimum"

Emission corresponding to "optimum"

Emission narrower than "optimum"

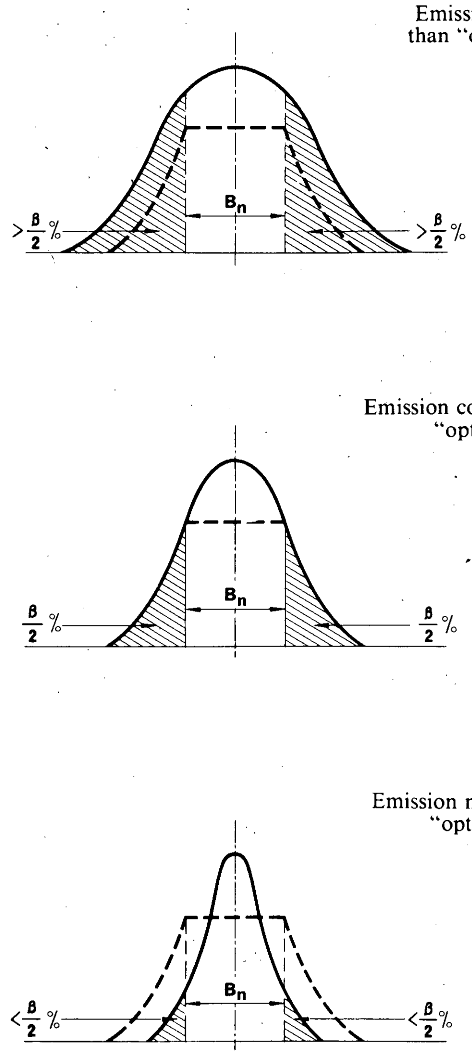


FIGURE 1 – *Evaluation of spectra, by comparing out-of-band power and band limitation*

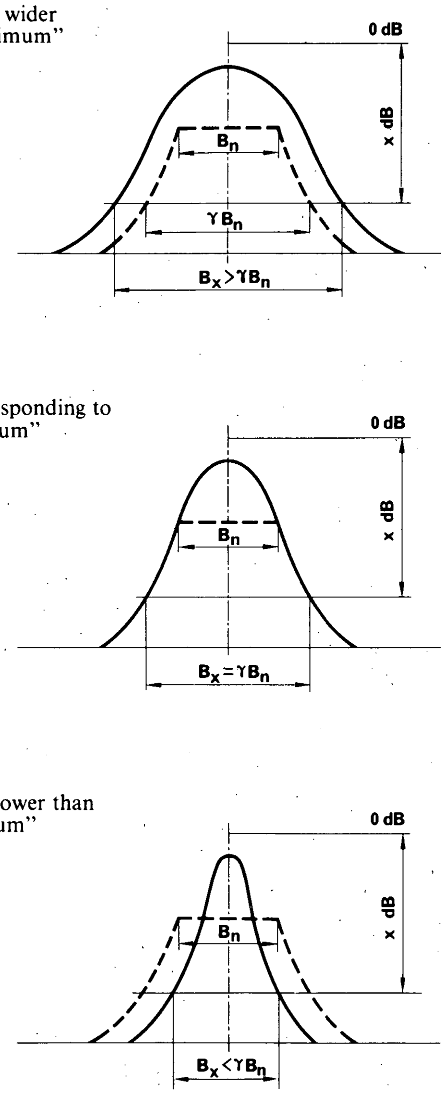


FIGURE 2 — *Evaluation of spectra by means of the x dB bandwidth*

B_n: necessary bandwidth

B_x: x dB bandwidth

x: value of measurement level (dB)

γ: required relationship between x dB bandwidth and necessary bandwidth, determined by the x dB level and the parameters of the limiting curve for the out-of-band spectrum

$\frac{\beta}{2}$: half of permissible out-of-band power

ANNEX II

(Extract from CCITT Recommendation G.227)

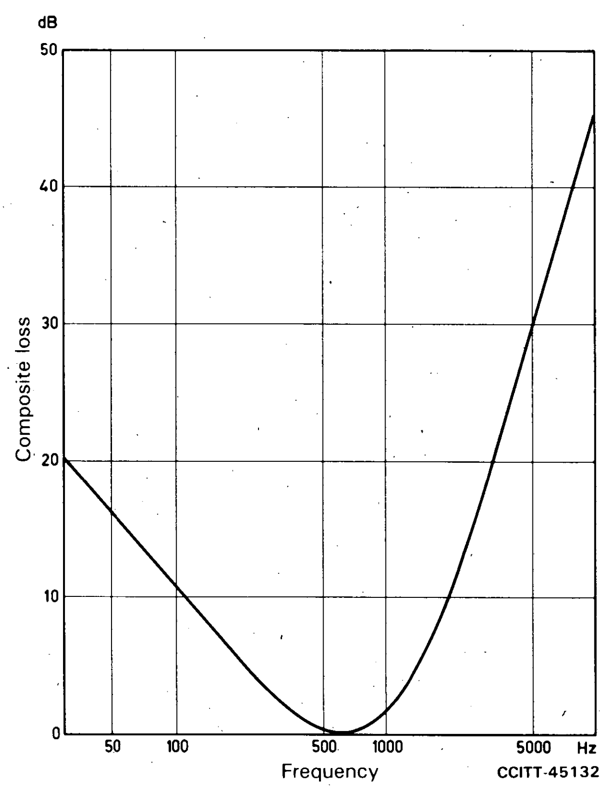
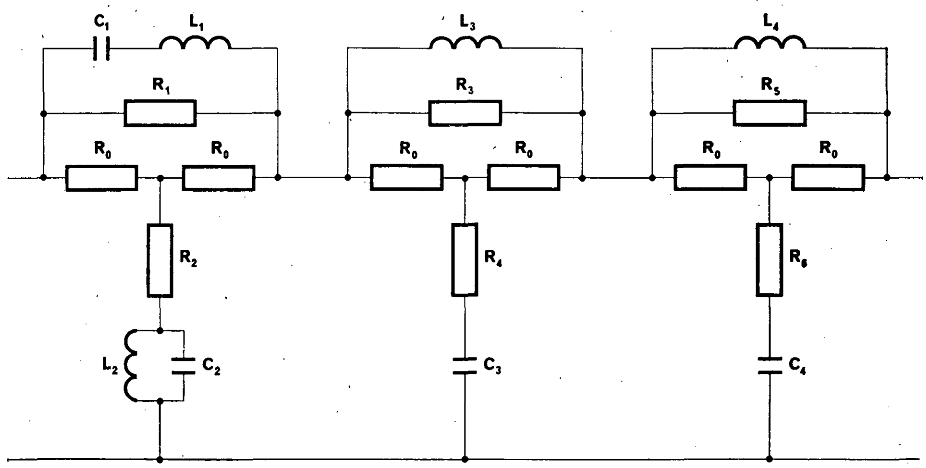


FIGURE 3 – *Relative response curve of the shaping network of the conventional telephone signal generator*



Section 1	Section 2	Section 3
$\frac{R_1}{R_0} = 45$	$\frac{L_1\,\omega_0}{R_0} = 0{\cdot}5$	$R_0C_1\,\omega_0 = 2$
$\frac{R_2}{R_0} = 0{\cdot}0222$	$\frac{L_2\,\omega_0}{R_0} = 2$	$R_0C_2\,\omega_0 = 0{\cdot}5$
$\frac{R_3}{R_0} = 10$	$\frac{L_3\,\omega_0}{R_0} = 0{\cdot}5$	$R_0C_3\,\omega_0 = 0{\cdot}5$
$\frac{R_4}{R_0} = 0{\cdot}1$	$\frac{L_4\,\omega_0}{R_0} = 1{\cdot}11$	$R_0C_4\,\omega_0 = 1{\cdot}11$
$\frac{R_5}{R_0} = 22$		
$\frac{R_6}{R_0} = 0{\cdot}0455$	$\omega_0 = 2\pi \times 10^3 \times \text{second}^{-1}$	

FIGURE 4 — *Shaping network of the conventional telephone signal generator*

R_0: characteristic impedance of network

Tolerance of components: ± 1%

ANNEX III

ACCURACIES REQUIRED FOR BANDWIDTH MEASUREMENT

1. Measurement of x dB bandwidth according to § 4.1

1.1 *Laboratory apparatus*

This type of equipment requires that the signals under test should give rise to a spectrum, the components of which are 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 on the accuracy of calibration of the attenuator and of the frequency meter.

An accuracy of ± 1% in the measurement of the amplitude is obtainable, but an accuracy of ± 5% is sufficient for most practical purposes.

1.2 *Automatic sweep apparatus*

Provided that the spectrum analyzer has the characteristics given in Annex IV, the amplitudes of the components can be measured with an accuracy of ± 2 dB. However, a higher degree of accuracy, of the order of ± 1 dB, should be aimed at, without automatic scanning and with static operation of the spectrum analyzer. The relationship between the error in the measurement of the x dB bandwidth and the error in the measurement of the spectrum component levels is given in Report 324.

The accuracy of measurement of frequency separation depends mainly on the linearity of the sweep and on the width of the explored band.

However, in the measurement of periodic signals, the frequency intervals between successive components are generally apparent.

2. Measurement of occupied bandwidth according to § 4.2

The accuracy of these methods depends on the accuracy of the measurement of the power ratio and on the characteristics of the filters employed. The relationship between the error in the measurement of the occupied bandwidth and the error in the power comparison is given in Report 324.

3. Effect of noise on the accuracy of bandwidth measurements

The effect of noise on the accuracy achieved in the measurement of bandwidth by various methods is discussed in Report 275, § 11.

ANNEX IV

CHARACTERISTICS OF MEASURING EQUIPMENT WITH AUTOMATIC FREQUENCY-SWEEP

Equipment designed for the sequential analysis of the spectra of radio transmitters (§ 4.1.1) when modulated by periodic signals (voltage spectrum analyzers), or random signals (power spectrum analyzers) should normally meet the following requirements.

1. Analyzing filter passband, Δf

The analyzing filter passband of a voltage spectrum analyzer at a level of -3 dB should not exceed $0.3\ F_m$, where F_m is the frequency of the transmitter modulating (keying) signal.

The analyzing filter passband of a power spectrum analyzer should not exceed $0.05\ B_n$, where B_n is the necessary bandwidth for the corresponding class of emission.

To increase the scanning speed, the shape of the filter frequency response curve should be approximately Gaussian.

2. Time constant of an averaging (post-demodulator) filter, τ

The time constant of the averaging filter of a voltage spectrum analyzer should be as short as possible, i.e. just sufficient to filter out the intermediate frequency component of the signal at the filter output.

The time constant of the averaging filter of a power spectrum analyzer is selected as:

$$\tau \geqslant \frac{16}{\Delta f} \ (\tau \text{ in seconds; } \Delta f \text{ in Hz}). \tag{1}$$

3. Scanning range, P

The scanning range should be adequate to include the outermost sideband components whose reproduction is desirable. For x dB bandwidth measurements, the scanning range may be selected on the basis of the condition:

$$P \approx 1.5\ B_x \tag{2}$$

where B_x is the x dB bandwidth.

For measuring the bandwidth and the out-of-band radiation spectra of transmitters working in the 150 kHz to 30 MHz range, it is desirable to have a continuous or discretely-varying scanning range between 1 and 60 kHz.

4. Scanning time, T

The permissible scanning time depends on the passband and the shape of the response curve of the analyzing filter, the type of detector used, the time constant of the averaging filter and the scanning range.

In the case of voltage spectrum analyzers where the analyzing filter has a Gaussian frequency response curve, the scanning time is determined by the formula:

$$T \geqslant \frac{P}{(\Delta f)^2} \ (T \text{ in seconds, } P \text{ and } \Delta f \text{ in Hz}). \tag{3}$$

When measuring the x dB bandwidth by means of power spectrum analyzers with an error not exceeding 10%, the permissible scanning speed, using a linear demodulator, a square-law detector, or a detector with logarithmic amplifiers, should be selected on the basis of the following conditions:

– with a spectrum slope, Q, at the B_x measurement point of less than 30 dB/octave:

$$T_{lin} \geqslant 8.3 \ \tau \ \frac{P}{B_x} \sqrt{3.4 \left(1 + \frac{3}{Q}\right)} \tag{4}$$

$$T_{quadr} \geqslant 11.8 \ \tau \ \frac{P}{B_x} \sqrt{3.4 \left(1 + \frac{3}{Q}\right)} \tag{5}$$

$$T_{log} \geqslant 11.8 \ \tau \ \frac{P}{B_x} \sqrt{0.1 \ Q} \tag{6}$$

– for $Q \geqslant 30$ dB/octave:

$$T_{lin} \geqslant \frac{2.3 \ P\tau \ |X|}{B_x} \tag{7}$$

$$T_{quadr} \geqslant \frac{4.6 \ P\tau \ |X|}{B_x} \tag{8}$$

$$T_{log} \geqslant \frac{4.6 \ P\tau}{B_x} \log \frac{V}{V - |X| + 1} \tag{9}$$

where X is the value of the measuring level in dB, and

V is the dynamic range of the spectrum analyzer in dB.

5. Suppression of automatic sweep

Provision should be made for stopping the automatic sweep to enable manual scanning to be used in certain cases, for example, when an automatic sweep would require too much time in relation to the equations given in § 4.

6. Form of display

For direct visual observation, the display may take the form of different types of cathode tubes, e.g. long afterglow tubes, memory tubes, as well as other devices, such as graphical recorders.

7. Dynamic range

The range of amplitude 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 separately and by stages the major and minor components such as may be obtained by the use of a calibrated attenuator or a calibrated scale applied to the oscilloscope screen.

8. Frequency stability

The frequency stability of the various beat 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 667

NATIONAL SPECTRUM MANAGEMENT DATA

(Decision 27-2)

(1990)

The CCIR,

CONSIDERING

(a) that administrations are facing increasingly voluminous and complex tasks in spectrum management due to the increased use of existing telecommunications and new telecommunications technology;

(b) that the efficient solution of spectrum management problems requires data storage, data retrieval, and analysis capabilities, and consequently requires effective spectrum management and application of computer methods;

(c) that IWP 1/2 has been tasked to develop recommended standards for computer generated national spectrum management data for exchange between administrations, bearing in mind the advantages of compatibility with standards used for the exchange of data between administrations and the IFRB (Decision 27);

(d) that IWP 1/2 has developed standards for computer generated national spectrum management data in the Handbook on Spectrum Management and Computer-aided Techniques,

UNANIMOUSLY RECOMMENDS

1. that the data elements described in Table II of Annex IV of the Handbook [ITU, 1986] should be used as the standard for specifying national spectrum management frequency assignments and notification data;

2. that the data elements should be periodically revised and updated.

REFERENCES

ITU [1986] Handbook on Spectrum Management and Computer-aided Techniques, 1983. Revised 1986, ITU, Geneva.

RECOMMENDATION 668

METHODS OF EXCHANGING COMPUTER PROGRAMS AND DATA FOR SPECTRUM MANAGEMENT PURPOSES

(Question 65/1)

(1990)

The CCIR,

CONSIDERING

(a) that the transfer of computer programs and spectrum management data would support and facilitate national spectrum management and coordination among administrations and with the IFRB in the field of spectrum management (see Decision 27);

(b) that such computer programs and spectrum management data can be transferred between computer systems of different administrations and the IFRB using existing telecommunications facilities;

(c) that such transfer via telecommunication networks generally involves administrative and maintenance tasks;

(d) that computer programs for spectrum management are available from the CCIR, administrations, or other sources;

(e) that it is effective for administrations to nationally use generally agreed data elements and compatible spectrum management computer programs;

(f) that many administrations have been successful in implementing such techniques in the development and maintenance of their national spectrum management;

(g) that data elements used in national spectrum management have been established in the IFRB's Preface to the IFL and recommended by the CCIR (see Recommendation 667);

(h) that remote real-time data entry and validation may be a costly service,

UNANIMOUSLY RECOMMENDS

1. that administrations should be encouraged to use the remote access facilities of the ITU computer system. First preference should be given to an implementation of a remote frequency assignment data entry system from administrations to the IFRB data base;

2. that administrations should be encouraged to use the same data capture and validation methods as the IFRB;

3. that administrations should be able to remotely retrieve spectrum management information from the IFRB data base; the following methods should be used in retrievals from data bases:

– on-line processing for small data retrievals;
– batch processing for large data retrievals;

4. that data base management systems used for spectrum management data should have adequate security features to prevent altering the data without adequate authorization;

5. that message formats for the exchange of data between administrations or between administrations and the IFRB should be based on Recommendation 667;

6. that administrations should be encouraged to make use of computer programs for frequency management and EMC analyses which are available under Resolution 88.

SECTION 1B: SPECTRUM SHARING AND PLANNING PRINCIPLES AND TECHNIQUES

RECOMMENDATION 337-2

FREQUENCY AND DISTANCE SEPARATIONS

(Question 18/1)

(1948-1951-1953-1963-1970-1974-1990)

The CCIR,

CONSIDERING

(a) that, in the more usual cases, the primary factors which determine appropriate frequency or distance separation criteria include:

- the signal power and spectral distribution required by the receiver;
- the power and spectral distribution of the interfering signals and noise intercepted by the receiver;
- the distance dependence of the transmission losses of the radio equipments;

(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, for aural reception, the discriminating properties of the human ear;

(d) that trade-offs in either frequency or distance separations of the radio equipments are possible,

UNANIMOUSLY RECOMMENDS

1. that the frequency-distance separations of the radio equipments should be calculated by the following method:

- determine the power and spectral distribution of the signal intercepted by the receiver;
- determine the power and spectral distribution of the interfering signals and noise intercepted by the receiver;
- that Report 654 be used to determine the basic measures which quantify the interaction effects among wanted signals, interference, and receiver characteristics for various frequency or distance separations;
- determine, from these data, the degree of frequency or distance separation that will provide the required grade of service and the required service probability. Account should be taken of the fluctuating nature both of the signal and of the interference, and, whenever appropriate, the discriminating properties of the listener or viewer;

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 frequency or distance separation among radio equipments.

Note – Recommendation 372 and Reports 322, 258 as well as Reports 413, 414 and 415 (Oslo, 1966), may be found useful in this connection.

RECOMMENDATION 669

PROTECTION RATIOS FOR SPECTRUM SHARING INVESTIGATIONS

(Question 45/1)

(1990)

The CCIR,

CONSIDERING

(a) that frequency sharing is an important aspect of efficient spectrum utilization;

(b) that the CCIR has placed a principal responsibility for the study of frequency sharing problems with Study Group 1 in coordination with other Study Groups;

(c) that work within and between CCIR Study Groups is relatively advanced in studies of frequency sharing;

(d) that Study Group 1 is cognizant of the work within and between Study Groups;

(e) that frequency sharing may have a much wider potential applicability than so far reflected in its practical use;

(f) that Study Group 1 is studying sharing problems common to two or more Study Groups in coordination with those groups;

(g) that it is desirable to determine the level of interference at which any emission, radiation or induction affects a radio service in order to derive criteria for frequency sharing, and that one method of specifying these interference levels is in terms of protection ratios;

(h) that the CCITT recommends establishing noise and interference criteria for the public switched network, that could be affected by spectrum sharing situations,

UNANIMOUSLY RECOMMENDS

1. that protection ratios for those modulation types given in Table IV of Report 525 are appropriate for spectrum sharing investigations unless more detailed technical information is available;

2. that in sharing situations involving radio circuits interconnected to the public switched network appropriate CCITT criteria should also be taken into account.

SECTION 1C: SPECTRUM MONITORING TECHNIQUES

RECOMMENDATION 575

PROTECTION OF FIXED MONITORING STATIONS AGAINST RADIO-FREQUENCY INTERFERENCE

(Questions 31/1 and 32/1)

(1982)

The CCIR,

CONSIDERING

(a) the benefits that accrue to an administration by operating fixed monitoring stations for domestic purposes as well as in the international monitoring system;

(b) that optimum performance can be obtained from a monitoring station operating with a minimum of radio-frequency interference;

(c) that radio-frequency interference levels are dependent upon the power radiated from nearby transmitters and other man-made radiating sources;

(d) that certain standards of signal levels are applicable to studies concerning the location and continuous operation of fixed monitoring stations;

(e) that it is a relatively simple matter to measure the field strength of discrete radio signals, and then to determine if interference will be produced in monitoring receivers despite steps taken by the monitoring service to eliminate the interference;

(f) that it is particularly important for developing countries to establish monitoring facilities in environments that may be expected to allow good results for the lifetime of the monitoring facility, in view of relocation costs,

UNANIMOUSLY RECOMMENDS

that administrations consider using the following field-strength criteria as standards above which a case-by-case interference analysis should be made, when siting and operating fixed monitoring stations, to help keep them free from radio-frequency interference:

Fundamental frequency, f	Field-strength standard (mV/m)	Root-sum-square values of more than one fundamental field strength (mV/m)
9 kHz $\leq f <$ 174 MHz	10	30
174 MHz $\leq f <$ 960 MHz	50	150

Note. – The root-sum-square field strength value applies to multiple signals, but only when all are within the RF passband of the monitoring receiver.

RECOMMENDATION 377-2

ACCURACY OF FREQUENCY MEASUREMENTS AT STATIONS FOR INTERNATIONAL MONITORING

(Question 22/1)

(1948-1956-1959-1963-1966-1982)

The CCIR,

CONSIDERING

(a) the requirements of the Administrations, of international organizations carrying out monitoring observations and of the IFRB, in respect of the frequency measurements necessary for the efficient performance of their duties;

(b) the general availability of suitable monitoring equipment for frequency measurements;

(c) that it is desirable that the errors of frequency measurement shall not exceed one-tenth of the frequency tolerances specified in Appendix 7 to the Radio Regulations,

UNANIMOUSLY RECOMMENDS

that monitoring equipment and procedures shall be such that frequency measurements shall be made with an accuracy equal to, or better than, that specified in Table I:

TABLE I – *Accuracy of frequency measurements at monitoring stations*

Type of measurement	Accuracy
1. Measurements of the frequencies of stations, except broadcasting stations, operating in the band 9 kHz to 4000 kHz	± 5 parts in 10^6 (or where this would be less than ± 1 Hz, to an accuracy of ± 1 Hz)
2. Measurements of the frequencies of broadcasting stations, operating in the band 9 kHz to 4000 kHz	± 1 Hz
3. Measurements of frequencies of stations operating in the band 4000 kHz to 29.7 MHz	± 1 Hz
4. Measurements of frequencies of stations, except television, operating in the band 29.7 MHz to 470 MHz(1)	± 0.5 parts in 10^6
5. Measurements of frequencies of stations, except television, operating in the band 470 MHz to 2450 MHz	± 2 parts in 10^6
6. Measurements of frequencies of television stations operating in the band 29.7 MHz to 2450 MHz	± 50 Hz
7. Measurements of frequencies of stations operating in the band 2450 MHz to 10.5 GHz	± 5 parts in 10^6
8. Measurements of frequencies of stations operating in the band 10.5 GHz to 40 GHz	± 10 parts in 10^6

(1) Land mobile service transmitters at 150 and 450 MHz have a sliding tolerance in parts in 10^6 (100-470 MHz).

Note. – It is realized that, while the accuracies quoted above are sufficient for international monitoring, different accuracies may be needed to meet national requirements.

RECOMMENDATION 378-4

FIELD-STRENGTH MEASUREMENTS AT MONITORING STATIONS AND EXPEDITIOUS METHODS FOR MAKING THESE MEASUREMENTS

(Question 24/1)

(1953-1956-1963-1966-1978-1982-1986)

The CCIR,

CONSIDERING

(a) that field-strength measurements are made at monitoring stations in the frequency range 9 kHz to 1 GHz;

(b) that accurate measurements, for use in connection with the international registration and assignment of frequencies, may be desirable;

(c) that stations participating in the international monitoring system, as a part of their normal work, need to make expeditious measurements of the field strength of harmful interference;

(d) that a lower degree of accuracy than that specified in § 2 below may sometimes be accepted, in the frequency band from 9 kHz to 30 MHz;

(e) that the publication of field strength data from monitoring is also desirable,

UNANIMOUSLY RECOMMENDS

1. that, to obtain the accuracies specified in § 2, the field-strength measuring equipment at monitoring stations should be installed and operated in accordance with Annex I 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 values above 1 μV/m, should be:

Frequency band (MHz)	Accuracy of measurement (dB)
Below 30	± 2
30 to 1000	± 3

3. that when, because of limitations of measuring instruments, interference, signal instability or for other reasons, the accuracies in § 2 are not obtainable, the measurements should nevertheless receive due consideration commensurate with the accuracy indicated.

4. that, for the expeditious measurement of field strength at monitoring stations, a method either of substitution or of overall calibration of the measurement system, providing an accuracy better than ± 6 dB be adopted from among the methods specified in Report 273.

ANNEX I

1. Antenna installation

1.1 *Frequencies of 30 MHz and below*

It is recommended that, for frequencies of 30 MHz and below, vertical antennas be used. A vertical antenna shorter than one-quarter of a wavelength may be used, with a ground system consisting of either buried radial conductors at least twice the length of the antenna and spaced 30°, or less apart, or an equivalent ground screen. An inverted cone type vertical antenna with a similar ground system may also be used, with some advantage.

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 voltage developed at the output of a vertical antenna shorter than one-quarter of a wavelength is substantially independent of frequency. Since the impedance of this antenna is capacitively reactive, the subsequent voltage response in a field-strength measuring instrument, when connected to a properly terminated transmission line, is essentially a direct function of frequency, resulting in a simple, relatively uniform calibration curve;

1.1.3 a conical form of a vertical antenna provides substantially greater pick-up than a short single element vertical antenna. It provides uniform impedance characteristics and reasonably smooth gain characteristics in the 2 to 30 MHz range; also it provides a uniform, frequency dependent calibration curve at frequencies below about 2 MHz, depending upon the size.

1.2 *Frequencies above 30 MHz*

Antennas for field-strength measurement at frequencies above 30 MHz 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, short monopole antennas, half-wave dipoles and high-gain antennas are appropriate;

1.2.2 it is preferable that the antennas be located at a height of 10 m above ground;

1.2.3 consideration must be given to surrounding terrain (possible obstructions) to minimize factors reducing accuracy. If at all possible, measurements should be taken at several adjacent locations (cluster observations) using the resultant average value, or by conducting continuously recorded measurements while moving in a radial direction to note effect of terrain and to allow statistical improvement of results.

1.3 *Antenna factor*

The error in the determination of the antenna factor should be kept within 1 dB. The antenna factor takes into account coupling or mismatch losses between the antenna and the 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. 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.

When the high-resolution monitoring technique described in § 2 of Report 273 (Dubrovnik, 1986) is used, the phase noise of local oscillators in the measuring receiver should be low to avoid masking of weak signals in the presence of a high-level signal [CCIR, 1982-86].

3. Calibration

The field-strength measuring installation should be calibrated as required to maintain the accuracies given in § 2 of this Recommendation. A suitable method of calibration, which takes into account the requirements of § 1.3, involves comparison of the indicated signal levels observed with the measuring equipment with the actual field strength, as determined by a calibrated field-strength meter of known accuracy, of emissions from stations operating on or near the frequency on which regular field-strength measurements are to be performed. Where such measurements are made over an extended frequency range, a calibration curve may be prepared based on comparison measurements at frequent intervals over the frequency range of interest. When performing these comparisons, the monitoring-station antenna and the field-strength meter antenna should have the same polarization (e.g. both antennas adjusted for reception of vertically-polarized emissions, or both for horizontally-polarized emissions). To ensure against variations in receiver gain, it is desirable to check the receiver at frequent intervals (e.g. daily) with a radio-frequency standard-signal generator of known and stable characteristics.

REFERENCES

CCIR Documents

[1982-86]: 1/124 (Hungarian People's Republic).

BIBLIOGRAPHY

Recommendations URSI [1960] Commission 1.

SELBY, M. C. [May, 1953] Accurate RF voltages. *Trans. AIEE* (Communications and Electronics), **6**, 158-164.

RECOMMENDATION 443-1

BANDWIDTH MEASUREMENTS AT MONITORING STATIONS

(Question 26/1, Study Programme 26A/1)

(1966–1978)

The CCIR,

CONSIDERING

(a) the need for the measurement of bandwidths of emissions at monitoring stations to promote efficient use of the radio-frequency spectrum;

(b) that the equipment for measuring occupied bandwidths at transmitting stations does not produce accurate measurements when employed at monitoring stations;

(c) the slow progress of studies concerning the best equipment and methods for occupied bandwidth measurements;

(d) the need for a uniform estimate of bandwidths at monitoring stations, to enable the IFRB to compare the results obtained by different monitoring stations;

(e) Recommendation 328 and Reports 275, 324 and 420 (Dubrovnik, 1986),

UNANIMOUSLY RECOMMENDS

that, until bandwidth measurement methods have been developed making full allowance for the specific character of the activities of monitoring stations, these stations should apply the method consisting of the measurement of the x dB bandwidth at 6 dB and 26 dB.

The x dB bandwidth is defined in § 1.14 of Recommendation 328. The x dB measurement procedures are described in § 4.1 of Recommendation 328. Reports 275, 324 and 420 (Dubrovnik, 1986) give x dB level values for a number of classes of emission at which the x dB bandwidths are either equal to the necessary bandwidths, or stand in a given relationship thereto, provided that the requirements relating to the limitation of bandwidths and out-of-band emissions indicated in § 2 and 3 of Recommendation 328 are fulfilled.

Report 275 also describes various methods of establishing the "0 dB" reference levels. By selecting appropriate x dB levels and assuming that an adequate signal to noise ratio is available at the monitoring station, it is also possible to determine if out-of-band emission spectra conform to the curves for the out-of-band spectra defined in § 3 of Recommendation 328 and Part E of Report 977. The indications contained in § 2 of Recommendation 328 should be adopted as a basis for this procedure.

RECOMMENDATION 182-3

AUTOMATIC MONITORING OF OCCUPANCY OF THE RADIO-FREQUENCY SPECTRUM

(Question 29/1)

(1956-1966-1982-1986)

The CCIR,

CONSIDERING

(a) that the increasing demand of 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;

(e) that digital computing techniques and equipment offer a number of advantages and opportunities over analogue techniques in the implementation of automatic monitoring systems and in the processing of information gathered by these systems,

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 MHz to 1 GHz: desirable 9 kHz to 10 GHz or more;
– swept frequency range	a) variable; typical range 20 to 5000 kHz for analogue equipment;
	b) variable, typical range 20 kHz to 100 MHz for digital equipment;
– number of sweeps per minute	variable; 6 to 6000; manual stop on the required frequency;
– maximum rate 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 μV/m or better; applicable to the frequency range up to 1 GHz;
– resolution bandwidth	variable; approximately 10 Hz to 10 kHz; applicable to the frequency range up to 1 GHz;
	Note – The frequency stability of the equipment has to be consistent with the resolution bandwidth.
– signal characteristics recorded	– carrier frequency, – bandwidth, – field strength, – duration of occupancy;
– type of record	computer-operated magnetic tape, cartridge form, digital format; calibration at appropriate intervals.

Note – Frequency resolving-power is the smallest frequency difference between two stable carriers of the same level which can be distinguished. For equipment using oscilloscopes, this power is the limit to which two stable carriers of the same level can be observed separately with a difference of 3 dB between the peak levels of the emissions and the minimum level between those peaks (see Fig. 1).

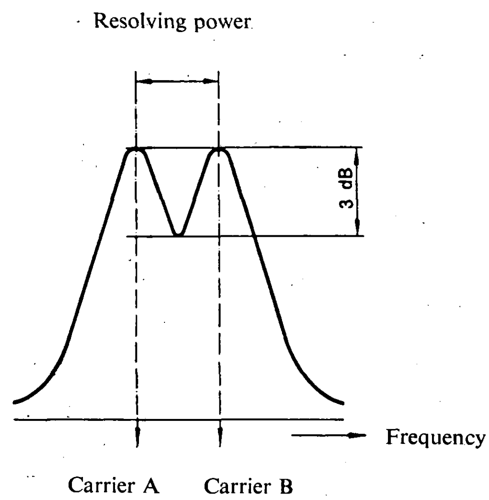


FIGURE 1

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;
- identification of the emission recorded, as appropriate;
- class of emission, as appropriate;
- direction of signal;
- noise level.

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

SECTION 1D: SPECTRUM UTILIZATION AND APPLICATIONS

RECOMMENDATION 433-4

METHODS FOR THE MEASUREMENT OF RADIO INTERFERENCE AND THE DETERMINATION OF TOLERABLE LEVELS OF INTERFERENCE

(Study Programme 4A/1)

(1966-1970-1974-1978-1990)

The CCIR,

CONSIDERING

(a) that it is necessary to know the influence of radiation from electrical apparatus and installations on radio services, especially broadcasting and mobile services, as a basis for interference suppression;

(b) that the establishment of standards for the measurement of radio interference from electrical devices and installations and for the permissible levels of interference, have been found necessary in many countries;

(c) that it would be of great practical advantage if the national regulations concerning the interference-producing properties of electrical equipment could be the same in all countries;

(d) that the International Special Committee on Radio Interference (CISPR) has done valuable work in this field and produced recommendations and reports towards international standardization;

(e) that many Administrations, Members of the ITU, are familiar with the work of the CISPR and its recommendations and reports, and that these have been studied within the CCIR,

UNANIMOUSLY RECOMMENDS

that as far as possible, Administrations should take into account the Recommendations, Reports and publications of the CISPR (see Annex I).

Note – Nevertheless, in certain cases, for apparatus installed at its place of operation, lower radio limits will be necessary, especially for protection of safety services (particularly aeronautical and maritime radionavigation).

ANNEX I

LIST OF CISPR PUBLICATIONS

1.	CISPR	Publication 11 (1975). Limits and methods of measurement of radio interference characteristics of industrial, scientific and medical (ISM) radio-frequency equipment (excluding surgical diathermy apparatus).
1.1		Amendment No. 1 (1976). Amendment No. 1 to CISPR Publication 11 (1975).
1.2		Publication 11A (1976). First supplement to CISPR Publication 11 (1975).
2.	CISPR	Publication 12 (second edition 1978). Limits and methods of measurement of radio interference characteristics of vehicles, motor boats, and spark ignited engine-driven devices.
2.1		Amendment No. 1 (1986). Amendment No. 1 to CISPR Publication 12 (1978).

3. CISPR Publication 13 (1975). Limits and methods of measurement of radio interference characteristics of sound and television receivers.

3.1 Amendment No. 1 (1983). Amendment No. 1 to CISPR Publication 13 (1975).

4. CISPR Publication 14 (second edition 1985). Limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus.

4.1 Amendment No. 1 (1987). Amendment No. 1 to CISPR Publication 14 (1985).

4.2 Amendment No. 2 (1989). Amendment No. 2 to CISPR Publication 14 (1985).

5. CISPR Publication 15 (third edition 1985). Limits and methods of measurement of radio interference characteristics of fluorescent lamps and luminaires.

5.1 Amendment No. 1 (1989). Amendment No. 1 to CISPR Publication 15 (1985).

6. CISPR Publication 16 (1987). CISPR specification for radio interference measuring apparatus and measurement methods.

7. CISPR Publication 17 (1981). Methods of measurements of the suppression characteristics of passive radio interference filters and suppression components.

8. CISPR Publication 18. Radio interference characteristics of overhead power lines and high-voltage equipment.

8.1 CISPR Publication 18-1 (1982) Part 1: Description of phenomena.

8.2 CISPR Publication 18-2 (1986) Part 2: Methods of measurement and procedure for determining limits.

8.3 CISPR Publication 18-3 (1986) Part 3: Code of practice for minimizing the generation of radio noise.

9. CISPR Publication 19 (1983). Guidance on the use of the substitution method for measurements of radiation from microwave ovens for frequencies above 1 GHz.

10. CISPR Publication 20 (1985). Measurement of the immunity of sound and television broadcast receivers and associated equipment in the frequency range 1.5 MHz to 30 MHz by the current-injection method. Guidance on immunity requirements for the reduction of interference caused by radio transmitters in the frequency range 26 MHz to 30 MHz.

11. CISPR Publication 21 (1985). Interference to radiocommunications in the presence of impulsive noise; methods of judging degradation and measures to improve performance.

12. CISPR Publication 22 (1985). Limits and methods of measurement of radio interference characteristics of information technology equipment.

13. CISPR Publication 23 (1987). Determination of limits for industrial, scientific and medical equipment.

Note 1 – The following IEC publications may also be of interest:

IEC Publication 106 (second edition 1974). Recommended methods of measurement of radiated and conducted interference from receivers for amplitude-modulation, frequency-modulation and television broadcast transmissions.

Amendment No. 1 (1983). Amendment No. 1 to IEC Publication 106 (1974).

Note 2 – These publications may be purchased from Central Office of the IEC (Sales Department), 1, rue de Varembé, CH-1211, Geneva 20, Switzerland.

RECOMMENDATION 508

USE OF RADIO-NOISE DATA IN SPECTRUM UTILIZATION STUDIES

(Question 46/1 and Study Programme 46A/1)

(1978)

The CCIR,

CONSIDERING

(a) that for system design and system performance analysis for use in spectrum utilization studies information concerning the composite radio-noise environment is needed;

(b) that this composite radio-noise environment can consist of various combinations of natural and man-made radio noise, both intentionally and unintentionally radiated;

(c) that much usable information is given in the Reports of various CCIR Study Groups,

UNANIMOUSLY RECOMMENDS

that the information contained in Reports 258, 322, 342, and 670 should be used in assessing the intensity and other characteristics of the radio-noise environment until new information to justify revision of these Reports is made available.

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

RESOLUTIONS AND OPINIONS

RESOLUTION 15-1

EXTENSION OF THE INTERNATIONAL MONITORING SYSTEM TO A WORLD-WIDE SCALE

(Question 32/1)

(1963–1970)

The CCIR,

CONSIDERING

(a) that Recommendation No. 30 of the World Administrative Radio Conference, Geneva, 1979, stresses the urgent need for improvement in the international monitoring system and invites administrations to make every effort to develop monitoring facilities;

(b) that there are still wide areas of the world where the facilities available to the international monitoring system are inadequate or non-existent;

(c) that it is of utmost importance, to satisfy the needs of the IFRB, laid down by the Radio Regulations, that all countries having domestic monitoring facilities make them available for international monitoring to the maximum possible extent;

(d) that it is recognized that certain stations may participate in only a limited part of the whole field of monitoring,

UNANIMOUSLY DECIDES

1. that all administrations now participating in the international monitoring system should be urged to continue to do so to the maximum extent possible;

2. that administrations, which do not at present participate in the international monitoring system, should be urged to make monitoring facilities available to that system, in accordance with Article 20 of the Radio Regulations;

3. that administrations, located in those areas of the world where monitoring facilities are inadequate, should be urged to promote the establishment of monitoring stations for their own use and make them available for international monitoring, in accordance with Article 20 of the Radio Regulations.

RESOLUTION 62

HANDBOOK FOR MONITORING STATIONS

(Question 32/1, Decision 53)

(1978)

The CCIR,

CONSIDERING

(a) the importance of monitoring in the improvement of general operation of expanding radio services;

(b) the difficulties encountered by administrations in collecting information required for the establishment or modernization of monitoring stations;

(c) the importance of making available information which would enable developing countries to set up their own stations and to take part in the international monitoring system;

(d) the need for visual and aural records of typical interfering radiations as an aid to personnel at stations in the international monitoring system;

(e) that the Handbook for Monitoring Stations is a valuable source of information on monitoring,

UNANIMOUSLY DECIDES

1. that the Handbook for Monitoring Stations together with complementary information, such as magnetic tape recordings, shall continue to be published and maintained by the CCIR Secretariat;

2. that the Handbook for Monitoring Stations will need to be revised to take into account advances in radio techniques;

3. that Administrations, Recognized Private Operating Agencies and International Organizations should submit proposed amendments and additions to the Handbook in the same form as other CCIR texts;

4. that Study Group 1 shall examine these amendments and additions and shall be responsible for the adoption of the final texts;

5. that the CCIR Secretariat shall publish these adopted texts for insertion in the Handbook.

RESOLUTION 71

HANDBOOK FOR COMPUTER-AIDED TECHNIQUES IN RADIO-FREQUENCY MANAGEMENT

(Questions 44/1, 45/1 and Decision 27-1)

(1982)

The CCIR,

CONSIDERING

(a) the importance of analytical techniques and the use of computers in spectrum management;

(b) that with the increasing complexity of spectrum management, due to growing demands on the spectrum, administrations may find it desirable to employ computer assisted analysis techniques to achieve more efficient spectrum utilization;

(c) that, because of continuing technological developments, increasingly powerful computers are available at reasonable cost, especially in the field of mini-computers;

(d) that a substantial range of spectrum utilization problems encompass data storage, retrieval and analysis activities and are consequently amenable to the application of computer based methods;

(e) that frequency coordination between administrations and with the IFRB would be enhanced by the transfer of computer generated data based on an agreed format;

(f) that Interim Working Party 1/2, constituted under the terms of reference of Decision 27, has developed draft Report AF/1(Rev.1) which contains valuable information about computer-aided techniques and is summarized in Report 841;

(g) that the World Administrative Radio Conference, (WARC) Geneva 1979, approved Recommendation No. 31 which specified that a Handbook on "computer-aided techniques" should be prepared by 1982,

UNANIMOUSLY DECIDES

1. that a Handbook describing spectrum management and computer-aided techniques (containing the material in draft Report AF/1(Rev.1) and such modifications as required) shall be published and maintained by the CCIR Secretariat;

2. that additional complementary information about computer programs that have been described in the Handbook should be obtained through IWP 1/2 and maintained by the CCIR Secretariat. This includes complete computer listings, operation manuals, engineering manuals and computer flow charts;

3. that the Secretary-General is invited to make this Handbook and complementary information available to administrations;

4. that the Handbook will need to be revised to take into account advances in computer-aided techniques;

5. that administrations, and other organizations participating in the work of the CCIR should submit proposed amendments and additions to the Handbook to the Director of the CCIR;

6. that Study Group 1 shall examine these amendments and additions and shall be responsible for further editions to the Handbook.

RESOLUTION 88-1

COMPUTER PROGRAMS FOR RADIO-FREQUENCY MANAGEMENT

(1986–1990)

The CCIR,

CONSIDERING

(a) that many administrations and organizations create, use and exchange various computer programs for radio-frequency management;

(b) that all administrations and organizations would benefit from the exchange of these programs, particularly if procedures are employed that enable them to be used with computers that are universally available to the maximum possible extent;

(c) that some computer programs have already been offered for such an exchange and are described in the CCIR List of Computer Programs for Radio Frequency Management and made available through the CCIR Secretariat,

NOTING

(a) that the WARC-79, in its Resolution No. 7 relating to the development of national radio-frequency management and No. 37 relating to the introduction and development of computer assistance in radio-frequency management within administrations and in its Recommendation No. 31 relating to a handbook for computer-aided techniques in radio-frequency management, indicated the importance of the radio-frequency management and computer-aided techniques;

(b) that Resolution No. 14 of the WARC-79 and Decision 56 of the CCIR relating to the transfer of technology, indicated needs for cooperation activities,

UNANIMOUSLY DECIDES

1. that administrations and other participants in CCIR work should be encouraged to submit their computer programs in accordance with Annex I;

2. that the Director, CCIR, should be requested to:

2.1 invite administrations and organizations which have such computer programs to consider the possibility of making them available to other parties through the CCIR Secretariat in a format that is compatible with computers to the maximum possible extent;

2.2 prepare and publish by means of Circular-letters and also in the ITU Telecommunication Journal information about computer programs which have been submitted;

2.3 transfer, as requested, the programs that have been made available, in the form they were received and without review with minimum administrative cost;

2.4 transfer these programs to Interim Working Party 1/2 for review and to examine for their portability, adequacy of documentation, and correctness, and to determine which of them may be recommended for general use;

2.5 make arrangements for the CCIR Secretariat to provide advice to the administrations that have little or no computer personnel or expertise with problems that may arise with their installation and use of these programs on microcomputers.

ANNEX I

INFORMATION FOR THE SUBMISSION OF PROGRAMS

1. The program should be submitted on a data storage medium in current use by the CCIR. Floppy disks (MS-DOS formatted, 5 1/4″, 360 kB or 1.2 MB; the 3 1/2″, 760 kB or 1.44 MB) or 9-track tape (1600 bits per inch) may be used as the file size dictates.

2. The program should not be copy protected.

3. The documentation should preferably include:

– description of the engineering method used in the program and applicable limitations;
– the users' manual;
– samples of typical input data and expected output data to demonstrate operation of the program;
– the program documentation to permit maintenance of the code;
– inventory of data elements used in the program;
– information about the computer hardware and additional software packages used to run the program.

4. Summary information about the program for publishing in Circular-letters and the ITU Telecommunication Journal should contain:

– title of the program;
– sub-title of the program if any;
– submitter/source address;
– description of the program, with indication of the documentation's language;
– programming language, source code;
– mode of operation;
– hardware requirement (i.e. monitor, printer, memory, storage capacity, RAM);
– input requirements, including data file(s);
– auxiliary data file(s);
– data output;
– output medium;
– date of last revision;
– references.

RESOLUTION 110

IMPROVEMENT OF NATIONAL RADIO SPECTRUM MANAGEMENT PRACTICES AND TECHNIQUES

(Questions 44/1, 45/1 and Decision 27-2)

(1990)

The CCIR,

CONSIDERING

(a) that WARC-79 in Resolution No. 7 indicated that the administrations of many developing countries need to strengthen the national radio-frequency management organization in order to effectively carry out their responsibilities at both the international and national level;

(b) that the IFRB and the CCIR have held two meetings in response to Resolution No. 7 of WARC-79 to organize meetings between representatives of developing and developed countries concerning the establishment and operation of national spectrum management organizations;

(c) that these national frequency management meetings have recommended that administrations of developing countries take into account the guidelines indicated in the IFRB/CCIR Booklet on National Frequency Management, the IFRB Handbook on Radio Regulations, and other relevant ITU documents including the CCIR Handbook on Spectrum Management and Computer-Aided Techniques, and the CCIR Handbook for Monitoring Stations;

(d) that the national frequency management meetings concluded that the terms of Resolution No. 7 had been fulfilled and recommended that the CCIR Study Group 1 continue the needed efforts on national frequency management particularly with regard to the use of computer-aided spectrum management,

UNANIMOUSLY DECIDES

1. that Study Group 1, in accordance with the conclusions of the Second National Frequency Management Meeting should take note of the special requirements of national spectrum management organizations from developing countries and devote particular attention to these matters during the regular meetings of the Study Group and its Interim Working Parties;

2. that such meetings shall be aimed at developing practices and techniques to improve spectrum management and include discussions concerning the establishment of computer-aided spectrum management systems;

3. that personnel involved in spectrum management from developing and developed countries and representatives from the IFRB are particularly invited to participate in the spectrum management studies of Study Group 1.

OPINION 2-2

COOPERATION WITH THE INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

(Questions 4/1, 10/1, 35/1, 46/1, 57/1 and 81/1)

(1963–1978–1990)

The CCIR,

CONSIDERING

(a) that cooperation between the International Special Committee on Radio Interference (CISPR), and the CCIR is desirable;

(b) that cooperation between the CISPR and the CCIR has been of value;

(c) that it is desirable to interchange information concerning the protection of radiocommunication services, in particular, safety services;

(d) that to facilitate the exchange of such information it is desirable to reach agreement on the methods of measurement and radiation limits adopted,

IS UNANIMOUSLY OF THE OPINION

that the CISPR should be invited

1. to advise the CCIR of any proposals they have under consideration for the methods of measurements and radiation limits;

2. to take into account all the studies done by the CCIR relevant for the work of CISPR;

3. to continue cooperation with the CCIR on the following subjects:

3.1 study of methods for the measurement of radio interference and, having due regard to the frequency bands used by safety services, of procedures (in some cases issued by the International Electrotechnical Commission), for limiting undesirable radiations produced by:

– electrical apparatus and installations (Question 4/1, Study Programme 4A/1);
– all types of receivers (Recommendation 239; Question 10/1; Publication 106 of the International Electrotechnical Commission);

3.2 determination of the maximum interference level tolerable in complete systems (Question 4/1);

3.3 identification of sources of interference with radio reception (Question 35/1);

3.4 study of the usable sensitivity of receivers in the presence of quasi-impulsive interference (Question 57/1);

3.5 study the relationships between various parameters of man-made noise, in particular between the quasi-peak voltage, the mean noise power, and the amplitude and time distributions of the received noise (Questions 46/1, 29/6 and Study Programmes 46A/1, 29C/6).

Note – The Director of the CCIR is invited to transmit this Opinion to the CISPR with Report 1104.

OPINION 11-1

LIST OF STATIONS USING SPECIAL MEANS OF IDENTIFICATION

(Question 34/1)

(1963–1970)

The CCIR,

CONSIDERING

(a) that the Radio Regulations set forth requirements for transmission of identifying signals by radio stations;

(b) that certain types of radio stations are exempted from the necessity of having a call sign from the international series, for example, stations which are identified by other means;

(c) that many stations, using complex or special types of emission, cannot be identified by ordinary means;

(d) that the monitoring stations participating in the international monitoring system need to be supplied with all the available information on means of identification used by radio stations;

(e) that the IFRB has prepared, on the basis of information received from Administrations, the list of stations which use special identification means;

(f) that, however, only a limited number of Administrations have so far furnished the Board with the information required for inclusion in this list,

IS UNANIMOUSLY OF THE OPINION

1. that administrations should make every effort to supply the IFRB with the information required to augment and keep up-to-date the list of stations using special means of identification;

2. that the IFRB should be requested to periodically urge administrations to provide the information required and to keep this list up-to-date by the publication of appropriate supplements.

OPINION 32-1

MEASUREMENT OF NOISE, SENSITIVITY AND SELECTIVITY OF AMPLITUDE-MODULATION AND FREQUENCY-MODULATION RECEIVERS

(Question 57/1)

(1970-1978)

The CCIR,

CONSIDERING

(a) that Recommendations 331 and 332 give general recommendations on receiver sensitivity and selectivity respectively;

(b) that Publication 315 of the International Electrotechnical Commission (IEC) or other publications which may replace or supplement them, give methods of measurement for various characteristics of amplitude-modulation and frequency-modulation sound-broadcasting receivers;

(c) that the IEC is currently expanding its work to provide methods of measurement for other types of receivers;

(d) that if common methods of measurement were adopted, it would facilitate the work of the CCIR and the IEC,

IS UNANIMOUSLY OF THE OPINION

1. that the methods of measurement specified by the IEC for receivers should be taken into consideration and may be used as a guide to the work of the CCIR;

2. that the texts of Recommendations 331 and 332 should be drawn to the attention of the IEC;

3. that the CCIR should indicate to the IEC those characteristics for which it considers that an agreed method of measurement is necessary;

4. that in those cases in which the IEC does not, as yet, propose methods of measurement, it should be asked to undertake any work necessary to produce a relevant method.

OPINION 35-1

COOPERATION BETWEEN MONITORING STATIONS

(Question 32/1)

(1970-1978)

The CCIR,

CONSIDERING

Question 32/1,

IS UNANIMOUSLY OF THE OPINION

1. that cooperation between monitoring stations should be encouraged and improved with a view to settling harmful interference caused by transmitting stations that are difficult to identify or cannot be identified; and that to this end:

1.1 the General Secretariat should complete the List of International Monitoring Stations which it now publishes by mentioning their telephone numbers, telegraphic addresses and their telex numbers, if they have one;

1.2 the CCIR Secretariat should publish the same information as an annex to Chapter 19 of the Handbook for Monitoring Stations, the publication and updating of which is called for by Resolution 62;

2. administrations be invited to accept officials from other administrations to train them in the monitoring of emissions.

Note – The Administrations of the Federal Republic of Germany, United States of America, Italy, Portugal and the United Kingdom have offered to receive officials from other administrations.

OPINION 64*

METHODS FOR MEASURING THE SPATIAL RADIATION DIAGRAM OF ANTENNAS

(Question 45/1)

(1982)

The CCIR,

CONSIDERING

(a) that the spatial radiation diagram of an antenna is one of the major items determining the efficient use of the radio frequency spectrum;

(b) that the location of the antenna and its environment may affect the radiation diagram to a large extent;

(c) that in computing the radiation diagram it may not be possible in all cases to allow for these environmental conditions;

(d) that in such cases it will be necessary to measure the radiation diagram in accordance with standard methods giving reproducible and comparable results;

(e) that the WARC-79 recommended a number of administrative world and regional conferences, during which it would be desirable to have comparable data of radiation diagrams available;

(f) that unified methods of measurement would facilitate both the exchange of information and transfer of technological developments between administrations concerned with frequency planning, particularly in the developing countries;

(g) that it is understood that the International Electrotechnical Commission (IEC) is studying methods for measuring antenna radiation diagrams,

IS UNANIMOUSLY OF THE OPINION

1. that the IEC should be invited to advise the CCIR of any proposals they have made (or have under consideration) relating to:

– methods for measuring *in situ* the spatial radiation diagram of transmitting antennas for different applications and frequency ranges with particular emphasis on the effects of polarization, radiation in unwanted directions and environmental conditions;

– the accuracies which may be achieved in performing such measurements.

---

* The Director, CCIR, is invited to transmit this Opinion to the IEC.

92-61-04161-2