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 III

FIXED SERVICE AT FREQUENCIES BELOW ABOUT 30 MHz

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

Geneva, 1990

CCIR

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

2. The objectives of the CCIR are in particular:

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

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

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

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

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92-61-04181-7

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.

Printed in Switzerland

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

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

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

1.1 *Numbering of texts*

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

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

1.2 *Recommendations*

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

1.2 *Recommendations (cont.)*

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

1.3 *Reports*

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

* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3 *Reports (cont.)*

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

* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3.1 *Note concerning Reports*

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

1.4 *Resolutions*

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

1.5 *Opinions*

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

1.6 *Decisions*

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

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

2.1 *Numbering of texts*

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

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

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

2.2 *Assignment of Questions*

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

2.3 *References to Questions*

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

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

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VOLUME III

FIXED SERVICE AT FREQUENCIES BELOW ABOUT 30 MHz

(Study Group 3)

TABLE OF CONTENTS

NUMERICAL INDEX OF TEXTS

Note – The Opinion which already appears in the table of contents, is not reproduced in this index.

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STUDY GROUP 3

FIXED SERVICE AT FREQUENCIES BELOW ABOUT 30 MHz

Terms of reference:

To study questions relating to complete systems for the fixed service operating at frequencies below about 30 MHz and terminal equipment associated therewith.

1986-1990	*Chairman:*	H. KAJI (Japan)
	Vice-Chairman:	J. E. ADAMS (United States of America)

The Study Group 3 texts which take into account the work carried out during the 1986-1990 study period, are published for the last time in Volume III.

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

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

STUDY GROUP 9

FIXED SERVICE

Scope:

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

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

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP 3

1. General

During the period 1986-1990, Study Group 3 held its Interim Meeting in Geneva from 16 to 20 November 1987, and its Final Meeting in Geneva from 13 to 19 September 1989. The Interim and Final Meetings were attended, respectively, by 62/48 delegates, in which the number of Administrations were 13/12, and considered 15/26 preparatory documents.

Study Group 3 prepared 2 revised Recommendations, 14 new or revised Reports, 4 new Questions, one new Study Programme and one revised Decision for consideration by the XVIIth Plenary Assembly. Review of existing texts were carried out by Questionnaire circulated to the participants of Study Group 3. Six Reports and 4 Questions (Annex I) were unanimously approved to be suppressed.

The Study Group has taken every effort to expand the work of the Group. However, activities of the Study Group in total remain unchanged, and are in the lowest level among the CCIR Study Groups as analyzed in Annex II. Now, it may be a suitable time to consider the future work from an organizational point of view.

In the following, results of the meetings and some organizational considerations are presented.

2. Results of the Meeting

2.1 *Complete radio systems*

Recommendation 240 on signal-to-interference protection ratios was substantially revised, filling the Table to the Recommendation with newly adopted numerical values of protection ratios up to more than 70%. Especially, protection ratio values for all kinds of telephone emission prescribed in the Table were completely provided.

Reports 990 and 991 were also modified to support the revision of the Recommendation.

Recommendation 348 on channel arrangement in multi-channel SSB and ISB transmitters for long-range circuits was amended, adding new bandwidth of 300 Hz to 3400 Hz for HF digital transmission to the conventional bandwidth of 250 Hz to 3000 Hz for multi-channel radiotelephone circuits.

In relation to this topic, Report 703 was revised by adding references on the use of AF channel to reduce signal distortions.

2.2 *Directivity of antennas*

This period, there were many contributions on antenna characteristics. Question Z/3 and Report 1129 deal with performance of antennas over real ground.

Report 1128 on adaptive receiving antenna arrays gives one solution to reduce the effect of interference in the HF band. As existing Question 29/3 deals with only transmitting antennas, Study Programme 29A/3, covering the study on receiving antennas, was drafted.

Report 356 on the use of directional antennas was revised by adding a new Annex which describes dipole arrays with aperiodic screens.

2.3 *Influence of the ionosphere*

Report 549 on HF ionospheric channel simulators was revised by adding new Annex III which describes multipath radio channel simulator.

2.4 *Automatically controlled HF radio systems*

Studies on automatically controlled HF radio systems were of great progress during this study period 1986-1990. The system provides optimum use of the assigned frequencies without requiring services of skilled operators. The reliability and availability that can be achieved are significantly better than those achievable with manual HF systems.

Report 1131, adaptive HF communication systems, describes the system from a view of efficient spectrum utilization.

Report 551, adaptive automatic HF radio systems, was revised by adding Annexes IV and V, in which practical systems to be used for data transmission and digital facsimile terminal are presented.

2.5 *Remotely controlled HF receiving and transmitting stations*

Report 994 was revised by adding § 4.2.4 and Annex VI which describe communication protocol for HF remote control equipment.

2.6 *Radio systems employing meteor-burst propagation*

On radio systems employing meteor-burst propagation, Question X/3 was adopted, and Report 1130, which describes system configuration and test results, was drafted.

2.7 *Digital transmission systems for HF radiotelephone circuits*

Report 1127 on digital transmission systems for HF radiotelephone circuits was highly appreciated by the participants as a first step to introduce digital technologies into HF telecommunication systems. Two systems are introduced in the Report.

2.8 *Data transmissions*

Studies on data transmission over HF circuit is continuing with a recognition that the study must undertake new role of radiocommunication below 30 MHz. Report 1132 on the use of coding diversity on HF data circuits, and Report 1133 on transmission systems using phase-shift keying were adopted. Considering that the efficiency of the data transmission could be improved by studying packet transmission protocols in the HF radio channel environment, Question W/3 was adopted.

2.9 *Others*

Question Y/3 on non-ionizing radiation hazards due to transmitting systems operating at frequencies below about 30 MHz was adopted. In the study of this Question, many complicated problems to be solved may appear. Conforming to the provision No. 202 of the Convention of Final Acts of the Plenipotentiary Conference (Nice, 1989) – "in formulating new questions, it shall be borne in mind that, in principle, their consideration should be completed in a period which is no longer than twice the interval between two Plenary Assemblies" – urgent studies and active contributions are requested.

3. Conference preparatory activities

Study Group 3 contributed to the work of JIWP 10-3-8/1 for BC-R(2). JIWP 10-3-6-8/1 was set up with the task of preparing a specific report on the inter-service sharing criteria to be submitted as an input to JIWP WARC-92. Study Group 3 nominated Vice-Chairman and a Rapporteur of the JIWP from Study Group 3.

4. Interim Working Parties

4.1 *IWP 3/1 (Decision 45-1)*

Chairman: J. Adams (United States of America)

IWP 3/1 met once in the 1986-1990 study period. The meeting considered contributions and filled the Table to Recommendation 240 with many newly derived numerical values of protection ratios. The Table was completed up to more than 70%. Especially, values of protection ratios were completely provided for all kinds of telephony emission prescribed in the Table.

In the Final Meeting of Study Group 3, the Chairman of IWP 3/1 proposed the termination of the work of IWP 3/1, as the Table of Recommendation 240 had already largely filled. A representative of the IFRB appraised the work carried out by the IWP 3/1. Study Group 3 decided to terminate IWP 3/1.

4.2 *IWP 3/3 (Decision 63-2)*

Chairman: S. Chow (Canada) until 1987
N. M. Serinken (Canada) from 1987

IWP 3/3 had no meeting but its work was carried out by correspondence. Questionnaire on a worldwide survey of HF communication systems was distributed to all participants in the work of Study Group 3.

Thirty-three replies have been received and 27 of these replies had provided data to the questionnaire. Four replies stated that they did not have HF systems in use. Number of voice networks is 32 465 and that of data networks is 420. Most of the network is used for point-to-point communications. Interconnection to public switched network is very rare.

Major problem areas identified from response were propagation prediction and lack of qualified operators. Study Group 3 approved modification of Decision 63 so as to investigate the best method of disseminating the information and, if required, generate a practical HF-systems guide.

5. Future work on HF fixed service

5.1 *Present situation of Study Group 3*

At the XVIth Plenary Assembly (Dubrovnik, 1986) CCIR Director has noted, in his review of the work of Study Group 3, that the rate of development of HF fixed services and requirements to economize in CCIR Study Group work may justify holding a single Study Group meeting between Plenary Assemblies or consolidation of the work with another Study Group.

In the Interim Meeting (Geneva, 1987), the Study Group discussed the future of the Group and confirmed the important role in promoting the introduction of digital technologies, expanding new services and establishing new communication channel between developing countries and the CCIR through the work of IWP 3/3.

Actually, however, even if contributions to the Final Meeting (Geneva, 1989) have fully reflected discussions in the Interim Meeting, activities of the Group in total remain unchanged, and are in the lowest level among the Study Groups as analyzed in Annex II.

Now, it may be a suitable time to solve the organizational problem posed by the Director to Study Group 3.

5.2 *Historical review of the activities of Study Group 3*

Analysis of existing texts in Volume III, as summarized in Annex III, clearly indicates that:

- most of the important Recommendations were drafted in the 1950s, in which HF fixed service was the only means to provide the international long-distance public communication network;
- in the 1960s, as satellite and cable systems began to be applied to long-distance fixed services, studies on the improvement of HF fixed service were urgent. Introduction of many new Questions, increased number of revised Recommendations and Reports in this decade, as appeared in Annex III, were the result of these activities;
- after the reorganization of the Study Groups in 1970, as long-distance fixed services were considerably shifted to satellite and cable links, and further, as there were many ping-pong-games in the assignment of old texts between Study Group 1 and Study Group 3, the number of contributions has markedly diminished.

  If the WARC-79 were not held, Study Group 3 might have died out in course of time;
- in the WARC-79, the IFRB requested Study Group 3 to expedite the study on protection ratios, in order to improve IFRB Technical Standards to be used for the reallocation work of HF frequency spectrum. Study Group 3, recognizing changed role of HF fixed service in its ability to provide small-capacity communications in areas where no other means of communication exists or where other means are not economically feasible, e.g., in sparsely populated area, have tried to reactivate the Group by introducing new Questions;
- now, there seem to be only a few people in administrations remaining in the work of HF fixed service. The number of contributions is small. Participants are limited and there are no participants from developing countries, making Spanish and Arabic interpretors needless. Expanded activities of Study Group 3 cannot be expected. Does the work on HF fixed service deserve to constitute one Study Group?
- next decade, in the 1990s, many important changes in ITU overall are foreseen. De-regulation and competition policy will penetrate into various administrations and organizations. "Economy and Efficiency" consideration is requested in all activities not only in ITU but also in every organization. In the Final Meeting, two Administrations have already declared informally to terminate the participation to the work of Study Group 3 in next study period;

– now, it may be a suitable time to terminate Study Group 3, and high priority Questions only and relevant texts (in Volume III) should be transferred to other suitable Study Groups. To consolidate all of the work of Study Group 3 with another Study Group is not suggested, because it would cause confusion in organizing the work of the new Study Group. We should not repeat the chaos experienced in the reorganization in 1970.

5.3 *Priority of Questions on HF fixed service*

The following priority, by the chairman's view, can be assigned to existing Questions on HF fixed service. Of course, further deep consideration by the administrations is requested.

– Question 14/3:	Automatically controlled radio systems in the HF fixed service
– Question 32/3: combined with	Frequency sharing with other services below 30 MHz
Study Programme 1A/3:	Signal-to-noise ratios and protection ratios, bandwidth, adjacent-channel spacing and frequency stability
– Question 12/3: combined with	Characteristics required for single-sideband and independent-sideband systems used for high-speed data transmission over HF radio circuits
Question W/3:	Packet data transmission protocols for systems operating below about 30 MHz
– Question 24/3:	Remotely controlled HF receiving and transmitting stations
– Question Z/3:	The performance over real ground of antennas operating at frequencies below about 30 MHz in the fixed service

5.4 *Preferable organization to deal with HF fixed service*

If existing Study Group 9 can expand its terms of reference to include HF fixed service, and nominate additional Vice-Chairman who is responsible for dealing with HF fixed service, the problem will be solved.

6. Conclusion

During this study period, significant results were obtained based on the concentrated work on protection ratios by IWP 3/1, on automatically controlled HF radio systems by IWP 3/3 and also on data transmission over HF circuit.

The current Chairman is resigning with the completion of the XVIIth Plenary Assembly. He announced his intention to do this at the Final Meeting of Study Group 3. Even if Study Group 3 has been most friendly and cost-effective, he dares to propose reorganization, expecting harmonized efficient work of the Study Groups in CCIR and further expansion of the work on HF fixed service.

The Chairman wishes to extend his thanks to Mr. Kirby, the Director of CCIR, for his kind and excellent guidance and to all the participants who took an active part in the work. He wishes to express his special gratitude to Messrs. J. Adams, T. Myles and N. Serinken, Chairmen of Working Groups and IWPs, and to Messrs. T. Takasugi and N. Yamasaki, for their efficient administrative support, without which he would have been unable to accomplish his duties.

ANNEX I

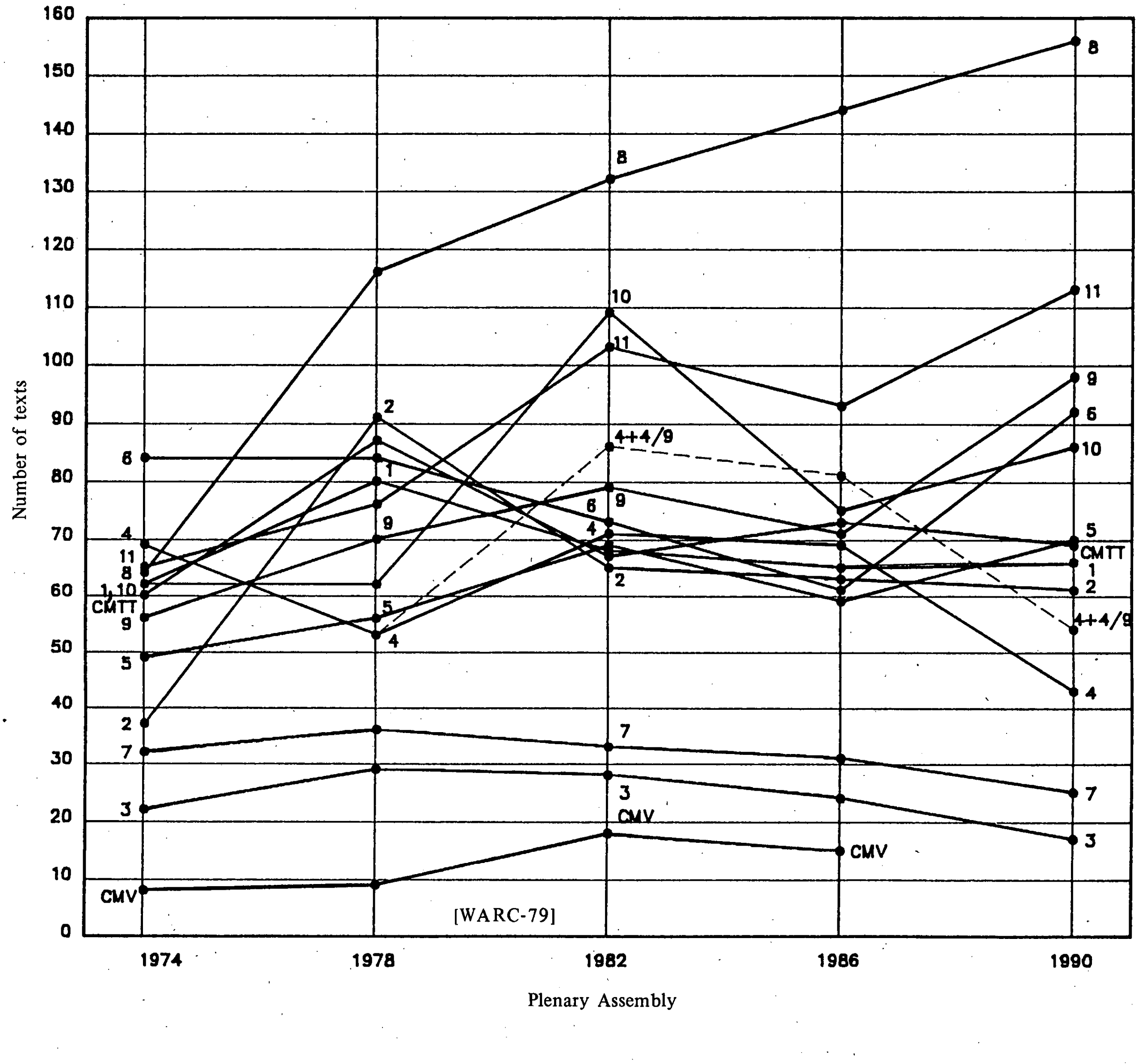
The following texts were unanimously decided to be suppressed.

Report 109-1	Question 4/3
Report 111	Question 7-1/3
Report 176-5	Question 27/3
Report 177-1	Question 28/3
Report 200-1	Decision 45
Report 434-1	

ANNEX II

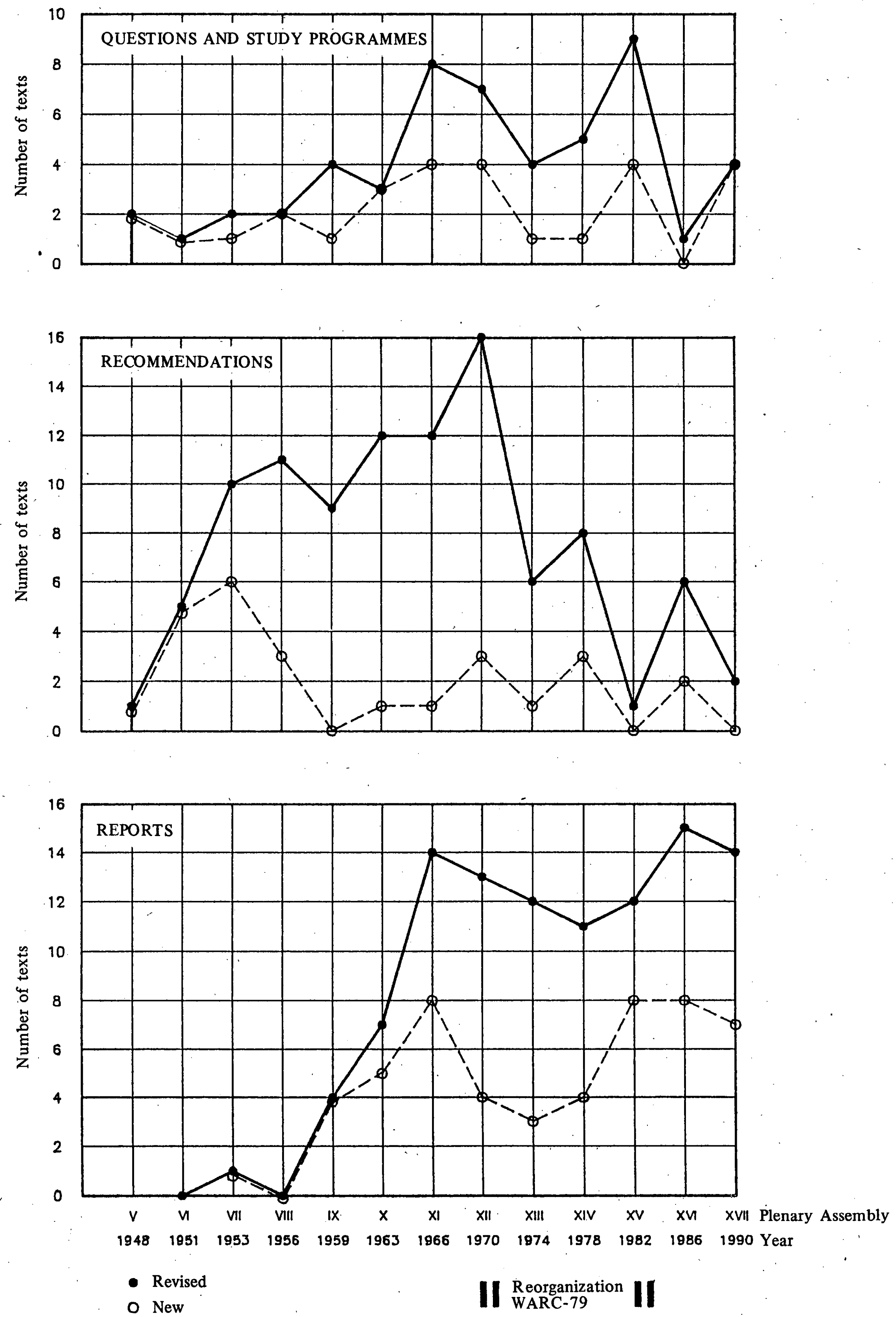
TRENDS OF CCIR WORK

1. New and modified texts for consideration by the Plenary Assembly



ANNEX III

REVIEW OF EXISTING TEXTS OF VOLUME III



SECTION 3A: COMPLETE RADIO SYSTEMS

3A a: Technical characteristics

RECOMMENDATION 240-5*

SIGNAL-TO-INTERFERENCE PROTECTION RATIOS

(Question 1/3, Study Programme 1A/3)

(1953–1956–1959–1970–1974–1978–1986–1990)

The CCIR,

CONSIDERING

that knowledge of the signal-to-interference protection ratios for various classes of emission is needed,

UNANIMOUSLY RECOMMENDS

1. that the values of signal-to-interference protection ratios for stable conditions, below which harmful interference occurs, shown in Table I are presently considered appropriate for the emissions indicated;

2. that studies should be continued to provide values of signal-to-interference protection ratios for stable conditions where they are not shown in the Table and also to review the values that are shown;

3. that the studies in connection with Recommendation 339 and Study Programme 1A/3 should be continued, in conjunction with those of Study Programme 28A/6 for the purpose of determining whether the provisional values given for the fading allowances may be accepted or should be modified;

4. that meanwhile, the values given may be regarded as provisional total fading allowances (combined fading safety factors and intensity fluctuation factors) and may be used as a guide, in conjunction with the values for signal-to-interference protection ratios (for stable conditions), appropriate to the various classes of emission.

Note 1 – Use of the recommended values only permits an estimate to be obtained, which may have to be adjusted for radio circuits of different lengths, depending on the grade of service required and on the specific propagation conditions on these radio circuits. In calculating the fading safety factor for rapid or short-period fading, a log-normal amplitude distribution of the received fading signal has been used (using 7 dB for the ratio of median level to level exceeded for 10% or 90% of the time), except for high-speed automatic telegraphy services, where the protection has been calculated on the assumption of a Rayleigh distribution.

Note 2 – Table I provides in column 1 of each interfering signal the value of the protection ratio as the ratio of wanted-to-unwanted signals whose powers are expressed in terms of peak envelope power (*P*X) when the occupied band of the interfering emission either falls entirely within the passband of the receiver, or covers it completely.

When one of the signals is expressed in terms of mean power (*P*Y) or carrier power (*P*Z) the corresponding value of the protection ratio can be obtained by appropriately using the conversion factors given in Recommendation 326.

Note 3 – Columns 2, 3 and 4 indicate the frequency separation necessary between the assigned frequency of a wanted signal and that of an interfering signal when the level of the latter is respectively 0, 6, and 30 dB higher than the wanted signal (as defined in No. 142 of the Radio Regulations, the assigned frequency is the centre of the assigned frequency band).

Note 4 – Signal processing techniques such as Lincompex, Syncompex, etc. and the use of noise reducers and notch filters may reduce the susceptibility of radiotelephone signals to interference.

* This Recommendation should be brought to the attention of Study Group 1.

TABLE I – *Minimum required protection ratios and frequency separations* *

WANTED SIGNAL		CLASS OF EMISSION OF INTERFERING SIGNAL																											
		Telegraphy												Telegraphy								Telegraphy							
Class of emission		A1A Manual				A1B 50 baud (1)				A1B 100 baud				A2A Manual				A2B 24 baud				F1B 50 baud 2D=200 Hz (1)				F1B 50 baud 2D=280 Hz (1)			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz		
A1A telegraphy aural reception		13				13				13												13				13			
A1B telegraphy 50 baud printer B = 500 Hz		13				11	0.36	0.44	1.41	(2) 12	(2) 0.25	(2) 0.35										13				13	0.46	0.54	1.24
A1B telegraphy 100 and 120 baud recorder B = ...		13				13				13												13				13			
A2A telegraphy aural reception																													
A2B telegraphy, 24 baud																													
F1B telegraphy (3) 50 baud, printer 2D=280 Hz; B=500 Hz						1.0	0.2	0.28	0.6	3												7				7.0	0.32	0.39	0.67
F1B telegraphy 50 baud, printer 2D=400 Hz; B=500 Hz						1.0				(2) 3	(2) 0.35	(2) 0.50										7				7			
F7B telegraphy 200 baud, printer ARQ 2D=... B=...		4				4				4																			
F7B telegraphy 200 baud, printer ARQ 2D=400 Hz; B=500 Hz		4				4				(4) 4	(4) 0.40	(4) 0.55																	
F7B (3), 50 baud printer 2D=1200 Hz B=1200 Hz	channel 1																					8				8			
	channel 2																					18				18			
R3C phototelegraphy		16				16				16												16				16			
F3C phototelegraphy 60 rpm, B=1000 Hz		15				15				15	1.00	1.20										15				15			
A3E telephony Double sideband (5) (6)	just usable	13				13				13				1				1				21				21			
	marginally commercial	29				29				29				17				17				33				33			
	good commercial	56				56				56				44				44				60				60			
H3E telephony Single sideband full-carrier (5) (6) (7)	just usable	7				7				7				–5				–5				15				15			
	marginally commercial	23				23				23				11				11				27				27			
	good commercial	50				50				50				38				38				54				54			
R3E telephony Single-sideband reduced carrier (5) (6) (7)	just usable	2				2				2				–10				–10				10				10			
	marginally commercial	18				18				18				6				6				22				22			
	good commercial	45				45				45				33				33				49				49			
J3E telephony Single-sideband suppressed carrier (5) (6) (7)	just usable	1				1				1				–11				–11				9				9			
	marginally commercial	17				17				17				5				5				21				21			
	good commercial	44				44				44				32				32				48				48			
R8E telephony Two independent sideband reduced or suppressed carrier (5) (6) (7)	just usable	7				7				7				–5				–5				15				15			
	marginally commercial	23				23				23				11				11				27				27			
	good commercial	50				50				50				38				38				54				54			
J2B																													
H2A/H2B																													
J7B multichannel V.F. telegraphy 250-3000 Hz		17.5				17.5				17.5												20.5				20.5			
J7B multichannel V.F. telegraphy 300-3400 Hz (8)		17.5				17.5	1.7	1.7	8.0	17.5	1.7	1.8	9.1									20.5	1.9	1.9	2.0	20.5			
R7B multichannel V.F. telegraphy reduced carrier		18.5				18.5				18.5												21.5				21.5			

TABLE I *(continued)*

WANTED SIGNAL		CLASS OF EMISSION OF INTERFERING SIGNAL																											
		Telegraphy																Telegraphy											
Class of emission		F1B 50 baud $2D=400$ Hz (1)				F1B 100 baud $2D=400$ Hz				F1B 100 baud $2D=500$ Hz				F1B 200 baud $2D=500$ Hz				F7B 100 baud $2D=400$ Hz				F7B 100 baud $2D=1500$ Hz				F7B 200 baud $2D=600$ Hz			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz		
A1A telegraphy aural reception		13				13				13				13				3				3				3			
A1B telegraphy 50 baud printer $B = 500$ Hz		13				13				13				13				(2) 3	(2) 0.40	(2) 0.55		3				3			
A1B telegraphy 100 and 120 baud recorder $B = ...$		13				13				13				13				3				3				3			
A2A telegraphy aural reception																													
A2B telegraphy, 24 baud																													
F1B telegraphy (3) 50 baud, printer $2D=280$ Hz; $B=500$ Hz		7				7				7				7				2				2				2			
F1B telegraphy 50 baud, printer $2D=400$ Hz; $B=500$ Hz		7				7				7				7				(2) 2	(2) 0.45	(2) 0.60		2				2			
F7B telegraphy 100 baud, printer ARQ $2D=...$ $B=...$																		4				4				4			
F7B telegraphy 200 baud, printer ARQ $2D=400$ Hz; $B=500$ Hz																		(4) 4	(4) 0.50	(4) 0.70		4				4			
F7B (3), 50 baud printer $2D=1200$ Hz $B=1200$ Hz	channel 1	8	0.85	0.95	1.51	8				8				8				8				8				8			
	channel 2	18	0.98	1.1	2.06	18				18				18				18				18				18			
R3C phototelegraphy		16				16				16				16				16				16				16			
F3C phototelegraphy 60 rpm, $B=1000$ Hz		15				15				15				15				15	1.10	1.20		15				15			
A3E telephony Double sideband (5) (6)	just usable	21				21				21				21				17				17				17			
	marginally commercial	33				33				33				33				35				35				35			
	good commercial	60				60				60				60				66				66				66			
H3E telephony Single sideband full-carrier (5) (6) (7)	just usable	15				15				15				15				11				11				11			
	marginally commercial	27				27				27				27				29				29				29			
	good commercial	54				54				54				54				60				60				60			
R3E telephony Single-sideband reduced carrier (5) (6) (7)	just usable	10				10				10				10				6				6				6			
	marginally commercial	22				22				22				22				24				24				24			
	good commercial	49				49				49				49				55				55				55			
J3E telephony Single-sideband suppressed carrier (5) (6) (7)	just usable	9				9				9				9				5				5				5			
	marginally commercial	21				21				21				21				23				23				23			
	good commercial	48				48				48				48				54				54				54			
R8E telephony Two independent sideband reduced or supressed carrier (5) (6) (7)	just usable	15				15				15				15				11				11				11			
	marginally commercial	27				27				27				27				29				29				29			
	good commercial	54				54				54				54				60				60				60			
J2B																													
H2A/H2B																													
J7B multichannel V.F. telegraphy 250-3000 Hz		20.5				20.5				20.5				20.5				20.5				20.5				20.5			
J7B multichannel V.F. telegraphy 300-3400 Hz (8)		20.5	1.9	1.9	2.1	20.5	1.9	1.9	2.8	20.5	2.0	2.0	2.9	20.5	1.9	2.0	3.1	20.5				20.5	2.4	2.5	3.5	20.5			
R7B multichannel V.F. telegraphy reduced carrier		21.5				21.5				21.5				21.5				21.5				21.5				21.5			

TABLE I *(continued)*

WANTED SIGNAL	CLASS OF EMISSION OF INTERFERING SIGNAL																											
	Telegraphy								Phototelegraphy								Telephony (7)											
Class of emission	F7B 200 baud $2D=3000$ Hz				F7B 50 baud $2D=1200$ Hz				R3C				F3C				A3E DSB (5) (9)				H3E full carrier				R3E reduced carrier			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz		
A1A telegraphy aural reception	3				3												5				5				10			
A1B telegraphy 50 baud, printer $B = 500$ Hz	3				3												5				5				10			
A1B telegraphy 100 and 120 baud recorder $B = ...$	3				3												5				5				10			
A2A telegraphy aural reception																	5				11				16			
A2B telegraphy, 24 baud																	5				11				16			
F1B telegraphy (3) 50 baud, printer $2D=280$ Hz; $B=500$ Hz	2				2												−3				3				8			
F1B telegraphy 50 baud, printer $2D=400$ Hz; $B=500$ Hz	2				2												−3				3				8			
F7B telegraphy 100 baud, printer ARQ $2D=...$ $B=...$	4				4																							
F7B telegraphy 200 baud, printer ARQ $2D=400$ Hz; $B=500$ Hz	4				4																							
F7B (3), 50 baud printer $2D=1200$ Hz $B=1200$ Hz — channel 1	8				8	1.24	1.33	2.32																				
F7B (3), 50 baud printer $2D=1200$ Hz $B=1200$ Hz — channel 2	18				18	1.33	1.51	3.08																				
R3C phototelegraphy	16				16																							
F3C phototelegraphy 60 rpm, $B=1000$ Hz	15				15																							
A3E telephony Double sideband (5) (6) — just usable	17				17				19				20				6				12				17			
A3E telephony Double sideband (5) (6) — marginally commercial	35				35				34				35				18				24				29			
A3E telephony Double sideband (5) (6) — good commercial	66				66				64				65				39				45				50			
H3E telephony Single sideband full-carrier (5) (6) (7) — just usable	11				11				13				14				0				6				11			
H3E telephony Single sideband full-carrier (5) (6) (7) — marginally commercial	29				29				28				29				12				18				23			
H3E telephony Single sideband full-carrier (5) (6) (7) — good commercial	60				60				58				59				33				39				44			
R3E telephony Single-sideband reduced carrier (5) (6) (7) — just usable	6				6				8				9				−5				1				6			
R3E telephony Single-sideband reduced carrier (5) (6) (7) — marginally commercial	24				24				23				24				7				13				18			
R3E telephony Single-sideband reduced carrier (5) (6) (7) — good commercial	55				55				53				54				28				34				39			
J3E telephony Single-sideband suppressed carrier (5) (6) (7) — just usable	5				5				7				8				−6				0				5			
J3E telephony Single-sideband suppressed carrier (5) (6) (7) — marginally commercial	23				23				22				23				6				12				17			
J3E telephony Single-sideband suppressed carrier (5) (6) (7) — good commercial	54				54				52				53				27				33				38			
R8E telephony Two independent sideband reduced or suppressed carrier (5) (6) (7) — just usable	11				11				13				14				0				6				11			
R8E telephony Two independent sideband reduced or suppressed carrier (5) (6) (7) — marginally commercial	29				29				28				29				12				18				23			
R8E telephony Two independent sideband reduced or suppressed carrier (5) (6) (7) — good commercial	60				60				58				59				33				39				44			
J2B																	5											
H2A/H2B																	−1											
J7B multichannel V.F. telegraphy 250-3000 Hz	20.5				20.5																							
J7B multichannel V.F. telegraphy 300-3400 Hz (8)	20.5	3.2	3.3	5.1	20.5																							
R7B multichannel V.F. telegraphy reduced carrier	21.5				21.5																							

TABLE I *(continued)*

CLASS OF EMISSION OF INTERFERING SIGNAL																												Provisional total fading allowances ([10]) for the protection of a fading signal against an interfering signal subject to fading and day-to-day intensity fluctuations. (See ([11])) (dB to be added to values in columns numbered 1)	
Telephony								Telegraphy								Multichannel V.F. telegraphy													
J3E suppressed carrier				B8E reduced or suppressed carrier				J2B				H2A/H2B				J7B suppressed carrier 250-3000 Hz				J7B suppressed carrier 300-3400 Hz				R7B reduced carrier					
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			dB	kHz			non-diversity	diversity
11				5				13				7																	
11				5				13				7																	27 ([12])
11				5				13				7																	
17				11																									
17				11																									
9				3				3				−3																	
9				3				3				−3																	27 ([12])
								4				−2																	
								4				−2																	12 ([13])
								16				10																20	
								15				9																20	
18				12				13				7				20				20				19					
30				24				29				23				34				34				33					
51				45				56				50				56				56				55				17 ([14])	
12				6				7				1				14				14				13					
24				18				23				17				28				28				27					
45				39				50				44				50				50				49					
7				1				2				−4				9				9				8					
19				13				18				12				23				23				22					
40				34				45				39				45				45				44				17 ([14])	
6				0				1				−5				8				8				7					
18				12				7				11				22				22				21					
39				33				44				38				44				44				43				17 ([14])	
12				6				7				1				14				14				13					
24				18				23				17				28				28				27					
45				39				50				44				50				50				49					
								17.5				11.5																	
								17.5				11.5																	
								18.5				12.5																	

Notes to Table 1:

* *Note* – Under "class of emission", B represents the receiver bandwidth and $2D$ represents the total frequency shift.

(1) Bandwidth of interfering signals limited to 500 Hz.

(2) For a probability of character error $P_c = 0.0001$.

(3) For a probability of character error $P_c = 0.001$.

(4) For a traffic efficiency of 90%.

(5) For telephony the values of protection ratios for stable conditions have been derived from information contained in Reports 989 and 990. The figures for A3E telephony are valid only for reception with an SSB receiver.

(6) With the use of a noise reducer for the wanted signal, the figures in column 1 are reduced by ..... dB (to be determined).

(7) With the use of Lincompex terminals for the wanted signal, the figures in column No. 1 are reduced by ..... dB (to be determined). When the interfering signal is a telephony transmission using Lincompex terminals, the figures in column No. 1 are increased by ..... dB (to be determined).

(8) Values derived from information contained in Report 991.

(9) Average degree of modulation 70%; sideband components extended to ± 3 kHz.

(10) Combined allowances for fading safety factor and intensity fluctuation factor.

(11) The probability distribution of the ratio of two signals fading independently has been applied in accordance with Doc. [CCIR, 1953]. The combined intensity fluctuation allowance for two signals has been taken as 7 dB, which represents a compromise between the 0 dB allowance, appropriate to perfectly correlated intensity fluctuations of the two signals, and the 14 dB allowance appropriate to uncorrelated intensity fluctuations of the two signals.

(12) For protection 99.99% of the time.

(13) Based on 90% traffic efficiency.

(14) Based on 90% protection.

REFERENCES

CCIR Documents

[1953]: London, 443 (USA).

RECOMMENDATION 338-2

BANDWIDTH REQUIRED AT THE OUTPUT OF A TELEGRAPH OR TELEPHONE RECEIVER

(Question 1/3, Study Programme 1A/3)

(1953–1963–1966–1970)

The CCIR,

CONSIDERING

(a) the urgent need to determine the minimum separation between frequency assignments of stations operating on adjacent channels, in the range 10 kHz to 30 MHz;

(b) that the width of the frequency band, which is necessary at the output of the receiver, is one of the factors which determine the band of frequencies required for the overall system;

(c) that, for telegraphy, the permissible degree of distortion is not yet defined;

(d) that, for telephony, the bandwidth may depend, among other factors, upon the type of privacy equipment in use,

UNANIMOUSLY RECOMMENDS

1. that, for telegraphy, a provisional value for the bandwidth necessary at the output of the receiver, under average practical conditions, should be as follows:

1.1 for classes of emission A1A and A1B, the bandwidth in hertz, after the final detector stage, should be equal to 2.5 times the modulation rate in bauds;

1.2 for class of emission F1B, the bandwidth in hertz after the discriminator, should be equal to 1.4 times the modulation rate in bauds.

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

2. that, for telephony, as a compromise between intelligibility and economy of bandwidth, the bandwidth necessary, for each speech channel at the output of the receiver, should be as follows:

2.1 in accordance with Recommendation 335, the upper limit frequency should be reduced to 3000 Hz or less but no lower than 2600 Hz. In the case of the improved radio telephone system using a linked compressor-expander (Recommendation 455), the bandwidth should be strictly preserved to not less than 3000 Hz;

2.2 the lower frequency limit of speech channels should be 250 Hz, and that of programme transmission channels should be 100 Hz;

2.3 for systems employing commercial privacy equipment, the necessary bandwidth for satisfactory service may require the use of an upper limit frequency greater than 2600 Hz (e.g. in five-band privacy equipment the necessary bandwidth is 2750 Hz, the upper limit being 3000 Hz).

RECOMMENDATION 339-6

BANDWIDTHS, SIGNAL-TO-NOISE RATIOS AND FADING ALLOWANCES IN COMPLETE SYSTEMS

(Question 1/3, Study Programme 1A/3)

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

The CCIR,

CONSIDERING

(a) that the studies requested in Study Programme 1A/3 have not yet been completed, and that it is desirable to classify the important points with which future studies will have to deal;

(b) that there is a need for numerical values which take into account fading and fluctuations in field intensity;

(c) that, however, the information contained in Annex I to Recommendation 313 and Report 266 gives some results from which provisional data on fading allowances can be derived,

UNANIMOUSLY RECOMMENDS

1. that meanwhile, the values given in Table I should be adopted as provisional values for the signal-to-noise ratio required for the class of emission concerned;

2. that meanwhile, the values given in the last two columns of Table I, in conjunction with the estimate of the intensity fluctuation factor given in Note 4 to this Table, may be used as an aid to estimate monthly-median values of hourly-median field intensities necessary for the various types and grades of service;

3. that Table I be extended to include additional systems as the pertinent information becomes available;

4. that the studies in connection with Study Programme 1A/3 should be continued, in conjunction with those of Study Programme 28A/6, for the purpose of determining whether the provisional values given in the Table may be accepted or should be modified.

Note 1 – In these studies, the procedures given in Report 195 should be given full consideration. Reports 413, 414 and 415 (Oslo, 1966) may also be consulted.

Note 2 – Use of the provisional recommended values only permits an estimate to be obtained, which may have to be adjusted for radio circuits of different lengths depending on the grade of service required.

TABLE I – *Required signal-to-noise ratios*

Class of emission	Pre-detection bandwidth of receiver (Hz)	Post-detection bandwidth of receiver (Hz)	Grade of service	Audio signal-to-noise ratio (1) (dB)	RF signal-to-noise density ratio(2) (3) (dB) Stable condition	Fading condition (4) non-diversity	(5) dual diversity
A1A Telegraphy 8 bauds	3000	1500	Aural reception (6)	–4	31	38	
A1B Telegraphy 50 bauds, printer	250	250	Commercial grade (7)	16	40		58
A1B Telegraphy 120 bauds, undulator	600	600		10	38		49
A2A Telegraphy 8 bauds	3000	1500	Aural reception (6) (19)	–4	35	38	
A2B Telegraphy 24 bauds	3000	1500	Commercial grade (7) (19)	11	50	56	
F1B Telegraphy 50 bauds, printer $2D$ = 200 Hz to 400 Hz	1500	100	Pc = 0.01 Pc = 0.001 Pc = 0.0001 (8)		45 51 56 (9)	53 63 74 (9)	45 52 59 (9)
F1B Telegraphy 100 bauds, printer $2D$ = 170 Hz, ARQ	300	300	(10)		43	52	
F7B Telegraphy 200 bauds, printer $2D$ = ..., ARQ			(10)				
F1B Telegraphy MFSK 33-tone ITA2 10 characters/s	400	400	Pc = 0.01 Pc = 0.001 Pc = 0.0001 (8)		23 24 26	37 45 52 (25)	29 34 39
F1B Telegraphy MFSK 12-tone ITA5 10 characters/s	300	300	Pc = 0.01 Pc = 0.001 Pc = 0.0001 (8)		26 27 29	42 49 56 (25)	32 36 42
F1B Telegraphy MFSK 6-tone ITA2 10 characters/s	180	180	Pc = 0.01 Pc = 0.001 Pc = 0.0001 (8)		25 26 28	41 48 55 (25)	31 35 41
F7B Telegraphy							
R3C Phototelegraphy 60 rpm	3000	3000			50	59	
F3C Phototelegraphy 60 rpm	1100	3000	Marginally commercial (22) Good commercial (22)	15 20	50 55	58 65	
A3E Telephony double sideband	6000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	50 59 67(14)	51 64 75(14) (20)	48 60 70(14) (15) (20)
H3E Telephony single-sideband full carrier	3000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	53 62 70(14) (23)	54 67 78(14) (20)	51 63 73(14) (15) (20)
R3E Telephony single-sideband reduced carrier	3000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	48 57 65(14) (24)	49 62 73(14) (20)	46 58 68(14) (15) (20)
J3E Telephony single-sideband suppressed carrier	3000	3000	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	47 56 64(14)	48 61 72(14) (20)	45 57 67(14) (15) (20)
B8E Telephony independent-sideband 2 channels	6000	3000 per channel	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	49 58 66(14)	50 63 74(14) (20)	47 59 69(14) (15) (20)
B8E Telephony independent-sideband 4 channels	12000	3000 per channel	Just usable (11) Marginally commercial (12) Good commercial (13)	6 15 33 (18)	50 59 67(14)	51 64 75(14) (20)	48 60 70(14) (15) (20)
J7B Multichannel V.F. telegraphy 16 channels 75 bauds each	3000	110 per channel	Pc = 0.01 Pc = 0.001 Pc = 0.0001 (8)		59 65 69 (21)	67 77 87 (21)	59 66 72 (21)
J7B Multichannel V.F. telegraphy 15 channels 100 bauds each with ARQ	3000	110 per channel	(10)				
R7B Multichannel V.F. telegraphy reduced carrier							
B7W Composite 16 channels 75 bauds each 1 telephony channel(16)	6000	110 per telegraphy channel 3000 for the telephony channel	Pc = 0.01 Pc = 0.001 Pc = 0.0001 (8)		60 66 70 (17)	68 78 88 (17)	60 67 73 (17)

Footnotes to Table I

(1) Noise bandwidth equal to post-detection bandwidth of receiver. For an independent-sideband telephony noise bandwidth equal to the postdetection bandwidth of one channel.

(2) The figures in this column represent the ratio of signal peak envelope power to the average noise power in a 1 Hz bandwidth except for double-sideband A3E emission where the figures represent the ratio of the carrier power to the average noise power in a 1 Hz bandwidth.

(3) The values of the radio-frequency signal-to-noise density ratio for telephony listed in this column, apply when conventional terminals are used. They can be reduced considerably (by amounts as yet undetermined) when terminals of the type using linked compressor-expanders (Lincompex) are used (see Report 354). A speech-to-noise (r.m.s. voltage) ratio of 7 dB measured at audio-frequency in a 3 kHz band has been found to correspond to just marginally commercial quality at the output of the system, taking into account the compandor improvement.

(4) The values in these columns represent the median values of the fading signal power necessary to yield an equivalent grade of service, and do not include the intensity fluctuation factor (allowance for day-to-day fluctuation) which may be obtained from Report 252-2 + Supplement (published separately) in conjunction with Report 322 (published separately). In the absence of information from these Reports, a value of 14 dB may be added as the intensity fluctuation factor to the values in these columns to arrive at provisional values for the total required signal-to-noise density ratios which may be used as a guide to estimate required monthly-median values of hourly-median field strength. This value of 14 dB has been obtained as follows:

The intensity fluctuation factor for the signal, against steady noise, is 10 dB, estimated to give protection for 90% of the days. The fluctuations in intensity of atmospheric noise are also taken to be 10 dB for 90% of the days (see Study Programme 1A/3). Assuming that there is no correlation between the fluctuations in intensity of the noise and those of the signal, a good estimate of the combined signal and noise intensity fluctuation factor is

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

(5) In calculating the radio-frequency signal-to-noise density ratios for rapid short-period fading, a log-normal amplitude distribution of the received fading signal has been used (using 7 dB for the ratio of median level to level exceeded for 10% or 90% of the time) except for high-speed automatic telegraphy services, where the protection has been calculated on the assumption of a Rayleigh distribution. The following notes refer to protection against rapid or short-period fading.

(6) For protection 90% of the time.

(7) For A1B telegraphy, 50 baud printer: for protection 99.99% of the time. For A2B telegraphy, 24 bauds: for protection 98% of the time.

(8) The symbol P_C stands for the probability of character error.

(9) Atmospheric noise (V_d = 6 dB) is assumed (see Report 322).

(10) Based on 90% traffic efficiency.

(11) For 90% sentence intelligibility.

(12) When connected to the public service network: based on 80% protection.

(13) When connected to the public service network: based on 90% protection.

(14) Assuming 10 dB improvement due to the use of noise reducers.

(15) Diversity improvement based on a wide-spaced (several kilometres) diversity.

(16) Transmitter loading of 80% of the rated peak envelope power of the transmitter by the multi-channel telegraph signal is assumed.

(17) Required signal-to-noise density ratio based on performance of telegraphy channels.

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

(19) Total sideband power, combined with keyed carrier, is assumed to give partial (two element) diversity effect. An allowance of 4 dB is made for 90% protection (8 bauds), and 6 dB for 98% protection (24 bauds).

(20) Used if Lincompex terminals will reduce these figures by an amount yet to be determined.

(21) For fewer channels these figures will be different. The relationship between the number of channels and the required signal-to-noise ratio has yet to be determined.

(22) Quality judged in accordance with article 23.1 of ITU publication "Use of the standardized test chart for facsimile transmissions".

(23) For class of emission H3E the levels of sideband signals and pilot-carrier corresponding to 100% modulation are each −6 dB relative peak envelope power (p.e.p.). SSB receiver used for reception.

(24) For class of emission R3E the pilot-carrier level of −20 dB relative to p.e.p. is applied and the level of the sideband signal corresponding to 100% modulation is 1 dB lower than the p.e.p.

(25) Dependent on fading rate, typical values shown.

RECOMMENDATION 349-4

FREQUENCY STABILITY REQUIRED FOR SYSTEMS OPERATING IN THE HF FIXED SERVICE TO MAKE THE USE OF AUTOMATIC FREQUENCY CONTROL SUPERFLUOUS

(Question 1/3, Study Programme 1A/3)

(1963–1966–1970–1978–1986)

The CCIR,

CONSIDERING

(a) that it is the practice with certain single-sideband (SSB) and independent-sideband (ISB) telephone systems, and with many telegraph systems, to employ automatic frequency control (a.f.c.) to adjust the receiver oscillator frequency in sympathy with variations in the frequency of the transmitted signal;

(b) that such automatic frequency control systems may give rise to difficulty under unfavourable conditions of propagation, at frequencies below 30 MHz;

(c) that the frequency stability, which can now be achieved, is much higher than that laid down in Appendix 7 to the Radio Regulations, and is approaching a value which could provide sufficient inherent stability to enable automatic frequency control to be dispensed with;

(d) that, with systems dispensing with automatic frequency control, the frequency error of the modulating and demodulating stages and of the radio-frequency translating stages at the transmitting and the receiving ends, together with the frequency error due to the propagation path, contribute to an overall frequency error;

(e) that the overall frequency error of the complete system is decisive and that as far as feasible this error should be shared equally by both the transmitting and the receiving ends;

(f) that, however, in certain cases when narrow-shift telegraph systems are employed, reasons other than frequency stability of the equipment may still require the use of automatic frequency control,

UNANIMOUSLY RECOMMENDS

1. that the values of permissible frequency errors given in Table I, should be considered as suitable for use on systems giving access to the public service network and dispensing with automatic frequency control;

2. that the figures in column (1) of Table I are decisive for the system, and that those given in the columns (2), (3) and (4) should be considered as an example as to how the overall frequency error could be split up into errors permissible in the parts constituting a complete system;

3. that, however, the use of automatic frequency control may be retained for telephone systems using Lincompex terminals, as set forth in Recommendation 455, and for multichannel voice-frequency telegraph systems on circuits where significant frequency deviations, due to propagation conditions, are encountered (see Annex I).

TABLE I

System	Maximum permissible overall error (Hz) (1)	Frequency error due to: Modulator stages (Hz) (2)	Demodulator stages (Hz) (3)	Frequency error due to the radio-frequency translating stages at both ends and to the propagation path(3) (Hz) (4)
1. Single-sideband and independent-sideband telephony	20	5	5	10
2. Radiotelegraphy:				
2.1 Two-tone multi-channel telegraphy with 340 Hz tone spacing and MCVF frequency-shift telegraphy with 340 Hz channel spacing	12(1)	3	3	6
2.2 Frequency-shift telegraphy F1B (e.g. 50 bauds, 200 Hz shift) and four-frequency diplex telegraphy F7B using narrow-band filters at the receiving end	12	3	3	6
2.3 Multichannel voice-frequency telegraph systems operating at modulation rates up to about 100 bauds, with 80 or 85 Hz frequency shift and 170 Hz channel spacing	12	3	3	6
2.4 F1B and F7B systems using a limiter/discriminator at the receiving end, modulation index $\approx$ 2 (e.g. 196 bauds, 400 Hz shift)	20(4)	3	3	14
2.5 Phototelegraphy(2)	16	4	4	8

(1) See [CCIR, 1962].

(2) For short-term frequency stability, see Recommendation 344.

(3) This is the maximum error at the demodulator in the frequency of the carrier, if transmitted.

(4) For radiotelegraph systems, which use a device at the receiving end to correct for possible bias distortion due to frequency error, values larger than those indicated in the Table may be permitted.

REFERENCES

CCIR Documents

[1962] Geneva: III/27.

ANNEX I

FACTORS OTHER THAN FREQUENCY STABILITY WHICH MAY MAKE THE USE OF AUTOMATIC FREQUENCY CONTROL DESIRABLE

1. Introduction

The above Recommendation, which is a reply to Question 182 (Los Angeles, 1959), tabulates the permissible overall frequency errors for various systems.

2. Relationship between distortion and frequency error

A number of HF radiotelegraph circuits operating at modulation rates of about 100 bauds with a channel spacing of 170 Hz, use sub-carriers on independent-sideband transmissions.

Measurements made on various well-designed frequency-shift telegraphy receivers have indicated an increase in element distortion of approximately 1.25% for each 1 Hz frequency error. Poorer band-pass filter designs or narrower channelling will raise this distortion considerably.

It has been observed that frequency changes due to ionospheric propagation of up to 7 Hz may occur during periods of up to 15 min [Rishbeth and Garriott, 1964; Davies, 1963]. This can, therefore, result in an additional distortion of up to 9%, which could be reduced by the application of automatic frequency control. Further information about the statistical distribution of these phenomena would be desirable to permit fuller evaluation of their effect on circuit efficiency.

REFERENCES

DAVIES, K. [1963] Doppler studies of the ionospheric effects of solar flares. Proc. International Conference on the Ionosphere, 76-83.

RISHBETH, H. and GARRIOTT, O. K. [March, 1964] Relationship between simultaneous geomagnetic and ionospheric oscillations. *Radio Sci.*, Vol. 68D, **3**, 339-343.

RECOMMENDATION 612*

MEASUREMENT OF RECIPROCAL MIXING IN HF COMMUNICATION RECEIVERS IN THE FIXED SERVICE

(Question 1/3, Study Programme 1A/3)

(1986)

The CCIR,

CONSIDERING

(a) that frequency synthesizers are widely used in HF communication receivers;

(b) that reciprocal mixing is an important characteristic of such receivers;

(c) that it is desirable to be able to compare the reciprocal mixing performance of different models of receivers;

(d) that to facilitate *(c)* it is necessary to standardize methods of measurement of reciprocal mixing;

(e) that the methods of measurement should be independent of receiver noise factor,

UNANIMOUSLY RECOMMENDS

that the reciprocal mixing performance of HF communication receivers should be established, using the methods of measurement specified in § 4 of Annex I.

ANNEX I**

1. Introduction

Frequency synthesizers are widely used in modern high quality HF communications receivers. Besides having high frequency stability and accuracy, a frequency synthesizer is easy to operate and control. At present, however, the frequencies provided by the synthesizer are not always sufficiently pure, so that a considerable number of spurious components may accompany the wanted signals in its frequency spectrum. At the same time, on both sides of the wanted output there are noise skirts which degrade the interference rejection and noise characteristics of the receiver. In recent years, a new requirement has therefore appeared in the specifications of HF receivers, i.e. reciprocal mixing, defined as the degradation of the receiver output signal-to-noise ratio due to the mixing of strong interfering signals with the noise skirts of the synthesizer. Relevant reciprocal mixing effects are described in Report 704. This Annex provides a quantitative relationship between the synthesizer out-of-band noise characteristics and receiver reciprocal mixing so that the requirements for synthesizer out-of-band noise characteristics can easily be specified and performance comparison between various receivers facilitated.

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* This Recommendation should be brought to the attention of Study Groups 1 and 8.

** This Annex contains text from Report 856 which is hereby deleted.

2. Effects of reciprocal mixing

Reciprocal mixing in a receiver occurs when, during the reception of a wanted signal, a strong out-of-band interfering signal mixes with out-of-band skirt noise from the synthesizer, producing mixing products which fall into the receiver IF band, causing the receiver output signal-to-noise ratio to be degraded (see Fig. 1).

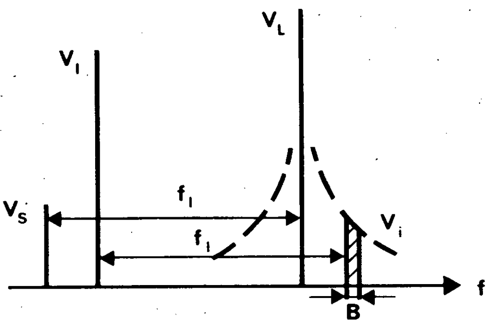

FIGURE 1 – *Reciprocal mixing*

B: bandwidth of the receiver (Hz)
f_I: first intermediate frequency
V_L: wanted output of the synthesizer
V_i: out-of-band noise density
V_I: a strong interfering signal at the receiver input
V_s: wanted signal

From Fig. 1, an equation showing the relationship between V_I and the following items, i.e. receiver output signal-to-noise ratio S_o/N_r, synthesizer output signal purity V_L/V_i as well as the wanted signal V_s, can be derived [Gao, 1977]:

$$V_{I(\mathrm{dB}(\mu\mathrm{V}))} = \left(\frac{V_L}{V_i}\right)_{\mathrm{dB}} - 10 \log B + V_{s(\mathrm{dB}(\mu\mathrm{V}))} - \left(\frac{S_o}{N_r}\right)_{\mathrm{dB}} \qquad (1)$$

Where S_o is the signal at the receiver output and N_r represents the reciprocal mixing products only when V_s is sufficiently large so that the front-end noise of the receiver can be neglected.

Assuming the noise density at 20 kHz away from the wanted output of the synthesizer of a given receiver is -120 dB/Hz relative to the wanted output of the synthesizer, $B = 2800$ Hz, $V_s = 40$ dB(μV), $S_o/N_r = 20$ dB, the $V_I = 105.5$ dB(μV).

It can be seen from the above, given the wanted signal V_s, the signal-to-noise ratio S_o/N_r at the receiver output, and the bandwidth B, the allowable level of interference V_I rises as the out-of-band noise density of the synthesizer V_i is reduced. It should be noted that, in the above calculation, the effects of second and subsequent down conversions are not taken into account. This is justified because the oscillators used are usually fixed and would have significantly less problems in maintaining spectral purity.

3. Measurement of reciprocal mixing

Up to now, there is no internationally adopted method for measuring reciprocal mixing. The differences in the measuring methods lie in the specified level of receiver input signals and in the method of measuring reciprocal mixing products at the output.

Methods commonly used for testing are given in Table I below:

TABLE I – *Methods of measuring reciprocal mixing*

Case	Wanted signal (dB(μV))	Method of measuring reciprocal mixing products at receiver output	Advantages	Disadvantages
1	No signal	Increase unwanted signal level to double the noise power N_r	Does not require a wanted signal	Dependent on noise factor. Pessimistic results compared with other methods
2	No signal	Increase the unwanted signal level until the noise power is equal to S_o dB(mW) obtained when a wanted signal 0 dB(μV) is applied to the input of the receiver	Independent of noise factor. Simple measuring configuration	
3	0	Increase unwanted signal level to raise the noise power by 10 dB		Dependent on noise factor. If NF > 15 dB, S_o / N_r too small to measure
4	10	Increase unwanted signal level to reduce the original signal-to-noise ratio by 10 dB [CCIR, 1982-86a]		Dependent on noise factor
5	10	Increase unwanted signal level to make the S_o / N_r equal to 10 dB	Independent of noise factor	
6	40	Increase unwanted signal level to make the S_o / N_r equal to 20 dB	Independent of noise factor	Requires high level, typically +110 dB(μV) of unwanted signal which can cause errors due to blocking, etc.

In-depth studies and experiments indicate that the methods given in cases 2 or 5 would be suitable as standard methods as they are independent of receiver noise factor and approximate operational conditions [CCIR, 1978-82]. In addition, the signal levels involved fall within the normal linear dynamic range of good quality communication receivers. It is considered that if a higher level of wanted signal is used, the level of the unwanted signal would be so large that receiver blocking might occur.

4. **Methods of measurement** [CCIR, 1982-86b]

4.1 *Method I* (see case 2, Table I)

The measurement shall be carried out with the receiver in a J3E mode (upper sideband with a nominal 3 kHz bandwidth), the automatic gain control inoperative, the RF/IF gain control at maximum and any input attenuator adjusted to minimum attenuation. Inoperative means that either the AGC is turned off or else the AGC is not affecting receiver gain [CCIR, 1982-86c].

The wanted signal shall comprise an unmodulated carrier at a level of 0 dB(μV) e.m.f. at a frequency 1000 Hz ± 3 Hz above the carrier frequency to which the receiver is tuned. The wanted signal shall be applied to the receiver input and the AF gain adjusted to provide a suitable level of output power, S_o. The wanted signal shall then be removed. The unwanted signal shall comprise an unmodulated carrier 20 kHz away from the wanted signal to which the receiver is tuned. The unwanted signal shall be applied to the receiver input and the level of the unwanted signal adjusted until the output noise power is equal to that obtained with the 0 dB(μV) e.m.f. wanted signal.

The reciprocal mixing characteristic is represented by the level of the unwanted signal.

4.2 *Method II* (see case 5, Table I)

The measurement shall be carried out with the receiver in a J3E mode (upper sideband with a nominal 3 kHz bandwidth), the AGC operative, the RF/IF gain control at maximum and any input attenuator adjusted to minimum attenuation.

The measurement shall be made by means of the simultaneous application of two test signals, the wanted signal and the unwanted signal to the input of the receiver. The signal-to-noise ratio shall be measured using a notch filter e.g. SINAD measuring equipment.

The wanted signal shall comprise an unmodulated carrier at a level of 10 dB(μV) e.m.f. at a frequency 1000 Hz ± 3 Hz above the carrier frequency to which the receiver is tuned.

The unwanted signal shall comprise an unmodulated carrier 20 kHz away from the wanted signal.

The level of the unwanted signal shall be adjusted until the output noise level is 10 dB below the wanted output signal level. It should be noted that wideband noise from the signal generator producing the unwanted signal may affect the measurement.

The reciprocal mixing characteristic is represented by the level of the unwanted signal.

4.3 *Typical values*

When the above two methods (case 2 and case 5) were used for measuring the performance of various receivers, it was found that the minimum and typical values of the reciprocal mixing characteristic were 90 dB(μV) and 96 dB(μV) respectively.

REFERENCES

GAO ZHONGPING [2 March, 1977] Preliminary investigations on some main performance objectives of HF SSB receivers. *Telecomm. Sci. Express.*

CCIR Documents

[1978-82]: 3/24 (China (People's Republic of)).

[1982-86]: **a.** 3/58 (China (People's Republic of)); **b.** 3/35 (United Kingdom); **c.** 3/59 (Japan).

RECOMMENDATION 454-1*

PILOT CARRIER LEVEL FOR HF SINGLE-SIDEBAND AND INDEPENDENT-SIDEBAND REDUCED-CARRIER SYSTEMS

(Question 1/3, Study Programme 1B/3)

(1970–1978)

The CCIR,

CONSIDERING

(a) that although for conventional radiotelephone systems a level of −26 dB appears, theoretically, to be adequate, operational experience shows that significant improvements in operational time are secured with higher levels;

(b) that, for radiotelephone systems employing a frequency-modulated control channel, further protection of the pilot carrier is necessary to ensure end-to-end circuit gain stability;

(c) that on currently operated multi-channel radiotelegraph systems a level of −26 dB is, both theoretically and in operational experience, inadequate to ensure reliable action of the automatic frequency control system down to the failure point of the telegraph channels;

(d) that a standard level of reduced pilot carrier for all single-sideband and independent-sideband emissions would be operationally advantageous,

RECOMMENDS

1. that a standard pilot-carrier level of −20 dB ± 1 dB relative to transmitter peak envelope power be adopted for all fixed service single-sideband and independent-sideband reduced-carrier HF radio emissions.

ANNEX I

SIGNAL-TO-NOISE RATIOS IN SIDEBAND AND CARRIER CHANNELS

1. Channels with conventional terminals

The minimum usable signal-to-noise ratio of a channel depends on its function. With a conventional terminal, only the speech channel and carrier channel need be considered while in the case of Lincompex equipment the control signal channel must be considered as well.

The carrier branch provides both automatic frequency control and automatic gain control functions. When the signal-to-noise ratio in the carrier branch is approximately 10 dB on an r.m.s. basis, the noise peaks will exceed the carrier peaks. Then large perturbations or even reversals of carrier phase will result so frequently as to impair operation of the automatic frequency control. This may be taken as the failure point of the carrier branch inasmuch as the automatic gain control is somewhat less affected by noise. The noise bandwidth of the carrier branch of a receiver varies among individual designs; for example in the United States of America it is commonly 35 Hz while in the United Kingdom it is 70 Hz and receivers used in the Netherlands, France and Japan have intermediate bandwidths.

The minimum usable speech-to-noise ratio depends on the type of terminal equipment used. For conventional terminals under stable circuit conditions a value of 15 dB corresponds to marginally commercial quality (see Recommendation 339). If these conditions and the foregoing ratio are assumed, the corresponding carrier-to-noise ratio can be calculated by taking into account the respective bandwidths of the speech and carrier channel and the mean speech level relative to p.e.p. Although the latter varies among Administrations, as well as the carrier filter noise bandwidth, such a calculation shows that, in the absence of selective fading, a carrier level of −26 dB relative to p.e.p. should be adequate to ensure that the automatic frequency control is not noticeably disturbed by noise before the speech channel of a conventional circuit becomes uncommercial.

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* The Administration of Pakistan reserved its opinion on this Recommendation. This Recommendation cancels Report 433 (New Delhi, 1970).

Recent operating experience in the United Kingdom has shown, however, that if the carrier-to-noise ratio is increased by 10 dB some 5% improvement in commercial channel hours is nevertheless realized.

2. Channels with Lincompex terminals

In a Lincompex system, there is a possibility of inadequate signal-to-noise ratio in the speech channel, in the pilot carrier channel and/or in the control signal channel. The control signal channel has a bandwidth of 200 Hz and the speech bandwidth is correspondingly reduced from the usual 2750 Hz of a conventional circuit to 2450 Hz to accommodate both the speech and control signals below 3 kHz (in accordance with Recommendation 455).

High noise in the control channel causes the circuit loss to fluctuate. This imparts a subjective "gritty" quality to the speech. The effect becomes excessive for control channel signal-to-noise ratios less than about 14 dB.

A speech-to-noise ratio of 7 dB has been found to represent just marginally commercial quality, taking into account the compandor improvement (see Note 3 to Table I of Recommendation 339).

It can be calculated that the minimum usable signal-to-noise ratios occur approximately together in the speech channel, the control signal channel and the carrier channel.

Thus the protection afforded to the carrier is commensurate with that of the control channel if selective fading is ignored. Nevertheless, the importance of the carrier in controlling the gain stability of up to four channels would appear to demand a higher signal-to-noise ratio, since in the Lincompex system gain stability is directly related to the performance of the automatic frequency control system.

3. Multichannel telegraph systems

The failure of a radiotelegraph channel equipped with automatic error-control facilities is not rigidly definable since it depends on the circuit efficiency that can be tolerated. At low values of circuit efficiency undetected character errors increase significantly and, for this reason, low efficiency circuits are unsuitable for telex operation. For other types of telegraph traffic, however, circuit efficiencies as low as 20% to 30% may be considered tolerable in certain circumstances. However, for the purpose of this assessment, a circuit efficiency of 50% is taken as the failure point. For a dual-diversity system working typical radio conditions, this corresponds to a median signal-to-noise ratio of approximately 8 dB in the telegraph channel, which, in a typical 100-baud system, has a bandwidth of 140 Hz.

According to Recommendation 326, it is typical of present practice that the mean power of each channel of a multi-channel telegraph system (class of emission R7B or B7B) be given by p.e.p./$4n$, when $n > 4$. Thus for a representative number of channels (say $4 < n < 10$), the power in a given telegraph channel will exceed that of a pilot-carrier of -26 dB relative to p.e.p. by at least 10 dB. But the carrier channel has an advantage with respect to noise bandwidth of only 3 to 6 dB since the ratio of the telegraph channel bandwidth to the carrier channel bandwidth is typically in range 2 to 4 (corresponding to a bandwidth range of 70 to 35 Hz). Therefore it is evident that the carrier channel will be at a net disadvantage and that a pilot carrier level of -26 dB relative to p.e.p. is inadequate over a wide range of circumstances to ensure reliable action of the automatic frequency control down to the failure point of the telegraph system.

The foregoing discussion makes no allowance for selective fading. It may be noted that in general the telegraph channels ordinarily derive substantial benefit from either space or frequency diversity while the carrier channel does not.

RECOMMENDATION 347

CLASSIFICATION OF MULTI-CHANNEL RADIOTELEGRAPH SYSTEMS FOR LONG-RANGE CIRCUITS OPERATING AT FREQUENCIES BELOW ABOUT 30 MHz AND THE DESIGNATION OF THE CHANNELS IN THESE SYSTEMS

(Question 2/3)

(1956–1959–1963)

The CCIR,

CONSIDERING

(a) that there exists a large number of long-range multi-channel radiotelegraph systems using frequencies below about 30 MHz and that it is desirable to classify them in categories;

(b) that the lack of uniformity in the arrangement and designation of the channels in these systems, may give rise to certain difficulties when one transmitting station has to work with several receiving stations;

(c) that the increasing use of multi-channel telegraph systems makes it desirable to adopt a uniform designation of channels in such systems,

UNANIMOUSLY RECOMMENDS

1. that the systems should be classified and the different categories designated by letters, as follows:

1.1 *Time-division multiplex systems:* capital letter T (for example, synchronous systems, such as Baudot, RCA and TOR multiplex and double-current cable code);

1.2 *Frequency-division multiplex systems*

1.2.1 Systems with *constant* frequency arrangements of significant conditions: capital letter U (for example: voice-frequency multiplex with frequency-shift);

1.2.2 Systems with *variable* frequency arrangements of significant conditions: capital letter V (for example: four-frequency diplex);

1.3 *Multi-channel systems using a combination of these processes*

1.3.1 Frequency-division systems, with constant frequency arrangement, combined with a time-division multiplex system 1.3.2 Four-frequency diplex system, combined with a time-division multiplex system	combination of the above-mentioned letters (always beginning with the frequency-division letters U or V);

2. when a multi-channel telegraph signal is applied to a multi-channel telephone transmitter, the designation of the telephone channel should come first in the sequence and should be in accordance with Recommendation 348;

3. when a multi-channel telegraph signal is applied to an independent-sideband transmitter used solely for telegraphy, the designation of the sideband should come first in the sequence. The letter H should denote the upper sideband, and the letter L the lower sideband;

4. that in time-division systems, the telegraph channels should be designated by capital letters A, B, C, D, etc.; for sub-division, the sub-channels should be designated by A1, A2, A3, A4, B1, B2, B3, B4, etc.;

5. that in frequency-division systems, the telegraph channels should be designated by figures;

6. that in a combination of multi-channel processes, the telegraph channels should be designated by a letter and figure sequence.

For example:

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

where channel B of the time-division system is sub-divided and sub-channel 2 is in use, the designation would be U3TB2;

if the above-mentioned system is applied to channel B of an independent-sideband telephone transmitter, the corresponding designation would be BU3TB or BU3TB2;

if the above-mentioned system is applied to the upper sideband of an independent-sideband multi-channel transmitter used solely for telegraphy, the corresponding designation would be HU3TB or HU3TB2;

where additional information is required, the multiplex system may be identified by a number inserted between the letters T and B, and where two sub-channels (quarter-channels) are linked together to form a half-speed sub-channel (half-channel), each quarter-speed sub-channel component may be designated by the use of numbers separated by an oblique stroke. The full designation HU3T4B2/4 would be applicable to the arrangement shown diagrammatically by the arrows on the right of the figure below;

in established communication networks, where the sub-carrier, multiplex system, channel and sub-channel arrangements are mutually known to the station management at each end of the circuit, it shall be permissible to shorten the full designation HU3T4B2/4 above, beginning at the first letter or number which is of major significance for identification purposes. For example, in the given instance 4B2/4 will identify the specific area illustrated by the arrows to the right of Fig. 1.

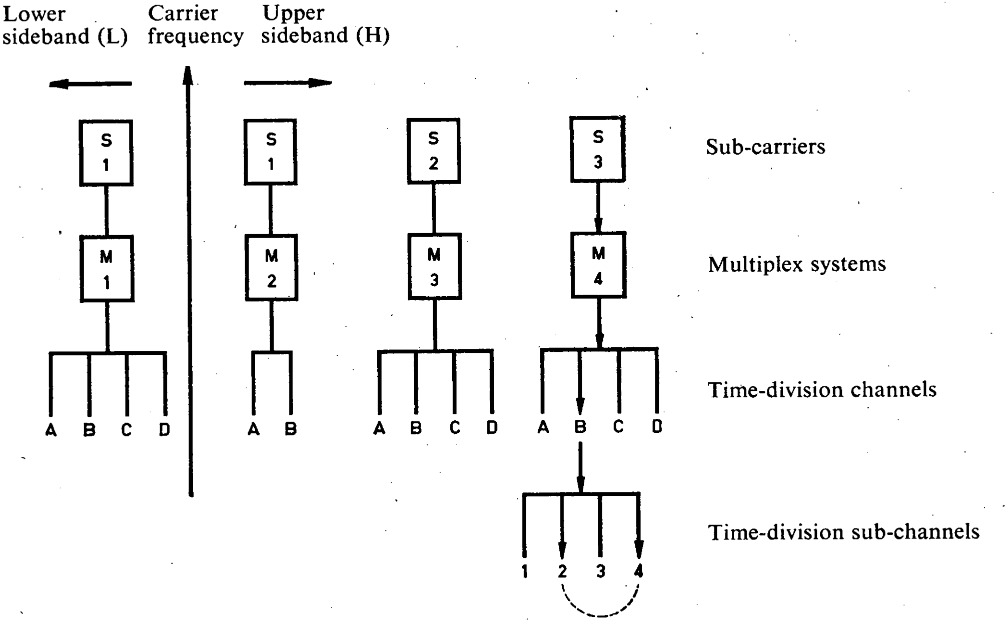

FIGURE 1 – *Multi-channel independent-sideband radiotelegraph transmitter*

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

RECOMMENDATION 348-4*

ARRANGEMENT OF CHANNELS IN MULTI-CHANNEL SINGLE-SIDEBAND AND INDEPENDENT-SIDEBAND TRANSMITTERS FOR LONG-RANGE CIRCUITS OPERATING AT FREQUENCIES BELOW ABOUT 30 MHz

(Question 2/3)

(1953-1956-1959-1963-1966-1974-1986-1990)

The CCIR,

CONSIDERING

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

(b) that, since it is necessary to economize in the use of the radio-frequency spectrum, when considering international circuits consisting mainly of single long-distance radio links, operating on frequencies below 30 MHz, it is desirable:

- to use independent-sideband transmissions to the maximum extent possible;
- to transmit a band less than the 300 to 3400 Hz recommended by the CCITT for landline circuits;
- to reduce the upper frequency to 3000 Hz, or less in special circumstances, but never below 2600 Hz;

(c) that there are already in operation international multi-channel radiotelephone circuits, in which the bandwidth allocated to each channel is 3000 Hz, but which are actually transmitting a speech band of 250 to 3000 Hz;

(d) that a number of countries also use a band for digital transmission with an upper frequency of 3400 Hz, and are actually transmitting a band from 300 to 3400 Hz;

(e) that, in general, the outer channels are liable to cause and receive more interference to and from stations operating on adjacent assigned frequencies, the outer channels being those located furthest from the assigned frequency;

(f) that there are advantages in adopting channel arrangements which are the same in all parts of the HF (decametric) range,

UNANIMOUSLY RECOMMENDS

1. that standard channel arrangements should be adopted for multi-channel radiotelephone systems;

2. that for channels with an effective frequency band of 2750 Hz the transmitted band in each channel should be from 250 Hz with an upper frequency of 3000 Hz, or lower in special circumstances, but never below 2600 Hz;

3. that for channels with an effective frequency band of 3000 Hz the transmitted band in each channel should be from 300 Hz with an upper frequency of 3400 Hz, or lower in special circumstances, but never below 2600 Hz;

4. that in four-channel systems the channel arrangement should be as shown in Fig. 1a);

* This Recommendation should be brought to the attention of Study Group 8.

5. that, when less than four channels are used, the channels nearest to the carrier should be selected according to the arrangements shown in Figs. 1b), 1c), 1d), 1e) or 1f).

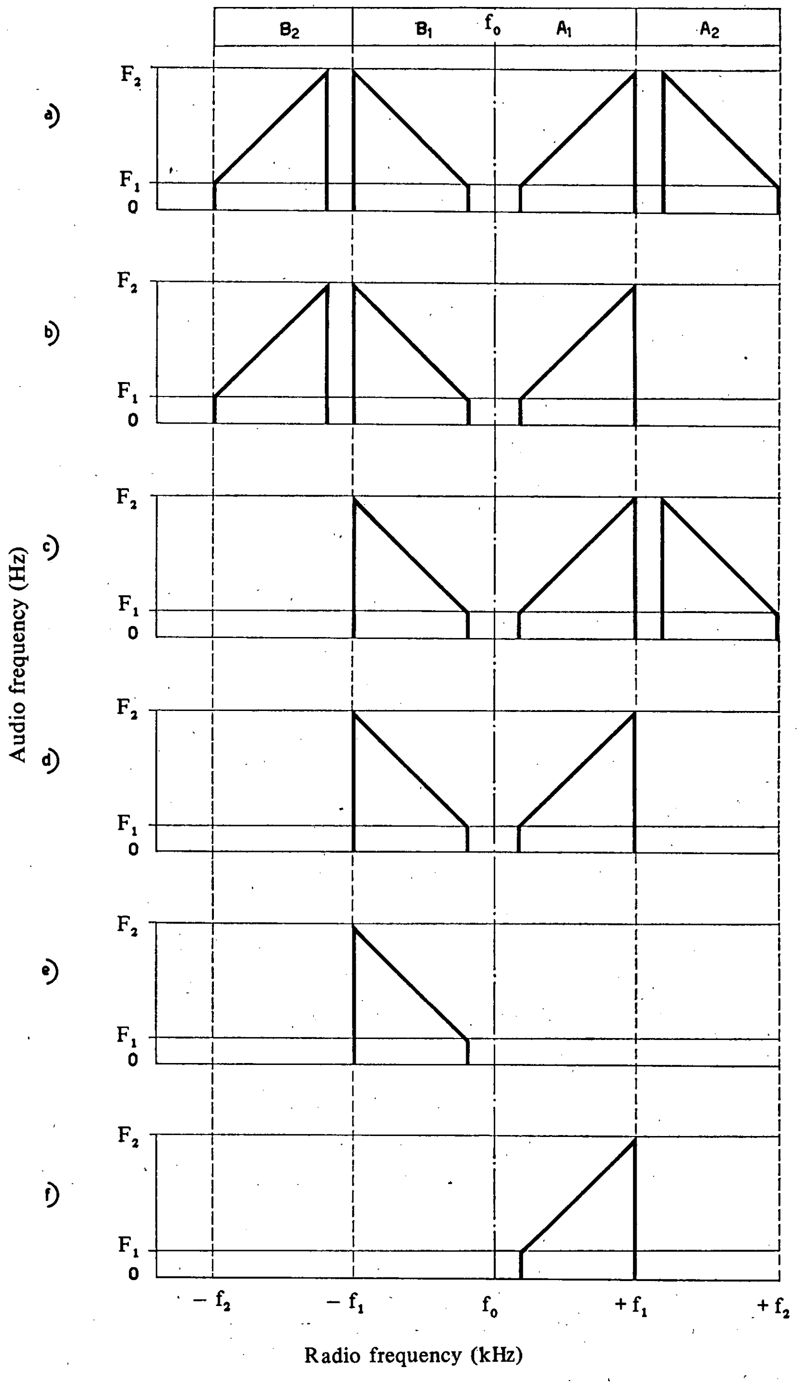

FIGURE 1 – *Relationship between audio frequencies and radio frequencies for the various channel arrangements*

For an effective channel frequency band of 2750 Hz:

$$F_1 = 250 \text{ Hz}; \; F_2 = 3000 \text{ Hz}; \; f_1 = 3 \text{ kHz}; \; f_2 = 6 \text{ kHz}.$$

For an effective channel frequency band of 3100 Hz:

$$F_1 = 300 \text{ Hz}; \; F_2 = 3400 \text{ Hz}; \; f_1 = 3.4 \text{ kHz}; \; f_2 = 6.8 \text{ kHz}.$$

RECOMMENDATION 436-2*

ARRANGEMENT OF VOICE-FREQUENCY TELEGRAPH CHANNELS WORKING AT A MODULATION RATE OF ABOUT 100 BAUDS OVER HF RADIO CIRCUITS

(Question 2/3, Study Programme 17A/3)

(1966–1970–1978)

The CCIR,

CONSIDERING

(a) that lack of standardization in the arrangement of channels for voice-frequency multi-channel telegraph systems working over HF radio circuits can give rise to difficulties when setting up such systems;

(b) that it is necessary to use the radio-frequency spectrum to the best advantage in the interests of both spectrum economy and circuit efficiency;

(c) that frequency-shift systems are in use on many routes;

(d) that the frequency-exchange method of operation is in use on long routes suffering from severe multipath distortion;

(e) that on such systems, radiotelegraph channels which operate synchronously at a modulation rate of 96 bauds and employ automatic error correction are being increasingly used,

UNANIMOUSLY RECOMMENDS

1. that the channel arrangement shown in Table I be preferred for voice-frequency multi-channel frequency-shift systems operating at a modulation rate of approximately 100 bauds over HF radio circuits;

2. that for frequency-exchange systems, the central frequencies of Table I should be used, and should be paired in the manner found to be best suited to the propagation conditions of the route. (A typical arrangement would take alternate pairs giving 340 Hz between tones.)

Note – Theoretical work in Japan indicates an optimum frequency-shift of 0.8 B (Hz), where B is the modulation rate in bauds. This would lead to a required minimum bandwidth (at the -3 dB points) of B (Hz). Laboratory experiments and measurements on the synchronous ARQ circuit Frankfurt-Osaka support these conclusions. For circuits which are not operating near MUF and for asynchronous circuits, some theoretical results indicate B to $2B$ as the best frequency-shift.

TABLE I – *Central frequencies of voice-frequency-shift telegraph channels with a channel separation of 170 Hz and a modulation index of about 0.8*
(Frequency-shift: ±42.5 Hz or ±40 Hz)

Channel position	Central frequency (Hz)	Channel position	Central frequency (Hz)
1	425	8	1615
2	595	9	1785
3	765	10	1955
4	935	11	2125
5	1105	12	2295
6	1275	13	2465
7	1445	14	2635
		15	2805

Note. – See CCITT Recommendation R.39 (Fascicle VII.1).

* This Recommendation cancels Report 198 (Geneva, 1963).

3A b: Antennas characteristics

RECOMMENDATION 162-2

USE OF DIRECTIONAL ANTENNAS IN THE BANDS 4 TO 28 MHz

(Question 29/3) *

(1953–1956–1966–1970)

The CCIR,

CONSIDERING

(a) that there is serious congestion in the fixed-service bands between 4 and 28 MHz;

(b) that occupancy of the radio-frequency spectrum is represented, not only by occupancy in bandwidth and time, but also by the spatial distribution of the radiated power;

(c) that radiation outside the directions necessary for the service can be effectively reduced by the use of directional antennas;

(d) that Articles 5, 18 and 19 of the Radio Regulations would seem to justify explicit requirements for the use of directional antennas in these bands;

(e) that the Panel of Experts, in Recommendation No. 13 of its Final Report, Geneva, 1963, advocates the use of directional antennas for transmission and reception in the fixed service;

(f) that the request by the Panel of Experts in Recommendation No. 38 of its Final Report, and the urgent question of the IFRB, Question 29/3, ask for specification of reasonable standards of directivity for antennas in the various types of radio services in the bands between 4 and 28 MHz, with due regard to economy of cost;

(g) that the adoption of minimum standards for directional antennas would contribute to the solution of frequency sharing problems;

(h) that antenna performance materially better than these minimum standards is attainable at economic cost using modern techniques,

UNANIMOUSLY RECOMMENDS

1. Definitions

That the following definitions should be used in specifying the performance of directional antennas:

1.1 *Directive gain (G_0)***

In a given direction, 4 π times the ratio of the intensity of radiation (power per unit solid angle (steradian)), in that direction, to the total power radiated by the antenna.

Note – The attention of the Joint CCIR/CCITT Study Group for Vocabulary (CMV) is drawn to this new definition of directive gain, and it is asked to say whether this is in accordance with the definitions proposed by other international organizations, e.g. the IEC.

1.2 *Service sector (S)*

The horizontal sector containing the main beam of the antenna radiation and including the direction required for service. It is very close to twice the angular width of the main beam measured to the half-power (–3 dB) points.

1.3 *Interference sector (I)*

The horizontal sector outside the main beam

$$I^\circ = 360^\circ - S^\circ$$

* This Question replaces Question 20/1 (New Delhi, 1970).

** See No. 154 of the Radio Regulations for a definition of power gain.

Note by the Secretariat. – The term "Directive gain" was replaced by the term "Directivity" (see Recommendation 341).

1.4 *Minimum standard antenna*

The antenna having the specified minimum characteristics as regards directive gain and service sector at its operating frequency or frequencies.

1.5 *Economic standard antenna*

The antenna having specified characteristics as regards directive gain and service sector at its operating frequency or frequencies which are justifiable on economic grounds (i.e. by savings in the cost of providing a given transmitter output power).

1.6 *Antenna directivity factor (M)**

The ratio of the power flux-density in the wanted direction to the average value of power flux-density at crests in the antenna directivity pattern in the interference sector. This is equivalent to the average improvement in signal-to-interference ratio achieved by using the actual antenna in place of an isotropic radiator in free space;

2. that the minimum standard antenna should have a directivity factor given by

$$M = 0.1\, f^2$$

f being the operating frequency in MHz;

3. that the economic standard antenna should have a directivity factor given by

$$M = 0.25\, f^2$$

4. that, for a radiated power of 5 kW or greater, the directivity factor, M, of the antenna used should be equal to or greater than that of the minimum standard antenna;

5. that, for a radiated power of 10 kW or greater, antennas having performances not worse than that of the economic standard antenna should be used to the extent practicable;

6. that, for transmitter powers below 5 kW, the power flux-density in the interference sector should not exceed that radiated in this sector from the minimum standard antenna with a total radiated power of 5 kW;

7. that, in the interests of reducing the effects of interference, the directivity factor, M, of the receiving antenna should be equal to or greater than that of the minimum standard antenna and should, as far as practicable, attain that of the economic standard antenna.

Explanatory notes

The values of directive gain and service sector appropriate to the specified values of M for the minimum standard antenna and the economic standard antenna respectively are given in the following Table I:

TABLE I

Operating frequency f(MHz)	Minimum standard antenna			Economic standard antenna		
	M	G_0(dB)	$S°$	M	G_0(dB)	$S°$
5	2.5	13.8	54	6.25	17.5	35
10	10	16.6	39	25	20.4	25
15	22.5	18.3	32	57	22.1	21
20	40	19.4	28	100	23.3	18

The antenna gain relative to a half-wave dipole above earth may be obtained by subtracting 8 dB from the value of G_0. It should be noted that the S value is the minimum bound at the directive gain specified and has been derived on the assumption that at least 40% of the total power is radiated in the main beam (a value appropriate to many rhombic antennas). Where (as is commonly the case) the (power) gain of the antenna (No. 154 of the Radio Regulations) is known, a suitable adjustement should be made to account for the efficiency of the antenna in deriving the directive gain.

* The derivation of the value of the directivity factor for any given antenna is explained in Report 356.

Furthermore, when calculated gains, based on constant-current formulae, are used to determine the *M*-factor, adjustment should be made to allow for the current decay along the actual antenna. Methods of making these adjustments are described in Report 356.

No preferred polarization or type of antenna is established. Horizontal polarization offers better ground reflection characteristics and, for receiving, some reduction of interference due to man-made noise. Where reflection over sea water or over earth of very high conductivity takes place, the use of vertical polarization can enhance the low-angle performance needed for long paths. This important consideration is reflected in the computation of M, which includes a weighting factor $10/\Delta$, where Δ is the vertical angle of optimum radiation. There is no requirement for the transmitting and receiving antennas to have the same polarization characteristics because of the randomization of the polarization in the ionospheric transmission process.

The *M*-factors chosen are largely based upon the measured performance of typical rhombic antennas and typical antenna-arrays. The radiation characteristics of single rhombic antennas in the interference zone are, in general, somewhat inferior to other types of antenna (e.g. half-wave antenna arrays), a fact which is reflected in the *M*-factor. Provided the parameters are correctly chosen, the performance of antennas of differing types possessing the same *M*-factor is comparable.

3A c: Influence of the ionosphere

RECOMMENDATION 520-1

USE OF HIGH FREQUENCY IONOSPHERIC CHANNEL SIMULATORS

(Question 21/3)

(1978–1982)

The CCIR,

CONSIDERING

(a) that testing of HF transmission systems while in operation is time-consuming and costly;

(b) that some Administrations have reported good correlation between the results of laboratory tests conducted on simulators and the results of tests of a data transmission system in operation,

UNANIMOUSLY RECOMMENDS

1. that, when simulators are used to predict, in a qualitative sense, how well a particular system of data transmission may be expected to perform on HF circuits, the representative channel parameter combinations listed in Annex I be considered on a provisional basis;

2. that, for comparative evaluation of different systems of data transmission, the additional channel parameter combinations listed in Annex II be considered on a provisional basis;

3. that studies in connection with Question 21/3 be continued for the determination of the parameter combinations to be used in the simulation of specific circuits of a given length and for a specific period of time;

4. that further studies in connection with Question 21/3 be undertaken to establish the most significant channel parameter combinations in the evaluation of systems designed for the transmission of analogue signals.

ANNEX I

SIMULATOR PARAMETERS FOR QUALITATIVE TESTING

1. If applicable, it is desirable to perform all simulator tests in both diversity and non-diversity configurations to evaluate the effectiveness of the diversity combining scheme used. Back-to-back tests with additive noise should be completed prior to testing with the simulator to ascertain that the equipment performs properly.

2. Representative channel parameter combinations

2.1 Gaussian noise and flat fading: bit error probability as a function of energy-per-bit to Gaussian noise density ratio for a single fading path with no frequency-shift.

Suggested values for frequency spread (fading rate): 0.2 Hz and 1 Hz.

2.2 Gaussian noise, multipath and fading: bit error probability as a function of energy-per-bit to Gaussian noise density ratio for two independently fading paths with equal mean attenuation, equal frequency spreads and non-frequency shifts.

Suggested parameter values for general testing:

2.2.1 *Good conditions*

Differential time delay: 0.5 ms
Frequency spread: 0.1 Hz

2.2.2 *Moderate conditions*

Differential time delay: 1 ms
Frequency spread: 0.5 Hz

2.2.3 *Poor conditions*

Differential time delay: 2 ms
Frequency spread: 1 Hz

2.2.4 *Flutter fading* (if required)

Differential time delay: 0.5 ms
Frequency spread: 10 Hz

Note – For simulation of specific circuits, delay values as a function of radio circuit length are given in Fig. 1 of Report 203.

2.3 Doppler, multipath and fading (if required): bit error probability as a function of frequency offset of both components of a two component multipath structure with equal mean attenuation, equal frequency spreads and no noise.

Suggested parameter values:

Differential time delay: 0.5 ms
Frequency spread: 0.2 Hz
Range of frequency offset: 0 to 10 Hz.

ANNEX II

ADDITIONAL PARAMETERS FOR COMPARATIVE TESTING

1. The following tests, in conjunction with those listed in Annex I, enable comparative evaluation of equipment.

2. Additional tests for comparative purposes

The following tests provide greater knowledge of the specific capabilities of a modem. In conjunction with the foregoing tests, this will enable comparative evaluation of equipment.

2.1 *Flat fading:* bit error probability as a function of frequency spread for a single fading path with no noise or frequency-shift.

Suggested range of frequency spread: 0.1 to 50 Hz.

The results of this test will show the capabilities of the modem with respect to frequency spread distortion in the channel and the effect of internal noise in the modem receiver (and RF receiver if it is used).

2.2 *Multipath and fading:* bit error probability as a function of the differential time delay of two independently fading paths with equal mean attenuation and equal frequency spreads and with no noise or frequency-shift.

Suggested parameter values:

Frequency spread: 0.2 Hz and 1 Hz
Range of differential time delay: 0.1 to 5 ms.

The result of this test will show the capabilities of the modem with respect to time spread and frequency spread distortion in the channel and the effect of internal noise and intermodulation distortion in the modem (and RF) receiver.

2.3 *Multipath and fading:* bit error rate as a function of the ratio of the mean levels of two independently fading paths with unequal mean attenuation, equal frequency spreads and with no noise or frequency-shift.

Suggested parameter values:

Differential time delay: 5 ms
Frequency spread: 0.2 Hz
Range of mean level ratios: −40 to 0 dB.

The results of this test will show the sensitivity of the modem to relative low strength path components with large time delays.

RECOMMENDATION 613

THE USE OF IONOSPHERIC CHANNEL SOUNDING SYSTEMS OPERATING IN THE FIXED SERVICE AT FREQUENCIES BELOW ABOUT 30 MHz

(Study Programme 20A/3)

(1986)

The CCIR,

CONSIDERING

(a) that ionospheric oblique path sounding allows the determination in real-time of ionospheric propagation conditions;

(b) that the results of sounding may be applied to the optimization of frequency utilization and circuit reliability for a communications circuit on the same path;

(c) that sounding on the frequencies assigned to a circuit also allows the signal-to-noise and interference ratios existing on those frequencies to be evaluated;

(d) that the proliferation of channel sounding systems increases the already severe congestion of the HF bands;

(e) that soundings on frequencies other than those assigned to the particular circuit may cause interference to other users and give information which cannot be directly applied to the frequency management of the circuit;

(f) that sounding more frequently than can be utilized by the frequency management procedures in use is unnecessary,

UNANIMOUSLY RECOMMENDS

1. that where ionospheric channel sounding is employed, it should take place only on the frequencies and within the channel bandwidths assigned to the communications circuit, the frequency utilization for which is being managed using the sounding information;

2. that the repetition rate of the sounding signals should be at the minimum rate required for frequency management;

3. that the radiated power of the sounding signals should be at the minimum level required for frequency management;

4. that in the event of natural disasters and emergencies which require the rapid establishment of telecommunications facilities, the constraints on the use of channel sounding may be relaxed.

3A d: Operational questions

There are no Recommendations in this Section.

3A e: Radio system employing meteor-burst propagation

There are no Recommendations in this Section.

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SECTION 3B: RADIOTELEPHONY

RECOMMENDATION 335-2

USE OF RADIO LINKS IN INTERNATIONAL TELEPHONE CIRCUITS

(Question 13/3)

(1951–1963–1966–1970)

The CCIR,

CONSIDERING

(a) that, at the present time, radiotelephone systems connecting the various countries often employ carrier-frequencies below about 30 MHz (further reference to 30 MHz in this Recommendation means "about 30 MHz");

(b) that the use of such a radio link, in a long-distance telephone circuit, implies certain special conditions, which introduce particular difficulties not encountered when purely metallic connections are used;

(c) that such a radiotelephone circuit differs from a metallic circuit in the following ways:

c.a such a radiotelephone circuit is subject to attenuation variation with the special difficulty of fading;

c.b such a radiotelephone circuit suffers from noise caused by atmospherics, the intensity of which may reach, or even exceed, a value comparable with that of the signal which it is desired to receive;

c.c special precautions are necessary in the setting up and maintenance of such a radiotelephone circuit, to avoid disturbance of the radio receiver by any radio transmitter and especially by its own radio transmitter;

c.d to maintain the radiotelephone link in the best condition from the point of view of transmission performance, it is necessary to take special measures to ensure that the radio transmitter always operates, as far as possible, under conditions of full loading, whatever may be the nature and the attenuation of the telephone system connected to the radiotelephone circuit;

c.e it is necessary to take measures to avoid or correct conditions of abnormal oscillation or cross-talk;

c.f although the recommended frequency band, to be effectively transmitted by international landline circuits, has been determined by a study of the requirements of the human ear, this band (for a radiotelephone circuit operating at a frequency below 30 MHz) may be limited by the necessity of obtaining the maximum number of telephone channels in this part of the radio-frequency spectrum and so that each telephone channel does not occupy a radio-frequency band larger than necessary;

c.g in general, such a radiotelephone circuit is a long-distance international circuit giving telephone service between two extended networks, and this fact is of great importance from two points of view:

> *c.g.a* on the one hand, international conversations, in general, are of great importance to the subscribers and, on the other hand, they are made in languages which are not always their mother tongue, so that high quality reception is particularly important;
>
> *c.g.b* the public should not be deprived of a very useful service under the pretext that it does not always satisfy the degree of excellence desirable for long-distance communication,

UNANIMOUSLY RECOMMENDS

1. Circuits above 30 MHz

that between fixed points, telephone communications should be effected wherever possible by means of metallic conductors, or radio links using frequencies above 30 MHz to make the allocation of radio frequencies less difficult; where this can be realized, the objective should be to attain the transmission performance recommended by the CCITT for international telephone circuits on metallic conductors;

2. Circuits below 30 MHz

2.1 that since it becomes necessary to economize in the use of the frequency spectrum, when considering international circuits which consist mainly of single long-distance radio links operating at frequencies less than 30 MHz, it is desirable to use single-sideband transmission to the maximum extent possible, to employ a speech band less than the 300 to 3400 Hz recommended by the CCITT for landline circuits and, preferably, to reduce the upper frequency of the speech band to 3000 Hz or less, but not below 2600 Hz, except in special circumstances;

2.2 that, although it will be necessary to tolerate large variations in noise level on such a radiotelephone circuit, every possible effort should be made to obtain minimum disturbance to the circuit from noise and fading by the use of such techniques as full transmitter modulation, directional antennas and single-sideband operation;

2.3 that, during the time that such a radiotelephone circuit is connected to an extension circuit equipped with echo suppressors (voice-operated switching device), the intensity of disturbing currents should not be sufficient to operate the echo suppressor frequently;

2.4 that such a radiotelephone circuit should be provided with an echo suppressor to avoid singing or echo disturbance on the complete circuit, or, preferably, with terminals using the principles of constant overall transmission loss, as set forth in Recommendation 455;

2.5 that such a radiotelephone circuit should be equipped with automatic gain control to compensate automatically, as far as possible, for the phenomenon of fading;

2.6 that the terminal equipment of such a radiotelephone circuit should be such that it may be connected, in the same way as any other circuit, with any other type of circuit;

2.7 that, where privacy equipment is used, this equipment should not appreciably affect the quality of telephone transmission;

2.8 that, when suitable automatic devices are not provided, the circuit controls should be adjusted, as often as necessary, by an operator to ensure optimum adjustment of transmitter loading, received volume and the operating conditions of the echo suppressor.

Note. – Although the requirements contained in § 2 of this Recommendation are much less severe than those imposed on international landline circuits, the objective remains to attain the same standards of telephone transmission in all cases. In view of this, it is desirable that the telephone systems connected to a radiotelephone circuit should conform to CCITT Recommendations covering the general conditions to be met by international circuits used for landline telephony, especially in respect of equivalent, distortion, noise, echoes and transient phenomena.

Bearing in mind the recommendations contained in §§ 1 and 2, it is desirable that in each particular case, Administrations and private operating agencies concerned should first reach agreement on how far the standards usually employed for international landline circuits may be attained in the case considered. If the technique of § 1 of this Recommendation can be used, the objective should be to obtain, as far as possible, the characteristics recommended by the CCITT for international landline circuits. Otherwise the Administrations and private operating agencies concerned should study the best solution from the point of view of both technique and economy.

RECOMMENDATION 336-2

PRINCIPLES OF THE DEVICES USED TO ACHIEVE PRIVACY IN RADIOTELEPHONE CONVERSATIONS

(Question 13/3)

(1951-1963-1966-1970)

The CCIR,

CONSIDERING

(a) that the devices referred to are intented to achieve privacy rather than secrecy in radiotelephone conversations;

(b) that, in the interest of maximum privacy, the details of the systems employed and of their performance, should be agreed upon between the Administrations and private operating agencies concerned,

UNANIMOUSLY RECOMMENDS

1. that the following statement of principles and characteristics of the devices concludes the study of Question 30 (Stockholm, 1948), for radio circuits operating at frequencies less than about 30 MHz;

1.1 *Principles of the devices*

Two general types of system are used to achieve privacy in radiotelephone circuits operating at frequencies less than about 30 MHz;

1.1.1 *For double-sideband systems* (see Note)

inverter systems, the speech band being inverted about a fixed frequency.

1.1.2 *For single-sideband and independent-sideband systems*

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

1.2 *Characteristics of the devices*

1.2.1 the band-splitting system provides privacy superior to that obtained with the inverter system, but for satisfactory operation it can tolerate less distortion;

1.2.2 the apparatus is designed to reduce attenuation distortion and the levels of unwanted products of modulation and of carrier signals to a minimum. The extent of the permissible distortion due to the presence of the privacy devices is, in general, dependent on the type of privacy and is usually agreed between the Administrations or private operating agencies concerned;

2. that, for frequencies above about 30 MHz, the details of the systems to be employed and of their performance should be agreed upon between the Administrations or private operating agencies concerned.

Note. – The attention of Administrations is drawn to No. 2700 of the Radio Regulations, which states:

"**2700** § 1. (1) Administrations are urged to discontinue, in the fixed service, the use of double-sideband radiotelephone (class A3E) transmissions."

RECOMMENDATION 480

SEMI-AUTOMATIC OPERATION ON HF RADIOTELEPHONE CIRCUITS

Devices for remote connection to an automatic exchange by radiotelephone circuits

(Question 13/3)

(1974)

The CCIR,

CONSIDERING

(a) that telephone circuit operation is substantially improved by the use of semi-automatic instead of manual working;

(b) that HF radiotelephone circuits will continue to be used for many years to come in the international fixed service;

(c) that employment of CCITT signalling codes on such circuits, even when they are equipped with systems of the type described in Recommendation 455, is difficult owing to the loss probabilities prescribed for the use of these codes in the international service;

(d) that, on the other hand, the use of signalling methods specially intended for radiotelephone channels makes it possible to transmit the information required for remote connection of an operator in one country to an automatic exchange in another country;

(e) that the FSK signalling system now in use on HF radiotelegraph circuits meets the requirements of *(d)* above;

(f) that Report 434 contains precise details on the use of, and tests made by certain countries with devices using the signals mentioned in *(e)* above and that the results are very satisfactory,

UNANIMOUSLY RECOMMENDS

that, when it is desired to provide remote dialling facilities into an automatic exchange via an HF radiotelephone circuit, the system parameters used should preferably conform to those described in Annex I to this Recommendation.

ANNEX I

The following specifications concern two devices, a "TRANSMITTING device" in OUTGOING country A and a "RECEIVING device" in INCOMING country B. The TRANSMITTING device is connected to the operating centre of country A (operators) and the RECEIVING device is connected to the automatic switching equipment of incoming country B by a dedicated line. The operator in country A can call a subscriber in country B in the same way as another subscriber in country B would do, since the TRANSMITTING AND RECEIVING devices establish a genuine remote connection between the operator in A and the automatic switching equipment in B.

Use by the two countries A and B of the devices described here permits semi-automatic operating, since the operator in A is in a sense a subscriber of the B network. Only terminal traffic will be allowed between the two countries, all transit traffic being excluded. Further, the two countries will have to agree on the facilities afforded to the operators in A (calling of special services such as information, calling in assistance-operators in B or other operators to reach subscribers in B not connected to an automatic exchange).

These specifications are concerned only with the compatibility of the TRANSMITTING and the RECEIVING devices permitting the remote connection of the outgoing operator to the incoming automatic switching equipment.

1. Interconnection

1.1 *The TRANSMITTING device* is connected on one side to the operating centre (operators) and on the other to the radiotelephone circuit:

- on the operating centre side: the operator must transmit to the TRANSMITTING device, for example, by separate wires, the SEIZING, DIALLING, END-OF-DIALLING and CLEARING information;
- on the radiotelephone circuit side: the TRANSMITTING device is placed in series on the *send* direction of the four-wire circuit.

1.2 *The RECEIVING device* is placed in the *receive* path of the four-wire circuit.

The voice circuit and the supervisory and signalling paths from the RECEIVING device are connected to the automatic exchange.

2. Signals transmitted in the forward direction

Information in the forward direction, i.e. from outgoing country A to incoming country B, supplied by the operator in A is converted into signals by the TRANSMITTING device using frequency modulation, which is particularly well suited to transmission on radiotelephone channels.

The TRANSMITTING device contains a voice-frequency FM oscillator of frequency F with a deviation of $\pm \Delta f$. The value of F is selected, by agreement between the two countries*, from the list of frequencies recommended by CCIR (Recommendation 436) with a frequency-shift according to Recommendation 246 of $\pm$ 85 Hz.

Table I below lists the various types and uses of signals

TABLE I

Signal	Signal transmitted on the radiotelephonic circuit	Recognition tolerance at the receiving end
SEIZING	frequency $F \pm \Delta f$ modulated at 100 ± 1 bauds for 300 ms and followed by the frequency $F + \Delta f$ permanently emitted until the beginning of the DIALLING signals	frequency $F \pm \Delta f$ modulated at 100 bauds for a period of 200 to 400 ms followed by the frequency $F + \Delta f$ for at least 300 ms
DIALLING	frequency $F \pm \Delta f$ modulated at the dial pulse rate (66/33 ms or 50/50 ms); the "off" corresponds to the frequency $F + \Delta f$, and the "on" (open) to frequency $F - \Delta f$	Minimum duration of "on" condition (frequency $F - \Delta f$): 25 ms
END-OF-DIALLING	frequency $F \pm \Delta f$ modulated at 100 bauds for 300 ms. No signalling frequency is emitted after this signal	Duration: 200 to 400 ms
CLEARING	frequency $F \pm \Delta f$ modulated at 100 bauds for 600 ms. No signalling frequency is emitted afterwards	Duration more than 500 ms

3. Signals used in the reverse direction

At all times the operator must be able to hear the supervisory signals generated by the distant automatic exchange.

This requires:

3.1 that the TRANSMIT and RECEIVE devices provide control signals to disable any echo suppressors or singing suppressors, included in the circuit, during the period between seizing and the end of dialling;

3.2 that in cases where supervisory signals are too low in frequency to be transmitted directly they must be translated into the voice-frequency band.

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* Different frequencies must be available when there are several circuits equipped with TRANSMITTING or RECEIVING devices in one and the same radiotelephone (transmitting) system to avoid false seizing caused by inter-channel cross-talk.

RECOMMENDATION 455-1

IMPROVED TRANSMISSION SYSTEM FOR HF RADIOTELEPHONE CIRCUITS

(Question 13/3)

(1970–1974)

The CCIR,

CONSIDERING

(a) that, to maintain a satisfactory standard on international radiotelephone circuits operating at frequencies below 30 MHz and connected to the national network, it is necessary to compensate, at the transmitting end, for most, if not all, of the variations in the subscribers' speech volume and of the losses between the subscriber and the international exchange;

(b) that, as a result, the circuit often operates under a condition of overall gain (two-wire to two-wire) and it is necessary to use a singing-suppressor to maintain stability;

(c) that the singing-suppressor markedly degrades the performance of the circuit, due to its switching action and its tendency to misoperation by noise or interference on the radio path;

(d) that the use of a singing-suppressor to maintain overall stability of the radiotelephone channel inhibits the interconnection, on a four-wire basis (see CCITT Recommendation G.101, Fascicle III.1) of radio circuits and long-distance cable or satellite circuits;

(e) that, if HF radiotelephone circuits were operated at a nearly constant overall transmission loss, the singing-suppressor could be eliminated and a radio circuit could be integrated into an international chain;

(f) that, to maintain a constant overall loss, while catering for variations in subscribers' speech volume and line loss, it is necessary to insert, at the receiving end of the circuit, a loss equivalent to the gain inserted at the transmitting end;

(g) that the advantages of compandor operation, as used on some line transmission systems, are well established, but cannot be directly realized on a radio circuit subject to fading;

(h) that, on such a radio circuit, an alternative means of conveying information as to the state of the compressor is necessary to control the expander;

(j) that these alternative means enable advantage to be taken of a compression ratio in excess of that employed in line compandors, which is generally 2/1;

(k) that the behaviour and advantages of a system employing a linked compressor and expander have been established (see Report 354);

(l) that with such an arrangement the two ends of a circuit will be complementary and the essential parameters of the system will have to be standardized,

UNANIMOUSLY RECOMMENDS

1. that, wherever possible, HF radiotelephone circuits should be operated on the basis of a constant overall transmission loss (two-wire to two-wire);

2. that a system comprising a compressor and expander linked by a control channel, which is separate from the speech channel and is resistant to fading distortion, should be used to achieve this performance*;

3. that the system should maintain optimum loading of the transmitter at all times despite variations in subscribers' speech volumes and line losses;

4. that the speech and control signals should both be contained within a single 3 kHz channel;

5. that such a system should be in accordance with the description and parameters listed below:

5.1 *General*

For convenience, the performance requirements of this document are based on a system configuration (one end is shown in Fig. 1) which on the transmit side employs pre-compressor delay in conjunction with a voice-signal amplitude assessor. This does not preclude other configurations which meet the requirements.

* Such a system is commonly known as Lincompex which is a convenient acronym for the phrase "linked compressor and expander". Lincompex is neither a proprietary name nor does it refer to the manufacturer of a particular equipment.

5.2 *Transmit side (Fig. 1a)*

5.2.1 *Speech channel*

5.2.1.1 *Steady-state conditions*
(compression and overall characteristics)

For input levels between +5 dBm0 to −55 dBm0 (Note 1) the output should lie within the limits shown in Fig. 2.

The overall amplitude/frequency response for the speech channel under both fixed-gain and assessor-controlled conditions at any level within the range +5 dBm0 to −55 dBm0 should be:

Above 250 Hz:

Attenuation relative to the maximum response in the band 250 to 2500 Hz (dB):

– For frequencies in the band 250 to 2500 Hz	$\leqslant 2$
– For frequencies in the band 2500 to 2700 Hz	$\leqslant 6$
– For frequencies in the band 2800 Hz and above	> 55

Below 250 Hz:

Increase in overall gain for frequencies below 250 Hz (dB)	$\leqslant 1$

5.2.1.2 *Transient response*
(overall, including amplitude assessor but excluding additional delay)

Attack time, Fig. 3a (ms) (Note 2)	7 ± 2
Recovery time, Fig. 3b (ms) (Note 2)	20 ± 5

5.2.2 *Control channel*

Frequency-modulated oscillator
(frequency controlled by amplitude assessor output):

Nominal centre frequency (Hz)	2900 ± 1
Maximum frequency deviation (Hz)	± 60
Change of frequency for each 1 dB change of input level (Fig. 4) (Hz)	2
Input level to transmit side to produce nominal centre frequency (dBm0)	−25
Oscillator frequency resulting from an input level of 0 dBm0 (Hz)	2850
Oscillator frequency when there is no input to the transmit side (Hz)	$\leqslant 2980$
For sudden increases in the input that exceed 3 dB, the time taken for the oscillator to complete 80% of the corresponding change in frequency should be (ms)	5 to 7
For sudden decreases in the input that exceed 3 dB, the rate of change of oscillator frequency should lie between (Hz/ms)	1.5 and 3.5
Output spectrum effectively limited between (Hz)	2810 and 2990
Output level relative to test tone level in the speech channel (dB)	−5

5.3 *Receive side (Fig. 1b)*

5.3.1 *Speech channel*

5.3.1.1 *Steady-state conditions*

The relative overall amplitude frequency response of the speech channel under fixed and controlled gain conditions should be:

Above 250 Hz:

Attenuation relative to the maximum response in the band 250 to 2500 Hz (dB):

– For frequencies in the band 250 to 2500 Hz	$\leqslant 2$
– For frequencies in the band 2500 to 2700 Hz	$\leqslant 6$
– For frequencies in the band 2800 Hz and above (fading regulator at fixed gain)	> 55

Below 250 Hz:

Increase in overall gain for frequencies below 250 Hz (dB)	$\leqslant 1$

5.3.1.2 *Fading regulator*

Steady-state conditions

For input levels between +7 dB and −35 dB, relative to the nominal design input level to the fading regulator, the output should be within the limits shown in Fig. 5. The nominal design input level which may vary between Administrations is the value measured at the input of the fading regulator, under steady-state conditions, when 0 dBm0 is applied to the transmit side.

Transient response

Attack time: Fig. 3c (ms)	11 ± 2
Recovery time: Fig. 3d (ms)	32 ± 6

5.3.1.3 *Expander*
(controlled by the discriminator output)

Effective dynamic range (dB)	60

5.3.2 *Control channel*

5.3.2.1 *Amplitude/frequency and differential-delay characteristics of filter*

Attenuation within the band 2810 Hz to 2990 Hz (relative to that at 2900 Hz) (dB)	−1 to +2
Differential delay within the band 2840 to 2900 Hz (ms)	< 3
Attenuation below 2700 and above 3150 Hz (relative to that at 2900 Hz) (dB)	> 55

5.3.2.2 *Discriminator* (Frequency/amplitude translator)

Characteristic at nominal control tone level

Changes in the expander output with changes in the frequency of the control tone between 2840 Hz and 2960 Hz, should lie within the limits shown in Fig. 6.

5.3.2.3 *Amplitude range of discriminator*

The performance quoted in § 5.3.2.2 should be met for control tone input signal levels to the discriminators from 0 dB to −30 dB relative to the nominal input level; with control tone input levels between −30 dB and −50 dB relative to nominal, an additional tolerance of ± 1 dB could be added to the limits shown in Fig. 6.

5.3.3 *Overall attack and recovery time*
(A sudden change of 24 Hz in the frequency of the control tone is used to simulate a 12 dB step)

Attack time: Fig. 3e (ms)	20 ± 5
Recovery time: Fig. 3f (ms)	20 ± 5

5.4 *Equalization (overall) of transmission time*

To ensure a reasonable transmission standard, in particular of tone pulses, such as would be used for ringing or signalling, the overall transmission times of the speech and control channels should be equalized at the input to the expander to within 4 ms. In addition, the differential delay over the section of the passband of the speech channel, i.e., 250 Hz to 2500 Hz, should not exceed 4 ms.

To ensure that this can be achieved with independent designs of equipment, the time equalization provided should be divided equally between the transmit and receive sides of the equipment and should be adjustable so that the time delay encountered in privacy systems can be taken into account.

5.5 *Ringing and dialling*

Care should be taken to ensure that ringing and dialling signals are either passed completely through the equipment at both ends or completely by-pass both ends. The first method is to be preferred.

5.6 *Transmitter loading*

To enable transmitters to be fully loaded whilst keeping intermodulation products and out-of-band radiation to an acceptable level, speech channel and control channel levels for each telephone channel as shown in Table I are recommended. These figures are based on a total mean power output of −6 dB relative to the peak-envelope-power rating (p.e.p.) of the transmitter and a carrier power of −20 dB relative to p.e.p.

TABLE I

Number of channels	Individual channel power dB relative to p.e.p.	
	Speech channel	Control channel
1	−7	−12
2	−10	−15
3(1)	−12	−17
4	−13	−18

(1) For operational convenience it may be desirable to use the same power levels for 3 channels as are used for 4 channels.

5.7 *Transmission path linearity*

The above loading conditions provide an adequate margin in the radio transmitter to allow for normal changes from the line-up condition on the Lincompex equipment and in the transmission path to the transmitter. Bearing in mind that the compressed nature of the Lincompex signal has a peak-to-mean ratio of about 8 dB with the possibility of transient peaks at the compressor output, adequate linearity margin should be allowed in the transmission equipment between the Lincompex transmit terminals and the transmitter. Similar considerations apply to equipment between the radio receiver output and the Lincompex receive terminals.

Fixed service receivers in current use are adequate for carrying Lincompex channels, but signal levels must be chosen such that adequate linearity margins exist.

5.8 *Frequency stability*

The maximum allowable end-to-end frequency error of each Lincompex channel should be within ± 2 Hz.

Note 1. – For definition of signal-to-test-level ratio (dBm0) see the relevant CCITT texts.

Note 2. – The definitions of attack time and recovery time which are similar to those defined by the CCITT for compandors (Recommendation G.162, Fascicle III.1), are as follows:

– *the attack time* of a compressor is defined as the time between the instant when a sudden increase of 12 dB in input is applied and the instant when the output voltage envelope reaches a value equal to 1.5 times its steady-state value;

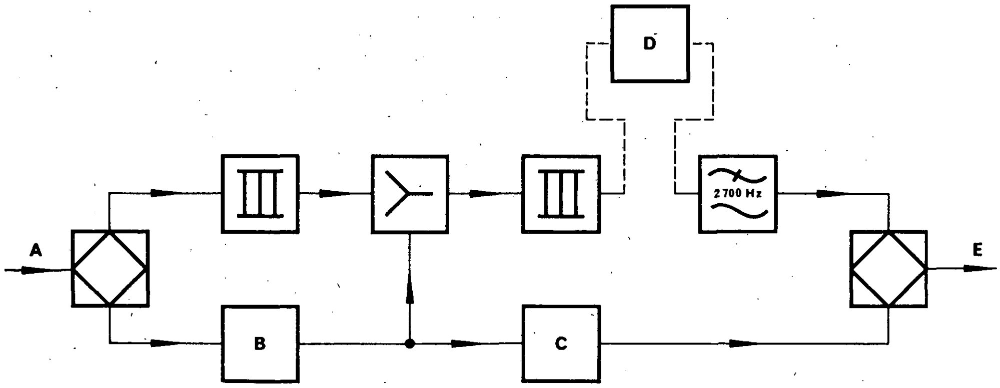
– *the recovery time* of a compressor is defined as the time between the instant when a sudden decrease of 12 dB in input is applied and the instant when the output voltage envelope reaches a value equal to 0.75 times its steady-state value.

Note 3. – The parameters listed above are considered to be the minimum that should be agreed if compatibility between equipment is to be ensured. In addition, maximum tolerances have been quoted, but it has been assumed that these will not be used as design limits.

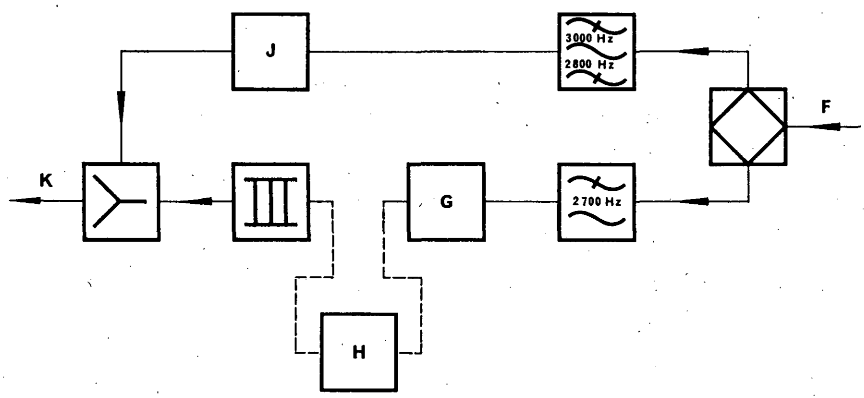
Note 4. – The temperature and power source variations with time, over which the parameters should be maintained, will vary between Administrations and have not therefore been included. The CCITT, however, in their specification for compandors (Recommendation G.162), state that the performance should be maintained over a temperature range of +10 °C to +40 °C and with power source variations of ± 5% of nominal.

Note 5. – Additional parameters which would normally be included in a specification for this class of equipment, i.e., input and output impedances and levels, signal-to-noise ratio, harmonic distortion, etc., have not been included as their value is not considered essential to compatibility between equipments. Administrations will wish to add their own values to ensure the satisfactory integration of the equipment into their own networks.

Note 6. – The type of transmission in the control channel according to this Recommendation is not considered as class of emission F3E; therefore any provision of the Radio Regulations according to which class of emission F3E is prohibited for the fixed services in the bands below 30 MHz does not apply.



(a) Transmit side

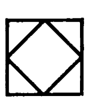


(b) Receive side

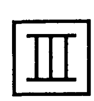
FIGURE 1 – *Schematic diagram of system*

A: From landline
B: Amplitude assessor
C: Frequency-modulated oscillator
D: Privacy device
E: To radio transmitter

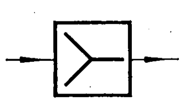
F: From radio receiver
G: Fading regulator (constant-volume amplifier)
H: Privacy device
J: Frequency discriminator
K: To landline



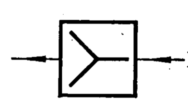
Hybrid transformer



Delay network



Compressor



Expander

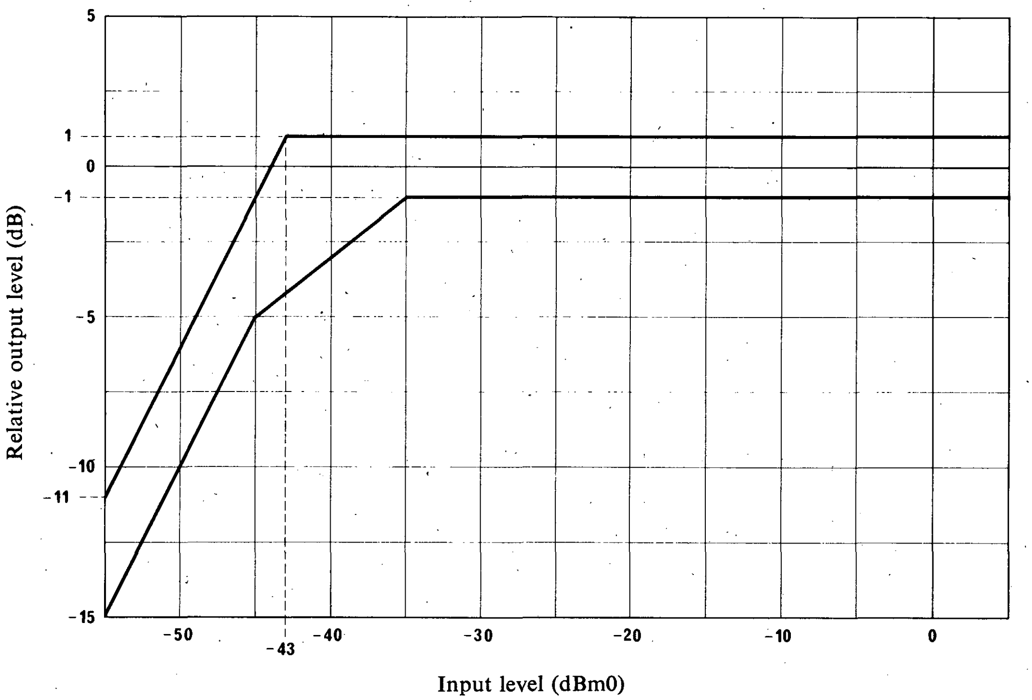
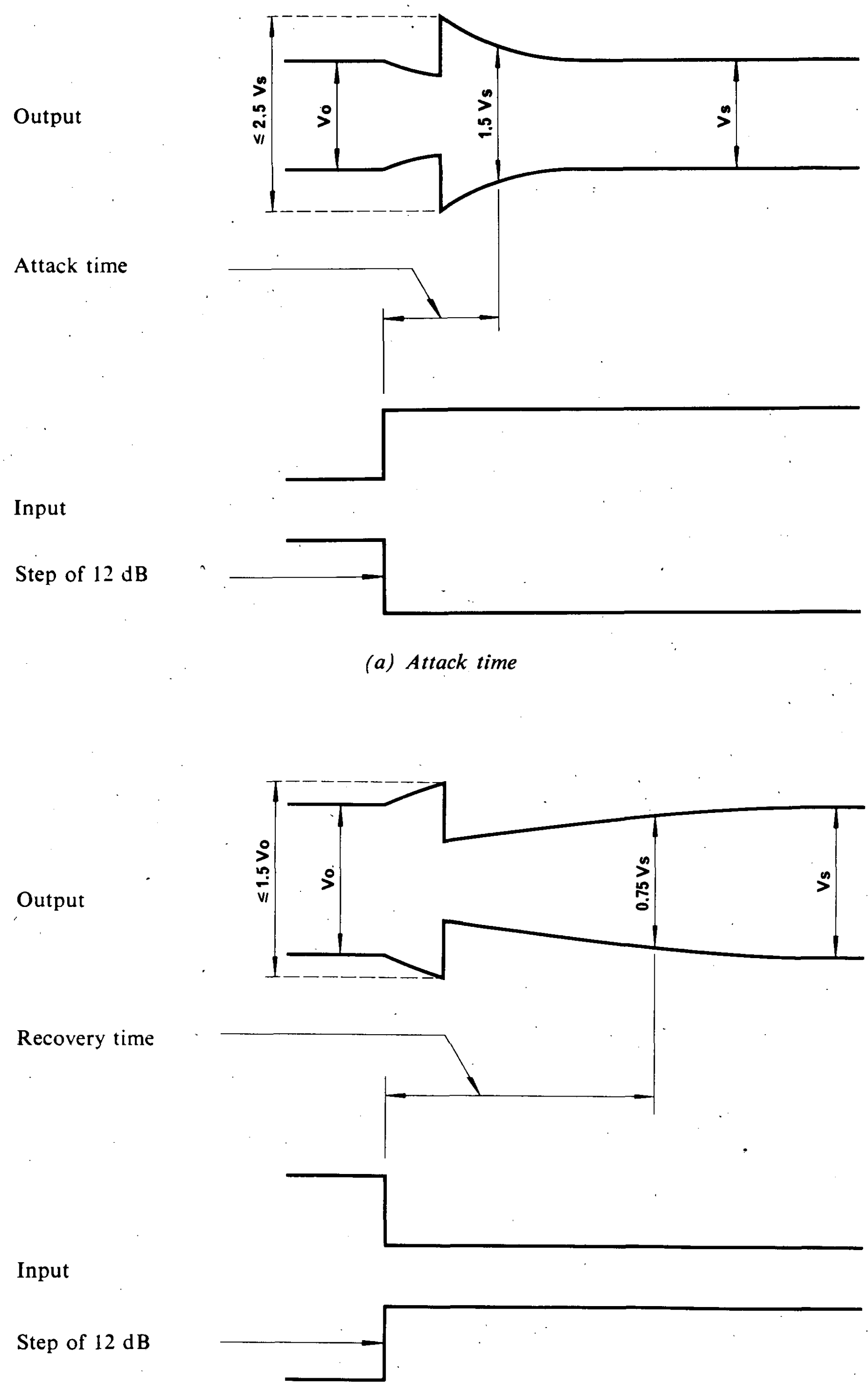


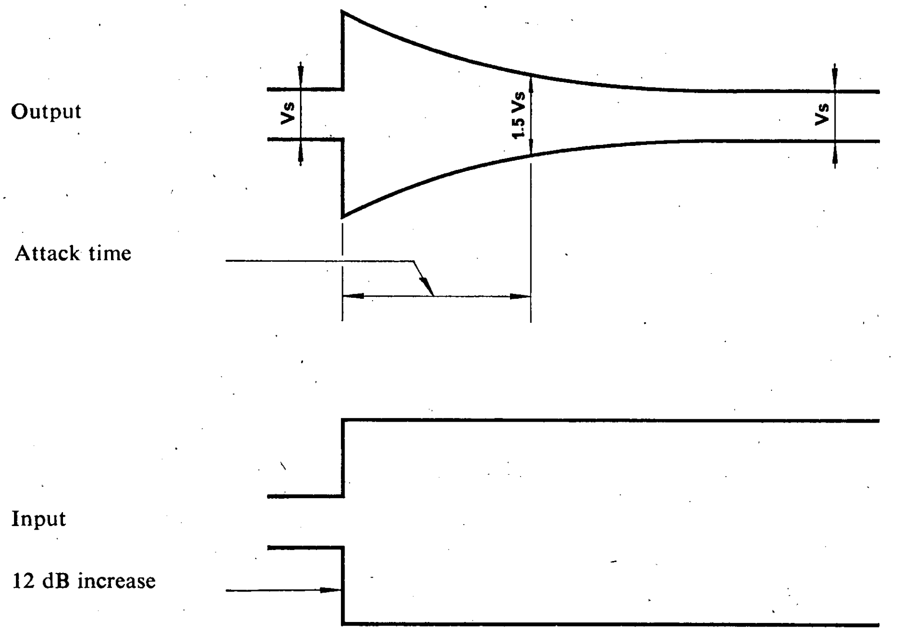
FIGURE 2 – *Input/output characteristic of transmit side*



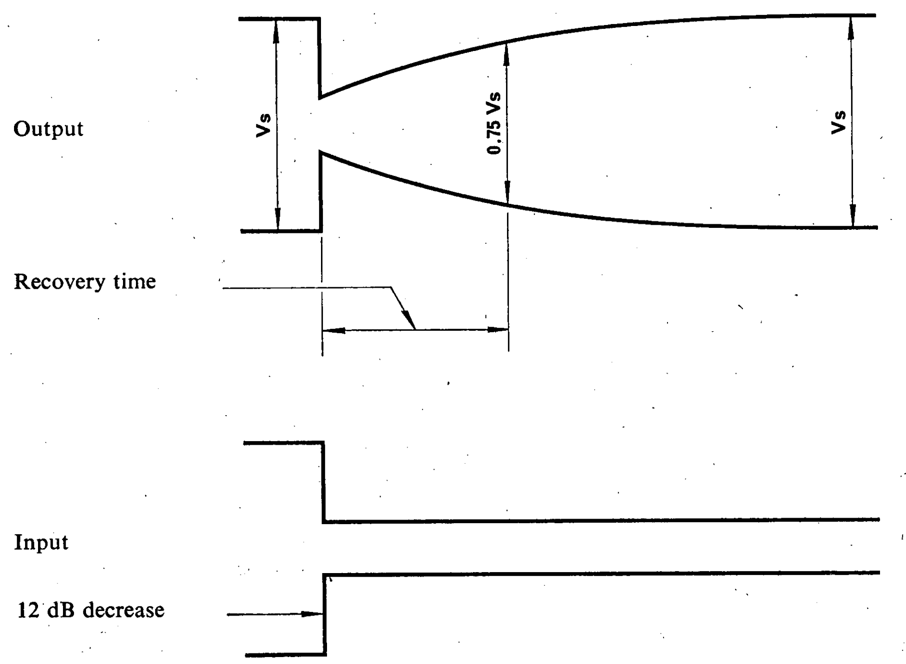
(a) Attack time

(b) Recovery time

FIGURE 3 – *Transient response of transmit side*

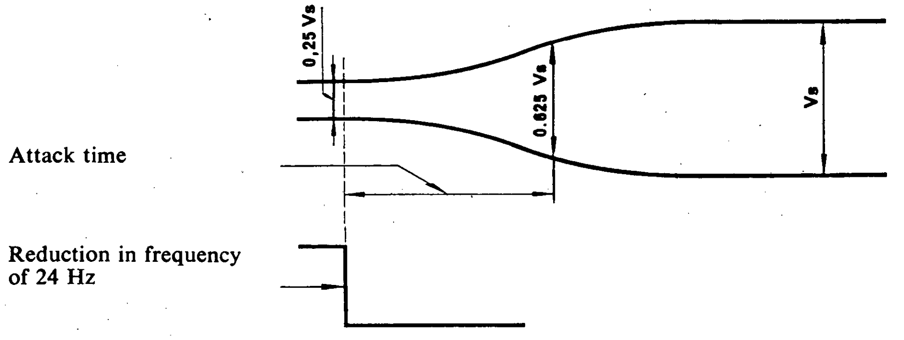


(c) Attack time

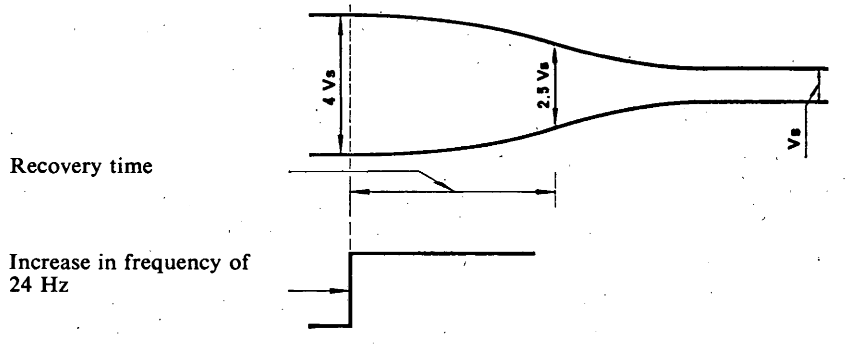


(d) Recovery time

FIGURE 3 (cont.) – *Transient response of fading regulator*



(e) Attack time



(f) Recovery time

FIGURE 3 (cont.) – *Transient response of receive side*

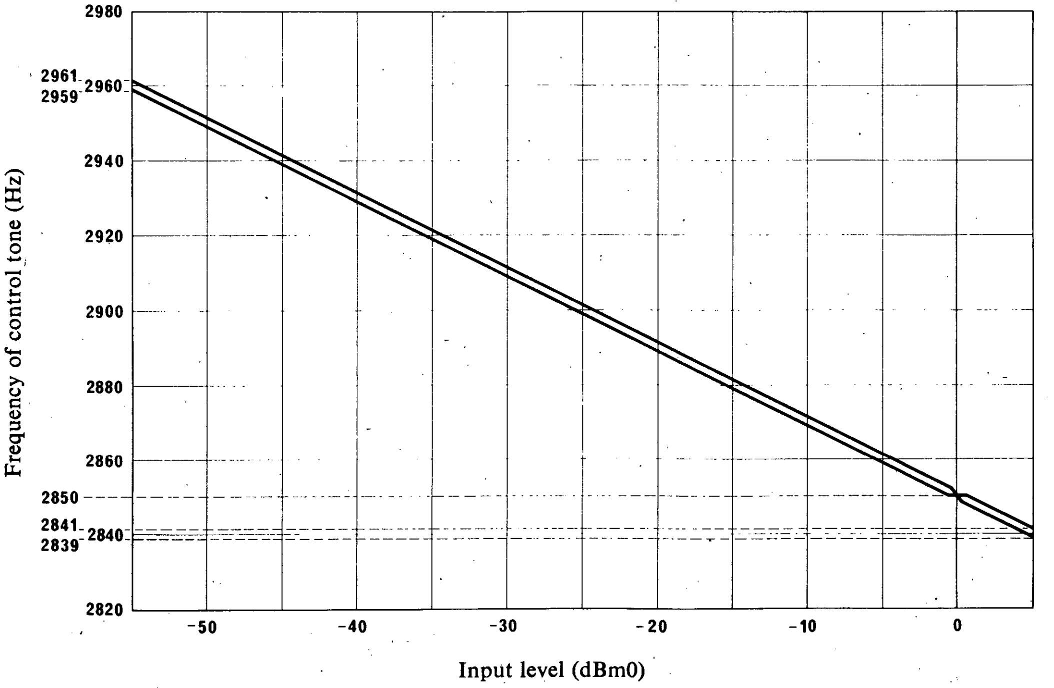


FIGURE 4 – *Variation in frequency of the control tone with changes of input level to the transmit side*

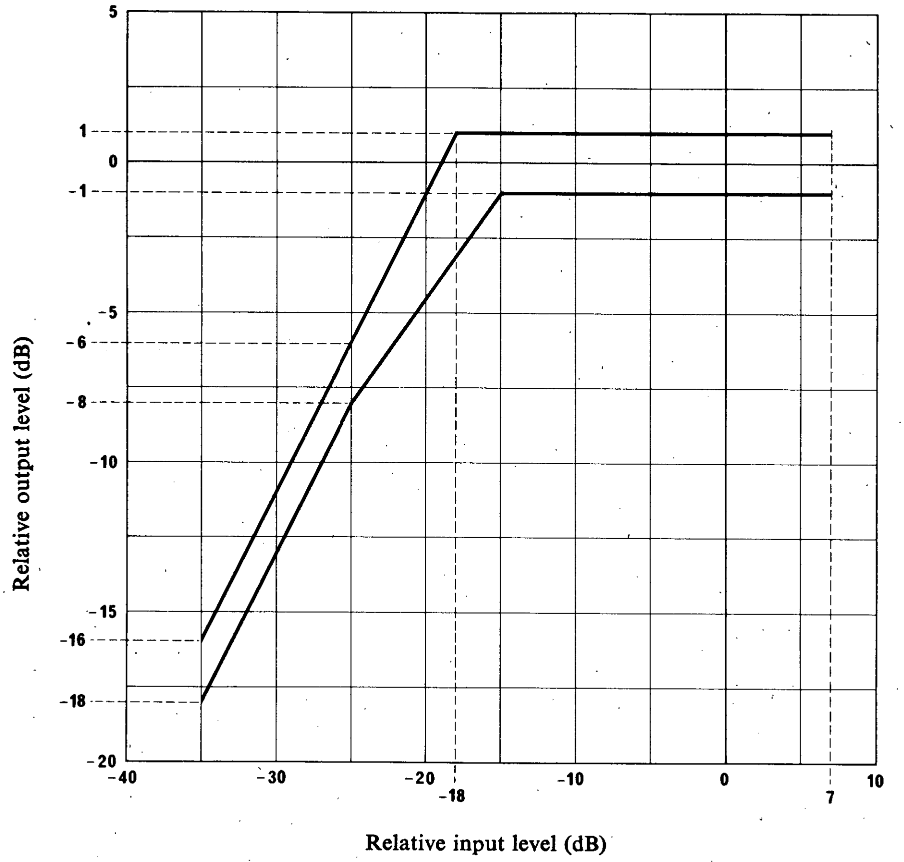


FIGURE 5 – *Input/output characteristic of fading regulator*
(see § 5.3.1.2)

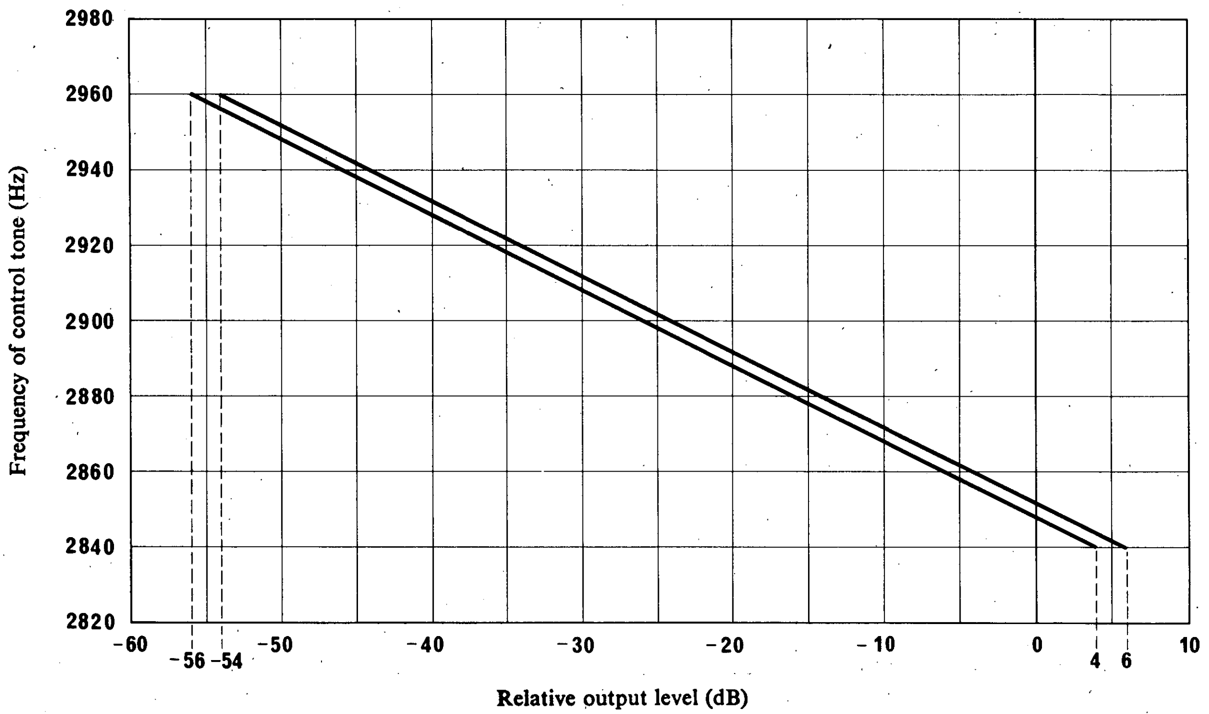


FIGURE 6 – *Variation in output level at the receiver side with change in frequency of the control tone*
(see § 5.3.2.3)

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SECTION 3C: DIGITAL TRANSMISSION

3C a: Radiotelegraph circuits

RECOMMENDATION 246-3

FREQUENCY-SHIFT KEYING *

(Question 8/3)

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

The CCIR,

CONSIDERING

(a) that frequency-shift keying is employed in radiotelegraphy in the fixed service;

(b) that it is desirable to adapt the frequency-shift used to the modulation rate;

(c) that it is desirable to standardize the main operating characteristics of systems employing frequency-shift keying;

(d) that various technical factors influence the choice of operating characteristics in such systems, in particular:

- economy of bandwidth and the consequent need to control the shape of the transmitted signals,
- signal distortion due to propagation conditions,
- instability of the characteristics of certain transmitter and receiver elements (such as oscillators, filters or discriminators), this instability being one of the reasons for the relatively large shift still employed in some existing types of equipment;

(e) that for synchronous transmissions using limiter-discriminator detection, a modulation index of about 0.8 is desirable for obtaining low bit error rates (see Recommendation 436 and Report 198, Geneva, 1963) and that for asynchronous (start-stop) transmissions, a modulation index between 1 and 2 is more appropriate;

(f) that for synchronous transmissions using filter-assessor detection, a sufficiently high value of frequency-shift is desirable to take advantage of frequency diversity effects;

(g) that difficulties can arise from the use of terms "mark" and "space" on teletype circuits and also that the CCIT, at its VIIth Plenary Assembly (1953), issued Recommendation I.4 introducing new terms; these terms have been published by the ITU in the "List of Definitions of Essential Telecommunication Terms", Part I, General Terms, Telephony, Telegraphy, June 1957,

UNANIMOUSLY RECOMMENDS

1. that for frequency-shift systems working on two conditions only (i.e. single channel or time division multiplex systems) and operating between about 3 MHz and 30 MHz, the value of the frequency-shift employed should be the lowest compatible with the maximum modulation rate regularly used, the propagation conditions and the equipment stability;

* For the use of frequency-shift keying in the maritime mobile service, see Appendix 38, § (c) of the Radio Regulations.

2. that for services where the transmitting equipment and the receiving equipment are of sufficient high stability* and selectivity, the following values of frequency-shift in Table I are preferred for new systems:

TABLE I

Maximum modulation rate (baud)		Frequency-shift (Hz)
Synchronous	Asynchronous	
–	50	70
100	50 and 75	85
200	100	170
–	200	340

3. that for systems using filter-assessor detection (see Report 345) or where the achievement of the necessary stability or receiver selectivity is impractical, the preferred values of frequency-shift are 200 Hz, 340 Hz, 400 Hz** and, for modulation rates above 250 baud, 500 Hz. The values of 140 Hz, 280 Hz and 560 Hz may be used provisionally, but 560 Hz should not be adopted for new systems. The value of the frequency-shift should, if possible, be maintained within ± 3% of its nominal value and, in any case, within ± 10%;

4.*** that the following equivalence among the various terms indicating circuit condition be adopted:

(Table II is in accordance with CCITT Recommendations U.1, see Fascicle VII.1 and V.1, see Fascicle VIII.1.)

TABLE II

Frequency of emission	Circuits using teleprinter or punched tape equipment							Circuits using Morse code
	International Telegraph Alphabet No. 2				Emitted 7-unit signal (2)	Data	Telex	
Higher frequency	Space	Start	No perforation	A (1)	B	0	Free line condition	Mark
Lower frequency	Mark	Stop	Perforation	Z (1)	Y	1	Idle circuit condition	Space

(1) on a wire circuit.
(2) on a radio channel.

* In the absence of a Recommendation on the stability required for narrow-band frequency-shift keying a provisional value of 12 Hz may be used for the maximum permissible overall frequency error, including modulator, demodulator and translating stages at both ends of the circuit.

** The value 170 Hz is used in the maritime mobile service (see Appendix 38, § (c) of the Radio Regulations).

*** When modification of equipment is necessary, it is recognized that it may take some time before the recommendations of these paragraphs can be implemented on circuits between different Administrations.

RECOMMENDATION 346-1

FOUR-FREQUENCY DIPLEX SYSTEMS

(Question 8/3)

(1956–1959–1963–1970)

The CCIR,

CONSIDERING

(a) that there are in use, in the fixed radiotelegraph services operating between 2 MHz and 27 MHz, four-frequency diplex (or twinplex) systems, in which each of four frequencies is used to transmit one of the four possible combinations of signals corresponding to two telegraph channels, it being understood that either one, or both of the two telegraph channels may be sub-channelled by time-division methods and that the use of such systems may be extended;

(b) that it is desirable to standardize the main characteristics of four-frequency diplex systems;

(c) that it may sometimes be necessary to employ the same radio transmitter to work with more than one receiving station;

(d) that circuit interruptions should be reduced to a minimum, by avoiding frequent changes of the spacing between adjacent frequencies and of the correspondence between the frequencies and the significant conditions of the channels;

(e) that various technical factors influence the choice of operating characteristics in such systems, in particular:

– the economy of bandwidth and the consequent need to control the shape of the transmitted signals;
– that a relatively wide spacing between adjacent frequencies may be necessary for high telegraph speeds;
– the signal distortion due to propagation conditions;
– the instability of the characteristics of certain receiver and transmitter elements such as oscillators, filters or discriminators;

(f) that many existing four-frequency diplex systems each use one of four values of spacing between adjacent frequencies with corresponding telegraph speeds;

(g) that it is desirable to use only one coding system, the simpler the better,

UNANIMOUSLY RECOMMENDS

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

TABLE I

Spacing between adjacent frequencies (Hz)	Nominal telegraph speed of each channel (bauds)
1000	over 300
500 (1)	200 to 300
400 (1)	100 to 200
200 (1)	200 (2)

(1) Lower telegraph speeds may be used with these spacings at present.

(2) Synchronous operation with phase-locked channels.

2. that the following system of coding be adopted:

TABLE II

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

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

A represents the start signal of the teleprinter,

Z represents the stop signal of the teleprinter;

Note. – When modification to equipment is required, it is recognized that it may take some time before the systems of coding indicated in this paragraph can be implemented on circuits between different administrations.

3. that the value of the frequency separation between adjacent frequencies employed should be the lowest of the preferred values compatible with the maximum telegraph speeds regularly used, the propagation conditions and the equipment stability;

4. that, when the two channels are not synchronized, it is desirable to limit the maximum rate of change of frequency to minimize the bandwidth of the emission.

RECOMMENDATION 106-1

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Study Programme 17A/3)

(1953–1970)

The CCIR,

CONSIDERING

(a) that, when voice-frequency equipment is used on radio circuits at frequencies lower than about 30 MHz, the quality of these circuits will, in general, be insufficient if no means of diversity reception is provided;

(b) that, in the presence of fading, space, polarization or frequency diversity gives comparable improvements in the quality of reception of telegraph signals transmitted over radio channels;

(c) that, for adequate frequency diversity, it appears necessary that the frequencies which are used in combination to obtain this diversity should differ by at least 400 Hz;

(d) that space or polarization diversity needs only half the bandwidth and less power for each telegraph channel, as compared with frequency diversity, but usually requires more equipment,

UNANIMOUSLY RECOMMENDS

1. that, when voice-frequency telegraph systems are used on radio circuits at frequencies lower than about 30 MHz, diversity reception should be used on the individual voice-frequency channels;

2. that, whenever practicable, space or, possibly, polarization diversity should be used in preference to frequency diversity;

3. that, for frequency diversity, the channel frequencies used in combination should have a separation of at least 400 Hz so that adequate diversity effects may be obtained.

RECOMMENDATION 342-2

AUTOMATIC ERROR-CORRECTING SYSTEM FOR TELEGRAPH SIGNALS TRANSMITTED OVER RADIO CIRCUITS

(Question 26/3)

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

The CCIR,

CONSIDERING

(a) that it is essential to be able to interconnect terminal start-stop apparatus employing the International Telegraph Alphabet No. 2 by means of radiotelegraph circuits;

(b) that radiotelegraph circuits are required to operate under varying conditions of radio propagation, atmospheric noise and interference, which introduce varying degrees of distortion which may at times exceed the margin of the receiving apparatus;

(c) that, in consequence, the transmission of 5-unit code signals over radio circuits is liable to errors and that such errors are not automatically detectable by the receiving apparatus;

(d) that an effective means of reducing the number of wrongly printed characters is the use of codes, permitting the correction of errors by detecting the errors and automatically causing repetition;

(e) that the method using synchronous transmission and automatic repetition (ARQ), is now well proven;

(f) that it is desirable to permit the correct phase to be established automatically on setting up a circuit;

(g) that certain circumstances can occur which result in a loss of the correct phase relationship between a received signal and the receiving apparatus;

(h) that it is desirable to permit the correct phase relationship to be re-established automatically after such a loss, without causing errors;

(j) that, to avoid mis-routing traffic, it is essential to prevent phasing to a signal which has been unintentionally inverted;

(k) that there is sometimes a need to subdivide one or more channels, to provide a number of sub-channels at a proportionately reduced character rate;

(l) that the method of automatically achieving the correct phase relationship between the received signal and the sub-channelling apparatus should be an integral part of the phasing process;

(m) that compatibility with existing equipment, designed in accordance with Recommendation 242, Los Angeles, 1959, is a requirement,

UNANIMOUSLY RECOMMENDS

1. that, when the direct use of a 5-unit code on a radio circuit gives an intolerable error rate and there is a return circuit, a 7-unit ARQ system be employed;

2. when automatic phasing of such a system is required, the 7-unit system, described in Annex I, should be adopted as a preferred system;

3. that equipment, designed in accordance with § 2, should be provided with switching, to permit operation with equipment designed in accordance with Recommendation 242, Los Angeles, 1959.

Note. – Methods in accordance with this Recommendation are described in [CCIR, 1962].

REFERENCES

CCIR Documents

[1962]: Geneva, III/17.

ANNEX I

1. Table of conversion

TABLE I

	International code No. 2	International code No. 3
A	ZZAAA	AAZZAZA
B	ZAAZZ	AAZZAAZ
C	AZZZA	ZAAZZAA
D	ZAAZA	AAZZZAA
E	ZAAAA	AZZZAAA
F	ZAZZA	AAZAAZZ
G	AZAZZ	ZZAAAAZ
H	AAZAZ	ZAZAAZA
I	AZZAA	ZZZAAAA
J	ZZAZA	AZAAAZZ
K	ZZZZA	AAAZAZZ
L	AZAAZ	ZZAAAZA
M	AAZZZ	ZAZAAAZ
N	AAZZA	ZAZAZAA
O	AAAZZ	ZAAAZZA
P	AZZAZ	ZAAZAZA
Q	ZZZAZ	AAAZZAZ
R	AZAZA	ZZAAZAA
S	ZAZAA	AZAZAZA
T	AAAAZ	ZAAAZAZ
U	ZZZAA	AZZAAZA
V	AZZZZ	ZAAZAAZ
W	ZZAAZ	AZAAZAZ
X	ZAZZZ	AAZAZZA
Y	ZAZAZ	AAZAZAZ
Z	ZAAAZ	AZZAAAZ
Carriage return	AAAZA	ZAAAAZZ
Line feed	AZAAA	ZAZZAAA
Figures	ZZAZZ	AZAAZZA
Letters	ZZZZZ	AAAZZZA
Space	AAZAA	ZZAZAAA
Unperforated tape	AAAAA	AAAAZZZ
Signal repetition		AZZAZAA
Signal α		AZAZAAZ
Signal β		AZAZZAA

2. Repetition cycles

2.1 Four characters for normal circuits, which are not subject to excessive propagation time. The cycle should comprise one "signal repetition" and three stored characters.

2.2 Eight characters on circuits for which the four-character repetition cycle is inadequate. The cycle should comprise one "signal repetition", three signals β and four stored characters, or one "signal repetition" and seven stored characters.

3. Channel arrangement

3.1 *Channel A*

3.1.1 For equipment employing a four-character repetition cycle: one character inverted followed by three characters erect (see Fig. 1a).

3.1.2 For equipment employing an eight-character repetition cycle: one character inverted followed by seven characters erect (see Fig. 2a).

3.2 *Channel B*

3.2.1 For equipment employing a four-character repetition cycle: one character erect followed by three characters inverted (see Fig. 1b).

3.2.2 For equipment employing an eight-character repetition cycle: one character erect followed by seven characters inverted (see Fig. 2b).

3.3 *Channel C*

As for Channel B (see Figs. 1c and 2c).

3.4 *Channel D*

As for Channel A (see Figs. 1d and 2d).

3.5 *Order of transmission*

3.5.1 Characters of Channels A and B are transmitted consecutively (see Figs. 1e and 2e).

3.5.2 Elements of Channel C are interleaved with those of Channel A (see Figs. 1g and 2g).

3.5.3 Elements of Channel D are interleaved with those of Channel B (see Figs. 1g and 2g).

3.5.4 In the aggregate signal, A elements precede those of C, and B elements precede those of D (see Figs. 1g and 2g).

3.5.5 The first erect character on A, transmitted after the inverted character on A, is followed by the erect character on B (see Figs. 1e and 2e).

3.5.6 The erect character on C is followed by the inverted character on D (see Figs. 1f and 2f).

3.5.7 The inverted character on A is element-interleaved with the erect character on C (see Figs. 1g and 2g).

4. Sub-channel arrangement

4.1 The character transmission rate of the fundamental sub-channel should be a quarter of the standard character rate.

4.2 Sub-channels should be numbered 1, 2, 3 and 4 consecutively.

4.3 Where a four-character repetition cycle is used, sub-channel 1 should be that sub-channel which has opposite keying polarity to the other three sub-channels of the same main channel (see Figs. 3a-d).

Where an eight-character repetition cycle is used, sub-channel 1 should be that sub-channel which has alternately erect and inverted keying polarity (see Figs. 3e-h).

4.4 When sub-channels of half-character rate, or three-quarter-character rate are required, combinations of the fundamental sub-channels should be arranged as shown in Table II.

TABLE II

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

5. Designation of aggregate signal

To assist in identifying the signal condition when applying the aggregate telegraph signal to modulate the radio channel, the following designation for the aggregate signal should be used:

TABLE III

Seven-unit code condition	Aggregate signal condition	
	Erect character	Inverted character
A	B	Y
Z	Y	B

6. Diagrams

As a result of the characteristics specified in §§ 2, 3 and 4 of this Annex, the transmission of characters will be as shown in Figs. 1, 2 and 3.

7. Automatic phasing

7.1 Automatic phasing should normally be used. It should be initiated either:

7.1.1 after a waiting period during which cycling due to the receipt of errors has occurred continuously on both channels of a 2-channel system, or on at least two main channels of a 4-channel system;

7.1.2 after equal counts of A and Z elements have been made over at least two consecutive system cycles whilst continuous cycling due to the receipt of errors is occurring on all main channels;

7.2 when the slave station is phasing, it should transmit in each channel, in place of the "signal repetition", a 7-element signal in which all 7 elements are of the same polarity, all other characters in the repetition cycle being transmitted unchanged. (Existing systems without this facility need not be modified because compatibility is assured.)

8. CCITT Recommendation S.12 (Fascicle VII.2) recommends that the interval between the beginning of successive start elements of the signals transmitted into the landline network be 145 5/6 ms. Therefore, the duration of the transmission cycle on the radio circuit and also the modulation rate must be chosen correspondingly, if connection to the network is required.

Practical values for the modulation rate in bauds and the duration of the transmission cycle, which enable synchronization to be effected by using a single oscillator for three cases, are shown in Table IV.

TABLE IV

Transmission cycle (ms)	Modulation rate (bauds)	
	2-channel operation	4-channel operation
145 5/6	96	192
This is the preferred standard. See CCITT Recommendations S.12 and S.13		
163 1/3 140	85 5/7 100	171 3/7 200

The transmission cycle of 145 5/6 ms is the preferred standard for connection to 50-baud networks.

The transmission cycle of 163 1/3 ms is suitable for connecting to 45-baud networks.

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

The tolerance on the frequency of the master oscillator, controlling the timing of each terminal equipment, should be $\pm 1 \times 10^{-6}$.

9. CCITT Recommendation U.20 (Fascicle VII.1) gives the signalling conditions to be used when telex communication is to be established by means of such radio circuits:

9.1 for circuits on switched telegraph networks, the conditions of CCITT Recommendation U.20 should apply;

9.2 for point-to-point circuits, Administrations may adopt, at the terminal equipment under their jurisdiction, their own method of stopping and starting the motors of the receiving machines, based on CCITT Recommendation S.7 (Fascicle VII.2);

9.3 signal β should normally be transmitted to indicate the idle circuit condition. However, for signalling purposes, the signals α and β may be employed.

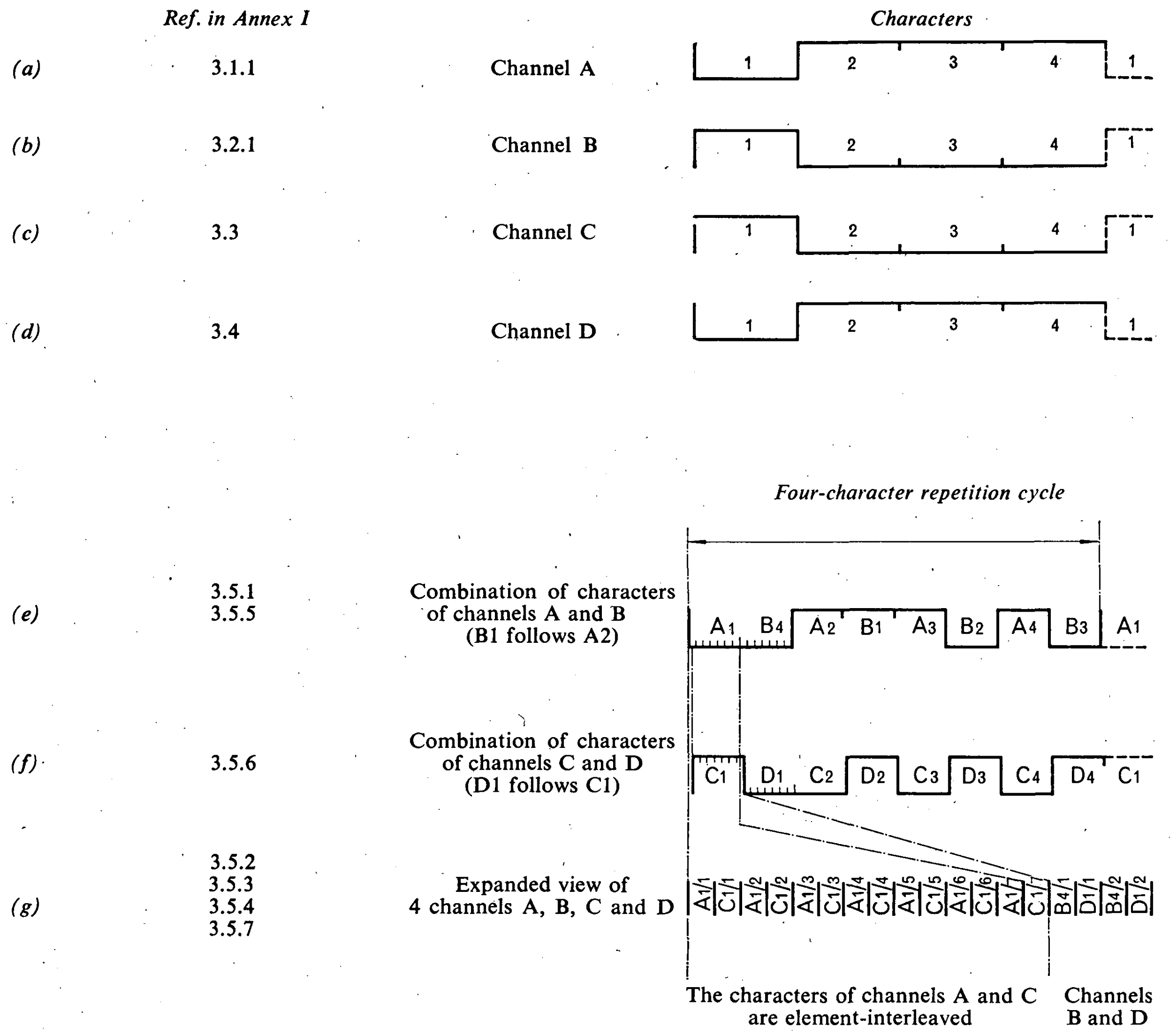

FIGURE 1 – *Channel arrangement for a four-character repetition cycle*

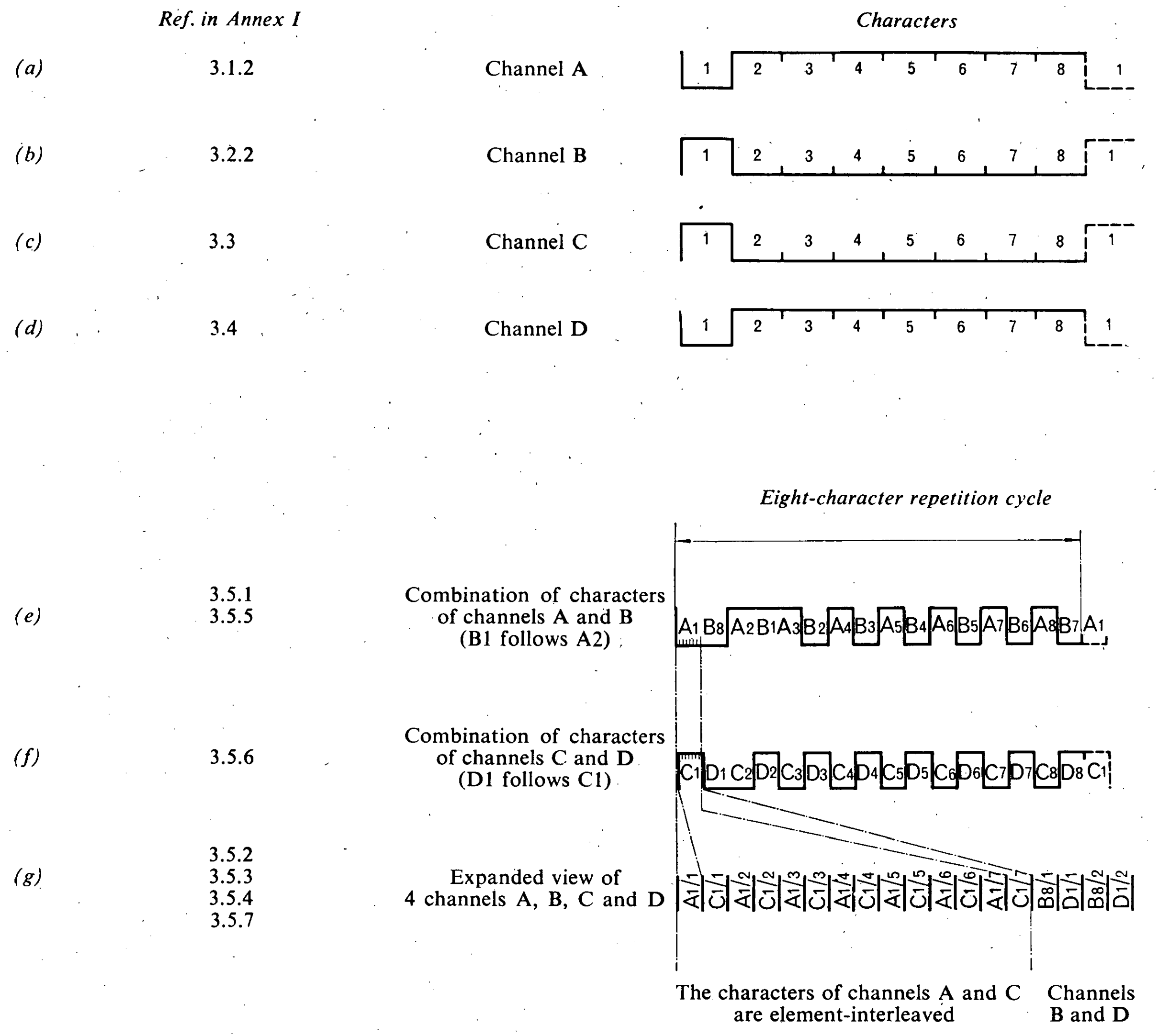

FIGURE 2 – *Channel arrangement for an eight-character repetition cycle*

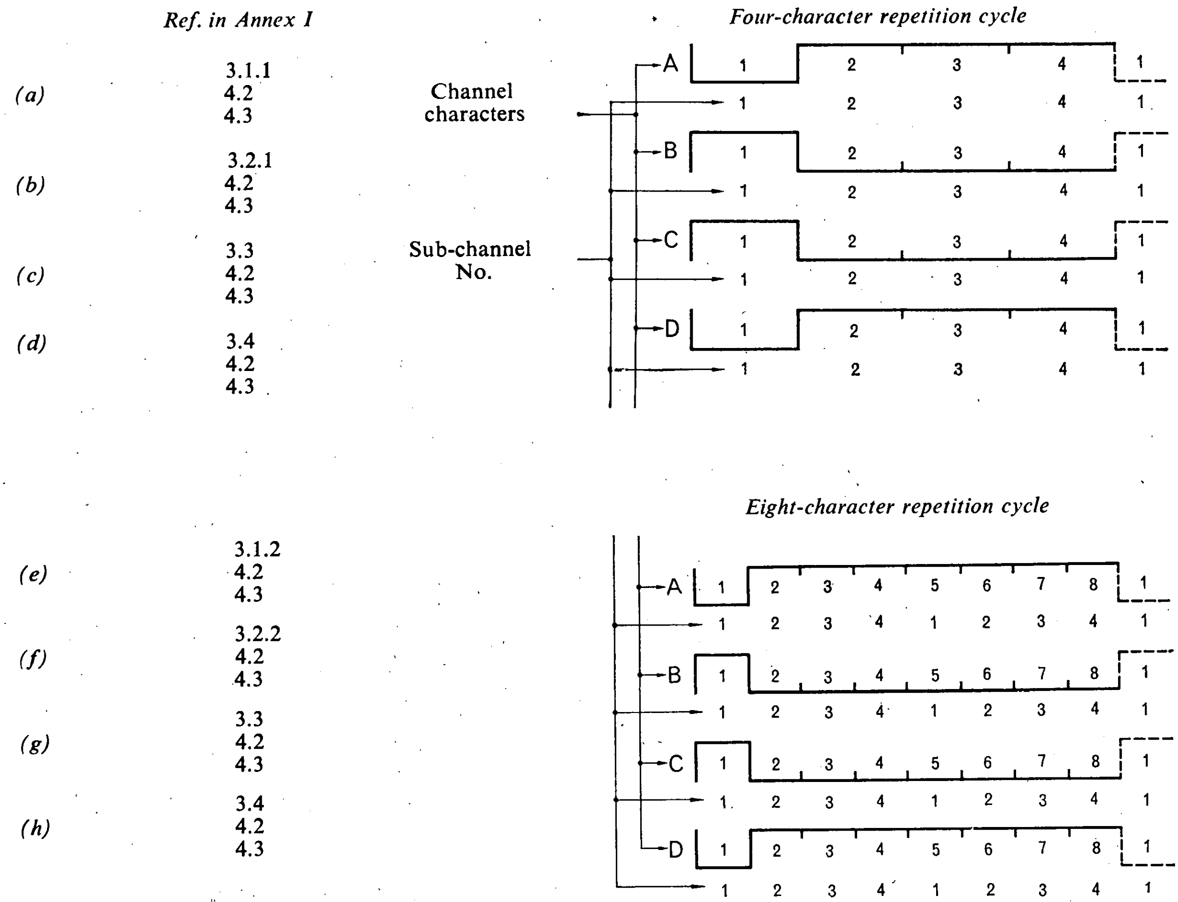

FIGURE 3 – *Sub-channelling arrangements for a four- and an eight-character repetition cycle*

ANNEX II

TERMS RELATED TO ARQ-SYSTEMS*

Part 1

1. Signal repetition
   RQ-signal
   Signal Roman one – the seven unit combination (AZZAZAA) which is used to request a repetition (RQ-signal) or to precede a re-transmission (BQ-signal);

2. Repetition cycle – the sequence of characters, the number of which is determined by the *loop time-delay of the system*, to provide automatic repetition of information;

3. RQ-cycle
   Request cycle – the *repetition cycle* transmitted by ARQ-apparatus at the detection of a mutilation;

4. BQ-cycle
   Response cycle – the *repetition cycle* transmitted by ARQ-apparatus at a request for repetition;

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* The twenty-three terms and definitions in Part 1 of this list have been studied by a joint Working Party of Study Groups III and XIV during the Xth Plenary Assembly of the CCIR, Geneva, 1963, as a provisional contribution (see § 2 of the Annex to Resolution 21 (Oslo, 1966) to the "List of Definitions of Essential Telecommunication Terms" (Part II to be published later).

The other terms and definitions contained in Part 2 of this list, which are of more general application, are given as information pending examination by the CCITT.

5. Non-print cycle	– the interval at the ARQ-receiver, initiated by the detection of a mutilation or a *signal repetition*, that has the same duration as a *repetition cycle* and during which all signals received are prevented from being printed;
6. Gated RQ	– a procedure in which a check is made for the presence of a signal repetition during a *non-print* cycle;
7. Tested RQ	– a procedure in which a check is made for the presence of a *signal repetition* and a check is made for the ratio A/Z on all characters received after the *signal repetition* within the *non-print cycle*;
8. Tested repetition cycle	– a *non-print cycle* in which a check is made for the presence of a *signal repetition* and for the correct ratio A/Z of all the characters received;
9. Cycling	– the condition that a repetition procedures is in progress;
10. Marking pattern	– a specific pattern of polarity inversions applied to characters in an *aggregate signal*;
11. Marked cycle System cycle	– a cycle consisting of a specific character *marking pattern*, that is continuously repeated and has the duration of a *repetition cycle*;
12. System phase Marked cycle phase	– the condition in which the *marking pattern* of the local timing coincides with the *marked cycle* of the received signal;
13. Phasing Phase hunting	– the condition in which a station is hunting for *character phase* or *system phase*;
14. Manual phasing	– *phasing* by manual action only;
15. Semi-automatic phasing	– *phasing* completed automatically after manual initiation;
16. Automatic phasing	– *phasing*, initiated and completed automatically after automatic detection of "out-of-phase";
17. Master station	– the station, the transmitting equipment of which is directly driven by a master oscillator but the receiver timing of which is normally synchronized to the incoming signal;
18. Slave station	– the station, receiver and transmitter timing of which are both synchronized to the received signal;
19. End-to-end time delay	– the delay between the output terminals of an ARQ-transmitter and the input terminals of the ARQ-receiver at the other end (this is the sum of radio and line circuit delays in one direction of a route);
20. Loop time-delay of a route	– the sum of the end-to-end delays in the send and return directions of a route;
21. Master station delay	– the period between the beginning of reception of a *signal repetition* at the ARQ-input terminals at the *Master station* and the beginning of transmission of the replying *signal repetition* at that station. *Note.* – This comprises the "scanning" and equipment delays and a further delay which, when added to the *loop time-delay of the system*, produces an integral multiple of the *character cycle* duration;

22. Slave station delay – the period between the beginning of reception of a *signal repetition* at the ARQ-input terminals at the *slave station* and the beginning of transmission of the replying *signal repetition* at that station.

Note. – This comprises "scanning" and equipment delays and a "pre-set" delay between the receiver and the transmitter;

23. Loop time-delay of a system (as seen from the master station) – the sum of the *loop time-delay*, measured under working conditions.

Part 2

(a) Aggregate signal – the synchronous signal produced by combining the channel signals;

(b) Balanced aggregate signal – an aggregate signal containing equal numbers of elements of each polarity;

(c) Character cycle – the period in which each channel of a time-division multiplex transmission has completed one character in the synchronous path;

(d) Element synchronism – in synchronous systems:
the condition in which an element of the local timing coincides completely with an element of the received signal;

(e) Synchronizing – the action of adjustment of element synchronism;

(f) Phase relationship – in synchronous systems:
the relative phase of receiving apparatus and incoming signals, or receiving and sending apparatus;

(g) Character phase – the condition in which a *character cycle* of the local timing coincides completely with a character cycle of the received signal.

Note. – Under these conditions, a character of the aggregate signal transmitted on a particular channel is received on the correct channel;

(h) Sub-channel – a teleprinter channel which is allocated a quarter rate of a normal channel, or multiples thereof;

(j) Sub-channel phase – the condition in which a character transmitted on a particular sub-channel is received on the correct sub-channel;

(k) Transposition – Add to definition 33.25 of the ITU "List of Definitions..." (Part I):
"Transpositions may be regarded as of first or higher order according to the number of interchanges occurring within a character."

RECOMMENDATION 518

SINGLE-CHANNEL SIMPLEX ARQ TELEGRAPH SYSTEM

(Question 26/3)

(1978)

The CCIR,

CONSIDERING

(a) that large areas of the world do not yet have the facility of being connected to the international telegraph network, although they have a potential need for the exchange of messages by telegraph;

(b) that the amount of traffic to be dealt with will initially be small and the distances to be bridged will usually be great; therefore, an HF radio system might best be suited to link an isolated station to one of the offices of the world-wide telegraph network;

(c) that use of automatic error correction ARQ can make the quality of the radio circuit comparable with that of landline connections;

(d) that to participate in the telex network, the direction of traffic flow should be instantly reversible;

(e) that the location of such isolated stations often does not permit the simultaneous use of the radio transmitter and radio receiver;

(f) that it may be useful to employ the same frequency in both directions of a circuit,

UNANIMOUSLY RECOMMENDS

that the single-channel simplex ARQ telegraph system described in §§ 1.2 and 3.1 of Annex I of Recommendation 476 for the maritime mobile service, be utilized also for the HF fixed service.

RECOMMENDATION 519

SINGLE-CHANNEL DUPLEX ARQ TELEGRAPH SYSTEM

(Question 26/3)

(1978)

The CCIR,

CONSIDERING

(a) that nowadays, multiplex systems with error correction by automatic repetition (ARQ), are frequently used in the transmission of telegraph signals over radio circuits; the characteristics of such ARQ systems are laid down in Recommendation 342;

(b) that where the volume of traffic does not justify the use of more than one channel, a single-channel ARQ system seems appropriate,

UNANIMOUSLY RECOMMENDS

that the systems based on the principles laid down in Recommendation 342, Annex I, §§ 1, 2, 4, 7 *, 8 ** and 9, where they apply to single-channel operation, are considered appropriate for application to single-channel duplex ARQ telegraph systems.

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* For the purpose of this Recommendation, Recommendation 342, § 7.1.2, Annex I, should be read as: "after appropriate counts of A and Z elements ...".

** For the purpose of this Recommendation, modulation rates of 48, 72 and 96 bauds with transmission cycles of 145 5/6, 97 2/9 and 72 11/12 ms apply respectively.

3C b: Data transmission

RECOMMENDATION 456

DATA TRANSMISSION AT 1200/600 BIT/S OVER HF CIRCUITS WHEN USING MULTI-CHANNEL VOICE-FREQUENCY TELEGRAPH SYSTEMS AND FREQUENCY-SHIFT KEYING

(Question 12/3)

(1970)

The CCIR,

CONSIDERING

(a) that the effects of the random variations and disturbances in the HF propagation medium, in particular the effects of multipath distortion, in general preclude the use of serial transmission of binary data at rates of 1200 or 600 bit/s;

(b) that voice-frequency multi-channel frequency-shift systems that operate synchronously at a modulation rate of approximately 100 bauds are in widespread use over HF circuits;

(c) that such systems in effect provide an aggregate capacity of up to 1500 bit/s;

(d) that such systems, therefore, are suitable, and in fact are being used for data transmission at the standard data rates of 1200 and 600 bit/s;

(e) that the presence of multiplexer and demultiplexer or of land lines in the complete circuit may introduce envelope delay distortion, this distortion being most severe for the lowest and highest channels of a multi-channel voice-frequency frequency-shift system,

UNANIMOUSLY RECOMMENDS

1. that for data transmission at binary data rates of 1200 or 600 bits/s using frequency-division multiplex frequency-shift systems, the system described in Annex I be preferred;

Note. – By agreement between Administrations, the use of systems with a different number of channels and other channel spacings and modulation rates, for data transmission at 1200/600 bit/s, is allowed.

2. that channel spacing and central frequencies of the channels of the frequency-shift system should be in accordance with Table I of Recommendation 436;

3. that channels 3 to 14 inclusive of Table I of Recommendation 436 should be used for the transmission of the data.

ANNEX I

1. Description of system

To avoid excessive multipath distortion, which would result when higher speed binary data streams are directly transmitted in serial form, the incoming-bit stream is converted into a number of relatively low-speed streams, which are transmitted simultaneously in parallel and recombined into a single serial data output at the receiving terminal.

In this way, the modulation rate of the channels transmitted over the HF circuit can be kept to an acceptable value.

A block diagram of the 1200 bit/s system is shown in Fig. 1.

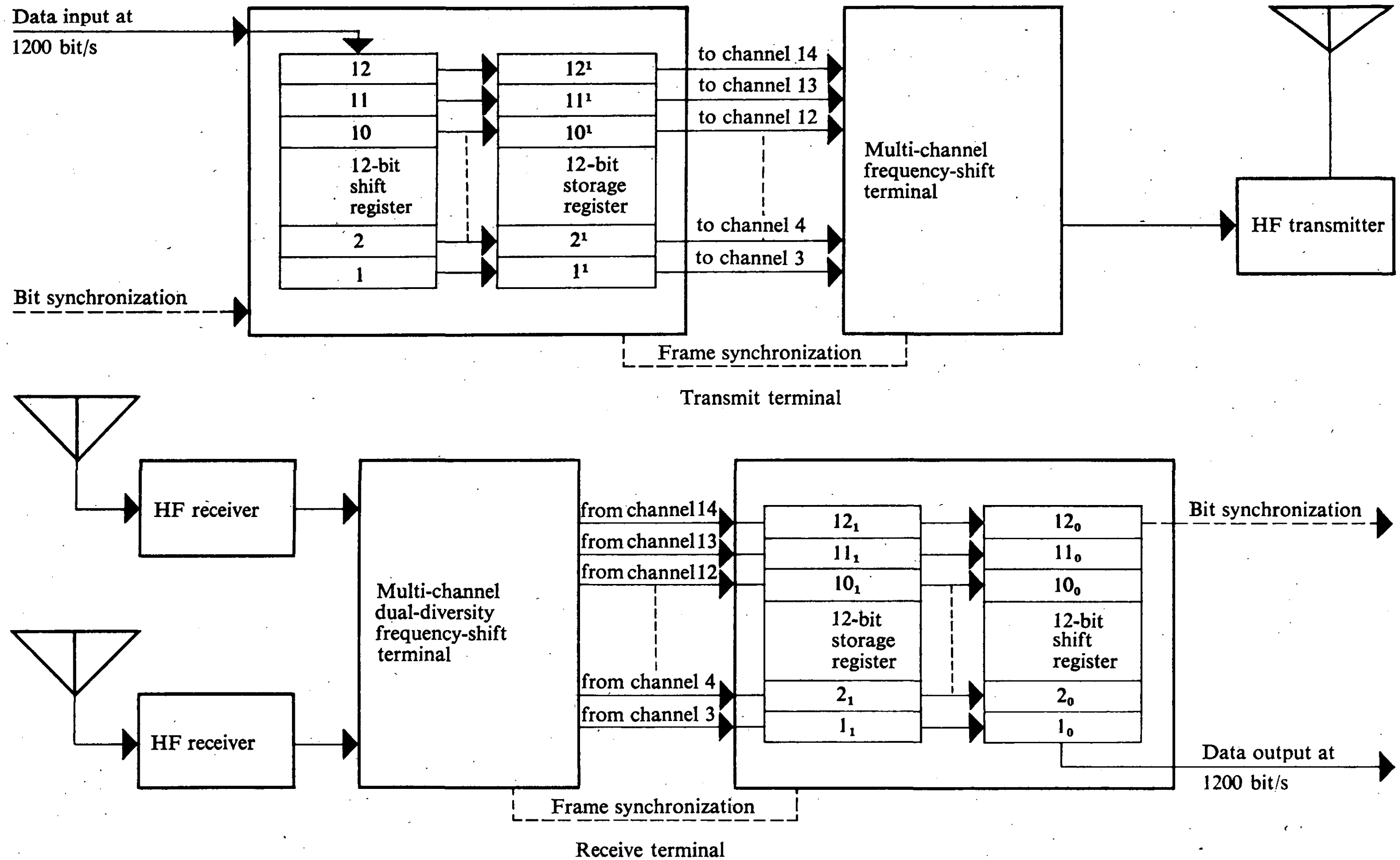


FIGURE 1 – *Data transmission system operating at 1200 bit/s*

2. Serial-to-parallel converter, transmission at 1200 bit/s

At the transmit side, the 1200 bit/s incoming-data stream is fed to a 12-bit shift register. At 12-bit intervals (i.e. at 10 ms intervals) the content of this register is transferred in parallel to a 12-bit storage register, the output of which is connected to 12 parallel channels of the multi-channel frequency-shift system.

Bit synchronization for the shift register may be:

2.1 extracted from the transitions of the data stream, provided the data stream is not expected to have excessive intervals during which no transitions occur (i.e. steady "1", or steady "0" condition);

2.2 obtained from a bit synchronizing signal from the data source, if available;

2.3 generated by an internal clock, in which case a synchronizing output is fed back to the data source.

The parallel transfer pulses are obtained from the bit synchronizing signal through a digital division process. If required, this frame synchronizing information may be transmitted over an additional channel of the frequency-shift system.

3. Channel arrangement, transmission at 1200 bit/s

The 12 channels of the frequency-shift system used for the transmission of the data information, each operating at a modulation rate of 100 bauds, shall be channels 3 to 14 inclusive of Table I of Recommendation 436; with channel 3 corresponding to the first (in time) bit of each 12-bit sequence, channel 4 to the second bit of this sequence, and so forth. The frequency spectrum occupied by these channels is that portion of the voice-frequency band which is least affected by envelope delay distortion caused by multiplexer and demultiplexer filters or by land lines which may be incorporated between the terminal sites and the HF transmitting and/or receiving sites.

4. Parallel-to-serial converter, transmission at 1200 bit/s

The parallel-to-serial converter at the receiving terminal shall be designed to perform the following functions:

4.1 to provide delay equalization for the 12 individual channels of the frequency-shift system;

4.2 to provide frame synchronization and bit synchronization by means of extracting synchronization information from the data channels (or from the additional frame synchronizing channel, if this is used);

4.3 to sample the outputs of the 12 data channels, store the sampled data in a 12-bit storage register, transfer the stored data to a 12-bit shift register once per frame interval (10 ms) and read out the data in serial form.

A bit synchronizing output terminal shall be provided for synchronization of associated data equipment which may require a separate synchronizing signal.

5. Data transmission at 600 bit/s

For data transmission at 600 bit/s the following modes of operation are optional:

5.1 the use of 6 instead of 12 channels of the frequency-shift system;

5.2 the use of 12 channels of the frequency-shift system with dualling of channels to provide in-band frequency diversity;

5.3 the use of 12 channels of the frequency-shift system and reducing the channel modulation rate from 100 bauds to 50 bauds;

5.4 the use of 12 channels of the frequency-shift system and applying binary coding techniques to provide error correction, error detection or combined error correction/detection.

The option of § 5.1 enables two independent data streams at 600 bit/s to be transmitted in a single 3 kHz voice band. The options of § 5.2 and 5.3 provide improved performance (i.e., lower error rate) with little or no additional equipment required, but at the cost of increased bandwidth. Where lowest error rate is required, the use of redundant coding (which may include time-diversity methods) of the option of § 5.4 is preferred.

3C c: Phototelegraphy (facsimile)

RECOMMENDATION 343-1

FACSIMILE TRANSMISSION OF METEOROLOGICAL CHARTS OVER RADIO CIRCUITS

(Question 1/3, Study Programme 1A/3)

(1956-1959-1963-1966)

The CCIR,

CONSIDERING

(a) that increasing use is being made of facsimile telegraphy for the transmission of meteorological charts for reception on direct-recording apparatus;

(b) that it is desirable to standardize certain characteristics of the radio circuits for this purpose,

UNANIMOUSLY RECOMMENDS

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

centre frequency	1900 Hz,
frequency corresponding to black	1500 Hz,
frequency corresponding to white	2300 Hz;

2. that, when direct frequency modulation is employed on radio circuits, the following characteristics should be used:

2.1 *HF (decametric) circuits*

centre frequency (corresponding to the assigned frequency)	f_0,
frequency corresponding to black	$f_0 - 400$ Hz,
frequency corresponding to white	$f_0 + 400$ Hz;

2.2 *LF (kilometric) circuits*

centre frequency (corresponding to the assigned frequency)	f_0,
frequency corresponding to black	$f_0 - 150$ Hz,
frequency corresponding to white	$f_0 + 150$ Hz.

RECOMMENDATION 344-2

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

(Question 1/3, Study Programme 1A/3)

(1948–1953–1956–1959–1963–1966–1970)

The CCIR,

CONSIDERING

(a) that to facilitate interworking, it is desirable to standardize the characteristics of systems employed for phototelegraph transmission over long-distance HF (decametric) circuits;

(b) that it is desirable to standardize certain characteristics of these systems in such a way as to make them equally suitable for transmission over metallic circuits;

(c) that the transmission system using direct amplitude modulation is generally unsatisfactory over HF (decametric) radio circuits, because of the intolerable fading ratio usually encountered;

(d) that the system of sub-carrier frequency modulation has proved satisfactory, but requires standardization in respect of the centre frequency and shift frequencies, taking into account the values of the picture-modulation frequencies to be transmitted;

(e) that, when a direct frequency-modulation system is employed, the terminal equipment normally used for a sub-carrier modulation system should be usable without serious modifications;

(f) that, taking into account the degree of distortion that is tolerable, the effect of multipath echoes on long-distance HF (decametric) radio circuits normally limits the maximum admissible picture-modulation frequency to approximately 600 Hz;

(g) that Recommendations M.880 (Fascicle IV.2), T.1, T.11, T.12, T.15 and T.20 (Fascicle VII.2) of the CCITT give standards for phototelegraph systems,

UNANIMOUSLY RECOMMENDS

1. that over the radio path:

1.1 the preferred method of transmission of half-tone pictures is by sub-carrier frequency modulation, of a single-sideband or independent-sideband emission with reduced carrier. The following characteristics should therefore be used:

centre frequency	1900 Hz,
frequency corresponding to white	1500 Hz,
frequency corresponding to black	2300 Hz;

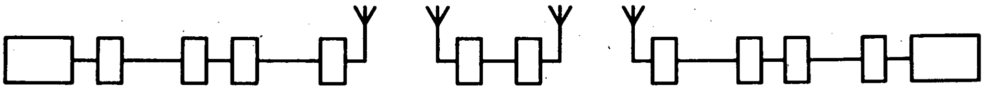
(The frequency 1500 Hz is also used for the phasing signal);

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

centre frequency (corresponding to the assigned frequency)	f_0,
frequency corresponding to white	$f_0 - 400$ Hz,
frequency corresponding to black	$f_0 + 400$ Hz;

(The frequency $f_0 - 400$ Hz is also used for the phasing signal);

1.3 that the frequency tolerances on each of the various sections of a combined radio and metallic circuit should be no greater than those proposed by the CCITT (see [CCIR, 1963-66]) as shown in Fig. 1, which gives the composition of a very long circuit of this type:



Sending station ↑

Receiving station ↑

Frequency tolerances (Hz) for short-term (1 s)

8 2 2 8 2 8 2 2

Frequency tolerances (Hz) for long-term (15 min)

16 2 2 16 2 16 2 2

FIGURE 1

If it is assumed that these deviations are distributed at random and if we take the standard deviation, we shall obtain the values 15 and 28 Hz respectively, which are not harmful for satisfactory reception, since CCITT Recommendation T.1 admits a maximum deviation of 32 Hz;

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

	a	*b*
index of cooperation	352	264
speed of rotation of drum in r.p.m.	60	90/45

(In due course, characteristic *b* will become obsolete);

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

The standards for both amplitude-modulated and frequency-modulated transmissions will be found in CCITT Recommendations T.1, T.11 and T.15.

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

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

REFERENCES

CCIR Documents

[1963-66]: III/3 (Annex V).

3C d: Performance of digital transmission systems

RECOMMENDATION 345

TELEGRAPH DISTORTION

(Question 1/3, Study Programme 1A/3)

(1953–1956–1959–1963)

The CCIR,

CONSIDERING

that the definitions applying to telegraph distortion and to the mutilation of telegraphic signals, which appear in Section 33, Part I, of the List of Definitions of Essential Telecommunication Terms, published by the International Telecommunication Union, give an answer to Question 18 (Stockholm, 1948), which required a general definition of telegraph distortion capable of being usefully applied to the cause of radiotelegraphy,

UNANIMOUSLY RECOMMENDS

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

Perfect modulation (or restitution) (Definition 33.01 of the List)

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

Incorrect modulation (or restitution)
Defective modulation (or restitution) (Definition 33.03 of the List)

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

Telegraph distortion (of a modulation or a restitution) (Definition 33.04 of the List)

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

(b) A modulation (or restitution) is affected by telegraph distortion, when significant instants do not coincide with the corresponding theoretical instants.

Transmitter distortion (Definition 33.059 of the 1st Supplement to the List)

A signal transmitted by an apparatus (or a signal at the output of a local line with its termination) is affected by telegraph distortion, when the significant intervals of this signal have not exactly their theoretical durations.

Degree of individual distortion of a particular significant instant (of a modulation or of a restitution) (Definition 33.06 of the List)

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

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

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

Degree of isochronous distortion (Definition 33.07 of the 1st Supplement to the List)

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

(b) Algebraical difference between the highest and lowest value of individual distortion affecting the significant instants of an isochronous modulation. (The difference is independent of the choice of the reference ideal instant.)

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

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

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

Degree of start-stop distortion (Definition 33.08 of the 1st Supplement to the List)

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

(b) The highest absolute value of individual distortion affecting the significant instants of a start-stop modulation.

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

Note 1. – See Note to Definition 33.07.

Note 2. – Distinction can be made between the degree of *late* (or positive) distortion and the degree of *early* (or negative) distortion.

Degree of gross start-stop distortion (Definition 33.09 of the List)

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

Note. – See Note to Definition 33.07.

Degree of synchronous start-stop distortion (i.e. at the actual mean modulation rate) (Definition 33.10 of the List)

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

Note 1. – See Note to Definition 33.07.

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

Characteristic distortion (Definition 33.15 of the List)

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

Fortuitous distortion (Definition 33.16 of the List)

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

Bias distortion, asymmetrical distortion (Definition 33.17 of the List)

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

Character error rate of a telegraph communication* (Definition 33.19 of the 1st Supplement to the List)

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

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

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

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

Note 4. – Faulty translation, resulting from a previous error in functional control (such as shift, line feed, synchronism, etc.), is not counted in calculating a character error rate; in such a case, the error in the functional control signal is alone counted and is counted only once.

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* *Note by the CCIR Secretariat (1982).* – The CCITT uses the English term "error ratio" instead of "error rate" in CCITT Recommendation G.702: Vocabulary of PCM and digital transmission terms (see CCIR Vol. XIII, Report 971, Appendix A, term 2015).

*Element error rate** [CCIR, 1963]**

The ratio of the number of unit elements incorrectly received to the total number of unit elements sent.

Efficiency factor in time (of a telegraph communication with automatic repetition for the correction of errors) (Definition 33.23 of the List).

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

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

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

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

Mutilation (Definition 33.24 of the List)

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

Transposition (Definition 33.25 of the List) (See also Annex II, Part 2, definition *k* of Recommendation 342)

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

REFERENCES

CCIR Documents

[1963]: Geneva, 203.

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* *Note by the CCIR Secretariat (1982).* – The CCITT uses the English term "error ratio" instead of "error rate" in CCITT Recommendation G.702: Vocabulary of PCM and digital transmission terms (see CCIR Vol. XIII, Report 971, Appendix A, term 2015).

** *Note by the CCIR Secretariat (1970).* – This term is now defined in the 2nd supplement to the List (Definition 52.28): The ratio of the number of elements incorrectly received to the total number of elements sent.

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OPINIONS

OPINION 66*

FREQUENCY SHARING BETWEEN SERVICES BELOW 30 MHz

(Question 32/3)

(1982)

The CCIR,

CONSIDERING

(a) Recommendations Nos. 301 and 504 of the WARC-79;

(b) that preliminary theorical studies have indicated that satisfactory sharing would be predictable with high confidence under certain circumstances;

(c) that practical experience has shown the difficulties of achieving frequency sharing in a way satisfactory to both parties due to there being a wide disparity in required field strengths, protection ratios and operating procedures,

IS UNANIMOUSLY OF THE OPINION

1. that, for the time being, sharing between services below 30 MHz requires consideration on a case by case basis;

2. that quantification of the constraints which need to be applied to ensure a satisfactory outcome requires further studies embracing all the many and diverse factors involved.

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* The Director, CCIR, is requested to bring this Opinion to the attention of the IFRB and Study Group 1, 8 and 10.

92-61-04181-7