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3.4 Carrier systems on 1.2/4.4 mm coaxial cable pairs

Recommendation G.339

12 MHz VALVE-TYPE SYSTEMS ON STANDARDIZED | fR 2.6/9.5 mm COAXIAL CABLE PAIRS

(For the text of this Recommendation, see Vol. III

of the *Orange Book* , Geneva, 1976)

The Recommendations in this sub-section relate to systems set up on 1.2/4.4 mm coaxial cable pairs in conformity with Recommendation G.622. These systems, which are all equipped with transistorized amplifiers, may be classified in two families, according to whether the distance between the repeaters is a multiple of 3 km or 2 km.

The first family comprises 1.3 MHz systems having repeaters with 6 km spacing and 6 MHz systems.

The second family comprises 1.3 MHz systems having repeaters with 8 km spacing, 4 MHz systems, 12 MHz systems and 18 MHz systems.

The main characteristics of these systems and the Recommendations in which they are to be found are given in the Table below.

H.T. [T1.339]

1.3 MHz	6 km approx.	60 to 1300 kHz	approx. 5	no	G.341	
6 MHz	3 km approx.	0.06 to 5.6 MHz	approx.	20 or 21	no	G.344
1.3 MHz	8 km approx.	60 to 1300 kHz	approx. 5	no	G.341	
4 MHz	4 km approx.	0.06 to 4 MHz	approx. 15 or 16	no	G.343	
12 MHz	2 km approx.	0.3 to 12.4 MHz	approx. 45	yes	G.345	
18 MHz	2 km approx.	0.3 to 17.5 MHz	approx. 60	yes	G.346	

MONTAGE: First family Second family

TABLE [T1.339], p.

Recommendation G.341

1.3 MHz SYSTEMS ON STANDARDIZED 1.2/4.4 mm | fR COAXIAL CABLE PAIRS

(amended at Geneva, 1964; further amended)

Preliminary note

The present Recommendation describes two types of systems on coaxial cable pairs providing 300 telephone channels in the approximate frequency band 0.06 to 1.3 MHz. The length of the elementary cable section is about 6 km for the first type of system and about 8 km for the second. The first is to be preferred when it is planned to equip the cable with 6 MHz repeaters later on, the second when it is planned to install systems belonging to the other family on the cable later on, i.e. the 4 MHz system, 12 MHz system or 18 MHz system.

1 Line frequencies

The system will carry 300 telephony channels, transmitted to line:

— either between 60 kHz and 1300 kHz as supergroups Nos. 1-5 of the 4 MHz system (Fig ure 1 *a)* /G.341);

— or between 64 kHz and 1296 kHz as a mastergroup with erect channel sidebands (Figure 1 *b)* /G.341).

Figure 1/G.341, p.2

2 Pilots and additional measuring frequencies

2.1 *Line-regulating pilots*

The CCITT recommends that 1364 kHz be used for the main line-regulating pilot on all regulated-line sections crossing a frontier. The main line-regulating pilot is used for automatic correction of cable attenuation with the temperature.

In any regulated-line section crossing a frontier, it is recommended that in both directions of transmission the Administration on the transmitting side permanently transmit an auxiliary line-regulating pilot at 60 or 308 kHz, as the Administration on the receiving side may choose, so as to provide for additional regulation, for example.

The frequency accuracy recommended for the pilots is $\pm | \times 10^{D}$lF261^{5}.

The power level of these pilots should be adjusted at the output of the transmit amplifier to have a nominal value of —10 dBm0. The harmonics of the 60 and 308 kHz pilots should each have a level not higher than —70 dBm0.

The tolerances for this level are the same as in Recommendation G.332, § 2.1.

Note — Some systems in use employ a pilot at —1.2 Nm0.

2.2 *Frequency-comparison pilots*

For national frequency comparison, it is recommended that a 60 or 308 kHz pilot be used. Should international frequency comparison appear desirable, the Administrations concerned will reach agreement on which of these two frequencies they will use.

The power level of a frequency-comparison pilot should be adjusted at the output of the transmit amplifier, to a nominal value of —10 dBm0. The harmonics of the frequency-comparison pilots should each have a level not higher than —70 dBm0.

2.3 *Additional measuring frequencies*

Frequencies that can be used as additional measuring frequencies are as follows:

— supergroups Nos. 1 to 5 frequency allocation: (60), (308), 556, 808, 1056, 1304 kHz;

— mastergroup frequency allocation: (60), (308), 804, 1052, 1304 kHz.

Note — One of the two frequencies in brackets will be used for the auxiliary line-regulating pilot.

The power level of these additional measuring frequencies should be adjusted, at the output of the transmit amplifier, to have a nominal value of —10 dBm0. The harmonics of the additional measuring frequencies below 650 kHz should each have a level at this point not higher than —70 dBm0.

Note — Some systems in use employ additional pilots at —1.2 Nm0.

The additional measuring frequencies should not be permanently transmitted. They will be transmitted only for as long as is necessary for actual measurement purposes.

3 Hypothetical reference circuit

The CCITT has defined two hypothetical reference circuits, one for supergroup arrangement and the other for mastergroup arrangement. Both are 2500 km long and are divided into nine homogeneous sections of 280 km each.

3.1 *Hypothetical reference circuit used in supergroup arrangement*

This hypothetical reference circuit (see Figure 2/G.341) has, for each direction of transmission, a total of:

This hypothetical reference circuit is also used for 4 MHz and 6 MHz systems transmitting supergroups on 1.2/4.4 mm coaxial pairs and for systems providing two supergroups on symmetric pairs.

— three pairs of channel modulators, each pair including translation from the audio-frequency band to the basic group and vice versa;

— six pairs of group modulators, each pair including translation from the basic group to the basic supergroup and vice versa;

— nine pairs of supergroup modulators, each pair including translation from the basic supergroup to the frequency band transmitted on the coaxial cable and vice versa.

It will be seen that there is a total of 18 modulations and 18 demodulations for each direction of transmission, assuming that each modulation or demodulation is carried out in a single stage.

Figure 2/G.341, p.

3.2 *Hypothetical reference circuit used in mastergroup arrangement*

This hypothetical reference circuit (see Figure 3/G.341) has, for each direction of transmission, a total of:

— three pairs of channel modulators, each pair including translation from the audio-frequency band to the basic group and vice versa;

— three pairs of group modulators, each pair including translation from the basic group to the basic supergroup and vice versa;

— six pairs of supergroup modulators, each pair including translation from the basic supergroup to the frequency band of the basic mastergroup and vice versa;

— nine pairs of mastergroup modulators, each pair including translation from the basic mastergroup to the frequency band transmitted on the coaxial cable and vice versa.

Figure 3/G.341, p.

4 Circuit noise

The general target noise values for cable systems (see Recommendation G.222) apply also to systems on 1.2/4.4 mm coaxial pairs, with the conditions given in Recommendation G.223.

In practice, it is sufficient to check by calculation that, for every telephone channel as defined by the relevant hypothetical reference circuit, the mean psophometric power at the end of the channel, referred to a zero relative level point, does not exceed 10 | 00 pW0p during any period of one hour.

5 Matching of the coaxial pair impedance and the repeater impedances

The sum N of three terms defined in Recommendation G.332, § 5 must be at least equal to:

— 54 dB for a 6 km elementary cable section;

— 52 dB for an 8 km elementary cable section.

These figures have been calculated so as to get a ripple in the attenuation/frequency characteristic not exceeding 0.8 dB at the end of a homogeneous section 280 km long. It has been assumed that the reflected currents add in phase in all the elementary cable sections of this homogeneous section (the spacing of the buried repeaters, on a small coaxial pair, generally being very regular). In addition, it has been assumed that it is highly improbable that a telephone channel will be on more than one homogeneous section of the hypothetical reference circuit in the lower part of the band of line frequencies. At higher frequencies, N should be well above the limit.

6 Relative levels and interconnection

6.1 *Relative levels and cabling loss for any repeater section*

6.1.1 The loss on any 6 km elementary cable section should be 35 dB at 1300 kHz. The relative power level at the input of the cable section (output of the repeater equipment) should be —13 dBr at 1300 kHz. Each Administration may so select the pre-emphasis characteristic that the level at this point and at frequency 60 kHz lies in the range —18 to —28 dBr.

6.1.2 The nominal loss on any 8 km elementary cable section should be 49 dB at 1300 kHz. The relative levels at the input of any cable section are not strictly standardized, values of —3.5 dBr and —4.3 dBr at the top channel are being used in connection with pre-emphasis values of 9 dB and 10 dB respectively.

6.2 *Frontier section*

For interconnection between two systems using different pre-emphasis characteristics, unless there are special arrangements between the Administrations concerned, the following recommendation will be applied:

6.2.1 In a 6 km elementary cable section crossing a frontier, the level at the end of the cable section (input of the repeater equipment) should be equal to —48 dBr at 1300 kHz.

As it may be necessary to insert equipment at the frontier crossing to eliminate the monitoring or fault-locating frequencies used in each country or to terminate the remote power supply section, it is possible that the sending relative power level at 1300 kHz may be less than —13 dBr. It is then necessary that the frontier section should be less than 6 km long. If the mdifference between the pre-emphasis characteristics used in both countries

is too great to be compensated for in this way, one of the Administrations Administrations concerned, chosen by mutual agreement, will have to make up for this difference at the attended receiving station on its territory which lies closest to the frontier.

6.2.2 For interconnection between two different systems of this type with 8-km elementary cable sections, the relative level at the frequency 1300 kHz should be —4.0 dBr at the input of the frontier cable section. According to Recommendation G.352 one of the Administrations concerned, chosen by mutual agreement, will have to make up for the slight differences in relative level and pre-emphasis at the attended repeater station which lies closest to the frontier.

6.3 *Relative levels in a terminal station; interconnection with other systems*

Recommendation G.213 explains the general principles to be adopted to facilitate interconnection of different systems in terminal stations.

7 Power-feeding and alarm systems

7.1 *Power-feeding across a frontier*

In the absence of a special agreement between the Administrations concerned with a power-feeding section crossing a frontier, it is recommended that each Administration power-feed only those repeater stations in its own country. Many Administrations use looped power-feeding on the two sides of a power-feeding station, half of each of the sections between this station and the adjacent power stations being so fed; they can close the loop at their frontier stations. Agreements will be necessary if, for example, the frontier is very far from the mid-point between the two nearest feeding stations, or if the Administrations concerned use looped power-feeding on the entire section between two feeding stations.

If the repeater stations in a country are fed from another country, special precautions will be required to protect the staff working on the cables.

7.2 *Remote power-feeding systems*

The CCITT is studying these systems from the following viewpoints:

— precautions to be taken to protect staff against normal voltages and remote power-feed currents, or the use of voltages and currents which are innocuous to persons working in repeater stations or on lines;

— protection of staff and equipment against induced voltages and currents;

— trouble in remote power-feeding operation caused by induced voltages and currents.

7.3 *Supervision and alarms in a frontier section*

This should be governed by agreement between the Administrations concerned. In particular, it is necessary at the points of interconnection between two systems that if frequencies are used for monitoring or for locating faults they be attenuated to a level of —50 dBm0 on the receiving sides to prevent any disturbance to similar frequencies used in the system farther down the line.

Note — Frequencies sent only over a system already withdrawn from service because of a fault may be selected by each Administration on the national level.

Recommendation G.343

4 MHz SYSTEMS ON STANDARDIZED 1.2/4.4 mm | fR COAXIAL CABLE PAIRS

(Geneva, 1964; further amended)

Preliminary note

The present Recommendation describes a system designed to carry a maximum of 960 carrier telephone channels on a 1.2/4.4 mm coaxial pair (see Recommendation G.622).

A system of this kind is produced by halving the length of the repeater section of a 1.3 MHz system (as described in Recommendation G.341) if this length is 8 km, corresponding to a nominal repeater spacing of 4 km for a 4 MHz system.

1 Line frequencies

The CCITT recommends the two plans in Figure 1/G.343. Plan 1 shows the supergroup allocations and Plan 2 the mastergroup allocations.

It may be desirable to make provision for the through-connection of entire mastergroups or a supermastergroup to this system. This can be effected in accordance with the frequency arrangement of Plan 2 in Figure 1/G.343.

Plan 2 uses the three lowest mastergroups in the 12 MHz system on a 2.6/9.5 mm coaxial pair. It permits, in particular, direct interconnection with a 12 MHz coaxial system using the Plan 1A frequency allocation shown in Figure 1/G.332 and with a radio-relay link of 900 or 1800 channels operated according to Recommendation G.423 (Figures 4/G.423 and 8/G.423).

2 Pilots and additional measuring frequencies

2.1 *Line-regulating pilots*

The frequencies recommended for the various cases indicated in § 1 above and shown in Figure 1/G.343 are as follows:

Plan 1 — The CCITT recommends the use of the following frequencies:

i) 60 kHz or 308 kHz for the lower line-regulating pilot;

ii) 4092 kHz or 4287 kHz for the upper line-regulating pilot.

However, each Administration, when so requested by another Administration, should permanently send a line-regulating pilot at 4287 kHz.

Plan 2 — The line-regulating pilots recommended in Recommendation G.332 for the 12 MHz system in the same frequency band.

In every instance, the recommended stability is $\pm | \times 10^{D}$lF261^{5}, the power level recommended is —10 dBm0, while the tolerances at this level are the same as in Recommendation G.332, § 2.1. The harmonics of the 60 and 308 kHz pilot should each have a level not higher than —70 dBm0.

Figure 1/G.343, p.

2.2 *Frequency comparison pilots*

Plan 1 — For a national routine frequency check as described in Recommendation G.225, a frequency of either 60 kHz or 308 kHz may be used for the frequency-comparison pilot.

The power level of a frequency-comparison pilot should be adjusted at the output of the transmit amplifier, to a nominal value of —10 dBm0. The harmonics of the frequency-comparison pilots should each have a level not higher than —70 dBm0.

The frequency 1800 kHz is provisionally reserved for international frequency comparisons, as required. However, if the Administrations concerned so desire, this frequency 1800 kHz may be used for the frequency-comparison pilot.

Administrations concerned with an international carrier system on coaxial cable may agree to use (if they consider it desirable) one of the lower line-regulating pilots (either 60 or 308 kHz) for level control as well as for frequency checking.

In any case, it is desirable that one of the following two solutions should always be applied, so as to allow the line-regulating pilots to be used at the same time for frequency checking:

— provide, in each regulated-line section, a master oscillator which is regularly compared, directly or indirectly, with a national frequency standard;

— if there is no master oscillator in a regulated-line section, then beyond the junction between the two regulated-line sections considered, reintroduce the lower line-regulating pilot coming from the previous section, after its level has been stabilized.

Generally speaking, it is possible for one pilot to have two or more functions if the Administrations concerned so decide.

Plan 2 — The same recommendation as for the 12-MHz system (Recommendation G.332, § 2.2).

2.3 *Additional measuring frequencies*

Plan 1 — Frequencies that may be used are the following:

60, 308, 556, 808, 1056, 1304, 1552, 1800, 2048,

2296, 2544, 2792, 3040, 3288, 3536 and 3784 kHz.

The recommended accuracy for the frequency of these signals is ± | 0 Hz. The power level of these additional measuring frequencies should be adjusted at the output of the transmit amplifier to have a nominal value of —10 dBm0.

The harmonics of the aditional measuring frequencies below 2.1 MHz should each have a level at this point not higher than —70 dBm0.

Plan 2 — The additional measuring frequencies recommended for the 12-MHz system in the same frequency band should be used (Recommendation G.332).

3 Hypothetical reference circuits

The hypothetical reference circuit depends on the line frequency arrangement.

With the supergroup arrangement, the first hypothetical reference circuit for the 1.3 MHz system, described in Recommendation G.341, § 3.1, is to be used.

With the mastergroup arrangement, the circuit to be used is:

— either the second hypothetical reference circuit for the 1.3 MHz system, described in Recommendation G.341, § 3.2,

— or the first hypothetical reference circuit for the 12 MHz system, described in Recommendation G.332, § 3.1.

4 Noise

Recommendation G.341, § 4 applies.

5 Matching of the coaxial-pair impedance and repeater impedances

For an elementary cable section above 4 km in length the sum *N* of the three terms defined in Recommendation G.332, § 5) must be at least equal to the following:

— 50 dB at 60 kHz,

— 57 dB above 300 kHz,

with linear variation from 50 dB to 57 dB in the 60-300 kHz band, in the case of a linear frequency scale.

Note — These values are based on the assumption that the attenuation/frequency characteristic does not show any ripple exceeding ± | dNp (about ± | dB) at the end of a homogeneous section 280 km long. A relaxed condition was applied at 60 kHz, as it may be difficult at low frequencies to obtain a reflection coefficient for the repeater input and output impedances which is sufficiently small in relation to the impedance of the cable.

6 Relative levels and interconnection

6.1 *Relative level at amplifier output*

- at 4028 kHz: —9 dBr, or
- at 4287 kHz: —8.5 dBr.

6.2 *Pre-emphasis characteristic*

This is defined by the formula:

$$A = 10 \log_{10} \left[1 + \frac{a}{1 + b\left(\frac{f}{f_r} - \frac{f_r}{f}\right)^2} \right] \text{ (dB)}$$

in which the constants are so selected as to give between 9 and 11 dB of pre-emphasis.

Both of the sets of values below meet this requirement:

1) $a = 10$ $b = 3$ $f_r = 4.7$ MHz

2) $a = 11.25$ $b = 1.56$ $f_r = 4.4$ MHz

6.3 *Interconnection in a frontier section of two systems in which the elementary cable sections are of the same nominal length* (this is true of two 4 MHz systems, and also of two 6 MHz systems)

As the relative line levels and the pre-emphasis characteristic are already covered by recommendations, the interconnection of two systems in a frontier section will not give rise to any great difficulty in this case. The Administration on the receiving side can receive the other Administration's line levels provided minor adjustments are made in the first main repeater station (for details, see Recommendation G.352).

6.4 *Interconnection of a 4 MHz and a 6 MHz system in a frontier section*

In the absence of a special agreement between Administrations, the method described in Recommendation G.352 should be applied in this case.

6.5 *Interconnection at a main station*

See Recommendation G.213.

7 Power-feeding and alarm systems

Recommendation G.341, § 7) also applies to systems conforming to the present Recommendation.

Recommendation G.344

6 MHz SYSTEMS ON STANDARDIZED 1.2/4.4 mm | fR COAXIAL CABLE PAIRS

(Geneva, 1964; further amended)

Preliminary note

The present Recommendation describes a 6 MHz system which may be used for transmitting a maximum of 1,260 telephone channels.

A system of this kind can be produced by halving the length of the elementary cable section of a 1.3 MHz system (as described in Recommendation G.341) if this length is 6 km, corresponding to a nominal repeater spacing of 3 km for the 6 MHz system.

1 Line frequencies

The CCITT recommends the three frequency allocation plans in Figure 1/G.344, each plan forming a whole within the line-frequency band.

Plans 1 and 2 show the supergroup allocations and Plan 3 the mastergroup allocations.

In Plan 1, the supergroups are assembled by means of carriers produced from a single frequency at 124 kHz. There are two possible methods of assembling the supergroups in the band 4404 to 5636 kHz. The first is to use carriers at 4092, 4340, 4588, 4836 and 5084 kHz and to keep the upper modulation band (the first two frequencies being the carriers corresponding to supergroups 15 and 16). The second method is to translate the assembly of supergroups 4 to 8, which are those of the basic mastergroup, using a carrier frequency of 6448 kHz obtained by multiplying by 4 the carrier frequency of 1612 kHz corresponding to supergroup 5.

In Plan 2, the five supergroups reversed in band 4332 to 5564 kHz correspond to mastergroup 4 of the 12 MHz line allocation, but they also represent a plan conveniently obtained with supergroup and group carrier frequencies.

Plan 3 consists of mastergroups 1-4 of the 12 MHz system (see § 1 of Recommendation G.332).

FIGURE 1/G.344, p.

2 Pilots and additional measuring frequencies

2.1 *Line-regulating pilots*

The frequencies recommended are 308 kHz on the one hand, and 4287 kHz or 6200 kHz on the other.

Note — The pilot at 4287 kHz cannot be used with television transmissions.

In every instance, the recommended stability is ± | × 10^{D}lF261^{5}, the power level recommended is —10 dBm0, while the tolerances at this level are the same as in Recommendation G.332, § 2.1. The harmonics of the 308 kHz pilot should each have a level not higher than —70 dBm0.

2.2 *Frequency comparison pilots*

Plans 1 and 2 — The same recommendation as for the 4 MHz system (Recommendation G.343, § 2.2).

Plan 3 — The same recommendations as for the 12 MHz system (Recommendation G.332, § 2.2).

2.3 *Additional measuring frequencies*

Plans 1 and 2 — All the additional measuring frequencies given in Recommendation G.343 (supergroups) should be used. In addition, in the frequency band above 4287 kHz, the following additional measuring frequencies are recommended:

— Plan 1: 5680 kHz,

— Plan 2: 5608 kHz.

However, the harmonics of the additional measuring frequencies below 2.8 MHz should comply with the relevant conditions indicated in Recommendation G.343.

Plan 3 — The additional measuring frequencies recommended for the 12 MHz system in the same frequency band (Recommendation G.332) should be used.

3 Hypothetical reference circuits

Same Recommendations as for the 4 MHz system (see § 3 of Recommendation G.343).

4 Noise

Recommendation G.341, § 4 applies.

5 Matching of the coaxial-pair impedance and repeater impedances

For an elementary cable section about 3 km in length the sum N of the three terms defined in Recommendation G.332, § 5) must be at least equal to 60 dB at all frequencies above 300 kHz.

A figure of 50 dB is recommended at 60 kHz. Between 60 and 300 kHz the acceptable limit varies progressively.

6 Relative levels and interconnection

6.1 *Relative levels at repeater output at 4287 MHz:*

Approximately —17 dBr.

6.2 *Pre-emphasis characteristics*

It has not been possible to reach agreement for recommending a pre-emphasis characteristic applicable to all cases. The pre-emphasis used in practice varies between 7 and 14 dB. Some Administrations use a pre-emphasis characteristic corresponding to the formula:

$$A = 10 \log_{10} \left(1 + a\right) \quad \text{(dB)}$$

$$A = 10 \log_{10} \left(1 + \frac{1}{1 + b \left(\frac{f}{f_r} - \frac{f_r}{f}\right)^2}\right) \quad \text{(dB)}$$

For the constants, a, b and f_r, the following figures may be indicated:

1) $a = 10$ $b = 2.20$ $f_r = 5.75$ MHz

2) $a = 24$ $b = 8.50$ $f_r = 6.40$ MHz

7 Interconnection

Interconnection should be in conformity with Recommendation G.352.

8 Power-feeding and alarm systems

Recommendation G.341 also applies to systems conforming to the present Recommendation.

Recommendation G.345

12 MHz SYSTEMS ON STANDARDIZED 1.2/4.4 mm | fR COAXIAL CABLE PAIRS

(Mar del Plata, 1968; further amended)

The provisions of this Recommendation are those appearing in Recommendation G.332 for systems on 2.6/9.5 mm coaxial pair, with the exception of the following provision:

5 Matching of the coaxial-pair impedance and repeater impedances

For an elementary cable section about 2 km in length, the recommended value of *N* is 63 dB throughout the transmitted frequency band, *N* being defined as in Recommendation G.332, § 5.

Recommendation G.346

18 MHz SYSTEMS ON STANDARDIZED 1.2/4.4 mm | COAXIAL CABLE PAIRS

(Geneva, 1980)

The provisions of this Recommendation are those appearing in Recommendation G.334 for 18 MHz systems on 2.6/9.5 mm coaxial pair, with the exception of the following provision:

5 Matching of repeater and line impedances

For an elementary cable section about 2 km in length, the recommended value of *N* is 63 dB throughout the transmitted frequency band, *N* being defined as in Recommendation G.332, § 5.

3.5 Additional Recommendations on cable systems

Recommendation G.352

INTERCONNECTION OF COAXIAL CARRIER SYSTEMS OF DIFFERENT DESIGNS

(amended at Mar del Plata, 1968 and Geneva, 1980)

In every case of interconnection of coaxial carrier systems of different types at frontiers, some special arrangements are required to enable the systems to interwork satisfactorily.

The following points require special attention:

This Recommendation applies to 1.3 MHz, 4 MHz, 6 MHz, 12 MHz, 18 MHz and 60 MHz systems.

1 Pilots

Each line-regulating pilot should be transmitted on the two systems to be interconnected, at the same absolute power level (referred to a point of zero relative level). If the two systems do not use the same frequencies for the pilots, each of the stations situated at the ends of the regulated-line section crossing the frontier should be equipped to send all the pilots needed by both systems.

2 Transmission conditions

For interconnecting systems using different pre-emphasis values and output levels at national boundaries, Administrations can agree to equalize the level differences by shortening the frontier cable section and adding suitable passive equalizer networks as indicated in Annex A.

There may be cases in which even shortening the cable section to zero is not sufficient to equalize completely the level differences. It is recommended in these cases that the residual small level differences be finally corrected in the next main repeater station.

In some cases it may be feasible to maintain the normal repeater spacing in the frontier cable section and to accept some level differences at some intermediate repeaters near the frontier, ancillary gain and correcting networks being provided in the nearest main station (see Annex B).

3 Power feeding

In the absence of a special agreement between the Administrations concerned in a power-feeding section crossing a frontier, it is recommended that each Administration power-feed only the repeater stations on its own territory.

4 Supervision and alarms

In each particular case, these points should be agreed by Administrations concerned.

5 Conditions for the repeater section

The CCITT has standardized the dimensions of the coaxial pairs to be used in the international European telephone network (see Recommendations G.622 and G.623). Nevertheless, this standardization allows certain variations, so that the coaxial pairs manufactured by different contractors in different countries may not have exactly the same characteristics. To ensure uniformity throughout the frontier repeater section, it is strongly recommended that, by agreement between the two Administrations concerned the manufacture of the whole section should be entrusted to the same firm. If the same contractor does not supply the whole section, the two Administrations concerned must *very carefully* coordinate their detailed specifications and their methods of laying and jointing, to ensure that the conditions recommended by the CCITT for the complete elementary cable section are met.

As regards matching of the impedance of this repeater section to the impedances of the two adjacent amplifiers, in the general case of a coaxial cable section between two adjacent repeaters and used for telephony only, the CCITT has defined only the permissible limits for the sum *N* of the three terms defined in Recommendation G.332, § 5.

It is recommended that the Administrations concerned with a coaxial cable section crossing a frontier, agree on the values for each of these three terms permissible to meet the above condition — i.e. agree on the use of as good a match as possible. It is also very desirable that, throughout a coaxial system the Administrations concerned should agree always to use the same methods, particularly in impedance matching, so as to simplify system maintenance.

ANNEX A

(to Recommendation G.352)

The interconnection of systems using different pre-emphasis values and output levels, at additional boundaries, can be achieved by the method shown in Figure A-1/G.352. Repeater locations are designated I to IV, the different systems used in the two countries are indicated by repeater types A and B; the dotted lines w, x, y and z show the possible locations of the actual frontier. The correcting networks shown between repeater points II and III are designed in conjunction with the cable length between II and III to compensate for the differences in level and pre-emphasis of systems A and B. The correcting networks may be mounted in the repeater boxes at II or at III or may be mounted one in each box. Alternatively, they could be mounted in a separate box between II and III. The distance between II and III will normally be less than the repeater spacing of system A or system B and could in the limit be zero, with the repeater boxes II and III adjacent to one another, the frontier would then be at w or z.

Figure A-1/G.352, p.

Interconnection of two systems can be established by this method, using only passive interconnecting networks, if the following condition is met: the repeater input level at any frequency of one system is lower than the output level of the other system at the same frequency, by a small amount (say 1 dB) to allow for the loss of the interconnecting circuit.

The repeaters of type A could be fed with power and supervised from the nearest power-feeding station in country A and similarly for type B repeaters. If the frontier were located at x or y, neither of the power-feeding and supervisory systems need cross the boundary.

With this method all repeaters could be of standard types and the output and pilot levels could be normal. Special correcting networks would be required.

ANNEX B

(to Recommendation G.352)

An alternative method to that given in Annex A is shown in Figure B-1/G.352, in which the ordinary length of repeater spacing with the nominal loss *a* is maintained in the frontier cable section. The nominal relative sending level of system I is n_{I} and that of system II is $n_{\mathrm{I\backslash dI}}$. The difference of the relative levels is defined as the differential pre-emphasis:

?63

pre

$= n_{\mathrm{I}} - n_{\mathrm{I\backslash dI}}$

It shall be assumed that ?63$_{\mathrm{p\backslash dr\backslash de}}$ is positive over the whole transmission band and that at the highest transmitted frequency, the sending levels of the two systems are almost equal. For the adaptation of the relative levels between system I and system II it is necessary to introduce an additional passive correction network ?63 pre in the direction III and an additional active correction network —?63 pre in the direction III.

For reasons associated with the size of the repeater housing and power supply, it may be desirable to avoid additional amplification in the frontier section, which usually has underground repeaters with a remote power supply. There is no great drawback in using the pre-emphasis of the foreign incoming system up to the following attended repeater station and to accommodate only in this station the requisite gain for transformation of the pre-emphasis. In the attended repeater station, there will be no special difficulty in getting the necessary space and current for the additional equipment. The requisite gain in the direction III (for

—?63 pre) and in the direction III (because of a possible basic loss in the ?63$_{p\dr\de}$network) is supplied by additional amplifiers which are usually already provided for in attended stations, to compensate for the basic attenuation of precision equalizers.

As indicated in Figure B-1/G.352 it may be well to use differential pre-emphasis for both directions in the same repeater station, for example on that side of the frontier where there is the system using the smallest pre-emphasis (higher sending relative level). If we assume as is shown in Figure B-1/G.352 that this is system I, the few underground repeaters of system I between the frontier and the attended repeater station will (in lower channels) be operated with the lower level of system II and will affect the overall noise performance of the whole system less critically than if the situation were reversed, such that system II were operated at a higher level.

Figure B-1/G.352, p.

Recommendation G.356

(120 + 120) CHANNEL SYSTEMS ON A SINGLE | fR COAXIAL PAIR

(For the text of this Recommendation, see Volume III
of the *Yellow Book* , Geneva, 1981)

3.6 Other carrier systems on open-wire lines

Even though the systems described in the present subsection are modern, particularly because the audio-frequency band effectively transmitted for each telephone channel is from 300 to 3400 Hz, the general Recommendations of Section 2 cannot be applied to them entirely, having regard to certain peculiarities of their makeup. For this reason the following special arrangements have been made.

Recommendation G.361

SYSTEMS PROVIDING THREE CARRIER TELEPHONE CIRCUITS

ON A PAIR OF OPEN-WIRE LINES

1 Standardized system

The particular system described below provides three good-quality telephone circuits in the frequency band above the existing audio circuit. This system can be arranged below the frequency band shown in Scheme I of Figure 1/G.311 for a 12-circuit system.

The arrangement of line frequencies in this system has been so specified that when such a system crosses a frontier (perhaps in a completely uninhabited area) it is not necessary to use modulators and demodulators.

Besides the audio circuit, it is possible with this arrangement of line frequencies to provide either one carrier telephone circuit together

and one two-way sound-programme circuit at 6.4 kHz or a two-way sound-programme circuit at 10 kHz (see Recommendations J.22 [1], J.23 [2], J.32 [3] and J.33 [4]).

This system can also include a certain number of telegraph channels without change to the transmitted frequency band of the carrier circuits. The bandwidth of the audio circuit, however, is in this case reduced.

The specification below has been designed for the above particular case.

1.1 *Frequency band transmitted*

The carrier frequency spacing should be 4 kHz.

The lower band transmitted to line for one direction of transmission should be between 4 and 16 kHz, and the upper band used for the other direction of transmission should be either 18 to 30 kHz or 19 to 31 kHz, so as to allow the use of staggered carrier frequencies if it is later decided to use a second similar system on the same pole route (see § 1.10 below and Figure 1/G.361).

Figure 1/G.361, p.

1.2 *Relative power level*

The relative power level at the output of the terminal equipments and intermediate repeaters, on each channel and for the frequency of this channel which corresponds to the audio-frequency 800 Hz should not be greater than +17 dBr.

1.3 *Pilots*

The pilots are normally 16.110 kHz for the lower line-frequency band and 31.110 kHz for the upper band. The relative frequency accuracy recommended for them is $\pm | .5 \times 10^{D}$lF261^{5}. This recommendation applies to all the four frequency spectra shown in Figure 1/G.361. The power level of the line pilots should be —15 dBm0.

The upper pilot of 31.110 kHz is suitable for most Administrations. Normally it may be expected to give a rather better regulation performance than a pilot of lower frequency.

In other cases it may be unsuitable for the following reasons:

1) The regulation may be affected when the open-wire pair is already equipped with a number of filters designed to separate 12-circuit systems from old-type 3-circuit systems.

2) When a single modulation stage is used for the low-frequency telephone channels of the standardized system, it is convenient for interband telegraph channels (see § 2 below) to be located above, rather than below, the frequency band occupied by the telephone channels in the high-frequency direction of transmission.

The CCITT accordingly recommends that an alternative pilot frequency of 17.800 kHz be used, when it is agreed between the Administrations concerned that the normal pilot frequency of 31.110 kHz is unsuitable either for the reasons given above or to meet other circumstances peculiar to the route.

1.4 *Variation (with frequency) of the overall loss at the output of the transmit terminal equipment*

See Recommendation G.232, § 1.

1.5 *Non-linearity distortion of all the terminal equipments*

See Recommendation G.232, § 7.

1.6 *Crosstalk in terminal equipments*

See Recommendation G.232, § 9.

1.7 *Impedance (as seen from the switchboard-jack)*

See Recommendation G.232, § 11.

1.8 *Stability of carrier generators*

So that the effect of the modulations and demodulations never gives rise to a difference greater than 2 Hz between the audio-frequency input and the audio-frequency output at the far end (where there is no intermediate demodulation and modulation), the stability of the carrier frequency generators should be such that the frequency is always correct to within $\pm | .5 \times 10^{D}$lF261^{5}.

1.9 *Carrier leak sent to line*

The power level of the carrier leak should not be greater than:

—17 dBm0 for one channel and for each direction of transmission;

—14.5 dBm0 for all channels of the system taken together and for each direction of transmission.

1.10 *Several systems working on the same route*

The CCITT recommends the four arrangements of frequencies shown in the diagrams of Figure 1/G.361. No order of preference has been decided and in each particular case the Administrations concerned will choose the most appropriate scheme(s).

Note — Also, by agreement between Administrations concerned, the lower frequency band transmitted to line, Schemes 2 and 4, may be inverted.

2 Systems using common repeaters for telephony and interband telegraphy

For international traffic, it is necessary to provide for an open-wire system which uses common line repeaters for telephone and interband telegraph channels.

2.1 *Line-frequency arrangement for telephony*

The arrangement of line frequencies as far as the telephone channels are concerned would be as shown in § 1 above.

2.2 *Line-frequency arrangements for telegraphy*

2.2.1 It is recommended that the system should provide four telegraph channels, the nominal frequencies to be used being as follows:

a) *Low-frequency direction of transmission*

3.22, 3.34, 3.46 and 3.58 kHz

b) *High-frequency direction of transmission*

i) telephone channels occupying the frequency band 18-30 kHz:

30.42, 30.54, 30,66 and 30.78 kHz

ii) telephone channels occupying the frequency band 19-31 kHz:

18.22, 18.34, 18.46 and 18.58 kHz

2.2.2 When inband signalling (as distinct from outband signalling at the edge of the 4-kHz band) is employed, it becomes possible to provide two additional telegraph channels having the following nominal frequencies:

a) *Low-frequency direction of transmission*

3.70 and 3.82 kHz

b) *High-frequency direction of transmission*

i) telephone channels occupying the frequency band 18-30 kHz:

30.18 and 30.30 kHz

ii) telephone channels occupying the frequency band 19-31 kHz:

18.70 and 18.82 kHz

2.2.3 Where, as a result of agreement between the Administrations concerned the system has an upper pilot of 17.800 kHz (see § 1.3 above), the following frequencies may be used as alternatives to those specified in §§ 2.2.1, b) ii) and 2.2.2, b) ii). This alternative arrangement permits, in certain types of systems, a more economical modulation process:

31.42, 31.54, 31.66 and 31.78 kHz instead of
18.22, 18.34, 18.46 and 18.58 kHz

also 31.18 and 31.30 kHz instead of 18.70 and 18.82 kHz

2.3 *Power transmitted to line*

The CCITT has not thought it desirable to standardize absolutely the power transmitted to the line as this may be dependent upon the conditions on the open-wire route. Neither was it thought necessary to differentiate between amplitude- and frequency-modulated telegraph channels. Under favourable conditions a typical value for the power on each telegraph channel would be —20 dBm0.

3 **Other systems** (formerly Part C)

In some cases it is necessary to operate across a frontier on an open-wire pair, without using demodulators and modulators at the frontier, using a system providing three good-quality telephone circuits (effective frequency bandwidth of each circuit — 300 to 3400 Hz), and having below about 6 kHz a frequency band which can be used for other purposes. In such cases the arrangement of line frequencies should be the subject of bilateral agreement between the Administrations concerned. The clauses in §§ 1.2, 1.4, 1.5, 1.6, 1.7, 1.8 and 1.9 above are applicable to all such systems.

The carrier frequency spacing could be 4 kHz, as in all other recommendations of the CCITT for modern carrier systems. This solution would permit the use on each telephone channel of outband signalling recognized by the CCITT (Recommendation Q.21 [5]). As a variant, a system could be used having a carrier frequency spacing of less than 4 kHz, but still providing an effectively transmitted bandwidth of 300-3400 Hz in each telephone channel. Such a system would facilitate the provision, if required, of up to six telegraph channels using the same line repeaters as the telephone channels.

Establishment of a model questionnaire concerning preliminary information which should be obtained relating to existing open-wire lines by Administrations wishing to set up multichannel carrier telephone systems

The CCITT

unanimously recommends

that the following questionnaire should be used:

(1) Which communication channels should be set up on carrier systems?

(2) Which lines are available for carrier working?

a) length of these lines,

b) gauge, nature of wire, distance between wires,

c) existing cable sections (location, type and length of these cables),

d) existing transpositions and crossings,

e) amongst available lines, are there two or more identical circuits which could be interchangeable, to which reserve circuits could be allocated?

(3) What are suitable points for installation of the repeaters? Where are audio-frequency repeaters already located on the lines to be equipped for carrier working?

(4) What are the locations of radio-transmitting stations liable to interfere with the carrier channels? What power and frequency are used by these transmitters?

(5) Are the new carrier circuits to be connected to other lines permanently or temporarily?

Certain lines and offices having been selected as a result of the answers to the above questions, Administrations should obtain the following information:

What are the results of impedance and attenuation measurements made on each of the proposed line sections throughout the frequency band to be used?

References

[1] CCITT Recommendation *Performance characteristics of 10-kHz type sound-programme circuits* , Vol. III, Rec. J.22.

[2] CCITT Recommendation *Performance characteristics of narrow-bandwidth sound-programme circuits* , Vol. III, Rec. J.23.

[3] CCITT Recommendation *Characteristics of equipment and lines used for setting up 10-kHz type sound-programme circuits* , Vol. III, Rec. J.32.

[4] CCITT Recommendation *Characteristics of equipment and lines used for setting up 6.4-kHz type sound-programme circuits* , Vol. III, Rec. J.33.

[5] CCITT Recommendation *Systems recommended for out-band signalling* , Vol. VI, Rec. Q.21.

3.7 International telephone carrier systems using submarine cable

Recommendation G.371

FDM CARRIER SYSTEMS FOR SUBMARINE CABLE

(Geneva, 1964; further amended)

1 Interconnection with overland systems

1.1 *Definition of* **submarine system/overland system interconnection point**

There is a basic difference between overland and submarine systems with regard to interconnection conditions. In the overland systems we are concerned with the connection, at a point close to a frontier, of two systems operated by different Administrations and designed by different manufacturers, sometimes according to different principles, although they respect the same CCITT Recommendations. In submarine systems there is usually one system, purchased, installed and operated jointly, and built by one manufacturer; in such systems terminal equipments include special equipment which are studied in relation to line equipment (remote feeding, equalization, location of faults, etc.) and which cannot be dissociated therefrom. It is this system as a whole which is interconnected with the overland networks of the two countries it connects; instead of one frontier point, there are two. This being so, the interconnection points are defined as the output(s) *S* and the input(s) *S'* of the special equipments which ensure the passage between the frequency

allocation used in the submarine cable system and a line-transmitted frequency allocation for an overland system (or part of such an allocation plan), so as to enable group, supergroup, or mastergroup translating equipment (depending on the capacity of the system) which conforms to CCITT Recommendations to be used on the other side of these interconnection points (see Figure 1/G.371).

Figure 1/G.371, p.

Because the CCITT does not recommend, in the case of a submarine cable system, the arrangement of line-transmitted frequencies, it is advisable for the capacity of a system to be defined in terms of the number of groups, supergroups, etc., provided; it being understood that each such group, supergroup, etc., can be made available, if necessary, as a group, supergroup, etc. link for the transmission of wide spectrum signals.

1.2 *Recommendations concerning the positioning of pilots and supervisory signals, etc.*

To avoid disturbing the operation of overland systems to which the submarine cable systems may be interconnected as indicated above, or limiting the alternative ways in which the system may be used, the CCITT recommends that submarine cable systems should not use any pilot inside the band of any group, supergroup, etc., transferred to the submarine system across the interface with the overland network and forming part of the defined system capacity. Furthermore, the repeater monitoring (supervisory) signals and remote signalling frequencies should be located outside each such band and preferably outside the limits of the band occupied by the telephone channels transmitted in either direction.

Note — For testing on a system taken out of service, the above restriction on the frequencies of repeater monitoring signals need not apply.

1.3 *Impedance and relative power levels*

If the signal transmitted at an interconnection point is constituted by a single CCITT multiplexing unit (i.e. a group, supergroup, etc.) in its basic frequency position, the point *S* can be regarded as corresponding to the receive side and the point *S*‘ to the transmit side of a group, supergroup, etc. distribution frame. The impedance and relative power level should be in accordance with Recommendation G.233.

Alternatively, the signal may consist of a number of groups, supergroups, etc. assembled in the frequency positions occupied on the line of an overland system. The points *S* and *S*‘ then correspond to the *T* (output), and *T*‘ (input) of a line link as defined in Recommendation G.213. The impedance and relative power level should be in accordance with Table 1/G.213.

When considering the loading conditions on overland transmission systems, due attention should be paid to the different conventional load values mentioned in § 3 below.

1.4 *Limits for residues of signals outside the transmitted bands*

In each of the two cases of interconnection considered in § 1.3 above, all unwanted signals from the submarine system should be suppressed according to CCITT Recommendations, particularly Recommendations G.242 and G.243. For this purpose, any necessary filtering additional to that in the regular equipment on the landline side of the interconnection point *S* , should be provided in the special equipment of the submarine system.

It is necessary, as regards the additional filtering in the special equipment, to take account of the particular line frequency plan used in the submarine system, the frequency positions and power levels of regulating, monitoring and supervisory pilots and of speech signals passed over service channels used for the operation of the submarine system. If these are different from the normal system arrangements to which the suppression requirements specified in Recommendations G.242, and G.243 were related, then the values of the suppression provided in the special equipment of the submarine system need to be adjusted accordingly.

The suppression conditions which apply at *S*‘ for signals originating in the overland system are those of Recommendation G.242 (through connection of groups, supergroups, etc.). Any supplementary suppression necessary for the protection of control signals, etc., in the submarine system, should be provided in the special equipment of the submarine system.

2 Frequency plans

It is recommended that circuits be assembled in the basic group, supergroup, mastergroup, etc. specified by the CCITT (Recommendation G.211).

To obtain a capacity of more than eight groups, but which can reach eight supergroups, it is recommended to limit the choice to systems providing two, five or eight supergroups. Because of the need in broadband submarine cable systems to maximize the economic use of the baseband, the CCITT does not recommend any specific values for larger capacity systems. In no case does the CCITT consider it necessary to standardize the line frequency band, which in each case is subject to agreement between the two Administrations concerned.

It is recommended that at the input and output of the special terminal equipment, at the interconnection points defined in § 1 above, the groups and possibly the supergroups are assembled in one of the frequency allocations (or part of such an allocation plan) already recommended by the CCITT for interconnection between radio-relay links and systems on metallic lines; these allocations are given in Table 1/G.423. If the capacity does not correspond to one of those mentioned in this table, the capacity immediately above should, of course, be taken.

It should be noted that these arrangements include the possibilities of the frequency allocation being a single group, supergroup or mastergroup, etc., in its basic frequency position.

3 General transmission conditions

The systems should satisfy all Recommendations in Sections 1 and 2 of the Series G Recommendations including: noise, crosstalk, attenuation distortion, error on the reconstituted frequency, variation of loss with time. However, for noise calculations it is necessary to specify a conventional load other than that of Recommendation G.223 which applies to carrier systems on land cables or radio links. For planning purposes a conventional load value of —13 dBm0 per audio channel should be used. This value may be relaxed should the planned operating requirements indicate that a lower power level may exist. Conversely a higher value might be considered if the systems considerations require this.

4 Cables

See Subsection 6.3 of the Series G Recommendations.

Assumes VF telegraphy and data systems operate at an aggregate power level of —13 dBm0 per audio channel.

MONTAGE: PAGE 172 = PAGE BLANCHE

SECTION 4

GENERAL CHARACTERISTICS
OF
INTERNATIONAL CARRIER TELEPHONE SYSTEMS
ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION
WITH METALLIC LINES

COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY .sp 2

4.1 General recommendations

Recommendation G.411

USE OF
RADIO-RELAY SYSTEMS FOR INTERNATIONAL

TELEPHONE CIRCUITS

The CCITT

unanimously recommends

that, between fixed points, telephone communications should be effected wherever possible by means of metallic conductors or radio-relay links using frequencies above 30 MHz to make the allocation of radio frequencies less difficult and, 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.

Reference

[1] CCIR Recommendation *Use of radio links in international telephone circuits* , Vol. III, Rec. 335, Dubrovnik, 1986.

This Recommendation is the same as an extract from CCIR Recommendation 335 [1].

Recommendation G.412

TERMINAL EQUIPMENTS OF RADIO-RELAY SYSTEMS FORMING PART OF A GENERAL TELECOMMUNICATION NETWORK

The CCITT,

considering

that in Europe, and also in other parts of the world, there is a vast international telecommunication network which (as well as national

networks) has been established in conformity with the Recommendations of the CCITT, particularly as far as the frequency spectrum of the telephone channels in the frequency band up to 4 MHz is concerned, and also as regards the essential technical characteristics of the terminal equipments of all the carrier systems;

considering, further,

that the increasing introduction of demand working and semiautomatic telephone service will lead, in the near future, to an appreciable increase in the number of long-distance national and international circuits,

and that consequently, during the next few years, it will be necessary to install multichannel telephone systems on radio links and to integrate these links with the general telecommunication network;

and considering finally

that interconnection of the systems should be made easy and that the task of the telephone Administrations which will have to use and maintain these systems should not be unnecessarily complicated;

unanimously recommends

that, when technically possible and economically desirable,

(1) systems on radio-relay links should be arranged in such a way that at points of interconnection with the general telephone network, the telephone circuits appear assembled in accordance with the rules already recommended by the CCITT for cable systems (this rule is covered by Recommendations G.421 and G.423);

(2) in all cases channel-modulating equipment should meet the basic specification clauses given in Recommendation G.232.

4.2 Interconnection of radio-relay links with carrier systems on metallic lines

Recommendation G.421

METHODS OF INTERCONNECTION

In studying the interconnection of radio-relay systems, either with one another or with systems on metallic lines, distinction should be made between the following cases:

1 Interconnection at audio-frequencies

Note from the Secretariat — This text relates to FDM radio-relay systems which were the subject of Recommenda tions G.432 and G.443 (now both deleted). As far as PCM radio-relay systems are concerned see CCIR Report 378 [1].

This is the normal method, at the present stage of technical development, whenever a radio-relay system using time-division multiplex is involved case of frequency-division multiplex and of systems on metallic lines.

2 Interconnection by through-group connection

With present technical development only radio-relay links having frequency-division multiplex can provide telephone channels assembled in groups, supergroups, mastergroups, and in some cases, supermastergroups or in 15-supergroup assemblies

Interconnection between a radio-relay system using frequency-division multiplex and a system on metallic lines can be carried out by through-connection of groups, supergroups, etc. This is possible because, according to the provisions of Recommendation G.423, the baseband of such a radio-relay system corresponds to that of a certain number of groups, supergroups or mastergroups transmitted to line in coaxial cable systems. These groups can be obtained from the relevant basic frequency band by means of translating equipment already standardized for cable systems in accordance with CCITT Recommendations.

Through-connection should then be carried out in accordance with Recommendation G.242, via the basic frequency range for groups (12 to 60 kHz or 60 to 108 kHz), for supergroups (312-552 kHz), etc. (see Recommendation G.211 and Figure 1/G.211, in particular).

3 Interconnection in the baseband

The baseband of frequency-division multiplex radio-relay links is the same as the frequency band of carrier systems on metallic lines, and interconnection in this band is possible in the conditions specified in Recommendation G.423.

Direct through-connection may also be made in this baseband, between metallic-line systems and radio-relay links, in accordance with the general provisions of Recommendation G.242, § 7.

For time-division multiplex radio-relay links, the baseband had been defined by the CCIR as ‘‘the series of modulated pulses before it is applied to the carrier frequency’’. Interconnection in the baseband of time-division radio-relay links with metallic-line systems has not yet been studied.

4 Interconnection at intermediate frequencies

5 Interconnection at radio frequencies

§§ 4 and 5 concern cases arising only in the interconnection of two radio-relay systems and are the concern of the CCIR.

Reference

[1] CCIR Report *Characteristics of digital radio-relay systems* , Vol. IX, Report 378, Dubrovnik, 1986.

Recommendation G.422

INTERCONNECTION AT AUDIO-FREQUENCIES

CCIR Recommendation 268 [1] states that, as far as is practicable, radio-relay systems for telephony providing circuits which may form part of an international connection should be such that these circuits conform with the relevant CCIR Recommendations for modern types of telephone circuit in the following respects:

1) the transmission characteristics of the circuits between audio-frequency terminals (the relevant Recommendations are contained in Section 1 of this Part);

2) the characteristics of the multiplex terminal equipment, where applicable (see Recommendations G.232 and G.412);

3) the method of signalling over international circuits, the relevant Recommendations are contained in Volume VI; see also the following Note:

Note — Since the CCITT Recommendations mentioned in 2) above envisage the use of well-defined audio signalling frequencies sent over the speech path, no signal repetition problems should arise.

When different signalling methods are used on a cable system and a radio-relay system, equipment will be necessary at the interconnection point to convert the two types of signalling to a common type, preferably d.c. signalling.

Reference

[1] CCIR Recommendation *Interconnection at audio frequencies of radio-relay systems for telephony* , Vol. IX, Rec. 268, Dubrovnik, 1982.

Recommendation G.423

INTERCONNECTION AT THE BASEBAND FREQUENCIES OF FREQUENCY-DIVISION MULTIPLEX RADIO-RELAY SYSTEMS

,

(amended at Geneva, 1964)

1 General principles

The CCIR issued Recommendations 380 [1] and 381 [2] so that, as far as possible, radio-relay links using frequency-division multiplex should have characteristics which allow direct interconnection at baseband frequencies

with systems of the same capacity on metallic lines having the same line frequencies.

Direct interconnection is advantageous, for example, in the following cases:

1) at a junction between a system on metallic lines and a radio-relay system of the same capacity, when it is not required to extract groups of telephone channels;

2) at a junction point between a radio-relay system and a short cable extension (see § 3 below). A cable extension is regarded as ‘‘short’’ if it does not require its own line-regulating system.

The pre-emphasis characteristics at the output of cable system repeaters have not been fully standardized by the CCITT. Moreover, line transmission in a repeater section of a system has various special features due, for example, to the presence of various pilots and to the power feeding of the repeaters. Further, points *R* and *T* defined in Recommendation G.213 may be very near to each other, or they may be linked by several kilometres of cable.

For these reasons, it is unnecessary to provide a direct interconnection of a telephony radio-relay link with either a symmetric cable pair or coaxial cable for a telephone system, such that the input and output levels of the relay link correspond exactly to the normal levels at the input and output of a repeater in the cable system. It is preferable to make the interconnection at a point in the telephone equipment where the level is independent of the frequency. Consequently, interconnection with multiplex telephone equipment in the baseband of a radio-relay link (which in accordance with CCIR Recommendation 381 [2] is always considered to be at one end of the line-regulating section on a radio-relay link) should always be effected in a main repeater station Interconnection with another system whether cable or radio-relay link will be effected in this station between points *T* and *T* ‘ defined in Recommendation G.213.

Brought up to date by the Secretariat after the Plenary Assembly of Mar del Plata, 1968.
Similarly to the corresponding CCIR Recommendations, this Recommendation applies to line-of-sight and near line-of-sight radio-relay systems and also to tropospheric scatter systems of the capacities concerned.
Described in § 3.18 of Recommendation G.211.

2 Baseband frequency limits, impedance and relative power levels

CCIR Recommendation 380 [1] includes a table which shows preferred values given by the CCIR for the following:

— baseband frequency limits;

— nominal baseband impedance;

— input and output relative power levels at the radio equipment (R' and R);

together with an annex on definitions which corresponds to CCITT Recommendation G.213.

Table 1/G.423 shows the frequency arrangements, corresponding to the baseband frequency limits in CCIR Recommendation 380 [1], recommended by the CCITT for radio-relay systems that may be interconnected with metallic lines. These frequency arrangements are produced by CCITT standardized frequency-translating equipments for cable systems.

Figures 1/G.423 to 10/G.423 show diagrams of the frequency arrangement for the radio-relay baseband, recommended for purposes of interconnection with coaxial cable systems.

Note 1 — All the diagrams in Figures 1/G.423 to 10/G.423 show the line pilots, the mastergroup pilots, the supermastergroup pilots, the 15-supergroup assembly pilots and the additional measuring frequencies which *may* be in the band transmitted (see § 3).

Note 2 — The meaning of the symbols used in these Figures is given at the beginning of this fascicle.

Note 3 — Some of the diagrams in the figures of other Recommendations also apply to radio-relay links (see Table 1/G.423).

3 Regulated-line sections — line-regulating and other pilots

In CCIR Recommendation 381 [2], the following pilots are recommended for the regulation of radio-relay links:

1) a continuity pilot outside the ''total bandwidth'' shown in Table 1/G.423;

2) a line-regulating pilot with a frequency of 308 kHz (or 60 kHz, depending on the radio-link capacity), and a level of —10 dBm0;

3) when required, an upper line-regulating pilot of frequency and level in accordance with CCITT Recommendations for the relevant cable systems.

3.1 *Pilot-blocking at an interconnection point*

The CCITT makes the following general recommendations to the CCIR: in all cases, the level of the continuity pilot of a radio-relay system should be reduced so that it is not greater than —50 dBm0 at an interconnection point with a system on a metallic line.

This interconnection point normally occurs at the limits of two regulated-line sections, one of them being on a metallic line and the other on a radio-relay system. This being so, at the interconnection point the following conditions should be observed:

1) the level of any line-regulating pilot on the metallic line should be reduced so that it is not greater than —50 dBm0, unless otherwise agreed by the Administrations concerned;

2) the absolute power level of any regulating pilot of the radio-relay link should be reduced so that it is below —50 dBm0 ;

3) any other pilot or additional measuring frequency of the metallic line system that is within the ''total bandwidth'' defined in Table 1/G.423 will be freely transmitted over the radio-relay system.

A radio-relay system may be extended by short cable sections that form part of the same regulated-line section; there may then be overall transmission of the pilot on that regulated-line section.

In the case of low-capacity systems (up to

120 channels) a line-regulating pilot of 60 kHz with a level of —10 dBm0 may be used; in this case the suppression level should conform with the provisions of the CCITT (Recommendation G.243 and Recommendation G.322, § 1.4). The level of the line-regulating pilot established by the CCITT for lines differs according to whether it concerns coaxial cables or symmetric pairs (—10 dBm0 for coaxial cables and —15 dBm0 for symmetric pair systems).

4 Limits for residues of signals outside the baseband

The CCITT makes the following recommendations to the CCIR for residues of signals outside the baseband frequency limits:

4.1 In the absence of any special agreement between Administrations, the level of any pilot or supervisory signal transmitted outside the baseband of a radio-relay system at a frequency not specified by the CCIR should be reduced, within the radio equipment, to —50 dBm0 at point *R* .

Similarly, in the absence of special agreements between Administrations, the levels of all pilots or supervisory signals sent over the cable system outside the baseband of the radio-relay link should be reduced, within the equipment of the cable system, to —50 dBm0 at point *T* .

4.2 If a radio-relay system service channel, adjacent to a telephone channel in the baseband, uses the levels, frequency allocation and signalling levels corresponding to those which would be recommended by the CCITT for an ordinary telephone channel in the same position in the frequency spectrum, the channel filters are sufficient to avoid the risk of crosstalk interference.

4.3 If the condition referred to in § 4.2 above is not met, an additional filter may be necessary and must be provided in the radio equipment.

4.4 The frequencies mentioned in §§ 4.1 and 4.2 above must be sufficiently distant from the baseband to ensure that the filters (or other appropriate devices) required to eliminate them do not cause attenuation distortion in the passband to exceed the recommended values.

4.5 To avoid overloading the cable system, the level of any signal transmitted beyond point *R* outside the baseband must be kept down to —20 dBm0. Moreover, the level of the total power of the residues of such signals (including noise and intermodulation products) must be kept down to —17 dBm0.

5 Other requirements intended to ensure satisfactory transmission performance

5.1 *Return loss*

This characteristic is of great importance for carrier cable systems, which comprise a number of fairly regularly spaced repeaters. It is felt that, in the case of radio-relay systems, the cable sections linking the radio equipment to the multiplex equipment are generally fairly short and of unequal lengths, so that there is little fear of systematic undulation of the attenuation/frequency characteristic.

That being so, it is recommended that at interconnection points *T* and *T* ‘ the return loss, in relation to the nominal impedance, should be at least 20 dB throughout the frequency band occupied by the telephone channels. The main purpose of this recommendation is to facilitate measurements and maintenance and to ensure some protection against the random reflections which occur at various points between the equipment and the cable sections; it takes into account the value of 24 dB for the return loss at *R* and *R* ‘ recommended by the CCIR [4].

Note — The attention of the CCIR is drawn to the fact that, if the cables joining the radio equipment to the multiplex equipment in the intermediate stations are long enough (for example 1 to 2 km) and not equipped with amplifiers, systematic reflection effects may occur. These special cases must be studied in accordance with the principles established by the CCITT (see Recommendation G.214); they do not seem to justify a general recommendation.

5.2 *Attenuation/frequency distortion*

According to the Recommendation cited in [5], the levels measured at the frontier on a high-frequency cable line section must not deviate at any frequency by more than ± | dB from the nominal values, whatever the pre-emphasis characteristic used. At point *T* , for a cable system, one can expect to find variations of the same order in relation to a flat characteristic.

No value is fixed for the radio-relay links in the Recommendation cited in [6]. The CCIR has recommended [7] the same tolerance of ± | dB at the points *R* and *R* ‘.

5.3 *Variation of loss with time*

The CCITT is studying the results that can be obtained on cable line-regulating sections, taking into account Recommendations M.530 [8] and G.333. When this study is complete, it will be possible to point out to the CCIR that a similar recommendation would be desirable for radio-relay links.

Table 1/G.423 T1.423, p.

Figure 1/G.423, p.

Figure 2/G.423, p.

Figure 3/G.423, p.

Figure 4/G.423, p.

Figure 5/G.423, p.

Figure 6/G.423, p.

Figure 7/G.423, p.

Figure 8/G.423, p.

Figure 9/G.423, p.

Figure 10/G.423, p.

References

[1] CCIR Recommendation *Interconnection at baseband frequencies of radio-relay systems for telephony using frequency-division multiplex* , Vol. IX, Rec. 380, Dubrovnik, 1986.

[2] CCIR Recommendation *Conditions relating to line regulating and other pilots and to limits for the residues of signals outside the baseband in the interconnection of radio-relay and line systems for telephony* , Vol. IX, Rec. 381, Dubrovnik, 1986.

[3] CCITT Recommendation *Valve-type systems offering 12 telephone carrier circuits on a symmetric cable pair [(12 + 12) systems]* , Orange Book, Vol. III-1, Rec. G.327, Figure 1/G.327, ITU, Geneva, 1977.

[4] CCIR Recommendation *Interconnection at baseband frequencies of radio-relay systems for telephony using frequency-division multiplex* , Vol. IX, Rec. 380, § 3, Dubrovnik, 1986.

[5] CCITT Recommendation *Bringing a new international carrier system into service* , Vol. IV, Fascicle IV.1, Rec. M.450, §§ 2.2 and 2.3.

[6] *Ibid.* , § 2.1.

[7] CCIR Recommendation *Interconnection at baseband frequencies of radio-relay systems for telephony using frequency-division multiplex* , Vol. IX, Rec. 380, Note 7, Dubrovnik, 1986.

[8] CCITT Recommendation *Readjustment to the nominal value of an international group, supergroup, etc., link* , Vol. IV, Rec. M.530.

4.3 Hypothetical reference circuits

Recommendation G.431

HYPOTHETICAL REFERENCE CIRCUITS FOR FREQUENCY-DIVISION MULTIPLEX RADIO-RELAY SYSTEMS

(modified at Geneva, 1964)

1 Hypothetical reference circuit for radio-relay systems providing 12 to 60 telephone channels

The hypothetical reference circuit defined in CCIR Recommendation 391 [1], for frequency-division multiplex radio-relay systems with a capacity of 12 to 60 telephone channels per radio channel, has a length of 2500 km.

This circuit has for each direction of transmission:

— three pairs of channel modulators,

— six pairs of group modulators,

— six pairs of supergroup modulators,

it being understood that a ''pair of modulators'' comprises a modulator and a demodulator (see Figure 1/G.431).

Figure 1/G.431, p.

This circuit also has six sets of radio modulators and demodulators, for each direction of transmission, so that they divide the circuit into six homogeneous sections of equal length (see Recommendation G.322).

2 Hypothetical reference circuit for radio-relay systems providing more than 60 telephone channels

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

The hypothetical reference circuit defined in CCIR Recommendation 392 [2], for frequency-division multiplex radio-relay systems with a capacity of more than 60 telephone channels per radio channel, has a length of 2500 km.

This circuit has for each direction of transmission:

— three pairs of channel modulators,

— six pairs of group modulators,

— nine pairs of supergroup modulators,

it being understood that a ‘‘pair of modulators’’ comprises a modulator and a demodulator (see Figure 2/G.431).

Figure 2/G.431, p.

This circuit also has nine sets of radio modulators and demodulators for each direction of transmission so that they divide the circuit into nine homogeneous sections of equal length (see Recommendation G.322).

References

[1] CCIR Recommendation *Hypothetical reference circuit for radio-relay systems for telephony using frequency-division multiplex with a capacity of 12 to 60 telephone channels* , Vol. IX, Rec. 391, Dubrovnik, 1986.

[2] CCIR Recommendation *Hypothetical reference circuit for radio-relay systems for telephony using frequency-division multiplex with a capacity of more than 60 telephone channels* , Vol. IX, Rec. 392, Dubrovnik, 1986.

Recommendation G.433

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

(Geneva, 1964)

(See CCIR Recommendation 396, Volume IX, Dubrovnik, 1986.)

Recommendation G.434

HYPOTHETICAL REFERENCE CIRCUIT FOR SYSTEMS USING ANALOGUE TRANSMISSION IN THE FIXED-SATELLITE SERVICE

(Geneva, 1964)

(See CCIR Recommendation 352, Volume IV, Dubrovnik, 1986.)

4.4 Circuit noise

Recommendation G.441

PERMISSIBLE CIRCUIT NOISE ON FREQUENCY-DIVISION

MULTIPLEX RADIO-RELAY SYSTEMS

1 Design objectives for noise on hypothetical reference circuits

In CCIR Recommendation 393 [1] it is recommended:

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

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

For carrier transmission systems with one minute mean noise power distributions which are not well defined, the inclusion of another one minute mean noise clause would be desirable to ensure equivalent performance for all systems. This clause would specify that: The mean psophometric noise power over one minute shall not exceed 20 | 00 pW0p for more than 3% of any month. This clause has not been specifically included because CCIR has determined that for radio-relay links the application of clauses 1.2.1 and 1.2.2 are sufficient to ensure, with high probability, that the additional clause will also be satisfied.

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

1.2 47 | 00 pW0p, psophometrically weighted, one-minute mean power, for more than 0.1% of any month;

1.3 1 | 00 | 00 pW0, unweighted (with an integrating time of 5 ms), for more than 0.01% of any month.’’

Adding these values to the 2500 pW0p of psophometric power allowed for multiplexing equipment (Recommendation G.222, § 3) gives the recommended objectives shown in Recommendation G.222, § 1.1 for the telephone transmission and signalling aspect. CCIR Recommendation 393 [1] gives the conditions for applying these objectives to radio-relay systems; these conditions are in general the same as those given in Recommendation G.222, § 2 and in Recommendation G.223.

The CCIR has not yet recommended any noise objectives in connection with voice-frequency telegraph transmission. CCITT Recommendation G.442 covers this aspect.

This Recommendation relates only to ‘‘line-of-sight’’ radio-relay systems. Trans-horizon radio-relay systems are dealt with in Recommendation 397 [2].

2 Noise on real circuits

(See CCIR Recommendation G.395 [3].)

References

[1] CCIR Recommendation *Allowable noise power in the hypothetical reference circuit for radio-relay systems for telephony using frequency division multiplex* , Vol. IX, Rec. 393, Dubrovnik, 1986.

[2] CCIR Recommendation *Allowable noise power in the hypothetical reference circuit of transhorizon radio-relay systems for telephony using frequency division multiplex* , Vol. IX, Rec. 397, Dubrovnik, 1986.

[3] CCIR Recommendation *Noise in the radio portion of circuits to be established over real radio-relay links for FDM telephony* , Vol. IX, Rec. 395, Dubrovnik, 1986.

Recommendation G.442

RADIO-RELAY SYSTEM DESIGN OBJECTIVES FOR NOISE AT THE FAR END OF A HYPOTHETICAL REFERENCE CIRCUIT WITH

REFERENCE TO TELEGRAPHY TRANSMISSION

(modified at Geneva, 1964)

As is shown in Recommendation G.222, if the intention is to use on radio links, amplitude-modulated voice-frequency telegraph equipment for 50 bauds conforming to Series R Recommendations, then in order to obtain telegraph connections with the quality indicated in Recommendation F.10 [1], the design of these radio links should include the objectives recommended for telephone transmission and signalling and, in addition, should include the objectives set out below:

On any telephone channel constituted in accordance with the hypothetical reference circuit for the type of radio link considered, the unweighted noise power, measured or calculated with a time-constant (integrating time) of 5 ms and referred to a zero relative level point, should not exceed 10^{6} pW0 during more than 10^{D}lF261^{5} (i.e. 0.001%) of any month, nor more than 0.1% of any hour.

Provided that short bursts of high-level noise due to causes other than propagation have been reduced to negligible proportions, and assuming that the fine structure of the noise is the same as white noise, it is assumed that, in designing line-of-sight radio links, the objective during any month is in practice equivalent to the following objective:

The unweighted noise power on a telephone channel at a zero relative point, calculated from measurements made with an integrating time of 1 second, should not exceed 2×10^{5} pW0 for more than 10^{D}lF261^{4} (i.e. for more than 0.01%) of any month.

With regard to the objective to be met during any hour, it may happen that on certain radio links unforeseen exceptional propagation conditions may result in this objective not being met during certain most unfavourable hours. These hours, called ‘‘hours of interrupted telegraph traffic’’, will be those during which a noise level of 10^{6} pW0 is exceeded for more than 36 seconds.

Every effort should be made to reduce the number of such hours to a very small fraction of the total time. Since it follows from the recommended objective for telephone signalling that the 5 ms unweighted noise power should not exceed 10^{6} pW0 during more than 10^{D}lF261^{4} (i.e. 0.01%) of any month, there should never be more than seven ‘‘hours of interrupted telegraph traffic’’ during a month.

It may then be expected that the telegraph service will be satisfactory. Nevertheless, to achieve this object, it may be necessary in certain cases to select the channels allocated to amplitude-modulated voice-frequency telegraphy for 50 bauds from among those which are the least sensitive to propagation noise.

Note 1 — Use of a measuring instrument having a 5-ms time constant (integrating time) is recommended so as to detect, in particular, the presence of short high-level noise bursts, such as those caused by power supplies and by the equipment. Administrations should take all possible practical steps to eliminate such noise.

It is expected that on the majority of line-of-sight radio links (if not on all) it will be possible to reduce short noise bursts to negligible proportions, and that for the majority of radio links, any remaining short high-level noise bursts will be due to propagation. Noise surges having a mean power in excess of about 10^{5} pW0 will then last from 1 to 10 seconds

and will have an approximately constant level during this period. Under these conditions, for propagation measurements and preliminary design measurements for radio links, instruments having a time constant (integrating time) of 1 second could be used.

Note 2 — The fraction 10^{D}lF261^{5} of a month, for a 2500-km circuit, leads to impracticably small fractions of the time for shorter circuits (for example, 10^{D}lF261^{6} for a 250-km circuit). It is for this reason that the practical objective refers to a greater fraction of the time (10^{D}lF261^{4} for 2500 km), together with a reduced power (2×10^{5} pW0), the latter measured with a time constant (integrating time) of 1 second.

Reference

[1] CCITT Recommendation *Character error rate objective for telegraph communication using 5-unit start-stop equipment* , Vol. II, Rec. F.10.

Recommendation G.444

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

USING FREQUENCY-DIVISION MULTIPLEX

(Geneva, 1964)

(See CCIR Recommendation 397, Volume IX, Dubrovnik, 1986.)

Recommendation G.445

ALLOWABLE NOISE POWER IN THE HYPOTHETICAL REFERENCE CIRCUIT FOR FREQUENCY-DIVISION | fR MULTIPLEX TELEPHONY

IN THE FIXED-SATELLITE SERVICE

(Geneva, 1964)

(See CCIR Recommendation 353, Volume IV, Dubrovnik, 1986.)

4.5 Radiotelephone circuits

Recommendation G.451

USE OF RADIO LINKS IN INTERNATIONAL TELEPHONE CIRCUITS

The CCITT,

considering

(a) that, at the present time, radiotelephone systems connecting the various countries often employ carrier-frequencies below about 30 MHz ;

Recommendation G.443 has been deleted, as has CCIR Recommendation 394.
CCIR Recomendation 335 [1].
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:

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

2) 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;

3) 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;

4) 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;

5) it is necessary to take measures to avoid or correct conditions of abnormal oscillation or cross-talk;

6) 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;

7) 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:

i) 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;

ii) 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 CCIR Recommendation 455 [2];

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 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 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 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 concerned should study the best solution from the point of view of both technique and economy.

References

[1] CCIR Recommendation *Use of radio links in international telephone circuits* , Vol. III, Rec. 335, Dubrovnik, 1986.

[2] CCIR Recommendation *Improved transmission system for HF radiotelephone circuits* , Vol. III, Rec. 455, Dubrovnik, 1986.

Recommendation G.453

IMPROVED TRANSMISSION SYSTEM FOR HF RADIO-TELEPHONE CIRCUITS

(See CCIR Recommendation 455 and Report 354 entitled ''Improved transmission systems for use over HF radiotelephone circuits''; Volume III, Dubrovnik, 1986.)

4.6 Devices associated with radiotelephone circuits

Recommendation G.464

PRINCIPLES OF THE DEVICES USED TO ACHIEVE PRIVACY

Recommendation G.452 has been deleted.
Recommendations G.461, G.642 and G.463 have been deleted.

IN RADIOTELEPHONE CONVERSATIONS

(See CCIR Recommendation 336, Volume III, Dubrovnik, 1986.)

4.7 Links with mobile stations

Recommendation G.471

CONDITIONS NECESSARY FOR INTERCONNECTION | fR OF MOBILE RADIOTELEPHONE

STATIONS AND INTERNATIONAL TELEPHONE LINES

(See CCIR Recommendation 77-3, Volume VIII, ITU, Geneva, 1978.)

Recommendation G.473

INTERCONNECTION OF A MARITIME MOBILE SATELLITE SYSTEM WITH THE INTERNATIONAL AUTOMATIC SWITCHED TELEPHONE SERVICE;

TRANSMISSION ASPECTS

(Geneva, 1980)

1 Purpose

In an international connection which includes a maritime mobile station, the maritime satellite system may be regarded from a transmission viewpoint as analogous to a national network, and the ship terminals as somewhat analogous to subscriber terminals within that network.

When a mobile station in a maritime satellite service is connected to a subscriber in the international automatic switched telephone network, the connection should, as far as possible, provide to each party a transmission quality which is not inferior to that recommended for an international connection between two terrestrial telephone subscribers (e.g. Rec. G.111 [1]).

The purpose of this Recommendation is to specify various transmission characteristics of the maritime satellite system which will ensure compliance with the above objective.

Should the recommended characteristics not be obtained, the transmission quality offered may not be in keeping with the importance, value and cost of the service.

2 Definitions (See Figure 1/G.473)

The following terms are necessary when describing the transmission performance of the maritime mobile satellite system. (Space-division switching of analogue signals is assumed at the maritime centre and at the maritime terminal. However, digital switching and transmission could in due time replace their analogue counterparts. This replacement would logically be reflected in the text of

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Note by the Secretariat — The XVth CCIR Plenary Assembly (Geneva, 1982) has deleted Recommendation 77-3.
Recommendation G.472 has been deleted.

this document where the word analogue is presently being used.)

2.1 **maritime mobile satellite system (maritime system)**

F: syst`eme mobile maritime à satellites (syst`eme maritime)

S: sistema m´ovil mar´itimo por sat´elite (sistema mar´itimo)

All of a temporary connection between a telephone at a *maritime terminal* , and the 4-wire virtual analogue switching points of an international switching centre. It comprises a *maritime terrestrial circuit* , a *maritime satellite circuit* and a *maritime local system*

2.2 **maritime terrestrial circuit**

F: circuit terrestre due syst`eme maritime

S: circuito mar´itimo terrenal

A 4-wire circuit in a wholly-terrestrial transmission medium, between a 4-wire switch at an international exchange and an analogue 4-wire interface at a *maritime centre* . In some situations it may traverse a national boundary so that for the purpose of this Recommendation it is not regarded as a national circuit.

2.3 **maritime satellite circuit**

F: circuit maritime par satellite

S: circuito mar´itimo por sat´elite

A 4-wire circuit between an analogue interface at a maritime centre, via a satellite repeater to a 4-wire or 2-wire analogue interface (which may be a switching device) at a *maritime terminal* .

2.4 **maritime local system**

F: syst`eme local maritime

S: sistema mar´itimo local

All equipment between the 4-wire or 2-wire interface (which may be a switching device) at a maritime terminal, and a 2-wire or a 4-wire telephone within the boundary of that terminal. It may include a 4-wire or 2-wire switching device using analogue switching.

2.5 **maritime centre** (shore station)

F: centre maritime | station terrienne c | ti`ere)

S: centro mar´itimo | estaci´on terrena costera)

A satellite earth station which provides a 4-wire analogue interface for connection to a maritime terrestrial circuit.

Note — For some nontransmission functions, a maritime centre may be classified as a CT. For the purpose of this Recommendation, a maritime centre is not regarded as a CT, but is an intermediate point in a maritime system.

2.6 **maritime terminal**

F: terminal maritime

S: terminal mar´itimo

A terminal station (in a maritime mobile satellite system) which provides a 4-wire analogue interface for connection to a maritime local system.

This term used for the purpose of this Recommendation is defined as *coast-earth-station* in the Radio Regulations (Article 1, No. 71) [18]).

This term used for the purpose of this Recommendation is defined as *ship-earth-station* in the Radio Regulations (Article 1, No. 73) [19]).

Figure 1/G.473, p.

3 Connections to the terrestrial network

Figure 2/G.473 shows how a telephone connection may be established between a maritime terminal MT1 or MT2 and a terrestrial subscriber on local exchange LE1 in Country No. 1 or a subscriber on local exchange LE2 in Country No. 2.

A connection from MT1 to LE2 for example, might be routed via MC1, the international chain, and the national chain of Country No. 2, or via MC2 and the national chain of Country No. 2. Other possible connections involving MT1, MT2, LE1 and LE2 may be inferred from the figure.

The essential point to note is that a connection involving an MT and an LE can incur a limiting international chain; therefore the transmission performance of the maritime system must be no worse than the limiting performance of a national system, if the transmission quality of connections between a maritime terminal and a terrestrial subscriber is not to be inferior to that recommended between two terrestrial subscribers in an international connection.

Figure 2/G.473, p.

4 The maritime satellite system

4.1 *Corrected reference equivalents*

Since the reference equivalents of any individual maritime system ought to be under the full control of the designer, without undue economic penalty, the long-term objectives of Recommendation G.121 [2] should apply.

Therefore the planning values of the corrected reference equivalents of a maritime system should lie within the following ranges:

Sending: 11.5 to 13 dB.

Receiving: 2.5 to 4.0 dB.

These values are referred to the virtual analogue switching points of the international circuits to which the maritime system can be directly connected. (See Figures 1/G.473 and 2/G.473, for a graphical description of the extent of the maritime system. See also Figure 3/G.473.)

4.2 *Loss of path a-b*

The loss between the points a and b (Figure 1/G.473) shall be not less than 12 dB over the bandwidth 0 to 4 kHz for all three types of maritime local system, and for all circuit-states during the setting-up, occupation, and clearing down of the maritime system. Any echo-control device should be rendered inoperative when checking compliance with this clause. This requirement also serves to control listener-echo effects on full-duplex data transmission when echo suppressors are disabled.

5 The maritime local system

5.1 *Corrected reference equivalents*

5.1.1 The reference equivalents of the maritime local system depend on the type of switching at the maritime terminal and the type of telephone. They are referred to the switch, and should lie within the ranges given in Table 1/G.473.

Table 1/G.473 T1.473, p.

5.1.2 In Type B and Type C local systems, the sidetone reference equivalent of the shipboard installation should exceed 17 dB when the 4-wire paths are properly terminated and no go-to-return path is present. Achievement of this objective may require particular attention to the impedances involved, e.g. the balance network in the telephone instrument.

The same objective also stands for a Type A local system, but is likely to be more readily achieved.

5.2 *Go-to-return cross talk* | Type A local system only)

When an echo suppressor is not fitted in a Type A installation, the linear go-to-return crosstalk ratio, measured at any frequency in the range 300 to 3400 Hz from the shipboard 4-wire switchpoints towards an off-hook telephone, should exceed 55 dB. The measurement includes the effects of electrical crosstalk attenuation (e.g between cable pairs) and the acoustic path between the earpiece and mouthpiece of the telephone handset.

When an echo suppressor is fitted in a Type A installation, the go-to-return crosstalk ratio of the local system may be less than the requirement of Recommendation G.131 [3] (43 dB), depending on the requirements of nontelephony services.

6 The maritime satellite circuit and the maritime terrestrial circuit (Figure 1/G.473)

6.1 *Scope*

The requirements of § 6 apply to the overall 4-wire path between the international virtual analogue switching points with the switchpoints at the maritime terminal. It is for the agencies jointly concerned in the connection of the maritime satellite system to the international telephone network to assign the allowable impairments to the circuit sections involved.

6.2 *Transmission loss*

The planning values of transmission loss in each direction are given in Table 2/G.473.

Table 2/G.473 T2.473, p.

If any signal-dependent services (e.g. compandors) are included in the maritime satellite circuit, the 800-Hz test tone used for measuring the loss should be set at the unaffected level (see [4]) of those devices. (This level is normally 0 dBm0, but other levels may be encountered in some designs of equipment.)

See Figure 3/G.473 for a graphical description of these losses and the associated relative levels.

6.3 *Effectively-transmitted bandwidth*

The preferred nominal frequency band is 300 to 3400 Hz, so as to ensure satisfactory speech quality on international connections. However, it is recognized that economic and/or technical considerations may favour a reduced nominal bandwidth; if so, the latter should be not less than 300 to 3000 Hz.

Figure 3/G.473, p.

6.4 *Attenuation distortion*

The loss, relative to the loss at 800 Hz, should lie within the limits given in Table 3/G.473 when the nominal bandwidth is 300 to 3400 Hz. When the nominal bandwidth is 300 to 3000 Hz, the bracketed values supersede the corresponding upper limits, but the remaining values still apply.

Table 3/G.473 T3.473, p.

6.5 *Crosstalk*

The requirements of the Recommendation cited in [5] apply.

6.6 *Noise*

As the circuit may contain speech-dependent devices (e.g. compandors) the customary specification of idle-circuit noise is inadequate. Therefore, the near-term objective is given by the solid lines in Figure 4/G.473, which relate subjectively equivalent speech signal-to-noise ratio (dB) [6] to mean speech power level (dBm0, time average while active).

The long-term objective is given by the dashed lines shown in Figure 4/G.473, expressing the performance likewise in terms of equivalent signal-to-noise ratio. It is recognized that it might be difficult, with the maritime mobile satellite facilities of today, to comply with the long-term objective. When practicable, however, it is expected that the system in the future will comply with this objective.

6.7 *Echo control*

The echo loss a-t-b shall conform to the Recommendations cited in [7] and [8] i.e. not less than 56 dB. An echo control device is always required at the terrestrial end.

When a 2-wire telephone is used at the maritime terminal, an echo control device is also required at the maritime terminal.

When a 4-wire telephone is used at the maritime terminal, the echo loss may be sufficient without the use of an echo control device. If it is not sufficient, an echo control device is recommended at the maritime terminal.

The echo control device should comply with the appropriate clauses of Rec. G.161 [9], G.164 [10] and G.165 [11].

6.8 *Group-delay distortion*

No recommendation is made concerning group-delay distortion when the maritime system is used in the automatic switched international telephone service [6].

When a maritime system is connected at a terminal international centre to an international line (Recommendation M.1010 [12]) to form part of a special-quality international leased circuit, the group-delay distortion of the overall circuit must comply with the requirements of the Recommendation cited in [13].

Figure 4/G.473, p.

7 Application of this Recommendation

Supplement No. 23 provides explanatory notes for the information of designers of maritime satellite systems, and illustrates various practical realizations of systems which will comply with this Recommendation.

References

[1] CCITT Recommendation *Corrected reference equivalents (CREs) in an international connection* , Red Book, Vol. III, Rec. G.111.

[2] CCITT Recommendation *Corrected reference equivalents (CREs) of national systems* , Red Book, Vol. III, Rec. G.121.

[3] CCITT Recommendation *Stability and echo* , Vol. III, Rec. G.131.

[4] CCITT Recommendation *Characteristics of compandors for telephony* , Vol. III, Rec. G.162, § 1.

[5] CCITT Recommendation *General performance objectives applicable to all modern international circuits and national extension circuits* , Vol. III, Rec. G.151, §§ 4.1 and 4.2.3.

[6] CCITT manual *Transmission planning of switching telephone networks* , Chapter III, Annex 4, ITU, Geneva, 1976.

[7] CCITT Recommendation *Echo-suppressors suitable for circuits having either short or long propagation times* , Orange Book, Vol. III-1, Rec. G.161, B, ITU, Geneva, 1977.

[8] CCITT Recommendation *Influence of national networks on stability and echo losses in national systems* , Vol. III, Rec. G.122, § 1.

[9] CCITT Recommendation *Echo-suppressors suitable for circuits having either short or long propagation times* , Orange Book, Vol. III-1, Rec. G.161, ITU, Geneva, 1977.

[10] CCITT Recommendation *Echo suppressors* , Vol. III, Rec. G.164.

[11] CCITT Recommendation *Echo cancellers* , Vol. III, Rec. G.165.

[12] CCITT Recommendation *Constitution and nomenclature of international leased circuits* , Vol. IV, Rec. M.1010.

[13] CCITT Recommendation *Characteristics of special quality international leased circuits* , Vol. IV, Rec. M.1020, § 2.3.

[14] CCITT Recommendation *Corrected reference equivalents (CREs) in an international connection* , Red Book, Vol. III, Rec. G.111, § 1.1.

[15] CCITT Recommendation *The international routing plan* , Vol. VI, Rec. Q.13.

[16] CCITT Recommendation *The transmission plan* , Vol. III, Rec. G.101.

[17] CCITT Recommendation *Transmission losses, relative levels and attenuation distortion* , Orange Book, Vol. III-1, Rec. G.141, § A.a), ITU, Geneva, 1977.

[18] *Radio Regulations* , Article 1, No. 71, ITU, Geneva, 1980.

[19] *Ibid.* , No. 73.

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