5i’

Recommendation G.322

GENERAL CHARACTERISTICS RECOMMENDED FOR SYSTEMS ON SYMMETRIC PAIR CABLES

This Recommendation applies to systems using types of cable so far recommended by the CCITT (see Recommendation G.611) and providing 1, 2, 3, 4 or 5 groups or 2 supergroups.

1 General recommendations

1.1 *Hypothetical reference circuits*

1.1.1 The hypothetical reference circuit on symmetric pairs is 2500 km long, and is set up on a symmetric pair carrier system. For each direction of transmission, it has a total of:

Where systems provide 1, 2, 3 or 4 groups, it is possible to have a smaller number of modulations, but this does not detract from the usefulness of the idea of a hypothetical reference circuit on symmetric pairs.

— three pairs of channel modulators and demodulators,

— six pairs of group modulators and demodulators,

— six pairs of supergroup modulators and demodulators

Figure 1/G.322 shows a diagram of the hypothetical reference circuit on symmetric pairs. It will be seen that there is a total of 15 modulations and 15 demodulations for each direction of transmission supposing that each modulation or demodulation is effected by a single stage

Figure 1/G.322, p.

This hypothetical reference circuit consists of 6 homogeneous sections of equal length (see Recommendation G.212).

The number of pairs in the cable is assumed to be the same in all sections.

The hypothetical reference circuit on symmetric pairs thus defined is used for systems providing 1, 2, 3, 4 or 5 groups.

1.1.2 The composition of the hypothetical reference circuit for a 10-group (2-supergroup) carrier system should be the same as that of the hypothetical reference circuit for a 16-supergroup coaxial cable system (see [1]).

1.2 *Design objectives for circuit noise*

The objectives mentioned in Recommendation G.222 are applicable to hypothetical reference circuits in the circumstances indicated in Recommendation G.223.

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

The subdivision of the total noise between:

— basic noise,

— intermodulation noise,

— noise due to crosstalk,

is left entirely to the designer of the system, within the limits of 2500 pW0p for the terminal equipment and 7500 pW0p for the line.

Note — In planning a carrier system on symmetric pairs, calculation of the noise due to crosstalk could be carried out by the methods described in [2], [3] and [4].

1.3 *Line-frequency spectrum*

1.3.1 *Systems providing 1, 2 or 3 groups*

The line-frequency spectrum should be in accordance with the scheme shown in Figure 2 | fIa) /G.322.

1.3.2 *Systems providing 4 groups*

The frequency spectrum transmitted to line should be in accordance with Scheme 1 of Figure 2 | fIb) /G.322.

Note — By agreement between the Administrations concerned, it is possible to omit one group of supergroup 1* shown in Scheme 2 of Figure 2 | fIc) /G.322, for systems with five groups; if this is done, Scheme 1 | fIbis of Figure 2 | fIb) /G.322, is obtained.

1.3.3 *Systems providing 5 groups*

The frequency spectrum transmitted to line should be in accordance with Scheme 2 of Figure 2 | fIc) /G.322.

Note 1 — Where there is direct interconnection between a system with 5 groups on symmetric pairs and systems with a smaller number of groups, by agreement between the Administrations concerned, the system with 5 groups, shown in Scheme 2 | fIbis of Figure 2 | fIc) /G.322, may be used.

Note 2 — By agreement between the Administrations concerned, the arrangement in Figure 3/G.322 can be used for a supergroup on a coaxial cable system which is to be interconnected at basic supergroup frequencies (312-552 kHz) with either a 5-group system on symmetric pairs using Scheme 2 | fIbis [Figure 2 | fIc) /G.322], or with a 4-group system using Scheme 1 [Figure 2 | fIb) /G.322].

Supplement No. 8 [5] shows a simple way of assembling basic groups B into a supergroup in accordance with one of the schemes shown in Figure 3/G.322 and in Figure 1/G.338 [6] and vice versa.

1.3.4 *Systems providing 2 supergroups*

The frequency spectrum transmitted to line should be in accordance with either Scheme 3 or Scheme 4 of Figure 4/G.322, whichever the Administration decides.

Supergroups 1 and 2 are the same as those in coaxial cable carrier systems. Supergroup 1* is the same as that normally recommended for 5-group systems on symmetric cable pairs.

Note — By agreement between the Administrations concerned, for five group systems on symmetric cable pairs, instead of supergroup 1*, supergroup 1*‘ may be used [Scheme 2 | fIbis , Figure 2 | fIc) /G.322], which gives the arrangement shown in Scheme 3 | fIbis of Figure 4/G.322.

1.4 *Line-regulating pilots*

1.4.1 *Systems providing 1, 2, 3, 4 or 5 groups*

Either of the following methods can be used (see Figure 5/G.322).

Either of these methods can be chosen by the Administrations concerned and can be used without difficulty, provided the pilots are efficiently suppressed at the end of a regulated-line section.

Figure 2/G.322, p.

Figure 3/G.322, p.

Figure 4/G.322, p.

Figure 5/G.322, p.

Method A

1) A pilot at 60 kHz with a power level of —15 dBm0, this frequency being in the gap between groups A and B and it being understood that this pilot would be used for regulation of the line on all regulated-line sections, whatever their length, and also for synchronization or checking of frequencies.

2) Where necessary, and especially for long regulated-line sections, an additional line-regulating pilot 4 kHz above the maximum frequency transmitted to line and with a power level of —15 dBm0.

Note — There are in existence systems with five groups in which this pilot is only 1 kHz above the maximum frequency transmitted.

The recommendation under § 2) above does not apply to systems with a single group.

The recommended accuracy for these pilot frequencies is:

± | Hz for the 60-kHz pilot;

± | Hz for auxiliary pilot located 4 kHz above the maximum frequency of the channel group concerned.

Method B

Two pilots situated in the basic group B at 64 kHz and at 104 kHz transmitted with a power level of —17 dBm0.

On the high-frequency line, it is possible to have two pilots per 48 kHz of transmitted band and, from amongst these pilots, 16 kHz and the maximum transmitted frequency less 4 kHz are selected.

For systems having two or more groups, a third line-pilot is used, located between the top and bottom pilots, 64 kHz is the frequency used in 2-group systems, and 112 kHz in 5-group systems.

Note — Method B is hardly compatible with the use of a supergroup pilot and/or the alternative group pilot 104.08 kHz (Table 4/G.232 and Recommendation G.233, § 9).

1.4.2 *System providing 2 supergroups*

The following frequencies and levels are recommended (as shown in Method A of § 1.4.1 above):

— lower pilot: 60 kHz power level of —15 dBm0;

— upper pilot: 4 kHz above the highest transmitted frequency, i.e. at 556 kHz, power level of —15 dBm0.

The recommended accuracy for the frequencies of these pilots is as follows:

± | Hz for the 60-kHz pilot;

± | Hz for the 556-kHz pilot.

Note — If a supergroup is through-connected from a coaxial-pair system to occupy the position of the upper supergroup in the band of line frequencies, there can be a residue from a line-regulating pilot or additional measuring frequency. The recommendations for the through-supergroup equipment (Recommendation G.243) ensure that this residue will be sufficiently attenuated to cause no interference with the line-regulating pilots or additional measuring frequencies of another coaxial-pair system when these are sent at a power level of —10 dBm0. So that there will be no interference with the 120-circuit system line-regulating pilot sent at —15 dBm0, this system should incorporate its own additional protection of 5 dB at 556 kHz for a through-connected supergroup.

1.5 *Matching of repeater and line impedances*

It is desirable to limit the return-current coefficient at the ends of an elementary cable section so that the effect of the reflected near-end crosstalk does not contribute excessively to the total far-end crosstalk.

For example, in a cable which has a near-end crosstalk ratio of 56.5 dB and which meets the limit for far-end crosstalk ratio (direct far-end crosstalk) of at least 69.5 dB (the cable being between impedances equal

to its characteristic impedance), the contribution of the reflected near-end crosstalk would be insignificant compared with the effect of the far-end crosstalk at the maximum frequency transmitted, if the return current coefficients between repeaters and line have the following values.

The modulus of the return-current coefficient between the input (or output) impedance of the repeater (in its normal operating condition and including line transformers and equalizers) measured between the line terminals at the frequency f, and the nominal value of the impedance at the frequency f of the cable pair connected to the input (or output) of the repeater, should not exceed the value given by the formulae:

$0.15 \sqrt{\frac{f}{f_{max.}}}$ or 0.25 for systems with 1, 2 and 3 groups;

$0.08 \sqrt{\frac{f}{f_{max.}}}$ or 0.10 for systems with 4 and 5 groups or systems with 2 supergroups on paper-insulated cables (types II and III in Recommendation G.611);

$0.10 \sqrt{\frac{f}{f_{max}}}$ or 0.17 for systems with 5 groups or systems with 2 supergrops on polythene or styroflex-insulated cables (types II | fIbis and III | fIbis in Recommendation G.611).

Note — The values of the return-current coefficient recommended for systems with 1, 2 or 3 groups would in general be unsatisfactory if they were tolerated on all the sections of a line link; but they have been accepted as limits for a frontier section because, first, an international circuit will usually comprise only one such frontier interconnection and, second, the matching conditions at such a point may be complicated by the fact that one of the repeaters of this section may not have been specified for the exact type of cable to which it is connected.

2 **Special recommendations** (formerly Part B)

2.1 *Systems to be used simultaneously with valve-type systems in the same cables*

In those exceptional cases when some pairs in an elementary cable section are already equipped with valve-type systems and it is desired to equip the free pairs with new transistor systems without changing the existing installations, the new system using transistors must meet the recommendations in § 1 above and also the provisions of Recommendation G.324 [7] relating to valve-type systems. However, it may depart from those Recommendations specifying permissible values for amplifier harmonic margin and overload point [8].

Note — Recommendation G.323 gives an example of a 60-channel high-gain transistor system.

2.2 *Low-gain systems*

2.2.1 *Relative level at the output of the repeaters*

The relative level per channel, at any frequency, at the output of each repeater shall be:

—11 dBr for systems with 1, 2 or 3 groups;

—14 dBr for systems with 4 or 5 groups or 2 supergroups.

2.2.2 *Monitoring frequencies*

If a monitoring (or fault-locating) frequency is sent over a normally operating system, it may for example be in the band 560-600 kHz for a 2-supergroup system.

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

2.2.3 *Harmonic distortion*

The harmonic distortion of a repeater should not exceed a value corresponding to the limits shown in the Table 1/G.322.

Table 1/G.322 T1.322, p.

2.2.4 *Noise factor*

The noise factor of a complete repeater (taking into account noise due to the transistors, the input network and the line-matching network) must not exceed 10 dB.

2.2.5 *Overload point*

The overload point, defined in § 6.1 of Recommendation G.223, must be at least 14 dBm for the intermediate repeaters.

Note — For determination of this overload point, account has been taken of a margin of a few decibels for level variations due to geographical differences with respect to the theoretical site of a repeater, to temperature variations of the cable, to equalization inaccuracies, etc. In stations where this margin is unnecessary, a repeater overload point that is slightly lower may therefore be chosen.

2.2.6 *Crosstalk ratio between repeaters in the same station*

A typical figure for the crosstalk ratio between repeaters in the same station is 87 dB. With this figure it is possible to use repeater stations regardless of the cable-balancing method adopted.

Note — If, however, the cable is balanced by elementary sections in the conventional way, a figure of 80 dB is adequate.

The figures given above apply to all the equipment at the repeater station, from the input transformer to the output transformer.

2.2.7 *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.

References

[1] CCITT Recommendation *4-MHz valve-type systems on standardized 2.6/9.5-mm coaxial cable pairs* , Orange Book, Vol. III-1, Rec. G.338, c), ITU, Geneva, 1977.

[2] *Method of use by the French Administration of the hypothetical reference circuit for carrier systems on symmetric pairs* , CCITT Blue Book, Vol. III, Part 4, Annex 14, ITU, Geneva, 1965.

[3] *Contribution by the Federal German Administration to the study of noise on carrier systems worked over symmetric pairs* , CCITT Blue Book, Vol. III, Part 4, Annex 15, ITU, Geneva, 1965.

[4] *Calculation of crosstalk noise on symmetric pair systems* , CCITT Blue Book, Vol. III, Part 4, Annex 16, ITU, Geneva, 1965.

[5] *Method proposed by the Belgian Telephone Administration for interconnection between coaxial and symmetric pair systems* , Green Book, Vol. III-2, Supplement No. 8, ITU, Geneva, 1973.

[6] CCITT Recommendation *4-MHz valve-type systems on standardized 2.6/9.5-mm coaxial cable pairs* , Orange Book, Vol. III-1, Rec. G.338, Figure 1/G.338, ITU, Geneva, 1977.

[7] CCITT Recommendation *General characteristics for valve-type systems on symmetric cable pairs* , Orange Book, Vol. III-1, Rec. G.324, ITU, Geneva, 1977.

[8] *Ibid.* , B.c) and B.d).

[9] CCITT Definition: *n* , Vol. X (Terms and Definitions).

Recommendation G.323

A TYPICAL TRANSISTORIZED SYSTEM ON SYMMETRIC CABLE PAIRS

This Recommendation defines a typical 60-channel system installed on symmetric pairs in cable (differing for the two directions of transmission) which comply with Recommendation G.611 and equipped with transistorized high gain amplifiers. This system should meet the requirements of Recommendation G.322. It must not be considered as recommended by CCITT in preference to other systems which would also meet the requirements of Recommendation G.322. It has been specified because it can be used simultaneously with 60-channel valve-type systems in the same cables.

The main features are given below:

1 Frequencies transmitted to line: 12-252 kHz

2 Transmission levels

— without pre-emphasis —5 dBr — with pre-emphasis at 12 kHz, —11 dBr at 252 kHz, —1 dBr

3 Line-pilot frequencies

— for amplification regulation independent of frequency 248 kHz — for linear regulation with frequency 16 kHz — for supplementary regulation (curvilinear) 112 kHz

4 Repeater station amplification

(with average regulator positions of the automatic amplification regulation) 50 ± | dB

5 Limits of the automatic amplification regulation

a) in unattended repeater stations with gain depending on the soil temperature at 12 kHz, ± | .1 dB at 252 kHz, ± | .1 dB b) in pilot-regulated stations: — for amplification regulation independent of frequency 248 kHz, | ± | dB — for linear regulation with frequency 16 kHz, ± | .5 dB — for supplementary regulation (curvilinear) 112 kHz, | ± | dB

6 Absolute thermal noise level at the repeater input in the 248-252 kHz spectrum —132 dBm

7 Nonlinearity attenuation of the repeaters for a fundamental wave power level of 0 dBm at the output

— for the second harmonic higher than 87 dB — for the third harmonic higher than 109 dB

8 Reflection coefficient modulus at the repeater input and output in relation to the characteristic impedance of the cable less than the lower of the two values:

$0.1\sqrt{\frac{f}{f_{max.}}}$ or 0.2

9 Absolute overload point of the amplifiers higher than 23 dBm

10 Signal-to-crosstalk ratio between the two transmission directions in the station with 52 dB gain at 252 kHz

— for 100% combinations greater than 87 dB

— for 75% combinations greater than 95 dB

11 Power feeding

Up to 12 unattended repeater stations are placed between the attended repeater stations. Direct current power is fed to six stations on each side of the attended repeater station by an earth-wire system, the repeaters of a system on the power-feed section being inserted in series in a power circuit.

If the induced outside voltages are more than 75 volts, the supply can be 2-wire without earth return and the number of unattended repeater stations on the section between the two attended repeater stations should not exceed six. The maximum power-feed is 500 volts.

As far as the effect of induced voltages, raising of the earth potential in the neighbourhood of electric installations, and surges due to lightning is concerned, see K-series Recommendations.

12 Remote control of repeaters

In this system the efficiency of the repeater is checked from the amplification and nonlinearity attenuation in the frequency combination of $2f_1 - f_2$.

Recommendation G.324

GENERAL CHARACTERISTICS FOR VALVE-TYPE SYSTEMS ON SYMMETRIC CABLE PAIRS

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

of the *Orange Book* , Geneva, 1976.)

Recommendation G.325

GENERAL CHARACTERISTICS RECOMMENDED FOR SYSTEMS PROVIDING 12 TELEPHONE CARRIER CIRCUITS ON A SYMMETRIC CABLE PAIR [(12 + 12) SYSTEMS]

Systems of the (12 + 12) type on symmetric pair in cable are used for carrier working either on old deloaded cables or on cables specially constructed for the purpose (without a second cable being required). These systems may be used in regional or local relations, or in long-distance relations, trunk or international.

This Recommendation applies to systems for long-distance relations making use of the kinds of cable at present recommended by the CCITT (see Recommendation G.611) and to multiple-twin quad cables with conductors of 0.9 mm diameter, with an effective capacitance of 35 to 40 nF/km or other kinds of deloaded cables of equivalent quality. For systems used for local or regional relations, some clauses of the present Recommendation may be made less stringent.

1 Frequency spectrum transmitted to line

The CCITT recommends that the line-frequency spectrum should be in accordance with Scheme 1 or 2 of Figure 1/G.325.

Figure 1/G.325, p.

Administrations concerned in setting up such an international system should agree to use either one or the other of the two schemes.

2 Line-regulating pilots

The following frequencies are recommended:

— with Scheme 1: 60 kHz and 72 kHz;

— with Scheme 2: 54 kHz and 60 kHz.

The recommended accuracy is ± | Hz for the 60-kHz pilot. The frequency tolerance for other pilots will be decided by agreement between the Administrations concerned.

All these pilots should be transmitted at power level of —15 dBm0.

3 Hypothetical reference circuit for (12 + 12) symmetric-pair system

This is 2500 kilometres long, and for each direction of transmission comprises a total of:

— three channel translation pairs;

— nine special translation pairs translating a basic group into the band transmitted to line, and vice versa.

This circuit is carried on a (12 + 12) symmetric-pair system in cable, with pairs assumed to be of conductors of 0.9-mm diameter, with an effective capacitance of 35 to 40 nF/km.

Figure 2/G.325 shows one of the three identical parts of which this hypothetical reference circuit is made up. All in all, it has 18 homogeneous sections, each 140 kilometres long.

Figure 2/G.325, p.

Note 1 — There are only half as many translation pairs as there are homogeneous sections, because one of the two bands transmitted to line corresponds to a basic group (see Figure 2/G.325).

Note 2 — With systems using frequency-frogging in the repeaters, the appropriate modulators form part of the high-frequency line.

4 Design objectives for circuit noise

The objectives set forth in Recommendation G.222 apply to the hypothetical reference circuit for symmetric-pair (12 + 12) systems, in the circumstances described in Recommendation G.223.

In practice, it will suffice to check by calculation that the mean psophometric power at the end of every telephone channel as defined by the hypothetical reference circuit, at zero relative level, does not exceed 10 | 00 pW0p during any hour.

Provisonally, it is recommended that this overall limit be apportioned between the total noise components as follows:

— line noise (including noise due to special translation equipment) 9000 pW0p — noise due to channel translating equipment 1000 pW0p

Apportionment of total noise inherent in the system among:

— basic noise,

— intermodulation noise,

— noise due to crosstalk,

is left entirely to the discretion of the carrier system designer, up to 1000 pW0p for channel translating equipment and 9000 pW0p for the line.

Note — In accordance with all recommendations on cable systems in the Series G Recommendations, the design objective as regards noise power does not take into consideration noise from external sources; it is assumed that this is negligible compared with the figure of 10 | 00 pW0p.

With regard to real circuits, Administrations must take whatever steps are required in each individual case to ensure that clicks arising on audio-frequency pairs in the same cable as a (12 + 12) system and transmitted by crosstalk do not create excessive noise on the circuits of that system which may be used for international communications.

5 Error on the reconstituted frequency

The difference between a frequency sent at the origin of a homogeneous section 140 km long (see § 3 above and Figure 2/G.325) and the frequency received at the end of that section, should not exceed a figure provisionally fixed at 0.3 Hz; this figure is the same whether there is frequency-frogging in the intermediate repeaters or not.

6 Direct line interconnection

When Administrations desire the direct line interconnection of two systems (with, of course, the same allocation of line-transmitted frequencies) it is recommended that each of these systems should meet the following requirements on the interconnection section (except where agreed otherwise between the Administrations concerned):

These values apply to low-gain systems. They are not valid for high-gain systems, i.e. for systems whose gain is substantially above 30 dB.

1) Relative level per channel, at all frequencies, at the output of the frontier repeaters: —15 dBr

2) Attenuation of the frontier elementary cable section at the highest frequency transmitted to line: 25 dB

Note — For composite cables, agreement should be reached between the two Administrations concerned to fix the attenuation of the frontier section in such a way that the repeaters of the symmetric pairs and those of the coaxial cables can be housed in the same frontier stations.

3) Matching of the impedances of the frontier repeaters and the line. The modulus of the return-current coefficient between the input (or output) impedance of a repeater and the characteristic impedance of the line should not exceed the lower of the two values:

$$0.15\sqrt{\frac{f}{f_{max}}} \quad \text{or } 0.25$$

7 Interconnection in a main station

If such interconnection is necessary, either for operating reasons or because the two systems to be interconnected use different allocations of frequencies transmitted to line, one of the following procedures may be followed:

1) interconnection at a group distribution frame, with use of the basic group, levels and impedance applied normally by the Administration to which the frame belongs;

2) direct interconnection between the two systems. If they use different allocations of frequencies transmitted to line, the two Administrations concerned shall reach agreement on which of them shall install the necessary demodulators (the line of separation between the two types of equipment will then be CC‘ or DD‘ on Figure 3/G.325).

Figure 3/G.325, p.

In the absence of such an agreement, each incoming system must comprise equipment required for the outgoing system, in each direction of transmission (the separating line in Figure 3/G.325 would then be the oblique DC‘).

Unless there is a specific agreement, the relative power level will be —36 dBr at sending (input of each system — points C‘ and D in the case of Figure 3/G.325). The points considered do not correspond to points *T* and *T* ‘ defined in Recommendation G.213. In particular, a translating equipment of any type cannot be connected to it without precautionary measures (see the levels indicated in the Table 1/G.233).

By agreement between Administrations, interconnection can be effected as indicated in Figure 4/G.325, a method whereby it is possible to replace three modulators by one.

Figure 4/G.325, p.

8 Essential clauses for a model specification

See Recommendation G.326.

Recommendation G.326

TYPICAL SYSTEMS ON SYMMETRIC CABLE PAIRS [(12 + 12) SYSTEMS]

This Recommendation defines typical systems using one symmetric cable pair for the two directions of transmission. These systems must meet the requirements set forth in Recommendation G.325. They have been defined for the benefit of Administrations which do not themselves study specifications for the supply of cables and equipment. They must not be considered as

recommended by the CCITT in preference to other systems which would also meet the requirements of Recommendation G.325. Administrations and manufacturers which contemplate designing such systems are asked to adhere, as far as possible, to the characteristics of one of the typical systems defined below.

The following abbreviations will be used:

— A: low-gain systems;

— B: high-gain systems without frequency-frogging;

— C: high-gain systems with frequency-frogging in each line repeater.

1 General characteristics

1.1 *Relative levels*

Crosstalk restricts the gain of low-gain systems to about 30 dB. Furthermore, the exact length of an elementary cable section is often determined with respect to a loading step. The result is a maximum attenuation of about 27 to 30 dB, for an elementary cable section and a repeater output level of —10 to —13 dBr, at least in the upper frequency band transmitted to line.

In high-gain systems, frequency-frogging is in general use, with or without pre-emphasis; in this case, the siting of the loading coils has no effect on the placing of repeaters. Typical values are: 56 to 60 dB, attenuation for an elementary cable section and either 0 dBr or +7 dBr as the repeater output level for systems without frequency-frogging, or with frequency-frogging but without pre-emphasis. Other values are applicable for systems with frequency-frogging and with pre-emphasis.

1.2 *Matching of repeater and line impedances*

The same values are applied in a normal section as those recommended for a frontier section in Recommendation G.325, § 6.

2 Characteristics of repeaters

2.1 *Nonlinear distortion*

The harmonic margin and intermodulation products are not less than the figures in Table 1/G.326.

Table 1/G.326 T1.326, p.

2.2 *Noise factor*

The noise factor of a complete repeater (including the equalizers or other passive networks, if any) should not exceed 10 dB at the highest frequencies transmitted.

Note — In low-gain systems, this figure is not critical and may be exceeded.

2.3 *Overload point*

See § 6 of Recommendation G.223.

2.4 *Crosstalk ratio repeaters in the same station*

The crosstalk ratio between repeaters in the same station should not be less than:

a) 82 dB in type A systems,

b) 80 dB in type B and C systems.

These values are valid for all the equipment at the repeater station, from the input transformer to the output transformer.

3 Types of cable used (formerly Part C)

(12 + 12) systems can be established:

1) on deloaded old cables, or

2) on new cables, comprising quads reserved for high-frequency operation.

The equipments defined in this Recommendation may be used on both types of cable, but when they are used on deloaded old cables there are other conditions which should be met, apart from those indicated in this Recommendation. In particular, if the disturbance caused by other pairs in the same cable is too great, the noise objectives in Recommendation G.325, § 4, cannot be achieved.

Reference

[1] CCITT Definition: *n* , Vol. X, (Terms and Definitions).

Recommendation G.327

VALVE-TYPE SYSTEMS OFFERING 12 CARRIER TELEPHONE CIRCUITS

ON A SYMMETRIC CABLE PAIR [(12 + 12) SYSTEMS]

(For the text of this Recommendation, see Vol. III of the Orange Book, Geneva, 1976.)

3.3 Carrier systems on 2.6/9.5 mm coaxial cable pairs

The Recommendations of this sub-section relate to systems established on 2.6/9.5 mm coaxial cable pairs in conformity with Recommendation G.623. The following Table gives a list of these systems with a summary of their characteristics.

H.T. [T1.327]

TABLE 1/G.327

Table 1/G.327 [T1.327] + REMARQUES, p.

Recommendation G.332

12 MHz SYSTEMS ON STANDARDIZED 2.6/9.5 mm COAXIAL CABLE PAIRS

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

This Recommendation defines a coaxial cable system providing 2700 telephony channels in the frequency band 0.3 MHz to about 12.4 MHz which, according to the provisions of Recommendation J.73 [1], can alternatively be used to provide 1200 telephone channels in the frequency band 0.3 MHz to about 5.6 MHz and one TV-channel in the band of about 6 MHz to 12.3 MHz for the transmission of a vestigial sideband television signal with an effectively transmitted video-frequency band up to 5.5 MHz. The repeaters should be spaced at about 4.5 km.

1 Arrangement of line frequencies for telephony

The arrangement of the line frequencies for telephony shall conform to Plans 1A, 1B or 2 described below. Plan 1A is to be preferred to Plan 1B. In international relations between countries using different modulation procedures (see Recommendation G.211) and in the absence of any special arrangement between the Administrations concerned including, if necessary, the Administrations of transit countries, Plans 1 are to be preferred to Plan 2.

1.1 *Frequency arrangement of Plan 1A*

Plan 1A uses the first modulation procedure described in Recommendation G.211.

The telephone channels should first be assembled into basic supermastergroups. Three supermastergroups are transmitted to line in accordance with the frequency arrangement of Figure 1/G.332.

In this figure the virtual carrier frequencies of the two lower supermastergroups are shown.

1.2 *Frequency arrangement of Plan 1B*

Frequencies below 4287 kHz

For frequencies below 4287 kHz, Plan 1B uses the second modulation procedure described in Recommendation G.211.

The telephone channels should first be assembled into supergroups. Fifteen supergroups are transmitted to line in accordance with the frequency arrangement of Figure 2/G.332 (frequencies below 4287 kHz). These fifteen supergroups comprise the basic 15-supergroup assembly (No. 1) described in Recommendation G.233; the carrier frequencies are shown in that Recommendation. Figure 3/G.332 gives further details of the frequency arrangement below 4287 kHz.

Frequencies above 4287 kHz

For frequencies above 4287 kHz, Plan 1B uses the first modulation procedure described in Recommendation G.211.

For frequencies above 4287 kHz, the frequency arrangement of Figure 2/G.332 is identical with that of Figure 1/G.332.

Figure 1/G.332, p.

Figure 2/G.332, p.

Figure 3/G.332, p.

1.3 *Frequency arrangement of Plan 2*

This plan uses the second modulation procedure described in Recommendation G.211.

The telephone channels should be assembled into basic (No. 1) 15-supergroup assemblies. Three 15-supergroup assemblies are transmitted to line in accordance with the frequency arrangement shown in Figure 4/G.332. In this figure, the virtual carrier frequencies of 15-supergroup assemblies Nos. 2 and 3 are shown.

2 Pilots and additional measuring frequencies

2.1 *Line-regulating pilots*

The CCITT recommends that 12 | 35 kHz be used for the main line-regulating pilot.

In any regulated-line section crossing a frontier, it is recommended that in both directions of transmission the Administration on the sending side should permanently transmit one or two auxiliary line-regulating pilots at 308 and/or 4287 kHz, at the choice and request of the Administration on the receiving side so as to provide for additional regulation, for example.

The frequency accuracy recommended for the pilots is ± | × 10^{D}lF261^{5}.

The power level of the main and auxiliary line-regulating pilots should be adjusted at the point of injection to have a value of —10 dBm0. The harmonics of the 308 and 4287 kHz pilot should each have a level not higher than —70 dBm0.

Equipment should be designed in such a way that these pilots may be blocked at the end of a regulated-line section, so that their level shall be at least 40 dB below that of the pilots used on other sections.

Figure 4/G.332, p.

The following tolerances for the level of these pilots are recommended:

1) The design of equipment should be such as to allow the error in the level of any pilot as transmitted, due to finite level adjustment steps, to be kept within ± | .1 dB.

2) The change in output level of the pilot generator with time (which is a factor included in equipment specifications) must not exceed ± | .3 dB during the interval between two maintenance adjustments, e.g. in one month.

3) To reduce pilot level variations with time, it is advisable to have a device to give an alarm when the variation at the generator output exceeds ± | .5 dB, the zero of the warning device being aligned as accurately as possible with the lining-up level of the transmitted pilot.

The attention of Administrations is drawn to the difficulty which could result from an appreciable reduction in the absolute power level of the pilot sent to line; such a reduction is liable to cause ‘‘near singing’’, resulting from the operation of the automatic gain-control amplifiers. It would be desirable to make arrangements for overcoming this difficulty if it should arise.

Note — When pre-emphasis and de-emphasis is applied on the line link, it is necessary to define the line pilot level with reference to a point, possibly hypothetical, at the input to or output from the line, at which the relative levels of all telephone channels are equal over the whole of the line-frequency band. When a part of the line-frequency band is to be used to provide a television channel, different pre-emphasis and de-emphasis networks may be required but this will not affect the definition of line pilot levels. Figures 5/G.332 and 6/G.332 show two hypothetical arrangements for the purpose of this definition.

2.2 *Frequency comparison pilots*

Administrations wishing to make an international frequency comparison shall choose the frequency 300, 808 or 1552 kHz for this purpose, when it is impossible to use 308 or 1800 kHz. International comparison of national standards is relatively rare. During a specified period of time, it will always be possible to use for such comparisons one of the frequencies mentioned above, even though it may normally be used as an additional measuring frequency.

Figure 5/G.332, p.

Figure 6/G.332, p.

A frequency of 300 kHz can be used for national comparisons when Administrations do not wish to use the 308 kHz pilot for this purpose. In this case, it is recommended that the 300 kHz be transmitted at a power level 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*

If the frequency allocation without mastergroups is used at frequencies below 4 MHz (Figures 3/G.332 and 4/G.332), the following frequencies *may* be used for additional measuring frequencies:

560, 808, 1056, 1304, 1552, 1800, 2048, 2296,

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

Any Administration using 12-MHz working on a line crossing a frontier should, at the request of any other Administration concerned, transmit or measure the measuring frequencies appearing in the following preferred list:

560, 808, 1304, 1800, 2296, 2792 and 3536 kHz.

Administrations should likewise transmit or measure, at the request of corresponding Administrations, any measuring frequency which may be used in other circumstances, namely:

— at frequencies below 4 MHz, if frequency allocation with mastergroups indicated in Plan 1A (Figure 1/G.332) is used:

560, 808, 1304, 1592 and 2912 kHz;

— at frequencies above 4 MHz, if Plan 1A (Figure 1/G.332) or 1B (Figure 2/G.332) is used:

5608, 6928, 8248

, 8472, 9792 and 11 | 12 kHz.

A frequency of 8248 kHz can be used as a radio-relay link line-regulating pilot. In such a case, the precautions shown in Recommendation G.423 should be applied.

Plan 2 (Figure 4/G.332) is used under the conditions described in Recommendation G.211 for the application of the second modulation process, the additional frequencies above 4 MHz are:

5392, 7128, 8248, 8472, 8864, 9608 and 11 | 44 kHz.

All these frequencies are recapitulated in Table 1/G.332.

Table 1/G.332 T1.332, p.

The absolute frequency variation of additional measuring frequencies below 4 MHz should never be outside limits of ± | 0 Hz from their nominal value. For frequencies above 4 MHz, the relative frequency variation referred to the nominal value should never exceed ± | $\times 10^{D}$lF261^{5}.

The power level of the additional measuring frequencies should be adjusted at the point of injection to have a value of —10 dBm0. The harmonics of additional measuring frequencies below 6 MHz should each have a level at this point not higher than —70 dBm0.

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

Arrangements should be made in equipment for the 12-MHz system, so that the 308-kHz line-regulating pilot is protected from disturbances from a pilot or additional measuring frequency of the same frequency coming from a 4-MHz system when this protection is not already provided by the equipment of the 4-MHz system.

Note — Some Administrations use new manual or automatic methods of equalizing attenuation distortion, e.g. equalizers based on the Cosine function, using frequencies which do not appear in the list of additional measuring frequencies recommended by the CCITT.

Obviously, no additional measuring frequency which might leave the national network should be sent at the same frequency as one of the pilots recommended by the CCITT.

3 Hypothetical reference circuit

This hypothetical reference circuit is 2500 km long and is divided into nine sections of 280 km each. The three line frequency arrangement plans recommended in § 1 require modulation stages of different number to carry a voice signal in the line frequency position. This is bound to affect the constitution of the hypothetical reference circuit. In these circumstances, the CCITT recommends the hypothetical reference circuits represented in Figures 7/G.332 and 8/G.332.

The Note of § 2.1 still applies.

3.1 *Hypothetical reference circuit for the Plans 1A and 1B frequency allocations*

This is shown in Figure 7/G.332. It has, for each direction of transmission, a total of:

— two 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;

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

— seven pairs of mastergroup modulators, each pair including translation from the basic mastergroup to the basic supermastergroup 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 7/G.332, p.

3.2 *Hypothetical reference circuit for the Plan 2 frequency allocation*

This is shown in Figure 8/G.332. It has, for each direction of transmission, a total of:

— two 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 the basic 15-supergroup assembly and vice versa;

— nine pairs of 15-supergroup modulators, each pair including translation from the basic 15-supergroup assembly to the frequency band transmitted on the coaxial cable and vice versa.

In the case of plan 1B, this hypothetical reference circuit is not valid for the frequency band 312-4028 kHz.

Figure 8/G.332, p.

4 Design objectives for circuit noise

The objectives given in Recommendation G.222 are applicable to the hypothetical reference circuit for 12-MHz systems on coaxial cable, in the circumstances indicated in Recommendation G.223.

In practice, it is sufficient to check for each telephone channel as defined by the hypothetical reference circuit, that 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.

The subdivision of the total noise between basic noise and intermodulation noise is left entirely to the designer of the system, within the limits of 2500 pW0p for the terminal equipment and 7500 pW0p for the line.

5 Matching of the impedance of a coaxial pair and the impedances of the repeaters

Z_L is the characteristic impedance of the line (for any frequency *f* effectively transmitted), this impedance being the ordinate for the frequency *f* of a smooth curve, agreed by the Administrations concerned as being representative of the average impedance/frequency characteristic of the type of coaxial cable concerned;

Z_R is the worst value of the input impedance (for the frequency *f*) of the equipment of a repeater station, as seen from the line (see Figure 9/G.332);

Z_E is the worst value of the output impedance (for the frequency *f*) of the equipment of a repeater station, as seen from the line;

A = al the total image attenuation (at the frequency *f*) of the line between two adjacent repeater stations, a being the average attenuation of the coaxial cable per unit length and *l* the average length between two adjacent repeater stations.

Figure 9/G.332, p.

Then the factor *N* is defined by the formula:

$$N = 2A + 20 \log_{10} \left| \frac{Z_E(f) + Z_L(f)}{Z_E(f) - Z_L(f)} \right| + 20 \log_{10} \left| \frac{Z_L(f) + Z_R(f)}{Z_L(f) - Z_R(f)} \right| \quad \text{(dB)}$$

The present Recommendation refers only to 12-MHz systems on 2.6/9.5-mm coaxial pairs having repeaters with a nominal spacing of about 4.5 km.

The sum *N* of the three terms defined above must in this case be equal to at least 48 dB at 300 kHz and to at least 55 dB at all frequencies above 800 kHz. Between 300 and 800 kHz the permissible limit in decibels varies linearly with the frequency.

Note — The CCITT has defined the permissible limits for N, as a sum of the three terms (see the above formula). It is recommended that Administrations concerned with a coaxial cable section crossing a frontier should agree on permissible values in this particular case for each of these three terms to meet the above condition, that is to say, agree on the use of as good a match as possible or of a methodical mismatch at the ends of the repeater section.

6 Relative levels and interconnection in a frontier section

6.1 *Interconnection in a frontier section*

In an elementary cable section which crosses a frontier, the relative level at the input of the cable section (output of the repeater equipment) should be equal to —13 dBr at 12 | 35 kHz.

Note 1 — This recommendation is based on the assumption that the attenuation in the frontier section is approximately 37 to 38 dB. This should be taken into consideration in determining the actual length of the frontier section.

Note 2 — When the pre-emphasis curves of the two systems are different, Recommendation G.352 should be applied.

6.2 *Relative levels in any elementary cable section*

It has not been possible to standardize a single value.

6.3 *Pre-emphasis*

From the information supplied by various Administrations, the pre-emphasis generally lies between 9 and 12 dB.

7 Power-feeding and alarm systems

7.1 *Power feeding across a frontier*

7.2 *Power-feeding systems*

The text of Recommendation G.341, §§ 7.1 and 7.2, applicable to all 1.2/4.4-mm pair systems, still applies for 12-MHz transistor systems on 2.6/9.5-mm pairs.

7.3 *Supervision and alarms in a frontier section* (see Annex A)

8 Use of 12 MHz systems for television transmission

8.1 *General*

This § summarizes all the additional conditions recommended for the transmission of television on a 12 MHz system. The characteristics of the television signal are discussed in Recommendation J.73 [1].

8.2 *Circuit noise*

When a 12 MHZ system is used for a television transmission on the basis of a hypothetical reference circuit 2500 km in length, the mean value of the thermal line noise should not exceed 1 pW0p/km. Experience has shown that a mean value of 1.5 pW0p/km for the total line noise is sufficient when the noise is measured in normal telephony conditions.

8.3 *Matching of repeater and line impedance*

For the transmission of a television programme, it is recommended that number *N* defined in § 5 of the present Recommendation should be at least 70 dB in the band occupied by the television signal.

8.4 *Arrangement of frequencies transmitted in line*

The 12 MHz system provides a television channel and 1200 telephone channels. Figure 10/G.332 shows the frequency arrangement recommended for television transmission. The television channel is capable of transmitting the signals of all television systems defined by the CCIR with a video bandwidth not exceeding 5.5 MHz.

Figure 10/G.332, p.

ANNEX A

(to Recommendation G.332)

Frequencies used for supervision or fault location

The frequencies or frequency bands used in various countries for supervising or for locating faults are given in Table A-1/G.332 for information.

H.T. [T2.332]

TABLE A-1/G.332

Country	Band (kHz)
Belgium	{
280 and 12 | 00 and 170 to 210 for regulation	
}	
Japan	13 | 00 to 13 | 80
France	12 | 00 to 12 | 00
Netherlands	{
280 and 170 to 210 for regulation	
}	
F.R. of Germany	269 and (13 | 00 ± | 5)
United Kingdom	13 | 00 + 12,5
Sweden	12 | 00 to 13 | 00

Table A-1/G.332 [T2.332], p.

Note — A fault-tracing system was used by the Chile Telephone Company using direct currents transmitted over interstitial pairs of the cable, which obviates any risk of interference with the systems mentioned above.

Reference

[1] CCITT Recommendation *Use of a 12-MHz system for the simultaneous transmission of telephony and television* , Vol. III, Rec. J.73.

Recommendation G.333

60 MHz SYSTEMS ON STANDARDIZED 2.6/9.5 mm COAXIAL CABLE PAIRS

Introduction

This Recommendation defines a coaxial cable pair system providing 10 | 00 telephone channels in the frequency band of approximately 4 to 60 MHz. The system may be used for the transmission of six television signals without any telephone signal or for a mixed transmission of telephone and television signals. The nominal repeater spacing is approximately 1.5 km and can be obtained by dividing the repeater spacing of 12 MHz systems by three.

1 Line frequencies

The allocation of line frequencies for telephony should be in conformity with one of the two plans given below.

1.1 *Plan 1 — Line-frequency allocation and modulation stages for 60-MHz systems* (Figure 1/G.333)

Figure 1/G.333, p.

In this plan, the basic block for interconnection is the supermastergroup of 8516 to 12 | 88 kHz recommended by the CCITT in Recommendation G.211. It thus contains the three mastergroups constituting the basic supermastergroup, but the same frequency band could contain a 15-supergroup assembly (see Plan 2).

All modulation and demodulation between the basic supermastergroup and the line-frequency band is carried out in one modulation step. The carrier frequencies for this modulation are shown in Figure 1/G.333. They are all low multiples of 440 kHz, or multiples of 2200 kHz. These two fundamental frequencies are both closely related to frequencies normally used in the 12-MHz systems.

The extraction of blocks directly from the line-frequency band can be carried out individually for the four lowest supermastergroups. Higher supermastergroups can only be extracted in the form of an assembly of four supermastergroups. This method is chosen to save frequency bandwidth.

The two lowest supermastergroups are identical with supermastergroups Nos. 2 and 3 shown in Figure 1/G.332.

1.2 *Plan 2 — Line-frequency allocation and modulation stages for 60-MHz systems* (Figure 2/G.333)

Figure 2/G.333, p.

According to Plan 2, eleven assemblies of 15 supergroups are translated into the frequency band 8620 to 12 | 36 kHz which lies within the frequency band of the basic supermastergroup.

The 15-supergroup assemblies transmitted to line and numbered 3 to 13, are obtained in the same way as the corresponding supermastergroups of Plan 1 above. The assembly of 15 supergroups numbered 2 is obtained by modulation of a 15-supergroup assembly in the band 312-4028 kHz, the carrier frequency being 68 × 124 = 8432 kHz.

The facilities for extracting blocks directly from the basic-frequency band are identical to those of Plan 1.

The two lowest 15-supergroup assemblies are identical with the second and third 15-supergroup assemblies in Figure 4/G.332.

Note — It is understood that Plan 1 would be chosen in those countries whose national networks are based upon the use of basic mastergroup and supermastergroups, whereas Plan 2 could be adopted in those countries whose national networks are based on the use of supergroup assemblies only.

In international connections between countries using the same plan in their national networks, i.e. both using Plan 1 or both using Plan 2, the plan common to these two countries would naturally be used.

However, in international connections between countries which use different plans in their national networks and in the absence of any special agreement between the interested Administrations, including Administrations of transit countries, use of Plan 1 is recommended.

2 Pilots and additional measuring frequencies

2.1 *Line-regulating pilots*

The CCITT recommends that 61 | 60 kHz should 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 temperature correction of the cable attenuation.

In any regulated-line section crossing a frontier, it is recommended that in both directions of transmission the Administration on the transmitting side should permanently transmit so as to provide, for example, for additional regulation, one or more auxiliary line-regulating pilots chosen by the Administration on the receiving side from the following list:

4287 kHz, 12 | 35 kHz, 22 | 72 kHz and 40 | 20 kHz.

The power level of these pilots should be regulated, at the output of the transmit amplifier, to a nominal value of —10 dBm0. The harmonics of the 4287, 12 | 35, 22 | 72 kHz pilots should each have a level not higher than —70 dBm0.

The frequency stability recommended for pilots is better than ± | $\times$ 10^{D}lF261^{5}.

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

2.2 *Frequency comparison pilots*

Since international comparison of frequencies is rarely carried out, the CCITT recommends that Administrations choose one of the following two frequencies:

— 4200 kHz, which is a multiple of 300 kHz and a neighbouring value of 4400 kHz,

— 8316 kHz (27 $\times$ 308 kHz) which can easily be included in the free intervals of the two frequency arrangements proposed (Figures 1/G.333 and 2/G.333).

It is recommended that this pilot be transmitted at a power level 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 may be used as additional measuring frequencies are given in Table 1/G.333.

The power level of these additional measuring pilots should be adjusted at the output of the transmit amplifier, to obtain a nominal value of the line pilot of —10 dBm0. The harmonics of additional measuring frequencies below 30 MHz should each have a level at this point not higher than —70 dBm0.

The frequency stability recommended is better than ± | $\times$ 10^{D}lF261^{5}.

The additional measuring pilots should not be permanently transmitted. They will be transmitted only for as long as is necessary for actual measurement purposes. This does not apply when the frequency is used as a line pilot.

2.4 *Band reserved for monitoring and fault-tracing signals*

These signals should be below the 4200 kHz frequencies comparison pilot.

3 Hypothetical reference circuit

3.1 *General considerations*

The reference circuit has to reflect what is expected to be the practical application of the system. The spacing of main stations is the same as in earlier systems, e.g. the 12 MHz system. A length of 2500 km, divided into 9 sections each of 280 km with a total of 10 main stations, has therefore been adopted.

3.2 *Modulation*

With either of the line-frequency allocations recommended in § 1 above, five modulation stages are generally needed to place a particular channel in its position in the line-frequency band.

On the above basis, the hypothetical reference circuits shown in Figures 3/G.333 and 4/G.333 are recommended by the CCITT.

3.3 *Direct through-connection at line frequencies*

It was agreed that direct through-connection was envisaged not for points intermediate between the main stations as defined above, but rather at these stations themselves so that demodulation would be avoided. While this would be an advantage from the point of view of the amount of modulation equipment, it would involve more severe requirements on line equipment.

Table 1/G.333 T1.333, p.

Figure 3/G.333, p.

Figure 4/G.333, p.

It has, however, been found possible to use restricted through-connection at main repeater stations with equipment designed to meet the normal noise objectives defined in connection with a hypothetical reference circuit for the 60-MHz system on coaxial pairs (see Figure 3/G.333) without incurring a noise penalty.

The necessary restrictions are as follows:

1) The frequency band containing supermastergroups 6 to 9 inclusive may be directly through-connected over a total length which must not exceed 830 km, but the adjacent frequency bands in the sections concerned must be homogeneous sections which are not abnormally long.

2) It is in principle also possible to use direct through-connection for the frequency band containing supermastergroups 2-5 inclusive provided that the adjacent frequency bands containing supermastergroups 6-9 and 10-13 are transmitted on normal length homogeneous sections. In practice it may be necessary to restrict the through-connection to supermastergroups which have a sufficiently low impedance mismatch effect (§ 7) to permit the extension without excessive accumulation of attenuation roll effect.

4 Circuit noise

It is recommended that the system be designed on the basis of Recommendation G.222, i.e. in such a way as to obtain a mean psophometric power of about 3 pW per km of line, on the worst telephone channel having the same composition as the 2500-km hypothetical reference circuit.

5 Matching of repeater impedances and line impedance

A value of 65 dB is recommended for the magnitude *N* defined in Recommendation G.332, § 5.

6 Interconnection

Levels in a main station | see Recommendation G.213)

When one part of the frequency band is transmitted without demodulation, the same value of —33 dBr is recommended at the output of the direct through-connection filter.

The level at the repeater output on the highest channel should be —19 ± 1 dBr.

Note — Values for pre-emphasis ranging from 7 to 10 dB are commonly used.

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 used 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 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*

Although CCITT does not recommend the use of a specific remote power-feeding system for the 60-MHz coaxial line system, in practice only the constant current d.c. feeding via the inner conductors of the two coaxial pairs of a system is used.

The 60-MHz coaxial cable system may be subject to induced voltages and currents caused by lightning, power lines, railways, etc.

Precautions must be taken to protect the staff from any possible danger arising from the normal operating voltages and remote power-feed currents as well as from the induced voltages and currents.

Many national Administrations have issued detailed rules and regulations for the protection of persons. It is obligatory in most cases to meet these rules and regulations. In addition the CCITT Directives [2] give guidance on these problems.

Precautions are also needed for the protection of the equipment against induced voltages and currents. The equipment should therefore be designed in such a way that it passes the tests specified in Recommendation K.17 [3].

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.

8 Use of 60-MHz systems for television transmission

8.1 *General remarks*

In § 8 all additional requirements are summarized which are recommended in the case of television transmission on the 60-MHz system. The characteristics of the television signal in the first intermediate frequency allocation (transmit side conditions) are dealt with in Recommendation J.77 [4].

8.2 *Ciruit noise*

If the 60-MHz system is used for television transmission on the basis of a hypothetical reference circuit (HRC) of a length of 2500 km, the mean value of the thermal noise of the line should not exceed 1 pW0p/km. Experience has shown that a mean value of 1.5 pW0p/km total noise of the line is sufficient when measured according to normal telephone conditions. In making through-connections between homogeneous sections of an HRC, different transmission bands may be used. As different transmission bands give different distributions of basic noise and intermodulation noise, it seems justified to assign noise limits which are average values within the whole transmission band, i.e., among the five measuring channels recommended in Recommendation G.228.

8.3 *Matching of repeater impedances and line impedance*

For television programme transmission a value of at least 72 dB for the magnitude *N* , defined in Recommendation G.332, § 5, has been agreed to in the band occupied by television signals.

8.4 *Number, nature and position of line television channels*

Television signals may be transmitted without any other wanted signals or simultaneously with telephone channels. In the first case, there are six television channels. In the case of mixed transmission, the attention of Administrations is drawn to the fact that, if there are more than two television channels, harmful interference may occur between the two types of signal, especially interference to telephony from television. This clause is therefore limited to cases where the number of channels is less than or equal to two.

Whether or not the 60 MHz system is allocated wholly or partially to television, television channels are capable of transmitting the signals of all television systems defined by the CCIR having a video bandwidth not exceeding 6 MHz.

When a 60 MHz system is used entirely for television, it can provide six television channels, arranged in three pairs each of which extends over the bandwidth of four supermastergroups. The line-frequency allocation is shown in Figure 5/G.333.

When transmission is mixed, a distinction should be made according to whether the number of television channels is two or one.

If there are two, the use of channels 3 and 4 is recommended.

In the case of a single television channel, there are two possibilities:

— first alternative: channel 3 or channel 4, the choice being immaterial;

— second alternative: channel 1.

The first alternative has the advantage of low group delay distortion and is suitable for long links. The second allows the use of simple modulation equipment, if modulation method No. 2 is applied (see Note 1 below). On the other hand, it has the disadvantage of a higher group delay distortion, requiring the use of correctors whose complexity increases with the length of exceeds a certain limit.

Note 1 — Two recommended modulating methods are shown in Annex A.

Note 2 — A television channel-pair pilot can be provided at the mean of the carrier frequencies of each television channel pair, i.e. 12 | 60 kHz (4 × 3190 kHz), 31900 kHz (10 × 3190 kHz) and 51 | 40 kHz (16 × 3190 kHz). It is recommended that these pilots be transmitted at a power level of —10 dBm0. The harmonics of the pilot 12 | 60 kHz should have a level of not higher than —70 dBm0; the level of the harmonics of the other pilots should not exceed —50 dBm0.

Figure 5/G.333, p.

8.5 *Pilots and additional measuring frequencies*

Those pilots and additional measuring frequencies (mentioned in § 2), falling in gaps between TV channels, can be used.

ANNEX A
(to Recommendation G.333)

Modulation methods for television transmission | fR on the 60-MHz system

Two recommended modulating methods are shown in Figure A-1/G.333 and Figure A-2/G.333 respectively. The modulation methods are compatible with those of the 18-MHz system (see Annex A to Recommendation G.334).

Figure A-1/G.333, p.

Figure A-2/G.333, p.

References

[1] CCITT Recommendation *Routine maintenance measurements to be made on regulated line sections* , Vol. IV, Rec. M.500.

[2] CCITT manual *Directives concerning the protection of telecommunication lines against harmful effects from electricity lines* , ITU, Geneva, 1963, 1965, 1974 and 1978.

[3] CCITT Recommendation *Tests on power-fed repeaters using solid state devices in order to check the arrangements for protection from external interference* , Vol. IX, Rec. K.17.

[4] CCITT Recommendation *Characteristics of the television signals* transmitted over 18-MHz and 60-MHz systems , Vol. III, Rec. J.77.

Recommendation G.334

18 MHz SYSTEMS ON STANDARDIZED 2.6/9.5 mm COAXIAL CABLE PAIRS

(Geneva, 1980)

Introduction

Amplifier design technique has made it possible to provide a usable band of about 18 MHz while still keeping the repeater spacing of about 4.5 km as defined in Recommendation G.332; the CCITT has therefore defined an 18 MHz system which offers a transmitting capacity of 3600 telephone channels in the case of pure telephone application. Alternatively, the system may be used for the transmission of up to two TV channels or one TV signal plus 1800 telephone channels. Another possibility is that the bandwidth above 12 **|** 35 kHz could be used for the provision of an 8448 kbit/s digital path.

1 Arrangement of line frequencies for telephony

The arrangement of line frequencies most suitable for the network of a particular Administration depends to a high degree on the organization of this network with respect to the interconnection with and through connection to the other systems existing in this network. On the other hand, it is very desirable to limit the number of different frequency plans for the 18 MHz system.

The CCITT therefore recommends that in any case one of the following three plans should be applied. However, in international connections between countries which use different modulation procedures (see Recommendation G.211) and in the absence of any special arrangements between the interested Administrations including, if necessary, the Administrations of transit countries, Plan 1 is to be preferred.

1.1 *Frequency arrangement of Plan 1*

Plan 1 uses the first modulation procedure described in Recommendation G.211.

The telephone channels should first be assembled into basic supermastergroups. The four supermastergroups are transmitted to line in accordance with the frequency arrangement of Figure 1/G.334.

Note — The arrangement of the supermastergroups No. 1, 2 and 3 is the same as in Plan 1A of the 12-MHz system (Recommendation G.332) and supermastergroup No. 4 corresponds to its arrangement in Plan 1 of the 60-MHz system (Recommendation G.333).

1.2 *Frequency arrangement of Plan 2*

This Plan uses the second modulation procedure described in Recommendation G.211.

The telephone channels should first be assembled into basic (No. 1) 15-supergroup assemblies. Four 15-supergroup assemblies are transmitted to line in accordance with the frequency arrangement shown in Figure 2/G.334.

Note — The arrangement of the 15-supergroup assemblies Nos. 1, 2 and 3 is the same as in Plan 2 of the 12-MHz system (Recommendation G.332).

Figure 1/G.334, p.

Figure 2/G.334, p.

1.3 *Frequency arrangement of Plan 3*

This Plan uses the first modulation procedure described in Recommendation G.211, but adds a further intermediate frequency position.

The telephone channels should first be assembled into basic supermastergroups. The four supermastergroups are then translated into the position of the supermastergroups Nos. 6-9 as in Plan 1 of the 60-MHz system (Recommendation G.333).

By translating with an additional 40 | 80 kHz carrier frequency, these supermastergroups are transmitted to line in accordance with the frequency arrangement of Figure 3/G.334.

Note 1 — This arrangement is best suited to those networks which need frequent direct through-connections between the 18-MHz and 60-MHz systems. It therefore makes use of a wider frequency band for through-connection than the basic supermastergroup. The arrangement is also suitable for the interconnection of 18-MHz systems and for the interconnection between 18-MHz systems and 60-MHz systems via the basic supermastergroup 8516-12 | 88 kHz, because the relatively large frequency space between the supermastergroups permits the use of simpler through supermastergroup filters.

Note 2 — This arrangement can handle also 15-supergroup assemblies by bringing them first into the frequency band of the basic supermastergroup (15-supergroup assembly No. 3).

Figure 3/G.334, p.

2 Pilots and additional measuring frequencies

2.1 *Line-regulating pilots*

It is recommended that 18 | 80 kHz be used for the main line regulating pilot

In any regulated-line section crossing a frontier, it is recommended that in both directions of transmission the Administration on the sending side should, if requested, permanently transmit an auxiliary line-regulating pilot at 308 kHz to provide facilities for additional regulation, for example.

For Frequency Plans 1 and 2 as defined under § 1 above, 4287 kHz and/or 12 | 35 kHz may be used as additional auxiliary line-regulating pilots on request of the Administration on the receiving side.

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18 | 80 kHz is a multiple of 308 kHz (60 × 308) and of 440 kHz (42 × 440).

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

The power level of the main and auxiliary line-regulating pilots should be adjusted at the point of injection to have a value of —10 dBm0. The harmonics of the 308 kHz and 4287 kHz pilots should each have a level not greater than —70 dBm0.

Equipment should be designed in such a way that these pilots may be blocked at the end of a regulated-line section, so that their level shall be at least 40 dB below that of the pilots used on other sections.

The following tolerances for the level of these pilots are recommended:

2.1.1 The design of equipment should be such as to allow the error in the level of any pilot as transmitted, due to finite level adjustment steps, to be kept within ± | .1 dB.

2.1.2 The change in output level of the pilot generator with time (which is a factor included in equipment specifications) must not exceed ± 0.3 | B during the interval between two maintenance adjustments, e.g. in one month.

2.1.3 To reduce pilot level variations with time, it is advisable to have a device to give an alarm when the variation at the generator output exceeds ± | .5 dB, the zero of the warning device being aligned as accurately as possible with the lining-up level of the transmitted pilot.

2.2 *Frequency comparison pilots*

Administrations wishing to make an international frequency comparison shall choose the frequency 300, 308 or (for Plans 1 and 2 only) 4200 kHz for this purpose. International comparison of national standards is relatively rare. During a specified period of time, it will always be possible to use for such comparisons one of the frequencies mentioned above, even though it may normally be used for other purposes.

It is recommended that the frequency comparison pilot be transmitted at a power level 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 may be used as additional measuring frequencies are given in Table 1/G.334.

The absolute frequency variation of additional measuring frequencies below 4 MHz should never be outside limits of ± | 0 Hz from their nominal value. For frequencies above 4 MHz, the relative frequency variation referred to the nominal value should never exceed ± | $\times 10^{D}$lF261^{5}.

The power level of the additional measuring frequencies should be adjusted at the point of injection to have a value of —10 dBm0. The harmonics of the additional measure frequencies below 9 MHz should each have a level not higher than —70 dBm0 as transmitted to the line. The additional measuring frequencies should not be permanently transmitted. They will only be transmitted for as long as is necessary for actual measurement purposes.

Arrangements should be made in equipment for the 12-MHz system, so that the 308 kHz line-regulating pilot is protected from disturbances from a pilot or additional measuring frequency of the same frequency coming from a 4-MHz system when this protection is not already provided by the equipment of the 4-MHz system.

Note — Some Administrations use new manual or automatic methods of equalizing attenuation distortion, e.g. equalizers based on the Cosine function, using frequencies which do not appear in the list of additional measuring frequencies recommended by the CCITT.

Obviously no additional measuring frequency which might leave the national network should be sent at the same frequency as one of the pilots recommended by the CCITT.

H.T. [T1.334]
TABLE 1/G.334

Frequency plan 1 (kHz)	Frequency plan 2 (see Note 1) (kHz)	Frequency plan 2 (see Note 2) (kHz)	Frequency plan 3 (kHz)
	| 60		| 52
	| 08	1 | 56	
	1 | 04	1 | 52	
1 | 92	1 | 00	2 | 48	1 | 72
	2 | 96	2 | 44	
2 | 12	2 | 92	3 | 40	
		3 | 88	3 | 92
	3 | 36	3 | 84	4 | 58
5 | 08	5 | 92		6 | 72
6 | 28	7 | 28		7 | 92
8 | 48 (see Note 3)	8 | 48		
8 | 72	8 | 72		
	8 | 64		9 | 58
9 | 92	9 | 08		10 | 72
11 | 12	11 | 44		
	12 | 76	11 | 92	
12 | 78	13 | 52	13 | 58	
14 | 08	14 | 40	15 | 72	
15 | 28	16 | 76	16 | 92	

Note 1 — Additional measuring frequencies to be sent or measured on request.

Note 2 — Other additional measuring frequencies which can be sent.

Note 3 — A frequency of 8248 kHz can be used as a radio-relay link line-regulating pilot. In such a case, the precautions shown in Recommendation G.423 should be applied.

Table 1/G.334 [T1.334], p.

3 Hypothetical reference circuit

3.1 *General considerations*

The hypothetical reference circuit is 2500 km long and is divided into nine homogeneous sections of 280 km each.

3.2 *Modulation*

The three line-frequency allocations recommended in § 1 above need different numbers of modulating stages to bring an audio signal into the line-frequency position. This has to be reflected in the constitution of the hypothetical reference circuit.

On the above basis, the hypothetical reference circuits, as shown in Figure 4/G.334 and Figure 5/G.334, are recommended by the CCITT.

Figure 4/G.334, p.

Figure 5/G.334, p.

3.2.1 *Hypothetical reference circuit for the Plan 1 frequency allocation*

This is shown in Figure 4/G.334. It has, for each direction of transmission, a total of:

— two 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;

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

— seven pairs of mastergroup modulators, each pair including translation from basic mastergroup to the basic supermastergroup and vice versa;

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

3.2.2 *Hypothetical reference circuit for the Plan 2 frequency allocation*

This is shown in Figure 5/G.334. It has, for each direction of transmission, a total of:

— two 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 basic 15-supergroup assembly and vice versa;

— nine pairs of 15-supergroup assembly modulators, each pair including translation from the basic 15-supergroup assembly to the frequency band transmitted on the coaxial cable and vice versa.

3.2.3 *Hypothetical reference circuit for the Plan 3 frequency allocation*

This is shown in Figure 4/G.334. It differs from that for Plan 1 only by the fact that the supermastergroup modulators consist of two translating stages.

4 Circuit noise

In accordance with Recommendation G.222 the system is to be designed in such a way as to obtain a mean psophometric noise power of 3 pW0p per km of line or less as a design objective for the worst telephone channel in the 2500-km hypothetical reference circuit as defined under § 3 above.

5 Matching of repeater and line impedances

The present Recommendation refers only to 18-MHz systems on 2.6/9.5-mm coaxial pairs in which the nominal spacing between repeaters is approximately 4.5 km.

The sum *N* of the three terms defined as in G.332, § 5 must in this case be equal to at least 48 dB at 300 kHz and to at least 55 dB at all frequencies above 800 kHz. Between 300 and 800 kHz the permissible limit in decibels varies linearly with the frequency.

6 Relative levels

Levels in the main station (see Recommendation G.213).

When one part of the frequency band is transmitted without demodulation, the same value of —33 dBr is recommended at the output of the direct through-connection filter.

7 Power feeding

Recommendation G.341, §§ 7.1 and 7.2, applies.

8 Monitoring and fault tracing bands

Frequency bands for monitoring and fault tracing signals should be situated below 300 kHz and/or above 18 | 80 kHz, that is, leaving a clear band for traffic signals.

9 Use of 18-MHz systems for television transmission

9.1 *General remarks*

In § 9 all additional requirements are summarized which are recommended in the case of television transmission on the 18-MHz system. The characteristics of the television signal in the first intermediate frequency allocation (transmit side conditions) are dealt with in Recommendation J.77 [1].

9.2 *Circuit noise*

If the 18-MHz system is used for television transmission on the basis of a hypothetical reference circuit of a length of 2500 km, the mean value of the thermal noise of the line should not exceed 1 pW0p/km. Experience has shown that a mean value of 1.5 pW0p/km total noise of the line is sufficient when measured according to normal telephone conditions.

9.3 *Matching of repeater impedances and line impedance*

For television programme transmission a value of at least 70 dB for the magnitude *N* , defined in Recommendation G.332 § 5, is recommended in the band occupied by television signals.

9.4 *Line-frequency allocation of the television channels*

9.4.1 *TV transmission only*

The 18-MHz system can provide two television channels. The line-frequency allocation is shown in Figure 6/G.334. The television channels are capable of transmitting the signals of all television systems defined by the CCIR having a video bandwidth not exceeding 6 MHz.

Note 1 — Two recommended modulating methods are shown in Annex A.

Note 2 — A television channel-pair pilot can be provided at the mean of the two carrier frequencies, i.e. 9570 kHz (3 × 3190 kHz). It is recommended that this pilot be transmitted at a power level of —10 dBm0. The harmonics should have a level of not higher than —50 dBm0.

Figure 6/G.334, p.

9.4.2 *Mixed telephone-television transmission*

One television channel and a maximum of two 900-channel groups can be provided. Two line-frequency allocations are possible:

a) the upper television channel 2* of Figure 6/G.334;

b) the lowest television channel (TV channel No. 1) of the 60-MHz television line-frequency allocation of Figure 4/G.333.

Note 1 — The modulation methods for a) and b) conform to the first modulation steps of Figure A-1/G.334 and Figure A-2/G.334 respectively in Annex A.

9.5 *Pilots and additional measuring frequencies*

Pilots and additional measuring frequencies (mentioned in § 2), outside the television channels can be used.

ANNEX A
(to Recommendation G.334)

Modulation methods for television transmission on the 18-MHz system

Two recommended modulating methods are shown in Figure A-1/G.334 and Figure A-2/G.334 respectively. The modulation methods are compatible with those of the 60-MHz system (see Annex A to Recommendation G.333).

Figure A-1/G.334, p.

Figure A-2/G.334, p.

Reference

[1] CCITT Recommendation *Characteristics of the television signals transmitted over 18-MHz and 60-MHz systems* , Vol. III, Rec. J.77.

Recommendation G.337

GENERAL CHARACTERISTICS OF SYSTEMS ON | fR 2.6/9.5 mm COAXIAL CABLE PAIRS

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

of the *Orange Book* , Geneva, 1976)

Recommendation G.338

4 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)