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ITU-T G.322

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STANDARDIZATION SECTOR
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INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES

GENERAL CHARACTERISTICS RECOMMENDED FOR SYSTEMS ON SYMMETRIC PAIR CABLES

ITU-T Recommendation G.322

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.322 was published in Fascicle III.2 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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:

- three pairs of channel modulators and demodulators,
- six pairs of group modulators and demodulators,
- six pairs of supergroup modulators and demodulators[1)] .

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[1)].

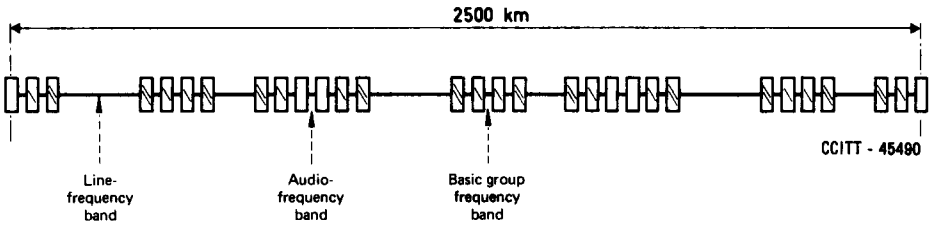

FIGURE 1/G.322

Diagram of the hypothetical reference circuit on symmetric cable pairs

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.

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1) 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.

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 10 000 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 *a)*/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 b) /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 *c)*/G.322, for systems with five groups; if this is done, Scheme 1 *bis* of Figure 2 *b)* /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 *c)*/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 *bis* of Figure 2 *c)*/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 *bis* [Figure 2 *c)*/G.322], or with a 4-group system using Scheme 1 [Figure 2 *b)*/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.

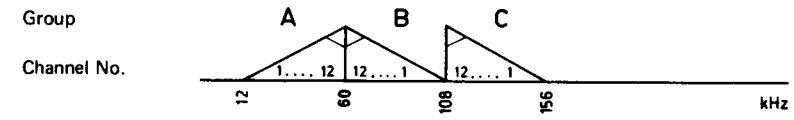
Note - By agreement between the Administrations concerned, for five group systems on symmetric cable pairs, instead of supergroup 1*, supergroup 1*' may be used [Scheme 2 *bis*, Figure 2 *c)*/G.322], which gives the arrangement shown in Scheme 3 *bis* of Figure 4/G.322.

1.4 *Line-regulating pilots*

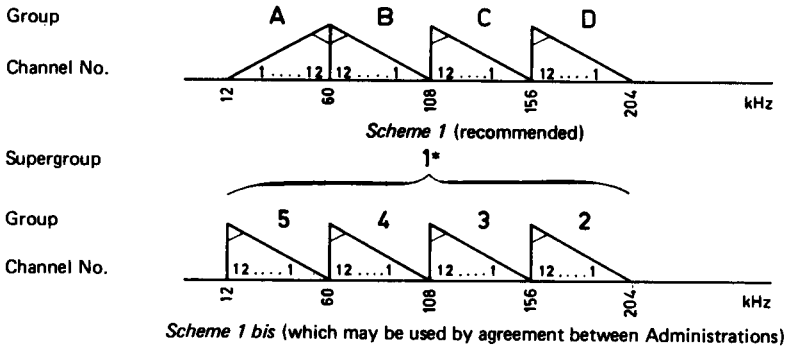
1.4.1 *Systems providing 1, 2, 3, 4 or 5 groups*

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

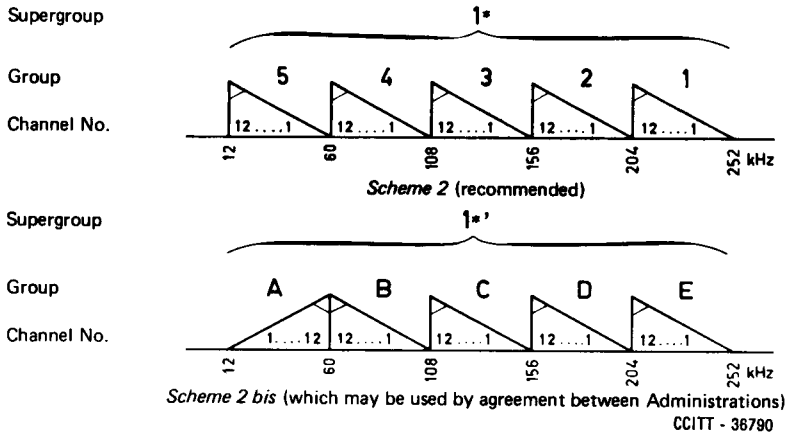
Either of these methods can be chosen by the Administrations concerned and can be used without difficulty, provided the pilots are efficiently suppressed at the end of a regulated-line section.



a) Systems providing one, two or three groups



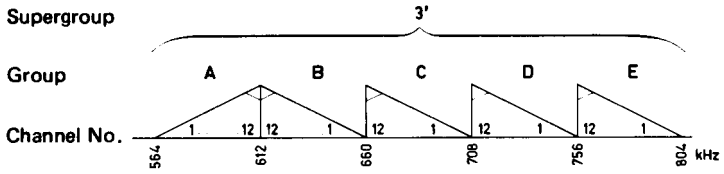
b) Systems providing four groups



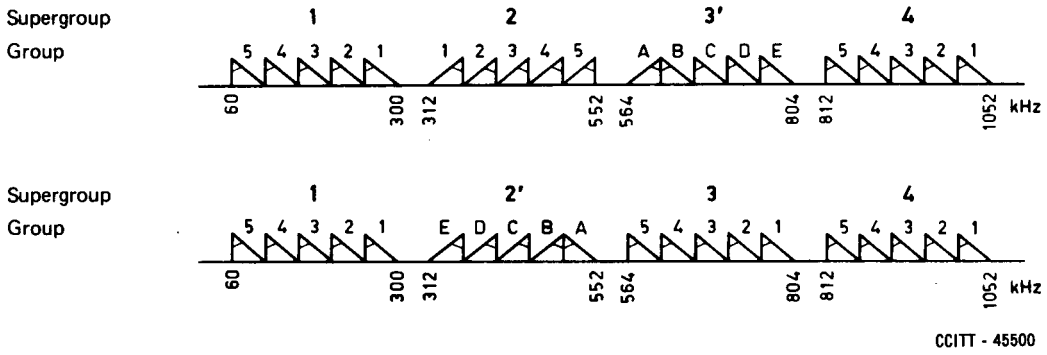
c) Systems providing five groups

FIGURE 2/G.322

Line-frequency allocation for international carrier systems on symmetric cable pairs



a) Arrangement of groups and channels (supergroup 3' has been shown as an example)



b) Example of possible positions, in the coaxial line-frequency band of the supergroup corresponding to Scheme 2 bis of Figure 2c)/G.322

FIGURE 3/G.322

Arrangement of groups in a supergroup, which may be used in coaxial carrier systems interconnected with systems on symmetric pairs

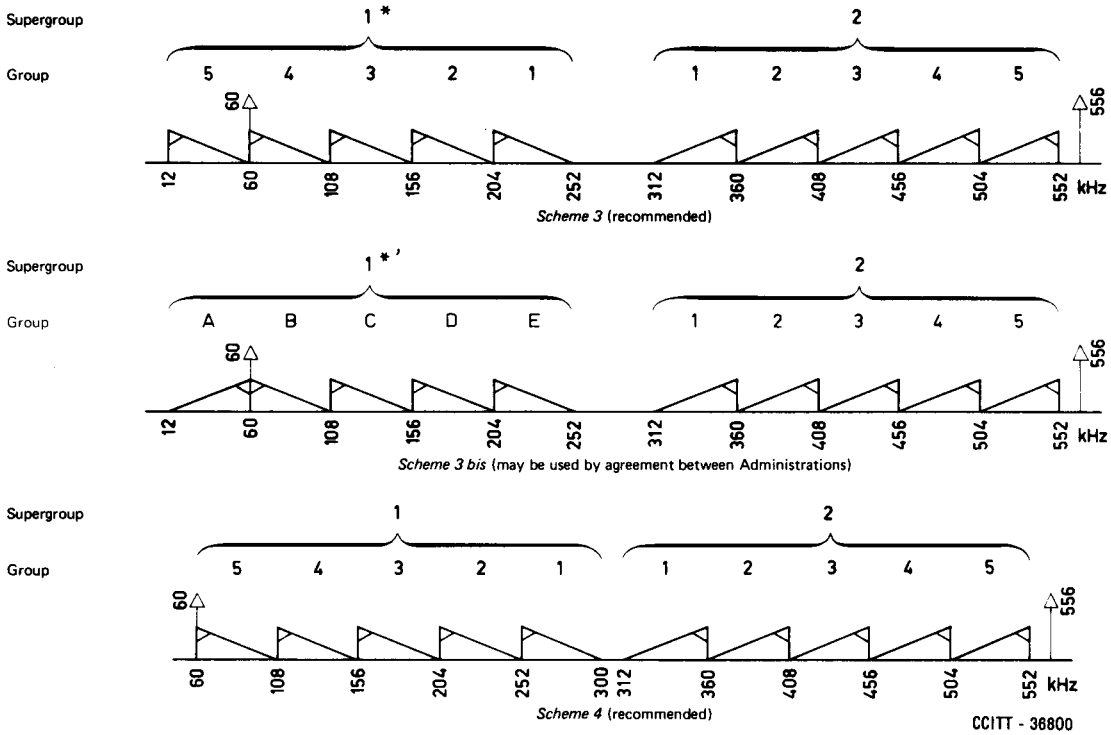
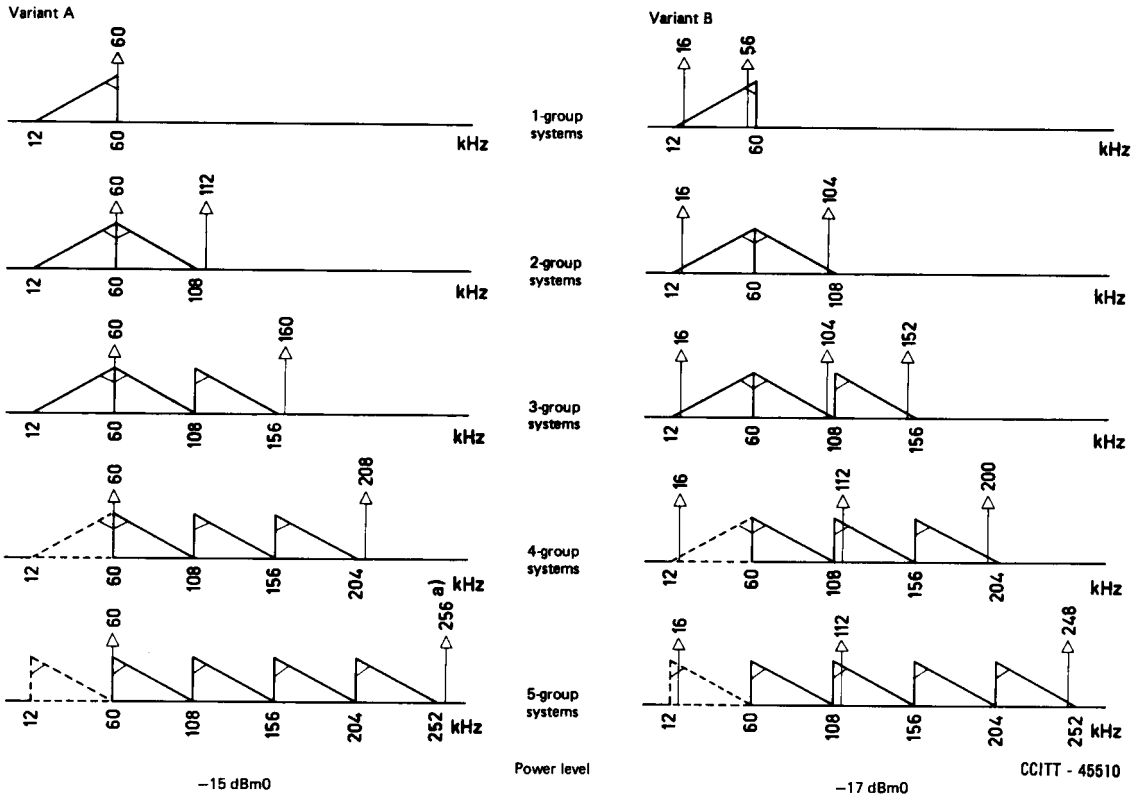


FIGURE 4/G.322

Line-frequency allocation for international carrier systems providing 2 supergroups on symmetric pair cables



a) Recommended frequency; there are systems using 253 kHz.

Note – The group shown dotted can be inverted without changing the frequencies recommended for pilots.

FIGURE 5/G.322

Line-regulating pilots for carrier systems on symmetric pairs

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:

± 1 Hz for the 60-kHz pilot;

± 3 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:

± 1 Hz for the 60-kHz pilot;

± 3 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:

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

$0.08 \sqrt{\frac{f_{max.}}{f}}$ 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);

$0.10 \sqrt{\frac{f_{max.}}{f}}$ or 0.17 for systems with 5 groups or systems with 2 supergrops on polythene or styroflex-insulated cables (types II *bis* and III *bis* 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

Limits for	Systems providing		
	1, 2 or 3 groups	4 or 5 groups	2 supergroups
2nd-order harmonic margin[a)]	79 dB	82 dB	85 dB
3rd-order harmonic margin[a)]	92 dB	98 dB	104 dB

[a)] For definition, see Reference [9].

Note - These values are measured for a power of 1 mW applied at a point of zero relative level on any channel.

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-l, 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.

[31 *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^{th} order harmonic distortion,* Vol. X (Terms and Definitions).