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SECTION 3

INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES

3.1 Systems providing a group on an open-wire pair

Recommendation G.311

GENERAL CHARACTERISTICS OF SYSTEMS PROVIDING 12 CARRIER TELEPHONE CIRCUITS ON AN OPEN-WIRE PAIR

(amended at Geneva, 1964, and Mar del Plata, 1968)

The CCITT,

considering

that, in the international telephone service, it is very desirable to standardize as far as possible 12-channel carrier telephone systems on open-wire lines using one of the basic groups employed in carrier systems on symmetric cable-pairs or coaxial cables,

unanimously recommends

that multichannel carrier systems on open-wire lines constructed in the future for the provision of international telephone circuits should satisfy the following conditions:

1 Frequency band effectively transmitted by each telephone circuit

The audio-frequency band effectively transmitted by each telephone circuit should extend from 300 Hz to 3400 Hz.

2 Basic group

The basic group should be that standardized for carrier systems on unloaded symmetric cable-pairs and coaxial cables, i.e.:

Group B: In each direction of transmission 12 channels in the band between 60 and 108 kHz transmitting the lower sideband for each individual channel.

3 Relative levels

The relative power level at the output of the terminal equipment and the intermediate repeaters should be, on each channel and at the frequency on this channel which corresponds to an audio-frequency of 800 Hz, equal to the nominal relative level with the following tolerances:

— terminal equipment: ± | dB;

— intermediate repeater equipment: ± | dB for a route of length comparable to a typical homogeneous section — i.e. some 450 km or comprising about four elementary line sections.

The maximum value of the nominal relative level should be +17 dBr at the input to the open-wire line.

The inherent physical characteristics of open-wire line routes result in significant deviations from a regular attenuation/frequency characteristic and the relatively large and varied changes of line attenuation with weather conditions may not always permit the tolerances recommended above for the output of intermediate repeater stations to be met, either when the route is newly commissioned or in subsequent maintenance.

To achieve the tolerances recommended at the output of intermediate repeaters while retaining reasonable design and maintenance standards, it will be necessary for the open-wire line and the repeater equipment to comply with the following standards of performance and tolerances:

1) The attenuation/frequency characteristic of the open-wire elementary line section should be as near as possible to a smooth curve, which for each 48-kHz bandwidth corresponding to a direction of transmission will be substantially a straight line, i.e. a linear frequency characteristic. Deviations from this straight line should not exceed 0.5 dB in any elementary line section (see Recommendation G.313).

2) In each direction of transmission and under dry weather conditions the attenuation/frequency characteristic of any elementary line section, comprising an open-wire line and a repeater at the receiving end should be within ± | .3 dB of the straight line representing the best approximation to the measured attenuation/frequency characteristic of the line. These tolerances require a high standard of design, construction and maintenance of the open-wire line and may also necessitate equalization of the residual attenuation distortion of the elementary line section.

3) The gain regulation characteristic of the repeater should be such that the change in gain to compensate for a change in weather conditions is a linear function of the frequency and should correct a linear line attenuation/frequency characteristic with tolerances not exceeding the following:

— for all conditions between dry and normal wet weather conditions, i.e. where Recommendation G.312 recommends a maximum repeater gain of about 43 dB, a tolerance of ± | .5 dB;

— when there is an appreciable deposit of ice on the wires, i.e. where Recommendation G.312 suggests a maximum repeater gain of about 64 dB, a tolerance of ± | dB.

4 Frequencies transmitted to line

The system should have 12-carrier telephone circuits.

The system should use one pair of open-wire lines. The lowest frequency transmitted to line should be high enough to allow the use of a three-channel carrier telephone system at the same time as the system giving 12-carrier telephone channels.

Figures 1/G.311 and 2/G.311 show two methods of dividing the line-frequency spectrum and the corresponding pilot frequencies available (Schemes I and II). In order to ensure some measure of uniformity in the international telephone network, it is recommended that Administrations concerned with an international carrier system should always choose one or the other of these systems, if possible.

The CCITT does not specially recommend either Scheme I or Scheme II. The Administrations concerned in setting up a 12-channel carrier telephone system on international open-wire lines must judge in each case which of the two schemes is technically and economically more suitable.

Further, the use on different pairs of the same route of several 12-channel carrier systems would involve careful positioning of the modulated groups in the line-frequency spectrum. As an example, Figures 3/G.311 and 4/G.311 show two methods used in some countries. Table 1/G.311 gives the carrier frequency allocation for the method shown in Figure 3/G.311.

Figure 1/G.311 p.

Figure 2/G.311 p.

Figure 3/G.311 p.

Figure 4/G.311, p.

H.T. [T1.311]
TABLE 1/G.311
Table showing carrier frequency allocation

System	{	{		
	1st group modulation	2nd group modulation	1st group modulation	2nd group modulation
	(kHz)	(kHz)	(kHz)	(kHz)
SOJ-A-12	340	484	340	308
SOJ-B-12	340	364	340	543
SOJ-C-12	340	484	340	541
SOJ-D-12	340	364	340	306

Table 1/G.3111 [T1.311], p.

5 Pilot frequencies

Each system will have an automatic gain regulator controlled by two pilots having different frequencies for each of the two directions of transmission. It is not possible to standardize frequencies of the pilots to be used on international open-wire carrier systems throughout the international telephone service, because agreement has not been reached on the choice of a particular division of the line-frequency spectrum. It is left to Administrations concerned in such an international connection to take a decision on this subject. *It is extremely desirable* that agreement should be reached between them to use the *same* method of division of the line-frequency spectrum, and the same pilot frequencies (i.e. either Scheme I of Figure 1/G.311 or Scheme II of Figure 2/G.311), in order to avoid intermediate modulating and demodulating equipments at the frontier repeater stations, or any other method of changing from one system to another. If agreement cannot be reached, one of two things can be done:

1) Consider the frontier repeater station where two different systems are interconnected as the end of a regulated-line section — i.e. stop the pilot of each country at the frontier and introduce there the pilot used by the other country, which should be reintroduced into the line on the other side of the frontier.

2) Choose pilots which, in the two systems, have exactly the same relative positions with reference to the centre of the group of telephone channels transmitted to line and the same relative levels, because it is then possible to translate the pilots together with the groups.

The nominal power level of each pilot should be as low as possible, having regard to the type of system used. It is recommended that in all cases this absolute level should not exceed —20 dBm0. The stability of the pilots should be such that their frequency is always accurate to within less than 5×10^{D}lF261^{6}.

6 Stability of the carrier frequency generators

So that the effect of the modulations or demodulations shall never produce a difference greater than 2 Hz between the audio-frequency applied at the input of a channel and that which is received at the corresponding end (where there is not intermediate demodulation and remodulation), the stability of the carrier generators must be such that their frequency is always accurate to within less than 5×10^{D}lF261^{6}.

7 Hypothetical reference circuit over open-wire lines

This hypothetical reference circuit is 2500 km long and is set up on a carrier system providing 12 circuits on open-wire pairs.

For each direction of transmission, this hypothetical reference circuit has a total of:

— 3 pairs of channel modulators and demodulators,

— 6 pairs of group modulators and demodulators.

Figure 5/G.311 shows a diagram of this hypothetical reference circuit. It will be seen that there is a total of 9 modulations and 9 demodulations for each direction of transmission, supposing that each modulation or demodulation is effected in a single stage

Figure 5/G.311 p.

The assumptions regarding the numbers of pairs in different homogeneous sections of the hypothetical reference circuit, the lengths of the homogeneous sections, the interconnections of channels and groups at the ends of sections and the law of addition of noise arising in different sections that apply to the hypothetical reference on symmetric pairs (see Recommendation G.322, § 1.1) should also apply to the hypothetical reference circuit on open-wire lines.

Moreover, the line-frequency arrangements recommended in § 4 above (giving relative ‘‘staggering’’ and/or ‘‘inversion’’ of channels) are applied to each section of the circuit in equal numbers.

8 Design objectives for circuit noise

It is not possible on a single 12-circuit open-wire carrier system to set up a telephone circuit having the same constitution as given by the hypothetical reference circuit, since at a group derivation point all the telephone channels transmitted to line are extracted *en bloc* , from the system concerned. However, the hypothetical reference circuit defined above, with a certain number of modulations, is useful in designing equipment such that the circuits set up on these systems may satisfy the appropriate Recommendations.

The following objective shall be used in the design of 12-circuit carrier systems on open-wire lines.

Each telephone channel conforming to the definitions of the hypothetical reference circuit on open-wire lines must be so designed that the mean psophometric noise power at the end of the hypothetical reference circuit, referred to a point of zero relative level, does not exceed 20 | 00 pW0p during any hour.

The same assumptions apply for the calculation of noise as are indicated in Recommendation G.223, due allowance being made for the makeup of the hypothetical reference circuit on open-wire lines.

Note — The psophometric power of 20 | 00 pW0p corresponds to normal conditions in rainy weather; this figure may be exceeded only in very unfavourable weather conditions.

It is recommended that this overall limit be subdivided among the main components of total noise as follows:

— line noise: 17 | 00 pW0p;

— noise due to terminal equipment: 2 | 00 pW0p.

The distribution of total noise between:

— basic noise,

— intermodulation noise, and

— crosstalk noise

is left entirely to the designer of the system, within the limits of 2500 pW0p for the terminal equipment and 17 | 00 pW0p for the line.

Note — As a simple example, a detailed distribution among the various components of total line noise is shown in Supplement No. 6 [1].

9 Characteristics of an actual 2500-km circuit

If the lines are carefully built (taking into account the information given in the Note under § 2 in Recommendation G.313), and if the design has been drawn up in accordance with the appropriate Recommendations, it is probable that circuits having a constitution comparable to that of the hypothetical reference circuit will satisfy these Recommendations during most of the time.

Note — Since open-wire lines are exposed to weather variations, it is to be expected that, if a large part of a circuit is exposed to very unfavourable weather, certain conditions will not be satisfied (e.g. crosstalk, line relative levels and noise conditions).

Reference

[1] *Example showing how the total value of line noise specified for the hypothetical reference circuit on open-wire lines might be broken down into its various components* , Green Book, Vol. III-2, Supplement No. 6, ITU, Geneva, 1973.

Recommendation G.312

INTERMEDIATE REPEATERS FOR OPEN-WIRE CARRIER SYSTEMS

CONFORMING TO RECOMMENDATION G.311

1 Maximum gain

Where icing of lines is exceptional, the repeaters (in the direction in which the highest frequencies are transmitted) must have a gain of at least 43 dB at the upper frequency transmitted to line, this gain being measured between the line terminals of the repeater station equipment (which includes directional filters, equalizers, etc.), the level regulators being in the position of maximum gain.

In countries where icing of lines is a very serious problem, it is possible to use repeaters having a maximum gain of 64 dB at the upper frequency transmitted to line, these repeaters also being designed to deal with the greater slope of the attenuation/frequency characteristic, under icing conditions.

2 Impedance

Experience shows that because of different methods of construction the nominal values of the impedance of open-wire lines vary from 530 to 630 ohms.

The impedance of the repeater station equipment, seen from the terminals to which the line is connected, should be adjusted at the highest frequency transmitted to line in such a way that the modulus of the return current coefficient at the junction between this equipment and the line is not greater than 0.05 in the upper part of the line-frequency spectrum, and not greater than 0.075 in the lower part.

3 Minimum value of harmonic margin

The harmonic distortion of a repeater should not exceed a value corresponding to the following limits:

When a sinusoidal test signal with a power level of 0 dBm0 is applied at the input to a telephone circuit, the second order harmonic margin (ratio of the second harmonic to the fundamental) should be not less than 70 dB; the third order harmonic margin (ratio of the third harmonic to the fundamental) should be not less than 80 dB.

4 Overload point

The overload point of a repeater as defined in § 6 of Recommendation G.223 should be not less than +33 dBm.

5 Stability

Near singing should not occur if the line terminals are closed at each side with any impedance (from a very small value and with any angle).

6 Minimum crosstalk ratio between repeaters in the same station

If a disturbing voltage is applied to a repeater in a station (so as to include all station wiring and auxiliary apparatus) and the input to another repeater in the same station is closed with an impedance equal to the nominal impedance of the line, then the voltages at the output of these two repeaters, when compared (again including all station wiring and auxiliary apparatus), should give a crosstalk ratio of not less than 74 dB, the two repeaters being in their normal working conditions.

Recommendation G.313

OPEN-WIRE LINES FOR USE WITH 12-CHANNEL CARRIER SYSTEMS

1 Attenuation of an elementary line section

The maximum relative level at the input of a repeater section has been fixed at +17 dBr. The lowest relative level on an open-wire line should not be allowed to fall below —17 dBr during normal wet weather conditions.

These conditions are all that need to be observed if only one 12-circuit carrier system is to be used on an open-wire route. (See Annex A.)

Where it is desired to use several systems, there are additional requirements to be met. The attenuation/frequency characteristic should be as near as possible to a smooth curve. For example, on a new 12-circuit carrier route, deviations from a regular curve not exceeding 0.5 dB, in any elementary line section and throughout the frequency band transmitted to line, should be obtainable.

2 Crosstalk

The far-end crosstalk ratio between two pairs of wires allocated to carrier systems using the same line-frequency band should not be less than 65 dB in any elementary line section (the length being about 100 km), at any frequency in the frequency band effectively transmitted.

Near-end crosstalk attenuation, measured at the terminal equipments or in repeater stations, should not be less than 42 dB at any frequency in the band of frequencies effectively transmitted to line.

Note — It is considered that the conditions shown above can be met if sufficient care is taken in the construction of the line. Open-wire routes intended to carry several 12-circuit carrier systems should be transposed in the normal way for the frequency band concerned.

Information about crosstalk between circuits on open-wire lines and transposition systems for routes intended to carry several 12-circuit carrier systems will be found in the following publications:

1) Methods for increasing crosstalk attenuation between open-wire lines, by M. Vos and C. | . Aurell (*Ericsson Technics* , No. 6, 1936). (The French translation of this article is contained in duplicated Document No. 10 of the 3rd CE-CCIF — 1947/1948.)

2) Crosstalk on open-wire lines (Bell Telephone System Monograph 2520).

3) Replies to Question 40 of the 3rd CE of the CCIF given in the following documents:

Document No. 13 of the 3rd CE-CCIF — 1955/1956 (Cuban Telephone Company),

Document No. 33 of the 3rd CE-CCIF — 1955/1956 (Italian Administration),

Document No. 71 of the 3rd CE-CCIF — 1955/1956 (USSR Administration),

Document No. 73 of the 3rd CE-CCIF — 1955/1956 (Australian Administration).

Administrations intending to work a single 12-circuit carrier system on an existing route will find relevant information in the Annex A.

3 Underground cable sections

When it is necessary to use sections of underground cable, either at the terminal repeater stations or as an intermediate section in the open-wire route, consideration should be given to matching the impedance of the open-wire pairs to that of the underground cable pairs,

1) by using a low capacity cable loaded appropriately to match its impedance to that of the open-wire line,

2) by means of matching transformers and/or separating filters mounted on or at the foot of the poles at the ends of the section.

4 Precautions for the elimination of crosstalk in repeater stations

It is recommended that over a distance of some 25 m from a repeater station, separate underground cables be provided to extend the open-wire line into the station. It may also be necessary to insert longitudinal chokes in other pairs, with or without crosstalk suppression filters.

5 Protection against external voltage surges

The French Administration uses the following methods of protection which are given for information:

The line filters should be protected on the line side by fuses and lightning arrestors.

Where the output of the audio-frequency circuit is connected directly to an open-wire line, the output of the audio filter should be protected in the same way.

Audio-frequency filters should be balanced and should be built to withstand a test voltage of 3000 volts d.c. to frame.

High-frequency filters may have a balanced first half-section connected to the other filter sections by a transformer. The first half-section should be capable of withstanding a test voltage of 3000 volts to frame. The remainder of the filter may be unbalanced if it immediately precedes the terminal equipment. If there is a cable in between, two transformers should be used to preserve the balance and, if necessary, to correct for impedance.

Also for information, the following protective methods were used by the Cuban Telephone Company:

1) Carbon arrestors are fitted:

i) on the terminal pole (with a breakdown voltage of 750 volts);

ii) between the leading-in cable and the equipment (with a breakdown voltage of 350 volts).

In very unfavourable conditions, these arrestors fuse and connect the line to earth.

2) Thyrite arrestors are placed in the line filters to afford protection against voltages which are not high enough to operate the carbon arrestors.

3) Protection by line discharge coils is also used where necessary in areas with severe lightning.

ANNEX A

(to Recommendation G.313)

Special case of a single 12-circuit carrier system to be worked over an existing open-wire line

When an Administration intends to work a single 12-circuit carrier system over existing open-wire lines, it would be well advised to take the following considerations into account:

The attenuation/frequency characteristic of the pair which it is proposed to use should be measured, and also that of the reserve pair. Factors affecting the attenuation of a particular pair are:

— the distance between conductors,

— the diameter and type of conductor,

— insulation methods, and

— transposition schemes.

If the distance between wires is constant, if the pair consists of uniform conductors throughout its length and if the transposition scheme used gives frequent and regularly spaced transpositions, the pair can be considered suitable for 12-circuit carrier working.

When routes are transposed to allow working up to 30 kHz there will generally be no difficulty in working a single 12-circuit carrier system, provided attention is given to matching the impedance between open-wire and underground cable sections, including terminal sections at repeater stations, by using transformers or correctly loaded cable.

On routes transposed for only voice-frequency working, it is feasible to erect two additional pairs for use by a 12-circuit carrier system, by fixing an arm to an extension at the top of the pole and by suitably transposing the additional pairs. The addition arm should be at least 61 cm away from the highest existing arm. Alternatively, if there is no need for extra conductors, a transposition scheme suitable for working up to 30 kHz can be introduced, which should make it possible to work a single 12-circuit carrier system. Whether a route should be rebuilt will depend on the rate of growth of traffic and it might be more economical to use from the outset a transposition scheme suitable for several 12-circuit carrier systems. In such a case the residual life of the route is an important factor.

Comments in §§ 3, 4 and 5 also apply to this special case.

Recommendation G.314

GENERAL CHARACTERISTICS OF SYSTEMS PROVIDING EIGHT CARRIER TELEPHONE CIRCUITS ON AN OPEN-WIRE PAIR

(Geneva, 1964)

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

of the *Orange Book* , Geneva, 1976)

3.2 Carrier telephone systems on unloaded symmetric cable pairs, providing groups or supergroups

The Recommendations of this sub-section refer to systems which provide one or more groups of 12 long-distance telephone circuits using unloaded symmetric cable pairs in accordance with Recommendation G.611. Recommendations G.322, G.323 and G.324 relate to systems for which both constituent channels in each circuit are established over different cables, one for each direction of transmission. Recommendations G.325, G.326 and G.327 apply to (12 + 12) systems.