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INTERNATIONAL ANALOGUE CARRIER SYSTEMS

GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS

NOISE OBJECTIVES FOR DESIGN OF CARRIER-TRANSMISSION SYSTEMS OF 2500 KM

ITU-T Recommendation G.222

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.222 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.

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Recommendation G.222

NOISE OBJECTIVES FOR DESIGN OF CARRIER-TRANSMISSION SYSTEMS OF 2500 km

1 Design objectives in respect of noise produced by the line and the frequency division modulating equipment on hypothetical reference circuits of 2500 km for telephony

In order to ensure that multichannel carrier systems on cable and on radio-relay links shall comply with standards of performance considered as equivalent in respect of noise, the following design objectives should apply to the noise *at a zero relative level point* in any telephone channel having the same composition as the hypothetical reference circuit on such systems.

1.1 To ensure adequate performance in respect of telephone speech and signalling on cable systems, the mean psophometric noise power over one minute shall not exceed 10 000 pW0p.

1.2 To ensure adequate performance in respect of telephone speech and signalling on radio-relay links:

1.2.1 the mean psophometric noise power over one minute shall not exceed 10 000 pW0p for more than 20% of any month;

1.2.2 the mean psophometric noise power over one minute shall not exceed 50 000 pW0p for more than 0. 1 % of any month;

1.2.3 the unweighted noise power, measured or calculated with an integrating time of 5 ms shall not exceed 1 000 000 pW0 (10^6 pW0) for more than 0.01% (10^{-4}) of any month.

Note - For carrier transmission systems with one-minute mean noise power distributions which are not well defined, the inclusion of another one-minute mean noise clause would be desirable to ensure equivalent performance for all systems. This clause would specify that:

The mean psophometric noise power over one minute shall not exceed 20 000 pW0p for more than 3% of any month.

This clause has not been specifically included because the CCIR has determined that for radio-relay links, the application of clauses 1.2.1 and 1.2.2 are sufficient to ensure, with high probability, that the additional clause will also be satisfied.

1.3 If it is intended to use amplitude-modulated voice-frequency telegraph equipment for 50 bauds conforming to the Series R Recommendations and to obtain the quality shown in Recommendation F.10 [1], the mean nonweighted noise power over 5 ms must not exceed 10^6 pW0 during more than 0.001% (10^{-5}) of any month, nor more than 0.1% of any hour, for cable systems and for radio-relay links.

If frequency-modulated voice-frequency telegraph equipment operating at 50 bauds is used, it is to be expected that the quality specified in §§ 1.1 and 1.2 respectively above will be satisfactory as far as the telegraph transmission is concerned.

The conditions under which the above design objectives should apply are given in § 2 below.

2 Conditions in which the design objectives for hypothetical reference circuits apply

2.1 The values mentioned in § 1 above are design objectives and it is not intended that they should be quoted in specifications for equipment or used for acceptance tests. The noise on a homogeneous section of an actual carrier system is dealt with in Recommendation G.226.

The following Recommendations specify the conditions in which these general objectives apply to different types of system, account being taken of the special characteristics of each system:

- symmetric pair cable systems (Recommendation G.322);
- symmetric pair cable "12 + 12" systems (Recommendation G.326);
- 4-MHz systems (Recommendation G.338 [2]), 12-MHz systems (Recommendations G.332 and G.339), 18 MHz systems (Recommendation G.334) and 60 MHz systems (Recommendation G.333) on 2.6/9.5-mm coaxial pairs;
- systems on 1.2/4.4-mm coaxial pairs (Recommendations G.341, G.343, G.344, G.345 and G.346);
- radio-relay links using frequency-division multiplex (Recommendation 393 [3] of the CCIR).

In particular, Recommendation G.442 lays down objectives for the use of amplitude-modulation voice-frequency telegraphy used in line-of-sight radio-relay systems.

Tropospheric-scatter radio-relay systems should meet the objectives of this Recommendation, or other objectives, according to the circumstances of operation (see CCIR Recommendation 397 [4]).

Other objectives are recommended for systems providing 12 carrier circuits on an open-wire pair (see Recommendation G.311).

2.2 Designers are expected to fit their distribution curves to fall below both points given in § 1.2.1 and § 1.2.2 above.

2.3 In connection with § 1.2.2 above, the CCITT would have preferred to indicate a figure of 100 000 pW0p (average psophometric power over one minute at a zero relative level point), not to be exceeded during more than 0.01% of any month. On account of difficulties in measurement, a figure of 50 000 pW0p for 0.1% of any month has been shown.

2.4 Within each homogeneous section of a hypothetical reference circuit, the telephone channels will occupy the same position in relation to each other. Within these sections, certain intermodulation products (those of odd order) tend to add on the basis of linear addition of voltages, but between sections it may be considered that in respect of noise a power-additive law applies exclusively.

In a part of a hypothetical reference circuit consisting of one or more equal homogeneous sections, the one-minute mean noise power not exceeded during 20% of any month shall be considered to be proportional to the number of homogeneous sections involved.

2.5 In parts of a hypothetical reference circuit consisting of one or more equal homogeneous sections, the small percentage of any month in which the one-minute mean power may exceed the design objective for 0.1% of the time or less shall be regarded as proportional to the number of homogeneous sections involved. This principle also applies to the objective mentioned in § 1.2.3 above.

2.6 Although in principle it is to be understood that the general noise objectives are all-embracing, in practice it is recognized that there will be abnormalities from time to time which will result in additional noise sources becoming evident. Often, such extra contributions can be accommodated within the margin available within the system design. In other cases, no concern need be felt provided that such additional contributions are small compared to the general objective, for example, less than 10% of the power or probability of occurrence respectively.

In any case, all necessary precautions should be taken during the installation and putting into service of the systems so that noises of external origin are reduced to a negligible value of, at the most, 10% of the limits fixed as objectives.

2.7 Recommendation G.223 gives the other hypotheses which are recommended for the calculation of the noise on the hypothetical reference circuits for telephony.

3 Circuits more than 2500 kilometres long

3.1 The CCITT recognizes that in order to meet national and international noise performance objectives some large countries have found it necessary to introduce terrestrial FDM carrier transmission systems that are based on the hypothetical reference circuit described in Recommendation G.215. The noise performance objective for these systems corresponds approximately to 5000 pW0p on the 2500 km hypothetical reference circuit instead of the 10 000 pW0p mentioned in §§ 1.2.1 and 1.2.2 above. These values include the noise contributed by multiplex equipment.

3.2 The basic hypothetical reference circuit for satellite systems is defined in CCIR Recommendation 352, and provisional noise objectives appropriate to the design of such systems in consideration of the values contained in § 1 above, are contained in CCIR Recommendation 353 [6].

4 Design objectives for noise produced by modulating equipments and additional equipments

The general objectives mentioned in § 1 above include the noise produced by modulating and additional equipments. The mean psophometric power, which corresponds to the noise produced by all modulating equipment mentioned in the definition of the hypothetical reference circuit in question and by all additional equipment, should not exceed 2500 picowatts at a zero relative level point. This value of psophometric power refers to the whole of the noise due to various sources (thermal noise, intermodulation, crosstalk, power supplies, etc.). Its allocation among the various equipments can to a certain extent be left to the discretion of design engineers. However, to ensure a measure of agreement in the allocation chosen by different Administrations, the maximum values given in Table 1 /G.222 are recommended for the modulating equipments.

The allocation of a large part of the noise to channel-modulating equipment is justified because these equipments are the most numerous in a network and therefore are constructed as economically as possible.

For the through-filters a noise objective of a maximum of 10 pW0p is recommended. This value refers to the nominal band of the through-connected groups; the noise outside that band must be considerably lower, to avoid a significant contribution of noise to channels situated in adjacent frequency bands.

For other units of additional equipment (regulating equipment, equalizers, standby switching equipment, etc.) a value of about 15 pW0p is indicated as a guideline to the designer.

The above statement does not apply to line standby switching equipment whose noise has to be considered together with that of the line.

The load assumption of through-filters and additional equipments should be in line with Recommendation G.223, G.228 and G.230. Account should be taken of the possible presence of additional signals outside the nominal frequency band arising from adjacent channels.

TABLE 1/G.222

Equipment	Maximum value contributed by the send and receive side together	Assumptions about loading
Channel modulators	200 pW0p[a)]	Adjacent channels loaded with: −15 dBm0 ⎫ (Signal corresponding ⎭ to Recommendation G.227) Other channels loaded with: −6.4 dBm0
Group modulators	80 pW0p	Load in group to be measured: +3.3 dBm0 Load in other groups: −3.1 dBm0 (each)
Supergroup modulators	60 pW0p	Load in supergroup to be measured: +6.1 dBm0 Load in other supergroups: +2.3 dBm0 (each)
Mastergroup modulators	60 pW0p	Load in each mastergroup: +9.8 dBm0
Supermastergroup[b)] modulators	60 pW0p	Load in each supermastergroup: +14.5 dBm0
Basic 15-supergroup assembly modulators[c)]	60 pW0p	Load in each 15-supergroup assembly: +14.5 dBm0

a) No account is taken of the values attributed to pilot frequencies and carrier leaks.

b) Valid also for 15-supergroup assembly modulators of the 60-MHz system (Recommendation G.333) to modulate from position No. 3 into the line frequency position and vice versa.

c) In the case of the 60-MHz system (Recommendation G.333) valid for the first modulating stage to bring the basic 15-supergroup assembly into the frequency band of the basic supermastergroup and vice versa.

Note - In Recommendation G.230 methods for measuring the noise produced by modulating equipments are described.

References

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

[2] 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, ITU, Geneva, 1977.

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

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

[5] CCIR Recommendation *Hypothetical reference circuits for telephony and television in the fixed satellite service,* Vol. IV, Rec. 352, Dubrovnik, 1986.

[6] CCIR Recommendation *Allowable noise power in the hypothetical reference circuit for frequency-division multiplex telephony in the fixed satellite service,* Vol. IV, Rec. 353, Dubrovnik, 1986.