INTERNATIONAL TELECOMMUNICATION UNION

ITU-T G.143

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TRANSMISSION SYSTEMS AND MEDIA

GENERAL CHARACTERISTICS OF THE 4-WIRE CHAIN OF INTERNATIONAL CIRCUITS; INTERNATIONAL TRANSIT

CIRCUIT NOISE AND THE USE OF COMPANDORS

ITU-T Recommendation G.143

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.143 was published in Fascicle III.1 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.143

CIRCUIT NOISE AND THE USE OF COMPANDORS

(Geneva, 1964; amended at Mar del Plata, 1968;
Geneva, 1972 and 1980 and Malaga-Torremolinos, 1984)

1 Noise objectives for telephony

1.1 *Principle*

Taking into account the network performance objectives for noise allowed in national networks (Recommendation G.123), it is desirable that the circuit performance objective for the mean psophometric power in any hour of the total noise generated by a chain of six international circuits, some of which may exceed 2500 km in length, on a connection used for international telephone calls, should not exceed 50 000 picowatts referred to a zero relative level point of the first circuit in the chain (level -43 dBm0p).

Of course, a lower value of the total noise may be expected when the international chain consists of only a small number of international circuits, not exceeding 2500 km in length and conforming to Recommendation G.152 (in particular, the circuit performance objective for the noise of such circuits is that the mean psophometric power in any hour does not exceed 10 000 pW at a zero level point on the circuit, level - 50 dBm0p).

However, as connections longer than 25 000 km will be set up, the CCITT recommends, as an objective, that on sections longer than 2500 km used for international traffic, line equipment be supplied with a circuit performance objective for noise -not greatly exceeding L picowatts on a circuit L km long (see [1]). There is obvious advantage in working to the same standard on short sections when. this can reasonably be done.

Note 1 - Noise objectives for maintenance purposes are the subject of Recommendation M.580 [2]. Table 4/M.580 of that Recommendation is reproduced here:

TABLE 4/M.580

Maintenance noise objectives for public telephone circuits

Distance (km)	<320	321 to 640	641 to 1600	1601 to 2500	2501 to 5000	5001 to 10000	10001 to 20000
Noise (dBm0p)	–55	–53	–51	–49	–46	–43	–40

Note 2 - Strictly speaking, the noise objective for communication-satellite systems (see Recommendation G.153, § 3) cannot be expressed in the form of a given number of picowatts per km. See also the Note of Recommendation M.580 [2].

1.2 *Noise produced by equipment*

The equipment design objective for noise produced by the modulating equipment in the international chain of circuits in the longest hypothetical reference connection (see Figure 1/G.103) can be estimated on the assumption that such equipment comprises:

- 6 channel-modulation pairs, or 8 to 10 if 3-kHz-spaced channel equipment is used on transoceanic routes;
- 12 to 14 group-modulation pairs;
- 18 to 24 supergroup-modulation pairs;

for all of which a total circuit performance for the combined psophometric power of 5000 to 7000 pW0p (at a point of zero relative level on the first circuit of the international chain of 4-wire circuits) is a generous assumption.

The equipment design objective of -67 dBm0p for the hourly-mean psophometric power level at each international switching point quoted in Recommendation Q.45 [3] is equivalent to about 2000 pW0p at a point of zero relative level on the first circuit in the 4-wire chain.

It may thus be seen that the equipment design objective for the noise produced by the equipment does not constitute a large part of the network performance objective for the total noise generated by the international chain.

1.3 *Division of the overall circuit performance objective for noise*

The land sections in the international chain, set up on cable carrier systems or on radio-relay links, should in principle afford circuits of the quality defined above. In practice, by agreement between Administrations, the circuit performance objective for noise could be shared between the submarine and overland systems in such a way that the submarine cable systems contribute at a somewhat lower rate, e.g. 1 pW/km, and the overland systems contribute at a somewhat higher rate, e.g. a maximum of 2 pW/km. This result may be achieved either by setting up special systems, or by a proper choice of channels in systems designed to the 3 pW/km objective.

Note - In some countries, overland systems forming part of a circuit substantially longer than 2500 km (e.g. 5000 km or more) have. been constructed with the same circuit performance objective for noise as the submarine cable system, i.e. 1 pW/km.

1.4 *Circuits operated with speech concentrators*[1)]

It would be desirable for all the circuits making up a group for use with a concentrator system to have approximately the same noise power level under operating conditions.

2 Use of syllabic compandors[2), 3), 4)]

For many years, international (and national) circuits will continue to be provided on existing transmission systems which have been designed to other standards, e.g. 4 pW/km, as given in Recommendation G.152. Furthermore, the circuit noise produced by transmission systems can increase above the values originally achieved because of ageing effects, and changes of system loading. There is therefore a need for a simple practical criterion that can be applied for planning purposes to an international circuit to determine if, as far as noise power is concerned, it is suitable for establishing multicircuit worldwide telephone connections or whether it can be made suitable by fitting compandors[2)] .

It is recommended that, for the present, the systematic use of compandors conforming to Recommendation G.162 in the long-distance national and international network be restricted.

Compandors conforming to Recommendation G.166 may be used in the network provided planning is done to minimize the number of compandored circuits in tandem. It is desirable to have at most one compandored circuit in a connection. Preliminary results obtained by one Administration indicate that for voice operation no more than three compandored circuits in tandem should be allowed. Some high speed modems (9.6 kbit/s) may experience difficulty on

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1) For example, TASI (Time Assignment Speech Interpolation) of CELTIC (Concentrateur exploitant les temps d'inoccupation des circuits); see Recommendation G.163.

2) The instantaneous compandors that are associated with certain transmission systems are considered to be an integral part of these systems.

3) For characteristics of syllabic compandors for telephony on high capacity long distance systems, see Recommendation G.166.

4) See Annex A for further considerations relating to the use of syllabic compandors.

a connection with even one compandored circuit. To ensure compliance not more than one compandored circuit should be used in the international segment. Additional information is required before a firm planning rule can be established including possible application in national extensions on circuits with moderate noise levels.

It must be pointed out that the action of a compandor doubles the effect of any variations in the transmission loss occurring in that part of the circuit which lies between the compressor and the expander and for this reason compandors, if needed, should be fitted at the ends of circuit sections provided by inherently stable line transmission systems such as submarine cable systems.

The following planning rule is recommended by the CCITT as a guide for deciding whether an international circuit requires a compandor:

If the hourly-mean psophometric circuit noise power level of an international circuit substantially longer than 2500 km (e.g. 5000 km or more) is less than -44 dBm0p (at a point of zero relative level on the circuit) no compandor is necessary.

If the circuit noise power level is - 44 dBm0p (40 000 pW0p) or greater, a compandor should be fitted.

It is, of course, to be understood that circuits of length 2500 km or less will always meet the appropriate general noise objectives (Recommendation G.222 [4]) without the need for compandors.

Note 1 - This rule has been devised to make possible the planning of the international telephone network, using presently available circuits. It should in no way be interpreted as relaxation of the design objectives recommended in § 1 of this Recommendation, nor should it be applied for maintenance purposes (see Note 1 of § 1.1 above).

Note 2 - The compandors used should conform to the limits proposed in Recommendation G.162 or in Recommendation G.166.

Note 3 - In accordance with the Recommendation cited in [5], circuits with a noise power level of -37 dBm0p or worse are removed from service.

3 Noise limits for telegraphy

Noise limits for telegraphy are given in Recommendation H.22 [6].

4 Noise limits for data transmission

The following objectives are acceptable for data transmission at data signalling rates not exceeding 1200 bit/s. It is expected that the values actually experienced on many circuits and connections will be better than the following limits.

4.1 *Leased circuits for data transmission*

A reasonable limit for uniform spectrum random noise for a data transmission *leased* circuit, assuming that plant liable to impulsive noise interference is avoided, and as high a modulation rate as possible is to be used without significant error rate, would appear to be -40 dBm0p.

4.2 *Switched connections*

For switched connections a limit of, say, - 36 dBm0p without compandors may be taken for intercontinental circuits on which compandors may be used.

ANNEX A
(to Recommendation G.143)

Additional considerations relating to the use of syllabic compandors

(The following information was available from Study Group XII)

This annex addresses compandor advantage in § A.1, followed by a recommendation of the permissible advantage limits for planning purposes (§ A.2). A requirement of circuit stability between compressor and expander is given in § A.3, and §§ A.4 and A.5 deals with aspects of system loading and companded circuits in tandem.

A.1 *Compandor advantage*

To define **compandor advantage**, assume:

a) an international circuit not equipped with compandors and contributing N dBm0 of noise to the overall end-to-end connection (including typical national extensions) and meeting the noise objectives of Recommendation G.152 or Recommendation G.153, and

b) the same international circuit equipped with compandors and connected to typical national extensions, yielding the noise performance subjectively equivalent to or better than that of the circuit described in a), while contributing N' dBm0 of noise in between compressor and expander.

Then the compandor advantage for the international circuit of b) is defined as $(N' - N)$ dB.

A.2 *Compandor advantage limit*

For planning purposes, the compandor advantage defined in § A.1 should not exceed 10 dB.

Note - It should be emphasized that this value applies to the international portion of the connection only. Other portions of the connection could permit a higher value when selected with due regard to the effect it has on the total noise of the end-to-end connection during the presence of the signal.

A.3 *Circuit stability*

The international circuit between compressor and expander should have an insertion loss which, when considered over a long period of time, has a standard deviation not exceeding 0.75 dB.

A.4 *Circuit loading*

It is generally advisable to select the unaffected level of the compandor equal to - 10 dBm0. However, if Administrations mutually desire to operate at a different value of unaffected level, it should be selected such that it results in a system loading which minimizes total distortion due to noise, intermodulation, or other load dependent characteristics and should always be dictated by the allowable compandor advantage limit.

A.5 *Compandored circuits in tandem*

The following paragraphs apply to circuits fitted with compandors according to Recommendation G.162.

Results of experiments with compandored circuit links in tandem show that two compandored links in tandem can produce a noticeable degradation only if the second link exceeds, by a considerable margin, the recommended compandor advantage limit of 10 dB. The experiment was admittedly designed to uncover gross effects by limiting the subjective judgement to only seven persons per test condition.

The conclusion drawn was that two links in tandem, each of which is limited to 10 dB compandor advantage, will not pose a restriction to users. This however, does not constitute sufficient guidance for application for the number of compandored links permissible in an end-to-end international connection.

References

[1] CCITT *Red Book,* Vol. V *bis,* Annexes B and C, ITU, Geneva, 1965.

[2] CCITT Recommendation *Setting-up and lining-up an international circuit for public telephony,* Vol. IV, Rec. M.580.

[3] CCITT Recommendation *Transmission characteristics of an international exchange,* Vol. VI, Rec. Q.45.

[4] CCITT Recommendation *Noise objectives for design of carrier-transmission systems of 2500 km,* Vol. Ill, Rec. G.222.

[5] CCITT Recommendation *Setting-up and lining-up an international circuit for public telephony,* Vol. IV, Rec. M.580, § 6.

[6] CCITT Recommendation *Transmission requirements of international voice-frequency telegraph links (at 50, 100 and 200 bauds)*, Vol. III, Rec. H.22.