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ITU-T

TELECOMMUNICATION
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OF ITU

G.120

(12/98)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

International telephone connections and circuits – General characteristics of national systems forming part of international connections

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Transmission characteristics of national networks

ITU-T Recommendation G.120

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION G.120

TRANSMISSION CHARACTERISTICS OF NATIONAL NETWORKS

Summary

This Recommendation was revised to consolidate all the characteristics of national networks into one Recommendation. Additionally, it tightened the requirement for noise induced by power lines and it now makes provision for the addition of Asynchronous Transfer Mode (ATM) technology to be integrated into the PSTN. This Recommendation provides guidance regarding the performance of national networks.

Source

ITU-T Recommendation G.120 was revised by ITU-T Study Group 12 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 3rd of December 1998.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation the term *recognized operating agency (ROA)* includes any individual, company, corporation or governmental organization that operates a public correspondence service. The terms *Administration, ROA* and *public correspondence* are defined in the *Constitution of the ITU (Geneva, 1992)*.

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Recommendation G.120

TRANSMISSION CHARACTERISTICS OF NATIONAL NETWORKS

(revised in 1998)

1 Scope

This Recommendation provides transmission performance guidance for national networks that form part of international connections to provide international telephony services.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] *Transmission planning of switched telephone networks*, ITU, Geneva, 1976.

[2] ITU-T Recommendation G.103 (1998), *Hypothetical reference connections.*

[3] ITU-T Recommendation G.111 (1993), *Loudness Ratings (LRs) in an international connection*.

[4] ITU-T Recommendation G.113 (1996), *Transmission impairments*.

[5] ITU-T Recommendation G.114 (1996), *One-way transmission time*.

[6] Recommendation G.116[1], *Transmission performance objectives applicable to end-to-end international connections*.

[7] ITU-T Recommendation G.121 (1993), *Loudness Ratings (LRs) of national systems*.

[8] ITU-T Recommendation G.122 (1993), *Influence of national systems on stability and talker echo in international connections*.

[9] ITU-T Recommendation G.131 (1996), *Control of talker echo*.

[10] ITU-T Recommendation G.173 (1993), *Transmission planning aspects of the speech service in digital public land mobile networks*.

[11] ITU-T Recommendation G.174 (1994), *Transmission performance objectives for terrestrial digital wireless systems using portable terminals to access the PSTN*.

[12] ITU-T Recommendation G.175 (1997), *Transmission planning for private/public network interconnection of voice traffic*.

[13] CCITT Recommendation G.232 (1984), *12-channel terminal equipments.*

[14] Recommendation G.235 (1988, withdrawn, *Blue Book*, Volume III, Fascicle III.2.) – *16-channel terminal equipments.*

[1] Presently at the stage of draft.

[15] ITU-T Recommendation G.712 (1996), *Transmission performance characteristics of pulse code modulation channels.*

[16] CCITT Recommendation Q.31 (1988), *Noise in a national 4-wire automatic exchange.*

[17] CCITT Recommendation Q.45 (1984), *Transmission characteristics of an analogue international exchange.*

[18] ITU-T Recommendation Q.551 (1996), *Transmission characteristics of digital exchanges.*

[19] ITU-T Recommendation Q.552 (1996), *Transmission characteristics at 2-wire analogue interfaces of digital exchanges.*

[20] ITU-T Recommendation Q.553 (1996), *Transmission characteristics at 4-wire analogue interfaces of digital exchanges.*

[21] ITU-T Recommendation Q.554 (1996), *Transmission characteristics at digital interfaces of digital exchanges.*

3 Application of ITU-T Recommendations on telephone performance to national networks

The different parts of a national network provided by both analogue and digital transmission systems to be used for an international connection should meet the following general recommendations:

3.1 The national sending and receiving systems should satisfy the limits recommended in:

– Recommendation G.113 as regards to transmission impairments;

– Recommendation G.114 as regards to group delay;

– Recommendation G.121 as regards to Loudness Rating (LR);

– Recommendation G.122 as regards to balance return loss and transmission loss;

– Recommendation G.131 as regards to echo control[2];

– Recommendation G.120:

- Clause 5 as regards to attenuation distortion;
- Clause 6 as regards to circuit noise;
- Clause 7 as regards to error on the reconstituted frequency;
- Clause 8 as regards to group delay distortion;
- Clause 9 as regards to linear crosstalk of circuits[3];
- Clause 10 as regards to non-linear distortion of analogue transmission systems; and
- Clause 11 as regards to variations of transmission loss with time.

3.2 Long-distance trunk circuits forming part of the main arteries of the national network should be high-velocity propagation circuits which enable the limits fixed in Recommendation G.114 to be respected.

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[2] Recommendation G.131 applies to control of network originated echo. Additional guidance for echo control can be found in: Recommendation G.116 for terminals, Recommendation G.173 for connecting digital public land mobile networks, Recommendation G.174 for connecting terrestrial digital wireless systems using portable terminals and Recommendation G.175 for connecting private networks.

[3] Guidance applicable to linear crosstalk on connections can be found in Recommendation G.116.

3.3 National trunk circuits should have characteristics enabling them to conform to Recommendation G.131.

3.4 International centres [Plesiochronous Digital Hierarchy (PDH)/Synchronous Digital Hierarchy (SDH)] should satisfy Recommendations Q.551, Q.552, Q.553 and Q.554.

National automatic analogue 4-wire centres should observe the noise limits specified in Recommendation Q.31.[4]

National digital switching centres should satisfy Recommendations Q.551, Q.552, Q.553 and Q.554.

International and national switching centres (Asynchronous Transfer Mode) should, in general, meet the Q.500-series Recommendations.[5]

4 National transmission plan

Every Administration is free to choose whatever method it considers appropriate for specifying transmission performance and to adopt the appropriate limits to ensure satisfactory quality for national calls. Nevertheless, the recommendations relating to Loudness Ratings (LRs), Recommendation G.121, should be satisfied for international calls.

NOTE – To meet this twofold condition with respect to national and international calls, each Administration has to draw up a national transmission plan, i.e. it must specify limits for each part of the national network.

The manual cited in [1] contains descriptions of the transmission plans adopted by various countries and also some indications concerning the methods that can be used to establish such a plan.

In particular, Annexes A and B to Recommendation G.111 contain useful information for Administrations who wish to apply the LR method to their national connections.

5 Attenuation distortion

The circuit performance objectives for attenuation distortion of international circuits and national extension circuits were originally selected so that acceptable performance would be obtained on analogue 4-wire chains of up to 12 circuits. Although it is recognized that the network is continuing its evolution to an all digital network, it is recommended that the individual equipment network performance objectives as presented in the following Recommendations not be relaxed: G.232 (which gives equipment design objectives for analogue 12-channel terminal equipments); G.712 (which gives equipment design objectives for digital PCM channelizing equipments); and Q.552 and Q.553 (which give equipment design objectives for digital switches).

It follows from the Recommendations mentioned above that, as a rule, the frequency band effectively transmitted by a telephone circuit, according to the definition adopted by the ITU-T (i.e. the band in which the attenuation distortion does not exceed 9 dB compared with the value for 1020 Hz), will be a little wider than the 300-3400 Hz band, and for a single pair of channel terminal equipments of this type, the attenuation distortion at 300 Hz and 3400 Hz should never exceed 3 dB and in a large number of equipments should not average more than 1.7 dB. It is recommended that all channel terminal equipments, including digital switches with analogue interfaces, be designed such that they can comply with the line-up limits specified in Figure 1. Analogue terminal equipments with

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[4] In accordance with Recommendation Q.31, the limits are the same as those which were specified in Recommendation Q.45 of the *Red Book* (1984).

[5] For example, the group delay requirement cannot be met if cell assembly of DS-0 rates is performed.

3-kHz-channel spacing, i.e. equipment intended to be G.235 compliant (Note that Recommendation G.235 is no longer in force.) is no longer recommended for use in international connections.

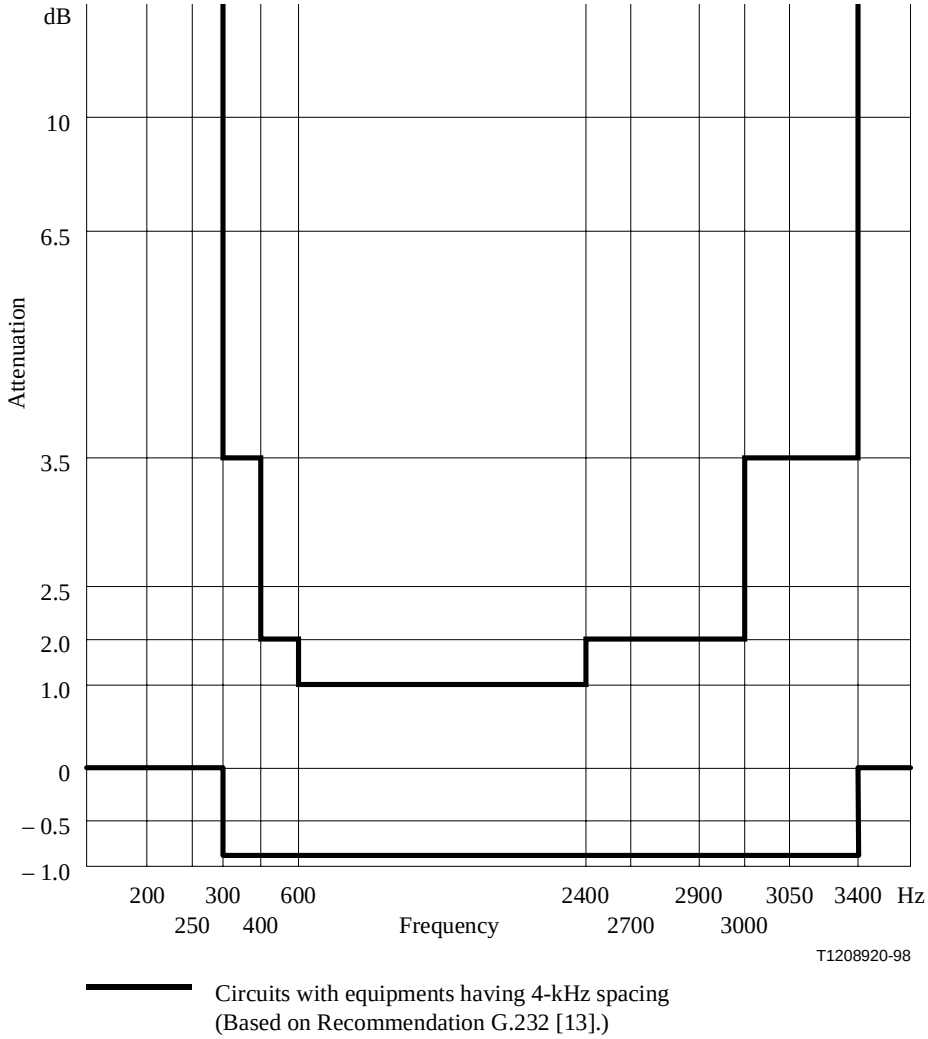

Figure 1/G.120 – Line-up limits of circuits with 4-kHz channel equipment

NOTE 1 – The ITU-T examined the possibility of recommending a specific frequency below 300 Hz as the lower limit of the frequency band effectively transmitted by network channelizing equipments, taking the following considerations into account:

1) The results of subjective tests carried out by certain Administrations show that it is possible to improve transmission quality if the lower limit of the transmitted frequency band is reduced from 300 Hz to 200 Hz. These tests show a definite increase in the loudness of the received speech, and also in the quality of the transmission as judged by opinion tests; the improvement in articulation is, on the other hand, very slight.

2) However, such an extension would probably have the following disadvantages:

   a) it would slightly increase the cost of equipment;

   b) it would introduce some difficulties in balancing the terminating sets at the ends of the 4-wire chain, if it were desired to use 4-wire circuits without exceeding the values of nominal transmission loss recommended in the new transmission plan;

   c) it would increase the possible susceptibility to interference, whether as subjective noise or as disturbances interfering with carrier equipment;

d) the additional energy transmitted in consequence of extending the band could increase the loading of carrier systems;

e) the out-of-band signalling systems recognized by the ITU-T could not be used.

In view of the above, the ITU-T has issued the aforementioned Recommendations (G.232, G.712, Q.552 and Q.553) concerning signals transmitted at frequencies between 300 and 3400 Hz on network channelizing equipments.

NOTE 2 – In applying the Recommendations (G.232, G.712, Q.552 and Q.553), Administrations may mutually agree to transmit signals at frequencies below 300 Hz over international circuits. Every Administration may, of course, decide to transmit signals at frequencies below 300 Hz over its national extension circuits, provided it is still able to apply the ITU-T transmission plan to international communications.

6 Circuit noise

6.1 Noise induced by power lines

The network performance objective for the noise produced from the influence of all the power lines affecting one or more parts of a chain of telephone lines[6] joining a subscriber's set to its international centre should not exceed 0.5 mV (psophometric weighed), this being the value at the line[6] terminals of the subscriber's set (when receiving), it being assumed that the telecommunication installations inserted in that chain are balanced to earth as perfectly as possible, in conformity with the most modern equipment construction.

It should be noted that, even in the case of perfectly balanced lines[6], the insertion of equipment having too great a degree of unbalance to earth may cause unacceptable noise at the customer's terminal.

In every national network, it is usually possible, in practice, to find switching centres such that some of the lines[6] that terminate at those centres (lines[6] in cable, conforming to ITU-T Recommendations) are free from noise arising from neighbouring power lines. It is then sufficient to determine the psophometric e.m.f.s arising from all the power lines[6] affecting one or more parts of the chain of lines[6] joining such a centre to the subscriber's set.

6.2 Noise contributed by transmission systems

6.2.1 Analogue systems

6.2.1.1 Analogue circuit ranging in length from very short distances up to 2500 km

The circuits in question are mostly set up in cable or radio-relay link carrier systems, such that the noise objectives of Recommendation G.222 are applicable to a circuit with the same make-up as the hypothetical reference circuit 2500 km long.

A consequence of Recommendation G.222 is that for a circuit the accumulated line noise should correspond to an average of not more than 2 pW0p/km, excluding very short circuits and those with a very complicated composition. Subclause 6.4 provides planning information regarding noise allocation for incremental analogue systems.

NOTE 1 – The permissible noise contributions from equipment do not depend on whether the circuits form part of the international 4-wire chain or are connected to it by 2-wire switching. However, the circuit noise powers assume that the hypothetical reference connections of Recommendation G.103 are, or will be in

6 "Line" as used in 6.1 should be understood as meaning subscriber's line, trunk junction or trunk circuit.

future, reasonably typical of connections. They also assume that the total length of circuits connecting the local exchange to the primary centre is not excessive.

NOTE 2 – Under the above conditions and assuming the maximum noise values permitted for pairs of channel modulators (200 pW0p), group modulators (80 pW0p) and supergroup modulators (60 pW0p), a total noise power of 500 pW0p will not be exceeded by a circuit connecting the local exchange to the primary centre (Figure 6/G.103) when its length is less than about 50 to 100 km.

6.2.1.2 Very long-distance circuits (about 2500-25 000 km)

The circuits in question are mostly set up in cable or radio-relay link carrier systems, such that the noise objectives of Recommendation G.222 are applicable.

A consequence of Recommendation G.222 is that for these circuits the accumulated line noise should correspond to an average of not more than 2 pW0p/km. Subclause 6.4 provides planning information regarding noise allocation for incremental analogue systems.

6.2.2 Use of companders to control noise on analogue systems

Companders are no longer recommended for use on international connections.

6.2.3 Digital system

Circuits provided by PCM systems which accord with Recommendation G.712 will have an acceptable noise performance which is substantially independent of their length.

6.2.4 Mixed circuits

The noise value in a circuit provided by both analogue and digital transmission systems depends on the whole length of analogue sections and of the number of codecs in a circuit. The noise generated in the analogue segment of the circuit should not be inconsistent with the noise recommendations of 6.2.1 above.

6.3 Noise in a national 4-wire automatic exchange[7]

6.3.1 Analogue 4-wire automatic exchanges

The noise requirements for an analogue 4-wire automatic exchange are specified in Recommendation Q.31 which contained limits similar to those which were specified in Recommendation Q.45.

The ITU-T recommends that no more than analogue 4-wire automatic exchanges be implemented to meet international traffic communications needs.

6.3.2 Digital 4-wire automatic exchanges

The digital switch should comply with Recommendations Q.551, Q.552, Q.553 and Q.554.

6.4 Noise allocation for a national system

6.4.1 General planning assumptions

Network planning should recognize the current state of evolution of the network and the rapid growth of digital wireless access services. As a result, operating configurations using analogue accesses and digital circuits, i.e. IDNs configured as per Figures 2/G.103 and 3/G.103, or digital accesses and telephone sets, i.e. ISDNs configured as per Figure 1/G.103, should be considered the norm in the majority of the national systems.

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[7] In accordance with Recommendation Q.31 [16], the limits are the same as in Recommendation Q.45 [17].

6.4.2 Noise allocations for planning digital systems

Noise allocation on a national basis is not required when national systems are planned using operating configurations consistent with Figures 1/G.103, 2/G.103 and 3/G.103.

6.4.3 Noise allocations for planning incremental analogue transport systems

Noise allocation, when planning to increment a national access arrangement using analogue technology, should comply with the following.

The noise powers indicated in the following text are nominal values.

Network planning should be such that the noise power entering the international network and attributable to national sending systems meets the limits of the following rule:

The psophometric noise power introduced by the national sending system at a point of zero relative level on the first international circuit must not exceed either (4000 + 4*L*) or (7000 + 2*L*) pWp, whichever is less, and where *L* is the total length in kilometres of the long-distance FDM carrier systems in the national chain. The corresponding quantities referred to the send virtual switching point are (1800 + 1.8*L*) and (3100 + 0.9*L*) pWp.

The derivation of this rule is explained in Annex A.

NOTE – A problem, which has already arisen in some national networks, as regards the receiving direction, is that when losses are reduced the circuit noise becomes more noticeable, particularly during periods of no conversation. This is particularly relevant in the case of large countries in which the noise contribution from line systems is high. Hence, if an Administration complies with a recommendation concerning national noise power levels and then subsequently improves transmission, perhaps by introducing 4-wire switching in lower-order exchanges, it may find itself in a worse situation as regards noise. It follows that it is important to preserve a proper balance between noise and loss.

7 Error on the reconstituted frequency

The recommended method of implementing active echo control to operate in compliance with Recommendation G.131 is through the use of echo cancellers. However, echo cancellers require that there be constraints placed on the error on the reconstituted frequency within the echo path. As the channels of any international telephone circuit should be suitable for terminating any international call, the network performance objective for the accuracy of the virtual carrier frequencies should be such that the difference between an audio frequency applied to one end of the circuit and the frequency received at the other end should not exceed 2 Hz, even when there are intermediate modulating and demodulating processes.

8 Group-delay distortion

The network performance objectives for the permissible differences for a national 4-wire extension, between the minimum group delay (throughout the transmitted frequency band) and the group delay at the lower and upper limits of this frequency band are indicated in the Table 1.

Group-delay distortion is of importance over a band of frequencies where the attenuation is of importance, i.e. at which the attenuation is less than 10 dB relative to the value at 800 Hz. This will normally be the case for frequencies higher than about 260-320 Hz and lower than about 3150-3400 Hz respectively for the lower and upper limit of the frequency band as indicated in Table 1.

Table 1/G.120 – Group-delay distortion limits for national 4-wire extensions

	Lower limit of frequency band (ms)	Upper limit of frequency band (ms)
Each of the national 4-wire extensions.	15	7.5
NOTE – Limits given in Table 1 should be met both for analogue circuits and mixed circuits with analogue and digital sections.		

9 Linear crosstalk of circuits

The circuit performance objective for the near-end or far-end crosstalk ratio (intelligible crosstalk only) measured at audio-frequency at trunk exchanges between two complete circuits in terminal service position should not be less than 65 dB.

NOTE – When a minimum noise level of at least 4000 pW0p is always present in a system (e.g. this may be the case in analogue satellite systems), a reduced crosstalk ratio of 58 dB between circuits is acceptable.

10 Non-linear distortion of analogue transmission systems

Experience has shown that telephone circuits set up on systems for which the ITU-T has issued Recommendations (the elements of which systems, taken separately, meet the relevant non-linearity requirements) are suitable for telephone transmission.

NOTE – In analogue carrier telephone circuits, the non-linear distortion produced by the line amplifiers and by modulation stages other than the channel-translating equipment can be ignored. Hence the above remarks are applicable to circuits of any length.

11 Variations of transmission loss with time

The ITU-T recommends the following objectives:

a) The standard deviation of the variation in transmission loss of a circuit should not exceed 1 dB. This objective can be obtained already for circuits on a single group link equipped with automatic regulation and should be obtained for each national circuit, whether regulated or not.

b) The difference between the mean value and the nominal value of the transmission loss for each circuit should not exceed 0.5 dB.

ANNEX A

Noise allocation for a national system

A.1 It is desirable that the noise power arising in national networks be limited in terms of the level appearing at the virtual switching points – the agreed interface between the national and the international network. In order to do this, some particular distribution of losses within the national network must be assumed. The solution is to adopt an agreed reference connection in order to specify maximum noise power levels from national sources referred to the virtual switching point of the international circuit.

A.2 Having regard to the way in which national networks are constructed, it is appropriate to express the noise allowance in the form $A + BL$ where A is a fixed allowance resulting from noise in exchanges and from short-haul multiplex systems, B is an allowance for a noise rate per unit length from long-haul multiplex systems and L is the total length of these latter systems in the national portion of the international connection. Two such expressions are necessary, one for countries of average size and another for large countries (in the sense of Recommendation G.121).

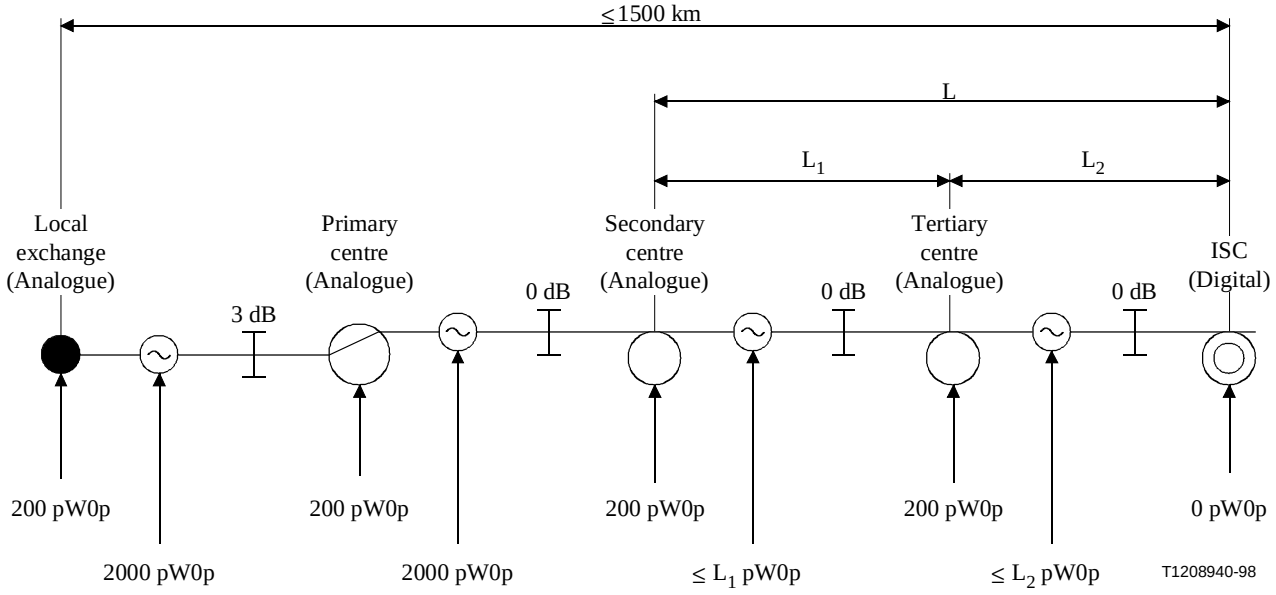
A.3 This approach is comparatively straightforward in the national sending system and serves to limit the amount of noise injected into the international connection.

A.4 *Average-sized countries* [i.e. not greater than 1500 km from the International Switching Centre (ISC) to the most remote local exchange].

The relevant hypothetical reference chain for the national sending system is given in Figure A.1. The circuit between the local exchange and the primary centre is assumed to be routed on an FDM carrier system of length not exceeding 250 km and operated at a nominal loss of 3 dB. The noise power on this circuit is taken to be the maximum value of 2000 pW0. The circuit between the primary centre and the secondary centre is also assumed to be routed on an FDM carrier system of the same type.

The line noise power rate of the two long-distance trunk circuits is assumed to be 4 pW/km and the total line length of these two circuits ($L_1 + L_2$ in Figure A.1) approaches the limit of 1500 km arbitrarily defining "a country of average size" in Recommendation G.121. It is thus assumed that the distance covered by the two short-haul systems is a very small proportion of the total length of the complete national sending system.

Each exchange is assumed to contribute 200 pWp in accordance with Recommendation G.103, Note 11 to Figure 6/G.103 and Recommendation Q.31.



NOTE – The noise values shown in this figure are maximum values; see also the corresponding element of Figure 1/G.103.

Figure A.1/G.120

The total noise power level referred to a point of zero relative level on the first international circuit at the ISC is (moving from right to left and adding in each successive noise contribution encountered):

$$0 + 4L_2 + 200 + 4L_1 + 200 + 2000 + 200 + \frac{1}{2}(2000) + \frac{1}{2}(200) = 3900 + 4L \ \ pW0$$

where $L = L_1 + L_2$. This may be conveniently rounded off to $4000 + 4L$ pW0.

This expression is valid for L not exceeding 1500 km leading to, at that distance, 10 000 pW0.

A.5 Large countries

When L is in excess of 1500 km the additional long-distance circuits in the national network should in principle be engineered to international standards, and in particular some large countries have found it necessary to plan national systems with noise power rates lower than 4 pW/km.

A convenient value to assume is 2 pW/km; this is in rough agreement with the practice of one such large country and is also in line with Recommendation G.153.

The rule for large countries has been established as shown in Figure A.2 in which the $4000 + 4L$ rule is shown passing through the point (1500 km, 10 000 pW). A line with a slope of 2 pW/km is constructed to pass through the same point and its intercept is seen to be 7000 pW. Hence the rule for large countries is $7000 + 2L$ pW0. (The 0.5 dB nominal loss of the last national circuit has been ignored for simplicity's sake.)

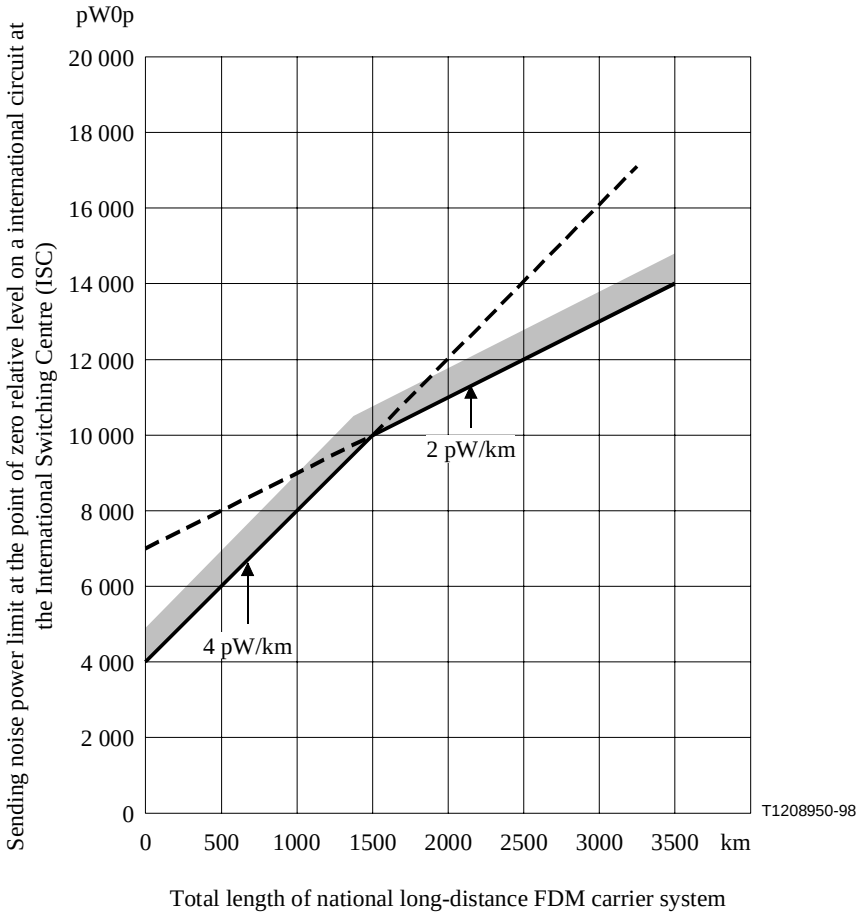


Figure A.2/G.120

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