5i’

1.2 General characteristics of national systems forming part of international connections

The following subsection groups together the Recommendations which national systems must conform to if international communications are to be of reasonable quality.

The principles of these Recommendations also apply in cases where an international circuit is 2-wire switched at one end in an international centre. This case may arise while the CCITT transmission plan is being implemented. The figure below illustrates the arrangement.

Figure CCITT-44861, p.

Recommendation G.120

TRANSMISSION CHARACTERISTICS OF NATIONAL NETWORKS

1 Application of CCITT 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:

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

— Recommendation G.121 as regards loudness rating (LR);

— Recommendation G.133 as regards group-delay distortion;

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

— Recommendation G.123 for circuit noise.

Note — Reference should also be made to Recommendations P.12 [2] and G.113.

1.2 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. They should conform to Recommendations G.151 and G.152.

Former Recommendation P.21 [1].

Loaded-cable circuits should conform to Recommendation G.124 [3] and carrier circuits to Recommendation G.123.

1.3 National trunk circuits should have characteristics enabling them to conform to Recommendations G.131, G.132 and G.134 as regards the other characteristics of the 4-wire chain constituted by the international telephone circuits and the national trunk extension circuits.

1.4 International centres should satisfy Recommendations Q.45 [4], Q.45 | fIbis , Q.551, Q.552 and Q.553.

National automatic 4-wire centres should observe the noise limits specified in Recommendation G.123, § 3.

Manual telephone trunk exchanges should satisfy Recommendation P.22 [5].

Information on the transmission performance of automatic local exchanges is given in the CCITT manual cited in [6].

2 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, it being understood that in addition the Recommendation 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 [6] 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 LE method to their national connections.

References

[1] CCITT Recommendation *Application of CCITT Recommendations on telephone performance to national networks* , Red Book, Vols. V and V | fIbis , Rec. P.21, ITU, Geneva, 1962 and 1965; amended at Mar del Plata, 1968, to become Rec. P.20 (G.120) *Transmission characteristics of national networks* , White Book, Vol. V (Vol. III), ITU, Geneva, 1969.

[2] CCITT Recommendation *Articulation reference equivalent (AEN)* , Yellow Book, Vol. V, Rec. P.12, ITU, Geneva, 1981.

[3] CCITT Recommendation *Characteristics of long-distance loaded-cable circuits liable to carry international calls* , Orange Book, Vol. III, Rec. G.124, ITU, Geneva, 1977.

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

[5] CCITT Recommendation *Manual trunk exchanges* , Orange Book, Vol. V, Rec. P.22, ITU, Geneva, 1977.

[6] CCITT manual *Transmission planning of switched telephone networks* , ITU, Geneva, 1976.

Recommendation G.121

LOUDNESS RATINGS (LRs) OF NATIONAL SYSTEMS

Preamble

Paragraphs 1 to 5 of this Recommendation apply in general to all analogue, mixed analogue/digital and all digital international telephone connections. However, where recommendations are made on specific aspects in § 6 for mixed analogue digital or all-digital connections, § 6 will govern.

All sending and receiving LRs in this Recommendation are ‘‘nominal values’’ as explained in § 4 of this Recommendation and are referred to the corresponding virtual analogue switching points of an international circuit at the international switching centre unless otherwise stated.

The definition of the virtual analogue switching points of international circuits can be found in Figure 1/G.111.

The CCITT,

considering

(a) that loudness ratings (LRs) as defined in Recommendation P.76 have been determined by subjective tests described in Recommendation P.78 and that the difference between the values thus determined in various laboratories (including the CCITT Laboratory) are smaller than for Reference Equivalents;

(b) that for planning purposes, LRs are defined by objective methods as described in Recommendations P.65, P.64 and P.79;

(c) that the conversion formulae from Reference Equivalents and corrected reference equivalents (CREs) (see Annex C to Recommendation G.111) are not accurate enough to be applied to specific sets; that therefore, the Administrations who still rely on values of Reference Equivalents (determined in the past in the CCITT Laboratory) for the type of the sets they use need to find recommended values of CREs in CCITT documentation,

recommends

(1) that the values given below in terms of LR should be used by Administrations to verify that their national systems meet the general objectives resulting from Recommendation G.111,

(2) that Administrations employing CREs should preferably translate the LRs of this Recommendation into their national CREs by the methods given in Annex C to Recommendation G.111 or, as a second choice, apply the values given in Volume III of the *Red Book* .

Note 1 — The main terms used in this Recommendation are defined and/or explained in Annex A to Recommendation G.111.

Note 2 — For many telephone sets using carbon microphones, the SLR and STMR values can only be determined with limited accuracy.

1 Nominal LRs of the national systems

1.1 *Definition of nominal LRs of the national systems*

Send and Receive Loudness Ratings, SLRs and RLRs respectively, may in principle be determined at any interface in the telephone network. When specifying SLRs and RLRs of a national system, however, the interface is chosen to lie at the international exchange.

An increasing number of international systems will be connected to national systems via a *digital* | interface where by definition the relative levels are 0 dBr. Therefore, in this Recommendation and in Recommendation G.111 the SLRs and RLRs of the *national systems* | are referred to a *0 dBr exchange test point* | at the international exchange. See Recommendation G.101, § 5. This convention is applied both for digital and analogue interconnections between the national and international systems (unless otherwise specified in particular cases).

However, the concept of ‘‘virtual analogue switching point’’, VASP, has also been used in the planning of all-analogue, mixed analogue-digital and digital systems. If the connection to the international circuit is made on an analogue basis the *actual* | relative levels at the interface may of course be chosen by the Administration concerned. For a discussion of these matters, see Recommendation G.111, § 1.1.

In this Recommendation, values at the VASP are also given.

1.2 *Traffic-weighted mean values of the distribution of send and receive loudness ratings, SLRs and RLRs*

An objective for the mean value is necessary to ensure that satisfactory transmission is given to most subscribers. Transmission would not be satisfactory if the maximum values permitted in § 2 were consistently used for every connection.

An appropriate subdivision of the overall loudness requirement is obtained by the following long-term objectives referred to a 0 dBr international switching point.

SLR : 7 to 9 dB

RLR : 1 to 3 dB

and at the VASP

SLR : 10.5 to 12.5

RLR : —3 to —1

Note 1 — In some networks the long-term values cannot be attained at this time and appropriate short-term objectives are at 0 dBr

SLR : 7 to 15 dB

RLR : 1 to 6 dB

and at the VASP

SLR : 10.5 to 18.5 dB

RLR : —3 to 2 dB

Note 2 — In some networks the actual traffic distribution is known only incompletely. In such cases, subscribers generating heavy traffic, like PBXs, should be given special consideration.

Note 3 — The long-term traffic weighted mean values of LRs should be the same for each *main* | type of subscriber categories, such as urban, suburban and rural. Only considering the mean value for the *whole* | country in the transmission plan might lead to a discrimination of some important customer groups.

Note 4 — The ranges stated for SLR and RLR are for planning and do not include measuring and manufacturing tolerances.

Note 5 — Some Administrations have found it advantageous in some circumstances to include a manual volume control in the receive part of the digital telephone set. See the remarks made in Rec. G.111, § 3.2.

2 Maximum Send and Receive Loudness Ratings, SLR and RLR

2.1 *Values for each direction of transmission*

The maximum SLRs and RLRs given below in Table 1/G.121 mainly apply when the national system is predominantly analogue. When modernizing networks by digital techniques, efforts should be made to avoid having those maximum values for the national system.

H.T. [T1.121]

TABLE 1/G.121

Nominal maximum LRs recommended for national systems

Country size | ua)	{	VASP SLR	RLR	SLR	RLR
Average	Up to 3	16.5	13 |	20 |	9 |
Large	4	17 |	13.5	20.5	9.5
Large	5	17.5	14 |	21 |	10 |

a) See Recommendation G.101, § 2.2.

b) Analogue or mixed analogue/digital.

Note — When comparing these maximum values of LRs with LRs determined for existing networks some discrepancies may be found. If the actual LRs are greater by 2 or even 3 dB this is no cause for concern. On the other hand, if a margin of 2 or 3 dB seems to appear, the permissible attenuation for subscriber lines should not automatically be increased. The first step should instead be to use the margin to improve the traffic-weighted mean values referred to in § 1.2. _

Table 1/G.121 [T1.121], p.

2.2 *Difference in transmission loss between the two directions of transmission in national systems*

It has been found pratical to introduce a certain difference in loss between the directions 4-wire-to-2-wire and 2-wire-to-4-wire. As can be seen from Figure 1/G.121 this difference is equal to $D_o = (R - T)$ dB referred to the 0 dBr 4-wire reference points. Referred to the VASPs as in Figure 1/G.122 the difference is $D_v = (R - T - 7)$ dB. For international transmission compatibility it is desirable that Administrations choose approximately the same value of these differences. Table C-1/G.121 indicates that $R = 7$, $T = 0$ dB are the most common pad values, giving $D_o = 7$, $D_v = 0$ on the average. For planning of new networks, these are the preferred values. Thus, the difference in loss between the two directions of transmission on an international connection should not exceed 8 dB, preferably not 6 dB.

The following points should be noted:

1) Bearing in mind that most Administrations allocate the losses of their national extension circuits in much the same sort of way connections set up in practice should not exhibit differences much in excess of 3 dB.

2) As far as speech transmission is concerned, from the studies carried out by several Administrations in 1968-1972, it is clear that for connections with overall LRs falling within the range found in practice, no great disadvantage attaches to any reasonable difference in LR between the two directions of transmission.

3) When devising national transmission plans, Administrations should take into account the needs of data transmission between modems complying with the pertinent Recommendations.

3 Minimum SLR

Administrations must take care not to overload the international transmission systems if they reduce the attenuation in their national trunk network.

Provisionally a nominal minimum value of $SLR = -1.5$ dB referred to a 0 dBr point or 2 dB referred to the send virtual analogue switching point of the international circuit is recommended in order to control the peak value of the speech power applied to international transmission systems. It should be noted that the imposition of such a limit does not serve to control the long-term mean power offered to the system.

In some countries a very low sending loudness rating value may occur if unregulated telephone sets are used. Furthermore, the speech power applied to the international circuits by operators' sets must be controlled so that it does not become excessive.

4 Determination of nominal Loudness Ratings

Loudness Ratings and their properties and uses are explained in Annex A to Recommendation G.111. There it is described how a particular LR of a national system may be determined as a sum of the individual LRs of its parts. Also, rules are given for how to obtain the individual LRs of these parts, i.e. for telephone sets, subscriber lines, junctions, channel equipment, etc.

Note that Send and Receive Loudness Ratings of *analogue telephone sets* | are measured under specified conditions which do not exactly correspond to those valid for a national system which is part of an international connection. The measurements are done with a terminating impedance of 600 ohms resistive and over a much wider bandwidth (100-8000 Hz or 200-4000 Hz) than the assured bandwidth of the international connection (300-3400 Hz).

Therefore, to avoid confusion, measured values of Send and Receive Loudness Ratings of *analogue* | telephone sets are designated by the index ''w'' (for wideband). To get the proper values of SLR and RLR for *planning* | international connections, 1 dB should be added to the measured values in order to compensate for bandwidth and impedance mismatch effects. Thus,

$$SLR = SLR_w + 1$$

$$RLR = RLR_w + 1$$

A *digital* | telephone set, however, does not need these corrections because the codec and filters in the set limit the band anyhow.

In general, the loudness loss between *two electrical interfaces* , | the Circuit Loudness Rating CLR, is equal to the corresponding difference in relative levels. (Unless an interface with a ‘‘jump’’ in relative level is included in the path. See § 6.3.)

‘‘Nominal value’’ here signifies a ‘‘reasonable engineering average’’ for typical conditions as exemplified in what follows, excluding ‘‘worst cases’’.

With regard to circuits and other items of equipment, variations with time, temperature etc. are not included in the nominal CLRs, Circuit Loudness Ratings.

For telephone sets, most Administrations today have to accept a large variety of types which comply with some national specification having rather wide limits. The requirements for SLR and RLR usually refer to a measuring setup with a variable artificial line terminated by a feeding bridge and a nominal impedance which may be complex or, most often, 600 ohms.

The specification is often drawn up in the form of upper and lower limits for SLR_w | and RLR_w | as functions of line length (or possibly line current). The ‘‘nominal’’ SLR_w | and RLR_w | of telephone set plus subscriber line may then be interpreted as the arithmetic mean between the upper and lower limit curves.

In practice, the subjective quality impression of the overall loudness changes rather insignificantly for fairly large variations of OLR around the optimum value and it is unlikely that sets with worst possible LRs are associated with limiting line lengths. Therefore, rather wide manufacturing tolerances, commonly about ±3 dB, can be accepted for the individual set SLR (set) and RLR (set). (SLR (set) and RLR (set) refer to set measurements without the subscriber line but as function of line current, including the 1 dB bandwidth correction.)

Note however, that the *sum* | of SLR (set) + RLR (set) for an individual 2-wire telephone set must be controlled more carefully so that is does not decrease below a certain minimum value. The reason is that, under certain circumstances, subscribers react very unfavourably to strong sidetone and talker echo. Both effects depend directly on this LR sum in addition to the unavoidable network impedance variations. This minimum limit is often translated into a minimum limit for STMR as measured against a specified impedance. See § 5 for a discussion.

5 Sidetone

5.1 *General*

Especially for those connections approaching the limits for high Loudness Ratings and/or noise, further transmission impairments should be avoided. One important precaution is to ensure that an adequate *sidetone*
| performance is maintained for the various circuit combinations occurring in the telephone system. (‘‘Adequate’’ is in most cases to be interpreted as a sufficiently high sidetone loss.)

For 2-wire telephone sets, the sidetone performance is basically dependent on set sensitivity and impedance variation limits as explained in Annex A to Recommendation G.111. Thus, a national transmission plan should not only give rules for allocation of losses in the network but also provide an appropriate impedance strategy to follow. (An example is given in Supplement No. 10 of Vol. VI.)

Note that for sidetone evaluations one has to consider the line impedance ‘‘seen’’ by the 2-wire telephone set in the actual, *complete*
| connection. In modern system configurations this impedance cannot always be simulated by an artificial line terminated by a simple R-C network. Either one has to use a more elaborate measuring setup or resort to computations from known data of the circuits involved. (A number of computer programs exists which can be employed for such purposes.)

Of special interest is the fact that a 4-wire link inserted in a 2-wire connection may cause large impedance variations. As this is a common network practice — for instance digital exchanges — a simplified calculation method is discussed in Annex B.

Ideally, a 2-wire telephone set could be designed to have an adaptive sidetone balancing function, thus widening the acceptable range of line impedances. Such costly techniques are very exceptional, however, and should not be prescribed for the ‘‘standard’’ sets to be used in the network. A possible, cheaper alternative is to design a set with a $Z_{s\backslash do}$ | varying in a predetermined manner with the line feeding current. ($Z_{s\backslash do}$ = equivalent sidetone balance impedance.) However, the best strategy is to control the impedances in the network. Thus, the use of complex nominal input impedances to exchanges is tending rather to reduce the range of impedances seen from the set.

Digital telephone sets are of course connected 4-wire to the digital network and thus there exists no near-end impedance mis-match to produce a sidetone effect. Instead, a small, internal feedback from send to receive is introduced. For judging the overall transmission quality the far-end effects have to be considered. However, those effects caused by impedance mis-matches and/or acoustic echoes can have a substantial influence.

Under some difficult transmission circumstances, analog telephone sets are also 4-wire connected to the network. This applies for (analog) mobile and maritime services and, in the past, for some exceptionally large, private networks.

5.2 *Talker's sidetone STMR*

STMR, the sidetone masking rating, is explained in Annex A.1 to Recommendation G.111. How to determine STMR is described in Annexes A.3 and A.4 to Recommendation G.111. See also Annex B to Recommendation G.121 and Recommendations P.76 and P.79.

In a face-to-face conversation there is a certain airpath feedback from the talker's mouth to his ear, partly via room reflexions. Using the handset in a telephone conversation the electric sidetone path should provide about the same feedback, the acceptable range being rather large. Unfortunately, in many present 2-wire connections the impedance deviations from the ideal are so large that the electric sidetone feedback becomes too strong, i.e. STMR too low. This causes the speaker to lower his voice and/or move the ear-phone away from his ear, thus impairing the acoustic transmission quality.

The following values are given as a guide for transmission planning.

For 2-wire telephone sets:

STMR = 7 — 12 dB: Preferred range.

STMR = 20 dB: Upper limit, above which the connection feels dead.

STMR = 3 dB: Lower limit, acceptable only for low-loss connections, i.e. low OLR.

STMR = 1 dB: Lowest (short-term) limit for exceptional cases, such as very short subscriber lines.

For digital (4-wire) telephone sets:

STMR = 15 ± 5 dB: Preferred range for near-end, introduced sidetone (far-end effects disregarded).

Note 1 — When *STMR* = 7 or 8 dB, this corresponds to the average acoustic loss from the talker's mouth to his ear via the electric sidetone path being about 0 dB in typical cases.

Note 2 — STMR has to be determined for the *complete* | connection. (See the comments made in § 5.1.)

Note 3 — In the presence of high room noise, requirements on LSTR may be the controlling factor.

Note 4 — If the reflected electric signal has a noticeable delay it is interpreted as an echo rather than sidetone, which means it needs more suppression to avoid subscriber dissatisfaction. See Recommendations G.122 and G.131. (Recent investigations indicate that at a delay of 2-4 ms, the echo begins to be clearly distinguishable from even a strong ‘‘normal’’ sidetone.) The problem is under study in Question 9/XII.

5.3 *Listener's sidetone LSTR*

LSTR, the listener's sidetone rating is defined in Annex A.1 to Recommendation G.111. How to determine LSTR is described in Annexes A.3 and A.4 to Recommendation G.111.

The presence of a listener's sidetone means that room noise is picked up by the handset microphone and transmitted to the handset ear via the electric sidetone path. LSTR is a measure of how well this room noise sidetone is suppressed. Too low values of LSTR means that the room noise will be *amplified* | at the handset ear. This is obviously very disturbing for subscribers in noisy environments, especially for high-loss connections.

Note — High noise gives the impression of lower received speech levels.

For a particular telephone set there is a fixed relation between the talker's and the listener's sidetone, STMR and LSTR respectively. For sets with linear microphones LSTR is typically between 1.5 and 4 dB higher than STMR, independent of the noise level. For carbon microphone sets the difference is dependent on the room noise level, a threshold effect being noticeable. For 60 dB(A) room noise (Hoth-type) the difference is in the order of 6 to 8 dB. (For other noise levels and some handset designs the difference can be as high as 15 dB.)

In general, subscribers prefer sets with linear microphones because the sound quality is much superior. However, when replacing old carbon microphone sets in noisy environments with modern linear sets, care must be taken to ensure that the LSTR-value is sufficiently high. (However, some linear microphone sets do include a noise threshold function.)

The following value should be striven for in modern telephone systems:

$$LSTR > 13 \text{ dB}$$

Note 1 — *LSTR* = 13 dB corresponds approximately to that of the earcap of the handset functions as a shield for the room noise with an average attenuation of 5 or 6 dB. (For the higher frequencies; the lower frequencies leak past the earcap.)

Note 2 — LSTR has to be determined for the *complete*
| connection. (See the comments made in § 5.1.)

6 Incorporation of PCM digital processes in national extensions

6.1 *Effect on national transmission plans*

The incorporation of PCM digital processes into national extensions might require that existing national transmission plans be amended or replaced with new ones.

The national transmission plans to be adopted should be compatible with existing national analogue transmission plans and also capable of providing for mixed analogue/digital operation. In addition, the plans should be capable of providing for a smooth transition to all-digital operation.

Thus, the transmission planning of transitional phases should preferably not involve any degradation of the quality previously experienced.

6.2 *Transmission loss considerations*

Where the national portion of the 4-wire chain is wholly digital between the local exchange and the international exchange, the transmission loss which the extension must contribute to the maintenance of stability and the control of echo on an international connection can be introduced at the local exchange. The manner in which the required loss should be introduced is to be governed by the national transmission plan adopted. Three of possibly many different configurations of such national extensions are shown in Figure 1/G.121.

In case 1 and 2 of Figure 1/G.121, the R pad represents the transmission loss between the 0 dBr point at the digital/analogue decoder and the 2-wire side of the 2-wire/4-wire terminating unit. Similarly, the T pad represents the transmission loss between the 2-wire side of the 2-wire/4-wire terminating unit and the 0 dBr point at the analogue/digital coder. In practice there can be levels other than 0 dBr and hence consequential changes in the R and T pad-values.

The individual values of R and T can be chosen to cater for the national losses and levels, provided that the CCITT Recommendations for international connections are always met. It is recognized that for evolving networks, the values of R and T may not be the same

as the values appropriate to the all digital 4-wire national chain. However, for the case of an all-digital national chain, the choice of values of R and T is particularly important in determining the performance in respect of echo and stability. For example, if the balance return loss at the 2-wire/4-wire terminating unit can approach 0 dB under worst case terminating conditions, then the sum of R and T needs to be at least so high that the requirements of Recommendation G.122 are to be met. Examples of the values for R and T that have been adopted by some Administrations are given in Annex C to Recommendation G.121.

In case 2 of Figure 1/G.121, it is possible with a sufficiently high balance return loss to comply with the Recommendations concerning loudness ratings, stability, and echo without requiring a particular value for the sum of the R and T pad values. However it will still be necessary to comply with the provisions concerning differential loss (§ 6.4 of this Recommendation) which in turn implies that

$$R — T = 3 \text{ to } 9 \text{ dB}$$

Figure 1/G.121, p.3

Figure 1/G.121, p.4

However, a local exchange designed on these principles and which is at the end of a national extension containing asymmetric analogue portions cannot take the whole of the asymmetry allowance.

The R and T pads shown in Figure 1/G.121 are also shown as analogue pads. This type of pad might not necessarily be introduced under all conditions. In some situations it might be more practical to introduce the required loss at the local exchange, or at some other point of the national extension, by means of digital pads. However, if digital pads are used, their detrimental effect on digital data or other services requiring end-to-end bit integrity must be taken into account as indicated in Recommendation G.101, § 4.4 and G.103, § 4.

For speech, the quantizing distortion will increase. See Recommendation G.113, § 4. The concept of relative levels is also affected by a digital pad. See § 6.3.

The arrangement in case 3 of Figure 1/G.121 assumes 4-wire digital switching at the local exchange in combination with a 4-wire digital local line and a 4-wire ‘‘digital telephone set’’.

Stability and echo on international connections are governed by Recommendation G.122.

6.3 *The designation of relative levels and digital pads*

‘‘Relative level ´which one can determine gain or loss between points in a system as well as signal handling requirements for transmission equipment. The general definitions are found in Recommendation G.101. To clarify further the use of relative levels in Recommendations G.111 and G.121 some special aspects will be discussed here.

The relative level at a point of a circuit is in principle determined by comparison with the ‘‘transmission reference point’’, TRP, for that circuit, a *hypothetical* | point used as the zero relative level point. Such a point exists at the sending end of each channel of a 4-wire switched circuit preceding the international exchange.

When the international connection is *digital* | by means of a conventional PCM system, the transmission reference point is equal to the digital exchange test point i.e. the digital bit stream is associated with a relative level of 0 dBr. The power handling capacity of the digital bit stream is interpreted as the clipping level of a sinusoidal signal when introduced via an ideal codec: +3.14 dBm for the A-law, +3.17 for the μ-law (see Recommendation G.101, §§ 5.3.2.4 to 5.3.3.2).

When the international connection is established by an *analogue* | (FDM) system, the transmission system would be designed to handle a power load of —15 dBm per channel at the transmission reference point if this existed in physical form. Thus, when the transmission system has a (nominal) power handling capacity of (—15 + S) dBm at the actual international interconnection point the relative level at that point is +S dBr.

In normal network situations, the relative level at a certain point is numerically equal to the ‘‘composite gain’’ between that point and the transmission reference point for the circuit concerned at the reference frequency 1020 Hz. For instance, for analogue international connections the sending relative level at VASP, the virtual analogue switching point, is —3.5 dBr (by definition). The loss of the international circuit is 0.5 (as recommended by the CCITT) and thus the relative level at the receive VASP in the other country is —4 dBr.

Likewise, in normal network cases, circuits are interconnected with matching power handling capabilities.

Thus digital (PCM) bit streams not subjected to digital gain or loss are always associated with a relative level of 0 dBr.

In some exceptional cases however, the rules relating relative level to ‘‘composite loss’’ and ‘‘power handling capacity’’ do not apply exactly. For practical reasons some types of interfaces will have ‘‘jumps’’ in relative levels because two (or more) different transmission reference points occur in tandem.

One example is digital gain or loss introduced in the send direction. Following the definition given in Recommendation G.101, § 5.3.2.6 there will be a jump in relative level as illustrated in Figure 2/G.121 at point B. The loss between points A and B is T dB but the difference in relative level is 0 dB.

Another example is to be found in certain international connections which include several 4-wire (analogue or mixed analogue-digital) systems in cascade between the VASPs. If there are no such circuits, for stability reasons the loss is then made equal to n | (mu | .5 dB.

Figure 2/G.121, p.

Note 1 — The ‘‘power handling capacity’’ refers to a *nominal* | load, not to the *actual* | load which the system is subjected to. For instance, for an analogue system at the TRP the nominal load of —15 dBm corresponds to 0.032 mW of which 0.010 mW is considered to originate from signalling and tones, 0.022 mW from speech, carrier leaks and voice telegraphy. The nominal speech load at the TRP thus is —16.6 dBm taken as an average with time from a batch of channels during a busy hour. The actual average speech level may very well differ from this value. This is of course even more probable for an individual channel. (However, the aim should always be for the actual load to be close to the nominal load for which the transmissions system gives optimum performance.)

Note 2 — For many reasons, digital gain or loss should be used only exceptionally in a network.

Note 3 — If digital gain or loss is introduced the firm relations between relative level and power handling capacity may be lost. For instance, in an arrangement in accordance with Figure 2/G.121 the actual possible maximum peak level to the right of point B (i.e. at 0 dBr) will be *T* dB lower than + 3.14 dBm. Likewise, to the left of point B (i.e. at —*T* dBr) the noise threshold level will be *T* dB higher than in a normal PCM system.

ANNEX A
(to Recommendation G.121)

Evaluation of the nominal differences

of loss between the two directions of transmission

A.1 Consider an international connection between primary centres in two Administrations, established over one international circuit as shown in Figure A-1/G.121.

Figure A-1/G.121, p.

The nominal overall losses in each of the two directions of transmission are:

$$1\ \ 2 = t_1b_1 + 0.5 + a_2t_2 \quad \text{(dB)}$$

and

$$2\ \ 1 = t_2b_2 + 0.5 + a_1t_1 \quad \text{(dB)}$$

where *a* | and *b* | are defined as in Recommendation G.122, so that the difference between the two directions is:

$$(t_1b_1 - a_1t_1) - (t_2b_2 - a_2t_2) = d_1 - d_2$$

in which *d* signifies $d_1 = t_1b_1 - a_1t_1$ or $d_2 = t_2b_2 - a_2t_2$.

Note — As long as the 2-wire nominal impedance are resistive there is no problem in defining ‘‘loss’’. The modern trend is toward using complex nominal impedances, however, and then some conventions have to be observed. In Recommendation Q.551, § 1.2.3 — § 1.2.5 is prescribed how to measure digital exchanges with analogue parts. In short, the rules are:

a) The equipment (circuit) is measured under nominally matched impedance conditions for the analogue ports. During the measurements, the 4-wire loop must be broken in the return direction. (In practice, this means *either* | between two physical impedances as is the case for 600 ohms measurements *or* | between a low-impedance generator and a high-impedance indicator. Either method can be used, depending on what is most practical. The measurement results do not differ very much.) Note when the second method is used, a 6 dB correction must be applied.

b) The nominal loss is the composite loss at the reference frequency 1020 Hz (i.e. the voltage loss corrected by 10 times the logarithm of the impedance ratio).

c) The attenuation distortion as a function of the frequency f | is 20 times the logarithm of the ratio of the voltage at 1020 Hz to the voltage at f.

ANNEX B

(to Recommendation G.121)

Transmission considerations for a 4-wire loop

inserted in a 2-wire circuit

B.1 *General*

A 4-wire loop normally exhibits a considerable change of phase as a function of frequency. Thus, it may have a large influence on the attenuation distortion and the impedances when inserted in a 2-wire circuit because of the reflexions encountered. In what follows exact expressions will be given for loss and impedance together with an approximate rule useful for estimating certain sidetone effects.

Figure B-1/G.121, p.

In Figure B-1/G.121 is shown a 4-wire loop with 2-wire ports Nos. 1 and 2. The following designations are used.

Terminating impedances: Z_1 and Z_2.

2-wire input impedances (4-wire loop open): $Z_{o\backslash d1}$ and $Z_{o\backslash d2}$.

Balance impedances: $Z_{b\backslash d1}$ and $Z_{b\backslash d2}$.

Loss and phase shift under matched load conditions, i.e. $Z_1 = Z_{o\backslash d1}$ and $Z_2 = Z_{o\backslash d2}$;

from port 1 to port 2 (4-wire loop open from port 2 to 1): L_1 dB, B_1 deg;

from port 2 to port 1 (4-wire loop open from port 1 to 2): L_2 dB, B_2 deg.

We now define the following (complex) factors:

The balance return losses at port 1 and 2 are:

Note that the balance return losses may become *negative* | for some terminations. Therefore, a few comments will be given on this aspect as some peculiar circuit configurations can be encountered during the setup of a call.

The minimum balance return loss at a port with (2-wire) input impedance Z_o | and balance impedance Z_b | occurs when the terminating impedance is a *pure reactance* , | the value of which depends on Z_o | and Z_b. (Thus in general, neither the open- or the short-circuit condition!)

The minimum balance return loss value is:

Formula F3.121 to be inserted here.

where

Formula F4.121 to be inserted here.

A case of special interest is when by design Z_o | is made identical with Z_b. Then Equation (B-4) transforms into:

Formula F5.121 to be inserted here.

This minimum occurs when the terminating impedance is a pure reactance *jX* | of *opposite* | sign to the reactance of Z_o | and has the value:

Formula F6.121 to be inserted here.

Note 1 — In general, the more reactive Z_o | and Z_b | are, the lower will the minimum balance return loss be when unfortunate terminations are met within the network. For instance, if Z_o | and Z_b | would be exactly matched to the unloaded subscriber cable characteristic impedance angle of —45^o, $(L_{b\backslash dr})_{m\backslash di\backslash dn}$, equals —7.7 dB. Thus, extremely reactive values of Z_o | and Z_b | should be avoided.

Note 2 — For *normal* | cases encountered in the network the terminations, as well as the balancing networks, most often have a negative reactive component. The balance return loss and the return loss also do not differ very much numerically.

Note 3 — In many practical cases open- and short-circuit conditions represent ‘‘worst cases’’.

B.2 *Attenuation*

According to the CCITT convention for loss with complex, nominal impedances, the loss from port 1 to port 2 with the 4-wire loop closed is

Formula F7.121 to be inserted here.

The sum of the first four terms represents the loss which would be measured with the 4-wire loop broken in the return direction from port 2 to port 1. The second term is a correction for the terminating impedances being unequal. (Assuming Z_1 and Z_2 are the nominal, reference impedances.) The third and fourth terms represent mis-match effects.

Finally, the fifth term shows the ripple effects due to loop phase shift and non-perfect balancing at the ports, i.e. $Z_{b\backslash d1}$ not being equal to Z_1 and $Z_{b\backslash d2}$ not to Z_2.

B.3 *Impedance*

When the 4-wire loop is closed the input impedance at port 1 is:

Formula F8.121 to be inserted here.

A measure of the deviation of $Z_{i\backslash dn\backslash d1}$ from the nominal 2-wire input impedance $Z_{o\backslash d1}$ can be had from the return loss:

Formula F9.121 to be inserted here.

Using Eq. (B—8) we get

Formula F10.121 to be inserted here.

Note 1 — The last term in Equation (B-10) represents a (high-periodicity) ripple. However, often it is not very large. If $Z_o = Z_b$ | it is zero!

Note 2 — If the loop loss $(L_1 + L_2)$ is low, the effective input impedance at one port can be appreciably affected by conditions at the other.

B.4 *Sidetone considerations*

Sidetone effects can be most critical for subscribers very close to a digital exchange, i.e. with zero line length. Therefore, we will here study this case in some detail.

If a subscriber is connected directly to port 1 in Figure B-1/G.121, Equation (B-8) can be used to compute the impedance Z | the telephone set sees at its terminals. Then the sidetone balance return loss $A_{r\backslash ds\backslash dt}$ | and its weighted mean value A_m | is calculated as is shown in Annex A.4.3 to Recommendation G.111, using the telephone set input impedance Z_c | and its equivalent sidetone balance impedance $Z_{s\backslash do}$. | Finally, the talker's and the listener's sidetones, STMR and STLR respectively, are obtained using the value of A_m | in Equation (A.4-3) in Annex A to Recommendation G.111.

The procedure just described is somewhat tedious as it involves the exact computation of the 2-wire impedance of the closed 4-wire loop. To give a rapid indication of the magnitude of sidetone effects the following simplified method can be used.

The sidetone mis-match effects are considered as the superposition of two ''echo'' effects, namely:

a) The sidetone balance return loss $A_{r\backslash ds\backslash dt\backslash d1}$ between the telephone set and the *nominal* | input impedance $Z_{o\backslash d1}$ of the (near-end) port to which the set is connected. The weighted mean value $A_{m\backslash d1}$ is computed using Equation (A.4-3) in Annex A to Recommendation G.111.

b) The far-end port impedance mis-balancing translated to the near-end part i.e. the return loss $L_{r\backslash d1}$ as given by Equation (C-10) is used to compute a mean value $A_{m\backslash d2}$ by means of Equation (A.4-3) in Annex A to Recommendation G.111.

Finally, the two ''sidetone echoes'' are added on a power basis to give a new weighted mean value:

Note — The far-end impedance mis-match effects will of course be interpreted not as a sidetone but as an echo if the round trip delay is long. The change from sidetone to echo perception might begin at a delay of about a few milliseconds. (This problem is under study in Question 9/XII.) Long-delay echoes are far more noticeable than sidetone.

ANNEX C
(to Recommendation G.121)

Examples of values of R and T pads adopted by some Administrations

This annex gives the values of R and T pads that have been adopted by some Administrations for their digital networks. The values given are those appropriate for digital connections between subscribers with existing analogue 2-wire subscriber lines on digital local exchanges. It is recognized that different values may be appropriate for connections in the evolving mixed analogue/digital network.

These values are given as guidance to developing countries who are considering the planning of new networks. If similar values are adopted for new networks then, in association with adequate echo and stability balance return losses, there are unlikely to be difficulties in meeting the requirements of Recommendation G.122.

Ignoring the last term.

Some Administrations consider losses in terms of the input and output relative levels. These values can be derived from Table C-1/G.121 by using the relationship given in Figure C-1/G.121.

Figure C-1/G.121, p.

In this circuit, it is assumed that the relative levels of the encoder input and the decoder output are 0 dBr, that the T-pad represent all the loss between the 2-wire point, t, and the ecoder input, and that the R-pad represents all the loss between the decoder output and t. Accordingly, the relation between relative levels and losses is:

$$L_i = T \, , \, L_o = -R$$

Note — The modern trend is to use a complex nominal impedance at the 2-wire port. See the note in Annex A.1 for how ‘‘loss’’ should be interpreted in such a case.

In exceptional cases, some of the R and T losses may be achieved by digital pads. See § 6.2 and § 6.3 for a discussion.

In general, the range of input levels has been derived assuming that speech powers in the network are close to the conventional load assumed in the design of FDM systems. However, actual measurements reveal that this load is not being attained (see Supplement No. 5 to Fascicle III.2 of the *Yellow Book*). For this reason, it may be that there is some advantage in adopting different input (and output) levels for future designs of exchange. However, any possible changes need to take into account:

i) the range of speech powers encountered on an individual channel at the exchange input and the subjective effects of any peak clipping, noting that any impairment is confined to that channel;

ii) levels of non-speech analogue signals (e.g. from data modems or multifrequency signalling devices) particularly from customers on short exchange lines;

iii) the need to meet the echo and stability requirements of Recommendation G.122, particularly when the sum of R and T is less than 6 dB;

iv) the need to consider the difference in loss between the two directions of transmission, as required by § 6.3 of Recommendation G.121.

At this stage Administrations should note that there may be some advantage in considering a range of level adjustment for future designs of digital local exchange.

H.T. [T2.121]

TABLE C-1/G.121

Values of R and T for various countries

	Connection type		
	Own exchange {	{	

	R dB	T dB	R dB	T dB	R dB	T dB
{ Germany (F.R.) (For subscribers on short lines: R = 10 dB, T = 3 dB) }	7	0	7	0	7	0
Australia	6	0	6	0	6	0
Austria	7	0	7	0	7	0
Belgium	7	0	7	0	7	0
Canada	0	0	3	0	6	0
Denmark	6	0	6	0	6	0
Spain	7	0	7	0	7	0
United States	0	0	3	0	6	0
Finland	7	0	7	0	7	0
France	7	0	(not used)	(not used)	7	0
India	6	0	6	0	6	0
Italy	7	0	7	0	7	0
Japan	4	0	8	0	8	0
The Netherlands 4.5 (National) 10.5 (International) }	4.5 1.5	1.5	4.5	1.5	{	
Norway	5	2	5	2	5	2
{ United Kingdom (Values shown are for median lines; additional loss is introduced on short local lines in both directions of transmission) }	6	1	6	1	6	1
Sweden 5 (National) 7 (International) } 0 (National) 0 (International) }	5 {	0	5	0	{	
USSR	7	0	7	0	7	0
Yugoslavia	7	0	7	0	7	0
New Zealand	7	0.5	7	0.5	7	0.5

Table C-1/G.121 [T2.121], p.

Recommendation G.122

INFLUENCE OF NATIONAL SYSTEMS ON STABILITY,

TALKER ECHO, AND LISTENER ECHO IN INTERNATIONAL CONNECTIONS

(Geneva, 1964; amended at Mar del Plata, 1968,

Geneva, 1972, 1976
and 1980; Malaga-Torremolinos, 1984 and Melbourne, 1988)

1 Introduction

The information provided in this Recommendation applies to all national systems.

Representations of a national system which extend up to the virtual analogue switching points are shown in Figure 1/G.122.

FIGURE 1/G.122, p.

The transmission loss introduced between *a* | nd *b* | y the national system, referred to as the loss (*a* -*b*), is important from three points of view:

a) it contributes to the margin that the international connection has against oscillation during the setting-up and clearing-down of the connection. A minimum loss over the band 0-4 kHz is the characteristic value;

b) it contributes to the margin of stability during a communication. Again, a minimum loss in the band 0-4 kHz is the characteristic value, but in this case the subscribers’ apparatuses (telephone, modem, etc.) are assumed to be connected and in the operating condition;

c) it contributes to the control of echoes and, in respect of the subjective effect of talker echo, a weighted sum of the loss (*a* -*b*) over the band 300-3400 Hz is the characteristic value.

In addition, echoes circulating in any of the 4-wire loops in the national system or in the international 4-wire chain, give rise to listener echo, which can affect voice-band analogue data transmission.

The requirements stated in this Recommendation represent network performance objectives.

2 Loss (a-b) to avoid instability during set-up, clear-down and changes in a connection

2.1 Instability should be avoided during all normal conditions of set-up, clear-down and other changes in the composition (e.g. call-transfer) of a complete connection. To ensure adequate stability of international connections the distribution (taken over many actual calls) of the loss (a -b) during the worst situation should be such that the risk of a loss (a -b) of 0 dB or less does not exceed 6 in 1000 calls when using the calculation method applied in § 2.2. This requirement should be observed at any frequency in the band 0 to 4 kHz.

Note 1 — The signalling and switching systems have an influence on the loss (a -b) under set-up and clear-down conditions. For example, in some systems 4-wire registers control the set-up and do not establish the 4-wire path until the answer signal is successfully received. In others, circuits are released immediately if busy conditions are encountered. In these circumstances the risk of oscillation does not arise.

Note 2 — Recommendation Q.32 gives information on methods of securing an adequate loss (a -b) of an incoming national system before the called-subscriber answers (i.e. while ringing tone is transmitted) or if busy or number unobtainable conditions are encountered.

Note 3 — If there are no such arrangements as described in Notes 1 or 2 above then in general it would be safe to assume that there is no balance return loss provided by the called local telephone circuit (if 2-wire). In this case the necessary loss (a -b) must be provided by the transmission losses in the national system.

Note 4 — The stability of international telephone connections at frequencies outside the band of effectively transmitted frequencies (i.e. below 300 Hz and above 3400 Hz) is governed by the following transmission losses at the frequencies of interest:

— the balance return loss at the terminating units;

— the transmission losses of the terminating units;

— the transmission losses of the 4-wire circuits.

Note 5 — Conditions which only last for a few tens of milliseconds can be left out of consideration because in such a short time oscillations cannot build up to a significant level.

2.2 The limit recommended in § 2.1 may be met, for instance, by imposing the following simultaneous conditions on the national network:

1) The sum of the nominal transmission losses in both directions of transmission a -b and t -b measured between the 2-wire input of the terminating set t , and one or other of the virtual switching points on the international circuit, a or b should not be less than (4 + n) dB, where n is the number of analogue or mixed analogue-digital 4-wire circuits in the national chain.

2) The stability balance return loss at the terminating set t , should have a value not less than 2 dB for the terminal conditions encountered during normal operation.

3) The standard deviation of variations of transmission loss of a circuit should not exceed 1 dB (see Recommendation G.151, § 3).

In a calculation to verify if these values are acceptable, it may be assumed that (see [1]):

— there is no significant difference between nominal and mean value of the transmission losses of circuits;

— variations of losses for both directions of transmission of the same circuit are fully correlated;

— distributions are Gaussian.

For the loss (a -b), it then results:

Mean value: $2 + 4 + n = 6 + n$ dB

Standard deviation: $\sqrt{n}$ dB

With n = 4 the mean value becomes 10 dB and the standard deviation 4 dB, resulting in a probability for values lower than 0 dB of 6×10^{D}lF261^{3}.

Note — There is no need for the two quantities a -t and t -b to be equal, so that differential gain can be used in the national network. This practice may be needed to meet the requirements of Recommendation G.121, § 2, but it implies that the transmission loss in terminal service of the 4-wire chain plus the terminating sets may be different according to the direction of transmission. The choice of the nominal value of the transmission loss t -b should in all cases be made with an eye to Recommendation G.121, § 3 dealing with the minimum sending reference equivalent to be imposed in each national chain, to avoid any risk of overloading in the international network.

3 Unweighted loss (a-b) on established connections

3.1 The objective is that the risk of the loss (a -b) reaching low values at any frequency in the range 0-4 kHz should be as small as practicable. This requires restrictions on the distribution of values of

stability loss (a -b) for the population of actual international calls established over the national system. Such a distribution can be characterized by a mean value and a standard deviation.

The objective will be obtained by a national system sharing a mean value of at least (10 + n) dB together with a standard deviation not larger than $\sqrt{.25\tilde{}+\tilde{}4n}$ dB in the band 0-4 kHz; where n is the number of analogue or mixed analogue-digital 4-wire circuits in the national chain. Other distributions are acceptable as well, as long as they yield equivalent or better results calculated according to the convention of [1].

Note 1 — See Note in § 2.2.

Note 2 — In the more conventional case of a of Figure 1/G.122, the loss (a -b) is calculated as the sum of circuit losses, terminating loss and stability balance return loss. In fact the loss (a -b) at a given frequency is the sum of the circuit losses at that frequency plus the balance return loss at the same frequency. For planning purposes, it may be assumed that the stability loss is equal to or greater than the sum of the stability balance return loss plus the sum of the circuit losses at the reference frequency. This follows from the observation that the least circuit loss typically occurs in the vicinity of the reference frequency.

Note 3 — Wholly digital circuits may be assumed to have a transmission loss with mean value and standard deviation equal to zero. Voice coders in circuits or in exchanges are expected to offer smaller variations in transmission loss than carrier circuits. For the variations in transmission loss of a coder-decoder combination, standard deviations in the order of 0.4 dB have been reported.

Note 4 — The subscriber's apparatus (telephone, modem, etc.) in the local telephone circuit is assumed to be ''off hook'' or equivalent, and thus providing balance return loss.

Note 5 — In practice, the distribution of stability balance return loss is distinctly skew, most of the standard deviations being provided by values above the mean. It could be unduly restrictive to assume a normal distribution.

Note 6 — The CCITT manual cited in [3] describes some of the methods proposed, and in some cases successfully applied, by Administrations to improve balance return losses.

3.2 The distribution of stability loss (a -b) recommended in § 3.1 above could, for example, be attained if, in addition to meeting the conditions of § 2.2 the mean value of the stability balance return loss at the terminating set is not less than 6 dB and the standard deviation not larger than 2.5 dB.

4 Echo loss (a-b) on established connections

4.1 In order to minimize the effects of echo on international connections it is recommended that the distribution of echo loss ($a-b$) for the population of actual international calls established over the national system should have a mean value of not less than $15 + n$ dB with a standard deviation not exceeding $\sqrt{\;+4n}$, where n is the number of analogue or mixed analogue-digital 4-wire circuits in the national chain.

Other distributions are acceptable as well, as long as they yield equivalent or better results calculated according to the convention of Supplement No. 2.

Note 1 — Echo suppressors and cancellers according to Recommendations G.164 and G.165, typically require 6 dB of signal loss ($a-b$) for the *actual* signal converging the canceller or being controlled by the suppressor. This signal loss ($a-b$) is the ratio of incident to reflected signal power on the return path. The value of signal loss ($a-b$) will depend both upon the loss ($a-b$) frequency response and the signal spectrum. Therefore, it is desirable from a performance point of view that the stability loss ($a-b$) during an established connection should be at least 6 dB, since this will ensure proper operation for any signal (frequency spectrum) in the band 0-4 kHz.

However it may not be practical to always achieve this level of performance, especially at the higher frequencies characteristic of voice-band data signals. For speech, typically the speech signal loss ($a-b$) will be at least 6 dB if the echo loss is 6 dB. However, for voice-band data signals a higher echo loss is required to ensure a data signal loss ($a-b$) of 6 dB. For some data signals an echo loss of at least 10 dB is required. It should be noted that some modems operating half-duplex on satellite circuits equipped

with echo cancellers may require proper operation of the canceller to prevent long delay echoes that exceed the receiver squelch period from causing data transmission problems.

Note 2 — See Note 2 in § 3.1. In a similar manner for planning purposes it can be assumed that the echo loss is equal to or greater than the sum of the echo balance return loss and the circuit losses at the reference frequency.

Note 3 — Recommendation G.131 provides guidance on the application of echo control devices.

4.2 The echo loss ($a-b$) is derived from the integral of the power transfer characteristic $A(f)$ weighted by a negative slope of 3 dB/octave starting at 300 Hz, extending to 3400 Hz, as follows:

$$\text{Echo loss } L_e = 3.85 - 10 \log_{10} \left[\int_{300}^{3400} \frac{A(f)}{f} \, df \right] \text{ dB}$$

where

$$A(f) = 10^{-L_{ab}(f)/10}$$

with L_{ab} = loss ($a-b$)

Note 1 — The above method replaces an earlier method in which the echo loss of the path $a-t-b$ was provisionally defined as the expression in transmission units of the unweighted mean of the power ratios in the band 500-2500 Hz. The new method has been found to give better agreement with subjective opinion for individual connections. However, study has shown that echo path loss distributions for large samples of actual connections calculated by the two methods have almost identical means and standard deviations. Therefore, data gathered by the older method is still considered useful in planning studies.

Note 2 — Evidence was presented which showed that a white noise signal is not necessarily optimum to measure the residual echo level after cancellation, because an echo cancellor does not converge to quite the same condition as it does with a real speech signal. It may be better to use the conventional telephone signal (Recommendation G.227 [5]) or better still, an artificial speech signal (see [6]). A good compromise is the weighted noise signal based on the principle recommended above.

Note 3 — Improved balance return losses at *t* can be obtained when the local exchange uses 4-wire switching and the local line is permanently associated with the 2-wire/4-wire conversion unit and its balance network (see Recommendation Q.552 for examples). When there is 2-wire switching a compromise balance network must be used.

Note 4 — There is evidence that a 4-wire handset telephone in normal use can contribute significant acoustic echo to the communication. Hence in some circumstances (low transmission loss, long delay times) echo control devices may be needed.

4.3 An example of how the recommendation quoted in § 4.1 above can be achieved would be for the mean value of the sum of the transmission losses *a* -*t* and *t* -*b* not to be less than (4 + *n*) dB with a standard deviation from the mean not exceeding 2 $\sqrt{fIn}$ dB, accompanied by an echo balance return loss at the terminating set *t* , of not less than 11 dB with a standard deviation not exceeding 3 dB.

5 Effects of listener echo (receive end echo) |

5.1 *General*

It has been assumed in §§ 1 to 4 that only one 2-wire-4-wire-2-wire loop (further referred to as loop) occurs in a connection. Consequently, the requirements in §§ 1 to 4 are valid for that case, i.e. they refer to the ‘‘semi-loop’’ seen directly from the VASPs (virtual analogue switching points). However, in mixed analogue/digital connections several loops may occur when 4-wire digital exchanges (including PABXs) are connected 2-wire to other exchanges. Such loops have typically low loss and short delay times (at most a few milliseconds). Signals reflected twice, i.e. at both hybrids that terminate a loop, would therefore contribute to listener echo. These listener echo signals:

— can lead to objectionable ‘‘hollowness’’ in voice communications, and

— can impair the bit error ratio of received voice-band data signals.

In general it has been found that for satisfactory transmission, data modem receivers require higher values of listener echo loss (in the band 500-2500 Hz) than speech (in the band 300-3400 Hz).

The effect of listener echo is characterized by the difference in level between the direct signal and the multiple reflected signal. In Figure 2/G.122 the loss of the direct path is assumed to be *S* dB, whereas the loss along the path of the reflected signal is L dB. The listener echo loss (LE) then is *L* — *S* dB. It can be seen from Figure 2/G.122 that if only two reflections occur (only double-reflected signals), the listener echo loss LE equals the loss around the loop (open-loop loss, OLL), as all other losses are incurred equally by the direct and the reflected signals.

FIGURE 2/G.122, p.

It should be noted that usually the listener echo will consist of a series of signals being reflected two times, four times, etc. and hence LE and OLL are in principle not equal. In practice however LE and OLL may be taken as equal when OLL exceeds about 8 dB.

The loss around the loop can be measured by breaking the loop at some point, injecting a signal and measuring the loss incurred in traversing the open loop. All impedance conditions of the closed loop and at the 2-wire ends should be preserved whilst making the measurement. The measured quantity is the open-loop loss (OLL).

For practical purposes, semi-loop measurements may be more easily carried out, especially in the case of 4-wire exchanges with 2-wire circuit terminations, since it is sometimes difficult to maintain a connection through a 4-wire exchange and interrupt one direction of transmission. Figure 3/G.122 explains the notion of the semi-loop loss (SLL).

The use of ‘‘listener echo’’ in this context might be misleading. It could be substituted by a more appropriate term. The term ‘‘received end echo’’ is a term preferred by some Administrations.

The sum of the two semi-loop losses of a 2-wire/4-wire/2-wire device is equal to its open-loop loss (and hence very nearly to its listener echo loss) — again assuming that impedance conditions at the 2-wire ends are preserved whilst making the measurements.

FIGURE 3/G.122, p.

5.2 *Limitation of listener echo*

5.2.1 *Voice-band data transmission*

The minimum values for the listener echo loss are under study. However, the following consideration provides an example and may serve as an indication of what values of OLL might be required by existing types of modems with a bit rate of up to 2.4 kbit/s, in order to obtain high quality data transmission:

— a complete connection should not contain more than five (exceptionally seven) physical loops;

— loops with very high OLL (exceeding, e.g. 45 dB) need not be included in the number of loops in the connection;

— the OLL of each loop at any frequency in the band 500-2500 Hz, should not be less than the values indicated in Table 1/G.122 (based on $OLL = 18 + 10 \log m$, where m = total number of loops).

H.T. [T1.122]

TABLE 1/G.122

In one national system		
Maximum total number of loops in international connection } Number of national loops	OLL of each loop	{
1	22 dB	3
2	25 dB	5
3	26.5 dB	7

TABLE 1/G.122 [T1.122], p.

5.2.2 *Voice transmission*

Voice performance in the presence of listener echo can be quantified in terms of a weighted value of OLL over the voice-frequency band of 300-3400 Hz. Two weighting functions have been defined in Supplement No. 3 in Volume V.

Using the information given in Recommendation P.11 appropriate values of OLL may be derived as a function of loop round-trip delay for satisfactory voice transmission. These values are presently under study.

ANNEX A

(to Recommendation G.122)

Measurement of stability loss (a -b) **and echo loss** (a -b)

The stability loss (a -b) and the echo loss (a -b) as defined in §§ 3.1 and 4.1 respectively may be measured by apparatus at the international centre in accordance with the principle of Figure A-1/G.122.

In respect of the echo measurement, the combined response of the send and receive filters must be such that the definition given in § 4.2 of the text is effectively implemented, e.g. such that the difference between a measured echo loss and one calculated from the loss/frequency characteristic does not exceed 0.25 dB.

The allocation of the total response between send and receive is not critical and any reasonable division may be used provided that:

— excessive interchannel interference is avoided in national transmission systems due to an unrestricted spectrum of the transmitted signal;

— unwanted signals that may give rise to errors, e.g. hum, circuit noise, carrier leak signals, are prevented from entering the receiver.

Appropriate arrangements (not shown) are needed for automatic or manual access to the 4-wire switches at the international centre and also to ensure that due account is taken of the transmission levels at the actual switching points.

As far as the stability measurement is concerned, if a sweep oscillator is used, attention must be paid to the risks of engendering false operation of national signalling systems.

For both measurements anomalous results may be obtained if echo suppressors are encountered in the national extension.

To measure the echo loss (a -b), the output of the send filter is first connected to the input of the receive filter and the appropriate level set and noted. The apparatus is then connected as in Figure A-1/G.122 and the new reading on the meter noted. The loss so indicated is the echo loss (a -b).

Figure A-1/G.122, p.

ANNEX B

(to Recommendation G.122)

Explanation of terms associated with the path *a-t-b*

(Contribution of British Telecom and Australia)

B.1 *Return loss*

This is a quantity associated with the degree of match between two impedances and is given by the expression:

$$\text{Return loss of } Z_1 \text{ versus } Z_2 = 20 \log_{10} \left| \frac{Z_1 + Z_2}{Z_1 - Z_2} \right| \text{ dB}$$

The use of the expression ''return loss'' should be confined to 2-wire paths supporting signals in the two directions simultaneously.

B.2 *Balance return loss*

A clear definition is given in the preamble of Recommendation G.122. Figure B-1/G.122 illustrates the definition.

Figure B-1/G.122, p.

The 2-wire portion must be in the condition appropriate to the study, e.g., if speech echo is being studied the telephone set must be in the speaking condition.

In the particular case (which occurs very often) in which the impedances presented by each of the paths in the 4-wire portion is also Z_B (e.g. 600 ohms) then the terminating set presents an impedance of the 2-wire point which is substantially equal to Z_B. Figure B-2/G.122 illustrates this case.

Figure B-2/G.122, p.

The term ‘‘balance return loss’’ (*not* | eturn loss) should always be used for the contribution to the loss of the path *a -t -b* attributable to the degree of match between Z_B and $Z_{T\backslash\mathrm{d}W}$.

B.3 *Transmission loss of the path a-t-b*

There is room for confusion here because the concept can be applied to arrangements in which there is no physical point ‘‘*t* ’’ at all, e.g. as in some laboratory simulations of long connections in which echo is introduced by a controlled unidirectional path bridging the two 4-wire paths. The point ‘‘*t* ’’ is necessary in the Recommendation because practical public switched telephone networks are being dealt with.

Thus in general two cases arise.

Case 1: There does exist a point ‘‘*t* ’’ (Figure B-3/G.122).

Figure B-3/G.122, p.

The transmission loss of the path *a -t -b* may be calculated from

$$\text{loss}\,(a\text{-}t) + 20\log_{10}\left|\frac{Z_B(fR) + Z_{TW}(fR)}{Z_B(fR) - Z_{TW}(fR)}\right| + \text{loss}\,(t\text{-}b)$$

The diagram is drawn in terms of the virtual switching points of the international circuit with their associated relative levels. The subscript *i* in the abbreviation dBr_i signifies that these relative levels are with respect to a 0 dBr point of the international circuit.

It is clear that any other convenient pair of relative levels (differing by 0.5 dB in the correct sense) can be used in practice, e.g., the actual switching levels used in an international centre.

Case 2: There does not exist any ‘‘*t* ’’ (Figure B-4/G.122).

This relates particularly to laboratory testing arrangements.

Figure B-4/G.122, p.

In this case the loss of the path *a* -‘‘*t* ’’-*b* may be calculated from: ($R + E + S$) dB (assuming acoustic feedback at the 4-wire telephone to be negligible).

In both cases the loss of ‘‘the path *a* -*t* -*b* ’’ can in principle be directly measured by the principles described in Annex A, i.e. by injecting a signal at *a* and measuring the result at *b* , so that one may properly say for all cases

$$\left\{ \begin{matrix} \text{ttransmission loss} \\ \textit{of the path a -t -b} \end{matrix} \right\} \equiv \left\{ \begin{matrix} \text{ttransmission loss} \\ \textit{between a } \text{and } b \end{matrix} \right\}$$

or, more shortly

$$\text{loss } (a\text{ -}t\text{ -}b) \equiv \text{loss } (a\text{ -}b)$$

B.4 *Stability and echo losses*

So far the quantities dealt with are functions of frequency and yield a graph of attenuation/frequency distortion. When it is required to characterize such a graph with a single number, additional qualifying indications are, for example, stability loss (*a* -*b*) and echo loss (*a* -*b*).

The text of this Recommendation gives the definitions of these single-number descriptions thus: the stability loss (*a* -*b*) is the least value (measured or calculated) in the band 0-4 kHz (see §§ 2.1 and 3.1), and the echo loss (*a* -*b*) is a weighted integral of the loss/frequency function over the band 300-3400 Hz, as defined in § 4.2.

When the echo-path loss/frequency characteristic is available in graphical or tabular form, alternative techniques for the calculation of echo loss (*a* -*b*) are preferable to that suggested for the field measurement given in Annex A.

Note — When evaluating echo loss from graphical or tabulated data, sufficient frequency points should be taken to ensure that the influence of the shape of the amplitude/frequency characteristic is adequately preserved. The more irregular the shape, the more points should be taken for a given accuracy.

Graphical data (trapezoidal rule)

If the loss/frequency characteristic of the echo-path is available in graphical form (or the data were suitably measured) the echo loss may be calculated by using the trapezoidal rule as follows:

1) Divide the frequency band (300 to 3400 Hz) into *N* sub-bands of equal width on a log-frequency scale.

2) Read off the echo loss at each of the $N + 1$ frequencies at the edges of the *N* sub-bands, and express it as an output/input power ratio, A_i.

3) Calculate the echo loss using the formula:

$$L_e = -10 \log_{10}$$

[Formula Deleted]

Tabulated data

When the loss/frequency data are only available at $N + 1$ discreet frequencies, which are nonuniformly spaced on a log-frequency scale, proceed as follows:

An approximation to the formula for echo loss (a -b) given in the text is:

$$L_e = 3.24 - 10 \log_{10} \left[\sum_{i=1}^{N} (A_i + A_{i-1}) (\log_{10} f_i - \log_{10} f_{i-1}) \right]$$

where

A_0 is the output/input power ratio at frequency of f_0 = 300 Hz,

A_i the ratio at frequency f_i, and

A_N the ratio at frequency f_N = 3400 Hz.

Note 1 — The approximation involved is to assume that within the sub-band f_{i-1}, to f_i, the power ratio is constant and has the value $A(f) = (A_i + A_{i-1})/2$.

Note 2 — The constant 3.24 in the approximate formula arises from a combination of the constant 3.85 in the definition and other constants produced by the approximation.

The sum of product terms in the approximation formula may be conveniently calculated as illustrated by the following example:

H.T. [T2.122]
TABLE B-1/G.122

f (Hz) (1) f log 1 0 f (2) } f log 1 0 f | (em | og 1 0 f — 1 (3) } f A | | fIA — 1 (6) }	{ { loss (dB) (4) f (3) × (6) (7)	ratio A (5)	{			
300	2.477		∞	0 |		
		0.222			0.124	0.0275
500	2.699		9.05	0.124		
		0.204			0.402	0.0820
800	2.903		5.56	0.278		
		0.097			0.636	0.0617
1000	3.000		4.46	0.358		
		0.176			0.838	0.1475
1500	3.176		3.19	0.48		
		0.125			0.970	0.1213
2000	3.301		3.09	0.49		
		0.097			0.881	0.0855
2500	3.398		4.08	0.391		
		0.079			0.571	0.0451
3000	3.477		7.45	0.180		
		0.055			0.180	0.0099
3400	3.532		∞	0 |		

TABLE B-1/G.122 [T2.122], p.

$$L_e = 3.24 — 10 \log 0.5804 = 5.6 \text{ dB}$$

B.5 *Overall loudness rating of the echo path* (Talker echo loudness rating, TELR)

Recommendation G.131 is concerned with complete talker echo paths and it is convenient to characterize this path in terms of loudness rating (LR). By convention we may regard the echo balance return loss as the contribution it makes to the overall loudness rating (OLR) of the mouth-ear echo path. Naturally, as indicated in § 2 of the text, the echo loss (*a* -*b*), when this is already known, may be used instead of the sum of three quantities: the LR (*a* -*t*), the echo balance return loss at *t* (averaged according to § 2) and the LR (*t* -*b*).

Hence the nominal overall loudness rating of the echo path may be calculated as illustrated in Figure B-5/G.122.

Figure B-5/G.122, p.

Overall Loudness Rating of the echo path (Talker echo loudness rating, TELR), see Annex A/G.111

= SLR + RLR of the talker's national system,

+ twice the LR of the international chain (i.e.: $2L_i$),

+ the echo loss (*a* -*b*) of the listener's national system (i.e. averaged according to this Recommendation).

B.6 *Résumé of useful terms*

return loss — Relates to a 2-wire bidirectional circuit; classical definition.

balance return loss — Proportion of the loss at the *a* -*t* -*b* path attributable to the degree of match between the 2-wire impedance and the balance impedance at the terminating unit. Applicable only if there is a point ''*t* ''.

transmission loss of the path *a* -*t* -*b* — Can be regarded as the loss (*a* -*b*), whether there exists a physical point ''*t* ´.LP **stability loss** (*a* -*b*) — The least value of the loss (*a* -*b*) in the band 0 to 4 kHz.

echo loss (*a* -*b*) — The loss (*a* -*b*) averaged according to the definition in § 2 of the text.

echo balance return loss — A balance return loss averaged according to § 2 of the text.

overall loudness rating of the echo path (Talker echo loudness rating, TELR) — The sum of the send loudness rating and receive loudness rating of the talker's national system, twice the LR of the international chain, and the echo loss (*a* -*b*) of the listener's national system.

References

[1] *Calculations of the stability of international connections established in accordance with the transmission and switching plan* , CCITT Green Book, Vol. III-2, Supplement No. 1, ITU, Geneva, 1973.

[2] CCITT Recommendation *12-channel terminal equipments* , Vol. III, Rec. G.232, § 2.

[3] CCITT manual *Transmission planning of switched telephone networks* , ITU, Geneva, 1976.

[4] CCITT Recommendation *Reduction of the risk of instability by switching means* , Vol. VI, Rec. Q.32.

[5] CCITT Recommendation *Conventional telephone signal* , Vol. III, Rec. G.227.

[6] CCITT Question 8/XII, Annex 2, Contribution COM XII-No. 1, Study Period 1981-1984, Geneva, 1981.

Recommendation G.123

CIRCUIT NOISE IN NATIONAL NETWORKS

(Geneva, 1964; amended at Mar del Plata, 1968,

Geneva, 1972, 1976 and 1980 and Melbourne 1988)

1 Noise induced by power lines

‘‘Line’’ as used in this § 1 should be understood as meaning subscriber’s line, trunk junction or trunk circuit.
The network performance objective for the psophometric e.m.f. of the noise produced by magnetic and/or electrostatic induction from all the power lines affecting one or more parts of a chain of telephone lines joining a subscriber’s set to its international centre should not exceed 1 millivolt, this being the value at the line 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 , the insertion of equipment having too great a degree of unbalance to earth may cause unacceptable noise at the terminals of a subscriber’s receiver.

In every national network, it is usually possible, in practice, to find switching centres such that some of the lines that terminate at those centres (lines in cable, conforming to CCITT specifications) 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 affecting one or more parts of the chain of lines joining such a centre to the subscriber’s set.

2 Noise contributed by transmission systems

2.1 *Analogue systems*

2.1.1 *Very-long-distance circuits* | (about 2500-25 | 00 km)

If an extension circuit more than 2500 km long is used in a large country, it will have to meet all the recommendations applica-ble to an international circuit of the same length (Recommendation G.153). This implies that the equipment design objective for the line noise in channels used to provide these circuits should not exceed 2 pW0p/km.

2.1.2 *Circuit ranging in length from very short distances up to 2500 km*

These circuits should meet the requirements of Recommendation G.152. This implies that according to the noise objectives of Recommendation G.222 [1] the accumulated line noise should correspond to an average of not more than 3 pW0p/km and the noise power produced by the various modulating equipments should meet the provisions of the Recommendation cited in [2].

Taking account of the particular structure of a real circuit the pertinent Recommendations CCITT/G.226 [3] (for cable systems) or CCIR/395 [4] (for radio-relay systems) must be applied when assessing its noise performance.

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 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. The attention of Administrations is drawn to a conclusion of studies carried out by the CCITT during the 1964-1968 Study Period, that if the additional percentage of ‘‘poor or bad’’ opinions on the quality of connections due to noise introduced by the circuits connecting the local exchange to the primary centre is not to exceed one half of that caused by the presence in the connection of all other sources of circuit noise, then the noise contributed by each one of these circuits should be limited to about 500 pW0p (mean for all the channels of the system during any hour).

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 1/G.103) when its length is less than about 50 to 100 km.

Note 3 — In the case that those circuits are operated with compandors conforming to Recommendation G.162, the permitted noise powers are to be understood inclusive of the effect of the compandor gain.

2.2 *Digital system*

Circuits provided by PCM systems which accord with the G.700 Series of Recommendations, in particular Recommendation G.712 [5], will have an acceptable noise performance which is substantially independent of their length.

2.3 *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.

Noise limits and measurement methods for a mixed circuit are studied under Questions 26/XII, 16/IV and 18/IV.

3 Noise in a national 4-wire automatic exchange

3.1 *Definition of a* **connection through an exchange**

Noise conditions in a national 4-wire automatic exchange are defined by reference to a ‘‘connection’’ through this exchange. By ‘‘connection through an exchange’’ is to be understood the pair of wires corresponding to a direction of transmission and connecting the input point of a circuit incoming in the exchange to the output point of a different circuit outgoing from the exchange. These input or output points are those defined in Recommendation Q.45 (points A and D of Figure 1/Q.45 [8]) and are not necessarily the same as the text access points defined in Recommendation M.640 [9].

In accordance with Recommendation Q.31 [6], the limits are the same as in Recommendation Q.45 [7].

3.2 *Equipment design objective for the mean noise power during the busy-hour*

The mean of the noise over a long period during the busy-hour should not exceed the following values:

1) Psophometrically weighted noise: —67 dBm0p (200 pW0p),

2) Unweighted noise: —40 dBm0 (100 | 00 pW0) measured with a d evice with a uniform response curve throughout the band 30-20 | 00 Hz.

Note — A sufficient variety of connections should be chosen to ensure that the measurements are representative of the various possible routes through the exchange.

3.3 *Equipment design objective for the impulsive noise during the busy-hour*

Noise counts should not exceed 5 counts in 5 minutes at the threshold level of —35 dBm0 (see the Recommendation cited in [10] for measurement procedure).

Note — Figure 3/Q.45 [11] shows the maximum number of impulsive noise counts acceptable in a 5-minute period.

4 Noise allocation for a national system (guide for planning purposes)

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 + 4L) or (7000 + 2L) 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 + 1.8L) and (3100 + 0.9L) 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.

ANNEX A
(to Recommendation G.123)

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 CT3 to the most remote local exchange)

The relevant hypothetical reference chain for the national sending system is given in Figure A-1/G.123 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/G.123) 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 § 3 of the text, or Q.31 [6].

Figure A-1/G.123, p.

The total noise power level referred to a point of zero relative level on the first international circuit at the CT3 is (moving from right to left and adding in each successive noise contribution encountered):

$$200 + 4L_2 + 200 + 4L_1 + 200 +$$
$$2000 + 200 + ½ (2000) + ½ (200) = 3900 + 4L \text{ pW0}$$

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 | 00 pW0.

Note by the CCITT Secretariat — The noise values shown in this figure are maximum values; see also the corresponding element of Figure 1/G.103.

A.5 *Large countries*

When L is in excess of 1500 km the additionnal 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/G.123 in which the 4000 + 4L rule is shown passing through the point (1500 km, 10 | 00 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.123, p.

References

[1] CCITT Recommendation *Noise objectives for design of carrier-transmission systems* , Vol. III, Rec. G.222.

[2] *Ibid.* , § 4.

[3] CCITT Recommendation *Noise on a real link* , Vol. III, Rec. G.226.

[4] CCIR Recommendation *Noise in the radio portion of circuits to be established over real radio-relay links for FDM telephony* , Vol. IX, Rec. 395, ITU, Geneva, 1986.

[5] CCITT Recommendation *Performance characteristics of PCM channels between 4-wire interfaces at voice frequencies* , Vol. III, Rec. G.712.

[6] CCITT Recommendation *Noise in a national 4-wire automatic exchange* , Vol. VI, Rec. Q.31.

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

[8] *Ibid.* , Figure 1/Q.45.

[9] CCITT Recommendation *Four-wire switched connections and four-wire measurements on circuits* , Yellow Book, Vol. IV, Rec. M.640, ITU, Geneva, 1981.

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

[11] *Ibid.* , Figure 3/Q.45.

Recommendation G.125

CHARACTERISTICS OF NATIONAL CIRCUITS ON CARRIER SYSTEMS

(Geneva, 1964; amended at Mar del Plata, 1968 and Geneva, 1972)

Carrier circuits which are likely to form part of international connections should meet the requirements of Recommendation G.132 as far as attenuation distortion is concerned. The circuits should transmit all types of signal (e.g. speech, data, facsimile) which might normally be expected, according to Recommendations over this part of the connection.

Recommendations relating to the noise performance of national circuits are now to be found in Recommendation G.123 (circuit noise in national networks).

MONTAGE : RECOMMANDATION G.131 SUR LE RESTE DE CETTE PAGE