INTERNATIONAL TELECOMMUNICATION UNION

ITU-T G.171

(11/88)

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

TRANSMISSION SYSTEMS AND MEDIA

TRANSMISSION PLAN ASPECTS OF SPECIAL CIRCUITS AND CONNECTIONS USING THE INTERNATIONAL TELEPHONE CONNECTION NETWORK

TRANSMISSION PLAN ASPECTS OF PRIVATELY OPERATED NETWORKS

ITU-T Recommendation G.171

Superseded by a more recent version

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.171 was published in Fascicle III.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation G.171

TRANSMISSION PLAN ASPECTS OF PRIVATELY OPERATED NETWORKS

(Geneva, 1980; amended at Malaga-Torremolinos, 1984 and Melbourne, 1988)

1 General

This Recommendation primarily concerns privately switched networks for telephony. In certain circumstances these networks may be suitable for the transmission of analogue encoded data signals but no special arrangements have been made to ensure satisfactory performance in this respect. Although digital facilities on a portion of a circuit or digital switches may be employed, §§ 1-9 of this Recommendation mainly covers analogue interconnection of circuits and switches. §§ 10 and 11 cover some aspects of all digital connections.

It should be noted that not all Administrations provide such a facility. Others permit interconnection between private telephone networks and the public telephone network. In this latter case assurance cannot always be given that transmission performance conforming to CCITT standards will be obtained. In a similar manner the interconnection of multiple private networks may result in connections with degraded transmission performance.

It is not intended that this Recommendation should prevent the making of bilateral agreements for special network configurations. In such circumstances it is suggested that the network plans given here be used as a guide to permissible alternative arrangements.

The transmission plan described in this Recommendation is similar to that of the switched public network and therefore it is desirable that several other Recommendations such as G.151 be complied with where possible and appropriate. In this respect, it is noted that some requirements in Recommendation G.151 are more stringent than those contained in this Recommendation (e.g. attenuation distortion), and some impairments which are more important for voice-band data are covered in G.151 but are not included in this Recommendation.

A major consideration in the private plan is that typically, a PBX functions both in the role of a local exchange and a tandem centre and therefore it is necessary to use a technique such as pad switching to achieve the appropriate connection loss.

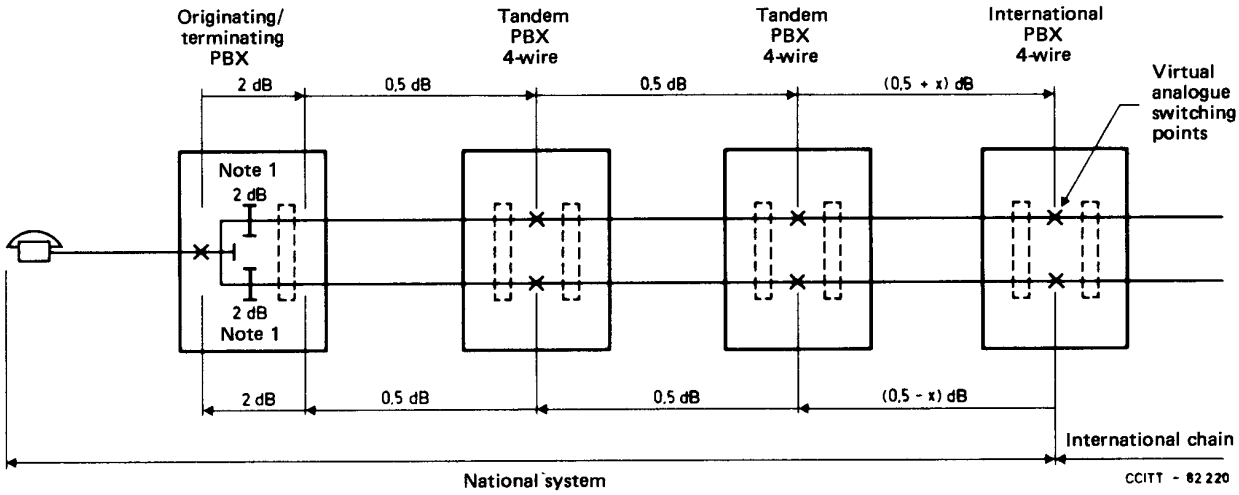
The network configurations discussed in this Recommendation may also be implemented by replacing some or all of the PBXs with switching capability dedicated to a private user that is located on the premises of the telephone Administration rather than on the customers' premises.

Recommendation M.1030 provides information on the maintenance of international leased circuits forming part of private switched networks. Recommendation Q.8 describes signalling systems to be used for international leased circuits.

2 Network configurations

2.1 *Preferred 4-wire network configurations*

The preferred network configurations are shown in Figure 1/G.171 and Figure 2/G.171. Four-wire PBXs are used in conjunction with low loss 4-wire circuits. The loss plans shown are for illustration and are based on the national plans discussed in Recommendation G.121. For convenience the later figures will only use the variable loss plan for illustration. It should be noted that the fixed loss plan without modification, (Figure 2/G.171) is only suitable when the national system is limited in size at most to 1000 to 1500 km.



Note 1 – 2 dB switchable pad or equivalent. The pad is switched in on terminating/originating connections and out on tandem connections.

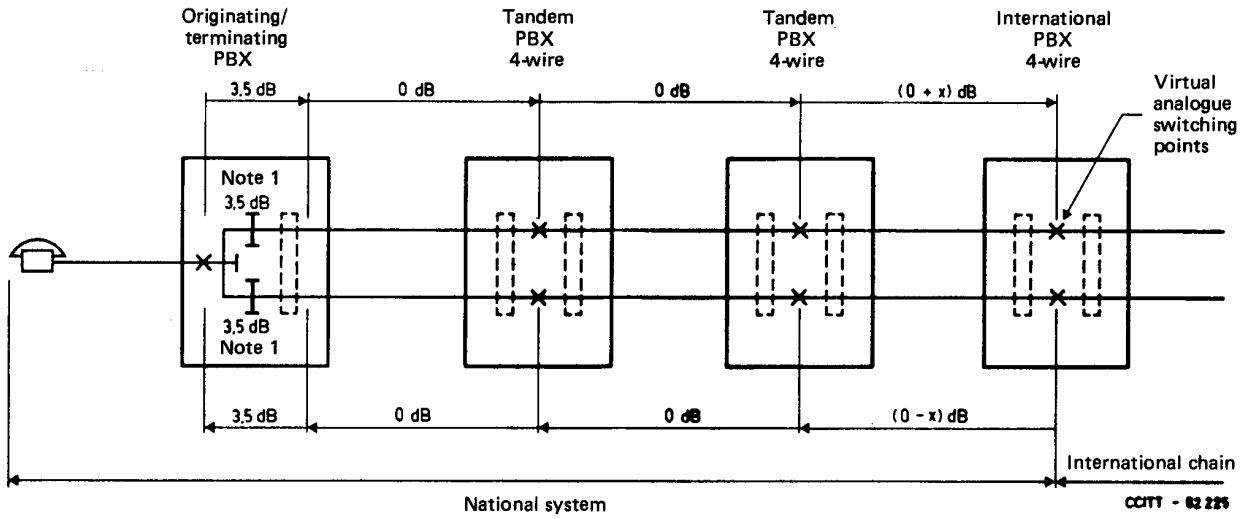
Note 2 – The value of x is the loss necessary to convert between actual and virtual analogue switching points.

Note 3 – Denotes echo canceller or half echo suppressor that may be fitted.

FIGURE 1/G.171

4-wire network configuration variable loss

d01



Note 1 – 3.5 dB switchable pad or equivalent. The pad is switched in on terminating/originating connections and out on tandem connections.

Note 2 – The value of x is the loss necessary to convert between actual and virtual analogue switching points.

Note 3 – Denotes echo canceller or half echo suppressor that may be fitted.

FIGURE 2/G.171

4-wire network configuration fixed loss

d02

At each PBX a switchable pad or equivalent is used in such a manner that the pad is "out" of the circuit when the PBX switch is in the tandem mode but is "in" the circuit at an originating/terminating PBX. This allows a flexible configuration of PBXs while maintaining control on echo loss and overall loudness rating. The PBX terminating the international chain is referred to as the International PBX (IPBX). Conceptually the virtual analogue switching points are located at the IPBX.

It should be noted that typically short PBX subscriber lines may need more loss in the connections to meet the Recommendations on send and receive LR at the virtual analogue switching points. This will of course depend on the send and receive LR of the telephone and subscriber line. It may also be necessary to add loss on intra-PBX calls.

2.2 *Allowed network configuration using 2-wire circuits*

The configuration shown in Figure 3/G.171 allows for the use of 2-wire circuits. This is not desirable and should be avoided. If used, 2-wire circuits should only be deployed between an originating/terminating PBX and the first tandem PBX. A 2-wire circuit may be all 2-wire or consist of a mix of 2-wire and 4-wire segments.

The use of 2-wire circuits may require special loss control at the connecting tandem PBX. If the stability/echo requirements of §§ 5 and 6 cannot be met otherwise, it will be necessary to switch the pad or equivalent loss into the tandem connection to the 2-wire circuit. This would require special translation and control at the tandem PBX to identify 2-wire trunks not consistent with the stability/echo requirements. If this is not possible the added loss is required on all tandem connections, causing a degradation in overall loudness rating.

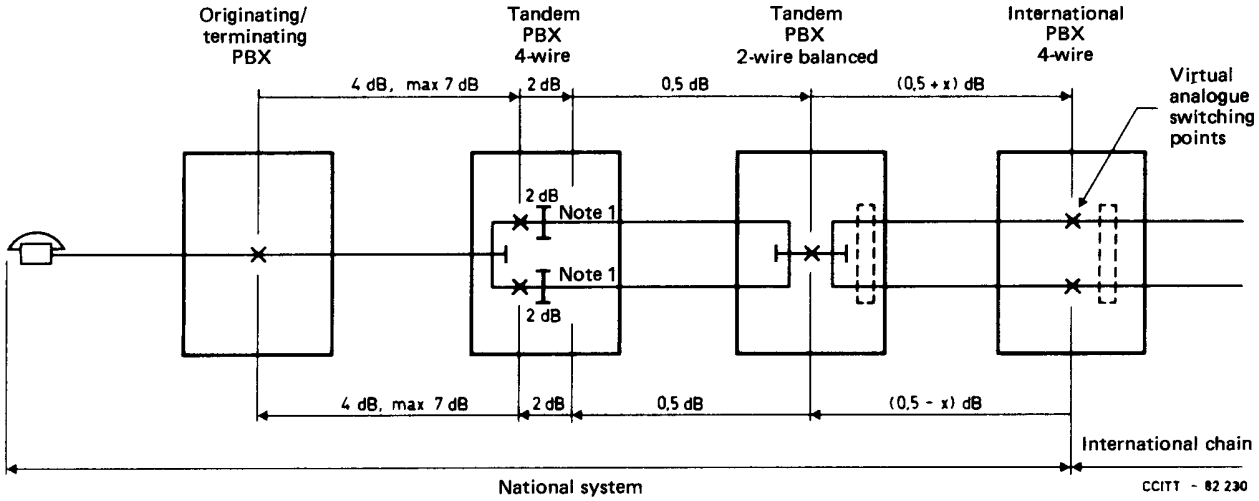
2.3 *Balanced 2-wire tandem PBXs*

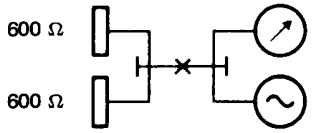
As shown in Figure 3/G.171, 2-wire PBXs may be used in the tandem mode if the collection of interconnected 4-wire interfaces meet balance requirements as shown in Note 2. With a mean echo loss of 27 dB and a standard deviation of 3 dB, the effects of echo at the PBX are negligible with respect to the principal echo at the originating/terminating PBX or at the tandem PBX connected to a 2-wire circuit. Recommendation G.131 refers to these balance values in reference to tandem 2-wire switches. It is provisionally recommended, that at most three 2-wire PBXs be contained in a single national extension. This would correspond to a 2-wire terminating/originating PBX with two additional balanced 2-wire tandem PBXs.

As shown in Figure 4/G.171, the IPBX may be 2-wire. The virtual analogue switching points are adjacent to the 2-wire/4-wire terminating unit on the 4-wire side. If the PBX is used for tandem switching it must be balanced and pad switching or equivalent should be employed as previously described.

2.4 *Network constraints*

To control loss, distortion, noise and delay a maximum of seven circuits in tandem is recommended from originating to terminating PBX. Allocation of the number of circuits between national and international chains should remain flexible and should be done on an individual network basis subject to the seven circuit maximum. There should, however, be a maximum of five tandem circuits in a connection in any single national extension.





Note 1 – 2 dB switchable pad or equivalent. The pad is switched in the tandem connection to a 2-wire circuit if the stability balance requirements of §§ 5 and 6 cannot be met otherwise.

Note 2 – Two-wire balanced PBX.

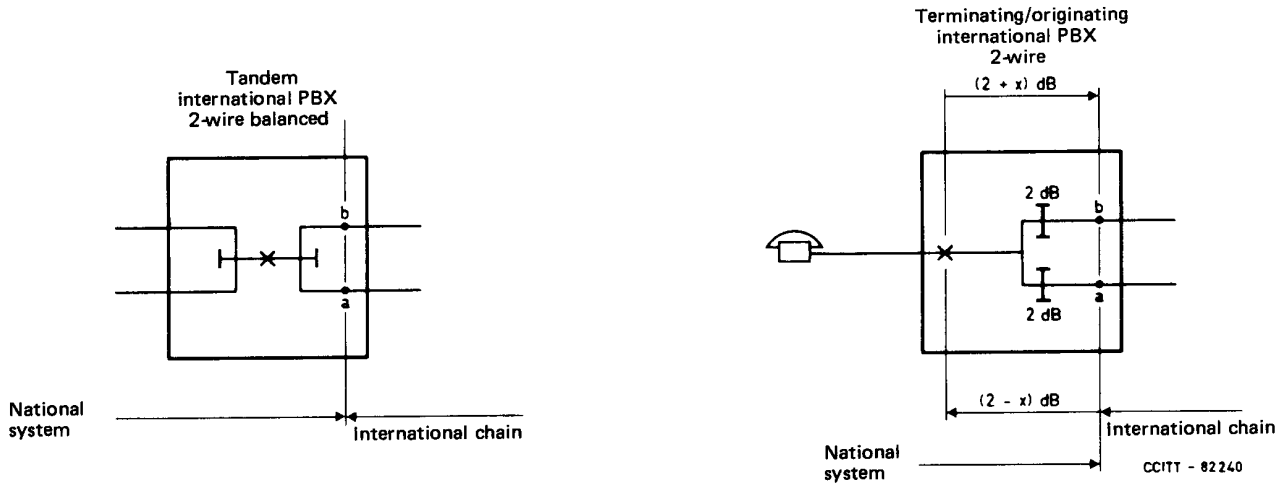
Note 3 – The value of x is the loss necessary to convert between actual and virtual analogue switching points.

Note 4 – Denotes echo canceller or half echo suppressor that may be fitted.

FIGURE 3/G.171

Network configuration using 2-wire circuits

d03



Note – The value of x is the loss necessary to convert between actual and virtual analogue switching points.

FIGURE 4/G.171

International PBX 2-wire

d04

Recommendation G.114 on mean one-way propagation time should be observed. In particular, at most one satellite circuit should be present in a connection. If it is not possible to adhere to this constraint assurance cannot be given that transmission conforming to CCITT standards will be obtained.

The arrangements shown in the Figures 1/G.171 to 4/G.171, are suggested methods of meeting the Recommendations on stability, echo and CRE (LR) as given in §§ 5, 6 and 7. Other approaches achieving the same performance are acceptable.

3 Nominal transmission loss of international circuits

3.1 *Four-wire circuits*

Recommendation G.111 is applicable to this type of circuit and therefore the normal transmission loss at the reference frequency between the virtual analogue switching points will be 0.5 dB for circuits employing analogue transmission. An indication of the locations of the virtual analogue switching points is also given in Recommendation G.111 and conceptually these will be at the private exchange on which the circuit terminates. Four-wire circuits do not contain 2-wire circuit sections.

3.2 *Two-wire presented circuits*

This nomenclature is intended to cover circuits which are not available with a 4-wire interface (e.g., circuits between 2-wire switching nodes).

For the purposes of this Recommendation the location of the virtual analogue switching points for this type of circuit can be considered as being adjacent to the 2-wire/4-wire terminating unit (4-wire side). It can then be treated in the same way as a 4-wire circuit. (See Figure 4/G.171.)

Note 1 – The real loss of the circuit between actual switching points at the reference frequency cannot be exactly specified without prior knowledge of the switching levels.

Note 2 – Differences between the two directions of transmission in the real loss of the circuit may occur. The annexes to Recommendation G.121 examine this effect in some detail.

Note 3 – A circuit is defined as the complete transmission path between the switch points of the two private exchanges concerned.

Note 4 – Actual transmission loss will differ from the nominal values and will vary with time. For all circuits, variations with time of the overall loss at the reference frequency (including daily and seasonal variations but excluding amplitude hits) should be as small as possible but should not exceed ± 4 dB.

4 Nominal transmission loss of national circuits

4.1 *Four-wire circuits*

The nominal loss at the reference frequency should be 0.5 dB between actual switching points. This includes 4-wire circuits terminated on balanced 2-wire PBXs. The loss of the circuit between the actual and virtual analogue switching points of the IPBX depends upon the PBX transmission level used in the national plan.

4.2 *Two-wire circuits*

Two-wire circuits may contain mixed 2-wire/4-wire segments. The nominal loss at the reference frequency should not exceed 7 dB, and should preferably be lower, for example 4 dB.

Note 1 – Certain national arrangements in large countries may employ a nominal loss in excess of 0.5 dB on 4-wire circuits or may employ a distance dependent loss in order to improve talker echo performance without use of echo control devices. This approach is acceptable if the Recommendations on LR of § 7 are satisfied.

Note 2 – Since leased circuits may contain circuit sections routed in local unloaded distribution cable pairs, care will be needed to ensure that there is an adequate stability bearing in mind the relative gain introduced by unloaded cable pairs.

Note 3 – Loss variation should be controlled as described for international circuits.

5 Stability

5.1 *National 2-wire circuits/2-wire presented circuits*

Two-wire presented circuits are 4-wire circuits terminated on 2-wire PBXs. Provisionally the nominal loss around any 4-wire loop should not be less than 6 dB at any frequency in the band 0 to 4 kHz, for all the terminal conditions encountered in normal operation (e.g. including the idle state and the set-up phase of the connection).

5.2 *Terminating systems for international circuits*

National terminating systems which interface with international circuits should comply with the stability requirements of Recommendation G.122. In the case of 2-wire presented international circuits, the virtual analogue switching points can be considered as being adjacent to the 2-wire/4-wire terminating unit (4-wire side). (See Figure 4/G.171.)

During the set-up and clear-down of a call the loss between virtual analogue switching points (*a*-*b*) must satisfy that of Recommendation G.122, § 1.

The signalling system has an influence on the loss under set-up conditions as explained in Recommendation G.122. If the requirement cannot be met with the configurations described herein, it will be necessary to increase either the switched or fixed losses.

During an established communication, the suggested configurations of Figures 1/G.171, 2/G.171 and 3/G.171 provide for compliance with Recommendation G.122 as follows. Assuming that the PBX subscriber lines have a distribution of stability balance return loss equivalent or superior to that of public subscriber lines and that the distribution has a mean value of 6 dB and a standard deviation of $\sqrt{6.25}$ dB, then the distribution of stability of loss (*a*-*b*) is consistent with the recommended distribution of Recommendation G.122, § 1 using the same assumptions as contained in that Recommendation.

Note – In order to obtain the recommended value of stability on 2-wire presented low-loss (e.g. 3 dB) circuits, it will be necessary for the 2-wire/4-wire terminating units to be located at the private exchanges. This may not be necessary on circuits with a higher nominal loss. The CCITT manual cited in [1] gives guidance on this topic.

6 Echo

6.1 *Terminating systems for international circuits*

National terminating systems which interface with international circuits should comply with the echo loss (*a*-*b*) requirements of Recommendation G.122, § 2 and the requirements of Recommendation G.131, § 2 for the control of echo.

During an established communication, the suggested configuration of Figures 1/G.171, 2/G.171 and 3/G.171 provide for compliance with Recommendation G.122, § 2 as follows. Assuming that PBX subscriber lines have a distribution of echo balance return loss equivalent or superior to that of public subscriber lines and that the distribution has a mean value of 11 dB with a standard deviation of 3 dB, then the distribution of echo loss (*a*-*b*) is consistent with the recommended distribution of Recommendation G.122, § 2 using the same assumptions as contained in that Recommendation.

6.2 *Echo control devices*

When echo control devices (e.g., echo suppressors or echo cancellers) are necessary it is preferable that they be located at the private exchange. This minimizes end delay and also allows disabling of the device during tandem operation, if necessary. In addition, some signalling systems require local disabling of echo control devices during

certain signalling phases. The echo control device (echo canceller or far-end operated half-echo suppressor) for the international circuit would be located at the PBX terminating the international chain, since this same PBX typically could originate/terminate traffic or tandem switch to many trunks without echo control. However, if connecting national circuits introduces enough delay to warrant echo control, then echo control devices would also be provided on these circuits.

If far-end operated half-echo suppressors are used, intermediate suppressors should be disabled. This is not necessary for echo cancellers since tandem operation does not cause degraded performance. In either case the functioning echo control device on the connection is effectively moved closer to the PBX subscriber line, further reducing end delay. The echo control devices are located in the 4-wire portion of the network and between the first hybrid and the international chain. However, the devices may be located at the international centre when the previously described performance factors can still be satisfactorily controlled and there is a maintenance and/or cost advantage for such location.

The loss of circuits fitted with echo control devices should be 0 dB.

Echo suppressors and cancellers according to Recommendation G.164 and Recommendation G.165, typically require 6 dB of signal loss (*a-b*) for the *actual* signal converging the canceller or being controlled by the suppressor. 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 this may not be economically achievable. The spectrum of a typical speech signal and return path is such that if the *echo* loss (*a-b*) is at least 6 dB, then the signal loss (*a-b*) for the speech signal is expected to be at least 6 dB and the echo control devices should operate properly. However, the spectrum of some voice-band data signals and of the return path is such that an echo loss (*a-b*) of at least 10 dB is required to ensure that the signal loss (*a-b*) for the actual data signal is 6 dB. (Modems operating half-duplex on satellite circuits may require echo protection for proper operation.) Therefore, when an echo control device is located at a PBX, the echo loss at the 4-wire terminals of the device looking towards the subscriber line should be at least 6 dB for 99.5% of the connections and 10 dB for 95% of the connections for all network configurations during an established communication. This is not a new requirement in that the values are consistent with the recommended distribution for echo loss independent of the number of circuits between the echo control device and the subscriber line, assuming the distribution is Gaussian, which is a conservative assumption.

The suggested configuration of Figures 1/G.171, 2/G.171 and 3/G.171 provides for compliance with the minimum echo loss Recommendations. Using these configurations there is always a loss pad or equivalent between the echo control device and the 2-wire termination. Then, under the conditions described in § 6.1, the distribution of echo loss at the terminals of the echo control device is consistent with the recommended distribution.

If the private network uses echo suppressors and connects to a public network using echo cancellers, then difficulty in canceller convergence may be experienced when the suppressor is in the tail path of the canceller. However, performance will then be determined by the echo control devices at each end of the connection.

7 Loudness ratings (LRs) of extension circuits

7.1 *Loading*

Administrations must ensure that the technical arrangements that they authorize in respect of operating levels, sensitivities, etc. for private networks are not in conflict with the design criteria of the international transmission system. Attention is drawn to Recommendation G.121, § 3, which specifies a nominal minimum value of 2 dB sending LR referred to the virtual analogue switching point.

7.2 *Sending LR*

The maximum sending LR of the telephone and PBX subscriber line circuit (that portion analogous to the local telephone circuit in the public network) should not exceed 10.5 dB. This value is in accord with the example of a maximum local telephone circuit used in Figure 1/G.103. In practice, it is to be expected that most sending LR values will be considerably lower than this limit.

Administrations should attempt to choose values such that they comply with the preferred long-term objective of Recommendation G.121, § 1 (value referred to the virtual analogue switching point).

7.3 *Receiving LR*

The maximum receiving LR of the telephone and PBX subscriber line circuit (that portion analogous to the local telephone circuit in the public network) should not exceed 4 dB. This value is in accord with the example of a maximum local telephone circuit used in Figure 1/G.103. In practice it is to be expected that most receiving LR values will be considerably lower than this limit although due account must be taken of the need to preserve adequate margins against excessive noise, crosstalk and sidetone.

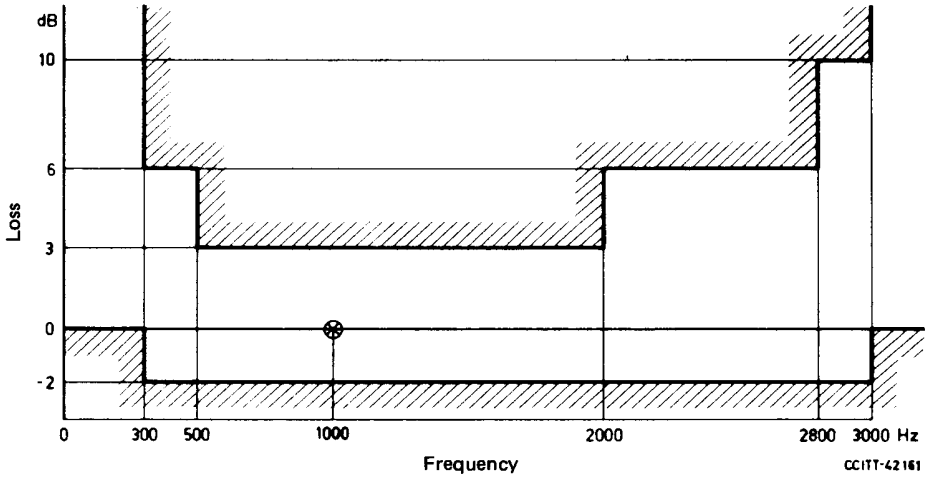
Administrations should attempt to choose values such that they comply with the preferred long-term objective of Recommendation G.121, § 1 (values referred to the virtual analogue switching point).

The sending LR and receiving LR for all connections should be such that there is compliance with Recommendation G.111, § 3.2 on overall LR.

8 Loss/frequency distortion

8.1 *Four-wire circuits*

The loss/frequency distortion of each 4-wire circuit should not exceed the limits shown in Figure 5/G.171. These limits are also applicable to the 4-wire portion of the circuit if it is terminated in a 2-wire switching node (see § 2).



Note – The figures of 300 Hz and 3 kHz for the limitation of edge-band gain are provisional because Recommendation G.232 [2] permits a wider frequency range for FDM terminal equipment.

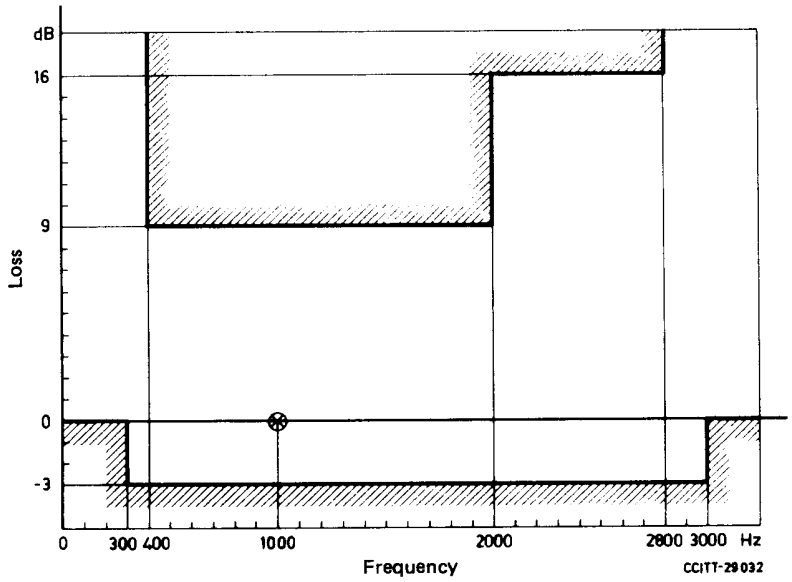
FIGURE 5/G.171

Limits for overall loss of the circuit relative to that at 1000 Hz for 4-wire circuits

d05

8.2 *Two-wire presented circuits*

The loss/frequency distortion of each 2-wire circuit should not exceed the limits shown in Figure 6/G.171.



Note – The figures of 300 Hz and 3 kHz for the limitation of edge-band gain are provisional because Recommendation G.232 [2] permits a wider frequency range for FDM terminal equipment.

FIGURE 6/G.171

Limits for overall loss of the circuit relative to that at 1000 Hz for 2-wire presented circuits

d06

9 Noise

The requirements of the relevant Recommendations should be met in respect of noise by each of the circuit sections and Recommendations G.123 and G.143, § 1 gives some general guidance on system noise characteristics. The nominal level of random noise power at the private exchange will depend upon the actual constitution of the circuit but should not exceed –38 dBm0p (provisional maintenance limit for circuits longer than 10 000 kilometres). In practice circuits of shorter length will exhibit substantially less random noise. Figure 7/G.171 serves as a guide to the expected performance.

Circuits having sections routed via communication satellites, designed according to Recommendation G.153, may be assessed in respect of noise performance by ascribing a nominal 1000 km of circuit length for the satellite path. It should be noted, however, that although such an allowance is appropriate for most satellites carrying international traffic, there may be certain locations where noise levels in excess of this value may be found.

10 Digital interconnection

In a digital private network of digital PBXs digitally interconnected a principal issue is the loss plan. In order to achieve transparent digital connections in the PBX network, the loss between digital interfaces should be 0 dB. However, it is necessary to insert loss in the PBX associated with the interconnection of digital and analogue interfaces. If digital loss is introduced between digital interfaces, it is desirable that options be made available to bypass the digital pad so that transparent connections can be provided. The bypass of digital pads may require special signalling arrangements.

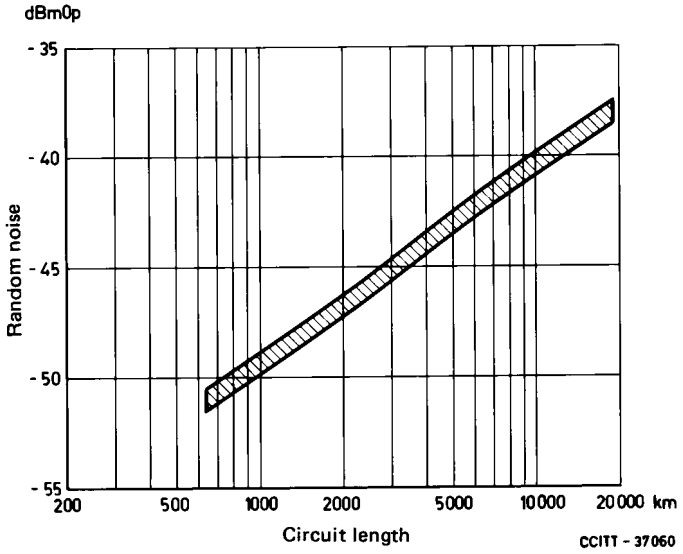


FIGURE 7/G.171

Random noise circuit performance

d07

In a private network there are normally several different categories of analogue interfaces on the digital PBX. Such interfaces correspond to on-premise stations, off-premise stations, analogue tie trunks to the other PBXs and analogue connections to the PSN. The port-to-port loss matrix in the digital PBX between the combination of analogue and digital interfaces in conjunction with the loss of any analogue facilities and lines make up the overall loss plan. Different PBXs using the same port-to-port loss matrix are compatible for use in the same network consistent with the overall loss plan.

Because of the many different types of cross connections the overall loss plan represents a compromise, with optimum performance not being achieved on all connections. The loss plan should provide for acceptable send, receive, and overall loudness rating as discussed in § 7.3 of this Recommendation for all connection types. The annex to this Recommendation describes, as an example, one loss plan developed to meet this objective. At the current time the annex does not deal with digital interfaces to digital telephones.

11 Interconnection to the public switched telephone network

It is not always possible to assure that transmission performance meets CCITT standards when interconnecting private networks to the public switched network. This situation is complicated by the many different types of connections that are possible. In analogue networks a common interconnection problem is an increase of loss and a degradation in overall loudness rating. Relative level requirements at the digital exchange as described in Recommendation Q.552 (§ 2.2.4) should be complied with. For digital networks it is possible to make the interconnection more nearly transparent. The following guidelines apply to digital networks:

i) The preferred interconnnection between digital PBX and digital end-office employs digital facilities with a transparent connection at the end office. The loss preferably should be moved to the private network at the digital/analogue conversion point or digital telephone.

ii) Encoding and decoding levels in the private network should be consistent with the national plan and provide loudness ratings as in Recommendation G.121.

iii) A synchronization plan for the private network should be compatible with the national synchronization strategy.

When an analogue or digital private network is interconnected to the public switched network and an international connection is established, the national extension consists of the PSTN and connected private network. All requirements on the national extension should be complied with in this configuration. In particular the loudness rating requirements of Recommendation G.121 and the echo and stability requirement of Recommendation G.122 should be complied with. The PSTN with the private network connected should meet the echo and stability requirements at the virtual analogue switching point.

Control of delay and talker-echo performance can create problems on interconnections of private networks and the PSN. First, since it is likely that echo control devices in the private network will be in tandem with such devices in the PSN, echo cancellers should be used in the private network to prevent impairment. Further specific areas of concern are as follows:

i) Talker echo performance on calls where echo control is not normally provided in the PSN. The additional private network delay may result in unacceptable performance on a significant proportion of calls (Rule M, Recommendation G.131).

ii) The additional private network delay may result in the end-delay limits for existing PSN echo control devices being exceeded. In order to control these factors it may be necessary to deploy echo cancellers in the private network on the interconnecting circuit, particularly to control reflections back to the PSN. The delay limits and/or echo control strategy used in the private network should ensure acceptable talker-echo performance in accordance with the rules in Recommendation G.131, § 2.3. In addition, the private network delay limits should be as low as practicable to minimize overall connection delays in accordance with Recommendation G.114.

Other parameters essential to an acceptable overall performance include quantizing distortion, sidetone, noise, attenuation distortion, group delay distortion, crosstalk, error rate, jitter and wander. It is not practicable to provide private network limits for these parameters consistent with the national extension over-all requirements for all configurations. It is important that the constituent parts of the private network be designed in accordance with the relevant CCITT Recommendation covering these parameters.

References

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

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

ANNEX A

(to Recommendation G.171)

Digital private network loss plan/performance

A.1 *Introduction*

In the United States, the electronic industries association (EIA) is working on a proposed standard [1] for the port-to-port losses of a digital PBX. This contribution describes the loss plan and some network performance results which form the rationale for the plan. The intent of the contribution is only to provide background material to assist in the study of the question. In particular the information can help in developing an extension to Recommendation G.171, to cover the agreed upon first priority of work on a digital private network loss plan including interconnection to public networks.

A.2 *Digital private networks*

The loss plan for digital private networks is patterned after the predivestiture AT&T public switched digital network. The latter specifies a fixed 6 dB local exchange-to-local exchange loss for most connections [2]. Moreover, it was planned to function harmoniously with the existing extensive analogue network, such that hybrid connections would provide quality performance.

The end-to-end loss for digital private networks is 12 dB for connections terminated in on-premises stations (ONS) at both ends. The 6 dB difference between such connections and public switched digital networks connections was proposed to compensate for the difference between the public network average subscriber line loss (approximately 4 dB) and a private network on-premises station average line loss (approximately 1 dB). Thus, 3 dB of the 12 dB end-to-end loss is assigned to each line, at each end of the connection (see Figure A-1/G.171).

When an off-premises station (OPS) is used instead of an ONS, then the 3 dB allocation to the subscriber line is dropped, because an OPS line has loss comparable to a regular subscriber line or is designed for via net loss (VNL) + 4 dB loss. Thus, if both ends of a digital private network connection terminate in OPS lines, the end-to-end loss will be 6 dB. If one end of the connection is terminated in OPS and the other in ONS, then the end-to-end connection loss will be 9 dB.

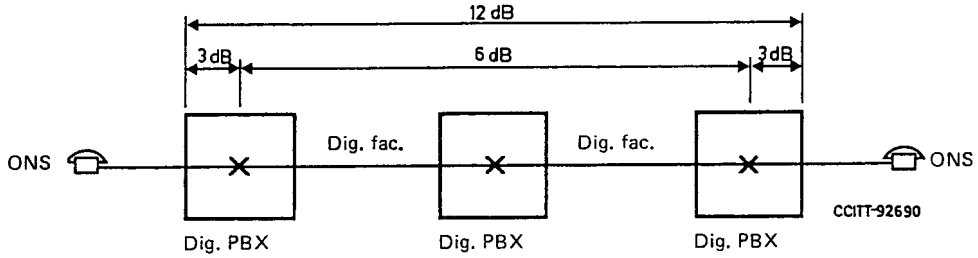


FIGURE A-1/G.171

Digital private network connection

d08

A.3 *The EIA loss plan*

The EIA loss plan for digital PBXs was proposed to implement the loss plan of digital private networks. It also provides flexibility to digital PBXs to operate in a mixed analogue/digital environment, and to interconnect private and public networks.

The EIA loss plan for digital PBXs is presented in Table A-1/G.171. The Table shows the loss to be inserted by the PBX between various interfaces, in the two transmission directions. The method of implementation of loss (analogue, digital or both) is not specified. However, in an end-to-end digital connection all the loss is inserted at the terminating PBX, except for the 3 dB loss allocated to an originating ONS. As an example, to achieve the 12 dB loss value shown in Figure A-1/G.171, each end-PBX has to insert 3 dB loss in the transmit direction, and 9 dB loss (6 + 3) in the receive direction (this is specified by cell 1-D); but, the middle PBX should not insert any loss (cell 4-D).

As stated before, the Table also specifies loss values to interface with analogue private network facilities, and with the public network through analogue or digital facilities. Loss values are also specified for satellite PBX trunks. Satellite PBX trunks are in general short. Therefore, by specifying a separate set of loss values for interconnections with such trunks, it is possible to obtain better overall performance. Where analogue facilities are used, it is assumed that they are designed to VNL.

TABLE A-1/G.171

Digital PBX loss plan

		A ONS		B OPS		C A / TT		D D / TT		E S / ATT S / DTT	
		↑	↓	↑	↓	↑	↓	↑	↓	↑	↓
1 ONS	–	6		3		3		3		3	
	–		6		3		3		9		3
2 OPS	–	3		0		2		0		2	
	–		3		0		2		6		2
3 A / TT	–	3		2		0		–3		0	
	–		3		2		0		3		0
4 D / TT	–	9		6		3		0		6	
	–		3		0		–3		0		0
5 S / ATT S / DTT	–	3		2		0		0		0	
	–		3		2		0		6		0
6 A / CO	–	0		0		0 / 2		–3 / 0		0	
	–		0		0		0 / 2 (Note 2)		3 / 6 (Notes 1, 2)		0
7 D / CO	–	3		0		2		0 / –3		0	
	–		3		0		2		6 / 3 (Note 3)		0
8 A / TO	–	6		3		0		–3		3	
	–		6		3		0		3		3
9 D / TO	–	9		6		3		0		6	
	–		3		0		–3		0		0

(Values in dB)

PBX Interfaces

ONS Line interface to on-premises line

OPS Line interface to off-premises line

A / TT Analogue trunk interface to tie trunk

D / TT Digital trunk interface to digital tie trunk, combination tie trunk or any other tie trunk with a digital termination at the muPBX

S / ATT Analogue trunk interface to analogue satellite PBX tie trunk

S / DTT Digital trunk interface to digital satellite PBX tie trunk

PBX Interfaces (cont.)

A / CO Analogue trunk interface to analogue Central Office (CO) trunk

D / CO Digital trunk interface to digital CO Trunk, combination CO trunk or any other CO trunk with a digital termination at the muPBX

A / TO Analogue trunk interface to analogue Toll Office (TO) trunk

D / TO Digital trunk interface to digital TO trunk, combination TO trunk, or any other TO trunk with a digital termination at the muPBX

Note 1 – The –3 / 3 dB value pair should be provided for connections between an A / CO port and a D / TT port serving as the interface to a combination tie trunk to a satellite PBX.

Note 2 – It is desirable that the low-loss option (0 / 0 or –3 / 3) be used when the muPBX-CO trunk loss is greater than or equal to 2 dB *and* the ERL ≥ {18,13} *and* SRL ≥ {10,6} measured into a 900 ohm +2.16 μF termination at the CO. [The notation {M,L} signifies that the median value is M and the lower limit is L.]

Note 3 – The 0 / 6 dB loss pair shall always be provided. The –3 / 3 dB loss pair is a desirable option to be used for internetwork applications in which no significant configuration will encounter echo, stability, or overload problems because of the reduced loss. With the –3 / 3 dB loss pair, subscriber station DTMF signals transmitted through the DCO into the private network might experience nonrecoverable digit mutilation in secondary signalling applications (DTMF signalling after the connection has been established, e.g., order entry) because of the 3 dB gain.

A.4 *Grade-of-service study results in support of the EIA PBX loss plan*

Since the loss plan for private digital networks is patterned after the AT&T public switched digital network loss plan, it is expected that the performance of private digital networks will be comparable to that of the public switched digital network. The end office-to-end office 6 dB loss for public switched digital connections is a compromise value. As Figure A-2/G.171 shows, the optimum loss value is a function of the connection length (which determines the round trip delay of reflected signals). But, the 6 dB compromise loss will provide quality performance for most connections. Equivalently, the Grade-of-Service (GOS) of a connection will depend on the end-to-end loss. The 12 dB end-to-end loss for digital private networks (or the 3 dB allocation to each ONS loop) is supported by the following GOS results.

Figure A-3b/G.171 shows the loss-noise-echo GOS [1)] for private digital network connections with ONS at both ends, as a function of loss. Loss is presented in terms of the variable P value assigned to each ONS, in addition to a fixed end-to-end 6 dB loss (see Figure A-3a/G.171). Three connection lengths are considered: short, medium, and long, having lengths of 45 miles, 250 miles, and 1820 miles, respectively. The echo return loss used in this simulation has a mean value of 12 dB and a standard deviation of 3. As the results show, the optimal value of P increases with the length of the connection.

1) GOS is shown in terms of the mean percent good-or-better rating using the Cavanaugh, Hatch, Sullivan model.

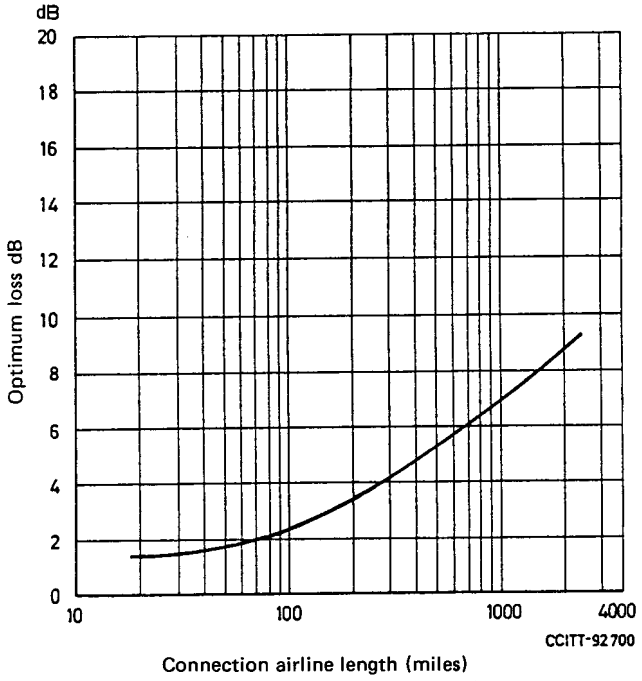


FIGURE A-2/G.171

Switched digital network optimum loss
(from Ref. 2)

d09

Figure A-4a/G.171 is similar to Figure A-3a/G.171 except that one ONS is replaced with an OPS. The PBX on which the OPS homes, does not have a "P" loss associated with the OPS line. Also, the echo return loss parameters are different. Figure A-4b/G.171 shows the loss-noise-echo GOS results for the connection of Figure A-4a/G.171, for the three private network lengths, as perceived by the ONS customer (the GOS for the OPS customer will be different). The dependency of the GOS results on the value of P is similar to those of Figure A-3b/G.171. For P = 6 dB, the performance on the long connection (see Figure A-4b/G.171) will be close to optimal. However, the performance on the other connections will start to deteriorate. The deterioration will be significant when both ends of a connection terminate in ONS (see Figure A-3b/G.171). Since connections with ONSs are the prevailing type, a value of P = 3 dB provides the best compromise, and is the value selected.

The P = 3 dB value is also used when the interconnecting facilities are analogue and as the following example shows, it is a good compromise for interconnections of private and public networks. Figure A-5a/G.171 is such an example. Figure A-5b/G.171 displays the corresponding GOS results as perceived by the ONS customer.

A.5 *Conclusions*

A loss plan for digital private networks, which is implemented through the proposed EIA PBX loss plan, is discussed. It is shown through GOS results that the loss plan represents a good compromise and provides a high level of performance and flexibility for various connection types.

Simulated connections
Digital
ONS → ONS

Tie trunk lengths

Short	45 miles
Medium	250 miles
Long	1820 miles

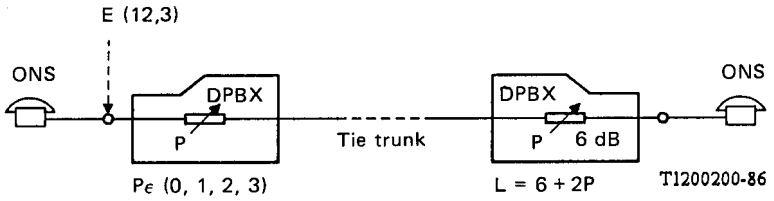


FIGURE A-3a/G.171

d10

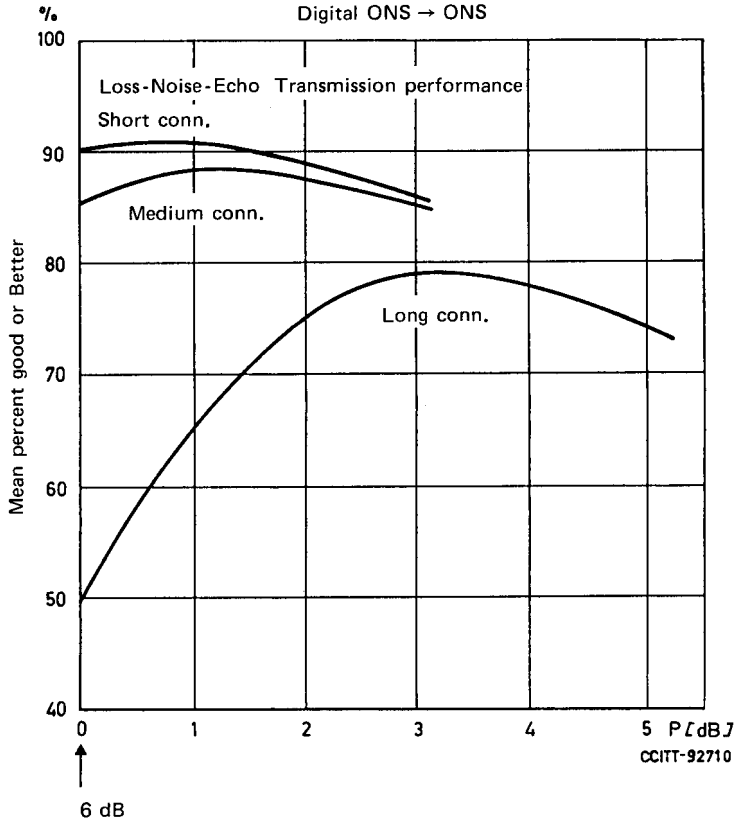


FIGURE A-3b/G.171

d11

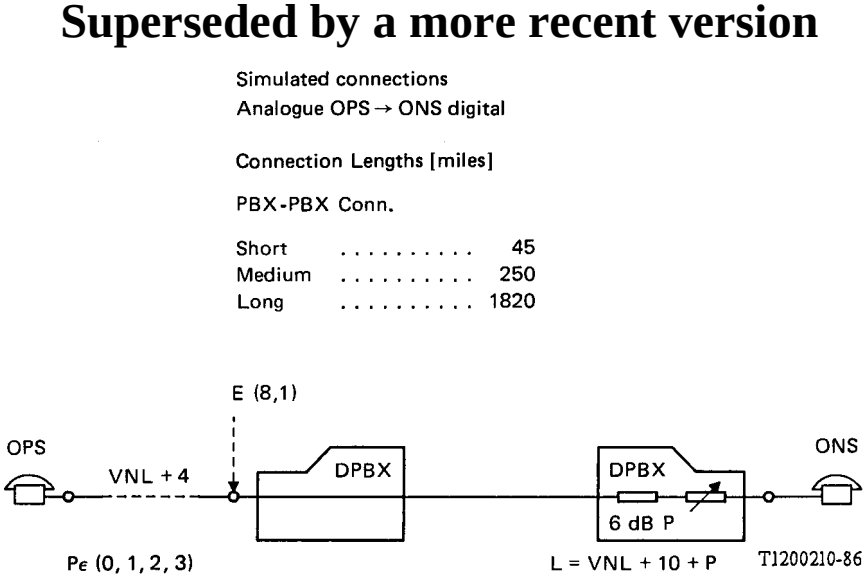


FIGURE A-4a/G.171

d12

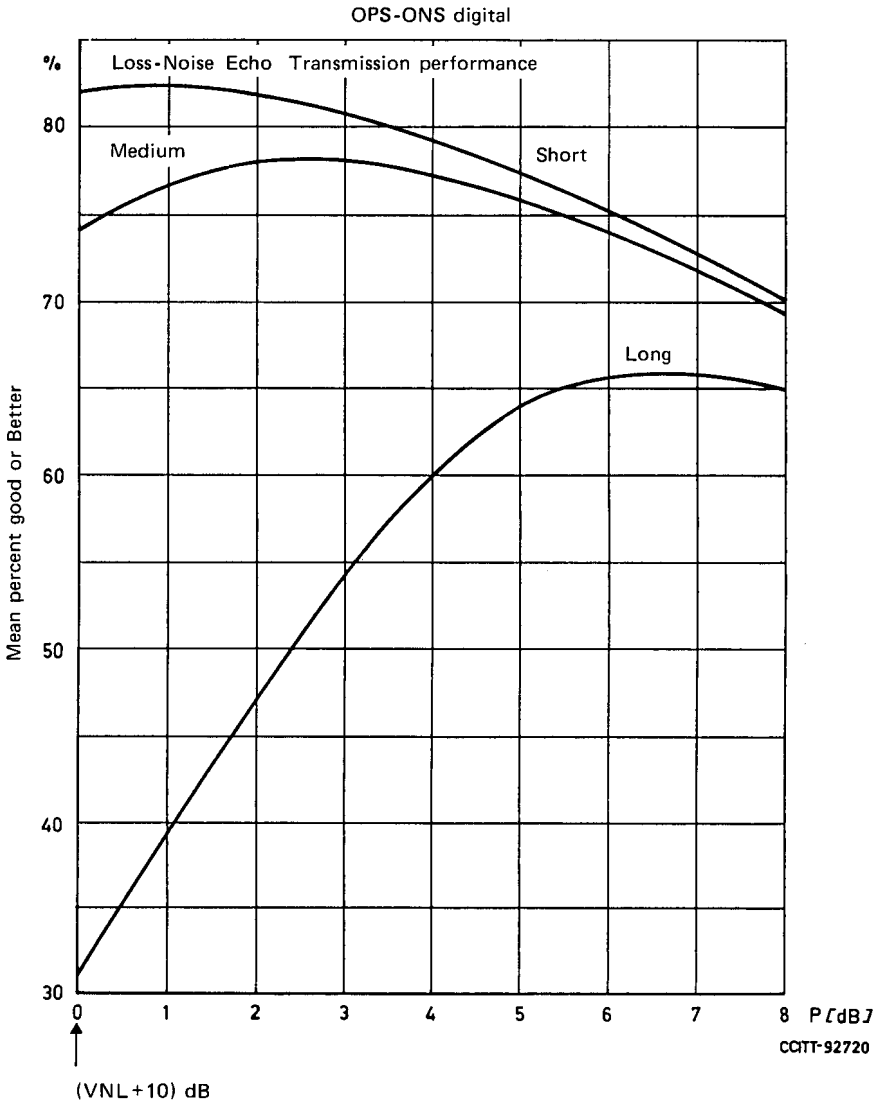


FIGURE A-4b/G.171

d13

Simulated connections
Analogue
Public network → Private network

Connection Lengths [miles]

PBX-PBX conn.

Short	45
Medium	250
Long	1820

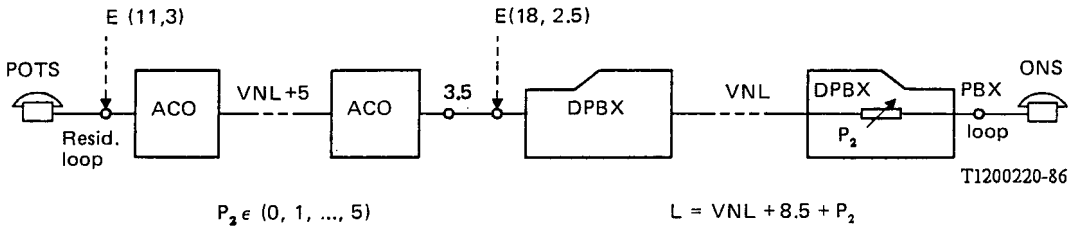


FIGURE A-5a/G.171 d14

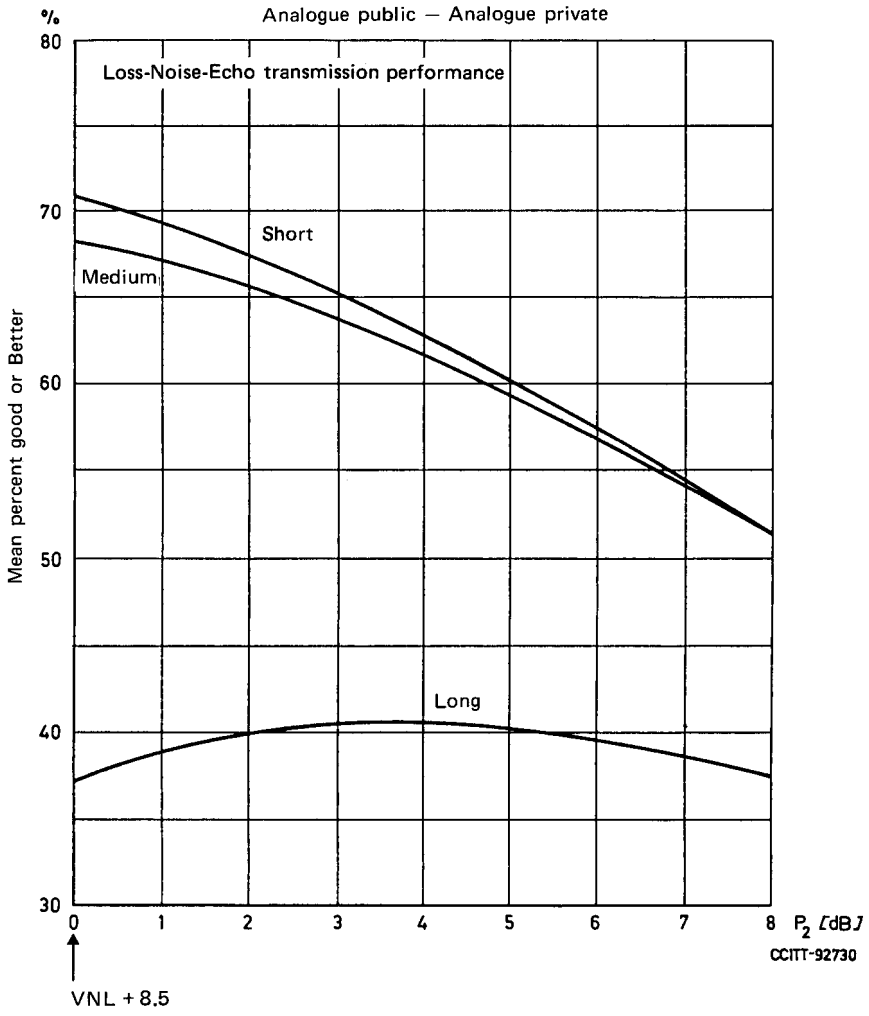


FIGURE A-5b/G.171 d15

References

[1] EIA PN-1378, Private branch exchange (PBX) switching equipment for voiceband applications.

[2] AT&T, Notes on the network, 1980.