1.7 Transmission plan aspects of special circuits and connections using the international telephone connection network

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.

Figure 1/G.171, p. 1

Figure 2/G.171, p. 2

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.

Figure 3/G.171, p. 3

Figure 4/G.171, p. 4

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 ± | 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 standad deviation of $\sqrt{.25}$ 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).

Figure 5/G.171, p.

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.

Figure 6/G.171, p.

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 | 00 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, p. 7

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 bewtween 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, p.

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.

H.T. [1T1.171]

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 9 3	6	3	3	3	3
— 2 OPS — 3 0 2 6 2	3	0	2	0	2
— 3 A/TT — 3 2 0 3 0	3	2	0	—3	0
— 4 D/TT — 3 0 —3 0 0	9	6	3	0	6

—
{
5 S/ATT
5
S/DTT
—
3
2
0
6
0
}
	3	2	0	0	0

—
{
6 A/CO
—
0
0
0/2
(Note 2)
3/6
(Notes 1, 2)
0
}
	0	0	0/2	—3/0	0

—
{
7 D/CO
—
3
0
2
6/3
(Note 3)
0
}
	3	0	2	0/—3	0

— 8 A/TO — 6 3 0 3 3	6	3	0	—3	3
— 9 D/TO — 3 0 —3 0 0	9	6	3	0	6
(Values in dB)					

Tableau A-1/G.171 [1T1.171], p. 9

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 ≥" { 8,1 } *and* SRL ≥" { 0, } measured into a 900 ohm +2.16 µF termination at the CO. [The notation { , } 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.

Tableau A-1/G.171 [2T1.171], p. 10

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 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.

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

Figure A-2/G.171, p. 11

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.

Figure A-3a/G.171, p. 12

Figure A-3b/G.171, p. 13

Figure A-4a/G.171, p. 14

Figure A-4b/G.171, p. 15

Figure A-5a/G.171, p. 16

Figure A-5b/G.171, p. 17

References

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

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

Recommendation G.172

TRANSMISSION PLAN ASPECTS OF INTERNATIONAL CONFERENCE CALLS

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

The transmission considerations given here are applicable to conference calls set up and operated in accordance with Recommendation E.151.

1 In order to respect CCITT Recommendations concerning loudness ratings on international connections, high quality bridging equipment shall be used. This equipment shall be designed to provide a nominal transmission loss of 0 dB in the direction from whichever participant is for the moment active (speaking) to all inactive (listening) participants. This loss shall be measured between equal level switching points of national circuits or virtual switching points of international circuits.

Note — Some conference bridges employ the use of automatic gain control (AGC) to minimize the contrast that exists between the speech levels of participants on connections having different losses, and the above consideration does not apply for such bridges. The transmission consideration for bridges with AGC is a subject for future study.

2 A modern conference bridge shall be used which employs techniques to avoid excessive transmission impairment from the accumulation of noise and echo at the output of the bridge in a multiport conference arrangement.

In a conference connection with two bridges: one bridge has N1 ports including a talker and the other bridge has N2 ports, noise increases as the number of ports is increased, according to the approximate rule: 10 log (N1 + N2 — 1).

Talker and listener echoes also increase as the number of ports is increased as shown in Figure 1/G.172.

The multi-bridge configuration thus highlights the need for noise and echo control.

Note 1 — For example, a conference bridge which provides voice-activated switched loss or its equivalent may be used. In such a bridge, 15 dB of loss would be connected in each input to the bridge when the customer on that path is inactive. When a participant becomes active the loss is switched from his talking path to his listening path differential action protects the talker from echo and prevents a reduction of singing margin when the switch is operated. The loss which normally exists in the transmit path attenuates weak input signals such as noise before they enter the bridge. With this arrangement the level of the total signal reflected back to any active port will be the sum of the individual reflections from all other ports diminished by 30 dB.

This bridge can be equipped with about 30 ports.

Note 2 — A description of a conference bridge employing voice-activated switched loss is available in Annex 2 to Question 6/XVI in Volume III-3 of the *Green Book* . The transmission requirements contained in that annex could be used for the design of bridging equipment. Requirements for the design of bridging equipment using other techniques to control level contrast and noise and echo accumulation are the subject of future study.

Figure 1/G.172, p. 18

3 Optimum operation of a conference bridge is obtained when its location is close to the center of the connection. This tends to equalize loss from the bridge to all conference locations on the connection, thus minimizing level contrast. Thus bridging equipment for international calls should be at high order transit centers.

4 Bridging equipment should be 4-wire presented and 4-wire switched on both national and international circuits, wherever possible.

5 Attention is called to Recommendation G.114 concerning mean one-way propagation time which recommends that connections with delays in excess of 400 ms should not be used except under the most exceptional circumstances. To comply with this recommendation, care should be taken in the selection of a connection diagram so as to avoid the use of more than a single satellite circuit. For some conferences, using a single star network, this could influence the choice of location for the conference bridge. For other conferences, the use of a multiple star network could be selected with a single satellite circuit, equipped with appropriate echo suppressors, linking the conference bridges.

6 The conference connections should be carefully chosen so as to minimize the number of voice-activated switched loss devices in tandem to no more than two per conference leg. This includes customer premises conference equipment (such as loudspeaking telephones) and network equipment (such as echo suppressors), but excludes the bridging equipment.

7 Whenever the conference involves a single person at a location using a subscriber handset the room noise should be limited to about 60 dBSPL(A) at the user position to provide good quality transmission. Figure 2/G.172 shows the mean opinion score of transmission quality versus room noise [1]. Failure of the customer to comply with this guideline may cause the conference to be unacceptable.

8 When a conference involves more than a single person at each location it may be desirable to use conference rooms equipped with microphones and loudspeakers. To assure an adequate signal-to-noise ratio and freedom from the effects of conference room reverberation, the microphone and loudspeaker placement guidelines contained in Supplement No. 4, Volume V should be followed

Figure 2/G.172, p.

Reference

[1] *Guidelines for improving telephone communications in noisy room environments* , Bell System Technical Reference, PUB 42902, February 1980, American Telephone and Telegraph Co.

Sound pressure level relative to 20 µPa and using the A-weighting. See Recommendation P.54 for information concerning sound level measurements.

Another problem associated with hands-free conferencing is the likelihood of acoustic feedback between loudspeaker and microphone. While this feedback is today generally controlled using voice-activated switched loss in the conference room terminal equipment, note is taken of the fact that Study Group XV has proposed new studies to determine how to use echo cancellers to control the acoustic feedback

1.8 Protection and restoration of transmission systems

Recommendation G.180

CHARACTERISTICS OF N + M TYPE DIRECT TRANSMISSION | fR RESTORATION SYSTEMS

FOR USE ON DIGITAL SECTIONS, LINKS OR EQUIPMENT

(Melbourne, 1988)

1 General

Transmission restoration functions are often implemented in the modern telecommunication networks to improve the availability and quality of service, by minimizing the effects or potential effects of a transmission failure, and to make the maintenance operations easier.

The terminology and general principles of transmission restoration are described in Recommendation M.495. The functional organization for automatic transmission restoration is described in Recommendation M.496.

2 Object of Recommendation

This Recommendation specifies the characteristics of equipment for N + M type direct transmission restoration systems (protection link switching) for digital transmission links (see Recommendation G.701). The general arrangement of a system for N + M direct transmission restoration is shown in Figure 1/G.180. This Recommendation refers to the equipment labelled as RSE (Restoration Switching Equipment) and RSCE (Restoration Switching Control Equipment).

This Recommendation is intended also to cover the case where the signals at the interfaces T belong to different hierarchical levels. In this case, each access at one side can be a group of accesses as indicated in the example of Figure 2/G.180. The left part of this figure refers to the particular case where the restored path is not on a complete link but just through a multiplex equipment.

Note — The equipment specified in this Recommendation can possibly be used also for N + M automatic or semi-automatic transmission rerouting (protection network switching) but generally this type of restoration function is implemented by different equipment, often incorporating also other functions (such as, for example, automatic digital distribution frames). This type of equipment is under study.

Three types of direct transmission restoration systems are considered by this Recommendation:

The first one should permit routing of any one of N normal links on to any one of M restoration links.

The second type should permit the interconnection of any of the N accesses to any one of the N + M links.

The third one should permit routing of any one of N normal links to a single restoration link (in many cases this type can be considered just a special case of the first type).

For all the types two options exist:

a) to switch the two directions of transmission independently; and

b) to switch the two directions of transmission simultaneously.

This Recommendation does not cover the restoration systems fully embedded in transmission systems and the 1 + 1 systems where the switching occurs at the receive end only (see Recommendation G.181).

The hierarchical levels at interfaces T are those specified in Recommendation G.702 (hierarchy levels 1 and up).

Figure 1/G.180, p. 20

Figure 2/G.180, p. 21

3 RSE specifications

Two types of RSE are considered by this Recommendation: the ‘‘regenerative’’ and the ‘‘non-regenerative’’ ones.

The first type, where the digital signal undergoes a complete process of retiming and reshaping, makes the RSE a digital equipment and it is sometimes considered to be advantageous, e.g. from the station cabling point of view.

The second type, where the output signal is proportional to the input signal (except for minor distortion) is considered to be useful in some circumstances, e.g. from a reliability and cost point of view.

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3.1 *Interfaces*

3.1.1 *Transmission path interfaces* (T)

The relevant parameters and the recommended values are listed in the uppermost part of Table 1/G.180 for the non-regenerative RSE and in the uppermost part of Table 2/G.180 for the regenerative RSE.

H.T. [T1.180]

TABLE 1/G.180

Provisionally recommended values for the interface and transfer characteristics of non-regenerative RSE

I N T E R F A C E	**Nominal impedance** {
	 {
	
	 Accepted levels
		As stated in Rec. G.703
		
		 {

TR A N S F E R Transfer function between the input and the output of the RSE (terminated on the nominal impedances) (Note 2)

< | fIx % of the interconnecting pair loss and phase distortion allowed in Rec. G. 703 for the relevant hierarchical level, or the complement thereof, plus or minus *y* dB flat loss.

It is assumed that the loss vs frequency distortion approximates to the $\sqrt{fIf\ |}$ law (Notes 3 and 4)

Crosstalk attenuation > *Y* 1 dB from any channel > *Y* 2 dB multi-channel interference evaluated on a voltage-sum basis. These values apply up to a frequency value equal to the nominal bit-rate (Note 5)

Note 1 — The value for *z*

is under study. A possible value is *z* = 6 dB.

Note 2 — As a corresponding requirement is under study to permit the connection of test equipment in protected monitoring points, the relevant specification could alternatively be adopted.

Note 3 — The values of *x* and *y* are under study. A proposal states: *x* = 10% and *y* = 0.5 dB.

Note 4 — A delay limit will be also considered in future if benefit is expected from that.

Note 5 — The *Y* 1 and *Y* 2 limits are under study. *y* 1 = 40 and *y* 2 = 30 have been proposed as compromise values among different proposals. Different limits could possibly be adopted for RSE having a different configuration (e.g. N + 1 or N +M).

Tableau 1/G.180 [T1.180], p.

3.1.2 *Control interfaces*

The only control interface of the RSE is X. This interface is not at present specified by the CCITT. However in the future, it may be specified as a Q interface (see Recommendation G.771).

If the interface X is not standardized, the separation between the RSE and RSCE (and consequently between §§ 3 and 4 of this Recommendation) will be somewhat arbitrary.

3.2 *Operational aspects*

3.2.1 *Transfer of the switched signals*

The relevant parameters and the recommended values are listed in the lower part of Table 1/G.180 for the non-regenerative RSE and in the lower part of Table 2/G.180 for the regenerative RSE.

H.T. [T2.180]

TABLE 2/G.180

Interface and transfer characteristics recommended for regenerative restoration switching equipment

General Nominal bit rate and tolerance }	{ As stated in Rec. G.703	
{	Intrinsic output jitter	{
T R A N S F E R	Jitter transfer Error performance Others (Note 1)	{ { {

Note 1 — A delay limit will also be considered in future if benefit is expected from that.

Note 2 — Further study is necessary whether or not the digital signal should be replaced by a signal other than AIS in a restoration switching condition.

Note 3 — Evaluated under maximum loading condition and excluding any external source of interference.

Tableau 2/G.180 [T2.180], p. 23

3.2.2 *Response*

For RSE providing M restoration paths to N normal paths (M = 1 included) it is recommended that in response to a RSCE command the RSE should apply the incoming interface signal belonging to a given normal link to the input port of a given restoration link. The signal should not be removed from the input port of the concerned normal link, except that it may be replaced by a test signal.

For RSE providing N + M link to N accesses it is recommended that in response to a RSCE command, the SCE should apply the incoming interface signal belonging to a given access from 1 to N to a given link from 1 to N + M.

It is recommended that the time required for the above response actions, that is the ‘‘restoration transfer time’’, should be less than tx ms. The value for tx is under study.

Note — The characteristics necessary to specify the option of detecting in the RSE a failed path and to pass this information to the RSCE are under study.

3.2.3 *Other operational aspects*

A recognized failure of the RSCE or its disconnection from the RSE at interface X (when applicable) should either:

a) Cause the RSE to route all the signals on the N normal links. After the failure of the RSCE is cleared or the RSCE is reconnected to the RSE, normal restoration operations will resume.

b) Not alter the state of the RSE. The cross-connection pattern of the RSE should be available by interrogation from the RSCE to enable it to update, when the failure is cleared or it is reconnected to the RSE, its own record on the cross-connection pattern.

For the restoration systems of the second type (as defined in § 2 of this Recommendation) alternative b) only holds. For the systems of the first and third types both alternatives are applicable.

Note — The recommended behaviour of the RSE in case of own power failure is under study.

4 RSCE specifications

4.1 *Interfaces*

Interfaces Y, Z and Q of the RSCE (see Figure 1/G.180) are under study, including the bit rate and the tolerable bit error ratio for the Z interface.

4.2 *Operational aspects*

4.2.1 *Responses*

A switching to a restoration link should be initiated under a request coming from interfaces Y, Z, Q (and X where the faults are detected within the RSE) or on command from the local manual control.

When decided in the RSCE the allocation of a restoration link can optionally take place according to defined priority rules based on:

— defined priority for each normal link;

— request type (low or high priority request).

Otherwise the allocation should be specified by the information coming from interfaces Z, Q or local manual control.

For the restoration systems providing M restoration links (M = 1 included) on N normal links, when a successful restoration request clears, traffic should be returned to the pertinent normal link and the pertinent restoration link should be released.

It should be possible from interfaces Z, Q and under local manual control to lock in a working link (e.g. during system maintenance).

The time required for the above recommended restoration action is the sum of the ‘‘waiting time’’ and the ‘‘restoration procedure time’’. The two components should remain within the following limits:

— waiting time (under study);

— restoration procedure time (under study).

Note — Values to be recommended may be different for the three types of systems considered under § 2 and could depend on the interface over which the information is transferred. No precise proposed value exists at the moment. For a N + 1 system, one proposal indicates that the sum of the ‘‘restoration procedure time’’ and of the ‘‘restoration transfer time’’ should not exceed, in 90% of the occasions, 50 ms plus the time required for the communications.

4.2.2 *Alarm and status criteria*

Under study (see Appendix I to this Recommendation).

4.2.3 *Monitoring and self-test procedures*

Under study (see Appendix II to this Recommendation).

SUPPLEMENT A
(to Table 2/G.180)

Maximum permissible intrinsic jitter at output ports

of regenerative restoration switching equipmemt

(Values for bit rates of the 1544 kbit/s digital hierarchy are under study)

For asynchronous space matrix RSE

H.T. [T3.180]

{		Measurement filter bandwidth {	
		f 4	
2 | 48	0.1	20 Hz	100 kHz
8 | 48	0.1	20 Hz	400 kHz
34 | 68	0.075	100 Hz	800 kHz
139 | 64	0.05	200 Hz	3500 kHz

Tableau [T3.180], p. 24

H.T. [T4.180]

	Maximum value Unit interval peak-peak	Measurement filter bandwidth {			
{	{				
	{				
	f 1	f 3	f 4		
2 | 48	0.25	0.05	20 Hz	18 kHz (700 Hz)	100 kHz
8 | 48	0.25	0.05	20 Hz	3 kHz (80 kHz)	400 kHz
34 | 68	0.35	0.05	100 Hz	10 kHz	800 kHz
139 | 64	under study	0.05	200 Hz	10 kHz	3500 kHz

Note 1 — UI Unit interval for 2 | 48 kbit/s 1 UI 488**,18** ns for 8 | 48 kbit/s 1 UI 118**,18** ns for 34 | 68 kbit/s 1 UI 29.1 ns for 139 | 64 kbit/s 1 UI 7.18 ns.

Note 2 — These figures shall be met for any valid signal in the absence of input jitter. The measurement shall be implemented using equipment designed in accordance with CCITT Recommendation O.171.

Note 3 — Recommendation G.823 § 2 indicates the measurement method.

Note 4 — The frequency values in parentheses only apply to certain national interfaces.

Tableau [T4.180], p. 25

SUPPLEMENT B
(to Table 2/G.180)

Jitter transfer characteristics recommended for

regenerative restoration switching equipment

(Values for the bit rates of the 1544 kbit/s digital hierachy are under study.)

Figure, p. 33

H.T. [T5.180]

{ Parameter value Digital rate (kbit/s) } Test signal (pseudo-random as Rec. O.151) }	*x* (dB) (Note 5)	—*y* (dB)	*f* 0 (Hz)	*f* 5 (kHz)	*f* 6 (kHz)	*f* 7 (kHz)	{
2 | 48 **(** —8.4**)** (—9.5) }	0.5 (Note 1)	{ 36 (1.4)	100 (4.4)	100	$2^{15} — 1$		
8 | 48 **(** —9.5**)** (—7.5) }	0.5 (Note 1)	{ 6 (160)	19 (400)	400	$2^{15} — 1$		
34 | 68 **(** —9.5**)** }	0.5 (Note 1)	{ 20	64	800	$2^{23} — 1$		
139 | 64 **(** —9.5**)** }	0.5 (Note 1)	{ 20	64	3500	$2^{23} — 1$		

Note 1 — The frequency *f* 0 should be as low as possible (e.g., 10 Hz) taking into account the limitations of measuring equipment.

Note 2 — The measuring method should be selective with a bandwidth sufficiently small referred to the relevant measuring frequency, but not wider than 40 Hz.

Note 3 — In the *f* 6 to *f* 7 frequency range the jitter gain should be less than *y* dB, with the exception of spurious responses, which should be suppressed below —6 dB.

Note 4 — The frequency values shown in parentheses only apply to certain national interfaces.

Note 5 — A value of 0.2 dB has been suggested as technically possible for this type of equipment. This may be useful where large numbers of RSE are employed in the network.

Tableau [T5.180], p. 26

H.T. [T6.180]

{ Parameter value Digital rate (kbit/s) } Test signal (pseudo-random as Rec. O.151) }	x (dB)	—y (dB)	f 0 (Hz)	f 5 (kHz)	f 6 (kHz)	f 7 (kHz)	{
2 | 48	0.5	19.5	(Note 1)	40	400	100	2^{15} — 1
8 | 48	0.5	19.5	(Note 1)	100	1000	400	2^{15} — 1
34 | 68	0.5	19.5	(Note 1)	300	3000	800	2^{23} — 1
139 | 64	0.5	under study	(Note 1)	900	under study	3500	2^{23} — 1

Note 1 — The frequency f 0 should be as low as possible (e.g., 10 Hz) taking into account the limitations of measuring equipment.

Note 2 — The measuring method should be selective with a bandwidth sufficiently small referred to the relevant measuring frequency, but not wider than 40 Hz.

Note 3 — The need to tolerate spurious responses greater than y dB in the frequency range f 6 to f 7 is for further study.

Tableau [T6.180], p. 27

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APPENDIX I
(to Recommendation G.180)

Proposals for alarms and status criteria

(Both refer to a N + 1 system)

H.T. [T7.180]

Proposed by STC PLC {
Proposed by AT&T and Philips Telecommunications
}

{

Alarms

It is proposed that the system should include:

a)
System fail.
b)
Protection failure.
c)
Manual switch in operation.
d)
System software self check in operation.
e)
Control system failure.
f)
System software failure.
g)
Communication failure.
h)
Stand-by channel failure.
i)
Power supply failure.
j)
Card removal.

} {

Separate alarm criteria shall be issued at the occurrence of the following faulty conditions:

a)
Loss of signal at the traffic input port, transmit side.
b)
Loss of signal at the traffic output port, receive side.
c)
Automatic lock-in (see Note).
d)
Switch failure.
e)
Protection failure.
f)
Control system failure.
g)
Communication failure.
h)
Stand-by channel failure.
i)
Power supply unit failure.
j)
Loss of power supply.
k)
Switch exerciser failure.

Separate status criteria shall be issued, on the occurrence of the following situations:

a)
Switch operated.
b)
Switch locked.
c)
Switch request pending.
d)
Switch in manual mode.

The protective switching control equipment shall make available to the

remote control and maintenance centre alarm and status information corresponding to the criteria shown above. }	
{ *Note* — This system is required to automatically lock in the normal or the protection channel if an excessive number of switching operations are made in a given period. }	

Tableau [T7.180], p. 28

APPENDIX II

(to Recommendation G.180)

Proposals for monitoring and self-test procedures

(Both refer to a N + 1 system)

H.T. [T8.180]

Proposed STC PLC *Standby Channel Monitoring* The system should include means of monitoring the standby channel continuously for proper operation. *Self-check* The system should include self-check facilities as follows: a) Communication channel. b) Background-checking of the memory, coaxial relay drive buffer and other hardware. c) Correct programme execution. }	{

{
Proposed by AT&T and Philips Telecommuncations
}
Standby Channel Monitoring
The standby channel shall be monitored continuously for proper operation.
Switch Exerciser
The protective switching system shall provide a switch exerciser meeting the following requirements:
The exerciser shall test the complete switch-over procedure up to but excluding the last transfer switch in the direction of transmission.
The switching system shall drop the exerciser routine and serve switch requests from failed or deteriorated channels.
A facility for including the last switch in the exercise routine may be provided. This feature shall have the capability of being disabled.
}
	{

Tableau [T8.180], p. 29

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CHARACTERISTICS OF 1 + 1 TYPE RESTORATION SYSTEMS

FOR USE ON DIGITAL TRANSMISSION LINKS

(Melbourne, 1988)

1 General

Transmission restoration functions are often implemented in the modern telecommunication network to improve the availability and quality of services, by minimizing the effects or potential effects of a transmission failure, and to make the maintenance operations easier.

The terminology and general principles of transmission restoration are described in Recommendation M.495. The functional organization for automatic transmission restoration is described in Recommendation M.496.

2 Object of Recommendation

This Recommendation specifies the characteristics of equipment for 1 + 1 type transmission restoration systems (protection link switching) for digital transmission links, (see Recommendation G.701). The general arrangement of a system of this type is shown in Figure 1/G.181. It uses hybrid on the send side, splitting the input path into two output paths. On the receive side the two paths are supervised and are connected further by a switch automatically controlled by the received signals. The switch may additionally be operated manually or by some kind of remote procedure. The two transmission directions are handled independently.

This Recommendation refers to the equipment labelled as H (hybrid) RSE (restoration switching equipment) and RSCE (restoration switching control equipment).

This Recommendation does not cover the restoration systems fully embedded in transmission systems.

The hierarchical level at interface T is 2048 kbit/s. Other hierarchical levels are under study.

3 Equipment specifications

Equipment H and RSE (see Figure 1/G.181) may be of the regenerative or non-regenerative type.

3.1 *Interfaces*

3.1.1 *Transmission path interfaces* (T)

For H and RSE equipment of the regenerative type the interfaces shall be as specified in Recommendation G.703. The intrinsic output jitter should be not greater than 0.05 UI (measurement filter bandwidth: 20 Hz to 100 kHz).

For H and RSE equipment of the non-regenerative type the interface characteristics are under study.

3.1.2 *Control interface* (X)

The control interface X is not at present standardized by CCITT. However in the future it may be specified as a Q interface (see Recommendation G.771).

3.2 *Operational aspects*

3.2.1 *Transfer of the switched signals*

For H and RSE equipment of the regenerative type the jitter transfer gain should be not greater than 0.5 dB (the frequency limits are under study).

For H and RSE equipment of the non-regenerative type the transfer characteristics are under study.

3.2.2 *Response*

Switching between the two paths occurs only on the receive side, as indicated in Figure 1/G.181.

One of the two paths may be the path with the primary right, e.g. path II/II‘. If this path fails the switch is operated to path III/III‘. After restoration of path II/II‘ the switch will automatically be set back to this path.

If the two paths have the same right the switch will remain in the last position even after restoration of a failed path. This is the preferred method.

Note — Paths II/II‘ and III/III‘ have the same performance under normal planning conditions of transmission routes and systems. The ‘‘method of the same right’’ reduces the frequency of switching and resynchronization by a factor of 2.

Switching to a failed path must be avoided.

The RSCE should operate the switch:

— automatically according to the criteria expressed by Tables 1/G.181 and 2/G.181, based on AIS reception and loss of incoming signal or (as an option) on transmission quality (see Note);

— manually on command from the local manual control;

— under a request coming from interface X.

Note — As an option the switching can be based on transmission quality as defined in Recommendation G.821 and by agreement between Administrations. In this case the transmitted signals need to have a standard frame structure in accordance with Recommendation G.704 which for 2048 kbitB/Fs should also include the CRC4 option.

It is recommended that the time required for the above response actions, that is the ‘‘confirmation time’’ plus the ‘‘restoration transfer time’’ should be less than 10 ms for terrestrial routes and 500 ms for satellite routes.

Figure 1/G.181, p. 30

H.T. [T1.181]

TABLE 1/G.181

Response criteria for the hybrid H at the transmit side

Fault condition Consequent action (signal at II and III) }	{
No signal at I	AIS
AIS receive at I	AIS

{
Failure of power supply, system failure
}
AIS
(if possible | ua))
}
	{

a) The equipment may not be able to send AIS; this depends on the nature of the nature of the failure.

Tableau 1/G.181 [T1.181], p. 31

H.T. [T2.181]

TABLE 2/G.181

Switching criterion for the RSE at the receive side

Condition	Consequence action	Remark
Received signal II‘ and III‘	(See note)	Signal at IV
{ Received signal at II‘ AIS or no signal at III‘ }	Switch to II‘	Signal at IV
{ Received signal at III‘ AIS or no signal at II‘ }	Switch to III‘	Signal at IV
AIS at II‘ and III‘ Received AIS is through-connected }	Switch to II‘ or III‘	{
No signal at II‘ and III‘ The switching equipment sends AIS at IV }	{	
{ AIS at II‘ and no signal at III‘ } Received AIS is through-connected } { AIS at III‘ and no signal at II‘ }	Switch to II‘ Switch to III‘	
{ Correct signal at II‘ Bad quality at III‘ }	Switch to II‘	Correct signal at IV
{ Correct signal at III‘ Bad quality at II‘ }	Switch to III‘	idem
{ Bad quality at II‘ AIS or no signal at III‘ }	Switch to II‘	Bad quality at IV
{ Bad quality at III‘ AIS or no signal at II‘ }	Switch to III‘	idem
{ Bad quality at III‘ Bad quality at II‘ }	(See Note)	Bad quality at IV
{ Failure of power supply system failure } The switching equipment sends AIS (if possible) at IV *Note* — Switch to paths II/II‘ or III/III‘ if both paths have the same right. Switch to the path with the primary right if the other method is used (see § 3.2.2). **M=** Optional }	{	

Tableau 2/G.181 [T2.181], p. 32

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