INTERNATIONAL TELECOMMUNICATION UNION

ITU-T G.142

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

TRANSMISSION SYSTEMS AND MEDIA

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

TRANSMISSION CHARACTERISTICS OF EXCHANGES

ITU-T Recommendation G.142

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.142 was published in Fascicle III.1 of the *Blue Book*. This file is an extract from the *Blue Book.* While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

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Recommendation G.142

TRANSMISSION CHARACTERISTICS OF EXCHANGES

(Geneva, 1980; amended at Melbourne, 1988)

This Recommendation consists of two parts. The first part, § 1, is concerned with the voice-frequency transmission characteristics of international analogue exchanges. The information involved is encompassed within Recommendation Q.45 [1]. The second part, § 2, is concerned with the voice-frequency transmission considerations that should be taken into account in the design of digital exchanges and their incorporation into the network. The digital exchanges referred to include local exchanges and transit exchanges (national and international). The transmission considerations relate primarily to the properties which digital exchanges should possess to enable them to operate under different and changing network conditions with respect to the content of analogue, mixed analogue/digital and all-digital plant.

Detailed transmission characteristics for digital exchanges are contained in Recommendations Q.551, Q.552, Q.553 and Q.554 (Fascicle VI.5).

1 International analogue exchange

The commissioning objectives for the transmission requirements to be respected by an international analogue exchange are included in Recommendation Q.45 or Q.45 *bis.*

2 Digital exchanges

2.1 *Digital processes - Effect on transmission*

Digital (TDM) exchanges, to varying degrees, are required to include such digital processes as analogue-to-digital coders, digital-to-analogue decoders and digital recording processes, examples of which are companding law converters and digital pads. The extent to which such digital processes might be included in a digital exchange is determined by the network environment in which the exchange is to operate (i.e., all-analogue, mixed analogue/digital or all-digital).

Digital processes such as those referred to above, attract transmission penalties. These penalties can be expressed in terms of "units of transmission impairment".

A limit is placed on the permissible accumulation of units of transmission impairment in an international telephone connection. Details of the planning rule resulting from this limit and the penalties introduced by individual digital processes are given in Recommendations G. 101, § 4 and G. 113, § 3.

In accordance with Recommendation G.113, § 3 it is provisionally recommended that no more than 14 units of transmission impairment be permitted to accumulate in an international connection. Of these 14 units, a maximum of 5 units could be introduced by each national extension and a maximum of 4 units by the international portion. Since one 8-bit PCM codec pair (coder and decoder) introduces 1 unit of transmission impairment, it is clear that unintegrated PCM digital processes involving analogue/digital conversions, (e.g. codecs) or digital processes involving the recoding of information (e.g. digital pads) should not be allowed to proliferate in an uncontrolled fashion. Figure 1/G.142 shows some of the transmission paths that might be established through a digital exchange and the "units of transmission impairment" attributable to the digital processes in these paths.

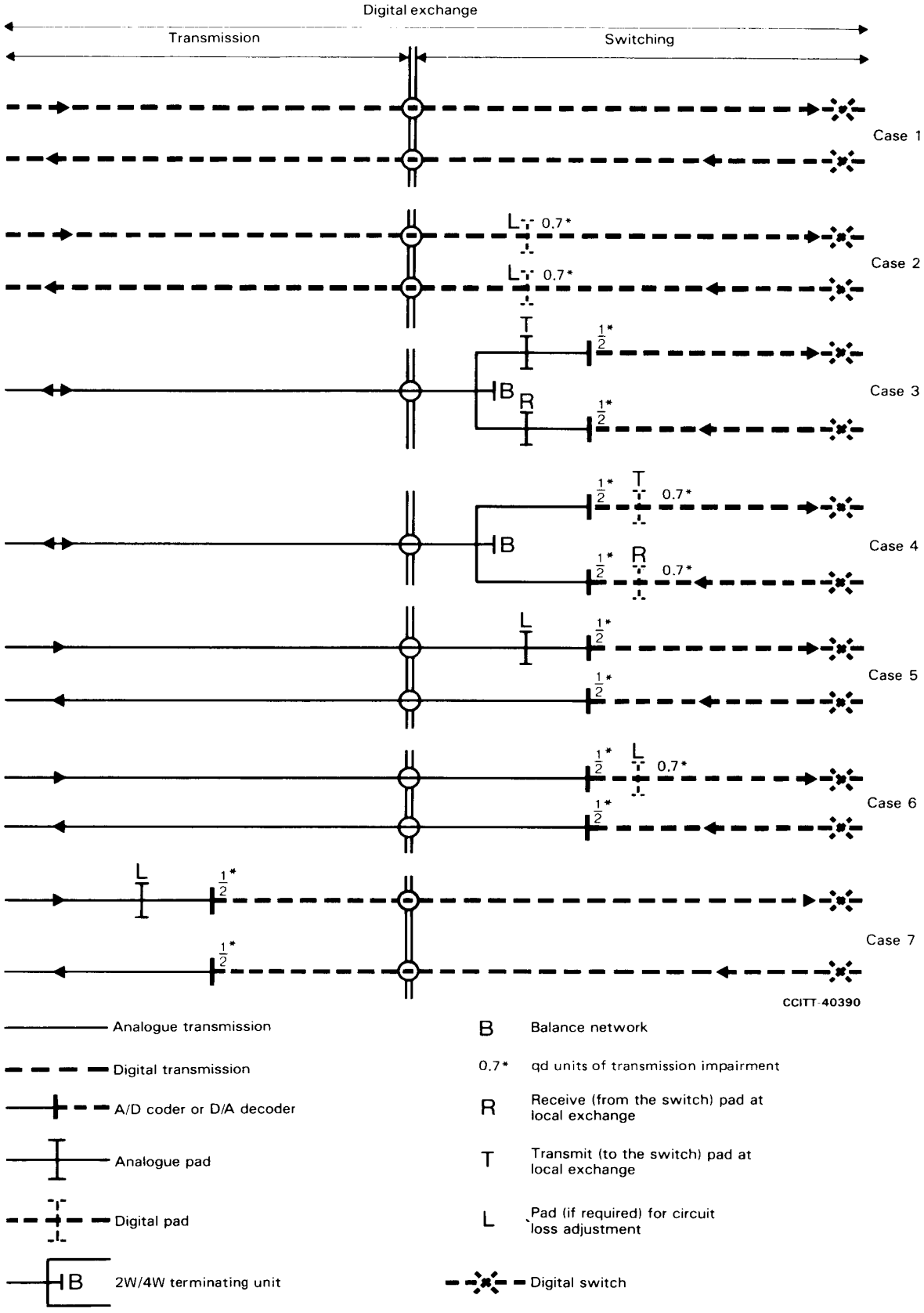

FIGURE 1/G.142

Transmission paths at digital exchanges

2.2 *Transmission loss through a digital exchange*

The 4-wire digital switching function at a digital exchange should introduce a nominal transmission loss of 0 dB. Thus, in Figure 1/G.142 (Case 1) if a 0 dBm0 sinusoidal test signal is introduced at the analogue terminals of an ideal coder connected to the input of a digital switch, a Digital Reference Sequence (DRS) should be transmitted unaltered through the switch and produce a 0 dBm0 sinusoidal signal at the analogue terminals of a decoder connected to the output of the digital switch.

Except for the transmission loss considered above (and perhaps the possible loss due to exchange wiring) all transmission losses which are to be introduced by a digital exchange, either in a digital or analogue form, are to be governed by the applicable transmission plan (see § 2.4 below).

2.3 *Relative levels*

On digital paths within an all-digital network, relative levels have no real meaning or use. However, as long as a substantial portion of the worldwide telephone network is of an analogue nature, it is necessary and useful to assign relative levels to digital exchanges.

The relative levels assigned to a digital exchange are applicable at the virtual analogue switching points of the exchange. The virtual analogue switching points are theoretical points as explained in Recommendation G.101, § 5.1. The concept of applying relative levels at the virtual analogue switching points of a digital exchange is dealt with in Recommendations G.101, § 4.2 and G.101, § 5.2.

In accordance with Recommendation G.101, § 5.2 the send relative level at an international digital exchange should be -3.5 dBr. In the case of digital exchanges in national extensions, the send relative levels should be governed by the applicable national transmission plan.

With regard to the receive relative level at a digital exchange, this level is related to the transmission loss of the circuits terminating at the exchange. In the case of an international digital exchange, it is desirable to have the receive relative level at -3.5 dBr to avoid having to introduce digital pads. But see the general Note in Recommendation G.101, § 4.2 for exceptions. In the case of national extensions, the receive relative levels, as in the case of the send relative levels, are to be determined on the basis of the applicable national transmission plan.

2.4 *Echo and stability control*

The overall echo and stability losses presented by a national extension are a function of the relevant transmission losses and, in the case of the use of 2-wire conversion circuits, the balance return loss introduced by the 2-wire/4-wire conversion circuit. Both contributions need to be considered in the design of digital local exchanges where there is generally scope for improving the echo and stability losses. Such improvements are likely to be needed as connections in digital networks will tend to have lower losses and longer delays than analogue connections with a consequent worsening in echo performance.

2.4.1 *Transmission loss contribution*

The requirements for controlling stability and echo on international connections under all-digital or mixed analogue/digital network conditions are dealt with in Recommendation G.122. In accordance with the latter Recommendation, the national extensions are to be mainly responsible for effecting this control. Arrangements for doing so are dealt with in Recommendation G.121, § 6.

Recommendation G.121, § 6 provides the framework within which individual national transmission plans are to provide for the necessary features to effect the required control. In the case of a digital 4-wire national extension (i.e., ail-digital down to the local exchange but with 2-wire analogue subscriber lines), the control can be effected entirely at the local exchange. Where the national extension is to be of a mixed analogue/digital nature, the control under some national transmission plans might be distributed among the different parts of the national extension but the main burden would in general still lie with the local exchange. Figure 1/G.142 contains examples of some of the different arrangements that might be encountered at a digital exchange.

The arrangement in Case 1 of Figure 1/G.142 deals with the termination of a digital circuit at what might be a national or international digital exchange. In this particular case, the circuit is to be operated without. introducing additional loss at the exchange.

The arrangement in Case 2 of Figure 1/G.142 also deals with the termination of a digital circuit at a national or international digital exchange. However, in this case, the relevant transmission plan requires that loss should be associated with the circuit at the exchange through the medium of digital pads. See § 2.6 below regarding the use of digital pads.

The arrangement in Case 3 of Figure 1/G.142 deals with the termination of a 2-wire subscriber's line at a digital local exchange. The pads designated R and T are pad symbols intended to represent loss or level adjustment made in the analogue portion. Recommendation G.121, § 6 is concerned with the appropriate choice of values for R and T.

The arrangement in Case 4 of Figure 1/G.142 is similar to that of Case 3 except that the losses R and T are shown as being provided in the digital portion. See § 2.6 below regarding the use of digital pads.

The arrangement in Cases 5, 6 and 7 of Figure 1/G.142 deals with the termination of analogue circuits at a national or international digital exchange. In Case 5, an analogue pad (L) is used to develop the required loss of the circuit in accordance with the relevant transmission plan. Case 6 is similar to Case 5 except that a digital pad (L) is used to develop the required circuit loss. Case 7 is also similar to Case 5 except that the analogue pad (L) as well as the A/D coder and D/A decoder are provided as part of the transmission equipment associated with the circuit rather than by equipment that is built-in as part of the switching system. Although not shown in Figure 1/G.142, the A/D coders, the D/A decoders, the 2-wire/4-wire terminating units and the pads involved in Cases 2, 3 and 4 can also be provided as part of the transmission equipment on the transmission side of the exchange rather than by equipment that is built-in as part of the switching system.

2.4.2 *Balance return loss contribution*

The contribution of balance return loss to the overall echo and stability losses is illustrated in Cases 3 and 4 of Figure 1/G.142 which show the situation of 2-wire local lines terminating on a digital local exchange. The achieved balance return loss is determined by the match between the impedance presented by the 2-wire local line and customer terminating apparatus and the balancing impedance chosen for the digital exchange line card.

In many designs of digital local exchange there is no 2-wire switch and the 2-wire line is permanently connected to the line card. This arrangement has significant advantages for balance return loss as there is likely to be a significant reduction in the range of impedances presented to any single line card. It is then possible to choose a line card balancing impedance more closely matched to the local line impedances and obtain an improvement in balance return loss compared with the conventional compromise impedances.

The optimum balancing impedance will not be the same for all Administrations as it needs to take into account the local cable types used together with the range of customer apparatus impedances. It is possible that the use of different exchange balancing impedances for different local line classes will give an improvement in performance at the expense of some increase in network Administration. In general it has been found that the use of balancing networks which resemble the impedance presented by local cable give the optimum performance. Examples of balancing impedances adopted by a number of Administrations are given in Recommendation Q.552.

Further improvement in balance return loss is possible where the impedance of the customer apparatus can be influenced by the Administration. Telephone instruments with an input impedance close to the impedance of the local cable can result in an improvement in the balance return loss at the digital local exchange in the order of 10 dB on short local lines.

2.5 *Local transmission*

On local calls between subscribers served by the same digital local exchange, the switching of 2-wire subscriber lines such as those shown in Figure 1/G.142, Case 3, results in an equipment arrangement which takes on the appearance of a voice-frequency repeater - see Figure 2/G.142. As is well known, such an arrangement must include sufficient loss around the loop to provide for an adequate margin of stability. To provide for this loss, some 2-wire to 2-wire attenuation may be acceptable in some cases. The attenuation might be supported by the national transmission plan, as it provides adequate loudness rating distribution for local calls. However, in cases where the 2-wire to 2-wire attenuation is to be comparable to that generally prevailing at an analogue exchange, i.e., approximately 0 dB, adequate balance return losses must be provided at the 2-wire/4-wire junctions. This could entail increasing the existing values of balance return loss at these points. Methods for doing this are under study by Study Group XII.

Increasing the balance return losses as referred to above should also be beneficial to the control of echo and stability in national connections beyond the local exchange as well as on international connections.

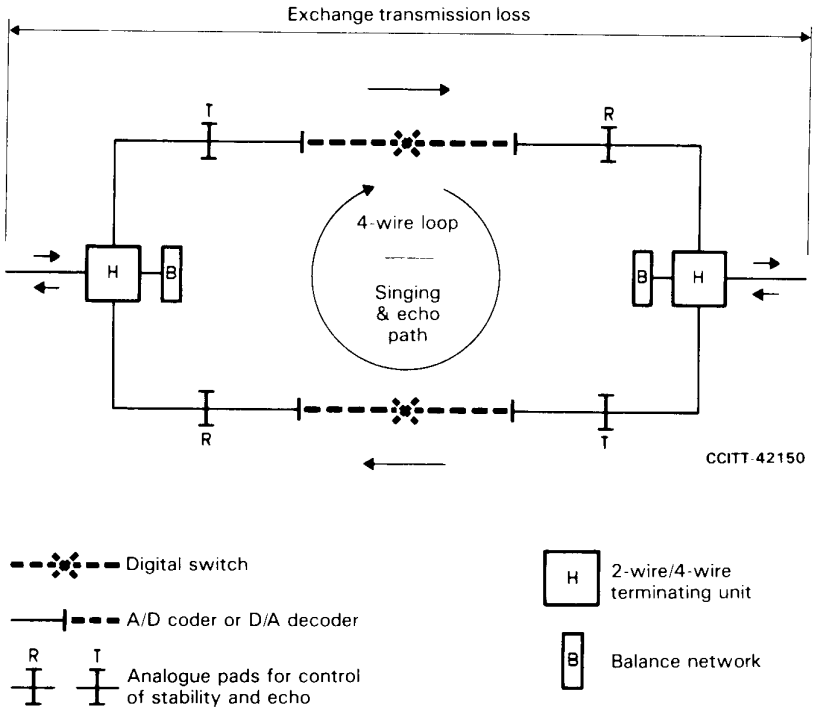

FIGURE 2/G.142

Configuration of digital local exchange on 2-wire to 2-wire connections

2.6 *Sidetone and input impedance*

Digital local exchanges can have a significant influence on the sidetone performance of telephone instruments, particularly those instruments on relatively short local lines. The reason for this can be seen in Figure 2/G.142 where the impedance presented by the exchange to the local line is a function of the input impedance of the line card and the characteristics of the singing and echo path within the exchange.

For optimum sidetone performance on short local lines the input impedance of the exchange line card should be close to the anti-sidetone impedance of the telephone instrument. In the case where the telephone instrument is designed to give good sidetone performance on long local lines this anti-sidetone impedance is likely to be close to the characteristic impedance of the 2-wire local cable. This would lead to the digital local exchange also presenting an impedance close to that of the 2-wire local cable.

On longer local lines the exchange impedance will have less effect on the sidetone performance as the impedance presented to the telephone is masked by the local cable impedance.

The final choice of exchange impedance needs to take into account a number of factors:

- telephone set impedance and sensitivity characteristics;
- local line network characteristics;
- digital exchange current feeding arrangements,

the objective being that the customer should not see a worsening in sidetone performance when connected to a digital exchange. The impedance chosen by a number of Administrations are given in Recommendation Q.552 and it is clear that there is a considerable difference between the impedances which reflects the differences between the national networks.

2.7 *Digital pads*

The use of a digital pad to produce the required transmission loss in a digital path attracts a transmission penalty. This penalty has to come out of the allowance of "units of transmission impairment" allotted to the national and international portions of international connections - see Recommendation G.113, § 3. Additionally, since digital pads involve the use of digital recoding processes, the use of such pads in paths where bit integrity must be preserved is unattractive. This can be an important consideration where multipurpose networks are contemplated. Consequently, if digital pads must be introduced, arrangements should be made to switch them out or to bypass them.

2.8 *Transmission delay*

Transmission delays through digital exchanges could be significant. For example, such delays could have the effect of decreasing the length of connections on which echo control devices (e.g., echo suppressors or echo chancellers) should be applied. Transmission delays at digital local exchanges (or at digital PBXs) could in some cases also affect the impedance match between subscriber lines and the exchange (or PBX) in a way that could adversely affect subscriber sidetone. Transmission delays through digital exchanges should, therefore be minimized. See Recommendation G.114, § 2 for details of the delay introduced by various items of digital equipment and systems.

For transmission delays that might be encountered at digital exchanges; see Recommendation Q.551.

Reference

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