INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

G.142

(12/98)

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

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

International telephone connections and circuits – General characteristics of the 4-wire chain of international circuits; international transit

Transmission characteristics of exchanges

ITU-T Recommendation G.142

(Previously CCITT Recommendations)

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ITU-T RECOMMENDATION G.142

TRANSMISSION CHARACTERISTICS OF EXCHANGES

Summary

This Recommendation was revised to remove text that referred to international analogue exchanges. The ITU-T no longer recommends the placement of new or continued operation of analogue international exchanges. Additionally, this Recommendation was written so as to recognize that both Plesiochronous Digital Hierarchy/Synchronous Digital Hierarchy (PDH/SDH) and digital ATM switching technology may be used in the PSTN. This Recommendation provides transmission performance planning guidance for digital exchanges.

Source

ITU-T Recommendation G.142 was revised by ITU-T Study Group 12 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 3rd of December 1998.

FOREWORD

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

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

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

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

NOTE

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

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

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Recommendation G.142

TRANSMISSION CHARACTERISTICS OF EXCHANGES

(Geneva, 1980; amended at Melbourne, 1988, revised in 1998)

1 Scope

This Recommendation 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.

2 General

Detailed transmission characteristics for PDH/SDH digital exchanges are contained in Recommendations Q.551, Q.552, Q.553 and Q.554. While no detailed Recommendations have been specifically generated for switches which use ATM technology, in general, ATM switches should comply with the requirements defined in the Q.550 series Recommendations. It is understood that due to the different mode of operation of ATM switches, as compared to their PDH/SDH counterparts, certain parameters like group delay may be different for an ATM switch that performs cell assembly when information from one DS-0 is placed within a specific cell.

3 References

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

– ITU-T Recommendation G.101 (1996), *The transmission plan*.

– ITU-T Recommendation G.113 (1996), *Transmission impairments*.

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

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

– ITU-T Recommendation G.126 (1993), *Listener echo in telephone networks*.

– ITU-T Recommendation G.176 (1997), *Planning guidelines for the integration of ATM technology into networks supporting voiceband services*.

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

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

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

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

– ITU-T Supplement 31 to the G-series Recommendations (1993), *Principles of determining an impedance strategy for the local network*.

4 Digital exchanges

4.1 Digital processes – Effect on transmission

Digital PDH/SDH exchanges and digital ATM exchanges, to varying degrees, currently 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. mixed analogue/digital or all-digital). While a number of signal processing functions such as echo control, speech compression and PDH/SDH to ATM interworking may be performed by physically distinct network elements, this does not preclude the incorporation of these digital signal processing functions into digital switches.

Digital processes such as those referred to above attract transmission penalties. These penalties can be expressed in terms of "quantization distortion units (qdus) or units of equipment impairment factor (eif)". The impact of these impairments on a connection can be evaluated using the "quantization factor method" or the "equipment impairment factor method", as discussed in Recommendation G.113. Only the equipment impairment factor method which is discussed in clause 6/G.113 is recommended for evaluating the impairments associated with transmission devices which use non-waveform coding techniques.

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 5.6/G.113.

In accordance with 5.6/G.113, it is 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[1]. 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 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 2 also shows some of the transmission paths that might be established through a digital exchange. However, Figure 2 is intended to identify examples of where digital signal processing devices may be placed. It is recommended that the impairments caused by these signal processing devices be evaluated using the equipment impairment factor method presented in clause 6/G.113. It is important to understand that the equipment impairment factor method allows the performance evaluation to be performed if the impairments are specified in impairment units of eifs and or qdus.

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[1] It should be noted that 14 qdus equates to approximately 20 eif units.

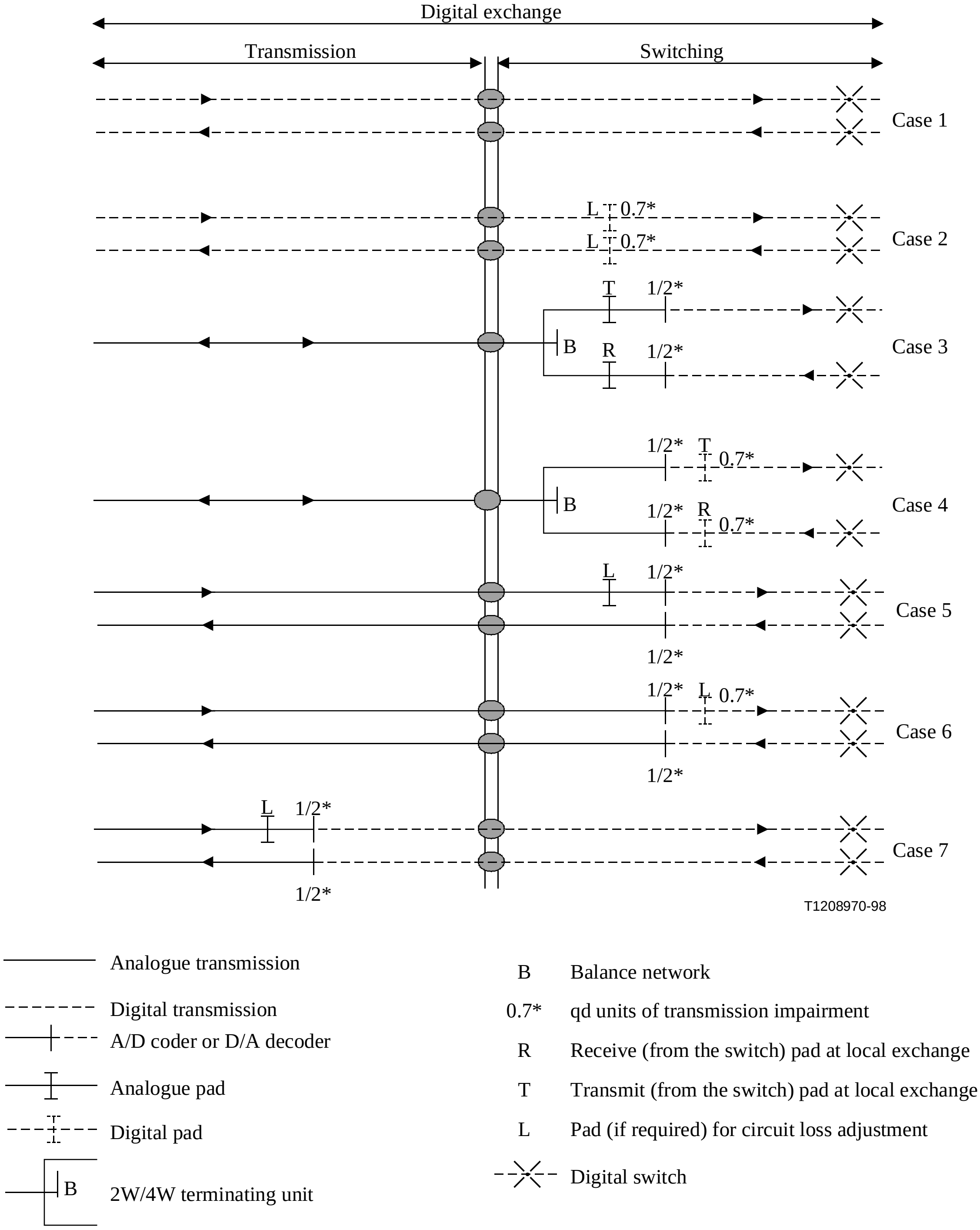

Figure 1/G.142 – Transmission paths at digital exchanges

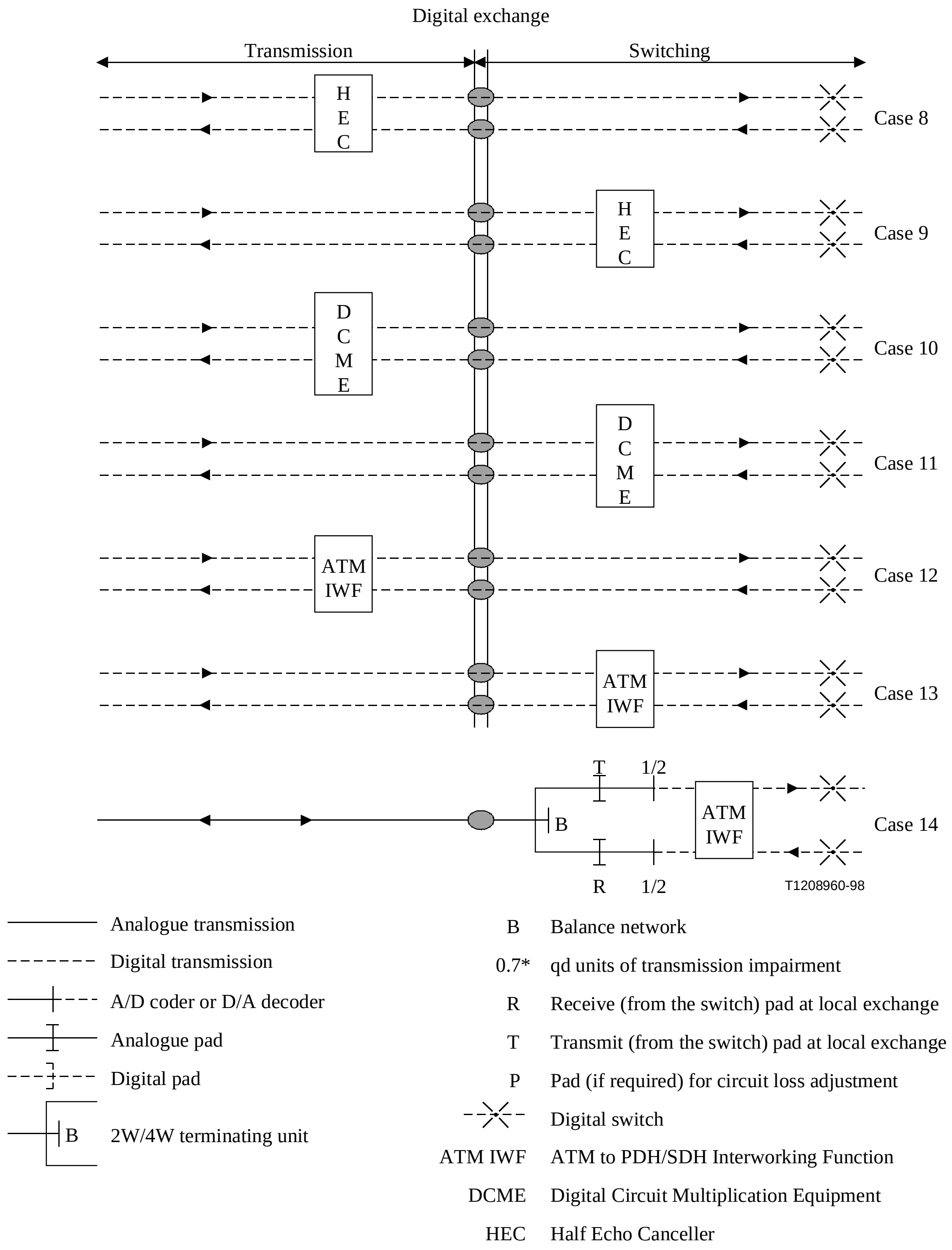

Figure 2/G.142 – Transmission paths at digital exchanges which include digital signal processing

4.2 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 (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 on analogue signals), 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 4.4 below).

4.3 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 international connecting points of the exchange. The virtual international connecting points are theoretical points, as explained in 3.10.1.3/G.101.

In accordance with 3.10.1.4/G.101:

- the send and receive relative levels at an international digital exchange should be 0 dBr, when digital facilities are being terminated;
- the send level is 0 dBr and the receiving level is –0.5 dBr at an international digital exchange, when the international exchange terminates national analogue extension facility.

In the case of digital exchanges in national extensions, the send relative levels should be governed by the applicable national transmission plan.

4.4 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. As integration of ATM switches may introduce significant incremental delay, a set of guidelines for introduction of ATM technology into the PSTN has been developed and published as Recommendation G.176.

4.4.1 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 clause 6/G.121.

Clause 6/G.121 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. all-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 contains examples of some of the different arrangements that might be encountered at a digital exchange.

The arrangement in (Case 1) of Figure 1 deals with the termination of a digital circuit at what might be a national or an 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 also deals with the termination of a digital circuit at a national 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 4.7 below regarding the use of digital pads.

The arrangement in (Case 3) of Figure 1 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. Clause 6/G.121 is concerned with the appropriate choice of values for R and T.

The arrangement in (Case 4) of Figure 1 is similar to that of (Case 3) except that the losses R and T are shown as being provided in the digital portion. See 4.7 below regarding the use of digital pads.

The arrangement in (Cases 5, 6 and 7) of Figure 1 deals with the termination of national 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, 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.

4.4.2 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 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. Supplement 31 to the G-series Recommendations provides principles of determining an impedance strategy for the local network. Recommendation G.126 provides guidance in regards to the balance requirements necessary to control listener echo.

4.5 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, (Case 3), results in an equipment arrangement which takes on the appearance of a voice-frequency repeater – see Figure 3. 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.

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.

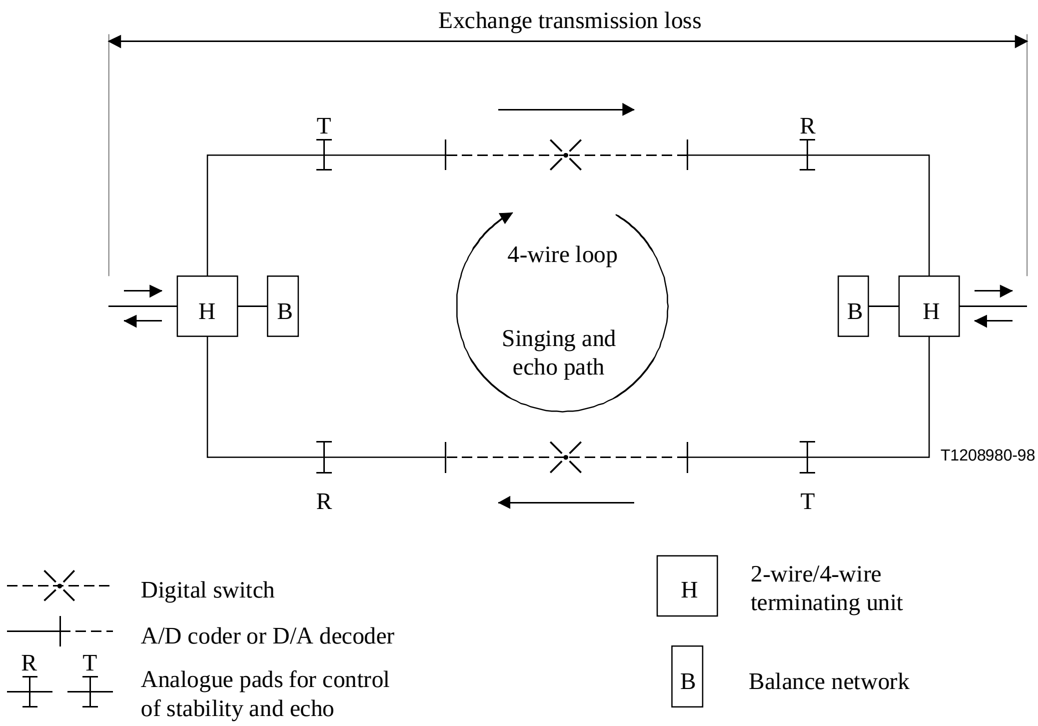

Figure 3/G.142 – Configuration of digital local exchange on 2-wire to 2-wire connections

4.6 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 3 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. Impedances 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 reflect the differences between the national networks.

4.7 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 5.6/G.113. 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 multi-purpose networks are contemplated. Consequently, if digital pads must be introduced, arrangements should be made to switch them out or to bypass them.

4.8 Transmission delay

Transmission delays through digital exchanges, especially if they also perform a speech processing function, e.g. digital speech compression, or PDH/SDH to ATM interworking, could be significant. For example, such delays could have the effect of decreasing the length of connections on which echo control devices (viz. echo cancellers) 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 Annex A/G.114 for details of the delay introduced by various items of digital equipment and systems. Recommendation G.176 provides guidance associated with the integration of ATM technology into the PSTN.

For transmission delays that might be encountered at digital PDH/SDH exchanges, also see Recommendation Q.551.

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