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DIGITAL EXCHANGES

**TRANSMISSION CHARACTERISTICS
AT 4-WIRE ANALOGUE INTERFACES
OF DIGITAL EXCHANGES**

ITU-T Recommendation Q.553

(Previously "CCITT Recommendation")

FOREWORD

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NOTE

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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TRANSMISSION CHARACTERISTICS AT 4-WIRE ANALOGUE INTERFACES OF DIGITAL EXCHANGES

(revised 1994)

1 General

This Recommendation provides characteristics for:

- 4-wire analogue interfaces (Type C₁₁, C₁₂ and C₁₃);
- input and output connections with 4-wire analogue interfaces, and
- half connections with 4-wire analogue interfaces;

in digital transit and combined local and transit exchanges in accordance with the definitions given in Recommendation Q.551, particularly in Figures 1/Q.551 and 2/Q.551.

The characteristics of the input and output connections of a given interface are not necessarily the same. The characteristics of half connections are not necessarily identical for different types of interfaces.

This Recommendation is intended for switched connections that may be part of an international long-distance connection via 4-wire line circuits interconnected by 4-wire exchanges. Since 4-wire analogue interfaces of digital exchanges may connect with circuits which are used for both international and national traffic, the same values recommended for international connections may also be used for connections entirely within the national network.

2 Characteristics of interfaces

2.1 Characteristics common to all 4-wire analogue interfaces

2.1.1 Exchange impedance

2.1.1.1 Nominal value

The nominal impedance at the 4-wire input and output interfaces should be 600 ohms, balanced.

2.1.1.2 Return loss

The return loss at the equipment ports, measured against the nominal impedance, should not be less than 20 dB over the frequency range 300 Hz to 3400 Hz.

NOTE – For output measurement, the exchange test point T_i must be driven by a PCM signal corresponding to the decoder output value number 0 for the μ -law or decoder output value number 1 for the A-law. (See 1.2.3.1/Q.551.)

2.1.2 Impedance unbalance about earth

The value for the Longitudinal Conversion Loss (LCL) at the equipment ports as defined in 4.1.3/G.117, with the circuit under test in the normal talking state, should exceed the minimum values of Figure 1, in accordance with Recommendations Q.45 *bis* and K.10.

NOTES

1 An Administration may adopt other values and in some cases a wider bandwidth, depending upon actual conditions in its telephone network.

2 A limit may also be required for the Transverse Conversion Loss (TCL) as defined in 4.1.2/G.117, if the exchange termination is not reciprocal with respect to the transverse and longitudinal connections. A suitable limit would be 40 dB to ensure an adequate near-end crosstalk attenuation between interfaces.

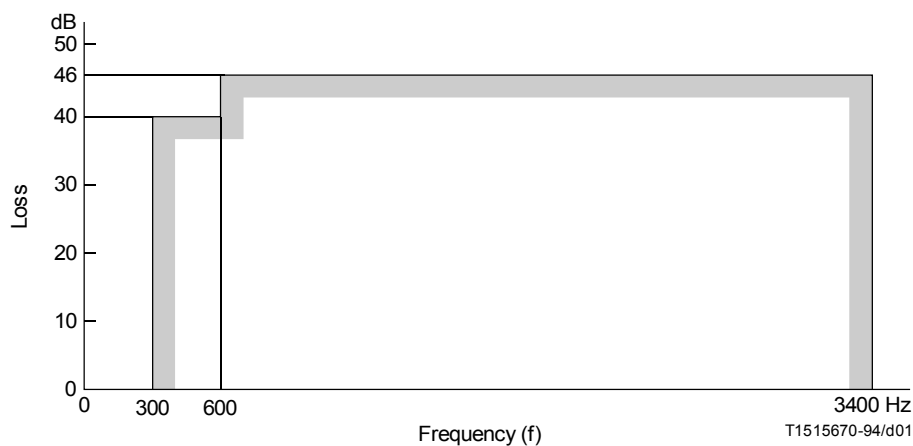


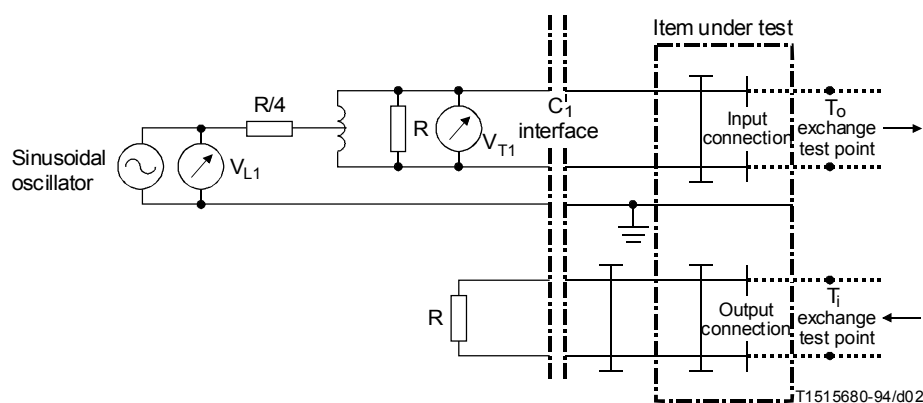
FIGURE 1/Q.553

Minimum values of LCL measured in the arrangement shown in Figure 2

Test method

LCL should be measured in accordance with the principles given in 2.1/O.9. Figure 2 shows the basic measuring arrangement. Arrangements containing two resistors each of value $R/2$ may also be used (see clause 3/O.9).

Measurements of the longitudinal and transverse voltages should be performed by means of a frequency-selective level meter.



$R = 600 \text{ ohms}$

NOTE – For output measurement the exchange test point T_i must be driven by a PCM signal corresponding to the decoder output value number 0 for the μ -law or decoder output value number 1 for the A-law. (See 1.2.3.1/Q.551.)

FIGURE 2/Q.553

Arrangement for measuring LCL

2.1.3 Relative levels

In assigning the relative levels to the interfaces, the limiting of “difference in transmission loss between the two directions of transmission” in Annex A/G.121 has been taken into account. For the national extension this is the value “loss (t-b)–loss (a-t)”. (See the text in the cited Recommendation for guidance.) This difference is limited to ± 4 dB. However, to allow for additional asymmetry of loss in the rest of the national network, only part of this difference can be used by the digital exchange.

2.1.3.1 Nominal levels

The nominal relative levels at the 4-wire analogue input and output interfaces of the digital exchange depend on the type of equipment which is connected to the exchange. (See Figure 1/Q.551.)

In practice it may be necessary to compensate for the loss between the output interfaces of the digital exchange and the input ports of the connected equipment to fulfil transmission plan conditions. The definition of adjustable steps for and the location of this compensation (digital exchange or connected equipment) is within national competence.

Nominal values of relative levels are given in 2.2.1, 2.3.1 and 2.4.1 for the different types of half connections.

2.1.3.2 Tolerances of relative levels

The difference between the actual relative level and the nominal relative level should lie within the following ranges:

- input relative level: -0.3 to $+0.7$ dB;
- output relative level: -0.7 to $+0.3$ dB.

These differences may arise, for example, from design tolerances, cabling (between analogue equipment ports and the DF) and adjustment increments.

NOTE – Adjustment of the relative level should be made in accordance with clause 3/G.712.

2.2 Characteristics of interface C₁₁

According to Figure 1/Q.551, the interface C₁₁ of a digital exchange is intended to interwork with the channel translating equipment of an FDM system.

2.2.1 Values of nominal levels

The nominal values of relative levels at the channel translating equipment are specified in Table 2/G.232 for the two recommended cases. With the pads in the channel translating equipment set to zero, these values are:

	Case 1	Case 2
R	+4.0 dBr	+7.0 dBr
S	–14.0 dBr	–16.0 dBr

The nominal values of relative levels at the digital exchange must be adjusted to compensate for the total loss between the interface of the digital exchange and the channel translating equipment. Therefore:

$$L_i = R - A_R$$

$$L_o = S + A_S$$

where:

A_R is the total loss in the receive path, e.g. direction of transmission from channel translating equipment to digital exchange.

A_S is the total loss in the send path, e.g. direction of transmission from digital exchange to channel translating equipment.

2.3 Characteristics of interface C₁₂

According to Figure 1/Q.551, the interface C₁₂ of a digital exchange is intended to interwork with the incoming and outgoing relay set of an analogue 4-wire exchange. (See Figure 1/Q.45 *bis*.)

2.3.1 Values of nominal levels

The nominal values of relative levels at the relay set of an analogue exchange are consistent with Table 2/G.232 for the two recommended cases. These values are:

	Case 1	Case 2
R	−14.0 dBr	−16.0 dBr
S	+4.0 dBr	+7.0 dBr

The nominal values of relative levels at the digital exchange must be adjusted to compensate for the total loss between the interface of the digital exchange and the relay sets of the analogue exchange. Therefore:

$$L_i = R - A_R$$

$$L_o = S + A_S$$

where:

A_R is the total loss in the receive path, e.g. direction of transmission from relay set to digital exchange.

A_S is the total loss in the send path, e.g. direction of transmission from digital exchange to relay set.

2.4 Characteristics of interface C₁₃

According to Figure 1/Q.551 the interface C₁₃ of a digital exchange is intended to connect to a 4-wire analogue switching stage. (See Figure 1/G.142, case 5.)

2.4.1 Values of nominal levels

The nominal values of relative levels are determined by the relative levels of the analogue 4-wire switching stages in the national transmission plans. For example, if these relative levels are −3.5 dBr in both directions of transmission, the nominal input and output levels of a C₁₃ interface are:

$$L_i = L_o = -3.5 \text{ dBr.}$$

Different levels at the switching stages and transmission loss between interface C₁₃ and the switching stages can require adjusting these levels.

3 Characteristics of half connections

3.1 Characteristics common to all 4-wire analogue interfaces

3.1.1 Transmission loss

3.1.1.1 Nominal value

The nominal transmission loss, according to 1.2.4.1/Q.551 is defined for input and output connections of a half connection with 4-wire analogue interface in 3.2.1, 3.3.1 and 3.4.1.

3.1.1.2 Tolerances of transmission loss

The difference between the actual transmission loss and the nominal transmission loss of an input or output connection of the same half connection according to 2.1.3.2 should lie within the following values:

$$-0.3 \text{ to } +0.7 \text{ dB.}$$

These differences may arise for example, from design tolerances, cabling (between analogue equipment ports and the DF) or adjustment increments.

3.1.1.3 Short-term variation of loss with time

When a sine-wave test signal at the reference frequency of 1020 Hz and at a level of -10 dBm0 (if preferred, the value 0 dBm0 may be used) is applied to a 4-wire analogue interface of any input connection, or a digitally simulated sine-wave signal of the same characteristic is applied to the exchange test point T_i of any output connection, the level at the corresponding exchange test point T_o and the 4-wire analogue interface respectively, should not vary by more than ± 0.2 dB during any 10-minute interval of typical operation under the steady state condition permitted variations in the power supply voltage and temperature.

3.1.1.4 Variation of gain with input level

With a sine-wave test signal at the reference frequency of 1020 Hz and at a level between -55 dBm0 and $+3$ dBm0 applied to the 4-wire analogue interface of any input connection, or with a digitally simulated sine-wave signal of the same characteristic applied to the exchange test point T_i of any output connection, the gain variation of that connection, relative to the gain at the input level of -10 dBm0, should lie within the limits given in Figure 3.

The measurement should be made with a frequency selective meter to reduce the effect of the exchange noise. This requires a sinusoidal test signal.

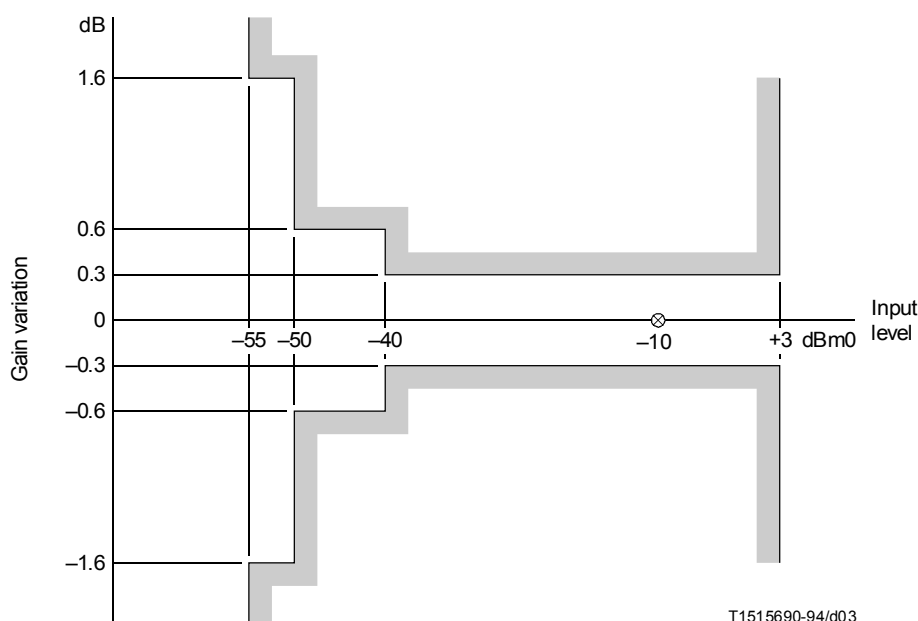
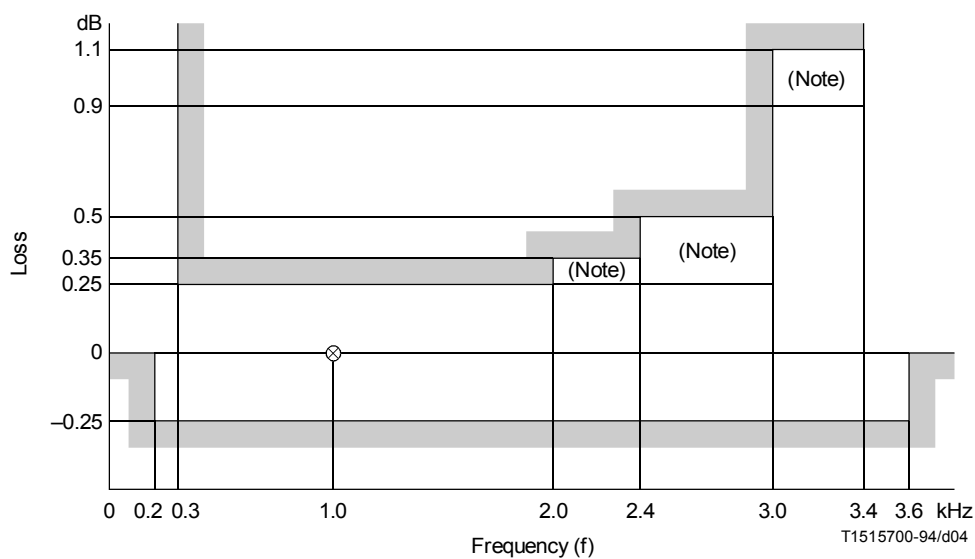


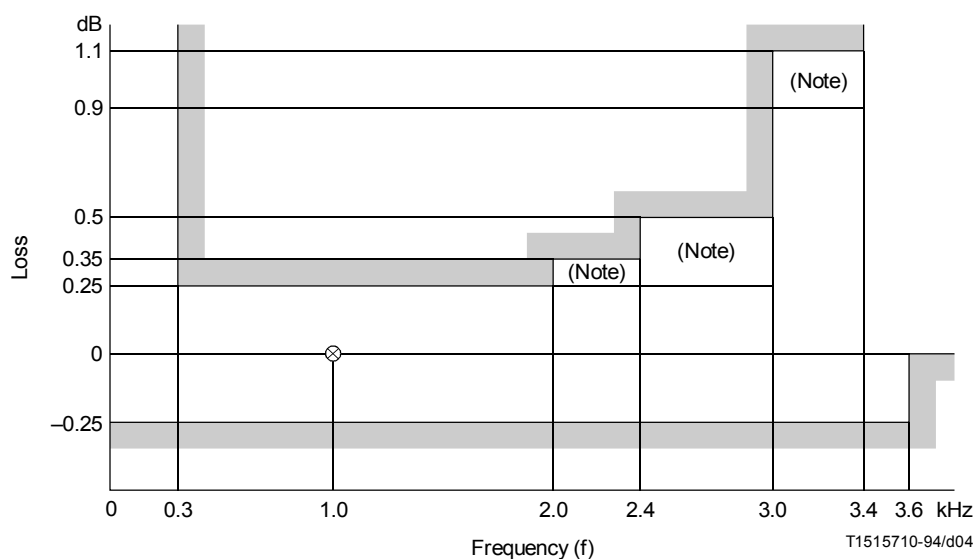
FIGURE 3/Q.553
Variation of gain with input level

3.1.1.5 Loss distortion with frequency

According to 1.2.5/Q.551 the loss distortion with frequency of any input or output connection should lie within the limits shown in the mask of Figure 4a) and b), respectively. The preferred input level is -10 dBm0.



a) Input connection



b) Input connection

NOTE – In the marked frequency ranges relaxed limits are shown which apply if the maximum length of exchange cabling (see clause 2/Q.551) is used. The more stringent limits shown apply if no such cabling is present.

FIGURE 4/Q.553
Loss distortion with frequency

3.1.2 Group delay

“Group delay” is defined in the *Blue Book*, Fascicle I.3.

3.1.2.1 Absolute group delay

See 3.3.1/Q.551.

3.1.2.2 Group delay distortion with frequency

Taking the minimum group delay, in the frequency range between 500 Hz and 2800 Hz, of the input or output connection as the reference, the group delay distortion of that connection should lie within the limits shown in the template of Figure 5. Group delay distortion is measured in accordance with Recommendation O.81.

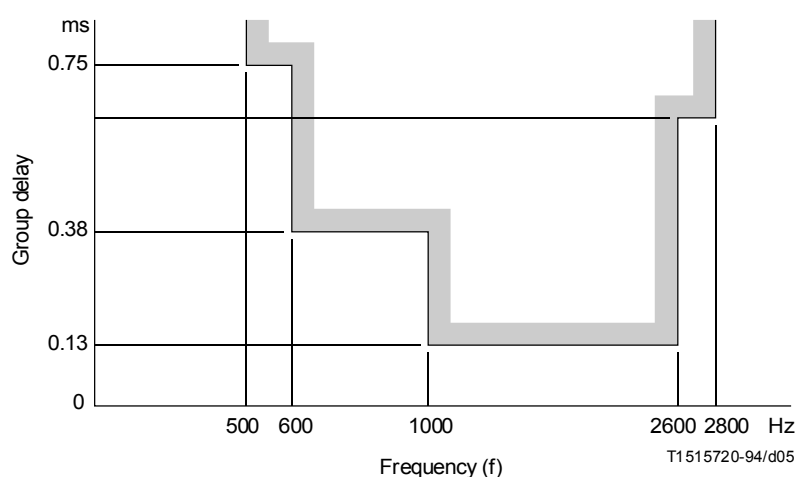


FIGURE 5/Q.553

Group delay distortion limits with frequency

3.1.3 Noise

3.1.3.1 Weighted noise

Two components of noise must be considered. One of these, namely noise arising from the coding process, the other from analogue sources, such as signalling equipment and the analogue circuit for impedance and level adaptation. The first component is limited to -67 dBm0p for input connections and to -70 dBm0p for output connections in accordance with Table 7/G.712; the other component to $-(67 + 3)$ dBm0p = -70 dBm0p for one 4-wire analogue interface including circuit noise in accordance with clause 3/G.123.

This results in the maximum values for the overall weighted noise in the talking state at the C₁-interface of a digital exchange:

- equipment with signalling on separate wires:
 - Input connection: -67 dBm0p;
 - Output connection: -70 dBm0p.
- equipment with signalling on the speech wires:
 - Input connection: -65.2 dBm0p;
 - Output connection: -67.0 dBm0p.

3.1.3.2 Unweighted noise

This noise will be more dependent on the noise from the power supply and on the rejection ratio.

NOTE – The need for and value of this parameter are both under study. Subclause 2.5.2/Q.45 *bis* and clause 3/G.123 must also be considered.

3.1.3.3 Impulsive noise

Limits should be placed on impulsive noise arising from sources within the exchange; these limits and measurement conditions are under study.

NOTES

1 The sources of impulsive noise are often associated with signalling functions (or in some cases the power supply) and may produce either transverse or longitudinal voltage at 4-wire interfaces.

2 The disturbances to be considered are those to speech or modem data at audio frequencies, and also those causing bit errors on parallel digital lines carried in the same cable.

3.1.3.4 Single frequency noise

The level of any single frequency (in particular the sampling frequency and its multiples), measured selectively at the interface of an output connection should not exceed -50 dBm0. Between 300 and 3400 Hz, the level of any single frequency measured selectively and corrected by the psophometric weighting factor (see Table 1/O.41) should not exceed -73 dBm0 (provisional value).

NOTE – See 1.2.3.1/Q.551 with regard to common measurement conditions

3.1.4 Crosstalk

For crosstalk measurements auxiliary signals are injected as indicated in Figures 6 to 9. These signals are:

- the quiet code (see 1.2.3.1/Q.551);
- a low level activating signal. A suitable activating signal is, for example, a sine-wave signal at a level in the range from -33 to -40 dBm0. Care must be taken in the choice of frequency and the filtering characteristics of the measuring apparatus in order that the activating signal does not significantly affect the accuracy of the crosstalk measurement.

3.1.4.1 Crosstalk measured with analogue test signal

3.1.4.1.1 Far-end and near-end crosstalk

A sine-wave test signal at the reference frequency of 1020 Hz and at a level of 0 dBm0, applied to an analogue 4-wire input interface, should not produce a level at either output of any other half connection exceeding -73 dBm0 for a near-end crosstalk (NEXT) path and -70 dBm0 for a far-end crosstalk (FEXT) path. These paths are shown in Figure 6.

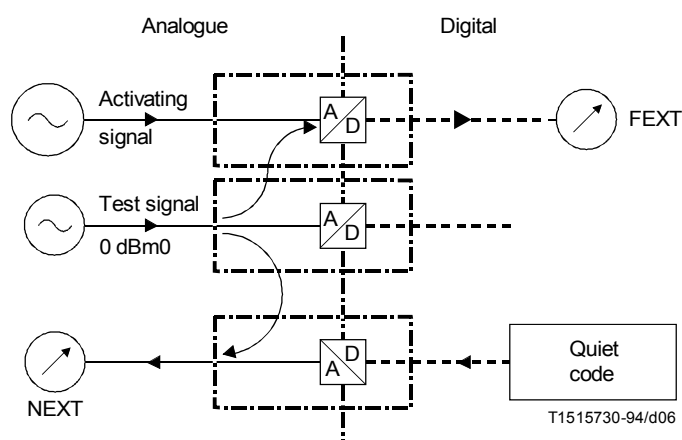


FIGURE 6/Q.553

Measurement with analogue test signal between different
input connections of half connections

3.1.4.1.2 Go-to-return crosstalk

A sine-wave test signal at any frequency in the range 300 to 3400 Hz and at a level of 0 dBm0, applied to the 4-wire interface of an input connection, should not produce a level exceeding –66 dBm0 at the analogue output of the same half-connection. See Figure 7.

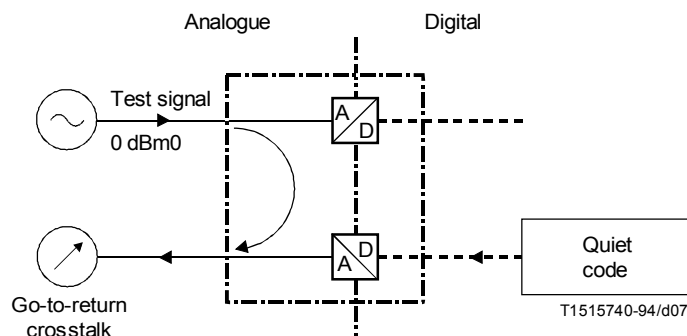


FIGURE 7/Q.553

Measurement with analogue test signals between go and return directions of the same half connection

3.1.4.2 Crosstalk measured with digital test signal

3.1.4.2.1 Far-end and near-end crosstalk

A digitally simulated sine-wave test signal at the reference frequency of 1020 Hz and at a level of 0 dBm0, applied to an exchange test point T_i , should not produce a level exceeding –70 dBm0 for near-end crosstalk (NEXT) or –73 dBm0 for far-end crosstalk (FEXT), at either output of any other half-connection. (See Figure 8.)

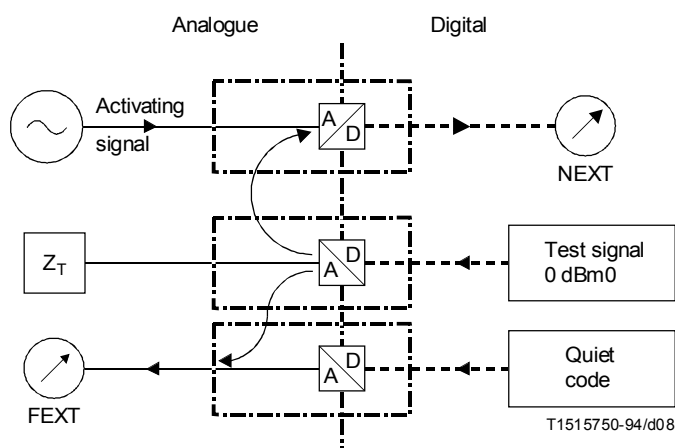


FIGURE 8/Q.553

Measurement with digital test signal between different output connections of half connections

3.1.4.2.2 Go-to-return crosstalk

A digitally simulated sine-wave test signal, at any frequency in the range 300 to 3400 Hz and at a level of 0 dBm0, applied to an exchange test point T_i of an output connection, should not produce a crosstalk level exceeding -66 dBm0 at the exchange test point T_o of the corresponding input connection. See Figure 9.

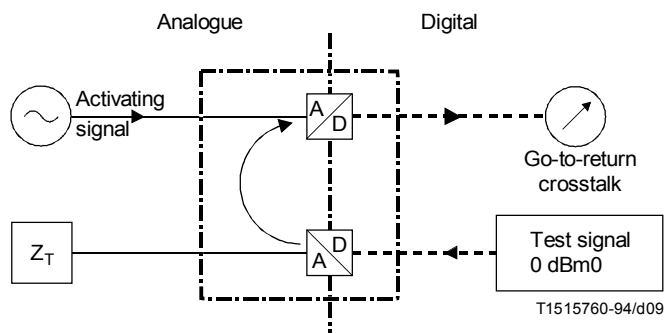


FIGURE 9/Q.553

Measurement with digital test signals between go and return directions of the same half connection

3.1.5 Total distortion including quantizing distortion

With a sine-wave test signal at the reference frequency of 1020 Hz (see Recommendation O.132) applied to the 4-wire interface of an input connection, or with a digitally simulated sine-wave signal of the same characteristic applied to the exchange test point T_i of an output connection, the signal-to-total distortion ratio, measured at the respective outputs of the half-connection with a proper noise weighting (see Table 4/G.223) should lie above the limits shown in Figure 10 for signalling on separate wires and in Figure 11 for signalling on the speech wires.

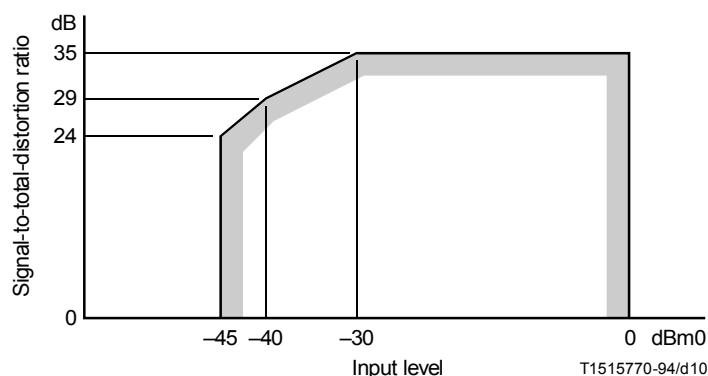


FIGURE 10/Q.553

Limits for signal-to-distortion ratio as a function of input level input or output connection with signalling on separate wires

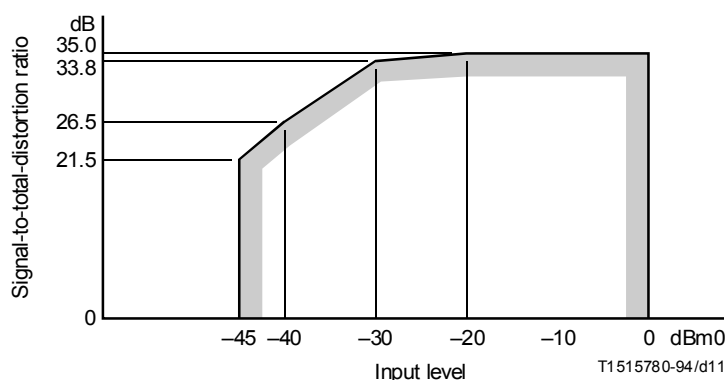


FIGURE 11/Q.553

**Limits for signal-to-total distortion ratio as a function of input level
input or output connection with signalling on the speech wires**

The values of Figure 11 include the limits for the coding process given in Figure 12/G.712 and the allowance for the noise contributed via signalling circuits from the exchange power supply and other analogue sources which is limited to $-(67 + 3) \text{ dBm0p} = -70 \text{ dBm0p}$ for one 4-wire analogue interface by clause 3/G.123.

3.1.6 Discrimination against out-of-band signals applied to the input interface

(Applicable only to input connections.)

3.1.6.1 Input signals above 4.6 kHz

With any sine-wave signal in the range from 4.6 kHz to 72 kHz applied to the 4-wire interface of a half connection at a level of -25 dBm0 , the level of any image frequency produced in the time slot corresponding to the input connection should be at least 25 dB below the level of the test signal. This value may need to be more stringent to meet the overall requirement.

3.1.6.2 Overall requirement

Under the most adverse conditions encountered in a national network the half connection should not contribute more than 100 pW0p of additional noise in the band 10 Hz to 4 kHz at the output of the input connection, as a result of the presence of out-of-band signals at the input port of the input connection.

3.1.7 Spurious out-of-band signals received at the output interface

(Applicable only to an output connection.)

3.1.7.1 Level of individual components

With a digitally simulated sine-wave test signal in the frequency range 300 to 3400 Hz and at a level of 0 dBm0 applied to the exchange test point T_i of a half connection, the level of spurious out-of-band image signals measured selectively at a 4-wire interface of the output connection should be lower than -25 dBm0 . This value may need to be more stringent to meet the overall requirement.

3.1.7.2 Overall requirement

Spurious out-of-band signals should not give rise to unacceptable interference in the equipment connected to the digital exchange. In particular, the intelligible and unintelligible crosstalk in a connected FDM channel should not exceed a level of -65 dBm0 as a consequence of the spurious out-of-band signals at the half connection.

3.2 Characteristics for interface C₁₁

3.2.1 Nominal value of transmission loss

According to the relative levels defined in 2.2.1, the nominal transmission losses of a half connection with a C₁₁ interface are:

- Input connection: $R - A_R$;
- Output connection: $-S - A_S$.

See 2.2.1 for definitions for R , S , A_R and A_S .

3.3 Characteristics for interface C₁₂

3.3.1 Nominal value of transmission loss

According to the relative levels defined in 2.3.1 the nominal transmission losses of a half connection with a C₁₂ interface are:

- Input connection: $R - A_R$;
- Output connection: $-S - A_S$.

See 2.2.1 for definitions for R , S , A_R and A_S .

3.4 Characteristics for interface C₁₃

3.4.1 Nominal value of transmission loss

According to the relative levels defined in 2.4.1 the nominal transmission losses of a half connection with a C₁₃ interface are:

- Input connection: -3.5 dB;
- Output connection: 3.5 dB.

Different levels at the switching stages and transmission loss between interface C₁₃ and the switching stages can require adjusting these losses.

