All drawings appearing in this Recommendation have been done in Autocad.

Recommendation Q.553

TRANSMISSION CHARACTERISTICS AT 4—WIRE ANALOGUE INTERFACES OF A DIGITAL EXCHANGE

1 General

This Recommendation provides characteristics for:

— 4—wire analogue interfaces (Type C_{11}, C_{12} and C_{13}),

— 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*

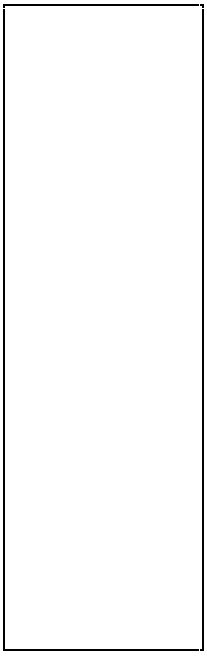
The return loss, measured against the nominal impedance, should not be less than 20 dB over the frequency range 300 Hz to 3400 Hz.

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 Recommendation Q.551, § 1.2.3.1.)

2.1.2 *Impedance unbalance about earth*

The value for the Longitudinal Conversion Loss (LCL) defined in Recommendation G.117, § 4.1.3, with the circuit under test in the normal talking state, should exceed the minimum values of Figure 1/Q.553, in accordance with Recommendations Q.45 *bis* and K.10.

Figure 1/Q.553 - CCITT 65090



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

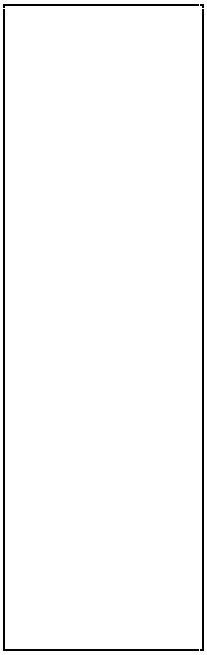
Note 2 — A limit may also be required for the Transverse Conversion Loss (TCL) as defined in Recommendation G.117, § 4.1.2, if the exchange termination is not reciprocal with respect to the transverse and longitudinal connections. A suitable limit would be 40 dB to ensure an adequate near—end crosstalk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

Test method

LCL should be measured in accordance with the principles given in Recommendation O.9, §§ 2.1 and 3. Figure 2/Q.553 shows the basic measuring arrangement.

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

Figure 2/Q.553 - T1102950-86



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 Recommendation G.121, Annex A 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 fulfill 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 Recommendation G.712, § 15.

2.2 *Characteristics of interface C_{11}*

According to Figure 1/Q.551, the interface C_{11} 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:

$$L_{\mathrm{i}} = R - A_R$$

$$L_{\mathrm{o}} = S + A_S$$

where

A_R = total loss in the receive path

A_S = total loss in the send path

2.3 *Characteristics of interface* C_{12}

According to Figure 1/Q.551, the interface C_{12} 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:

$$L_{\mathrm{i}} = R - A_R$$

$$L_{\mathrm{o}} = S + A_S$$

where

A_R = total loss in the receive path

A_S = total loss in the send path

2.4 *Characteristics of interface C_{13}*

According to Figure 1/Q.551 the interface C_{13} 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 identical with the virtual analogue switching point of —3.5 dBr in both directions of transmission, the nominal input and output levels of a C_{13} interface are:

$$L_i = L_o = —3.5 \text{ dBr}$$

Different levels at the switching stages and transmission loss between interface C_{13} 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 Recommendation Q.551 § 1.2.4.1, 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 to +0.7 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*

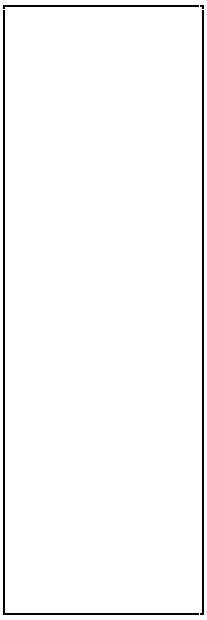
When a sine—wave test signal at the reference frequency of 1020 Hz and at a level of —10 dBm0 (if preferred, the value 0 dBm0 may be used) is applied to a 4—wire analogue interface of any input connection, or a digitally simulated sine—wave signal of the same characteristic is applied to the exchange 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/Q.553.

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 - CCITT 67340



3.1.1.5 *Loss distortion with frequency*

According to Recommendation Q.551, § 1.2.5, the loss distortion with frequency of any input or output connection should lie within the limits shown in the mask of Figures 4/Q.553, a) and b), respectively. The preferred input level is —10 dBm0.

3.1.2 *Group delay*

"Group delay" is defined in the Blue Book, Fascicle I.3.

3.1.2.1 *Absolute group delay*

See Recommendation Q.551, § 3.3.1.

3.1.2.2 *Group delay distortion with frequency*

Taking the minimum group delay, in the frequency range between 500 Hz and 2500 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/Q.553. Group delay distortion is measured in accordance with Recommendation O.81.

3.1.3 *Noise*

3.1.3.1 *Weighted noise*

Two components of noise must be considered: noise arising from the coding process and noise from the exchange power supply and other analogue sources transmitted through signalling circuits. The first component is limited by Recommendation G.714, §§ 9 and 10 to —66 dBm0p for an input connection; and to —75 dBm0p for an output connection. The other component is limited by Recommendation G.123, § 3 to —(67+3) dBm0p = —70 dBm0p for one 4—wire analogue interface.

Figure 4/Q.553, - T1102960-86 AND T1102970-86

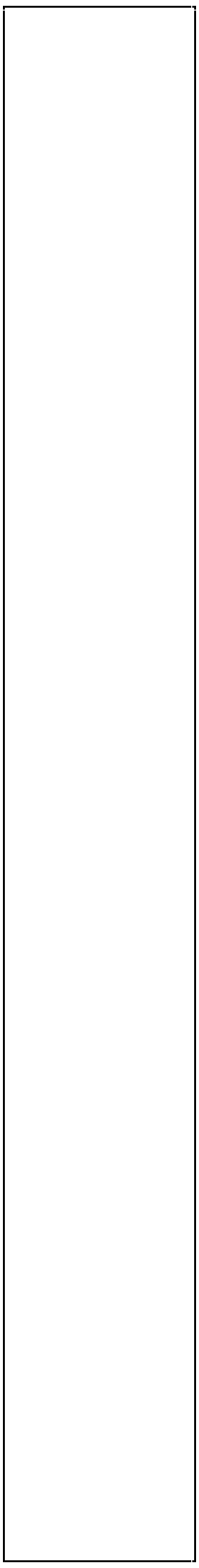
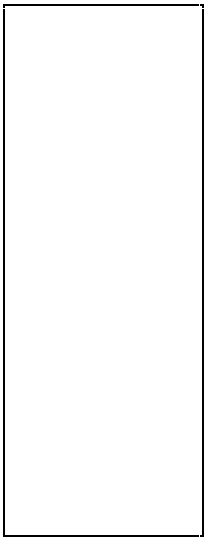


Figure 5/Q.553 - CCITT 46051



This leads to the following maximum values for the overall weighted noise at the output interfaces of a half connection of a digital exchange:

—	Input connection:	—64.5 dBm0p	for equipment with signalling on the speech wires;
		—66.0 dBm0p	for equipment with signalling on separate wires.
—	Output connection:	—68.8 dBm0p	for equipment with signalling on the speech wires;
		—75.0 dBm0p	for equipment with signalling on separate wires.

3.1.3.2 *Unweighted noise*

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

Note — The need for and value of this parameter are both under study. Recommendations Q.45*bis*, § 2.5.2 and G.123, § 3 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 are under study. Pending the results of this study, Recommendation Q.45 *bis*, § 2.5.3 may give some guidance on the subject of controlling impulsive noise with low frequency content.

Note 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.

Note 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. This latter case, involving impulsive noise with high frequency content, is not presently covered by the measurement procedure of Recommendation Q.45 *bis*.

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.

Note — See Recommendation Q.551, § 1.2.3.1.

3.1.4 *Crosstalk*

For crosstalk measurements auxiliary signals are injected as indicated in Figures 6 to 9/Q.553. These signals are:

— the quiet code (see Recommendation Q.551, § 1.2.3.1);

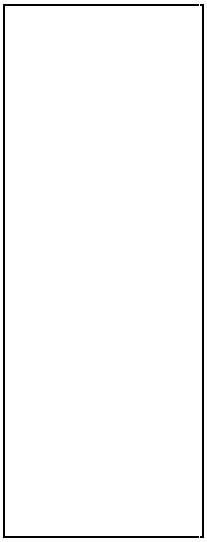
— a low level activating signal. Suitable activating signals are, for example, a band limited noise signal (see Recommendation O.131), at a level in the range —50 to —60 dBm0 or a sine—wave signal at a level in the range from —33 to —40 dBm0. Care must be taken in the choice of frequency and the filtering 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/Q.553.

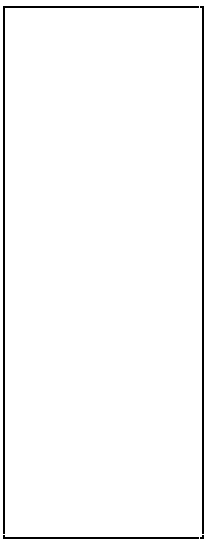
Figure 6/Q.553 - CCITT 56610



3.1.4.1.2 *Go—to—return crosstalk*

A sine—wave test signal at any frequency in the range 300—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/Q.553.

Figure 7/Q.553 - T1102980-86

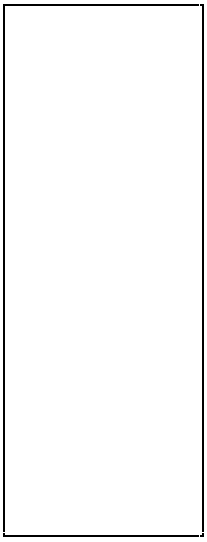


3.1.4.2 *Crosstalk measured with digital test signal*

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/Q.553.)

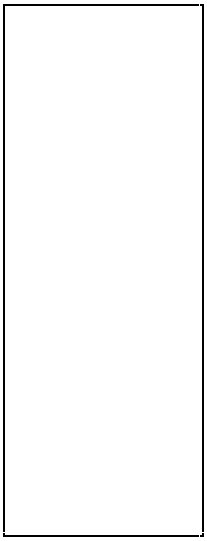
Figure 8/Q.553 - T1102990-86



3.1.4.2.2 *Go—to—return crosstalk*

A digitally simulated sine—wave test signal, at any frequency in the range 300—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/Q.553.

Figure 9/Q.553 - CCITT 56630



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/Q.553 for signalling on separate wires and in Figure 11/Q.553 for signalling on the speech wires.

Note — The sinusoidal test signal is chosen to obtain results independent of the spectral content of the exchange noise.

Figure 10/Q.553 - CCITT 46061

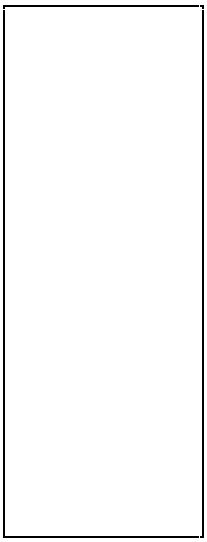
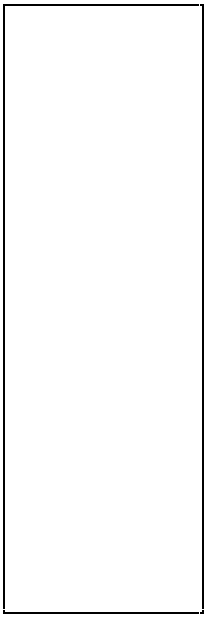


Figure 11/Q.553 - T1103000-86



The values of Figure 11/Q.553 include the limits for the coding process given in Figure 5/G.714 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) dBm0p = —70 dBm0p for one 4—wire analogue interface by Recommendation G.123, § 3.

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—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—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 C_{11}*

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 C_{11} 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 C_{12}*

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 C_{12} 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 C_{13}*

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 C_{13} interface are:

— Input connection: —3.5 dB,

— Output connection: 3.5 dB.

Different levels at the switching stages and transmission loss between interface C_{13} and the switching stages can require adjusting these losses.