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

Recommendation Q.552

xe ""§TRANSMISSION CHARACTERISTICS AT 2–WIRE ANALOGUE INTERFACES OF DIGITAL EXCHANGE

1 General

This Recommendation provides characteristics for:

– 2–wire analogue interfaces (Type C2 and Z),

– input and output connections with 2–wire analogue interfaces, and

– half–connections with 2–wire analogue interfaces,

in accordance with definitions given in Recommendation Q.551 particularly in Figure 1/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 valid for equipment that may terminate an international long–distance connection via 4–wire circuits interconnected by 4–wire exchanges. It also includes, in a separate category, characteristics for interfaces which cannot terminate an international connection and are therefore entirely national in application.

2 Characteristics of interfaces

Note – For measuring 2–wire analogue interface conditions it is necessary to apply a quiet code, i.e. a PCM signal corresponding to decoder output value 0 (m–law) or output value 1 (A–law), with the sign bit in a fixed state, to the exchange test point Ti, when no test signal is stipulated.

2.1 *Characteristics of interface C2*

The recommended values of interfaces C2 are valid for digital exchanges including PABXs with transit functions and routing capabilities for originating and terminating traffic. Depending on the type of traffic to be handled, two different sets of relative levels are required. This suggests subdivision into C21 and C22 interface specifications. The interface C21 provides the termination of outgoing and incoming international long distance connections and possible national connections, with the exchange acting as transit switch. The interface C22 provides for the connection of a 2–wire trunk line. A typical example is the interconnection of a Z interface with a C22 interface in a local exchange for routing through the 2–wire analogue trunk network. A C22 interface cannot be part of the international 4–wire chain (see Figure 2/Q.551).

2.1.1 *Exchange impedance*

2.1.1.1 *Nominal value*

Nominal values of exchange impedance should be defined depending on national conditions. The definition shall include a test network for the exchange impedance. Administrations may want to adopt different test networks corresponding to the cable types used (e.g. unloaded and loaded).

2.1.1.2 *xe ""§Return loss*

The return loss of the impedance presented by a C2 interface against the test network for the exchange impedance should comply with the limits given in Figure 1/Q.552.
Figure 1/Q.552 - CCITT 72230

2.1.2 *Impedance unbalance about earth*

The longitudinal conversion loss (LCL), defined in Recommendation G.117, § 4.1.3, should exceed the minimum values of Figure 2/Q.552 with the equipment under test in the normal talking state, in accordance with Recommendation K.10.

Note 1 – An Administration may adopt other values and in some cases a wider bandwidth, depending on 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 paths. A suitable limit would be 40 dB to ensure an adequate near–end crosstalk attenuation between interfaces.
Figure 2/Q.552 - CCITT 65091

Test method

Longitudinal conversion loss should be measured in accordance with the principles given in Recommendation O.121, §§ 2.1 and 3. Figure 3/Q.552 shows an example of the basic measuring arrangement for digital exchanges.

Measurements of the longitudinal and transverse voltages should preferably be done with a frequency–selective level meter.
Figure 3/Q.552 - CCITT 65101

2.1.3 *Longitudinal interference threshold level*

Under study.

2.1.4 *Relative levels*

2.1.4.1 *Nominal levels*

2.1.4.1.1 *xe ""§Interface C21*

C21 interfaces should meet the recommended values for Z interfaces in § 2.2.4.1 if no loss compensation comparable to § 2.2.4.3 is provided.

2.1.4.1.2 *xe ""§Interface C22*

To adjust the transmission loss of a digital transmission section to the values of national transmission planning for local or national traffic, depending on the relative levels given in §§ 2.1.4.1.1 and 2.2.4.1, the following ranges encompass the requirements for C22 interfaces of a large number of administrations:

– input level:
  Li = +3.0 to –7.0 dBr in 0.5 dB steps;
– output level:

According to Annex E of Recommendation G.121 (column 2 of Table E–1/G.121), the range of transmission loss from 1.0 to 8.0 dB for the digital transmission section encompasses the requirements of a large number of administrations.

In order to compensate loss on long toll or junction lines, an administration may, to satisfy local conditions, choose values of relative levels derived from the basic values as follows:

$$L`i = Li + x \text{ dB}$$

$$L`o = Lo - x \text{ dB}$$

where x should take a negative value. The value of x is in national competence. Such compensation of loss require careful selection and application of balance networks.

It has been recognized that it is not necessary for a particular design of equipment to be capable of operating over the entire level range.

2.1.4.2 *Tolerances of relative levels*

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

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

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

Note – Level adjustment procedures are given in Recommendation G.715, § 2.1.

2.2 *Characteristics ofxe ""§ interface Z*

The recommended values of interface Z are valid for digital local exchanges, PABXs and digital remote units. For PABXs, see Recommendation Q.551, § 2.1.1

2.2.1 *Exchange impedance*

2.2.1.1 *Nominal value*

The principal criterion governing the choice of the nominal value of the exchange impedance is to ensure an adequate sidetone performance for telephone sets, particularly those operated on short lines. If this criterion is met, the impedance will also be suitable for subscriber lines fitted with voice band modems.

As a general rule a complex exchange impedance with a capacitive reactance is necessary to achieve satisfactory values of stability, echo and sidetone. For additional information, see Supplement No. 2, Fascicle VI.5 of the CCITT Blue Book and Recommendations G.111 and G.121.

The use of the preferred configuration below will minimize the diversity of types of exchange impedances. At present no unique component values can be recommended. However, to provide guidance for administrations, examples of nominal values chosen by some administrations are given in Table 1/Q.552.

TABLE 1/Q.552

CCITT 53830

Test networks for exchange impedances being considered

	Rs (ohms)	Rp (ohms)	Cp (farads)
NTT	600	infinity	1 m
Austria, FRG	220	820	115 n
USA	900	infinity	2.16 m

BT

300

1000

220 n

New Zealand

370

620

310 n

Note 1 – The test network and the component values represent a configuration that exhibits the required exchange impedance. It need not necessarily correspond to any actual network provided in the exchange interface.

Note 2 – The range of component values reflects the fact that there are substantial differences in the sensitivity and sidetone performance of the various telephone instruments throughout the world. In general, the combination of short lines and sensitive telephone sets might be rather common in the future due to increased use of remote concentration. In order to control sidetone performance, Administrations need to take into account telephone set parameters. Not only should the parameters of existing telephone sets be considered but also the parameters that may be desirable in the future to allow improvement in sidetone performance to be achieved.

Note 3 – It may be necessary to group the subscriber lines of a particular exchange into classes, each requiring a different exchange impedance of the Z interface.

2.2.1.2

Return loss

Tolerances are needed for values of exchange impedance. For this purpose the return loss of the impedance presented by a 2–wire port against the test network for the exchange impedance should comply with limits which depend on the particular conditions of the subscriber network considered. These are given in the template of Figure 1/Q.552.

Some administrations may want to specify higher values. Examples of limit values for the return loss, currently accepted by some administrations, are given in Table 2/Q.552 for guidance.

TABLE 2/Q.552

Examples of limit values of return loss against the exchange impedance

FRG

14 dB at 300 Hz, rising (log *f* scale) to 18 dB at 500 Hz remaining at 18 dB to 2000 Hz and then falling (log *f* scale) to 14 dB at 3400 Hz.

NTT

22 dB: 300–3400 Hz.

BT

18 dB: 200–800 Hz; 20 dB: 800–2000 Hz; 24 dB: 2000–4000 Hz.

USA

20 dB: 200–500 Hz; 26 dB: 500–3400 Hz.

Austria

14.5 dB at 300 Hz, rising (log *f* scale) to 18 dB at 500 Hz remaining at 18 dB to 2500 Hz and then falling (log *f* scale) to 14.5 dB at 3400 Hz.

Note – The 12 dB spread in values stems from the difference in telephone set sensitivities.

2.2.2 *Impedance unbalance about earth*

The longitudinal conversion loss (LCL) of the Z interface should meet the values given in § 2.1.2 and Figure 2/Q.552, measured in accordance with the test method given in Figure 3/Q.552.

2.2.3 *xe ""§Longitudinal interference threshold levels*

The signalling and transmission performance of the Z interface can be degraded when the subscriber line is exposed to an electromagnetic field of sufficiently high intensity. The value of induced interference energy causing performance degradation may be below a level which would cause permanent damage or operate protective devices. Longitudinal interference may come from power or traction lines or radio frequency sources.

Radio frequency interference tests at the Z interface should be in accordance with Recommendations of the K–Series (intended by Study Group V).

Longitudinal interference tests relative to power and traction line sources should be performed according to Figure 4/Q.552.

Interference up to the interference threshold level should not affect signalling and transmission more than the limits stated below. Measurements should be performed using quiet code at the exchange test point Ti.

There are two groups of parameters to be observed while performing the tests:

i) signalling related parameters;

ii) transmission related parameters, i.e. noise parameters.

For group i) the performance of the signalling parameters mentioned in Recommendation Q.543 should be tested in a go – no go procedure under normal operating conditions.

For group ii) two test steps should be performed under normal operating conditions, the first step without and the second one with the longitudinal test generator connected to the coupling network. The additional noise in the second test step should not contribute more than:

LEN = *Y*1 pWp
using sinusoidal longitudinal test signal with X1 volts rms;

LEN = *Y*2 pWp using longitudinal EMF test signal with defined harmonic content (e.g., triangular waveform with X2 volts zero to peak).

The values Y1 and Y2 of the noise power must be specified depending on the interface the noise measuring set is connected to, i.e. the analogue interface at the termination T representing subscriber apparatus or the digital interface at the exchange test point To. The noise measuring set should be provided with a notch filter to exclude the activating signal at the nominal reference frequency.

The associated noise level limit results from the use of the equations given in §§ 3.3.2.1 and 3.3.3 of this Recommendation.

Note 1 – The values of X1 and X2 need further study. (Some administrations reported an X1 value of 15 volts and an X2 value of 25 volts.)

Note 2 – The value of the induced noise power *LEN* needs further study. (Attention is drawn to § 3.1.6.2 of this Recommendation and to § 1 of Recommendation G.123.)

Test method
Figure 4/Q.552 - CCITT 89630

The longitudinal interference test generator should provide the longitudinal interference EMF with the fundamental frequency of the interference source (as appropriate to national conditions, i.e. 16 2/3 Hz, 50 Hz or 60 Hz) with a sinusoidal waveshape, and additionally with a waveshape having a certain amount of harmonic content, e.g. a triangular waveshape.

The coupling network CN[1]) should represent a typical subscriber line (length, type of cable) exposed to power or traction line interference. The impedance of the coupling path within the network should be primarily capacitive. (One RPOA reported an impedance of –j 1.17 kohm at 60 Hz for each capacitor indicated in Figure 4/Q.552.)

The termination T representing subscriber apparatus should provide for an appropriate loop current and the requested internal impedance of the reference frequency signal generator.

Note 1 – Annex A gives an example of a CN applicable to the measuring arrangement of Figure 4/Q.552, the application of which needs further study.

Note 2 – The measuring arrangement in Figure 4/Q.552 covers the general use of subscriber equipment, as recommended in Recommendation K.4, without low impedance to earth, especially without signalling using earth return. National deviations from this general case need to be considered for each special type of subscriber circuit.

2.2.4 *Relative levels*

Operation of the Z interface in the ranges of relative levels given below is recommended when the interface terminates an entirely 4–wire international long–distance connection. Pairs of input and output levels can be chosen for internal, local, or national long–distance traffic in a wider range if these connections can be discriminated from international ones for correct level switching. If digital pads are used, the additional distortion must be considered (see Recommendation G.113, Table 1/G.113).

In assigning the relative levels for international long–distance connections to the interface it should be noted that:

– The limiting of "difference in transmission loss between the two directions of transmission" in Recommendation G.121, § 6.4 must be 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.
– If within the ranges of *Li* and *Lo* given under §§ 2.2.4.1.1 and 2.2.4.1.2, the values are chosen such that *Li – Lo* 6 dB and if adequate balance networks are used (e.g., § 3.1.8 and Figure 11/Q.552), the requirements of Recommendation G.121, § 6 (Incorporation of PCM digital processes in national extensions) as well as for Recommendation G.122 (Stability and echo loss) will be satisfied.

2.2.4.1 *Nominal levels*

2.2.4.1.1 *Input relative level*

According to Annex C to Recommendation G.121 (columns 1, 2 and 3 of Table C–1/G.121), the following range of input relative level for all types of connections (internal,

1) The exact definition of the harmonic content and the coupling network is for further study.

local, national and international) encompasses the requirements of a large number of administrations.

$$Li = 0 \text{ to } +2.0 \text{ dBr}$$

Note 1 – Recommendation G.101, § 5.3.2.3 indicates that if the minimum nominal send loudness rating (SLR) of the local system under the same conditions is not less than –1.5 dB, then the peak power of the speech will be suitably controlled. It follows that, for instance, the value *Li* = 0 dBr (lower limit of the range for *Li*) is suited to a send loudness rating –1.5 dB.

Note 2 – The values given above are in conformity with current national practices and with the existing text of Recommendation G.101. However, the latter is itself partly based on a very old investigation (which Study Group XII has been asked to review) of the relationship between loudness ratings and speech levels. This may, in the near future, lead to amending the basis of objectives, so that it may be useful to allow wider design margins.

2.2.4.1.2 *Output relative level*

According to Annex C to Recommendation G.121 (column 3 of Table C–1/G.121), the following range of output relative level for international long–distance connections encompasses the requirements of a large number of administrations.

$$Lo = -5.0 \text{ to } -8.0 \text{ dBr}$$

The chosen value may be used for connections entirely within a national network as well.

If the connection type can always be detected, the nominal output relative levels for local or national connections can take other values in accordance with national transmission planning. According to Annex C to Recommendation G.121 (columns 1 and 2 of Table C–1/G.121) the following range encompasses the requirements of a large number of administrations:

$$Lo = 0 \text{ to } -8.0 \text{ dBr}$$

It has been recognized that it is not necessary for a particular design of equipment to be capable of operating over the entire range.

2.2.4.2 *Tolerances of relative levels*

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

– input relative level:
  –0.3 to +0.7 dB,

– output relative level:

These differences may arise, for example, from design tolerances, cabling (between analogue ports and the DF) and adjustment increments. Short–term variation of loss with time as discussed in § 3.1.1.3 is not included.

Note – Procedures for adjusting relative level are given in Recommendation G.715, § 2.1.

2.2.4.3 *Consideration of short and long subscriber lines*

In order to compensate for the loss of short or long subscriber lines, an administration may choose values of the relative levels derived from the basic values as follows:

$$L`i = Li + \text{x dB}$$

$$L`o = Lo - \text{x dB}$$

The value of x is within national competence (e.g., x = 3 dB for short subscriber lines).

If values of $L`i$ and $L`o$ are chosen as indicated, the loss difference with respect to the conditions given in § 2.2.4.1 will be left unchanged.

The use of values of x < 0 requires careful selection of balance networks; values of x < –3 dB are not recommended.

3 xe ""§Characteristics of half–connections

For interfaces C2 this Recommendation is valid for digital local and transit exchanges and for C21 interfaces of PABXs connected to the digital local exchange by a digital transmission system.

For interface Z this Recommendation is valid for digital local and combined local/transit exchanges, for PABXs and for digital remote units, each connected to the digital local exchange by a digital transmission system. For further information concerning PABXs, see Recommendation Q.551, § 2.1.1.

Note – In measuring an input connection it is necessary to apply a quiet code, i.e. a PCM signal corresponding to decoder output value 0 (m–law) or output value 1 (A–law) with the sign bit in a fixed state to the exchange test point Ti. (See Recommendation Q.551, § 1.2.3.1.)

3.1 *Characteristics common to all 2–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 in §§ 3.2.1 and 3.3.1 for input and output connections of half–connections with a 2–wire analogue interface.

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, according to §§ 2.1.4.2 and 2.2.4.2 should lie within the following range:

–0.3 to +0.7 dB

These differences may arise, for example, from design tolerances, cabling (between analogue equipment ports and the DF) and adjustment increments. Short–term variation of loss with time as discussed in § 3.1.1.3 is not included.

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 is applied to the 2–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 Ti of any output connection, the level at the corresponding exchange test point To and the 2–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 1020 Hz and at a level between –55 dBm0 and +3 dBm0 applied to the 2–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 Ti of any output connection, the gain variation of that connection, relative to the gain at an input level of –10 dBm0, should lie within the limits given in Figure 5/Q.552.

The measurement should be made with a frequency–selective level meter to reduce the effect of the exchange noise. This requires a sinusoidal test signal.
Figure 5/Q.552 - CCITT 67340

3.1.1.5 *Loss distortion with frequency*

The loss distortion with frequency of any input or output connection according to Recommendation Q.551, § 1.2.5 should lie within the limits shown in the mask of Figure 6/Q.552 a) or 6/Q.552 b) respectively using an input level of –10 dBm0.

Note – The limits of this clause shall not apply to Z half–connections which include equalization for the distortion in the subscriber line.
Figure 6/Q.552 - T1102880-86 AND T1102890-86

3.1.2 *Group delay*

"Group delay" is defined in the Yellow Book, Fascicle X.1.

3.1.2.1 *Absolute group delay*

See Recommendation Q.551, § 3.3.1.

3.1.2.2 *xe ""§Group delay distortion with frequency*

Taking as the reference the minimum group delay, in the frequency range between 500 Hz and 2500 Hz, of the input or output connection, the group delay distortion of that connection should lie within the limits shown in the template of Figure 7/Q.552. Group delay distortion is measured in accordance with Recommendation O.81.

Figure 7/Q.552 - CCITT 72250

These requirements should be met at an input level of –10 dBm0.

3.1.3 *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 8/Q.552 and 9/Q.552. 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 *xe ""§Input crosstalk*

A sine–wave test signal at the reference frequency of 1020 Hz and at a level of 0 dBm0,

applied to an analogue 2–wire interface, should not produce a level in any other half–connection exceeding –73 dBm0 for near–end crosstalk (NEXT) and –70 dBm0 for far–end crosstalk (FEXT) (see Figure 8/Q.552).
Figure 8/Q.552 - T1102900-86

3.1.4.2 *xe ""§Output crosstalk*

A digitally simulated sine–wave test signal at the reference frequency of 1020 Hz applied at a level of 0 dBm0 to an exchange test point Ti, should not produce a level in any other half connection exceeding –70 dBm0 for near–end crosstalk (NEXT) and –73 dBm0 for far–end crosstalk (FEXT) (see Figure 9/Q.552).
Figure 9/Q.552 - T1102910-86

3.1.5 *xe ""§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 2–wire interface of an input connection, or with a digitally simulated sine–wave signal of the same characteristic applied to the exchange test point Ti of an output connection, the signal–to–total–distortion ratio, measured at the corresponding outputs of the half connection with a proper noise weighting (see Table 4/G.223) should lie above the limits given in §§ 3.2.3, Figures 13/Q.552 and 14/Q.552 for interface C2 and § 3.3.3, Figure 15/Q.552 for interface Z.

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

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

(Only applicable to input connections.)

3.1.6.1 *Input signals above 4.6 kHz*

With sine–wave signal in the range from 4.6 kHz to 72 kHz applied to the 2–wire interface of an input 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 2–wire interface of the input connection.

3.1.7 *Spurious out–of–band signals received at the output interface*

(Only applicable to an output connection.)

3.1.7.1 *Level of individual components*

With a digitally simulated sine–wave signal in the frequency range 300–3400 Hz and at a level of 0 dBm0 applied to the exchange test point Ti of a half connection, the level of spurious out–of–band image signals measured selectively at the 2–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 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 spurious out–of–band signals at the half–connections.

3.1.8 *Echo and stability*

Terminal Balance Return Loss (TBRL) as defined in § 3.1.8.1 is introduced in order to characterize the exchange performance required to comply with the network performance objective of Recommendation G.122 with respect to echo. The TBRL of an equipment port is measured in the talking state as in an established connection through a digital exchange.

The parameter "Stability Loss", as defined in Recommendation G.122, applies to the worst terminating conditions encountered at a 2–wire interface in normal operation.

3.1.8.1 *Terminal Balance Return Loss (TBRL)*

The term TBRL is used to characterize an impedance balancing property of the 2–wire analogue equipment port.

The expression for TBRL is:

$$\text{TBRL} = 20 \log \ .$$

where

Zo

Zb

Zt

Some administrations have found that it is advantageous to choose $Zo = Zb$ in order to optimize TBRL. In this case the expression reduced to

TBRL = 20 log

and the balance test network will be identical to the test network for the exchange impedance.

The balance test network should be representative of the impedance conditions to be expected from a population of terminated lines connected to 2–wire interfaces, as determined by the national transmission planning.

The TBRL is related to the loss *aio* between the exchange test point Ti and To of a half connection as follows:

$$\text{TBRL} = aio - (ao + ai)$$

where *ao* and *ai* are the losses between the exchange test point Ti and the 2–wire port and between the 2–wire equipment port and the exchange test point To, respectively.

TBRL can thus be determined by measurement of *aio* provided the sum (*ao* + *ai*) is known. This can be derived in several ways:

a) *ao* and *ai* are assigned their nominal values *NLo* and *NLi* as defined in §§ 3.2.1 and 3.3.1. Then:

$$\text{TBRL} = = aio - (NLo + NLi)$$

b) *ao* is measured with the load matched to the exchange impedance as actual transmission loss *ALo* and *ALi* (see § 3.1.1.2). Then:

$$\text{TBRL} = aio - (ALo + ALi)$$

c) the loss *aio* is measured with the 2–wire equipment port open– and short–circuited, giving losses *a`io* y and *a``io* respectively.

$$\text{TBRL} = aio -$$

Method b) provides the most accurate results.

Figure 10/Q.552 - CCITT 59692

Using the arrangement of Figure 10/Q.552 and sinusoidal test signals, the measured TBRL should exceed the limits shown in Figure 11/Q.552.

Figure 11/Q.552 - CCITT 56221

Figure 12/Q.552 gives examples of balance test networks adopted by some administrations for unloaded subscriber lines. These examples may provide guidance for other administrations in order to minimize the diversity of types of test networks.

Note – Some administrations may need to adopt several balance test networks to cover the various types of unloaded and loaded cables.

Figure 12/Q.552 - CCITT 56231

3.1.8.2 *xe ""§Stability loss*

The stability loss should be measured between the exchange test points Ti and To of a half–connection (Figure 10/Q.552) by terminating the 2–wire interface with stability test networks representing the “worst terminating condition encountered in normal operation”. Some administrations may find that open– and short–circuit terminations are sufficiently representative of worst–case conditions. Other administrations may need to specify, for example, an inductive termination to represent the worst–case condition.

With worst–case terminating conditions on the 2–wire interface of a half–connection, the stability loss Ti to To measured as *aio* should be:

Stability Loss = *aio* ³ x;

where x is under study for sinusoidal signals at all frequencies between 200 Hz and 3600 Hz. This frequency band is determined by the filters used in the interface designs.

The need for requirements outside this frequency band is also under study.

Where the digital exchange is connected to the international chain using only 4–wire switching and transmission, the half connection of the digital exchange may provide the total stability loss of the national extension. The value of stability loss (SL) that is required for a 2–wire interface is a matter of national control provided that the requirements of Recommendation G.122 are met. A SL value of 6 dB at all frequencies between 200 Hz and 3600 Hz will ensure that the G.122 requirements are met. However, SL values of between 6 dB and 0 dB will formally comply with the present requirements of G.122 (Red Book 1984) but further study is required to provide guidance in this area. One administration has found that a value of 3 dB is satisfactory in its environment.

Note – It is suggested that the half–connection of a digital PABX, or of a digital remote unit, when connected to the digital local exchange by a digital transmission system, should also meet the requirements of § 3.1.8.

3.2 *Characteristics ofxe ""§ interface C2*

3.2.1 *Nominal value of transmission loss*

According to the relative levels defined in § 2.1.4.1, the nominal transmission losses of input or output connections *NLi* and *NLo* of a half connection with C2 interfaces are in the following ranges:

C21 interfaces

NLi =

NLo

0 to 8.0 dB for international connections

C22 interfaces

NLi =

ü

ý

NLo

8.0 to –1.0 dB

It has been recognized that it is not necessary for a particular design of equipment to be capable of operating over the entire range of nominal transmission losses.

If a loss compensation is applied the nominal loss *NLi* and *NLo* should be corrected by the value of x dB chosen in connection with §§ 2.1.4.1.2 or 2.2.4.3.

3.2.2 *xe ""§Noise*

3.2.2.1 *Weighted noise*

For the calculation of noise, worst case conditions at the C2 interface are assumed. The band limiting effect of the encoder on the noise was not taken into account. For a more exact calculation further study is necessary.

3.2.2.1.1 *Output connection*

Two components of noise must be considered. One of these arises from the quiet decoder, the other from analogue sources, such as signalling equipment. The first component is limited by Recommendation G.714, § 10 as receiving equipment noise to –75 dBm0p; the other component by Recommendation G.123, § 3 to –(67+3) dBm0p = –70 dBm0p for one 2–wire analogue interface. This results in the maximum value for the overall weighted noise in the talking state at the C2 interface of a digital exchange of:

–68.8 dBm0p for equipment with signalling on the speech wires,

–75.0 dBm0p for equipment with signalling on separate wires.

3.2.2.1.2 *Input connection*

Two components of noise must be considered. One of these arises from the encoding process, the other from analogue sources, e.g. signalling equipment. The first component is limited by Recommendation G.714, § 9 as idle channel noise to –66 dBm0p; the other component by Recommendation G.123, § 3 to –(67+3) dBm0p = –70 dBm0p for one 2–wire analogue interface. This results in the maximum value for the overall weighted noise in the talking state at the exchange test point To of a digital exchange of:

–64.5 dBm0p for equipment with signalling on the speech wires,

–66.0 dBm0p for equipment with signalling on separate wires.

3.2.2.2 *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.

3.2.2.3 *xe ""§Impulsive noise*

It will be necessary to place limits 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 C2 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*.

3.2.3 *Values ofxe ""§ total distortion*

The total distortion including quantizing distortion of a half–connection with a C2 interface is measured in accordance with § 3.1.5.

The signal–to–total–distortion ratio for a half–connection at interface C2 should lie above the limits shown in Figure 13/Q.552 for equipment with signalling on separate wires, and in Figure 14/Q.552 for equipment with signalling on the speech wires both measured in the talking state.
Figure 13/Q.552 - CCITT 46061

Figure 14/Q.552 - T1102920-86

The values of Figure 14/Q.552 include the limits for the encoding process given in Figure 4/G.714 and the allowance for the noise contributed via signalling circuits from the exchange power supply and other analogue sources (e.g., analogue coupling), which is limited to –(67+3) dBm0p = –70 dBm0p for one C2 analogue interface by Recommendation G.123, § 3.

3.3 *Characteristics ofxe ""§ interface Z*

3.3.1 *Nominal value of transmission loss*

According to the relative levels defined in § 2.2.4.1, the nominal transmission losses of input or output connections *NLi* and *NLo* of a half–connection with Z interfaces are in the following ranges:

NLi =

NLo

5.0 to 8.0 dB for international connections

If a compensation for the loss of short or long subscriber lines is applied, the nominal loss *NLi* and *NLo* should be corrected by the value of x dB chosen in connection with § 2.2.4.3.

3.3.2 *xe ""§Noise*

3.3.2.1 *Weighted noise*

For the calculation of noise, worst–case conditions at the Z interface are assumed. The band limiting effect of the encoder on the noise has not been taken into account. For a more exact calculation further study is necessary.

3.3.2.1.1 *Output connection*

Two components of noise must be considered. One of these, e.g. noise arising from the decoding process, is dependent upon the output relative level. The other, e.g. power supply noise from the feeding bridge, is independent of the output relative level. The first component is limited by Recommendation G.714, § 10 as receiving equipment noise to –75 dBm0p; the other component is assumed by Recommendation G.123, Annex A to be 200 pWp (–67 dBmp). This can be caused by the main DC power supply and auxiliary DC–DC converters.

Information about the subject of noise on the DC power supply is given in Supplement No. 13 to the G-Series Recommendations (Orange Book, Volume III–3).

The total psophometric power allowed at a Z interface with a relative output level of *Lo* dB may be approximated by the formula:

$$PTNo = PAN + 10 \text{ pWp}$$

The total noise level is given by:

$$LTNo = 10 \log - 90 \text{ dBmp}$$

where

PTNo :
total weighted noise power for the output connection of the local digital exchange;

PAN :
Recommendation G.123, Annex A for local exchanges, i.e. 200 pWp;

LINo :
according to Recommendation G.714, § 10, i.e., –75 dBm0p;

Lo :
output relative level of a half–channel of a local digital exchange according to § 2.2.4.1.2, e.g., 0 to –8.0 dBr;

LTNo :
exchange.

For the range of output relative levels according to § 2.2.4.1.2 the resulting total psophometric powers and the total noise levels for the output connection are:

Lo

= 0

–5.0

–6.0

–7.0

–8.0

dBr

PTNo

= 231

210

208

206

205

pWp

LTNo

= –66.4

–66.8

–66.8

–66.9

–66.9

dBmp

3.3.2.1.2 *Input connection*

Two components of noise must be considered. One of these, e.g. noise arising from the encoding process, is dependent upon the output relative level. The other, e.g. power supply noise from the feeding bridge, must be corrected by the input relative level for calculation at the exchange test point To. The first component is limited by Recommendation G.714, § 9 as idle channel noise to –66 dBm0p; the other component is assumed by Recommendation G.123, Annex A to be 200 pWp (–67 dBmp) which results in –67 dBmp – *Li* at the exchange test point To.

The total psophometric power allowed at the exchange test point To with a relative input level of *Li* dB may be approximated by the formula:

$$PTNi = PAN \,.\, 10 + 10 \text{ pWp}$$

and the total noise level by

$$LTNi = 10 \log - 90 \text{ dBm0p}$$

where

PTNi :

PAN : weighted noise power caused by analogue functions according to Recommendation G.123, Annex A for local exchanges, i.e. 200 pWp;

LINi : idle channel noise (weighted) for the input connection of a digital local exchange according to Recommendation G.714, § 9 i.e., –66 dBm0p;

Li :

2.2.4.1.1, e.g. 0 and +1 dBr;

LTNi : total weighted noise level for the input connection of the local exchange.

For the relative levels according to § 2.2.4.1.1, the resulting psophometric power and the total noise levels for the input connection are:

Li

= 0

+1.0

+2.0

dBr

PTNi

= 451

410

377

pW0p

LTNi

= –63.5

–63.9

–64.2

dBm0p

Note – The calculation above is intended to account for the worst case. No band limiting effect of the encoder on the noise was taken into account.

3.3.2.2 *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. Recommendation G.123, § 3 must also be considered.

3.3.2.3 *xe ""§Impulsive noise*

It will be necessary to place limits on impulsive noise arising from sources within the exchange; these limits are under study.

Note 1 – The sources of impulsive noise are often associated with signalling functions (or in some cases the power supply and the ringing voltage) and may produce either transverse or longitudinal voltages at Z 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 subscriber 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*.

3.3.3 *Values ofxe ""§ total distortion*

The total distortion including quantizing distortion on half connections with Z interfaces is measured in accordance with § 3.1.5.

The signal–to–total distortion ratio required for a half connection may be approximated by the formula:

= *Ls* + *Lr* – 10 log

where

local exchanges;

Ls :

Lr :

output relative level *Lo* in dBr;

S/*N* : signal–to–total distortion ratio for PCM translating equipment in Recommendation G.714;

LN :

G.123, Annex A for local exchanges, i.e. –67 dBmp at the Z interface.

One resulting template for the signal–to–total distortion ratio of input and output connections in a local exchange is shown in Figure 15/Q.552 a) and b) as an example.

The values of Figure 15/Q.552 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 dBmp for a Z interface (with feeding) by Recommendation G.123, Annex A. As an example, the mean relative levels according to § 2.2.4.1 are assumed to be *Li* = 0 dBr and *Lo* = –7 dBr.

Note – For an input connection the calculation above is assumed to be the worst case. No band limiting effect of the encoder on the noise was taken into account.
Figure 15/Q.552 - T1102940-86