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**Business Telecommunications (BT);  
Transmission characteristics at 4-wire analogue interfaces of a  
digital Private Automatic Branch Exchange (PABX)**

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## 1 Foreword

This Interim-European Telecommunication Standard (I-ETS) was produced by the Business Telecommunications (BT) Technical Committee of the European Telecommunications Standards Institute (ETSI), and was adopted, having passed through the ETSI standards approval procedure.

This Standard was first prepared in the format of a CEPT Recommendation and was later converted into an ETSI standard. Consequently, it does not fully conform to the guidelines for the structure of ETSI standards although the ETSI "stylesheet" has been applied.

This Standard was submitted for Public Enquiry as an ETS, but, as it contains transmission parameters without specifying the exact measurement method it was decided to convert the standard into an I-ETS, thus allowing a two year period during which the BT Technical Committee can gain further experience with a view to modifying the parameter values and finalising the test method.

This Standard is intended to be used as a specification for the design of digital PABXs and for the harmonization of PABX transmission parameters throughout Europe. Parameters which are only of an informative instead of a normative character are highlighted as such.

During its preparation this I-ETS has been circulated to other European Standardization bodies (European Computer Manufacturers Association (ECMA) and European Committee for Electrotechnical Standardization (CENELEC)) who are also involved in the preparation of European Standards on ISPBXs.

There are three other standards directly connected with this Standard:

- |                |   |
|----------------|---|
| I-ETS 300 003: | Business Telecommunications (BT); Transmission characteristics of digital Private Automatic Branch Exchange (PABX).                                 |
| I-ETS 300 004: | Business Telecommunications (BT); Transmission characteristics at 2-wire analogue interfaces of a digital Private Automatic Branch Exchange (PABX). |
| I-ETS 300 006: | Business Telecommunications (BT); Transmission characteristics at digital interfaces of a digital Private Automatic Branch Exchange (PABX).         |

This Standard is based on information from CCITT Recommendations and the relevant Recommendation numbers are quoted where appropriate.

## 2 Scope

This Standard provides characteristics for:

- 4-wire analogue interfaces (Type M4 and K4),
- input and output connections with 4-wire analogue interfaces, and
- half connections with 4-wire analogue interfaces

in digital PABXs in accordance with the definitions given in I-ETS 300 003, (see also figures 1 and 3 of I-ETS 300 003).

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.

### 3 Related standards

I-ETS 300 003 (1991): "Business Telecommunications (BT); Transmission characteristics of digital Private Automatic Branch Exchange (PABX)".

I-ETS 300 004 (1991): "Business Telecommunications (BT); Transmission characteristics at 2-wire analogue interfaces of a digital Private Automatic Branch Exchange (PABX)".

I-ETS 300 006 (1991): "Business Telecommunications (BT); Transmission characteristics at digital interfaces of a digital Private Automatic Branch Exchange (PABX)".

NOTE: All references to CCITT recommendations refer to the 1988 editions ("Blue Book") except if expressly otherwise noted.

CCITT Recommendation G.111: Loudness ratings (LRs) in an international connection.

CCITT Recommendation G.117: Transmission aspects of unbalance about earth (definitions and methods).

CCITT Recommendation G.121: Loudness ratings (LRs) of national systems.

CCITT Recommendation G.123: Circuit noise in national networks.

CCITT Recommendation G.223: Assumptions for the calculation of noise on hypothetical reference circuits for telephony.

CCITT Recommendation G.712: Performance characteristics of PCM channels between 4-wire interfaces at voice frequencies.

CCITT Recommendation G.714: Separate performance characteristics for the encoding and decoding sides of PCM channels applicable to 4-wire voice-frequency interfaces.

CCITT Recommendation O.9: Measuring arrangements to assess the degree of unbalance about earth.

CCITT Recommendation O.81: Group-delay measuring equipment for telephone-type circuits.

CCITT Recommendation O.131: Quantizing distortion measuring equipment using a pseudo-random noise test signal.

CCITT Recommendation O.132: Quantizing distortion measuring equipment using a sinusoidal test signal.

CCITT Recommendation Q.45bis: Transmission characteristics of an analogue international exchange.

CCITT Recommendation Q.553: Transmission characteristics at 4-wire analogue interfaces of a digital exchange.

CCITT Fascicle I.3: Terms and definitions.

## 4 Definitions

**Interface K4:** As defined in subclause 4.6.2.2 of I-ETS 300 003, the interface K4 provides for the direct connection of 4-wire analogue circuits to the public switched telephone network (PSTN).

**Interface M4:** As defined in subclause 4.6.2.1 of I-ETS 300 003, the interface M4 provides for the connection of 4-wire analogue circuits to the PSTN with the PABX acting as a transit switch or the connection of 4-wire analogue circuits to other PABXs.

## 5 Four-wire interface specifications

When 4-wire analogue interfaces of digital PABXs are connected with circuits which are used for international or national as well as private traffic, the same values recommended for international or national connections may also be used for connections entirely within the private network.

### 5.1 Characteristics of interfaces

#### 5.1.1 Characteristics common to all 4-wire analogue interfaces

##### 5.1.1.1 PABX impedance

###### 5.1.1.1.1 Nominal value

The nominal impedance at the 4-wire input and output interfaces shall be either 600 ohms, balanced or as specified by some Administrations in Annex E.

###### 5.1.1.1.2 Return loss

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

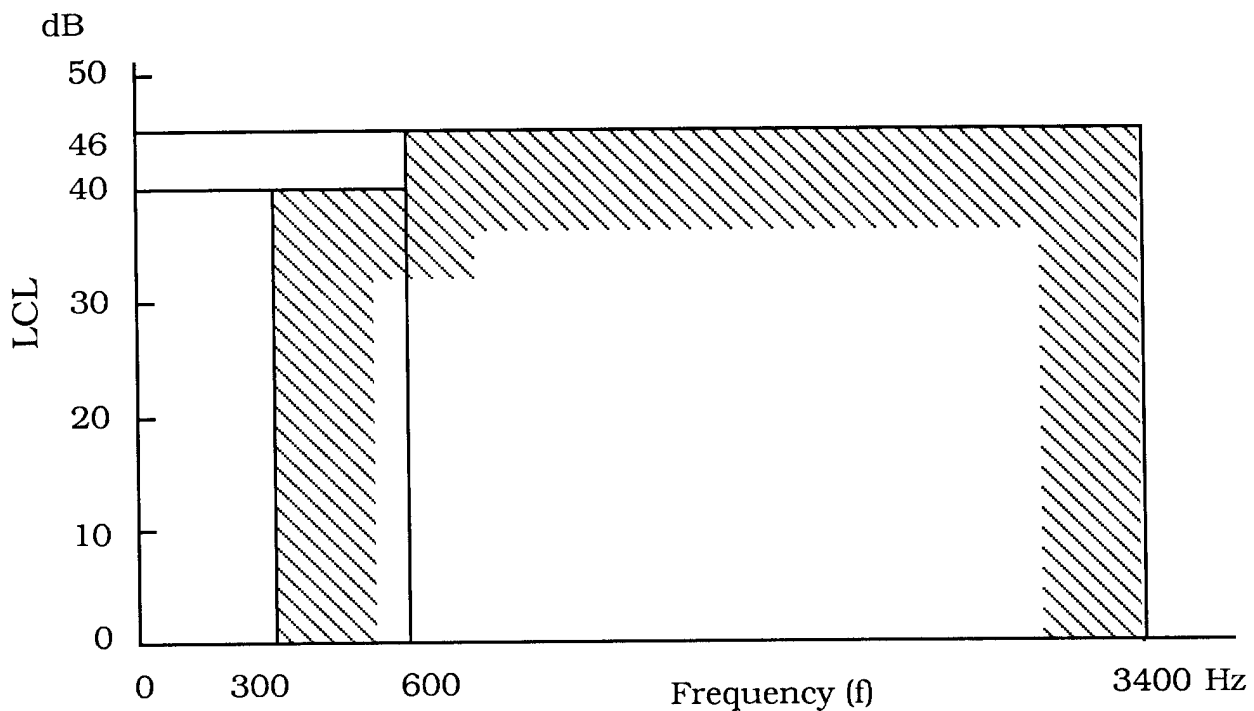
NOTE: For output measurement, the PABX test point  $T_i$  must be driven by a PCM signal corresponding to the decoder output value number 1 for the A-law (See I-ETS 300 003, subclause 5.1.1).

###### 5.1.1.2 Impedance unbalance about earth

The Longitudinal Conversion Loss (LCL) defined in CCITT Recommendation G. 117, § 4.1.3 shall exceed, as a minimum requirement, the following values (see also figure 1):

300 - 600 Hz	40 dB
600 - 3400 Hz	46 dB

with the equipment under test in the normal talking and quiescent state, in accordance with CCITT Recommendations Q.45bis and K.10. Some administrations specify other values and in some cases wider bandwidth (see Annex B).



**Figure 1: Minimum values of LCL measured in the arrangement shown in figure 2**

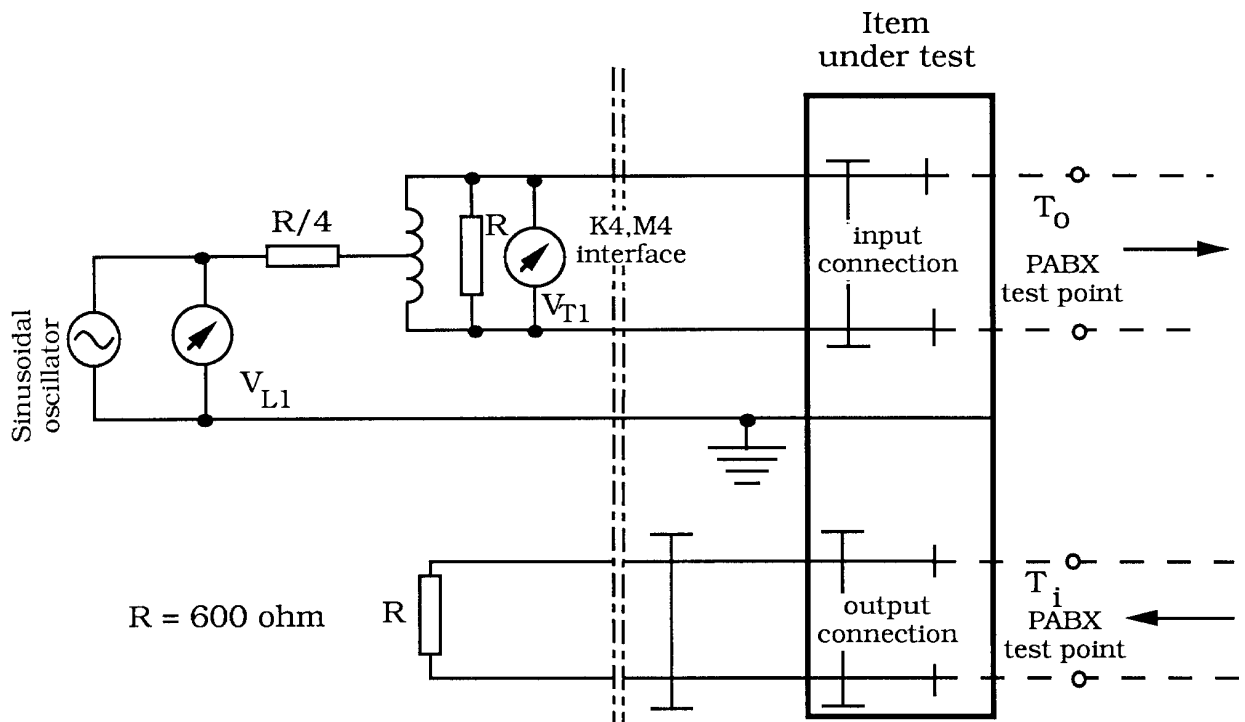
NOTE: A limit may also be required for the Transverse Conversion Loss (TCL) as defined in CCITT Recommendation G.117, § 4.1.2, if the PABX termination is not reciprocal with respect to the transverse and longitudinal connections. A suitable limit would be 40 dB to ensure an adequate near-end crosstalk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

**Test method:**

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

Transverse Conversion Loss shall be measured in accordance with the principles given in CCITT Recommendation O.9, § 2.2 and § 3. Measurements of the longitudinal and transverse voltages should preferably be done with a frequency-selective level meter.





$$\text{Longitudinal Conversion Loss (LCL)} = 20 \log_{10} \left| \frac{V_{L1}}{V_{T1}} \right| \text{ dB}$$

NOTE: For output measurement the test point  $T_i$  must be driven by a PCM signal corresponding to be decoder output value number 1 for the A-law. (See I-ETS 300 003, subclause 5.1.1).

**Figure 2: Arrangement for measuring LCL**

### 5.1.1.3 Relative levels

As presented in this standard, the values here are informative. However some Administrations may also apply these values for normative purposes.

NOTE: In assigning the relative levels to the interfaces, the limiting of "difference in transmission loss between the two directions of transmission" in CCITT Recommendation G.121, § 6.4 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). The difference is limited to  $\pm 4$  dB. However, to allow for possible asymmetry of loss in the public network, only a part of this difference can be used by the private network when connected to the public network.

#### 5.1.1.3.1 Nominal levels

Specified values of relative levels are given in Annex A for the different types of half connections.

NOTE 1: The nominal relative levels at the 4-wire analogue input and output interfaces of the digital PABX depend on the type of equipment which is connected to the PABX (See figure 3 of I-ETS 300 003 NOTE 4).

NOTE 2: In practice it may be necessary to compensate for the loss between the output interfaces of the digital PABX and the input ports of the connected equipments to fulfil transmission plan conditions. The definition of adjustable steps for and the location of this compensation (digital PABX or connected equipment) is installation specific.

#### 5.1.1.3.2 Tolerances of relative levels

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

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

NOTE 1: These differences may arise, for example, from design tolerances, cabling (between analogue cabinets and the Distribution Frame (DF)) and adjustment increments.

NOTE 2: Adjustment of the relative level should be made in accordance with CCITT Recommendation G.712, § 15.

### 5.2 Characteristics of half connections

#### 5.2.1 Characteristics common to all 4-wire analogue interfaces

##### 5.2.1.1 Transmission loss

As presented in this standard, the values here are informative. However some Administrations also apply these values for normative purposes.

##### 5.2.1.1.1 Nominal value

According to the relative levels defined in Annex A the nominal transmission losses of input or output connections NLi and NLo of a half connection with M4 and K4 interfaces are computed according to I-ETS 300 003, subclause 4.3.1.

##### 5.2.1.1.2 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 subclause 5.1.1.3.2 shall lie within the following values:

-0.3 to +0.7 dB

NOTE: These differences may arise for example, from design tolerances, cabling (between the analogue equipment port and the DF) or adjustment increments. Short-term variation of loss with time as discussed in subclause 5.2.1.1.3 is not included.

### 5.2.1.1.3 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 PABX test point  $T_i$  of any output connection, the level at the corresponding PABX test point  $T_o$  and the 4-wire analogue interface respectively, shall not vary by more than  $\pm 0.2$  dB during any 10-minute interval of typical operation under the permitted variations in the power supply voltage and temperature.

### 5.2.1.1.4 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 PABX 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, shall lie within the limits given in figure 3.

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

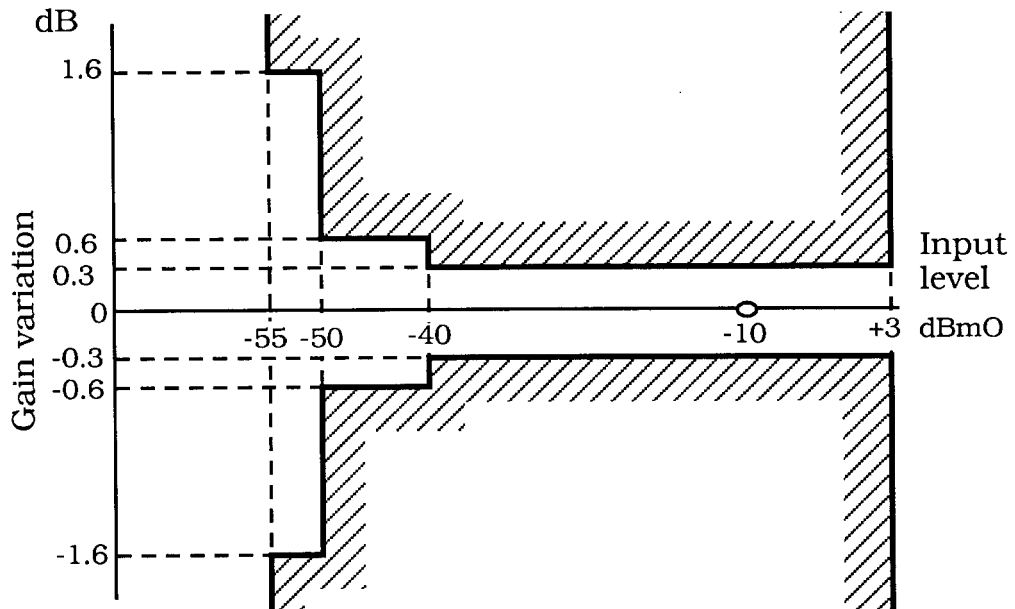
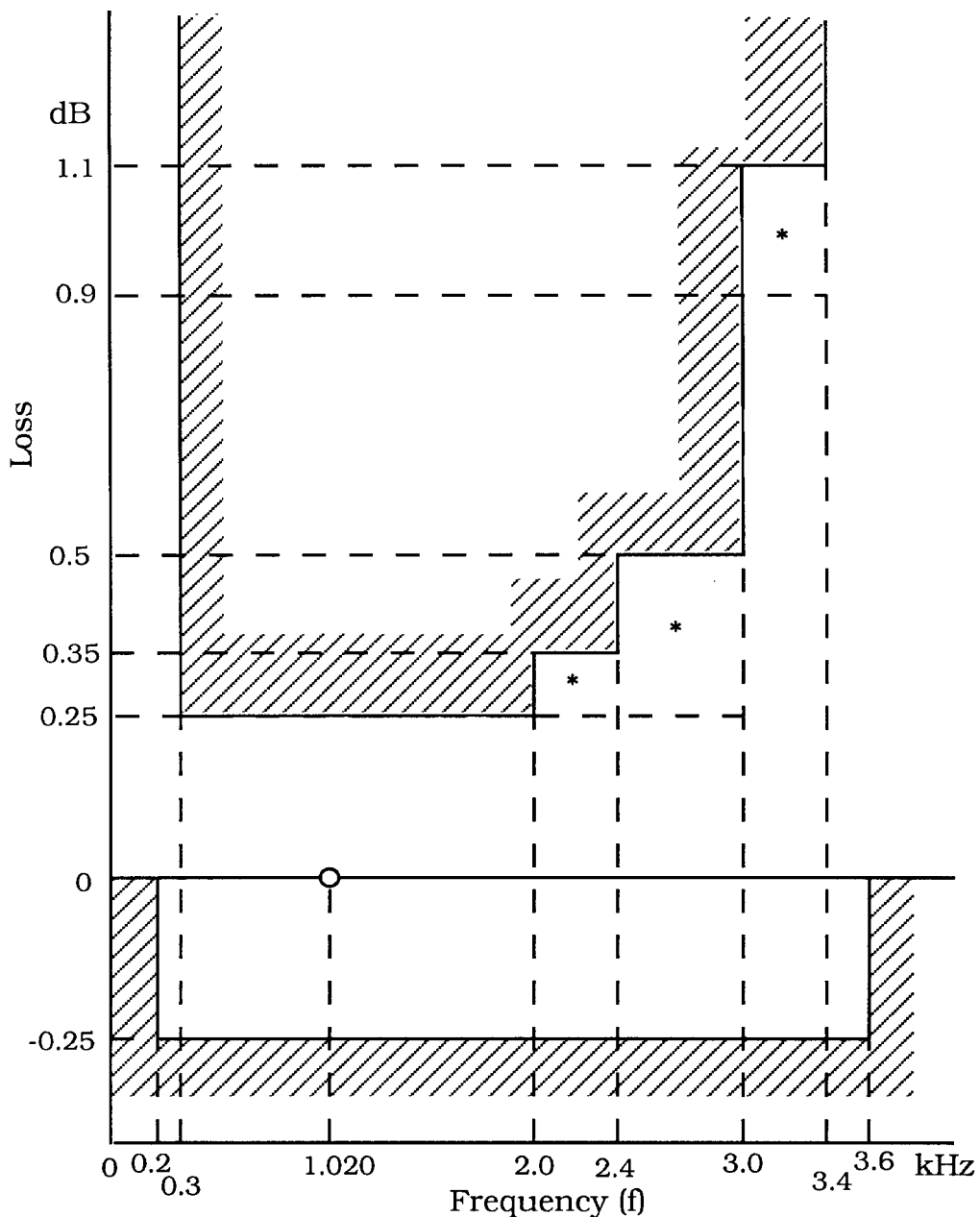


Figure 3: Variation of gain with input level

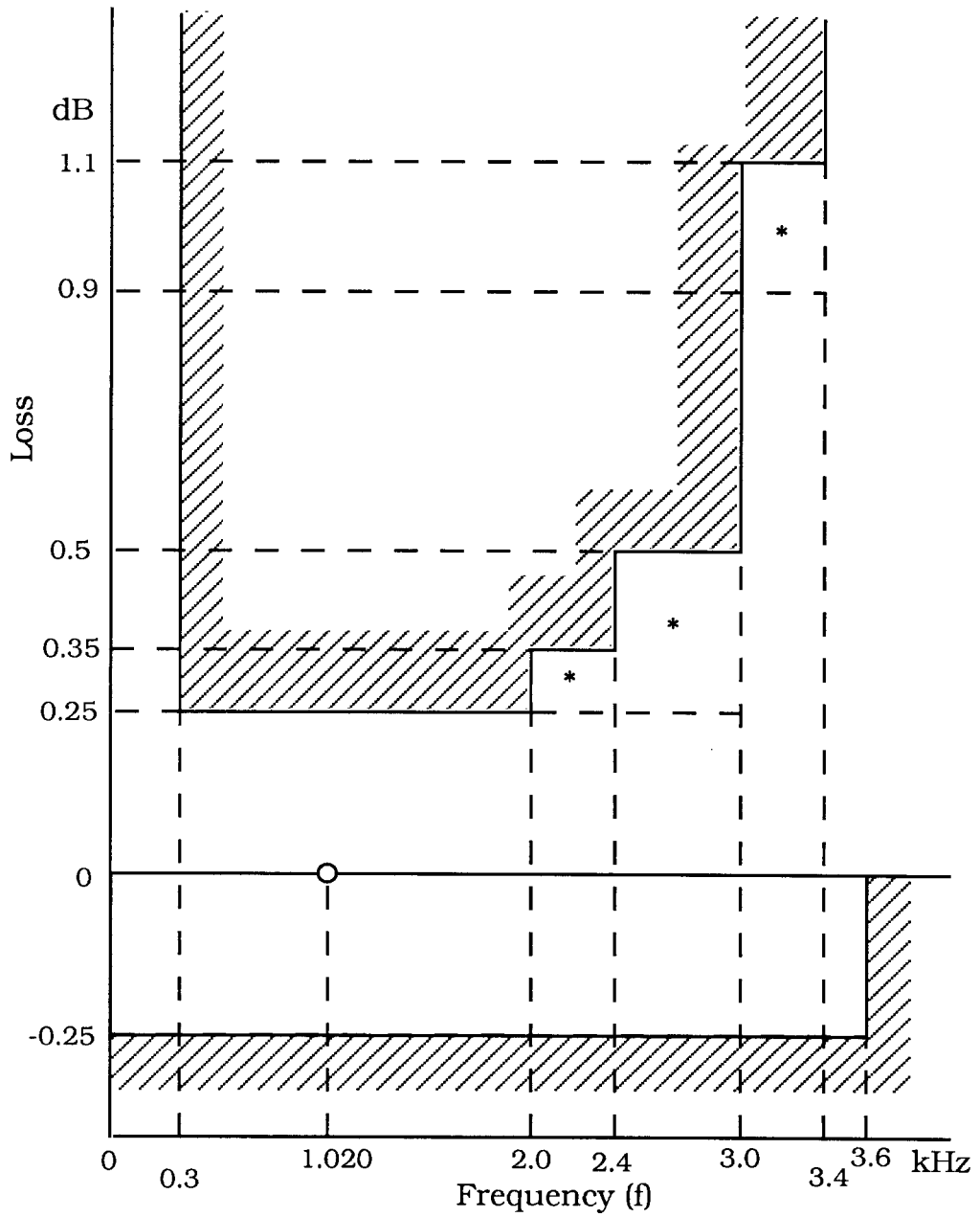
5.2.1.1.5 Loss distortion with frequency

According to I-ETS 300 003, subclause 4.4, the loss distortion with frequency of any input or output connection shall lie within the limits shown in the mask of figures 4a and 4b respectively. The preferred input level is -10 dBm0.



\* In the marked frequency ranges relaxed limits are shown which apply if the maximum length of cabling between cabinet and Main Distribution Frame (MDF) (I-ETS 300 003, subclause 4.6) is used. The more stringent limits shown apply if no such cabling is present.

Figure 4a: Loss distortion with frequency: Input Connection



\* In the marked frequency ranges relaxed limits are shown which apply if the maximum length of cabling between cabinet and MDF (I-ETS 300 003, subclause 4.6) is used. The more stringent limits shown apply if no such cabling is present.

**Figure 4b: Loss distortion with frequency: Output connection**

5.2.1.2 Group delay

5.2.1.2.1 Absolute group delay

NOTE: See I-ETS 300 003, subclause 4.7.3.1.

5.2.1.2.2 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 shall lie within the limits shown in the template of figure 5. Group delay distortion shall be measured in accordance with CCITT Recommendation O.81.

These requirements shall be met at an input level of -10 dBm0.

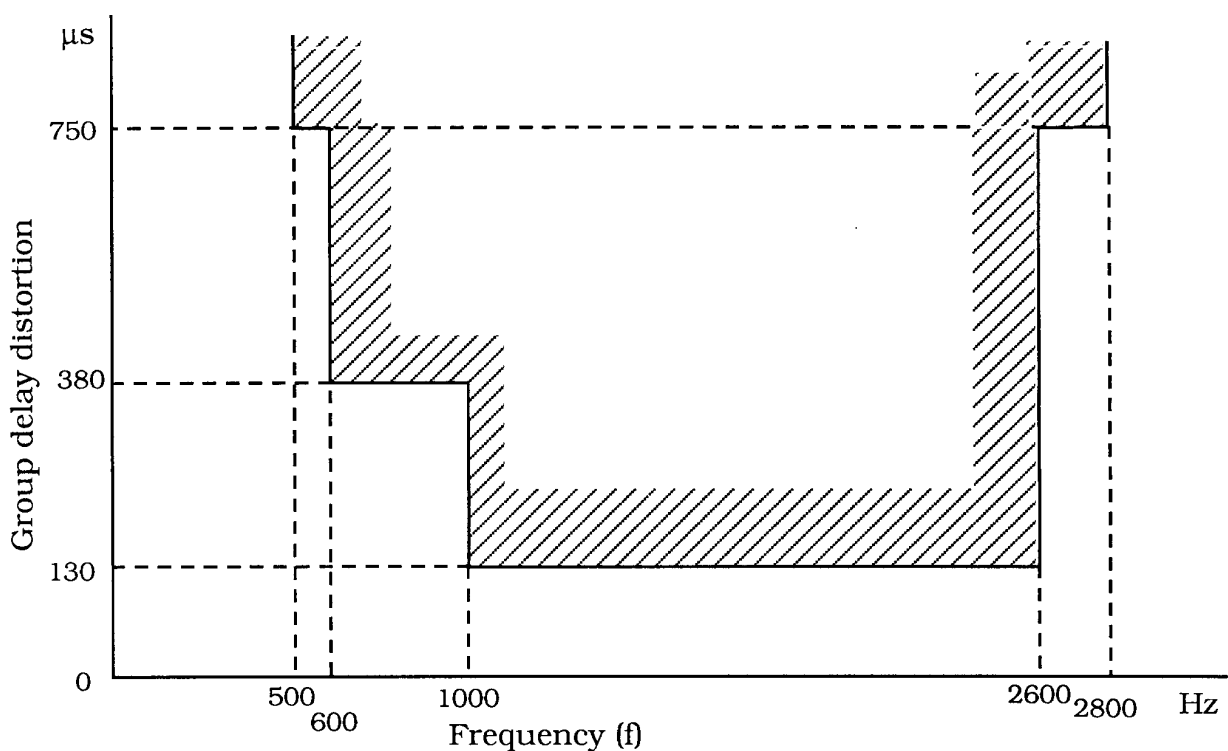


Figure 5: Group delay distortion limits with frequency

### 5.2.1.3 Noise

#### 5.2.1.3.1 Weighted noise

For the calculation of these values, two components of noise must be considered: noise arising from the coding process and noise from the PABX power supply and other analogue sources transmitted through signalling circuits. The first component is limited by CCITT 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 CCITT Recommendation G.123, § 3 to  $-(67 + 3)$  dBm0p = -70 dBm0p for one 4-wire analogue interface.

The following maximum values for the overall weighted noise at the output interfaces of a half connection of a digital PABX shall be used:

- 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.

#### 5.2.1.3.2 Unweighted noise

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

                      The need for and value of this parameter are both under study. CCITT Recommendations Q.45bis, § 2.5.2 and G.123, § 3 must also be considered.

#### 5.2.1.3.3 Impulsive noise

NOTE 1:       Limits should be placed on impulsive noise arising from sources within the PABX, these limits are under study. Pending the results of this study, CCITT Recommendation Q.45bis, § 2.5.3 may give some guidance on the subject of controlling impulsive noise with low frequency content.

NOTE 2:       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. 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 CCITT Recommendation Q.45bis.

#### 5.2.1.3.4 Single frequency noise

The level of any unwanted single frequency (in particular the sampling frequency and its multiples), measured selectively with a bandwidth of 80 Hz in the frequency range from 4 kHz to 72 kHz at the interface of an output connection shall not exceed -50 dBm0. Some Administrations specify the requirement in different ways (see Annex C).

NOTE 1:       In this case "unwanted" refers to self generated noise such as feedthrough of sampling frequencies and not to tones used for signalling or for normal traffic.

NOTE 2:       The values above are preliminary and will be adapted to CCITT values if CCITT comes to different results.

### 5.2.1.4 Crosstalk

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

- the quiet code (see I-ETS 300 003, subclause 5.1.1);
- a low level activating signal. Suitable activating signals are, for example, a band limited noise signal (see CCITT 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.

#### 5.2.1.4.1 Crosstalk measured with analogue test signal

##### 5.2.1.4.1.1 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, shall not produce a level, measured selectively, 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.

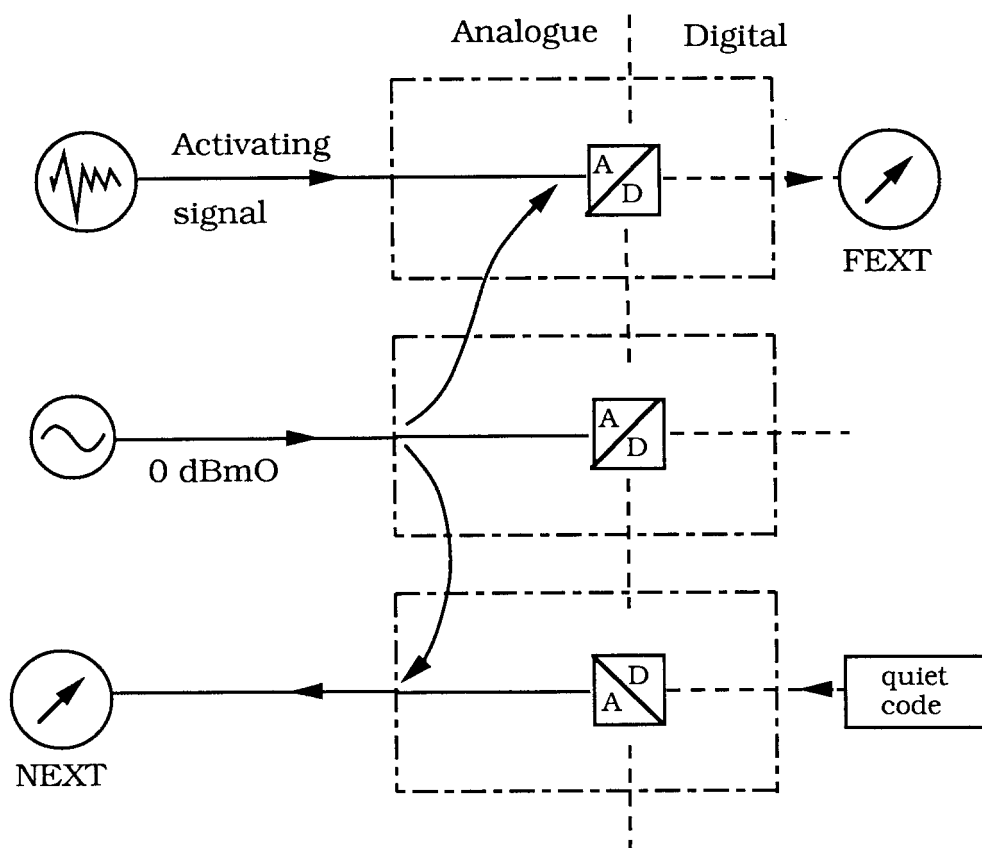


Figure 6: Measurement with an analogue test signal between different input connections of half connections



5.2.1.4.1.2 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, shall not produce a level exceeding -66 dBm0, measured selectively, at the analogue output of the same half connection. (See figure 7).

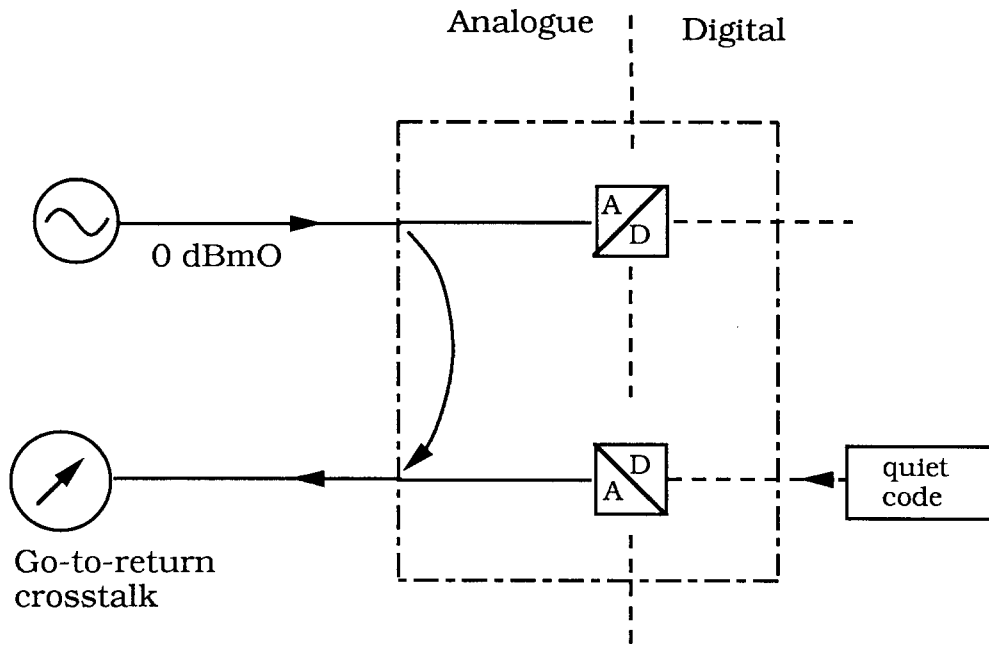


Figure 7: Measurement with an analogue test signal between go and return directions of the same half connection

5.2.1.4.2 Crosstalk measured with digital test signal

5.2.1.4.2.1 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 a PABX test point Ti shall not produce a level exceeding -70 dBm0, measured selectively, for Near-End Crosstalk (NEXT) or -73 dBm0 for Far-End Crosstalk (FEXT), at either output of any other half connection. See figure 8.

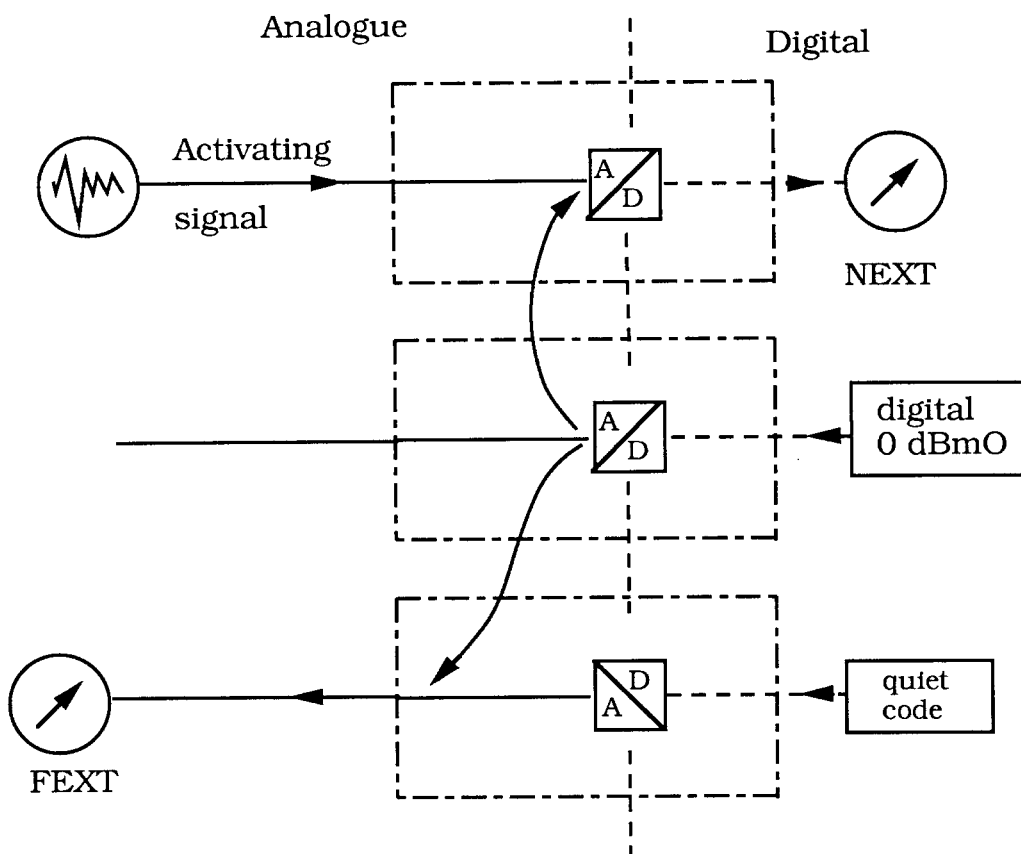


Figure 8: Measurement with a digital test signal between different output connections of half connections

5.2.1.4.2.2 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 a PABX test point  $T_i$  of an output connection, shall not produce a crosstalk level exceeding -66 dBm0, measured selectively, at the PABX test point  $T_o$  of the corresponding input connection. See figure 9.

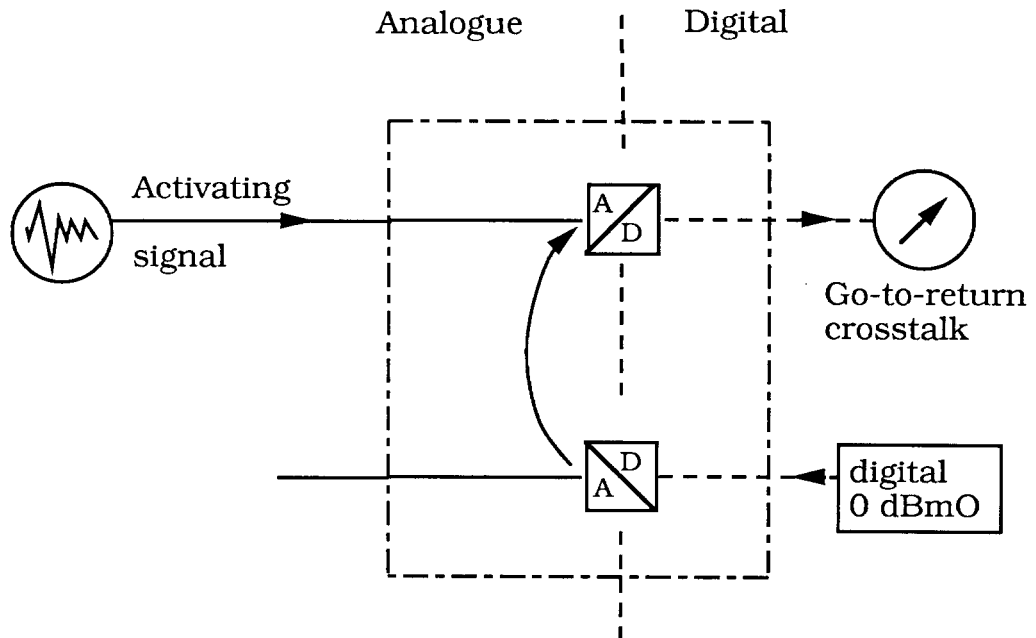


Figure 9: Measurement with a digital test signal between go and return directions of the same half connection

### 5.2.1.5 Total distortion including quantizing distortion

With a sine-wave test signal at the reference frequency of 1020 Hz (see CCITT 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 PABX 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 of CCITT Recommendation G.223) shall lie above the limits shown in figure 10 for signalling on separate wires and in figure 11 for signalling on the speech wires.

NOTE: The sinusoidal test signal is chosen to obtain results independent of the spectral content of the PABX noise.

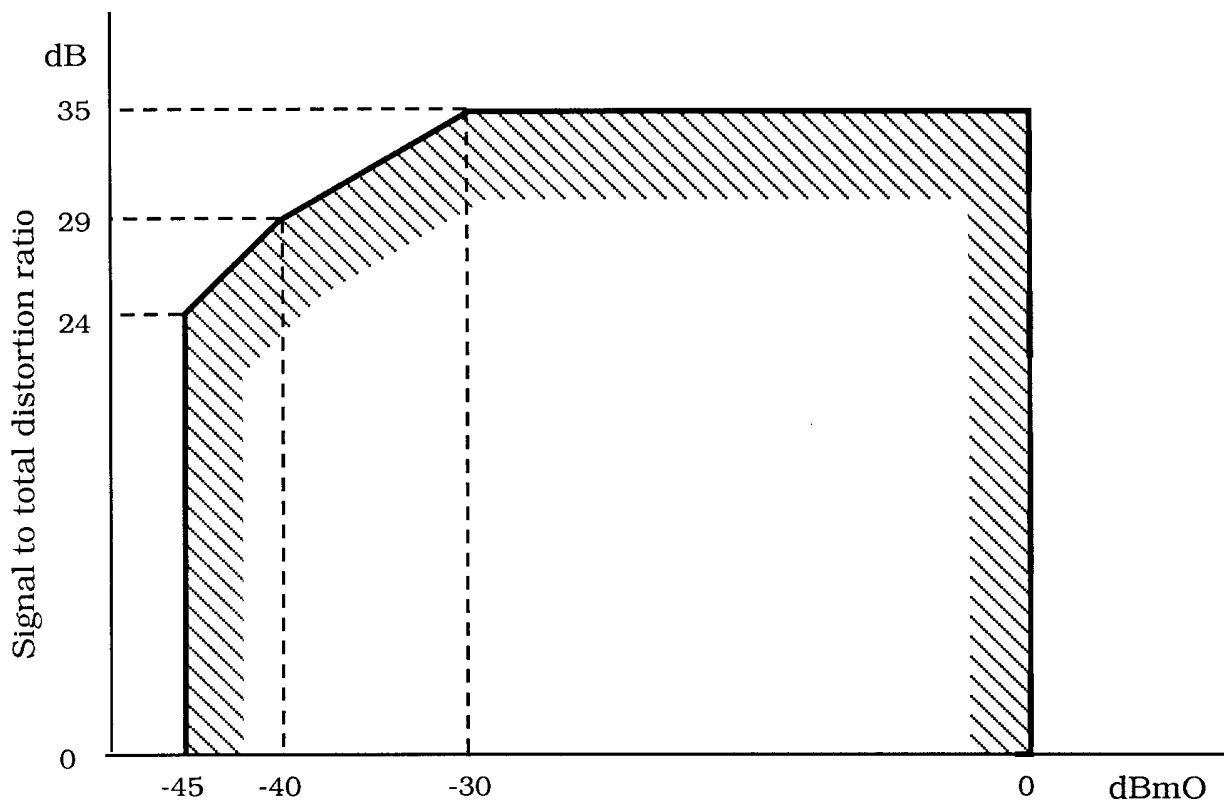
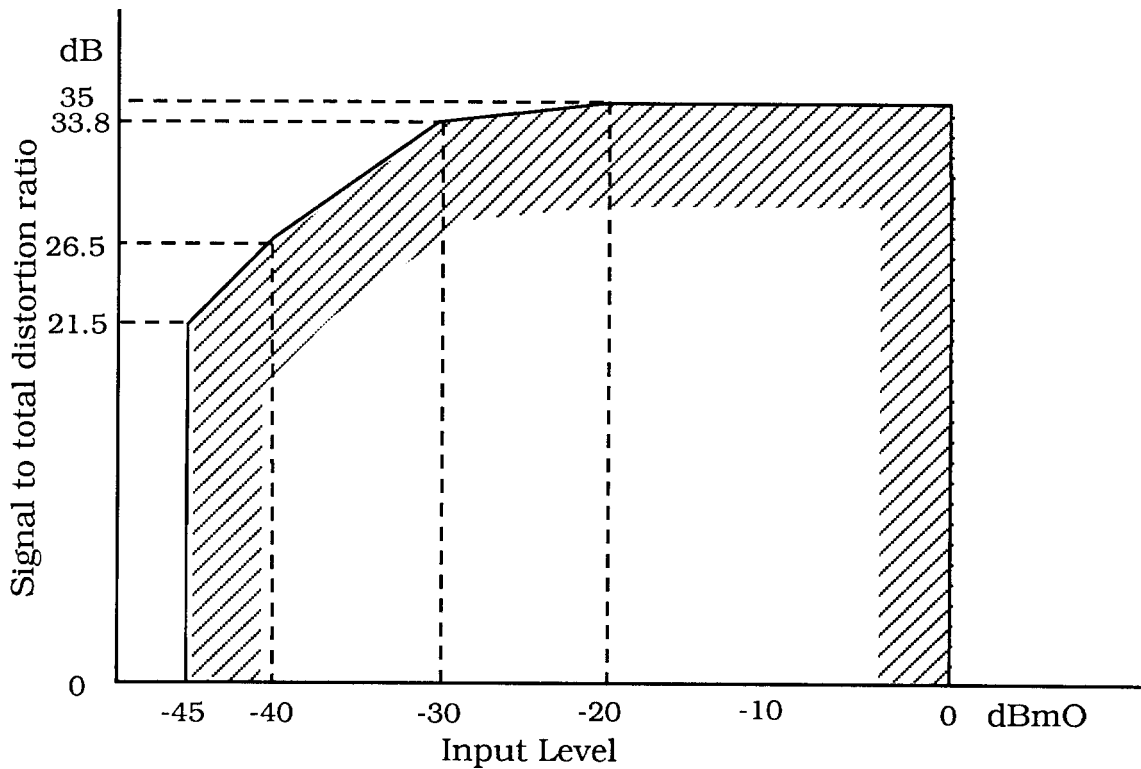


Figure 10: Limits for signal-to-total distortion ratio as a function of input level.  
Input or output connection with signalling on separate wires.



NOTE: The values of figure 11 include the limits for the coding process given in CCITT Recommendation G.714, figure 5 and the allowance for the noise contributed via signalling circuits from the PABX power supply and other analogue sources which is limited to  $-(67+3)$  dBm<sub>0p</sub> = -70 dBm<sub>0p</sub> for one 4-wire analogue interface by CCITT Recommendation G.123, § 3.

**Figure 11: Limits for signal-to-total distortion ratio as a function of input level. Input or output connection with signalling on the speech wires.**

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

##### 5.2.1.6.1 Input signals above 4.6 kHz

With any sine-wave signal in the range from 4.6 kHz to 72 kHz applied to a 4-wire interface of a half connection at a level of -25 dBm<sub>0</sub>, the level of any image frequency produced in the time slot corresponding to the input connection shall be at least 25 dB below the level of the test signal.

NOTE: If the respective values in CCITT will be changed, than the above given value will be corrected accordingly.

##### 5.2.1.6.2 Signals below 300 Hz

NOTE: At present no harmonized requirement can be specified. National values given by administrations shall be used and are given in annex D.

### **5.2.1.6.3 Overall requirement**

Under the most adverse conditions encountered in a national network the half connection shall not contribute more than 100 pWOp 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. This requirement is included as informative only.

### **5.2.1.7 Spurious out-of-band signals received at the output interface**

#### **5.2.1.7.1 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 PABX test point Ti of a half connection, the level of spurious out-of-band image signals measured selectively at a 4-wire interface of the output connection shall be lower than -25 dBm0.

NOTE: If the respective values in CCITT will be changed, than the above given value will be corrected accordingly.

#### **5.2.1.7.2 Overall requirement**

This requirement is included as informative only.

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

**Annex A: Relative levels for M4 and K4 interfaces in dBr**

**Table A.1: Values specified by different European Administrations**

	M4	
	Lo	Li
Austria	-3.5	-3.5
Denmark		under study
Finland	-3.5	-3.5
France option a (see NOTE 3)	-3.5	-3.5
option b	-4.9	-4.9
option c	-5.4	-5.4
FRG	-4.5	-2.5
FRG (NOTE 1)	-3.5	-3.5
Greece	-3.5	-3.5
Italy	-3.5	-3.5
Italy (NOTE 2)	-14+As	+4-Ar
Netherlands		under study
Norway	0	0
Portugal		under study
Sweden	-3.5	-3.5
Switzerland	-3.5	-3.0
United Kingdom	-4.5	+0.5

**Interface K4 is for use in the UK and Norway only:**

	K4	
	Lo	Li
United Kingdom		For further study
Norway	0	0

NOTE 1: In the case of Private Branch Network (PBN) with no traffic to the public network.

NOTE 2: In the case of connection to FDM systems Ar and As are, respectively, the total loss in the receive and send path between FDM systems and the PABX interface.

NOTE 3: These options are for the impedance values shown in annex E. Option a refers to the case of 600 ohm impedance.

**Annex B: Impedance unbalance about earth in different European Administrations**

**Table B.1: Interfaces K4 and M4**

Country	Frequency Range	LCL
Denmark	40 - 600 Hz	40 dB
	600 - 3400 Hz	46 dB
	>3400 Hz	6 dB decrease/octave
France	25 - 300 Hz	30 dB
	300 - 3400 Hz	52 dB
Norway (see NOTE)	16 - 300 Hz	40 dB
	300 - 600 Hz	46 dB
	600 - 3400 Hz	52 dB
Sweden	15 - 50 Hz	40 dB
	50 - 600 Hz	46 dB
	600 - 3400 Hz	52 dB
Switzerland	15 - 300 Hz	42 dB
	300 - 3400 Hz	52 dB

NOTE: This requirement applies to all states of normal operation lasting more than 100 ms.



**Annex C: Single frequency noise (dBm0)**

**Table C.1: Requirements specified, in the frequency ranges**

	15 - 75 Hz	75 - 300 Hz	0,3 - 3,4 kHz	3,4 - 150 kHz
by: Sweden	-17 dBm0	-27 dBm0	*	-50 dBm0

\* The requirements in the speech band 300 Hz - 3400 Hz are covered by those associated with psophometric noise. (See, subclause 5.2.1.3.1).

NOTE: This parameter is under study also in CCITT, mainly for the extent of the bandwidth where the measure has to be done.

**Annex D: Discrimination against out-of-band signals applied to the input interface: Signals below 300 Hz**

Sweden: The rejection of signals in the band 15 - 50 Hz shall be at least 20 dB.

Italy: The rejection of signals at 50 Hz shall be at least 20 dB. (under study).

## Annex E: Nominal values for input impedance and return loss

In France the following simple and complex impedances may be used:

	Rs (ohms)	Rp (ohms)	Cp (nF)
option a :	600	0	0
option b :	180	910	150
option c :	215	1000	137

For these complex impedances the return loss shall comply with the limits given in figure 2 of I-ETS 300 004.

NOTE: See, subclause 5.1.1.1.1.

## History

<b>Document history</b>	
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