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**I-ETS 300 003**

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# Business Telecommunications (BT); Transmission characteristics of digital Private Automatic Branch Exchanges (PABXs)

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

I-ETS 300 005: Business Telecommunications (BT); Transmission characteristics at 4-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 is related to the transmission properties of digital PABX-Systems to be connected to the public switched telephone network (PSTN), for PABX-Systems which have Digital Test Points.

Transmission characteristics for PABXs result from the public exchange transmission characteristics, because the PABXs are part of the global transmission performance. For this reason, CCITT Recommendations Q.551 to Q.554 will be the main reference. However, the particularities of PABXs (essentially the shortness of most of the extension lines) will be taken into account to determine the relative levels and the impedance at the internal interfaces.

The transmission parameters are considered at the interfaces indicated in figures 1, 2 and 3:

- K2 represents an analogue 2-wire interface to the public switched network.
- K4 represents an analogue 4-wire interface to the public switched network.
- KD represents a digital interface to the public switched network.

NOTE 1: The public switched network can have an analogue and/or digital transmission medium.

NOTE 2: The K4 interface is used in Norway and in the UK only.

- M2 represents an analogue 2-wire interface to a digital or analogue PABX.
- M4 represents an analogue 4-wire interface to a digital or analogue PABX.
- MD represents a digital interface to another PABX.
- M21 represents an analogue 2-wire interface, terminating an international/national 4-wire long distance connection, to a digital or analogue PABX.
- M22 represents an analogue 2-wire interface, terminating connections other than those of M21, to a digital or analogue PABX.
- L2 represents an analogue 2-wire extension line interface.
- LD represents a digital extension line interface.

Detailed transmission characteristics for these interfaces are provided in the following European Telecommunication Standards:

- I-ETS 300 004 for 2-wire analogue interfaces.
- I-ETS 300 005 for 4-wire analogue interfaces.
- I-ETS 300 006 for digital interfaces.

A PABX may provide interfaces other than those shown in figures 1, 2 and 3 which are not covered by this Standard. If provided, these other interfaces may be covered by national requirements.

The use of 4-wire analogue interfaces between PABXs located in different countries has not been considered and is subject to further study.

Interfaces similar to those designated L2 may be provided by PABXs and where necessary national requirements are applied. This may be justified due to ETSI not having considered their European standardization, e.g. because of their limited use, or because their function is to coordinate with pre-existing national standards.

It is necessary to ensure that representative feeding currents are flowing during the measurements of all these transmission parameters. These feeding currents can contribute to noise, distortion, crosstalk, variation of gain with input level, etc. Therefore appropriate allowances for this must be made. In some cases, where indicated, the permissible limits quoted include these allowances.

In the present Standards, values given for transmission characteristics relate to the path from a PABX test point to a PABX interface and vice versa; the overall characteristics for most connections involving two interfaces can be obtained by suitably combining these values.

These Standards consider analogue signals which are encoded in accordance with the A-law coding scheme (CCITT Recommendation G.711).

The values given are to be considered as either "design" or "performance objectives" according to the explanations of the terms given in CCITT Recommendation G.102 (Transmission Performance Objectives and Recommendations) and the particular context.

The specification clauses in this Standard exclude the effects of auxiliary functions such as echo suppression, echo cancellation, or non-telephony functions such as telemetering. Problems arising from transmission (by local exchange) and detection (by PABX) of metering impulses need further study.

## 3 Related standards

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 300 005 (1991): "Business Telecommunications (BT); Transmission characteristics at 4-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)".

ETS BT-2000: "Business Telecommunications (BT); Digital Private Automatic Branch Exchange (PABX) transmission characteristics measurements".

NOTE: ETS BT-2000 is still in preparation. It is intended that I-ETSs 300 003 to 300 006 will be revised and upgraded to ETSs when BT-2000 is completed.

ETR 004 (1990): "Business Telecommunications (BT); Overall transmission plan aspects of a private branch network for voice connections with access to the public network".

CCITT Recommendation G.101: The transmission plan.

CCITT Recommendation G.102: Transmission performance objectives and Recommendations.

CCITT Recommendation G.103: Hypothetical reference connections.

CCITT Recommendation G.122: Influence of national systems on stability, talker echo, and listener echo in international connections.

CCITT Recommendation G.131: Stability and Echo (General characteristics of the 4-wire chain formed by the International circuits and national extension circuits).

CCITT Recommendation G.171: Transmission plan aspects of privately operated networks.

CCITT Recommendation G.703: Physical/electrical characteristics of hierarchical digital interfaces.

CCITT Recommendation G.711: Pulse code modulation (PCM) of voice frequencies.

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

CCITT Recommendation G.713: Performance characteristics of PCM channels between 2-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 G.715: Separate performance characteristics for the encoding and decoding side of PCM channels applicable to 2-wire interfaces.

CCITT Recommendation I.431: Primary rate user-network interface - Layer 1 specification.

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 P.16: Subjective effects of direct crosstalk; thresholds of audibility and intelligibility.

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

CCITT Recommendation Q.521: Exchange functions.

CCITT Recommendation Q.543: Digital exchange performance design objectives.

CCITT Recommendation Q.551: Transmission characteristics of digital exchanges.

CCITT Recommendation Q.552: Transmission characteristics at 2-wire analogue interfaces of a digital exchange.

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

CCITT Recommendation Q.554: Transmission characteristics at digital interfaces of a digital exchange.

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

# 4 Definitions

## 4.1 Test points, PABX input and output and half connections

### 4.1.1 Test points

The test points shown in figure 3 are defined for specification purposes. They may not physically exist in a PABX but may be accessed via the digital switching network. In this case, a part or all of the switching network will be included in the path from the PABX interface to the points of access to the test points.

The transmission parameters affected by this means of access are:

Absolute group delay;

Jitter and Wander (possibly);

Bit Error Ratio (possibly).

For most other parameters, either the test points or the access points are located such that end-to-end performance can be determined by suitably combining performances between each interface and either the test points or the access points.

For measurement purposes, an access to the test points has to be physically available. This access must be digital in its nature and the use of standardized interfaces like 64 kbit/s, 2 Mbit/s or 144 kbit/s ($S_0$ - interface) are recommended.

NOTE: This physical access to the test points might be advantageous also for maintenance purposes. However, there is no obligation to provide test points on production systems in the field.

### 4.1.2 PABX input and output

The PABX input and output for a connection through a digital PABX are located at the interfaces identified in clause 2 and shown in figures 1, 2 and 3.

### 4.1.3 Half connections (analogue 2-wire or 4-wire, or digital)

**Input connection:** a unidirectional path from an interface of a digital PABX to a test point.

**Output connection:** a unidirectional path from a test point to an interface of a digital PABX.

**Half connection:** a bidirectional path comprised of an input connection and an output connection, both having the same interface.

## 4.2 Relative levels

### 4.2.1 Test points

The nominal relative level at the input and output test points is assigned to the value 0 dBr.

### 4.2.2 Analogue interfaces

The nominal relative level at the PABX input point is designated $L_i$.

The nominal relative level at the PABX output point is designated $L_o$.

### 4.2.3 Digital interfaces

The relative level to be associated with a point in a digital path carrying a digital bit stream generated by a coder provided in accordance with the principles of CCITT Recommendation G.101 is determined by the value of the digital loss or gain between the output of the coder and the point considered.

If there is no such loss or gain, the relative levels at the PABX input and output points (digital interfaces e.g. KD, MD, LD) are by convention said to be 0 dBr. For further information, see CCITT Recommendation G.101, § 5.3.2.4.

Relative levels have no meaning for digital bit streams which are not derived from analogue sources.

## 4.3 Transmission loss

### 4.3.1 Nominal transmission loss

A connection through the PABX (see figure 3) is established by connecting in both directions an input located at one interface to an output located at another interface.

The nominal transmission loss for a connection through a PABX is equal to the difference of the relative levels at the input and the output. Therefore the nominal transmission loss concerning analogue interfaces is defined as:

$$NL = L_i - L_o$$

where: $L_i$ and $L_o$ in dBr, NL in dB.

The nominal transmission loss between the input at an analogue interface and the test point is defined as:

$$NL_i = L_i$$

where: $L_i$ in dBr, $NL_i$ in dB.

The nominal transmission loss between the test point and the output of an analogue interface is defined as :

$NL_o = - L_o$

where: $L_o$ in dBr, $NL_o$ in dB.

NOTE 1: The nominal transmission loss, NL, may be implemented by an analogue loss pad. It may also be implemented by a digital loss pad. As a general principle, the use of digital loss pads should be avoided because bit integrity is lost for digital services, and additional transmission impairments are introduced for analogue services.

However, it is recognized that during the transition stage to a completely digital network, existing national transmission plans may require digital pads to be inserted for speech.

The nominal transmission loss of the PABX may be different in the two directions.

NOTE 2: Private networks used for voice transmission may require to use devices such as code converters, digital echo control devices, digital speech interpolation apparatus, all-zero-suppressors etc, which alter the bit integrity of the 64 kbit/s connection; these devices provided within the PABX provision must be made to render such devices inoperative as necessary (See CCITT Recommendation Q.521, § 4.3.7).

### 4.4 Loss distortion with frequency

The loss distortion with frequency is the logarithmic ratio of output voltage at the reference frequency (nominally 1020 Hz), U (1020 Hz), divided by its value at frequency f, U (f) :

$$LD = 20 \log \frac{U\,(1020\ Hz)}{U\,(f)}\ dB$$

See CCITT Recommendation G.101 § 5.3 and supplement No.1 in Fascicle VI.5 of the CCITT Blue Book.

### 4.5 Digital parameters

#### 4.5.1 Bit integrity

Bit integrity is the property of a digital half connection in which the binary values and the sequence of the bits in an octet at the input of the half connection are reproduced exactly at the output.

NOTE: Digital processing devices must be disabled to provide bit integrity when needed.

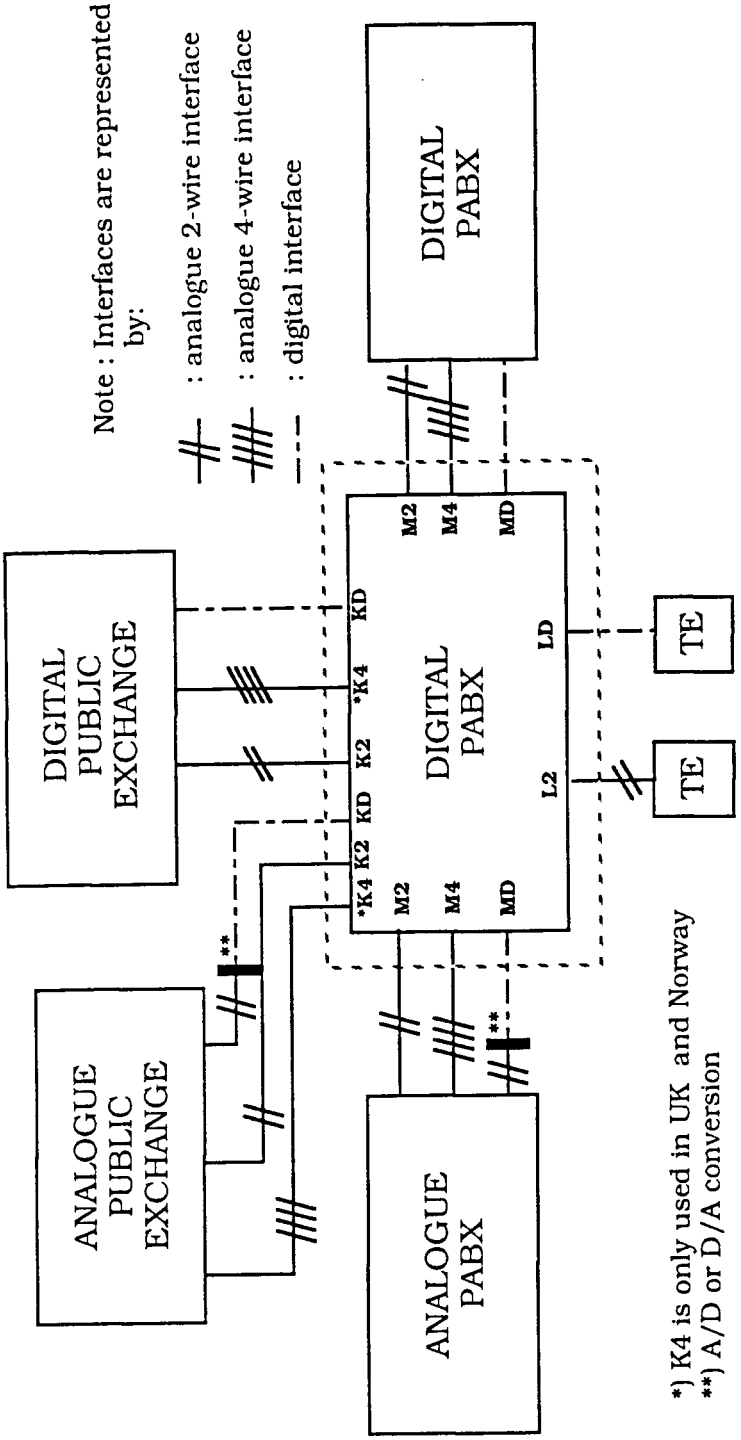
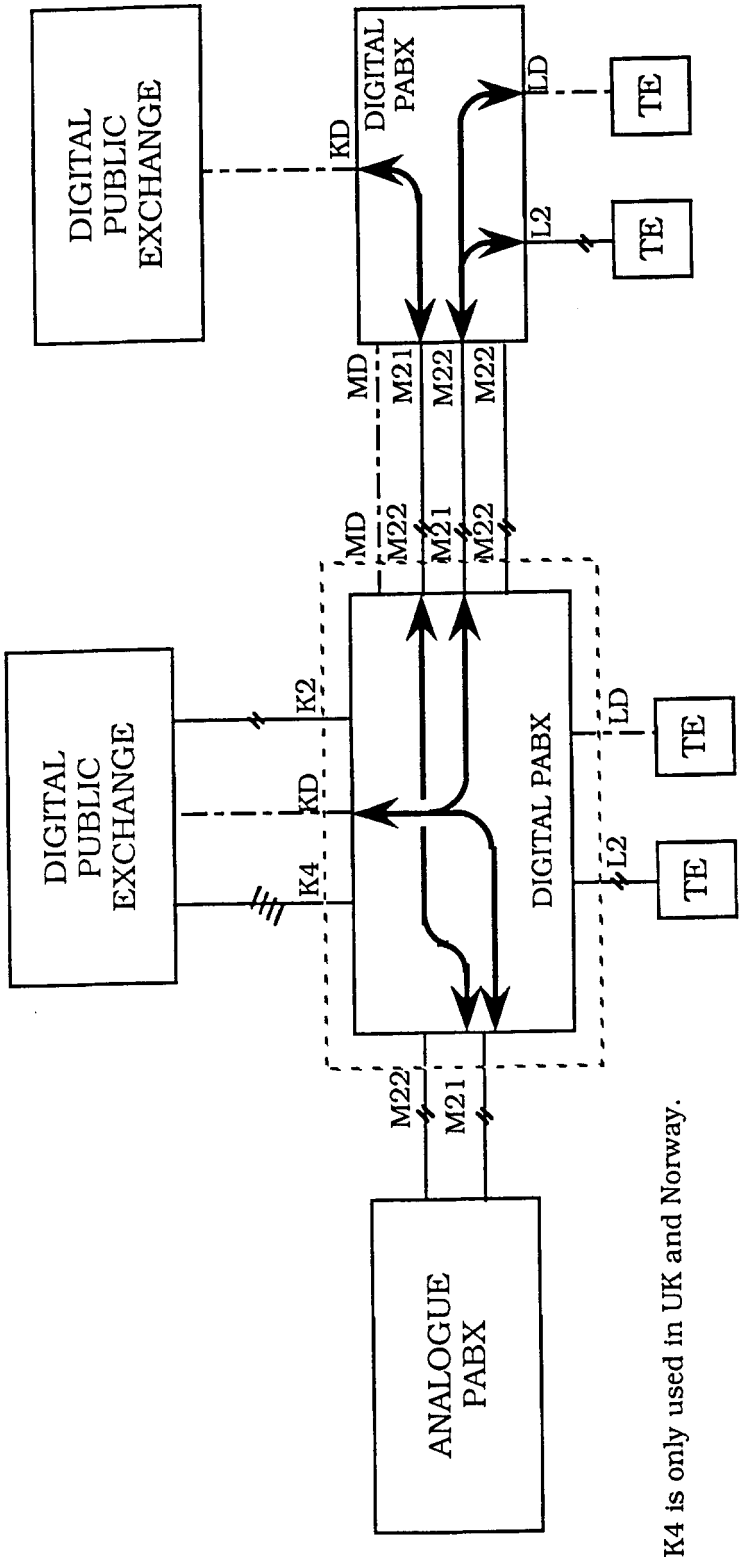



Figure 1: Interfaces of digital PABX's in network interconnections




K4 is only used in UK and Norway.

Figure 2: Detailed illustration for access to PSTN involving M2 interfaces

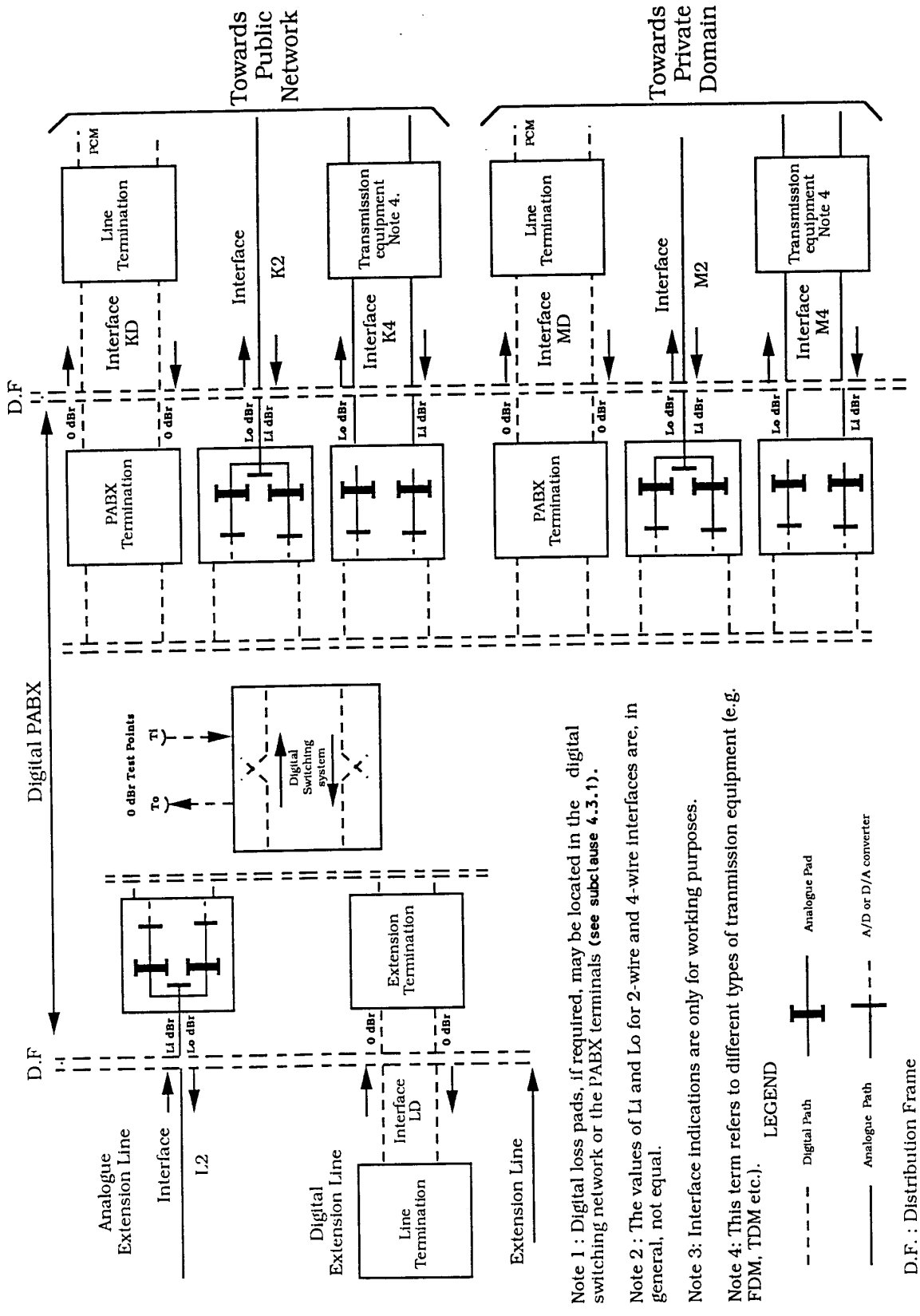



**Figure 3: Interfaces, transmission levels and test points at a digital PABX**

### 4.6 Characteristics of interfaces

The interfaces taken into account are those of figure 3. For voice frequency interfaces (L2, M2, M4, K2 and K4) the electrical parameters refer to the appropriate distribution frame (DF), including this DF, and the internal wiring between DF and switch. In general, it is assumed that the length of the cabling between the DF and the actual PABX does not exceed 100 m. In this respect CCITT Recommendation Q.45 bis, § 3 applies. For corresponding limitations on the location of digital interfaces, see CCITT Recommendation G.703.

#### 4.6.1 Two-wire analogue interface

Detailed transmission characteristics of 2-wire analogue interfaces are provided in I-ETS 300 004.

##### 4.6.1.1 Interface L2

The interface L2 provides for the connection of analogue extension lines and when through connected will carry signals such as speech and voice-band data. In addition, the interface provides for other functions such as DC feed, DC and multi-frequency push button signalling, ringing, etc.

NOTE: Since the interface L2 terminates the extension line, it is necessary to control the impedance and unbalance about earth.

##### 4.6.1.2 Interface M2

The interface M2 provides for the connection of 2-wire analogue circuits to other PABXs.

The interface M21 provides the termination of connections to/from the PSTN wired to all types of K-Interfaces with the PABX concerned acting as a transit switch (see figure 2).

The interface M22 provides the termination of connections other than those covered by M21. A typical example is the interconnection of an L2 interface with an M22 interface in a PABX for routings through existing 2-wire analogue circuits to other PABXs.

##### 4.6.1.3 Interface K2

The interface K2 provides for the connection of 2-wire analogue subscriber lines between PABX and Public Exchange and will carry signals such as speech, voice-band analogue modulated data and multi-frequency push-button signals. In addition, the interface K2 handles ordinary functions such as DC handling, ringing and metering detection, etc.

NOTE: Since the interface K2 ordinarily terminates the line to the public exchange, it is necessary to control the impedance and unbalance about earth.

#### 4.6.2 Four-wire analogue interfaces

Detailed transmission characteristics of 4-wire analogue interfaces are provided in I-ETS 300 005.

##### 4.6.2.1 Interface M4

The interface M4 provides for the connection of 4-wire analogue circuits to other PABXs.

With the PABX acting as a transit switch (see figures 1 and 3), this interface can be part of an incoming or outgoing connection to the public network.

NOTE: The performance of different transmission media used in conjunction with 4-wire analogue circuits between PABXs is not addressed in this standard.

##### 4.6.2.2 Interface K4

The interface K4 provides for the connection of public switched network lines.

NOTE: This interface is used in Norway and the UK only.

#### 4.6.3 Digital interfaces

Detailed transmission characteristics of digital interfaces are provided in I-ETS 300 006.

##### 4.6.3.1 Interface MD

The interface provides for the connection of a digital access to another PABX.

Interface MD1 provides for the connection of a basic rate access.

Interface MD2 provides for the connection of a primary rate access.

Interface MD3 provides for the connection of a non-ISDN access.

##### 4.6.3.2 Interface KD

The interface KD provides for the connection of a digital access to the PSTN.

Interface KD1 provides for the connection of a basic rate access to the ISDN.

Interface KD2 provides for the connection of a primary rate access to the ISDN.

Interface KD3 provides for the connection of a non-ISDN access to the PSTN.

##### 4.6.3.3 Interface LD

The interface LD provides for the connection of a digital access to the PABX for terminal equipment.

Interface LD1 provides for the connection of a terminal using the basic rate access arrangements.

Interface LD2 provides for the connection of a terminal using the primary rate access arrangements.

Interface LD3 provides for the connection of a terminal using a non-ISDN access arrangement.

### 4.7 Voice frequency parameters of a connection between two interfaces of the same PABX

#### 4.7.1 General

This section of this Standard provides guidance on obtaining the overall characteristics for connections between two interfaces at the DF of the same PABX.

For overall connection involving one or more digital interfaces, the results may be interpreted by assuming that ideal send and receive sides (see CCITT Recommendations G.714 and G.715) are connected to the digital inputs and outputs, respectively.

In this section transmission parameters relating to the input connection from a PABX interface to a PABX test point will be referred to as input parameters. Transmission parameters relating to the output connection from a PABX test point to a PABX interface will be referred to as output parameters.

### 4.7.2 Overall transmission parameters

#### 4.7.2.1 Transmission loss

The transmission loss in each direction through the PABX is equal to the algebraic sum of the input transmission loss and the output transmission loss in each direction between the two interfaces.

#### 4.7.2.2 Other overall parameters

The overall characteristic for the following parameters can be obtained in the same way:

- short-term variation of loss with time;
- attenuation/frequency distortion;
- variation of gain with input level.

### 4.7.3 Delay

#### 4.7.3.1 Absolute group delay

"Absolute group delay" refers to the minimum group delay measured in the frequency band 500-2800 Hz in one transmission direction. "Absolute group delay" is identical to the One-way Propagation Time. For switching systems the One-way Propagation Time includes times due to electronic devices such as frame aligners and time stages of the switching matrix but does not include times due to ancillary functions such as echo suppression or echo cancellation.

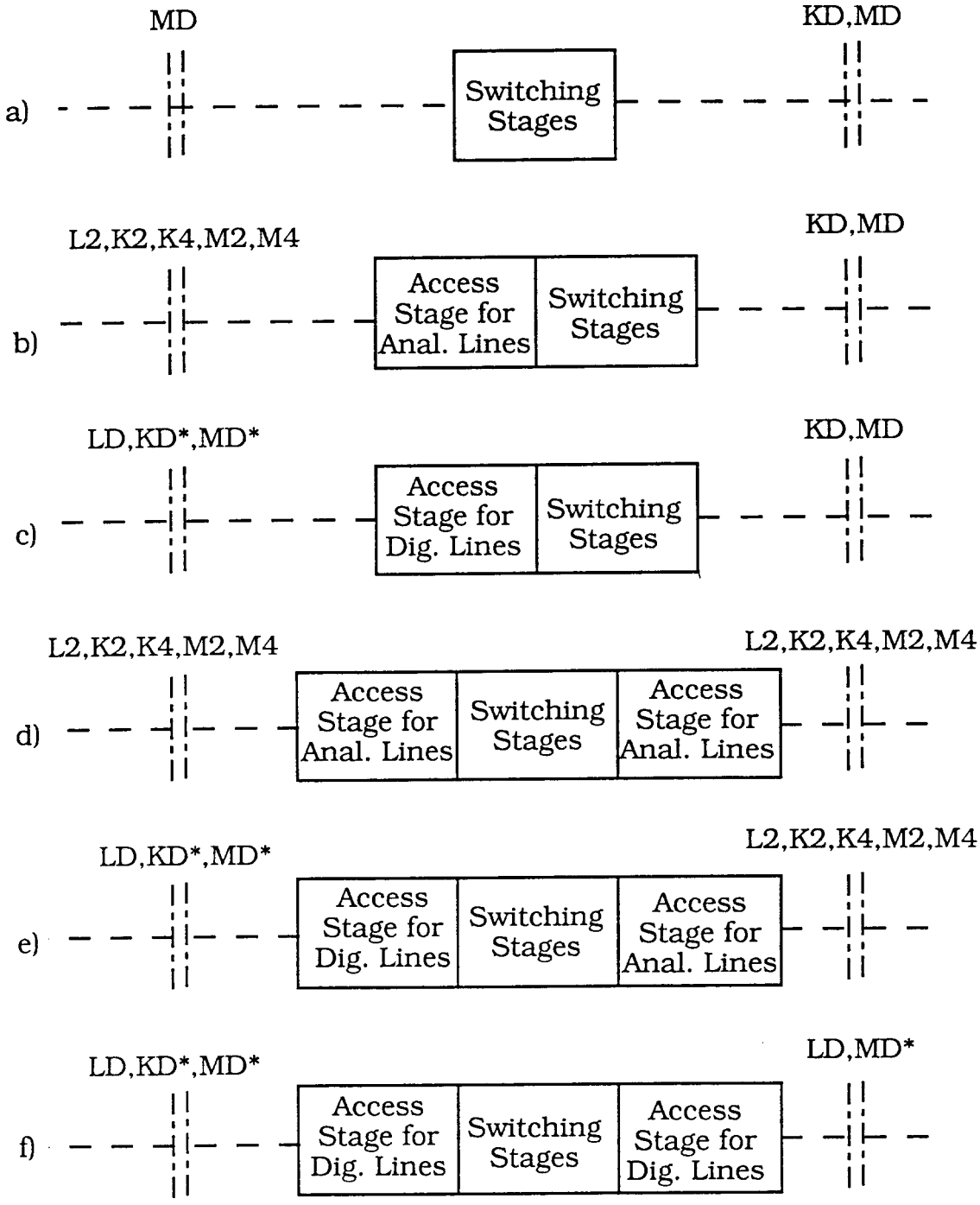
#### 4.7.3.2 Round trip delay

"Round trip delay" is the algebraic sum of the One-way Propagation Times in both directions of transmission between the two interfaces (of the PABX), as depicted in figure 4. The One-way Propagation Time through a PABX will vary mainly dependent on the PABX architecture, the types of connections involved and the traffic load. Taking this into account it results in the mean value of Round Trip Delay.

NOTE: For private networking purposes, a round trip delay based on single frequency measurement is sufficient.

#### 4.7.3.3 Group delay distortion

The total group delay distortion is equal to the sum of the input and the output group delay distortions in one transmission direction.




* Interface with a transmission rate lower than 2 Mbit/s.

NOTE: Interconnecting of K-type interfaces can create technical problems and is therefore for further study.

**Figure 4: PABX configurations as used for estimation for round trip / absolute group delay**

### 4.7.4 Noise and total distortion

NOTE: When evaluating the PABX noise characteristics, it is necessary to consider two components of noise. One of these arises from the PCM coding/decoding process, the other from analogue sources, e.g. signalling circuits, power supply, line power feeding on both sides of a connection between two interfaces through the same PABX.

The noise arising from the PCM encoding process is limited by CCITT Recommendation G.712 for all analogue interface types. The noise arising from analogue sources is considered in CCITT Recommendations G.103 and Q.552. Its value can be different for different interface types. For a given PABX (single or included in a private network) it is important, according to the CCITT Recommendation G.171, § 11, that the constituent parts be designed in accordance with the relevant CCITT Recommendation covering the noise for public exchanges. Normally this practice can guarantee an appropriate behaviour of the equipment. The above rules apply to both weighted noise and total distortion.

Considering the number of different interfaces (often having different relative levels) in a PABX, and the great number of possible connection combinations between these interfaces, the calculations for the overall noise contribution become very complex and cannot be handled in a simple way. Consideration of the contribution of noise and total distortion for each individual half connection as specified in I-ETS 300 004 and I-ETS 300 005 for the case in question should be preferred.

## 5 Voice frequency characteristics specified with reference to the entire connection (between two interfaces of the same PABX)

### 5.1 Measurement conditions

Rules, concerning how to perform the transmission parameter measurements relevant for the conformance testing of digital PABX's, are contained in ETS BT-2000 "Business Telecommunications (BT); Digital Private Automatic Branch Exchange (PABX) transmission characteristics measurements" (in preparation). This ETS has to be considered a necessary complement to I-ETSs 300 003 through 300 006.

### 5.1.1 Common measurement conditions

All digital signal processing devices which affect bit integrity of the 64 kbit/s path (e.g. digital loss pads, code converters, digital echo control devices, digital speech interpolation apparatus or all-zero suppressors) must be rendered inoperative when measuring the transmission parameters of this Standard. However, if the nominal transmission loss NL for speech connections is implemented by a digital loss pad, the loss pad must not be inoperative for the output connection when measuring parameters dependent on NL.

When measuring transmission parameters between 2-wire ports in a given direction, the opposite direction of transmission must be interrupted in order to avoid disturbing effects due to reflections at hybrids.

In addition, a quiet code, i.e. a PCM signal corresponding to decoder output value 1 (A-law) with the sign bit in a fixed state shall be applied to the test point.

### 5.1.2 Reference frequency

NOTE: The reference frequency of 1020 Hz is recommended for test frequency generating circuits or instruments that provide reference test frequencies. The specified frequency tolerance should be +2 to -7 Hz.

### 5.1.3 Impedance

Unless otherwise specified, measurements at analogue interfaces shall be made under nominally matched conditions.

NOTE: The preferred interpretation of this statement should be that the nominal PABX impedance should be used as the internal impedance of the analogue test generator and the analogue level meter. However, under some circumstances, it may be preferable to use a low-impedance generator and a high-impedance meter which corresponds to an exact matching to the actual PABX impedance.

(Losses measured according to the two methods will only differ by a small amount, in the same order of magnitude as the loss of a very short line).

### 5.1.4 Test levels at analogue interfaces

At the reference frequency, test levels are defined in terms of the apparent power relative to 1 mW.

Where no value is given, the test level should be -10 dBm0.

At frequencies different from the reference frequency, test levels are defined as having the same voltage as the test level at the reference frequency. Measurements are based on the use of a test generator with a frequency independent EMF.

The above considerations are primarily concerned with measurements at discrete frequencies. Their impact on the measurement at interfaces with complex impedances of broadband signals (e.g. random or quasi-random noise with defined spectral intensity) and vice versa needs further study.

## 5.2 Round trip delay

The round trip delay through a PABX shall conform to table 1 and is included as informative only.

**Table 1: Round trip delay between interfaces as depicted in figure 4**

| Figure | Mean (µs) | 0,95 probability of not exceeding (µs) |
|---|---|---|
| a | 900 | 1500 |
| b | 1950 | 2700 |
| c | 1650 | 2500 |
| d | 3000 | 3900 |
| e | 2700 | 3700 |
| f | 2400 | 3500 |

NOTE 1: These values for the round trip delays are applicable under reference load A conditions as defined in CCITT Recommendations Q.543.

NOTE 2: These values do not include the propagation delay associated with transmission across the link between the main part and any remotely located parts of a digital PABX.

NOTE 3: Attention is drawn to the desirability of avoiding - wherever possible - the use of echo control devices in a complete national connection. See CCITT Recommendation G.131 (To this end, the propagation delay of private networks should be restricted. Where permitted, the use of echo control devices will impose a further delay limit for satisfactory operation).

### 5.3 Weighted noise

The total psophometric noise power, contributed by a whole connection L2-L2, and measured at an L2 interface, should not exceed the value obtained from the equation below using the appropriate values of Lo and Li given in Annex D of I-ETS 300 004. It is included as informative only in this I-ETS but more details on this parameter are given in I-ETS 300 004 and I-ETS 300 005.

$$P_{TN} = P_{AN}(1 + 10^{0.1(L_o - L_i)}) + 10^{0.1(90 + L_{IN} + L_o)} \ldots . pWp$$

and, respectively, the total noise level

$$L_{TN} = [\, 10 \log \frac{(P_{TN})}{1pW} - 90 \,] \ldots . dBmp$$

where:

$P_{TN}$: Total weighted noise power in pWp of a whole connection through the PABX;

$P_{AN}$: Weighted noise power in pWp caused by analogue functions according to CCITT Recommendation G.103 figure 1, i.e. 200 pWp (-67dBmp).

$L_o$: Output relative level in dBr at the L2 interface.

$L_i$: Input relative level in dBr at the L2 interface of the same PABX.

$L_{IN}$: Weighted noise level (idle channel noise) in dBm0p for PCM translating equipment according to CCITT Recommendation G.712, i.e. -65 dBm0p.

$L_{TN}$: Total weighted noise level in dBmp of a whole connection L2-L2 through the local digital PABX.

Alternatively the same $P_{TN}$ and $L_{TN}$ can be obtained by adding the relevant values for input and output connections at L2 interfaces according to Standard I-ETS 300 004, subclause 5.2.3.2, observing that the values for $L_{INi}$ and $L_{INo}$ are different from $L_{IN}$.

NOTE 1: However, a small difference in the numerical results occurs due to approximation errors between $L_{IN}$ on the one hand compared with $L_{INi}$ and $L_{INo}$ on the other.

NOTE 2: For the other 2-wire analogue interfaces K2 and M2 (with signalling on the speech wires) similar considerations can be made to obtain the allowed psophometric noise, taking into account that interfaces with feeding bridge (M21 and some M22) can be considered as interface L2 and interfaces without feeding bridge (K2 and some M22) can be characterized with an analogue noise of 100 pW0p (-70 dBm0p).

NOTE 3: Interfaces with signalling on separate wires, obviously, have only noise contributions coming from the coding process (e.g. -66 dBm0p in one direction, -75 dBm0p in the other direction).

NOTE 4: CCITT Recommendation G.103 uses absolute levels for the subscriber part of the connection. Further study is needed to determine whether to use noise values expressed in dBm0p or dBmp (pWp).

### 5.4 Total distortion including quantizing distortion

The method shown below uses the sinusoidal test signal with the reference frequency of 1020 Hz as specified in CCITT Recommendation O.132.

The total distortion including quantizing distortion should not exceed the value obtained from the equation below. It is included as informative only in this I-ETS but more details on this parameter are given in I-ETS 300 004 and in I-ETS 300 005.

The ratio of signal-to-total distortion power for a whole connection through the PABX is given by the formula :

$$S/N_T = L_S + L_o - 10 \text{ Log } (10^{0.1(L_S + L_o - S/N)} + 10^{0.1L_N})$$

where:

$S/N_T$: Resulting signal-to-total distortion ratio in dB for a whole connection through a digital PABX.

$L_S$: Signal level of the measuring signal in dBm0.

$L_o$: Output relative level in dBr.

S/N: Signal-to distortion ratio in dB for PCM translating equipment as specified in CCITT Recommendation G.712 (whole connection).

$L_N$: Weighted noise in dBmp caused by analogue functions according to CCITT Recommendation G.103.

NOTE 1: CCITT Recommendation G.103 is using absolute levels for the subscriber part of the connection.

Further study is needed to determine whether to use noise values expressed in dBm0p (pWOp) or dBmp (pWp).

NOTE 2: No band limiting effect on the noise by the encoding process was taken into account to compensate for overall effects. Thus the calculation above is assumed to give the worst case requirements. See also NOTE 1.

This calculation of S/NT applies to all analogue interfaces. Total distortion including quantizing distortion using the noise method as specified in CCITT Recommendation O.131 will be the subject of further study.

### 5.5 Crosstalk

Where measurement of the signal to crosstalk ratio between any two complete connections (analogue to analogue) through the PABX is considered necessary, a sine wave test signal at the reference frequency of 1020 Hz and at a level of 0 dBm0 can be applied to the analogue 2-wire or 4-wire interface of one connection.

If auxiliary low level activation signal, for example a bandlimited noise signal (see CCITT Recommendation O.131) at a level in the range -50 to -60 dBm0 is injected into the input of the connection to be measured, the level produced in any other connection shall not exceed -67 dBm0. This measurement arrangement is shown in figure 5. Crosstalk is included as informative only in this I-ETS but more details on this parameter are given in I-ETS 300 004 and I-ETS 300 005.

NOTE 1: Care must be taken on the choice of frequency and the filtering characteristics of the selective measuring equipment, in order to avoid that the activating signal and noise affect the accuracy of the crosstalk measurement.

NOTE 2: The go-to-return crosstalk of 4-wire connections is covered by I-ETS 300 005, subclause 5.2.1.4.2.2.

NOTE 3: Measurement of NEXT (Near End CrossTalk) is not required, as it is the same as in half connections.

NOTE 4: If it is not possible, without considerable difficulty, to break the return path of the 4-wire loop, reflection should be minimized by making the terminating impedances and the balance impedance equal.

NOTE 5: Further study is required to determine whether more stringent limits or measurement at additional frequencies should be specified.

NOTE 6: Further study is needed to determine whether CCITT Recommendation P.16 (concerning crosstalk) is applicable.

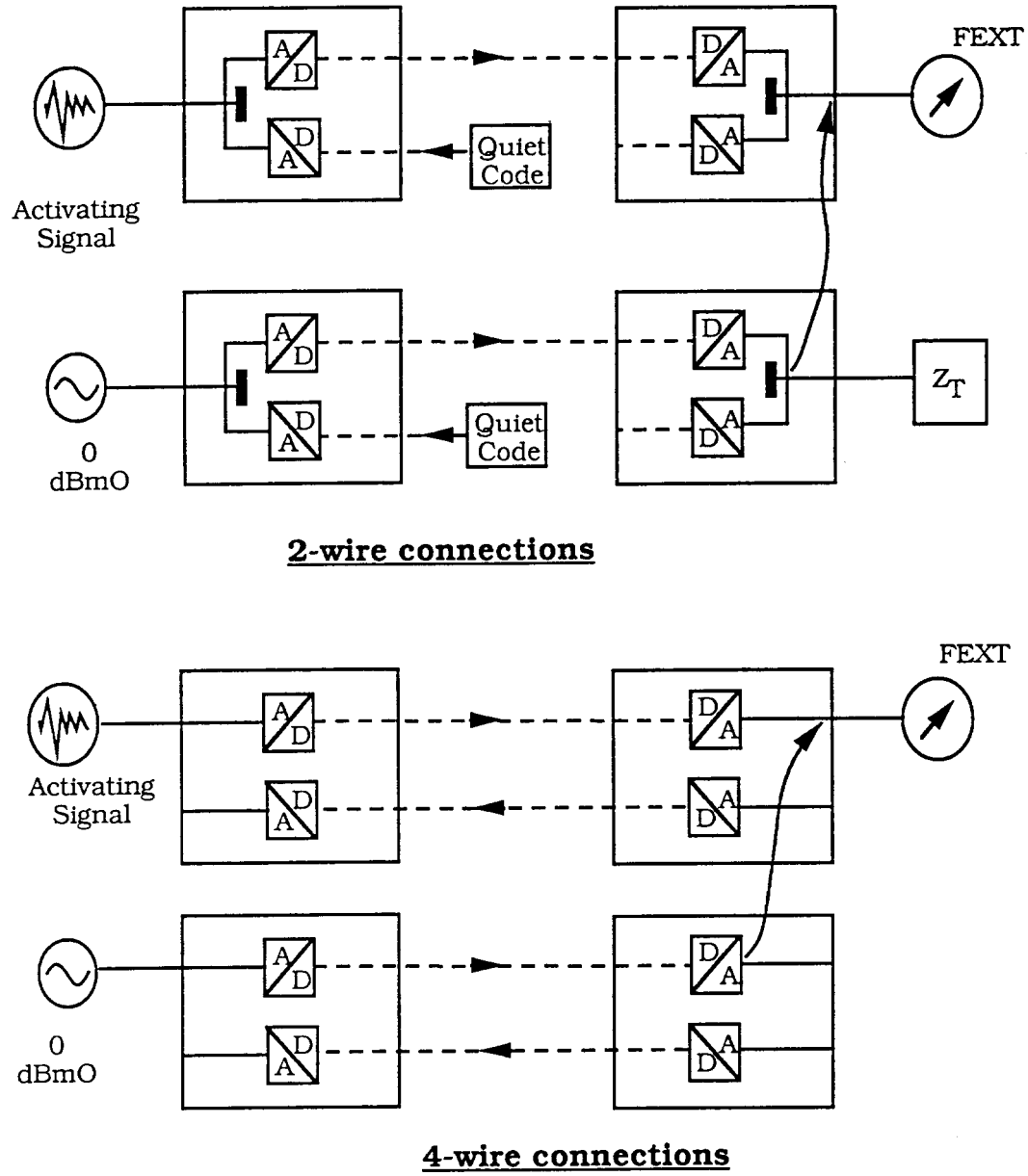



**Figure 5: Measurement of crosstalk between two connections**

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

NOTE: The values for these parameters for a complete connection through a PABX are identical to the corresponding values for a half connection. See I-ETS 300 004, subclause 5.2.1.6 and I-ETS 300 005, subclause 5.2.1.6.

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

NOTE: The values for these parameters for a complete connection through a PABX are identical to the corresponding values for a half connection. See I-ETS 300 004, subclause 5.2.1.7 and I-ETS 300 005, subclause 5.2.1.7.

### 5.8 Echo and stability

If in a digital PABX, 2-wire half connections (analogue interfaces) cooperate in such a way that an additional 2-wire - 4-wire - 2-wire loop is included as part of an international connection, then CCITT Recommendation G.122 concerning echo, stability and especially effects of listener echo has to be fulfilled. See ETR 004.

NOTE 1: When a complete connection, composed of a 2-wire analogue half connection and a 4-wire half connection, terminates the international chain, the total stability loss of the national extension is provided by the 2-wire analogue half connection. See I-ETS 300 004, subclause 5.2.1.8.

NOTE 2: The effects of listener echo depend on the maximum total number of loops in a complete connection. Listener echo signals :

- can lead to objectionable "hollowness" in voice communications, and
- can impair the bit error ratio of received voice-band data signals.

## History

| Document history | |
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