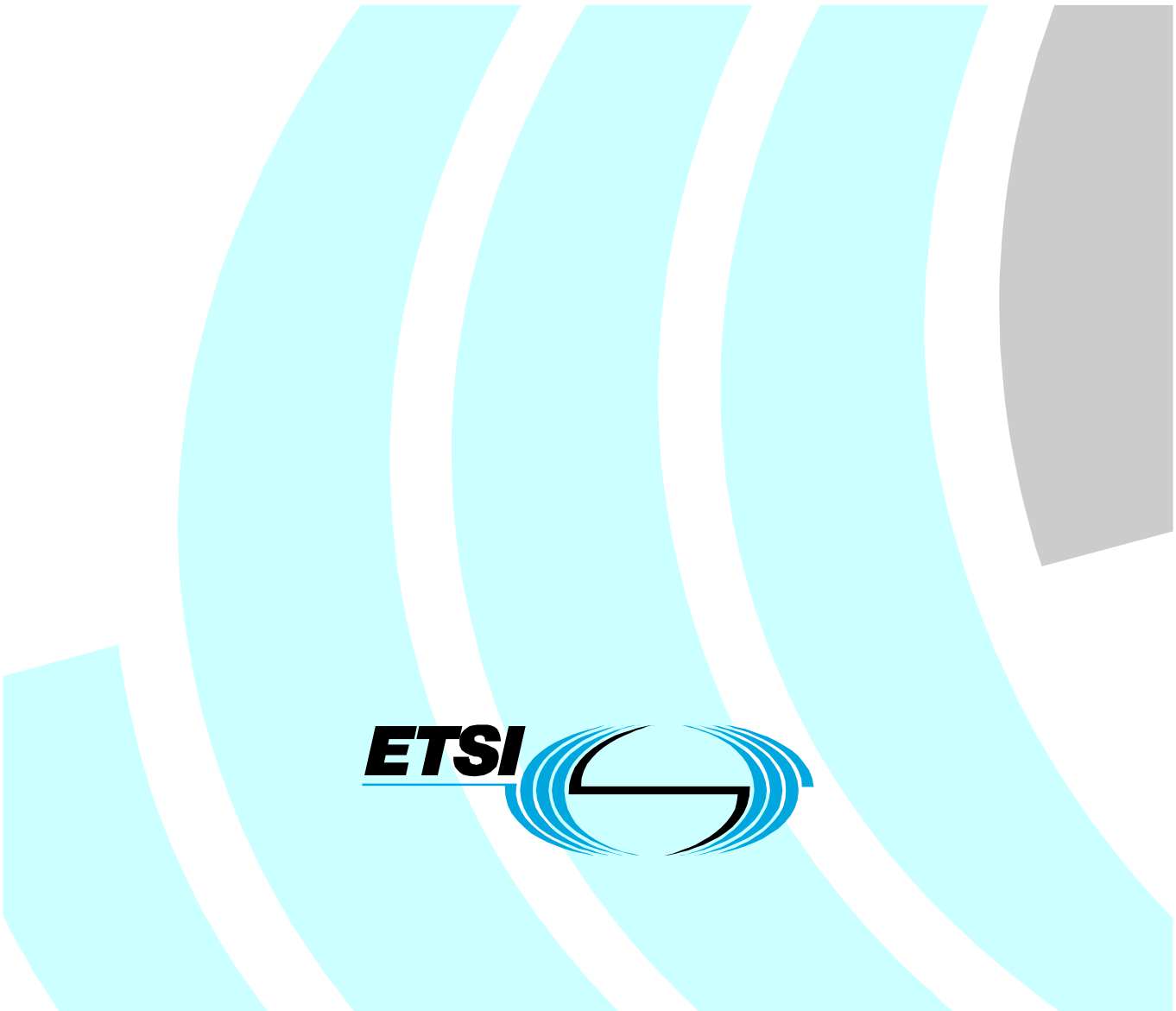
Final draft ETSI EG 202 192 V1.1.2 (2004-09)

ETSI Guide

Speech Processing, Transmission and Quality Aspects (STQ); Comparison of PBX transmission requirements in ANSI/TIA-464-C and ETSI ES 201 168 V1.2.1



Reference
DEG/STQ-00039

Keywords
digital, transmission

ETSI

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Sous-Préfecture de Grasse (06) N° 7803/88

Contents

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Foreword

This ETSI Guide (EG) has been produced by ETSI Technical Committee Speech Processing, Transmission and Quality Aspects (STQ), and is now submitted for the ETSI standards Membership Approval Procedure.

The present document is a Telecommunications Systems Bulletin (TSB), jointly produced by:

- Telecommunications Industry Association (TIA) Subcommittee TR-41.1, Multiline Telecommunications Systems (MLTS); and
- European Telecommunications Standards Institute (ETSI) Technical Committee (TC) Speech processing, Transmission and Quality aspects (STQ).

The document is being published as a TIA TSB-147 and as an EG. The document is not an industry standard and compliance to its contents is voluntary. The document compares corresponding Private Branch eXchange (PBX) transmission requirements in TIA and ETSI standards to be considered when developing equipments or standards intended for global application.

ETSI has granted TIA permission to use copyrighted material from ES 201 168 [8], in the TIA TSB-147. Likewise, TIA has granted ETSI permission to use copyrighted material from ANSI/TIA-464-C [7], in the present document.

Introduction

Over the last decade, continuing telecommunications improvements have brought the continents closer together - digital signalling allows calls to be established in less than a second and digital transmission has improved voice quality. Such changes have made it convenient to call anywhere in the world without a thought being given to past difficulties in completing such calls with acceptable transmission quality.

These improvements have made it possible for multi-national companies to efficiently conduct business in a real-time environment and to be able to efficiently design and produce world-wide products. This gives impetus to international telecommunications equipment suppliers and users of such equipment to consider the differences in transmission requirements of PBX systems that are manufactured for different world marketplaces.

The present document provides a comparison of North America and European PBX standards with the goal of creating maximum commonality for serving the global PBX marketplace, while recognizing the existence of differences in regional telecommunications environments, regulatory practices, geographic constraints, and customer expectations. Technical differences between the TIA and PBX standards are identified and rationalized.

1 Scope

The present document compares, in an orderly manner, like transmission requirements in ANSI/TIA-464-C [7] and those in ES 201 168 [8].

Since only the PBX transmission requirements in ANSI/TIA-464-C[7] and ES 201 168 [8] are compared, it is necessary to examine relevant portions of the scope of each of these standards to gain an overall idea of the scope of the comparison. ES 201 168 [8] provides transmission requirements while ANSI/TIA-464-C [7] provides transmission requirements as well as other PBX parameters, e.g. signalling and supervision. All appearance of ANSI/TIA-464-C [7] in the present document includes ANSI/TIA-464-C-1 [11].

The following table is an overview comparison of the two documents:

	ANSI/TIA-464-C	**ES 201 168**
SCOPE	Digital PBX	Digital PBX with test point
TRAFFIC	3,1 kHz voice	3,1 kHz voice
CODING (at interface to network)	μ-law	A-law
Measurement	Port-to-port (full-channel)	Port-to-test point (half-channel)
INCLUDES (interfaces): Analog Digital Cordless Loud-speaking (hands-free) Proprietary sets	 Yes Yes No No Yes	 Yes Yes Yes No Yes
Non-transmission requirements	Yes	No
Test methods for compliance	No	Yes

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

[1] ITU-T Recommendation G.122 (1993): "Influence of national systems on stability and talker echo in international connections".

[2] ITU-T Recommendation G.711 (1988): "Pulse code modulation (PCM) of voice frequencies".

[3] ITU-T Recommendation G.712 (2001): "Transmission performance characteristics of pulse code modulation channels".

[4] ITU-T Recommendation O.41 (1994): "Psophometer for use on telephone-type circuits".

[5] ITU-T Recommendation Q.551 (2002): "Transmission characteristics of digital exchanges".

[6] ETSI TR 101 802 (V1.1.1): "Speech processing, Transmission and Quality Aspects (STQ); The Concept of Relative Levels".

[7] ANSI-TIA-464-C-2002: "Telecommunications Multiline Terminal Systems Requirements for PBX Switching Equipment".

[8] ETSI ES 201 168 (V1.2.1): "Speech processing, Transmission and Quality Aspects (STQ); Transmission characteristics of digital Private Branch eXchanges (PBXs) for interconnection to private networks, to the public switched network or to IP gateways".

[9] ANSI/TIA-968-A-2002 and ANSI/TIA-968-A-1-2003: "Telecommunications - Telephone Terminal Equipment - Technical Requirements for Connection of Terminal Equipment to the Telephone Network".

[10] ANSI T1.508-2004: "Network Performance - Loss Plan for Evolving Digital Networks".

3 Abbreviations

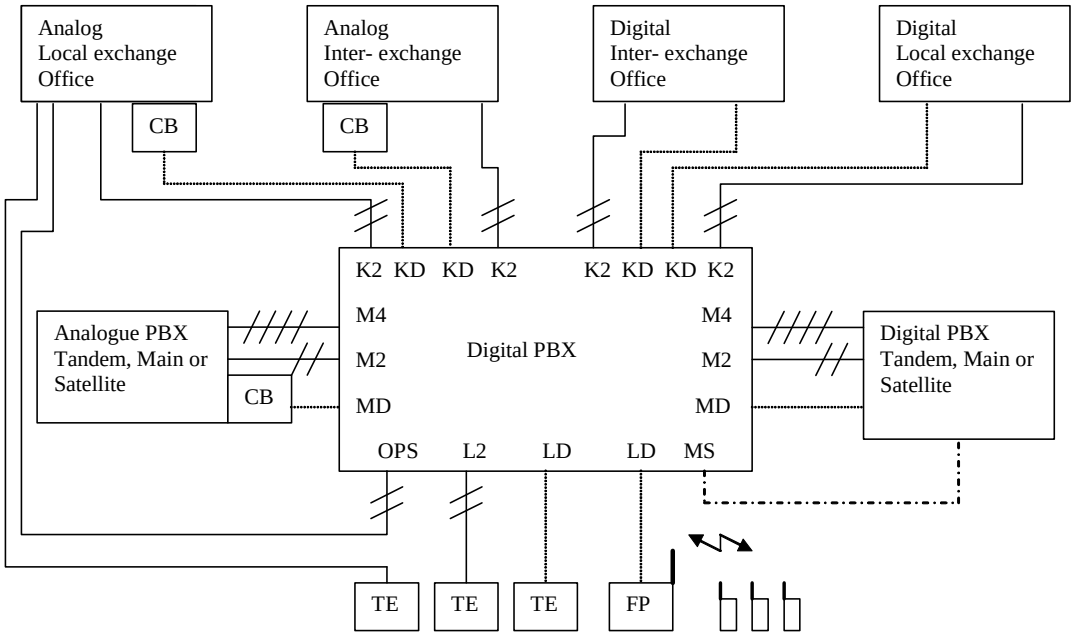
For the purposes of the present document, the following abbreviations apply:

AAL(A)	Analog Access Line - Analog connection to analog or digital Central Office
AAL(D)	Analog Access Line - Digital connection to an analog Central Office
ATT	Analog Tie Trunk - Private network connection to a remote PBX
DAL	Direct Access Line - Digital connection to a digital Central Office or another PBX
DGS	DiGital Station (telephone)
DID	Data IDentifier
DMW	Digital MilliWatt
ERL	Echo Return Loss
FCC	Federal Communications Commission
FEXT	Far End Cross Talk
GoS	Grade-of-Service
K2	Analog 2-wire trunk interface to analogue PSTN access line
KD	Digital trunk interface to digital PSTN access line
L2	Analog 2-wire extension interface
LCL	Longitudinal Conversion Loss
LD	Digital line interface to ISDN compatible station
M2	Analog 2-wire tie-line interface
M4	Analog 4-wire tie-line interface
MD	Digital tie-line interface
MS	Specific (non-analog) tie-line interface
NL	Nominal Loss
OLR	Overall Loudness Rating
ONS	Line interface to on-premises station
OPS	Line interface to Off-Premises Station
qdu	quantizing distortion unit
RED	Relative Envelope Delay
RLR	Receive Loudness Ratings
SLR	Send Loudness Ratings
TBRL	Terminal Balance Return Loss
TE	Terminal Equipment
ZLP	Zero Level Point

4 Reference model

Each of the documents in this comparison specifies the interfaces to which the PBX can connect and make connections between. An understanding of these interfaces is integral to the proper interpretation and application of the transmission requirements being compared.

Figure 1 presents a simplified model of the PBX interfaces in terms of the ETSI interface designations. The correspondence to TIA interface designations is shown in the figure. Note that there is no ETSI designation for an Off-Premises Station interface; thus the TIA designation is used for that interface.



KD = DAL or AAL(D)
K2 = AAL(A)
LD = DGS
L2 = ONS
MD = DAL
M2 = ATT
M4 = ATT

NOTE: Interfaces are represented by:

Analog 2-wire interface

Analog 4-wire interface

Digital interface

CB Channel Bank

Figure 1: Representative PBX network connections

5 Requirements

On the following pages, the corresponding requirements in each document are referenced and then compared side-by-side. This is followed by an analysis of the comparison where applicable. Additional sheets provide tables, figures, and background explanation for specific requirements.

5.1 Loss and loss - related parameters

5.1.1 Port to port insertion loss

ANSI/TIA-464-C	ES 201 168
6.2.3 Insertion loss criteria for PBX 6.2.5 PBX loss ranges Table 12 PBX loss plan	3.1.5 Transmission loss 5.2.1 Nominal transmission loss (analog interfaces) 6.2 Nominal transmission loss (digital interfaces) 7.2 Nominal transmission loss (system specific MS interfaces) 9.2 Transmission loss between interfaces Clause A.4.2: Measurements
The insertion loss is specified as port-to-port loss between PBX interfaces and loss ranges. Requirements are formatted in a loss plan matrix; each matrix cell defines the nominal insertion loss in dB for both directions of transmission. Table 1 gives the PBX loss plan for connections. Conditions: Measured at 1 004 Hz (nominal) with both source and measuring instruments at 600 Ω impedance.	Nominal transmission loss NL is defined as the difference between relative input level L_i of one port and the relative output level L_o of the other port in a connection, including the loss SL of an digital gain- or loss-pad. NL = L_i - L_o + SL where L_i and L_o are in dBr referenced to 0 dBr. The values for L_i and L_o must be stated by the supplier. Conditions: Measured at 1 020 Hz (nominal) with a test level of -10 dBmO (clause A.4.2).

Analysis: In ETSI, neither the port-to-port loss nor the allocation of loss is specified. However, the port-to-test point loss must be stated by the supplier on the basis of input/output levels. These losses are in many cases subject to national requirements, which differ from country to country on the signal levels at the point of connection to the PSTN while maintaining a harmonized requirement at the point of connection to the ISDN.

In TIA, the port-to-port-losses for PBXs were developed based on the loss plans for public and private networks. The PBX loss plan is intended to provide satisfactory Grade-of-Service (GoS) performance and compatibility with the public and private network loss plans. The following assumptions were the prime considerations:

1) The transmission loss and level plan of the PSTN, which is primarily an all-digital network with some fixed loss as described in ANSI T1.508-2004 [10], forms a basis for the private network loss plan.

2) Digital end offices insert 6 dB of loss, as described in ANSI T1.508-2004 [10], in the receive direction of analog access lines to ensure network stability and echo control.

3) Transmission facilities to be used have losses compatible with the PBX port-to-port losses.

4) PBX port-to-port losses associated with analog interfaces apply to any trunks with analog terminations at the PBX.

5) PBX port-to-port losses associated with digital interfaces apply to any trunks with digital terminations at the PBX.

6) Non-proprietary PBX stations have the following loudness ratings:

Station	SLR	RLR
OPS (see note 1)	8	-3
ONS (see note 2)	4	-7
DGS (see note 3)	8	2

NOTE 1: The OPS (Off-Premises Station) ratings are representative of 2 500-type sets operating on 26 gauge/2,75 km loops with normal 48 V battery feed and 600 Ω termination, as measured at a VG OPS port. See annex E of ANSI/TIA-470.110-C for further details.

NOTE 2: The ONS (On-premises Station) ratings are representative of 2500-type sets operating on very short loops with the typical current-limited battery feed and 600 Ω termination of VG ONS port. See annex E of ANSI/TIA-470.110-C for further details.

NOTE 3: The DGS (digital station) ratings are chosen to improve interoperability with the ITU-T standard SLR/RLR levels for digital sets of 8 and 2. See ANSI/TIA-810-A for further details.

Table 1: ANSI/TIA-464-C PBX loss plan

			A	B	C	D	E	F	G
			ONS	**OPS**	**DGS**	**DAL**	**AAL(A)**	**AAL(D)**	**ATT**
		Loss	↑	↑	↑	↑	↑	↑	↑
1	**ONS**	→	12	9	3	3	3	6	9
2	**OPS**	→	9	6	0	0	0	0	3
3	**DGS**	→	9	6	0	0	0	3	3
4	**DAL**	→	9	6	0	0	0	3	3
5	**AAL(A)**	→	0	0	-6	-6	0	0	0
6	**AAL(D)**	→	3	0	-3	-3	0	0	0
7	**ATT**	→	6	0	0	0	0	0	0

NOTE 1: The units for all loss values are dB.
NOTE 2: Losses have been selected as multiples of 3 dB, in the assumption that this may make implementation easier.

5.1.1.1 Insertion loss ranges and variations

ANSI/TIA-464-C	**ES 201 168**
6.2.5 PBX loss ranges Table 15 TIA-968-A allowable net loss between ports Table 16 ANSI/TIA-464-C-2002 [7] recommended net loss between ports Table 17 Difference between TIA-968-A [9] and ANSI/TIA-464-C-2002 [7] port loss	5.2.1 Nominal transmission loss (all analog interfaces) 6.2 Nominal transmission loss (all digital interfaces) 7.2 Nominal transmission loss (system specific MS interfaces)
The port-to-port losses in table 1are the recommended nominal values. Although there are no mandatory loss ranges associated with these values, it is desirable that the average 1 kHz loss fall within ±0,5 dB of the nominal loss values given in table 1. Tables 2 to 4 provide a cross reference from the table 1 loss values to the equivalent limits for the TIA-968-A [9]defined ports. Table 3 shows the losses recommended in ANSI/TIA-464-C-2002 [7], and table 4 shows the difference between the allowable and recommended losses.	Loss variations is the difference between actual measured and the nominal input/output transmission loss as stated by the supplier. This difference can be interpreted as the permitted tolerance due to design tolerances, cabling and adjustment increments. The values shall lie in the range: -0,35 dB to +0,35 dB for analog interfaces; -0,15 dB to +0,15 dB for digital interfaces. Conditions: The values are referred to input or output half-connection losses only and not to port-to-port connections.

Analysis: The TIA desired nominal values are shown in table 1, however a PBX may have a declared nominal value within the TIA range quoted above. The tolerance in clause 5.1.1.1 is applied to the declared nominal value. However, depending on allocation between input and output ports, meeting TIA connection requirements do not guarantee meeting ETSI half-channel requirements.

It should be noted that a number of analog connections have a zero tolerance between the table 1 values and the ANSI/TIA-968-A [9] requirements.

Care should be taken to ensure that no analog connection violates the ANSI/TIA-968-A [9]section 4.5.2.5 for allowable net amplification between ports. In general this is achieved by offsetting the nominal loss by amount equal to the maximum expected component tolerance and measurement error.

The recommended losses are based on a desirable port-to-port OLR of 10 dB. The change in the RLR of digital ports from 0 dB to 2 dB requires a corresponding decrease in loss for some of the analog stations to digital trunk connections, in order to maintain an optimum OLR.

ANSI/TIA-464-C-2002 [7] is intended to be in conformance with the ANSI/TIA-968-A [9] (formerly the terminal equipment certification requirements in part 68 of the FCC (Federal Communications Commission) Rules and Regulations). If the requirements in ANSI/TIA-968-A [9] are more stringent than those contained in ANSI/TIA-464-C-2002 [7], the provisions of ANSI/TIA-968-A [9] apply. Some of the desirable ONS and OPS losses would violate the ANSI/TIA-968-A [9] requirements for through-gain transmission. In these cases the losses have been set to levels compliant with the ANSI/TIA-968-A [9] requirements, even though this results in a less than optimum OLR of 13 dB. Until the requirements in ANSI/TIA-968-A [9] are changed, users should ensure they comply with the current ANSI/TIA-968-A [9] requirements for through-gain transmission.

Table 2: ANSI/TIA-968-A-1, section 4.5.2.5, Allowable Net Loss Between Ports

To			Tie trunk type ports			Integrated services trunk	OPS ports (2-wire)	Analog Public switched network ports (2-wire)		Subrate 1,544 Mb/s Digital PBX-CO Trunk Port (4-wire)
From (E)			Lossless 2/4-wire	Subrate 1,544 Mb/s satellite 4W	Subrate 1,544 Mb/s tandem 4W					
			ATT	DAL	DAL	DAL	OPS	AAL(A)	AAL(D)	DAL
			1	2	3	4	7	8	9	10
1	ATT	Lossless Tie Trunk Port (2/4-wire)	0 dB	-2 dB	-2 dB	-2 dB	-2 dB			
2	DAL	Subrate 1,544 Mb/s Satellite 4W Tie	-1 dB		-3 dB	-3 dB	-3 dB			
3	DAL	Subrate 1,544 Mb/s Tandem 4W Tie	2 dB	0 dB	0 dB	0 dB	0 dB			
4	DAL	Integrated Services Trunk	2 dB	0 dB	0 dB	0 dB	0 dB			
5	DGS	Approved Digital TE	2 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB
6	ONS	ONS Port with Approved TE	2 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB
7	OPS	OPS (2-Wire)	-2 dB	-4 dB	-4 dB	-4 dB	-4 dB	-4 dB	-4 dB	-4 dB
8	AAL(A)	Analog Public Switched Network port (2-wire)					-3 dB	-3 dB	-3 dB	
9	AAL(D)	Analog Public Switched Network port (2-wire)					-3 dB	-3 dB	-3 dB	
10	DAL	Subrate 1,544 Mb/s Digital PBX-CO Trunk Port (4-wire)					0 dB			
NOTE: Positive values denote loss. Negative (-) values denote gain.										

Table 3: ANSI/TIA-464-C-2002 Recommended Net Loss Between ports

To / From (E)			Tie trunk type ports: Lossless 2/4-wire	Tie trunk type ports: Subrate 1,544 Mb/s satellite 4W	Tie trunk type ports: Subrate 1,544 Mb/s tandem 4W	Integrated services trunk	OPS ports (2-wire)	Analog Public switched network ports (2-wire)		Subrate 1,544 Mb/s Digital PBX-CO Trunk Port (4-wire)
			ATT	DAL	DAL	DAL	OPS	AAL(A)	AAL(D)	DAL
			1	2	3	4	7	8	9	10
1	ATT	Lossless Tie Trunk Port (2/4-wire)	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB
2	DAL	Subrate 1,544 Mb/s Satellite 4W Tie	3 dB	0 dB	0 dB	0 dB	6 dB	0 dB	3 dB	0 dB
3	DAL	Subrate 1,544 Mb/s Tandem 4W Tie	3 dB	0 dB	0 dB	0 dB	6 dB	0 dB	3 dB	0 dB
4	DAL	Integrated Services Trunk	3 dB	0 dB	0 dB	0 dB	6 dB	0 dB	3 dB	0 dB
5	DGS	Approved Digital TE	3 dB	0 dB	0 dB	0 dB	6 dB	0 dB	3 dB	0 dB
6	ONS	ONS Port with Approved TE	9 dB	3 dB	3 dB	3 dB	9 dB	3 dB	6 dB	3 dB
7	OPS	OPS (2-wire)	3 dB	0 dB	0 dB	0 dB	6 dB	0 dB	0 dB	0 dB
8	AAL(A)	Analog Public Switched Network Port (2-wire)	0 dB	-6 dB	-6 dB	-6 dB	0 dB	0 dB	0 dB	-6 dB
9	AAL(D)	Analog Public Switched Network Port (2-wire)	0 dB	-3 dB	-3 dB	-3 dB	0 dB	0 dB	0 dB	-3 dB
10	DAL	Subrate 1,544 Mb/s Digital PBX-CO Trunk Port (4-wire)	3 dB	0 dB	0 dB	0 dB	6 dB	0 dB	3 dB	0 dB
NOTE: Positive values denote loss. Negative (-) values denote gain.										

Table 4: Difference between ANSI/TIA-968-A-1, section 4.5.2.5 and ANSI/TIA-464-C-2002 Port Loss

To / From (E)			Tie trunk type ports: Lossless 2/4-wire	Tie trunk type ports: Subrate 1,544 Mb/s satellite 4W	Tie trunk type ports: Subrate 1,544 Mb/s tandem 4W	Integrated services trunk	OPS ports (2-wire)	Analog public switched network ports (2-wire)		Subrate 1,544 Mb/s digital PBX-CO Trunk Port (4-wire)
			ATT	DAL	DAL	DAL	OPS	AAL(A)	AAL(D)	DAL
			1	2	3	4	7	8	9	10
1	ATT	Lossless Tie Trunk Port (2/4-wire)	0 dB	2 dB	2 dB	2 dB	2 dB			
2	DAL	Subrate 1,544 Mb/s Satellite 4W Tie	4 dB		3 dB	3 dB	9 dB			
3	DAL	Subrate 1,544 Mb/s Tandem 4W Tie	1 dB	0 dB	0 dB	0 dB	6 dB			
4	DAL	Integrated Services Trunk	1 dB	0 dB	0 dB	0 dB	6 dB			
5	DGS	Approved Digital TE	1 dB	0 dB	0 dB	0 dB	6 dB	0 dB	3 dB	0 dB
6	ONS	ONS Port with Approved TE	7 dB	3 dB	3 dB	3 dB	9 dB	3 dB	6 dB	3 dB
7	OPS	OPS (2-Wire)	5 dB	4 dB	4 dB	4 dB	10 dB	4 dB	4 dB	4 dB
8	AAL(A)	Analog Public Switched Network Port (2-wire)					3 dB	3 dB	3 dB	
9	AAL(D)	Analog Public Switched Network Port (2-wire)					3 dB	3 dB	3 dB	

To			Tie trunk type ports			Integrated services trunk	OPS ports (2-wire)	Analog public switched network ports (2-wire)		Subrate 1,544 Mb/s digital PBX-CO Trunk Port (4-wire)
From (E)			Lossless 2/4-wire	Subrate 1,544 Mb/s satellite 4W	Subrate 1,544 Mb/s tandem 4W					
10	**DAL**	Subrate 1,544 Mb/s Digital PBX-CO Trunk Port (4-wire)					6 dB			

NOTE 1: Positive values denote loss relative to ANSI/TIA-968-A [9] Negative (-) values denote gain relative to ANSI/TIA-968-A [9].
NOTE 2: The ANSI/TIA-968-A-1 [9] limits in table 2 are only provided as a convenience to users of this standard. Users should consult the latest ANSI/TIA-968-A-1 [9] to ensure that they are in compliance.
NOTE 3: The ONS ports with approved TE are for 2-wire on-premises station ports to separately approved terminal equipment.
NOTE 4: Subrate 1,544 Mb/s Digital PBX-CO trunk ports are for 4-wire 1,544 Mb/s High Capacity Circuit digital ports.
NOTE 5: The numbers in the first column of each table are used in the first row of each table as references to the ANSI/TIA-968-A [9] port nomenclature.

5.1.1.2 Digital pad disabling

ANSI/TIA-464-C	ES 201 168
Requirements not given	3.1.8.1 Bit integrity 4 Compliance principles
	Digital processing devices must be disabled to provide bit integrity when needed. If digital pads are part of the loss adjustment of input- and output half channels, they must be rendered inoperative during all transmission measurements, with the exception of the parameters Nominal Transmission Loss and Loss Tolerances

Analysis: There is no issue in about ANSI/TIA-464-C-2002 [7] the influence of digital pads on transmission parameters such as level tracking, quantizing distortion, output level, overload compression etc. With respect to the above mentioned parameters, the ETSI Standard is mainly based on ITU-T Recommendation G.712 [3], which provides parameters limits, assuming no digital loss or gain pads. To avoid the calculation and creation of new, extended limits for the standard, all digital signal processing devices including digital pads should be switched inoperative. This procedure was agreed upon since, usually, the influence on transmission quality of those devices is known and can be tolerated in practice.

5.1.2 Frequency response

5.1.2.1 Comparison of both definitions of frequency response

In both standards, the frequency response is defined as the difference between the actual loss at any frequency and the actual loss at the reference frequency 1 004 Hz (TIA) or 1 020 Hz (ETSI). With respect to the given frequency masks, positive values indicate more loss and vice versa. The loss at the reference frequency is assumed to be 0 dB.

By definition, loss is the logarithmic ratio between two values of power. For ANSI/TIA-464-C [7] requirements, measurements of frequency response are performed with all analog ports terminated with 600 Ω (section 6.2 of ANSI/TIA-464-C [7]). Since this termination is independent of frequency, the measured voltage response across the port interface is identical with the power response. In contrast, for ETSI requirements, the ports are terminated with their nominal impedance, which is capacitive complex, i.e. frequency dependent. Therefore, ETSI defines the frequency response loss distortion with frequency, (clause 3.1.6 of ES 201 168 [8]) as the logarithmic ratio between the actual measured voltage at the reference frequency (1 020 Hz) and the voltage at any other frequency. This definition is in accordance with ITU-T Recommendation Q.551, section 1.2.5 [5].

5.1.2.2 Analog to digital/digital to analog

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th colspan="5">ES 201 168</th></tr>
<tr><td colspan="3">6.3.1 Frequency response (attenuation distortion)
Figure 40 (a) Analog to digital
(b) Digital to analog</td><td colspan="5">3.1.6 Definition of loss distortion
5.2.3 Variation of gain with frequency (analog half connections)
Figures 7, 8 Loss distortion with frequency (input and output connections)</td></tr>
<tr><td colspan="3">Template: Figure 2
Response table (breakpoints):</td><td colspan="5">K2, L2, M2, K4 and M4 interfaces:
Template: Figure 2</td></tr>
<tr><th>Frequency (Hz)</th><th>Minimum (dB)</th><th>Maximum (dB)</th><th colspan="2">Frequency (Hz)</th><th>Minimum (dB)</th><th></th><th>Maximum (dB)</th></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td>Input</td><td>Output</td><td>(see note 3)</td></tr>
<tr><td>60</td><td>+20 (see note 1)</td><td>+3 (see note 2)</td><td></td><td>< 200</td><td>0</td><td>-0,3</td><td>-</td></tr>
<tr><td>200</td><td>0</td><td>+0,5</td><td>200</td><td>300</td><td>-0,3</td><td>-0,3</td><td>-</td></tr>
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<tr><td></td><td></td><td></td><td>3 000</td><td>3 400</td><td>-0,3</td><td>-0,3</td><td>+1,7</td></tr>
<tr><td></td><td></td><td></td><td>3 400</td><td>3 600</td><td>-0,3</td><td>-0,3</td><td>-</td></tr>
<tr><td></td><td></td><td></td><td>> 3 600</td><td></td><td>0</td><td>0</td><td>-</td></tr>
<tr><td colspan="3">Conditions:
Relative to loss measured at 1 004 Hz (nominal); "+" values indicate more loss, "-" values indicate less loss than measured at 1 004 Hz. For each connection category, 95 % of connections shall meet the above requirements.</td><td colspan="5">Conditions:
Referenced to 1 020 Hz. Preferred input level: -10 dBm0</td></tr>
<tr><td colspan="8">NOTE 1: N/A for digital to analog conversion.
NOTE 2: +2 dB for digital to analog conversion.
NOTE 3: Same for input and output.</td></tr>
</table>

Analysis: TIA requirements are tighter than ETSI with the exception of maximum loss relative to 1 004 Hz in the frequency range 600 Hz to 2 400 Hz. Though not shown in the template, TIA requirements extend beyond 4 000 Hz with minimum loss, relative to 1 004 Hz, of 28 (D-A) or 32 (A-D) dB at 4 600 Hz and beyond. In ETSI, requirements for the frequency response are only related to the speech band from 200 Hz to 3 600 Hz. Signals above 3,6 kHz, which may cause interference (harm) to the public network are considered as "access requirements", and contained in ENs or TBRs. For additional information see also "Comparison of both definitions of frequency response" in clause 5.1.2 of the present document.

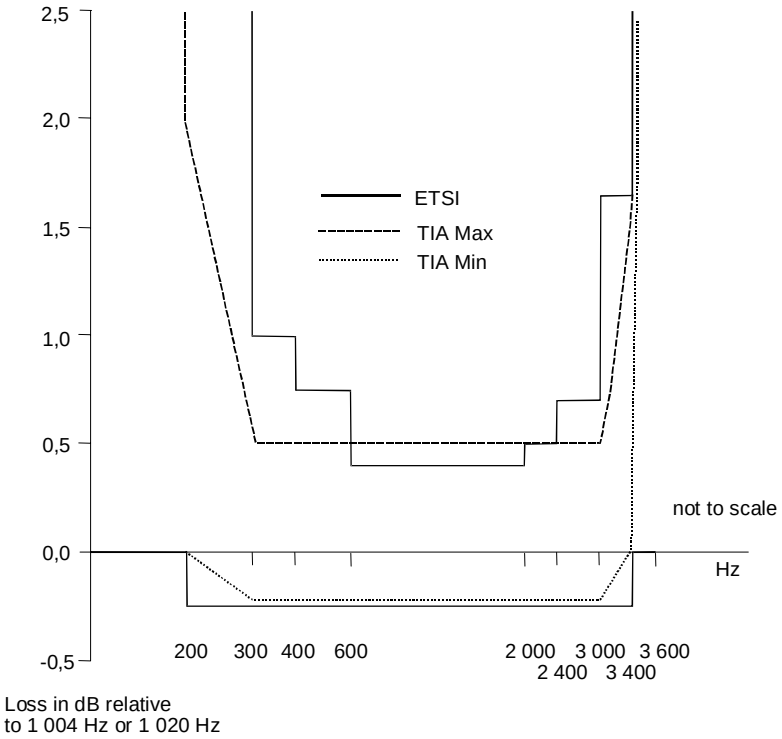

Figure 2: Analog to digital frequency response

5.1.3 Levels

5.1.3.1 Comparison of both definitions of interfaces levels

The understanding and use of interface levels differs between TIA and ETSI standards. In ANSI/TIA-464-C [7] a zero-level point (ZLP) is defined; generally it represents the digital (PCM) switching point in a PBX. A 0 dBm0 signal at this point will decode to 0 dBm, or 1 mW in 600 Ω, and furthermore corresponds to the Digital MilliWatt (DMW) as defined in ANSI/TIA-464-C [7] section B.3.3 and based on ITU-T Recommendation G.711 [2] section 5. Overload occurs at a level which, for μ-law coding, is greater than +3,17 dBm at a 0 dB interface. Transmission Level Translation (section 6.1.4.3): in many cases, the interface level will be different from the Zero-Level Point (ZLP) due to the losses introduced to meet the loss plan. In these cases (unless otherwise stated) the appropriate interface loss should be included when determining compliance with the requirements.

In ETSI, interface levels are expressed with the term "relative level". The values are given as relative input level L_i and relative output level L_o at each analog or digital interface. The purpose of this parameter must be seen in several ways. Primarily the relative level is directly related to the Nominal Loss (NL) of an input or output connection, which is defined as an unidirectional path between the interface and the test point. These relations are:

$$NL_i = L_i \qquad NL_o = L_o$$

Relative levels are used also in network planning in different applications. The relative output level at an interface may give an indication about the absolute signal power at this point, since signal levels are often expressed as a value in dBmO (e.g. -15 dBmO for test signals) which is understood as the absolute signal power at a 0 dBr point. The relative input level is used to control an overloading during encoding by signal sources in practical use. The relative levels are defined at a frequency of 1 020 Hz and corresponding to the Digital MilliWatt (DMW) and an analogue signal power of 1 mW as in TIA and based on ITU-T Recommendation G.711 [2].

The definition of a relative level in ETSI is referred to a termination with a frequency-dependant complex impedance. The nominal value of those impedances at the reference frequency 1 020 Hz may differ from 600 Ω, therefore the reference voltage is not necessarily 0,775 V. The definition can be given as follows:

- The output level at an interface is designated 0 dBr, if an internal digital signal, corresponding to the Digital MilliWatt (DMW), is resulting in an analogue signal of 1 020 Hz with an apparent power of 1 mW at the terminating complex impedance. Overload occurs at a level which, for A-law coding, is +3,14 dB above 1 mW (ITU-T Recommendation G.711 [2]). The definition of relative input levels is similar.

More detailed information about the concept and use of relative levels is given in TR 101 802 [6].

5.1.3.2 Interface levels

ANSI/TIA-464-C	ES 201 168
6.1.4.3 Transmission level translation Annex B3 Reference levels	3.1.4 Relative levels (definition for test point and analog interfaces) 6.2 Transmission loss (relative levels of digital interfaces)
The gain or loss from the port interface to the zero-level point has to be taken into account when making measurements. In the case of input ports, the input level should be increased or decreased by the amount equivalent to the loss or gain from the interface to the zero-level point. In the case of output ports, the output measurement should have an amount added or subtracted equivalent to the loss or gain from the zero-level point to the interface. This amount is not the same as specified in table 1, as table 1 is for port-to-port connections, and the port-to-ZLP-to-port losses and gains are defined by the PBX manufacturer. For nominal acoustic reference values, see section 5.3 of the present document.	The adjustment of relative input and output levels is left to the manufacturer's discretion. See also clause 5.1.1 of the EG 201 168.
Conditions: Measured at 1 004 Hz (nominal) with both source and measuring instruments at 600 Ω impedance.	Conditions: Measured at 1 020 Hz (nominal) with a test level of -10 dBmO (clause A.4.2)

Analysis: See clause 5.1.3.1 of the present document.

5.1.3.3 Level tracking: tracking error

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td colspan="3">6.3.4 Tracking error
Figure 41 Tracking error</td><td>5.2.2 Variation of gain with input level (analog half connections)
Figure 6 Variation of gain with input level</td></tr>
<tr><td colspan="3">1) For all port-to-port connections, the tracking error should not exceed the limits shown in figure 3.
2) Analog to digital connections and digital to analog connections:</td><td>Mask: Figure 3 below</td></tr>
<tr><td rowspan="2">Input signal (dBm)</td><td colspan="2">Tracking error (dB)</td><td rowspan="3">Conditions:
With a sine-wave test signal at 1 020 Hz over the range of input levels shown in figure 3, the gain variation, relative to the gain at -10 dBmO shall lie within the limits shown in figure 3.</td></tr>
<tr><td>Max.</td><td>Avg.</td></tr>
<tr><td>0 to -37
-37 to -50</td><td>±0,25
±0,5</td><td>±0,125
±0,25</td></tr>
</table>

Analysis: ETSI requirements cover a wide range of input levels than TIA; however, where the ranges overlap, TIA is tighter except for the input range of -37 dBm0 to -40 dBm0.

Remark: TIA does not define tracking error with respect to a reference input level. If the limits must be interpreted as absolute total loss deviations, in contrast to the deviation referred to the loss at a specific input level (0 dBm or -10 dBm), then ETSI and TIA requirements are not comparable.

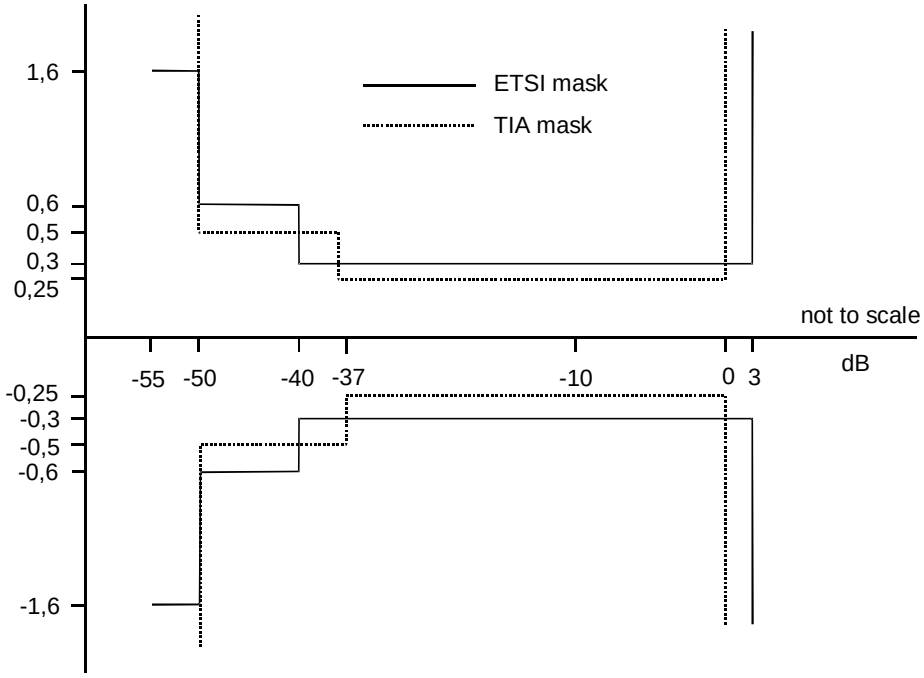

Figure 3: Level tracking: tracking error

5.1.3.4 Level tracking: overload compression

<table>
<tr><th>ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td>6.3.3 Overload compression
Figure 41 Overload compression</td><td>No comparable requirement.</td></tr>
<tr><td>Overload compression requirements are shown in figure 4.
Deviation is relative to 1 kHz.</td><td></td></tr>
</table>

Analysis: None.

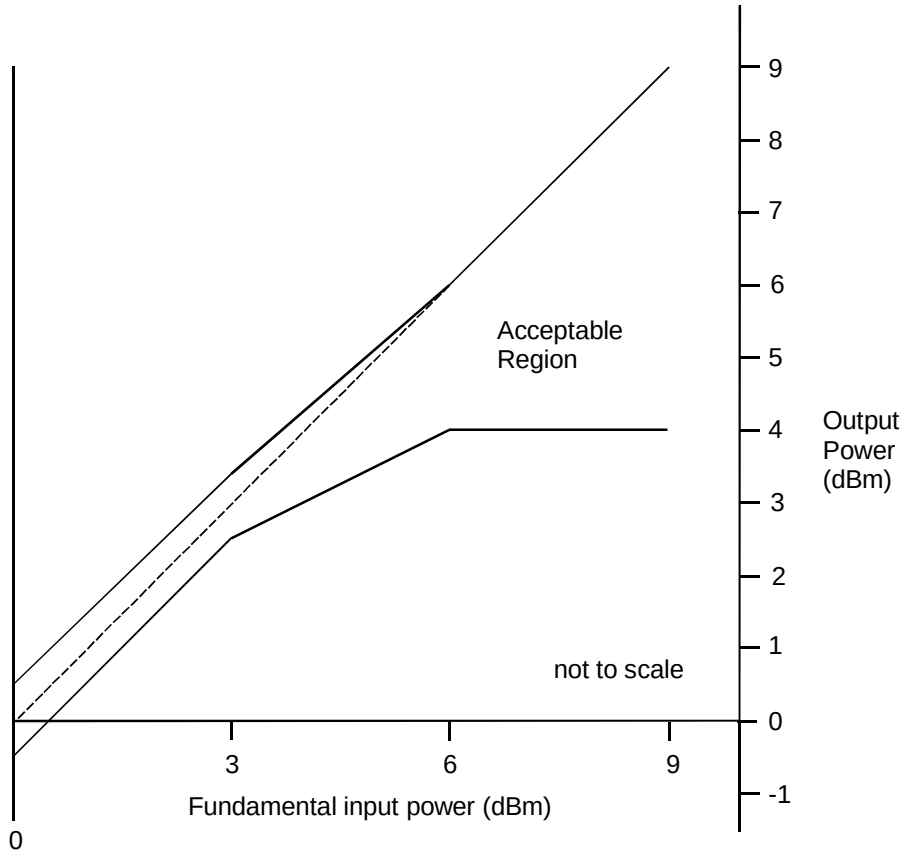

Figure 4: Level tracking: overload compression

5.1.3.5 Signal levels

ANSI/TIA-464-C-2002	ES 201 168
6.8 Signal levels	No comparable requirement.
The PBX shall comply with ANSI/TIA-968-A [9] section 4.5, for the following signal power limitations: 1) In-band signal power limits: a) Internal signal sources not intended for network control signalling; b) Internal signal sources intended primarily for network control signalling; c) Through transmission; d) Idle state circuit stability for tie trunks; e) Metallic signal power at frequencies in the range 3 995 Hz to 4 005 Hz; f) Longitudinal voltage in the 100 Hz to 4 000 Hz frequency range. 2) Out-of-band signal voltage limits: a) Metallic voltage; b) Longitudinal voltage. The above listed signal power limitations shall apply to: 1) Analog trunk interfaces (ground start, loop start, DID). 2) OPS interfaces. 3) Analog tie trunk interfaces. 4) Digital trunk interfaces (ground start, loop start, DID, ISDN basic rate and primary rate) with encoded analog contents. 5) Digital OPS interfaces with encoded analog contents. 6) Digital tie trunk interfaces with encoded analog contents.	

Analysis: Comparison not applicable. In Europe the signal levels are considered as parameters, which may cause harm to the (public) network. Since ETSI, as a general rule, is specifying those parameters in separate "access requirements", these requirements are no more part of ES 201 168. They are contained in ENs and TBRs or, (mainly in case of analog access) part of national regulation. A comparison between these regulations and ANSI/TIA-968-A [9] is outside the scope of the present document.

5.1.4 Hybrid balance

ANSI/TIA-464-C		**ES 201 168**	
6.4.1 Hybrid balance requirements Table 20 PBX minimum hybrid balance requirements		3.1.7.1 Terminal balance return loss (TBRL) definition 5.8.1 Terminal balance return loss (for 2-wire analog interfaces) Figure 13 Limits for TBRL	
All ports Template: Figure 5.		Template: Figure 5.	
Frequency range (Hz)	**Hybrid balance (dB)**	**Frequency range (Hz)**	**Hybrid balance (dB)**
200 to 500	Equal to or greater than the values located on a straight line intersection17 dB at 200 Hz and 22 dB at 500 Hz	300 to 500	Equal to or greater than the values located on a straight line intersection 16 dB at 300 Hz and 20 dB at 500 Hz
500 to 2 500	> 22 dB	500 to 2 500	> 20 dB
2 500 to 3 400	Equal to or greater than the values located on a straight line intersection 22 dB at 2 500 Hz and 17 dB at 3 400 Hz	2 500 to 3 400	Equal to or greater than the values located on a straight line intersection 20 dB at 2 500 Hz and 16 dB at 3 400 Hz
Lines plotted on a log/linear scale.		Lines plotted on a log/linear scale.	
Conditions: Measurements procedure outlined in clause 6.4.2. Test configurations shown in figures 43 (full channel method) and 44 (half channel method).		Conditions: Test procedure outlined in clause A.4.3.2.	

Analysis: For all ports, the TIA requirements are more stringent than the ETSI requirement.

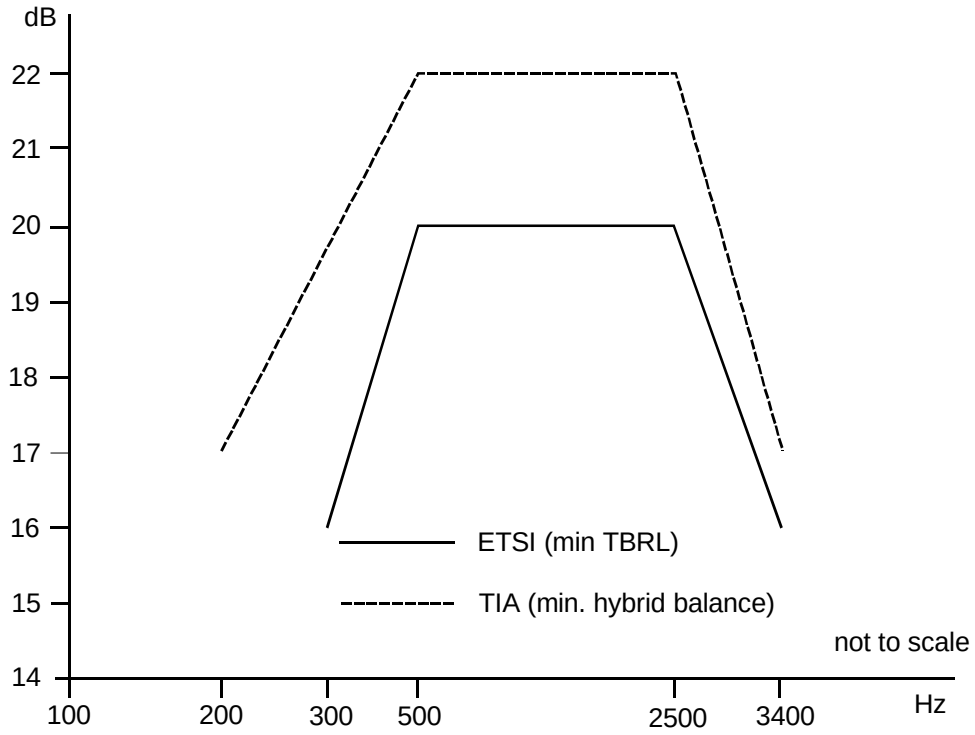

Figure 5: Hybrid balance

5.1.5 Input impedance

<table>
<tr><th colspan="2">ANSI/TIA-464-C</th><th colspan="2">ES 201 168</th></tr>
<tr><td colspan="2">6.4.3 Input impedance requirements
Table 21 PBX return loss requirements</td><td colspan="2">5.1 PBX input impedance of interfaces K2, L2, M2 and M4
Figure 5 Minimum value of return loss against the nominal PBX impedance</td></tr>
<tr><td colspan="2">All ports Template: Figure 6</td><td colspan="2">Impedance
Nominal PBX impedance:
2-wire ports: 270 Ω + (750 Ω // 150 nF)
4-wire ports: 600 Ω

Return loss: Template: Figure 6</td></tr>
<tr><th>Freq. range (Hz)</th><th>Mandatory Z-in (dB)</th><th>Freq. range (Hz)</th><th>RL (dB)</th></tr>
<tr><td>200 to 500</td><td>Equal to or greater than the values located on a straight line intersection 14 dB at 200 Hz and 22 dB at 500 Hz</td><td>300 to 500</td><td>Equal to or greater than the values located on a straight line intersection 14 dB at 300 Hz and 18 dB at 500 Hz</td></tr>
<tr><td>500 to 2 500</td><td>> 22</td><td>500 to 2 000</td><td>> 18</td></tr>
<tr><td>2 500 to 3 400</td><td>Equal to or greater than the values located on a straight line intersection 22 dB at 2 500 Hz and 14 dB at 3 400 Hz</td><td>2 000 to 3 400</td><td>Equal to or greater than the values located on a straight line intersection 18 dB at 2 000 Hz and 14 dB at 3 400 Hz</td></tr>
<tr><td colspan="2">Conditions:
Reference impedance is 600 Ω; for CO trunks & DID trunks, 600 Ω / 2,16µF is acceptable. Optionally, ONS reference impedance may be a three element network either that used for hybrid balance or ETSI nominal input impedance network.
Test configurations are given in figures 45 to 48 for 2-wire and 4-wire ports.</td><td colspan="2">Conditions:
Measured against the nominal PBX impedance (270 Ω + (750 Ω // 150 nF).
Test procedure for return loss outlined in clause A.4.3.1.</td></tr>
</table>

Analysis: ETSI requirements are less stringent than TIA for all frequencies. Measurement conditions differ; TIA connections measured through PBX to 4-wire port with 600 Ω termination. ETSI connections measured half-channel, with open loop inside the PBX to avoid signal reflections.

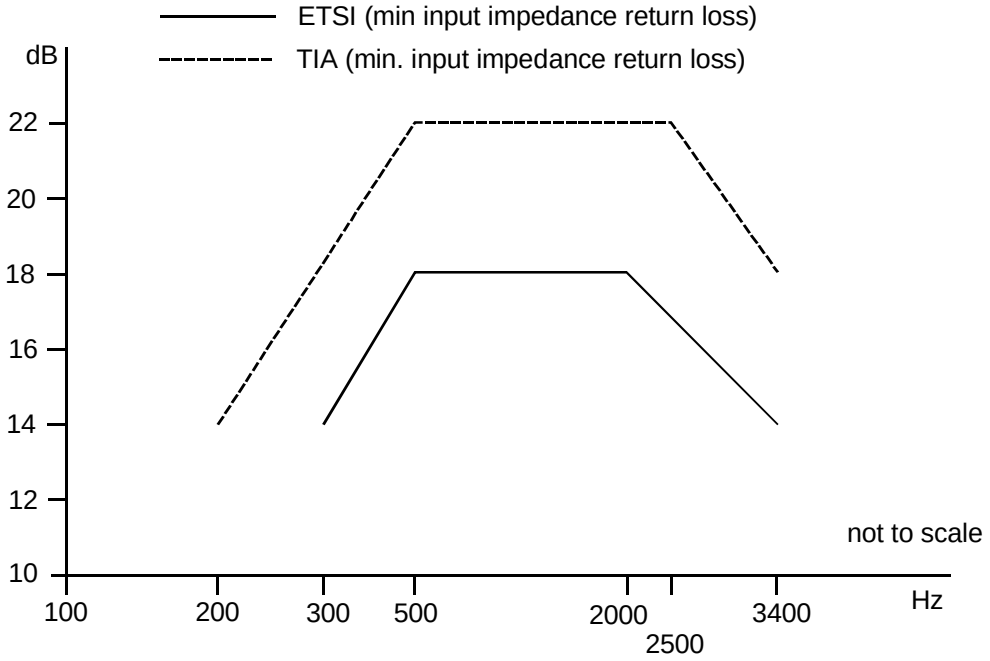

Figure 6: Input impedance return loss

5.1.6 Echo loss

ANSI/TIA-464-C	ES 201 168
Annex C: Loss definitions	3.1.7.3 Echo loss
The Echo Return Loss (ERL) is a weighted average of the return loss values over the frequency range 400 Hz to 3 400 Hz. Conditions: For calculation of echo loss, sub-multiples of 8 kHz should be avoided.	The echo loss is defined as the semi-loop loss averaged with 1/f power weighting over the telephone band. Reference is made to ITU-T Recommendation G.122 [1], paragraph 4 with the corresponding weighting algorithm. ETSI is giving only the definition of echo loss, no numerical requirements. Conditions: Calculation of echo loss is based on the values of semi-loop in the band 300 Hz to 3 400 Hz, using the given formula or the trapezoidal rule given in ITU-T Recommendation G.122 [1].

Analysis: In both cases, TIA and ETSI the echo loss is defined as a weighted average of the return loss of all equipment forming an echo source. This is resulting in one single value of echo loss to be used mainly for planning purposes. The weighting algorithms are not comparable.

5.1.7 Stability loss

ANSI/TIA-464-C-2002	ES 201 168
No comparable requirements.	3.1.7.2 Stability loss (Definition) 5.8.2 Stability loss (K2, L2, M2 interfaces) 9.6.1 Stability loss of interfaces connected to a KD Interface 9.6.2 Stability loss of interfaces connected to M4, MD or MS interfaces Clause A.4.3.2
	The stability loss is defined as the loss between the PBX test points (clause 3.1.7.2) of a half connection to a L2 or M2 interface with worst case terminating conditions simulated by a short circuit and adjusted for the relative input and output levels of these 2-wire interfaces (clause 4.3.2). The values of the stability loss should be stated by the supplier, in the frequency range between 200 Hz and 3 600 Hz (clause 5.8.2). For connections with a KD, M4, MD or MS interface, the stability loss shall be at least 6 dB (clauses 9.6.1 and 9.6.2).

Analysis: ETSI is referred to ITU-T Recommendation G.122 [1], taking into account, that a private network, connected digitally to a public network, may provide the total stability loss of the entire path across the public network (see clause 5.8.2 of ES 201 168 [8]).

5.2 Voice impairment parameters

5.2.1 Noise

5.2.1.1 Weighted noise

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th colspan="2">ES 201 168</th></tr>
<tr><td colspan="3">6.5.1.1 C-weighted-message noise
Table 23 PBX C-message weighted noise requirements</td><td colspan="2">5.4.1 Weighted noise of analog interfaces without a feeding bridge
5.4.2 Weighted noise of analog interfaces with a feeding bridge</td></tr>
<tr><th>Connection</th><th>Mean (desirable) dBmC</th><th>95 % (max.) dBmC</th><th>K2, L2, M2 and M4</th><th>(dBmOp)</th></tr>
<tr><td>Analog-to-analog</td><td>≤ 16</td><td>≤ 20</td><td>Input connection with signalling on speech wires</td><td>< -65,2</td></tr>
<tr><td>Analog-to-digital</td><td>≤ 15</td><td>≤ 19</td><td>Input connection with signalling on separate wires</td><td>< -67,0</td></tr>
<tr><td>Digital-to-analog</td><td>≤ 9</td><td>≤ 13</td><td>Output connection with signalling on speech wires</td><td>< -67,0</td></tr>
<tr><td colspan="3" rowspan="2">Conditions:
All analog interfaces, except the one(s) being tested, are terminated with appropriate impedances, and all digital input ports, other than the one(s) being tested, are supplied a digital equivalent of zero volt.</td><td>Output connection with signalling on separate wires</td><td>< -70,0</td></tr>
<tr><td colspan="2">Interfaces with feeding bridge:
Limit for weighted noise is calculated for every input and output connection depending on the relative levels. Values are expressed in dBmp.</td></tr>
<tr><td colspan="3">Test arrangement shown in figure 49.</td><td colspan="2">Conditions:
Measurement method: Clause A.4.5.1</td></tr>
</table>

Analysis: These requirements are not directly comparable, because of different weightings and reference values. However, with respect to the reference the following conversion can be used:

Value in dBrnC - 90 = Value in dBmp

According to annex A to ITU-T Recommendation O.41 [4] the different readings due to the weighting filters can be neglected (0,5 dB for white noise), therefore the above conversion can be used in all practical applications. Furthermore comparison is difficult, since ETSI specifies noise limits for input and output connections, in contrast to port-to-port connections in TIA also follows ITU-T Recommendations, taking into account, that noise is a combination of noise sources, each of which may be influenced by the adjustment of relative levels or may be level independent. Consequently, for interfaces with feeding bridge (L2 and some M-interfaces), the noise limits may differ for every interface.

5.2.1.2 3-kHz flat noise

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td colspan="3">6.5.1.2 3 kHz flat noise</td><td>No comparable requirements</td></tr>
<tr><td>Percentage of connections</td><td>50 %(dBrn)</td><td>90 %(dBrn)</td><td rowspan="3"></td></tr>
<tr><td>3 kHz flat noise</td><td>≤ 35</td><td>≤ 39</td></tr>
<tr><td colspan="3">Conditions:
For interface transmission levels other than 0 dB, the requirement should be shifted by a value that corresponds to the difference between the transmission level at that interface and 0 dB.</td></tr>
</table>

Analysis: Not specified by ETSI, so comparison is not pertinent.

5.2.1.3 Single frequency noise

ANSI/TIA-464-C	ES 201 168
No comparable requirements.	5.4.2 Single frequency noise of interfaces K2, L2, M2 and M4.
	The level of any "unwanted" single frequency (in particular the sampling frequency and its multiples), measured selectively with a bandwidth of 80 Hz from 4 kHz to 72 kHz shall not exceed -50 dBmO at the interface of an output connection. Conditions: No test signals are inserted into the half connection during measurements.

Analysis: The term "unwanted" refers to self generated noise (see note of clause 5.4.5) as it may occur by the sampling frequency itself or by other noise source (e.g. dc - dc power supply) in correlation with the sampling process. Comparison with TIA is not possible.

5.2.1.4 Spurious out of band signals

ANSI/TIA-464-C		ES 201 168
6.3.1 Frequency response		There are no requirements with respect to received out of band signals at the output of all types of analog interfaces. Those requirements are subject to access requirements (TBRs, ENs) and therefore not part of ES 201 168 [8].
Although not directly comparable, limits for signals above 4 kHz (out of band) are contained in the frequency response masks in clause 6.3.1. For analog to digital connections, the minimum loss, relative to the loss at 1 004 Hz, should follow the equation:		
Range		
3 400 Hz to 4 000 Hz	-14sin{[π*(4 000-F)]/1 200}+14	
4 000 Hz to 4 600 Hz	-18sin{[π*(4 000-F)]/1 200}+14	
over 4 600 Hz	32 dB	
For digital to analog connections, the minimum relative loss should follow the equations:		
Range		
3 400 Hz to 4 600 Hz	-14sin{[π*(4 000-F)]/1 200}+14	
4 600 Hz	28 dB	
Conditions: See also section 5.1.2 of the present document.		

Analysis: There are no directly comparable requirements for out of band signals received at the output ports of a connection. However, values for minimum relative loss in the range from 4 kHz to 12 kHz in the frequency response masks of ANSI/TIA-464-C [7], section 6.3.1 can be interpreted as limits for out of band signals.

5.2.2 Balance

5.2.2.1 Longitudinal balance

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td colspan="3">6.5.2.1 Longitudinal-to-metallic balance
Table 24 PBX longitudinal-to-metallic balance requirements
Figure 50 Longitudinal balance limits</td><td>Requirements not given.</td></tr>
<tr><td>Frequency (Hz)</td><td>Minimum balance (dB)</td><td>Average balance (dB)</td><td></td></tr>
<tr><td>200 to 1 000</td><td>58</td><td>63</td><td></td></tr>
<tr><td>1 000 to 3 000</td><td>58 to 53</td><td>63 to 58</td><td></td></tr>
<tr><td colspan="3">Conditions:
TIA considers longitudinal-to-metallic balance as a performance parameter for measuring product immunity against the conversion of disturbing longitudinal voltage into unwanted metallic noise. It applies to loop/ground start CO/FXO trunks, reverse battery (DID) trunks, OPS/FXS lines, and digital service trunks. Figure 50 shows a "desirable" region for average balance.</td><td></td></tr>
</table>

Analysis: Comparison not applicable. However, from previous ETSI standards I-ETS 300 004 (see bibliography), the LCL requirement was about 18 dB less stringent than the TIA requirement. In Europe the longitudinal to metallic balance is considered as a parameter, which may cause harm to the (public) network. Since ETSI, as a general rule, specifies those parameters in separate "Access Requirements", these requirements are not part of ES 201 168 [8]. They are contained on TBRs and ENs or, (mainly in case of analog access) part of national regulation. Also high LCL may indirectly be required to meet the immunity requirements called for under the European EMC Directive.

5.2.2.2 Transverse balance

<table>
<tr><th colspan="4">ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td colspan="4">6.5.2.2 Transverse balance
Table 25 Termination and frequency ranges
Table 26 Frequency ranges of transverse balance for digital services
Table 27Transverse balance limits
Figure 51 Transverse balance requirements for digital service interfaces</td><td>Requirements not given.</td></tr>
<tr><td>Interface</td><td>State</td><td>Frequency range (Hz)</td><td>Minimum balance (dB)</td><td></td></tr>
<tr><td rowspan="2">CO trunk loop start</td><td rowspan="2">On-hook</td><td>200 to 1 000</td><td>≥ 60</td><td></td></tr>
<tr><td>1 000 to 4 000</td><td>≥ 40</td><td></td></tr>
<tr><td></td><td>Off-hook</td><td>200 to 4 000</td><td>≥ 40</td><td></td></tr>
<tr><td>CO trunk ground start</td><td>Off-hook</td><td>200 to 4 000</td><td>≥ 40</td><td></td></tr>
<tr><td>Reverse battery (DID)</td><td>Off-hook</td><td>200 to 4 000</td><td>≥ 40</td><td></td></tr>
<tr><td>OPS line</td><td>Off-hook</td><td>200 to 4 000</td><td>≥ 40</td><td></td></tr>
<tr><td colspan="4">NOTE: These are regulatory requirements.</td><td></td></tr>
<tr><td colspan="4">Conditions:
The ANSI/TIA-464-C [7] requirements are taken directly from the FCC Part 68 technical requirements to protect the network from harm caused by the conversion of metallic signals into longitudinal signals that could cause excessive noise in other pairs of a multi-pair cable. The requirement defines ten measurement conditions, together with a transverse balance test circuit and termination schematics.

Test arrangement and termination arrangement shown in Figures 52 to 56.</td><td>See also clause 5.2.2.1 of the present document.</td></tr>
</table>

Analysis: Comparison not applicable. However, from previous ETSI standards (I-ETS 300 004), the LCTL requirement was nearly identical to the TIA requirement in the off-hook case.

5.2.3 Crosstalk

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th colspan="2">ES 201 168</th></tr>
<tr><td colspan="3">6.5.3 Crosstalk</td><td colspan="2">5.5 Crosstalk</td></tr>
<tr><td>Between any established connection and any other connection (dB)</td><td>Between any established connection and at least 95 % of all other connections (mandatory) (dB)</td><td>Between any established connection and at least 95 % of all other connections (desirable) (dB)</td><td>Connection type</td><td>(dBmO)</td></tr>
<tr><td>≥ 70</td><td>≥ 75</td><td>≥ 80</td><td>Input (FEXT): All interfaces
Input (NEXT): L2, K2
Input (NEXT): M4, 4w-2w
Output (FEXT): L2, K2
Output (FEXT): M4, 4w-2w
Output (NEXT): L2, all M interfaces
Output (NEXT): K2</td><td>< -73
< -73 (see note 1)
< -73
< -73 (see note 1)
< -73
< -73
< -66</td></tr>
<tr><td colspan="3" rowspan="2">Conditions:
Full channel tests for every combination of through connection, for all interface categories over the 200 to 3 200 Hz frequency band.
Test circuit is shown in figure 57.</td><td colspan="2">NOTE 1: Values specified in dBm
NOTE 2: NEXT: Near End Crosstalk
FEXT: Far End Crosstalk</td></tr>
<tr><td colspan="2">Conditions:
Measurement details are in clause A.4.4.
Requirements measured as "Crosstalk-Level" for an input signal of 1 020 Hz with a level of 0 dBmO.</td></tr>
</table>

Analysis: TIA does not specify the input level, but when the ETSI input signal level is applied the TIA requirement is about 3 dB to 5 dB more stringent than TIA measurement conditions, if liberally interpreted, requires a near-infinite number of test. The ETSI requirement is more detailed but the test conditions more practical.

5.2.4 Distortion

5.2.4.1 Quantization distortion

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th colspan="3">ES 201 168</th></tr>
<tr><td colspan="3">6.5.4 Quantization distortion
Table 28 PBX quantization distortion limits</td><td colspan="3">5.6 Total distortion including quantizing distortion
9.3 Quantizing distortion units (qdu)
Figures 9 to 12
Limits for signal-to-total distortion ratio of Analog interfaces (various interfaces/conditions)</td></tr>
<tr><td>Input signal level (dBm)</td><td>Input/output level ratio (mandatory)</td><td>Input/output level ratio (desirable)</td><td>Input level dBm0</td><td colspan="2">Minimum signal to total distortion ratio
Input or output connection</td></tr>
<tr><td colspan="3">Analog-to-analog connection</td><td></td><td>A</td><td>B</td></tr>
<tr><td>0 to -30</td><td>≥ 33</td><td>≥ 37</td><td>0</td><td>35,0</td><td>35,0</td></tr>
<tr><td>-40</td><td>≥ 27</td><td>≥ 31</td><td>-20</td><td>35,0</td><td>35,0</td></tr>
<tr><td>- 45</td><td>≥ 22</td><td>≥ 26</td><td>-30</td><td>35,0</td><td>33,8</td></tr>
<tr><td colspan="3">Digital-to-analog and analog-to-digital connections</td><td>-40</td><td>29,0</td><td>26,5</td></tr>
<tr><td>0 to -30</td><td>≥ 35</td><td>-</td><td>-45</td><td>24,0</td><td>21,5</td></tr>
<tr><td>-40</td><td>≥ 29</td><td>-</td><td colspan="3">A: For interfaces with signalling on separate wires.
B: For interfaces with signalling on the speech wires.</td></tr>
<tr><td>-45</td><td>≥ 25</td><td>-</td><td colspan="3">For interfaces with feeding bridge, the curves are calculated on the basis of different noise sources (see also clause 5.2.1 of the present document).</td></tr>
<tr><td colspan="3" rowspan="2">Conditions:
To be met on 95 % of connections in each category.
Input: 1 kHz sine wave.
Output: C message weighted distortion level.</td><td colspan="3">Conditions:
Measured with a sine wave signal of 1 020 Hz. A connection between two analog interfaces and without an inserted digital loss pad or with a pad of 6,02 dB, is forming 1 quantizing distortion unit (qdu). The number of qdu for a connection shall be stated by the supplier.</td></tr>
</table>

Analysis: Some of the ETSI requirements are virtually identical to the TIA half channel requirements, while others are less stringent. The coding schemes and weightings are different and the test methods are also different. In practice, it is not possible to measure quantization distortion alone because of the presence of other sources of distortions, such as noise. Therefore in ETSI this parameter is called "Total distortion including quantizing distortion". The number of qdu in a connection through the PBX is mainly used for planning purposes.

5.2.4.2 Single frequency distortion

ANSI/TIA-464-C	ES 201 168
6.5.5 Single frequency distortion	5.7.1 Input signals above 4,6 kHz
≤-28 dBm Conditions: For each connection category, 95 % of connections shall meet the above requirements. Input: Any single frequency in the range of 0 kHz to 12 kHz at a constant 0 dBm level. Output: At any other single frequency. Adjust input level if overload the point differs from +3 dBm.	For an input signal in the range from 4,6 kHz to 72 kHz with a level of -25 dBmO any image frequency produced in the time slot of an input connection shall be at least 25 dB below the test level. Conditions: Test method given in clause A.4.2.1.5.

Analysis: These requirements are not directly comparable due to the differences in input level and frequency range, but at least part of their intents are the same. Ignoring the differences, the TIA requirement is 3 dB more stringent.

5.2.5 Delay

<table>
<tr><th colspan="2">ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td colspan="2">6.4.6 Echo path delay
Table 20 Echo path delay for PBX</td><td>3.1.10.3.1 Mean one-way transmission time (definition)
9.5 Mean one-way transmission time</td></tr>
<tr><td>Connection</td><td>Round trip delay (ms)</td><td rowspan="8">No numeric requirement for echo path delay.

The mean one-way transmission time in a connection between two interfaces shall be a value stated by the supplier.</td></tr>
<tr><td>1 Station - station</td><td>3,0</td></tr>
<tr><td>2 Station - analog trunk</td><td>3,0</td></tr>
<tr><td>3 Analog trunk - analog trunk</td><td>3,0</td></tr>
<tr><td>4 Station - digital interface</td><td>2,4</td></tr>
<tr><td>5 Analog trunk - digital interface</td><td>2,4</td></tr>
<tr><td>6 Digital interface - digital interface</td><td>2,0</td></tr>
<tr><td colspan="2">Conditions:
Requirement for all frequencies in range of 300 Hz to 3 400 Hz. For each connection category, 95 % of connections shall meet the above requirement.</td></tr>
</table>

Analysis: ETSI requirements have shifted from specifying mandatory upper limits to the echo path delay to complete deletion of numeric values.

5.3 Loudness levels

ANSI/TIA-464-C	ES 201 168
A.4.2 Acoustic reference levels Table A4 Interface acoustic reference values for ISPBX	3.1.15 Acoustic reference level (ARL) - definition 8.2.2 Send and Receive Loudness Ratings (SLR and RLR) for 3,1 kHz handset system specific telephones
Nominal acoustic reference values treat the PBX/line port combination as a single system for defining loudness ratings at PBX interfaces. The values are presented in table 5.	Sending and receiving loudness ratings (SLR and RLR) of system specific telephones shall be stated by the manufacturer.

Analysis: Requirements are not directly comparable. The TIA requirements address the PBX with its terminal as a "black box" where the requirements are given at the interface to external connections. Clause 8.2.2 of ES 201 168 [8] addresses system specific handsets (i.e. no telephones connected to an L interface) with the SLR and RLR values referred to the PBX digital test point.

However, the requirements are related. The overall objective is that of providing satisfactory end-to-end transmission quality for nearly every call via all categories of external connection. The TIA requirements are designed to optimize the loudness levels at each such connection interface regardless of the terminal loudness values. With respect to ETSI requirements, it would be expected that the supplier-specified loudness values of a system-specific handset, together with the supplier-specified port-to-port loss for each PBX connection involving that handset, will be such that the resulting system interface levels are optimized for end-to-end transmission performance.

Table 5: Interface acoustic reference values for PBX (see note 1)

PBX Interface	Port designation	SLR (dB)			RLR (dB)			ERL(A) (dB)
		min.	nom.	max.	min.	nom.	max.	
On-premises line (from ONS port - note 2)	ONS	9	14	19	-5	0	5	N/A
On-premises line (from ICS port - note 2)	ONS	12	17	25	-2	3	8	N/A
ISDN - compatible line (including DAL)	ICS	3	11	19	-8	0	5	N/A
Off-premises line	OPS	6	11	19	-8	-3	2	N/A
Analog tie trunk	ATT	6	11	19	-8	-3	2	18
Digital tie trunk (note 3)	ISD/TT	6	11	19	-2	3	8	24
Analog Access Line; analog interface	AAL(A)	3	8	16	-11	-6	-1	12
Analog Access Line; digital interface (note 4)	AAL(D)	6	11	19	-8	-3	2	18
Analog to trunk	A/TO	9	14	22	-5	0	5	24
Satellite tie trunk	S/ATT, S/DTT	6	11	19	-8	-3	2	18
Integrated services trunk	IST	6	11	19	-5	0	5	21

NOTE 1: The values in this table pertain to connections between the designated interface and an ONS or ICS port. Tolerances on RLR and on ONS port SLR are assumed to be ±5,0 dB; to be compatible with the SLR tolerance range for ISDN terminals in (Ref. 3), the maximum SLR values in this table are extended to nominal +8 dB. For this reason, the SLR ranges for the two ONS cases (first two rows) are dissimilar.
NOTE 2: For an ONS interface, the ARLP values differ between connection to another ONS port or to an ICS port; reflecting the intent to align ICS connections to equivalent loudness on intra-PBX connections.
NOTE 3: For connections from ICS to ISD/TT, RLR values are -5 dB, 0 dB and 5 dB, respectively.
NOTE 4: The ARLP value for the AAL(D) interface is such that it conforms to the criteria for analog access lines in Ref. 8; thus, for AAL(D) connections to the PSTN, a DEO inserts the required public network loss (e.g. 6 dB receive-side loss for connections to a digital tandem connecting trunk).

5.4 Other impairment parameters

5.4.1 Intermodulation distortion

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td colspan="3">6.6.1 Intermodulation distortion
Table 29 Intermodulation distortion limits</td><td>Requirements not given.</td></tr>
<tr><td rowspan="2">Connection interface categories</td><td colspan="2">Distortion limits (dB below received level)</td><td rowspan="6"></td></tr>
<tr><td>(R2)</td><td>(R3)</td></tr>
<tr><td>Up to 4,8 kb/s data</td><td>39</td><td>51</td></tr>
<tr><td>Up to 9,6 kb/s data</td><td>46</td><td>56</td></tr>
<tr><td colspan="3">Conditions:
Intermodulation is measured using four-tone method that employs two pairs of equal-level tones transmitted at a total, composite power level of -13 dBm. One pair at 857 Hz and 863 Hz, the second pair at 1 372 Hz and 1 388 Hz. Intermodulation distortion is measured as the second-order (R2) and third-order (R3) products resulting from the application of the four tones.</td></tr>
<tr><td colspan="3">R2 is the average power level in the 503 Hz to 537 Hz and 2 223 Hz to 2 257 Hz frequency bands, expressed in dB below the received power level in the 1 877 Hz to 1 923 Hz frequency bands, expressed in dB below the received power level.</td></tr>
<tr><td colspan="3">R3 is the total power level in the 1 877 Hz to 1 923 Hz frequency bands, expressed in dB below the received power level.</td></tr>
</table>

Analysis: Comparison not applicable. Intermodulation or harmonic distortion is caused by non-linearity present in the electric-to-electric transfer function of the PBX. This form of distortion is of primary concern to the transmission of data. ITU-T Recommendation G.712 [3] Recommendation noted that the intermodulation distortion are in practice always met if the requirements according to total distortion including quantization distortion and variation of gain with input level are met. In ETSI this requirements omitted due to these issues in the ITU-T Recommendation.

5.4.2 Group delay distortion

<table>
<tr><th colspan="3">ANSI/TIA-464-C</th><th>ES 201 168</th></tr>
<tr><td colspan="3">6.6.2.2 Relative Envelope Delay (RED)
Figure 58 Relative envelope delay vs. frequency</td><td>5.3 Group delay distortion</td></tr>
<tr><td colspan="3">For station-to-trunk and trunk-to-trunk interface the Relative Envelope Delay (RED) shall lie below the following values:</td><td rowspan="4">No requirements.</td></tr>
<tr><td>Frequency (Hz)</td><td>Mandatory RED (µs)</td><td>Desirable RED (µs)</td></tr>
<tr><td>500
800
1 000
1 150
2 300
2 500
2 700
3 000</td><td>-
375
190
150
150
190
375
-</td><td>300
150
75
75
75
75
150
300</td></tr>
<tr><td colspan="3">For station-to-station twice the RED values are permitted.</td></tr>
<tr><td colspan="3">Conditions:
For each connection category, 95 % of connections shall meet the above requirements. The test signal is a carrier 50 % amplitude modulated with a sinusoidal frequency of 83,3 Hz.</td><td></td></tr>
</table>

Analysis: In ETSI group delay distortion is considered as an impairment mainly to non-voice or data transmission. Since ES 201 168 [8] does not apply to services other than 3,1 kHz voice telephony (see clause 1), requirements for this parameter are not included.

5.4.3 Impulse noise

ANSI/TIA-464-C	ES 201 168
6.6.3 Impulse noise	No requirements for impulse noise.
On 95 % or more of all connections through each connection category, the impulse noise level shall not exceed zero counts above a threshold of 55 dBmC in a measurement interval of 5 minutes. It is desirable not to exceed a noise level of 47 dBmC.	
Conditions: Impulse noise limits shall be met under fully loaded busy-hour PBX traffic condition.	

Analysis: In ETSI group impulse noise is considered as an impairment mainly to non-voice or data transmission. Since ES 201 168 [8] does not apply to services other than 3,1 kHz voice telephony (see clause 1), requirements for this parameter are not contained in not included.

5.4.4 Jitter

ANSI/TIA-464-C	ES 201 168
6.6.4 Jitter	No requirements for jitter.
Jitter on a port-to-port connection shall not exceed 2 degrees within the 4 Hz to 300 Hz frequency band.	

Analysis: Comparison not applicable. In Europe the jitter is considered as a parameter, which may cause harm to the (public) network. Since ETSI, as a general rule, is specifying those parameters in separate "access requirements", these requirements are not part of ES 201 168. They are contained in TBRs and ENs or, part of national regulation.

5.4.5 Gain hit

ANSI/TIA-464-C	ES 201 168
6.6.5 Gain hit	No requirements for gain hit.
No more than one gain hit per hour at a threshold level of 3 dB. If there is more than one gain hit in a period of 1 hour, the subsequent hour shall have zero hits.	
Conditions: A gain hit is an incidental modulation resulting in a rapid positive or negative shift of signal gain lasting for a period of at least 4 ms.	

Analysis: Comparison not applicable.

5.4.6 Phase hit

ANSI/TIA-464-C	ES 201 168
6.6.6 Phase hit	No requirements for phase hit.
No more than one gain hit per hour exceeding a threshold of 20 degrees. If there is more than one phase hit in a period of 1 hour, the subsequent hour shall have zero hits.	
Conditions: A phase hit is an incidental modulation resulting in a rapid positive or negative shift of signal phase lasting for a period of at least 4 ms.	

Analysis: Comparison not applicable.

5.4.7 Dropout

ANSI/TIA-464-C	ES 201 168
6.6.7 Dropout	No requirements for dropout.
No more than one dropout per hour exceeding a threshold of 6 dB. If there is more than one dropout in a period of 1 hour, the subsequent hour shall have zero dropouts. Conditions: A dropout is a negative gain hit lasting a period of at least 10 ms.	

Analysis: Comparison not applicable.

Annex A (informative): Bibliography

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

ANSI/TIA-470.110-C: "Telecommunications - Telephone Terminal Equipment - Handset Acoustic Performance Requirements".

ANSI/TIA/EIA-810-A: "Telecommunications - Telephone Terminal Equipment-Transmission Requirements for Narrowband".

History

Document history		
V1.1.2	September 2004	Membership Approval Procedure MV 20041119: 2004-09-21 to 2004-11-19