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Foreword

This ETSI Technical Report (ETR) has been produced by the Business TeleCommunications (BTC) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

This ETR provides background information on the development of the standards defining the Open Network Provision (ONP) minimum set of leased lines.

The minimum set of leased lines includes the 2 048 kbit/s structured and unstructured leased lines, the 64 kbit/s leased lines and the 2 and 4 wire ordinary and special quality leased lines.

These leased line standards resulted from a mandate from the Commission of the European Union to provide harmonised standards for the support of the Directive on Open Network Provision of leased lines (92/44/EEC).

Introduction

The Council Directive on the application of Open Network Provision (ONP) to leased lines (92/44/EEC), (the "Directive"), concerns the harmonisation of conditions for open and efficient access to, and use of, the leased lines provided to users on public telecommunications networks and the availability throughout the European Union of a minimum set of leased lines with harmonised technical characteristics.

The consequence of the Directive is that telecommunications organisations within the European Union shall make available to users a set of leased lines between points in these countries with uniform connection characteristics, presented to the user at specified interfaces. Under the Second Phase Directive (91/263/EEC), terminal equipment for connection to these leased lines will be required to fulfil certain essential requirements.

Other countries outside the European Union may also choose to provide leased lines according to the standards produced to support the Directive.

A set of technical standards have been produced by the BTC Technical Committee in support of the Directive. ETSI standards and CCITT Recommendations have been used as the basis for the standards which have been developed. These standards covering both analogue and digital leased lines.

The purpose of this ETR is to provide background information to telecommunications organisations, manufacturers, and private telecommunication network operators (users) on the choice of technical characteristics of both analogue and digital leased lines included as part of the minimum set.

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1 Scope

This ETR is intended to provide information which will help in the understanding of the "minimum set" of leased lines under the Open Network Provision (ONP) Leased Line Directive 92/44/EEC and the reasons behind the inclusion of particular parameters within the leased line standards.

This ETR is not intended to, and should not be used to, impose additional requirements on the leased line providers and terminal equipment manufactures. Where examples are given of possible implementations, these should not be taken as being the only implementations possible within the definition of the leased line standards.

It is not intended that this ETR should contain all the information on the technical characteristics of the leased lines standards themselves, however, summaries of the main requirements contained within the leased line standards are tabulated, for information only, within this ETR.

Clause 4 presents an overview of the ONP concept applied to leased lines and lists the types of leased lines included within the minimum set. This includes an explanation of the terminology necessary to understand how public telecommunications networks present leased lines to users.

Clause 5 describes a method of classification of telecommunications facilities which has been used to classify the leased lines (the attribute technique). The classification makes it easy and coherent for users to compare the different properties of the various leased line types.

Following this comparison, in clauses 6 and 7 this ETR presents background information on the choice of the parameters.

2 References

This ETR incorporates by dated and undated reference, provisions from other publications. These references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETR only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] 73/23/EEC: "Council Directive of 19 February 1973 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits".

[2] 89/336/EEC: "Council Directive of 3 May 1989 on the approximation of the laws of Member States relating to electromagnetic compatibility".

[3] 90/387/EEC: "Council Directive of 28 June 1990 on the establishment of the internal market for telecommunications services through the implementation of the open network provision".

[4] 91/263/EEC: "Council Directive of 29 April 1991 on the approximation of the laws of Member States concerning telecommunications terminal equipment, including the mutual recognition of their conformity".

[5] 92/44/EEC: "Council Directive of 5 June 1992 on the application of Open Network Provision to leased lines".

[6] CCITT Recommendation G.114 (1988): "Mean one-way propagation time".

[7] CCITT Recommendation G.122 (1988): "Influence of national systems on stability, talker echo, and listener echo in international connections".

[8] CCITT Recommendation M.1020 (1988): "Characteristics of Special Quality International Leased Circuits with Special Bandwidth Conditioning".

[9] CCITT Recommendation M.1040 (1988): "Characteristics of Ordinary Quality International Leased Circuits".

[10] CCITT Recommendation O.132 (1988): "Quantizing distortion measuring equipment using a sinusoidal test signal".

[11] CCITT Recommendation O.41 (1988): "Psophometer for use on telephone-type circuits".

[12] CCITT Recommendation O.71 (1988): "Impulsive noise measuring equipment for telephone-type circuits".

[13] CCITT Recommendation O.81 (1988): "Group-delay measuring equipment for telephone-type circuits".

[14] CCITT Recommendation O.91 (1988): "Phase jitter measuring equipment for telephone-type circuits".

[15] CCITT Recommendation O.95 (1988): "Phase and amplitude hit counters for telephone-type circuits".

[16] CCITT Recommendation V.2 (1988): "Power levels for data transmission over telephone lines".

[17] EN 28877 (1989): "Information processing systems - Interface connector and contact assignments for ISDN basic access interface located at reference points S and T".

[18] EN 60950 (1992): "Safety of information technology equipment including electrical business equipment".

[19] ETS 300 011 (1992): "Integrated Services Digital Network (ISDN); primary rate user-network interface, Layer 1 specification and test principles".

[20] IEC 603-7: "Connectors for frequencies below 3 MHz for use with printed circuit boards - Part 7: Detailed specification for connectors, 8-way, including fixed and free connectors with common mating features".

[21] ISO/IEC 10173 (1991): "Information technology - Integrated Services Digital Network (ISDN) primary access connector at reference points S and T".

[22] ITU-T Recommendation G.703 (1991): "Physical/electrical characteristics of hierarchical digital interfaces".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETR, the following definitions apply:

Background Block Error (BBE): An errored block not occurring as part of a severely errored second.

Background Block Error Ratio (BBER): The ratio of errored blocks to total blocks during a fixed measurement interval excluding all blocks during severely errored seconds and while the leased line is in the unavailable state.

block: For the 2 048 kbit/s leased lines, a block is a set of 2 048 consecutive bits. The length of each block corresponds to a period of 1 millisecond.

errored block: A block in which one or more bits are in error.

Errored Second (ES): A one-second period with one or more errored blocks.

Errored Seconds Ratio (ESR): The ratio of errored seconds to total seconds during a fixed measurement interval. The errored seconds ratio is not evaluated while the leased line connection is in the unavailable state.

errored sub-multiframe: For D2048S, this is a sub-multiframe where the calculated CRC-4 does not correspond with the CRC-4 contained within the next sub-multiframe.

frame: For D2048S, this is a sequence of 256 bits of which the first 8 bits define the frame structure.

frame slip: For D2048S, this is a slip of one complete frame.

group delay: A measure of the propagation time through the leased line. For a given frequency it is equal to the first derivative of the phase shift through the leased line, measured in radians, with respect to the angular frequency measured in radians per second.

group delay distortion: The difference between group delay at a given frequency and minimum group delay, in the frequency band of interest.

leased lines: The telecommunications facilities provided by a public telecommunications network that provide defined transmission characteristics between network termination points and that do not include switching functions that the user can control, (e.g. on-demand switching).

multiframe: For D2048S, this is a sequence of two sub-multiframes containing the multiframe alignment word.

Network Termination Point (NTP): All physical connections and their technical access specifications which form part of the public telecommunications network and are necessary for access to and efficient communication through that public network.

sa bits: For D2048S, this is bits 4 to 8 (bits Sa4 to Sa8) in frames not containing the frame alignment signal.

Safety Extra-Low Voltage (SELV) circuit: A secondary circuit which is so designed and protected that under normal and single fault conditions the voltage between any two accessible parts, or between one accessible part and the equipment protective earthing terminal for a class I equipment, does not exceed a safe value, (subclause 1.2.8.5 EN 60950).

satellite transmission: Transmission via an earth orbiting satellite.

severely disturbed period: For out of service measurements, a severely disturbed period occurs when, over a period of time equivalent to four contiguous blocks, either all the contiguous blocks are affected by a high bit error density of ≥ 10-2, or a loss of signal is observed. For in-service monitoring purposes, a severely disturbed period is estimated by the occurrence of loss of signal or loss of frame alignment.

Severely Errored Second (SES): For D2048S leased lines, a one-second period which contains ≥ 805 errored blocks or at least one severely disturbed period.

Severely Errored Second (SES): For D2048U leased lines, a one-second period which contains ≥ 30 % errored blocks or at least one severely disturbed period.

Severely Errored Second (SES): For D64U leased lines, a one-second period where at least 0,1 % of the bits are errored.

Severely Errored Seconds Ratio (SESR): The ratio of severely errored seconds to total seconds during a fixed measurement interval. The severely errored seconds ratio is not evaluated while the leased line connection is in the unavailable state.

slip: A sequence of one or more extra or missing consecutive unit intervals in the bit stream.

Sub-Multiframe (SMF): For D2048S, a sequence of 8 frames, each of 256 bits, over which the CRC-4 is calculated.

terminal equipment: Equipment intended to be connected to the public telecommunications network; i.e.:

- to be connected directly to the termination of a public telecommunication network; or

- to interwork with a public telecommunications network being connected directly or indirectly to the termination of a public telecommunications network,

in order to send, process, or receive information. The system of connection may be wire, radio, optical, or other electromagnetic system.

unavailability period: An unavailability period begins at the onset of 10 consecutive severely errored seconds. These 10 seconds are considered to be part of the unavailability period. The unavailability period ends at the onset of 10 consecutive non-severely errored seconds. These 10 seconds are not considered part of the unavailability period.

unavailable state: The leased line connection is in the unavailable state if an unavailability period is occurring in one or both directions of transmission.

voice bandwidth: The band of frequencies over the range 300 Hz to 3 400 Hz.

3.2 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

A20	Analogue 2-wire Ordinary quality voice bandwidth ONP leased line
A2S	Analogue 2-wire Special quality voice bandwidth ONP leased line
A4O	Analogue 4-wire Ordinary quality voice bandwidth ONP leased line
A4S	Analogue 4-wire Special quality voice bandwidth ONP leased line
ADPCM	Adaptive Differential Pulse Code Modulation
AIS	Alarm Indication Signal
AMI	Alternate Mark Inversion
BBE	Background Block Error
BBER	Background Block Error Ratio
BIS	Bringing Into Service
CMI	Coded Mark Inversion
CRC-4	Cyclic Redundancy Check (4 bit)
CTR	Common Technical Regulation
D2048S	Digital 2 048 kbit/s Structured ONP leased line
D2048U	Digital 2 048 kbit/s Unstructured ONP leased line
D64U	Digital 64 kbit/s Unrestricted ONP leased line with octet integrity
DTMF	Dual Tone Multi-Frequency
EMC	ElectroMagnetic Compatibility
ES	Errored Second
ESR	Errored Seconds Ratio
FDM	Frequency Division Multiplexing
HDB3	High Density Bipolar code 3
ISDN	Integrated Services Digital Network
LOF	Loss Of Frame
LOS	Loss Of Signal
NTP	Network Termination Point
NTU	Network Termination Unit
ONP	Open Network Provision
PABX	Private Automatic Branch eXchange
PCM	Pulse Code Modulation
ppm	parts per million
PRBS	Pseudo Random Bit Sequence
PSTN	Public Switched Telephone Network
PTNX	Private Telecommunications Network eXchange
QDU	Quantizing Distortion Unit
rms	root mean square

RPO	Reference Performance Objective
SELV	Safety Extra-Low Voltage
SES	Severely Errored Second
SESR	Severely Errored Seconds Ratio
SLR	Sending Loudness Rating
SMF	Sub-MultiFrame
TNV	Telecommunications Network Voltage
TO	Telecommunications Organisation
UI	Unit Interval

4 Open Network Provision and leased lines

4.1 The ONP concept and its application to leased lines

Open Network Provision (ONP) is a regulatory concept introduced by the Commission of the European Communities. It is intended to ensure "harmonised conditions for open and efficient access to and use of public telecommunications networks and, where applicable, public telecommunications services." In particular, ONP specifies a set of harmonised conditions called the "ONP conditions". These govern the technical interfaces (including the definition of network termination points), conditions of use, and tariff principles of the network or service to which they are applied.

The general principles of ONP are contained in Council Directive 90/387/EEC, the "ONP Framework Directive". These principles are applied to a number of areas of telecommunications, including leased lines. Leased lines are specifically covered by Council Directive, 92/44/EEC, the "ONP Leased Line Directive".

The ONP Leased Line Directive calls upon Member States to ensure that the respective Telecommunications Organisations (TO) provide a minimum set of leased line types, defined in annex II of the Directive by means of compliance with ITU-T Recommendations. These leased line types, together with the acronyms by which they are denoted, are:

- Ordinary quality voice bandwidth analogue, 2 and 4 wire (A2O and A4O respectively);
- Special quality voice bandwidth analogue, 2 and 4 wire (A2S and A4S respectively);
- 64 kbit/s digital unrestricted with octet integrity (D64U);
- 2 048 kbit/s digital unstructured (D2048U);
- 2 048 kbit/s digital structured (D2048S).

The provision of this minimum set of leased line types is not intended to preclude TOs from offering other types of leased line for which there is market demand. The intention of the Directive is to ensure the common availability of a minimum set of leased line types throughout the European Union.

On the instructions of the Council, a number of European Telecommunication Standards (ETSs) have been produced to more accurately and consistently define the minimum set of leased lines.

4.2 Structure of the leased line standards

The leased line standards produced by ETSI have been based on a generic model for leased lines, shown in figure 1.

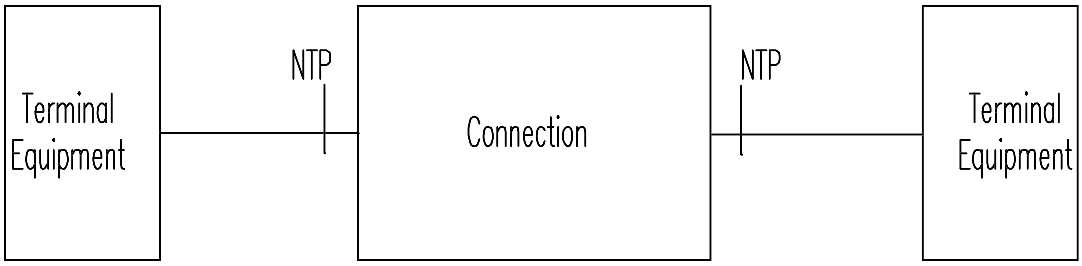

Figure 1: Generic model for leased lines

The central part of the model is the "connection". A connection may include some, or all of a series of transmission channels or telecommunication circuits, switching capabilities, and other functional units. It is set up to provide for the transfer of signals between two Network Termination Points (NTPs) in a public telecommunications network, to support one or more communications between terminal equipments.

The connection is presented to the user via an "interface presentation" at the NTPs. The NTP comprises all physical connections and their technical access specifications that form part of the public telecommunications network and that are necessary for access to and efficient communication through that network. The NTP may, or may not, be presented by means of, or coincident with, an electrical equipment referred to as the Network Termination Unit (NTU). For the purpose of this model, the NTU (where it exists) is contained within the connection.

The NTP is also the point at which terminal equipment is attached to the leased line. In this context terminal equipment is equipment intended to be connected to the public telecommunications network, both connected directly and indirectly.

The approach that has been taken with the set of ETSs for leased lines is illustrated in figure 2.

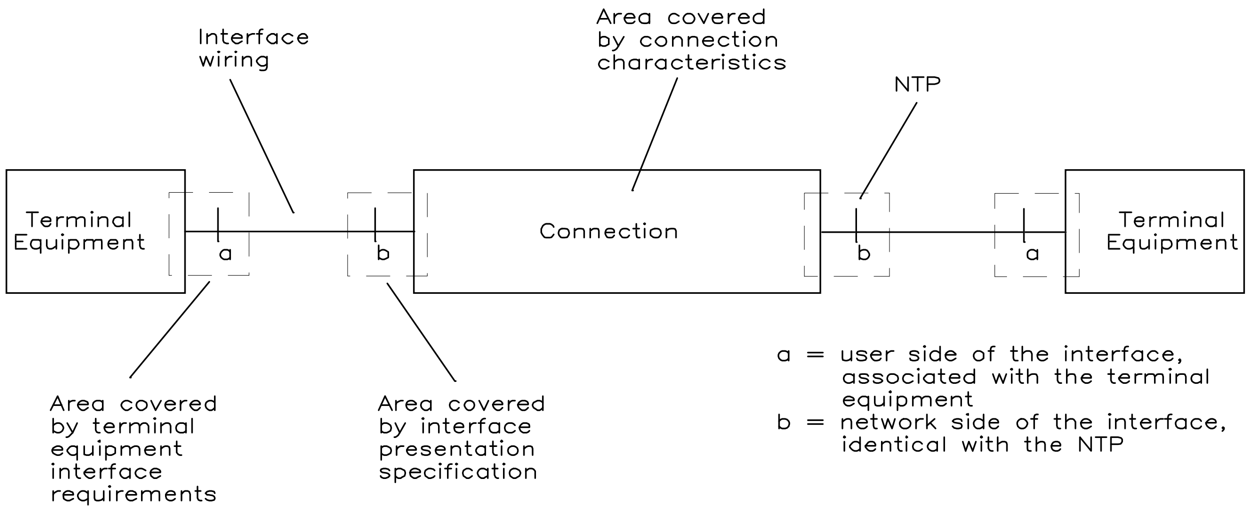

Figure 2: Approach to leased line ETSs

This approach has led to the production of two different types of standards: the first defining the functionality of the leased lines, the second defining the functionality of the terminal equipment.

The interface wiring between the two interface points (a and b) is left unspecified except to the extent necessary to specify the functional performance of the terminal equipment and the NTP.

The functionality of the leased lines can be defined by:

- the characteristics of the connection, defining the performance of the leased line; and

- the characteristics of the interface, describes the requirements applying at the network end when viewed from outside the network.

For the digital leased lines these two aspects are covered in separate ETSs, i.e. two ETSs for each leased line type. The separation of connection characteristics from the interface presentation facilitates the provision of a particular connection type over evolving networks. In the future a new leased line type with the same connection characteristics but with a different interface presentation can be specified. Together, the ETSs for interface presentation and connection characteristics contain the harmonised technical characteristics of the leased lines as required by the ONP Leased Line Directive.

For the analogue leased lines, however, the connection characteristics and the interface presentation are covered by a single ETS which defines the harmonised technical characteristics of the leased lines as required by the ONP Leased Line Directive. Two separate ETSs could not be produced due to the close relationship between the connection characteristics and the interface presentation of analogue leased lines.

These leased line ETSs take into account the need for leased lines to satisfy a number of essential requirements specified by the Directive. These essential requirements are intended to meet two objectives. Firstly, they should to place no technical restrictions on the interconnection of leased lines among each other nor on the interconnection of leased lines and public telecommunications networks. Secondly, they should allow, within the user capacity or payload, a fully transparent service that the user can employ in an unstructured manner as he wishes, e.g. where no channel allocations are forbidden or prescribed.

In all cases, the ETSs defining the leased lines are used, or will be used, under the Directive.

The complete set of leased line standards produced by ETSI in support of the ONP Leased Line Directive and which are the subject of this ETR, are listed in annex A.

4.2.1 Terminal equipment standards

In addition to the specific leased line standards, ETSI has produced, for each leased line type, a terminal equipment ETS and a Technical Basis for Regulation (TBR).

The terminal equipment ETS defines the necessary functionality for the terminal equipment to interwork with the leased line and the far end terminal equipment in order to interchange data. The ETSs for terminal interface requirements are voluntary but manufacturers of terminal equipment are expected to apply these standards to their terminal equipment designs.

The TBR is a subset of the ETS and defines the harmonised attachment requirements for each terminal equipment interface in accordance with the "essential requirements" defined in article 4 of the "Second Phase Directive" (91/263/EEC). The TBRs form the basis of the Common Technical Requirement (CTR) defined within 91/263/EEC and are legally binding on terminal equipment manufacturers under the terms of the Directive.

While article 4 of 91/263/EEC defines the full set of essential requirements in paragraphs 4(a) to 4(g), the TBR is restricted to satisfying the requirements of articles 4(d) - prevention of harm to the network and 4(f) - interworking with the network for the purpose of establishing, clearing, transferring and charging for calls. Articles 4(a) and 4(b) are covered by separate Directives, article 4(c) by the EMC Directive, article 4(e) is not applicable and neither is 4(g) since these are access TBRs which exclude the specification of particular services such as the justified case of voice telephony.

The complete set of terminal equipment standards, both ETSs and TBRs are listed in annex A.

5 Classification of leased lines

5.1 The CCITT attribute technique

The description of the characteristics of a connection by its attributes was first introduced for the ISDN in CCITT Recommendations I.140 and I.340. It has been modified and used in the ETSs for leased lines in order to describe the characteristics of the leased lines connection types.

The purpose of the method is to describe objects in a structured, simple manner, and to highlight the important aspects of the object. These important aspects are termed attributes. Each attribute is independent of the others. To describe a particular object the attributes are assigned values. Each attribute takes one of a set of pre-defined values.

This subclause lists the attributes that have been used to describe the leased lines. Some attributes are common for all the leased lines; for example, all leased lines are permanent, bi-directional, symmetric, point-to-point. Attributes not relevant for leased lines have not been included.

The complete list of attributes for leased lines is given in table 1. Table 2 summarises the interface specifications for the digital leased lines and terminal equipment. Note that the interfaces of the leased line are, in general, "reciprocal", i.e. the parameters are specified identically for the leased line interface and the terminal equipment interface. Tables 3 and 4 summarise the parameters defining the leased line and terminal equipment respectively.

In all cases, these tables are only summaries of the requirements; reference should be made to the applicable standard to determine the complete requirement.

Table 1: Attributes of connection types

Attribute	D64U	D2048U	D2048S	A2O	A2S	A4O	A4S
Information transfer rate	64 kbit/s Codirectional (network synchronous)	2 048 kbit/s ± 50 ppm (user timing)	2 048 kbit/s (user timing ± 50 ppm or network synchronous)	voice bandwidth (nominally 300 Hz to 3 400 Hz)			
Information transfer susceptance	Unrestricted digital information			Not applicable			
Structure	Unrestricted (octet integrity)	Unstructured	Structured (frame integrity)	Unstructured			
Transmission delay - terrestrial - satellite	10 ms + 10 ms / 1 000 km < 350 ms			15 ms+ 10 ms / 1 000 km < 350 ms			
Jitter	Input jitter tolerance and maximum output jitter are defined for all digital leased lines. Due to the nature of the specifications it is not possible to summarise the parameters in this table.						
Slips per 24 hours	< 5	< 5	≤ 5				
Errors / 24 h (terrestrial)							
- ES	< 5 324	< 2 889	< 1 645				
- SES	< 105	< 117	< 68				
- errored milliseconds	Not applicable	< 22 395	< 12 732				
Errors / 24 h (satellite)							
- ES	< 5 324	< 2 889	< 2 592				
- SES	< 105	< 117	< 112				
- errored milliseconds	Not applicable	< 22 395	< 19 933				
Reference connections			Informative annex				
Availability			Informative annex	Informative annex			

Table 2: Parameters defining the digital leased line interface and terminal equipment interface

	D64U	D2048U	D2048S
Interface	120 ohms balanced pair		
Connection	Hardwired (see note)		
Impedance towards ground	1 000 ohms for input and output		
Input return loss	Specified for 4 kHz to 384 kHz	Specified for 51 kHz to 3 072 kHz	
Input loss tolerance	3 dB	6 dB	
Immunity against reflections	Immunity to 20 dB reflections	Immunity to 18 dB reflections	
Longitudinal voltage immunity	Unspecified	Immunity to 2 volts rms	
Longitudinal conversion loss	Specified for input and output	Unspecified	
Output return loss	Unspecified		
Safety	SELV		
Touch current	≤ 0,25 mA		
Surges	10 impulses at 1 kV (1,2/50µs) common mode 10 impulses at 250V (1,2/50µs) transverse mode		
Mains simulation	10 impulses at 2,5 kV (10/700µs) common mode 10 impulses at 2,5 kV (10/700µs) transverse mode		
Impulse transfer	2,5 kV (10/700µs) common mode 2,5 kV (10/700µs) transverse mode		
Conversion of common mode to transverse mode	2 impulses at 1 kV (1,2/50µs)		
NOTE: Initially a connector to ISO 10173 was specified in some standards, however since this was impossible to obtain the standards were modified to allow hardwired connection.			

Table 3: Parameters defining analogue leased lines

Requirement	A20	A2S	A4O	A4S
Connection characteristics				
Overall loss	0 to 25 dB at 1 020 Hz	0 to 17 dB at 1 020 Hz	0 to 21 dB at 1 020 Hz	0 to 13 dB at 1 020 Hz
Loss/frequency distortion	Fig 1/M.1040 increased range up to 3,6 kHz	Fig 1/M.1020 increased range up to 3,6 kHz	Fig 1/M.1040 increased range up to 3,6 kHz	Fig 1/M.1020 increased range up to 3,6 kHz
Maximum mean input power	-9 dBm		-13 dBm	
Maximum instantaneous power	+4 dBm		0 dBm	
Transmission delay - terrestrial - satellite	 < 15 ms + 10 ms / 1000 km < 350 ms			
Group delay distortion	No requirement	Fig 2/M.1020	No requirement	Fig 2/M.1020
Amplitude hits	No requirement	≤ 10 hits in 15 minute period	No requirement	≤ 10 hits in 15 minute period
Other variations	< ±4 dB within the nominal overall loss figures at 1 020 Hz			
Random circuit noise	< -41 dBm0p			
Impulsive noise	No requirement	≤ 18 peaks in 15 minutes ≥ -21 dBm0	No requirement	≤ 18 peaks in 15 minutes ≥ -21 dBm0
Phase jitter	No requirement	≤ 10° pk-to-pk	No requirement	≤ 10° pk-to-pk
Quantisation distortion	≤ 7.5 QDU ≤ 1 ADPCM	≤ 3 QDU no ADPCM	≤ 7.5 QDU ≤ 1 ADPCM	≤ 3 QDU no ADPCM
Total distortion	No requirement	>28 dB signal to distortion ratio	No requirement	>28 dB signal to distortion ratio
Single tone interference	No requirement	≤ -44 dBm0	No requirement	≤ -44 dBm0
Frequency error	No requirement	≤ ± 5 Hz	No requirement	≤ ± 5 Hz
Harmonic distortion	No requirement	≥ 25 dB below fundamental	No requirement	≥ 25 dB below fundamental
Echo control devices	No echo control devices		Not applicable to 4 wire lines	
Talker echo	> 10 dB		Not applicable to 4 wire lines	
Listener echo	> 20 dB		Not applicable to 4 wire lines	
Stability	Stable over 0 Hz to 4 kHz		Not applicable to 4 wire lines	
Network interface presentation				
Connector	EN 28877			
Hardwired	Documented within the standards			
Return loss (see note)	> 6 dB against 270 Ω + 750 Ω // 150 nF		> 6 dB against 600 Ω	
Power feeding	Not allowed in either direction			
Safety	TNV circuit			
Overvoltage protection	General national practice			
ElectroMagnetic Compatibility	No requirement			
NOTE: A weighted return loss measurement is allowed if the limit of 6 dB is not met at all frequencies.				

Table 4: Parameters defining the 2 and 4-wire analogue terminal equipment interface

Requirement	2-wire	4-wire
Connector	EN 28877	EN 28877
Return loss	≥ 8 dB against 270 Ω + 750 Ω // 150 nF	≥ 8 dB against 600 Ω
Longitudinal conversion loss	50 Hz to 300 Hz ≥ 40 dB 300 Hz to 3 400 Hz ≥ 46 dB	
Sending loudness rating	≥ -5 dB	≥ -1 dB
Maximum mean power	≤ -9 dBm	≤ -13 dBm
Maximum instantaneous voltage	≤ 2,0 volts	≤ 1,1 volts
Maximum power in a 10 Hz bandwidth	Defined from 0 Hz to 4 300 Hz	
Equipment with an electrical input	No requirement	
Maximum sending power above 4,3 kHz	Defined from 4 300 Hz to 2 MHz	
Power feeding	Not allowed in either direction	
Safety	TNV circuit	
ElectroMagnetic Compatibility	No requirement	

6 Digital leased lines

6.1 Connection characteristics

The following subclauses give details of the specific requirement for the connections.

6.1.1 Information transfer rate

6.1.1.1 Information transfer rate (64 kbit/s)

The 64 kbit/s leased line employs the timing option of ITU-T Recommendation G.703 known as codirectional timing. That is, the timing information from the network to the terminal equipment is provided within the data stream to the terminal equipment. Since the network provides the timing information, the transfer of information is at a nominal rate of 64 kbit/s synchronous to the network. While ITU-T Recommendation G.703 specifies a tolerance of ± 100 ppm on the bit rate, the tolerance of the signal provided by the network will, in normal operating conditions, be significantly better than this.

6.1.1.2 Information transfer rate (2 048 kbit/s unstructured)

The 2 048 kbit/s unstructured leased line is capable of carrying timing provided by the user (i.e. from the terminal equipment) within the limits of 2 048 kbit/s ± 50 ppm as specified in ITU-T Recommendation G.703. While the leased line is capable of carrying different timing in each direction (within these limits), most user applications would generally need the timing in each direction to be the same in order to avoid slips within the terminal equipment.

6.1.1.3 Information transfer rate (2 048 kbit/s structured)

During the production of the D2048S standards, the specification of a single timing implementation was attempted; however, due to the diversity of existing networks this did not prove feasible. As such, it was necessary to include possible three timing specifications for the D2048S leased line connection. The leased line shall either:

a) be capable of carrying user timing in both directions over the range 2 048 kbit/s ± 50 ppm; or

b) provide timing that is synchronous to the network timing (referred to as network timing); this is timing that is derived from the source or sources of timing that are used for the network and will be similar to that provided by other digital services. (Network timing is timing that is derived from the source or sources of timing that are used for the network. Thus the timing provided by the leased line will be similar to that provided by other digital services.)

c) take user timing within the range 2 048 kbit/s ± 50 ppm from one input and provide this timing at both outputs of the leased line.

In these three cases, the terminal equipments at either end of the leased line may need to be configured differently in order to establish synchronous data transfer and, if required, synchronous operation.

The particular timing mechanism is specified by the leased line provider and cannot be specified by the leased line user, i.e. there is no obligation on the leased line provider to implement more than one timing mechanism. Note, therefore, that when one network operator offers leased lines that carry user timing and another network operator offers leased lines that are synchronous to the network, a leased line between these two networks will be synchronised to the network and hence the output at each end will carry network timing, not user timing.

6.1.2 Information transfer susceptance

All the leased lines are capable of transferring unrestricted digital information within the part of the bit stream allocated to the user (i.e. the payload). For the D64U and D2048U leased lines, the full bandwidth is available to the user for the payload; for the D2048S leased line, a 1 984 kbit/s payload bandwidth is available. Within these bandwidths, there is no limitation on the bit patterns that the user may transmit. It should, however, be noted that in the case of the D2048S leased line, continued simulation by the user of the frame alignment signal and non-frame alignment signal may result in failure to achieve frame alignment.

6.1.3 Structure

6.1.3.1 Structure (64 kbit/s)

The 64 kbit/s leased line is capable of carrying unrestricted digital data but the coding method used, Coded Mark Inversion (CMI) separates the bits into groups of eight bits known as octets. This octet structure is maintained end-to-end across the leased line, giving the leased line octet integrity. This capability may be employed by the leased line user when it is necessary to identify an octet or byte structure within their data, for example digital speech (A-law or μ-law encoded) or computer data.

6.1.3.2 Structure (2 048 kbit/s unstructured)

There is no structure imposed on the 2 048 kbit/s unstructured leased line. The user terminal may employ whatever structure it requires.

6.1.3.3 Structure (2 048 kbit/s structured)

The 2 048 kbit/s structured leased line requires a structure based on ITU-T Recommendations G.704 and G.706. The bit stream is divided into frames of 256 bits each, eight of these frames form a sub-multiframe and sixteen frames (two sub-multiframes) form a multiframe. The first eight bits of the frame mark the frame structure. Within these eight bits are defined the CRC-4 bits, E-bits, A-bit and S_a-bits.

6.1.3.3.1 CRC-4 and E bits

The CRC-4 is provided within the frame structure in order that the leased line provider may monitor the transmission quality of individual sections while the leased line is in service. In order to separately monitor the performance of each section, especially when more than one network operator is involved, it is normally necessary that the CRC-4 at the start of each section corresponds to the user data. The CRC-4 may therefore be updated as necessary at the start of each section (e.g. within the Network Termination Unit (NTU)) and is not carried transparently end-to-end over the leased line. As such, the CRC-4 can have no significance on an end-to-end basis. This is illustrated in figure 3.

NOTE 1: If the user requires a valid CRC-4 on an end-to-end basis, then consideration should be given to the use of the unstructured leased line. It should be noted, however, that the leased line provider is unable to monitor the performance of the unstructured leased line using the CRC-4.

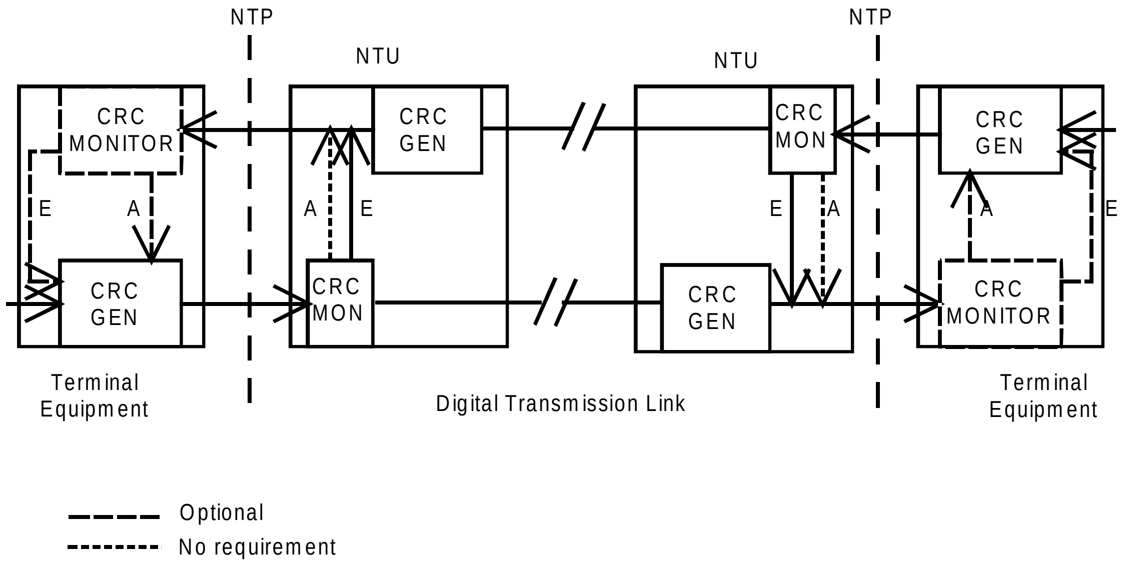

Figure 3: CRC-4 processing

For correct operation, the terminal equipment is required (by both the TE ETS and the TBR) to provide CRC-4 information in the data transmitted towards the leased line. The leased line is required to validate this CRC-4 and, in the event of an error being detected, will indicate this to the terminal equipment by setting one of the E-bits to zero for a period of one sub-multiframe. Thus, the receipt of an error signal by the terminal equipment, indicates that an error has occurred in the bit stream between the terminal equipment and the point at which the verification is performed (e.g. the NTU).

NOTE 2: The intent of the connection characteristics standard is that the verification should be performed within the NTU at the input of the leased line to effectively monitor the leased line performance. However, this cannot be included as a specific requirement since the definition of functionality within the network is outside the scope of the standard. Where the verification is not performed within the NTU but, for example, in the local exchange, it is not possible for either the user or the network operator to determine if the error occurred in the customer premise wiring or the access line to the local exchange.

Following the monitoring of the CRC-4 (e.g. in the NTU) the network equipment would normally be expected to regenerate the CRC-4 information, removing any indication to subsequent equipment that an error may have occurred in the previous section. Thus, subsequent network equipment and the far end terminal equipment will receive no indication that an error has occurred.

NOTE 3: It is also the intent of the connection characteristics standard that the NTU at the far end will update the CRC-4 to correspond with the data transmitted to the terminal equipment. Thus, when the terminal equipment receives an incorrect CRC-4 check, this indicates an error in the customer premises wiring and not within the network.

6.1.3.3.2 A-bit

No requirements were place on the leased line connection with regard to the use of the A-bit contained within timeslot zero (the first eight bits of the frame), since existing networks used the A-bit differently. It is not possible for many networks based on 64 kbit/s cross connect switches to transparently transmit the A-bit end-to-end since the complete frame signal is terminated within the network and the A-bit is used to indicate errors within particular sections.

There is, therefore, no requirement on the leased line provider to transparently transmit end-to-end the A-bit received from the terminal equipment, to transmit a defined value of the A-bit at the output of the leased line or to take specified action on receipt of particular values of the A-bit received at the input to the leased line.

6.1.3.3.3 S_a-bits

The S_a-bits contained within the frame alignment signal are for the specific use of the network operator or leased line provider. There is no requirement on the leased line for these to be transparently carried end-to-end and their status at the output of a leased line is undefined. Note that there is also no requirement for the terminal equipment to transmit a particular value of the S_a-bits; if a certain setting of the S_a-bits by the terminal equipment is likely to cause a disturbance within the network, then the network should protect itself against this, possibly within the NTU.

6.1.4 Establishment of connection

For all the digital leased lines types, there is no requirement for any protocol exchange or other intervention by the user to establish the leased line connection.

NOTE: An error in CCITT Recommendation I.140 previously caused this to be known as "Establishment of communication". This has been corrected in the ETS 300 419, but should be corrected at the next revision of ETS 300 247 and ETS 300 289.

6.1.5 Symmetry

All the digital leased line type are symmetrical, that is, the same nominal requirements apply in each direction of transmission. For example, a 2 048 kbit/s leased line cannot be structured in one direction of transmission and unstructured in the opposite direction or carry user timing in one direction but require network timing in the opposite direction.

6.1.6 Communication configuration

The communication configuration of all the leased line types included in the ONP minimum set is point-to-point. That is, each leased line has only two ends and all data transfer is between these two end points.

6.1.7 Delay

The connection delay is specified identically for the 64 kbit/s and 2 048 kbit/s leased lines at a figure of 10 ms + 10 µs/km for terrestrial links or up to 350 ms where satellites are involved in the transmission.

The specification for terrestrial links is derived from CCITT Recommendation G.114 which states that for purely digital networks the propagation time will probably not exceed 3 ms + 4 µs/km, based on one PCM coder or decoder and five digitally switched exchanges and coaxial cable systems. This has been increased in the ONP standards to take into account optical fibre systems (5 µs/km) and to allow delay specification in terms of the geographical distance rather than the routed distance which is unknown. This allows the leased line user to know what the maximum delay will be and also limits the maximum routed distance.

6.1.8 Jitter

Jitter is the phase modulation of the data pulses from an equipment which causes the data pulses to arrive either early or late, thus potentially generating transmission errors. The two main parameters used to characterise jitter are the amplitude of the phase modulation, expressed as a peak-to-peak deviation, and the frequency of the deviation. The jitter frequency is typically a combination of the different frequencies generated by the components and equipments involved.

CCITT Recommendation G.823 defines limits for jitter for specific equipments. These limits cover two specific aspects of jitter: maximum output jitter and input jitter tolerance.

The maximum output jitter is the jitter from an equipment under worse case input conditions. It is generally composed of jitter intrinsic to the equipment (intrinsic jitter) and jitter transferred from other inputs, e.g. other timing sources. It is generally possible to define a "jitter transfer function" which is the gain (or loss) in jitter between one input and an output; hence the jitter at the output is the sum of the intrinsic jitter and the product of the input jitter and the transfer function.

It is not, however, practical to use this method to describe the jitter performance of a leased line which is composed of a complex series of equipments. The jitter requirements for a leased line connection is, therefore, specified in terms of:

- input jitter level at which the leased line performance is not degraded beyond the specified performance; and

- a maximum output jitter in the presence of worse case input jitter.

The input jitter level is not necessarily specified at the levels stated in CCITT Recommendation G.823. Since CCITT Recommendation G.823 specifies the maximum jitter level that should occur within the network, if the NTU was required to accept this level of jitter, it would immediately have to perform a jitter reduction to avoid exceeding the maximum jitter level within the network. The maximum jitter from the terminal equipment is therefore limited to below the CCITT Recommendation G.823 levels to avoid the network needing to perform an immediate jitter reduction.

Thus, while the equipment providing the interface may be able to tolerate a high level of input jitter, it is not considered relevant to include this in the leased line standards since the leased line user is only concerned with the maximum jitter that can be applied to the connection input to ensure adequate end-to-end performance.

As stated previously, CCITT Recommendation G.823 is generally applicable to equipments and is not normally applied to complete connections. Care should be taken in the definition of the input jitter stimulus while testing since some network configurations are especially sensitive to single frequency jitter at certain frequencies where the jitter is amplified considerably at each repeater and will not tolerate single frequency jitter for a significant period of time. In these cases, specifically the 2 048 kbit/s leased lines, the jitter tolerance of the network is tested by applying a broadband jitter signal.

6.1.8.1 Jitter (64 kbit/s)

The limits for input jitter tolerance of the connection are taken directly from table 2 of CCITT Recommendation G.823 for the frequency range 20 Hz to 20 kHz.

The limits for maximum output jitter allowed from the connection are taken directly from table 1 of CCITT Recommendation G.823 for the frequency range 20 Hz to 20 kHz. The output jitter is tested with the maximum sinusoidal input jitter as specified above. These limits for maximum output jitter are directly compatible with the input jitter tolerance of the terminal equipment.

6.1.8.2 Jitter (2 048 kbit/s)

The limits for input jitter are based on the limits for terminal equipment output, specified in subclause A.3.3 of ETS 300 011 for the frequency range 4 Hz to 100 kHz. These limits allow for a jitter increase within the connection before jitter reduction is required.

The limits for maximum output jitter allowed from the connection are taken directly from table 1 of CCITT Recommendation G.823 for the frequency range 20 Hz to 100 kHz.

The method of testing the jitter performance of the connection is different from that normally used for equipments, i.e. the use of a single sinusoidal jitter frequency applied to the input bit stream. Some countries advised that the use of single jitter frequencies for significant periods would cause problems within their networks with the jitter reduction equipment being unable to cope with this, e.g. the possibility of a leased line having a high jitter amplification factor for a very narrow band of frequencies due to the concatenation of a number of identical repeaters. It was stated that single jitter frequencies are not representative of what occurs in practice and that other methods of jitter measurement should be used.

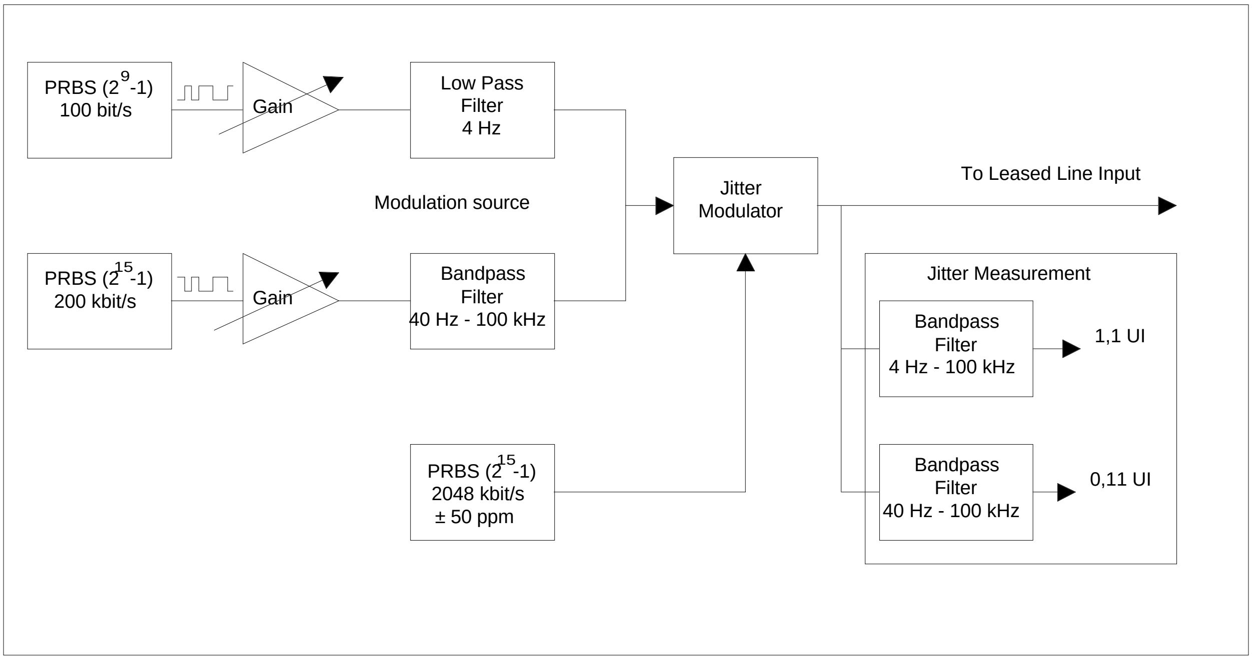

Figure 4: Input jitter generation

A new method of testing susceptibility to jitter was devised in conjunction with representatives from TM Technical Committee, although this method is not recognised by the ITU-T. TM Technical Committee is reviewing new methods for jitter testing of connections; any new standards or recommendations for jitter testing of connections should be reviewed by BTC Technical Committee for applicability to the leased line standards.

The new method of testing input jitter susceptibility produces a broadband jitter spectrum, equivalent to the jitter mask generally used for single frequency jitter generation (see figure 4). The input signal PRBS (2^9-1) at 100 bit/s should generate a spectrum that is substantially flat from 0,5 Hz to 50 Hz, and so will have energy around 4 Hz. The gains are adjusted until the jitter measured in both measurement filters is the value specified for the filter concerned. The text of the specific test requirements (stimulus) clearly state that the two signals are added together. They are not set up in isolation from each other.

All filters are defined as first order filters, with cutoffs at 6 dB per octave (20 dB per decade).

6.1.9 Slip

Slip occurs at a point between two parts of the communication link that are operating at similar but not identical bit rates (plesiochronously). If a piece of equipment is transmitting data at a rate X towards another piece of equipment which is operating at a rate Y, then depending on whether X is greater of less that Y, there will be either a loss of, or a gain of data at the received piece of equipment. The addition or loss of bits in a bit stream is referred to as slip.

Typically the data transfer between two pieces of equipment will be buffered; if the data rate into the buffer is on average the same as the data rate out of the buffer, and the buffer size is large enough, no slips will occur. When the average data rates are not exactly the same, the buffer will either overflow, causing loss of data, or become empty, causing spurious data to be added to the output bit stream. In a structured communication channel, the slips can be controlled such that either a frame of data is either inserted or lost; this is known as a controlled slip or frame slip. Where a slip is not of a complete frame (typically one bit), this is known as an uncontrolled slip. In general, there is no equipment which can detect uncontrolled slips and these generally appear to the user as a Severely Errored Second (SES).

CCITT Recommendation G.822 specifies controlled slip objectives for a 64 kbit/s international digital connections. For a connection comprising 13 nodes operating plesiochronously, the nominal slip rate would be 1 in 5,8 days. In a practical international end-to-end connection containing both national and international portions, the slip rate may significantly exceed this value due to various design, environmental and operational conditions (see CCITT Recommendation G.822). A threshold of slip performance of ≤ 5 in 24 hours is set as a compromise between desired service requirements and normally achievable performance. While the slip performance objective can be modelled against the particular implementation (i.e. national and international portions), the majority of slip performance (80 %) can be anticipated to occur in the local portion, hence no distance dependent allowance in the overall figure is made for "short" leased lines.

While the figure of ≤ 5 slips in 24 hours is specified in CCITT Recommendation G.822 for 64 kbit/s digital connections; this figure is also taken within the leased line standards to specify the required performance for 2 048 kbit/s connections.

6.1.10 Error performance

Errors are caused by various influences such as:

- human intervention;
- thermal noise;
- induced voltages in equipment and cables due to lightning, radio transmissions and other electromagnetic effects;
- loss of synchronisation following uncontrolled slips;
- joints and connections.

The main cause of errors is induced voltages and such errors frequently occur in dense bursts due to particular phenomena. Due to improvements in technology resulting in part from a greater understanding of electromagnetic effects, there is a long term trend for error rates to reduce. Studies in ITU-T have concluded that error rates for lines have a low dependence on distance.

6.1.10.1 Error performance and use of reference connections

The error performance figures for the leased lines are specified in terms of errored seconds, severely errored seconds and (for the 2 048 kbit/s leased lines only) the background block errors.

In each of the standards, the error performance figures are stated independent of leased line connection distance. The advantage of this is that a single, target figure, for error performance is given for all leased lines, and the user will know the error performance to be expected. In practice, the variation in the error performance with distance is small, since the error apportionment method used in the standards for the derivation of error rates (taken from ITU-T Recommendation G.826) allocates a significant proportion (37 %) of the errors to the termination countries, hence the difference between the requirements for a "short" leased line and a "long" leased line would differ by less than a factor of 3 even though the length might differ by a factor of 100. As the error allowance are of the same order of magnitude, for satellite or for terrestrial, only one common set of distance independent error performance values were initially specified for each leased line type in the D64U and D2048U leased line standards, however this was reviewed, and changed, for the D2048S leased line standards.

Full details on the derivation of the error performances for each leased line is given in annex B of each of the applicable leased line standards. Additional information is given in the following subclauses.

6.1.10.2 Error performance (64 kbit/s)

The error performance figures for the 64 kbit/s leased line are derived from CCITT Recommendation G.821 which recommends the characterisation of the error performance in terms of errored seconds and severely errored seconds. The figures within the standard are 24 hour test limits; annex B of ETS 300 288 gives a detailed explanation of how the error figures contained within the standard are derived from the figures contained within CCITT Recommendation G.821.

NOTE: The error allocation used within ETS 300 288 for severely errored seconds has allocated 100 % of the error figures for normal operating conditions. CCITT Recommendation G.821 allocates 50 % of the errors for normal operating conditions and 50 % to accommodate the occurrence of adverse network conditions.

6.1.10.2.1 Possible enhancements

a) The error performance figures for the 64 kbit/s leased line are based on 80 % of the reference figures given in CCITT Recommendation G.821. This figure being based on the error performance of a satellite connection. Consideration should be given to the inclusion of a separate figure for a terrestrial connection which would give error figures approximately 65 % of the reference figures given in CCITT Recommendation G.821.

b) The error allocation used within ETS 300 288 for severely errored seconds has allocated 100 % of the error figures for normal operating conditions. CCITT Recommendation G.821 allocates 50 % of the errors for normal operating conditions and 50 % to accommodate the occurrence of adverse network conditions. Consideration should be given to reducing the figures of ETS 300 288 to reflect the specified limits for "normal operating conditions".

c) The method used for the calculation of 24 hour test limits from the long term error performance figures makes various statistical assumptions. While this is not wrong, it is not a commonly used method. ITU-T Recommendation M.2100 proposes an alternative method for the derivation of short term test limits. Consideration should be given to the use of this method which has been used in the D2048S leased line connection characteristics standard.

6.1.10.3 Error performance (2 048 kbit/s unstructured)

The D2048U leased line standard specifies error performance figures for a worst case situation of 1 satellite, 4 transit countries and 4 000 km, giving a error performance figure of 88% of the figures specified in CCITT Recommendation G.826.

The error performance figures for the 2 048 kbit/s leased line are derived from ITU-T Recommendation G.826 which recommends the characterisation of the error performance in terms of errored seconds, severely errored seconds and background block errors. The figures within the standards are 24 hour test limits; annex B of ETS 300 247 gives a detailed explanation of how the error figures contained within the standards are derived from the figures contained within ITU-T Recommendation G.826.

NOTE: The definition of a Severely Errored Second (SES) within the leased line standards specifies a one second period which contains ≥ 30% errored blocks. While this is the generic specification for an SES, for historical reasons the SES threshold on 2 048 kbit/s PDH equipments developed prior to the acceptance of CCITT Recommendation G.826, was a BER of $\geq 10^{-3}$. This threshold will be maintained for 2 048 kbit/s PDH equipment according to both CCITT Recommendation G.826 and M.2100 due to the large number of these systems in service. It is for in-service measurements translated into a threshold for an SES of 805 errored blocks (i.e. a block of 2 048 bits with an anomaly consisting of at least one faulty frame alignment sequence or an error according to the CRC-4 calculation) in these Recommendations. In addition to having a high number of errored blocks, an SES shall also be counted for each second with a defect, being a Loss Of Signal (LOS), a Loss Of Frame alignment (LOF) or an alarm indication signal (AIS) while the connection is in the available state. It is noted that for determination in service of Errored Seconds (ES) and SES on D2048U connections only the defect LOS is available. Each second with one of these defects shall be counted as both an ES and an SES unless the connection has reached the unavailable state.

6.1.10.3.1 Possible enhancements

a) The reference connection comprising 1 satellite link, 4 transit countries and 4 000 km routed distance is possibly unrepresentative. Consideration should be given to the specification of two reference connections as for the D2048S standards, i.e. a terrestrial connection comprising two terminating countries and one transit country, the total routed distance being 5 500 km, and a satellite connection comprising one satellite hop and up to 2 000 km routed distance.

b) The method used for the calculation of 24 hour test limits from the long term error performance figures makes various statistical assumptions. While this is not wrong, it is not a commonly used method. ITU-T Recommendation M.2100 proposes an alternative method for the derivation of short term test limits. Consideration should be given to the use of this method which has been used in the D2048S leased line connection characteristics standard.

6.1.10.4 Error performance (2 048 kbit/s structured)

The D2048S leased line standard specifies error performance figures for the following two reference connections:

- a terrestrial connection comprising two terminating countries and one transit country, the total routed distance being 5 500 km;

- a satellite connection comprising one satellite hop and up to 2 000 km routed distance.

The error performance figures for the 2 048 kbit/s leased line are derived from CCITT Recommendation G.826 which recommends the characterisation of the error performance in terms of errored seconds, severely errored seconds and background block errors. The figures within the standards are 24 hour test limits; annex C of ETS 300 419 gives a detailed explanation of how the error figures contained within the standards are derived from the figures contained within CCITT Recommendation G.826.

NOTE: See also note to subclause 6.1.10.2.

6.1.10.5 Applicability of ITU-T Recommendation M.2100

6.1.10.5.1 Bringing Into Service (BIS) limits

ITU-T Recommendation M.2100 (October 1992, published August 1993), which supersedes CCITT Recommendation M.550, defines the concept of BIS limits for digital transmission systems, paths and sections based on the Reference Performance Objective (RPO) limits derived from G-series Recommendations. While CCITT Recommendation M.550 was written for systems based on the 64 kbit/s bit rate, CCITT Recommendation M.2100 states (in subclause 2.4.1) that the principles contained within the recommendation can be applied to any performance objectives derived from the relevant G-series Recommendations.

NOTE: ITU-T Recommendation M.2100 is currently being revised and a new version is expected to be published in 1995.

The BIS limits are more stringent that the normal error performance limits and are for the use of the network provider, in order that they can ensure that, even with long term degradation, the path still meets the published error performance limits. BIS limits are normally specified over short measurement periods (less than 24 hours) in order to reduce the time spent testing.

It is recommended that future revisions of the digital leased line standards consider the inclusion of short term BIS limits **for information** to assist the leased line provider. The leased line provider may choose to use these limits to ensure that the leased line meets the required performance levels. This has already been included in the ETSs for the Higher Order Leased Lines (34 Mbit/s and 140 Mbit/s).

6.1.10.5.2 Reduction in the measurement period

Published error performance limits generally refer to a long term (greater than one month) measuring period. Directly reducing these to a short term is not statistically valid due to the spread of errors that generally occurs in practice. This has been recognised within the leased line connection characteristics standards where various statistical methods have been used to derive 24 hour test limits from long term error performance figures.

ITU-T Recommendation M.2100 presents, in subclause 2.6.1, a method of converting long term error performance limits to 24-hour BIS test limits (S1 and S2). S1 is the limit below which bringing into service is accepted, S2 is the limit above which bringing into service is rejected. Between S1 and S2 the results are inconclusive.

The same statistical process could be used in the leased line standards be used to deduce 24 hour test limits in order to verify the long term error performance figures. The method used in the D2048U and D64U leased line standards for the derivation of 24 hour test limits is significantly more complex than that presented in ITU-T Recommendation M.2100. The simpler method, defined in ITU-T Recommendation M.2100 was used for the derivation of 24 hour test limits for the D2048S leased line. In practice, the conversions to 24 hour test limits as defined in the standards and in ITU-T Recommendation M.2100 give identical results to within one error per 24 hour period. However, it is recommended that derivation of 24 hour test limits is in future performed according to the method of ITU-T Recommendation M.2100 since this less complex.

6.1.11 Availability

Availability was omitted as a normative requirement in the leased line standards due the potential problems of testing the availability of a leased line over a sufficiently long period for the result to be statistically valid.

The production of I-ETS 300 416 has lead to availability information becoming available which can be used to provide an estimate the target availability for leased lines. This information has been included **for information** in an informative annex in the D2048S leased line standard.

It is recommended that when the D64U and D2048U standards are revised, similar informative annexes on availability are included.

6.2 Interface presentations (network and terminal equipment)

The following subclauses give details of the specific requirement for both the network interfaces and the terminal equipment interfaces. In general these requirements are the same for network interfaces and terminal equipment interfaces; where this is not the case (as in connectorisation for example) the differences are noted.

6.2.1 Connectors

Initially, the digital leased line standard were intended to define the use of the 8-way plug and socket defined in ISO 10173. While the plug and socket were designed specifically for the primary rate ISDN service, they could equally well be used for the leased line services with no damage anticipated if a terminal equipment is connected to the wrong service. ISO 10173 specifies only those connector dimensions needed to ensure intermatability of plug and socket. Complete detailed specifications of the connectors are the subject of IEC 603-7. However, it has proved impossible to obtain the ISO 10173 connectors due to (a) manufacturing tolerances are such that at the extremes, there would be insufficient material left to ensure adequate contact pressure, and (b) a reluctance for connector manufacturers to produce these connectors for what is expected to be low volumes.

The D64U and the D2048U standards were published specifying the ISO 10173 connector. As a result of the problems associated with this, amendments have been issued to these standards to remove the requirement for this connector. For leased lines, the use of hardwiring is allowed, or, with the agreement of the user, any suitable socket. The terminal equipment is required to provide a means of connection suitable for hardwiring and a variety of examples are given within the standard, however this is not an exhaustive list and other methods may also be used.

NOTE: An amendment to ETS 300 246 was not issued since this is intended to be superseded by ETS 300 418.

The D2048S standards were published without the requirement for the ISO 10173 and reflect the amended requirements of D64U and D2048U.

6.2.1.1 Shielding

A connector may have the capability for connecting shields. The use of a shielded cable by the terminal equipment supplier will depend on the strategy adopted for EMC control. The connector allows for separate shields on the transmit and receive pairs but these may be connected together or a single shield may be used.

In general, a 64 kbit/s signal will not require a shielded cable; however there may be a necessity for a shield if there is inadequate filtering of common mode signals at the terminal equipment.

The leased line provider may provide a point at the NTP to which shields may be terminated, however unless the characteristics of these points are well defined, it may not be possible for the user to determine what effect they may have on the EMC performance of the terminal equipment. It is intended that where these points are provided they will be signal return paths for high frequency signals and NOT equipment earths.

The connection of the shield point to ground or earth may invalidate compliance of the interface with SELV since under EN 60950 an earth should be considered a source of hazardous voltages. Both terminal equipment suppliers and leased line providers should consider the implications for safety when providing a shield or shield reference point.

NOTE: CENELEC/TC115 have stated that if the connector EN 28877 is used, the use of transmit and receive shield will cause problems when interconnecting through a generic cabling system specified in EN 50173 "Performance requirements of generic cabling systems". It may therefore be necessary to re-consider the use of the shield on these connectors.

6.2.2 Signal coding

6.2.2.1 64 kbit/s

The signal coding is defined in accordance with subclause 1.2.1.1.5 of ITU-T Recommendation G.703. The coded conversion rules are included in the standard for completeness; there is no intention that these be different from the ITU-T Recommendation.

6.2.2.2 2 048 kbit/s

The HDB3 signal coding is defined in accordance with clause 6 of ITU-T Recommendation G.703. The coded conversion rules are included in the standard for completeness; there is no intention that these be different from the ITU-T Recommendation.

6.2.3 Waveform shape

6.2.3.1 64 kbit/s

The 64 kbit/s leased line interface is implemented as two balanced pairs with an impedance of 120 ohms. The waveform shape is specified in accordance with requirements for a 64 kbit/s codirectional interface as specified in subclause 1.2.1.2 of ITU-T Recommendation G.703. The pulse masks are included within the standards for completeness; there is no intention that these be different from the ITU-T Recommendation.

6.2.3.2 2 048 kbit/s

Both the unstructured and structured 2 048 kbit/s leased line interfaces are implemented as balanced pairs with an impedance of 120 ohms. The waveform shape is specified in accordance with requirements for the 2 048 kbit/s interface as specified in clause 6 of ITU-T Recommendation G.703. The pulse masks are included within the standards for completeness; there is no intention that these be different from the ITU-T Recommendation.

ITU-T Recommendation G.703 allows either 75 ohm coaxial of 120 ohm balanced interface presentation. The leased line standards could not specify both these options since there was a basic requirement to ensure a consistent interface presentation throughout the Community. The 120 ohm interface was selected as it is compatible with the ISDN primary rate interface. The option of a coaxial interface with a 75 ohm impedance is not allowed under the leased line standards.

6.2.4 Impedance towards ground

A requirement for impedance towards ground has been included for both the 64 kbit/s and 2 048 kbit/s interfaces for both the network and terminal equipment interfaces. This requirement is necessary to control the longitudinal current that flows as a result of induced longitudinal voltages. Without this minimum impedance at both ends of the interface, the induced voltage might rise at one end of the cable. This would necessitate a more stringent requirement for tolerable longitudinal voltages at the opposite end to the one with the low impedance to earth. In general, an interface implemented with a transformer would easily meet this requirement; this requirement has therefore been included primarily to allow transformerless implementations.

For testing the leased line, the shield reference point will be used as the ground if this is provided by the leased line provider, otherwise the leased line provider should declare the point to be used for testing. For the terminal equipment, this requirement only applies if there is a ground, in which case the test will be made to the equipment common reference point or test reference point.

In the test, the impedance of the generator is not critical, provided that it can establish the required voltage across the frequency range. The test limit of 19,2 mV is derived as follows:

Figure 5 shows the equivalent test circuit. With an equivalent leased line impedance of greater than 1 000 ohms, the current (I_t) flowing through the 10 ohm resistor will be:

$$It < 2/(10+30+1000) \text{ amps rms} \quad \text{i.e. } It < 1{,}92 \text{ mA rms}$$

Thus the voltage (V_t)across the 10 ohm resistor should be $Vt < 19{,}2$ mV rms

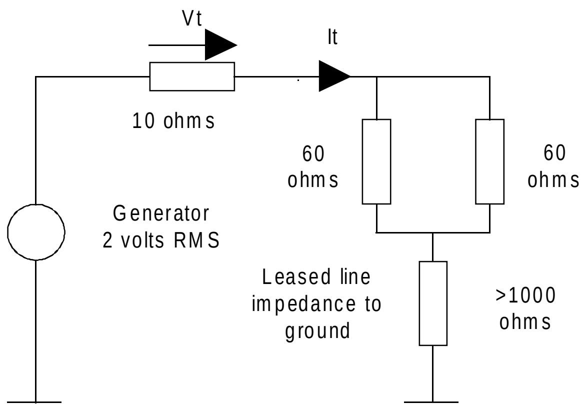

Figure 5: Measurement voltage limit for impedance towards ground

6.2.5 Input return loss

6.2.5.1 64 kbit/s

The input return loss figures, specifying the return loss against a non-reactive impedance of 120 ohms, are taken directly from subclause 1.2.1.3 of ITU-T Recommendation G.703.

The test is performed using a test voltage of 1 volt peak at the input to the interface, equivalent in amplitude to the pulse amplitude that will generally appear at the inputs.

6.2.5.2 2 048 kbit/s

The input return loss figures, specifying the return loss against a non-reactive impedance of 120 ohms, are taken directly from subclause 6.3.3 of ITU-T Recommendation G.703.

The test is performed using a test voltage of 3 volt peak at the input to the interface, equivalent in amplitude to the pulse amplitude that will generally appear at the inputs.

6.2.6 Input loss tolerance

6.2.6.1 64 kbit/s

A requirement for input loss tolerance has been included to ensure correct operation of the network and terminal equipment interfaces under typical cabling conditions. The loss tolerance figure of up to 3 dB has been taken from subclause 1.2.1.3 of ITU-T Recommendation G.703.

The test has been combined with the test for input coding and immunity against reflections.

6.2.6.2 2 048 kbit/s

A requirement for input loss tolerance has been included to ensure correct operation of the network and terminal equipment interfaces under typical cabling conditions. The loss tolerance figure of up to 6 dB has been taken from subclause 6.3.1 of ITU-T Recommendation G.703.

The test has been combined with the test for input coding and immunity against reflections.

6.2.7 Immunity against reflections

6.2.7.1 64 kbit/s

A requirement for immunity against reflections has been included to ensure correct operation of the network and terminal equipment interfaces under the effects of signal reflections that can arise at the interface due to impedance irregularities at digital distribution frames and at digital output ports. These figures have been taken from subclause 1.2.1.3 of ITU-T Recommendation G.703.

The test has been combined with the test for input coding and input loss tolerance.

6.2.7.2 2 048 kbit/s

A requirement for immunity against reflections has been included to ensure correct operation of the network and terminal equipment interfaces under the effects of signal reflections that can arise at the interface due to impedance irregularities at digital distribution frames and at digital output ports. These figures have been taken from subclause 6.3.4 of ITU-T Recommendation G.703.

The test has been combined with the test for input coding and input loss tolerance.

6.2.8 Longitudinal voltage immunity

6.2.8.1 64 kbit/s

It is necessary to operate under expected levels of longitudinal voltages that might be induced on the cable. However, a requirement on tolerance to longitudinal voltages has not been included for the 64 kbit/s leased line since there is no requirement under ITU-T Recommendation G.703 or any existing ETSI standard.

6.2.8.2 2 048 kbit/s

It is necessary to operate under expected levels of longitudinal voltages that might be induced on the cable. Therefore a requirement on tolerable longitudinal voltages has been included for the 2 048 kbit/s network and terminal equipment interfaces as specified in table 1 of ETS 300 011 referencing subclause 5.5 of ITU-T Recommendation I.431. In general, an interface implemented with a transformer would easily meet this requirement; this requirement has therefore been included primarily to allow transformerless implementations.

6.2.9 Longitudinal conversion loss

6.2.9.1 64 kbit/s

A requirement for longitudinal conversion loss has been included for the 64 kbit/s network and terminal equipment interfaces based on the requirement in ETR 005. The requirement is, however, relaxed by 10 dB across the frequency range since it was generally believed that the requirement in ETR 005 was too severe. The test method is derived from subclause 4.1.3 of CCITT Recommendation G.117 and subclause 2.1 of CCITT Recommendation O.9. While these subclauses specify the tests with centre tapped inductors, these have been replaced with matched impedances as defined in subclause 3.1 of CCITT Recommendation O.9 due to the potential problems of obtaining uniform inductance across the frequency range required. The actual value of the output impedance of the generator is irrelevant if the voltage across the generator is measured during the test.

6.2.9.2 2 048 kbit/s

A specification for longitudinal conversion loss has not been included for the 2 048 kbit/s leased line since there is no requirement under ITU-T Recommendation G.703 or any existing ETSI standard.

6.2.10 Output return loss

While ETS 300 166 includes figures for output return loss of network equipment for both 2 048 kbit/s and 64 kbit/s services, there is concern about the repeatability of measurements due to the signals coming out from the equipment and the leased lines. For measurements using a spectrum analyser continuous peaks would be detected due to the output signal, possibly masking the true measurement.

Output return loss figures may be added to the ETS for both the network and terminal equipment interfaces when the issue of testing and measurement is resolved.

6.2.11 Output signal balance

Output signal balance is not included in the standards since signal imbalance would cause levels of electromagnetic emission which are controlled under the EMC Directive.

6.2.12 Jitter

Jitter is the phase modulation of the data pulses from an equipment which causes the data pulses to arrive either early or late, thus potentially generating transmission errors. The two main parameters used to characterise jitter are the amplitude of the phase modulation, expressed as a peak-to-peak deviation, and the frequency of the deviation. The jitter frequency is typically a combination of the different frequencies generated by the components and equipments involved.

6.2.12.1 Leased line interfaces

The jitter requirement for the leased line is specified in the connection characteristics standard as the overall jitter performance, as seen by the user, is considered to be dependent on the performance of the connection; as such, there is no specific jitter requirement on the leased line interface.

The equipment providing the leased line interface (i.e. the NTU) will have its own jitter specification, capable of tolerating an input jitter level at least equivalent to that specified in the connection characteristics and with an output jitter level no higher than that specified in the connection characteristics. The precise definition of these values is outside the scope of the leased line standards.

6.2.12.2 Terminal equipment interfaces

ITU-T Recommendation G.823 defines limits for jitter for specific equipments. These limits cover two specific aspects of jitter:

a) maximum output jitter; and

b) input jitter tolerance.

The maximum output jitter is the jitter from an equipment under worse case input conditions. It is generally composed of jitter generated within the equipment (intrinsic jitter) and jitter transferred from other inputs, e.g. other timing sources. It is generally possible to define a "jitter transfer function" which is the gain (or loss) in jitter between one input and an output; hence the jitter at the output is the sum of the intrinsic jitter and the product of the input jitter and the transfer function, i.e.:

Output jitter = Intrinsic jitter + G(f) * Input jitter,

where G(f) is a frequency dependent jitter transfer function.

This method can be used to characterise an equipment where the input and outputs are known; it is not practical to use this method for the terminal equipments for connection to leased lines as these standards cover ONLY the leased line interface and are independent of any other interfaces; as such the output jitter from an equipment is specified as the maximum allowed under worse case input jitter on the other (undefined) inputs.

6.2.12.2.1 64 kbit/s terminal equipment

The limits for input jitter tolerance of the terminal equipment are taken directly from table 2 of ITU-T Recommendation G.823 for the frequency range 20 Hz to 20 kHz. This is compatible with the requirement on the leased line which allows the leased line output jitter to be up to the ITU-T Recommendation G.823 limit. This does not, however, allow for any jitter build up in the customer premises wiring between the NTU output and the terminal input; in practice any such jitter is likely to be low and would only have an effect if both the connection and the terminal equipment interface were operating near the limits of their specification.

The limits for maximum output jitter allowed from the terminal equipment are taken directly from table 1 of ITU-T Recommendation G.823 for the frequency range 20 Hz to 20 kHz. The output jitter is tested with the maximum sinusoidal input jitter as specified above when the output timing is taken from the 64 kbit/s leased line or the maximum input jitter as specified by the terminal equipment supplier when the output timing is taken from any other input. These limits for maximum output jitter are directly compatible with the input jitter tolerance of the leased line.

6.2.12.2.2 2 048 kbit/s terminal equipment

The limits for input jitter tolerance of the terminal equipment are taken directly from table 2 of ITU-T Recommendation G.823 for the frequency range 20 Hz to 100 kHz. This is directly compatible with the requirement on the leased line which allows the leased line output jitter to be up to the ITU-T Recommendation G.823 limit. This situation does not, however, allow for any jitter build up in the customer premises wiring between the NTU output and the terminal input; in practice any such jitter is likely to be low and would only have an effect if both the connection and the terminal equipment interface were operating near the limits of their specification. Note that the input jitter tolerance of 2 048 kbit/s leased line terminal equipment is different from the equivalent input jitter tolerance on ISDN primary rate terminal equipment; the output jitter level from leased lines is higher than that from ISDN networks, the 2 048 kbit/s terminal equipment is therefore required to tolerate a higher input jitter level.

The limits for maximum output jitter from the terminal equipment is defined at 0,11 UI between 40 Hz and 100 kHz in accordance with the specific requirements for Private Telecommunications Network eXchange (PTNX) interconnections (leased lines) given in subclause A.3.3 of ETS 300 011 (see annex A of ETS 300 011 for further details). While there is no explicit output jitter requirement on the terminal equipment below 40 Hz, the first order measurement filter at 40 Hz allows through attenuated jitter levels from lower frequencies. This therefore imposes a requirement on jitter levels below 40 Hz as determined by the characteristics of the first order filter, i.e. 0,22 UI at 20 Hz and 1,1 UI at 4 Hz. Since output jitter levels are normally dependent on the characteristics of the timing source, all output jitter measurements are required to be performed with maximum jitter applied the timing source. Where the timing source is the same, or another leased line interface, the applied jitter is the same as the maximum tolerable input jitter. Where the timing source is a different type of input, e.g. an ISDN primary rate interface or a higher rate interface, this is also required to provided with maximum jitter as determined by the particular specification of that interface.

6.2.13 Output timing - terminal equipment

Output timing from the leased line, under normal operating conditions, is considered to be a connection characteristic and is covered in that subclause. These subclauses deal only with output timing from the terminal equipments.

6.2.13.1 64 kbit/s terminal equipment

Since the 64 kbit/s leased line provides timing, the terminal equipment shall be capable of either synchronizing the output timing to the timing received from the leased line (i.e. applying a clock loop); or synchronizing the output timing to an external reference in order to avoid a high occurrence of slips. The latter case is intended for use when the external reference signal is of the same order of accuracy as the 64 kbit/s leased line (e.g. an ISDN primary rate access), however the accuracy of this external reference cannot be controlled within the terminal equipment interface standard.

The terminal equipment may provide both the timing options specified within the standard.

The requirement does not exclude other implementations of the timing, provided that one or more of the stated requirements are provided. For example, the terminal may also be capable of using an internal clock source to provide the output timing; however, this may lead to a high level of slips between the terminal equipment and the network.

6.2.13.2 2 048 kbit/s unstructured terminal equipment

The output timing is specified as 2 048 kbit/s ± 50 ppm only when the terminal equipment is running from an internal clock in the absence of any external reference signal.

The output timing is not specified in the situation where the terminal equipment is taking its clock from an external source since the terminal equipment cannot be expected to impose a greater accuracy than the accuracy of the external source (e.g. if the input signal drifts to 2 048 kbit/s + 200 ppm, the terminal cannot be expected to detect this and limit the frequency).

NOTE 1: Future revisions of the standard should consider a requirement on the output timing to be within 2 048 kbit/s ± 50 ppm when the external reference is operating within a range a specified by the manufacturer of the terminal equipment).

NOTE 2: Future revisions of the standard should consider changing the title of this subclause from "clock accuracy" to "output timing" in line with the D64U and the D2048S standards.

6.2.13.3 2 048 kbit/s structured terminal equipment

The D2048S leased line connection will either:

a) be capable of carrying user timing over the range 2 048 kbit/s ± 50 ppm (referred to as user timing); or

b) provide timing that is synchronous to the network timing (referred to as network timing); this is timing that is derived from the source or sources of timing that are used for the network and will be similar to that provided by other digital services;

c) take user timing within the range 2 048 kbit/s ± 50 ppm from one input and provide this timing at both outputs of the leased line.

The particular timing mechanism is specified by the leased line provider and cannot be specified by the leased line user.

In all cases the terminal equipments at either end of the leased line may need to be configured differently in order to establish synchronous data transfer and, if required, synchronous operation. The requirements on terminal equipment output timing imposed within the standard are sufficient for each terminal to be connected to, and operate with, each of the three types of leased line.

Note that the particular timing configuration of a terminal equipment should also take into account the other interfaces which may be connected to the terminal equipment.

6.2.13.3.1 Terminal configuration where the leased line carries user timing

Where the leased line is capable of carrying user timing and if synchronous operation of the two directions of transmission is required, one terminal equipment (referred to as the master) will be responsible for originating the timing signal. The other terminal equipment (referred to as the slave) will recover the timing from the leased line and transmit data back in the opposite direction of transmission in synchronism with this signal. This is referred to as "looping back" the timing and results in synchronous data transfer in both directions. The master terminal equipment may take its timing from an internal source (figure 6a) or from an external source (figure 6b) such as another leased line or an ISDN interface from the public network, if synchronous operation of the leased line connection with those services is required. An example of this is shown in figure 6, where the master terminal equipment takes its timing from an internal clock generator.

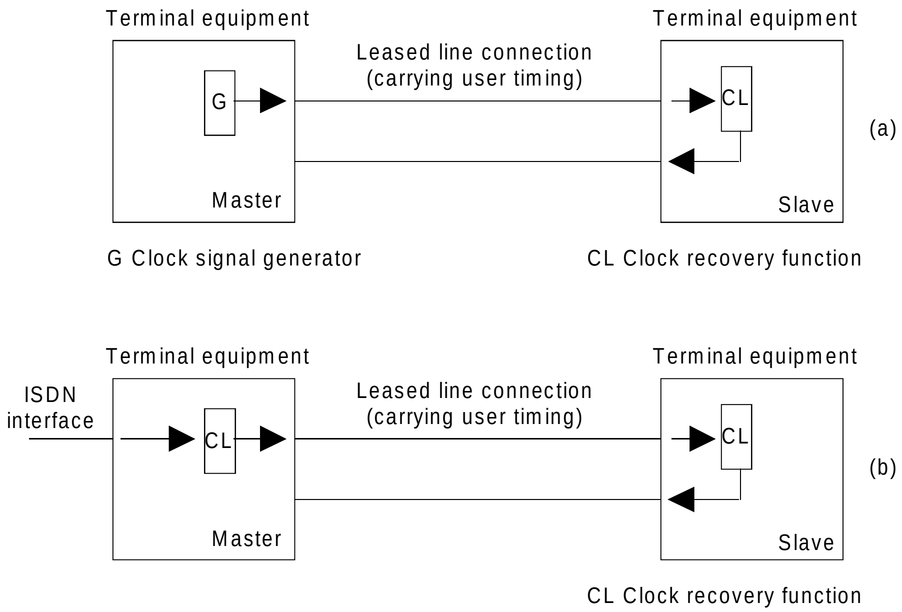

Figure 6: Examples of timing configuration of two terminal equipments in master/slave configuration with a leased line capable of carrying user timing

Other configurations are also possible. It is possible to use independent clock sources in each direction with both terminals acting as masters (see figure 7a). Any divergence between these clock sources would result in the occurrence of slips in the terminal equipment; this may not be satisfactory if synchronous data transfer is required. However, if both terminals extract their timing from high accuracy sources (see figure 7b), such as the public network, the overall synchronization would be satisfactory and the number of slips would be acceptable for most applications.

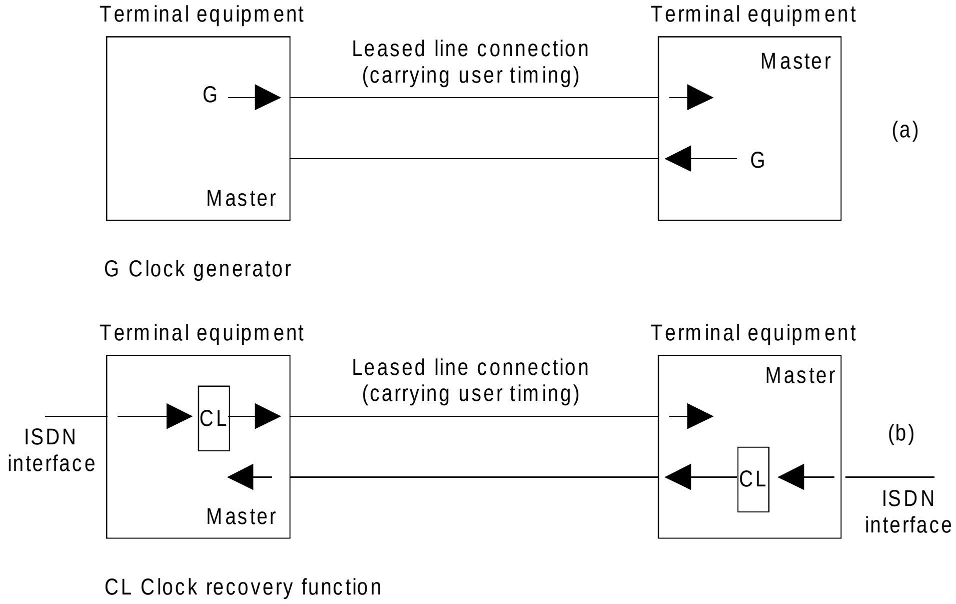

Figure 7: Timing configuration of two terminal equipments in master/master configuration with a leased line capable of carrying user timing

A configuration where both terminal equipments attempted to "loop back" the timing would not be practical with this type of leased line and may lead to an unstable operating condition.

6.2.13.3.2 Terminal configuration where the leased line uses network timing

Where the leased line provides network timing, both terminal equipments would generally extract the timing from the leased line and transmit data back in the opposite direction of transmission in synchronism with this signal (i.e. looping back of the timing signal), ensuring synchronous data transfer in each direction (see figure 8a).

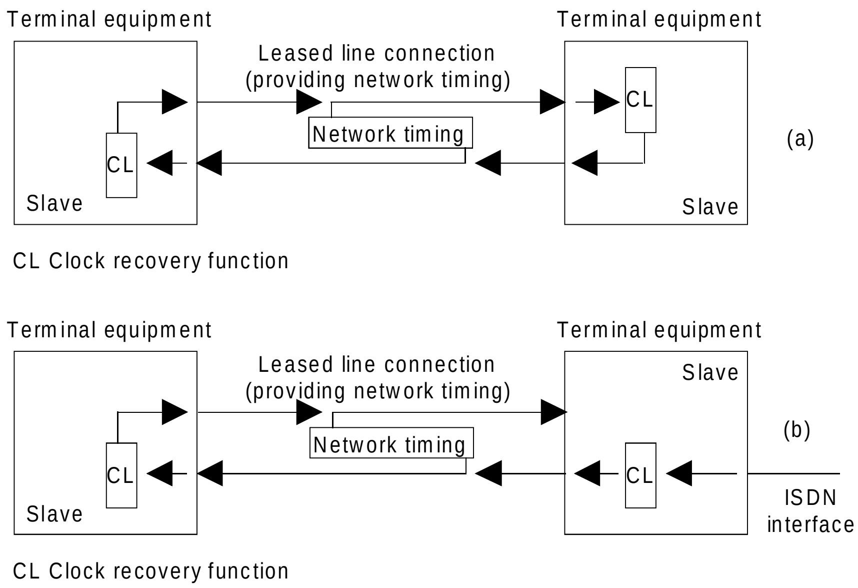

Figure 8: Timing configuration of two terminal equipments in slave/slave configuration with a leased line providing network timing

Other configurations are also available. A terminal equipment could use timing derived from another source, however this could generate slips between the terminal equipment and the network; the number of slips would depend on the accuracy of the timing sources. Timing derived from a source of equivalent accuracy such as the public ISDN network (see figure 8b), is likely to result in an acceptable number of slips, but not when an internal timing source within the limits of 2 048 kbit/s ± 50 ppm is used.

6.2.13.3.3 Terminal configuration where the leased line uses user timing

A third option available to leased line providers where the leased line timing is synchronised to the timing received from one of the terminal equipments. One terminal equipment is designated the master and the leased line takes its timing from this terminal equipment (i.e. uses the user timing); the timing of the leased line, in **both** directions of transmission is then synchronised to this timing. Thus, in order to avoid slips, the terminal at the far end should operate in slave mode, taking its timing from the leased line. The master terminal equipment may take its timing from an internal source (figure 9a) or from an external source (figure 9b).

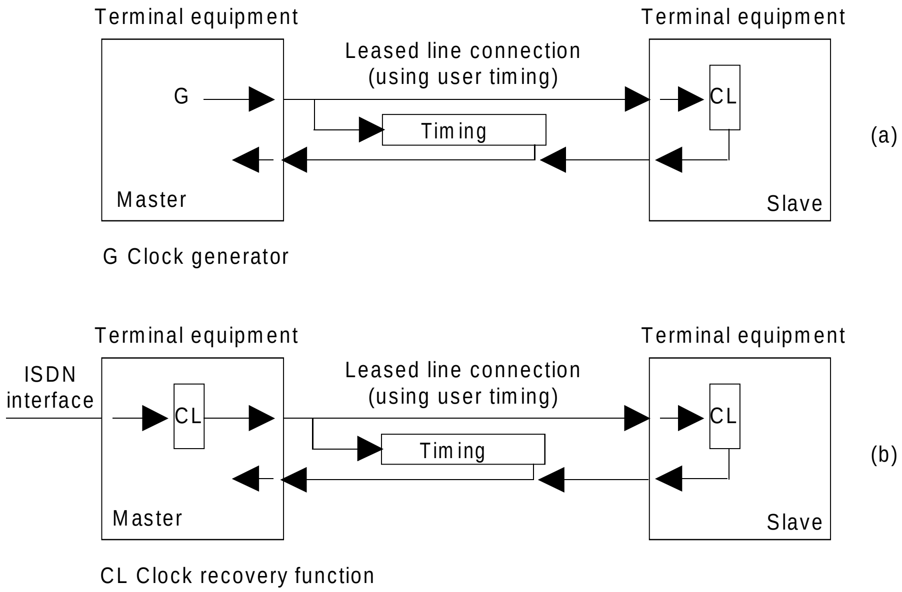

Figure 9: Timing configuration of two terminal equipments in master/slave configuration with a leased line using terminal equipment timing

An alternative timing configuration of master/master where both terminal equipments take their timing from equivalent high accuracy sources (e.g. the public ISDN) is also feasible where the leased line uses user timing (see figure 10).

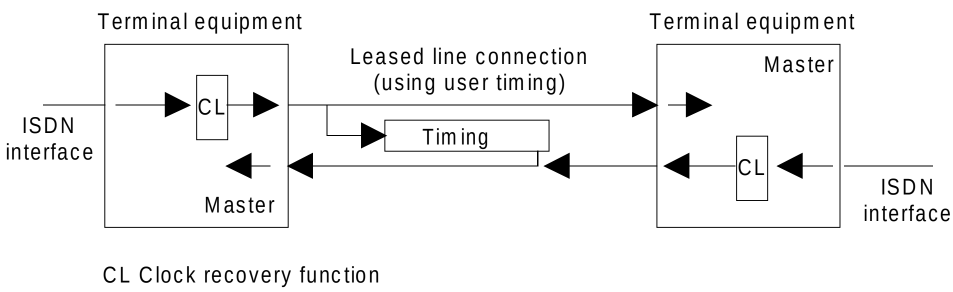

Figure 10: Timing configuration of two terminal equipments in master/master configuration with a leased line capable of carrying user timing

A configuration where both terminal equipments attempted to "loop back" the timing would not be practical with this type of leased line and may lead to an unstable operating condition.

7 Analogue leased lines

7.1 Selection criteria

These leased lines, based on the requirements of CCITT Recommendations M.1020 and M.1040, are not necessarily suitable for use in networked speech applications where low loss lines are required. This fact was recognised during the development of the existing standards when it was pointed out that standards based on CCITT Recommendations M.1030 and M.1035 would be more suitable for use in private networks designed to carry speech.

The following subclauses attempt to illustrate the considerations which would lead to the choice of a particular leased line from the four analogue alternatives.

7.1.1 2 wire or 4 wire

All point to point connections for data and most such connections for voice can generally be provided as 2 wire connections. Where the connection involves an inband signalling system that utilises a four wire path then 4 wire lines should be chosen. Where stability and echo are important then either the 4 wire alternative should be chosen or the special quality 2 wire line may be the appropriate choice.

7.1.2 Ordinary or special quality

Ordinary quality lines are intended for voice applications only, although in the majority of cases they will carry data without undue degradation. Lines with similar characteristics, based on CCITT Recommendation M.1040, are widely used in practice for the transport of data although there is no guarantee of their adequate performance in this field. Where it is necessary to guarantee the communication of data then special quality lines, based on CCITT Recommendation M.1020, should be selected.

7.2 Connection characteristics and network interface

Due to the close relationship between the connection characteristics and the interface specifications of analogue leased lines, these requirements are presented in a single standard for each of the four types of leased line.

In many cases the leased lines provided in conformance with these standards will provide a level of performance much better than that specified; this is especially true for the figures for overall loss where the figures given include allowances for long access sections. Where the actual performance available from a leased line offered under the ONP minimum set does not satisfy the needs of the user, the leased line provider may be able to provide an alternative more suitable type of leased line. Users are advised to discuss with the leased line provider the suitability of a particular leased line for their intended application.

If a leased line provider is unable to meet any of the parameters given within the leased line standards, the Directive on Open Network Provision of leased lines (92/44/EEC) allows the leased line provider to seek a concession against the standards from the National Regulatory Authority.

Figure 11 shows some of the different means by which analogue leased lines may be provided. In most cases, the leased lines will be connected back via the local loop to local exchange premises where transmission equipment for the connection of the leased lines to other parts of the public network will be housed, (leased lines will not normally be routed through the local exchange switching system). This local loop is normally provided using copper pairs which is frequently the main source of loss. In some cases the local loop may use radio technology or fibre optic cables, in which case the transmission would be digital, potentially resulting in lower loss.

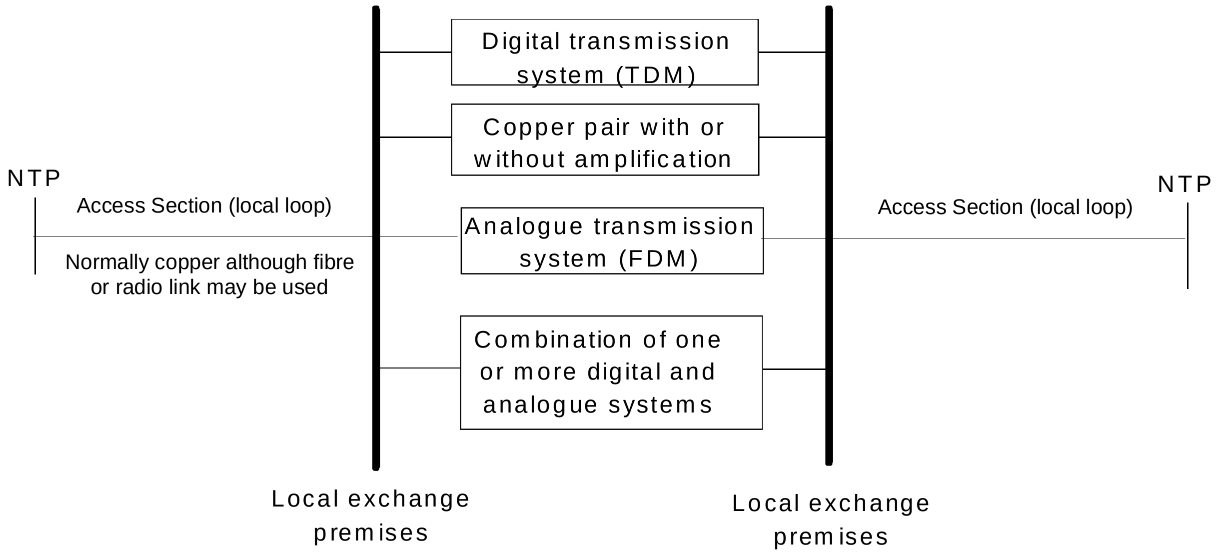

Figure 11: Means of providing analogue leased lines

The means of transmission between the local exchange premises may be one or more of the following:

a) Digital transmission on optical fibre, copper cable or microwave radio links, using Time Division Multiplexing (TDM);

b) Analogue transmission on copper cable or microwave radio using Frequency Division Multiplexing (FDM);

c) Analogue transmission on copper cable without multiplexing, with or without amplification.

In general, the trend is for the analogue transmission equipment in the public networks to be replaced by digital equipment, although it will be a number of years before all the analogue transmission equipment has been withdrawn.

7.2.1 Overall loss

7.2.1.1 General

The overall loss of a leased line is frequently of great importance in determining the suitability of a leased line for a particular application. The overall loss can, however, vary significantly between installations due to various factors such as the distance of the termination points of the leased line from the local exchange premises (resulting in long access sections) and the general practices adopted by the specific network provider.

The range of losses specified within the minimum set of analogue leased line standards encompasses what is generally available from leased line providers and represent the wide range of values that may occur in practice where the leased lines have been supplied in accordance with the general practice of the network providers. Losses are unlikely to occur at the extreme limits (e.g. 0 dB or 25 dB) and typical loss values should be significantly less than the worst case values.

In most cases it is not the geographical distance between the ends of the leased line which determines the overall loss, but the different components from which the leased line is constructed. Normally the main contributor to loss is the copper pair that provides the local loop, whose loss is distance dependent and may be up to some 10 dB, which would equate to a distance of 10-15 km depending on the type of cable. Thus a leased line between two adjacent customers premises may have a high loss in some circumstances. This is shown in figure 12.

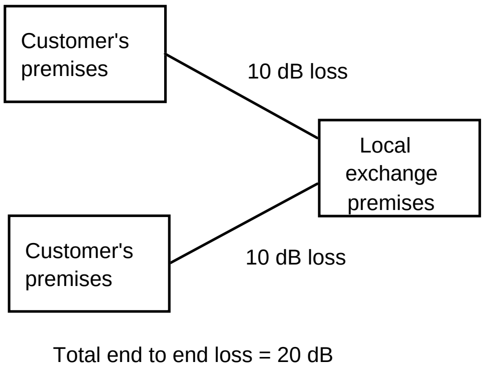

Figure 12: Example of a short ordinary quality leased line with high loss

The loss between the local exchange premises will be distance dependent only if copper cables without amplification are used. If an analogue or digital transmission system is used, this system will normally introduce a fixed and distance independent loss. Such systems will almost always be used for international leased lines and will frequently be used for long distance national leased lines.

This information shows why a leased line between two closely spaced NTPs that are both at some distance from the local exchange premises may have considerably greater loss than an international leased line between NTPs that are close to the local exchange premises (e.g. in a city centre). An example of a long international leased line with low loss is given in figure 13.

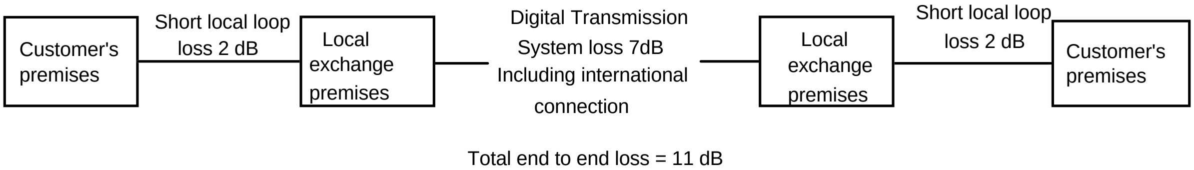

Figure 13: Example of a long international leased line with low loss

7.2.1.2 Derivation of limits

The maximum limits for overall loss were selected based both on what could occur in practice and what could be tolerated by modems given the allowed transmit levels. The derivation of the maximum tolerable losses is given in table 5.

Column 1 of table 5 shows the maximum mean input power levels for each leased line type, column 2 of table 5 shows the minimum output levels required for the leased lines; the difference between these two figures is the maximum loss tolerable overall loss of the leased line.

The minimum output levels of column 2 of table 5 are based on the defined performances of various modem types (see table 6) derived from various CCITT V series Recommendations. Table 6 shows that for modems which are generally connected to ordinary quality leased lines, the minimum receive level should be greater than -43 dBm. Since modems generally operate at the higher frequencies, it is necessary to take into account an additional loss of up to 9 dB loss at the upper end of the band compared to the mid-band; Thus a mid-band loss of -34 dBm is necessary, for ordinary quality leased lines, to ensure a higher frequency loss of -43 dB. For modems connected to special quality leased lines, the minimum receive level is -26 dBm; due to the flatter gain/frequency response required for special quality leased lines, this has also been taken as the minimum receive level mid-band.

For information, table 5 shows the minimum input and output relative levels associated with each leased line type.

Table 5: Transmission parameters for analogue leased lines

Leased line type	Maximum mean input power	Minimum output level	Maximum overall loss	Minimum input relative level	Minimum output relative level
	(1)	(2)	(3)	(4)	(5)
A2O	-9 dBm	-34 dBm	25 dB	+4 dBr	-21 dBr
A4O	-13 dBm	-34 dBm	21 dB	0 dBr	-21 dBr
A2S	-9 dBm	-26 dBm	17 dB	+4 dBr	-13 dBr
A4S	-13 dBm	-26 dBm	13 dB	0 dBr	-13 dBr

Table 6: Modem types and their application to leased lines

Leased line type	Modem type	CCITT Recommendation	Minimum receive level
A2O	2 400 bit/s 4 800 / 2 400 bit/s 9 600 bit/s	V.26 ter V.27 bis V.32	- 43 dBm - 43 dBm -------
A4O	4 800 / 2 400 bit/s	V.27 bis	- 43 dBm
A2S	2 400 bit/s 4 800 bit/s 4 800 / 2 400 bit/s	V.26 ter V.27 V.27 bis	- 26 dBm - 26 dBm - 26 dBm
A4S	2 400 bit/s 4 800 / 2 400 bit/s 9 600 bit/s 14 400 bit/s	V.26 V.27 bis V.29 V.33	- 26 dBm - 26 dBm - 26 dBm - 26 dBm

For test purposes, the overall loss of the leased line is tested at 1 020 Hz with the maximum mean signal level applicable to that type of leased line (-9 dBm or -13 dBm) into an impedance of 600 Ω. This impedance was chosen for test purposes for both 2 and 4 wire equipment since the majority of test equipment available to network operators is 600 Ω.

7.2.2 Loss/frequency distortion

The requirements for loss/frequency distortion are based on in CCITT Recommendations M.1020 and M.1040 with the requirement extended up to 3,6 kHz and modifications to the lower frequency mask. The requirement specifies how much the loss at frequencies in the voice band may deviate from the loss at 1 020 Hz. The permitted deviations are less for the special quality leased lines than for the ordinary quality ones.

The extension of the requirement up to 3,6 kHz allows the requirement to correspond with the definitions of FDM and PCM transmission equipment. The widening of the mask at low frequencies is to allow for the use of "cable only" leased lines over a short distance (< 30 km), where compensation for the lower loss at lower frequencies is not provided. International leased lines, as described by CCITT Recommendations M.1020 and M.1040 are not "cable only" and contain equalisers to account for the lower cable loss at lower frequencies.

Unlike the CCITT Recommendations, the ETSI standards specify the measurement level at which this requirement is no be met, this is to ensure consistency in testing and verification. The measurement level is defined to be the maximum mean input power level.

The test is specified in the same manner as for overall loss (i.e. with a 600 Ω impedance).

7.2.3 Transmission signals

Although the return loss of the two-wire leased lines are specified in terms of complex impedances, because of the difficulty of identifying test equipment which uses complex impedance terminations all transmission parameters (except return loss) are specified with 600 ohms non-reactive line terminations.

Certain requirements are specified at a frequency of 1 020 Hz; since some network equipment may be susceptible to this frequency, any frequency between 1013 Hz and 1022 Hz is permitted for test purposes.

7.2.3.1 Maximum mean input power

CCITT Recommendations M.1020 and M.1040 do not define mean sending levels; they only recommend minimum receive relative levels. In order to achieve the aim of the ONP Directive in harmonization of technical characteristics of the leased line and to ensure portability of terminal equipment, it is necessary to specify the input level of the leased lines.

In order to be compatible with the associated terminal equipment standards, the input level of the leased line is specified in terms of a "maximum mean input power". That is, a mean power level with which the leased line shall be capable of operating.

A survey of various telecommunication organisations throughout Europe showed no clear agreement on input levels for leased lines. However, it was generally accepted that sending levels of -9 dBm (2-wire circuits) and -13 dBm (4-wire circuits) were widely used by modems for connection to the PSTN and other lines and that these figures should be adopted for these leased lines.

Compliance with this requirement is assumed if the leased line meets the loss/frequency distortion test at the applicable send levels of -9 dBm (2-wire circuits) and -13 dBm (4-wire circuits).

7.2.3.2 Maximum instantaneous power

Subclause 1.3 (ii) of CCITT Recommendation V.2 states "provisionally, the maximum value of the instantaneous power shall not exceed a level corresponding to that of a 0 dBm0 sine wave signal." Applying this to the leased lines means that the 2-wire leased line shall be capable of operating with a maximum instantaneous power level of +4 dBm and the 4-wire leased line shall be capable of operating with a maximum instantaneous power level of 0 dBm.

It is necessary to take care when verifying compliance with this requirement since the public network may use equipment (e.g. frequency division multiplexing equipment) that may be affected by continuous signals of excessive amplitude which may result in major distortion to channels allocated to other users.

Testing is therefore limited to a sine wave, at 1 020 Hz, of no more than 100 ms in duration at a level of +4 dBm or 0 dBm as applicable. To ensure that a leased line is capable of operating with this signal, there should be no clipping to this signal at the output of the leased line. It should be noted that a definition of "clipping" is not given and it is left to the "engineering judgement" of the tester to determine if clipping has occurred.

7.2.3.3 Maximum power in a 10 Hz bandwidth

This requirement is not applicable to the leased line connection, however there is a note included for information within the leased line standards to indicate that such a requirement is imposed on the terminal equipment to limit interference within the network.

7.2.3.4 Maximum input power outside the voice band

This requirement is not applicable to the leased line connection, however there is a note included for information within the leased line standards to indicate that such a requirement is imposed on the terminal equipment to limit interference within the network.

7.2.4 Transmission delay

The requirement for terrestrial delay is based on CCITT Recommendation G.114 adjusted from transmission distance to geographical distance. It accounts for transmission delays and some effects of digital process delays. The calculation gives a base value of 8 ms which was increased to 15 ms to allow for the use of loaded cable sections.

The maximum transmission delay for links via a satellite is specified at 350 ms; this is the same as for the digital leased line standards.

The transmission delay of a 4-wire leased line can be tested if the probable assumption is made that the two directions of transmission follow the same path. A recognisable signal is injected at one end of the leased line; at the other end a piece of test equipment monitors the line and on receipt of this signal sends another signal in the opposite direction of transmission. The difference between the time the original signal was sent and the signal being received is the round trip delay. If it is assumed that both directions of transmission follow the same path, the transmission delay for each direction is half the round trip delay, less any time delay within the test equipment.

Such a test is not suitable for the 2-wire standards where the provision of a suitable return connection, either following the same path, or with a known transmission delay, is unlikely. The transmission delay for a 2-wire leased line needs to be determined from the network operators plans.

7.2.5 Group delay distortion

The requirement applies only to the special quality lines and is taken from subclause 2.3 of CCITT Recommendation M.1020. There is no equivalent requirement for ordinary quality leased lines within CCITT Recommendation M.1040.

The test method is specified using test equipment as defined in CCITT Recommendation O.81; further details of the test principles used are given in this Recommendation.

7.2.6 Variation of overall loss with time

7.2.6.1 Amplitude hits

The requirement applies only to the special quality lines and is taken from subclause 2.4.1 of CCITT Recommendation M.1020. A minimum duration of 4 ms has been added to the requirement since the test equipment, specified in CCITT Recommendation O.95 specifies a guard interval to prevent the registration of amplitude hits less than 4 ms. There is no equivalent requirement for ordinary quality leased lines within CCITT Recommendation M.1040.

Testing is performed using an amplitude hit detector complying with CCITT Recommendation O.95 using a test signal which is sent at a frequency of 1 020 Hz and at a level of -9 dBm for 2-wire leased lines and -13 dBm for 4-wire leased lines; further details of the test principles used are given in this Recommendation.

7.2.6.2 Other variations

The requirement to limit the variation with time of the overall loss of the leased line is taken from subclause 2.4.2 of CCITT Recommendation M.1020. Because of the actual pattern of use of ordinary quality leased lines, this requirement was also applied to them. The requirement has been made inclusive of the overall loss requirement, thus any variation with time cannot take the overall loss figure outside the limits specified for each leased line.

Testing of this parameter cannot easily be performed, however records of loss measurements can be recorded over a period of time.

7.2.7 Random circuit noise

The requirement on random circuit noise is taken from subclause 2.3 of CCITT Recommendation M.1040 and subclause 2.5 of CCITT Recommendation M.1020. The value ensures that the noise, weighted according to the sensitivity of the human ear to the various frequencies, will be at a suitable level below the minimum signal delivered to the receiver. The provisional limit stated in both CCITT Recommendations M.1020 and M.1040 is for a random circuit noise figure of -38 dBm0p for leased lines of distances greater than 10 000 km, with annex A showing, for shorter leased lines, the variation of random circuit noise against length of circuit of FDM carrier systems. With a maximum length of 9 000 km assumed for Europe, the figure of -38 dBm0p reduces to -41 dBm0p which is the requirement stated within all the standards; this is, however, the worse case figure and it would be anticipated that shorter leased lines would have correspondingly better figures.

This requirement defines the level of psophometric noise in dBm0p, i.e. in terms of the relative level at the output of the leased line on the user's premises; however this is only capable of being tested when the output relative level can be declared. Where the output relative level either is not, or cannot be, declared by the leased line provider, the random circuit noise level shall be 28 dB below a received test signal which is sent at a frequency of 1 020 Hz and at a level of -9 dBm for 2-wire leased lines and -13 dBm for 4-wire leased lines.

Therefore, for 2-wire and 4-wire leased lines, where the output relative level either is not, or cannot be, defined, the maximum noise level is:

2-wire:	-(37 + overall loss) dBmp
4-wire:	-(41 + overall loss) dBmp

Testing is performed using a psophometer complying with ITU-T Recommendation O.41; further details on psophometric noise are given in this Recommendation.

7.2.8 Impulsive noise

The requirement to limit the impulsive noise on special quality leased lines is taken from CCITT Recommendation M.1020. There is no requirement on ordinary quality leased lines. Measurement is performed using an instrument complying with CCITT Recommendation O.71; the threshold for the impulse noise level is defined in terms of relative value but this is only applicable for those occasions when the output relative level can be declared. It is re-defined in terms of absolute value for those situations where an output relative level either is not, or cannot, be declared.

Therefore, for 2-wire and 4-wire leased lines, where the output relative level either is not, or cannot be defined, the threshold should be set to:

2-wire:	-(17 + overall loss) dBm
4-wire:	-(21 + overall loss) dBm

Note that the test specified in the leased line standards is with a test sender sending at -9 dBm or -13 dBm; this necessitates the notch filter being switched in on the test receiver. It is also possible to perform the test without the test signal being applied, in which case the line should be terminated in either the reference impedance or 600 ohms and the notch filter need not be used; different test results may be obtained when testing with and without the test tone. Further details of the test principles used are given in CCITT Recommendation O.71.

7.2.9 Phase jitter

The special quality requirement is taken from CCITT Recommendation M.1020. There is no equivalent requirement for ordinary quality leased lines within CCITT Recommendation M.1040.

Testing is performed using a test sender and receiver complying with CCITT Recommendation O.91; further details of tests procedures can be found in this recommendation.

7.2.10 Distortion

7.2.10.1 Quantizing distortion

Figures of 7,5 and 3 Quantizing Distortion Unit (QDU) are specified for ordinary quality and special quality lines respectively. The presence of ADPCM (2,5 QDU for PCM-ADPCM-PCM) may, possibly, interfere with data transmission and introduce delay. The decision was taken during the drafting of the standards to permit the ordinary quality lines to be capable of realisation in all known European network applications and accept that data transmission may not always be ideal. The requirement is restricted for special quality lines to ensure that the transmission of data would not be impeded.

There is no test for compliance with the requirement on quantization distortion since QDUs cannot be measured. Compliance with this requirement can only be checked by reference to the network operators plans.

7.2.10.2 Total distortion

The special quality requirement is taken from CCITT Recommendation M.1020. There is no equivalent requirement for ordinary quality leased lines within CCITT Recommendation M.1040.

Compliance with the requirement is tested using equipment designed for the purpose, compliant with CCITT Recommendation O.132.

7.2.11 Single tone interference

The special quality requirement is from M.1020. There is no equivalent requirement for ordinary quality leased lines within CCITT Recommendation M.1040.

Compliance with the requirement is tested by monitoring the leased line with a selective level meter for any tone within the specified frequency range.

7.2.12 Frequency error

The special quality requirement is taken from CCITT Recommendation M.1020. There is no equivalent requirement for ordinary quality leased lines within CCITT Recommendation M.1040.

Compliance is tested by transmitting a single frequency into the leased line, at the specified level and frequency, and verifying that the received signal at the far end is within the specified tolerance.

7.2.13 Harmonic distortion

The special quality requirement is taken from CCITT Recommendation M.1020. There is no equivalent requirement for ordinary quality leased lines within CCITT Recommendation M.1040.

Compliance is tested at 700 Hz only; this frequency is chosen since this gives harmonics at 1 400 Hz, 2 100 Hz and 2 800 Hz within the specified frequency band.

7.2.14 Echo and stability

These provisions apply to the two wire lines only.

7.2.14.1 Echo

7.2.14.1.1 Echo control devices

The inclusion of echo control devices may possibly interfere with data transmission; as such, these are excluded form both ordinary and special quality leased lines.

There can be no test for the presence of echo control devices.

7.2.14.1.2 Talker echo

Talker echo is limited within the 2-wire standards to a level > 10 dB below the input signal. Figure 14 illustrates the source of talker echo: if a 2-wire leased line has a 4-wire path, then some of the input signal may be reflected back to the talker at the point of 4 to 2 wire conversion at the listener's end of the connection.

No test is specified within the standards due to the complexity of conducting such a test; it is recommended that this requirement be checked by calculation using information from the network operator.

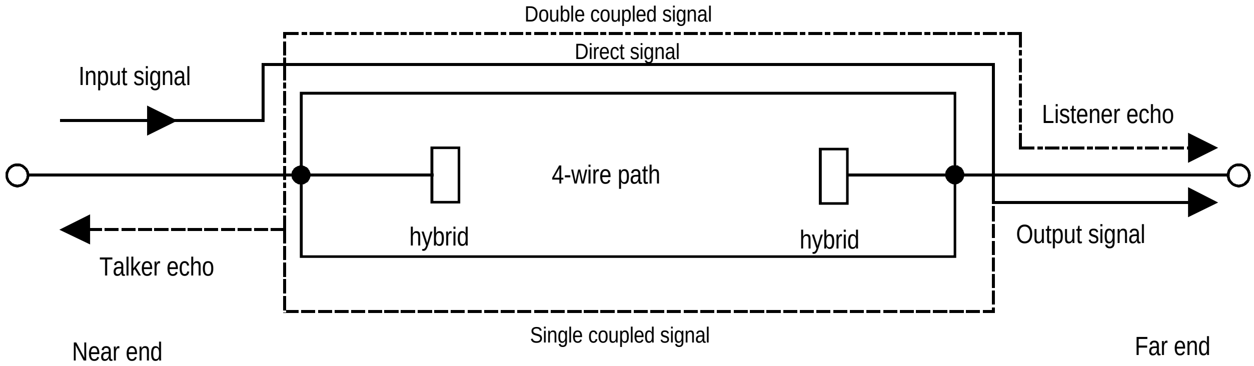

Figure 14: Talker and listener echo

7.2.14.1.3 Listener echo

Listener echo (sometimes called receive end echo) is limited within the 2-wire standards to a level > 20 dB below the output signal. Figure 14 illustrates the source of listener echo: if a 2-wire leased line has a 4-wire path, then some of the input signal may be reflected back within the 4-wire path at each conversion point (i.e. double reflection). Due to the mechanism which generates listener echo, this will generally be at a lower level than talker echo.

No test is specified within the standards due to the complexity of conducting such a test; it is recommended that this requirement be checked by calculation using information from the network operator.

7.2.14.2 Stability

There is a requirement that the 2-wire leased line be stable over the frequency range 0 Hz to 4 000 Hz under all terminating conditions. This includes the conditions of open and short circuit.

The frequency range 0 Hz to 4 000 Hz is wider than the range specified in standards for digital PABXs (i.e. 200 Hz to 3 600 Hz); this is because the PABX standard assume that there will be codecs within the connection, ensuring high loss below 200 Hz and above 3 600 Hz. It cannot be assumed that codecs will be present within the leased line connection.

The test is specified in terms of a reference signal level (threshold) that shall not be exceeded when the far end of the leased line is either open or short circuit; these two being considered the worst case terminations. The measurement of signal level is performed with a high impedance meter as this is again considered the worst case scenario. The test threshold is defined in the test as 22 dB below the level that would be received if a signal of -9 dBm at a frequency of 1 020 Hz were transmitted into the far end of the leased line; this level is 6 dB above the psophometrically weighted noise level that is specified for the leased line.

7.2.15 Connector

This is the ISDN basic access connector. It was chosen as a widely available connector to a European standard. An RJ/11 connector had also been considered to avoid the danger of plugging into the wrong socket, however this was not the specified in a European standard.

7.2.16 Hardwired presentation

As with the digital leased line standards an option for a hardwired presentation is included.

7.2.17 Return loss

CCITT Recommendations M.1020 and M.1040 do not consider the interface presentation. It is necessary to include a specification for the return loss of the leased line in order to ensure that there was not a significant mismatch-match between leased line and terminal equipment. It is not necessary to specify a high return loss since these leased lines are primarily for use with data and hence ensuring sufficient speech quality is outside the scope of these standards.

A complex reference impedance of 270 ohms + 750 ohms in parallel with 150 nF was selected for the 2-wire leased line; this is the harmonised impedance agreed within ETSI for 2-wire PSTN interfaces. For the 4-wire interface, a reference impedance of 600 ohms is specified as this is common throughout a large part of Europe. A return loss of 6 dB against each of these impedances is specified for both the 2-wire and 4-wire leased lines. This value can, in general, be met across the frequency band by the majority of network operators within Europe; however problems can occur at the upper range of the frequency band when using loaded cables.

In order to overcome the problems in meeting this return loss that may occur when using loaded cables, the leased line standards allow the alternative use of a weighted return loss across the frequency band. This is allowed for both 2-wire and 4-wire leased lines since loaded cable may also exist in 4-wire local ends. In most circumstances, however, it is anticipated that the leased lines will meet the return loss requirement across the frequency band without the need to calculate the weighted return loss. An informative annex to the standards illustrates the use of the weighting function.

7.2.18 Power feeding

Power feeding is not permitted over the interface either from the network to the terminal equipment of in the opposite direction.

To ensure that the leased line does not feed power, compliance is verified by ensuring that the current from the leased line, into 300 ohms, is less than 1 mA. There can be no test to ensure that the leased line does not require power from the terminal equipment interface, however none of the tests specified in the standards specify power feeding into the leased line and the leased line is required to meet the specified requirements without power feeding.

7.2.19 Safety

Telecommunications Network Voltage (TNV) is specified as the safety level since this allows for the typical voltages occurring within the telecommunications network and leased lines are not be capable of being separated from other conventional telecommunications circuits.

7.2.20 Overvoltage protection

No European standard exists that is suitable to apply to a leased line interface. CCITT Recommendation K.21 specifies some requirements, however these are general recommendations which it is not practical to extract into a regulatory standard. It is considered, however, by some people that overvoltage protection is an EMC issue and that equivalent requirements should not be imposed which are already covered by another regime (i.e. the EMC Directive, 89/336/EEC).

Leased line providers are required to provide primary protection in accordance with the general practice adopted in the country where the leased line is terminated.

7.2.21 ElectroMagnetic Compatibility (EMC)

There are currently no EMC requirements within the standards; general requirements are imposed under EMC Directive (89/336/EEC). Any requirements specific to the leased line (i.e. spurious generation of signals) may be added to the standards when appropriate specifications become available if these requirements are not imposed under the EMC Directive.

7.3 Terminal equipment interface

7.3.1 Return loss

7.3.1.1 2-wire terminal equipment

The return loss of 2-wire terminal equipment is specified as 8 dB against a complex impedance of 270 Ω in series with a parallel combination of 750 Ω and 150 nF (the reference impedance). A return loss of 8 dB is specified so that terminal equipment with 600 ohm impedance would meet the requirement even though the requirement is performed against a complex impedance.

Since the terminal equipment cannot be expected to match 600 ohm perfectly, allowance should be made for the spread of terminal equipment. Figure 15 shows the return loss of the reference impedance against 600 ohms.

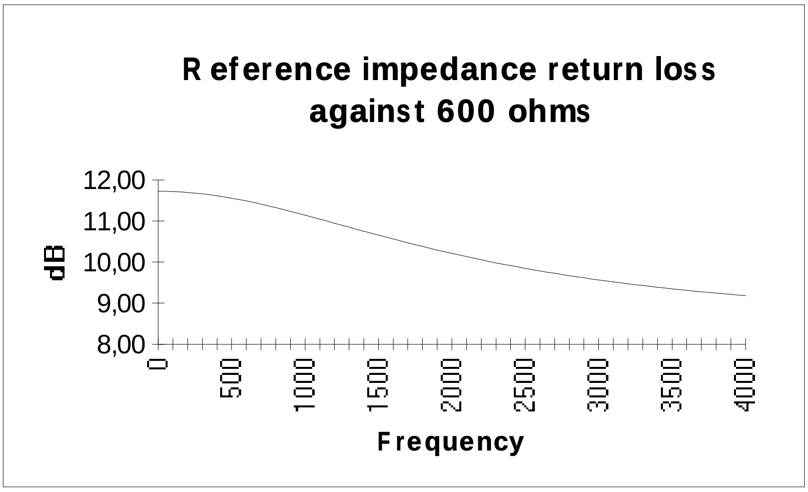

Figure 15: Return loss of the reference impedance against 600 Ω

7.3.1.2 4-wire terminal equipment

As for the two-wire terminal equipment, the return loss of the 4-wire interface is specified as 8 dB (in this case against 600 ohms) to allow for a variety of complex impedances.

7.3.2 Longitudinal conversion loss

The inclusion of a requirement for longitudinal conversion loss was requested by various TOs to protect the network from interference since signal unbalance may cause:

a) high noise levels;

b) crosstalk of sufficient severity to be a problem to other network users;

c) longitudinal signals received by the network to be converted to transverse signals of sufficient level to cause interference and harm to the network.

NOTE: Certain networks have high longitudinal signal levels of typically 65 volts rms.

A proposal to extend the requirement into the low outband (e.g. up to 20 kHz), in order to protect against low frequency signalling meter pulses, was rejected since meter pulses and similar signals should not be occurring on the leased lines.

7.3.3 Transmission signals

For the terminal equipment interface it is necessary to distinguish various types of equipment depending on the source of the signal transmitted at the interface. Three categories have been defined in the standard:

a) Any terminal equipment where the output signal is derived from an integral acoustic interface, e.g. a telephone.

b) Any terminal equipment where the output signal is generated electrically within the terminal equipment, e.g. a modem, answering machine or an equipment generating DTMF tones.

c) Any through connecting terminal equipment where the output signal is derived from another electrical interface, e.g. a PABX.

Terminal equipments may belong to more than one category. A telephone may be in both category a) for telephony and category b) for the generation of Dual Tone Multi-Frequency (DTMF) tones. A function for generating synthetic or recorded speech or music, such as is found in answering machines or voice mail, is included in category b).

7.3.3.1 Equipment with an acoustic interface

The requirement is defined in terms of the Sending Loudness Rating (SLR) at the leased line interface. The possibility of defining the requirement in terms of average power levels, as in ETS 300 001, was rejected since ETS 300 001 includes various national differences.

Since the precise value of the SLR is dependent on the method of testing, the test details are clearly specified within the test requirement. The values of the weighting factors used in the generation of the SLR are taken from table 2 of CCITT Recommendation P.79 but are reduced by 0,3 dB (in accordance with the Recommendation) to take into account the reduced measurement bandwidth.

The minimum SLR values of -5 dB and -1 dB for 2-wire and 4-wire terminal equipments refer to the actual measured value rather than the nominal value, i.e. there is no tolerance on the specified values. Additionally, these values quoted within the ETSs are at levels consistent with the applicable TBRs and have been specified to ensure no harm to the network. It is recommended that for normal operation, the SLR should be greater than or equal to -2 dB for 2-wire terminal equipment and +2 dB for 4-wire terminal equipment.

7.3.3.2 Equipment with internally generated electrical signals

7.3.3.2.1 Maximum mean power

The requirements for the maximum mean power level from the terminal equipment are consistent with the specification for the requirements on the leased lines (see subclause 7.2.3.1) and consistent with values taken from CCITT Recommendation V.2.

7.3.3.2.2 Maximum instantaneous power

The requirement for the maximum instantaneous power level from the terminal equipment is specified, not as a power level but as a maximum instantaneous voltage. This was selected since it is (a) consistent with ETS 300 001, and (b) should be easier to measure.

The voltages selected were chosen following a review of the levels in ETS 300 001 and at a level which should not harm the network.

7.3.3.2.3 Maximum power in a 10 Hz bandwidth

An initial value for the maximum power in a 10 Hz bandwidth was taken from the provisional value of -10 dBm0 given in subclause 1.3 (iii) of CCITT Recommendation V.2. The final values contained within the standards were selected with the aim of:

- matching the existing requirements of network operators;
- limiting out of band signal levels below 300 Hz;
- controlling out of band signals above the upper voice bandwidth limit of 3 400 Hz, up to a frequency of 4,3 kHz (at which point the requirement for "maximum sending power above 4,3 kHz" applies).

There is concern that the restriction between 3,4 kHz and 4,0 kHz may restrict the use of modems designed to operate to the specification of ITU-T Recommendation V.34. These modems transmit "probing tones" above 3,4 kHz to determine if there is usable bandwidth at this level. While these modems may exceed the stated maximum power in a 10 Hz bandwidth, these probing tones are of short duration (normally less than 150 ms), occur only during the initialization of the modem and are difficult to measure during testing. as such, it was agreed that modems should not be tested during their initialization phase and a statement was added to the test that "In the case of data equipment (e.g. modems) the maximum power shall only be measured during the data transfer phase".

7.3.3.3 Equipment with an electrical input

This category includes all the applications where the signal is derived from a source external to the terminal equipment, typically this includes through connection equipment such as PABXs.

It is not practical for the terminal equipment to limit the level of signals that originate from another interface on the terminal equipment. Therefore there is no requirement on this category of equipment within this ETS. It is recommended that the equipment supplier should indicate allowed input signal levels at other ports to which through connection is allowed.

7.3.4 Maximum sending power above 4,3 kHz

The requirement is imposed on the terminal equipment to limit interference to the network. The choice of values for the maximum power above 4,3 kHz were selected to place a realistic limit, consistent with typical existing limits, on the level of signal from the terminal equipment.

The use of a 120 Ω terminating impedance was selected as being a more realistic value for use at high frequencies, since the module of the reference impedance at 1 020 Hz (842 Ω) or at higher frequencies (270 Ω) are too far from the actual input impedance of the leased line in most of the range outside the voice band.

The different measurement bandwidths over the frequency range (300 Hz up to 7,0 kHz, 1 kHz from 7,0 kHz to 200 kHz and 10 kHz from 200 kHz to 2 MHz) have been specified to give a compromise between consistent and rapid testing. These measurement bandwidths should be available on all test equipment.

Note that while the specifications for out of band noise may appear at first glance to allow an increase of 5 dB in the signal level above 7,0 kHz, this increase is purely due to the change in measurement bandwidth from 300 Hz to 1 kHz ($10\log_{10}$ (1000/300) ≈ 5 dB).

7.3.5 Power feeding

Power feeding is not permitted over the interface either from the terminal equipment to the network of in the opposite direction.

To ensure that the terminal equipment does not feed power, compliance is verified by ensuring that the current from the terminal equipment interface, into 300 ohms, is less than 1 mA. There can be no test to ensure that the terminal equipment does not require power from the leased line interface, however none of the tests specified in the standards specify power feeding into the terminal equipment interface and the terminal equipment is required to meet the specified requirements without power feeding.

7.3.6 Terminal equipment receive functionality

The subject of whether the functionality of the terminal equipment input port should be defined in the ETS to a greater extent than currently proposed was discussed during the production of the standards. The present standards specify the input port primarily in terms of the return loss, there is no requirement on the input port actually being able to receive the input signal, (the present input requirement could be met by a 600 ohm resistor).

The digital standards impose a requirement on the terminal equipment to be able to recognise the input signal and to derive the equivalent binary code correctly, without errors; there is no such functional requirement on the analogue input ports. For an analogue terminal, however, the performance of the input receive capability is closely related to the functionality of the terminal equipment. It is not possible to define a minimum "input detect threshold" due to:

- the use that the input signal may be put to, e.g. to drive an analogue transducer, as input to a modem or signal processor or for direct connection through to another port; and

- the fact that the output signal from the leased line could vary in level by up to 25 dB means that either the terminal equipment may need some adjustment to operate satisfactorily with this range of input signal, or the terminal may only be designed to operate over a portion of this range.

The question therefore arises, should an terminal be capable of operating over the complete range of loss of the applicable leased line. This has been a requirement on the digital terminal equipments - they should operate correctly with interfering voltages and high cable loss. It was decided, however, that this exceeded the scope of the terminal equipment standards and encroached too much upon the functionality aspects and received quality of terminal equipment.

Annex A (informative): Standards defining the ONP minimum set of leased lines

Table A.1: ETSI standards defining the D2048U leased line and terminal equipment

Number / date	Title	Comment
ETS 300 246 1993-10	Business Telecommunications (BT); Open Network Provision (ONP) technical requirements 2 048 kbit/s digital unstructured leased lines Interface presentation	Due to be superseded by ETS 300 418
ETS 300 247 1993-10	Business Telecommunications (BT); Open Network Provision (ONP) technical requirements 2 048 kbit/s digital unstructured leased lines Connection characteristics	
ETS 300 247/A1 1995-07	Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured leased lines Connection characteristics	Changes interface presentation reference to ETS 300 418
ETS 300 248 1993-10	Business Telecommunications (BT); Open Network Provision (ONP) technical requirements 2 048 kbit/s digital unstructured leased lines Terminal equipment interface	
ETS 300 248/A1 1995-06	Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured leased lines Terminal equipment interface	Changes connector specification from ISO/IEC 10173
ETS 300 418 1995-08	Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured and structured leased lines (D2048U and D2048S) Interface presentation	Supersedes ETS 300 246
TBR 12 1993-12	Business Telecommunications (BT); Open Network Provision (ONP) technical requirements 2 048 kbit/s digital unstructured leased lines (D2048U) Attachment requirements for terminal equipment interface	
TBR 12/A1 1995-06	Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured leased lines (D2048U) Attachment requirements for terminal equipment interface	Changes connector specification from ISO/IEC 10173

Table A.2: ETSI standards defining the D2048S leased line and terminal equipment

Number / date	Title	Comment
ETS 300 418 1995-08	Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured and structured leased lines (D2048U and D2048S) Interface presentation	
ETS 300 419 1995-08	Business TeleCommunications (BTC); 2 048 kbit/s digital structured leased lines (D2048S) Connection characteristics	
ETS 300 420 1995-08	Business TeleCommunications (BTC); 2 048 kbit/s digital structured leased lines (D2048S) Terminal equipment interface	
TBR 13 1995-08	Business TeleCommunications (BTC); 2048 kbit/s digital structured leased lines (D2048S) Attachment requirements for terminal equipment interface	

Table A.3: ETSI standards defining the D64U leased line and terminal equipment

Number / date	Title	Comment
ETS 300 288 1994-01	Business TeleCommunications (BTC); 64 kbit/s digital unstructured leased lines Interface presentation	
ETS 300 288/A1 1995-06	Business TeleCommunications (BTC); 64 kbit/s digital unstructured leased lines Interface presentation	Changes connector specification from ISO/IEC 10173
ETS 300 289 1994-01	Business TeleCommunications (BTC); 64 kbit/s digital unstructured leased lines Connection characteristics	
ETS 300 290 1994-01	Business TeleCommunications (BTC); 64 kbit/s digital unstructured leased lines Terminal equipment interface	
ETS 300 290/A1 1995-06	Business TeleCommunications (BTC); 64 kbit/s digital unstructured leased lines Terminal equipment interface	Changes connector specification from ISO/IEC 10173
TBR 14 1994-04	Business TeleCommunications (BTC); 64 kbit/s digital unstructured leased lines Attachment requirements for terminal equipment interface	
TBR 14/A1 1995-06	Business TeleCommunications (BTC); 64 kbit/s digital unstructured leased lines Attachment requirements for terminal equipment interface	Changes connector specification from ISO/IEC 10173

Table A.4: ETSI standards defining the 2-wire analogue leased line and terminal equipment

Number / date	Title	Comment
ETS 300 448	Business TeleCommunications (BTC); Ordinary quality voice bandwidth 2-wire analogue leased line (A2O) Connection characteristics and interface presentation	
ETS 300 449	Business TeleCommunications (BTC); Special quality voice bandwidth 2-wire analogue leased line (A2S) Connection characteristics and interface presentation	
ETS 300 450	Business TeleCommunications (BTC); Ordinary and special quality voice bandwidth 2-wire analogue leased lines (A2O and A2S) Terminal equipment interface	
prTBR 15	Business TeleCommunications (BTC); Ordinary and special quality voice bandwidth 2-wire analogue leased lines (A2O and A2S) Attachment requirements for terminal equipment interface	

Table A.5: ETSI standards defining the 4-wire analogue leased line and terminal equipment

Number / date	Title	Comment
ETS 300 451	Business TeleCommunications (BTC); Ordinary quality voice bandwidth 4-wire analogue leased line (A4O) Connection characteristics and interface presentation	
ETS 300 452	Business TeleCommunications (BTC); Special quality voice bandwidth 4-wire analogue leased line (A4S) Connection characteristics and interface presentation	
ETS 300 452	Business TeleCommunications (BTC); Ordinary and special quality voice bandwidth 4-wire analogue leased lines (A4O and A4S) Terminal equipment interface	
prTBR 17	Business TeleCommunications (BTC); Ordinary and special quality voice bandwidth 4-wire analogue leased lines (A4O and A4S) Attachment requirements for terminal equipment interface	

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