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**Transmission and Multiplexing (TM);
Digital fixed point-to-point radio link equipment
operating in the frequency range 24,25 GHz to 29,50 GHz**

ETSI

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Contents

Foreword	5
1 Scope	7
2 Normative references	7
3 Symbols and abbreviations	9
3.1 Symbols	9
3.2 Abbreviations	9
4 General characteristics	9
4.1 Frequency bands and channel arrangements	9
4.1.1 Channel plan	9
4.1.2 Co-polar channel spacing for systems operating on different antennas over the same route	9
4.2 Compatibility requirements between systems.....	9
4.3 Environmental conditions.....	10
4.3.1 Equipment within weather protected locations	10
4.3.2 Equipment for non-weather protected locations.....	10
4.4 Electromagnetic compatibility	10
4.5 Telecommunications Management Network (TMN) interface	10
4.6 System block diagram	10
4.7 Branching/feeder/antenna requirements	11
4.7.1 Antenna radiation patterns	11
4.7.2 Waveguide flanges.....	12
4.7.3 Cross-Polar Discrimination (XPD).....	12
4.8 Power supply.....	12
5 Parameters for digital systems.....	12
5.1 Transmission capacity	12
5.2 Baseband parameters	12
5.2.1 Plesiochronous interfaces	12
5.2.2 Integrated Service Digital Network (ISDN) interface (primary rate)	12
5.2.3 SDH baseband interfaces	13
5.3 Transmitter characteristics	13
5.3.1 Transmitter power	13
5.3.2 RF spectrum mask.....	14
5.3.3 Spectral lines at the symbol rate	15
5.3.4 Spurious emissions	15
5.3.5 Radio frequency tolerance	15
5.4 Receiver characteristics for unprotected systems	15
5.4.1 Spurious emissions	16
5.4.2 Input level range.....	16
5.5 System performance for unprotected systems	16
5.5.1 Equipment background BER.....	16
5.5.2 BER performance.....	17
5.5.3 Interference sensitivity.....	17
History.....	19

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Foreword

This European Telecommunication Standard (ETS) has been produced by the Transmission and Multiplexing (TM) Technical Committee of the European Telecommunications Standards Institute (ETSI).

This ETS specifies the minimum performance parameters for radio relay equipment operating in the frequency range 24,25 GHz to 29,50 GHz.

Transposition dates	
Date of adoption of this ETS:	16 August 1996
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1 Scope

This European Telecommunication Standard (ETS) defines the minimum technical requirements for terrestrial digital radio relay systems operating in the frequency range 24,25 GHz to 29,50 GHz.

Digital systems covered by this ETS are intended to be used for point-to-point connections in local and regional networks at data rates between 2 Mbit/s and 155 Mbit/s. Typical applications include:

- a) network extensions;
- b) customer connections;
- c) inter-cellular links.

For digital systems, with capacities up to 34 Mbit/s, two types of equipment are specified:

- Grade A equipment, intended for applications where moderate frequency congestion is envisaged;
- Grade B equipment, intended for applications where higher nodal capacity is required.

The equipment covered by this ETS is intended to be used in systems designed to meet the appropriate error performance and availability objectives defined by ITU-T and ITU-R Recommendations. The parameters specified fall into two categories:

- a) those that are required to provide compatibility between Radio Frequency (RF) channels occupied by different sources of equipment at the same nodal point;
- b) parameters defining the equipment performance of the proposed system.

This ETS deals with RF and baseband characteristics.

As regards the Synchronous Transfer Module-level 1 (STM-1) signal, the Section Overhead (SOH) processing is covered in ITU-R Recommendation 750 [19].

Rainfall is the main propagation factor limiting error performance in frequency bands above 20 GHz. Therefore distortion sensitivity is not likely to be significant for short haul operation. Signatures for systems are not specified.

Safety regulations are outside the scope of this ETS.

2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative 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 ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

- [1] ETS 300 019: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment".
- [2] prETS 300 132-1: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment interface; Part 1: Interface operated by Alternating Current (AC)".
- [3] prETS 300 132-2: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment interface; Part 2: Interface operated by Direct Current (DC)".
- [4] ETS 300 233: "Integrated Service Digital Network (ISDN); Access digital section for ISDN primary rate".

- [5] ETS 300 385: "Radio Equipment and Systems (RES); Electro-Magnetic Compatibility (EMC) standard for digital fixed radio links and ancillary equipment with data rates at around 2 Mbit/s and above".
- [6] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".
- [7] ITU-T Recommendation G.704: "Synchronous frame structures used at 1544, 6312, 2048, 8488 and 44736 kbit/s hierarchical levels".
- [8] ITU-T Recommendation G.707: "Synchronous digital hierarchy bit rates".
- [9] ITU-T Recommendation G.708: "Network node interface for the synchronous digital hierarchy".
- [10] ITU-T Recommendation G.709: "Synchronous multiplexing structure".
- [11] ITU-T Recommendation G.773: "Protocol suites for Q-interfaces for management of transmission systems".
- [12] ITU-T Recommendation G.781: "Structure of Recommendations on equipment for the synchronous digital hierarchy (SDH)".
- [13] ITU-T Recommendation G.782: "Types and general characteristics of synchronous digital hierarchy (SDH) equipment".
- [14] ITU-T Recommendation G.783: "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".
- [15] ITU-T Recommendation G.784: "Synchronous digital hierarchy (SDH) management".
- [16] ITU-T Recommendation G.957: "Optical interfaces for equipments and systems relating to the synchronous digital hierarchy".
- [17] ITU-T Recommendation I.412: "ISDN user-network interfaces - Interface structures and access capabilities".
- [18] ITU-R Recommendation 748: "Radio-Frequency channel arrangements for radio-relay systems operating in the 25.25 to 27.5 and 27.5 to 29.5 GHz Bands".
- [19] ITU-R Recommendation 750: "Architecture and functional aspects of radio-relay systems for SDH-based networks".
- [20] ITU-R Recommendation 751: "Transmission characteristics and performance requirements of radio-relay systems for SDH-based networks".
- [21] IEC Publication 153-2: "Hollow metallic waveguides; Part 2: Relevant specifications for ordinary rectangular waveguides".
- [22] CEPT Recommendation T/R 13-02: "Preferred channel arrangements for fixed services in the range 22.0 - 29.5 GHz".

3 Symbols and abbreviations

3.1 Symbols

For the purposes of this ETS, the following symbols apply:

dB	decibel
dBc	decibel relative to mean carrier power
dBi	decibel relative to an isotropic radiator
dBm	decibel relative to 1 milliWatt
dBW	decibel relative to 1 Watt
GHz	Gigahertz
kHz	kilohertz
Mbit/s	Mega-bits per second
MHz	Megahertz
ppm	parts per million

3.2 Abbreviations

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

BER	Bit Error Ratio
C/I	Carrier to Interference ratio
CMI	Code Mark Inversion
EMC	Electro-Magnetic Compatibility
IF	Intermediate Frequency
ISDN	Integrated Service Digital Network
PDH	Plesiochronous Digital Hierarchy
RF	Radio Frequency
SDH	Synchronous Digital Hierarchy
SOH	Section Overhead
STM-1	Synchronous Transfer Module-level 1
sub-STM-1	subrate STM-1
TMN	Telecommunications Management Network
XPD	Cross-Polar Discrimination

4 General characteristics

4.1 Frequency bands and channel arrangements

4.1.1 Channel plan

The frequency range is 24,25 GHz to 29,50 GHz. The channel plan shall be in accordance with CEPT Recommendation T/R 13-02 [22] or ITU-R Recommendation 748 [18].

4.1.2 Co-polar channel spacing for systems operating on different antennas over the same route

Table 1

Minimum bit rate (Mbit/s)	2	2x2	8	2x8	34	51(sub- STM-1)	140 and 155
Channel spacing (MHz)	3,5	3,5	7	14	28	28 or 56	56 or 112

NOTE: n x 2 Mbit/s bit rates may be used.

4.2 Compatibility requirements between systems

There is no requirement to operate transmitting equipment from one manufacturer with receiving equipment from another, or to multiplex different manufacturers equipment on the same polarisation of a common antenna.

4.3 Environmental conditions

The equipment shall meet the environmental conditions set out in ETS 300 019 [1] which defines weather protected and non-weather protected locations, classes and severity tests.

4.3.1 Equipment within weather protected locations

Equipment intended for operation within temperature controlled locations or partially temperature controlled locations shall meet the requirements of ETS 300 019 [1] classes 3.1 and 3.2 respectively.

Optionally, the more stringent requirements of ETS 300 019 [1] classes 3.3 (non temperature controlled locations), 3.4 (sites with heat trap) and 3.5 (sheltered locations) may be applied.

4.3.2 Equipment for non-weather protected locations

Equipment intended for operation in non-weather protected locations shall meet the requirements of ETS 300 019 [1], class 4.1 or 4.1E.

Class 4.1 applies to many ETSI countries and class 4.1E applies to all ETSI countries.

4.4 Electromagnetic compatibility

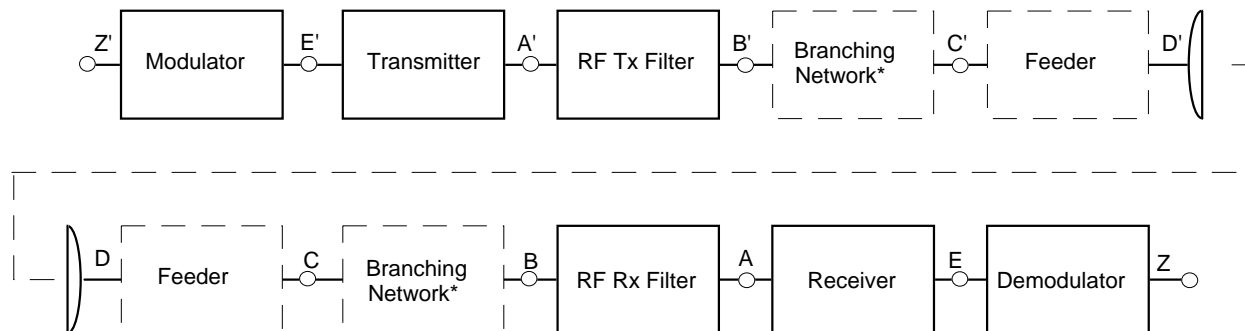
Equipment shall operate under the conditions specified in prETS 300 385 [5].

4.5 Telecommunications Management Network (TMN) interface

For Synchronous Digital Hierarchy (SDH) equipment the TMN interface shall be in accordance with ITU-T Recommendations G.784 [15] and G.773 [11] and ITU-R Recommendations 750 [19] and 751 [20].

NOTE: The standardization of TMN interface functionalities is under development in ETSI Technical Committee TM, and will be applicable to the radio relay systems considered in this ETS.

4.6 System block diagram



NOTE 1: The points listed above are reference points only.

NOTE 2: Points B and C, B' and C' may coincide.

Figure 1: System block diagram

4.7 Branching/feeder/antenna requirements

4.7.1 Antenna radiation patterns

The antenna radiation pattern shall be within the envelope given in figures 2 or 3, for Type A and Type B antennas, respectively. Type B antennas are intended for applications where high nodal capacity is required.

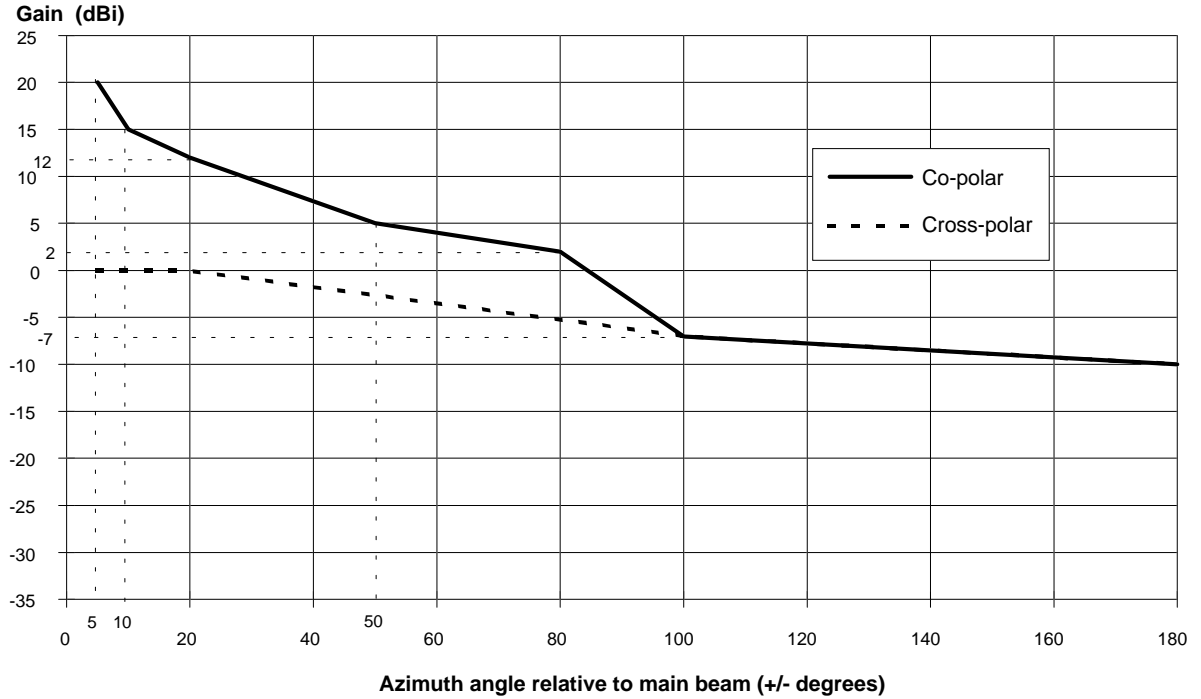


Figure 2: Type A antenna radiation pattern. Gain relative to an isotropic radiator (dBi)

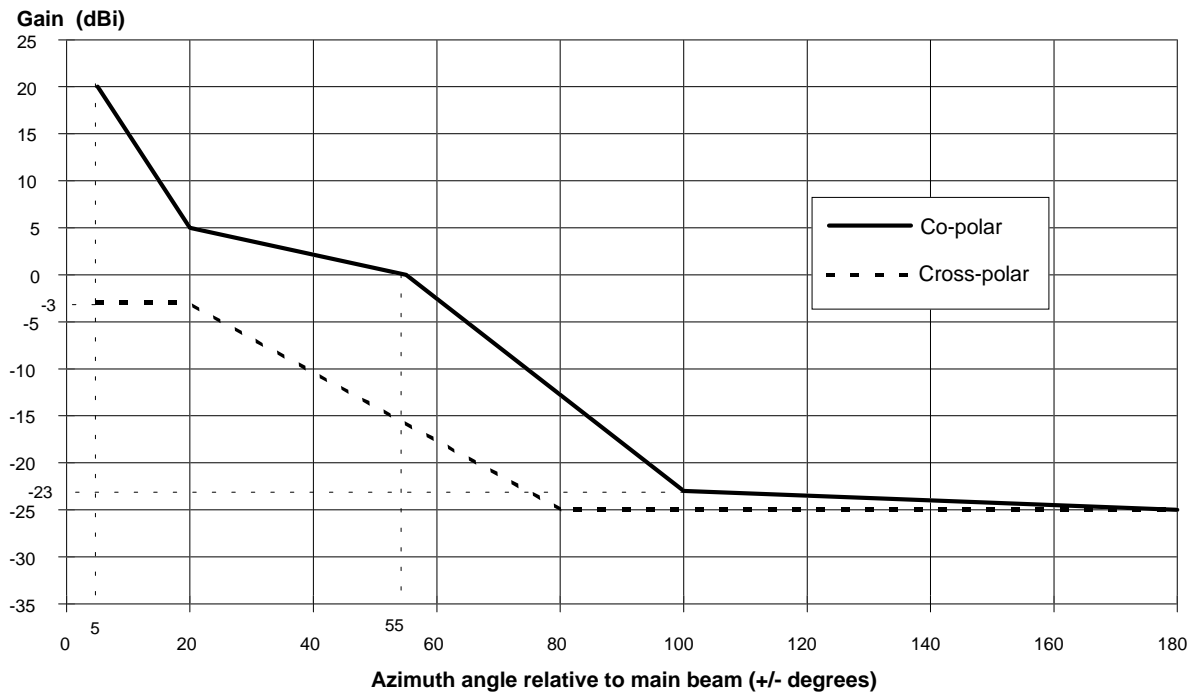


Figure 3: Type B antenna radiation pattern. Gain relative to an isotropic radiator (dBi)

4.7.2 Waveguide flanges

When flanges are required, one of the following types shall be used:

- UBR/PBR/CBR 260, for the complete frequency range 24,25 GHz to 29,50 GHz;
- UBR/PBR/CBR 220, for the lower part of the frequency range;
- UBR/PBR/CBR 320, for the higher part of the frequency range.

NOTE 1: The upper frequency limit for waveguide R 220 is 26,5 GHz, according to IEC Publication 153-2 [21].

NOTE 2: The lower frequency limit for waveguide R 320 is 26,5 GHz, according to IEC Publication 153-2 [21].

4.7.3 Cross-Polar Discrimination (XPD)

The antenna XPD-value within the 1 dB beam width shall not be less than 24 dB.

4.8 Power supply

The power supply interface shall be in accordance with ETS 300 132-1 [2] and ETS 300 132-2 [3].

5 Parameters for digital systems

5.1 Transmission capacity

Bit rates: 2 Mbit/s, 2x2 Mbit/s, 8 Mbit/s, 2x8 Mbit/s, 34 Mbit/s, 51 Mbit/s (subrate STM-1), 140 Mbit/s and 155 Mbit/s (STM-1).

System rates configured as n-times 2 Mbit/s are also considered.

5.2 Baseband parameters

5.2.1 Plesiochronous interfaces

Plesiochronous interfaces at 2 Mbit/s, 8 Mbit/s, 34 Mbit/s and 140 Mbit/s shall comply with ITU-T Recommendation G.703 [6]. Parameters for service channels and wayside traffic channels are outside the scope of this ETS.

In the interim period, while SDH networks become established, 140 Mbit/s Plesiochronous Digital Hierarchy (PDH) signals shall be carried "open port", i.e. in a transparent manner independent of their content. They shall be mapped into a 155 Mbit/s STM-1 signal as described in ITU-T Recommendations G.708 [9] and G.709 [10].

5.2.2 Integrated Service Digital Network (ISDN) interface (primary rate)

The transmission of 2 Mbit/s signals using the structure and functions of ISDN primary multiplex signals shall be in accordance with ITU-T Recommendations G.703 [6], G.704 [7] and I.412 [17] and ETS 300 233 [4].

5.2.3 SDH baseband interfaces

SDH baseband interfaces shall be in accordance with appropriate sections of ITU-T Recommendations G.703 [6], G.707 [8], G.708 [9], G.709 [10], G.781 [12], G.782 [13], G.783 [14], G.784 [15] and G.957 [16] and ITU-R Recommendation 750 [19].

Either of two STM-1 interfaces shall be used:

- a Code Mark Inversion (CMI) electrical (ITU-T Recommendation G.703 [6]);
- an optical (ITU-T Recommendation G.957 [16]).

The use of reserved bytes contained in the SOH, and their termination shall be in accordance with ITU-R Recommendation 750 [19].

5.3 Transmitter characteristics

The specified transmitter characteristics shall be met with the appropriate baseband signals applied at point Z' of figure 1. For PDH interfaces this shall be a pseudo-random binary sequence. For SDH a suitable STM-1 test signal are for further study.

5.3.1 Transmitter power

Transmitter output power at point C' of the system block diagram, given in figure 1, shall be in the range +5 dBm to +30 dBm (tolerances included).

NOTE 1: Some regulatory administrations define sub-ranges within the above range.

NOTE 2: A capability for output power level adjustment may be required for regulatory purposes, in which case the range of adjustment should be in increments of 5 dB or less.

NOTE 3: The nominal output power is declared by the manufacturer.

NOTE 4: At WARC 92 an amendment was made to the Radio Regulations for this band, adding footnote 2504A which states:
"As far as practical, sites for transmitting stations, in fixed or mobile services, employing maximum values of equivalent isotropic radiated power (e.i.r.p.) density exceeding 24 dBW in any 1 MHz band in the frequency band 25,25 - 27,50 GHz should be selected so that the direction of maximum radiation of any antenna will be at least 1,5° from the geostationary-satellite orbit, taking into account the effect of atmospheric refraction. The provisions of No. 2504A shall apply until such time as the CCIR has made a recommendation on the e.i.r.p. density limits which should apply in the band."

Depending on environmental conditions (see subclause 4.3), the nominal output power tolerance shall be within:

- ± 2 dB, for classes 3.1 and 3.2 as defined by ETS 300 019 [1];
- ± 3 dB, for all other classes.

5.3.2 RF spectrum mask

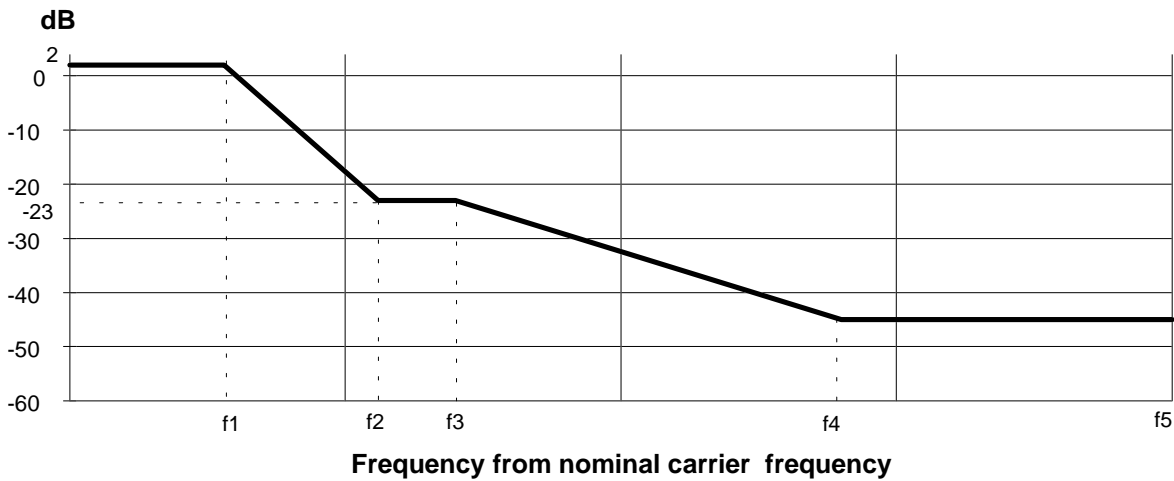
The equipment shall comply with the RF power spectrum masks given in figures 4 and 5. The 0 dB level shown on the spectrum masks relates to the spectral power density of the nominal centre frequency disregarding residual carrier. The masks take into account the allowance for frequency tolerance, including ageing effects.

Table 4 shows the recommended spectrum analyser settings.

Table 4: Spectrum analyser settings for RF power spectrum measurement

Bit rate (Mbit/s)	2	2x2	8	2x8	34	51(sub-STM-1)	140 or 155
Channel spacing (MHz)	3,5	3,5	7	14	28	28 or 56	56 or 112
Intermediate Frequency (IF) bandwidth (kHz)	30	30	30	30	100	100	100
Video bandwidth (kHz)	0,1	0,1	0,1	0,1	0,3	0,3	0,3
Total scan time (seconds)	10	10	10	20	20	20	20
Total sweep width (MHz)	20	50	50	100	150	300	600

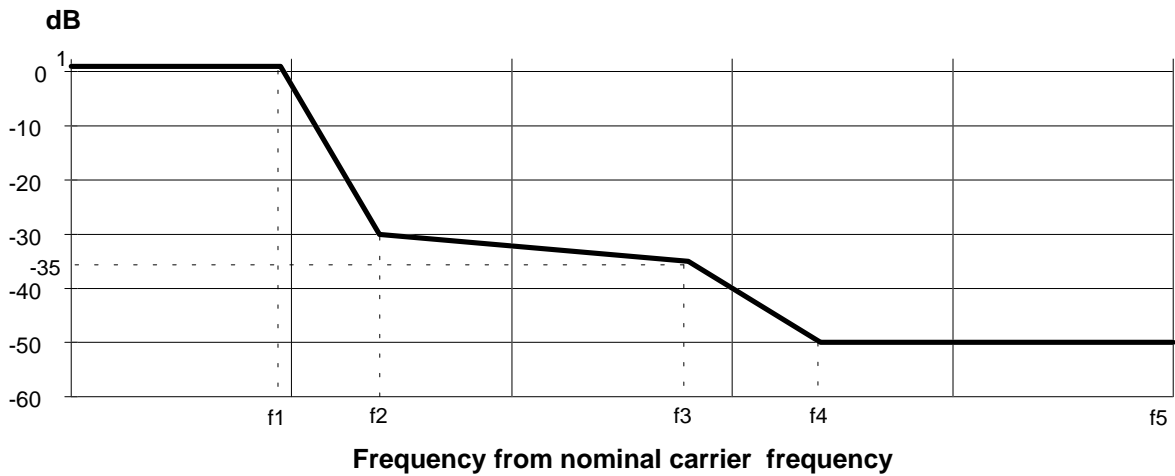
NOTE: n x 2 Mbit/s bit rates may be used.



Bit Rate	Channel Spacing	f1	f2	f3	f4	f5
2 Mbit/s	3,5 MHz	1,3 MHz	2 MHz	2,3 MHz	4,3 MHz	8,75 MHz
2x2 Mbit/s	3,5 MHz	1,4 MHz	2,8 MHz	3,5 MHz	7 MHz	8,75 MHz
8 Mbit/s	7 MHz	2,8 MHz	5,6 MHz	7 MHz	14 MHz	17,5 MHz
2x8 Mbit/s	14 MHz	5,6 MHz	11,2 MHz	14 MHz	28 MHz	35 MHz
34 Mbit/s	28 MHz	11 MHz	19 MHz	25 MHz	45 MHz	70 MHz
51 Mbit/s (sub-STM-1)	56 MHz	18 MHz	32 MHz	40 MHz	70 MHz	140 MHz
140/155 Mbit/s	112 MHz	40 MHz	78 MHz	90 MHz	125 MHz	280 MHz

NOTE: nx2 Mbit/s bitrates may be used.

Figure 4: Limits for spectral power density



Bit Rate	Channel Spacing	f1	f2	f3	f4	f5
51 Mbit/s (sub-STM-1)	28 MHz	9,5 MHz	14 MHz	28 MHz	34 MHz	70 MHz
140/155 Mbit/s	56 MHz	22,5 MHz	33 MHz	65 MHz	80 MHz	140 MHz

NOTE: nx2 Mbit/s bitrates may be used.

Figure 5: Limits of spectral power density

5.3.3 Spectral lines at the symbol rate

The RF spectrum mask shall not apply to the spectral lines at the symbol rate. The level of these spectral lines, at a distance from the channel centre frequency equal to the symbol rate shall be less than -35 dBc.

5.3.4 Spurious emissions

The frequency range in which the spurious emission specifications apply is 30 MHz to 80 GHz. The limit values measured at point C' of figure 1 are:

- 30 MHz to 21,2 GHz \leq -60 dBm;
- 21,2 GHz to 80 GHz \leq -30 dBm.

(Preliminary values subject to consultation with CEPT and other relevant parties).

For the purpose of this ETS the spurious emissions are defined as emissions at frequencies that are outside the nominal carrier frequency $\pm 2,5$ times the relevant channel spacing. Within the exclusion bandwidth defined above, emission levels shall not exceed the limits fixed by the spectrum mask given in subclauses 5.3.2 and 5.3.3.

NOTE: For the purpose of this ETS the measurement bandwidth shall be in the range 100 kHz to 120 kHz.

5.3.5 Radio frequency tolerance

Short term radio frequency tolerance shall be less than ± 20 ppm.

5.4 Receiver characteristics for unprotected systems

All parameters are referred to point C of figure 1. Losses in RF couplers used for protected systems are not taken into account in the limits specified below.

5.4.1 Spurious emissions

The frequency range in which the spurious emission specifications apply is 30 MHz to 80 GHz. The limit values measured at point C of figure 1 are:

- 30 MHz to 21,2 GHz ≤ -60 dBm;
- 21,2 GHz to 80 GHz ≤ -30 dBm.

(Preliminary values subject to consultation with CEPT and other relevant parties).

For the purpose of this ETS the spurious emissions are defined as emissions at frequencies that are outside the nominal carrier frequency $\pm 2,5$ times the relevant channel spacing. Within the exclusion bandwidth defined above, emission levels shall not exceed the limits fixed by the spectrum mask given in subclauses 5.3.2 and 5.3.3.

NOTE: For the purpose of this ETS the measurement bandwidth shall be in the range 100 kHz to 120 kHz.

5.4.2 Input level range

The input level range is referred to point C of figure 1.

The lower limit for the receiver input level shall be given by the threshold level for Bit Error Ratio (BER) = 10^{-3} as specified in table 5. The upper limit for the receiver input level, is -15 dBm. At this upper threshold, the BER shall be less than 10^{-3} .

5.5 System performance for unprotected systems

All parameters are referred to point C of figure 1. Losses in RF couplers used for protected systems are not taken into account in the limits specified below.

All measurements shall be carried out with the test signals defined in subclause 5.3.

5.5.1 Equipment background BER

Equipment background BER is measured under simulated operating conditions without interference with a signal level at point C of figure 1 which is 10 dB above the lower limit for the receiver input level which gives a BER = 10^{-6} as specified in table 5 the bit error rates shall be:

- for systems less than 34 Mbit/s: BER $<10^{-10}$;
- for systems of 34 Mbit/s and above: BER $<10^{-11}$.

5.5.2 BER performance

Receiver thresholds (dBm) referred to point C of the system block diagram, given in figure 1, for BER of 10^{-3} , 10^{-6} and 10^{-8} shall be equal to or lower than those stated in table 5.

Table 5: BER performance thresholds

bit rate Mbit/s	Channel spacing MHz	BER		10^{-3}		10^{-6}		10^{-8}	
		Grade		A	B	A	B	A	B
		2	3,5	-87	-90	-82	-85	-79	-82
2x2	3,5	-84	-87	-79	-82	-76	-79		
8	7	-81	-84	-76	-79	-73	-76		
2x8	14	-78	-81	-73	-76	-70	-73		
34	28	-75	-78	-70	-73	-67	-70		
51	56	-77		-72		-69			
140/155	112	-72		-67		-64			
51	28	-75		-72		-70			
140/155	56	-70		-67		-65			

NOTE 1: Grade A, grade B equipment, refer to clause 1.
NOTE 2: nx2 Mbit/s bitrates may be used.

5.5.3 Interference sensitivity

All receive signal levels and Carrier to Interference ratio (C/I) measurements are referred to point C of the system block diagram, given in figure 1:

- a) co-channel interference.

The limits of co-channel interference shall be as in table 6, giving maximum C/I values for 1 dB and 3 dB increase of the 10^{-6} and 10^{-3} BER limits specified in table 5.

Table 6: Co-channel interference sensitivity

Co-channel	BER	10^{-3}				10^{-6}			
		increase of limits		3 dB		1 dB		3 dB	
		Grade		A	B	A	B	A	B
bit rate	Channel spacing MHz								
2	3,5	21	18	18	15	26	23	22	19
2x2	3,5	21	18	18	15	26	23	22	19
8	7	21	18	18	15	26	23	22	19
2x8	14	21	18	18	15	26	23	22	19
34	28	21	18	18	15	26	23	22	19
51	56	18		15		23		19	
140/155	112	18		15		23		19	
51	28	26		23		31		27	
140/155	56	26		23		31		27	

NOTE 1: Grade A, grade B equipment, refer to clause 1.
NOTE 2: nx2 Mbit/s bitrates may be used.

b) adjacent channel interference.

The limits of adjacent channel interference shall be as given in table 7, giving maximum C/I values for 1 dB and 3 dB increase of the 10^{-6} and 10^{-3} BER limits specified in table 5.

Table 7: Adjacent channel interference sensitivity

Adjacent channel	BER	10^{-3}				10^{-6}			
	increase of limits	1 dB		3 dB		1 dB		3 dB	
	Grade	A	B	A	B	A	B	A	B
Bit rate	Channel spacing MHz								
2	3,5	-5	-8	-8	-11	0	-3	-4	-7
2x2	3,5	+1	-2	-2	-5	+6	+3	+2	-1
8	7	-2	-5	-5	-8	+3	0	-1	-4
2x8	14	-2	-5	-5	-8	+3	0	-1	-4
34	28	-2	-5	-5	-8	+3	0	-1	-4
51	56	-5		-8		0		-4	
140/155	112	-5		-8		0		-4	
51	28	-8		-11		-3		-7	
140/155	56	-8		-11		-3		-7	

NOTE 1: Grade A, grade B equipment, refer to clause 1.
 NOTE 2: nx2 Mbit/s bitrates may be used.

c) Carrier wave spurious interference.

For a receiver operating at the 10^{-6} BER threshold specified in subclause 5.5.2 the introduction of a carrier wave interferer at a level of +30 dB, with respect to the wanted signal and at any frequency up to 60 GHz, excluding frequencies either side of the wanted frequency by up to twice the relevant co-polar channel spacing, shall not result in a BER greater than 10^{-5} .

History

Document history			
July 1994	Public Enquiry	PE 67:	1994-07-25 to 1994-11-18
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September 1996	First Edition		