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**Transmission and Multiplexing (TM);
Digital Radio Relay Systems (DRRS);
Low and medium capacity point-to-point DRRS operating
in the frequency range 2,1 to 2,6 GHz**

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Foreword

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

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Date of adoption:	2 May 1997
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1 Scope

This European Telecommunication Standard (ETS) specifies the minimum performance parameters for terrestrial low and medium capacity Point-to-Point (P-P) digital fixed service radio relay equipment operating in the range 2,1 to 2,6 GHz. The requirements and limits given in this ETS are relevant to all environmental conditions for the chosen climatic class. Test methods are under study.

Digital systems are intended to be used for P-P connections in local and regional networks at data rates of $N \times 64$ kbit/s, $N \times 2$ Mbit/s ($N = 1, 2, 4, 8, 16$), 2×8 Mbit/s and 34 Mbit/s. Other data rates may also be foreseen. Typical applications include:

- a) customer connections;
- b) Integrated Services Digital Network (ISDN) extension;
- c) mobile base station connections;
- d) telemetry and telecontrol, including transportable and off-shore use;
- e) digital TV application.

The parameters to be specified fall into two categories:

- a) Those that are required to provide compatibility between channels from different sources of equipment on the same route, connected either to:
 - separate antennas; or
 - separate polarizations of the same antenna.
- b) Parameters defining the transmission quality of the proposed system.

This ETS deals with Intermediate Frequency (IF), Radio Frequency (RF) and baseband characteristics relevant to low and medium capacity Plesiochronous Digital Hierarchy (PDH) transmission. Antenna/feeder system requirements are covered in EN 300 631 [12].

Due to the wide spread of applications and corresponding system rates, parameters such as RF spectrum masks and receiver sensitivity are related to standardized channel spacings rather than to minimum system rates. This allows individual countries to allocate a bandwidth and therefore a standard channel spacing in accordance with the foreseen services and their own frequency management and radio network planning.

As the maximum bit rate in a given bandwidth depends on the system spectral efficiency, different equipment classes are defined:

- | | |
|----------|--|
| Class 1: | equipment performance based on typically 2-states modulation scheme (e.g. 2-FSK (Frequency-Shift Keying), Gaussian Minimum Shift Keying (GMSK) with discriminator detection, or equivalent); |
| Class 2: | equipment performances based on typically 4-states modulation scheme (e.g. 4-FSK, 4 - QAM (Quadrature Amplitude Modulation), or equivalent); |
| Class 3: | equipment performances based on typically 16-states modulation scheme (e.g. 16-QAM, or equivalent). |

Safety aspects are outside the mandate of ETSI and they will not be considered in this ETS.

2 Normative references

This ETS incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate place 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] CEPT Recommendation T/R 13-01: "Preferred channel arrangements for fixed services in the range 1 - 3 GHz".
- [2] ETS 300 019, Parts 1 and 2 (1994): "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; subparts 1-1 to 1-7: Classification of environmental conditions; subparts 2-1 to 2-7: Specification of environmental tests".
- [3] ITU-T Recommendation G.703 (1991): "Physical/electrical characteristics of hierarchical digital interfaces".
- [4] ITU-R Recommendation F.696-1: "Error performance and availability objectives for hypothetical reference digital sections utilizing digital radio-relay systems forming part or all of the medium-grade portion of an ISDN connection".
- [5] ITU-R Recommendation F.697-1: "Error performance and availability objectives for the local-grade portion at each end of an ISDN connection utilizing digital radio-relay systems".
- [6] ITU-T Recommendation G.773 (1993): "Protocol suites for Q-interfaces for management of transmission systems".
- [7] ITU-T Recommendation G.821 (1988): "Error performance of an international digital connection forming part of an integrated services digital network".
- [8] ITU-T Recommendation G.826 (1993): "Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate".
- [9] ETS 300 385: "Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) standard for digital fixed radio links and ancillary equipment with data rates at around 2 Mbit/s and above".
- [10] ITU-T Recommendation V.11 (1993): "Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s".
- [11] ITU-T Recommendation G.712 (1992): "Transmission performance characteristics of pulse code modulation".
- [12] EN 300 631: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Antennas for point-to-point radio links in bands 1 to 3 GHz".
- [13] ITU-T Recommendation V.24 (1993): "List of definitions for interchange circuits between terminal equipment (DTE) and data circuit-terminating equipment (DCE)".
- [14] ETR 080 (1996): "Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines".
- [15] ITU-R Recommendation F.746: "Radio-frequency channel arrangements for radio-relays systems".

- [16] ITU-R Recommendation F.634-3: "Error performance objectives for real digital radio-relay links forming part of a high-grade circuit within an integrated services digital network".
- [17] prETS 300 339: "Radio Equipment and Systems (RES); General Electro-Magnetic Compatibility (EMC) for radio equipment".
- [18] ETS 300 132: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) and Part 2: Operated by direct current (dc)".

3 Abbreviations and symbols

3.1 Abbreviations

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

BB	BaseBand
BER	Bit Error Ratio
CW	Continuous Wave
EMC	ElectroMagnetic Compatibility
FEC	Forward Error Correction
FSK	Frequency Shift Keying
GMSK	Gaussian Minimum Shift Keying
IF	Intermediate Frequency
IF/RF	Intermediate Frequency/Radio Frequency
ISDN	Integrated Services Digital Network
LO	Local Oscillator
NRZ	Non Return to Zero
PDH	Plesiochronous Digital Hierarchy
P-P	Point-to-Point
PRBS	Pseudo Random Binary Sequence
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
RSL	Receive Signal Level
RX	Receiver
S/I	Signal to Interference ratio
SRL	Spectrum Reference Level
TMN	Telecommunications Management Network
TX	Transmitter
XPD	cross-Polar Discrimination
W/U	Wanted to Unwanted signal ratio

3.2 Symbols

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

dB	deciBel
dBm	deciBel relative to 1 mW
GHz	GigaHertz
kHz	kiloHertz
km	kilometre
kbit/s	kilobits per second
Mbit/s	Megabits per second
MHz	MegaHertz
ppm	parts per million
ns	nanosecond

4 General characteristics

4.1 Frequency bands and channel arrangements

The systems are required to operate in the 2,1 and 2,6 GHz frequency bands as shown below in accordance with the CEPT Recommendation T/R 13-01 [1]:

- 2 025 to 2 110 MHz paired with 2 200 to 2 290 MHz;
- 2 520 to 2 593 MHz paired with 2 597 to 2 670 MHz;

and in the 2,3 to 2,5 GHz frequency band in accordance with the ITU-R Recommendation F.746 [15].

4.2 Modes of operation

Depending on the application, it shall be possible to operate the system in vertical or horizontal polarization. In the case of multiple channels on the same or parallel paths, alternate polarizations may be used as specified by ITU-R Recommendation F.746 [15].

4.2.1 Channel spacing

Depending on the application, the following standard channel spacings may be used:

500 kHz, 1 MHz, 1,75 MHz, 2 MHz, 3,5 MHz, and additionally for Class 2 and Class 3 equipments only 7 MHz, 14 MHz.

4.2.2 Transmit/receive duplex frequency separation

The duplex frequency separation for the 2,1 GHz frequency band is 175 MHz.

The duplex frequency separation for the 2,6 GHz frequency band is 74 MHz.

The duplex frequency separation for the 2,3 to 2,5 GHz frequency band is 94 MHz.

4.3 Installation

4.3.1 Environmental conditions

The equipment shall be required to meet environmental conditions set out in ETS 300 019 [2] which defines weather protected and non weather protected locations Classes and test severities.

4.3.1.1 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 [2] Classes 3.1 and 3.2 respectively.

Optionally, the more stringent requirements of ETS 300 019 [2] Classes 3.3 (non temperature controlled locations), 3.4 (sites with heat trap) and 3.5 (sheltered locations) may be applied.

4.3.1.2 Equipment for non-weather protected locations

Equipment intended for operation within non weather protected locations shall meet the requirements of ETS 300 019 [2], Class 4.1 or 4.1E.

Class 4.1 applies to many European countries and Class 4.1E applies to all European countries.

For systems within radio cabinets giving full protection against precipitation, wind, etc. the ETS 300 019 [2] Classes 3.3, 3.4 (A and D) and 3.5 may be applied also for equipment intended for operation in non-weather protected locations.

4.3.2 Electromagnetic compatibility conditions

Equipment operating at bit rates of 2 Mbit/s and above shall meet the requirements of ETS 300 385 [9].

For lower capacities the subject is under study, however ETS 300 339 [17] shall apply.

4.3.3 Power supply

The equipment shall operate from one or more of the power supplies detailed in ETS 300 132 Parts 1 and 2 [18] shown in table 1.

Table 1: Power supplies covered by ETS 300 132 Parts 1 and 2 [18]

For 230 V ac nominal:	207 to 253 V (see Part 1)	50 Hz \pm 2 Hz
For 48 V dc nominal:	-40,5 to -57 V (see Part 2)	-
For 60 V dc nominal:	-50,0 to -72 V (see Part 2)	-

For dc systems, the positive pole of the voltage supply shall be earthed at the source.

It may be required to operate from power supplies within the ranges specified in table 2 which are not detailed in ETS 300 132 Parts 1 and 2 [18].

Table 2: Power supplies not included in ETS 300 132 Parts 1 and 2 [18]

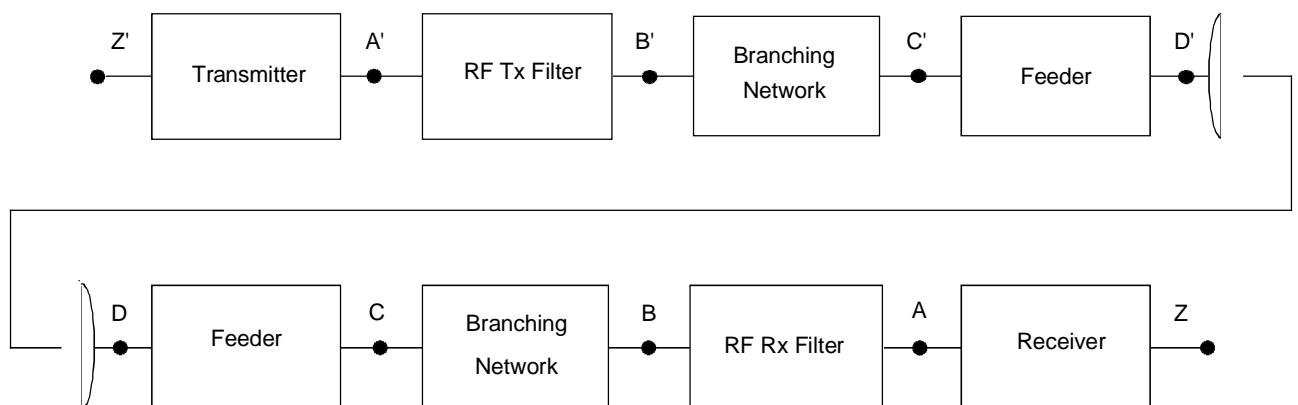
For 110 V ac nominal:	99 to 121 V	60 Hz \pm 2 Hz
For 24 V dc nominal:	-21,8 to -28,15 V	-

4.4 TMN requirements

Telecommunications Management Network (TMN) interface, if any, should be in accordance with ITU-T Recommendation G.773 [6].

4.5 Block diagram

The system block diagram is shown in figure 1. The intersection points are for reference only and not necessarily measurement purposes, nor do they indicate a specific design structure.



NOTE 1: For the purpose of defining the measurement points, the branching network does not include a hybrid.

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

Figure 1: System block diagram

4.6 Radio Frequency (RF) interfaces

RF interfaces for antenna port at reference points C and C' (unless an integral antenna is used) shall be of 50 Ω coaxial. Standard IEC connectors shall be used.

5 Baseband characteristics

5.1 Plesiochronous Digital Hierarchy (PDH) interfaces

Table 3 indicates relevant references for the ITU-T hierarchical baseband digital interfaces covered by this ETS.

Table 3: Baseband interfaces

Bit rate	Interface
64 kbit/s	ITU-T Recommendation G.703 [3], ITU-T Recommendation V.11 [10]
2/8/34 Mbit/s	ITU-T Recommendation G.703 [3]

ISDN interface according to ETR 080 [14] may also be foreseen and other data rate interfaces are subject to customer requirement.

5.2 Analogue interfaces

Table 4 below indicates relevant references for the baseband analogue interfaces covered by this ETS.

Table 4: Analogue interfaces

Type	Interface
2-wires	ITU-T Recommendation G.712 [11]
4-wires	ITU-T Recommendation G.712 [11]

Systems incorporating analogue interfaces, as primary service, shall provide digital test points (binary Non Return to Zero (NRZ) data + clock) at the transmitted bit rate (digital access of the input/output multiplexer) for system characteristics measurement purposes.

6 Transmitter characteristics

6.1 Output power

The maximum value of output power, referred to point C' shall not exceed +40 dBm.

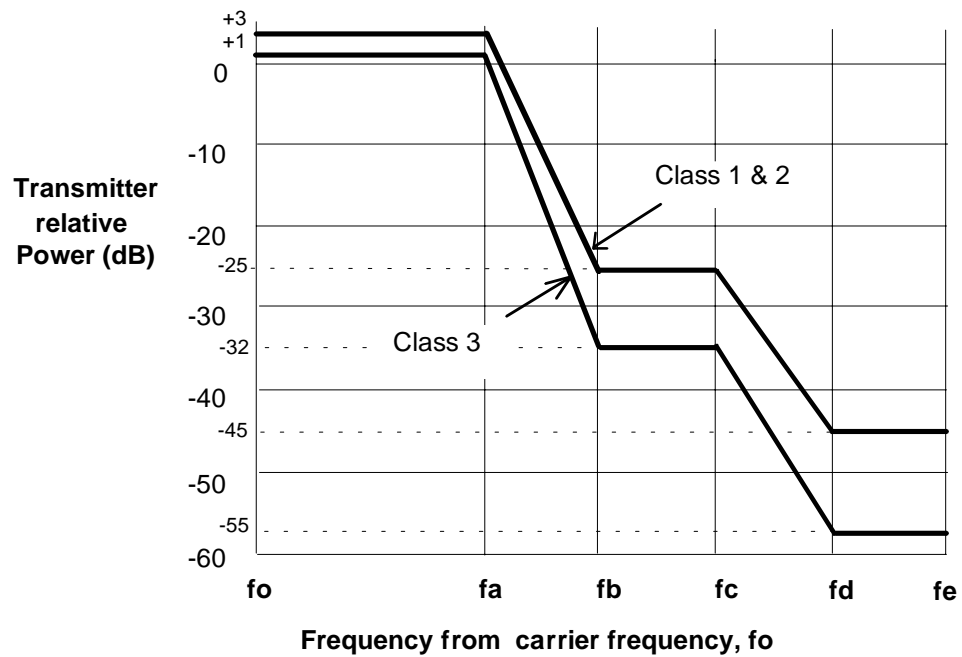
If for regulatory purposes, a reduced range of output power is required, then an internal or external means of adjustment shall be provided.

The tolerance value around the nominal or selected value of output power is +2/-1 dB.

6.2 RF spectrum masks

The spectrum masks relative to standard channel spacings and spectrum analyser settings for measurement purposes are shown in figure 2.

According to the channel spacing allocation, the equipment shall comply with the digital RF power spectrum mask given in figure 2. The 0 dB level shown on the spectrum masks relates to the spectral power density of the nominal centre frequency disregarding residual carrier. All spectrum masks include an allowance for frequency stability and accuracy, including ageing effects.



Channel Spacing	fa	fb	fc	fd	fe
500 kHz	210 kHz	325 kHz	450 kHz	800 kHz	1 250 kHz
1 MHz	420 kHz	650 kHz	900 kHz	1 600 kHz	2 500 kHz
1,75 MHz	750 kHz	1 150 kHz	1 600 kHz	2 800 kHz	4 375 kHz
2 MHz	840 kHz	1 300 kHz	1 800 kHz	3 200 kHz	5 000 kHz
3,5 MHz	1 500 kHz	2 400 kHz	3 500 kHz	6 000 kHz	8 750 kHz
7 MHz	3 000 kHz	4 800 kHz	7 000 kHz	12 000 kHz	17 500 kHz
14 MHz	6 000 kHz	9 600 kHz	14 000 kHz	24 000 kHz	35 000 kHz

Figure 2: Limits of spectral power density as a function of channel spacing

The mask in figure 2 refers to nominal centre frequency and includes an allowance for frequency stability.

Table 7: Spectrum analyser settings

Parameter	Settings						
	0,5	1	1,75	2	3,5	7	14
Channel spacing (MHz)	0,5	1	1,75	2	3,5	7	14
RF centre frequency	fo	fo	fo	fo	fo	fo	fo
Amplitude scale (dB/div)	10	10	10	10	10	10	10
IF bandwidth (kHz)	3	10	10	30	30	30	100
Sweep width (MHz)	5	10	10	15	20	50	100
Scan time	Auto	Auto	Auto	Auto	Auto	Auto	Auto
Video bandwidth filter (Hz)	100	100	100	300	300	300	1 000

6.3 Spectral lines at the symbol rate

The power level of spectral lines at a distance from the channel centre frequency equal to the symbol rate shall be more than 35 dB below the transmitter output power level (reference point B').

6.4 Spurious emissions

For the purposes of this ETS the spurious emissions are defined as emissions at frequencies which are outside the nominal carrier frequency $\pm 2,5$ times the relevant channel spacing.

The frequency range in which the spurious emission specification is to apply is 30 MHz to 10 GHz. The values measured at point C' shall be ≤ -60 dBm.

This is a provisional limit subject to consultation with CEPT and other relevant parties.

For the purposes of this ETS the measuring bandwidth is in the range 100 kHz to 120 kHz.

Within the exclusion bandwidth defined above the unwanted emission level shall not exceed the limits fixed by the relevant spectrum mask.

6.5 Radio frequency tolerance

Radio frequency tolerances are included in the spectrum masks given in figure 2. They include both tuning accuracy and environmental effects as well as long term ageing.

NOTE: For conformance testing purposes, the manufacturer should state the frequency tolerance to be taken into account for long term ageing and the mask reduced accordingly.

6.6 Return loss

The return loss measured towards the transmitter output port (point C') at the operating frequency shall not be less than 15 dB.

7 Receiver characteristics

7.1 Receiver image rejection

The definition of a receiver image rejection is not applicable to receivers with direct demodulation.

If applicable, the receiver rejection at image frequencies which fall within the transmitter half band shall be:

Class 1 and 2:	75 dB minimum;
Class 3:	85 dB minimum.

7.2 Receiver spurious emissions

The frequency range in which the spurious emission specification is to apply is 30 MHz to 10 GHz. The values measured at point C shall be ≤ -60 dBm.

This is a provisional limit subject to consultation with CEPT and other relevant parties.

For the purpose of this ETS the measuring bandwidth is in the range 100 kHz to 120 kHz.

7.3 Input level range

The dynamic range of the receiver for a Bit Error ratio (BER) $< 10^{-3}$ shall extend for a minimum of 55 dB above the lower threshold for BER = 10^{-3} referenced to point C.

7.4 Return loss

The return loss measured towards the receiver input (point C) at the operating frequency shall not be less than 15 dB.

8 System characteristics

8.1 BER as a function of receiver input level

The reference point for the definition of the BER curve as a function of receiver input level is point C. The receive signal level for the relevant BER given in tables 5a), 5b) and 5c) shall not be exceeded (these levels do not include any hybrid loss).

Table 5a): Receiver sensitivity for Class 1 equipment

Channel spacing	BER 10 ⁻³ level (dBm)	BER 10 ⁻⁶ level (dBm)
500 kHz	-96	-92
1 MHz	-93	-89
1,75 MHz	-91	-87
2 MHz	-90	-86
3,5 MHz	-87	-83

Table 5b): Receiver sensitivity for Class 2 equipment

Channel spacing	BER 10 ⁻³ level (dBm)	BER 10 ⁻⁶ level (dBm)
500 kHz	-99	-95
1 MHz	-96	-92
1,75 MHz	-94	-90
2 MHz	-93	-89
3,5 MHz	-90	-86
7 MHz	-87	-83
14 MHz	-84	-80

Table 5c): Receiver sensitivity for Class 3 equipment

Channel spacing	BER 10 ⁻³ level (dBm)	BER 10 ⁻⁶ level (dBm)
500 kHz	-93	-89
1 MHz	-90	-86
1,75 MHz	-88	-84
2 MHz	-87	-83
3,5 MHz	-84	-80
7 MHz	-81	-77
14 MHz	-78	-74

8.2 Equipment background BER

Equipment background BER (or residual BER) is measured under simulated operating conditions over an artificial hop without interference with a signal level at point C which is between 15 dB and 40 dB above the lower limit for receiver input level which gives BER = 10⁻³. The measurement period shall not be less than 15 hours.

For measurements at system access rates between 64 kbit/s and 192 kbit/s:

- Background BER < 10⁻⁹.

For measurements at system access rates above 192 kbit/s:

- Background BER < 10⁻¹⁰.

8.3 Interference sensitivity

The method to uniquely define equipment parameters to evaluate interference sensitivity between dissimilar equipment, e.g. capacity, modulation method etc. is subject to further study.

Method of testing like interferer W/U

For a receiver operating at the 10^{-6} BER threshold given in table 5a), 5b) and 5c), the introduction of a like interferer at a level given in table 6, with respect to the wanted signal shall not result in a BER greater than 10^{-5} . Measurements shall be done with an interferer at the co-channel frequency and at the first and second adjacent channel frequencies.

Reference points

All receive signal levels and S/I measurements shall be referred to point C of the block diagram shown in figure 1.

8.3.1 Co-channel interference

The limits of the co-channel interference sensitivity shall be as given in table 6.

8.3.2 Adjacent channel interference

The limits of the adjacent channel interference sensitivity shall be as given in table 6.

Table 6: W/U conditions for co and adjacent channel interferences tests

	Channel spacing	Co-channel	Adjacent channel	
		0	1	≥ 2
Frequency separation	500 kHz	0 kHz	500 kHz	1 MHz
	1 MHz	0 kHz	1 MHz	2 MHz
	1,75 MHz	0 kHz	1,75 MHz	3,5 MHz
	2 MHz	0 kHz	2 MHz	4 MHz
	3,5 MHz	0 kHz	3,5 MHz	7 MHz
	7 MHz	0 kHz	7 MHz	14 MHz
	14 MHz	0 kHz	14 MHz	28 MHz
W/U ratio (dB)	Class 1 & 2	23 dB	0 dB	-25 dB
	Class 3	30 dB	0 dB	-25 dB
NOTE: These values do not include any cross-polar discrimination improvement.				

8.3.3 CW spurious interference

The Continuous Wave (CW) spurious response rejection ratio of a receiver is a measure of its ability to discriminate between the wanted signal at the nominal channel frequency of the receiver and an unwanted signal at any other frequency at which a response is obtained.

For a receiver operating at the 10^{-6} BER threshold given in table 5a), 5b), 5c), the introduction of a CW interferer at a level of +30 dB, with respect to the "wanted" signal and at any frequency in the range 30 MHz to 10 GHz, excluding frequencies either side of the wanted frequency by up to twice the co-polar channel spacing, shall not result in a BER greater than 10^{-5} .

This test is designed to identify specific frequencies at which the receiver may have a spurious response, for example, image frequency, harmonics of the receive filter, etc. The actual test range should be adjusted accordingly. The test is not intended to imply a relaxed specification at all out of band frequencies specified elsewhere in this ETS.

9 Feeder/antenna requirements

The parameters and values are specified in EN 300 631 [12].

Annex A (informative): Indicative channel capacities

The indicative channel capacities (gross bit rate) for the three classes of equipment are based on the maximum gross bit rate for the minimum modulation level of each class. It is possible to improve on the gross bit rate by using higher modulation schemes within each class. The use of higher modulation levels within each class is permitted so long as the limits of the relevant spectral power density mask are not exceeded.

Table A.1: Indicative channel capacities (gross bit rate) for each equipment class

Channel spacing	Class 1	Class 2	Class 3
500 kHz	400 kbit/s	650 kbit/s	1 300 kbit/s
1 MHz	800 kbit/s	1 300 kbit/s	2 600 kbit/s
1,75 MHz	1 400 kbit/s	2 275 kbit/s	4 550 kbit/s
2 MHz	1 600 kbit/s	2 600 kbit/s	5 200 kbit/s
3,5 MHz	2 800 kbit/s	4 500 kbit/s	9 100 kbit/s
7 MHz	Not applicable	9 000 kbit/s	18 200 kbit/s
14 MHz	Not applicable	18 000 kbit/s	38 000 kbit/s

History

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