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European Standard (Telecommunications series)

**Fixed Radio Systems;
Point-to-point equipment;
High capacity fixed radio systems carrying SDH
signals (2 x STM-1) in frequency bands
with 40 MHz channel spacing and
using Co-Channel Dual Polarized (CCDP) operation**



Reference

REN/TM-04140

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM), and is now submitted for the ETSI standards One-step Approval Procedure.

The present document introduces new classes and grades of equipments focused on applications with single or few channels per links, with or without the XPIC option, suitable for co-polar adjacent channel operation; typical for mobile networks infrastructures.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

1 Scope

The present document specifies the minimum performance parameters for a high capacity digital radio-relay system operating in frequency bands with 40 MHz channel spacing in the 4 GHz, 5 GHz, U6 GHz and 11 GHz bands. The channel capacity is 1 x STM 1 on each polarization that allows to transmit up to $2 \times$ STM 1 signals in the same RF channel by using both polarizations in co-channel dual polarized (CCDP) mode of operation with cross-polar interference canceller techniques (XPIC).

The present document is also applicable to 1 x STM-1 ACCP systems operating with co-polar arrangement of 40 MHz for which the CCDP operation with XPIC is considered a non applicable option; for those systems the clauses relevant to XPIC operation (i.e. co-channel "internal" interference) are not applicable. These systems are intended for local high capacity links (e.g. mobile infrastructure connections) where few channels may be used by different operators) and the crowded environment may require co-polar operation on adjacent channels.

Recognizing the benefits from the industrial point of view, two different grades of system have been defined.

- Grade A: based on 30 MHz-like system technology (i.e. based on 128 states modulation) with reduced receiver BER threshold capability.
- Grade B: based on 40 MHz system technology (i.e. based on 64 states modulation) with improved receiver BER threshold capability.

It has to be noted that STM-1 systems can be grouped in order to offer an SDH interface higher than STM-1.

The area of application of these digital radio-relay systems is foreseen to be in trunk and access networks forming part of an SDH-network including optical rings.

Systems considered in the present document shall be able to respect ITU-R and ITU-T performance objectives.

The systems considered should operate in these networks having regard for existing hop length, which are considered to be normally up to about 30 km to 40 km for access and about 60 km for trunk networks, respectively. Hop lengths greater than this latter length are used in special applications.

The systems considered in the present document are intended to allow operation with respect to existing PDH systems using 16 QAM modulation and transmitting 140 Mbit/s applying a channel spacing of 40 MHz.

The parameters specified fall into two categories:

- a) parameters that are required to provide compatibility between channels connected to the same antenna via a multichannel branching system, or channels on the same route connected to separate antennas;

NOTE: Due to the internal functionality of the XPIC, equipment operating on both polarization of the same channel is considered to form a single CCDP system.

- b) parameters defining the transmission quality of the proposed system.

The standardization deals with baseband, IF and RF characteristics relevant to SDH. Antenna/feeder system requirements are also considered for information to the reader, however antenna characteristics are generally covered in EN 300 833 [34].

Baseband interfaces have to be considered for STM-1 signals in accordance with ITU-T Recommendations G.707 [1] and G.957 [2]. PDH interfaces according to ITU-T Recommendation G.703 [3] for signals mapped into STM-1 signals according to ITU-T Recommendation G.707 [1] could be used.

Safety aspects will not be considered in the present document.

2 References

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

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

- [1] ITU-T Recommendation G.707/Y.1322 (2000): "Network node interface for the synchronous digital hierarchy (SDH)".
- [2] ITU-T Recommendation G.957 (1999): "Optical interfaces for equipments and systems relating to the synchronous digital hierarchy".
- [3] ITU-T Recommendation G.703 (2001): "Physical/electrical characteristics of hierarchical digital interfaces".
- [4] CEPT/ERC/REC 12-08: "Harmonized radio frequency channel arrangements and block allocations for low, medium and high capacity systems in the band 3 600 MHz to 4 200 MHz".
- [5] ITU-R Recommendation F.635-6: "Radio-frequency channel arrangements based on a homogeneous pattern for radio-relay systems operating in the 4 GHz band".
- [6] ITU-R Recommendation F.1099-3: "Radio-frequency channel arrangements for high-capacity digital radio-relay systems in the 5 GHz (4 400 - 5 000 MHz) band".
- [7] CEPT/ERC/REC 14-02: "Radio-frequency channel arrangements for medium and high capacity analogue or high capacity digital radio-relay systems operating in the band 6 425 MHz - 7 125 MHz".
- [8] ITU-R Recommendation F.384-7: "Radio-frequency channel arrangements for medium and high capacity analogue or digital radio-relay systems operating in the upper 6 GHz band".
- [9] CEPT/ERC/REC 12-06: "Harmonized radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 10,7 GHz to 11,7 GHz".
- [10] ITU-R Recommendation F.387-8: "Radio-frequency channel arrangements for radio-relay systems operating in the 11 GHz band".
- [11] ITU-T Recommendation G.826 (1999): "Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate".
- [12] ITU-R Recommendation F.1397: "Error performance objectives for real digital radio links used in the international portion of a 27 500 km hypothetical reference path at or above the primary rate".
- [13] ITU-R Recommendation F.1491: "Error performance objectives for real digital radio links used in the national portion of a 27 500 km hypothetical reference path at or above the primary rate".
- [14] ITU-R Recommendation F.752-1: "Diversity techniques for radio-relay systems".
- [15] ITU-R Recommendation F.1093-1: "Effects of multipath propagation on the design and operation of line-of-sight digital radio-relay systems".
- [16] ITU-R Recommendation F.1101: "Characteristics of digital radio-relay systems below about 17 GHz".
- [17] ETSI EN 300 019 (all parts): " Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment;".

- [18] ETSI ETS 300 132-1: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) derived from direct current (dc) sources".
- [19] ETSI EN 300 132-2: " Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc)".
- [20] ETSI EN 300 385: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for fixed radio links and ancillary equipment".
- [21] ETSI EN 300 417-7-1: "Transmission and Multiplexing (TM); Generic requirements of transport functionality of equipment; Part 7-1: Equipment management and auxiliary layer functions".
- [22] ETSI EN 301 167: "Transmission and Multiplexing (TM); Management of Synchronous Digital Hierarchy (SDH) transmission equipment; Fault management and performance monitoring; Functional description".
- [23] ITU-T Recommendation G.783 (2000): "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".
- [24] ITU-T Recommendation G.784 (1999): "Synchronous digital hierarchy (SDH) management".
- [25] IEC 60154 (all parts): "Flanges for waveguides".
- [26] ETSI ETS 300 635: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH); Radio specific functional blocks for transmission of M x STM-N".
- [27] ITU-R Recommendation F.750-4: "Architectures and functional aspects of radio-relay systems for synchronous digital hierarchy (SDH)-based network".
- [28] ETSI TR 101 035: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH) aspects regarding Digital Radio Relay Systems (DRRS)".
- [29] ITU-T Recommendation O.151 (1992): "Error performance measuring equipment operating at the primary rate and above".
- [30] ITU-T Recommendation O.181 (2002): "Equipment to assess error performance on STM-N interfaces".
- [31] CEPT/ERC/REC 74-01: "Spurious emissions".
- [32] ITU-R Recommendation SM.329-9: "Spurious emissions".
- [33] ITU-R Recommendation F.1191-2: "Bandwidths and unwanted emissions of digital fixed service systems".
- [34] ETSI EN 300 833: "Fixed Radio Systems; Point-to-point Antennas; Antennas for point-to-point fixed radio systems operating in the frequency band 3 GHz to 60 GHz".
- [35] ETSI TR 101 036-1: "Fixed Radio Systems; Point-to-point equipment; Generic wordings for standards on digital radio systems characteristics; Part 1: General aspects and point-to-point equipment parameters".
- [36] ETSI EN 301 489-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements".
- [37] ETSI EN 301 489-4: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 4: Specific conditions for fixed radio links and ancillary equipment and services".
- [38] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

- [39] ITU-T Recommendation G.828: "Error performance parameters and objectives for international, constant bit rate synchronous digital paths".
- [40] ITU-T Recommendation G.829: "Error performance events for SDH Multiplex and regenerator sections".
- [41] ITU-R Recommendation F.1492: "Availability objectives for real digital radio-relay links forming part of international portion constant bit rate digital path at or above the primary rate".
- [42] ITU-R Recommendation F.1493: "Availability objectives for real digital radio-relay links forming part of national portion constant bit rate digital path at or above the primary rate".
- [43] ITU-R Recommendation F.1102-1: "Characteristics of fixed wireless systems operating in frequency bands above about 17 GHz".
- [44] ITU-R Recommendation P.530-10: "Propagation data and prediction methods required for the design of terrestrial line-of-sight systems".
- [45] ETSI EN 301 126-1: "Fixed Radio Systems; Conformance testing; Part 1: Point-to-point equipment - Definitions, general requirements and test procedures".
- [46] ETSI ETS 300 019-1-3: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weatherprotected locations".
- [47] ETSI ETS 300 019-1-4: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weatherprotected locations".

3 Symbols and abbreviations

3.1 Symbols

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

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

3.2 Abbreviations

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

ACCP	Adjacent Channel Co-Polar
ATPC	Automatic Transmit Power Control
BBER	Background Block Error Rate
BER	Bit Error Rate
CCDP	Co-Channel Dual Polar
CMI	Coded Marked Inverted
CSmin	minimum practical Channel Separation (for a given radio-frequency channel arrangement)
CW	Continuous Wave
DC	Direct Current
EMC	Electro Magnetic Compatibility

Fc	cut-off Frequency
IF	Intermediate Frequency
IPI	Inter Port Isolation
LO	Local Oscillator
NFD	Net Filter Discrimination
PDH	Plesiochronous Digital Hierarchy
PRBS	Pseudo Random Bit Sequence
QAM	Quadrature Amplitude Modulation
RCSOH	Radio Complementary Section OverHead
RF	Radio Frequency
RL	Return Loss
RSL	Receive Signal Level
RX	Receiver
S/I	Signal to Interference ratio
SOH	Section OverHead
S/XPI	Signal to Cross Polar Interference ratio
SDH	Synchronous Digital Hierarchy
STM	Synchronous Transfer Module
TMN	Telecommunications Management Network
TX	Transmitter
XPD	Cross Polar Discrimination
XPI	Cross Polar Interference
XPIC	Cross Polar Interference Canceller

4 General Characteristics

4.1 Frequency bands and channel arrangements

The equipment shall operate on one or more of the channels as defined below.

4 GHz

The frequency range is 3,6 GHz to 4,2 GHz. The channel plan shall be in accordance with CEPT/ERC/REC 12-08 [4], annex A, Part 1 or ITU-R Recommendation F.635-6 [5], with 40 MHz channel spacing. The centre gap is 80 MHz.

5 GHz

The frequency range is 4,4 GHz to 5 GHz. The channel plan shall be in accordance with ITU-R Recommendation F.1099-3 [6] with 40 MHz channel spacing. The centre gap is 60 MHz.

U6 GHz

The frequency range is 6 425 GHz to 7 110 GHz. The channel plan shall be in accordance with CEPT/ERC/REC 14-02 [7] or ITU-R Recommendation F.384-7 [8] with 40 MHz channel spacing. The centre gap is 60 MHz.

11 GHz

The frequency range is 10,7 GHz to 11,7 GHz. The channel plan shall be in accordance with CEPT/ERC/REC 12-06 [9] or ITU-R Recommendation F.387-8 [10] with 40 MHz channel spacing. The centre gap is 130 MHz, 90 MHz or 50 MHz according to the frequency arrangement.

NOTE: With a frequency arrangement providing a central gap of 50 MHz, common TX/RX operation of the nearest channels is not required.

4.2 Modes of operation

The mode of operation is co-polar with possible frequency reuse with co-channel dual polar (CCDP) operation for all frequency bands.

The actual exploiting of both polarization is considered optional, while compatibility with other systems, that fully exploit the CCDP frequency reuse, is maintained.

NOTE: For frequency planning purposes these systems can be deployed with co-polar operation using adjacent channel (ACCP) or frequency reuse with co-channel dual polar operation (CCDP). The combination of both operations is to be considered in the frequency planning.

In defining system characteristics for CCDP systems the additional losses introduced by the branching networks must be taken into account. Depending on the implementation (split branching for even and odd channels followed by a 3 dB loss hybrid put at reference points C and/or C', narrow band RF filters concept or other solutions) additional losses ranging from 3 dB to 6 dB must be considered in evaluating the available net system gain.

When narrow-band RF filters are used losses affect directly receiver thresholds at reference point B. As a consequence this must be taken into account in specifying receiver threshold limits.

4.3 Compatibility requirements between systems

The compatibility requirements between systems are as follows:

- a) There shall be no requirement to operate transmitting equipment from one manufacturer with receiving equipment from another.
- b) There shall be no requirement to operate, on the same radio frequency channel, systems from different manufacturer on vertical and horizontal polarization.
- c) There may be a requirement to multiplex different manufacturers equipment on the same polarization of the same antenna, on different frequency channels. This is not applicable to systems with integral antenna.

4.4 Error performance and availability requirements

Equipment shall be designed in order to meet network performance and availability requirements foreseen by ITU-T Recommendations G.826 [11] and G.828 [39].

The events for SDH multiplex and regenerator sections should be measured according to ITU-T Recommendation G.829 [40].

The performance and availability objectives for any overall radio connection, used in the international or national portion of the digital path, have to be based on the criteria defined in:

- ITU-R Recommendations F.1397 [12] and F.1492 [41], for international portion;
- ITU-R Recommendations F.1491 [13] and F.1493 [42], for the national portion.

The implication of the link design on the performance is recognized and the general design criteria reported in ITU-R Recommendations F.752-1 [14], F.1093-1 [15], F.1101 [16], F.1102-1 [43] and F.1397 [12] are to be applied according the foreseen propagation scenario reported in ITU-R Recommendation P.530-10 [44].

4.5 Environmental profile

The equipment shall be required to meet the environmental conditions set out in the multipart standard EN 300 019 [17] which defines weather protected and non-weather protected locations, classes and test severity.

The equipment shall comply with all the requirements of the present document at all times when operating within the boundary limits of the operational environmental profile of the equipment.

The environmental profile of the equipment shall be declared by the manufacturer.

The fulfilment of EN 300 019 [17] environmental profiles is voluntary and not essential from the point of view of the R&TTE Directive [38]; for this purpose any operational environmental profile, as declared by the manufacturer, shall be used.

Any test, carried out to generate the test report and/or declaration of conformity, required to fulfil any Conformity assessment procedure foreseen by the R&TTE Directive [38] for radio equipment, shall be carried-out with the same principles and procedures, for reference and extreme conditions, reported in clause 4.4 of EN 301 126-1 [45].

4.5.1 Equipment within weather protected locations (indoor locations)

Equipment intended for operation within temperature controlled locations or partially temperature controlled locations shall meet the requirements of ETS 300 019-1-3 [46] classes 3.1 and 3.2 respectively.

Optionally, the more stringent requirements of ETS 300 019-1-3 [46] classes 3.3 (Non temperature controlled locations), 3.4 (Sites with heat trap) and 3.5 (Sheltered locations) may be applied.

4.5.2 Equipment for non-weather protected locations (outdoor locations)

Equipment intended for operation within non-weather protected locations shall meet the requirements of ETS 300 019-1-4 [47], class 4.1 or 4.1E.

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

4.6 Mechanical dimensions

For outdoor installation, the outdoor unit may be separable from the antenna.

For indoor installation the equipment shall conform to EN 300 019 [17].

Other mechanical arrangement which can be made compatible with EN 300 019 [17] may also be considered.

4.7 Power supply

The power supply interface shall be in accordance with the characteristics of one or more of the secondary voltages foreseen in ETS 300 132-1 [18] and EN 300 132-2 [19].

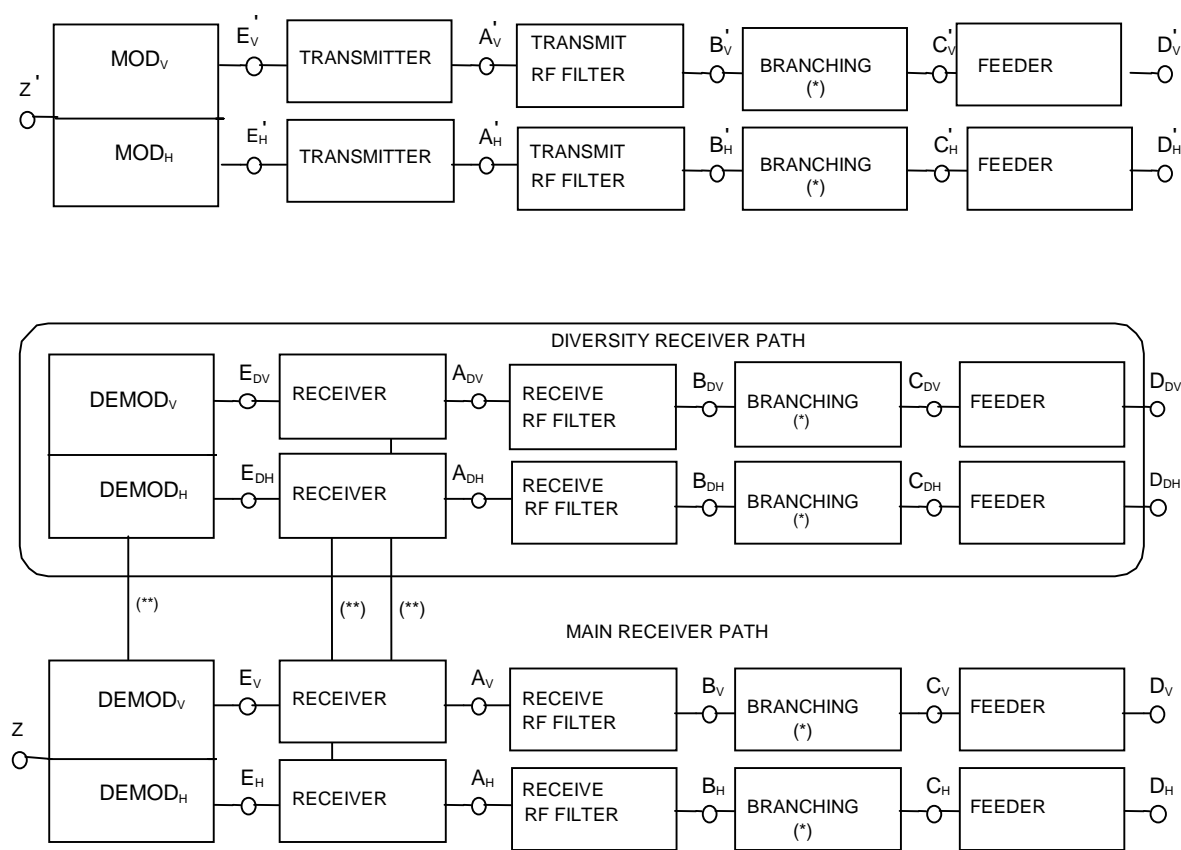
NOTE: Some applications may require secondary voltages that are not covered by ETS 300 132-1 [18] and EN 300 132-2 [19].

For DC systems, the positive pole of the voltage supply shall be earthen at the source.

4.8 Electromagnetic compatibility

The equipment shall comply with EN 300 385 [20] or to relevant parts of the multipart standard EN 301 489-1 [36] and EN 301 489-4 [37].

4.9 Block diagram



(*) No filter included.

(**) Connection at IFor Baseband.

NOTE 1: A 2 x STM-1 or 2 x 140 Mb/S interface is used at Z and Z'.

NOTE 2: For the purpose of defining the measurement points, the branching network does not include a hybrid.

NOTE 3: The points shown above are reference points only; points C and C', D and D' in general coincide.

NOTE 4: Points B and C, B' and C' may coincide when simple duplexer is used.

NOTE 5: Diversity is an optional feature.

NOTE 6: When CCDP operation mode is not provided only one half of the dual TX and RX paths (e.g. the H or V path) is relevant.

Figure 1: Block diagram

4.10 TMN interface

Where provided, TMN interface shall follow relevant ITU-T and ITU-R Recommendations, and ENs/ETSs.

NOTE: The standardization of TMN interface functionalities is under responsibility and development in ETSI TC TMN (formerly in TM2), and will be applicable to the radio relay systems considered in the present document.

The management requirements (i.e. fault management, performance management, etc.) shall be compliant with the specification for a STM-1 rate defined in EN 300 417-7-1 [21], EN 301 167 [22] and in ITU-T Recommendations G.783 [23] and G.784 [24].

4.11 Branching feeder and antenna requirements

4.11.1 Antenna radiation pattern

The radiation pattern shall be in accordance with EN 300 833 [34]. See also clause A.1.

4.11.2 Antenna cross-polar discrimination

The cross polarization discrimination shall be in accordance with EN 300 833 [34]. See also clause A.1.

4.11.3 Antenna Inter-Port Isolation (IPI)

See clause A.1.

4.11.4 Waveguide flanges

If a waveguide flange is used at point C/C', the following type shall be used in accordance with IEC 60154 [25].

Table 1: RF Waveguide interfaces

Frequency band	Waveguide flange
4 GHz	UDR/UBR/PBR/CBR 40
5 GHz	UDR/UBR/PBR/CBR 48
U6 GHz	UDR/UBR/PBR/CBR 70
11 GHz	UDR/PDR/CDR 100 UBR/PBR/CBR 100 UDR/PDR/CDR/120 UBR/PBR/CBR 120

4.11.5 Return Loss (RL)

The minimum return loss of the branching system shall be 24 dB for indoor systems and 20 dB for partially outdoor systems. The measurement shall be referred to reference point C/C' towards the radio equipment and across a frequency band greater than or equal to 1,3 times the maximum symbol frequency foreseen for the equipment.

Equipment according to the present document may also have system configurations with integral antennas or very similar technical solutions, without long feeder connections; return loss is not considered an important requirement. In these cases there shall be no requirement.

For feeder/antenna RL information see clause A.1.

4.11.6 Intermodulation products

When multi-channel branching system are concerned, in case the system is intended to comply with compatibility requirement in clause 4.3 c), each intermodulation product, caused by different transmitters linked to the same antenna branching system, shall be less than -110 dBm referenced to reference point C with an output power per transmitter relevant to the one referred in clause 5.3.1.

NOTE: The reference power shall be the maximum power stated by the manufacturer for the equipment. This clause is not intended for conformance test, but only, if required, for type test agreed between user and manufacturer. The measurement, if any, will be carried out with unmodulated signals of the same power of the average level of the digital signals.

5 Parameters for digital systems

5.1 Transmission capacity

The transmission capacities considered in the present document are:

- 2 x STM-1 (2 x 155,520 Mbit/s) and 2 x 139 264 Mbit/s in a 40 MHz RF channel using CCDP operation;
- STM-1 (155,520 Mbit/s) and 139 264 Mbit/s in a 40 MHz RF channel using ACCP and no frequency reuse.

5.2 Baseband parameters

5.2.1 Plesiochronous interfaces

The PDH interfaces at 140 Mbit/s may be used. They shall be compliant with ITU-T Recommendation G.703 [3]. These baseband signals shall be carried "open port", i.e. in a transparent manner independent of their content and they shall be mapped into a STM-1 signal as described in ITU-T Recommendation G.707 [1].

Parameters for service channels and wayside traffic channels are outside the scope of the present document.

5.2.2 SDH baseband interface

The SDH baseband interface shall be in accordance with ITU-T Recommendations G.703 [3], G.707 [1], G.783 [23], G.784 [24], G.957 [2], and ETS 300 635 [26].

Two STM-1 interfaces are possible:

- STM-1 optical interface (ITU-T Recommendation G.957 [2]);
- STM-1 CMI electrical interface (ITU-T Recommendation G.703 [3]).

The use of reserved bytes contained in the SOH, and their termination shall be in accordance with ITU-R Recommendation F.750-4 [27]. Further details on the possible use of the SOH bytes including additional RFCOH or RCSOH are given in ETSI TM4 document TR 101 035 [28].

5.3 Transmitter characteristics

The specified transmitter characteristics shall be met with the appropriate baseband signals applied at reference points Z' of figure 1. For PDH interfaces this shall be a PRBS in accordance with ITU-T Recommendation O.151 [29], for SDH interfaces this shall be in accordance with ITU-T Recommendation O.181 [30].

5.3.1 Transmitter power range

Transmitter maximum mean output power at reference point C' of the system block diagram (figure 1) shall not exceed +38 dBm (including tolerance and, if applicable, ATPC/RTPC influence).

A capability for output power level adjustment may be required for regulatory purposes, in which case the range of adjustment, either by fixed or automatic attenuators, should be in steps of 5 dB or less.

5.3.2 Automatic Transmit Power Control

ATPC is an optional feature.

The manufacturer shall declare if the equipment is designated with ATPC as a fixed permanent feature.

If implemented, the ATPC range shall not be less than 10 dB.

NOTE: For hop lengths of more than about 35 km an ATPC device with a range of more than 20 dB may be required for use on the same polarization on different antennas on the same route.

Equipment with ATPC will be subject to Manufacturer declaration of ATPC range and related tolerances.

Testing shall be carried out with output power level corresponding to:

- ATPC set manually to a fixed value for system performance (clauses 5.5 and 5.6);
- ATPC set at maximum provided power for TX spectral emissions (clause 5.3).

Further information on ATPC is given in clause A.2.

5.3.3 Transmitter output power tolerance

The nominal output power shall be declared by the supplier.

The tolerance of the nominal output power shall be within:

- for systems operating within non-weather protected locations classes 4.1 and 4.1E and within classes 3.3, 3.4 and 3.5 weather protected locations defined in EN 300 019 [17]:
nominal output power ± 2 dB;
- for systems operating within other classes of weather protected locations defined in EN 300 019 [17]:
nominal output power ± 1 dB;

The above limits are intended as ETSI voluntary requirements; from the point of view of declaration of conformity to article 3.2 of the R&TTE Directive [38], the power tolerance shall be:

- nominal output power ± 2 dB;

within the environmental profile declared by the manufacturer for the intended limits of usage of the equipment.

5.3.4 TX local oscillator frequency arrangements

There shall be no requirement on transmitter LO frequency arrangement.

5.3.5 RF spectrum mask

The spectrum masks are shown in figures 3 and 4; in figure 3 masks are shown both for the normal channels and for the inner side of innermost channels on the same branching networks and fix a lower limit of -95 dB in order to control local interference between transmitters and receivers on same polarization.

Spectrum masks in figure 3 are applicable to multi-channel systems (systems typically in fully indoor trunk applications) where all channels in both polarization are exploited under the same branching/antenna system and systems from different suppliers may be required to operate under the same branching system according clause 4.3 c).

NOTE: Due to limitations of some spectrum analysers, difficulties may be experienced when testing high capacity/wideband systems. The spectrum masks in figure 3 shall be verified directly by measurement (referenced to point B' of figure 1) up to the limit marked with (a). Since it is not possible to measure attenuation values up to 95 dB directly, for measuring values above 65 dB the following options are to be considered:

- a) measurement using high performance spectrum analyser;
- b) use of notch filters and two step measurement technique;
- c) by adding a measured filter characteristic to the spectrum measured at reference point A' of figure 1.

Where difficulties are experienced, the plots of one test conducted at ambient and environmental extremes may be produced as evidence to conformance to the spectrum mask.

The mask given in figure 4 is applicable to systems with no requirements to operate different supplier equipments under the same branching systems according to clause 4.3 c).

The 0 dB level shown on the spectrum masks relates to the spectral power density of the nominal carrier centre frequency, disregarding residual of the carrier (eventually due to modulation imperfection).

Masks shall be measured with a modulating base-band signal given by a PRBS signal given in ITU-T Recommendation O.151 [29] in the case of PDH signal or in ITU-T Recommendation O.181 [30] for STM-N signal.

The masks do not include frequency tolerance.

Table 2 shows the recommended spectrum analyser settings.

Table 2: Spectrum analyser settings for RF power spectrum measurement

Parameter	Setting
RF centre frequency	Spectrum centre
Amplitude scale	10 dB/div
IF bandwidth	100 kHz
Sweep width	100 MHz
Scan time	Automatic
Video bandwidth filter	100 Hz

5.3.6 Discrete CW lines exceeding the spectrum mask limit

5.3.6.1 Spectral lines at the symbol rate

The level (reference point B') of spectral lines at a distance from the channel centre frequency equal to the symbol rate shall be:

- less than -37 dBm for systems with symbol rates > 27 Mbaud (for adjacent analogue 2 700 channels compatibility on the same route);
- more than 43 dB below the mean power level of the carrier for systems with symbol rate ≤ 27 Mbaud.

5.3.6.2 Other spectral lines

In case some CW components exceed the spectrum mask, an additional allowance is given.

Those lines shall not:

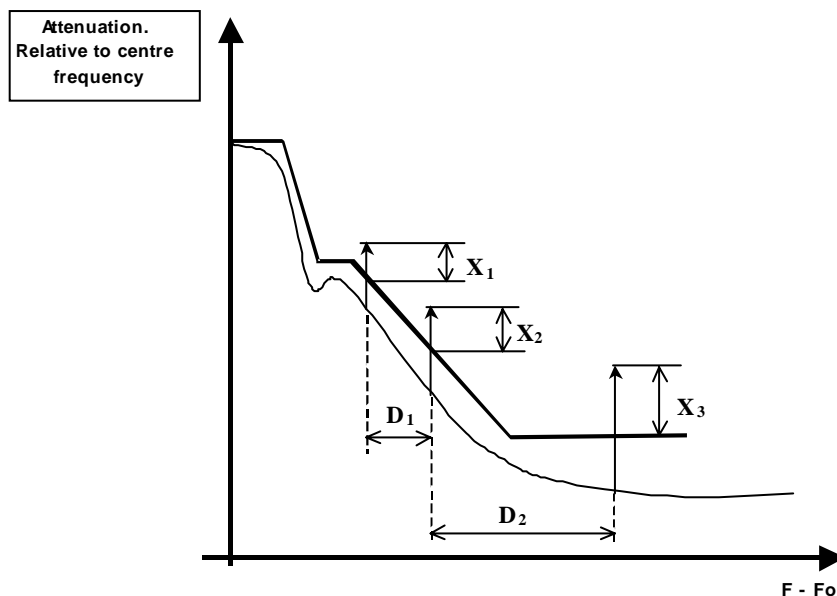
- exceed the mask by a factor more than $\{10 \log (CS_{\min}/IF_{bw}) - 10\}$ dB;
- be spaced each other in frequency by less than CS_{\min} .

Where:

CS_{\min} = 10 000 kHz for 4 GHz, 5 GHz, U6 GHz and 11 GHz bands.

IF_{bw} is the recommended resolution bandwidth, expressed in kHz, reported in table 3.

Figure 2 shows a typical example of this requirement.



$$X_1, X_2, X_3 \text{ [dB]} \leq 10 \log(CS_{\min} / IF_{bw}) - 10$$

$$D_1, D_2 \geq CS_{\min}$$

Figure 2: CW lines exceeding the spectrum mask (typical example)

5.3.7 Spurious emissions

It is necessary to define spurious emissions from transmitters for two reasons:

- to limit interference into systems operating wholly externally to the system under consideration (external emissions) which limits are referred by CEPT/ERC/REC 74-01 [31] based on ITU-R Recommendations SM.329-9 [32] and F.1191-2 [33];
- to limit local interference within the system where transmitters and receivers are directly connected via the filter and branching systems (internal emissions).

This leads to two sets of spurious emission limits where the specific limits given for "internal" interference are required to be no greater than the "external" level limits at reference point B' for indoor systems and C' for outdoor systems (where a common TX/RX duplexer is used).

5.3.7.1 Spurious emissions - external

According to CEPT/ERC/REC 74-01 [31] the external spurious emissions are defined as emissions at frequencies which are removed from the nominal carrier frequency more than $\pm 250\%$ of the relevant channel separation. Outside the band of $\pm 250\%$ of the relevant channel separation, the Fixed Service radio systems spurious emission limits, defined by CEPT/ERC/REC 74-01 [31] together with the frequency range to consider for conformance measurement, shall apply.

5.3.7.2 Spurious emissions - internal

Additional spurious emission limits might be required when:

- there is the requirement of coexistence of new digital systems with existing analogue systems on the same route;
- there is the requirement of clause 4.3 c) to multiplex equipment from different manufacturers on the same branching system.

In these cases the levels of the spurious emissions from the transmitter, referenced to reference point C' are specified in table 3.

The required level will be the total average level integrated over the bandwidth of the emission under consideration.

Table 3: Internal levels for the transmitter spurious consideration

Spurious emission type	Specification limit	Controlling factor
Discrete (CW) spurious emissions within the same transmitter half band	< -60 dBm	Within transmitters half band, digital interference to analogue systems on the same route
All spurious emissions within the receiver half band	< -90 dBm	Within receivers other half band, digital into digital interference on the same local multichannel branching/antenna system when compatibility according to clause 4.3 c) is required.

5.3.8 Radio frequency tolerance

Maximum radio frequency tolerance shall not exceed:

- a) ± 30 ppm for operation in environmental classes 3.1 and 3.2 (or equivalent weather-protected environment).
- b) ± 50 ppm or ± 400 kHz, whichever is the more stringent, for operation in other environmental classes.

This limit includes both short-term factors (environmental effects) and long-term factors (ageing effects).

In the type test the manufacturer shall state the guaranteed short-term part and the expected ageing part.

The above limits are intended as ETSI voluntary requirements; from the point of view of the R&TTE Directive [38] declaration of conformity only the less stringent limits of bullet B) above apply.

5.4 Receiver characteristics

In specifying receiver characteristics, it is intended that the receiver under test shall operate as a part of the complete receiving system comprising all components, including the Cross Polar Interference Canceller (XPIC), if applicable.

The systems shall operate loaded, at the baseband interface(s), with PRBS signal given in ITU-T Recommendation O.151 [29], in the case of PDH signal, or in ITU-T Recommendation O.181 [30] for STM-N signal; for CCDP systems, both interfaces shall be loaded.

The requirements under this clause assume that the receiver is not subject to any interference.

For receiver operation under XPI-conditions see clause 5.6.

5.4.1 Input level range

The lower limit for the receiver input level shall be given by the threshold level for Bit Error Ratio (BER) = 10^{-3} . The upper limit for the receiver input level, where a BER of 10^{-3} is not exceeded shall be -17 dBm; a BER of 10^{-10} may only be exceeded for levels greater than -21 dBm. These limits apply without interference and are referenced to point B.

For systems that are not intended to comply with any compatibility requirements under clause 4.3 c), the upper limit for the receiver input level, where a BER of 10^{-3} is not exceeded shall be -20 dBm. A BER of 10^{-10} may only be exceeded for levels greater than -24 dBm.

For equipment designed to operate only with ATPC as a fixed permanent feature, the above maximum input levels are reduced by an amount up to the ATPC range.

These limits apply without interference and are referenced to point B of figure 1.

5.4.2 RX local oscillator frequency arrangements

There shall be no requirement on receiver LO frequency arrangement.

5.4.3 Spurious emissions

5.4.3.1 Spurious emissions - external

At reference point C, the limit values of CEPT/ERC/REC 74-01 [31] shall apply.

5.4.3.2 Spurious emissions - internal

Spurious emissions which fall within receivers half band shall be:

- < -105 dBm, for systems with multichannel branching networks.

The required level (referenced to point B) will be the total average level integrated over the bandwidth of emission under consideration.

For digital systems without branching networks (i.e. single transceiver with duplexer) there will be no requirement.

5.4.4 Receiver image rejection

If applicable, the receiver image(s) rejection shall be as listed in table 4.

Table 4: Receiver image rejection

Controlling factor	Image rejection
a) if image(s) frequency falls within receiver half band and branching on different polarizations is used as defined by the compatibility requirements in clause 4.3 c)	≥ 90 dB
b) in systems not intended to fulfil any compatibility requirements in clause 4.3 c)	Not Applicable
c) if image(s) frequency falls in the transmitter half band and mixed manufacturer branching is used as defined by the compatibility requirements in clause 4.3 c)	≥ 120 dB

5.5 System performance without diversity

All parameters are referred to reference point B or C of figure 1. Losses in RF couplers used for protected systems are not taken into account.

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

5.5.1 BER as a function of receiver input signal level RSL

Receiver BER thresholds (dBm) referred to reference point C (for systems with simple duplexer) or B (for system with multi-channel branching system) of the System Block Diagram (figure 1) for BER of 10^{-3} , 10^{-6} and 10^{-10} shall be equal to or lower than those stated in table 5 (these levels do not include any hybrid loss). The values of table 5 shall be measured with the same input level on both polarizations.

Table 5: BER performance thresholds

Equipment grade	Frequency ⇒	RSL @ 4 GHz, 5 GHz and U6 GHz [dBm]	RSL @ 11 GHz [dBm]
	BER ↓		
A	10^{-3}	-68	-67
	10^{-6}	-65	-64
	10^{-10}	-62	-61
NOTE 1: According to the scope, grade A systems are likely to be implemented in outdoor and partially outdoor systems only; therefore the above limits are inclusive of any affecting factor.			
B	10^{-3}	-73	-71,5
	10^{-6}	-69	-67,5
	10^{-10}	-65	-63,5
NOTE 2: These limits are required when the connection of multichannel systems to the same antenna port of even and odd channels, spaced about 40 MHz on the same polarization, is made with a 3 dB hybrid coupler placed at reference point C. When alternatively, for the above purpose, narrow-band branching filters solution is used, these limits may be 1,5 dB higher. For outdoor and partially outdoor systems that are not subject to the compatibility requirements as stated in clause 4.3 c) there is a 2 dB relaxation on the above BER performance thresholds. The above foreseen relaxations are not intended to be additive, in cases where both could be applicable, the supplier shall declare which one he adopts.			

5.5.2 Equipment residual BER

Equipment residual BER is measured under simulated conditions over an artificial hop with a signal level at point B (or C) which is between 15 dB and 40 dB above the lower level which gives $BER = 10^{-3}$ and with less than 5 dB difference between the two polarizations. In a measurement period of 24 hours the number of bit errors should be less than 10 ($BER \leq 10^{-12}$).

5.5.3 Interference sensitivity

All receive signal levels and S/I measurements are referred to reference point B (for system with multi-channel branching system) or C (for systems with simple duplexer) of the Block Diagram (figure 1).

5.5.3.1 Co-channel "external" interference sensitivity

The following specifications apply to "external" interference from similar systems but from a different route (nodal interference).

The limits of the co-channel interference sensitivity shall be as given in table 6a, giving maximum S/I values for 1 dB and 3 dB degradation of the 10^{-6} BER limit specified in clause 5.5.1.

Table 6a: Co-channel "external" interference sensitivity

Degradation →	S/I at BER = @ 10^{-6} RSL degradation	
	1 dB	3 dB
Grade A	37	33
Grade B	33	29

For frequency coordination purpose intermediate values may be found in the curve supplied in informative annex A.

5.5.3.2 Adjacent channel interference sensitivity

The limits of the adjacent channel interference sensitivity shall be as given in table 6b for like modulated signals spaced of 1 channel spacing, giving maximum S/I values for 1 dB and 3 dB degradation of the 10^{-6} BER limits specified in clause 5.5.1.

Table 6b: 1st Adjacent channel interference sensitivity

Degradation →	S/I at BER = @ 10^{-6} RSL degradation	
	1 dB	3 dB
Grade A and B	-4	-8
NOTE: To cope with different fading effects in systems operating on adjacent channels on the same route but using different antennas, S/I values tighter by up to about 10 dB may be required, depending on hop length, fading occurrence factor and ATPC range. The relationship of these parameters on performance prediction is under study.		

For frequency co-ordination purpose intermediate values may be found in the curve supplied in informative annex A.

5.5.3.3 CW interference

For a receiver operating at the 10^{-6} BER threshold given in clause 5.5.1, the introduction of a CW interferer at a certain level specified below, with respect to the wanted signal and at any frequency in the range 9 kHz to the 3rd harmonic of the receiver operating frequency, excluding frequencies either side of the wanted centre frequency of the RF channel by up to 250 % the channel spacing, shall not result in a BER greater than 10^{-5} .

The level of the CW interferer shall be: +30 dB.

NOTE: When waveguide is used between ref. points A and C, which length is higher than twice the free space wavelength of the cut-off frequency (F_c), the lower limit of measurement will be increased to $0,7 F_c$ and to $0,9 F_c$ when the length is higher than 4 times the same wavelength.

This test is designed to identify specific frequencies at which the receiver may have a spurious response, e.g. 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 elsewhere specified in the present document.

5.5.4 Distortion sensitivity

For the different grades of equipment the following requirements apply.

Grade A:

- for a delay of 6,3 ns and a BER of 10^{-3} the width of the signature should not exceed ± 17 MHz relative the channel assigned frequency and the depth should not be less than 15 dB;
- for a delay of 6,3 ns and a BER of 10^{-6} the width of the signature should not exceed ± 19 MHz relative the channel assigned frequency and the depth should not be less than 12 dB.

Grade B:

- for a delay of 6,3 ns and a BER of 10^{-3} the width of the signature should not exceed ± 17 MHz relative the channel assigned frequency and the depth should not be less than 18 dB;
- for a delay of 6,3 ns and a BER of 10^{-6} the width of the signature should not exceed ± 19 MHz relative the channel assigned frequency and the depth should not be less than 16 dB.

These limits are valid for both minimum and non-minimum phase cases.

The limits specified should also be verified by the loss-of-synchronization and re-acquisition signatures.

The sensitivity to dynamic fading is not subject of standardization, however it can be evaluated with the following parameters for a notch speed up to 100 MHz/s (sweeping activated in \pm half channel spacing), with a notch depth 1 dB less stringent than the above figures for BER = 10^{-3} or BER = 10^{-6} , the BER should not be higher than 10^{-3} or 10^{-6} , respectively.

5.6 Cross Polar Interference Sensitivity

This clause covers specific aspects of the performance of the system in presence of cross polarization interference (XPI) coming from the twin system on opposite polarization, not covered in the previous ones, that are mitigated by the XPIC operation. See clause A.6 for the measurement test set.

These characteristics are applicable only to systems offering frequency reuse option.

5.6.1 Co-channel "internal" interference sensitivity in flat fading conditions

The following specifications applies to "internal" interferer from the cross polarized channel of the same system.

For the frequency bands given under clause 5.1 the limits of the co-channel interference sensitivity for the system shall be as given in table 7.

Table 7: Degradation versus S/I in co-channel "internal" interference

Reference BER	10^{-6}	10^{-6}
RSL degradation	1 dB	3 dB
S/I (dB)	17	13

For frequency coordination purpose intermediate values may be found in the curve supplied in annex A.

Referring to the measurement test bench in annex A note that measurement must be made adding the same values of noise and interference to both the paths, and varying the phase shifter of the interfering path we have to find the worst condition for this characteristic.

5.6.2 Co-channel "internal" interference sensitivity in dispersive fading conditions

To evaluate the performance during multipath propagation, dispersive cross-polarized main signals and non dispersive cross-polarization interferences are used in test bench in clause A.6.

Performance is evaluated by means of a signature degraded by the presence of Cross Polar Interference. In the above defined measurement conditions, the notch frequencies and depths are kept equal on both paths.

Limits for BER = 10^{-6} are reported in table 8.

Table 8: Degraded signature vs. XPI

S/XPI [dB]	Signature width [MHz]	Signature depth [dB]
15	± 23	10

5.7 System characteristics with diversity

Space, angle and frequency diversity techniques are applicable. In this clause only combining techniques are considered.

5.7.1 Differential delay compensation

It should be possible to compensate for differential absolute delays due to antennas, feeders and cable connections on the two diversity paths. The limit is at least 75 ns of differential absolute delay.

5.7.2 BER performance

When both receiver inputs (main and diversity, point B and BD) are fed with the same signal level at an arbitrary phase difference, input level limits for specified BER shall be lower than those given under clause 5.5.1 for the case without diversity by more than 2,5 dB.

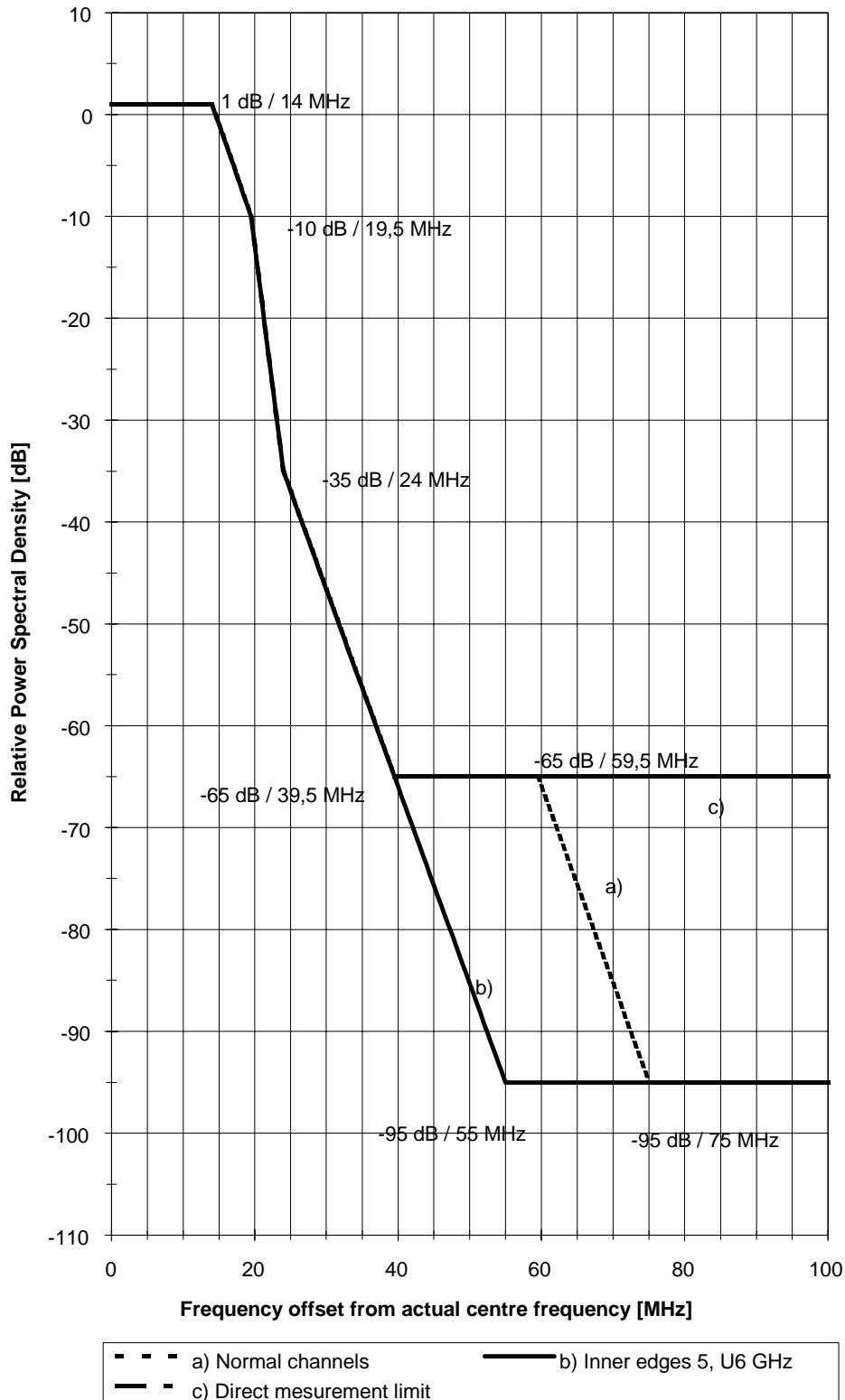
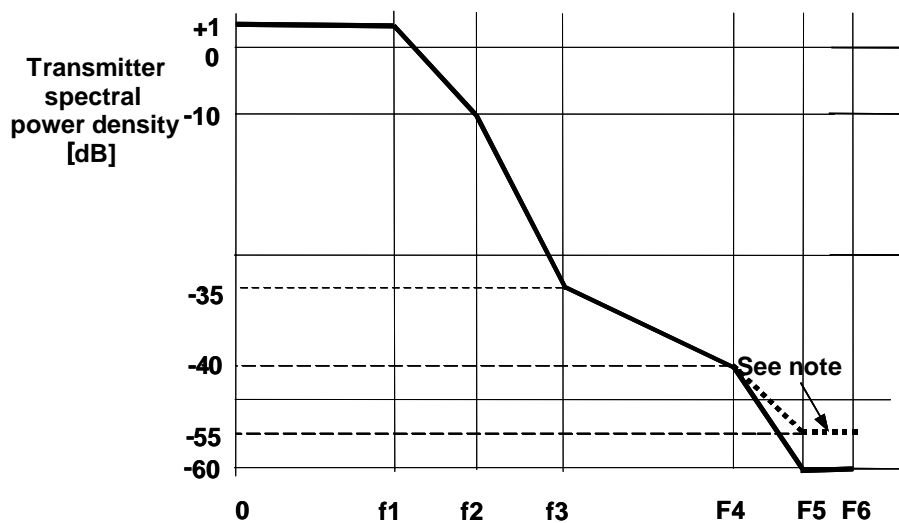


Figure 3: Limits of power spectral density for equipment with compatibility requirements according to clause 4.3 c)



f 1 [MHz]	f 2 [MHz]	f 3 [MHz]	f 4 [MHz]	f 5 [MHz]	f 6 [MHz]
14	19,5	24	54	67	100

NOTE: The spectral noise floor at -60 dB is applied to systems operating in frequency bands below 10 GHz.
For systems operating at 11 the spectral noise floor is -55 dB.

Figure 4: Limits of power spectral density for equipment with no compatibility requirements according to clause 4.3 c)

Annex A (informative): Additional Information

A.1 Antenna requirements

NOTE: The assumptions in this annex refer to EN 300 833 [34].

A.1.1 Antenna radiation patterns

For equipment on which the antenna forms an integral part, the radiation pattern should be in accordance with EN 300 833 [34].

A.1.2 Antenna Cross-Polar Discrimination (XPD)

Under normal unfaded propagation conditions the antenna XPD value shall be considered as not less than 28 dB.

It must be noted that some critical hops could require greater values of XPD.

A.1.3 Antenna Inter-Port Isolation (IPI)

Compatibility criteria of innermost cross polarized TX and RX equipment will be guaranteed with an IPI not less than 40 dB.

A.1.4 Feeder/antenna return loss

The minimum return loss of the feeder/antenna system connected to indoor systems should be considered not less than 24 dB. The measurement are referred to reference point C/C' towards the antenna.

A.2 Automatic Transmit Power Control

Automatic Transmit Power Control (ATPC) may be useful in some circumstances, e.g.:

- to reduce interference between neighbouring systems or adjacent channels of the same system;
- to improve compatibility with analogue and digital systems at nodal stations;
- to improve residual BER or BBER performance;
- to reduce upgrading problems;
- to reduce transmitter power consumption;
- to reduce digital-to-digital and digital to analogue distant interference between hops which re-use the same frequency;
- to increase system gain during flat fading attenuation conditions.

ATPC as an optional feature is aimed at driving the TX Power Amplifier output level from a proper minimum which facilitates the radio network planning requirements and which is used under normal propagation conditions up to a maximum value which fulfils all the specifications defined in the present document.

For planning conditions in a nodal environment a system equipped with ATPC can be considered to operate with its minimum transmitter power.

A.3 Spectrum masks

The spectrum masks given in figures 3 and 4 cannot be used for the direct evaluation of the Net Filter Discrimination (NFD) with respect to an adjacent channel spaced 40 MHz apart.

The required NFD can be derived as the difference between the co-channel interference (stated in clause 5.5.3.1 table 6a and the measured value of the adjacent interference sensitivity S/I referred to the same bit error ratio. This procedure is stated in ETSI document TR 101 036-1 [35].

A.4 Co-channel (internal and external) and adjacent channel interference

The reference performance for co-channel (internal and external) and adjacent channel S/I , spaced by one channel spacing, is shown in figures A.1, A.2 and A.3.

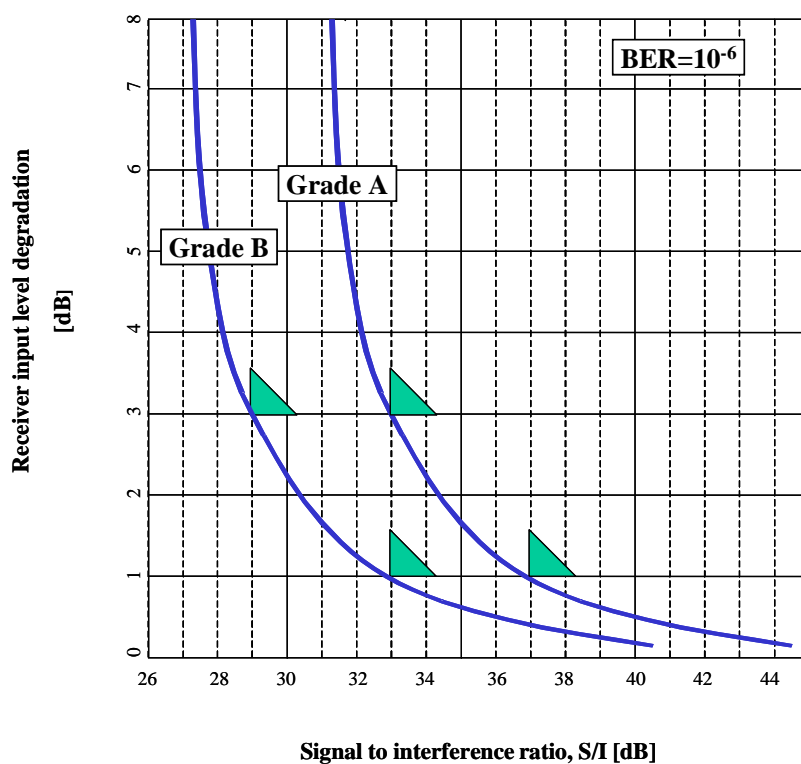


Figure A.1: Co-channel (external) interference threshold degradation referenced at point B (or C)

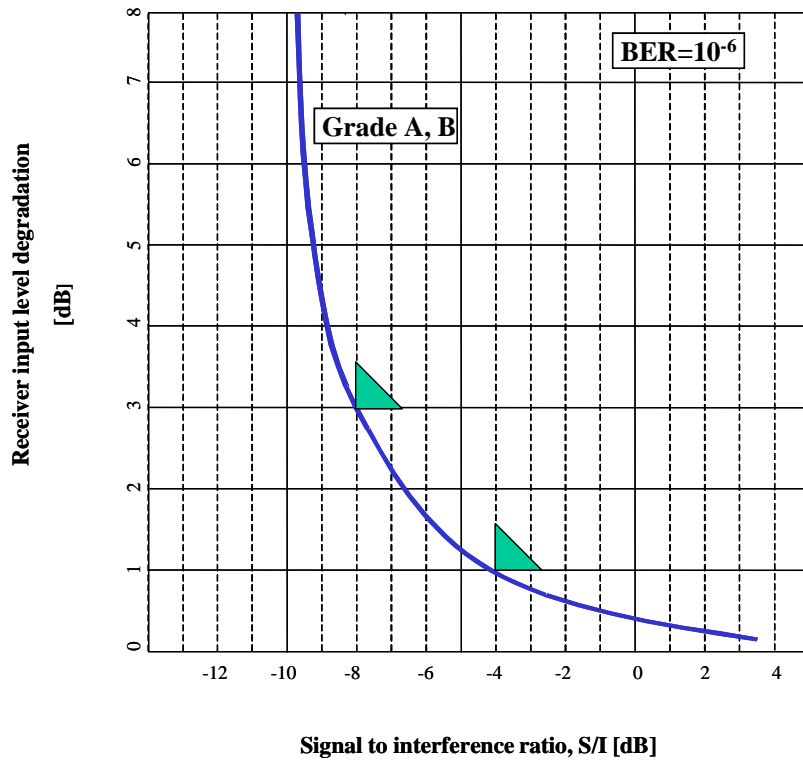


Figure A.2: Adjacent channel interference threshold degradation referenced at point B (or C)

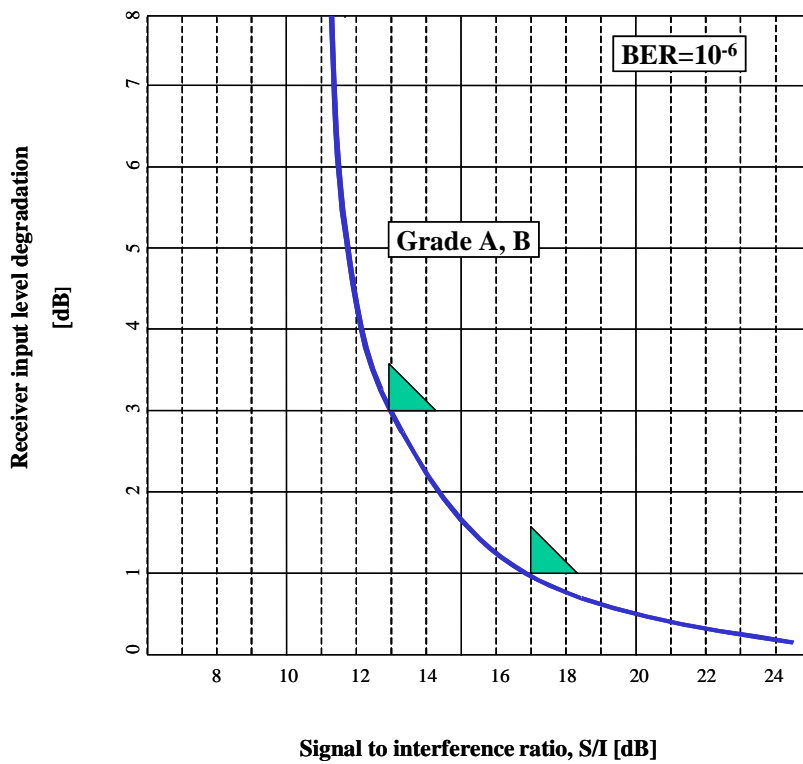


Figure A.3: Co-channel (internal) interference threshold degradation referenced at point B (or C)

A.5 Measurement test set for XPI characteristics

We define in figure A.4 a measurement set-up that allows to simulate wanted signals affected by flat and/or dispersive fading conditions in presence of XPI (Cross Polar Interference) which level and phase can also be varied.

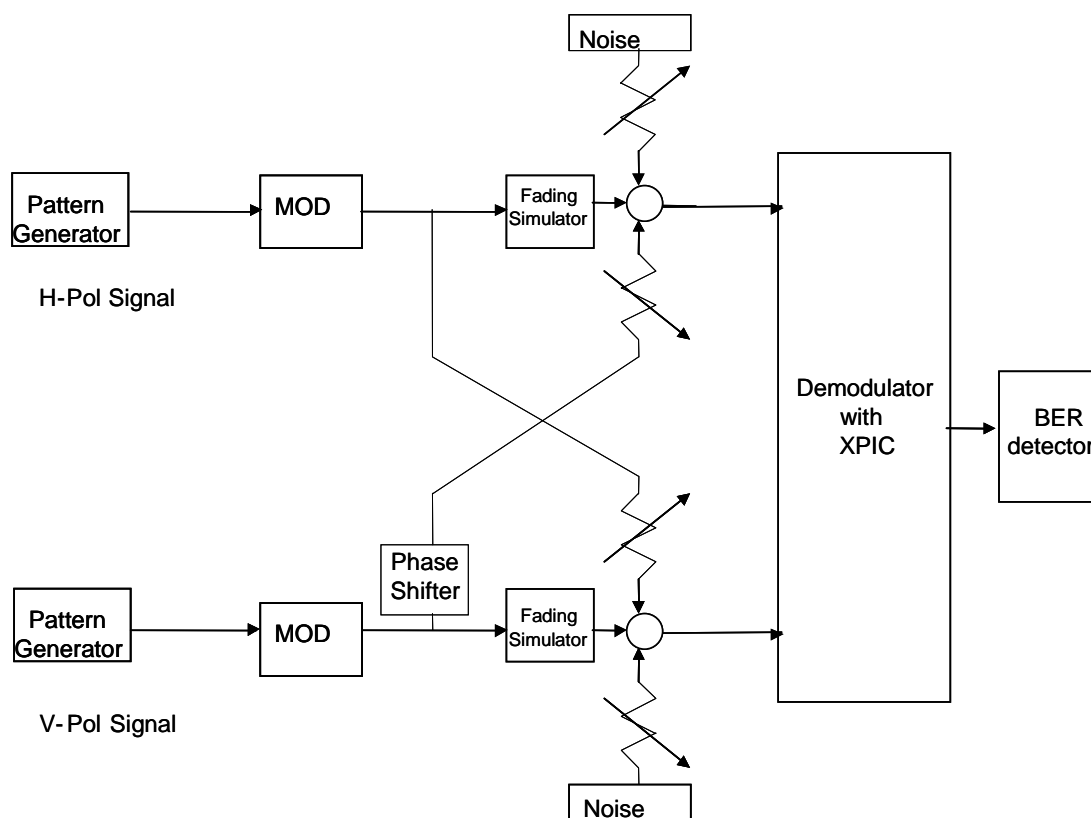


Figure A.4: Measurement test set

Annex B (informative): Bibliography

ITU-T Recommendation G.827 (2000): "Availability parameters and objectives for path elements of international constant bit-rate digital paths at or above the primary rate".

ITU-R Recommendation F.695: "Availability objectives for real digital radio-relay links forming part of a high-grade circuit within an integrated services digital network".

History

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