



**Fixed Radio Systems;  
Characteristics and requirements  
for point-to-point equipment and antennas;  
Part 2-1: System-dependent requirements  
for digital systems operating in frequency bands  
where frequency co-ordination is applied**

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Reference

REN/ATTM-04017

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## Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

The present document is part 2-1 of a multi-part deliverable covering the Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas. Full details of the entire series can be found in part 1 [15].

<b>National transposition dates</b>	
Date of adoption of this EN:	5 December 2014
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## Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**may not**", "**need**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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## Introduction

The introduction of EN 302 217-1 [15] applies.

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# 1 Scope

The present document summarizes all system-dependent requirements for Point-to-Point (P-P) equipment in applications deployed in bands where frequency co-ordination is generally applied. These requirements are introduced in two different clauses sub-sets:

- **Main requirements** are requirements that are also related to the "essential requirements" under article 3.2 of the R&TTE Directive [1] and further detailed in the Harmonized Standard EN 302 217-2-2 [16].
- **Complementary requirements** are requirements that are not related to essential requirements under article 3.2 of the R&TTE Directive [1]. Nevertheless they have been commonly agreed for proper system operation and deployment when specific deployment conditions or compatibility requirements are present. Compliance to all or some of these requirements is left to supplier decision.

Description and limits for parameters relevant to essential requirements under article 3.2 of R&TTE Directive [1] are given in the Harmonized Standard EN 302 217-2-2 [16].

For other system-dependent parameters where standardization is required but that do not affect the R&TTE Directive "essential requirements" mentioned above, description and limits are detailed in the present document in clause 6 and in the annex A, annex F and annex G.

The present document deals with Radio Frequency (RF) and base-band equipment characteristics; antenna system requirements are covered in EN 302 217-4-1 [i.9] and EN 302 217-4-2 [i.10].

The present document does not cover test procedures and test conditions which are set out in EN 301 126-1 [14].

As the maximum transmission rate in a given bandwidth depends on system spectral efficiency, equipment are subdivided in different spectral efficiency classes as defined in EN 302 217-2-2 [16].

The spectral efficiency classes are indicative only and do not imply any constraint to the actual modulation format, provided that all the requirements in the relevant parts of this Multi-part deliverable for the declared class are met.

Guidance on the definition of radio parameters relevant to the essential requirements under article 3.2 of R&TTE Directive [1] for DFRS may be found in TR 101 506 [i.6].

Technical background for most of the parameters and requirements referred to in this Multi-part deliverable may be found in TR 101 036-1 [i.5].

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## 2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

### 2.1 Normative references

The following referenced documents are necessary for the application of the present document.

- [1] 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).
- [2] CENELEC EN 122150: "Sectional Specification: Radio frequency coaxial connectors - Series EIA flange".

- [3] CEPT/ERC/DEC(00)07: "ERC Decision of 19 October 2000 on the shared use of the band 17.7 - 19.7 GHz by the fixed service and Earth stations of the fixed-satellite service (space-to-Earth)".
- [4] ETSI EN 300 019-1-0: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-0: Classification of environmental conditions; Introduction".
- [5] ETSI EN 300 019-1-1: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-1: Classification of environmental conditions; Storage".
- [6] ETSI EN 300 019-1-2: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-2: Classification of environmental conditions; Transportation".
- [7] ETSI EN 300 019-1-3: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weatherprotected locations".
- [8] ETSI EN 300 019-1-4: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weatherprotected locations".
- [9] ETSI EN 300 019-2-0: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-0: Specification of environmental tests; Introduction".
- [10] ETSI EN 300 019-2-1: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-1: Specification of environmental tests; Storage".
- [11] ETSI EN 300 019-2-2: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-2: Specification of environmental tests; Transportation".
- [12] ETSI EN 300 019-2-3: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-3: Specification of environmental tests; Stationary use at weatherprotected locations".
- [13] ETSI EN 300 019-2-4: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-4: Specification of environmental tests; Stationary use at non-weatherprotected locations".
- [14] ETSI EN 301 126-1: "Fixed Radio Systems; Conformance testing; Part 1: Point-to-Point equipment - Definitions, general requirements and test procedures".
- [15] ETSI EN 302 217-1: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 1: Overview and system-independent common characteristics".
- [16] ETSI EN 302 217-2-2: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-2: Digital systems operating in frequency bands where frequency co-ordination is applied; Harmonized EN covering the essential requirements of Article 3.2 of the R&TTE Directive".
- [17] IEC 60153-2: "Hollow metallic waveguides. Part 2: Relevant specifications for ordinary rectangular waveguides".
- [18] IEC 60154-2: "Flanges for waveguides. Part 2: Relevant specifications for flanges for ordinary rectangular waveguides".
- [19] IEC 60169-1: "Radio-frequency connectors. Part 1: General requirements and measuring methods".
- [20] IEC 60339 (all parts): "General purpose rigid coaxial transmission lines and their associated flange connectors".

- [21] IEC 60835-2-4: "Methods of measurement for equipment used in digital microwave radio transmission systems - Part 2: Measurements on terrestrial radio-relay systems - Section 4: Transmitter/receiver including modulator/demodulator".
- [22] IEC 60835-2-8: "Methods of measurement for equipment used in digital microwave radio transmission systems - Part 2: Measurements on terrestrial radio-relay systems - Section 8: Adaptive equalizer".
- [23] IEEE 802.3-2005: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications".
- [24] IEEE 1802.3-2001: "IEEE Conformance Test Methodology for IEEE Standards for Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications".
- [25] Void.
- [26] Recommendation ITU-R F.1093-2: "Effects of multipath propagation on the design and operation of line-of-sight digital fixed wireless systems".
- [27] Void.
- [28] Recommendation ITU-T O.151: "Error performance measuring equipment operating at the primary rate and above".
- [29] Recommendation ITU-T O.181: "Equipment to assess error performance on STM-N interfaces".
- [30] Recommendation ITU-T O.191: "Equipment to measure the cell transfer performance of ATM connections".

## 2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ECC/REC(02)06: "Channel arrangements for digital Fixed Service Systems operating in the frequency range 7125-8500 MHz".
- [i.2] ERC/REC 12-03: "Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 17.7 GHz TO 19.7 GHz".
- [i.3] ERC/REC 14-01: "Radio-frequency channel arrangements for high capacity analogue and digital radio-relay systems operating in the band 5925 MHz - 6425 MHz".
- [i.4] ERC/REC 14-02: "Radio-frequency channel arrangements for high, medium and low capacity digital fixed service systems operating in the band 6425-7125 MHz".
- [i.5] ETSI TR 101 036-1: "Fixed Radio Systems; Generic wordings for standards on DFRS (Digital Fixed Radio Systems) characteristics; Part 1: General aspects and point-to-point equipment parameters".
- [i.6] ETSI TR 101 506: "Fixed Radio Systems; Generic definitions, terminology and applicability of essential requirements under the article 3.2 of 1999/05/EC Directive to Fixed Radio Systems".
- [i.7] ETSI TR 102 243-1: "Fixed Radio Systems; Representative values for transmitter power and antenna gain to support inter- and intra-compatibility and sharing analysis; Part 1: Digital point-to-point systems".
- [i.8] ETSI TR 103 103: "Fixed Radio Systems; Point-to-point systems; ATPC, RTPC, Adaptive Modulation (mixed-mode) and Bandwidth Adaptive functionalities; Technical background and impact on deployment, link design and coordination".



- [i.9] ETSI EN 302 217-4-1: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-1: System-dependent requirements for antennas".
- [i.10] ETSI EN 302 217-4-2: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-2: Antennas; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".
- [i.11] ETSI TR 101 854: "Fixed Radio Systems; Point-to-point equipment; Derivation of receiver interference parameters useful for planning fixed service point-to-point systems operating different equipment classes and/or capacities".
- [i.12] Recommendation ITU-R F.383-9: "Radio-frequency channel arrangements for high capacity fixed wireless systems operating in the lower 6 GHz (5 925 to 6 425 MHz) band".
- [i.13] Recommendation ITU-R F.384-11: "Radio -frequency channel arrangements for medium- and high-capacity digital fixed wireless systems operating in the 6 425-7 125 MHz band".
- [i.14] Recommendation ITU-R F.385-10: "Radio-frequency channel arrangements for fixed wireless systems operating in the 7 110-7 900 MHz band".
- [i.15] Recommendation ITU-R F.595-10: "Radio-frequency channel arrangements for fixed wireless systems operating in the 17.7-19.7 GHz frequency band".
- [i.16] Recommendation ITU-R P.530-15: "Propagation data and prediction methods required for the design of terrestrial line-of-sight systems".
- [i.17] J. Redd: "Calculating Statistical Confidence Levels for Error-Probability Estimates" Lightwave Magazine, pp. 110-114, April 2000.

NOTE: Available on the web at <http://www.lightwaveonline.com/>.

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## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

For the purposes of the present document, the terms and definitions given in EN 302 217-1 [15] apply.

### 3.2 Symbols

For the purposes of the present document, the symbols given in EN 302 217-1 [15] apply.

### 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in EN 302 217-1 [15] apply.

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## 4 General characteristics

### 4.1 Frequency bands and channel arrangements

Frequency bands and channel arrangements, which are relevant for equipment covered by the present document, are defined by Recommendation ITU-Rs and/or ECC (or CEPT/ERC) Recommendations and are referenced in the first table of each annex A through annex Ea (i.e. table A.1 through table Ea.1) of EN 302 217-2-2 [16].

Recommendation ITU-Rs and ECC (or CEPT/ERC Recommendation, see note) recommended frequency channel arrangements, known at the date of publication of this Multi-part deliverable, are set out for reference only. In general, the channel arrangement is relevant neither to article 3.2 of the R&TTE Directive [1] nor for other requirements in the present document; only the frequency band, actual channel separation and, in some cases innermost channels separation are relevant for defining the set of parameters and test suites relevant to each system.

NOTE: CEPT Recommendations were published until 2002 as CEPT/ERC Recommendations; consequently to the restructuring of ERC under new ECC organization, Recommendations developed after that date formally changed their reference as ECC Recommendations, without changing their applicability.

Other national or future Recommendation ITU-Rs or ECC Recommendations, set around the same or close to the frequency range of present Recommendation ITU-Rs or ECC Recommendations, are considered applicable to systems assessed against this Multi-part deliverable, provided that they use the same channel separation.

Specification and tests of wide radio-frequency band covering units and *multirate* or *mixed-mode* equipment are placed in normative annex G of EN 302 217-2-2 [16]. Whenever applicable, it is also valid for assessing parameters specified in the present document.

## 4.2 Special compatibility requirements between systems

There shall be no requirement to operate transmitting equipment from one supplier with receiving equipment from another and, depending on the deployment conditions, it shall be possible to operate the system in vertical and/or horizontal polarization, if required by the channel arrangement.

To be compatible with certain constraints given by existing installations and/or deployments already made with systems from other supplier or for different FS applications, new systems on the same path may be subject to additional requirements, other than those derived for a single supplier or same application environment.

NOTE: This does not imply that when a single supplier is involved there are no similar requirements; however, they do not need standardization because many other technical and cost-effective solutions might be flexibly adopted under suppliers' own responsibility only.

For the purposes of this Multi-part deliverable the following set of compatibility requirements between systems has been defined:

- a) There may be a requirement to multiplex different suppliers' equipment on the same polarization of the same antenna. This will not apply to systems with an integral antenna.
- b) There may be a requirement to multiplex different suppliers' equipment on different polarizations of the same antenna. This will not apply to systems with an integral antenna.

## 4.3 Transmission capacity and spectral efficiency

See clause 1.5 of EN 302 217-2-2 [16].

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# 5 Main requirements

The following clauses summarize requirements related to the "essential requirements" under article 3.2 of the R&TTE Directive [1] that are further detailed in EN 302 217-2-2 [16]. However, for some requirements, besides the relevant essential limits set out in EN 302 217-2-2 [16] for the purpose of their separate publishing in the Official Journal of the European Communities (OJEU) under the R&TTE Directive [1], additional, non-essential, more stringent limits are here set out in response to specific compatibility requirements by network operators when deploying new systems on the same routes with existing systems from other suppliers.

## 5.1 System nominal loading

The specified transmitter and receiver characteristics shall be met with the appropriate baseband signals applied at reference point X' and received from reference point X of figure 1 of EN 302 217-1 [15].

**Table 1: Baseband test signals**

Type of baseband signal interface at X/X'	Test signal to be applied according to...
PDH	PRBS Recommendation ITU-T O.151 [28]
SDH	Recommendation ITU-T O.181 [29]
ATM	Recommendation ITU-T O.191 [30]
Ethernet interface (packet data)	IEEE 802.3 [23], IEEE 1802.3 [24]
Other than the above	Relevant standards which the interface refers to

## 5.2 Environmental profile

The required environmental profile for operation of the equipment shall be declared by the supplier. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the required operational environmental profile.

Preferably, the selected environmental profiles should be one of more ETSI profiles in EN 300 019 series (see [4] through [13]), standardized for various operating, transport and storage situations.

## 5.3 Transmitter characteristics

### 5.3.1 Transmitter power and power tolerance

#### 5.3.1.1 Maximum power

The Maximum Output Power is an essential requirement under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

For guidance, in addition to the absolute maximum transmitter power, typical values of transmitter highest power for real equipment, of feeder loss and length, and of antenna diameter and gain are provided in TR 102 243-1 [i.7] in order to support inter-systems and intra-system compatibility and sharing analysis.

In some frequency bands, or parts of frequency bands, Recommendation ITU-Rs define specific limits in terms of output power and/or EIRP (or output power and/or EIRP density) in order to improve the compatibility with other Radio Services sharing these frequency bands with the FS.

An additional capability for output power level adjustment may be required, for regulatory purposes, in the interface regulations according to article 4.1 of the R&TTE Directive [1], in which case the range of adjustment, either by fixed or automatic attenuators, should be in increments of 5 dB or less.

In particular, for the band 18 GHz, the FS shall, where practical, implement the appropriate mitigation techniques as required in ERC/DEC(00)07 [3]. See annex H.

#### 5.3.1.2 Transmitter output power tolerance

The power tolerance around the nominal output power together with the associated environmental profile, declared by the supplier, is considered essential under article 3.2 of R&TTE Directive [1]. For relevant limits see EN 302 217-2-2 [16].

Additionally, it should be taken into consideration that, in general, the declared profile for R&TTE Directive [1] assessment might not be coincident with the ETSI standardized ones in EN 300 019 series (see [4] through [13]), which have been specifically designed for telecommunication equipment in various deployment situations. Therefore, the supplier may decide to comply with equal or more stringent limits for operation of the system over some ETSI standardized environmental condition for which the system is designed to operate. Limits for this case are reported below.

The tolerance of the nominal output power shall be:

- a) Systems operating within class 3.1 or class 3.2 of weather protected locations defined in EN 300 019-1-0 [4] and EN 300 019-1-3 [7]:  
The nominal output power, when specified, shall be within  $\pm A$  dB value reported in table 2.
- b) Systems operating within one or more of non-weather protected locations class 4.1 and class 4.1E, defined in EN 300 019-1-0 [4] and EN 300 019-1-4 [8], and/or within class 3.3, class 3.4 and class 3.5 (particular extreme conditions of weather protected locations) defined in EN 300 019-1-0 [4], EN 300 019-1-3 [7]:  
The nominal output power shall remain within  $\pm B$  dB value, reported in table 2, within one or more of the above environment classes, specified by the manufacturer.

**Table 2: Power tolerance for indoor operation**

Operating frequency band (GHz)	$\pm A$ (dB)	$\pm B$ (dB)
1 to 2,7	Not defined	+2 / -1
3 to 30	$\pm 1$	$\pm 2$
> 31	$\pm 2$	$\pm 3$

## 5.3.2 Transmitter power and frequency control

### 5.3.2.1 Transmitter power control (ATPC and RTPC)

#### 5.3.2.1.1 Automatic Transmitter Power Control (ATPC)

This functionality is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

Besides those essential requirements specified in EN 302 217-2-2 [16], ATPC may be requested as mandatory functionality in the licensing conditions (see note 1) for the following purposes (see note 2):

- a) to enhance network density;
- b) as a mitigation factor for sharing with other Services due to ECC Decisions (see note 3).

NOTE 1: User information: it is expected that Administrations explicitly state whether ATPC is used as a regulatory measure for either frequency coordination or as a mitigation technique to protect other services in its radio regulation interface for notification according to article 4.1 of the R&TTE Directive [1].

NOTE 2: User information: License conditions are under administration responsibility; in principle, from technical point of view, when used as mitigation factor, ATPC would not be used to enhance network density because this could invalidate the expected mitigation.

NOTE 3: User information: for example is in the 18 GHz band, where there is sharing between FS and FSS, ATPC will become a mandatory feature for all new equipment to be deployed after the date referred by ERC/DEC(00)07 [3], however, that Decision clarify also that actual usage of ATPC will be required by administrations only where practical and depending on local sharing conditions with satellite services and local deployment conditions in existing networks. The ATPC range is not subject to standardization.

In case a), the administration might specify that the transmitter output emission meets the spectrum mask limits set out in clause 4.2 of EN 302 217-2-2 [16] throughout an ATPC range specified in the license conditions. The manufacturer may choose to comply also with this requirement that in no case is considered essential to the assessment of article 3.2 of R&TTE Directive [1].

In case b), the administration might require that the equipment operate with ATPC enabled. This does not imply any additional constraint besides the presence of the optional ATPC functionality, which in no case is considered essential to the assessment of article 3.2 of R&TTE Directive [1].

The supplier shall declare the ATPC range within which the spectrum mask is still fulfilled; the declaration should take into account, if relevant, that the ATPC range is often interlaced and interchangeable with the available RTPC range (see note 4).

The spectrum mask shall be tested (additionally to the tests required in EN 302 217-2-2 [16] and with the same test method) also with the maximum ATPC attenuation and, if applicable, of the associated maximum RTPC attenuation included (see note 4). This is not applicable for testing the masks for compatibility under the same antenna systems described in annex A; in that case, the maximum TX power should be used, while RTPC can be taken into account on a station-by-station term.

NOTE 4: Further guidance on ATPC and RTPC operation can be found in TR 103 103 [i.8].

#### 5.3.2.1.2 Remote Transmitter Power Control (RTPC)

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

#### 5.3.2.2 Remote Frequency Control (RFC)

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

### 5.3.3 Radio Frequency (RF) spectrum mask

The radio frequency spectrum density mask is relevant to essential requirements under article 3.2 of R&TTE Directive [1], the limits for the essential portion of RF spectrum density masks are found in EN 302 217-2-2 [16].

Additional requirements, not relevant to essential requirements under article 3.2 of R&TTE Directive [1], for spectrum density masks may be necessary in cases where there is a requirement for internal system dependent reasons related only to TX/RX compatibility between equipment from different suppliers operating on the innermost channels of some channel arrangements (see compatibility requirements in clause 4.2). These more stringent requirements are reported in clause 6.3.2.

### 5.3.4 Discrete CW components exceeding the spectrum mask limit

#### 5.3.4.1 Discrete CW components at the symbol rate

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

#### 5.3.4.2 Other discrete CW components exceeding the spectrum mask limit

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

### 5.3.5 Spurious emissions - external

"External" limit for spurious emissions from transmitters are necessary in order to limit interference into other systems operating wholly externally to the system under consideration (external emissions).

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

### 5.3.6 Radio frequency tolerance

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

## 5.4 Receiver characteristics

### 5.4.1 Spurious emissions-external

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

## 5.5 System performance without diversity

### 5.5.1 BER as a function of receiver signal level

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

### 5.5.2 Interference sensitivity

#### 5.5.2.1 Co-channel "external" interference sensitivity

"External" co-channel interference is considered to be that interference from a system fully independent from the one under test (i.e. a system deployed by another operator in the same geographical area and is not related to the "internal" requirement for equipment using XPIC, specified in clause 6.3 of the present document).

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

#### 5.5.2.2 Adjacent channel interference sensitivity

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16] (see note).

NOTE: User information: for ACCP/CCDP applications of spectral efficiency classes higher than 4L systems in frequency bands below 15 GHz with CS  $\geq$  14 MHz, to cope with differential fading effects on the longer hops in systems operating on adjacent channels on the same route but using different antennas, some literature report that C/I values up to about 10 dB tighter than those reported in EN 302 217-2-2 [16] may be necessary. However, additional burden to the assessment is not considered necessary, because this actually depends, link by link, on the hop fading occurrence factor and the ATPC range implemented on all adjacent systems (i.e. the higher is the ATPC common range, the lower is the C/I sensitivity need). The relationship of these parameters on hop performance prediction is not identified.

#### 5.5.2.3 CW spurious interference

This parameter is relevant to essential requirements under article 3.2 of R&TTE Directive [1] and is specified in EN 302 217-2-2 [16].

## 6 Complementary requirements

The following clauses consider requirements that are not related to essential requirements under article 3.2 of the R&TTE Directive [1]. Nevertheless, all or some of these requirements are considered useful for proper system operation and deployment when specific deployment conditions or compatibility requirements, as defined in clause 4.2, are present. Compliance to all or some of these requirements is left to supplier decision.

### 6.1 Branching/feeder requirements

#### 6.1.1 Waveguide flanges (or other connectors)

When flanges (or coaxial types) are required at reference point(s) B, B', C and C' of figure 1 of EN 302 217-1 [15], the following types shall be used:

- UBR/PBR/CBR/CAR (Square flanges) or UDR/PDR/UER (Rectangular flanges) or UAR/PAR (Circular flanges)-XXX (waveguide type reference number) flanges according to IEC 60154-2 [18] shall be used for the bands and waveguides specified in table 3; for reader convenience figure 1 shows the representative shapes of the above flanges. When the same band appears covered by two different options, both are admitted, provided that adaptors are available.
- Coaxial connectors can be used, as an option, for all frequency bands (see note). The impedance of the coaxial ports shall be nominally 50  $\Omega$ .

NOTE: User information: For coaxial connectors, a number of popular standards exist; for example, a range of coaxial connectors referred to in parts 1 and 2 of IEC 60339 [20], IEC 60169-1 [19], EN 122150 [2]. However, it should be noted that these standards are not exhaustive.

**Table 3: Waveguides useable for various frequency bands**

Frequency band(s)	"R XXX" waveguide designation (and its frequency range in GHz) according to IEC 60153-2 [17]
1,4 GHz and 2,5 GHz bands	None
2,1 GHz to 2,5 GHz bands	(Only coaxial connections are commonly used)
3,5 GHz band	Either R 32 (2,6 to 3,95) or R 40 (3,3 to 4,9)
4 GHz band	R 40 (3,3 to 4,9)
5 GHz band	R 48 (3,95 to 5,85)
L6/U6 GHz band	R 70 (5,85 to 8,2)
7 GHz band(s)	Either R 70 (5,85 to 8,2) or R 84 (7,05 to 10)
8 GHz band	R 84 (7,05 to 10)
10,5 GHz and 11 GHz bands	Either R 100 (8,2 to 12,4) or R 120 (10 to 15)
13 GHz band	Either R 120 (10 to 15) or R 140 (12,4 to 18)
15 GHz band	R 140 (12,4 to 18)
18 GHz band	Either R 180 (15 to 22) or R 220 (18 to 26)
23 GHz band	R 220 (18 to 26)
26 GHz band	Either R 220 (18 to 26) or R 260 (22 to 33)
28 GHz band	Either R 260 (22 to 33) or R 320 (26,5 to 40)
31 GHz and 32 GHz bands	R 320 (26,5 to 40)
38 GHz band	R 320 (26,5 to 40)
42 GHz band	Either R 400 (33 to 50) or R 500 (40 to 60)
48,5 GHz to 50,2 GHz bands	R 500 (40 to 60)
52 GHz band	Either R 500 (40 to 60) or R 620 (50 to 75)
55 GHz band	Either R 500 (40 to 60) or R 620 (50 to 75)
70 GHz and 80 GHz bands	R 740 (60 to 90)

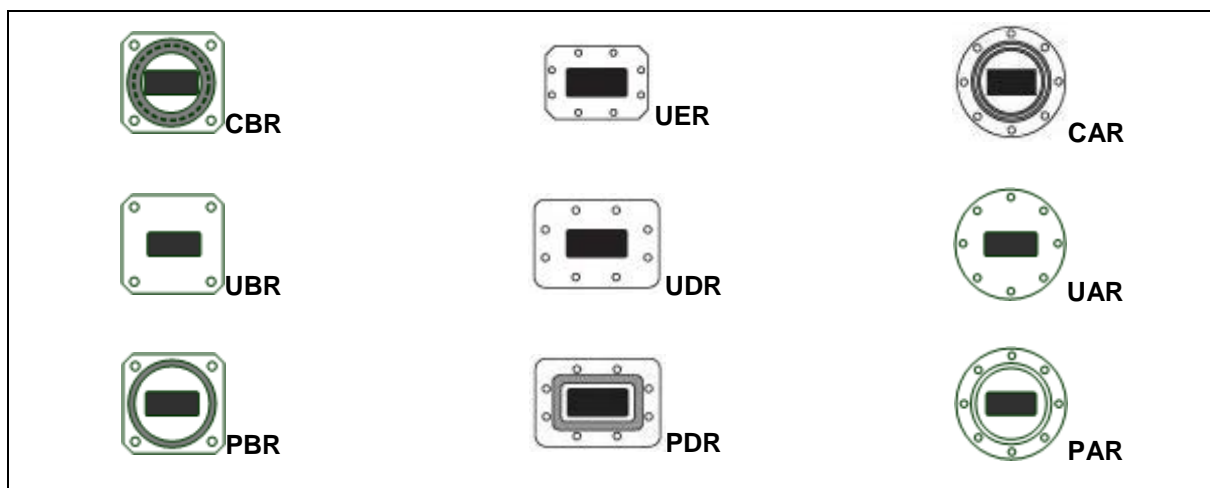


Figure 1: Waveguide Flange Shapes

### 6.1.2 Return loss of feeder/antenna systems at equipment antenna port (C/C' reference point)

It is frequent practice that equipment without integral antennas is connected to feeder/antenna systems from other supplier.

For equipment in the scope of the present document, that uses outdoor radio frequency units, which are likely to have integral antennas or similar technical solutions, without long feeder connections, the impact of return loss at the antenna port on system performance is negligible and does not require standardized limits.

For fully indoor systems, which are generally deployed with longer feeder connections to an external antenna, and may be required to operate with respect to compatibility requirements specified in clause 4.2 list items a and b, the minimum return loss, for negligibly affecting BER and RBER performances, depends on the signal bandwidth and modulation complexity used or, in case of *mixed-mode* systems, chosen as *reference mode*. However, the effectiveness of the used error correction technology also plays a significant effect.

The manufacturer shall declare the minimum required return loss of the feeder/antenna systems connected at the antenna port (point C and C' of figure 1 of EN 302 217-1 [15]).

The manufacturer shall also declare the guaranteed return loss of the equipment antenna port (i.e. towards the equipment), see note.

NOTE: For guidance only, this is typically around 20 dB for waveguide connections and around 15 dB when coaxial connections are considered.

For feeder/antenna return loss information, see EN 302 217-4-1 [i.9].

## 6.2 Intermodulation products

Where multi-channels branching system is concerned and where the system is intended to comply with compatibility requirement in clause 4.2, each odd order intermodulation product, caused by different transmitters linked to the same branching system, shall be less than -110 dBm referenced to reference point B of figure 1 of EN 302 217-1 [15] with an output power per transmitter limited to the maximum power stated by the supplier for the equipment.

The reference power shall be the maximum power stated by the supplier for the equipment. This clause is not intended for use with conformance tests, but only, if required, for type tests agreed between user and supplier. The measurement, if any, shall be carried out with un-modulated signals of the same power of the average level of the digital signals.



## 6.3 Transmitter characteristics

### 6.3.1 Spurious emissions - internal

This category covers emissions that, only for compatibility of TX and RX digital systems of different suppliers connected to the same antenna (see clause 4.2), may be required to be more stringent than the "external" emissions detailed in clause 5.1.6.

The levels of the spurious emissions from the transmitter, referenced to reference point B' of figure 1 of EN 302 217-1 [15] are specified in table 4.

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

**Table 4: Internal levels for the transmitter spurious emissions**

Controlling factor for requirement application	Spurious emission frequency relative to channel assigned frequency	Specification limit
Within receive half band, digital into digital interference on the same local multi-channel branching/antenna system, for digital systems with compatibility requirements as specified in clause 4.2a) (co-polar operation).	All spurious signals within the receive half band	$\leq -90$ dBm
Within receive half band, digital into digital interference for digital systems without branching network (i.e. single transceivers with duplexer), for digital systems with compatibility requirements as specified in clause 4.2b) (cross-polar operation).		$\leq -70$ dBm

### 6.3.2 Radio Frequency (RF) spectrum mask when mixed supplier compatibility is required

For systems, which are intended to comply with compatibility requirement under clause 4.2, to guarantee normal and innermost TX to RX channel compatibility, the TX noise floor and inner side of the innermost transmitter shall offer sufficient attenuation to the locally interfered receiver.

For this purpose the overall Net Filter Discrimination (NFD) should be enough for giving an acceptable threshold degradation to the local receiver; this can be accomplished only with suitable combined filtering of both interfering TX and victim RX (see background in TR 101 036-1 [i.5]).

Examples of suitable spectrum masks (TX filtering) insofar defined for most common system and channel arrangement are given in annex A of the present document. For corresponding RX filtering see clause 6.4.4.

Their attenuation/frequency parameters are defined in the same way as in clause 4.2.4 of EN 302 217-2-2 [16].

The spectrum analyser settings for measuring the RF spectrum mask are shown in table 6 of clause 5.2.4 of EN 302 217-2-2 [16].

Since it might be difficult or not practical to make direct measurement of this characteristic, in alternative, the supplier shall give the attenuation data of all RF filters, implemented in the TX chain after the transmit power amplifier output, to be eventually added to the spectrum tested in that point (reference point A' in figure 1 of EN 302 217-1 [15]).

## 6.4 Receiver characteristics

### 6.4.1 Maximum input level and input level range

The input Receiver Signal Level (RSL) range, under flat fading condition, where the BER is kept lower than a specified level (typically  $10^{-6}$  for availability purpose and, for quality purpose,  $10^{-8}$  for system RIC  $\leq 100$  Mbit/s or  $10^{-10}$  for system RIC  $> 100$  Mbit/s) depends on various parameters such as, but not limited to, frequency band, hop length and spectrum efficiency class. In principle, the highest is the range, the more flexible is the use of the equipment; however, high capacity systems with complex modulations (e.g. classes 5L and higher) suffer from one side of relatively higher RSL/BER thresholds and from the other side from more sensitivity to non-linear distortion caused by RX chain saturations.

It is also recognized that the higher modes (e.g. class 7 and class 8 and, in some cases, also class 6H or lower classes) are hardly suitable as reference-mode because their very limited fade margin might not be enough to guarantee the required performance and availability objectives in typical links. Therefore, they are likely to be used only during dynamic operation with a lower class reference-mode. Nevertheless, their systems characteristics are also reported for possible use by special equipment or for reference in administrative licensing procedures.

A unique standardized approach is not therefore advisable, nevertheless the necessary fade-margin shall be accommodated (see note); the following "design objectives" are given for guidance only.

NOTE: Enhanced input level range for sensitive modulation formats is currently obtained through ATPC activation.

The limits for the RSL threshold for a BER  $\leq 10^{-6}$  and BER  $\leq 10^{-8}$  or BER  $\leq 10^{-10}$  are specified in the relevant annex of EN 302 217-2-2 [16]. The upper limit for the RSL, where the same BER values is experienced, due to non-linear distortions, should be equal to or higher than the values shown in table 6.

However, when the lower BER thresholds, compared to the upper limit levels in table 6, result in a total RSL range of:

$\geq 50$  dB for BER  $\leq 10^{-6}$

$\geq 47$  dB for BER  $\leq 10^{-8}$

$\geq 44$  dB for BER  $\leq 10^{-10}$

the maximum RSL given in table 6 may be reduced accordingly.

When *mixed-mode* systems are concerned the above limits are intended relevant to the *reference mode(s)* only.

These limits apply without interference and are referenced to point B (point B and point C may coincide when simple duplexer is used) of figure 1 of EN 302 217-1 [15].

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.

Table 5: Minimum upper input received signal level

Spectral efficiency		BER (see note 1 and note 2)	Minimum upper value of RSL (dBm) (see note 2 and note 3)		
			Frequency Range (GHz)		
Reference index	Class		Up to 18 GHz	23 GHz to 55 GHz	71 GHz to 86 GHz
1, 2, 3, 4, 5	1, 2, 3, 4L, 4H	$\leq 10^{-6}$	-21	-23	-23
		$\leq 10^{-8}$	-22	-24	-
		$\leq 10^{-10}$ (see note 4)	-23	-25	-25
6, 7	5L, 5H	$\leq 10^{-6}$	-22	-24	-24
		$\leq 10^{-8}$	-24	-25	-
		$\leq 10^{-10}$ (see note 4)	-25	-26	-26
8, 9	6L, 6H	$\leq 10^{-6}$	-23	-25	-25
		$\leq 10^{-8}$	-24	-26	-
		$\leq 10^{-10}$ (see note 4)	-25	-27	-27
10, 11	7, 8	$\leq 10^{-6}$	-24	-26	-26
		$\leq 10^{-8}$	-25	-27	-
		$\leq 10^{-10}$ (see note 4)	-26	-28	-28

NOTE 1: BER =  $10^{-6}$  range for all systems, BER =  $10^{-8}$  range for system RIC  $\leq$  100 Mbit/s or BER =  $10^{-10}$  range for system RIC > 100 Mbit/s.

NOTE 2: In case of *multi-channel* systems, when carrying STM-4 or when carrying payload interface capacity spread on different channels, the test shall be made changing the RSL of all channels simultaneously. For more details see clause G.3 in EN 302 217-2-2 [16].

NOTE 3: When ATPC is used as permanent feature, the requirement is intended with ATPC enabled. In this case the values in the column shall be relaxed by the ATPC minimum attenuation.  
Example: a system with permanent ATPC in the range between 6 dB (minimum) and 20 dB (maximum) is subject to a maximum RSL 6 dB lower than the values in the table (e.g. the -23 dBm become -29 dBm).

NOTE 4: BER  $\leq 10^{-9}$  for non Ethernet-based systems with 64 kbit/s  $\leq$  minimum RIC  $\leq$  192 kbit/s.

## 6.4.2 Spurious emissions - internal

For systems without the compatibility requirements of clause 4.2 there is no requirement.

When equipment is required to share the same antenna with other equipment, the spurious emissions limits, referenced to point B of figure 1 of EN 302 217-1 [15], are specified in table 6.

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

Table 6: Limits of spurious emissions-internal

Controlling factor	Specification limit
Spurious falling in the same receive half-band for systems with compatibility requirements of clause 4.2a).	$\leq -110$ dBm
Spurious falling in the same receive half-band for systems with compatibility requirements of clause 4.2b).	$\leq -70$ dBm

## 6.4.3 Image rejection

The requirement for a minimum receiver image rejection is not applicable to receivers with direct demodulation.

When down conversion is used, the receiver image(s) rejection shall be as listed in table 7.

**Table 7: Receiver image rejection**

Controlling factor	Image rejection
a) For any image frequency falling within the receive half band while using branching on different polarizations as defined under the compatibility requirements in clause 4.2b).	$\geq 90$ dB
b) For systems not intended to fulfil any compatibility requirements in clause 4.2a) and/or 4.2b).	Not Applicable
c) For any image frequency falling within the receive half band, while using branching on same polarization as defined in clause 4.2a, or in the transmit half band on different polarization, as defined by the compatibility requirements in clause 4.2b).	$\geq 100$ dB
d) For any image(s) frequency(ies) falling within transmit half band, while using branching on same polarization as defined by the compatibility requirements in clause 4.2a).	$\geq 120$ dB

In addition, due to particular conditions of frequency channel arrangements in bands below 3 GHz, independently from requirements in table 7, the receiver image(s) rejection shall be:

- Class 1 and class 2: 75 dB minimum;
- Class 4L: 85 dB minimum.

#### 6.4.4 Innermost channel selectivity

For systems, which are intended to comply with compatibility requirement under clause 4.2, to guarantee innermost TX to RX channel compatibility, the inner side of the innermost receiver shall offer sufficient selectivity on the locally interfering transmitter.

Examples of selectivity mask insofar defined for most common system and channel arrangement are given in annex A of the present document.

Since it is not considered feasible to make a practical measurement of this characteristic, the supplier shall give the design data of all filters (at RF, IF and baseband levels) implemented on the receiver chain of the innermost channels.

### 6.5 System performance without diversity

#### 6.5.1 Equipment Residual BER (RBER)

The RBER limits under simulated operating conditions without interference (see note 1) shall be maintained within the following RSL range:

- Lower RSL limit: 10 dB above the BER threshold  $10^{-6}$  (as specified in clause 5.3.1).
- Upper RSL limit: 5 dB less than the minimum upper limit of RSL for BER  $10^{-6}$  derived from clause 6.4.1.

All limiting conditions in clause 6.4.1, such as maximum RSL range and permanent ATPC feature, should be taken into account (see following examples).

**EXAMPLE 1:** 7 GHz class 2 system with minimum RIC = 2 Mbit/s, CS = 1,75 MHz,  
RSL threshold BER  $10^{-6} \leq -93$  dBm (but any declared better value should be used for this example).  
Maximum required RSL range for BER  $10^{-6} \geq 50$  dB  
Upper RSL limit for BER  $10^{-6}$  (from table 6)  $\geq -21$  dBm  
Upper RSL limit for BER  $10^{-6}$  (from RSL range)  $\leq -93 + 50 = -43$  dBm  
Actual minimum RSL limit for BER  $10^{-6} = -43$  dBm  
Maximum RSL requirement (RBER)  $\geq -43 - 5 = -48$  dBm (no permanent ATPC functionality)  
Maximum RSL requirement (RBER) with permanent ATPC functionality  $\geq -48$  dBm - ATPC  
(e.g. -54 dBm assuming minimum 6 dB attenuation).

EXAMPLE 2: 80 GHz class 4L system with minimum RIC = 2 Gbit/s, CS = 1 000 MHz,  
 RSL threshold BER  $10^{-6} \leq -51,5$  dBm (but any declared better value should be used for this example).  
 Maximum required RSL range for BER  $10^{-6} \geq 50$  dB  
 Upper RSL limit for BER  $10^{-6}$  (from table 6)  $\geq -23$  dBm  
 Upper RSL limit for BER  $10^{-6}$  (from RSL range)  $\leq -51,5 + 50 = -1,5$  dBm  
 Actual minimum RSL limit for BER  $10^{-6} = -23$  dBm  
 Maximum RSL requirement (RBER)  $\geq -28$  dBm (no permanent ATPC functionality)  
 Maximum RSL requirement (RBER) with permanent ATPC functionality  $\geq -28$  dBm - ATPC  
 (e.g. -34 dBm assuming minimum 6 dB attenuation).

The requirement is intended between base-band ports at reference points X' and X shown in figure 1 of EN 302 217-1 [15]. As the measurement is made on the tributaries, the clause relative to one rate is also applicable to systems for  $n \times$  the same rate (e.g. requirement for 2 Mbit/s is applicable to  $n \times 2$  Mbit/s); however, when the system can be configured with different tributary capacities (e.g. STM-1 or  $63 \times 2$  Mbit/s), the more stringent requirement applies.

NOTE 1: User information: To guarantee the degree of service, see clause G.1, the RBER limit is assumed to be met also in presence of adjacent channel interferer at C/I ratio  $\sim 0$  dB or less for ACCP systems and  $\sim 10$  dB or less for ACAP systems. This has not been considered worth of additional requirement in the present document, because modern systems, even the most simple, usually implement highly efficient error correction codes, which render this additional interference burden irrelevant with respect to the RBER. Therefore, additional burden to the assessment is not necessary.

In the above conditions the RBER shall be:

- Ethernet and other packet data interface capacity: RBER  $< 10^{-12}$ . However, it is recognized that test equipment on copper-line interface might not have the capability of testing such low BER. In this case alternative methodology could be needed.
- PDH and SDH hierarchic interface capacity:
  - For systems capacity between 64 kbit/s and 192 kbit/s: RBER  $< 10^{-9}$ .
  - For systems capacity above 192 kbit/s and less than 34 Mbit/s: RBER  $< 10^{-10}$ .
  - For PDH systems capacity equal to 34 Mbit/s and less than 140 Mbit/s: RBER  $< 10^{-11}$ .
  - For systems capacity at PDH 140 Mbit/s and SDH up to STM-4 (see note 2): RBER  $< 10^{-12}$ .

NOTE 2: User information: For STM-4 capacity on multi-channel trunk systems at or below 11 GHz (for long radio connections) some operator may require a RBER  $< 10^{-13}$ ; however, this has not been considered as general requirement in the present document.

This requirement is intended for the payload bit rates defined in clause 5 or equivalent payload rates as defined in annex F.

Systems designed for CCDP operation, shall guarantee RBER with its own cross-polar corresponding equipment active and set at a RSL difference, with respect to that under test, of less than 5 dB.

In case of *multi-channel* systems (e.g. *two-channel* system when carrying STM-4 or when carrying  $4 \times$  STM-1, with each STM-1 mixed on both carriers) the test shall be made changing simultaneously the RSL of all equipment operating on all channels. For more details see clause G.3 in EN 302 217-2-2 [16].

EN 301 126-1 [14] recognizes that this requirement is subject to a supplier declaration only. However, in clause G.1 some background information relating to the actual test methods and test confidence is given.

Annex G also provides information for defining the minimum recording time and the maximum numbers of errors not to be exceeded.

## 6.5.2 Distortion sensitivity

### 6.5.2.1 Introduction

Transmission channel distortion due to multipath propagation typically affects the performance and availability of P-P links as function of four parameters:

- The system bandwidth (wider bands are more affected).
- The hop length (longer hops are more affected).
- The operating frequency (lower frequency bands are, in general, more affected because hop lengths are usually longer than in higher bands), see note.
- The modulation format (higher states modulations are more affected).

NOTE: Actually, the formulas in Recommendation ITU-R P.530 [i.16] imply that, on the same hop length, higher frequencies are more sensitive; however, the opposite effect of reduced length is much more effective.

Therefore, for counteracting multipath effects, P-P receivers, depending on the target operational ranges of those parameters, implement digital adaptive equalizer, which complexity is generally tailored to their operational needs.

It was commonly understood that systems with bandwidth lower than about 14 MHz and with operating frequency higher than about 18 GHz are not significantly affected by multipath. However, the recent standardization in this Multi-part deliverable of wider system bandwidth (110/112 MHz from 18 GHz band and above) associated to higher spectral efficiency classes (512/1024/2048 QAM with channel separation  $\geq 14$  MHz) suggests that the multipath sensitivity might sometimes extend beyond 18 GHz.

### 6.5.2.2 Requirement

Reference is made to the signature concept, measurement and the representative parameters width ( $W$ ), depth ( $B_c$ ) and normalized system parameter ( $K_n$ ) defined in Recommendation ITU-R F.1093 [26] (see note).

Equipment for nominal CS  $\geq 14$  MHz and operating frequency up to the whole 18 GHz band (17,7 GHz to 19,7 GHz) shall have a *signature* (see definition in EN 302 217-1 [15]) within one of the limits provided hereafter.

The *signature* limits are defined as follows:

- For a reference delay ( $\tau_r$ ) of 6,3 ns and a BER of  $10^{-6}$  the *signature* shall exhibit a normalized system parameter ( $K_n$ ) (see note), calculated with the actually declared *signature* parameters ( $W$  and  $B_c$ ) and symbol rate (SR) of the system under test, equal to or less than the  $K_n$  limits defined in table 8 or table 9, as appropriate.
- The limits are intended as the mean value (i.e. arithmetical sum divided by 2) of  $K_n$  separately calculated for the minimum and the non-minimum phase cases.
- The actual *signatures* shall also contain in their area the loss of synchronization and re-acquisition signatures (see IEC 60835-2-4 [21] and IEC 60835-2-8 [22]).
- The limits are valid also with a notch sweep speed declared by the manufacturer.
- For *mixed-mode* systems the limits apply only for the *reference modes*.

NOTE: For reader convenience, the relationships between  $W$ ,  $B_c$  and  $Kn$  defined in Recommendation ITU-R F.1093 [26] are here summarized:

$$Kn = (T^2 \times W \times \lambda_a) / \tau_r$$

where:

$T$ : system baud period (ns) (i.e. equal to  $1/SR$  expressed in Gbaud/s)

$W$ : *signature* width (GHz)

$\tau_r$ : reference delay (ns) for  $\lambda_a$

$\lambda_a$ : average of (linear) *signature* depth ( $\lambda_c$ ) variable with frequency ( $f$ ) as:

$$\lambda_a = \frac{\int_{f=-W/2}^{f=+W/2} \lambda_c(f) df}{W}$$

where:

$$\lambda_c(f) = 1 - b_c(f),$$

$$b_c = 1 - 10^{-B_c(dB)/20}$$

$B_c$ : *signature* depth expressed in dB

Table 8 gives the limits for SDH single-mode or preset-mode systems, i.e. STM-1/ $N \times$  STM-1/STM4 or equivalent traffic, in 28 MHz, 40 MHz or 56 MHz nominal CS.

Table 9 gives the limits for generic mixed-mode systems (e.g. suitably scaled for constant equalization structure from 4QAM to 2048QAM).

**Table 8: Kn limits for single or preset mode equipment of SDH or equivalent PDH traffic**

Spectral efficiency		Nominal payload Bit-Rate	Nominal CS (MHz)	Maximum Kn (reference to ITU-R F.1093 [26])
Reference index	Class			
5	4H	STM-1	56	1,0
6	5L	STM-1	40	1,15
7	5H	STM-1	28	1,3
7	5H	2 x STM-1	56	1,3

**Table 9: Kn limits for the reference modes of mixed-mode equipment**

Spectral efficiency		Maximum Kn (reference to ITU-R F.1093 [26])
Reference index	Class	
2	2	0,30
3	3	0,45
4	4L	0,6
5	4H	0,75
6	5L	0,9
7	5H	1,05
8	6L	1,2
9	6H	Supplier declaration
10	7	
11	8	

### 6.5.2.3 Assessment

It is recognized that dedicated test equipment for signature is hardly available and will likely completely disappear in future; other non specific test setups are possible, but they could be complex, bulky and hardly suitable for standardization. On the other hand, the present digital equalizer technology has solved most of the possible hardware problematic that sometimes affected older equalizers techniques.

Therefore, the formal assessment of Kn limits set in previous clause are subject only to supplier declaration.

## 6.5.3 Interference sensitivity for CCDP with XPIC operation

### 6.5.3.1 General

The level and impact of Cross Polar Co-channel Interference depends on the frequency band, class of equipment, climatic conditions, antenna discrimination and hop length. When these factors are favourable, CCDP can be achieved without the use of an XPIC.

Whenever XPIC is implemented for systems operating (permanently or as *reference-mode*) on classes equal to or higher than 5L, with channel separations from 27,5 MHz to 60 MHz the following applies.

The "internal interference" notation is hereby considered to be that given by the twin systems sharing the same XPIC system in absence of any other "external interference".

### 6.5.3.2 Co-channel "internal" interference sensitivity in flat fading conditions

For the frequency 10.

**Table 10: Degradation versus C/I (co-channel "internal" interference)**

Reference BER →	10 <sup>-6</sup>	
	RSL Degradation →	
	1 dB	3 dB
<b>C/I (dB) for class 5L and class 5H equipment</b>	17	13
<b>C/I (dB) for class 6L and class 6H equipment</b>	24	20
<b>C/I (dB) for class 7 and class 8 equipment</b>	Supplier declaration	Supplier declaration

Referring to the measurement test bench in annex G, the measurements shall be made adding the same values of noise and interference to both the paths, and varying the phase shifter of the interfering path in order to find the worst condition for this characteristic.

## 6.6 System characteristics with diversity

The following clauses define requirements where space, angle and frequency diversity techniques are applicable. Only combining techniques are considered.

### 6.6.1 Differential delay compensation

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

### 6.6.2 BER performance

When both receiver inputs (main and diversity, reference point B and D of figure 1 of EN 302 217-1 [15]) are fed with the same signal level with an arbitrary phase difference, the input level limits for the specified BER values defined under clause 5.3.1, shall be lower than those given under clause 5.3 for the case without diversity:

- More than 2,5 dB for IF or baseband combining systems.
- More than 1,5 dB for RF combining systems.
- No improvement for baseband switch systems.



# Annex A (normative): Spectrum masks and receiver selectivity when mixed supplier compatibility is required

## A.0 Introduction

When only one supplier provides all the equipment attached to a single antenna, it is responsibility of that supplier to adopt the appropriate measures so as to guarantee local TX and RX compatibility.

When different suppliers' equipment is expected to be connected to the same antenna system, clause 4.2 defines the possible compatibility requirements.

In the latter case, this annex defines the requirements for the noise floor of the normal channels and, for the most common cases of innermost channels of some well known channel arrangements, the limits for the combined innermost channels spectrum masks and receiver selectivity already standardized.

It should be noted that the limits reported in this annex are necessary only when the innermost TX and RX channels are physically present on the same antenna and they are from different manufacturers. Whenever they are from the same manufacturer, they are not mandatory, but the manufacturer will in general declare the maximum degradation [in dB] expected on the  $BER = 10^{-6}$  threshold of the receiver under the assumptions reported in clause A.2.

TR 101 854 [i.11] provides the background for the practical calculation of the NFD derived from the TX spectrum mask and RX selectivity, including the possible refined improvement considering the typical spectrum shaping.

For information, the further calculation of the expected  $BER = 10^{-6}$  threshold degradation can be made from the following equations:

$$\text{Assuming that } K \text{ (dB) represents the } I/N \text{ ratio } \frac{\text{TX interference into RX bandwidth}}{\text{RX noise power}} \text{ (dB)} \quad (\text{A.1})$$

Where the RX bandwidth spans, in principle, to the overall operating band, and includes residual of all local TX carriers connected to the same antenna.

$$K(\text{dB}) = \{P_{\text{tx}}(\text{dBm}) - \text{TX/RX decoupling} - \text{Other losses} - \text{NFD}\} - \{-114 + 10\log(\text{RX Symbol rate in MHz}) + \text{NF}\} \quad (\text{A.2})$$

Other losses are branching and feeder losses, for instance.

TX/RX decoupling depends on antenna, feeder and equipment antenna port characteristics; the following typical reference values are assumed:

- TX and RX on same antenna port: 25 dB
- TX and RX on cross-polar antenna ports: 45 dB
- TX and RX on separate antennas: 70 dB

Then the  $BER = 10^{-6}$  threshold degradation is calculated as:

$$\text{Threshold Degradation (dB)} = 10\log\left(1 + \frac{1}{10^{-K/10}}\right) \quad (\text{A.3})$$

EXAMPLE: Commonly used values:  
 $K = -10 \text{ dB} \rightarrow \text{Degradation} \cong 0,4 \text{ dB}$   
 $K = -6 \text{ dB} \rightarrow \text{Degradation} \cong 1 \text{ dB}$   
 $K = -3 \text{ dB} \rightarrow \text{Degradation} \cong 1,8 \text{ dB}$   
 $K = 0 \text{ dB} \rightarrow \text{Degradation} \cong 3 \text{ dB}$

## A.1 TX masks assessment

Since it is not possible to measure spectrum attenuation values up to 105 dB directly, the relative power spectral density below -65 dB level, shown in figure A.1, figure A.2, figure A.4 and figure A.5 of the present annex should be subject to a supplier declaration (see note).

NOTE: User guidance: the values beyond -65 dB may be indirectly evaluated by adding a measured filter characteristic to the spectrum measured at reference point A' (Power amplifier output) of figure 1 of EN 302 217-1 [15]. Due to the limitations of some spectrum analysers, difficulties may be experienced when testing high capacity/wideband systems. In this event, the following options may be considered: measurement using high performance spectrum analyser, use of notch filters (for blocking the TX carrier power for improving the dynamic range of the analyser) and the two step measurement technique.

## A.2 Normal channels - Emission mask floor

### A.2.1 RBER impact

In 18 GHz band and higher bands, for spectral efficiency classes 5H (subclass B) and above systems, EN 302 217-2-2 [16] does not require attenuation greater than 50 dB or 45 dB for the spectrum mask floor relevant to R&TTE Directive [1] compliance. However, for guaranteeing RBER performance in the presence of multiple (i.e. 2<sup>nd</sup>, 3<sup>rd</sup>, etc.) adjacent channels on the same route regardless of the FEC algorithm implemented, a mask floor at -55 dB might be required. The corresponding frequency corner may be derived extending the last slanted segment of the mask (provided in EN 302 217-2-2 [16]) down to intercept the -55 dB ordinate.

However, actual performance depends on the interference-limited efficiency of the error correction algorithm and from the actual number of adjacent channels foreseen; therefore this requirement may be substituted by a supplier declaration of the interference-limited RBER capability of the equipment.

### A.2.2 Local TX to RX compatibility

#### A.2.2.1 Spectrum mask

For all channels but the innermost one, the only additional requirement with respect to the spectrum mask defined in EN 302 217-2-2 [16] is that the mask floor of the TX emission within the receiver sub-band should, if necessary, be improved until the formulas (A.2) and (A.3) above, calculated with NFD equal to the expected noise floor attenuation, gives an acceptable (see note) BER threshold degradation.

NOTE: Acceptable, means commonly agreed between customer and supplier.

EXAMPLE: Assuming:  
 TX output power = +30 dBm,  
 Copolar TX/RX decoupling (antenna circulator) = 25 dB (compatibility clause 4.2a))  
 Additional losses (branching circulators) = 1,5 dB  
 NF = 5 dB  
 RX Symbol Rate = 22,4 Mbit/s  
 Acceptable BER threshold degradation  $\leq 1$  dB (i.e. K = -6 dB)  
 Applying formula (A.2) above results in NFD  $\geq 105$  dB  
 Hence, the TX mask floor spectral density in the RX sub-band should also be extended down to:  
 Relative Spectral density = - NFD = -105 dB  
 Similarly, when considering:  
 Cross-polar decoupling (antenna diplexer) = 45 dB (compatibility clause 4.2b)),  
 Relative Spectral density = -85 dB.

Most significant examples of spectral density masks limits for normal channels fulfilling clause 4.2a) (co-polar operation under the same antenna) or clause 4.2b) (cross-polar operation under the same antenna) compatibility requirement are shown together those for innermost channels in figure A.1, figure A.2, figure A.4 and figure A.5 of the present annex.

### A.2.2.2 Receiver selectivity

Applying the same formulas and example in clause A.0 above, it is easily understood that the required NFD (105 dB in the example) can only be obtained when the contribution of the residual of the innermost TX carrier is sufficiently reduced by the RX filter so as not to increase the interference generated by the off-carrier spectrum falling directly into the innermost RX band.

Therefore, the total RX filters attenuation on the TX sub-band should be at least of the same entity of the TX spectrum attenuation in the RX sub-band.

Figure A.3 shows the required selectivity for all channels and that for the innermost channel case.

---

## A.3 Innermost channels for channel arrangements from about 4 GHz to about 8,5 GHz with channel separation of 28 MHz to 30 MHz

The following clauses refer requirements when channel separation between 28 MHz and 30 MHz are considered. However, it is recognized that, in some cases, it is possible to combine two 28/30 MHz channels for the use of a single 56/60 MHz system. This case has not been addressed with specific mask limits. Nevertheless, the general concepts still apply and suitable masks can be studied and agreed among the concerned actors.

### A.3.1 Innermost channels spectrum masks

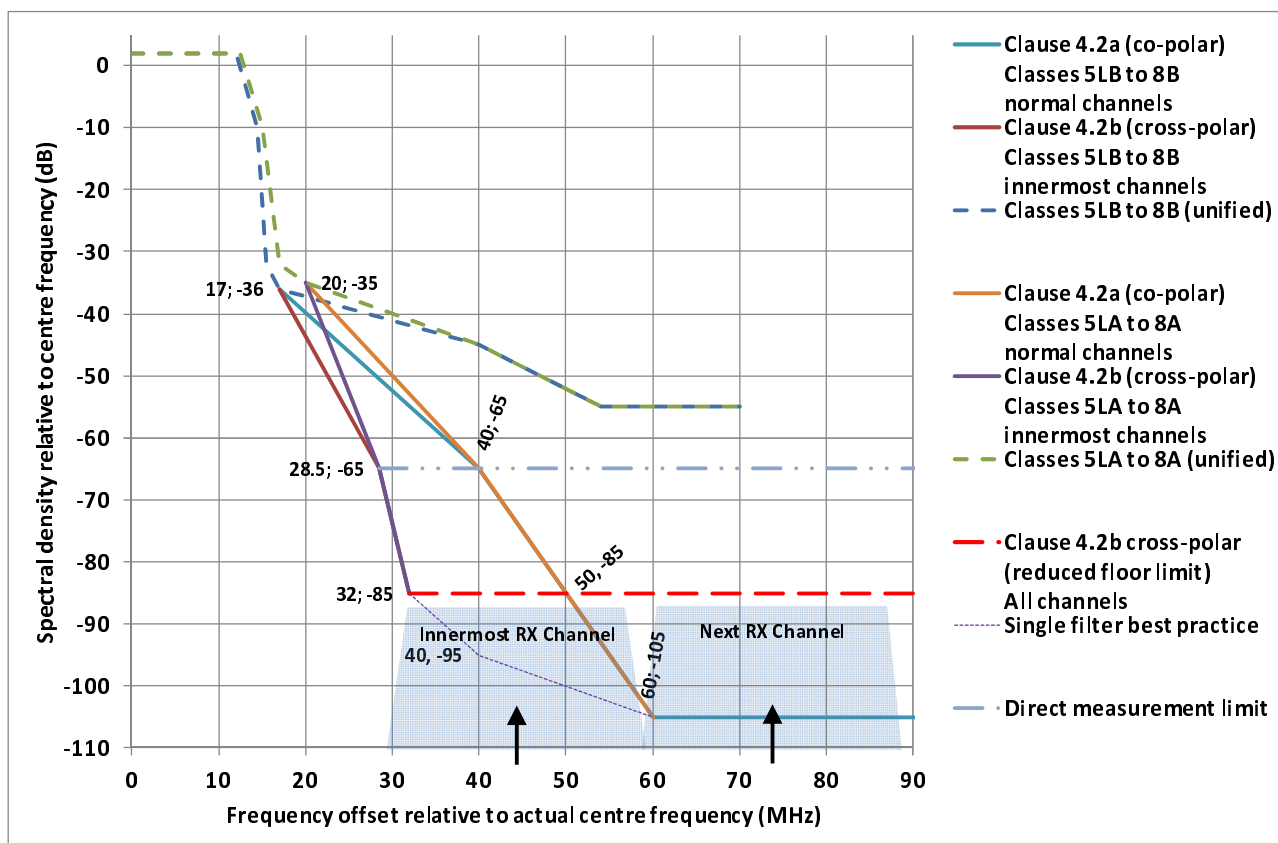
This clause reports only the limits for the most significant and common cases of innermost channel compatibility.

For the lower 6 GHz (L6) band, where the centre gap is 44,49 MHz, figure A.1 shows the limits of masks for normal channels, which are intended to comply with the most stringent compatibility requirement, for normal channels under clause 4.2a) (co-polar operation on the same antenna) and for the inner edges of the centre gap channels 8 and 1' under clause 4.2b) (cross-polar operation of both channels on the same antenna). The masks are specified for equipment with spectral efficiencies equal to or higher than 5L and for sub-classes A and B (see note 1).

When compatibility of the innermost channels under clause 4.2a) is necessary, see note 2.

**NOTE 1:** This arrangement is defined in ERC/REC 14-01 [i.3] and Recommendation F.383 [i.12]. It is commonly understood that in this band only high capacity systems are employed; however, if lower spectral efficiency classes are used, the mask are considered valid as well.

**NOTE 2:** For equipment exploiting CCDP operation, figure A.1 shows that the compatibility, according clause 4.2a), of the co-polarized innermost systems is not possible (i.e. the required 105 dB spectrum attenuation is not met with conventional single channel filter practice) unless different antennas for H and V channels are used, or additional, high complexity, filtering (typically stop-band) are properly designed and placed on the TX and RX chains. This additional filtering has not been considered suitable for standardization.



**Figure A.1: L6 GHz band, limits of power spectral density for normal channels and the inner edges of the innermost channels (reference point B' of figure 1 of EN 302 217-1 [15])**

For the 7 GHz and 8 GHz bands, various innermost channels separation are reported ranging from 42 MHz to 63 MHz or larger width. The 42 MHz case foresees only co-polar operations; therefore, the innermost channel compatibility falls in the case described in note 2 above and has not been standardized.

When the centre gap is 56 MHz (channel arrangement according to annex 3 of Recommendation ITU-R F.385 [i.14]), for guaranteeing compatibility between co-polarized signals innermost channels on the same antenna, a mask is specified for the innermost edges of the centre gap channels, the mask is given in figure A.2.

Other innermost separations such as 49 MHz, 58 MHz, 59,5 MHz or 63 MHz (reported in ECC/REC(02)06 [i.1]) may be properly derived by scaling figure A.1 or figure A.2.

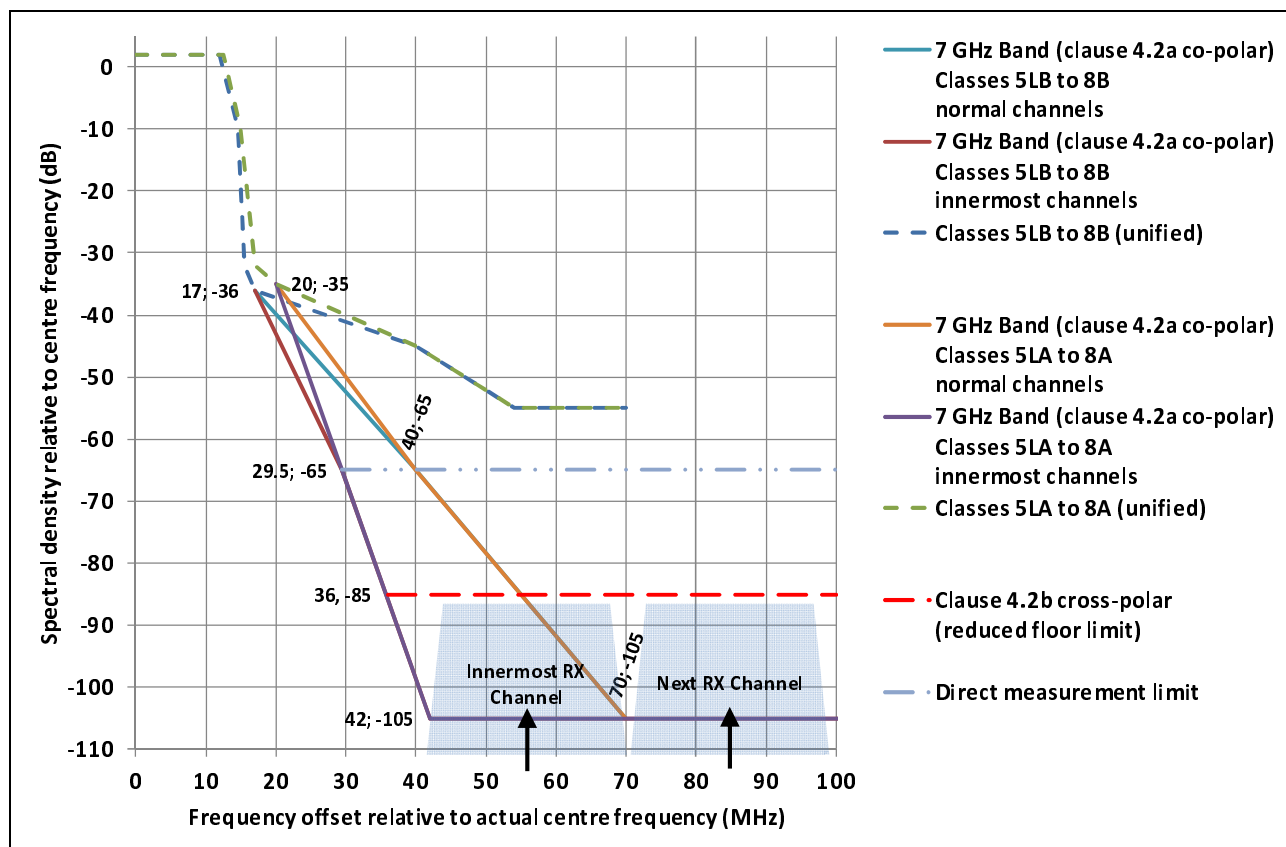


Figure A.2: 7 GHz band with 56 MHz co-polar centre gap, limits of power spectral density for normal channels and the inner edges of the innermost channels (reference point B' of figure 1 of EN 302 217-1 [15])

### A.3.2 Receiver innermost channel selectivity

Only two general purpose selectivities, variable according to the possible in-band different shaping between "A" and "B" sub-classes, are standardized. Due to the fact that most of the selectivity is usually obtained at IF and BB level, no detailed variants according to the actual centre gap is retained necessary.

For systems which are intended to comply with compatibility requirements under clause 4.2 list item a) and/or list item b), to guarantee innermost TX/RX channel compatibility in L6 GHz band, the inner side of the innermost receiver selectivity (combination of all RF, IF and Base-band filters) shall be within the mask given in figure A.3; figure A.3 shows also the possibly relaxed selectivity for other normal channels.

Since it is not considered feasible to make a practical measurement of this characteristic, the supplier shall give the design data of the filters implemented on this receiver.

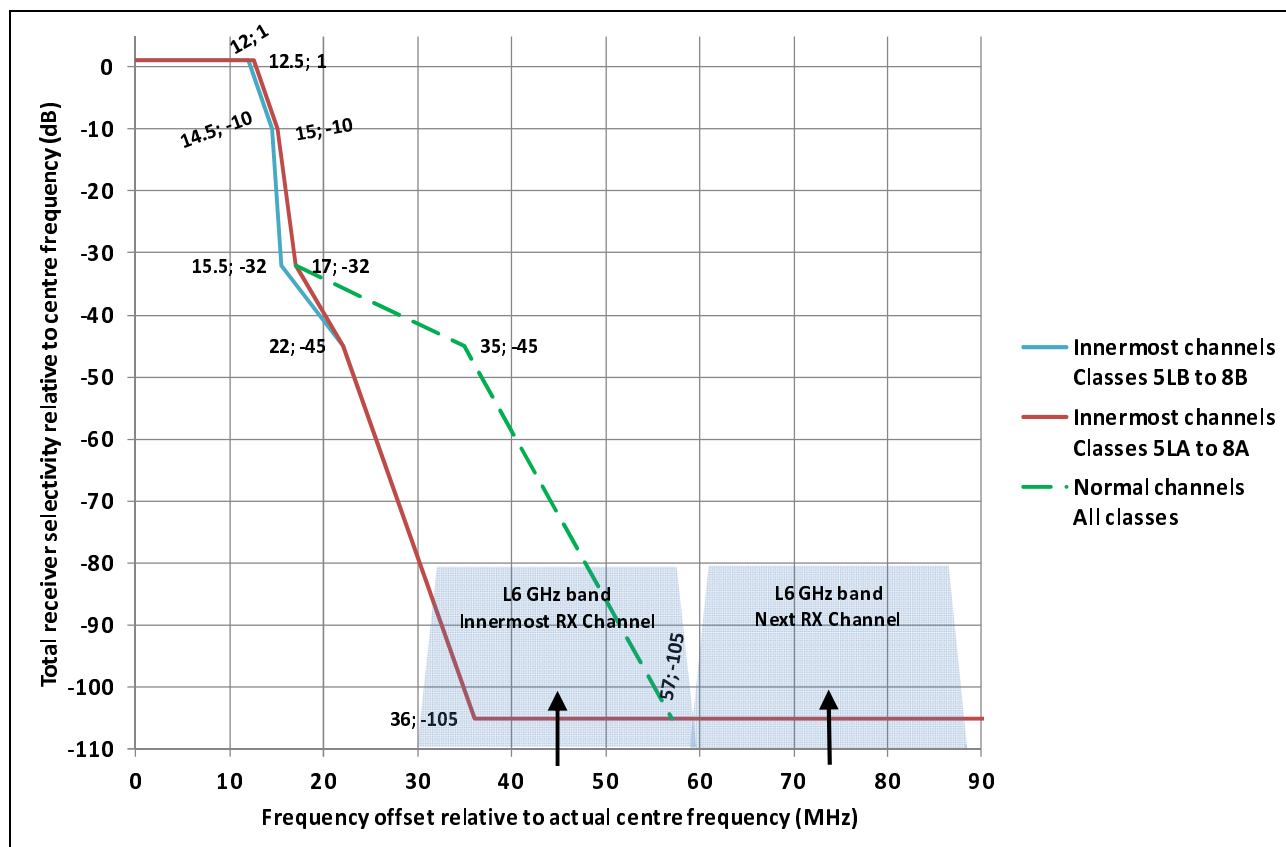


Figure A.3: Overall minimum receiver selectivity of normal channels and of the inner side of innermost receivers for L6 GHz band (reference point B of figure 1 of EN 302 217-1 [15])

## A.4 Innermost channels for channel arrangements from about 4 GHz to 11 GHz with channel separation of 40 MHz

The following clauses refer requirements when channel separation 40 MHz is considered. However, it is recognized that, in some cases, it is possible to combine two 40 MHz channels for the use of a single 80 MHz system. This case has not been addressed with specific mask limits. However, the general concepts still apply and suitable masks can be studied and agreed among the concerned actors.

### A.4.1 Innermost channels spectrum masks

This clause reports only the limits for the most significant and common cases of innermost channel compatibility.

For the upper 6 GHz (U6) band, where the centre gap is 60 MHz, figure A.4 shows the limits of masks for normal channels, which are intended to comply with the most stringent compatibility requirement under clause 4.2a) (co-polar operation on the same antenna) and for the inner edges of the centre gap channels 8 and 1' under clause 4.2b) (cross-polar operation of both channels on the same antenna). The masks are specified for equipment with spectral efficiencies equal to or higher than 5L and for sub-classes A and B (see note 1).

When compatibility of the innermost channels under clause 4.2a) is necessary, see note 2.

NOTE 1: This arrangement is defined in ERC/REC 14-02 [i.4] and Recommendation ITU-R F.384 [i.13]. It is commonly understood that, in this band, 40 MHz channel arrangement is used only for high capacity systems; however, if lower spectral efficiency classes are used, the mask are considered valid as well.

NOTE 2: For equipment exploiting CCDP operation, figure A.4 shows that the compatibility, according clause 4.2 item a), of the co-polarized innermost systems is not possible (i.e. the required -105 dB spectrum attenuation is not met with conventional single channel filter practice) unless different antennas for H and V channels are used, or additional, high complexity, filtering (typically stop-band) are properly designed and placed on the TX and RX chains. This additional filtering has not been considered suitable for standardization.

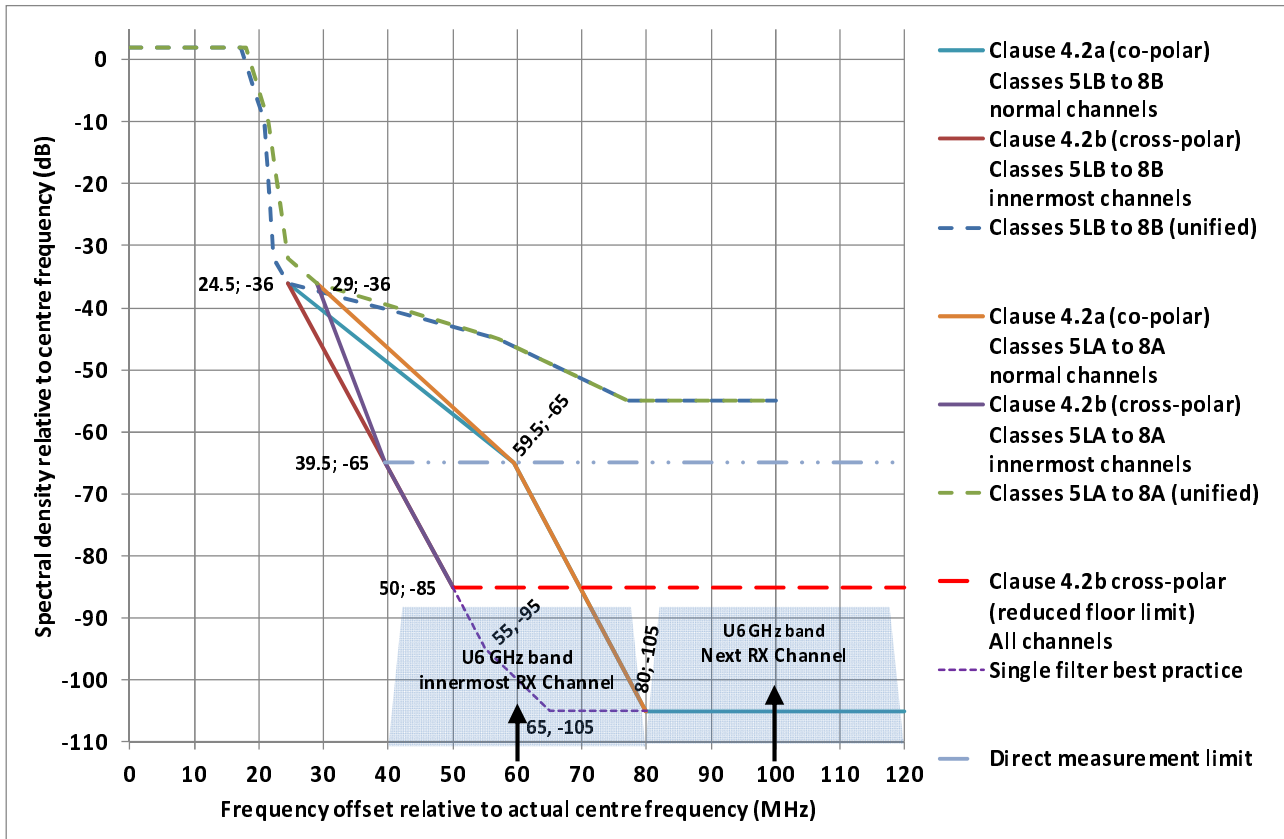


Figure A.4: U6 GHz band, limits of power spectral density for normal channels and the inner edges of the innermost channels (reference point B' of figure 1 of EN 302 217-1 [15])

## A.4.2 Receiver innermost channels selectivity

Only two general purpose selectivities, variable according the possible in-band different shaping between "A" and "B" sub-classes, are standardized. Due to the fact that most of the selectivity is usually obtained at IF and BB level, no detailed variants according the actual centre gap is retained necessary.

For systems which are intended to comply with compatibility requirements under clause 4.2 list item a) and/or list item b), to guarantee innermost TX/RX channel compatibility in U6 GHz band, the inner side of the innermost receiver selectivity (combination of all RF, IF and Base-band filters) shall be within the mask given in figure A.5; figure A.5 shows also the possibly relaxed selectivity for other normal channels.

Since it is not considered feasible to make a practical measurement of this characteristic, the supplier shall give the design data of the filters implemented on this receiver.

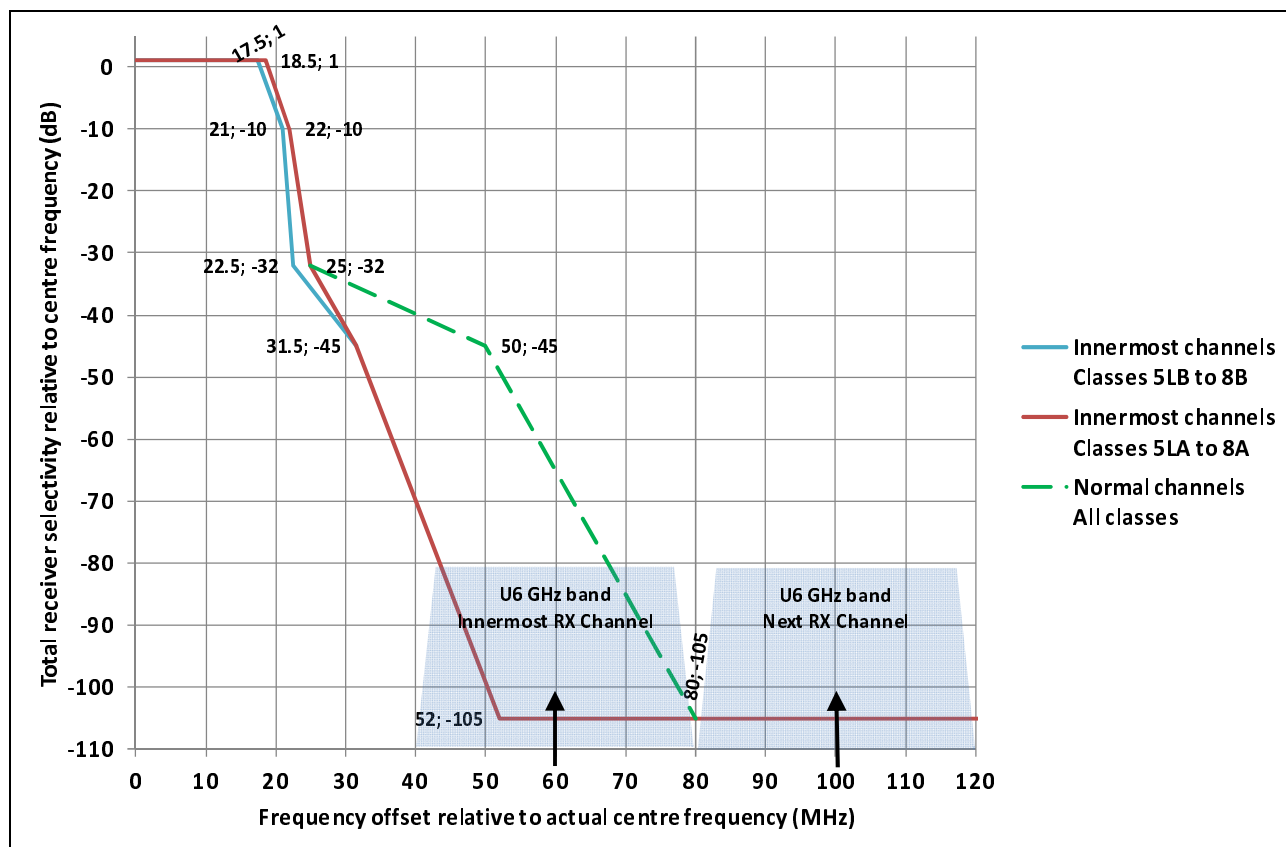


Figure A.5: Overall minimum receiver selectivity of normal channels and of the inner side of innermost receivers for U6 GHz band (reference point B of figure 1 of EN 302 217-1 [15])

## A.5 Innermost channels for 18 GHz channel arrangements with channel separation of 55 MHz

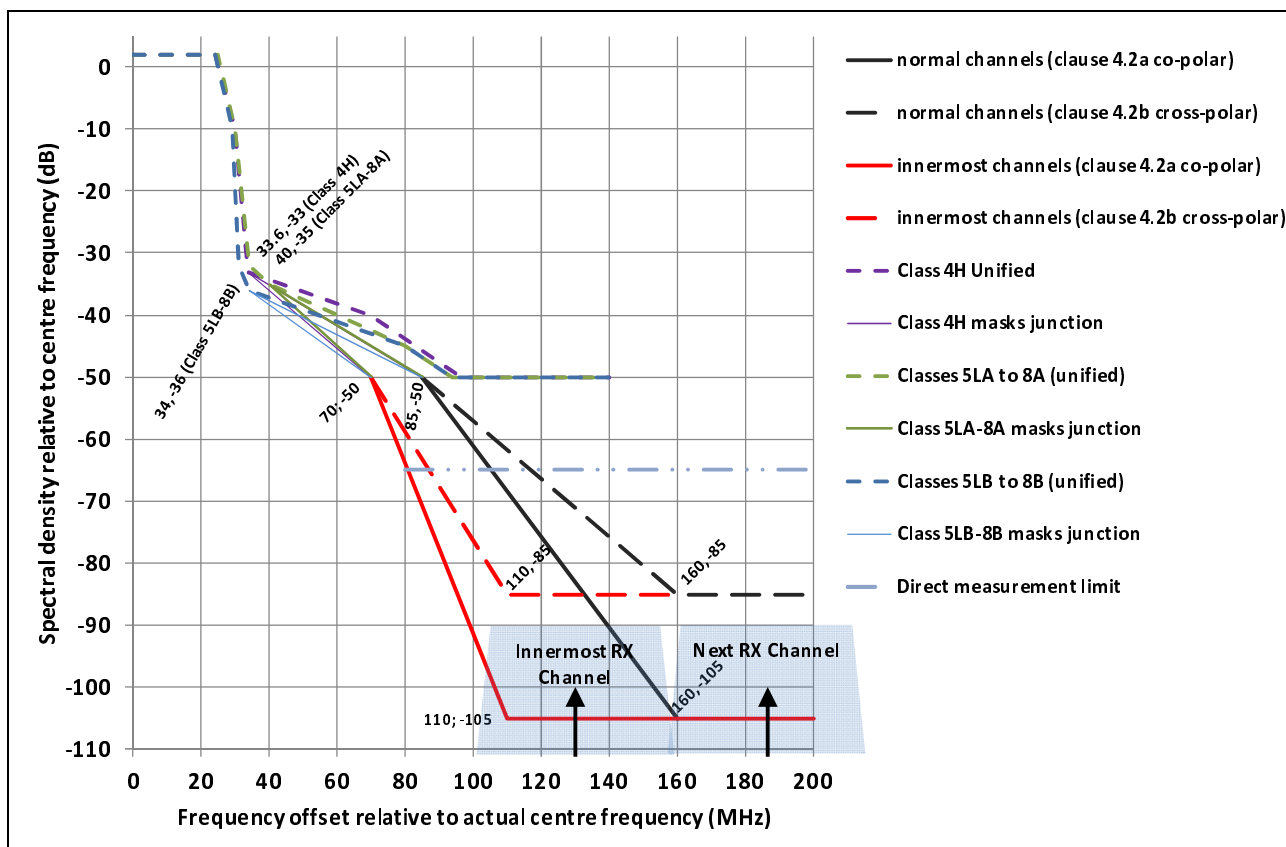
The following clauses refer requirements when channel separation 40 MHz is considered. However, it is recognized that, in some cases, it is possible to combine two 55 MHz channels for the use of a single 110 MHz system. This case has not been addressed with specific mask limits. However, the general concepts still apply and suitable masks can be studied and agreed among the concerned actors.

### A.5.1 Innermost channels spectrum masks

For the upper 18 GHz band, where, for the 55 MHz channel separation, the centre gap is 130 MHz, figure A.6 shows the limits of masks for normal channels, which are intended to comply with the most stringent compatibility requirement under clause 4.2a) (co-polar operation on the same antenna) and for the inner edges of the centre gap channels 17 and 1' also under clause 4.2a) (co-polar operation of both channels on the same antenna). Two more relaxed masks are also given whenever those channels are subject only to less stringent clause 4.2b) (cross-polar operation on the same antenna). The masks are specified for equipment with spectral efficiencies equal to or higher than 4H and for sub-classes A and B (see note).

NOTE: This arrangement is defined in ERC/REC 12-03 [i.2] and Recommendation ITU-R F.595 [i.15]. It is commonly understood that, in this band, 55 MHz channel arrangement is used only for high capacity systems; however, if lower spectral efficiency classes are used, the mask are considered valid as well.



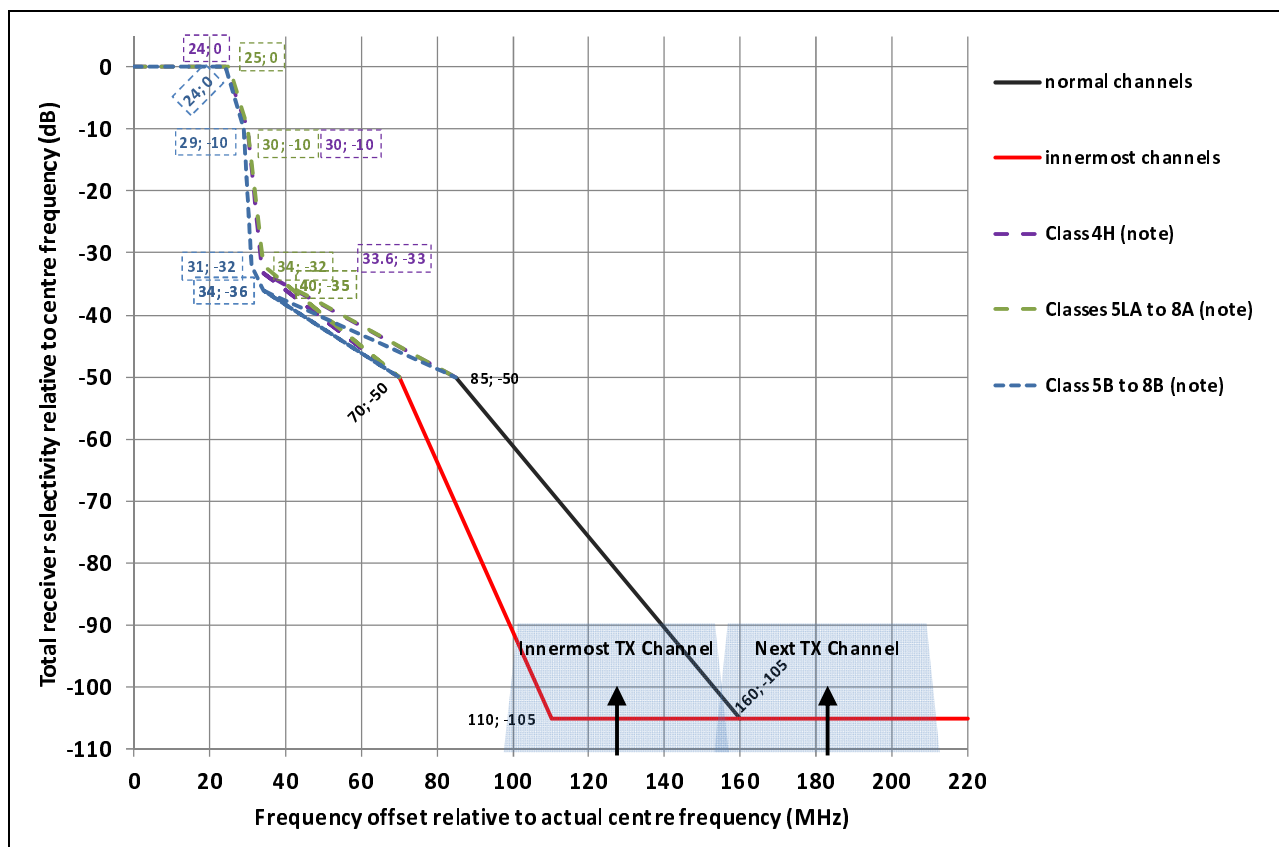


**Figure A.6: 18 GHz band, Limits of spectral power density for normal channels and for the inner edges of the innermost channels (at reference point B' of figure 1 of EN 302 217-1 [15])**

## A.5.2 Receiver innermost channels selectivity

Only two general purpose selectivities, variable according to the possible in-band different shaping among equipment classes, are standardized. Due to the fact that most of the selectivity is usually obtained at IF and BB level, no detailed variants are retained necessary.

For systems which are intended to comply with compatibility requirements under clause 4.2a) and/or clause 4.2b), to guarantee innermost TX/RX channel compatibility in 18 GHz band, the inner side of the innermost receiver selectivity (combination of all RF, IF and Base-band filters) shall be within the mask given in figure A.7.



NOTE: The corner points of the main lobe filter are the same of the relevant spectrum masks a part from the +2 dB (K1 value) brought down to 0 dB; see EN 302 217-2-2 [16].

**Figure A.7: Overall minimum receiver selectivity of normal channels and of the inner side of innermost receivers for 18 GHz band (at reference point B of figure 1 of EN 302 217-1 [15])**

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Annexes B to E:  
Deleted and left void

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## Annex F (normative): Definition of equivalent data rates for packet data, PDH/SDH and other signals on the traffic interface

Annex F of EN 302 217-2-2 [16] provides the conditions under which the BER oriented specifications in the present document can be used for systems with traffic interface other than PDH/SDH.

Clause G.4 of the present document gives also information on the BER/FER equivalence.

## Annex G (informative): Additional information

### G.1 Residual Bit Error Ratio (RBER) and Residual Frame Error Ratio (RFER)

In particular applications, where there is a high density of radio links in a specific area, e.g. nodal site, closely located radios may use adjacent channels. Therefore, to guarantee the grade of service, the equipment needs to meet the RBER criteria in the presence of adjacent channel interference.

The RBER is standardized in order to match the ESR (or the BER) performance required by ITU-R transmission performance recommendations.

To have sufficient confidence in the measurement, where the BER is relatively low compared to the actual payload, the test time is very long. To have sufficient confidence in measuring RBER where it is relatively low compared to the actual payload bit rate, the testing period becomes significantly long.

It may be estimated from the formula given in "Calculating Statistical Confidence Levels for Error-Probability Estimates" [i.17]:

$$N = \frac{1}{BER} \left[ -\ln(1-CL) + \ln \left( \sum_{k=0}^E \frac{(N \times BER)^k}{k!} \right) \right] \quad (G.1)$$

Where:  $N = \text{Bit-rate (Hz)} \times \text{recording time (s)}$  is number of bits received with "E" errors detected giving "CL" confidence level of having the given BER.

Formula (G.1) can also be resolved in term of the CL relative to the numbers (x) of error detected, the following formula is obtained:

$$CL_{(E=x)} = 1 - e^{-\left\{ \ln \left[ \sum_{k=0}^x \frac{(N \times BER)^k}{k!} \right] - (N \times BER) \right\}} \quad (G.2)$$

The formula (G.2) above assumes errors are not created in burst (as usual happens when error correction is implemented); longer recording times can be used as declared by manufacturer depending on actual error distribution due to different modulation and error correction implemented on the system.

When error correction feature is implemented it may be possible to reduce the measurement time by estimating the RBER, from the value tested without error correction, using the relevant BER improvement formula declared by the supplier.

The equipment maximum allowed number of errors level under simulated operating conditions is measured with a signal level at reference point B (or C) of figure 1 of EN 302 217-1 [15], which is 10 dB above the RSL which gives  $BER \leq 10^{-6}$  (as specified in clause 5.3.1 and in EN 302 217-2-2 [16]). All measurements should be made at the payload bit rate defined in clause 4.3.

For a  $CL \approx 50\%$  confidence, the measurement period and maximum number of errors allowed are given in table G.1.

Table G.1: Maximum permitted number of bit errors

Bit rate (Network interface)	RBBER objective	Minimum recording time (hours) (confidence ~ 50 %)	Maximum allowed number of bit Errors
Packet 10 Mbit/s	10 <sup>-12</sup>	102	3
Packet 100 Mbit/s		24	8
Packet 1 000 Mbit/s		3	10
PDH 2 Mbit/s	10 <sup>-10</sup>	17,25	12
PDH 8 Mbit/s	10 <sup>-10</sup>	4,25	12
PDH 34 Mbit/s	10 <sup>-11</sup>	9,5	11
PDH 140 Mbit/s	10 <sup>-12</sup>	23,5	11
SDH up to STM-1	10 <sup>-12</sup>	23	12
SDH STM-4	10 <sup>-12</sup>	5	10
	10 <sup>-13</sup>	50	10

Another more practical option is to ensure that no errors (or any defects) occur during the minimum recording time. It can be calculated with the formula (G.2); when putting  $E = 0$  the formula is highly simplified and the results with  $CL \sim 63\%$  confidence (see note) are shown in table G.2 for PDH and SDH signals and table G.3 for packet data signals; for other rates (possibly used under the provision of annex F) values may be extrapolated from the closest ones.

NOTE: While this method is faster, the confidence level drops sharply when one single error is detected.

Table G.2: PDH and SDH rates - Zero errors/defects recording times

Bit rate (Mbit/s) (Network interface)	RBBER objective	Minimum recording time (minutes) (confidence ~ 63 %)	Errors/defects
PDH 2	10 <sup>-10</sup>	82	0
PDH 8	10 <sup>-10</sup>	20	0
PDH 34	10 <sup>-11</sup>	50	0
PDH 140	10 <sup>-12</sup>	113	0
SDH STM-1	10 <sup>-12</sup>	108	0
SDH STM-4	10 <sup>-12</sup>	27	0
SDH STM-4	10 <sup>-13</sup>	270	0

Table G.3: Packet data rates - Zero errors/defects recording times

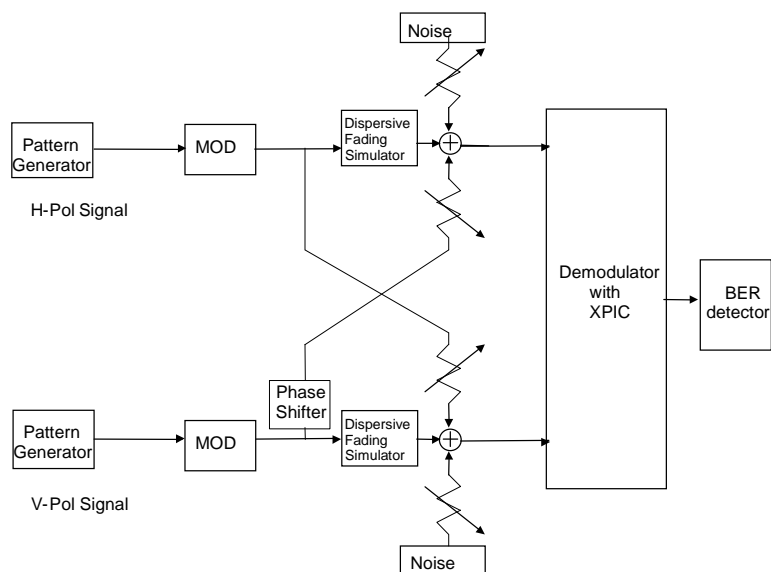
Bit rate under test (Mbit/s) (see note 2)	RBBER objective	Equivalent FER (see note 1)	Minimum recording time (minutes) (confidence ~ 63 %) (full loading) (see note 2)	Errors/defects
10	10 <sup>-10</sup>	$5 \times 10^{-8}$	17	0
	10 <sup>-11</sup>	$5 \times 10^{-9}$	170	0
	10 <sup>-12</sup>	$5 \times 10^{-10}$	1 700 (28 hours)	0
100	10 <sup>-11</sup>	$5 \times 10^{-9}$	17	0
	10 <sup>-12</sup>	$5 \times 10^{-10}$	170	0
1 000	10 <sup>-12</sup>	$5 \times 10^{-10}$	17	0
	10 <sup>-13</sup>	$5 \times 10^{-11}$	170	0

NOTE 1: 64 octets Ethernet frame calculated according formulas in clause G.4.

NOTE 2: In case the actual System Capacity (SC) does not allow Full Load Capacity (FLC) the recording time will be increased by a factor FLC/SC (e.g. for a 10baseT load transported on a 8 Mbit/s system rate the recording time will become  $17 \times 10/8 \approx 21$  minutes).

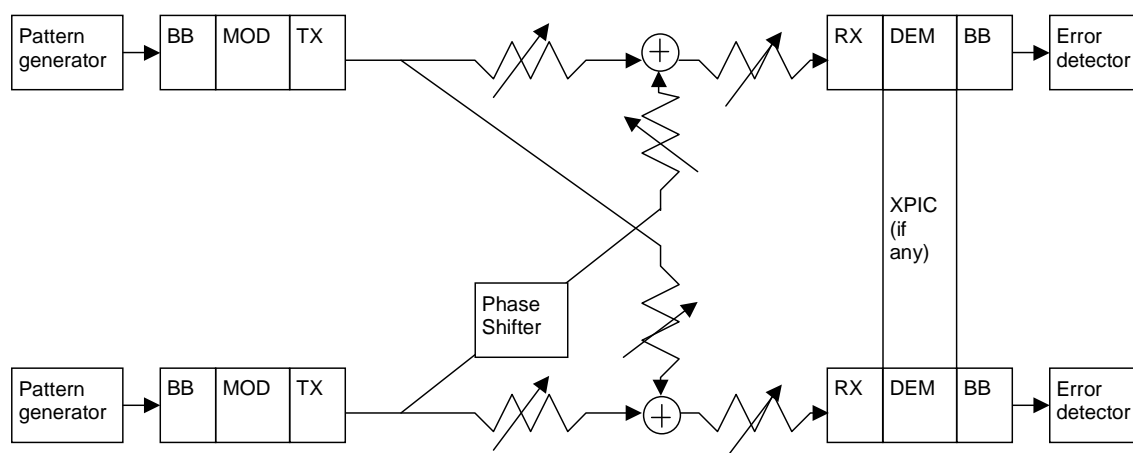
## G.2 Measurement test set for XPI characteristics

In figure G.1, a measurement set-up is defined that allows simulating wanted signals affected by flat and/or dispersive fading conditions in the presence of XPI (Cross Polar Interference) where level and phase can be varied.



**Figure G.1: IF measurement test set**

When only not-dispersive tests are considered, an alternative, full RF, test set-up, that allows to simulate wanted signals affected by flat fading conditions in presence of cross polar interference, which level and phase can also be varied, may be used as shown in figure G.2.



**Figure G.2: RF measurement test set**

## G.3 Differential delay compensation range

When frequency diversity hitless protection is integrated within the radio system it is desirable to provide the means to compensate for differential absolute delays due to antennas, feeders, cable connections, and relative velocities on different RF channels.

For indoor systems with multitrack and multi-vendor physical structure, the range of adjustment of differential absolute delay in the order of about 600 ns with a minimum step size equivalent to the symbol period is considered adequate for most applications. For outdoor and more compact single-vendor structure systems, this capability is under the responsibility of the supplier.

## G.4 FER/BER equivalence and FER performance measurement equipment settings (example)

### G.4.1 FER/BER equivalence

FER and BER can be translated as described herein. The "useful" part (i.e. excluding preamble, delimiter and interframe gap) of Ethernet frames can range from 64 octets up to 1 522 octets. For this analysis 64 octet frames are used, based on errors uniformly distributed over the bit stream (see note 1).

NOTE 1: When frames become longer the actual distribution of errors becomes more important. From one hand the probability of errored frames is higher; from the other hand, due to the fact that error correction codes tend to concentrate errors in bursts, the higher probability of having frames affected by more than one error would reduce again the overall probability of errored frames. Therefore, the 64 octets case is the one that more closely fits with the theory in uniform error distribution; BER/FER translation for longer frames may be produced through specific comparison tests on actual equipment.

An Ethernet frame is considered errored if at least one bit in the "useful" part of the frame is errored. The probability of having errored frames (FER) is the probability of having frames with one error/frame ( $p_{e=1}$ ) plus the probabilities of having two errors/frame ( $p_{e=2}$ ) and so on (see example).

EXAMPLE: For 64 octet frame, assuming a uniform distribution of errors, the probability FER would be:

$$FER = \sum_{i=1}^{i=64 \times 8 = 512} p_{e=i}$$

the probability of having exactly one errored bit in a 64 octet frame  $p_{e=1}$  is:

$$p_{e=1} = BER \times (1 - BER)^{[(64 \times 8) - 1]} \times (64 \times 8)$$

the probability that a frame contains exactly two errors  $p_{e=2}$  is:

$$p_{e=2} = \frac{BER^2 \times (1 - BER)^{[(64 \times 8) - 2]} \times (64 \times 8) \times [(64 \times 8) - 1]}{2}$$

As it can be seen in table G.4 that, at least for  $BER < 10^{-5}$ ,  $p_{e=2}$  is already negligible with respect to  $p_{e=1}$ ; the addenda for higher number of errors/frame are definitely irrelevant. Therefore, it can be assumed that:

$$FER \cong p_{e=1}$$

The formulas above determine (see note 2) the probabilities and the equivalent FER shown in table G.4.

NOTE 2: The FER so calculated may be considered "worst case" because, besides the positive impact of error concentration, the probability that errors happen outside the "useful" part would also improve the real FER (e.g. if Ethernet physical layer is transmitted transparently, the 64 octets frames are actually part of at least 84 octets basic time slots).

**Table G.4: FER/BER equivalence (64 octets per frame)**

Channel BER	Probability of 1 bit error per frame ( $p_{e=1}$ )	Probability of 2 bit errors per frame ( $p_{e=2}$ )	FER ( $\cong p_{e=1} + p_{e=2}$ )
$1 \times 10^{-4}$	$4,86 \times 10^{-2}$	$1,24 \times 10^{-3}$	$4,98 \times 10^{-2}$
$1 \times 10^{-5}$	$5,09 \times 10^{-3}$	$1,30 \times 10^{-5}$	$5,10 \times 10^{-3}$
$1 \times 10^{-6}$	$5,12 \times 10^{-4}$	$1,31 \times 10^{-7}$	$5,12 \times 10^{-4}$
$1 \times 10^{-8}$	$5,12 \times 10^{-6}$	$1,31 \times 10^{-11}$	$5,12 \times 10^{-6}$
$1 \times 10^{-10}$	$5,12 \times 10^{-8}$	$1,31 \times 10^{-15}$	$5,12 \times 10^{-8}$
$1 \times 10^{-12}$	$5,12 \times 10^{-10}$	$1,31 \times 10^{-19}$	$5,12 \times 10^{-10}$
$1 \times 10^{-13}$	$5,12 \times 10^{-11}$	$1,31 \times 10^{-21}$	$5,12 \times 10^{-11}$



## G.4.2 FER equipment settings and measurement techniques (example)

Equipment used: IEEE 802.3 [23] compliant Ethernet frame test equipment.

The transmitting Ethernet port of the test equipment should be configured to the following settings:

- Mode: Single burst.
- Count: 10 000 000 frames.
- Length: Fixed, 64 bytes.
- Interframe Gap: 96 ns for 1 Gbit/s, 0,96 µs for 100 Mbit/s, 9,6 µs for 10 Mbit/s.

FER can be calculated by the following formula after using the above measurements:

- $FER = 1 - (\text{number of non-errored frames received}) / (\text{number of frames transmitted})$ .

For example if 50 frames are lost or errored then the number of non-errored frames indicated by the test equipment is 9 999 950. The resulting  $FER = 1 - 9\,999\,950 / 10\,000\,000 = 5 \times 10^{-6}$ .

## G.5 Automatic Transmitter Power Control (ATPC)

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

- To reduce interference between neighbouring systems or adjacent channels of the same system, while maintaining a high system gain as a countermeasure against multipath or rainfall attenuation.
- To improve compatibility with analogue and digital systems at nodal stations.
- As a mitigation factor for improving sharing with other services.
- To improve residual BER or BBER performance.
- To reduce up-fading 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 (with possible overdrive conditions with reduced linearity) as a countermeasure against extreme rainfall attenuation.
- In frequency bands where multipath is the dominant propagation factor, to improve adjacent channel protection to differential fading conditions caused by operation of adjacent channels on different antennas on parallel routes (e.g. operated by different operators).

According to the definitions of ATPC power conditions in clause 3.1 of EN 302 217-1 [15], ATPC, as an optional feature, is aimed at driving the TX power amplifier output level from a proper "minimum power" which facilitates the radio network planning requirements and which is used under normal propagation conditions up to a "maximum nominal power" value which fulfils all the specifications defined in the present document.

ATPC may also be used to increase the output power above the "maximum nominal power" up to a "maximum available power" specified by the supplier, with the agreement of administrations and operators, during fading conditions. Therefore, when ATPC is disabled, the nominal output power for stable operation is lower than the maximum in dynamic operation with ATPC enabled; this can be useful because in frequency ranges above 13 GHz the main limiting factors are given by non selective fading events. In such cases ATPC may be employed as a fixed feature (i.e. the ATPC may not be disabled) in order to reach a higher nominal system gain (i.e. defined by the "maximum available power").

For planning considerations in a nodal environment a system equipped with ATPC can be considered to operate at "minimum power".

Care should be taken of the fact that the use of ATPC increases the percentage of time in which the system operates at low receiver signal level; care should be taken that the threshold of ATPC intervention is designed to be in a RSL region where the BBER is still met, so that, even if the system would remain at constant RSL for higher percentage of time, an increase of Errored Blocks (EB), Background Block Error Ratio (BBER) or Residual BER (RBER) objectives is avoided with respect to a system without ATPC function enabled; additional information may be found in TR 101 036-1 [i.5].

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## Annex H (informative): Mitigation techniques referred in ERC/DEC(00)07 (18 GHz band)

In accordance to the ERC/DEC(00)07 [3] the FS should, where practical, implement the following mitigation techniques:

- a) Automatic Transmitter Power Control: to be applied in the whole band, to all new equipment installed after the 1<sup>st</sup> January 2003 (see note).
- b) EIRP limited to the minimum necessary to fulfil the performance objectives of the fixed link.
- c) Antennas: use of high performance (low sidelobe) antennas in areas of dense FS deployment.

NOTE: This date is subject to review in light of market development of FS and FSS in this band.

Equipment suppliers should consult national regulatory authorities to know which mitigation techniques may need to be implemented (which in some cases are presented also in ECC web site: <http://www.cept.org/ecc>).

## Annex I (informative): Change History

Major variants with respect to previously published versions.

Version	Date	Major variants with respect to previous version
V1.1.3	December 2004	First Publication superseding a number of other older "historical" standards.
V1.2.1	June 2007	<ul style="list-style-type: none"> <li>- Definitions of spectral efficiency classes moved to EN 302 217-2-2</li> <li>- References to the superseded "historical" standards removed with consequent redefinition of "system types" described in annex A to annex E</li> <li>- Various clarifications added where necessary</li> </ul>
V1.3.1	January 2010	<ul style="list-style-type: none"> <li>- Normative and Informative references subdivided</li> <li>- Reference added (new clause 5.0) to the impact of "environmental profile" on the requirements</li> <li>- Recall added to the definition of "radio frequency tolerance" in the Radio Regulations</li> <li>- Rationalization of system types in annex D for 13 GHz, 15 GHz and 18 GHz bands</li> </ul>
V2.1.1	mm/2014	<ul style="list-style-type: none"> <li>- Alignment to the corresponding revision of EN 302 217-2-2 [16] in the field of: <ul style="list-style-type: none"> <li># Extension of the spectral efficiency classes subdivision to formally cover the whole granularity of modulation reference index from 1 (2 states, spectral efficiency class 1) to 9 (512 states, spectral efficiency class 6H) and to newly introduced 10 (1 024 states, spectral efficiency class 7) and 11 (2 048 states, spectral efficiency class 8).</li> <li># Removal of the other system identification parameter based on A.1, ..., B.1, ..., C.1, ..., D.1, ..., E.1, ... notations. Unique system identification is based on operating frequency band, operating radio frequency channel separation and spectral efficiency class to which a minimum RIC is associated.</li> <li># Use, as system identification method, of the "minimum radio interface capacity (RIC)", more appropriate for new Ethernet oriented systems, in place of the previous PDH/SDH oriented one.</li> </ul> </li> <li>- Rationalization and harmonization of RSL range and maximum input level</li> <li>- Rationalization of Residual BER limits and background</li> <li>- Revision of return loss requirements at antenna port</li> <li>- Unification and updating to current technology of system <i>signature</i> performance</li> <li>- Aggregation of all requirements for mixed supplier equipment compatibility on the same antenna in a single annex A</li> <li>- Consequent removal of all "system specific" annexes (previous annex A to annex E) because, after the above changes, this differentiation is no longer needed</li> </ul>

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## History

<b>Document history</b>		
V1.1.3	December 2004	Publication
V1.2.1	June 2007	Publication
V1.3.1	January 2010	Publication
V2.0.1	August 2014	EN Approval Procedure      AP 20141205: 2014-08-07 to 2014-12-05
V2.1.1	December 2014	Publication