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Technical Report

Fixed Radio Systems;
Point-to-point equipment;
Generic wordings for standards on digital radio systems characteristics;
Part 1: General aspects and point-to-point equipment parameters

Reference

RTR/TM-04068

Keywords

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

It is designed to provide the generic wording for standards (ETSs and ENs) produced by ETSI WG TM4, concerning Fixed Radio Systems, formerly known as Digital Radio Relay Systems (DRRS) and point-to-point specific equipment.

The present document was originally published by TM as an internal document (TM TR 006-01), but since it has been found useful to refer to the content in other TM documents (standards and reports) it has been re-published as a TR. This has been done solely to make the content publicly available and no changes to the text have been made other than editorial changes.

1 Scope

The present document defines the major issues for the standardization of the general aspects of Fixed Radio Systems (FRS) formerly known as Digital Radio Relay Systems (DRRS) and for point-to-point specific equipment parameters, in order to maintain a generic format for the editorial and technical contents. It is also essential to maintain a common understanding of the reasons behind the way certain parameters are defined among the various FRS standards, which deal with the same general topics and may differ from each other merely from the point of view of numerical requirements. The present document therefore also explains the reasoning behind why the parameters in FRS standards are defined in the way they are.

The present document aims to cover every issue that may be required. Specific standards may differ from the guidelines contained within the present document only if the specific argument is not covered or there is good technical reason for not following them.

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] EN 301 126-1: "Fixed Radio Systems; Conformance testing; Part 1: Point-to-Point equipment. Definitions, general requirements and test procedures".

[2] SR 001 262: "ETSI drafting rules".

[3] 89/336/EEC "Electromagnetic Compatibilty Directive".

Suggested reference documents for the production of FRS/DRRS ETSs and ENs are given in annex 1.

3 Definitions and abbreviations

3.1 Definitions

For definitions relevant to conformance test requirements and test typology refer to EN 301 126-1 [1].

3.2 Abbreviations

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

DRRS Digital Radio Relay System
FRS Fixed Radio System

4 Basis for reference

a) Appendix A of the present document forms a template to be used during the elaboration of FRS standards (ETS/EN). Appendix B of the present document provides additional guidance on the use of the template document and the clause numbering in Appendix B follows the numbering in Appendix A so, for example:

- clause B.5.2 (Appendix B) offers guidance on the elaboration of clause 5.2 (Appendix A)
- B.annex B (Appendix B) offers guidance on the elaboration of annex B (Appendix A)

Appendix A contains the issues to be considered when producing a Fixed Radio Systems (FRS) standard. These systems were formerly referred to as Digital Radio Relay Systems (DRRS). These include:

- generic text, for normative requirements, to be used, under that item, in every new standard regarding FRS/DRRS characteristics (general aspects and point-to-point equipments parameters), where only a numerical value in the item (where it is required) has to be changed or included;
- the meaning or phrasing of these standard texts shall not be altered unless a specific, different requirement is considered necessary. In this case a brief description of the background motivation for each change shall be documented in an informative annex;
- in some cases, a selection of different statements on the same issue, which may be applicable depending the type of system, are shown in <u>*underlined italic characters*</u>. In this case, the relevant phrase shall be applied;
- clarification, if necessary, of the test methods in order to have a common understanding of the requirements among the various certification laboratories;
- the contents of appendix A shall be used to draw up ETSs and ENs on FRS/DRRS equipment characteristics, unless the argument to be dealt with is not thereby covered.
- annex A (Normative) to appendix A, example for the inclusion of the requirements for ENs intended for harmonization under the EMC Directive 86/339EC [3];
- annex B (Normative) to appendix A, example for the inclusion of the Administrations requirement of a unique system type identifying code for licensing procedures;
- annex C (informative) to appendix A gives additional information for some FRS/DRRS characteristics, which are usually not the subject of standardization, but are however referred to for additional information.

b) Appendix B contains a brief description of the general technical background of the issue itself to support the standard text and/or illustrations and to give guidance on the numerical requirements of each issue (when applicable). This information has been supplied for the guidance of the editorial groups and would not form part of any standard produced.

Appendix A: Text for the standardized items

NOTE: The ETSI Secretariat supplies a toolbook (http://www.etsi.org/toolbook) which gives a brief guide to the use of the ETSI templates and style sheets when working on the production of standards and other documents for ETSI. It is recommended that the toolbook is read in conjunction with the present document. It has to be noted that the ETSI Drafting rules are available in SR 001 262 [2].

1 Scope

No standard text is given since it will vary according to the type of equipment and its use.

However the following specific sentences on applicable antenna standards, conformance test procedures, different equipments spectrum efficiency classes (if any), safety aspects and to the "Generic wording" technical background shall be made as:

- the present document deals with radio frequency (RF) and base-band equipment characteristics; antenna system requirements are covered in EN(ETS) 30…….*(quote the relevant antenna standard)*;

- the present document does not cover aspects related to test procedures and test conditions which are demanded to the scope of EN 301 126;

- technical specifications relevant to the EMC Directive 89/336/EEC [51], are reported in annex A (normative).

As the maximum transmission rate in a given bandwidth depends on system spectral efficiency, different equipment classes are defined in TR 101 036-1 [47] *(quote in the EN only the relevant classes; e.g.2, 4 and 5)*:

Class 1: equipment spectral efficiency based on typical 2-states modulation scheme (e.g. 2-FSK, 2-PSK or equivalent);

Class 2: equipment spectral efficiency based on typical 4-states modulation scheme (e.g. 4-FSK, 4-QAM, or equivalent);

Class 3: equipment spectral efficiency based on typical 8-states modulation scheme (e.g. 16 QAM or 32-QAM, or equivalent);

Class 4: equipment spectral efficiency based on typical 16 or 32-states modulation scheme (e.g. 16 QAM or 32-QAM, or equivalent);

Class 5: equipment spectral efficiency based on typical 64 or 128-states modulation scheme (e.g. 64 QAM or 128-QAM, or equivalent);

Class 6: equipment spectral efficiency based on typical 256 or 512-states modulation scheme (e.g. 256 QAM or 512-QAM, or equivalent).

The above classes are indicative only and do not imply any constraint to the actual modulation format, provided that all the requirements in the present document are met.

"Safety aspects will not be considered in the present document. However, for complying EC Directive R&TTE [50], compliance to CENELEC EN 60950 *(or any other applicable safety standard harmonized under the EC Directive …….)* will be required."

Technical background for most of the parameters and requirements referred in the present document may be found in TR 101 036-1 [47].

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

In the latter case, the time frame of application and new certification procedures for new releases of these normative references next to the date of the first public enquiry of the present document or to the first certification of the equipment shall be agreed between the supplier and the regulatory authority. These new certification procedures will cover in any case only the parameters subject to changes from the on going release during the previous certification.

[1] ITU-R Recommendation F.634-4: "Error performance objectives for real digital radio-relays links forming part of a high grade circuit within an integrated services digital network".

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

[3] ITU-R Recommendation F.696-1: "Error performance and availability objectives for hypothetical reference digital sections utilizing digital radio-relay systems forming part of all of the medium-grade portion of an ISDN connection".

[4] ITU-R Recommendation F.697-2: "Error performance and availability objectives for the local-grade portion at each end of an ISDN connection utilizing digital radio-relays systems".

[5] ITU-R Recommendation F.746-4: "Radio-frequency channel arrangements for radio-relays systems".

[6] ITU-R Recommendation F.752-1: "Diversity techniques for radio-relays systems".

[7] ITU-R Recommendation F.1093-1: "Effects of multipath propagation on the design and operation of line-of-sight digital radio-relays systems".

[8] ITU-R Recommendation F.1101: "Characteristics of digital radio-relay systems below about 17 GHz".

[9] ITU-R Recommendation F.1102: "Characteristics of radio-relay systems operating in frequency bands above about 17 GHz".

[10] ITU-R Recommendation F.1092-1: "Error performance objectives for constant bit rate digital paths at or above the primary rate carried by digital radio-relay systems which may form part of the international portion of a 27 500 km hypothetical reference path".

[11] ITU-R Recommendation F.1189-1: "Error performance objectives for constant bit rate digital paths at or above the primary rate carried by digital radio-relay systems which may form part of the national portion of a 27 500 km hypothetical reference path".

[12] ITU-R Recommendation F.750-3: "Architectures and functional aspects of radio-relay systems for SDH-based networks".

[13] ITU-R Recommendation F.751-2: "Transmission characteristics and performance requirements of radio-relay systems for SDH-based networks".

[14] ITU-R Recommendation F.1191-1: "Bandwidths and unwanted emission of DRRS".

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

[16] ITU-T Recommendation G.821 (1996): "Error performance of an international digital connection forming part of an integrated services digital network".

[17] ITU-T Recommendation G.826 (1999): "Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate".

[18] ETS 300 385: "Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) standard for digital fixed radio links and ancillary equipment with data rates at around 2 Mbit/s and above".

[19] EN 300 385 V.1.2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for fixed radio links and ancillary equipment".

[20] ITU-T Recommendation V.11: "Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s".

[21] ITU-T Recommendation V.24: "List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)".

[22] ITU-T Recommendation V.28: "Electrical characteristics for unbalanced double-current interchange circuits".

[23] EN 300 339: "Electromagnetic compatibility and Radio spectrum Matters (ERM); General ElectroMagnetic Compatibility (EMC) for radio communications equipment".

[24] ETS 300 233: "Integrated Services Digital Network (ISDN); Access digital section for ISDN primary rate".

[25] EN 300 631: "Fixed Radio Systems; Point-to-Point Antennas; Antennas for Point-to-Point fixed radio systems in the 1 GHz to 3 GHz band".

[26] ETS 300 833: "Fixed Radio Systems; Point to Point Antennas; Antennas for point-to-point fixed radio systems operating in the frequency band 3 GHz to 60 GHz".

[27] ETS 300 019: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment".

[28] ETS 300 132-1: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) derived from direct current (dc) sources".

[29] ETS 300 132-2: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc)".

[30] ETS 300 635: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH); Radio specific functional blocks for transmission of M x STM-N".

[31] ITU-T Recommendation G.784: "Synchronous digital hierarchy (SDH) management".

[32] ITU-T Recommendation G.773: "Protocol suites for Q-interfaces for management of transmission systems".

[33] EN 300 645: "Telecommunications Management Network (TMN); Synchronous Digital Hierarchy (SDH) radio relay equipment; Information model for use on Q interfaces".

[34] ITU-T Recommendation I.412 (1988): "ISDN user-network interfaces - Interface structures and access capabilities".

[35] ITU-T Recommendation G.704 (1998): "Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels".

[36] ITU-T Recommendation G.707 (1996): "Network node interface for the synchronous digital hierarchy (SDH)".

[37] IEC 60154-2: "Flanges for waveguides. Part 2: Relevant specifications for flanges for ordinary rectangular waveguides".

[38] ITU-T Recommendation G.783 (1997): "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".

[39] ITU-T Recommendation G.957 (1999): "Optical interfaces for equipments and systems relating to the synchronous digital hierarchy".

[40] ITU-T Recommendation O.151 (1992): "Error performance measuring equipment operating at the primary rate and above".

[41] EN 301 390: "Fixed Radio Systems; Point-to-point and Point-to-Multipoint Systems; Spurious emissions and receiver immunity at equipment/antenna port of Digital Fixed Radio Systems".

[42] TR 101 127: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Synchronous Digital Hierarchy (SDH); High capacity DRRS carrying SDH signals (1 x STM-1) in frequency bands with about 30 MHz channel spacing and using Co-Channel Dual Polarized (CCDP) operation".

[43] EN 301 126-1: "Fixed Radio Systems; Conformance testing; Part 1: Point-to-Point equipment - Definitions, general requirements and test procedures".

[44] ITU-R Recommendation SM.329-7: "Spurious emissions".

[45] CEPT/ERC Recommendation 74-01: "Spurious Emissions".

[46] TR 101 035 "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH) aspects regarding Digital Radio Relay Systems (DRRS)".

[48] ITU-T Recommendation O.181: "Equipment to assess error performance on STM-N interfaces".

[49] ERC/DEC (97)10 (30th June 1997) on the mutual recognition of conformity assessment procedures including marking of radio equipment and radio terminal equipment.

[50] 5/99/EC "Radio Equipment and Telecommunications Terminal Equipment and the mutual recognition of their conformity".

[51] 89/336/EEC "Electromagnetic Compatibilty Directive".

3 Symbols and abbreviations

3.1 Symbols

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

dB	decibel
dBc	decibel relative to mean carrier power
dBi	decibel relative to isotropic radiator
dBm	decibel relative to 1 mW
Fc	cut-off frequency
GHz	GigaHertz

kbit/s	kilobits per second
kHz	kiloHertz
km	kilometre
Mbit/s	Megabits per second
MHz	MegaHertz
mW	milliWatt
ns	nanosecond
ppm	parts per million

3.2 Abbreviations

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

AGC	Automic Gain Control
ATPC	Automatic Transmit Power Control
BB	Base Band
BBER	Background Block/Bit Error Ratio
BER	Bit Error Rate
BWe	Evaluation bandwidth
C/I	Carrier to Interence ratio
CW	Continuous Wave
DC	Direct Current
DRRS	Digital Radio Relay System
EB	Errored Blocks
EIRP	Equivalent Isotropically Radiated Power
ES	Errored Seconds
FDMA	Frequency Division Multiple Access
FRS	Fixed Radio System
FSK	Frequency-Shift Keying
IF	Intermediate Frequency
IM	Intermodulation
IPI	Inter Port Isolation
LO	Local Oscillator
MSK	Minimum Shift Keying
NFD	Net Filter Discrimination
PDH	Plesiochronous Digital Hierarchy
PRBS	Pseudo Random Binary Sequence
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
RES	Radio Equipment and Systems
RF	Radio Frequency
RFC	Remote Frequency Control
RL	Return Loss
RSL	Receiver input Signal Level
RTPC	Remote Transmit Power Control
Rx	Receiver
SDH	Synchronous Digital Hierarchy
S/N	Signal to Noise ratio
SOH	Section OverHead
SW	Software
TFM	Tamed Frequency Modulation
TMN	Telecommunications Management Network
T_X	Transmitter
XIF	XPIC Improvement Factor
XPD	Cross-Polar Discrimination
XPIC	Cross-Polar Interference Canceller

4 General characteristics

4.1 Frequency bands and channel arrangements

4.1.1 Channel arrangement

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

The frequency range(s) is (are) *lower frequency* to *higher frequency* GHz. The channel arrangement shall be in accordance with *ITU-R; CEPT or other references [Reference to be made to clause 2].*

The description of relevant channel plan, channel spacing, alternated/co-channel arrangement, basic rasters (if any), reference frequency etc. is given in informative annex C.

4.1.2 Channel spacing for systems operating on the same route

System bit rates and their relevant *co-polar (or alternated or interleaved)* channel spacing in the present document are reported in table 1 (for the precise payload bit rates see subclause 5.1).

NOTE: According to system characteristics the equipment can be connected either to separate antennas or on separate polarization to the same antenna.

Table 1: Digital systems channel spacings for various bit rates

	Payload Bit Rate [Mbit/s]⇒	**2**	**2 × 2**	**8**	**2 × 8**	**34**	**51**	**140 and 155**
Channel Spacing [MHz]	Class x equipments	3,5	7	14		56		
	Class y equipments	3,5	3,5	7	14	28	56	112
	…………	……	……	…..	…..	……	…..	……
	Class z equipments			3,5	7	14	14/28	56

NOTE 1: n x 2 Mbit/s and n × 34 bit rates may be used where appropriate.
n × 2 Mbit/s mapped into SDH VC12 transport bit rates may be used where appropriate (e.g. three or four times VC12 into an 8 Mbit/s channel spacing).

NOTE 2: Other payloads equivalent in bit-rate are also considered.

For regulatory purpose it is required that each of the above options is uniquely identified by a relevant system type short reference. Normative annex *2* reported the categorization of these system types.

4.2 Compatibility requirements between systems

One or more of the following statements will be applicable:

a) there shall be no requirement to operate transmitting equipment from one manufacturer with receiving equipment from another;

b) there shall be a requirement to multiplex on the same dual polarized antenna *(channel nth and 1st excluded, if applicable)* all the radio channels foreseen by the *relevant ITU-R or CEPT Recommendation or other identified channel plan*;

NOTE: On a national customer basis it may be required to multiplex equipments from different manufacturer on the same branching/antenna of one polarization.
This will result in additional national customer requirement for branching mechanical arrangement, which will be verified in an acceptance test.

c) *there shall be (or there shall not be)* a requirement to multiplex different manufacturers equipment on the same polarization of the same antenna;

d) *there shall be (or there shall not be)* a requirement to multiplex different manufacturers equipment on different polarization of the same antenna;

e) depending on the application, it shall be possible to operate the system in vertical and/or horizontal polarization, if required by the channel arrangement;

f) in the case of multiple paths on parallel channels, it shall be possible to operate the system in *Alternate frequency (or co-channel or interleaved frequency reuse)* channel arrangement, as defined by ITU-R Recommendation F.746-4 [5].

4.3 Performance and availability requirements

Equipment shall be designed in order to meet network performance and availability requirements foreseen by ITU-T Recommendation(s) *G.821 [16] or/and G.826 [17]*, following the criteria defined in ITU-R Recommendations *F.634-4 [1], F.695 [2], F.696-1 [3], F.697-2 [4], F.1092-1 [10] and F.1189-1 [11] for high or medium or local grade or international or national portion* of the digital connection.

The implication of the link design on the performance is recognized and the general design criteria reported in ITU-R Recommendations F.752-1 [6], F.1093-1 [7], F.1101 [8], F.1102 [9] and F.1092-1 [10] are to be applied.

4.4 Environmental conditions

The equipment shall be required to meet the environmental conditions set out in ETS 300 019 [27] which defines weather protected and non-weather protected locations, classes and test severity.

The manufacturer shall state which class the equipment is designed to withstand.

4.4.1 Equipment within weather protected locations (indoor locations)

Equipment intended for operation within temperature controlled locations or partially temperature controlled locations shall meet the requirements of ETS 300 019 [27] classes 3.1 and 3.2 respectively.

Optionally, the more stringent requirements of ETS 300 019 [27] classes 3.3 (non-temperature controlled locations), 3.4 (sites with heat trap) and 3.5 (sheltered locations) may be applied.

4.4.2 Equipment for not-weather protected locations (outdoor locations)

Equipment intended for operation within non-weather protected locations shall meet the requirements of ETS 300 019 [27], class 4.1 or 4.1E.

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

4.5 Power supply

The power supply interface shall be in accordance with the characteristics of one or more of the secondary voltages foreseen in ETS 300 132-1 [28] and ETS 300 132-2 [29].

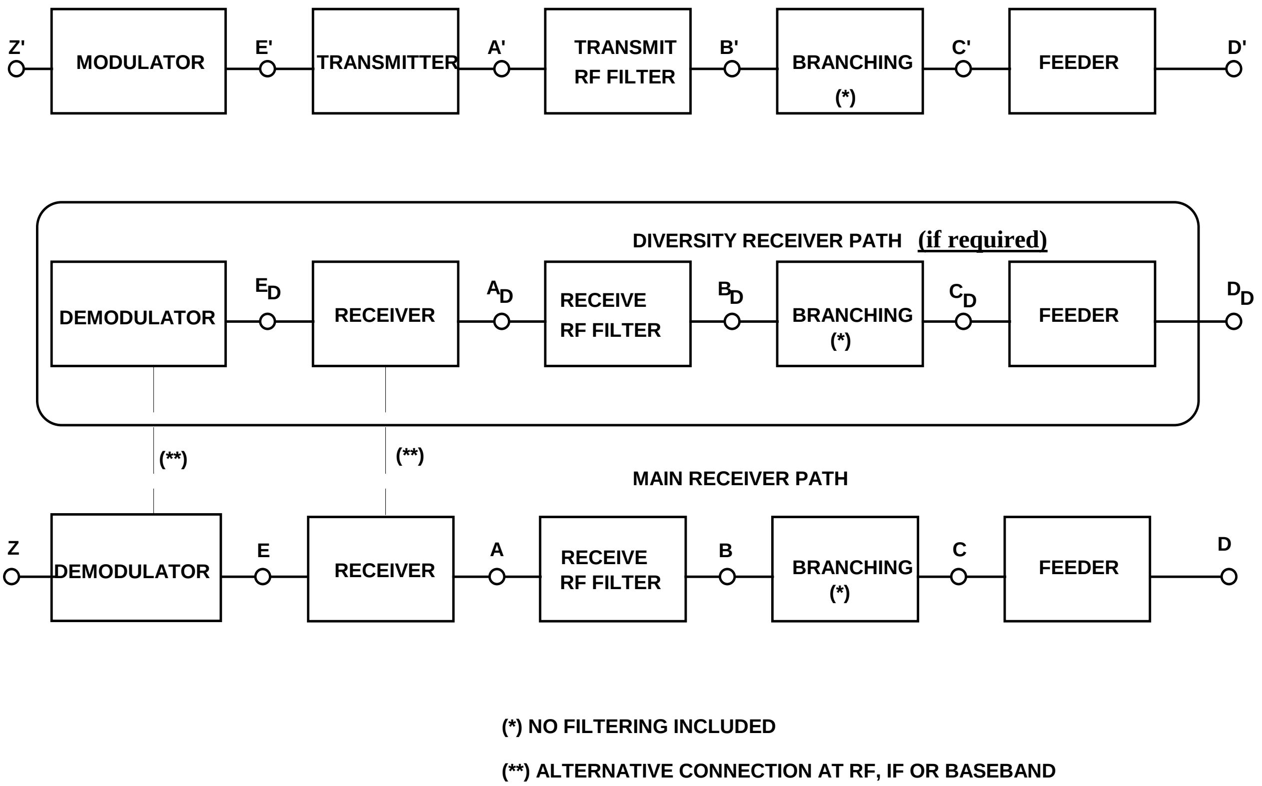
NOTE: Some applications may optionally require secondary voltages that are not covered by ETS 300 132.

For DC systems, the positive pole of the voltage supply will be earthed at the source.

4.6 Electromagnetic compatibility

The system shall operate under the conditions specified in ETS 300 385 [18].

4.7 System block diagram



NOTE 1: For the purpose of defining the measurement points, the branching network does not include a hybrid.
NOTE 2: The points shown above are reference points only; points C and C', D and D' in general coincide.
NOTE 3: *(to be included only if applicable)*
Points B and C, B' and C' may coincide when simple duplexer is used.

Figure 1: System block diagram

4.8 Telecommunications Management Network (TMN) interface

For Synchronous Digital Hierarchy (SDH) equipment ITU-T Recommendations G.784 [31] and G.773 [32] and ITU-R Recommendations F.750-3 [12] and F.751-2 [13] give the general requirements for TMN interface and functionality; EN 300 635 [30] and EN 300 645 [33] give the radio specific functional block description and the related radio fragment information model respectively.

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

4.9 Branching/feeder/antenna requirements

4.9.1 Antenna radiation patterns

See annex A.

4.9.2 Antenna Cross-Polar Discrimination (XPD)

See annex A.

4.9.3 Antenna Inter-Port Isolation (IPI)

See annex A.

4.9.4 Waveguide flanges (or other connectors)

When *flanges (or other connector types)* are required at reference point*(s) B, B', C, C'*, the following type shall be used according to IEC 60154-2 [37]:

UBR/PBR/CBR-XXX (or other connectors type), for the complete frequency range *lower limit* to *upper limit GHz* *(if applicable).*

NOTE: UBR/PBR/CBR YYY (or other connectors type) may be used for the lower part of the band lower limit to upper limit GHz. UBR/PBR/CBR ZZZ (or other connectors type) may be used for the higher part of the band lower limit to upper limit GHz.

4.9.5 Return loss (RL)

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

NOTE: On a national customer basis it may be required to multiplex equipment from different manufacturers on the same branching/antenna of one polarization.
This will result in additional national customer requirements for RL also at reference points B and B', which will be verified in an acceptance test.

When antenna is integral part of the equipment there shall be no requirement.

For feeder/antenna RL requirement see annex A.

4.9.6 Intermodulation products

When multi-channel branching system are planned, each intermodulation product caused by different transmitters linked to the same antenna shall be less than -*XXX* dBm referenced to reference point B with an output power per transmitter relevant to the one referred in subclause 5.3.1.

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

5 Parameters for digital systems

5.1 Transmission capacity

Payload bit rates(s) considered in the present document are: *2,048 Mbit/s, 2 × 2,048 Mbit/s, 8,448 Mbit/s, 2 × 8,448 Mbit/s, 34,386 Mbit/s, 51,840 Mbit/s (STM-0), 139,264 Mbit/s, 155,520 Mbit/s (STM-1), or other capacities. System rates configured as n × 2 Mbit/s and n-times 2 Mbit/s mapped into SDH VC12 transport bit rates (sub-STM-0 rates sSTM-1n) may be used where appropriate*.

In the following these capacities will be simply referred as 2 Mbit/s, 2 × 2 Mbit/s, 8 Mbit/s, 2 × 8 Mbit/s, nxVC12 (sSTM-1n) 34 Mbit/s, 51 Mbit/s (STM-0), 140 Mbit/s, and 155 Mbit/s (STM-1).

The above system capacity are reported as the most common digital data rates for classical PSTN transport networks; however systems used in access network may offer other internationally standardized data interface of equivalent bit-rate as required by the market growth.

5.2 Baseband parameters

One or more of the following subclauses will be applicable.

5.2.1 Plesiochronous interfaces

Plesiochronous interfaces at 2 Mbit/s, 8 Mbit/s, 34 Mbit/s and 140 Mbit/s shall comply with ITU-T Recommendation G.703 [15]. Parameters for service channels and wayside traffic channels are outside the scope of the present document.

5.2.2 ISDN interface (primary rate)

The transmission of 2 Mbit/s signals using the structure and functions of ISDN primary multiplex signals is to be in accordance with ITU-T Recommendations G.703 [15], G.704 [35], I.412 [34] and ETS 300 233 [24].

5.2.3 Other data channel baseband interface

One of the following sentence may be applicable:

- *the data interfaces should be in accordance to….(e.g. ITU-T Recommendations V.11 [20], V.24 [21] and V.28 [22]*);
- *the data interface offered by the equipment shall be declared by the supplier together with the relevant set of applicable international standards in agreement with the network operator*.

5.2.4 SDH baseband interface

The SDH baseband interface shall be in accordance with ITU-T Recommendations G.703 [15], G.707 [36], G.783 [38], G.784 [30] and G.957 [39] and ITU-R Recommendation F.750-3 [12].

Two STM-N interfaces are possible:

- STM-1 CMI electrical (ITU-T Recommendation G.703 [15]);
- STM-N optical (ITU-T Recommendation G.957 [39]).

The use of reserved bytes contained in the Section OverHead (SOH), and their termination shall be in accordance with ITU-R Recommendation F.750 [12]. Further details on the possible use of the SOH bytes reserved for future international standardization are given in TR 101 035 [46].

5.2.5 Analogue channel baseband interface

If applicable characteristic of analogue interfaces may be reported here.

5.3 Transmitter characteristics

The specified transmitter characteristics shall be met with the appropriate baseband signals applied at reference point Z' of figure 1. For Plesiochronous Digital Hierarchy (PDH) interfaces this shall be a Pseudo-Random Binary Sequence (PRBS) according ITU-T Recommendation O.151 [40]. For SDH interface a suitable test signal is to be defined.

5.3.1 Transmitter power range

Transmitter nominal output power at reference point *B' (for equipment with multichannel branching system) or C' (for equipment with simple duplexer)* of the system block diagram (figure 1) shall be in the range *+X to +Y dB*m.

Automatic Transmit Power Control (ATPC) is not to be considered, unless ATPC is considered a fixed feature and used on permanent base. The manufacturer will state, in the conformance test, the ATPC options and functionality.

Regulatory administrations may define sub-ranges within the above range as specified in table 2.

NOTE 2: The technological evolution may result in equipment falling outside of the range(s) foreseen in this clause. In this case the equipments of different output power sub-ranges are not considered to require individual type approval, however their use is subject to individual national agreements.

Table 2: Output power sub-ranges (including tolerance)

sub-range 1	> $x1_L$ dBm	< = $x1_H$ dBm
sub-range 2	> $x2_L$ dBm	< = $x2_H$ dBm
....	....	....
sub-range N	> xN_L dBm	> xN_H dBm

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

5.3.2 Transmit power and frequency control

5.3.2.1 Automatic Transmit Power Control (ATPC)

Equipment with ATPC will be subject to manufacturer declaration of ATPC ranges and related tolerances. Testing shall be carried out with output power level corresponding to:

- ATPC set manually to a fixed value for system performance (subclauses 5.5 and 5.6);
- ATPC set at maximum provided power for Tx performance (subclause 5.3).

(The following sentence may also be required, particularly in frequency bands where rain attenuation is dominant):

- not to impair ES performance, it is preferable that the threshold of ATPC intervention is designed to be in a RSL region where the BBER of subclause 5.5.2 is still met (see informative annex A).

5.3.2.2 Remote Transmit Power Control (RTPC)

RTPC is an optional feature. Equipment with RTPC will be subject to manufacturer declaration of RTPC ranges and related tolerances. Testing shall be carried out with output power level corresponding to:

- RTPC set manually to the maximum and to the minimum values for system performance (subclauses 5.5 and 5.6);
- RTPC set at maximum provided power for Tx performance (subclause 5.3);
- Radio Frequency (RF) spectrum mask shall be verified in three points (low, medium, high) of the RTPC power excursion. When these spectrum measurements are made, difficulties may be experienced. Actual measurements methods shall be addressed in further investigations and will be defined in the conformance testing standard, EN 301 126-1 [43].

5.3.2.3 Remote Frequency Control (RFC)

RFC is an optional feature. Equipment with RFC will be subject to manufacturer declaration of RFC ranges and related change frequency procedure. Testing shall be carried out including:

- RFC setting procedure at least for three frequencies (lower, centre and higher of the covered range);
- RFC setting procedure shall not produce emissions outside the previous and final frequency spectrum mask.

5.3.3 Transmitter output power tolerance

The tolerance of the nominal output power shall be within:

- nominal output power ± *2 or 3* dB: for systems operating within non-weather protected locations;
- nominal output power ± *1 or 2* dB: for systems operating within weather protected locations.

5.3.4 Transmitter local oscillator frequency arrangements

One or more of the following statements may be applicable:

- *when separate transmit and receiver Local Oscillators (LO) are used, the LO frequencies for both transmitters and receivers should be arranged so that for channels in the lower half of each go or return sub-band the frequency is higher than the channel assigned frequency, and for channels in the upper half of each go or return sub-band the LO frequency is lower than the channel assigned frequency*;
- *whenever a single LO is used for both transmitter and receiver the LO frequency shall be arranged between or above or below the corresponding transmit and receive frequencies*;
- *there shall be no requirement on transmitter LO frequency arrangement*.

5.3.5 Radio Frequency (RF) spectrum mask

The spectrum masks are shown in figure 2, both for the normal channels on the same branching networks (curves a, b) and for the inner side of innermost channels on the same branching networks (curves c, d). *If applicable the following statement may apply too. Curves a and c apply only to single RF channel systems (partially outdoor) systems*.

NOTE 1: Equipment for innermost channels are not considered to require individual type approval testing provided that the manufacturer supplies evidence of the design data of the adopted filters to match the requirement of subclauses 5.3.5. and 5.4.5.

The 0 dB level shown on the spectrum masks relates to the spectral power density of the nominal centre frequency disregarding residual carrier.

Masks shall be measured with a modulating base-band signal given by a PRBS *signal given in ITU-T Recommendation O.151 [40]* in the case of PDH signal *or in ITU-T Recommendation O.181 [48] for STM-N signal*.

The masks do not include frequency tolerance.

The masks given in figure 2 fix lower limits of Ax dB and Ac dB respectively in order to control local interference between transmitters and receivers on different or same polarization respectively.

Due to limitations of some spectrum analysers, difficulties may be experienced when testing high capacity/wideband systems. In this event, the following options are to be considered: measurement using high performance spectrum analyser; use of notch filter; two step measurement technique. When difficulties are experienced, the plots of one test may be produced as evidence of conformance to the spectrum mask.

Table 3 shows the recommended spectrum analyser settings.

Table 3: Spectrum analyser settings for RF power spectrum measurement

Channel separation [CS]	**MHz**	### ...		**0,003 < CS ≤ 0,03**	**0,03 < CS ≤ 0,3**	**0,3 < CS ≤ 0,9**	**0,9 < CS ≤ 12**	**12 < CS ≤ 36**	**36 < CS**		**≤...**
Centre frequency		f_o		f_o	f_o	f_o	f_o	f_o	f_o		f_o
Sweep width	**MHz**	...		0,5	2	5	20	50	200		...
Scan time		auto		auto	auto	auto	auto	auto	auto		auto
IF bandwidth	**kHz**	...		1	3	10	30	100	300		...
Video bandwidth	**kHz**	...		0,03	0,1	0,1	0,3	0,3	0,3		...

Frequency from nominal channel or actual transmitter centre frequency [MHz]

NOTE 1: a) Normal channel spectrum with nearest local receiver on cross polarization.
b) Normal channel spectrum with nearest local receiver on co-polarization.
c) Inner side of innermost channel with nearest local receiver on cross polarization.
d) Inner side of innermost channel with nearest local receiver on co-polarization.
e) Limit of direct measurement at reference point B' or C'.

NOTE 2: The minimum level e) in the mask(s) of figure 2 is indicative of the available sensitivity on most common spectrum analysers; this limit may be improved if better instruments become available on the market. In this case the manufacturer may state a new measurement limit (which result in a relaxation on filter requirement) provided that, if necessary, he will supply the instrument for the type approval test.

① Frequency zone of nearest local receiver on cross polarization.

② Frequency zone of nearest local receiver on co-polarization.

③ *Frequency zone where standard channels mask has to be defined according to interference requirements*.

Figure 2: Limits of spectral power density

If necessary for ENs dealing with multiple bit rates/channel spacing the following statement and table will apply.

Reference frequencies f 1 to f N are reported in table 4 for the bit rate and channel spacing foreseen:

Table 4: Spectrum mask frequency limits

Spectrum efficiency class	Bit Rate	Channel Spacing	f_1	f_2	f_3	....	....	f_{N-1}	f_N
	....	....	....	....	....	....	....	....	....
	....	....	....	....	....	....	....	....	....
	....	....	....	....	....	....	....	....	....

For EN drafting f_N shall be *equal to or higher than* 250 % of relevant channel spacing, depending on whether the internal system operation or same antenna operation compatibility *does not require or requires* spectrum limitation above this limit.

5.3.6 Discrete CW components inside ±250 % of the channel spacing

The emission includes in this range only the fundamental and out of band emissions. All emissions shall be in accordance with the spectrum mask however it is possible that there may be discrete CW spectral components which are seen to exceed the limits of the spectrum mask when performing the transmitter tests.

5.3.6.1 Discrete CW components at the symbol rate

The power level (reference point B') of spectral lines at a distance from the channel centre frequency equal to the symbol rate shall be less than -x dBm *or x dB below the average power level of the carrier*.

5.3.6.2 Other discrete CW components exceeding the spectrum mask limit

At the same reference point where spectrum mask is defined, the overall mean power level of these CW components, integrated over a band between 50 % and 150 % of the channel separation, shall be *X* dB below the mean power level of the carrier.

The overall mean power level of these CW components integrated over a band between 150 % and 250 % of the channel separation shall be *Y* dB below the mean power level of the carrier.

5.3.7 Spurious emissions

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

a) to limit interference into other systems operating wholly externally to the system under consideration (external emissions), which limits are referred by CEPT/ERC Recommendation 74-01 [45] based on ITU-R Recommendations SM.329-7 [44], and ITU-R Recommendation F.1191-1 [14];

b) to limit local interference within the system where transmitters and receivers are directly connected via the filter and branching systems (internal emissions).

This leads to two sets of spurious emission limits at reference point *B'* (*for systems with multichannel branching operation) or C' (for all other cases). (Note that "internal" limits are required not to be more relaxed than the "external" ones).*

5.3.7.1 Spurious emissions - external

According to CEPT/ERC Recommendation 74-01 [45] the external spurious emissions are defined as emissions at frequencies which are removed from the nominal carrier frequency more than ± 250 % of the relevant channel separation.

Outside the band of ± 250 % of the relevant channel separation, the Fixed Service radio systems spurious emission limits, defined by CEPT/ERC Recommendation 74-01 [45] together with the frequency range to consider for conformance measurement, shall apply.

5.3.7.2 Spurious emissions - internal

One or both of the two following sentences groups (A or B) may be applicable:

- *Group A) When equipment of different manufacturer are intended to share the same antenna*.

Being the requirement to multiplex equipment from different manufacturers *on the same branching system or on different polarization of the same antenna*, the levels of the spurious emissions from the transmitter, referenced to reference point C' are specified in table 5 below.

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

Table 5: Internal levels for the transmitter spurious emissions

Spurious Emission Frequency Relative to Channel Assigned Frequency	Specification Limit	Controlling Factor for requirement application
The average level of all spurious signals both discrete/CW and noise-like (including L.O., +/- IF, +/- 2 x IF), evaluated as total average signal level	≤ -XX dBm	If spurious signal's frequency falls within receiver half band, for digital systems with compatibility requirement as in subclause 4.2 x)
	≤ -YY dBm	If spurious signal's frequency falls within receiver half band, for digital systems with compatibility requirement as in subclause 4.2 y)

- Group B) When equipment of different manufacturer are not intended to share the same antenna.

Being no requirement to multiplex equipment from different manufacturers on the same branching system or on different polarization of the same antenna, no specific limits for interworking purpose are standardized.

5.3.8 Radio frequency tolerance

Maximum radio frequency tolerance shall not exceed +X ppm. This limit includes both short-term factors (environmental effects) and long-term ageing effects.

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

5.4 Receiver characteristics

5.4.1 Input level range

One or more of the following statement, for any relevant 10^{-x} BER threshold required, will be applicable:

the input level range for a *BER < 10^{-x}* shall extend from the upper limit of *- XX dBm* to the limit specified for *BER = 10^{-x}* in subclause 5.5.1.

5.4.2 Rx Local Oscillator (LO) frequency arrangements

One or more of the following statements may be applicable:

- *the receiver's LO frequencies shall be selected in order to avoid the possibility of local transmitters falling at the image frequency of the receivers;*
- *when separate transmit and receiver local oscillators are used, the LO frequencies for receivers should be the same of the corresponding transmitters;*
- *whenever a single LO is used for both transmitter and receiver the LO frequency shall be arranged between or above or below the corresponding transmit and receive frequencies;*
- *there shall be no requirement on receiver LO frequency arrangement.*

5.4.3 Spurious emissions

See subclause 5.3.7.

5.4.3.1 Spurious emissions - external

At reference point C, the limit values *of CEPT/ERC Recommendation 74-01 [45]* shall apply.

5.4.3.2 Spurious emissions - internal

When equipments are foreseen to share the same antenna the following sentences may be applicable:

- spurious emissions which fall within receivers half band shall be < *-XX dBm* (referenced to reference point B) for digital systems with multi-channel branching networks and < *-YY dBm* (referenced to reference point C) for digital systems without branching networks (i.e. with duplexer);
- the required level will be the total average level integrated over the bandwidth of the emission under consideration.

5.4.4 Receiver image rejection

If applicable, the receiver image(s) rejection shall be *≥ XX dB*.

Also the following statement may be applicable:

- *the receiver rejection at image(s) frequency(ies) which fall(s) within the transmitter half band shall be ≥ Y dB*.

5.4.5 Innermost channel receiver selectivity

To guarantee innermost T_X/R_X channel compatibility (as specified in subclause 5.5.1) the inner side of the innermost receiver shall be within the mask given in figure 3.

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

Figure as Required

Figure 3: Overall minimum receiver selectivity of the inner side of innermost receiver

5.5 System performance without diversity

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

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

5.5.1 BER as a function of receiver input signal level RSL

Receiver BER (Bit or Block Error Rate) thresholds (dBm) referred to reference point C (for systems with simple duplexer) or B (for system with multi-channel branching system) of the system block diagram (figure 1) for BER of 10^{-x}, 10^{-y} and 10^{-z} shall be equal to or lower than those stated in table 6 (these levels do not include any hybrid loss).

One of the following statement may also be applicable:

- *when innermost T_X/R_X channel local interference is present, the allowed threshold degradation on the values stated in table 6 are X' dB at 10-x, Y' dB at 10-y and Z' dB at 10-z when an additional decoupling ≥ D dB is introduced simulating an achievable antenna IPI and feeder losses (or, if applicable, antenna circulator decoupling);*

NOTE: Equipment for innermost channel are not considered to require individual type approval testing provided that the manufacturer shall supply evidence of the design data of the adopted filters to match the requirement of subclauses 5.3.5. and 5.4.5.

- *the threshold values stated in table 6 shall be met even when innermost T_X/R_X channel local interference is present, with an additional decoupling ≥ D dB is introduced simulating an achievable antenna IPI and feeder losses (or, if applicable, antenna circulator decoupling); nevertheless an actual thresholds degradation on actual BER performances may be present.*

Table 6: BER performance thresholds

	RSL @ BER ➔	RSL @ 10^{-x}	RSL @ 10^{-y}	RSL @ 10^{-y}
Bit rate (Mbit/s) 🡓	Channel spacing (MHz)🡓			

5.5.2 Equipment Background BER (BBER)

The equipment BBER level under simulated operating conditions without interference is measured with a signal level at reference point B (or C) which is 10 dB above the level which gives BER = 10^{-6} (as specified in subclause 5.5.1):

- *for systems of less than 196 kbit/s: BBER < under study;*
- *for systems less than 2 Mbit/s: BBER < under study;*
- *for systems less than 34 Mbit/s: BBER < under study;*
- *for systems of 34 Mbit/s and above: BBER < under study;*
- *all measurements are made at the payload bit rate defined in subclause 5.1.*

NOTE 1: Equipment which may supply different payload bit rates on the same aggregate transport rate are not required to perform individual BBER type approval for every possible payload port, the manufacturer will present one for type approval and make conformance declaration for the others.

Table 7 gives the minimum recording time and the maximum numbers of errors that shall not be exceeded:

NOTE 2: When FEC is implemented, its activity may be recorded and BBER estimated, on a lower time base, by a law, stated by the manufacturer, which effectiveness may be verified, at suitable higher BER points, by the body which performs the test.

Table 7: Allowed number of errors in a 24 hours background BER test

Bit rate	Channel spacing	Minimum recording time	Maximum errors number
....	....		....
....	....		....
....	....		....

5.5.3 Interference sensitivity

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

5.5.3.1 Co-channel *"external"* interference sensitivity

In the case of systems with XPIC the following specification applies to "external" interferers from similar systems but from a different route (nodal interferer).

The limits of co-channel interference shall be as in table 8, giving maximum C/I values for 1 dB and 3 dB degradation of the 10^{-6} and 10^{-3} BER limits specified in subclause 5.5.1.

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

Table 8: Co-channel "external" interference sensitivity

co-channel "external" interference		RSL @ BER →	RSL @ 10^{-3}		RSL @ 10^{-6}	
		degradation →	1 dB	3 dB	1 dB	3 dB
Spectrum efficiency class ↓	Bit rate (Mbit/s) ↓	Channel spacing (MHz) ↓				
1						
2						
……						

5.5.3.2 Co-channel "internal" interference sensitivity

a) In flat fading conditions

The following specification applies to systems with XPIC only; the "internal interference" is considered that given by the twin system sharing the same XPIC system.

The limits of the co-channel "internal" interference sensitivity shall be as in table 9. Values of XIF used for curves in these figures have been derived from subclause 1.3 of TR 101 127 [42].

Table 9: Co-channel "internal" interference sensitivity

co-channel "internal" interference		RSL @ BER →	RSL @ 10^{-3}		RSL @ 10^{-6}	
		degradation →	1 dB	3 dB	1 dB	3 dB
Spectrum efficiency class ↓	Bit rate (Mbit/s) ↓	Channel spacing (MHz) ↓				
1						
2						
……						

b) In dispersive fading conditions

The subject is still under study. A preliminary procedure for evaluating XPIC performance in this conditions is given in subclause 1.3 of TR 101 127 [42].

5.5.3.3 Adjacent channel interference

The limits of adjacent channel interference shall be as given in *table(s) 10.1 to 10.n* for like modulated signals spaced of *1 to n channel spacing respectively*, giving maximum C/I values for 1 dB and 3 dB degradation of the 10^{-6} and 10^{-3} BER limits specified in subclause 5.5.1.

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

Table 10.1: 1st adjacent channel interference sensitivity

1st adjacent channel interference		RSL @ BER →	RSL @ 10^{-3}		RSL @ 10^{-6}	
		degradation →	1 dB	3 dB	1 dB	3 dB
Spectrum efficiency class ↓	Bit rate (Mbit/s) ↓	Channel spacing (MHz) ↓				
1						
2						
[……]						

Table 10.n: nth adjacent channel interference sensitivity

nth adjacent channel interference		RSL @ BER →	RSL @ 10^{-3}		RSL @ 10^{-6}	
		degradation →	1 dB	3 dB	1 dB	3 dB
Spectrum efficiency class ↓	Bit rate (Mbit/s) ↓	Channel spacing (MHz) ↓				
1						
2						
……						

5.5.3.4 CW spurious interference

For a receiver operating at the RSL specified in subclause 5.5.1. for 10^{-6} BER threshold, the introduction of a CW interferer at a level of *+XX dB*, with respect to the wanted signal and at any frequency up to 60 GHz, excluding frequencies either side of the wanted frequency by up to twice the relevant co-polar channel spacing, shall not result in a BER greater than 10^{-5}.

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

5.5.3.5 Front-end non-linearity requirements (two-tone CW spurious interference)

For a receiver operating at the RSL specified in subclause 5.5.1 for 10^{-6} BER threshold, the introduction of two equal CW interferes each with a level of *+YY dB*, with respect to the wanted signal and located at the 2nd and 4th adjacent channel in the receive halfband, shall not result in a BER greater than 10^{-5}.

5.5.4 Distortion sensitivity

One of the following three statements will be applicable, depending on the frequency band and/or the system baud-rate and distortion sensitivity:

1) *for a delay of 6,3 ns and a BER of 10^{-3} the width of the signature shall not exceed ±XX MHz relative to the channel assigned frequency and the depth shall not be less than XX dB:*

   - *for a delay of 6,3 ns and a BER of 10^{-6} the width of the signature shall not exceed ±XX MHz relative to the channel assigned frequency and the depth shall not be less than XX dB;*

   - *these limits are valid for both minimum and non-minimum phase cases;*

   - *the limits specified for BER = 10^{-3} shall also be verified by the loss of synchronization and re-acquisition signatures.*

2) *Rainfall is the main propagation factor in the 18 GHz band limiting performance. Powerful equalizers to compensate propagation distortion are not considered necessary for 18 GHz equipment. The specifications for distortion sensitivity are given below in the form of signatures:*

   - *for two path propagation with a delay of 6,3 ns and a BER of 10-3 the width of the signature shall not exceed ±XX MHz relative to the assigned channel centre frequency, the depth shall not be less than X dB;*

   - *for two path propagation with a delay of 6,3 ns and a BER of 10-6 the width of the signature shall not exceed ±XX MHz relative to the assigned channel centre frequency, the depth shall not be less than X dB;*

   - *these limits are both valid for minimum and non-minimum phase cases. They shall also be verified by the loss-of-synchronization and re-acquisition signatures.*

3) *Outage from multipath phenomena is not considered relevant for the systems subject to the present document.*

5.6 System characteristics with diversity

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

5.6.1 Differential delay compensation

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

5.6.2 BER performance

When both receiver inputs (main and diversity, reference point B and BD) are fed with the same signal level at an arbitrary phase difference, input level limits for specified BER values of subclause 5.5.1 shall be lower than those given under subclause 5.5 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.

5.6.3 Interference sensitivity

[Under study]

5.6.4 Distortion sensitivity

[Under study]

Annex A (normative): Essential requirements for the EMC Directive

NOTE: (For Rapporteurs) This normative annex is required when the EN is foreseen for being harmonized under the EMC Directive (for formal mutual acceptance of conformance assessment).

The clauses of the present document: reported in table 1.1, are relevant for the EC Council Directive 89/336 [51].

Table 1.1: Subclauses of the present document relevant for compliance with the essential requirements of the EC Council Directive 89/336 [51]

Clause/subclause number, or annex reference	Title	Corresponding article of Council Directive 89/336/EEC	Qualifying remarks
	Spurious emission tests		
5.3.7.1	Transmitter Spurious emissions	4(a)	
5.4.3.1	Receiver Spurious emissions	4(a)	
	Receiver Immunity tests		
5.5.3.4	CW spurious interference	4(b)	

Annex B (normative): System type codes for regulatory procedures

NOTE: *(For Rapporteurs) This normative annex is required for simpler licensing procedures.*

System types reported in the present document shall be identified with the codes reported in table B.1.

Table B.1: System type codes for radio equipments reported in EN 300 431(EXAMPLE), relevant to regulatory procedures for national licensing

Spectrum efficiency class ↓	System grade ↓	Channel spacing [MHz] ↓	Bit-rate [Mbit/s] ↓	Frequency band (Note 2) ↓	System type codes (Note 3) ↓
1	A	3,5	2	B1	01
				B2	02
2	A	3,5	2x2	B1	03
				B2	04
		7	8	B1	05
				B2	06
		14	2x8	B1	07
				B2	08
		28	34	B1	09
				B2	10
	B	3,5	2	B1	11
				B2	12
		3,5	2x2	B1	13
				B2	14
		7	8	B1	15
				B2	16
		14	2x8	B1	17
				B2	18
		28	34	B1	19
				B2	20
		56	51	B1	21
				B2	22
3	not applicable	28	51	B1	25
				B2	26
4	not applicable	3,5	8	B1	27
				B2	28
		7	2x8	B1	29
				B2	30
		14	34	B1	31
				B2	32
		14	51	B1	33
				B2	34
		28	TBD	B1	35
				B2	36
		56	140 or 155	B1	37
				B2	38
5a	not applicable	28	140 or 155	B1	39
				B2	40
Spectrum efficiency class ↓	**System grade ↓**	**Channel spacing [MHz] ↓**	**Bit-rate [Mbit/s] ↓**	**Frequency band (Note 2) ↓**	**System type codes (Note 3) ↓**
5b	not applicable	28	140 or 155	B1	41
				B2	42

NOTE 1: n.a. not applicable.

NOTE 2: Option B1 refers to systems operating in frequency band 24 500 MHz to 26 500 MHz (ERC Recommendation. T/R 13-02 [1] annex B.
Option B2 refers to systems operating in frequency band 27 500 MHz to 29 500 MHz (ERC Recommendation. T/R 13-02 [1] annex C.

NOTE 3: The codes in the table are consistent with the preliminary ERC Decision on EN 300 431 (EXAMPLE) (codes 23 and 24 are not longer used due to the deletion of Grade A systems for 112 MHz channels).
Systems of spectrum efficiency class 1 were classified as class 2 in previous EN 300 431 (EXAMPLE); similarly systems for channel spacing 56 MHz of spectrum efficiency class 4 were previously classified as class 3. This is due only to rationalization of the definitions of classes but do not imply any change in systems specifications.

Annex C (informative): Additional Information

C.1 Radio Frequency (RF) channel arrangement

The relevant radio frequency channel arrangement is provided by (*related ITU-R, CEPT or other body recommendation)*; however, for readers convenience, figure C.1 gives its general overview.

The centre gap is *actual value or other reference to the basic raster relationship (e.g. taken as a multiple of the basic raster of 3,5 MHz)*.

The innermost channels are *actual value of the spacing if relevant for particular selectivity or other reference MHz* spaced.

The transmitter receiver duplex frequency separation is *value or any other motivated duplex frequency separation definition.*

Figure as Required

Figure C.1: Radio frequency channel arrangement

C.2 Antenna requirements

C.2.1 Antenna radiation patterns

For equipment on which the antenna forms an integral part, the radiation pattern should be in accordance with *EN 300 631 [25] or ETS 300 833 [26]*.

C.2.2 Antenna cross-Polar Discrimination (XPD)

For equipment on which the antenna forms an integral part, the antenna XPD should be in accordance with *EN 300 631 [25] or ETS 300 833 [26]*.

C.2.3 Antenna Inter-Port Isolation (IPI)

Compatibility criteria *(reported in subclause 5.5.1 if applicable)* of innermost cross-polarized TX and RX equipment will be guaranteed with an IPI of *"X" dB plus twice a feeder loss of "Y" dB*.

C.2.4 Feeder/antenna return loss

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

For partially outdoor systems the antenna return loss should be considered not less than 20 dB. The measurement shall be referred to reference point C/C' towards the antenna.

C.3 Automatic Transmit Power Control (ATPC)

Automatic Transmit Power Control (ATPC) may be useful in some circumstances, for example:

- to reduce interference between neighbouring systems or adjacent channels of the same system;
- to improve compatibility with analogue and digital systems at nodal stations;
- to improve residual BER or BBER performance;
- to reduce upfading 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 as a countermeasure against rainfall attenuation;
- in frequency bands where multipath is dominant propagation factor, to improve adjacent channel protection to differential fading conditions caused, by operation of adjacent channels on different antennas on parallel route (e.g. operated by different operators).

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

ATPC may also be used to increase the output power above the nominal level up to the maximum level specified by the manufacturer, with the agreement of administrations and operators, during fading conditions. This can be useful because in frequency ranges above 13 GHz the main limiting factors are given by non selective fading events.

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

In some systems ATPC may be employed as a fixed feature in order to reach a higher nominal system gain; when ATPC is a fixed feature the ATPC range is defined as the power interval from the maximum (including tolerances) output power level to the lowest transmitter output power level (at reference point B') with ATPC; when it is optional two ranges may be defined, a "down-range" from the nominal level to the minimum (including tolerances) and an "up-range" from the nominal level to the maximum (including tolerances). Therefore, in such systems, when ATPC is disabled, the nominal output power for stable operation is lower than the maximum in dynamic operation with ATPC enabled.

To avoid reduction in the practical ATPC range, the minimum power level should not be less than 5 dBm.

The use of the ATPC may increase the percentage of time in which the system operates at low receiver signal level; it may be preferable 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 an higher percentage of time, an increase of errored blocks (EB) or background block error ratio (BBER) objectives is avoided with respect to a system without ATPC function.

C.4 Co-channel and adjacent channel interference

The reference performances for co-channel and adjacent channel *spaced by one or more channel spacing* C/I are shown in figures C.1.a, C.2.1*, C.2.2......C.2.n*.

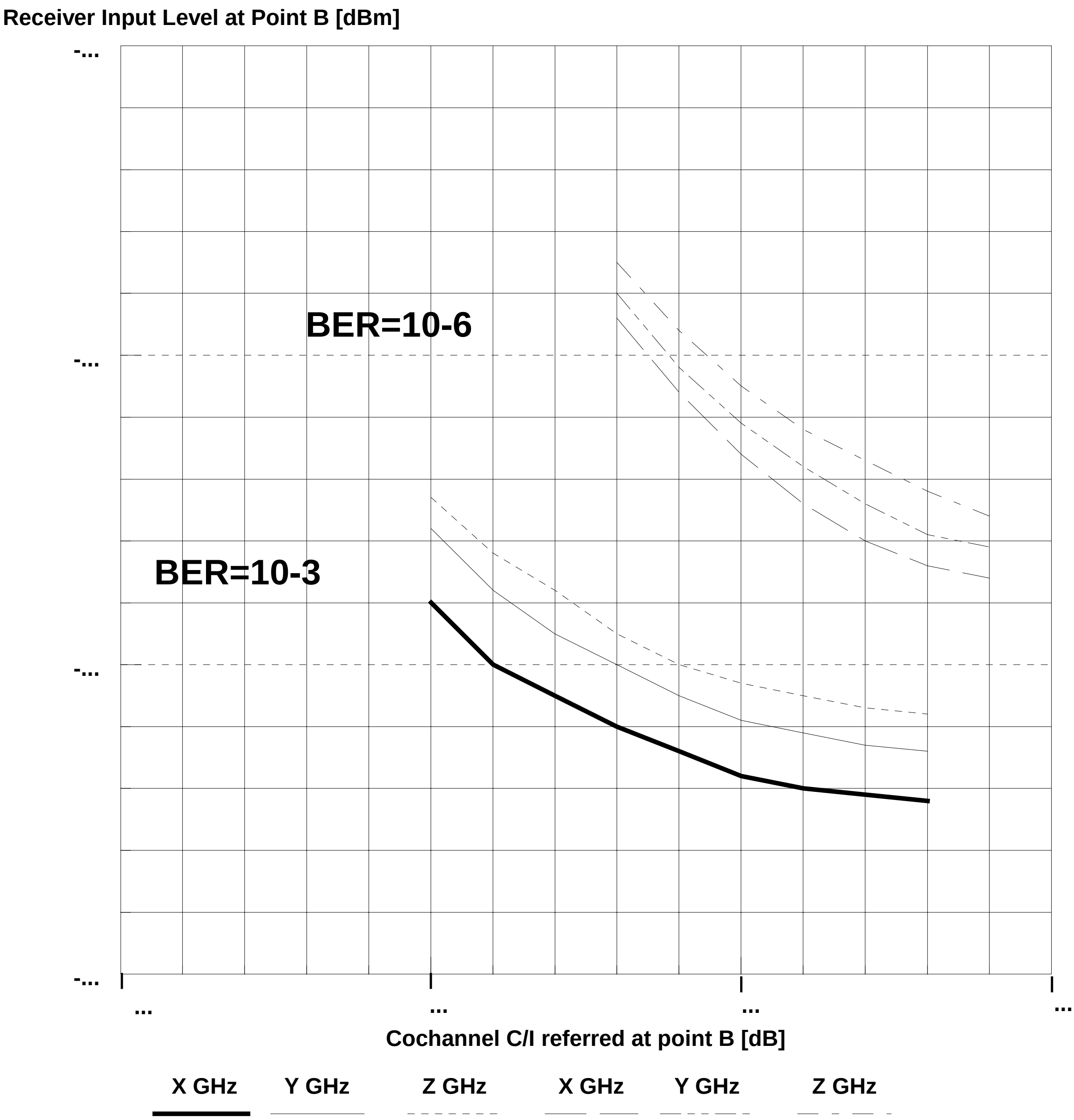


Figure C.1a: Co-channel interference threshold degradation

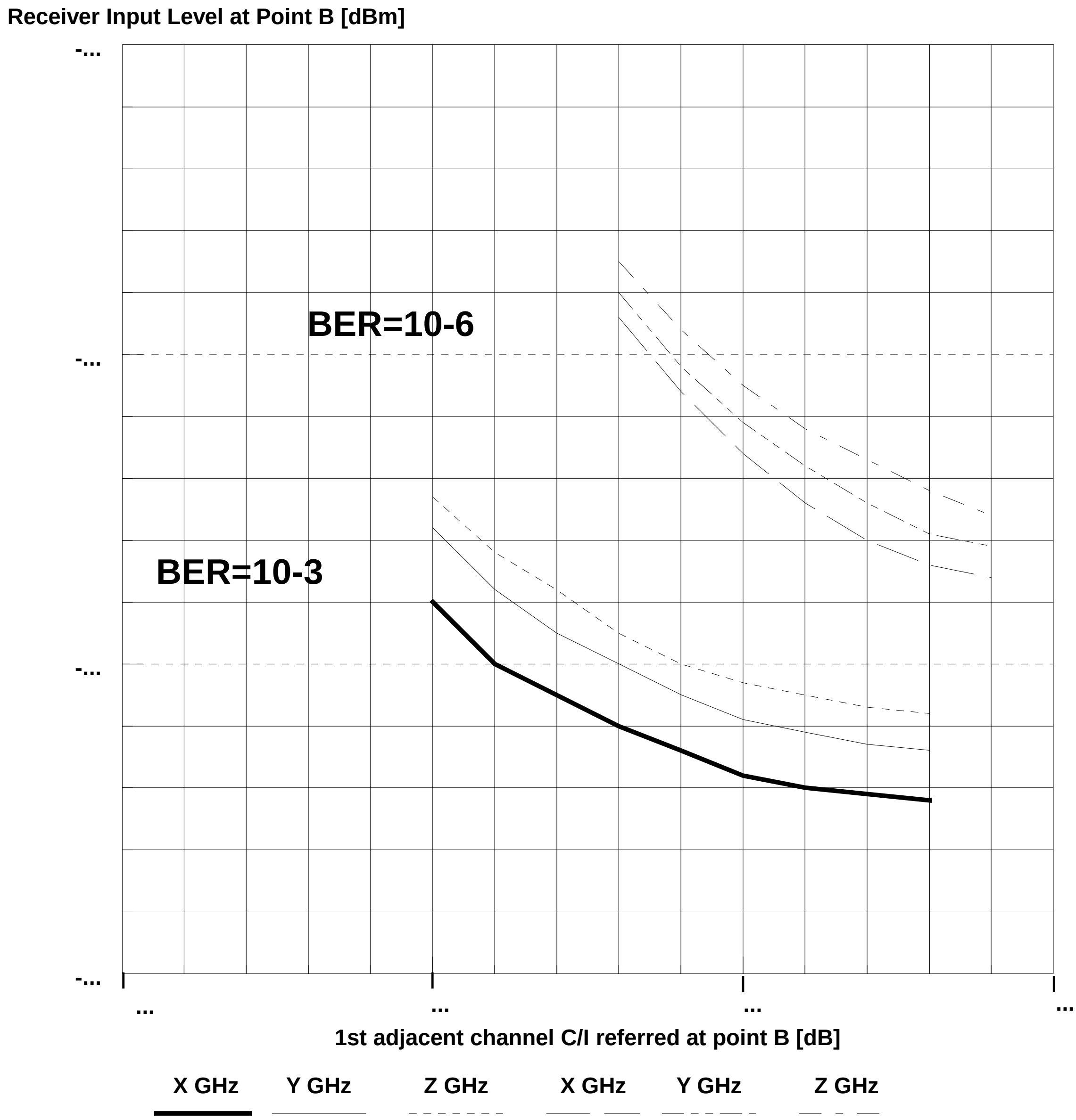


Figure C.2.1: 1st adjacent channel interference threshold degradation

Figure as required

Figure C.2.2: 2nd adjacent channel interference threshold degradation

Figure as required

Figure C.2.n: Nth adjacent channel interference threshold degradation

Appendix B: Background for the standardized items and for the normative and informative annexes

B.1 Scope

This clause contains a brief description of the equipment type, its use within the network, specific requirements and any other information useful to identify the commercial and technical environment in which it will be used. This clause will be used by ETSI as a database and document sales reference, so it should be short, concise, and aimed at those who may be unfamiliar with FRS/DRRS or radio systems in general.

In the scope should be placed all the reference to those side standardization area which are relevant to the system operation, while not specifically related to the equipment parameters reported in the standard itself.

These arguments may be summarized as:

- antennas parameters: antenna parameters are considered essential for a correct and efficient spectrum management. WG TM4 decided not to include antenna parameters in each equipment standard but to produce a set of specific standards covering all the relevant parameters for P-P and P-MP antennas in every relevant frequency band. Reference to the required antenna standard is therefore required;

- conformance testing procedures: even if not mandatory, testing procedures are extremely helpful for mutual recognition of type tests under the procedures set by ERC Decision (97)/10 [49] and in future for a common base for presumption of conformity and market survey under the scope of the R&TTE EC Directive [50]. WG TM4 decided not to include conformance testing procedures in each equipment standard but to produce a set of specific standards covering the testing procedures and characterization of parameters from the regulatory point of view for P-P and P-MP equipment and antennas. Reference to the required standard is therefore required;

- spectrum efficiency classes: standards for fixed radio systems are usually structured as multiple system types (for different capacity and spectrum efficiency in the various options of channel separation provided by CEPT channel arrangements). Therefore the proposed 5 classes are used to identified the spectrum efficiency options for regulatory purpose only. This should not be considered compulsory for the actual modulation format used. The class number should be maintained constant even if some are not foreseen for the standard under development;

- safety aspects: safety requirement for equipment shall be explicitly excluded by any EN; however safety is required for compliance to the presumption of conformity to harmonized standards under the scope of EC R&TTE Directive [50]. Therefore reference to the applicable CENELEC standard(s) is to be made;

- generic Wording technical background: WG TM4 produced and maintain the present document in order to give the users of ETSI standards on Fixed Radio Systems the technical background of most parameters reported in WG TM4 standards. Reference to the present document is therefore considered necessary for solving doubts on the correct interpretation of the standard requirements.

B.2 About normative references

These are references made to other Standards and Recommendations, either from ETSI or from other bodies (e.g. ITU-T or ITU-R) that contain normative information and/or parameters that are referenced in the text of the standard.

"Normative" references are not applicable to the deliverable types Technical Report (TR) or ETSI Guide (EG).

Remember, it is particularly important to include a version identifier of these references because of the possible negative impact on the equipment characteristics, cost, availability and certification of changes made in later versions. If it is required that the latest version of a normative reference is used, then the issue date should not be included.

B.3 Definitions, symbols and abbreviations

The purpose of this subclause is to give the full meaning of the definitions, abbreviations and symbols used in the EN.

B.4 General characteristics

B.4.1 Frequency bands and channel arrangements

A figure of the relevant channel plan, if any, is suitable for reference in understanding the related problems.

B.4.1.1 Channel arrangement

This subclause gives the frequency range(s) for the equipment subject to the EN, together with references to the relevant CEPT and/or ITU-R Recommendations or other applicable documents; the description of the main features of the channel plan(s) is ERC (or ITU-R) responsibility that may change it without the standard is affected, therefore it is not appropriate that detailed reference is given in the main body of ENs. For reader convenience only, a specific informative annex may be produced.

For radio frequency channel arrangements definition and background see ITU-R Recommendation F.746-4 [5].

B.4.1.2 Channel spacing for systems operating on the same route

This subclause may only be relevant for ENs where the use of multiple bit rates and equipment classes on different channel spacing is required. If only one bit rate/channel spacing is provided this may be given in the title of the EN, but it is preferable if it is stated somewhere in the text as well.

The co-polar (or alternated or interleaved) channel spacings in this clause coincides with that used for first adjacent channel interference performance.

The actual connection to the antenna port(s) may be different; for example even if systems are specified for co-polar adjacent channel operation, it may be convenient to connect two adjacent channels to different polarization of the same antenna.

All the possible system types summarized in this clause, should be identified with a specific numeric code to be reported in the specific normative annex 2; these codes would be required by licensing administration to uniquely and easily refer to the system proposed for license.

B.4.2 Compatibility requirements between systems

This subclause covers the requirements for mixing systems of different suppliers on the same antenna system either on the same polarization or on opposite polarization but still on the same antenna.

This requirement, if present, will imply other requirements for related parameters, namely transmit spectrum masks (see subclause B.5.3.5), internal T_X and R_X spurious emissions (see subclauses 5.3.7.2 and 5.4.3.2) and antenna Inter-Port Isolation (IPI) (see subclause B.4.8.3); which, together have to guarantee the required compatibility (i.e. no degradation or an allowed amount of thresholds degradation which value will be stated in the subclause B.5.5.1 where flat fade threshold behaviour is stated).

B.4.3 Performance and availability requirements

Performance and availability are regulated by ITU-T Recommendation G.821 [16] and ITU-T Recommendation G.826 [17] for error and block error objectives respectively.

ITU-T Recommendation G.826 [17] is the most recently delivered recommendation, so it is more applicable for new systems, nevertheless ITU-T Recommendation G.821 [16] is so wide applied among the actual international network, that it still will last for long time.

ITU-T Recommendations cover the performance aspects of the hypothetical reference circuit, while radio connections within the network should conform to ITU-R Recommendations which transform ITU-T general requirements into specific requirements for hypothetical and real radio reference paths of local grade (ITU-R Recommendation F.697-2 [4]), medium grade (ITU-R Recommendation F.696-1 [3]) or high grade (ITU-R Recommendation F.634-4 [1] and ITU-R Recommendation F.695 [2]) for ITU-T Recommendation G.821 [16] based networks or national portion (ITU-R Recommendation F.1189-1 [11]) and international portion (ITU-R Recommendation F.1092-1 [10]) for ITU-T Recommendation G.826 [17] based networks.

These aspects are not directly related to equipment performance to be specified in an EN because they are strongly related to the hops length and/or dispersive behaviour and cannot be matter of any conformance test; nevertheless the equipment shall incorporate suitable features in order to be capable of meeting the requirements on standard hops and connections.

Consequently, this subclause shall state in which grade of network performance, or in which portion (national or international) of the network, the equipment under the EN is to be used.

B.4.4 Environmental conditions

This subclause refers to the requirement dictated by the practical use of the equipment when introduced in the actual network locations.

The term "environmental" refers to every kind of climatic, chemical, mechanical, biological and other stresses which the equipment is required to withstand and are generally given in ETS 300 019 [27].

In general only environmental conditions during operation are a matter for ETS/EN but, whenever applicable, transport and storage environments may also be quoted from the same ETS 300 019 [27].

Although radio-relay engineers would refer to the radio equipment location as "indoor" or "outdoor", ETS 300 019 [27] terminology uses "weather protected" and "not weather protected" respectively. Under these two general headings, various sub-classes are depicted for better matching the different types of situations in which electronic equipment may be located.

The "E" in class 4.1E stands for extreme, so the temperature range is wider than and includes the range of normal class 4.1. Therefore equipment rated for 4.1E can be used anywhere in Europe, equipment rated for class 4.1 is only suitable for the more temperate regions with no significantly extreme weather conditions.

It is possible to test equipment cabinets to ETS 300 019 [27], and this shall be kept in mind when deciding the parameters under which a piece of equipment is to be tested. For instance, it may be possible to use a piece of equipment rated for class 3.1 outdoors if protected by a previously approved class 4.1E cabinet.

Environments other than those referred by ETS 300 019 [27] may be added to the standard text, provided that acceptable reasons are given.

B.4.5 Power supply

ETSI WG EE2 is responsible for characteristics at primary AC (mains) and secondary DC (battery) inputs. ETS 300 132-1 [27] and ETS 300 132-2 [28] should be used for reference.

These ETSs are relevant for conventional telecommunication centres. However the new scenario of private operators and customer premises, will possibly require different kinds of power supply interfaces, that is presently under study by WG EE2.

B.4.6 ElectroMagnetic Compatibility (EMC)

There are many different approaches and European bodies which deal with this subject. In 1992 WG RES9 was given the responsibility within ETSI for EMC of fixed radio systems and also reached agreement with WG EE4, which is responsible for other transmission equipment, regarding the boundary where the ETSs produced by the two bodies are applicable (i.e. if the multiplexer is an integral part of the radio equipment it will also fall under RES9). This is reflected in a joint EE4/RES9 meeting report (2nd February 1993). However in 1997 all EMC activities of RES9 and EE4 have been unified in the newly established WG ERM/EMC under the also new TC-ERM.

The EMC requirement for Point to Point Fixed Radio Systems of 2 Mbit/s and above were covered by ETS 300 385 [18] issued by WG RES9 where two classes of equipment type are considered (class A for commercial grade and class B for equipments which are supposed to meet standard ITU-T/ITU-R performance also in a polluted RF environment).

Following specific request from TM4, WG ERM/EMC has produced a revision of this standard; the new version EN 300 385 V1.2.1 [19] covers all Fixed Radio Systems, including P-P, P-MP and analogue systems of any system rate. This new version merged the two classes of equipments A and B previously defined for differentiating the expected network performance into a single one with all the immunity criteria left to supplier declaration.

In principle emissions and immunity phenomena at antenna port are also required for conformity to EMC European Directive, however in producing ETS/EN 300 385 it has been agreed that Spurious emissions and CW spurious interference rejection would remain in each product standard, therefore these requirements shall be included in TM4 equipment standards (see subclauses 5.3.7.1, 5.4.3.1 and 5.5.3.4).

The upper-bound frequency where EMC is defined within ETSI is up to now fixed to 1 GHz and this is also reflected in the ERM/EMC standards, nevertheless TM4 has expressed the opinion that in the present fixed/mobile environment this limit has to be raised to 2 GHz.

B.4.7 System block diagram

The reported block diagram is for standard point-to-point transceiver systems, other specific block diagrams may also be applicable.

B.4.8 TMN interface

This argument is currently under responsibility, study and definition by ETSI WGs TM2 and TM3; TM4 contribution shall, in general, be addressed to the above WGs, giving proper resourcing, by means of specific joint activity, to support the development of specific radio information models. Nevertheless, other specific TM4 ETSs for PDH or analogue systems, if any result from a specific activity, might be applicable.

B.4.9 Branching/feeder/antenna requirements

A set of antenna standards has been produced or is under production by TM4; therefore equipment standards should no longer contain antenna parameters.

The Scope of ENs (see clause 1) should contain the appropriate reference to the applicable antenna standard.

B.4.9.1 Antenna radiation patterns

The antenna radiation pattern is related to the network environment, so that it is, in general, a matter for National planning standards; however, when the antenna is an integral part of the equipment, reference to the antenna performance or, when available, to the relevant antenna EN, for certification purposes, shall be included in the equipment EN.

For dual polarized antennas, co-polar and cross-polar patterns shall be included for each polarization.

TM4 is working on EN 300 631 [25] and an update of ETS 300 833 [26] which deal with antenna characteristics; as a consequence these may be considered an informative part of radio equipment EN.

B.4.9.2 Antenna Cross-Polar Discrimination (XPD)

This factor is optional and may be useful for frequency co-ordination purpose or may be necessary for a minimum system performance (e.g. for co-channel use of multi-state high capacity systems or when, in alternated arrangements, adjacent channel NFD value is not enough to bear propagation induced de-polarization).

Under the above conditions a minimum requirement for XPD discrimination in unfaded conditions or, when available, reference to the relevant antenna EN has to be stated.

B.4.9.3 Antenna Inter-Port Isolation (IPI)

When equipment of different manufacturers and/or already existing analogue or digital equipment are required to be connected to different polarizations of the same antenna, a reference value of IPI *(plus, if applicable, an additional feeder loss which integrate the H/V local discrimination)* shall be stated.

With this value *compatibility (e.g. the required maximum threshold degradation stated in subclause 5.5.1 is achieved)* between innermost cross-polarized local TX and RX equipment is considered.

B.4.9.4 Waveguide flanges (or other connectors)

Standardization of flanges (or other connectors) is required at B-B' reference points when equipment from different suppliers is intended to be used on the same polarization of the same antenna, or at C-C' reference points unless integral antennas are required (see compatibility requirement in subclause 4.2).

B.4.9.5 Feeder/antenna return loss

Return Loss (RL) at reference point C/C' is of particular importance when long feeders are used to connect branching and antenna systems.

Mismatch at both end of the feeder may create echo distortion that, on first conservative assumption may be considered as a co-channel interference with C/I ≅ RL@(C/C') + RL@(D/D'); thus the value of RL may depend on the radio system type.

NOTE: This is valid if feeder transmission time delay is much higher than the symbol time interval of the system and neglecting the benefit of feeder attenuation.

When the feeder is not present or it is of negligible length, RL impact may be reduced to the produced transmission loss due to power reflection and a value of 20 dB may be in any case enough.

It has to be noted that branching systems realized with simple duplexer, due to the absence of wide band RF termination may not give the required RL on a full-band coverage but only on smaller bands across the relevant channel(s) frequency of the transmitter(s) and receiver(s) of the equipment under test.

B.4.9.6 Intermodulation products

When considering the inclusion of a multi-channel branching system, the transmitter power passing through slight non-linearities in the branching and antenna circulators, feeders and antenna may generate 3rd or higher order intermodulation products. These intermodulation products may fall at local receiver frequencies and cause threshold degradation (see background of subclause B.5.3.5).

The level of the intermodulation product which may cause degradation depends on:

- the frequency on which the intermodulation products actually fall (worst case is co-channel and outside a benefit of a "pseudo NFD" may be taken into account);
- it should be noted that n-th order intermodulation products have a bandwidth "n" times wider than the generating signals;
- the threshold of the receiver and its sensitivity to co-channel interference which may be taken from subclauses B.5.5.1 and B.5.5.3 (e.g. 1dB threshold degradation is obtained with a level of an in band intermodulation product of IM $\cong$ Threshold$|_{BER = 10^{-3}}$ - C/I$|_{1dB@BER = 10^{-3}}$).

Due to the high complexity of a test bay and difficulties in measurement itself, unless a full exploited multi-channel system is built up, this feature is not intended to be matter for conformance test but system design shall be carried out in order to meet this requirement avoiding in-field interference problems.

B.5 Parameters for digital systems

B.5.1 Transmission capacity

Bit rates at payload input port(s) shall be stated, in general these are standard ITU-T foreseen bit rates of PDH or SDH; other bit rates are also possible for special applications.

B.5.2 Baseband parameters

Reference to international standards for electrical, optical and, if applicable, physical characteristics are to be made.

B.5.3 Transmitter characteristics

B.5.3.1 Transmitter power range

The transmitter nominal power level is, in general, subject to standardization in order to provide proper network design on both, links and nodes points of frequency co-ordination arising from the introduction of different equipment from different suppliers.

For this purpose regulatory administrations may choose to apply a limitation in the allowed range of transmitted power in order to limit harmful interference.

In any case the maximum allowed EIRP radiation (including any ATPC overdrive power) shall be within the radio regulation limits or any specific limits set by ITU-R for sharing conditions in certain frequency bands.

The ATPC range should not be taken into account unless for systems which use it on permanent base (ATPC cannot be disabled).

B.5.3.2 Transmit power and frequency control

B.5.3.2.1 Automatic Transmit Power Control (ATPC)

General

ATPC is a feature that is used for one or more of the following purposes:

- to reduce interference in crowded nodal stations;
- to minimize non linear distortion due to saturation in T_X/R_X circuits during normal propagation, keeping BBER as lower as possible in multi-state FRS/DRRS;
- to increase the available system gain increasing the output power over the nominal level which may guarantee suitable non linear distortion. This may be done during deep fadings, so that the additional non linear distortion become negligible with respect to the already thermally impaired S/N;
- in frequency bands where multipath is dominant propagation factor, to improve adjacent channel protection to differential fading conditions caused, by operation of adjacent channels on different antennas on parallel route (e.g. operated by different operators).

When ATPC is used, the nodal interference environment may be evaluated with the minimum transmitted power. In fact even if output power increases, the receive level, which actually produce nodal interference at the far end location, never increases over the level during normal propagation.

ATPC may be offered or used on an optional basis or, in some systems, it may be a fixed feature (ATPC cannot be disabled).

The use of the ATPC may increase the percentage of time in which the system operates at low receiver signal level; the threshold of ATPC intervention should be 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 an higher percentage of time, an increase of EBs is avoided with respect to a system without ATPC function.

ATPC intervention threshold

The ATPC is used to reduce the interference reducing the transmitted power.

In conventional ATPC systems, the activation threshold is based on the receiver level only, and until the received signal level is higher than the ATPC activation threshold, the transmitted power is kept at the lower value.

While propagation events further increase the attenuation, the ATPC attenuation decreases, so a greater power is transmitted until the higher transmitted power is reached. The relationship between attenuation due propagation (Flat Fade) and BER can be evaluated from the typical example is given in figure A.2.

As it can be seen, for a attenuation in a given range of value the ATPC intervention produces a constant receive level and therefore a constant BER value. So if this value is greater than the RBER, the number of EB may be higher than a system without ATPC. The value depends on the percentage of time for which the attenuation is in the range from A_1 to A_2. Hence the contribution to the total Background Block Error (BBE) due to ATPC intervention is given by:

$$BBE = BER_{ATPC} * N_{BL} * T_{ATPC} = BER_{ATPC} * N_{BL} * \left(T_{A1} - T_{A2}\right)$$

where BER_{ATPC} represents the constant BER value during the range of ATPC intervention, T_{ATPC} the percentage of time for which attenuation in the interval [A1-A2] and T_{A1}, T_{A2} represent the percentage of time of attenuation A1 or A2 is exceeded and N_{BL} represents the number of block per second.

If the threshold of ATPC intervention is not well set, the ATPC produces some events similar to a reduced flat margin, so the system may not be complied with the RBER requirements. If the ATPC threshold intervention is set in such a way that BER_{ATPC} < RBER no extra BBER are due to ATPC.

This item is particularly important in the high frequency bands, where ATPC is connected to rain attenuation and the percentage of time for which attenuation is in that range may be significant.

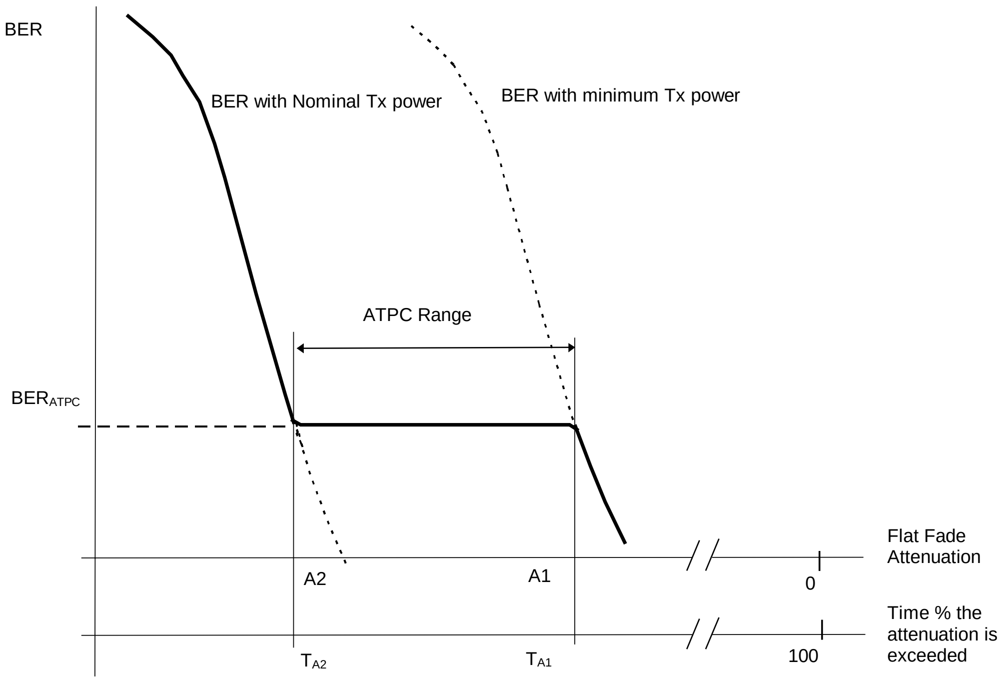


Figure B.1: BER vs Fading attenuation for a system with ATPC

B.5.3.2.2 Remote Transmit Power Control (RTPC)

This function may be useful for radio system used in micro-cells connection for frequency management purpose when new adjacent cells are exploited. Transmit power may be adjusted continuously or in steps by a SW control from a local terminal or a remote supervisory centre.

The spectrum mask is assumed to remain unchanged, however for wide band, low power systems, in particular in higher frequency bands at low RTPC level, the spectrum measurement sensitivity may become a limiting factor unless more complex test procedure is used; the argument is demanded to the conformance testing standards EN 301 026-1 [43].

B.5.3.2.3 Remote Frequency Control (RFC)

This function may be useful for radio system used in micro-cells connection for frequency management purpose when new adjacent cells are exploited. Transmit and receive frequency be set within a range of channels frequencies by a SW control from a local terminal or a remote supervisory centre.

B.5.3.3 Transmitter output power tolerance

The power stated in subclause B.5.3.1 is the nominal output power for the purposes of this test (e.g. that used for system gain evaluation). Within the climatic range of operation the output power may vary and, if not controlled, interference or lack in system gain may arise.

Range of thermal stability depends on the implementation or not of Automatic Gain Control (AGC) of the power amplifier and on the relevant frequency band in which the equipment operates.

B.5.3.4 Tx local oscillator frequency arrangements

Unless direct RF modulation is performed, a RF local oscillator is required to transfer the modulated IF signal to the required frequency band.

Up conversion may be performed selecting either the upper or the lower side-band of a mixer (spaced by ± IF frequency from the LO).

The selection of the side band has no impact on the system performance, apart from:

- LO frequency leakage may fall on one of the receiver connected to the same antenna;
- LO frequency leakage when outside the ± 250 % of channel separation, is included into the external spurious emissions.

In the first case a higher selectivity is required not to impair the threshold of the interfered receiver (see background of subclause B.5.3.5).

In the second case CEPT/ERC Recommendation 74-01 [45] has fixed the limit of -50 dBm or -30 dBm (for frequency below or above 21,2 GHz).

It is traditional in order to avoid, as much as possible, both the problems above the selection of LOs according the first statement reported in the following "standard text".

Nowadays new techniques, mainly that of a single LO for both T_X and R_X mixers, may require different implementation depending choices.

B.5.3.5 RF spectrum mask

a1) General considerations

Output spectrum generated by FRS/DRRS may be described (see figures B.2, B.4 and B.6) as constituted by five main elements:

- signal main lobe (noise-like spectral density);
- secondary(ies) modulation lobe(s) and/or 3rd order intermodulation of the transmitter (noise-like spectral density adjacent to the main lobe);
- background noise due to the noise figure of the transmitter or to residual flickering noise of the digital to analogue modulator circuits (wide band noise-like spectral density);
- spectral lines due to the modulation process (discrete CW components related to the symbol frequency and its harmonics);
- other emissions (e.g. discrete CW leakage of LO or noise-like spectral density at image frequency if applicable).

This spectrum is then filtered by a RF filter.

Emission limits has to be a spectrum mask for the noise-like spectral density part and an absolute power level (or an attenuation relative to the carrier average power) for the discrete CW components.

According to ITU-R Recommendation F.1191-1 [14] and CEPT/ERC Recommendation 74-01 [45], the frequency boundary for limitation of out-of-band emissions is defined as ± 250 % of the relevant channel spacing, the spectrum mask shall be defined for regulatory purpose, from carrier centre frequency up to this boundary; however for "internal system compatibility" (i.e. when equipment of different manufacturer are required to share the same branching or antenna) the spectrum may be defined also beyond such boundary.

Output spectrum limitation at B' (or C') reference point is required:

- for frequency co-ordination among different equipments of different suppliers;
- for their connection to the same antenna;
- for their use on parallel route and/or for nodal concurrent hops;
- for regulatory purpose and advanced sharing studies.

ITU-R SG1 "Spectrum Management" has established the TG1/5 in order to answer the mandate of WRC 95 and WRC 97 for studies on limits for digital modulations. Under this activity CEPT has proposed the introduction, on a new preliminary recommendation, of "generic spectrum masks" generated as envelopes of all presently standardized CEPT and ETSI fixed radio systems.

The proposed masks should not endanger any future development, however, if they will be endorsed by ITU-R, would fix an absolute limits that could not be exceeded by ETSI standards.

These mask presently appears in ITU-R Doc. 1-5/TEMP/83r1 (1/99).

These masks have been subdivided by mixing the following macro-typologies of applications which define the general shaping requirement of the spectrum mask:

- digital systems of all modulation formats excluding FDMA P-MP systems;
- FDMA (Frequency division multiple access) systems which are characterized by a multi-carrier transmission methodology with sharper decay of the spectrum outside the assigned channel, but with flat 3rd order intermodulation products.

a2) Spectrum and frequency co-ordination (digital and analogue)

For frequency co-ordination purpose some factors are necessary:

- a spectrum mask which gives the attenuation of the noise-like spectral density relative to the actual centre frequency spectral density;
- a formula, related to the modulation format, which gives the relationship between the reference centre frequency spectral density and the total average power of the carrier. This may be necessary in order to evaluate, when required (e.g. for compatibility with analogue signals), the absolute value noise-like power of the digital signal integrated within a required bandwidth (e.g. 4 kHz) at a certain offset frequency removed from carrier centre frequency. For phase and angle modulation formats the well known relationship applies:

$$(P - Po)[dB] = 10\log\frac{Fs}{BWe}$$

- where:
  - P is the total average power of the carrier [dBm];
  - Po is the average power level [dBm] falling into the BWe (Evaluation Bandwidth);
  - Fs is the symbol frequency of the modulated signal.

For frequency modulated signals the evaluation of the reference level require solution of very complex integrals.

For the simplest cases of 2 and 4 FSK modulation formats simpler expressions may be derived which give for the ratio spectral density at centre frequency to carrier mean power normalized in a band equal to bit-rate:

$$\frac{S_0[Fb]}{P} = \left(\frac{2}{\pi h}\right)^2$$ for 2 levels FSK; and

$$\frac{S_0[Fb]}{P} = \frac{2}{(3\pi h)^2}\left[10 - \cos(3\pi h) - 9\cos(\pi h) + \frac{1}{2}\left(\frac{10 - \cos(6\pi h) - 6\cos(4\pi h) - 3\cos(2\pi h)}{2 - \cos(3\pi h) - \cos(\pi h)}\right)\right]$$ for 4 levels FSK,

where:

S_0[Fb] = spectral density at centre frequency normalized in a band equal to the bit-rate;

h = 2 (Δf / Fs) = modulation index;

Δf = peak frequency deviation;

Fb = bit rate.

Other special cases of frequency modulations of interest are Minimum Shift Key (MSK) and Tamed Frequency Modulation (TFM) which needs far more complex simulations; these two cases are considered defined or of practical application only for h = 0,5.

In figure B.1a the computed values of So[Fb] are reported; these are theoretical values and slight difference in practical applications is possible.

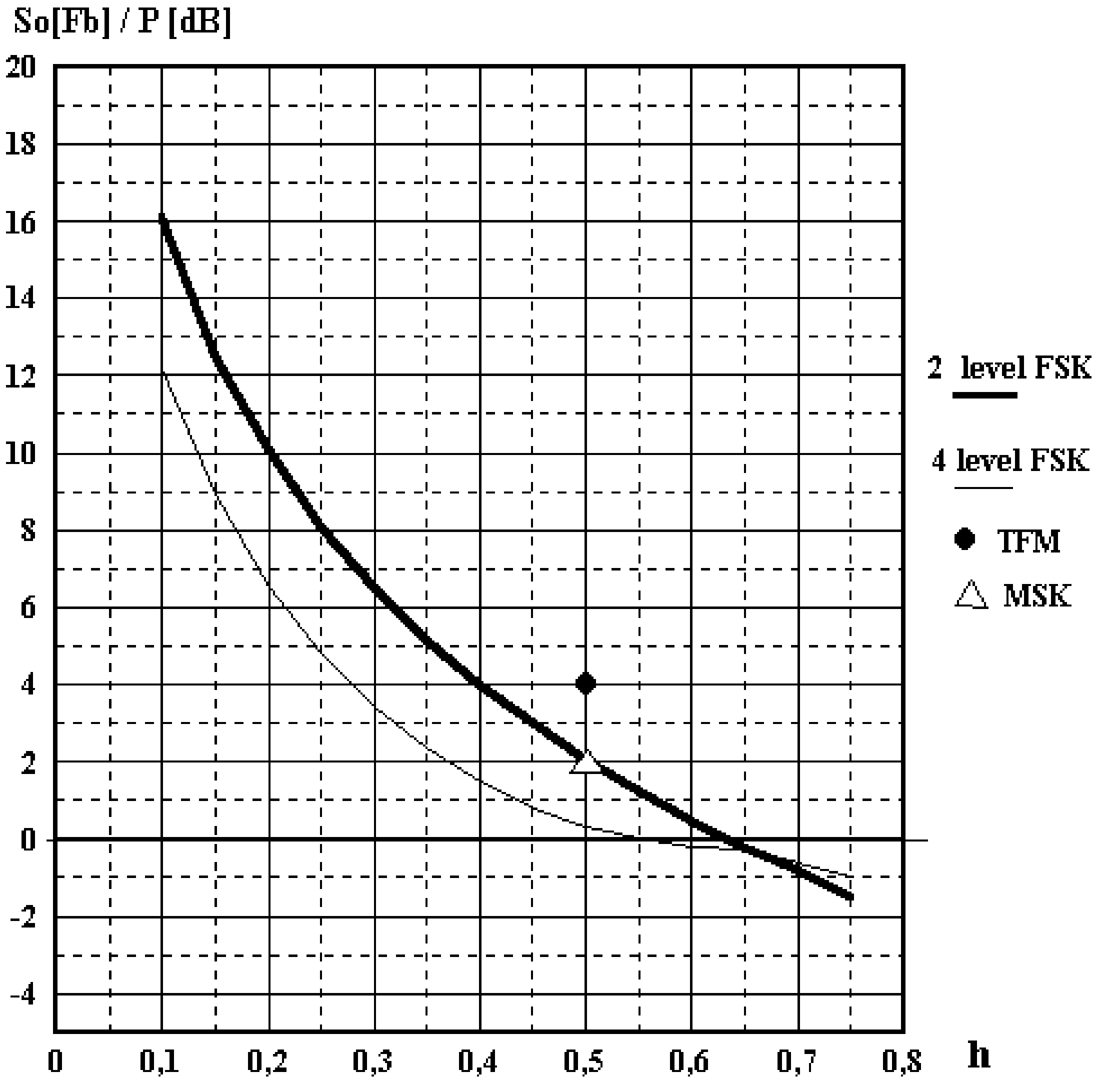


Figure B.1a: Normalized spectral density to carrier mean power ratio (at centre frequency in a band equal to the bit-rate)

For practical spectrum analyser evaluation the actual measured value of the ratio is obtained from the value taken by figure B.1a as:

$$(P - P_0) \cdot [dB] = S_0[Fb] / P - 10\log(Fb / BWe)$$

An absolute limit or a relative attenuation with respect to the carrier average power for other discrete spurious emissions.

Other details on spectrum emission may be found in ITU-R Recommendations F.1101 [8] and F.1102 [9].

a3) Spectrum and NFD in digital to digital interference relationship

Moreover the spectrum mask constitutes the main factor which controls the Net Filter Discrimination (NFD) as defined by ITU-R Recommendation F.746-4 [5], which is useful to evaluate interference into receivers aligned on frequencies different from that of the interfering transmitter, figure B.2 shows typical scenario of a generalized noise-like spectrum emission.

Spectrum mask is strictly related to the digital to digital adjacent (by one or more channel spacing) channel interference which will be required in the following subclause B.5.5.3 and their values shall have congruence to each other.

A particular case of interference which has to be controlled by the transmitted spectrum mask is the local transmitter to receiver interference between the innermost channels of the frequency plan which may be connected to the same antenna, either on same or on cross polarization; when it is the case, not to burden every transceiver with complex and costly filters, special spectrum mask (and special receiver selectivity) may be required for these innermost channel only. In the most critical case of very narrow YS (as defined in ITU-R Recommendation F.746-4 [5]), the NFD may be strongly dependent from the receiver selectivity too, due to the required high rejection to the main lobe of the interfering transmitter; in this case a mask for the selectivity of innermost receiver may also be required (see subclause B.5.4.5).

With reference to figure B.3 it can be shown that, in general, interference to the firsts adjacent channels is related to the shape of the spectrum mask in its decaying part of the main signal lobe, but also to the interfered receiver filters; for this case the NFD has to be calculated through integration methods (see figure B.3 zones ①).

In other cases (e.g. adjacent channels by more than one channel spacing or relatively wide spaced innermost T_X/R_X interference) which receiver frequencies fall into the background noise part of the emitted spectrum (as shown in figure B.3 zones ② to ⑤), NFD may be easily evaluated as:

$$NFD(f)[dB] \cong S(f)[dB] + X[dB] + 10\log\frac{\text{Fs of interfering signal}}{\text{Fs of interfered signal}}$$

where S(f) is the relative attenuation of the spectrum mask at frequency away from carrier centre frequency by f [MHz] and X[dB] is the allowed overshoot of the spectrum mask defined in figure B.2.

This NFD values may be used to evaluate the interference sensitivity on adjacent channels interference (reference to subclause B.5.5.3) from the co-channel behaviour of the interfered receiver with the following relationships:

$$\left.\frac{C}{I}\right|_{\text{nth}\cdot\text{adjacent}\cdot\text{ch}} = \left.\frac{C}{I}\right|_{\text{cochannel}} + \text{NFD} \qquad [\text{for same BER degradation}]$$

a4) Local receiver thresholds degradation

NFD may be used to evaluate the level of local interference (I_L) into receivers connected to the same branching or antenna (or even to different antennas of concurrent routes to the same nodal station) with the following relationship:

$$I_L[dBm]\Big|_{(\text{on local Rx})} = P_{Tx}[dBm]\Big|_{(\text{of local Tx})} - \text{NFD}[dB] - \text{D}[dB]$$

were D[dB] is the additional decoupling (if any) due to antenna circulator (co-polar interference) or IPI of the antenna (cross-polar interference) or antenna angular decoupling (nodal interference).
With I_L value the thresholds degradation may be evaluated by comparison with the total noise integrated on BW_n (receiver equivalent noise bandwidth):

$$\text{Threshold degradation}[dB]\Big|_{(\text{onlocalRx})} = 10\log\rangle 10^{-114+10\log BW[Mhz]} + 10^{I_L}\langle - \rangle - 114 + 10\log BW_n[Mhz]\langle$$

and, if applicable, reported to subclause B.5.5.2.

NOTE: It has to be noted that I_L being a constant interference level, as a first assumption, it may be added to the receiver noise and as a fixed noise figure degradation giving a fixed amount of dB degradation whatever the RSL was.

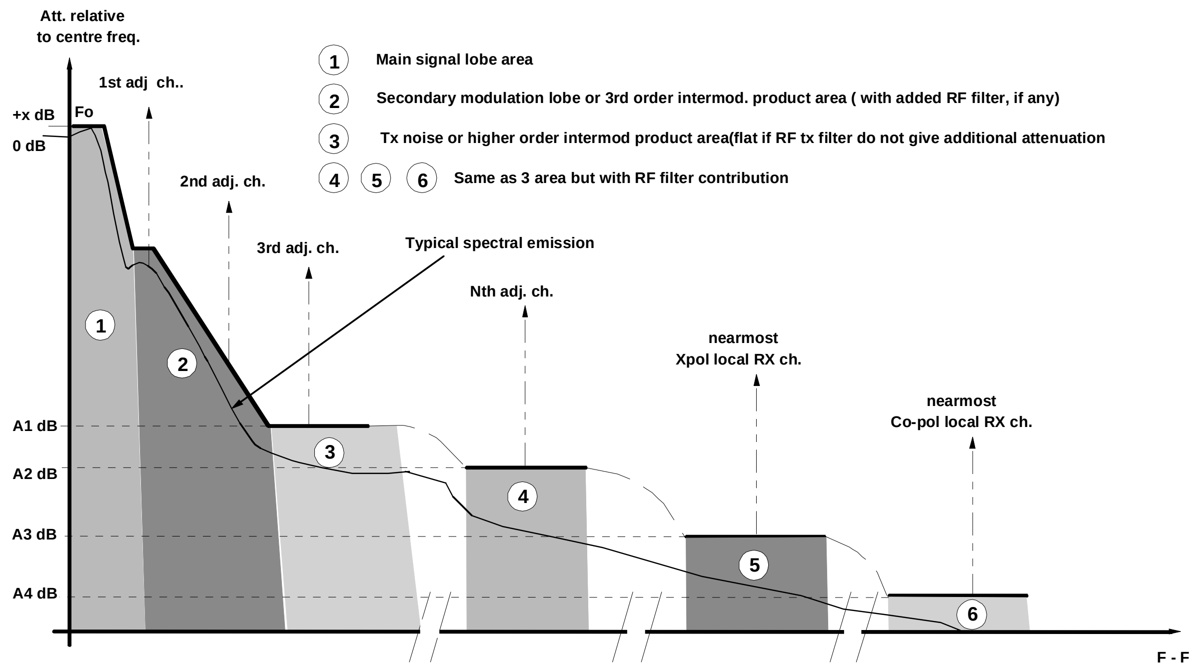


Figure B.2: Emitted spectrum areas (noise-like typical scenario)

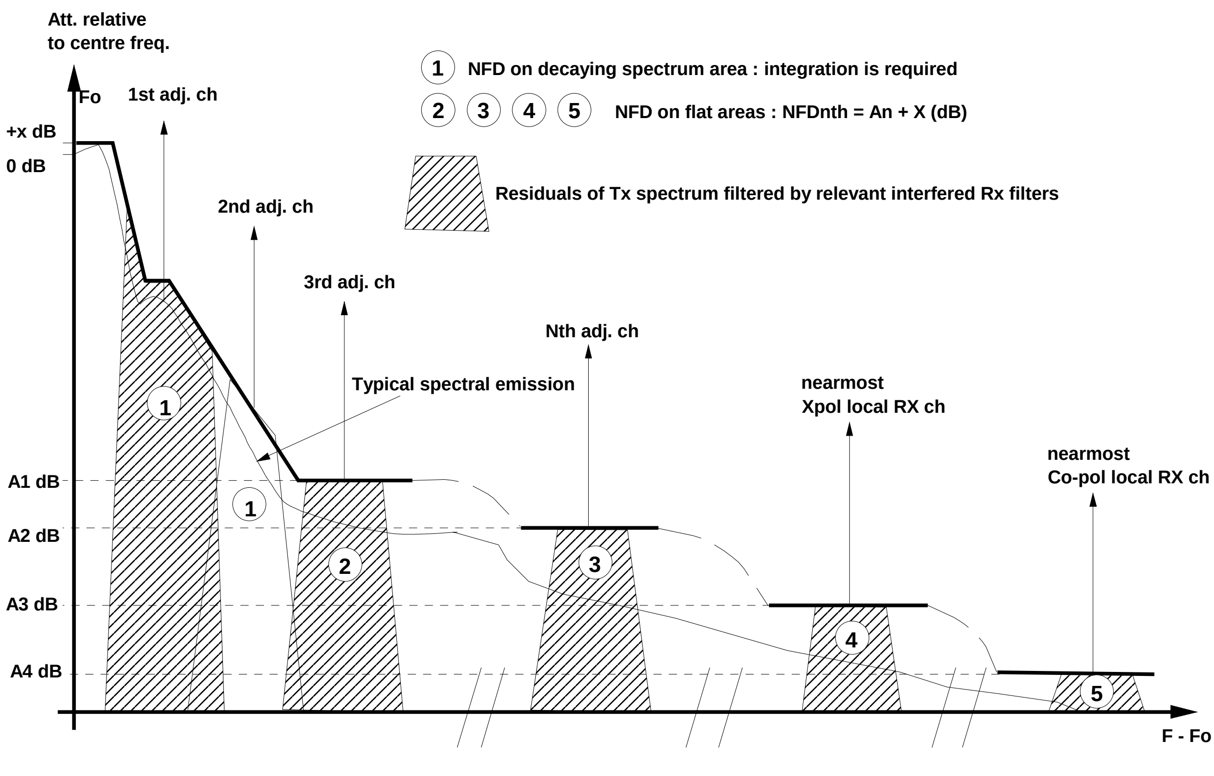


Figure B.3: NFD relationship with spectrum mask

a5) Practical measurement impact

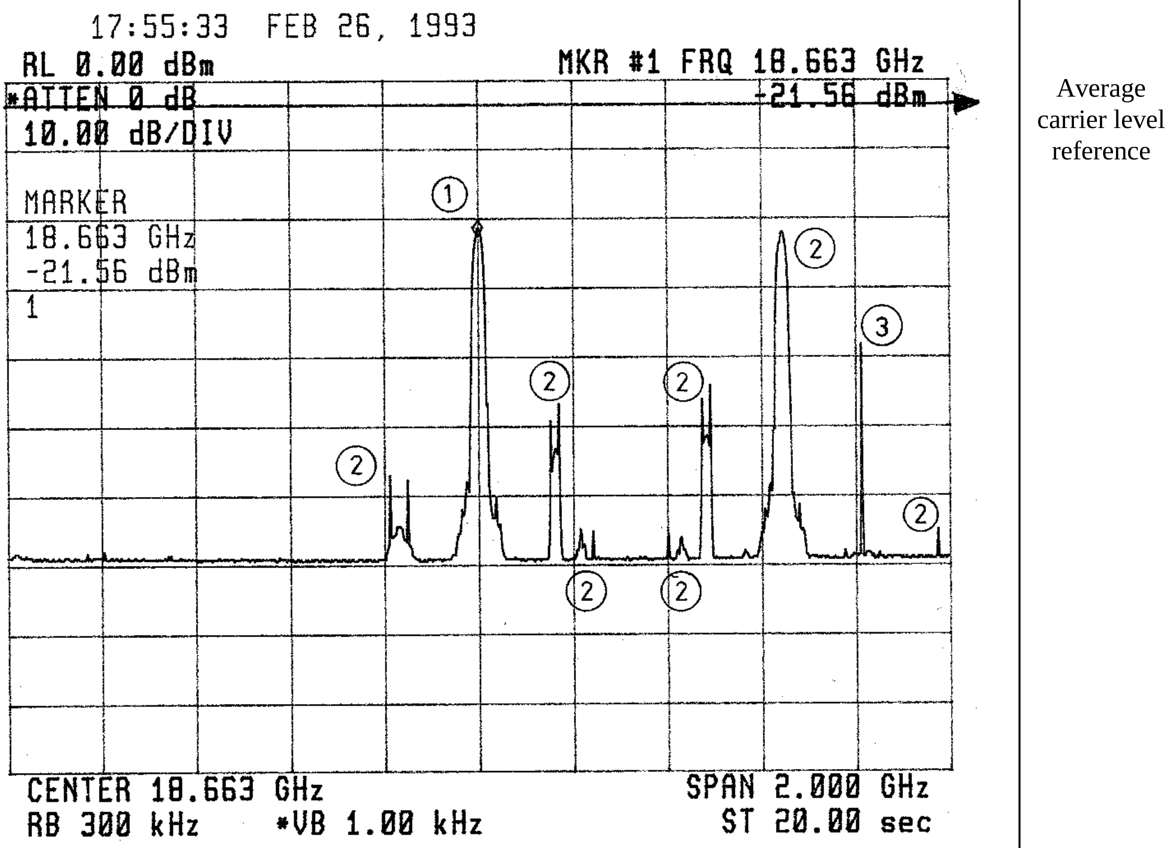
Practical measurements of spectrum density mask give the following difficulties that have to be taken into account in the mask definition for FRS/DRRS ENs:

- being the spectral density of a noise-like type, there is a lower bound measurement limit due to the noise floor of the spectrum analyser (which cannot be improved by IF bandwidth but only by using a better instrument), this noise floor worsens as the frequency increases;

- in particular wide band signals with low power output, typical of higher frequency bands systems, may experience power densities in the lower portion of the spectrum mask, which may fall beyond common spectrum analyser capability. In this event, in agreement with the regulatory administrations participating to WG TM4 activity, the following options have been considered,: measurement using high performance spectrum analyser; use of notch filter; two step measurement technique. When difficulties are experienced, the plots of one test carried out in a precedent time, may be produced and accepted as evidence of conformance to the spectrum mask;

- the measurement sensitivity may not be increased by increasing the input level into the spectrum analyser, because of the possibility of 3rd order intermodulation distortion from the instrument itself, which may exceed the level of the spectrum under test;

- if wide band measurement were required (spectrum masks defined very far from centre frequency) the presence of conversion harmonics of the spectrum analyser may fake the measurement, requiring lengthy manual identification of the false components; a pre-selector option may override this limitation, but further reduces the available sensitivity of ~ 10 dB (see figures B.4 and B.5).

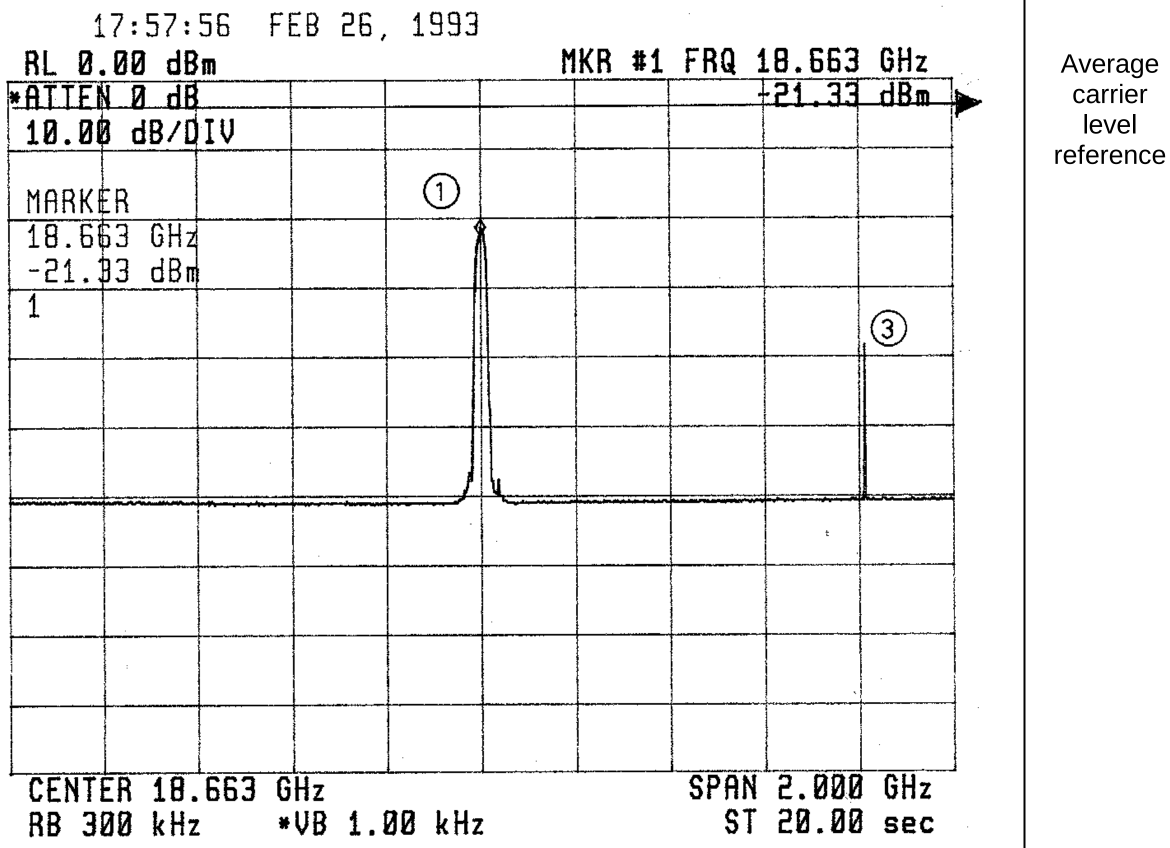


① Main signal spectrum.

② False emissions (spectrum analyser conversions)

③ Real spurious emission (L.O. leakage)

Figure B.4: Example of wide band spectrum measurement (reference point A') by an analyser without pre-selector



① Main signal spectrum.

③ Real spurious emission (L.O. leakage).

Figure B.5: Same wide band spectrum measurement of the example in figure B.4 but by an analyser with pre-selector

On the consequence when high spectrum reduction is required for "internal compatibility" the spectrum mask shall indicate the measurement limits for "external compatibility" (i.e. for regulatory purposes) and the exceeding part shall be measured through alternative measurement if possible (e.g. measurement at reference point A' and adding Tx filter attenuation to estimate the spectrum value at reference point B' or C') or it may be subject of manufacturer declaration.

Also the symbol frequency (F_s) of the signal under test has an impact on the maximum relative sensitivity that can be measured, this is actually shown in figure B.6, where the measurement results on different F_s with different BWe are reported.

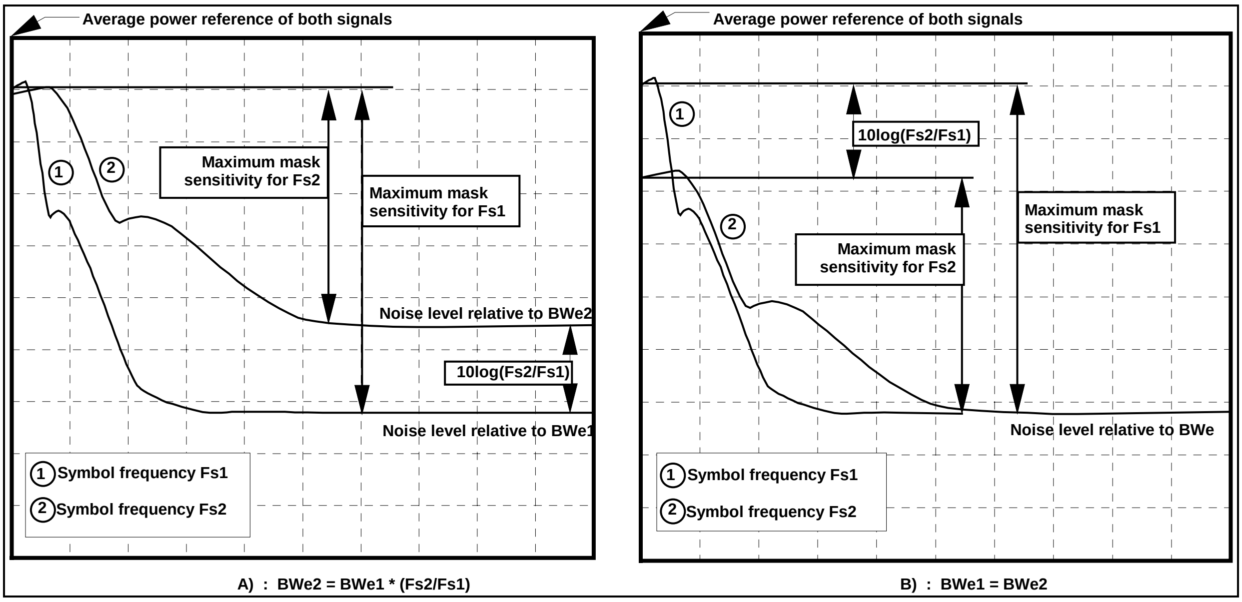


Figure B.6: Example of spectrum measurement results with different F_s and BWe

To avoid slight uncertainty due to selection of different BWe/Video filter/sweep time selection, two of these parameters (i.e. BWe and Video filter should be referred in the EN/EN, leaving the third element (sweep time) to be automatically selected by the spectrum analyser in order to maintain calibrated results.

The BWe and Video filters have been usually standardized by WG TM4 and the practical used values as function of the channel separation reported in table 3, have been also proposed to ITU-R TG1/5 for a "generic limits for out-of-band emissions" (see previous background in a1) therefore these values is expected to be used in any future standard.

a6) Discrete CW components and BWe impact

Evaluation bandwidth (BWe) and discrete components of unwanted emission give additional difficulties to be carefully analysed; from the point of view of the noise-like spectral components BWe is not influent for relative attenuation measurement in spectrum mask evaluation, provided that it were smaller than Fs.

On the contrary discrete components have a fixed power level which is independent from BWe, so that the relative level compared to noise-like spectral densities will change according to the ratio between different selected BWe (example in figure B.7).

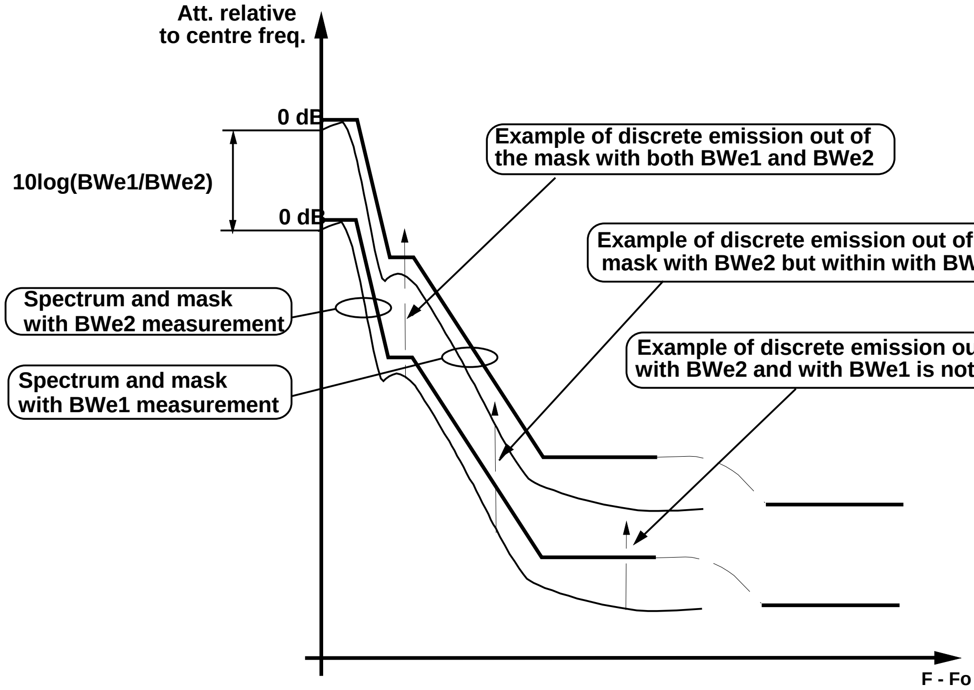


Figure B.7: Impact of BWe in spectrum mask measurement

From this considerations discrete components of unwanted emission (or some of them well identified) may have an absolute level limits or an attenuation relative to carrier mean power, see subclause B.5.3.6 (spectral line at symbol rate) and subclause B.5.3.7 (spurious emission), due also to the fact that Out-of-band emission limits are set as relative attenuation while CEPT/ERC limits of Spurious emissions require an absolute level.

Another approach for discrete components may be to limit them within the spectrum mask, but this means that systems with different F_S rate may result in having different level allowance on emission which, on the contrary, are rate independent. (Unless BWe were carefully chosen to follow the same ratio of F_s: BWe1/BWe2 = F_s1/F_s2, and this would require a spectrum analyser with continuously selectable resolution BWe).

a7) RF frequency tolerance and spectrum mask

In principle two approaches may be possible:

- include the RF frequency tolerance into the spectrum mask; this means that an allowance has to be taken into account in drawing the mask itself. This approach may be useful for an EN dealing with high frequency systems with a wide variety of bit rates and possible far different hardware realization, which may trade off frequency tolerance with spectrum width (frequency deviation for FSK modulation or roll-off factor for angle modulation). In this case the 0 MHz reference for the spectrum mask will be the "nominal" channel centre frequency;

- during discussion for conformance testing measurements (EN 301 126-1 [43]) agreement was reached of not supporting this possibility any longer; new ETSs will not use this option;

- not include frequency tolerance into the spectrum mask; this means that the mask may be tailored on the emitted spectrum itself. This approach may be more suitable for EN dealing with high capacity systems where frequency tolerance effect on adjacent channel compatibility is small and modulation format is in practice fixed by the network application itself. However modern small capacity FRS/DRRS make often use of synthesizers that give sufficiently low frequency instability which still may be neglected in a generic interference evaluation. In this case subclause B.5.3.8 shall apply and the 0 MHz reference for the spectrum mask will be the "actual" transmitted centre frequency.

WG TM4 has decided, for coherence among all the produced ENs that the second approach will be used for any new or revised EN.

B.5.3.6 Discrete CW components inside ±250 % of the channel spacing

The emission includes in this range only the fundamental and out of band emissions.

Digital modulated carriers basically produce a spectral power density distribution which shape depends from the modulation parameters itself and are well defined by an attenuation mask expressed in dB relative to centre frequency. However other spectral lines emissions are unavoidably generated by actual systems.

According to the reference BWe required for spectrum measurement, these CW components may exceed the mask; however their actual power content may be negligible when compared to the actual spectrum power when integrated over the adjacent channels band.

For these spectral lines a limit in dBc is far more appropriate. Therefore limits for discrete spectral lines might not be considered within the spectral density masks but a specific limit, when appropriate, may be given.

B.5.3.6.1 Discrete CW components at the symbol rate

These discrete, out of band emissions, components are one example of what has been already discussed in the previous subclause B.5.3.5; they are close to the main signal lobe and are due to unavoidable imperfections and non-linearity of practical implementation of radio transmitters and modulators.

B.5.3.6.2 Other discrete CW components exceeding the spectrum mask limit

Inside the ± 250 % of channel separation where Out-of-band are defined, due to various circuits imperfections (e.g. mixing sub-harmonics or carrier synthesizers phase locked loops and other clocks components).

Therefore, when digital to analogue compatibility is not required (and nowadays this may be considered always true), some CW components may be allowed to exceed the spectrum mask, provided that their total power relative to the carrier, integrated in the first and the second adjacent channel (i.e. from 50 % to 150 % and from 150 % to 250 % of the channel spacing) is small in comparison to the required NFD (given by the foreseen co-channel to adjacent channel C/I interference performance or derived by the spectrum mask itself).

B.5.3.7 Spurious emissions

Two different sets and limits for spurious emission may be included, one for "external" reasons in order to limit the emissions that through the antenna radiation pattern may fall into other nearby systems, the other for "internal" reasons in order to limit emissions that may fall into receivers connected to the same branching/antenna system of the transmitter.

The external emissions concept and definition have been firstly reported in ITU-R Recommendation F.1191-1 [17].

ITU-R TG1/3 of SG-1 (Spectrum Management), with CEPT active participation, has revised in 1996 the ITU-R Recommendation SM.329-7 [44] introducing the definition of spurious emission, frequency range recommended reference bandwidth and the recommended spurious emission levels for all services, which are in line, for Fixed Service, to ITU-R SG-9 Recommendation F.1191-1 (14).

The following reference bandwidths (see note 1) are recommended by ITU-R Recommendation SM.329-7 [44] and CEPT/ERC Recommendation 74-01 [45]:

- 1 kHz between 9 kHz and 150 kHz;
- 10 kHz between 150 kHz and 30 MHz;
- 100 kHz between 30 MHz and 1 GHz;
- 1 MHz above 1 GHz.

NOTE 1: A reference bandwidth is a bandwidth in which spurious emissions level is specified; actual measurements may be carried out with different bandwidth but the results should be normalized into the reference bandwidth with the rules specified by CEPT/ERC Recommendation 74-01 [45].

CEPT supported the Category B limits in SM.329-7 [44] and further specified the transition area near the boundary between out-of-band and spurious emissions in the CEPT/ERC Recommendation on "Spurious Emissions" produced by PT SE-21.

In particular the Category B limits has been defined as:

- 9 kHz to 21,2 GHz ≤ - 50 dBm (≤ - 40 dBm for P-MP terminal stations);
- 21,2 GHz to 300 GHz (Note) ≤ - 30dBm.

NOTE 2: In CEPT/ERC Recommendation 74-01 [45] and in a further draft revision of ITU-R Recommendation SM.329-7, under discussion in TG 1/5, as guidance for practical purposes, the following measurement parameters are normally recommended.

Fundamental frequency range	**Spurious frequency range**	
	lower frequency	**upper frequency (The test should include the entire harmonic band and not be truncated at the precise upper frequency limit stated)**
9 kHz - 100 MHz	9 kHz	1 GHz
100 MHz - 300 MHz	9 kHz	10th harmonic
300 MHz - 600 MHz	30 MHz	3 GHz
600 MHz - 5,2 GHz	30 MHz	5th harmonic
5,2 GHz - 13 GHz	30 MHz	26 GHz
13 GHz - 150 GHz	30 MHz	2nd harmonic
150 GHz - 300 GHz	30 MHz	300 GHz

ETSI WG TM4, waiting for final decision form CEPT, started EN 301 390 [41] to define the limits for Fixed Radio Systems from ETSI point of view; this activity is nearly finalized and will endorse the CEPT/ERC limits for all P-P systems and for P-MP with fundamental emission below 21,2 GHz, while for P-MP systems with fundamental emissions above 21,2 GHz a tighter limit above 21,2 GHz should be required.

Therefore when EN 301 390 [41] would be finally published it may be referred as unique reference for "external spurious emission" of all Fixed Radio Systems; in the mean time CEPT/ERC Recommendation 74-01 [45] will apply.

For "internal" spurious limit the following consideration may be applicable:

- the level of interference falling in the band of a generic receiver has to be compared with the BER 10^{-3} threshold referred in subclause B.5.5.1;
- the allowed C/I (e.g. threshold degradation < 1 dB) may be found in subclause B.5.5.3.1 for co-channel interference ≤ 1 dB;
- the maximum allowable level (e.g. threshold degradation < 1 dB) of spurious emission falling in receiver sub-band may be derived by the following relationship:
  - spurious emission level ≤ RSL @10^{-3} threshold;
  - C/I co-channel @ 1dB degradation + D[dB] where D is the T_X/R_X decoupling already defined in the background of subclause B.5.3.5;
  - being, in general, the receiver bandwidth comparable with the spectrum width of the "internal" emissions, the required level will be the total average level of the emission under consideration.

When the equipment output include a section of plain waveguide, which acts as a high-pass filter, the lower frequency limit of measurement may be increased to a frequency lower than the cut-off frequency (fc) where the waveguide sufficient attenuation to guarantee that the CEPT limits are surely met (80 dB attenuation is considered enough when considering the limits of maximum output power, of spurious emission and them reasonable intrinsic relative attenuation).

The attenuation introduced at frequency "f" by a below cut-off waveguide is given by:

$$A[dB/cm] = \frac{2\pi \times 8,69 \times f_c[GHz]}{30} \times \sqrt{1 - \left(\frac{f}{f_c}\right)^2}$$

Figure B.8 shows the waveguide length necessary for 80 dB attenuation at frequencies lower than f/f_c 0,7.

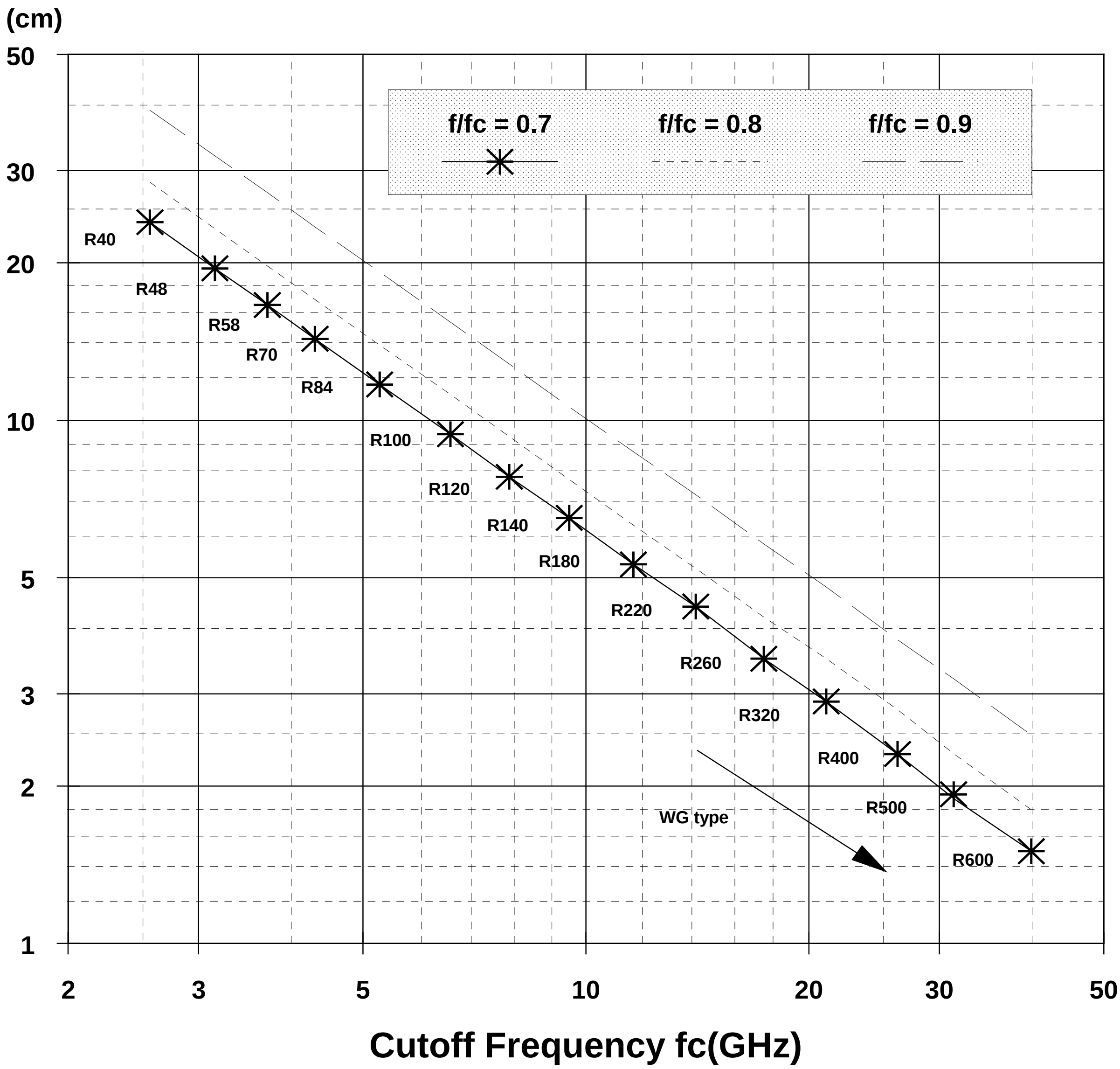


Figure B.8: Cut-off waveguide length for > 80 dB attenuation

B.5.3.8 Radio frequency tolerance

If spectrum masks do not include an allowance for frequency tolerance (see subclause B.5.3.5) a value shall be stated in order to control interference environment, since this limit includes both short-term factors (environmental effects) and long-term ageing effects, the EN should define a way to guarantee that the type test also covers the effects of ageing.

This can be achieved provided that the actual short-term value is lower than the standardized limit, the manufacturer will state the expected ageing and, if applicable, the maintenance procedure of realignment in order to guarantee that the total frequency instability will remain within the limits.

New ENs will not include frequency tolerance into the spectrum mask (see also subclause B.5.3.5, a1)).

B.5.4 Receiver characteristics

B.5.4.1 Input level range

FRS/DRRS may experience BER both during deep fading (which may increase the noise floor above the threshold) and up-fading phenomena (which may generate 3rd order intermodulation distortion due to saturation in the receiver RF/IF chain).

In order to evaluate the flat fade margin available on the standardized system, the maximum nominal input level has to be defined taken into account a suitable margin to cope with up-fading induced performance degradation; this means that it is necessary to define not only the usual BER thresholds but also the minimum up-faded RSL versus BER.

B.5.4.2 Rx local oscillator frequency arrangements

Unless direct RF demodulation is performed, a RF local oscillator is required to transfer the RF modulated signal to the required IF.

Down conversion may be performed selecting either the upper or the lower side-band of a mixer (spaced by ± IF frequency from the LO).

The selection of the side band has no impact on the system performance, a part from the additional consideration that the receivers LO frequencies allocation, which, usually, are the same of the corresponding transmitters LOs, may give the problem of a local transmitter allocated nearby the image frequency; this results in additional selectivity constrains (see subclause B.5.4.5).

Nowadays new techniques, mainly that of a single LO for both T_X and R_X mixers may require implementation dependent choices.

B.5.4.3 Spurious emissions

The same background as subclause B.5.3.7 is applicable.

B.5.4.4 Receiver IF

Often FRS/DRRS, unless direct RF demodulation is implemented, use one or more IF in order to achieve suitable selectivity.

On the other hand the presence of an IF may facilitate some measurement (e.g. S/N versus BER) during maintenance, training and type approval by the user; for this purpose it may be useful that the IF frequency is chosen where standard instruments may be available (i.e. 35 MHz, 70 MHz or 140 MHz). When more than one IF is used (multiple conversion receivers) one may be required to fall upon the standardized ones.

However new highly integrated digital systems (e.g. for the lower bit rates and when high complexity digital adaptive equalizers make amplitude and group delay distortions unessential for the performance of the system) may not supply IF external access and/or monitoring points. Moreover modern link analyser offer wide band operation.

Therefore WG TM4 decided that this section is no longer of importance and may be deleted from the "Generic Wording". Very specific need should be treated as special case.

B.5.4.5 Receiver image rejection

For some systems, typically with a multi-channel branching system, particular problems may arise. For instance, a local transmitter near the image(s) frequency(ies) of some receivers. Suitable image(s) rejection values are necessary in order to avoid impairment of the receiver performance due to interference at this(these) frequency(ies).

The required receiver RF attenuation (e.g. for less than 1 dB threshold degradation of this(these) receivers) may be taken as:

A@(Tx fo) ≥ P_{out}(Tx) – RSL@10^{-3} threshold – C/I cochannel@1dB degradation – D – NFD@(| (| Frx - Ftx |) - Fi |)

where D is the T_X/R_X decoupling already defined in the background of subclause 5.3.5 and Fi is the IF image frequency.

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

B.5.4.6 Innermost channel receiver selectivity

This optional subclause may be necessary when very high selectivity on innermost channels is required due to the very narrow YS (as defined in ITU-R Recommendation F.746-4 [5]) provided by the radio frequency channel arrangement (see also subclause B.5.3.5).

A mask of the total RF, IF and BB attenuation to ensure the necessary rejection to the interfering transmitter signal being the transmitter spectrum mask is itself not enough to guarantee a suitable NFD.

The measurement of this requirement may not be performed by any practical measurement methods, nevertheless it may be checked on the design data that should be supplied during conformance testing.

B.5.5 System performance without diversity

B.5.5.1 BER as a function of receiver input signal level RSL

RSL versus suitable BER thresholds (typically three at high, medium and low BER) should be stated.

The reference point may be C for simple systems with a duplexer or B for systems with multi-channel branching system.

BER may mean either bit error rate or block error rate.

When different system grade are foreseen each one will have its own required values.

When specific local "internal" interference may be present (e.g. innermost T_X/R_X local interference of frequency channel arrangements with particular troublesome YS value), the allowed thresholds degradation, if any, or a "no degradation" condition, shall be stated together with the minimum additional decoupling D dB (e.g. to simulate antenna circulator, antenna IPI or feeder losses) necessary to guarantee the degradation itself.

B.5.5.2 Equipment Background BER (BBER)

The BBER is standardized in order to match the Errored Seconds (ES) % (or the EB %) performance required by ITU-R transmission performance.

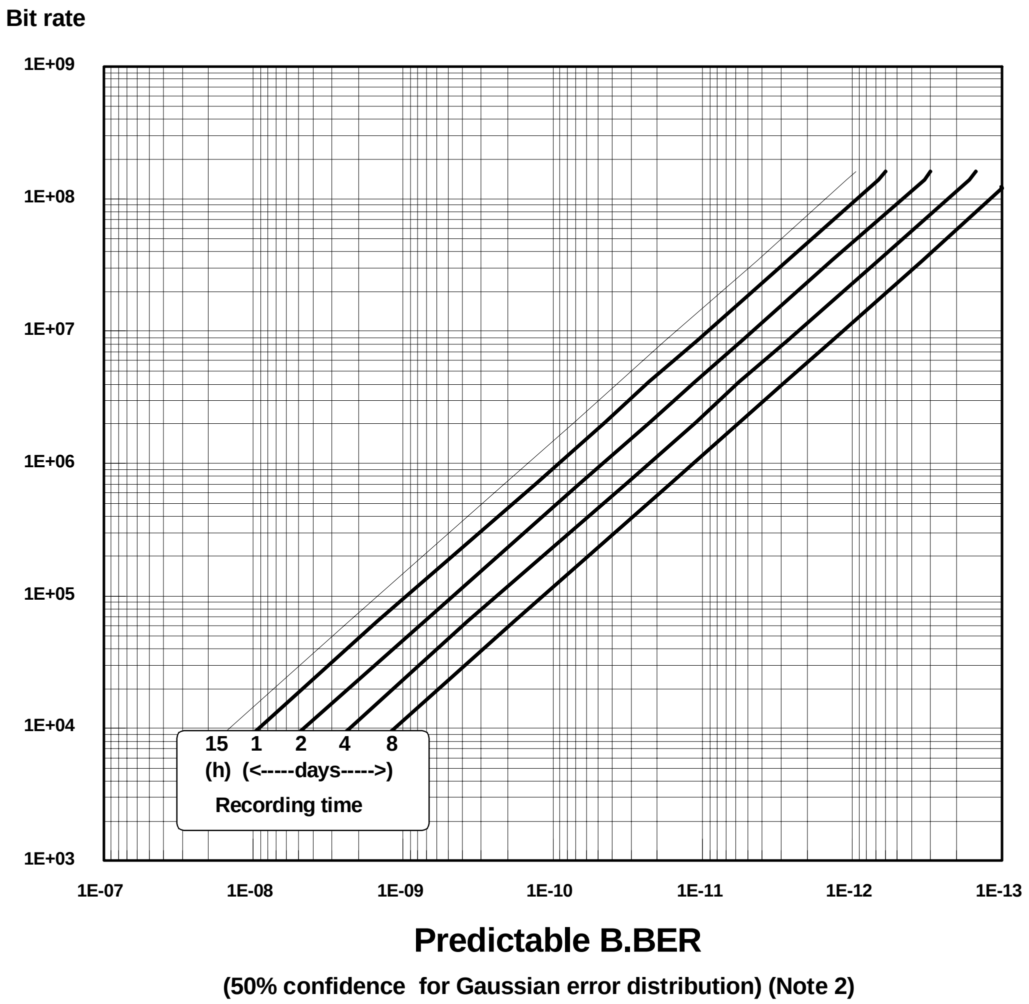
ITU-R Recommendation F.634-4 [1] reports a provisional method for in-field evaluation of BBER.

The standardized value may vary with the transmission bit rate and a suitable method for type test evaluation may be also suggested (e.g. number of errors or errored blocks within a suitable time period).

As a matter of fact the average time needed to measure BBER with 50 % confidence on a statistical "Gaussian" base is:

$$t[h] = \frac{k}{\mathrm{BBER} \times (\mathrm{Bit\ rate}) \times 3600}$$

where k is a factor for due confidence of the measurement.



NOTE 1: Confidence: 50 % of BERmeas. ≤ BBER.
46 % of BBER ≤ BERmeas. ≤ 2 x BBER.
3 % of 2 x BBER ≤ BERmeas. ≤ 3 x BBER.
≤ 1 % of BERmeas. ≥ 3 x BBER.

NOTE 2: For non-gaussian (burst) error distribution, about same confidence may be obtained by multiplying these figures for the average coding/mapping/FEC errors-per-burst induced on the measuring port.

Figure B.9: result for 50 % confidence on a gaussian error distribution base

This time, when codes/scramblers/FECs may produce non-gaussian errors distribution, should be even more increased by a factor typically equal to the average error number in error bursts induced on the measuring port (because, in this case, the burst distribution only is gaussian).

These measuring times have an impact on the type approval/conformance tests, which, for the lowest bit-rates, may not be practically performed if the required BBER is too low.

The following solutions may be used:

- fix the required BBER on the base of a reasonable test time;
- when FEC is implemented, its activity may be recorded and BBER estimated by a law, stated by the manufacturer, which effectiveness may be verified, at suitable higher BER points, by the body which performs the test.

B.5.5.3 Interference sensitivity

The determination of interference sensitivity is necessary for frequency co-ordination when the standardized equipment is used in field.

If the radio system works on a co-channel band reuse frequency plan and makes use of XPIC (cross Polar Interference Canceller) in order to reduce the interference from its twin cross-polarized system, two different types of co-channel behaviour may be defined; one from any "external" completely un-correlated source (which does not benefit of XPIC improvement), and another "internal" to the system from the twin system (on which XPIC is active).

"External" co-channel interference is the basic performance which depends from the modulation format only (the use of error correction techniques may also have slight influence) while the "internal" one strongly depends on the XPIC design.

XPIC may be used to combat de-polarization effects caused by multipath propagation and/or rain attenuation. The XPIC behaviour is proposed to be described by three characteristic values:

1) the asymptotic (or residual) XPD which is the limiting value of C/I achieved at the output of the XPIC for large values of C/I at the receiver inputs;

2) the XPD improvement factor XIF in case of flat cross-talk and co-channel fading (rain model);

3) the XPD improvement factor XIF in case of dispersive co-channel fading and dispersive cross-talk (multipath model).

Adjacent (at one or more channel spacing) channel interference performance shall be congruent with the spectrum mask of the interfering signal (see background to subclause 5.3.5) and, vice versa, specific requirements on adjacent (at one or more channel spacing) channel interference performance shall be reflected in the interfering transmitter spectrum mask.

The limits are given in a table form for 1 dB and 3 dB threshold degradation versus like modulated C/I ratio in order to give clear point of measurement for conformance-testing; for frequency co-ordination purposes intermediate values shall be recorded in an informative annex.

CW interference sensitivity may also be required in order to verify a minimum rejection, on a very wide band basis, of the possible frequency(ies) which may be sensitive for the equipment under test (e.g. harmonics, sub-harmonics, shifter and IF related frequencies).

B.5.5.3.1 Front-end non-linearity requirements (two-tone CW spurious interference)

The introduction of frequency and rate agile radio relay system opens up the risk for non-linear effects in the receivers. In order to assure that such effects need not to be considered at the frequency planning of radio network, a two-tone requirement is needed. The intention of this requirement is to represent worst case conditions, with respect the interference levels and frequencies.

B.5.5.4 Distortion sensitivity

The concept of "signature" of a radio receiver has been introduced by Bell Research Labs in the late 1970s.

It is not the only one that may be used to characterize multipath propagation, however it is the most practical for a laboratory simulated hop measurement.

The delay of the two rays is usually as 6,3 ns, due to the fact that the original Bell Research Labs experimental hop Atlanta-Palmetto, where the theory was produced, shows practical distortions well approximated by a two rays model with that delay. On different hops, this delay is expected to be different in a range of few ns. However, for uniformity of results, the 6,3 ns delay has been widely used as reference for equipment characterization.

In principle, the measurements should be made applying a two rays fade simulator at RF level; however, as a consequence of the intrinsic RF to IF down conversion linearity, the measurement is usually made by IF fade simulator, provided that suitable IF section points be provided on the equipment; a lot of standard IF instruments are now available on market.

B.5.6 System characteristics with diversity

Diversity techniques are to be used for performances and/or availability requirement.

This subclause is therefore optional.

B.5.6.1 Differential delay compensation

When space diversity is used the antenna spacing follows the well known empirical formula D > 2 000 λ_0 which lead to a path delay difference between the two signals of the order from few to some tenths of meters corresponding to a differential time delay.

This difference shall be re-equalized before the RF, IF or BB combiner to avoid producing a multipath-like distortion on the combined signal.

A minimum delay recovery capability, which is higher for the lower frequency bands, has to be foreseen.

B.5.6.2 BER performance

When combining in phase two equal coherent signals a gain of 6 dB is obtained, while adding the two incoherent receiver noises the total only increases by 3 dB.

As a consequence a theoretical gain of 3 dB on the S/N ratio and RSL is obtained with respect to a single reception; nevertheless, in practical applications, slight difference may arise (e.g. when digital control of discrete phase steps is applied).

When the selection of signals coming from different antennas is made through a baseband switch, no improvement is expected.

B.Annex A:
Annex A - Essential requirements for the EC Council Directive 89/336 (EMC Directive)

When the standard is requested of being harmonized under the EMC directive 89/336 EC the table shall point to the relevant essential parameters clauses contained in the EN.

B.Annex B:
Annex B - System type codes for regulatory procedures

For facilitating the identification of the system parameters and avoiding confusions during the licensing procedure, Administrations requires a unique system type code similar to that adopted by ERC in ERC Decisions for TM4 standards.

B.Annex C:
Additional Information

Subclauses 5.5.3.1 and 5.5.3.3 required, for conformance test purpose, only points at 1 dB and 3 dB degradation point, however field problematics require a wider range of values.

The requirements of subclauses 5.5.3.1 and 5.5.3.3 should be given in a graphical format to aid frequency co-ordination problematics.

History

Document history		
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