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Technical Report

**Transmission and Multiplexing (TM);
Digital Radio Relay Systems (DRRS);
Generic wordings for standards on DRRS characteristics;
Part 1: General aspects and point-to-point equipment parameters**

European Telecommunications Standards Institute

Reference

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Contents

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Foreword

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

It is designed to provide the generic wording for standards (ETSs and ENs) produced by ETSI WG TM4, concerning 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 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 DRRS 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 DRRS 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

For the purposes of the present document, the following references have been used:

[1] ETSI handbook: "Guide to the application of PNE rules to the drafting and presentation of ETSI Standards" (this is now contained within the ETSI Rapporteurs survival guide [3]).

[2] CEN/CENELEC Internal Regulations, Part 3: "Rules for the drafting and presentation of European Standards (PNE-Rules); Edition 1991-09".

[3] ETSI Rapporteurs survival guide.

[4] DEN/TM-04026: "Transmission and Multiplexing (TM); Conformance testing of Digital Radio Relay Systems (DRRS)".

NOTE: Reference [3] has now been replaced with "Making the ETSI deliverable template work for you".

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

3 Definitions

For definitions relevant to conformance test requirements and test typology refer to DEN/TM-04026 [4].

4 Basis for reference

a) Annex 1 contains the issues to be considered when producing a DRRS standard. These include:

- generic text, for **<u>normative</u>** requirements, to be used, under that item, in every new standard regarding 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 content of annex 1 shall be used to draw up ETSs and ENs on DRRS equipment characteristics, unless the argument to be dealt with is not thereby covered.

b) annex A gives additional information for some DRRS characteristics, which are usually not the subject of standardization, but are however referred to for additional information.

c) Informative annex 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.

Annex 1: Text for the standardized items

NOTE: The ETSI Secretariat supplies a handbook "Making the ETSI deliverable template work for you" 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 handbook is read in conjunction with this document.

1 Scope

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

However specific sentence on safety aspects shall be made as:

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

2 Normative references

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or

b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or

c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or

d) publications without mention of a specific version, in which case 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 case of d) above, 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 this *ETS/EN* 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.

General ETSI and/or IEC and/or ISO normative on drawing ETSs/ENs, if any, should be placed here. *A list, with bookmarks, of the relevant normative references shall follow (as example):*

[1] ITU-R Recommendation F.634: "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-relays 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.697-1: "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: "Radio-frequency channel arrangements for radio-relays systems".

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

[7] ITU-R Recommendation F.1093: "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-relays systems below about 17 GHz".

[9] ITU-R Recommendation F.1102: "Characteristics of digital radio-relays systems above about 17 GHz".

[10] ITU-R Recommendation F.1092: "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: "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 27500 km hypothetical reference path".

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

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

[14] ITU-R Recommendation F.1191: "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 (1988): "Error performance of an international digital connection forming part of an integrated services digital network".

[17] ITU-T Recommendation G.826 (1993): "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] ITU-T Recommendation V.11: "Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s".

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

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

[22] prETS 300 339: "Radio Equipment and Systems (RES); General Electro-Magnetic Compatibility (EMC) for radio equipment".

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

[24] EN 300 631: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Antennas for point-to-point radio links in the 1 GHz to 3 GHz band".

[25] prETS 300 833: "Transmission and Multiplexing (TM); Radio relay equipment; Antennas used in point-to-point radio-relay systems operating in the frequency band 3-60 GHz".

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

[27] 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".

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

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

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

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

[32] prETS 300 645: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH) radio relay equipment; Information model for use on Q-interfaces".

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

[34] ITU-T Recommendation G.704 (1991): "Synchronous frame structures used at primary and secondary hierarchical levels".

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

[36] ITU-T Recommendation G.781 (1994): "Structure of Recommendations on equipment for synchronous digital hierarchy (SDH)".

[37] ITU-T Recommendation G.782 (1994): "Types and general characteristics of synchronous digital hierarchy (SDH) equipment".

[38] ITU-T Recommendation G.783 (1994): "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".

[39] ITU-T Recommendation G.957 (1995): "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] DEN/TM-04040: "Transmission and Multiplexing (TM); Generic standard on unwanted emissions and receiver immunity at antenna ports of Digital Radio Relay Systems (DRRS)".

[42] DES/TM-04010: "Transmission and Multiplexing (TM); High capacity Digital Radio Relay Systems (DRRS) carrying Synchronous Digital Hierarchy (SDH) signals (1xSTM-1) in frequency bands with about 30 MHz channel spacing and using co-channel (orthogonal) arrangements".

[43] DEN/TM-04026: "Transmission and Multiplexing (TM); Conformance testing of Digital Radio Relay Systems (DRRS)".

3 Definitions, symbols and abbreviations

No standard text is given; the following is an example of the standard layout.

NOTE: Only include those definitions, abbreviations and symbols used in your document.

3.1 Definitions

These should be inserted in the following format: definition: (space) Text. For example:

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

definition: This is a definition.

3.2 Symbols

These should be inserted in the following format: symbol (tab) text. *For instance*:

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
ppm	parts per million
ns	nanosecond
mW	milliWatt

3.3 Abbreviations

These should be inserted in the following format: abbreviation (tab) text. *For instance*:

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

ATPC	Automatic Transmit Power Control
BB	Base Band
BER	Bit Error Rate
BWe	Evaluation bandwidth
CCIR	see ITU-R
CCITT	see ITU-T
CEPT	Conférence des Administrations Européennes des Postes et Télécommunications
EN	European Norm
ETS	European Telecommunications Standard
ETSI	European Telecommunications Standards Institute
IF	Intermediate Frequency
IPI	Inter Port Isolation
ITU-R	International Telecommunication Union-Radiocommunication sector (previously CCIR)
ITU-T	International Telecommunication Union-Standardization sector (previously CCITT)
LO	Local Oscillator
MSOH	Multiplex Section OverHead
NFD	Net Filter Discrimination
NNI	Network Node Interface
PDH	Plesiochronous Digital Hierarchy
PRBS	Pseudo Random Binary Sequence
RES	Radio Equipment and Systems
RF	Radio Frequency
RFC	Remote Frequency Control
RL	Return Loss
RS	Receive Signal level
RSOH	Regenerator Section OverHead
RTPC	Remote Transmit Power Control
Rx	Receiver
SDH	Synchronous Digital Hierarchy
S/I	Signal to Inteference ratio
S/N	Signal to Noise ratio
SOH	Section OverHead
TC	Technical Committee

TM	Transmission and Multiplexing
TMN	Telecommunications Management Network
TX	Transmitter
WG	Working Group
W/U	Wanted to Unwanted ratio
XPD	Cross-Polar Discrimination
XPIC	Cross-Polar Interference Canceller
XPIRF	Cross-Polar Interference Reduction Factor

4 General characteristics

4.1 Frequency bands and channel arrangements

4.1.1 Channel plan

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 plan shall be in accordance with *ITU-R; CEPT or other references [Reference to be made to clause 2] with description of relevant channel spacing, alternated/co-channel arrangement, basic rasters (if any), reference frequency etc. The channel plan is given in figure A.1.*

The centre gap shall be *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 reference to "approximately half of the allocated frequency band" or any other motivated duplex frequency separation definition.*

4.1.2 *Co-polar (or alternated or interleaved)* channel spacing for systems operating *on the same antenna/branching or on different polarization of the same antenna or on different antennas* on the same route

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

Table 1: Channel spacings for particular bit rates

Payload bit rate (Mbit/s)	....	*2*	*2 × 2*	*8*	*2 × 8*	*34*	*51*	*140 and 155*	....
Channel spacing (MHz)	....	....	....	....	....	....	....	....	....
NOTE: n × 2 Mbit/s bit rates may be used where appropriate.									

4.2 Compatibility requirements between systems

One or more of the following statements will be applicable:

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

- *there shall be (or there shall not be)* a requirement to multiplex different manufacturers equipment on the same polarization of the same antenna;
- *there shall be (or there shall not be)* a requirement to multiplex different manufacturers equipment on different polarization of the same antenna;
- depending on the application, it shall be possible to operate the system in vertical and/or horizontal polarization, if required by the channel arrangement;
- 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 [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 [1], F.695 [2], F.696-1 [3], F.697-1 [4], F.1092 [10] and F.1189 [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 [6], F.1093 [7], F.1101 [8], F.1102 [9] and F.1092 [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 [26] 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 [26] classes 3.1 and 3.2 respectively.

Optionally, the more stringent requirements of ETS 300 019 [26] 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 [26], 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 [27] and ETS 300 132-2 [28].

NOTE: Some applications may 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.

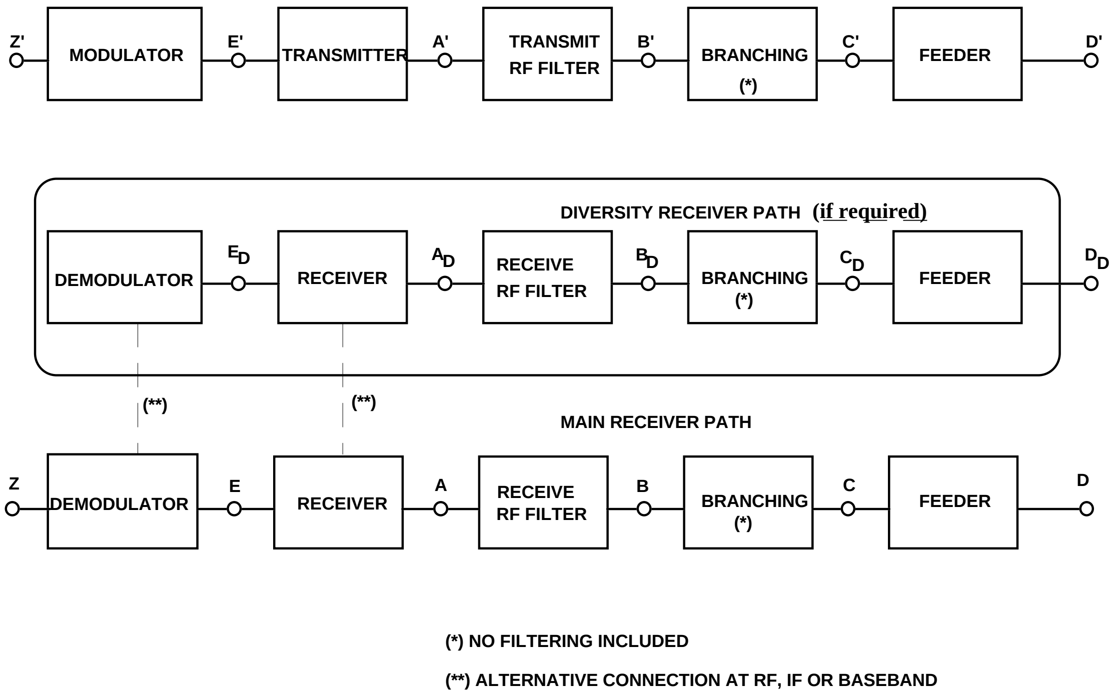
4.6 Electromagnetic compatibility

One or both of the following statements will be applicable:

- Equipment *with capacity of about 2Mbit/s and above* shall operate under the conditions specified in ETS 300 385 [18].

- For *lower capacities* the subject is under study, however ETS 300 339 [22] shall apply on provisional basis.

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 [30] and G.773 [31] and ITU-R Recommendations F.750 [12] and F.751 [13] give the general requirements for TMN interface and functionality; ETS 300 635 [29] and ETS 300 645 [32] 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 TM2, and will be applicable to the radio relay systems considered in this ETS.

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:

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

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.

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

5 Parameters for digital systems

5.1 Transmission capacity

Payload bit rates(s) considered in this *ETS/EN* 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 (sub-STM-1), 139,264 Mbit/s, 155,520 Mbit/s (STM-1), or other capacities. System rates configured as n × 2 Mbit/s are also considered.*

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

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 this ETS/EN.

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 [34], I.412 [33] and ETS 300 233 [23].

5.2.3 Data channel baseband interface

The characteristic of any non-G.703 data interfaces should be given here (see ITU-T Recommendations V.11 [19], V.24 [20] and V.28 [21]).

5.2.4 SDH baseband interface

The SDH baseband interface shall be in accordance with ITU-T Recommendations G.703 [15], G.707 [35], G.781 [36], G.782 [37], G.783 [38], G.784 [30] and G.957 [39] (with possible simplifications under study in ETSI TM3 and TM4) and ITU-R Recommendation F.750 [12].

Two STM-1 interfaces shall be possible:

- CMI electrical (ITU-T Recommendation G.703 [15]);
- 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 ETSI TM4 document (report on SDH aspects TM4(93) 63 annex 1).

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) not considering Automatic Transmit Power Control (ATPC), unless ATPC is considered a fixed feature, shall be in the range *+X to +Y dB*m.

NOTE 1: The manufacturer will state, in the conformance test, if ATPC is optional or fixed feature.

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

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).

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.

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 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 an STM-1 test signal to be defined.*

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.

Since, for spectrum analyser distortion and sensitivity limits, it is not possible to measure attenuation values up to *Y dB* directly, values in figure 2 lower than e) limit shall be verified by adding a measured filter characteristic to the spectrum at A'.

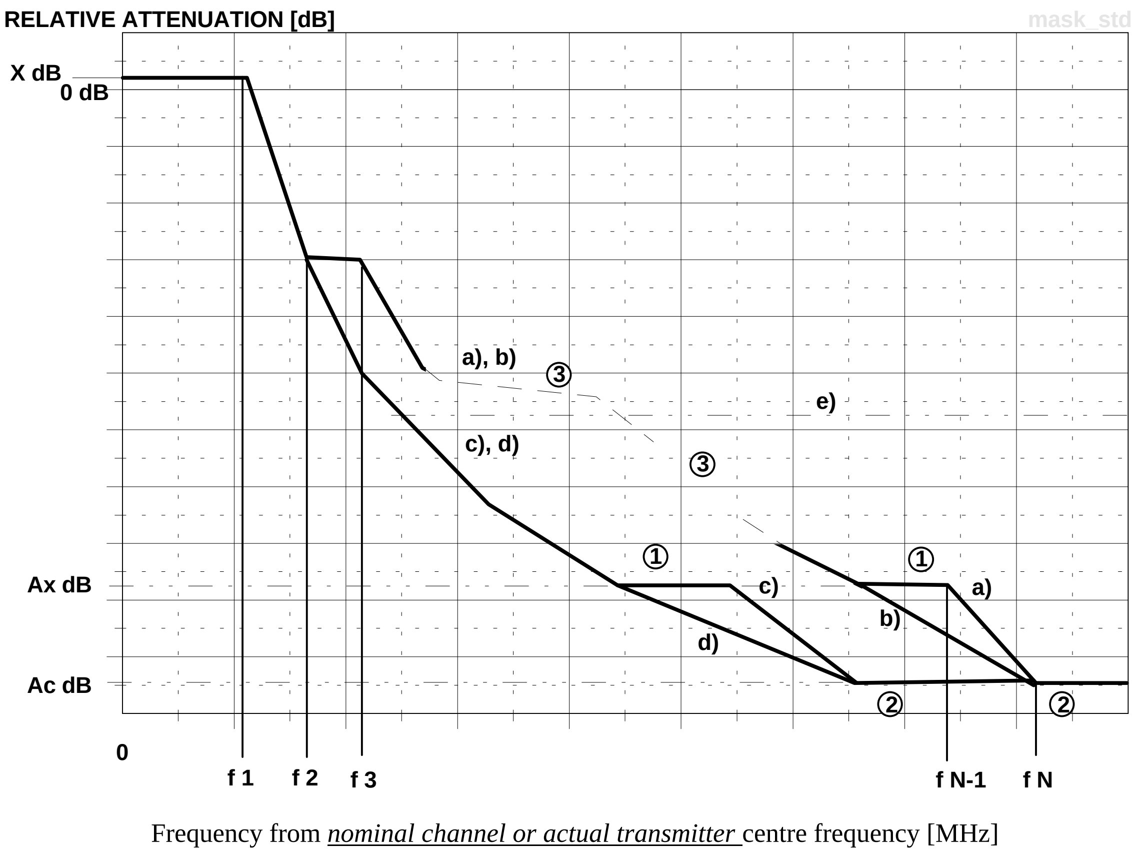
NOTE 2: The minimum level e) in the mask(s) of figure 2 is indicative of the available sensitivity on most common spectrum analysers; this limit may be improved if a better instruments will become available on the market. In this case the manufacturer may state a new measurement limit (which result in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

The spectrum analyser settings for measuring the RF spectrum mask detailed in figure 2 are shown in the table 3 below.

Table 3 shows the recommended spectrum analyser settings *for measurement on a band ≤10 Fs across centre frequency, for wider band measurement an Intermediate Frequency (IF) bandwidth of 1 MHz and a video bandwidth of 10 kHz may be used.*

Table 3: Spectrum analyser settings for RF power spectrum measurement (*under study*)

Symbol frequency	Mbaud	≤ ...	≤0,03	≤0,1	≤0,3	≤1	≤3	≤10	≤30	≤100	≤...
Centre frequency		fo	fo	fo	fo	fo	fo	fo	fo	fo	fo
Sweep width	MHz	...	0,2	0,5	2	5	20	50	200	500	...
Scan time		auto	auto	auto	auto	auto	auto	auto	auto	auto	auto
IF bandwidth	kHz	...	1	3	3	10	30	30	100	100	...
Video bandwidth	kHz	...	0,03	0,03	0,1	0,1	0,1	0,3	0,3	0,3	...



KEY:
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: 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 ETSs/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

Bit Rate	Channel Spacing	f 1	f 2	f 3	....	....	f N-1	f N
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....

NOTE: f N is *equal to or higher than* 250 % of relevant channel spacing, because the system operation *does not require or requires* spectrum limitation above this limit.

5.3.6 Spectral lines 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*.

Other unwanted emissions at distance from transmitter centre frequency equal to multiples of the symbol rate shall fall within the spectrum mask provided by subclause 5.3.5.

5.3.7 Spurious emissions

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

a) to limit interference into systems operating wholly externally to the system channel plan (external emissions);

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 where the specific limits given for 'internal' interference are required to be no greater than the 'external' level limits at reference point B' f*or indoor systems and C' for outdoor systems (where a common Tx/Rx duplexer is used).*

5.3.7.1 Spurious emissions - external

According to ITU-R Recommendation F.1191 [14], the external spurious emissions are defined as emissions at frequencies which are outside the nominal carrier frequency ±250 % of the relevant channel spacing.

When DEN/TM-04040 [41] is finalized, it shall be used as reference for the level limits till an official standardization will be issued by CEPT. In the meantime refer to the limits stated below, which have been used in the already published ETSs.

Meanwhile the frequency range in which the spurious emission specifications apply is 30 MHz to *twice the upper frequency band limit.*

NOTE: When a waveguide is used between reference point A' and C', which length is higher than twice the free space wavelength of cut-off frequency (Fc), the lower limit of measurement will be increased to 0,7 Fc and to 0,9 Fc when the length is higher than four times the same wavelength.

The limit values measured at reference point C' are:

30 MHz	to	21,2 GHz	<=-60 dBm
21,2 GHz	to	*twice the upper frequency band limit*	<=-30 dBm

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

Due to the lack of guidance from CEPT on BWe (evaluation bandwidth), for the purposes of this standard the measuring bandwidth will be in the range 100 kHz to 120 kHz up to 21,2 GHz and 1 MHz above this limit, except for equipments occupying a channel spacing of *less than 250 kHz (and/or less than 2,5 MHz)* where the measuring bandwidth shall be reduced *to 3 kHz (and/or to 30 kHz)* within *±1 MHz (and/or ±10 MHz)* of the nominal carrier frequency.

For "noise-like" emissions, the limits are intended not to be exceeded in any elementary measuring bandwidth.

Within the ±250 % of the relevant channel spacing the unwanted emission level shall not exceed the limits fixed by the relevant spectrum mask.

5.3.7.2 Spurious emissions - internal

The levels of the spurious emissions from the transmitter, referenced to reference point B' are specified in table 5.

The required level will be the total average level 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 LO, ±IF, ±2 x IF), evaluated as total signal level	≤ -XX dBm	If spurious signal's frequency falls within receiver half band, for digital systems with multi-channel branching networks
	≤ -YY dBm	If spurious signal's frequency falls within receiver half band, for digital systems without branching networks (i.e. with duplexer)
Other spurious evaluated as in subclause 5.3.7.1	*as required by subclause 5.3.7.1*	If spurious signal's frequency falls within transmitter half band.

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 LO frequency arrangement.*

5.4.3 Spurious emissions

See subclause 5.3.7.

5.4.3.1 Spurious emissions - external

See subclause 5.3.7.1.

5.4.3.2 Spurious emissions - internal

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).

5.4.4 Receiver IF

If, for test and maintenance point purposes, receiver IF frequency(ies) is(are) used, one of them shall be *either 35 MHz or 70 MHz or 140 MHz* in order to allow the use of standard test equipment.

5.4.5 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.

5.4.6 Innermost channel receiver selectivity

To guarantee innermost TX/RX 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 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 below (these levels do not include any hybrid loss).

One of the following statement may also be applicable:

- *when innermost Tx/Rx 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 Tx/Rx 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^{-z}**
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 below, 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 above.

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
bit rate 🡻	Channel spacing MHz🡻				

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 DES/TM-04010 [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**
bit rate ↓	**Channel spacing MHz↓**				

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 DES/TM-04010 [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* below 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**
bit rate ↓	**Channel spacing MHz↓**				

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**
bit rate ↓	**Channel spacing MHz↓**				

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 this *ETS/EN.*

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 this ETS/EN.*

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 (informative): Channel arrangements, antennas and power control

A.1 Radio Frequency (RF) channel arrangement

The relevant radio frequency channel arrangement provided by *related ITU-R, CEPT or other body* is given in figure A.1:

Figure A.1: Radio frequency channel arrangement

A.2 Antenna requirements

TM4 has started activities to standardize antennas radiation patterns and integral antennas will be described in ETS 300 631 [24] and ETS 300 833 [25].

A.2.1 Antenna radiation patterns

One of the following statement is applicable:

- for equipment on which the antenna forms an integral part, the radiation pattern should be in accordance with *ETS 300 631* [24] *or ETS 300 833 [25];*
- for equipment on which the antenna forms an integral part, the antenna radiation pattern shall be within the envelope given in figure*(s) A.2A ÷ A.2N .for Type A ....and Type N antennas respectively. Type A antennas are intended for application where (motivation here) is required, ...and type N antennas are intended for application where (motivation here) is required.*

Figure A.2A: Type A antenna radiation pattern (under test conditions)

Figure A.2..: Type .... antenna radiation pattern (under test conditions)

Figure A.2N: Type N antenna radiation pattern (under test conditions)

A.2.2 Antenna cross-Polar Discrimination (XPD)

One of the following statement is applicable:

- for equipment on which the antenna forms an integral part, the antenna XPD should be in accordance with *ETS 300 631* [24] *or ETS 300 833 [25];*
- under normal unfaded propagation conditions the antenna XPD value (*within the "X" dB or "Y" degree beam width if relevant for performance considered)* shall be considered as not less than *"Z" dB.*

A.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.*

A.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.

A.3 Automatic Transmit Power Control (ATPC)

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

- to reduce interference between neighbouring systems or adjacent channels of the same system;
- to improve compatibility with analogue and digital systems at nodal stations;
- to improve residual BER or BBER performance;
- to reduce 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.

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.

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).

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

A.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 A.3, A.3.1 *,A.3.2 ......A.3.n*

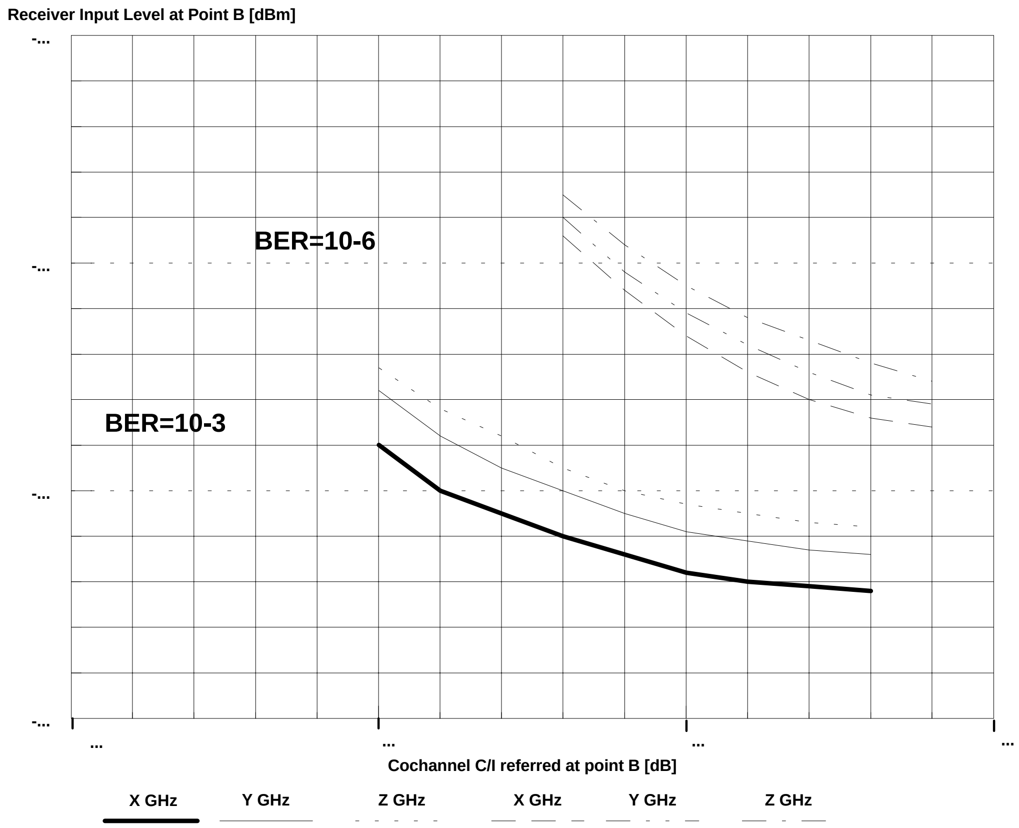


Figure A.3: Co-channel interference threshold degradation

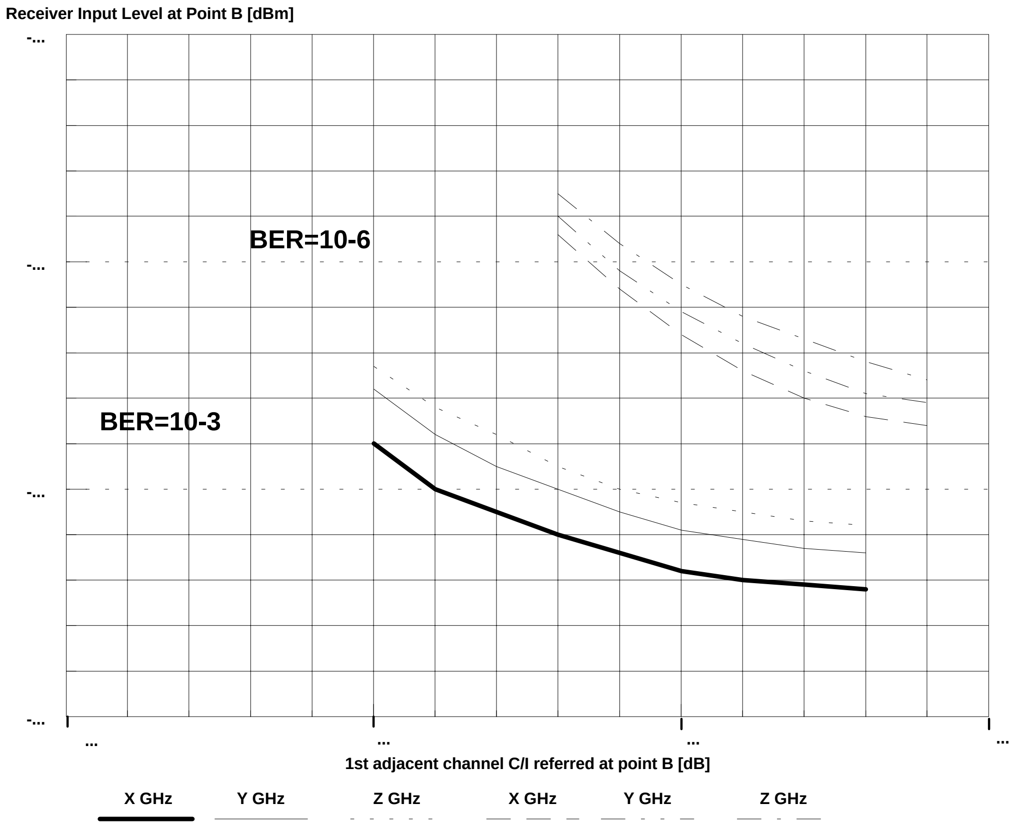


Figure A.3.1: 1st adjacent channel interference threshold degradation

Figure A.3.2: 2nd adjacent channel interference threshold degradation

....

....

Figure A.3.n: Nth adjacent channel interference threshold degradation

Annex B (informative): Background for the standardized items and for the informative annex

B.1 Scope

This bclause 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 DRRS or radio systems in general.

Moreover, being safety aspects not included in the ETSI term of reference, safety requirement for equipment shall be explicitly excluded by any ETS or EN.

B.2 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.

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

Remember, it is particularly important to include an issue date 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 ETS/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 plan

This subclause gives the frequency range(s) for the equipment subject to the ETS/EN, together with references to the relevant ITU-R Recommendations and/or CEPT or other applicable documents, and a description of the main features of the channel plan(s).

For channel plans definition and background see ITU-R Recommendation F.746 [5].

B.4.1.2 Co-polar (or alternated) channel spacing for systems operating on the same antenna/branching or on different polarization of the same antenna or on different antennas on the same route

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

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) 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 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.697-1 [4]), medium grade (ITU-R Recommendation F.696-1 [3]) or high grade (ITU-R Recommendations F.634 [1] and F.695 [2]) for ITU-T Recommendation G.821 [16] based networks or national portion (ITU-R Recommendation F.1189 [11]) and international portion (ITU-R Recommendation F.1092 [10]) for ITU-T Recommendation G.826 [17] based networks.

These aspects are not directly related to equipment performance to be specified in an ETS/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 this ETS/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 [26].

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 [26].

Although radio-relay engineers would refer to the radio equipment location as "indoor" or "outdoor", ETS 300 019 [26] 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 [26], 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 [26] 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.
ETSs 300 132-1 [27] and 300 132-2 [28] should be used for reference.

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).

The EMC requirement for DRRS of 2Mbit/s and above are 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).

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 RES9 standards, nevertheless TM4 has expressed the opinion that in the present fixed/mobile environment this limit has to be raised to 2 GHz (this matter is also under study by RES9).

For equipment which does not fall in the above ETS 300 385 [18] coverage, the subject of producing other standards should be agreed between TM4 and RES9. In the event of a suitable standard not being available, EMC testing would proceed using the general EMC standard, ETS 300 339 [22] with pass/fail criteria agreed with the notified body.

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

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 ETS, for certification purposes, shall be included in the equipment ETS/EN.

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

TM4 is working on ETS 300 631 [24] and ETS 300 833 [25] which deal with antenna characteristics; as a consequence these may be considered an informative part of radio equipment ETS.

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 ETS 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 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 "nth 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 the 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 shall be within the radio regulation limits.

B.5.3.2 Transmit power and frequency control

B.5.3.2.1 Automatic Transmit Power Control (ATPC)

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 TX/RX circuits during normal propagation, keeping BBER as lower as possible in multi-state 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.

When ATPC is used 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 used on an optional basis or, in some systems, as a fixed feature.

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.

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 may fall outside the frequency band.

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 has provisionally fixed the limit of -60 dBm or -30 dBm (for frequency below or above 21,2 GHz) which is applicable within the band too.

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 TX and RX mixers, may require different implementation depending choices.

B.5.3.5 RF spectrum mask

a1) General considerations

Output spectrum generated by 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 that ITU-R Recommendation F.1191 [14] defines the frequency limits for limitation of unwanted emissions as ±250 % of the relevant channel spacing, the spectrum mask shall be defined, from carrier centre frequency up to a frequency span equal or higher than that.

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.

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

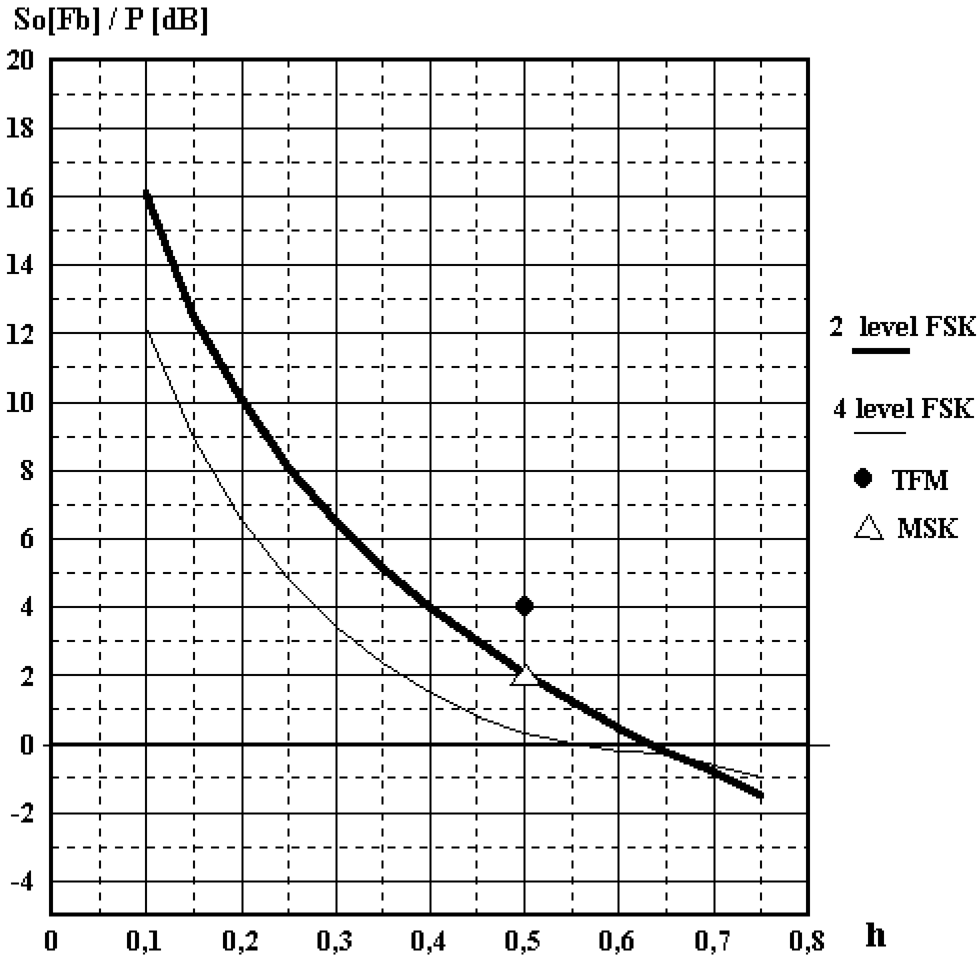


Figure B.1: Normalized spectral density to carrier mean power ratio (at centre frequency in a band equal to the bit-rate)

For practical spectrum analyser evaluation the actual measured value of the ratio is obtained from the value taken by figure B.1 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 [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, 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 Tx/Rx 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:

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

where S(f) is the relative attenuation of the spectrum mask at frequency removed 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:

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

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:

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

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):

$$\text{Threshold degrad}[dB] | (\text{on local Rx}) = 10\log\left\langle 10^{-114+10\log BW[Mhz]} + 10^{I_L} \right\rangle - \left\langle -114 + 10\log BW_n[Mhz] \right\rangle$$

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

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

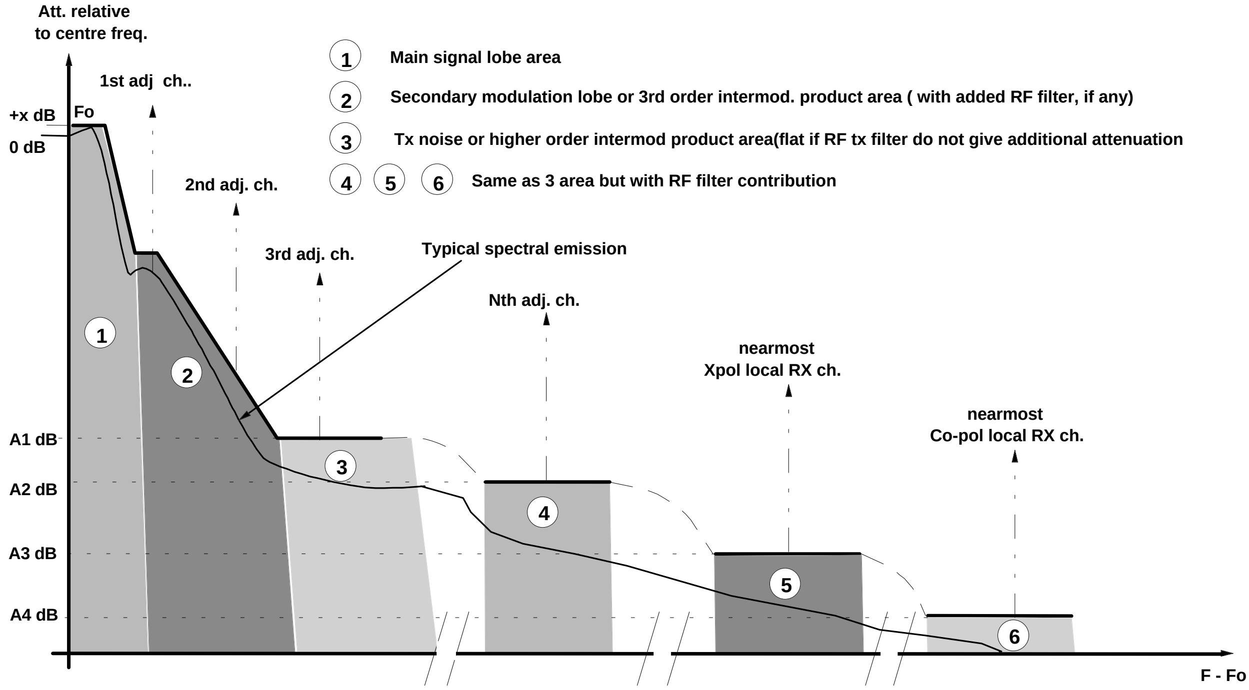


Figure B.2: Emitted spectrum areas (noise-like typical scenario)

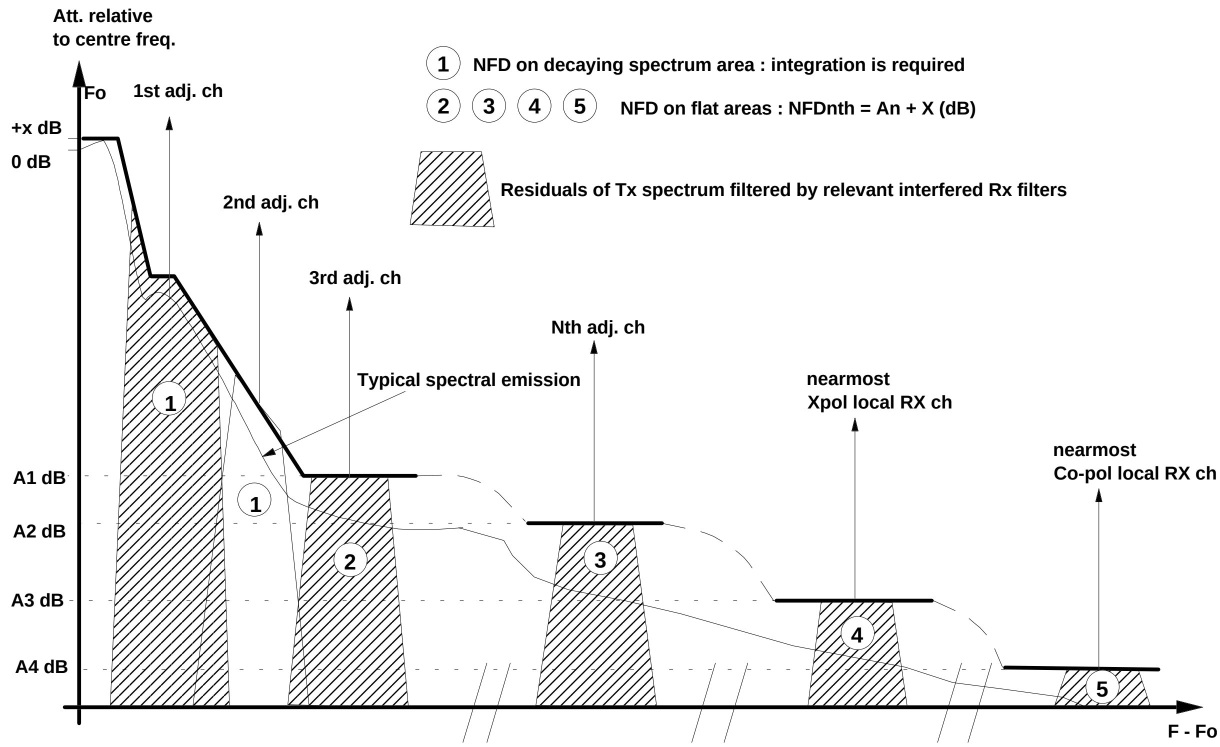
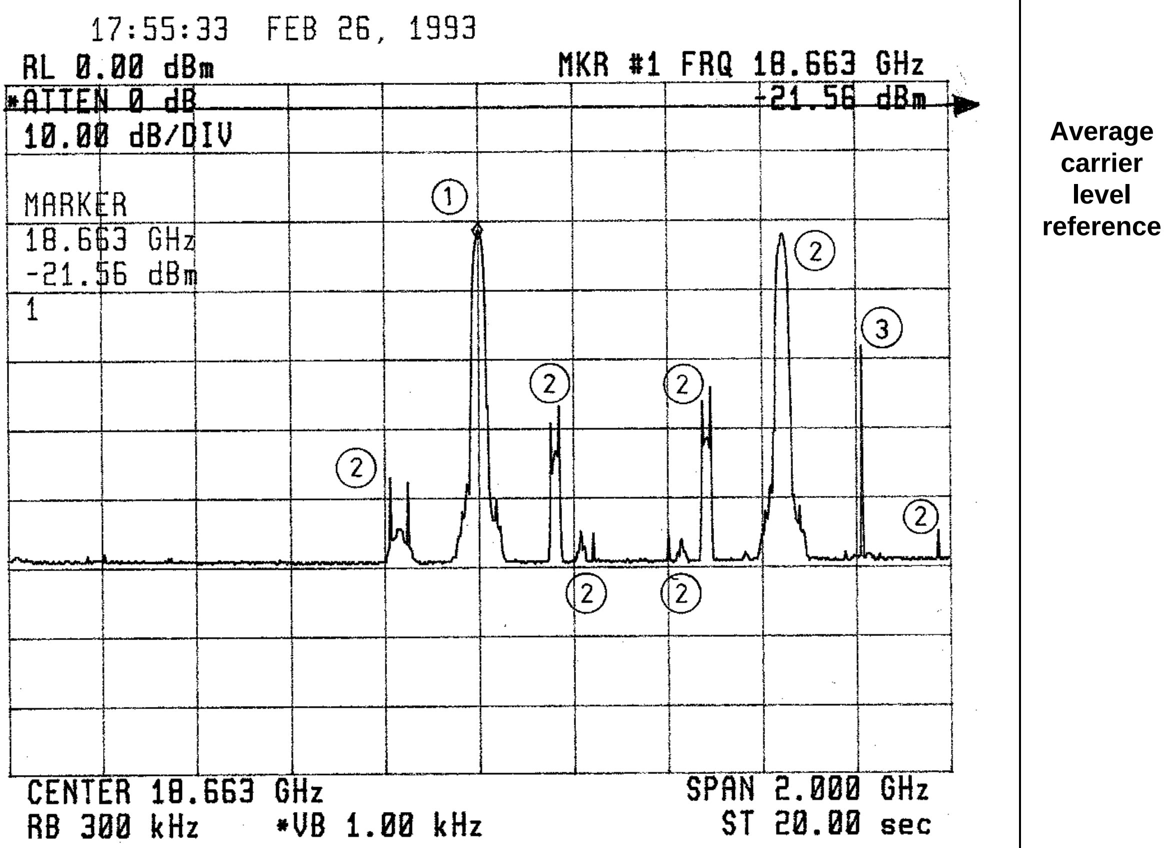


Figure B.3: NFD relationship with spectrum mask

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 DRRS ETSs/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 a better instrument), this noise floor worsens as the frequency increases;
- 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).

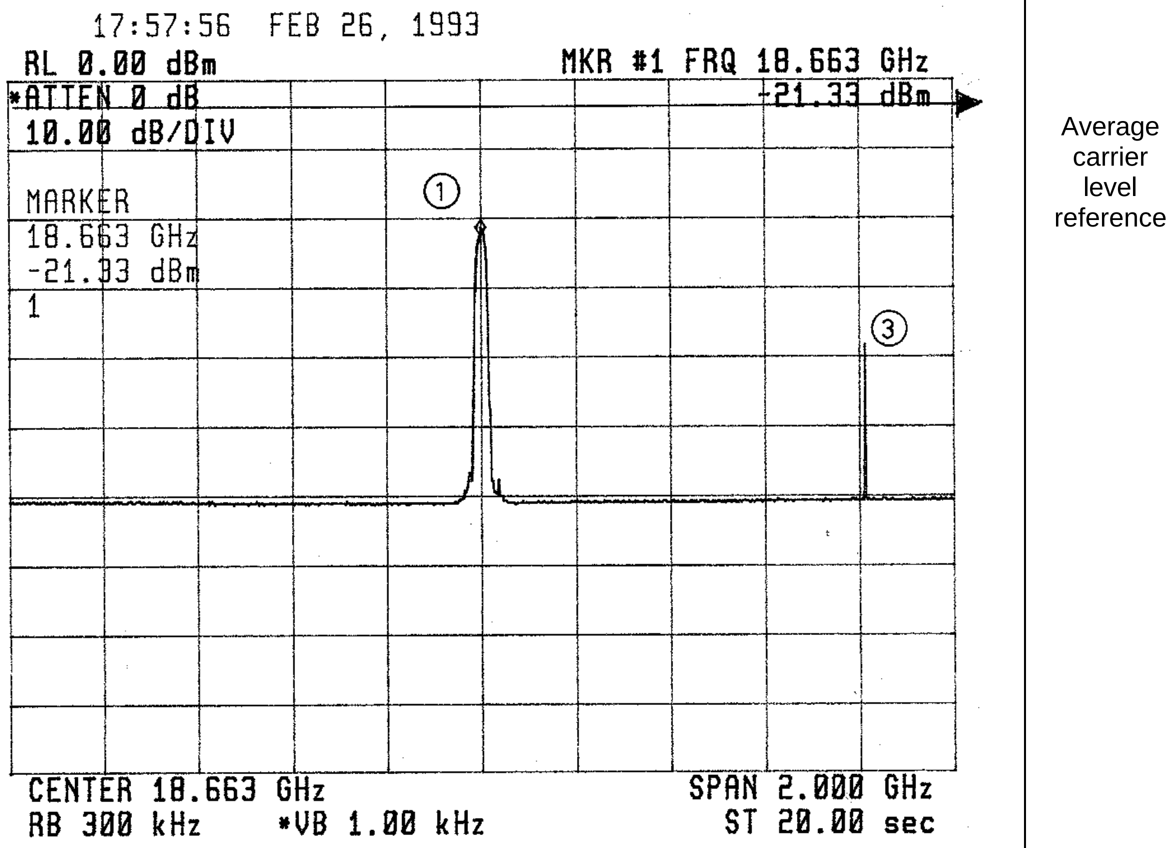


① Main signal spectrum.

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 the spectrum mask shall indicate the measurement limits and the exceeding part shall be measured through alternative measurement (e.g. measurement at reference point A' and adding Tx filter attenuation to estimate the spectrum value at reference point B' or C').

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.

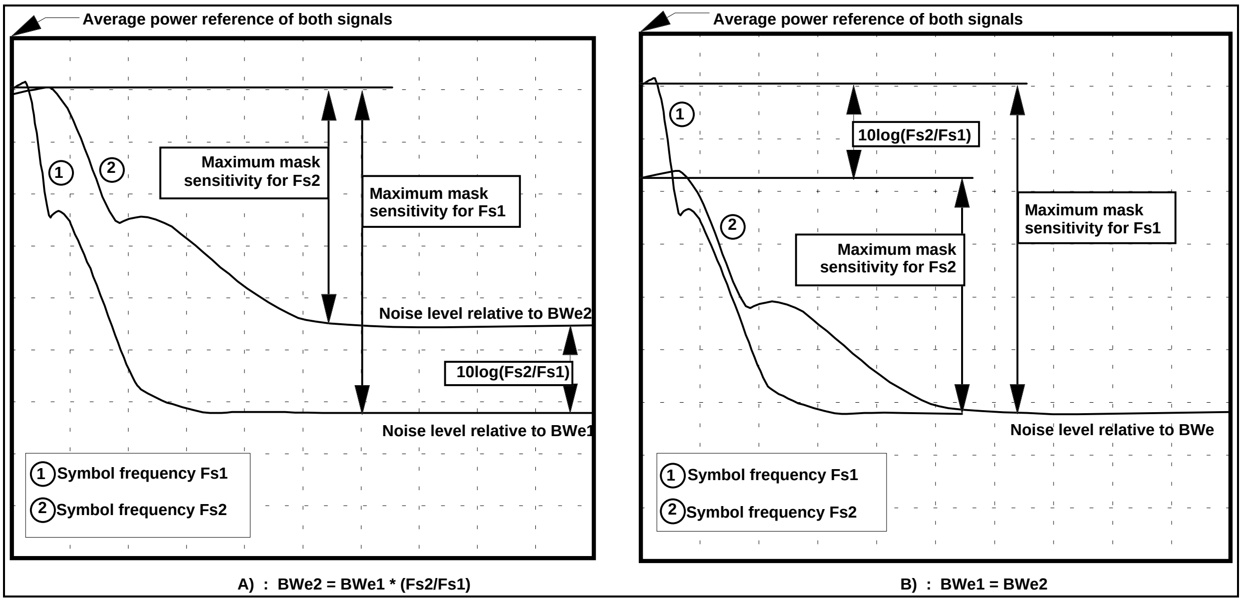


Figure B.6: Example of spectrum measurement results with different F_S and BWe

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 ETS/EN, leaving the third element (sweep time) to be automatically selected by the spectrum analyser in order to maintain calibrated results.

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).

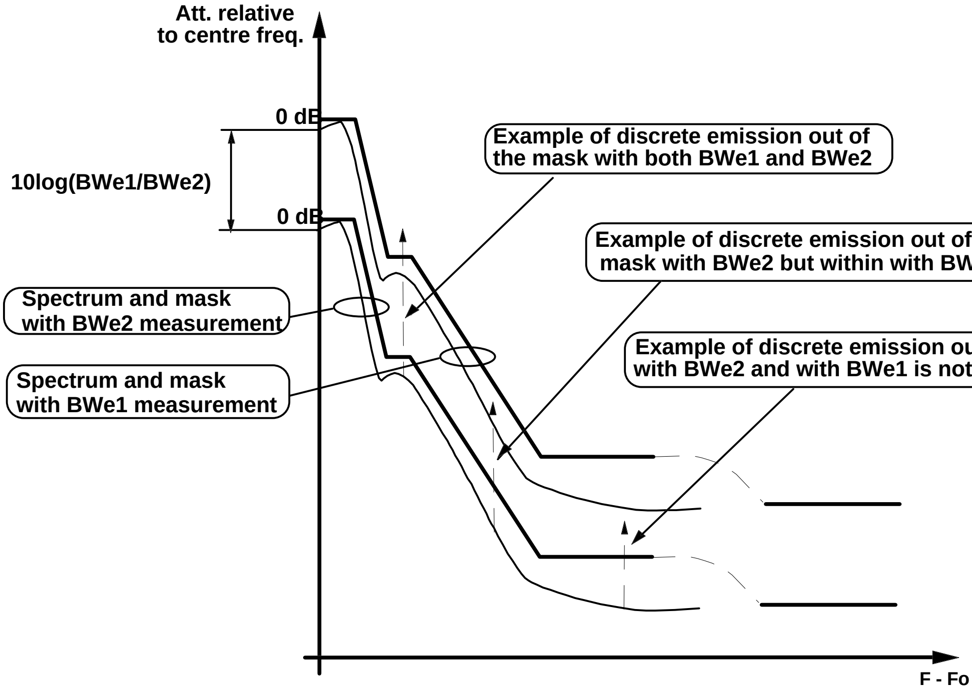


Figure B.7: Impact of BWe in spectrum mask measurement

From this considerations discrete components of unwanted emission (or some of them well identified) may have different absolute level limits (or an attenuation relative to carrier average 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 CEPT normative will fix absolute level limits for emission.

NOTE: Presently a strong practical limitation is present into the proposed CEPT spurious limits because a BWe not provided.

Another approach for discrete components may be to limit them within the spectrum mask, but this means that systems with different Fs 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

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 ETS/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 (DEN/TM-04026 [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 ETS/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 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.

B.5.3.6 Spectral lines 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.5.3.7 Spurious emissions

The general background has already been discussed in subclause B.5.3.5.

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 are reported in ITU-R Recommendation F.1191 [14].

For "external" emissions one input document to CEPT from the UK has proposed the following limits, with the purpose of a measurement with unmodulated carrier:

- 30 MHz to 21,2 GHz ≤ -60 dBm;

- 21,2 GHz to twice the upper limit of the frequency band ≤ -30dBm.

NOTE: Unfortunately no BWe has been stated for the measurement; this have an intrinsic contradiction (e.g. a noise-like emission of 1MHz bandwidth of -58 dBm will result out of limit, meanwhile 1 000 CW emission spaced 1 kHz each one of -62 dBm will be within the limit, while the total power across one MHz will actually be -32 dBm, well above than the limit of -60dBm).

That document gives no reference to the measuring BWe, for the "noise-like" emissions these levels may be considered as the maximum level falling in any elementary measuring BWe, which will be stated in the ETS, disregarding the total amount of the emission itself.

TM4 has started DEN/TM-04040 [41] for defining the suitable limits for radio links correct interworking; the deliverable ETS will be forwarded to CEPT for proper consideration.

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 Tx/Rx 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.

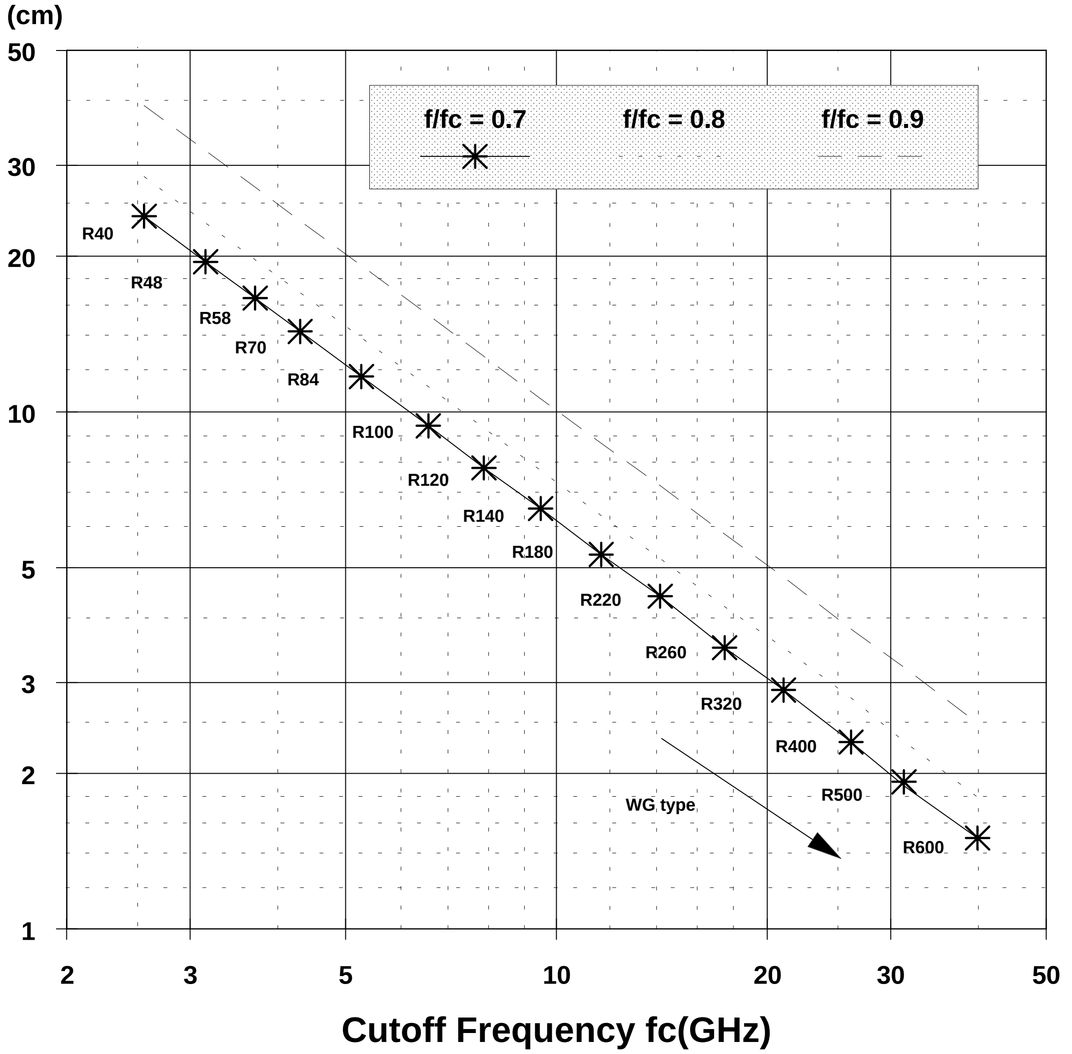


Figure B.8: Cuttoff waveguide length for >80 dB attenuation

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 ETS/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

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 TX and RX 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 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, 70 or 140 MHz). When more than one IF is used (multiple conversion receivers) one may be required to fall upon the standardized ones.
However some highly integrated systems (e.g. for the lower bit rates and when amplitude and group delay distortions are relatively unimportant for the performance of the system) may not have IF external access and/or monitoring points.

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:

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

where D is the Tx/Rx 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 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 Tx/Rx 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 ES % (or the EB %) performance required by ITU-R transmission performance.

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

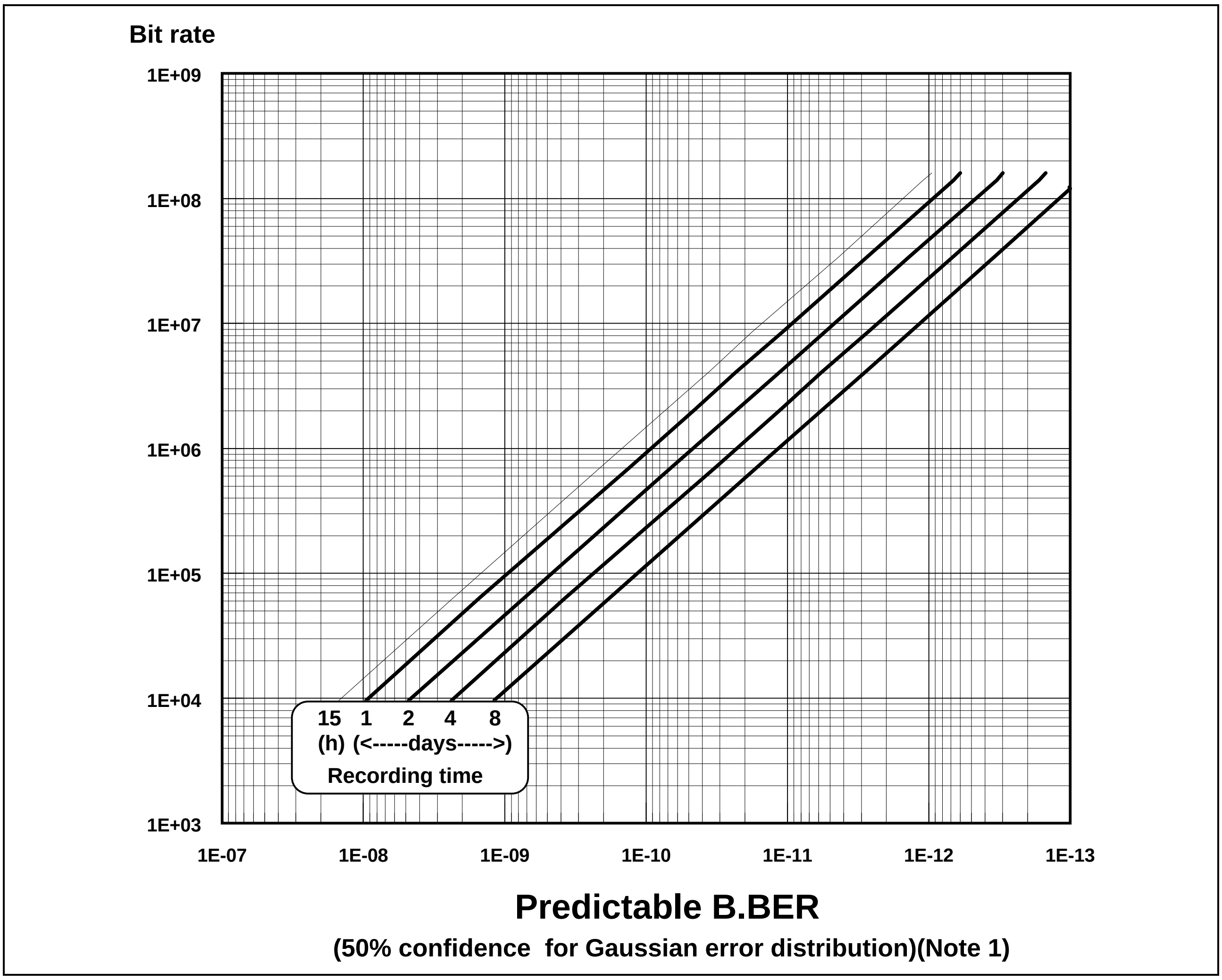
The standardized value may vary with the transmission bit rate and a suitable method for type test evaluation may be also suggested (e.g. number of errors or errored blocks within a suitable time period).

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

$$t[h] = \frac{k}{\mathrm{BBER} \times \mathrm{Bit-rate} \times 3\,600}$$

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

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



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: 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 $D > 2\,000\ \lambda_0$ 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.5.7 Co-channel and adjacent channel Interference

Subclauses B.5.5.3.1 and B.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 B.5.5.3.1 and B.5.5.3.3 should be given in a graphical format to aid frequency co-ordination problematics.

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