



Requirements on signal interferer handling

Reference

DTS/ERM-573

Keywordsinterference analysis, radio, receiver,
requirements, testing**ETSI**

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2019.

All rights reserved.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.

3GPP™ and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

oneM2M™ logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners.

GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Contents

Intellectual Property Rights	5
Foreword.....	5
Modal verbs terminology.....	5
Executive summary	5
Introduction	6
1 Scope	7
2 References	7
2.1 Normative references	7
2.2 Informative references.....	7
3 Definition of terms, symbols and abbreviations.....	8
3.1 Terms.....	8
3.2 Symbols.....	8
3.3 Abbreviations	9
4 Existing RX requirements and Spectrum Efficiency.....	9
4.1 Introduction	9
4.2 Classification of existing RX parameters [i.1]	9
4.2.1 Overview	9
4.2.1.1 Introduction.....	9
4.2.1.2 RX parameters related to sensitivity	9
4.2.1.3 RX parameters related to resilience	10
4.2.2 Receiver Parameters proposed in ETSI EG 203 336	10
4.2.3 In-band RX parameters	13
4.2.3.1 Sensitivity	13
4.2.3.2 Co-Channel rejection	13
4.2.3.3 Dynamic range	13
4.2.3.4 Desensitization (In-band signals).....	14
4.2.4 Adjacent channel RX parameters.....	14
4.2.4.1 Adjacent signal selectivity (first and second adjacent channel)	14
4.2.5 Remote band RX parameters	14
4.2.5.1 Blocking	14
4.2.5.2 Spurious response rejection.....	14
4.2.6 Combined band RX parameters	15
4.2.6.1 Reciprocal Mixing.....	15
4.2.6.2 Intermodulation	15
5 Baseline Receiver parameters	16
5.1 Introduction	16
5.2 Receiver Baseline Sensitivity (RBS).....	16
5.2.1 Definition.....	16
5.2.2 Applicability	17
5.2.3 Limits.....	17
5.2.4 Conformance.....	17
5.3 Receiver Baseline Resilience (RBR)	17
5.3.1 Definition.....	17
5.3.2 Applicability	18
5.3.3 Limits.....	18
5.3.4 Conformance/Testing for compliance with technical requirements.....	19
6 RX conformance tests	19
6.1 Introduction	19
6.2 Conformance test for RBS	19
6.2.1 General.....	19
6.2.2 Test setup.....	19
6.2.3 Test procedure	20

6.3	Conformance test for RBR	21
6.3.1	General	21
6.3.2	Test setup	21
6.3.3	Test procedure	22
7	Summary and conclusion	23
Annex A (informative): Baseline Compliance Criteria		25
A.1	Baseline Compliance Criteria	25
A.2	Receiver Sensitivity	25
A.3	Receiver Resilience (~ selectivity)	26
A.4	Mapping to radiodetermination and RFID systems	27
Annex B (informative): Example: CEN DSRC OBU		28
B.0	Introduction	28
B.1	General	28
B.2	Receiver Baseline Resilience	28
B.2.1	Definition	28
B.2.2	Applicability	28
B.2.3	Limits/Requirements	29
B.2.4	Conformance/Testing for compliance with technical requirements	29
Annex C (informative): Example: Radio determination		30
C.0	Introduction	30
C.1	General	30
C.2	Receiver Baseline Sensitivity	31
C.2.1	Definition	31
C.2.2	Applicability	31
C.2.3	Limits/Requirements	31
C.3	Receiver Baseline Resilience	31
C.3.1	Definition	31
C.3.2	Applicability	32
C.3.3	Limits/Requirements	32
Annex D (informative): RBS and RBR using Power relations		33
D.0	Introduction	33
D.1	RBS	33
D.2	RBR	33
Annex E (informative): Related definitions in Radio Regulations (RR)		35
Annex F (informative): RX parameter mapping from EC		36
	History	37

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

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

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Executive summary

The present document provides a limited set of baseline receiver requirements to address the spectrum efficiency requirements of the RED and provides a sound basis to justify the use of this set in Harmonised Standards to claim presumption of conformity. It addresses the Assessment of Compliance of Documents drafted by the ESOs clause 7 of [i.7].

These baseline receiver requirements were developed based on the findings of ETSI TR 103 566 [i.2], where the signal interferer handling concept from ETSI TS 103 361 [i.3] has been analysed on its applicability for the RED.

An example of a set of two parameters is given in clause 5 of the present document providing guidance for HS development, which can be further refined by the responsible TB.

Baseline comprises the following parameters:

- receiver baseline sensitivity; and
- receiver baseline resilience.

These baseline parameters are put in relation to existing receiver parameters given in ETSI EG 203 336 [i.1].

The present document specifies this baseline parameter concept and the corresponding test and measurement procedures, but it does not specify receiver parameter values. These values should be derived from technical specifications defined by the responsible ETSI Technical Committees (see clause 2.8.2 in [i.8]) and/or the findings of regulatory studies conducted by the relevant bodies like CEPT ECC WG SE or other sources of state of the art requirements.

An example mapping of the baseline parameters to radiodetermination (Annex C) and CEN DSRC Tolling systems (Annex B) is proposed.

RX measurements have to be done in a normal operational environment covering the typical interference scenarios. This operational environment can be derived from the intended use of the device to be tested. The relevant interfering signals can be chosen based on the methodology specified in ETSI TS 103 361 [i.3] where a similar approach has been taken for UWB based devices.

Introduction

Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment (the RED [i.4]) was ratified by the European Parliament at Strasbourg on 16 April 2014. The previous legislation (the R&TTE Directive [i.13]) was repealed with effect from 13 June 2016. The RED came into force on 13 June 2016 with a one-year transition period, during which both the old and new Directives could be used for declaring product compliance. The European Commission requested ETSI to provide harmonised standards in support of the RED in response to Standardisation Request M/536.

The scope of the RED is broader than that of the R&TTE Directive [i.13]. In addition, its Essential Requirements were clarified, especially with respect to receivers. Receiver (RX) parameters were to be included in the standards to support a more efficient use of the spectrum. In Annex F, a current list from DG GROW [i.5] is available mapping receiver parameters from ETSI Guide [i.1] to relevant standards. This list is part of the assessment of compliance of harmonised standards, see clause 7 in *Vademecum Part I* [i.7]. ETSI was required to create new or update its existing harmonised standards accordingly. This task has presented new technical challenges in relation to certain equipment categories, specifically for:

- receive-only equipment;
- radio determination equipment;
- radio equipment operating at frequencies below 9 kHz;
- radio equipment/systems in which the receiver should be tested within the system (e.g. inductive systems).

Some of these challenges have already been addressed by ETSI STF 494 (06/2015 - 03/2016) which developed a new concept for RX requirements and tests for UWB devices, which is documented in ETSI TS 103 361 [i.3].

The subject of efficient use of radio spectrum is broad in scope but the theoretical basis for making statements about spectrum efficiency is lacking. Factors that affect spectrum efficiency include transmit power, modulation rates, receiver sensitivity and robustness to interference as well as medium access mechanisms and data transfer protocols. The present document addresses receiver aspects only. For this purpose, it provides a limited set of applicable baseline receiver requirements that address the spectrum efficiency requirement of the RED. Depending on the choice of parameters, these baseline RX requirements encompass the classical parameters given in [i.1], see also Table 1.

1 Scope

The present document specifies a limited set of baseline receiver requirements aiming to meet the *essential requirements* of Article 3.2 of the Radio Equipment Directive [i.4] by developing provisions for harmonised standards, see clauses 2.8.2 and 2.10.2 in Vademecum Part III [i.8] to support assessment of compliance of harmonised standards, see clause 7 in Vademecum Part I [i.7].

These receiver requirements are related to effective and efficient use of the radio spectrum and not to quality aspects of products.

These baseline receiver parameters are equivalent to the receiver parameter as given in ETSI EG 203 336 [i.1].

2 References

2.1 Normative references

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

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

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

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

Not applicable.

2.2 Informative references

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

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

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

- [i.1] ETSI EG 203 336 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guide for the selection of technical parameters for the production of Harmonised Standards covering article 3.1(b) and article 3.2 of Directive 2014/53/EU".
- [i.2] ETSI TR 103 566 (V1.1.1): "Evaluation status on receiver requirement on Signal interferer handling".
- [i.3] ETSI TS 103 361: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Receiver technical requirements, parameters and measurement procedures to fulfil the requirements of the Directive 2014/53/EU".
- [i.4] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.5] ETSI OCG RED EMCD (19)071009r1: "Revised draft map of receiver parameters by EC".

NOTE: Available at [https://docbox.etsi.org/OCG/OCG_Red-Emcd/05-CONTRIBUTIONS/2019//OCGREDEMCD\(19\)071009r1_Revised_draft_map_of_receiver_parameters_by_EC.zip](https://docbox.etsi.org/OCG/OCG_Red-Emcd/05-CONTRIBUTIONS/2019//OCGREDEMCD(19)071009r1_Revised_draft_map_of_receiver_parameters_by_EC.zip).

[i.6] ETSI EN 300 674-2-2: "Transport and Traffic Telematics (TTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5 795 MHz to 5 815 MHz frequency band; Part 2: Harmonised Standard for access to radio spectrum; Sub-part 2: On-Board Units (OBU)".

[i.7] Ref. Ares(2015)4888382 - 06/11/2015 Commission Staff working document: "Vademecum on European Standardisation in support of Union legislation and policies; Part I: Role of the Commission's Standardisation requests to the European standardisation organisations".

NOTE: Available at <https://ec.europa.eu/docsroom/documents/13507/>.

[i.8] Ref. Ares(2015)4888510 - 06/11/2015 Commission Staff working document: "Vademecum on European standardisation in support of Union legislation and policies; Part III: Guidelines for the execution of standardisation requests".

NOTE: Available at <https://ec.europa.eu/docsroom/documents/13509/>.

[i.9] Recommendation ITU-R SM.332-4: "Selectivity of receivers".

[i.10] ETSI EN 300 676-1: "Ground-based VHF hand-held, mobile and fixed radio transmitters, receivers and transceivers for the VHF aeronautical mobile service using amplitude modulation; Part 1: Technical characteristics and methods of measurement".

[i.11] ERC/REC 74-01: "ERC Recommendation of 1998 on unwanted Emissions in the Spurious Domain".

[i.12] Recommendation ITU-R F.1191: "Necessary and occupied bandwidths and unwanted emissions of digital fixed service systems".

[i.13] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TR 103 566 [i.2] apply.

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI TR 103 566 [i.2] and the following apply:

d_{RBS}	reference distance for the definition of receiver sensitivity
d_{RBR}	reference distance for the definition of receiver resilience
$d_{\text{RBR_int}}$	reference distance for the interfering signal

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TR 103 566 [i.2] and the following apply:

NZIF	using Near-Zero Intermediate-Frequency technology
RBR	Receiver Baseline Resilience
RBS	Receiver Baseline Sensitivity
RED	Radio Equipment Directive
RUT	Receiver Under Test

4 Existing RX requirements and Spectrum Efficiency

4.1 Introduction

Article 3.2 of the RED [i.4] calls of "effective and efficient use of radio spectrum" without providing guidance on the means or methods nor on the criteria to judge such use. Ideally, these criteria should be extractable from the relevant regulatory documents including ECC reports, decisions and recommendations.

In order to assist its Technical Body members with the development of Harmonised Standards, ETSI adopted ETSI EG 203 336 [i.1]. ETSI EG 203 336 [i.1] lists a variety of equipment parameters including many receiver parameters that the TBs should consider in their work. This list is inclusive and does not provide guidance on the applicability of the parameters to different technologies or types of equipment. Specific guidance on the relationship between these parameters and their impact on efficient use of radio spectrum is not given.

Several of the RX parameters given in ETSI EG 203 336 [i.1] and ETSI TR 103 566 [i.2] can be classified into groups of RX parameters covering the same or at least similar RX properties. These parameters are partly specific to a given technology as are the corresponding test suites. In order to make sure that the spectrum efficiency aspects of non-classical receivers are adequately covered, a classification of the existing parameters is needed.

4.2 Classification of existing RX parameters [i.1]

4.2.1 Overview

4.2.1.1 Introduction

In general, two receiver properties contribute to the effectiveness and efficiency of spectrum utilization of a radio system: receiver sensitivity with regard to the wanted signal and receiver resilience with regard to unwanted signals.

In this clause, a classification proposal for existing classical RX parameters is given based on above receiver properties and on the frequency band in relation to the operational frequency band of the system under evaluation.

NOTE: Although antenna parameters determine overall receiver performance, they are not considered here.

4.2.1.2 RX parameters related to sensitivity

Receiver sensitivity is determined by a number of factors, including receiver thermal noise, implementation margins, operating bandwidth, received signal modulation and the resistance to strong unwanted signals. Of these factors, operating bandwidth and signal modulation are fundamental determinants of receiver performance; the other factors are subject to design and implementation considerations. For further details, see clause 4.2.2 below.

4.2.1.3 RX parameters related to resilience

A receiver's performance in the presence of unwanted signals, its resilience, is affected by signals in different frequency bands:

- **In-band RX parameters:** In this class, RX parameters related to in-band effects are summarized. In most cases no additional out-of-band interfering signals are considered in the test suites for these parameters. All interfering signals considered are in-band signals, e.g. a signal from the same type of system in the same band (co-channel rejection) or any other signals (desensitization based on in-band signals).
- **Adjacent channel RX parameters:** In this class, RX parameters are related to effects caused by signals in the neighbour/adjacent channel or more general frequency bands. For channelized systems these are the first and second adjacent channel, for non-channelized systems the related frequency band corresponds mainly to the out-of-band domain up to the spurious domain (250 % rule).
- **Remote band RX parameters:** In this class, RX parameters are related to effects caused by signals in frequency bands with a significant distance from the centre frequency of the system under evaluation. In most cases, these effects are related to frequency bands in the spurious domain, thus 250 % of the operational bandwidth from the centre frequency.
- **Combined band RX parameters:** In this class, RX parameters are related to combined effects of signals in different frequency bands.

For further details, see clause 4.2.3 below.

4.2.2 Receiver Parameters proposed in ETSI EG 203 336

ETSI EG 203 336 [i.1] lists a number of receiver parameters together with testing considerations. These RX parameters are listed in Table 1 below.

Table 1: RX parameters proposed in ETSI EG 203 336 [i.1]

Performance criterion (PC): Objective testable BER, PER, FAR etc. at the edge between go/no-go of the EUT fc: centre frequency of the wanted signal									
	Scenario	Effect	Typical Wanted signal	Unwanted signal	Unwanted signal frequencies	Unwanted signal modulation	Unwanted signal strength	Applicable Classification	Comment
Sensitivity	EUT with counter-part	Minimum possible Rx power to be determined	Representative signal	/	/	/	/	Receiver sensitivity	A minimum sensitivity does not necessarily improve spectrum efficiency; it may improve spectrum efficiency when linked to the Tx power
Co-channel rejection	EUT with counter-part + one unwanted signal	Degradation of performance by a co-channel interferer	Sensitivity + 3 dB degradation	Typically a similar signal within same allocated band	fc	Any modulation	Power of the expected signal at the EUT (depends on use case)		
Adjacent channel selectivity	EUT with counter-part + one unwanted signal	Degradation of performance by an adjacent signals	Sensitivity + 3 dB	Typically a similar signal within same allocated band or in the close OOB domain of the transmitter	e.g. at $f_c \pm \text{OBW}$	modulation of the expected signals	Power of the expected radio user at the EUT (minimum x dBm)	Receiver resilience wrt in-band signals	See note
Blocking	EUT with counter-part + one unwanted signal	Degradation of performance by a remote band signals	Sensitivity + 3 dB	strong signals in remote bands (e.g. spurious domain of the transmitter)	At a minimum of two frequencies (e.g. one test with $f_1=f_c+2,5 \times \text{OBW}$ and one test with $f_2=f_c+10 \times \text{O}$)	CW	Power of the expected radio user at the EUT (minimum y dBm)	Receiver resilience wrt remote band signals	
Intermodulation	EUT with counter-part + two unwanted signals	Degradation of performance (non-linear effect of the amplifier) by two adjacent/remote signals	Sensitivity + 3 dB	Two strong signals at f1 and f2 produce an intermodulation product at fc	f1, f2	One signal CW, the other modulated	Power of the expected radio users at the EUT (minimum a dBm)	Receiver resilience wrt multiple in-band signals	
Spurious response rejection				Image frequencies are hard to be find by measurements without knowledge of the receiver concept (e.g. heterodyne, etc. IF frequency, etc.)				Receiver resilience wrt one or more strong out of band signals	Can be tested with the blocking test when choosing the image frequencies

NOTE: Adjacent channel requirements are applicable to narrow band/channelized systems.

The metric which will be evaluated in the RX test suites is the operational performance of the system under evaluation. In several cases, this is the Bit Error Ratio or Block Error Ratio. Other metrics are possible. An overview is shown in Table 1.

For (Ultra)Wideband systems the same effects at the receiver are covered by the in-band interferer test as described in UWB ETSI TS 103 361 [i.3] under "signal interferer test".

4.2.3 In-band RX parameters

4.2.3.1 Sensitivity

See ETSI EG 203 336 [i.1], clause 5.3.2.

Receiver sensitivity is the ability to receive a wanted signal at a defined input signal level while providing a pre-determined level of performance.

Receiver sensitivity should be included in Harmonised Standards because:

- good sensitivity is generally valuable in minimizing interference as it allows the corresponding transmitter power to be lower for a particular link budget (see note);
- knowledge of sensitivity may also be needed to act as a performance reference point when specifying other parameters;
- knowing the sensitivity of receivers is essential when planning coverage areas for the siting of wide area transmitters, e.g. cellular base stations and broadcast transmitters, or the link budget calculation of fixed links for reaching the expected availability and QoS.

NOTE: In some cases (e.g. in license exempt bands), the receiver sensitivity may follow other considerations possibly suggesting that the "best practice" sensitivity is not worth to be pursued, for example optimum receiver sensitivity might exceed the link budget required for the purposes of reduced immunity to interference (i.e. because sensitivity is often a trade-off with receiver desensitization and/or blocking).

Technical Bodies should specify receiver sensitivity also for integral-antenna equipment (in particular for mobile telephones and communication equipment used in safety of life applications) to ensure that the antenna performance is included in the assessment.

4.2.3.2 Co-Channel rejection

See ETSI EG 203 336 [i.1], clause 5.3.3.

Receiver co-channel rejection is a measure of the capability of a receiver to receive a wanted signal, without exceeding a given degradation, in the presence of an unwanted signal, both signals being at the nominal frequency of the receiver.

When specifying tests for receiver co-channel rejection Technical Bodies should specify the unwanted signal which may be similar to the wanted signal, or an unwanted interfering signal defined in ECC sharing or compatibility studies, or a suitable test signal defined by the relevant ETSI Technical Body.

Technical Bodies may consider specifying additional tests in a Harmonised Standard where the co-channel interfering signal has a frequency offset from the wanted signal (which is on the nominal frequency) in order to evaluate the effect of allowable frequency offsets (see clause 5.2.5 in ETSI EG 203 336 [i.1]).

NOTE: Receiver co-channel rejection is essential to determining the spatial reuse of the same frequency, e.g. in nearby geographic areas or in other sectors/directions in the same node. The primary determinant of the receiver co-channel rejection is the modulation of the wanted signal which determines the minimum Signal to Interference Ratio required for achieving a given level of performance. Contributions to co-channel rejection used for system planning are often complex: factors may include: propagation conditions, antenna diversity and antenna beam steering.

4.2.3.3 Dynamic range

See ETSI EG 203 336 [i.1], clause 5.3.4.4.1.

Receiver "dynamic range" is a generic term broadly defined as the range of input signal levels over which a receiver functions at a specified performance level.

The "dynamic range" of a receiver may be specified in a Harmonised Standard by the selectivity parameters (see clause 5.3.4 in ETSI EG 203 336 [i.1]).

4.2.3.4 Desensitization (In-band signals)

See ETSI EG 203 336 [i.1], clause 5.3.4.4.3.

Desensitization is a degradation of receiver sensitivity caused by the presence of a large unwanted signal outside its operating channel or bandwidth. The term is most commonly applied when an unwanted signal is present in a receiver which is above the receiver's linear "dynamic range" resulting in desensitization, for example by the process of gain compression. It should be noted that gain compression can occur in any stage of the receiver.

4.2.4 Adjacent channel RX parameters

4.2.4.1 Adjacent signal selectivity (first and second adjacent channel)

See ETSI EG 203 336 [i.1], clause 5.3.4.3.3. Also named "Adjacent channel selectivity".

Receiver adjacent signal selectivity (adjacent channel selectivity) can be part of multiple signal selectivity (more than one interfering signal) because attenuation of the interfering signal will require linear signal processing in the receiver even if the specified interferer is a constant envelope signal.

For receivers using Near-Zero Intermediate-Frequency technology (NZIF), i.e. where the first intermediate frequency is similar to or less than the receiver channel spacing (or receiver bandwidth), Technical Bodies should consider specifying adjacent channel selectivity tests with unwanted signals simultaneously applied on upper and lower adjacent channels (Figure 1). This should be considered because the adjacent channel rejection of NZIF receivers may be asymmetric.

Technical Bodies may consider testing the adjacent channel selectivity on both sides of the receive frequency simultaneously also in cases where the adjacent channel interference level is expected to be significantly higher than the wanted signal.

4.2.5 Remote band RX parameters

4.2.5.1 Blocking

See ETSI EG 203 336 [i.1], clause 5.3.4.3.1.

Where relevant, Technical Bodies should also consider receiver blocking as a measure of the capability of a receiver to receive a wanted signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequency other than those of the spurious responses or of the adjacent channels. Furthermore, Technical Bodies should consider practical measurement methods as testing at "any frequency" is clearly an unbounded requirement.

Where spurious response rejection and blocking are both specified, receiver blocking should usually be specified at a more stringent level than that specified for spurious response rejection (clause 5.3.4.2.2 in ETSI EG 203 336 [i.1]) at frequencies relatively far removed from the operating frequency, but still within the operating frequency range, e.g. for narrowband systems, a typical practical blocking test may evaluate performance with unwanted signals at $F_{rx} \pm 1$ MHz, ± 2 MHz, ± 5 MHz and ± 10 MHz.

Technical bodies may also limit the acceptable number of spurious response frequencies.

4.2.5.2 Spurious response rejection

See ETSI EG 203 336 [i.1], clause 5.3.4.2.2.

The spurious response rejection is a measure of the capability of the receiver to receive a wanted signal without exceeding a given degradation in to the presence of an unwanted signal at any frequency at which a response is obtained. The frequencies of the adjacent signals (channels) are excluded. Technical Bodies should specify the frequency range over which this requirement should be evaluated.

Technical Bodies may specify a frequency search method to identify the specific frequencies at which spurious responses occur.

NOTE: Technical Bodies may consider specifically identifying image-rejection and intermediate-frequency rejection as particular cases of receiver spurious responses. This may be done as part of the method of measurement or by setting specific limits for these particular cases. In the case of direct conversion receivers that do not have an image response, then the Frx/2 and Frx/3 may be considered.

4.2.6 Combined band RX parameters

4.2.6.1 Reciprocal Mixing

See ETSI EG 203 336 [i.1], clause 5.3.4.4.2.

Noise sidebands of the Local Oscillator (LO) mix with unwanted signals producing unwanted noise at the operational frequencies of the receiver which may result in degraded receiver sensitivity. In direct Digital Down Conversion receivers (DDC) a similar effect occurs caused by the phase jitter of the clock associated with the ADC.

NOTE: The term "jitter" is often used in digital systems whereas the term "phase noise" is used in traditional radio systems. However, the two terms refer to the variation in phase of a signal and are therefore essentially the same phenomenon.

In many receivers, degradation due to reciprocal mixing may occur before degradation due to non-linearity. As a result, reciprocal mixing could be the dominant effect impacting a receiver's performance.

4.2.6.2 Intermodulation

See ETSI EG 203 336 [i.1], clause 5.3.4.3.2.

Radio-frequency intermodulation response rejection is a measure of the capability of the receiver to receive a wanted signal, without exceeding a given degradation in to the presence of at least two unwanted signals at frequencies F_1 and F_2 with a specific frequency relationship to the wanted signal frequency.

Technical bodies should consider specifying a minimum of second order intermodulation and third order intermodulation performance. Further information is available in Recommendation ITU-R SM.332-4 [i.9]. The following second order terms should be considered:

- $F_{if} = F_1 + F_2$ (tests should be made with frequencies such that the unwanted signals will have frequencies close to, but not necessarily equal to, half the intermediate frequency)
- $F_{if} = F_1 - F_2$
- $F_{rx} = F_1 + F_2$
- $F_{rx} = F_1 - F_2$

The following third order term should be considered:

- $F_{rx} = 2 F_1 - F_2$ when $|F_1 - F_2| = f_x$

- where:

- tests should be carried out at all frequencies that meet the above conditions; and
- typically $f_x =$ channel spacing or twice the channel spacing.

Technical Bodies may consider specifying second order intermodulation by specifying a cross modulation test. Cross modulation is defined as the transposition of the Amplitude Modulation (AM) component from a strong unwanted signal to the wanted signal.

The testing of second order intermodulation has been unusual in Harmonised Standards, limited mainly to systems using analogue AM modulation such as VHF aeronautical service (e.g. ETSI EN 300 676-1 [i.10]). In systems with constant envelope modulations and superheterodyne receivers cross modulation is very unlikely to be a cause of receiver degradation. Many digital modulations which use amplitude and phase modulation can have significant AM content which makes cross modulation a more significant potential degradation mechanism. Furthermore, the increasing prevalence of direct conversion receiver technology also increases the significance of second order intermodulation effects.

NOTE: In Digital Down Conversion (DDC) receivers nonlinearity of the Analogue - Digital Converter (ADC) may result in intermodulation with static signals. In this case, dithering of the input signal is required for a meaningful test; this can be done in the ADC and Technical Bodies should consider how to include this in test methods if considered appropriate.

5 Baseline Receiver parameters

5.1 Introduction

This clause provides models of clauses addressing Receiver Requirements which can be used as examples in the development process of new Harmonised Standards. The text "*the present document*" is included as reference to the Harmonised Standard using these models. The models of clauses are written in italics. The models of clauses provide text but leave actual parameters values for specific applications and the associated limits to the Technical Body.

Where relevant, "**Application notes**" on the text are provided. These application notes are written in normal letters.

5.2 Receiver Baseline Sensitivity (RBS)

5.2.1 Definition

Receiver baseline sensitivity is the capability to receive a wanted signal at application or use case related defined input signal levels while providing a pre-determined minimum acceptable level of performance.

Applications notes:

- The purpose of the sensitivity requirement is to assure a basic measure of efficient use of spectrum that strikes a balance between sensitivity and the need to avoid being sensitive to interference.
- The pre-determined minimum acceptable level of performance is the basis for many other receiver parameters.

In the following list, some reasons to include receiver sensitivity into a Harmonised Standard are given:

- The defined sensitivity is an important input to or result of coexistence investigations in the regulation process in CEPT.
- Knowing the sensitivity of receivers is essential when planning coverage areas for the siting of wide area transmitters, e.g. cellular base stations and broadcast transmitters, or the link budget calculation of fixed links for reaching the expected availability and QoS.
- Adequate sensitivity allows the corresponding transmitter power to be lower for a particular link budget, especially for noise limited systems.
- Knowledge of sensitivity may also be needed to act as a performance reference point when specifying other parameters.

The values of the sensitivity and the basic operating conditions could come out of the relevant regulation processes and the related radiocompatibility studies in CEPT (including ETSI SRDocs).

For radiodetermination applications, the link budget is the most relevant parameter to determine the proper operation of a device. In the link budget the technical parameters (sensitivity and the transmit power) and the application related parameters (e.g. attenuation, frequency range and object to be detected) are considered.

For specific applications a sensitivity range defining a required minimum and maximum sensitivity might be appropriate (e.g. tolling, NFC).

Receiver sensitivity may follow other considerations possibly suggesting that the "state of the art" sensitivity is not worth to pursue or may even be counterproductive. A very sensitive receiver might exceed the link budget required for the service or a specific application resulting in reduced immunity to interference (i.e. because sensitivity is often a trade-off with receiver effective blocking). The appropriate value for the sensitivity shall be defined by the responsible Technical Body taking into account the specific application related requirements.

5.2.2 Applicability

The receiver baseline sensitivity requirement is applicable to all devices addressed by the present document.

Application notes:

- Excluded from applicability of this requirement are transmit-only devices.
- The TB addressing the excluded requirement will have to devise appropriate text.

5.2.3 Limits

Receiver baseline sensitivity shall be better than <xx> dBm (or <y> dBm/MHz) under the following operating conditions:

Application notes:

- The operating conditions include the signal levels, bandwidth, antenna parameters and pass/fail criteria. The specified operating conditions may need to be translated into measurement conditions that use different parameters.
- The present document will not provide any specific values and limits; these specifications shall be provided by the relevant and responsible technical bodies in ETSI. ETSI has agreements, e.g. with CEPT, that set requirements for co-operation with radio regulatory authorities. An example is given in clause A.3.
- If a Technical Body decides to use the sensitivity parameter, it is in its responsibility to define limits.
- Potential sources of limit values include regulatory documents, spectrum sharing studies, international Standards and Recommendations or a recognized publicly available (industry) standard.

5.2.4 Conformance

The corresponding measurement description is in the RBS conformance test clause <x.y>.

Application notes:

- In the present document, model of conformance test clause is given in clause 6.2.

5.3 Receiver Baseline Resilience (RBR)

5.3.1 Definition

Receiver Baseline Resilience (RBR) is defined as the capability to maintain a pre-determined minimum acceptable level of performance in the presence of unwanted signals over the frequency band of operation, applicable adjacent and remote frequency bands.

Application notes:

- The purpose of the RBS requirement is to assure a basic measure of interference robustness; its value should be consistent with the state of the art in digital technologies making use of RF transmission.

- The underlying assumption is that a poor RBR value at any frequency indicates a poor receiver design that is not spectrum efficient.
- The level(s) of the unwanted signal(s) and the frequency of their sources is usually given in radiocompatibility studies; such studies usually make assumptions about the robustness of victim receivers.
- The unwanted signal levels can be specified as an absolute value or as relative values, e.g. as the difference between the wanted and the unwanted signals. The specification is the responsibility of the relevant Technical Body and shall include the assumed coexistence scenarios for the application covered in the Harmonised Standard.

5.3.2 Applicability

The RBR requirement is applicable to all devices addressed by the present document.

Application note:

- Excluded from applicability of this requirement are transmit-only devices. For such devices other criteria apply, e.g. as documented by ECC sharing studies and reports or EU regulation.

5.3.3 Limits

Receiver baseline resilience shall be better than the pass/fail criteria given below under the operating conditions in Table <X>.

The pass/fail criteria for the RBR requirement are:

- *No loss of connection with any of the unwanted signals applied.*
- *No loss of transmitted data with any of the unwanted signals applied.*
- *Etc.*

Application notes:

- The pass/fail criteria will be different for different types of equipment - e.g. no loss of data is equivalent to no loss of operating range for radiodetermination equipment.
- The operating conditions include the wanted and unwanted signal levels, frequencies and bandwidth as well as antenna parameters. The specified operating conditions may need to be translated into measurement conditions that use different parameters.
- The present document does not provide any specific values for the limits of the parameters defined in the present document. These specifications shall be provided by the relevant and responsible technical bodies in ETSI/ETSI has agreements, e.g. with CEPT, that set requirements for co-operation with radio regulatory authorities. One example is given in Table 2. Some additional example for information are given in Annexes C and D.
- If a Technical Body decides to use resilience parameters, it is in its responsibility to define limits.
- Potential sources of limit values include regulatory documents, spectrum sharing studies, international Standards and Recommendations or a recognized publicly available (industry) standard.
- In the present document, example of pass/fail criteria table is given in Table 2.

Table 2: Example requirements and limits

Wanted Signal level and bandwidth	Frequency offset of the unwanted signal	Level of the unwanted signal	Type of Signal	Note
Xx dBm in yy MHz	± 10 MHz (see note 1)	To be defined by Technical Body	to be defined by Technical Body (see note 2)	Equivalent to Adjacent channel/band rejection or selectivity
	± 20 MHz(see note 1)	To be defined by Technical Body	to be defined by Technical Body (see note 2)	Equivalent to second Adjacent channel/band rejection or selectivity
	± 50 MHz (see note 1)	To be defined by Technical Body	to be defined by Technical Body (see note 2)	Equivalent to receiver blocking
	± 100 MHz (see note 1)	To be defined by Technical Body	to be defined by Technical Body (see note 2)	Equivalent to receiver blocking
	± 200 MHz (see note 1)	To be defined by Technical Body	to be defined by Technical Body (see note 2)	Equivalent to receiver blocking
NOTE 1: The frequencies given here are related to bandwidth of the EUT and to the upper and lower edge of the operating frequency range as defined in the present document.				
NOTE 2: The "Type of Signal" should be defined by the relevant technical body based on the radio environment.				

5.3.4 Conformance/Testing for compliance with technical requirements

The corresponding measurement description is in the RBR conformance test clause <x.y>.

Application notes:

- In the present document, model of conformance test clause is given in clause 6.3.

6 RX conformance tests

6.1 Introduction

In this clause, considerations regarding conformance tests are presented that cover the RBS and RBR measurements.

These considerations need to be adapted and extended by the responsible TB during the development of the Harmonised Standard to the actual needs of the devices under test based on their intended use.

6.2 Conformance test for RBS

6.2.1 General

The basic test setup of a RBS test is depicted in following clauses. The RBS conformance test is in main part equivalent to the sensitivity test given in ETSI EG 203 336 [i.1].

6.2.2 Test setup

The test can be performed based on radiated and conducted measurements.

In Figure 1, a test setup for a radiated measurement of receiver baseline sensitivity is depicted.

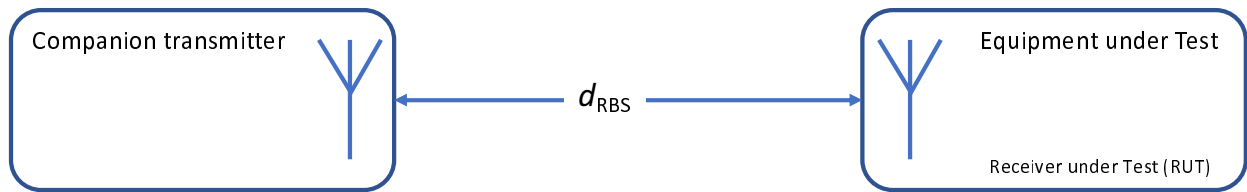


Figure 1: Radiated test setup receiver baseline sensitivity with distance as parameter for a communication device with integrated antennas

In this setup, the distance d_{RBS} is the defined requirement for the sensitivity. The limit is specified as the distance d_{RBS} up to which a device need to operate as intended using a given TX power level.

In the depicted setup, the material separating the TX and the RX can be air or any other material deployed in the actual intended use case, e.g. a wall, human tissue, etc.

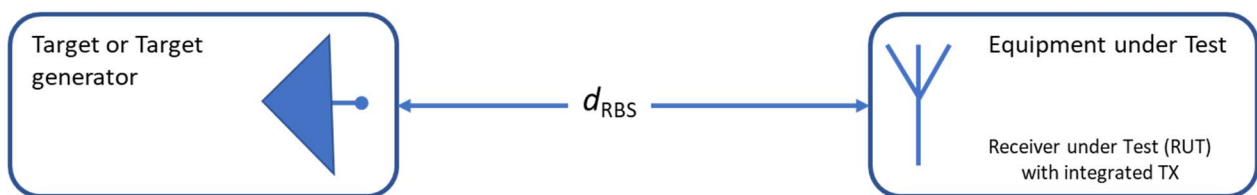


Figure 2: Radiated test setup receiver baseline sensitivity with distance as parameter for a radiodetermination device with integrated antennas

In Figure 2 a similar set-up is depicted for a radio determination device. Here the companion transmitter has been replaced by a target or target generator representing a typical object to be detected. The radio characteristics of the target or target generator shall be specified by the responsible technical bod in the harmonised standard.

6.2.3 Test procedure

The tests should define the minimum requirement for efficient spectrum use. To avoid having to measure the actual signal level at the receiver, which may be impractical or even impossible depending on the application, the tests require a certain quality of reception for a given separation distance d_{RBS} between transmitter and receiver. For conducted test setup the separation distance d_{RBS} should be replaced by an equivalent signal attenuation or test signal level specified by the responsible Technical Body.

The following paragraphs describe the general test setup and procedure. Actual values for the test parameters shall be defined in the harmonised standards.

For communication devices in radiated test, the RUT (receiver under test as part of Equipment under Test) shall be placed at a distance d_{RBS} , from a companion transmitter device as depicted in Figure 1.

In general, the companion transmitter device shall be able to send out signals that the RUT was designed to receive.

The separation distance d_{RBS} between the companion transmitter and the RUT shall be specified in the harmonised standard and depend on the particular application. The distance shall be measured between the outer dimensions of the devices. The devices may be oriented such that the antennas are closest to each other.

Requirements for the frames to be transmitted from the companion transmitter to the RUT shall be specified by the responsible Technical Body in the harmonised standard. To avoid testing over unpractical distances (too far or too short), a scaling of transmitter signal can be performed. In this case, distance d_{RBS} shall be scaled according to the methodology specified by the responsible Technical Body.

For devices with antenna connectors where a conducted measurement is feasible, the responsible Technical Body shall specify a corresponding measurement procedure as part of the harmonised standard. In this case, the value d_{RBS} shall be taken as the basis for the specification of an equivalent attenuation value to be used to attenuate the signal from the reference transmitter to the RUT. The basic setup is depicted in Figure 3.

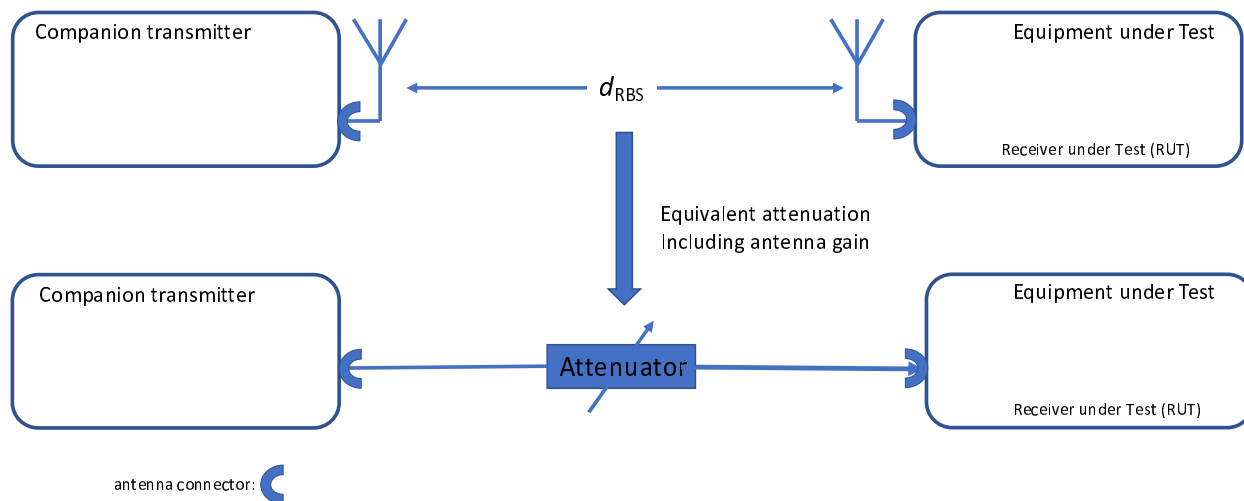


Figure 3: Conducted test setup receiver baseline sensitivity with attenuation as parameter for a communication device with antenna connectors

For radiodetermination devices, the RUT (receiver under test as part of Equipment under Test) shall be placed at a distance d_{RBS} from a target or target generator as depicted in Figure 2.

The separation distance d_{RBS} between the target or target generator and the RUT shall be specified in the harmonised standard and depend on the particular application. The distance shall be measured between the outer dimensions of the devices.

Requirements for the transmitted signal from the EUT shall be specified by the responsible Technical Body in the harmonised standard. To avoid testing over unpractical (too far or too short) distances, a scaling of transmitter signal can be performed or/and a target simulator/generator can be used. In this case, distance d_{RBS} shall be scaled according to the methodology specified by the responsible Technical Body.

6.3 Conformance test for RBR

6.3.1 General

The basic test setup of a RBR test is depicted in following clauses. Depending on the specified frequency ranges, used signal formats and number of signals the RBR conformance test is equivalent to receiver parameter given in ETSI EG 203 336 [i.1].

6.3.2 Test setup

Receiver baseline resilience tests the robustness of the receiver in the presence of interfering signals.

For communication devices, the RUT and the companion transmitter shall be placed at a separation distance d_{RBR} of each other. If the manufacturers documentation indicates that the RUT and/or companion transmitter have directional antennas, the devices shall be positioned such that the direction of maximum antenna gain points towards the other device.

In classic blocking test setup, the receiver reference signal is increased by 3 dB or 6 dB above the sensitivity limit (the measured of specified receiver sensitivity) in order to model the normal operational conditions of the device and to be able to accommodate a certain level of interference.

The receiver sensitivity level and the increase of the interfering signal shall be defined by the responsible Technical Body in the harmonised standard. The reference distance d_{RBR} shall be specified by the responsible Technical Body based on the relevant transmission medium depending on the intended use of the device. For typical communication devices this medium is air.

In Figure 4, a typical set-up for a communication device with integrated antennas is depicted. The TX power and the distances d_{RBR} and d_{RBR_Int} shall be defined by the responsible Technical Body in the harmonised standard.

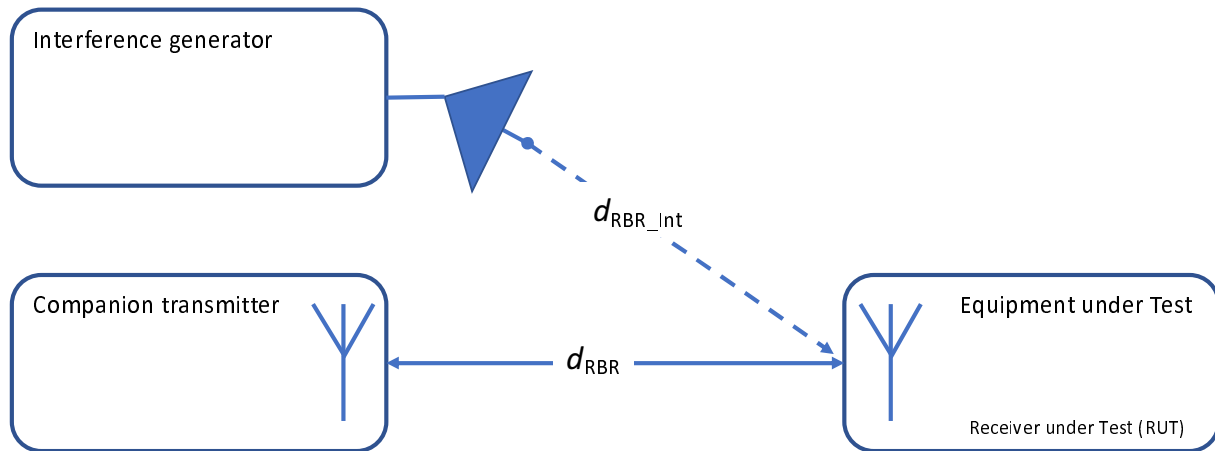


Figure 4: Measurement setup receiver baseline resilience (RBR) with distance d_{RBR} parameter as reference for a communication device with integrated antennas

For radiodetermination devices, the RUT and the target or target generator shall be placed at a separation distance d_{RBR} of each other. If the manufacturers documentation indicates that the EUT have directional antennas, the EUT shall be positioned such that the direction of maximum antenna gain points towards the target or target generator.

To take into account the interference, classic blocking tests increase the signal level by 3 dB from the receiver sensitivity level. The receiver sensitivity level and the increase shall be defined by the responsible Technical Body in the harmonised standard. The reference distance d_{RBR} shall be specified by the responsible Technical Body based on the relevant transmission medium depending on the intended use of the device. For typical radar devices, this medium is air and for other application, it can be human tissue, building material, or any other material.

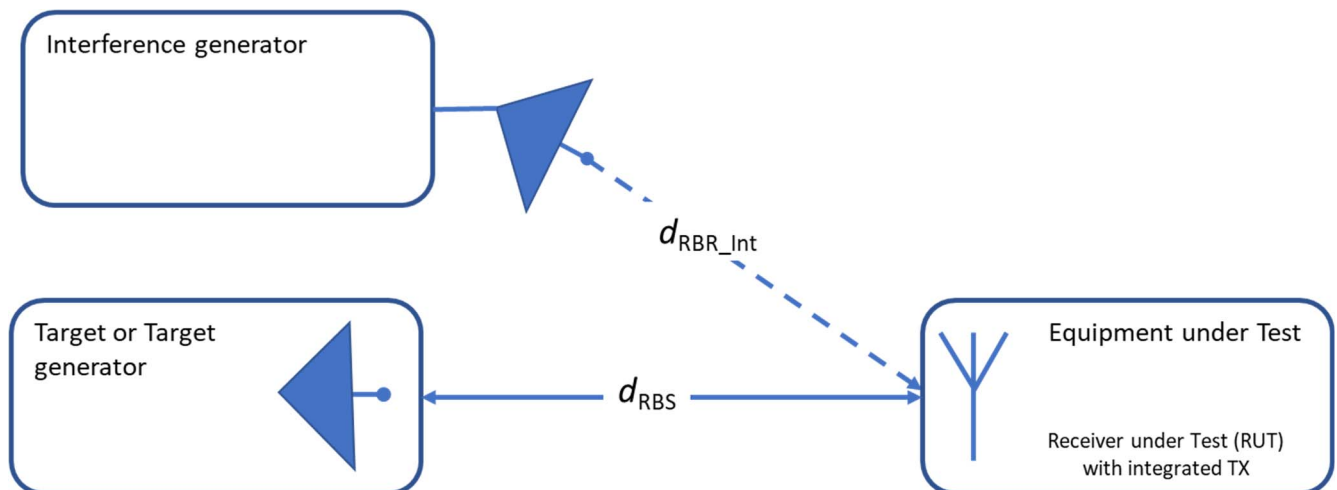


Figure 5: Measurement setup receiver baseline resilience (RBR) with distance d_{RBR} parameter as reference for a radiodetermination device with integrated antennas

6.3.3 Test procedure

The test procedure for both communication and radio determination devices is split into two sections.

Section 1: Test without the interfering signal.

Section 2: The interfering signal defined in the conformance section will be switched on.

Here is a more detailed test procedure:

- 1) Switch on the "Companion Transmitter" or target (generator), the interfering signal generator is switched off.
- 2) Transmit at least a minimum number of packets or conduct a minimum amount of measurements as specified by the responsible Technical Body to the RUT.
- 3) Monitor the reception of the packets at the RUT or the performance criterion specified by the responsible Technical Body.
- 4) The test is passed when a specified number of packets have been processed correctly or the performance criterion is met.
- 5) Switch on interference generator specified by the responsible Technical Body.
- 6) Repeat according to step 2, e.g. transmit at least 1 000 packets as specified by the responsible Technical Body to the RUT.
- 7) Repeat according to step 3, e.g. monitor the reception of the packets at the RUT.
- 8) Repeat according to step 4, e.g. test passed when a specified number of packets have been processed correctly.

The performance criteria for RBR like PER, detection probability, etc. shall be defined by the responsible TB.

7 Summary and conclusion

The present document provides a limited set of baseline receiver requirements to address the spectrum efficiency requirements of the RED and provides a sound basis to justify the use of this set in Harmonised Standards to claim presumption of conformity. It addresses the Assessment of Compliance of Documents drafted by the ESOs clause 7 of [i.7].

These baseline receiver requirements were developed based on the findings of ETSI TR 103 566 [i.2], where the signal interferer handling concept from ETSI TS 103 361 [i.3] has been analysed on its applicability for the RED. The concept of baseline requirements can support the specification work of the responsible technical bodies. It can also be used to harmonise the receiver parameter definition.

The proposed baseline requirements are not intended to replace the existing receiver parameter definitions in general but rather present an alternative for relevant applications where these parameters are more applicable. The deployment of the parameters are in the responsibility of the concerned TB.

An example of a set of two parameters is given in clause 5 of the present document providing guidance for HS development, which can be further refined by the responsible TB.

Baseline comprises the following parameters:

- receiver baseline sensitivity; and
- receiver baseline resilience.

These baseline parameters are put in relation to existing receiver parameters given in ETSI EG 203 336 [i.1] and the equivalence has been explained.

The present document specifies this baseline parameter concept and the corresponding test and measurement procedures.

The specification of the actual limits and receiver parameter values have to be specified by the responsible technical bodies in the harmonised standards. These values should be derived from technical specifications defined by the responsible ETSI Technical Committees (see clause 2.8.2 in [i.8]) and/or the findings of regulatory studies conducted by the relevant bodies like CEPT ECC WG SE.

An example mapping of the baseline parameters to radiodetermination (Annex C) and CEN DSRC Tolling systems (Annex B) is proposed.

RX measurements have to be done in a normal operational environment covering the typical interference scenarios. This operational environment can be extracted from the intended use of the device to be tested. The relevant interfering signals can be chosen based on the methodology specified in ETSI TS 103 361 [i.3] where a similar approach has been taken for UWB based devices.

As indicated in ETSI TR 103 566 [i.2], three types of signals could be considered for the tests:

- signal similar to the wanted signal format;
- CW; or
- based on the signal of a possible source of interferer.

ETSI TS 103 361 [i.3] provides an initial list of interferers to be considered. However, this list is not complete and should be expanded and updated on a regularly basis in order to reflect possible modifications in the allocations/assignments. This could be done in cooperation with CEPT and in particular, with the EFIS Maintenance Group (MG).

The test will be performed with the device performing according to its intended used and with the typical interference scenarios as defined by responsible Technical Body. If the system is still performing according to its intended use fulfilling the performance criteria specified in the harmonised standard by the responsible Technical Body, then the test is passed. Such a procedure is equivalent to a check of a given degradation of the Bit Error Rate (BER) while an interference criterion (C/I , level of blocking, etc.) is to be met for a classical receiver.

The baseline receiver requirements can be specified with reference to the RF power of the associated transmitters; the maximum RF power level. This ties the baseline receiver requirements to the existing technical regulation. The applicability of the baseline requirements is limited to transceiver based systems: broadcast systems and one-way systems are not covered because the receiver properties have no effect on the associated transmitter.

The base line receiver requirements are given in implementation independent terms; for a specific product or system, the applicable parameters such as transmitter RF power, receiver operating bandwidth and adjacent band interference levels have to be filled in by the Technical Body developing a harmonised standard. Especially for the definition of relevant interfering signals for the RBR a close cooperation with the relevant bodies in the CEPT is important.

Annex A (informative): Baseline Compliance Criteria

A.1 Baseline Compliance Criteria

Effective and efficient use of radio spectrum - per Article 3.2 of the RED [i.4] - is a complex subject with little established theory or practice. Absent this basis, a short term solution is to adopt baseline compliance criteria known to affect spectrum utilization and sharing; these include RF criteria for transmitter and receiver as well as medium access criteria.

The baseline transmitter criteria are laid down in regulation - e.g. the SRD Implementing Decision - which focuses on RF power levels and medium access restrictions but do not cover receiver requirements. Assuming that transmitter RF power criteria are adequately covered by existing regulation, the following considers only receiver criteria and adaptive medium access criteria.

Basic aspects of receiver performance are sensitivity and selectivity but the mapping to receiver measurements is not straightforward. If an explosion of HS is to be avoided, a way should be found to specify metrics that cover a range of equipment or equipment types rather than a single device or product per HS. Such metrics have to address receiver sensitivity and resilience.

A.2 Receiver Sensitivity

From the perspective of efficient use of spectrum receiver sensitivity need not be an absolute metric that has to be met by all products subject to a given HS. In practice, product sensitivity varies with purpose and design as well as operating conditions and allowing for flexibility in the HS would imply delegating receiver sensitivity requirements to manufacturers. This is unacceptable for the EC.

However, efficient use of spectrum is a complex matter that involves both transmitter and receiver; receiver sensitivity is only one aspect. For some services or systems, receiver sensitivity is determined by sharing studies and or regulation, international standards or industry standards. Absent such references, a Technical Body has to exercise its own judgment. Setting a sensitivity requirement is frequently motivated with reference to possibility that better receiver sensitivity allows reduction of transmitter power and so improve efficient use of radio spectrum. This viewpoint suggests that, in order to assure that spectrum capacity is not wasted, it is sufficient to prevent weak receiver designs to be compensated with higher transmitter power. Conversely, high transmitter power should imply a requirement for a sensitive receiver. This approach defines a minimum requirement for all products of a given type or class operating in a given frequency band but leaves product designers the freedom to define less sensitive but robust receivers - at the price of reduced transmitter power.

A flexible receiver sensitivity metric can be based on a combination of a reference value $RX_{refsens}$ (note 1) that is frequency band specific and the highest transmitter output and the lowest transmission rate (note 2) supported:

$$RX_{sens} = (RX_{refsens} + SCP \times \log(P_{max}/P_{dev})) \text{ dBm} \quad (\text{A.1})$$

NOTE 1: This level has to be chosen for a given frequency band such that existing products on the market remain compliant.

NOTE 2: Using PSD values normalizes the result of the formula so that it applies to different bandwidths of the same devices as well as to different bandwidths of different devices.

P_{max} is the maximum RF power allowed under the applicable regulation. SCP is the scaling factor for the RF power parameter: a higher SCP implies a more relaxed receiver sensitivity requirement for low power devices.

Using PSD instead of P to correct for differences in bandwidth (note 3) between different types of equipment gives the following formula:

$$RX_{sens} = (RX_{refsens} + SCP \times \log(PSD_{max}/PSD_{dev})) \text{ dBm/MHz} \quad (\text{A.2})$$

Using the value for 2,4 GHz WDS of -70 dBm/MHz for $RX_{refsens}$ and using 15 for SCP gives the following formula:

$$RX_{sens} = (-70 + 15 \times \log(\text{PSD}_{\max}/\text{PSD}_{\text{dev}})) \text{ dBm/MHz} \quad (\text{A.3})$$

The result is a flexible minimum requirement. In this example, a device operating at maximum allowed power density has to achieve a sensitivity of at least -70 dBm/MHz whereas a very low power device - e.g. 0 dBm - would need sensitivity of at least -40 dBm/MHz. For other frequency bands, a different baseline will be needed.

Note that this link to transmitter power relates this definition of a receiver requirement to a legal instrument - the spectrum regulation.

NOTE 3: For equipment with multiple bandwidths a bandwidth correction factor has to be added, e.g. $(\text{BW}_{\text{nom}}/\text{OCBW})$. The same effect is obtained by taking the PSD values instead of total RF power values.

A.3 Receiver Resilience (~ selectivity)

Similarly, selectivity need not be specified in absolute terms. Instead it can be linked to the receiver bandwidth and the required receiver sensitivity - RX_{sens} . Receiver selectivity is a complex subject in itself that contains many system aspects, including antenna properties. However, the ability of the receiver itself to deal with blocking signals is a good indicator of inherent receiver selectivity. For the purposes of the RED, the *blocking protection ratio* can be used to gauge receiver selectivity. This ratio is the difference between the wanted signal and the interfering signal, both expressed in dB. In order to decouple this metric from established terminology the term "Receiver Basic Resilience" or RBR is used in the following.

The interfering signal is determined by the environment - e.g. systems operating in the same and adjacent bands. Therefore, the reference levels and frequencies of interfering signals are fixed and applicable to all and any devices operating in a given frequency band. The actual levels of the Unwanted signal for a given receiver and use case depend on the assumed separation distance(s). Together the operating bandwidth, wanted signal modulation and antenna parameters these are part of the applicable operating conditions. The pass/fail criteria depend on the intended use, e.g.:

- No loss of connection with any of the unwanted signals applied.
- No loss of transmitted data with any of the unwanted signals applied.
- BER or PER less than x %.
- Etc.

The limit for the value of RBR for all equipment addressed by a Harmonised Standard and operating in a given frequency band is:

$$\text{RBR} = (RX_{\text{unwanted}} - RX_{\text{wanted}}) \text{ dB} \quad (\text{A.4})$$

$RX_{\text{unwanted}} = -U_i$ dBm at frequency f_i where I varies over range f_{op} to $f_{\text{op}} \pm \Delta f$. For radiated measurements the values of U_i should be corrected for frequency dependency of the antenna assembly over the range $f_{\text{op}} \pm \Delta f$.

The number and range of frequencies for the unwanted signals depends on the equipment, the levels depend on the systems operating in the frequency range of interest. Therefore, a harmonised standard may have to specify multiple RBR limit values (see note).

The wanted signal depends on the receiver's bandwidth and in a non-linear way. This can be expressed with the aid of a scaling factor for resilience (SCR) used as a fractional exponent on the occupied bandwidth, e.g. $\text{SCR} \times \log_{10} \text{OCBW}$ where OCBW is normalized to units of 1 MHz.

Using the basic sensitivity value obtained for the receiver and allowing for a degradation factor of e.g. 6 dB gives the following reference value for the wanted signal:

$$RX_{\text{wanted}} = (RX_{\text{sens}} + 6 + \text{SCR} \times \log_{10}(\text{OCBW})) \text{ dBm/MHz} \quad (\text{A.5})$$

where $RX_{\text{sens}} = \text{XX dBm}$ at f_{op} as measured and verified.

In this formula, SCR is equivalent to a fractional exponent of the OCBW; the value of 6,7 is the same as $\wedge^{2/3}$ which gives a spread of 10,5 dB over 40 MHz. Other values may be needed for other frequency bands.

NOTE: Depending on the frequency range of the unwanted signals, alignment with the EMC Immunity requirement should be considered.

A.4 Mapping to radiodetermination and RFID systems

The parallels between radiocommunication and radiodetermination are that both have a transmitter and a receiver. In case of a radiocommunication system the separation distance and propagation conditions determine the ratio between transmitted signal power and the received signal power. The RBS metric imposes a minimum value on this ratio, and this ratio determines a minimum operating range under give conditions. In case of a radiodetermination system, the ratio between the transmitted and the received signal is determined by the cross section of the "to be detected" target object as well as its separation distance and propagation conditions. The RBS metric can be applied here too: the $RX_{refsens}$ value is determined by the cross section of the target and its nominal distance from the transmitter and the assumed propagation conditions. These may include attenuation by a wall, etc. Note the signal returned by the reference target can be emulated, e.g. with a signal generator or a receive antenna of adequate gain coupled to an attenuator feeding a suitable and known "transmit" antenna.

Similarly, the RBR metric can be used for radiodetermination systems: using the measured RX_{sens} and adding a range degradation allowance expressed in dB; the bandwidth correction factor can be applied unchanged.

RFID systems with passive responders are basically similar to radiodetermination systems except that the target cross section should be replaced by the conversion ratio of a passive RFID responder.

Annex B (informative): Example: CEN DSRC OBU

B.0 Introduction

In Annex B an example mapping of the baseline parameters to CEN DSRC Tolling systems is proposed. The proposed signal formats and limit values have been taken from the original ETSI EN 300 674-2-2 [i.6].

This clause provides models of clauses addressing Receiver Requirements which can be used as examples in the development process of new Harmonised Standards. The text "*the present document*" is included as reference to the Harmonised Standard using these models. The example models are written in italics. The models of clauses provide text but leave actual parameters values for specific applications and the associated limits to the Technical Body.

Where relevant, "**Application notes**" on the text are provided. These application notes are written in normal letters.

B.1 General

The operating frequency range has to be defined by the TB. This could be the allocated frequency range or the TB could define a specific requirement including the corresponding measurement.

B.2 Receiver Baseline Resilience

B.2.1 Definition

Receiver Baseline Resilience (RBR) is defined as the capability to maintain a pre-determined minimum acceptable level of performance in the presence of unwanted signals in the applicable adjacent, second adjacent and remote frequency bands.

The RBR can be specified as an absolute value using the power of the unwanted signal or a relative value as the difference between the wanted and the unwanted signals. For the purpose of the present document the unwanted signal is always an unmodulated CW signal.

This requirement is equivalent to the following parameter from the ETSI EG 203 336 [i.1]:

- *Adjacent band and second adjacent band selectivity or rejection.*
- *Receiver blocking.*
- *Receiver spurious response rejection.*

The devices in the scope of the present document are non-channelized devices and operated over the complete operating frequency range. For this reason, the concept of adjacent and second adjacent channel has been replaced by the concept of adjacent and second adjacent bands.

Application notes:

- This explanation may need to be adapted by the responsible Technical Body (TC ERM).
- The operating frequency range has to be defined by the responsible Technical Body (TC ERM).

B.2.2 Applicability

These requirements are applicable to all device covered with the present document. For the purpose of the present document only the resilience against interference signals in the bands not covered by the operating frequency range are considered.

B.2.3 Limits/Requirements

For the given performance criteria of a BER better than e.g. 10^{-6} and the measurement setup given in the relevant clause. The OBU receiver has to withstand the interfering signal limits given in Table B.1.

Table B.1: Requirements and limits

Frequency	Limits	Signal	Note
± 10 MHz (see note 1)	-45 dBm/-40 dBm (see note 2)	CW	Equivalent to Adjacent channel/band rejection or selectivity
± 20 MHz (see note 1)	-45 dBm/-40 dBm (see note 2)	CW	Equivalent to second Adjacent channel/band rejection or selectivity
± 50 MHz (see note 1)	TBD	CW	Equivalent to receiver blocking
± 100 MHz (see note 1)	TBD	CW	Equivalent to receiver blocking
± 200 MHz (see note 1)	TBD	CW	Equivalent to receiver blocking
NOTE 1: The frequencies given here are related to the upper and lower edge of the operating frequency range as defined in the present document.			
NOTE 2: lower value is applicable for class 1 devices, the higher values for class 2.			

B.2.4 Conformance/Testing for compliance with technical requirements

The test shall be performed using the method of measurement as specified in clause 5.3.2.2 in ETSI EN 300 674-2-2 [i.6].

Annex C (informative): Example: Radio determination

C.0 Introduction

In Annex C an example mapping of the baseline parameters specified in the present document to radio determination systems is proposed. The models of clauses in clauses C.2 and C.3 are written as if it would be an EN.

This clause provides models of clauses addressing Receiver Requirements which can be used as examples in the development process of new Harmonised Standards. The text "*the present document*" is included as reference to the Harmonised Standard using these models. The example models are written in italics. The models of clauses provide text but leave actual parameters values for specific applications and the associated limits to the Technical Body.

Where relevant, "**Application notes**" on the text are provided. These application notes are written in normal letters.

C.1 General

For radio determination devices the wanted signal as basis for the RBS and RBR definitions is generated by the Devices Under Test (DUT) itself and not by the separate transmitter or source. The wanted signal at the input of the receiver is thus depended on signal properties of the transmitter, the transmission media, the distance and the characteristics of the object to be detected. The generation of the wanted signal is done by a passive reflection or back scattering object. The performance criteria in this case is typically the detection probability. This scenario is significantly different from the classical transmitter/receiver split.

Examples for this class of applications are:

- Automotive radar
- Material sensing devices
- Ground probing radar
- Cable detectors
- Medical sensor devices

In order to perform a proper test of the given requirements a clear definition of the target properties including a link to the intended use in the scope of the relevant EN is needed. By defining the properties of the object to be detected the wanted signal in the performance evaluation processes can be fixed. The definition of the target properties include:

- Object size
- Reflection properties (reflectivity)
- Detection distance
- Characteristics of transmission media
- Dynamic properties of the object/environment
- The required signal properties of the transmitter including TX power and modulation based on the intended use and the regulatory restrictions

By defining these parameters, a reference object for the detection and determination process is defined including the relevant environment (transmission media). In typical radar measurement setups the desired object size and reflection properties can be represented by choosing a suitable radar cross section. The detection distance, transmission medium characteristics and other properties need to be condensed to a suitable reference scenario. As it will differ depending on the intended use, this derivation should be motivated in a normative annex of the corresponding EN. In this manner, the main body of most standards can follow a consistent approach as detailed below.

In a harmonised standard the TX power for the definition of the wanted signal has to be fixed.

By fixing the TX power of the device the wanted signal strength can be derived in the conformance test.

C.2 Receiver Baseline Sensitivity

C.2.1 Definition

Receiver Baseline Sensitivity (RBS) is the capability to receive a wanted signal at application related defined input signal levels while providing a pre-determined minimum acceptable level of performance.

The limits to be fulfilled for the RBS value are expressed by the parameter set derived from the intended use as described in clause D.1.

The pre-determined minimum acceptable level of performance is the basis for all other receiver parameters.

Application note:

- The purpose of the sensitivity requirement is to assure a basic measure of efficient use of spectrum that strikes balance between sensitivity and the need to avoid being sensitive to interference.

C.2.2 Applicability

These requirements are applicable to all devices covered by the present document. For the purpose of the present document, only the resilience against interference signals in the bands not covered by the operating frequency range are considered.

C.2.3 Limits/Requirements

Here no detailed limits and requirements will be given. The actual limit values are in the responsibility of the Technical Body in charge of the EN.

C.3 Receiver Baseline Resilience

C.3.1 Definition

Receiver Baseline Resilience (RBR) is defined as the capability to maintain a pre-determined minimum acceptable level of performance in the presence of unwanted signals in the applicable adjacent, second adjacent and remote frequency bands.

The RBR can be specified as an absolute value using the power of the unwanted signal or a relative value as the difference between the wanted and the unwanted signals. For the purpose of the present document, the unwanted signal is always an unmodulated CW signal.

This requirement is equivalent to the following parameter from ETSI EG 203 336 [i.1]:

- *Adjacent band and second adjacent band selectivity or rejection*
- *Receiver blocking*

- *Receiver spurious response rejection*

The devices in the scope of the present document are non-channelized devices and operated over the complete operating frequency range. For this reason, the concept of adjacent and second adjacent channel has been replaced by the concept of adjacent and second adjacent bands.

Application notes:

- This explanation may need to be adapted by the responsible Technical Body (TC ERM).
- The operating frequency range has to be defined by the responsible Technical Body (TC ERM).

C.3.2 Applicability

These requirements are applicable to all device covered with the present document. For the purpose of the present document, only the resilience against interference signals in the bands not covered by the operating frequency range are considered.

C.3.3 Limits/Requirements

Here no detailed limits and requirements will be given. Defining actual values is under the responsibility of the Technical Body in charge of the EN.

Annex D (informative): RBS and RBR using Power relations

D.0 Introduction

This annex provides models of clauses addressing RBS and RBR using the power relation presented in Annex A which can be used as examples in the development process of new Harmonised Standards when a fixed relation between sensitivity and TX power is used. The focus here is onto the calculation scheme to calculate the RBS and RBR in relation to the TX power. The text “*the present document*” is included as reference to the harmonised standard using these models. The example models are written in italics. The models of clauses provide text but leave actual parameters values for specific applications and the associated limits to the Technical Body.

D.1 RBS

The value of RBS over the applicable frequency range shall be better than the value calculated according to Table D.1.

Where $RX_{refsens} = XX$ dBm as determined by the application domain.

Table D.1: Calculation scheme for RBS

Frequency	$RX_{refsens}$	SCP	P_{max}	P_{dev}	RBS
<i>Operating Frequency range</i>	<i>As determined by the applicable usage scenario(s) See note 1</i>	<i>As determined by the applicable usage scenario(s) See note 2</i>	<i>As given by the applicable regulation</i>	<i>As measured</i>	<i>See note 3 and note 4</i>
<p><i>NOTE 1: These values are determined by the usage scenarios for the applicable frequency band. Generally, $RX_{refsens}$ will be chosen so as to assure continuity with current practice and currently used technologies. Its scope is the applicable frequency band; not specific devices or applications.</i></p> <p><i>NOTE 2: The scaling factor SCF-S allows the range of RBS values to be adjusted to be consistent with the technological state of the art for equipment operating in a given frequency band.</i></p> <p><i>NOTE 3: RBS is calculated with the formula: $RBS = RX_{refsens} + SCP \times \log(P_{max}/P_{dev})$ dBm.</i></p> <p><i>NOTE 4: For $P_{dev} = P_{max}$, RBS defaults to $RX_{refsens}$.</i></p>					

D.2 RBR

The value of RBR over the applicable frequency range for all equipment addressed by the present document shall be determined as given in Table D.2.

Table D.2: Calculation scheme for RBR

Operating Frequency (see note 1)	RX_{sens} @ operating frequency (see note 2)	Occupied Bandwidth (OBW)	SCR (see note 2)	Wanted Signal RX_{wanted}	Unwanted Signal $RX_{unwanted}$	RBR @ frequency offset = $n \times OBW$ from f_{op}	
						n	RBR (see note 3)
f_{op}	-xx dBm	nn Hz	E.g. 6,7	$RX_{sens} + 6 + SCR$ $\times \log_{10} OBW$ dBm	-yy dBm	2	x1 dB
						4	x2 dB
						8	x3 dB
						12	x4 dB
<p>NOTE 1: This requirement applies at any frequency with the operating frequency range of the equipment. It should be validated at least 3 instances, low, medium and high values of f_{op}.</p> <p>NOTE 2: RX_{sens} is measured according to the requirements given in clause 6.2.</p> <p>NOTE 3: The values x1 through x4 give the minimum values that should be met.</p> <p>General Notes:</p> <ol style="list-style-type: none"> 1) The Scaling Factor for the bandwidth should be chosen to reflect the applicable range of equipment properties. 2) The factor 6 is an allowance for some degradation of performance in case the unwanted signal is present. 3) Depending on the systems operating in adjacent frequency bands, the unwanted signal requirement may have to be phrased as a table of unwanted levels for a set of frequencies. 							

Annex E (informative): Related definitions in Radio Regulations (RR)

Unwanted emissions (Article 1, No. 1.146 of the RR):

Consist of spurious emissions and out-of-band emissions.

Out-of-band and Spurious domains:

Out-of-band and spurious domain emission limits apply, respectively, to all unwanted emissions in the out-of-band and spurious domains.

Out-of-band domain (Article 1, No. 1.146A of the RR):

(of an emission): The frequency range, immediately outside the necessary bandwidth but excluding the spurious domain, in which out-of-band emissions generally predominate.

Spurious domain (Article 1, No. 1.146B of the RR):

(of an emission): The frequency range beyond the out-of-band domain in which spurious emissions generally predominate.

NOTE: Out-of-band *emissions*, defined based on their source, occur in the out-of-band domain and, to a lesser extent, in the spurious domain. Spurious emissions likewise may occur in the out-of-band domain as well as in the spurious domain.

Necessary bandwidth (Article 1, No. 1.152 of the RR):

For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

For application to multi-channel or multi-carrier transmitters/transponders, where several carriers may be transmitted simultaneously from a final output amplifier or an active antenna, the necessary bandwidth is taken to be the transmitter's or transponder's 3 dB bandwidth. For multi-carrier base stations and mobile stations in the Mobile Service, further guidance is given in Annex 2 of ERC/REC 74-01 [i.11].

For Fixed Service, Recommendation ITU-R F.1191 [i.12] is to be used to calculate the necessary bandwidth in the case of fixed digital radio multi-carrier systems.

For the Radiodetermination Service, the necessary bandwidth of frequency-agile radars is taken to be the part of the allocated band over which the carrier frequencies of those radars tune.

Annex F (informative): RX parameter mapping from EC

During the discussion between ETSI and the European Commission the EC has issued a list of RX parameters used in the complete set of harmonised standards [i.5]. This list has been presented in the ETSI OCG RED group. The structure of the list is depicted in Figure F.1.

EN + version (01 September 2018)	Article	Title	Frequency Band (s) (APPROXIMATE)	kHz, MHz or GHz	RED or R&T/ED	Receiver parameters applicable to the standard	This mapping is without prejudice to the re-assessment of Administrations who are invited to provide comments at any time. It is also without prejudice to the findings/comments of consultants, when/if new versions of these harmonised standards are resubmitted.										Comments (all ETSI comments are available in OCG REDEMCD(18)070028r1)	Number of receiver parameters that appear to be present or soundly justified (Y/A/I)	Number of receiver parameters that do not appear to be present or soundly justified (P/P/N)	Other (not applicable, indirectly covered)	
							Receiver parameters as listed in EG 203336v1.1.1														
							Sensitivity	Co-Channel Rejection	Adjacent Channel/Signal Selectivity	Blocking	Spurious response rejection	Intermodulation	Dynamic Range	Reciprocal Mixing	Desensitisation	Signal interference handling					Other rx parameters
	3(2), 3(3)(g)		0.5 - 4	MHz	RED	Y	Y	Y	I	Y	N	Y	I	I	P	I	-	RED: Desensitisation	4	2	5
	3(2)		0 - 1000	MHz	RED	Y	Y	Y	Y	Y	Y	I	I	I	P	I	-	RED: Desensitisation	6	1	4
	3(2)		0 - 1000	MHz	RED	Y	Y	Y	Y	Y	I	I	I	Y	I	I	-		7	0	4
	3(2)		0 - 1000	MHz	RED	Y	Y	Y	Y	Y	I	I	I	Y	I	I	-		7	0	4
	3(2)		0 - 1000	MHz	RED	Y	P	J	N	Y	N	N	N	I	I	I	-	RED: Performance	2	6	3
	3(2)		900	MHz	RED	Y	N	N	P	Y	P	N	N	P	I	I	-	RED: Performance	1	9	1
	3(2)		900	MHz	RED	Y	P	J	N	Y	N	N	N	I	I	I	-	RED: Performance	2	6	3
	3(2)		200	MHz	RED	Y	P	J	N	Y	N	N	N	I	I	I	-	RED: Performance	2	6	3

Figure F.1: RX parameter mapping table from EC [i.5]

Based on that list it can be seen that the usage of RX parameters in the different harmonised standards is not harmonised. The specified RX parameters depend on the technical requirements of the specific standards and are in the responsibility of the relevant technical group in ETSI.

History

Document history		
V1.1.1	September 2019	Publication