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Wireless Microphones;
Audio PMSE up to 3 GHz;
Part 1: Audio PMSE Equipment up to 3 GHz;
Harmonised Standard for access to radio spectrum

Reference

REN/ERM-TG17-157

Keywords

audio, audio-PMSE, C-PMSE, harmonised standard, radio, testing, wireless microphone, wireless microphone system

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Foreword

This Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.18] to provide one voluntary means of conforming to the essential requirements of 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 and repealing Directive 1999/5/EC [i.10].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

The present document is part 1 of a multi-part deliverable covering Wireless Microphones, Audio PMSE Equipment up to 3 GHz, as identified below:

Part 1: "Audio PMSE Equipment up to 3 GHz";

Part 2: "Class B Receivers" (see note);

Part 3: "Class C Receivers"(see note);

Part 4: "Assistive Listening Devices including personal sound amplifiers and inductive systems up to 3 GHz".

NOTE: Since the present document now covers Class A, B, and C receivers for audio PMSE, ETSI EN 300 422-2 and ETSI EN 300 422-3 will no longer be maintained.

National transposition dates	
Date of adoption of this EN:	18 November 2021
Date of latest announcement of this EN (doa):	28 February 2022
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 August 2022
Date of withdrawal of any conflicting National Standard (dow):	31 August 2023

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

This update includes changes requested by the EC for terminology in Harmonised Standards in addition to changes of the technical requirements.

Introduction

Audio Programme Making and Special Events (Audio PMSE) equipment up to 3 GHz are used in wireless applications for audio transmission purposes.

Following publication by ETSI of version 2.1.2 of ETSI EN 300 422-1 and its subsequent publication in the Official Journal, the present document has been revised with information gained from those using that version. The previous four-parts deliverable has been reformatted into two parts to accommodate the different types of equipment represented. The present document (Part 1) now covers Class A, B, and C receivers for audio PMSE. To avoid confusion, the numbering for ETSI EN 300 422-4 [i.4] (ALDs) has been retained.

Spectrum, power limits, and technical requirements for audio PMSE are shown in the latest version of:

- EC Decision on Short Range Devices [i.14];
- CEPT/ERC Recommendation 70-03 [i.12], annex 10;
- National Interface regulations; and
- compatibility studies.

Further information is given in CEPT/ERC Recommendation 25-10 [i.13], annexes 2 and 4. Further information is available via the ECO website:

https://cept.org/ecc/topics/programme-making-and-special-events-applications-pmse

and the EFIS database:

https://efis.cept.org/.

Unless otherwise stated in the EC SRD Decision [i.14], EC Decision 2014/641/EU [i.11] or national regulations, the use of audio PMSE equipment can be subject to an individual licensing regime.

Although the present document covers a spectrum up to 3 GHz, it should be emphasized that multi-channel audio PMSE systems used in professional productions are best suited to a spectrum under 2 GHz for reasons of propagation and body interaction. Further information on audio PMSE is available in ECC Report 204 [i.16].

Additional standards or specifications may be required for equipment:

1) intended to interface to Public Networks, e.g. PSTN. This facility may be subjected to regulatory conditions; or

2) other relevant radio standards.

1 Scope

The present document specifies technical characteristics and methods of measurements for audio PMSE equipment operating with up to 250 mW output power on radio frequencies up to 3 GHz (see note 1).

NOTE 1: For RF power levels above this, refer to ETSI EN 300 454-1 [i.3].

Audio Programme Making and Special Events (PMSE) equipment within the scope of the present document is used in wireless applications for audio transmission purposes including, but not limited to equipment such as wireless microphones, in-ear monitoring systems, conference systems, talkback systems, tour guide systems, Cognitive PMSE (C-PMSE), Wireless Multichannel Audio Systems (WMAS), and assistive listening devices.

Table 1: Radiocommunications service frequency bands

	Radiocommunications service frequency bands
Transmit	up to 3 000 MHz
Receive	up to 3 000 MHz

NOTE 2: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU [i.10] is given in annex A.

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.

[1] IEC 60244-13:1991: "Methods of measurement for radio transmitters - Part 13: Performance characteristics for FM sound broadcasting".

[2] ERC Recommendation 74-01 (May 2019): "Unwanted emissions in the spurious domain".

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: "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] Void.

[i.3] ETSI EN 300 454-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Wide band audio links; Part 1: Technical characteristics and test methods".

[i.4] ETSI EN 300 422-4: "Wireless Microphones; Audio PMSE up to 3 GHz; Part 4: Assistive Listening Devices including personal sound amplifiers and inductive systems up to 3 GHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[i.5] Void.

[i.6] ETSI EG 203 367 (V1.1.1): "Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the Directive 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment".

[i.7] ETSI TR 102 273 (V1.2.1) (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

[i.8] ETSI EN 301 489-9: "ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 9: Specific conditions for wireless microphones, similar Radio Frequency (RF) audio link equipment, cordless audio and in-ear monitoring devices; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU".

[i.9] Void.

[i.10] 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.11] Commission Implementing Decision 2014/641/EU of 01/09/2014 on harmonised technical conditions of radio spectrum use by wireless audio programme making and special events equipment in the Union (notified under document C(2014) 6011) (Text with EEA relevance).

[i.12] CEPT/ERC Recommendation 70-03: "Annex 10: Radio microphone applications including assistive listening devices (ALD), wireless audio and multimedia streaming systems".

[i.13] CEPT/ERC Recommendation 25-10: "Frequency Ranges for the Use of Terrestrial Audio and Video Programme Making and Special Events (PMSE) applications", Amended 18 October 2016.

[i.14] Commission Decision 2013/752/EC on harmonization of the radio spectrum for use by short-range devices as amended by subsequent Commission Decisions.

[i.15] Recommendation ITU-R BS.559-2: "Objective measurement of radio-frequency protection ratios in LF, MF, and HF broadcasting".

[i.16] ECC Report 204: "Spectrum Use and future requirements for PMSE".

NOTE: Available at https://docdb.cept.org/download/1f1d1819-5ca2/ECCREP204.PDF.

[i.17] Report Recommendation ITU-R SM.2152 (09/2009): "Definitions of Software Defined Radio (SDR) and Cognitive Radio System (CRS)".

[i.18] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

[i.19] ANSI C63.5: "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electro Magnetic Interference".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in Directive 2014/53/EU [i.10] and the following apply:

analogue modulation: modulation technique whereby message signal, which is the analogue of some physical quantity, is impressed on a carrier signal for transmission through a channel (e.g. FM)

antenna port: port, where a radio frequency antenna is connected to equipment or where a temporary antenna connector is provided

NOTE: 50 Ω connection points unless otherwise stated.

audio channel: monaural (mono) audio signal

audio limiting threshold: audio input or output level at which the transmitter audio limiter action may be said to commence

NOTE: It is specified with any accessible variable gain controls set according to the published information relevant to the equipment, with a sinusoidal input signal of 500 Hz.

audio PMSE: inclusive description consisting of wireless microphones, in-ear monitoring systems, conference systems, talkback systems, tour guide systems, Cognitive PMSE (C-PMSE), Wireless Multichannel Audio Systems (WMAS), and assistive listening devices

bodypack transmitter: wireless microphone that can be attached to the human body, sometimes referred to as body worn transmitter

centre frequency: centre frequency of the operating channel

channel separation: minimum separation in frequency between the centre frequencies of two adjacent usable channels

conducted measurements: measurements that are made using a direct connection to the Device Under Test (DUT)

conducted output power: output power which the transmitter delivers at its antenna port into a 50 Ohm load

conference system: multiple microphone and sound reinforcement system

NOTE: A conference system comprises one control unit and a number of delegate units for discussion groups and face-to-face meetings as well as far end-to-far end (including video) conference events.

confidence level: probability of the accumulated error of a measurement being within the stated range of uncertainty of measurement

control data: data for controlling or managing a device or system; can be uni-directional or bi-directional communication

corresponding device: device required to initiate transmissions by the DUT

C-PMSE: Cognitive Radio System (CRS) based on Recommendation ITU-R SM.2152 [i.17] and designed for the purpose and the specific requirements of PMSE applications

C-PMSE system: cognitive PMSE with information acquisition

declared channel bandwidth: width of a band of frequencies assigned to a single channel

dedicated antenna: antenna physically external to the equipment, using an antenna connector with a cable or a wave-guide and which has been designed or developed for one or more specific types of equipment, and is as such assessed in combination with the equipment against the requirements in the present document

digital modulation: any modulation scheme with discrete constellation points (e.g. FSK, PSK)

enclosure port: physical boundary of the apparatus through which electromagnetic fields may radiate or impinge

NOTE: In the case of integral antenna equipment, this port is inseparable from the antenna port.

error metric: measure for errors, which is typically formulated as relative value or rate in comparison to an error-free measure

frequency stability: spontaneous and/or environmentally caused frequency change within a given time interval

handheld microphone: wireless microphone which is designed to be held and operated in the human hand

In-Ear Monitor (IEM) system: transmitter and one or more bodypack miniature receivers with earpieces for personal monitoring of single- or dual-channel sound

integral antenna: antenna designed as a fixed part of the equipment (without the use of an external connector) which cannot be disconnected from the equipment by a user with the intent to connect another antenna

NOTE: An integral antenna may be fitted internally or externally. In the case where the antenna is external, a non-detachable cable or wave-guide can be used.

occupied (channel) bandwidth: bandwidth containing 99 % of the total transmit power of the signal

operating channel: frequency range in which transmissions from the device occur during operation

operating frequency: actual transmitted frequency

operational mode: mode in which the equipment is operated

out-of-band emission: emission on a frequency or frequencies immediately outside the operating channel which results from the modulation process but excluding spurious emissions

peak: spectrum analyser setting peak detection

port: any connection point on or within the Device Under Test (DUT) intended for the connection of cables to or from that equipment

portable equipment: radio and/or ancillary equipment intended for portable (e.g. handheld) operation, powered by its own integral battery

radiated measurements: measurements that involve the absolute measurement of a radiated electromagnetic field

radiated output power: mean output power of the transmitter measured as a radiated measurement

radio microphone: See wireless microphone.

receiver adjacent channel selectivity: measure of the capability of the receiver to operate satisfactorily in the presence of an unwanted signal, which differs in frequency from the wanted signal by an amount equal to the channel separation

receiver blocking: measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequencies other than those of the spurious responses or the adjacent channels or bands

receiver category: set of relevant receiver requirements and minimum performance criteria

receiver sensitivity: ability to receive a wanted signal at low input power level while providing a pre-determined level of performance

RF channel: specific amount of spectrum for transmission between at least two devices

spectrum scanning procedure: functionality that allows PMSE equipment to perform a scan in order to identify available frequencies within the tuning range of the equipment

spurious emissions: unwanted emissions in the spurious domain applying at frequencies beyond the limit of 250 % of the declared bandwidth above and below the centre frequency of the emission

EXAMPLE: Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out of band emissions.

tour guide system: equipment used for visitor guidance or interpreter or assistive listening applications

EXAMPLE: Tour guide systems are used for visitor guidance (such as factory or facility tours), and interpreter applications, but also can be used as assistive listening devices in theatres or opera houses. In some cases, hearing aids can be connected to the receivers. They can be permanently or temporarily installed in a wide variety of buildings or facilities. They are primarily designed for speech reproduction.

transmitter Inter Modulation Distortion (IMD): emission created by non-linearties in electronic circuits when at least two signals are mixed

transmitter intermodulation performance: measure of the capability of the transmitter to inhibit the generation of signals in its nonlinear elements caused by the presence of the wanted signal and an interfering signal reaching the transmitter via the antenna

transmitter intermodulation ratio: ratio of the power of the intermodulation product to the wanted signal, when an interference signal is injected into the antenna connector at a specific power level lower than that of the mean power of the wanted signal

tuning range: maximum frequency range over which the receiver or the transmitter can be operated without hardware or firmware modifications

wireless microphone: microphone combined with a radio transmitter as a handheld or bodypack device; sometimes referred to as radio microphone

Wireless Multichannel Audio Systems (WMAS): wireless audio transmission systems using digital broadband transmission techniques for microphone and in-ear monitor system applications, and other multichannel audio PMSE use, e.g. with the ability to support three or more audio channels per MHz

wireless talkback system: communication system used in a production

3.2 Symbols

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

λ	wavelength in metres
µF	microfarad
µW	microwatt
dB	decibel; logarithmic unit to express ratio between two quantities
dBA	A-weighted power quantity
dBc	power quantity relative to carrier power level
dBm	power quantity relative to 1 mW
f_{BLK}	frequency of blocker signal
B	declared channel bandwidth
f_c	centre frequency
f_{cm}	actual centre frequency
f_{INT}	frequency of interferer signal
f_{TOI}	frequency of third order intermodulation product
f_w	wanted frequency
GHz	gigahertz
kHz	kilohertz
MHz	megahertz
mW	milliwatt
nW	nanowatt
P_{min}	minimum RF power
R	distance
Ω	ohm

3.3 Abbreviations

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

AF	Audio Frequency
ALD	Assistive Listening Device
BER	Bit Error Rate
CEPT	European Conference of Postal and Telecommunications administrations
DUT	Device Under Test
e.i.r.p.	equivalent isotropically radiated power
e.r.p.	effective radiated power
EC	European Commission
ECC	Electronic Communications Committee
ECO	European Communications Office
EFIS	ECO Frequency Information System
EFTA	European Free Trade Association
EMC	Electro Magnetic Compatibility
emf	electromagnetic field
ERC	former European Radio Committee in CEPT, now ECC
EUT	Equipment Under Test
FM	Frequency Modulation
FSK	Frequency Shift Keying
IEC	International Electrotechnical Commission
IEM	In Ear Monitor system
IMD	Inter Modulation Distortion
ITU-R	International Telecommunication Union Radiocommunication sector
LF	Low Frequency
lim	limiting
NF	Noise Figure
OATS	Open Area Test Site
PER	Packet Error Rate
PMSE	Programme Making and Special Events
ppm	parts per million
PSK	Phase Shift Keying
PSTN	Public Switched Telephone Network
RBW	Resolution Bandwidth
RF	Radio Frequency
RMS	Root Mean Square
Rx	Receiver
SINAD	Ratio of (Signal + Noise + Distortion) to (Noise + Distortion)
SNR	Signal to Noise Ratio
SRD	Short Range Device
TOI	Third Order Intermodulation
Tx	Transmitter
Tx-IMD	Transmitter Inter Modulation Distortion
VBW	Video Bandwidth
VSWR	Voltage Standing Wave Ratio
WMAS	Wireless Multichannel Audio Systems

4 Technical requirements specifications

4.1 Environmental profile

The technical requirements of the present document apply under the environmental profile for the operation of the equipment, which shall be in accordance with its intended use (product information, see clause 5.3.1). The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the operational environmental profile defined by its intended use.

4.2 Conformance requirements

4.2.1 Transmitter RF Output Power

4.2.1.1 Definition

The *Transmitter RF Output Power* is the equivalent isotropically radiated power (e.i.r.p.) or effective radiated power (e.r.p.).

The declared *Maximum Transmitter RF Output Power* is maximum Transmitter RF Output Power as provided with the product information for testing (see clause 5.3.1).

4.2.1.2 Limit

The declared tuning range of the DUT might cover multiple frequency bands.

In all cases, the *Transmitter RF Output Power* limit defined in the latest version of CEPT/ERC Recommendation 70-03 [i.12], annex 10, National Interface regulations, EC decisions or licence terms for each frequency band shall not be exceeded.

4.2.1.3 Conformance

Conformance test as defined in clause 5.4.1 shall be carried out for each frequency band covered by the tuning range of the DUT.

4.2.2 Transmitter Frequency Stability

4.2.2.1 General

PMSE equipment is typically operating on an *Operating Channel* with a *Declared Centre Frequency* within its *Declared Tuning Range*.

4.2.2.2 Definition

The *Declared Centre Frequency* (f_c) is the centre of the *Operating Channel*.
Transmitter Frequency Stability is a measurement of the transmitter frequency error determined by the positive or negative difference between the declared centre frequency and the actual centre frequency of the device.

4.2.2.3 Limits

The *Centre Frequency* for any given channel shall be maintained within the range $f_c \pm \Delta$, where the values of Δ are given in table 2.

Table 2: Frequency Stability Δ

	Δ
$f_c < 1$ GHz	20 ppm
1 GHz $\leq f_c < 2$ GHz	15 ppm
$f_c \geq 2$ GHz	10 ppm

Equipment with a declared tuning range covering more than one range as given in table 2, need to conform to the least restrictive limit.

4.2.2.4 Conformance

Conformance tests as defined in clause 5.4.2 shall be carried out if the DUT is able to provide an unmodulated carrier.

In cases where the DUT cannot provide a mode with an unmodulated carrier, conformance is assessed in accordance with clause 5.4.3, which shall be carried out on the declared centre frequency f_c.

4.2.3 Declared Channel Bandwidth and Occupied Channel Bandwidth

4.2.3.1 Definitions

The *Declared Channel Bandwidth B* (provided with the product information, see clause 5.3.1) is the widest band of frequencies, assigned to a single channel.

The *Occupied Channel Bandwidth* is the bandwidth containing 99 % of the power of the signal.

4.2.3.2 Limits

The declared tuning range of the DUT might cover multiple frequency bands.

In all cases, the maximum occupied channel bandwidth (*Occupied Channel Bandwidth* limit), as defined in the latest version of CEPT/ERC Recommendation 70-03 [i.12] annex 10, National Interface regulations, EC decisions or licence terms for each frequency band shall not be exceeded.

Table 3: Declared Channel Bandwidth

Declared Channel Bandwidth (B)
50 kHz
75 kHz
100 kHz
125 kHz
150 kHz
175 kHz
200 kHz
250 kHz
300 kHz
400 kHz
500 kHz
600 kHz
other up to 20 MHz (for WMAS)

The *Declared Channel Bandwidth* shall be one of the values provided in table 3.

For WMAS the *Declared Channel Bandwidth* B shall be less than or equal to 20 MHz.

For equipment employing analogue modulation techniques (e.g. FM), the *Occupied Channel Bandwidth* shall be up to 100 % of the *Declared Channel Bandwidth.*

For equipment employing digital modulation techniques including WMAS, the *Occupied Channel Bandwidth* shall be between 70 % and 100 % of the *Declared Channel Bandwidth* during time intervals of transmissions.

In the case of devices with multiple RF antenna ports, each of these shall meet this requirement.

4.2.3.3 Conformance

Conformance tests as defined in clause 5.4.3 shall be carried out for each frequency band covered by the tuning range of the DUT to determine the *Occupied Channel Bandwidth*.

4.2.4 Transmitter unwanted emissions

4.2.4.1 Transmitter unwanted emissions in the spurious domain

4.2.4.1.1 Definition

Transmitter unwanted emissions in the spurious domain are emissions on a frequency or frequencies immediately outside the limit of 250 % of the declared channel bandwidth above and below the centre frequency of the emission.

The limits of unwanted emissions in the spurious domain from the transmitter into the antenna port are in terms of mean power. The mean power of any spurious domain transmission from a burst transmitter is the mean power averaged over the burst duration.

The level of spurious emissions shall be measured by either:

a) the power level from an external Antenna port;

 and

 their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation);

 or

b) their effective radiated power when radiated by the cabinet and the integral antenna, in the case of hand-portable equipment fitted with such an antenna and no external Antenna port.

4.2.4.1.2 Limits

The level of transmitter unwanted emissions in the spurious domain shall not exceed the limits given in table 4.

Table 4: Transmitter unwanted emission limits (from ERC Recommendation 74-01 [2])

Frequency range	Maximum power	RBW
9 kHz - 150 kHz	-36 dBm	1 kHz
150 kHz - 30 MHz	-36 dBm	10 kHz
30 MHz - 1 GHz	-36 dBm	$F_c + 2,5\ B \leq f \leq f_c + 4\ B$: 1 kHz $F_c + 4\ B < f \leq f_c + 10\ B$: 10 kHz $f > f_c + 10\ B$: 100 kHz $f < f_c - 10\ B$: 100 kHz $f_c - 10\ B \leq f < f_c - 4\ B$: 10 kHz $f_c - 4\ B \leq f \leq f_c - 2,5\ B$: 1 kHz
except:		
47 MHz - 74 MHz 87,5 MHz - 118 MHz	-54 dBm	100 kHz
174 MHz - 230 MHz 470 MHz - 862 MHz	-54 dBm	$F_c + 2,5\ B \leq f \leq f_c + 4\ B$: 1 kHz $F_c + 4\ B < f \leq f_c + 10\ B$: 10 kHz $f > f_c + 10\ B$: 100 kHz $f < f_c - 10\ B$: 100 kHz $f_c - 10\ B \leq f < f_c - 4\ B$: 10 kHz $f_c - 4\ B \leq f \leq f_c - 2,5\ B$: 1 kHz
1 GHz < $f \leq F_{upper}$	-30 dBm	$F_c + 2,5\ B \leq f \leq f_c + 10\ B$: 30 kHz $F_c + 10\ B < f \leq f_c + 12\ B$: 300 kHz $f > f_c + 12\ B$: 1 MHz $f < f_c - 12\ B$: 1 MHz $f_c - 12\ B \leq f < f_c - 10\ B$: 300 kHz $f_c - 10\ B \leq f \leq f_c - 2,5\ B$: 30 kHz

with B being the Declared Channel Bandwidth.

F_{upper} is defined in table 5.

Table 5: Frequency range for measurement of unwanted emissions (from ERC Recommendation 74-01 [2])

Applicable fundamental frequency range	Frequency range for measurements	
	Lower frequency	Upper frequency
9 kHz - 100 MHz	9 kHz	1 GHz
100 MHz - 300 MHz	9 kHz	10^{th} harmonic of the operating frequency
300 MHz - 600 MHz	30 MHz	3 GHz
600 MHz - 3 GHz	30 MHz	5^{th} harmonic of the operating frequency

4.2.4.1.3 Conformance

Conformance tests as defined in clause 5.4.4 shall be carried out.

4.2.4.2 Transmitter unwanted emissions in the out of band domain

4.2.4.2.1 Definition

Transmitter unwanted emissions in the out of band domain are emissions on a frequency or frequencies immediately outside the operating channel, which results from the modulation process, but excluding spurious emissions.

4.2.4.2.2 Limits

The following limits are applicable, where B is the *Declared Channel Bandwidth*.

The mean Power Density, measured with 1 kHz measurement bandwidth and RMS detector, of the transmitter unwanted emissions shall not exceed the limits of the masks provided in figure 1 for equipment employing analogue modulation and figure 2 for equipment employing digital modulation, but excluding WMAS.

The limits in figures 1 and 2 are relative to the transmitter RF output power according to clauses 4.2.1 and 5.4.1.

Figure 1: Transmit spectral power mask for equipment employing analogue modulation, RBW = 1 kHz

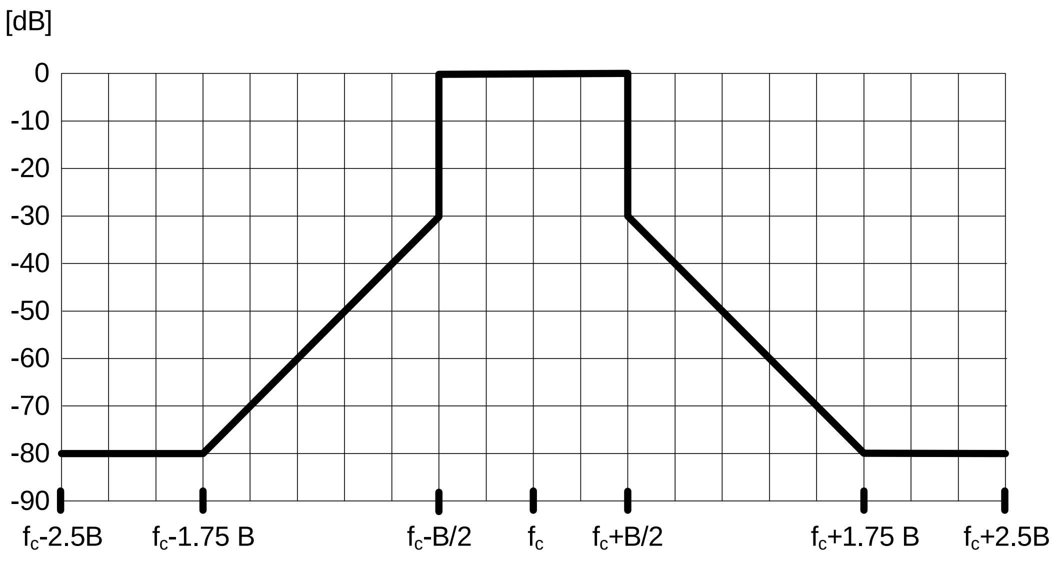


Figure 2: Transmit spectral power mask for equipment employing digital modulation, except WMAS, RBW = 1 kHz

The limits in figure 3 are applicable for WMAS, where B is the *Declared Channel Bandwidth*.

The mean Power Density, measured with 100 kHz measurement bandwidth and PEAK detector, of the transmitter unwanted emissions shall not exceed the limits of the mask provided in figure 3.

The limits in figure 3 are relative to transmitter RF output power according to clauses 4.2.1 and 5.4.1.

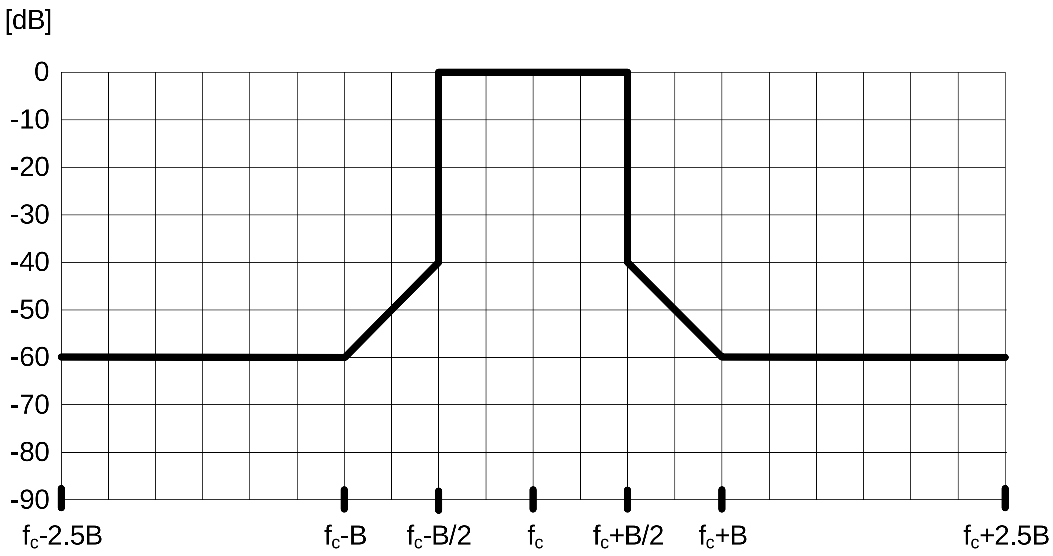


Figure 3: Transmit spectral power mask for WMAS, RBW = 100 kHz

The limits in figure 3 are provided with RBW = 100 kHz. The relevant measurements can also be performed with other RBW for certain ranges of B as given in table 3, accounting that the relevant limit given under RBW = 100 kHz needs to be converted appropriately by adding $c = 10 \times \log_{10}$ (RBW/100 kHz) for correction.

Table 6: Correction factor for different B and applicable RBW

B	RBW, VBW	c = correction factor
B < 2 MHz	10 kHz	-10 dB
2 MHz ≤ B < 5 MHz	25 kHz	-7 dB
5 MHz ≤ B ≤ 20 MHz	100 kHz	0 dB

4.2.4.2.3 Conformance

Conformance tests as defined in clause 5.4.3 shall be carried out.

4.2.5 Transmitter intermodulation attenuation

4.2.5.1 Definitions

The transmitter intermodulation attenuation is a measure of the capability of a transmitter to inhibit the generation of signals in its non-linear elements caused by the presence of the transmitter power and an interfering signal entering the transmitter via its antenna.

For the purposes of the present document, Transmitter Inter Modulation Distortion (Tx-IMD) measurements consider only Third Order Intermodulation (TOI) products at the transmitter side caused by the carrier frequency of DUT and an injected interfering frequency. These products are defined by:

$$f_{TOI} = 2 \times f_c - f_{INT} \text{ and } f_{TOI} = 2 \times f_{INT} - f_c$$

with:

- f_{TOI} = frequency of third order intermodulation product
- f_c = Declared carrier frequency of DUT
- f_{INT} = frequency of interferer

Tx-IMD is given in output power of TOI products relative to transmitter output power [dB].

4.2.5.2 Limits

The maximum resulting IMD product shall be at least 40 dB below the output power of the DUT.

4.2.5.3 Conformance

Conformance tests as defined in clause 5.4.5 shall be carried out.

4.3 Conformance requirements for receivers

4.3.1 Minimum performance criterion

The minimum performance criterion for the following receiver tests shall be 30 dB SINAD at the audio output of the DUT port for a measurement time ≥ 10 s without any dropouts or time outs in the measurement routine. This criterion shall be measured at the audio output port of the DUT, which shall be connected to a signal or audio analyser using an A-weighting filter.

If the receiver of a DUT is employed for receiving control data only, the performance criterion for the receiver tests shall be a Packet Error Rate (PER) of less than or equal to 10 %. For equipment that does not support a PER test to be performed, the minimum performance criterion shall be no loss of the wireless transmission function needed for the intended use of the equipment.

4.3.2 Receiver sensitivity

4.3.2.1 Definition

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

$$Rx_{sensitivity} = -174 \text{ dBm} + 10 \times \log(B) + NF + SNR_{needed}$$

with:

- NF = noise figure of the receiver in [dB]
- B = declared channel bandwidth in [Hz]
- SNR_{needed} = minimum needed signal-to-noise ratio for a given technology / operation mode in [dB]

The product information provided for the purpose of testing (see clause 5.3.1) shall provide:

- the *Receiver Category A, B or C* applicable for the equipment; and
- the *Declared Channel Bandwidth B.*

4.3.2.2 Limit

The measured Receiver sensitivity $Rx_{sensitivity}$ shall conform to the limits given in table 7 for the *Receiver Category* of the equipment.

Table 7: Limits for receiver sensitivity

Receiver category	Limits
A	$Rx_{sensitivity} \leq -90$ dBm
B	-90 dBm $< Rx_{sensitivity} \leq -70$ dBm
C	-70 dBm $< Rx_{sensitivity} \leq -50$ dBm

4.3.2.3 Conformance

Conformance test as defined in clause 5.5.1 shall be carried out.

4.3.3 Receiver adjacent channel selectivity

4.3.3.1 Definition

The adjacent channel selectivity is a measure of the capability of the receiver to operate satisfactorily in the presence of an unwanted signal on the next usable channel. It is given as ratio of unwanted signal output power to wanted signal output power in [dB].

The product information provided for the purpose of testing (see clause 5.3.1) shall provide:

- the *Receiver Category A, B or C* applicable for the equipment; and
- the *Declared Channel Separation.*

The adjacent channel is the next usable channel above or below the operating channel.

4.3.3.2 Limit

Receiver adjacent channel selectivity shall not go below the limits given in table 8 for the *Receiver Category* of the equipment.

Table 8: Limits for receiver adjacent channel selectivity

Receiver category	Limits
A	30 dB
B	25 dB
C	15 dB

4.3.3.3 Conformance

Conformance test as defined in clause 5.5.2 shall be carried out.

4.3.4 Receiver blocking

4.3.4.1 Definition

The receiver blocking is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted, unmodulated input signal at any offset frequency in the range between 3 × B and the receiver's tuning band. It is given as ratio of blocker signal output power to wanted signal output power in [dB].

The product information provided for the purpose of testing (see clause 5.3.1) shall include the *Receiver Category A, B or C* applicable for the equipment.

4.3.4.2 Limit

Receiver blocking, for any frequency within the specified ranges, shall not go below the limits given in table 9 for the *Receiver Category* of the equipment.

Table 9: Limits for receiver blocking

Receiver category	Limits
A	40 dB
B	30 dB
C	20 dB

4.3.4.3 Conformance

Conformance test as defined in clause 5.5.3 shall be carried out.

4.3.5 Receiver unwanted emissions in the spurious domain

4.3.5.1 Definition

Spurious emissions from the receiver or receiver combiner are radio frequency emissions at any frequency, generated by the equipment, antenna amplifier, down converters or active filters.

The level of spurious emissions shall be measured by either:

a) the power level from an external Antenna port;

   and

   their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation); or

b) their effective radiated power when radiated by the cabinet and the integral antenna, in the case of hand-portable equipment fitted with such an antenna and no external Antenna port.

4.3.5.2 Limit

The power of the spurious emissions shall not exceed the limits of table 10.

Table 10: Limits for receiver spurious emissions based on ERC Recommendation 74-01 [2]

Maximum power	Frequency range
-57 dBm	9 kHz ≤ f ≤ 1 GHz
-47 dBm	1 GHz < f

4.3.5.3 Conformance

Conformance test as defined in clause 5.5.4 shall be carried out.

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

5.1.1 Introduction

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use (provided with the product information, see clause 5.3.1).

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions within the boundary limits of the operational environmental profile defined by its intended use (provided with the product information, see clause 5.3.1) to give confidence of compliance for the affected technical requirements.

5.1.2 Normal test conditions

5.1.2.1 Normal temperature and humidity

Unless otherwise stated, the normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature: +15 °C to +35 °C;
- relative humidity: 20 % to 75 %.

The actual values during the tests shall be recorded.

5.1.2.2 Normal power source

The normal test voltage for the equipment shall be the nominal voltage for which the equipment was designed and shall use the power supply following the intended use (provided with the product information, see clause 5.3.1).

5.1.3 Extreme test conditions

Some tests in the present document need to be repeated at extreme temperatures. Where that is the case, measurements shall be made over the extremes of the operating temperature range as stated in product information provided for the purpose of testing (see clause 5.3.1).

5.2 Interpretation of the measurement results

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be included in the test report.

Informative values in table B.1 can be used for the interpretation of the results.

5.3 Definition of other test conditions

5.3.1 Product information for testing

Parameters of the requested information above are referenced as "declared" parameters in the present document.

These are:

- the declared tuning range(s);
- the declared centre frequencies, which can be, if required, concluded from tuning range(s) and tuning step size(s);
- the declared channel bandwidth;
- the declared operational environment profile; and
- the declared receiver class.

The information requested in the present clause should be included in the test report. This information is required in order to carry out the test suites and/or to declare compliance to technical requirements (e.g. technical requirements for which no conformance test is included in the present document):

1) in general:
   a) whether the equipment makes use of analogue modulation techniques (e.g. FM), digital modulation techniques (e.g. FSK, PSK) or WMAS for audio transmission;
   b) whether the equipment provides means to establish or support a spectrum scanning procedure and its associated receiver category;
   c) the applicable operational environmental profile and the operating temperature range;
   d) the applicable power source; e.g. battery, internal, or external supply and nominal voltage;
   e) whether the equipment is stand-alone equipment, combined equipment, or multi-radio equipment;
   f) the applicable test setup(s), if special information or instructions are required to improve testability;
   g) the applicable test fixture(s), if required;
   h) the applicable audio limiting threshold (see clause 5.3.2.1) or signal level (see clause 5.3.2.2) for the test signals;
2) with regards to antenna:
   a) whether the antenna(s) is(are) integral or dedicated antenna(s);
   b) the antenna gain, if applicable;

c) whether the equipment is for use with multiple antennas (e.g. Rx diversity) and if so, information on the applicable configuration for testing;

3) with regards to transmitter or transmitting part of transceiver:

a) the start and stop frequencies of the tuning range(s) supported by the equipment;

b) the channel bandwidth(s) supported by the equipment (declared channel bandwidth(s));

c) the channel separation supported by the equipment;

d) the tuning step size(s) or centre frequencies supported by the equipment;

e) the maximum RF transmit power e.i.r.p. of the equipment;

f) the operating modes e.g. emission type {ITU emission designator};

g) whether the equipment performs transmissions, which are continuous, non-continuous with constant duty cycle, or non-continuous without constant duty cycle;

h) in case of non-continuous transmission: the test mode occupying all supported frequency resources and has at least a duty cycle of 98 %, as stated in clause 5.3.2.5;

i) whether a corresponding device is required to initiate transmissions;

j) whether simultaneous transmission in one or more channels is used;

4) with regards to receiver or receiving part of transceiver:

a) the receiver category A, B, or C;

NOTE: Only one receiver category shall be selected for the device.

b) the start and stop frequencies of the tuning range(s) supported by the equipment;

c) the channel bandwidth(s) supported by the equipment (declared channel bandwidth(s));

d) the channel separation and tuning step size(s) supported by the equipment;

e) the receiver operational mode reaching the conditions as stated in clause 5.3.4.1;

f) whether a corresponding device is required to initiated reception;

5) with regards to WMAS, the minimum and the maximum number of audio channels supported.

5.3.2 Test signals

5.3.2.1 Audio test signal generation for equipment employing analogue modulation techniques

For normal test modulation, the audio frequency shall be a sinusoidal tone of 500 Hz, set at an input level to the transmitter 8 dB below the audio limiting threshold as stated with the product information (see clause 5.3.1).

For the purpose of measuring the transmit mask of analogue equipment, coloured noise according to Recommendation ITU-R BS.559-2 [i.15] shall be used, according to the following method:

With the Low Frequency (LF) audio signal generator set to 500 Hz, the audio input level to the DUT shall be adjusted to 8 dB below the audio limiting threshold (-8 dB (lim)) as declared in the product information for the purpose of testing (see clause 5.3.1).

Optionally a wave test signal file can be used which is available from the ETSI website.

The corresponding audio output level from the demodulator shall be measured and recorded.

The audio input level shall be increased by 20 dB, i.e. to +12 dB (lim), and the corresponding change in output level shall be measured.

It shall be checked that the audio output level has increased by ≤ 10 dB.

If this condition is not met, the initial audio input level shall be increased from -8 dB (lim) in 1 dB steps until the above condition is fulfilled, and the input level recorded in the test report. This level replaces the value derived from the manufacturer's declaration and is defined as -8 dB (lim).

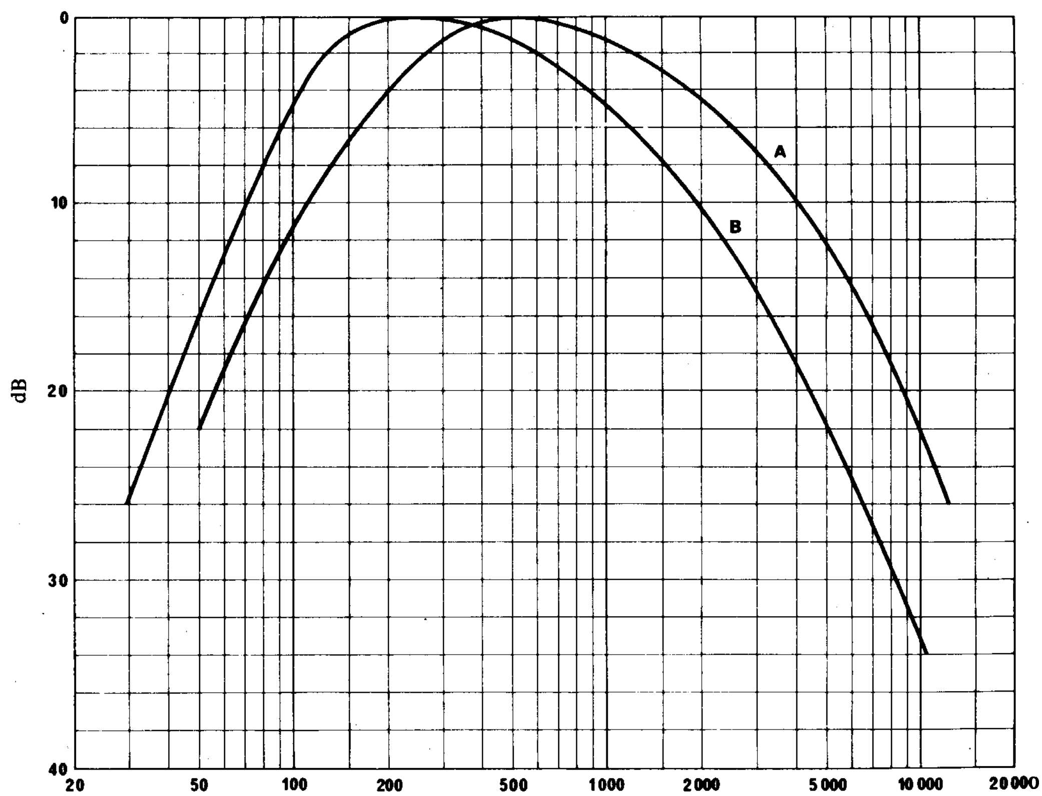
Measure the input level at the transmitter required to give +12 dB (lim).

The LF generator shall be replaced with the weighted noise source to Recommendation ITU-R BS.559-2 [i.15], band-limited to 15 kHz as described in IEC 60244-13 [1], and the level shall be adjusted such that the measured input to the transmitter corresponds to +12 dB (lim).

If the transmitter incorporates any ancillary coding or signalling channels (e.g. pilot-tones), these shall be enabled prior to any spectral measurements.

If the transmitter incorporates more than one audio input, e.g. stereo equipment, the second and subsequent channels shall be simultaneously driven from the same noise source, attenuated to a level of -6 dB (lim).

The resulting spectral distribution is shown in figure 4.



NOTE 1: Curve A = Frequency spectrum of standardized noise (measured with one-third octave filters).
NOTE 2: Curve B = Frequency response characteristics of the filter circuit.

Figure 4: Spectral distribution for determining transmitter occupied channel bandwidth

5.3.2.2 Audio test signal generation for equipment employing digital modulation techniques including WMAS

All measurements shall be carried out with audio input and output signals. The test signal shall be applied at 1 kHz, with the declared level provided with the product information (see clause 5.3.1).

If the DUT does not provide connectors for audio for the purpose of testing the DUT shall provide a mode able to generate the required test signals.

5.3.2.3 Wanted signal

The wanted signal shall be generated by a corresponding device fed by a 1 kHz sinusoidal audio input signal with an input level, which corresponds to 100 % modulation level for analogue equipment or which is limited to 6 dB below full scale for digital equipment. Alternatively, the signal can be generated by an appropriate signal generator or if no audio connectors are provided the signal can be generated by the corresponding device.

5.3.2.4 Unwanted signal

The unwanted signal shall be an unmodulated carrier generated by a signal generator.

5.3.2.5 Test signal for non-continuous transmitters

The test shall be based on a randomly generated payload.
Devices shall operate in a mode which occupies all supported frequency resources and shall have at least a duty cycle of 98 %. The applicable mode is provided with the product information (see clause 5.3.1).

5.3.3 Test setup

For DUT not needing a corresponding device the test setup shown in figure 5 should be used for all transmitter test unless otherwise stated.

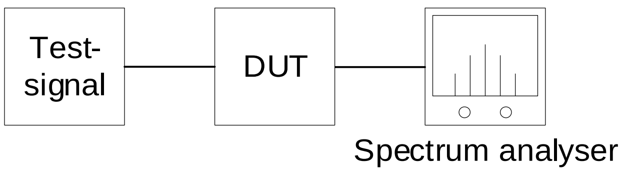


Figure 5: Example for a measurement setup for transmitter tests

If a corresponding device is needed, the test setup shown in figure 6 should be used for all transmitter tests unless otherwise stated.

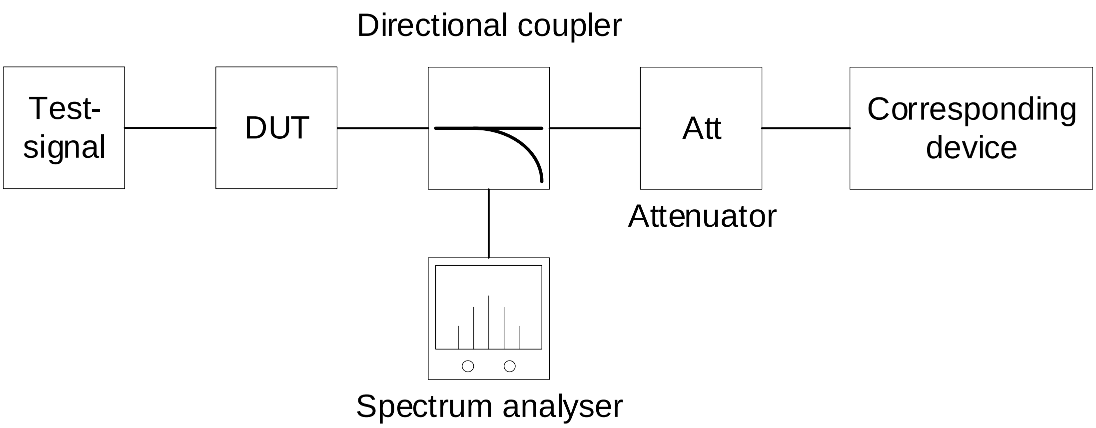


Figure 6: Example for a measurement setup with corresponding device

NOTE: If no audio connectors are provided by the DUT, the test signal can be generated by the DUT.

5.3.4 Test operational modes

5.3.4.1 Receiver operational mode

For all receiver tests, the DUT shall operate in its normal operational mode. If the DUT supports more than one mode of operation, all receiver tests shall be measured in the mode which operates with the corresponding modulation and coding scheme requiring the lowest SNR as provided with the product information (see clause 5.3.1).

5.3.4.2 Rx Diversity

If the DUT is equipped with Rx diversity, all receiver tests shall be performed in the configuration following the intended use and as described in the product information (see clause 5.3.1).

5.3.5 Antennas

5.3.5.1 Integrated and dedicated antennas

The equipment can have either integral antennas or dedicated antennas. Dedicated antennas, further referred to as *dedicated external antennas*, are antennas that are physically external to the equipment and are assessed in combination with the equipment against the requirements in the present document. It should be noted that the assessment does not necessarily lead to testing.

Although the measurement methods in the present document allow conducted measurements to be performed, it should be noted that the equipment together with all its intended antenna assemblies shall comply with the applicable technical requirements defined in the present document.

5.3.6 Presentation of equipment

Stand-alone equipment shall be tested against all requirements of the present document. For testing combined or multi-radio equipment guidance is given in ETSI EG 203 367 [i.6], clause 6.

The product information (see clause 5.3.1) shall state whether the equipment is stand-alone equipment, combined equipment or multi-radio equipment.

5.3.7 Conducted measurements, radiated measurements, relative measurements

Unless otherwise specified, either conducted or radiated measurements may be used. For integral antenna equipment, connectors may be provided to allow conducted measurements to be performed. In the case of integral antenna equipment that has no antenna connector(s), the manufacturer may be required to supply a test fixture, to allow relative measurements to be made. The test fixture and its use are further described in clause D.5.

5.4 Method of measurement for transmitters

5.4.1 Transmitter RF power

5.4.1.1 Test conditions

The conformance requirements in clause 4.2.1 shall be verified on the lowest and highest declared centre frequency of each frequency band covered by the DUT.

These measurements shall be performed under both normal and extreme test conditions.

The measurements may need to be repeated to cover each of the transmit operating modes the DUT supports.

The measurements shall be performed with the test signal specified in clause 5.3.2.1 (analogue modulation), clause 5.3.2.2 (digital modulation including WMAS) or clause 5.3.2.5 for the transmitter with non-continuous transmission applied.

The DUT shall transmit with its maximum RF output power.

5.4.1.2 Test method

5.4.1.2.1 Conducted measurement

The output of the DUT shall be connected to a spectrum analyser. Additional cable loss shall be considered.

The following analyser settings shall be used:

- Centre Frequency = f_c (declared centre frequency)
- Span = 10 × B
- RBW ≥ 2,5 × B
- VBW ≥ RBW
- Sweep Points ≥ 101
- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time = Sweep Points × 100 ms
- Sweep Time = Measurement Time
- Sweep Mode = Single sweep

When the sweep has finished, use a marker to find the PEAK of the displayed trace. This value denotes the maximum RF output power and is used as reference value for the transmit spectral power masks of clause 4.2.4.2.2.

5.4.1.2.2 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used with a spectrum analyser attached to the test antenna.

The test procedure is as described under clause 5.4.1.2.1.

5.4.2 Transmitter frequency stability

5.4.2.1 Test conditions

The conformance requirements in clause 4.2.2.3 shall be verified under both normal and extreme test conditions. The DUT shall operate in the middle of its frequency bands within its tuning range. The DUT shall be configured to operate at maximum RF output power.

5.4.2.2 Test method

5.4.2.2.1 Conducted measurement

5.4.2.2.1.1 Equipment able to provide an unmodulated carrier

This test method requires that the DUT can be operated in an unmodulated test mode.

The DUT shall be connected to a suitable frequency measuring device (e.g. a spectrum analyser) and operated in an unmodulated mode.

The result shall be recorded as the actual centre frequency f_{cm} of the DUT.

5.4.2.2.1.2 Equipment unable to provide an unmodulated carrier

In cases where the DUT cannot provide a mode with an unmodulated carrier, conformance is assessed in accordance with clause 5.4.3, which shall be carried out on the declared centre frequency f_c.

5.4.2.2.2 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used with a spectrum analyser attached to the test antenna.

The test procedure is as described under clause 5.4.2.2.1.

5.4.3 Transmitter unwanted emissions in the out of band domain and occupied channel bandwidth

5.4.3.1 Test conditions

The conformance requirements in clause 4.2.3.2 and in clause 4.2.4.2 shall be verified only under normal test conditions and when operating on a centre frequency in the middle of each frequency band within the tuning range of the DUT.

The measurements may need to be repeated to cover each of the transmit operating modes the DUT supports.

The measurements shall be performed with the test signal specified in clause 5.3.2.1 (analogue modulation) or 5.3.2.2 (digital modulation including WMAS) applied.

The DUT shall transmit with its maximum RF output power.

5.4.3.2 Test method

5.4.3.2.1 Conducted measurement

5.4.3.2.1.1 For analogue modulated equipment

The settings of the spectrum analyser shall be:

- Centre Frequency = fcm (actual centre frequency)
- Span = 5 × B
- RBW = 1 kHz
- VBW = 1 kHz
- Sweep Points ≥ Span / RBW
- Detector = PEAK (Max or Positive)
- Trace Mode = Clear Write
- Measurement Time ≥ 20 s
- Sweep Time = Measurement Time

- Sweep Mode = Single sweep

NOTE: If the DUT does not provide an unmodulated carrier to measure the actual centre frequency fcm according to clause 5.4.2, the declared centre frequency fc can be used.

Step 1:

Perform spectrum mask conformity test.

Step 2:

Use the 99 % bandwidth function of the spectrum analyser to measure the *Occupied Channel Bandwidth* of the DUT. This value shall be recorded.

5.4.3.2.1.2 For digital modulated equipment except WMAS

The settings of the spectrum analyser shall be:

- Centre Frequency = fcm (actual centre frequency)
- Span = 5 × B
- RBW = 1 kHz
- VBW = 1 kHz
- Sweep Points > Span / RBW
- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time ≥ 20 s
- Sweep Time = Measurement Time
- Sweep Mode = Single sweep

NOTE: If the DUT does not provide an unmodulated carrier to measure the actual centre frequency fcm according to clause 5.4.2, the declared centre frequency fc can be used.

Step 1:

Perform spectrum mask conformity test.

Step 2:

Use the 99 % bandwidth function of the spectrum analyser to measure the *Occupied Channel Bandwidth* of the DUT. This value shall be recorded.

5.4.3.2.1.3 For WMAS

The settings of the spectrum analyser shall be:

- Centre Frequency = fcm (actual centre frequency)
- Span = 5 × B
- RBW and VBW = see table 6
- Sweep Points > Span / RBW
- Detector = PEAK (Max or Positive)
- Trace Mode = MAX HOLD

- Measurement Time ≥ 60 s
- Sweep Time ≤ Measurement Time
- Sweep Mode = Continuous sweep

NOTE: If the DUT does not provide an unmodulated carrier to measure the actual centre frequency fcm according to clause 5.4.2, the declared centre frequency fc can be used.

Step 1:

Perform spectrum mask conformity test.

Step 2:

Use the 99 % bandwidth function of the spectrum analyser to measure the *Occupied Channel Bandwidth* of the DUT. This value shall be recorded.

5.4.3.2.2 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used.

The test procedure is as described under clause 5.4.3.2.1.

5.4.4 Transmitter unwanted emissions in the spurious domain

5.4.4.1 Test conditions

The conformance requirements in clause 4.2.4.1.2 shall be verified only under normal operating conditions and when operating on a centre frequency in the middle of each frequency band within the tuning range of the DUT.

The DUT shall be operated in the orientation which produces the highest output signal. This configuration shall be noted in the test report.

The measurements shall be performed with the test signal specified in clause 5.3.2.1 (analogue modulation) or 5.3.2.2 (digital modulation including WMAS) applied.

The DUT shall transmit with maximum RF output power.

5.4.4.2 Test method

5.4.4.2.1 Segmentation in smaller frequency bands

According to table 4 (Frequency range for measurement of unwanted emissions based on ERC Recommendation 74-01 [2]) the measured frequency range is defined by the lower and upper frequency.

Due to the large frequency range which has to be measured, the measurement may be segmented in smaller frequency bands which can be measured within one span of the spectrum analyser.

5.4.4.2.2 Conducted measurement

5.4.4.2.2.1 For equipment with continuous transmission

The settings of the spectrum analyser shall be:

- Centre Frequency = centre frequency in the middle of each frequency band
- Span = according to segmented frequency range

- RBW = according to table 3
- VBW ≥ RBW
- Sweep Points ≥ Span / RBW
- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time = Sweep Time
- Sweep Time = 10 s - 20 s
- Sweep Mode = Single sweep

5.4.4.2.2.2 For equipment with non-continuous transmission

The settings of the spectrum analyser shall be:

- Centre Frequency = centre frequency in the middle of each frequency band
- Span = according to segmented frequency range
- RBW = according to table 3
- VBW ≥ RBW
- Sweep Points ≥ Span / RBW
- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time = Sweep Time
- Sweep Time ≥ Sweep Points × 10 ms
- Sweep Mode = Single sweep

5.4.4.2.3 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used with a spectrum analyser attached to the test antenna.

The test procedure is as described under clause 5.4.4.2.2.

5.4.5 Transmitter intermodulation attenuation

5.4.5.1 Test conditions

The conformance requirements in clause 4.2.5.2 shall be verified under normal operating conditions and when operating on a centre frequency in the middle of each frequency band of the tuning range of the DUT.

The measurements shall be performed with the test signal specified in clause 5.3.2.1 (analogue modulation) or 5.3.2.2 (digital modulation including WMAS) applied.

The DUT shall transmit with maximum RF output power.

An additional unmodulated signal f_{INT} is used for interfering.

5.4.5.2 Test method

5.4.5.2.1 Conducted measurement

The test setup in case of no corresponding device is needed is shown in figure 7.

Figure 8 shows the test setup in case a corresponding device is needed.

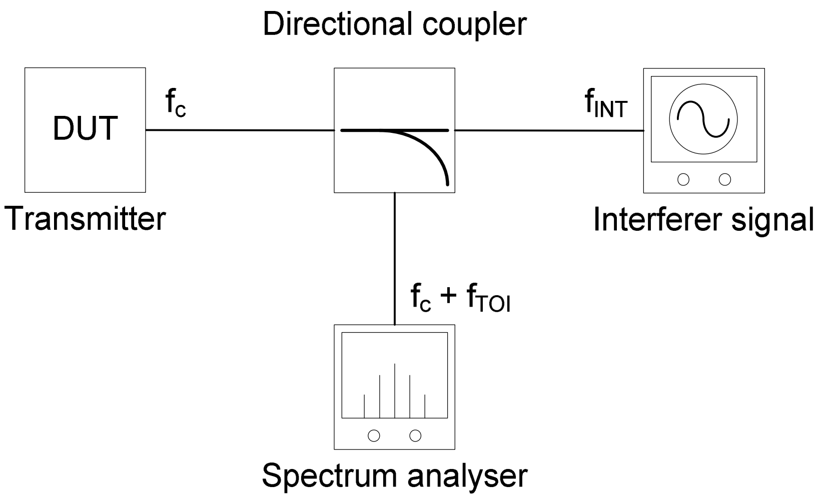


Figure 7: Measurement setup without corresponding device

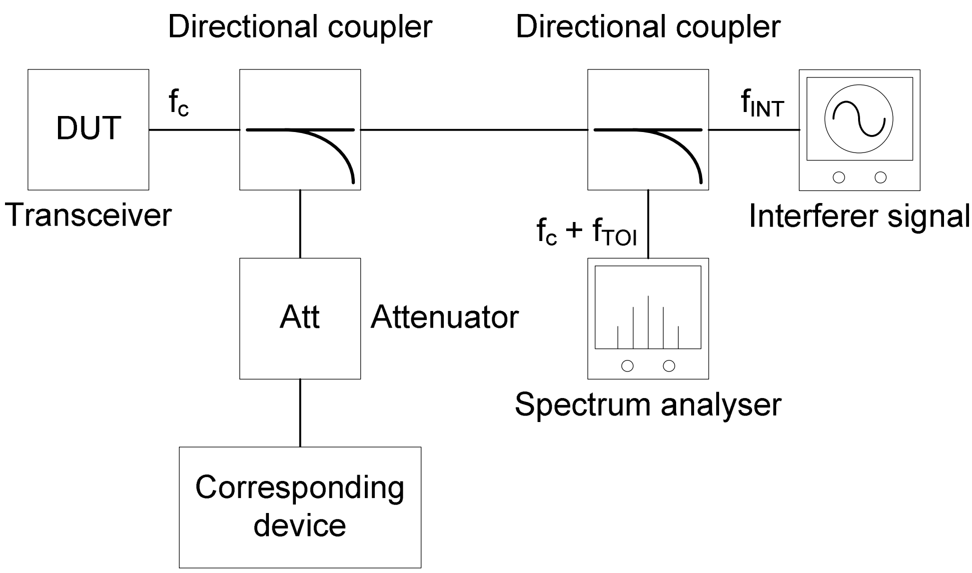


Figure 8: Measurement setup with corresponding device

The centre frequency of the interferer signal shall be set to $f_{INT1} = f_c + f_{offset}$ and $f_{INT2} = f_c - f_{offset}$ with:

- 2 MHz $\leq f_{offset} \leq$ 10 MHz for all equipment except WMAS; or
- 2,5 × B $\leq f_{offset} \leq$ half of tuning band for WMAS.

One frequency f_{offset} shall be chosen from the above-given range for all Tx intermodulation measurements. The power level of the interferer signal shall be -30 dB with respect to the output power of the DUT (see clause 5.4.1) measured at the output port of the DUT. The path loss of the connection between the interferer source and DUT shall be considered for determining the output power of the interferer signal.

Tx-IMD shall be measured with the following analyser settings:

Step 1:

- Centre frequency = $2 \times f_c - f_{INT1}$
- Span > $4 \times f_{offset}$
- RBW ≥ 2,5 × B
- VBW ≥ RBW
- Sweep Points ≥ 101
- Detector = RMS
- Trace mode = Clear Write
- Sweep Mode: Single Sweep
- Sweep time = AUTO

Step 2:

- Centre frequency = $2 \times f_{INT1} - f_c$
- Span > $4 \times f_{offset}$
- RBW ≥ 2,5 × B
- VBW ≥ RBW
- Sweep Points ≥ 101
- Detector = RMS
- Trace mode = Clear Write
- Sweep Mode: Single Sweep
- Sweep time = AUTO

Step 3:

- Centre frequency = $2 \times f_c - f_{INT2}$
- Span > $4 \times f_{offset}$
- RBW ≥ 2,5 × B
- VBW ≥ RBW
- Sweep Points ≥ 101
- Detector = RMS
- Trace mode = Clear Write
- Sweep Mode: Single Sweep
- Sweep time = AUTO

Step 4:

- Centre frequency = $2 \times f_{INT2} - f_c$

- Span > 4 × f_{offset}
- RBW ≥ 2,5 × B
- VBW ≥ RBW
- Sweep Points ≥ 101
- Detector = RMS
- Trace mode = Clear Write
- Sweep Mode: Single Sweep
- Sweep time = AUTO

The reference level of the analyser shall be set according to the signal power at f_c (see clause 5.4.1).

The highest level of the Tx-IMD products relative to the transmitter output power shall be recorded in the test report.

5.4.5.2.2 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used with the interfering carrier generated from a signal generator connected to an omnidirectional antenna placed on the same plane 1 m away from the desired antenna of the DUT within a chamber.

The interferer carrier generated by the signal generator shall have the same RF output power as the DUT referenced to the input to the antenna.

The test procedure is as described under clause 5.4.5.2.1.

5.5 Method of measurement for receivers

5.5.1 Receiver sensitivity

5.5.1.1 Test conditions

The conformance requirements in clause 4.3.2.3 shall be performed at normal test conditions and when operating on a centre frequency in the middle of each frequency band within the tuning range of the DUT.

The DUT shall operate according to clause 5.3.4.1.

The wanted signal according to clause 5.3.2.3 shall be set to the centre frequency of the DUT and in a corresponding operational mode.

5.5.1.2 Test method

5.5.1.2.1 Conducted measurement

In figure 9 the test setup which can be used for the receiver sensitivity test is shown. Between the output port of the corresponding device and the antenna port of the DUT, a variable attenuator with a step size of at least 1 dB shall be inserted.

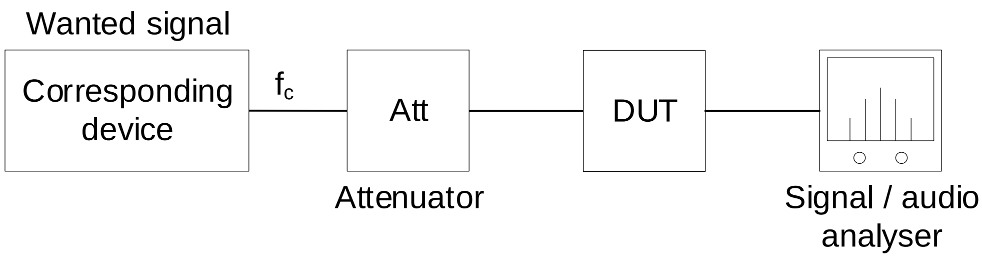


Figure 9: Receiver sensitivity test setup

A communication link is set up between the DUT and the corresponding device. The attenuation of the variable attenuator shall be decreased in 1 dB steps to a value at which the minimum performance criteria as specified in clause 4.3.1 is still met. The resulting level for the wanted signal at the input of the DUT is P_{min}, which denotes the receiver sensitivity.

5.5.1.2.2 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used.

The test procedure is as described under clause 5.5.1.2.1.

5.5.2 Receiver adjacent channel selectivity

5.5.2.1 Test conditions

The conformance requirements in clause 4.3.3.3 shall be performed at normal test conditions and when operating on a centre frequency in the middle of each frequency band within the tuning range of the DUT.

The DUT shall operate according to clause 5.3.4.1.

The wanted signal according to clause 5.3.2.3 shall be set to the centre frequency of the DUT and in a corresponding operational mode. The output level of the wanted signal shall be adjusted that its input level at the DUT's antenna port is equal to 3 dB above P_{min} (see clause 5.5.1.2.1).

The unwanted signal shall be set according to clause 5.3.2.4.

5.5.2.2 Test method

5.5.2.2.1 Conducted measurement

Figure 10 shows the test setup which can be used for performing the receiver adjacent channel selectivity test.

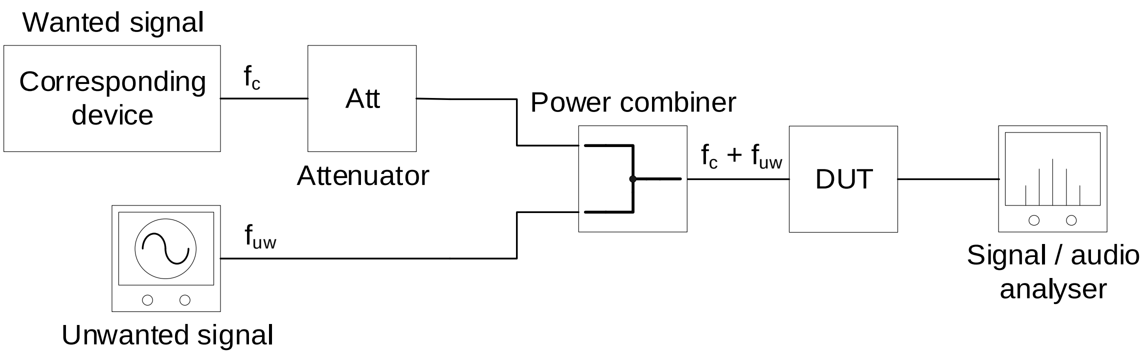


Figure 10: Test setup for receiver adjacent channel selectivity

The steps below define the procedure to verify the receiver adjacent channel selectivity requirement as described in clause 4.3.3.3.

Step 1:

With the unwanted signal generator switched off a communication link is set up between the DUT and the associated corresponding device.

Step 2:

The output level of the unwanted signal shall be adjusted that its input level at the DUT's antenna port is equal to 3 dB above P_{min} and its frequency is set to the nominal first adjacent channel centre frequency above the operating channel.

Step 3:

The output power level of the unwanted signal generator shall be increased by 1 dB steps to a value at which the minimum performance criteria as specified in clause 4.3.1 is still met. The ratio of the unwanted signal level and the wanted signal level gives the value of receiver adjacent channel selectivity for the above adjacent channel.

Step 4:

The output level of the unwanted signal shall be adjusted that its input level at the DUT's antenna port is equal to 3 dB above P_{min} and its frequency is set to the nominal first adjacent channel centre frequency below the operating channel.

Step 5:

The output power level of the unwanted signal generator shall be increased by 1 dB steps to a value at which the minimum performance criteria as specified in clause 4.3.1 is still met. The ratio of the unwanted signal level and the wanted signal level gives the value of receiver adjacent channel selectivity for the below adjacent channel.

The minimum of both values (results of Step 3 and Step 5) gives the receiver adjacent channel selectivity and shall be recorded.

5.5.2.2.2 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used.

The test procedure is as described under clause 5.5.2.2.1.

5.5.3 Receiver blocking

5.5.3.1 Test conditions

The conformance requirements in clause 4.3.4.2 shall be performed at normal test conditions and when operating on a centre frequency in the middle of each frequency band within the tuning range of the DUT.

The DUT shall operate according to clause 5.3.4.1.

The wanted signal according to clause 5.3.2.3 shall be set to the centre frequency of each frequency band and in a corresponding operational mode. The output level of the wanted signal shall be adjusted that its input level at the DUT's antenna port is equal to 3 dB above P_{min} (see clause 5.5.1.2.1).

The unwanted signal shall be set according to clause 5.3.2.4. Four frequencies shall be selected:

$$f_{uw1} = f_c - f_{offset1} \text{ and } f_{uw2} = f_c + f_{offset1} \text{ with } 3\ x\ B\ \geq f_{offset1} \geq 10xB.$$

$$f_{uw3} = f_c - f_{offset2} \text{ and } f_{uw4} = f_c + f_{offset2} \text{ with } 10\ x\ B\ \geq f_{offset2} \geq \frac{tuning\ band}{2}.$$

5.5.3.2 Test method

5.5.3.2.1 Conducted measurement

Figure 10 shows the test setup which can be used for performing the receiver blocking test.

The steps below define the procedure to verify the receiver blocking requirement as described in clause 4.3.4.

Step 1:

With the unwanted signal generator switched off a communication link is set up between the DUT and the associated corresponding device.

Step 2:

The output level of the unwanted signal shall be adjusted that its input level at the antenna port of the DUT is equal to 3 dB above P_{min}.

Step 3:

The centre frequency of the unwanted signal generator is set to f_{uw1}.

Step 4:

The output power level of the unwanted signal generator shall be increased by 1 dB steps to a value at which the minimum performance criteria as specified in clause 4.3.1 is still met. The ratio of the unwanted signal level and the wanted signal level gives the value of receiver blocking.

Step 5:

The output level of the unwanted signal shall be adjusted that its input level at the antenna port of the DUT is equal to 3 dB above P_{min}.

Step 6:

The centre frequency of the unwanted signal generator is set to f_{uw2}.

Step 7:

The output power level of the unwanted signal generator shall be increased by 1 dB steps to a value at which the minimum performance criteria as specified in clause 4.3.1 is still met. The ratio of the unwanted signal level and the wanted signal level gives the value of receiver blocking.

Step 8:

Repeat Step 3 to 7 replacing f_{uw1} with f_{uw3} and f_{uw2} with f_{uw4}.

The minimum of all measured blocking values gives the receiver blocking and shall be recorded.

5.5.3.2.2 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s).

The test set up as described in annex D shall be used.

The test procedure is as described under clause 5.5.3.2.1.

5.5.4 Receiver unwanted emissions in the spurious domain

5.5.4.1 Test conditions

The conformance requirements in clause 4.3.5.2 shall be performed at normal test conditions and when operating on the centre frequency of each frequency band within the tuning range of the DUT.

The DUT shall be configured into a continuous receive mode or shall be operated in a mode where no transmissions occur.

5.5.4.2 Test method

5.5.4.2.1 Segmentation in smaller frequency bands

The measured frequency range is defined by the lower and upper frequency with the lower frequency = 9 kHz and the upper frequency is according to table 4, where the fundamental frequency range should include the highest oscillator frequency used in the receiver and the harmonics are those of the highest oscillator frequency.

Due to the large frequency range which has to be measured, the measurement may be segmented in smaller frequency bands which can be measured within one span of the spectrum analyser.

5.5.4.2.2 Conducted measurement

Step 1:

Frequency range 9 kHz - 150 kHz

The settings of the spectrum analyser shall be:

- Centre Frequency = Span / 2
- Span = 141 kHz
- RBW = 1 kHz
- VBW = 1 kHz
- Sweep Points ≥ Span / RBW
- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time= Sweep Time
- Sweep Time = 20 s
- Sweep Mode = Single sweep

Step 2:

Frequency range 150 kHz - 30 MHz

The settings of the spectrum analyser shall be:

- Centre Frequency = Span / 2
- Span = 29,85 MHz or according to segmented frequency range
- RBW = 10 kHz
- VBW = 10 kHz
- Sweep Points ≥ Span / RBW

- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time = Sweep Time
- Sweep Time = 20 s
- Sweep Mode = Single sweep

If Span < 29,85 MHz due to the limited number of Sweep Points, repeat Step 2 until 30 MHz is reached.

Step 3:

Frequency range 30 MHz - 1 GHz

The settings of the spectrum analyser shall be:

- Centre Frequency = Span / 2
- Span = according to segmented frequency range
- RBW = 100 kHz
- VBW = 100 kHz
- Sweep Points ≥ Span / RBW
- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time = Sweep Time
- Sweep Time = 20 s
- Sweep Mode = Single sweep

If Span < 970 MHz due to the limited number of Sweep Points, repeat Step 3 until 1 GHz is reached.

Step 4:

Frequency range 1 GHz - F_{upper}

The settings of the spectrum analyser shall be:

- Centre Frequency = Span / 2
- Span = according to segmented frequency range
- RBW = 1 MHz
- VBW = 1 MHz
- Sweep Points ≥ Span / RBW
- Detector = RMS
- Trace Mode = Clear Write
- Measurement Time = Sweep Time
- Sweep Time = 20 s
- Sweep Mode = Single sweep

Repeat Step 4 as needed, until F_{upper} is reached.

The values measured in Step 1 to Step 4 shall be compared to the limits defined in clause 4.3.5.2.

5.5.4.2.3 Radiated measurement

Radiated measurements shall only be used for a DUT with integral antenna(s) and without a temporary antenna connector(s) / test fixture.

The test set up as described in annex D shall be used with a spectrum analyser attached to the test antenna.

The test procedure is as described under clause 5.5.4.2.2.

Annex A (informative): Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.18] to provide one voluntary means of conforming to the essential requirements of 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 and repealing Directive 1999/5/EC [i.10].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

Table A.1: Relationship between the present document and the essential requirements of Directive 2014/53/EU

Harmonised Standard ETSI EN 300 422-1					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Transmitter RF Output Power	3.2	4.2.1	U	
2	Transmitter Frequency Stability	3.2	4.2.2	U	
3	Declared Channel Bandwidth and Occupied Channel Bandwidth	3.2	4.2.3	U	
4	Transmitter unwanted emissions in the spurious domain	3.2	4.2.4.1	U	
5	Transmitter unwanted emissions in the out of band domain	3.2	4.2.4.2	U	
6	Transmitter intermodulation attenuation	3.2	4.2.5	U	
7	Minimum performance criterion	3.2	4.3.1	U	
8	Receiver sensitivity	3.2	4.3.2	U	
9	Receiver adjacent channel selectivity	3.2	4.3.3	U	
10	Receiver blocking	3.2	4.3.4	U	
11	Receiver unwanted emissions in the spurious domain	3.2	4.3.5	U	

Key to columns:

Requirement:

No A unique identifier for one row of the table which may be used to identify a requirement.

Description A textual reference to the requirement.

Essential requirements of Directive

Identification of article(s) defining the requirement in the Directive.

Clause(s) of the present document

Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

U/C Indicates whether the requirement is unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

Condition Explains the conditions when the requirement is or is not applicable for a requirement which is classified "conditional".

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (informative): Maximum measurement uncertainty

The measurements described in the present document are based on the following assumptions:

- the measured value related to the corresponding limit is used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter is included in the test report.

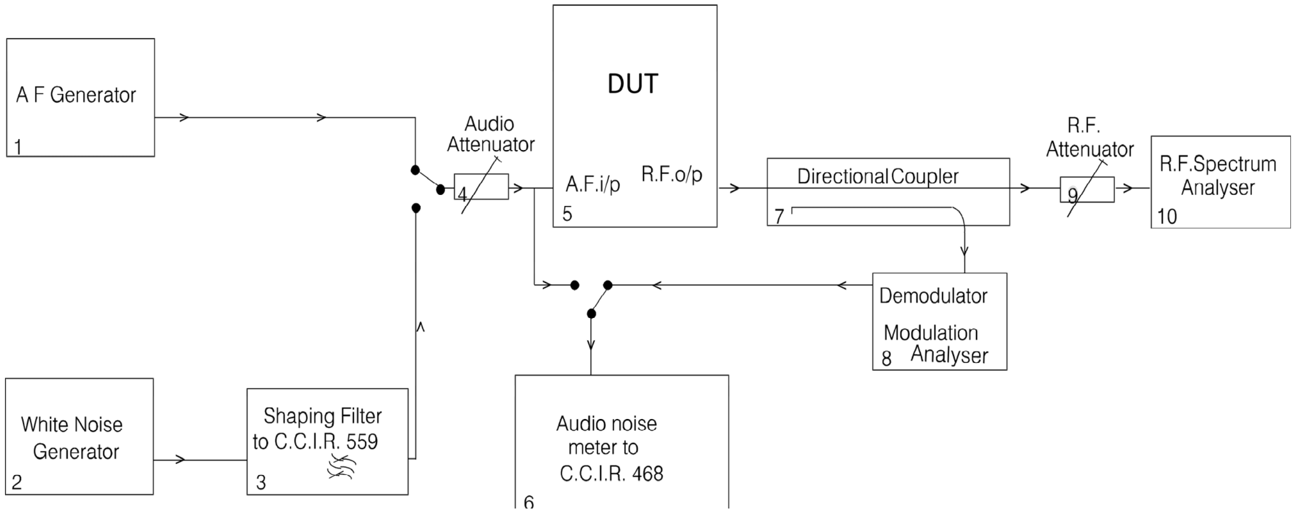
Table B.1 shows the recommended values for the maximum measurement uncertainty figures.

Table B.1: Maximum measurement uncertainty

Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-7}$
Audio Output power	±0,5 dB
Radiated RF power	±6 dB
Conducted RF power Variations using a test fixture	±0,75 dB
Maximum frequency deviation:	
• within 300 Hz and 6 kHz of audio frequency	±5 %
• within 6 kHz and 25 kHz of audio frequency	±3 dB
Deviation limitation	±5 %
Radiated emission of transmitter, Valid up to 12,75 GHz	±6 dB
Radiated emission of receiver, Valid up to 12,75 GHz	±6 dB

Annex C (informative): Measurement of Occupied Channel Bandwidth for analogue equipment

C.1 Test configuration for measurement of the Occupied Channel Bandwidth for analogue equipment



NOTE: If the DUT incorporates ancillary coding or signalling channels, for example, pilot tone, etc. these should be switched on prior to measuring the transmitter RF output spectrum.

Figure C.1

Annex D (normative): Radiated measurement

D.1 Test sites and general arrangements for measurements involving the use of radiated fields

D.1.1 General

This clause introduces the three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in the relevant parts of ETSI TR 102 273 [i.7] or equivalent.

NOTE: To ensure reproducibility and tractability of radiated measurements only these test sites should be used in measurements in accordance with the present document.

D.1.2 Anechoic chamber

An anechoic chamber is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The chamber usually contains an antenna support at one end and a turntable at the other. A typical anechoic chamber is shown in figure D.1.

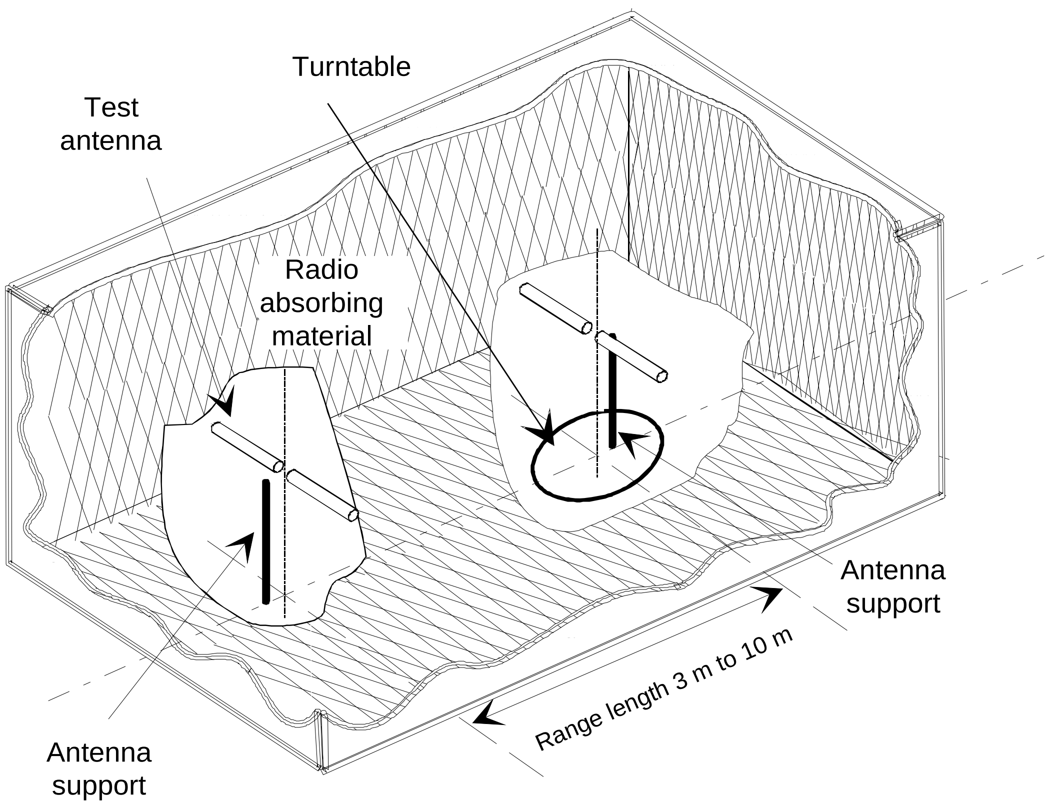


Figure D.1: A typical anechoic chamber

The chamber shielding and radio absorbing material work together to provide a controlled environment for testing purposes. This type of test chamber attempts to simulate free-space conditions.

The shielding provides a test space, with reduced levels of interference from ambient signals and other outside effects, whilst the radio absorbing material minimizes unwanted reflections from the walls and ceiling which can influence the measurements. In practice it is relatively easy for shielding to provide high levels (80 dB to 140 dB) of ambient interference rejection, normally making ambient interference negligible.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (DUT) at a suitable height (e.g. 1 m) above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2 / \lambda$ (m), whichever is greater (see clause D.2.7). The distance used in actual measurements shall be recorded with the test results.

The anechoic chamber generally has several advantages over other test facilities. There is minimal ambient interference, minimal floor, ceiling and wall reflections and it is independent of the weather. It does however have some disadvantages which include limited measuring distance and limited lower frequency usage due to the size of the pyramidal absorbers. To improve low-frequency performance, a combination structure of ferrite tiles and urethane foam absorbers is commonly used.

All types of emission, sensitivity and immunity testing can be carried out within an anechoic chamber without limitation.

D.1.3 Anechoic chamber with a conductive ground plane

An anechoic chamber with a conductive ground plane is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The floor, which is metallic, is not covered and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other. A typical anechoic chamber with a conductive ground plane is shown in figure D.2.

This type of test chamber attempts to simulate an ideal Open Area Test Site whose primary characteristic is a perfectly conducting ground plane of infinite extent.

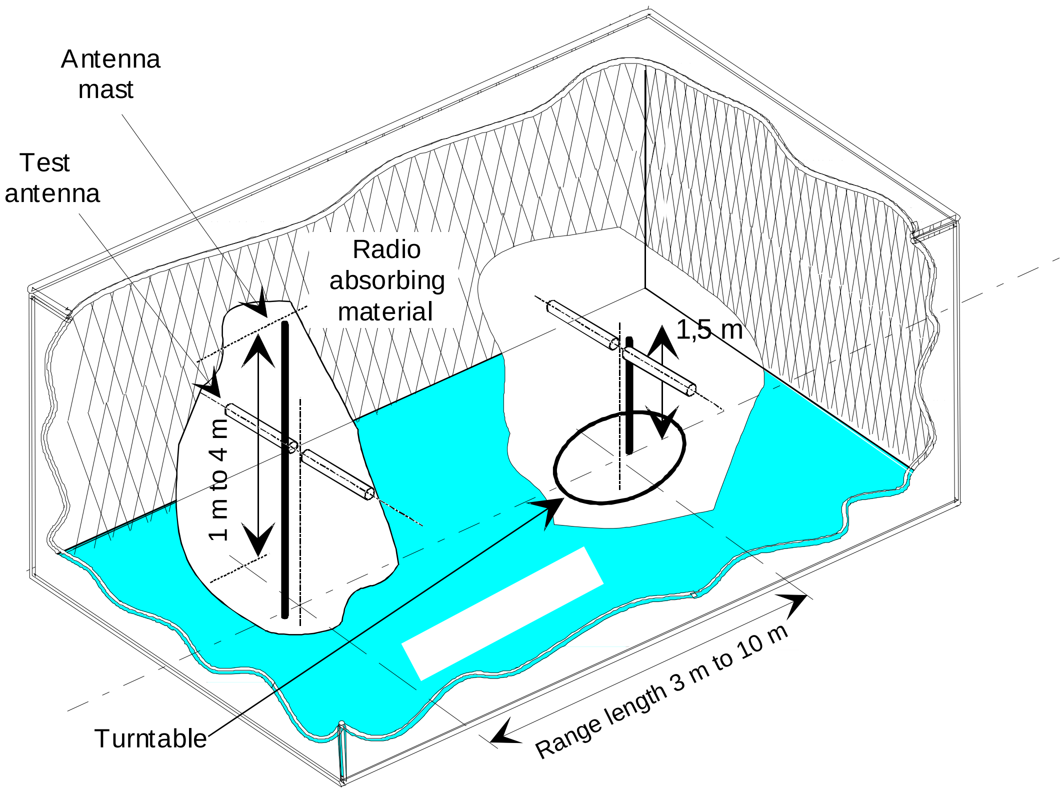


Figure D.2: A typical anechoic chamber with a conductive ground plane

In this facility, the ground plane creates the wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals from both the direct and reflected transmission paths. This creates a unique received signal level for each height of the transmitting antenna (or DUT) and the receiving antenna above the ground plane.

The antenna mast provides a variable height facility (from 1 m to 4 m) so that the position of the test antenna can be optimized for the maximum coupled signal between antennas or between a DUT and the test antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (DUT) at a specified height, usually 1,5 m above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2 / \lambda$ (m), whichever is greater (see clause D.2.7). The distance used in actual measurements shall be recorded with the test results.

Emission testing involves firstly "peaking" the field strength from the DUT by raising and lowering the receiving antenna on the mast (to obtain the maximum constructive interference of the direct and reflected signals from the DUT) and then rotating the turntable for a "peak" in the azimuth plane. At this height of the test antenna on the mast, the amplitude of the received signal is noted. Secondly, the DUT is replaced by a substitution antenna (positioned at the DUT's phase or volume centre) which is connected to a signal generator. The signal is again "peaked" and the signal generator output adjusted until the level, noted in stage one, is again measured on the receiving device.

Receiver sensitivity tests over a ground plane also involve "peaking" the field strength by raising and lowering the test antenna on the mast to obtain the maximum constructive interference of the direct and reflected signals, this time using a measuring antenna which has been positioned where the phase or volume centre of the DUT will be during testing. A transform factor is derived. The test antenna remains at the same height for stage two, during which the measuring antenna is replaced by the DUT. The amplitude of the transmitted signal is reduced to determine the field strength level at which a specified response is obtained from the DUT.

D.1.4 Open Area Test Site (OATS)

An Open Area Test Site comprises a turntable at one end and an antenna mast of variable height at the other end above a ground plane which, in the ideal case, is perfectly conducting and of infinite extent. In practice, whilst good conductivity can be achieved, the ground plane size has to be limited. A typical Open Area Test Site is shown in figure D.3.

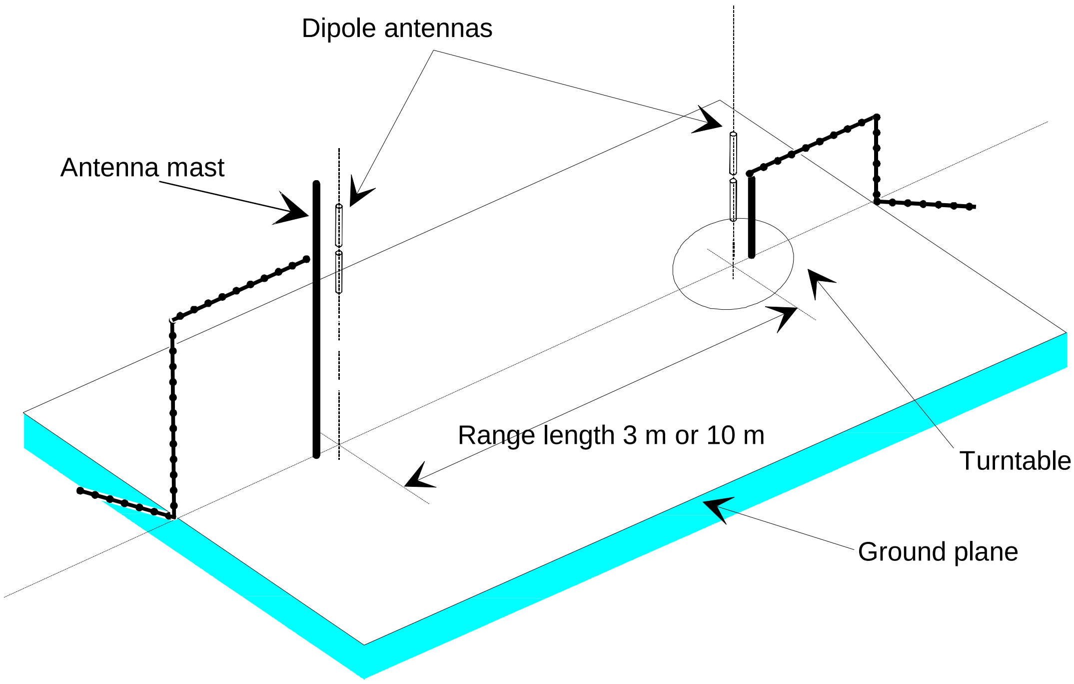


Figure D.3: A typical Open Area Test Site

The ground plane creates a wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals received from the direct and reflected transmission paths. The phasing of these two signals creates a unique received level for each height of the transmitting antenna (or DUT) and the receiving antenna above the ground plane.

Site qualification concerning antenna positions, turntable, measurement distance and other arrangements are the same as for an anechoic chamber with a ground plane. In radiated measurements, an OATS is also used in the same way as an anechoic chamber with a ground plane.

Typical measuring arrangement common for ground plane test sites is presented in figure D.4.

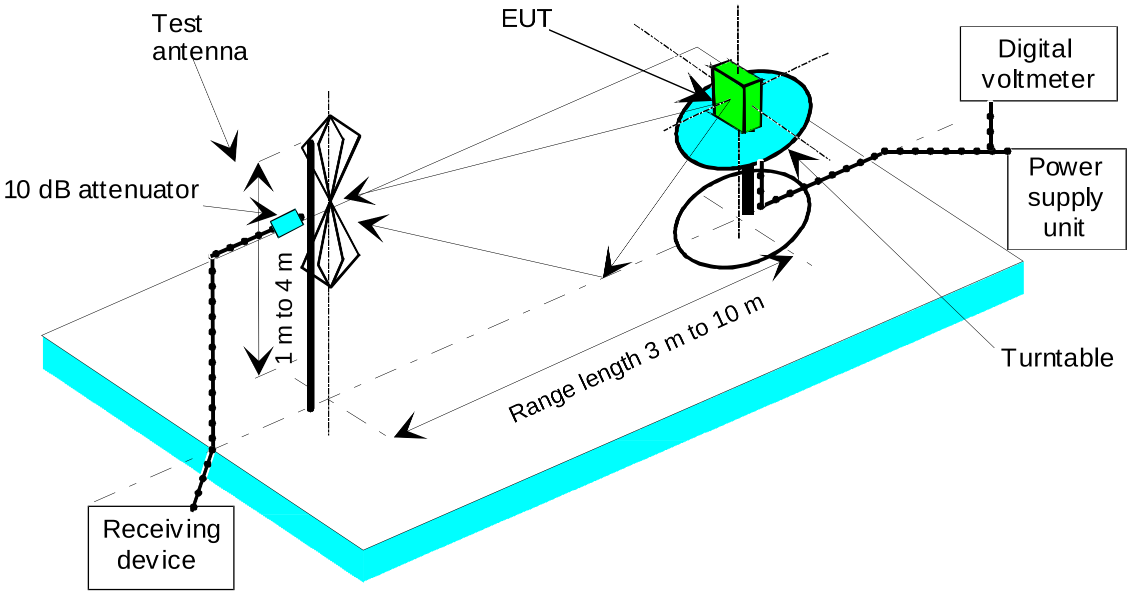


Figure D.4: Measuring arrangement on ground plane test site (OATS set-up for spurious emission testing)

D.1.5 Test antenna

A test antenna is always used in radiated test methods. In emission tests (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) the test antenna is used to detect the field from the DUT in one stage of the measurement and from the substitution antenna in the other stage. When the test site is used for the measurement of receiver characteristics (i.e. sensitivity and various immunity parameters) the antenna is used as the transmitting device.

The test antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization which, on ground plane sites (i.e. anechoic chambers with ground planes and Open Area Test Sites), should additionally allow the height of its centre above the ground to be varied over the specified range (usually 1 m to 4 m).

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [i.19] are generally recommended). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of the test. Below 80 MHz, shortened arm lengths are recommended. For spurious emission testing, however, a combination of bicones and log-periodic dipole array antennas (commonly termed "log periodic") could be used to cover the entire 30 MHz to 1 000 MHz band. Above 1 000 MHz, waveguide horns are recommended although, again, log-periodic could be used.

NOTE: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

D.1.6 Substitution antenna

The substitution antenna is used to replace the DUT for tests in which a transmitting parameter (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) is being measured. For measurements in the frequency band 30 MHz to 1 000 MHz, the substitution antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [i.19] is generally recommended). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of the test. Below 80 MHz, shortened arm lengths are recommended. For measurements above 1 000 MHz, a waveguide horn is recommended. The centre of this antenna should coincide with either the phase centre or volume centre.

D.1.7 Measuring antenna

The measuring antenna is used in tests on a DUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric field strength in the vicinity of the DUT. For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [i.19] is generally recommended). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of the test. Below 80 MHz, shortened arm lengths are recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the DUT.

D.1.8 Stripline arrangement

D.1.8.1 General

The stripline arrangement is a RF coupling device for coupling the integral antenna of an equipment to a 50 Ω radio frequency terminal. This allows the radiated measurements to be performed without an open-air test site but in a restricted frequency range. Absolute or relative measurements can be performed; absolute measurements require a calibration of the stripline arrangement.

D.1.8.2 Description

The stripline is made of three highly conductive sheets forming part of a transmission line which allows the equipment under test to be placed within a known electric field. They shall be sufficiently rigid to support the equipment under test.

D.1.8.3 Calibration

The aim of calibration is to establish at any frequency a relationship between the voltage applied by the signal generator and the field strength at the designated test area inside the stripline.

D.1.8.4 Mode of use

The stripline arrangement may be used for all radiated measurements within its calibrated frequency range.

The method of measurement is the same as the method using an open-air test site with the following change. The stripline arrangement input socket is used instead of the test antenna.

D.2 Guidance on the use of radiation test sites

D.2.1 General

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated tests are undertaken. These schemes are common to all types of test sites described in annex C.

D.2.2 Verification of the test site

No test should be carried out on a test site which does not possess a valid certificate of verification. The verification procedures for the different types of test sites described in annex C (i.e. anechoic chamber, anechoic chamber with a ground plane and Open Area Test Site) are given in ETSI TR 102 273 [i.7] or equivalent.

D.2.3 Preparation of the DUT

The manufacturer should supply information about the DUT covering the operating frequency, polarization, supply voltage(s) and the reference face. Additional information, specific to the type of DUT should include, where relevant, carrier power, channel separation, whether different operating modes are available (e.g. high and low power modes) and if the operation is continuous or is subject to a maximum test duty cycle (e.g. 1 minute on, 4 minutes off).

Where necessary, a mounting bracket of minimal size should be available for mounting the DUT on the turntable. This bracket should be made from low conductivity, low relative dielectric constant (i.e. less than 1,5) material(s) such as expanded polystyrene, balsa wood, etc.

D.2.4 Power supplies to the DUT

All tests should be performed using power supplies wherever possible, including tests on DUT designed for battery-only use. In all cases, power leads should be connected to the DUT's supply terminals (and monitored with a digital voltmeter) but the battery should remain present, electrically isolated from the rest of the equipment, possibly by putting tape over its contacts.

The presence of these power cables can, however, affect the measured performance of the DUT. For this reason, they should be made to be "transparent" as far as the testing is concerned. This can be achieved by routing them away from the DUT and down to either the screen, ground plane or facility wall (as appropriate) by the shortest possible paths. Precautions should be taken to minimize pick-up on these leads (e.g. the leads could be twisted together, loaded with ferrite beads at 0,15 m spacing or otherwise loaded).

D.2.5 Volume control setting for analogue speech tests

Unless otherwise stated, in all receiver measurements for analogue speech the receiver volume control where possible, should be adjusted to give at least 50 % of the rated audio output power. In the case of stepped volume controls, the volume control should be set to the first step that provides an output power of at least 50 % of the rated audio output power. This control should not be readjusted between normal and extreme test conditions in tests.

D.2.6 Range length

The range length for all these types of test facility should be adequate to allow for testing in the far-field of the DUT i.e. it should be equal to or exceed:

$$\frac{2(d_1 + d_2)^2}{\lambda}$$

where:

d_1: is the largest dimension of the DUT/dipole after substitution (m);

d_2: is the largest dimension of the test antenna (m);

λ: is the test frequency wavelength (m).

It should be noted that in the substitution part of this measurement, where both test and substitution antennas are half-wavelength dipoles, this minimum range length for far-field testing would be:

$$2\lambda$$

It should be noted in the test report when either of these conditions is not met so that the additional measurement uncertainty can be incorporated into the results.

NOTE 1: **For the fully anechoic chamber**, no part of the volume of the DUT should, at any angle of rotation of the turntable, fall outside the "quiet zone" of the chamber at the nominal frequency of the test.

NOTE 2: The "quiet zone" is a volume within the anechoic chamber (without a ground plane) in which a specified performance has either been proven by test or is guaranteed by the designer/manufacture. The specified performance is usually the reflectivity of the absorbing panels or a directly related parameter (e.g. signal uniformity in amplitude and phase). It should be noted however that the defining levels of the quiet zone tend to vary.

NOTE 3: **For the anechoic chamber with a ground plane**, a full-height scanning capability, i.e. 1 m to 4 m, should be available for which no part of the test antenna should come within 1 m of the absorbing panels. For both types of Anechoic Chamber, the reflectivity of the absorbing panels should not be worse than -5 dB.

NOTE 4: **For both the anechoic chamber with a ground plane and the Open Area Test Site**, no part of any antenna should come within 0,25 m of the ground plane at any time throughout the tests. Where any of these conditions cannot be met, measurements should not be carried out.

D.2.7 Site preparation

The cables for both ends of the test site should be routed horizontally away from the testing area for a minimum of 2 m (unless, in the case of both types of anechoic chamber, a back wall is reached) and then allowed to drop vertically and out through either the ground plane or screen (as appropriate) to the test equipment. Precautions should be taken to minimize pick up on these leads (e.g. dressing with ferrite beads or another loading). The cables, their routing and dressing should be identical to the verification set-up.

NOTE: For ground reflection test sites (i.e. anechoic chambers with ground planes and Open Area Test Sites) which incorporate a cable drum with the antenna mast, the 2 m requirement may be impossible to comply with.

Calibration data for all items of test equipment should be available and valid. For test, substitution and measuring antennas, the data should include gain relative to an isotropic radiator (or antenna factor) for the frequency of the test. Also, the VSWR of the substitution and measuring antennas should be known.

The calibration data on all cables and attenuators should include insertion loss and VSWR throughout the entire frequency range of the tests. All VSWR and insertion loss figures should be recorded in the log book results sheet for the specific test.

Where correction factors/tables are required, these should be immediately available.

For all items of test equipment, the maximum errors they exhibit should be known along with the distribution of the error e.g.:

- cable loss: ±0,5 dB with a rectangular distribution;
- measuring receiver: 1,0 dB (standard deviation) signal level accuracy with a Gaussian error distribution.

At the start of measurements, system checks should be made on the items of test equipment used on the test site.

D.3 Coupling of signals

D.3.1 General

The presence of leads in the radiated field may cause a disturbance of that field and lead to additional measurement uncertainty. These disturbances can be minimized by using suitable coupling methods, offering signal isolation and minimum field disturbance (e.g. optical and acoustic coupling).

D.3.2 Data signals

Isolation can be provided by the use of optical, ultra-sonic or infra-red means. Field disturbance can be minimized by using a suitable fibre optic connection. Ultra-sonic or infra-red radiated connections require suitable measures for the minimization of ambient noise.

D.3.3 Speech and analogue signals

D.3.3.0 General

Where an audio output socket is not available an acoustic coupler should be used.

When using the acoustic coupler, care should be exercised that possible ambient noise does not influence the test result.

D.3.3.1 Acoustic coupler description

The acoustic coupler comprises a plastic funnel, an acoustic pipe and a microphone with a suitable amplifier. The materials used to fabricate the funnel and pipe should be of low conductivity and low relative dielectric constant (i.e. less than 1,5):

- The acoustic pipe should be long enough to reach from the DUT to the microphone which should be located in a position that will not disturb the RF field. The acoustic pipe should have an inner diameter of about 6 mm and a wall thickness of about 1,5 mm and should be sufficiently flexible so as not to hinder the rotation of the turntable.
- The plastic funnel should have a diameter appropriate to the size of the loudspeaker in the DUT, with soft foam rubber glued to its edge, it should be fitted to one end of the acoustic pipe and the microphone should be fitted to the other end. It is very important to fix the centre of the funnel in a reproducible position relative to the DUT since the position of the centre has a strong influence on the frequency response that will be measured. This can be achieved by placing the DUT in a close-fitting acoustic mounting jig, supplied by the provider, of which the funnel is an integral part.
- The microphone should have a response characteristic flat within 1 dB over a frequency range of 50 Hz to 20 kHz, a linear dynamic range of at least 50 dB. The sensitivity of the microphone and the receiver audio output level should be suitable to measure a signal to noise ratio of at least 40 dB at the nominal audio output level of the DUT. Its size should be sufficiently small to couple to the acoustic pipe.
- The frequency correcting network should correct the frequency response of the acoustic coupler so that the acoustic SINAD measurement is valid.

D.3.3.2 Calibration

The aim of the calibration of the acoustic coupler is to determine the acoustic SINAD ratio which is equivalent to the SINAD ratio at the receiver output.

D.4 Standard test position

The standard position in all test sites, except the stripline arrangement, for equipment which is not intended to be worn on a person, including hand-held equipment, shall be on a non-conducting support with an ε_r as close as possible to one, height 1,5 m, capable of rotating about a vertical axis through the equipment. The standard position of the equipment shall be the following:

a) for equipment with an internal antenna, it shall be placed in the position closest to normal use as declared by the manufacturer;

b) for equipment with a rigid external antenna, the antenna shall be vertical;

c) for equipment with a non-rigid external antenna, the antenna shall be extended vertically upwards by a non-conducting support.

Equipment which is intended to be worn on a person may be tested using a simulated man as support.

The simulated man comprises a rotatable acrylic tube filled with salt water, placed on the ground.

The container shall have the following dimensions:

- Height: 1,7 ± 0,1 m;
- Inside diameter: 300 ± 5 mm;
- Sidewall thickness: 5 ± 0,5 mm.

The container shall be filled with a salt (NaCl) solution of 1,5 g per litre of distilled water.

The equipment shall be fixed to the surface of the simulated man, at the appropriate height for the equipment.

NOTE: To reduce the weight of the simulated man it may be possible to use an alternative tube which has a hollow centre of 220 mm maximum diameter.

In the stripline arrangement, the equipment under test or the substitution antenna is placed in the designated test area in the normal operational position, relative to the applied field, on a pedestal made of a low dielectric material (dielectric constant less than 2).

D.5 Test fixture

D.5.1 General

The test fixture is only needed for the assessment of integral antenna equipment.

D.5.2 Description

The test fixture is a radio frequency coupling device associated with an integral antenna equipment for coupling the integral antenna to a 50 Ω radio frequency terminal at the working frequencies of the equipment under test. This allows certain measurements to be performed using the conducted measurement methods. Only relative measurements may be performed and only those at or near frequencies for which the test fixture has been calibrated.

In addition, the test fixture may provide:

a) a connection to an external power supply;

b) in the case of assessment of speech equipment, an audio interface either by direct connection or by an acoustic coupler.

In the case of non-speech equipment, the test fixture can also provide the suitable coupling means e.g. for the data output.

The test fixture shall normally be provided by the manufacturer.

The performance characteristics of the test fixture shall be approved by the testing laboratory and shall conform to the following basic parameters:

a) the coupling loss shall not be greater than 30 dB;

b) a coupling loss variation over the frequency range used in the measurement which does not exceed 2 dB;

c) circuitry associated with the RF coupling shall contain no active or non-linear devices;

d) the VSWR at the 50 Ω socket shall not be more than 1,5 over the frequency range of the measurements;

e) the coupling loss shall be independent of the position of the test fixture and be unaffected by the proximity of surrounding objects or people. The coupling loss shall be reproducible when the equipment under test is removed and replaced;

f) the coupling loss shall remain substantially constant when the environmental conditions are varied.

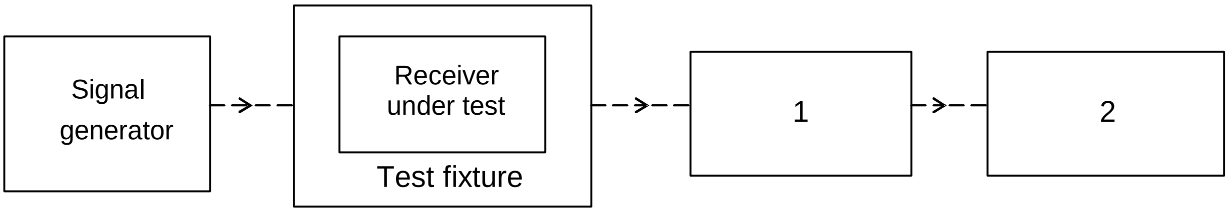
The characteristics and calibration shall be included in the test report.

D.5.3 Calibration

The calibration of the test fixture establishes a relationship between the output of the signal generator and the field strength applied to the equipment placed in the test fixture.

The calibration is valid only at a given frequency and for a given polarization of the reference field.

The actual set-up used depends on the type of equipment (e.g. data, speech, etc.).



NOTE 1: Coupling device, e.g. AF load/acoustic coupler (in the case of speech equipment).
NOTE 2: Device for assessing the performance, e.g. distortion factor/audio level meter, BER measuring device, etc.

Figure D.5: Measuring arrangement for calibration

Method of calibration:

a) Measure the sensitivity expressed as a field strength, as specified in the present document and note the value of this field strength in dBμV/m and the polarization used.

b) Place the receiver in the test fixture which is connected to the signal generator. The level of the signal generator producing:

- a SINAD of 20 dB;
- a bit error ratio of 0,01; or
- a message acceptance ratio of 80 %, as appropriate;

shall be noted.

The calibration of the test fixture is the relationship between the field strength in dBμV/m and the signal generator level in dBμV emf. This relationship is expected to be linear.

D.5.4 Mode of use

The test fixture may be used to facilitate some of the measurements in the case of equipment having an integral antenna.

It is used in particular for the measurement of the radiated carrier power and usable sensitivity expressed as a field strength under the extreme conditions.

For the transmitter measurements calibration is not required as relative measuring methods are used.

For the receiver measurements calibration is necessary as absolute measurements are used.

To apply the specified wanted signal level expressed in field strength, convert it into the signal generator level (emf) using the calibration of the test fixture. Apply this value to the signal generator.

Annex E (informative): Additional parameters identified under article 3.2 of Directive 2014/53/EU

Table E.1 lists parameters defined in ETSI EG 203 336 [i.1] under article 3.2 of Directive 2014/53/EU [i.10] but not implemented in the present document due to the stated reasons.

Table E.1: parameter

parameter	Comment
Transmitter Time domain characteristics	Time domain characteristics for Audio PMSE are not constrained by regulation. Audio PMSE equipment/systems do a close to 100 % occupancy in time to support application requirements (e.g. low latency, jitter-free latency, stable data-rate).
Transmitter Transients	Possible transmitter transients in time and frequency are to some extent captured by the spectrum mask tests. Audio PMSE equipment typical stays on its operation channel during operation.
Receiver co-channel rejection	This is not appropriate for an audio PMSE equipment which is a constant duty cycle transmission and cannot operate co-channel with other transmissions.
Receiver spurious response rejection	This is partly covered by the present document with the receiver blocking requirements, and EMC Standard ETSI EN 301 489-9 [i.8].
Receiver radio-frequency intermodulation	Audio PMSE as a constant duty cycle and low power (typically up to 50 mW) application with multiple RF channels in simultaneous operation uses frequency planning to avoid undesired interaction between transmissions. The effect of potential receiver intermodulation products is in practical deployments neglectable.
Receiver dynamic range	Audio PMSE equipment provides typical range information but is not specified for defined min/max distance. ETSI EG 203 336 [i.1] states in cases where distance is not specified, dynamic range is covered by selectivity and blocking. Selectivity and blocking are covered by the present document.
Reciprocal mixing	Referencing ETSI EG 203 336 [i.1] guidance, reciprocal mixing is implicitly covered by selectivity and blocking. Selectivity and blocking are covered by the present document.

Annex F (informative): Change history

Version	Information about changes
2.1.2	Adding relevant receiver parameters, changed to three part with three equipment classes; added new technology: WMAS
2.2.0	Incorporated three classes into one part; revision of requirements according to RED and review of test methods to support the requirements.

History

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