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Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement

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Foreword

This draft European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

The present document is part 1 of a multi-part deliverable covering Short Range Devices (SRD), as identified below:

Part 1: "Technical characteristics and methods of measurement";

Part 2: "Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU for non specific radio equipment";

Part 3-1: "Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Low duty cycle high reliability equipment, Social Alarms Equipment operating on designated frequencies (869,200 MHz to 869,250 MHz)";

Part 3-2: "Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Wireless alarms operating in designated LDC/HR frequency bands 868,60 MHz to 868,70 MHz, 869,25 MHz to 869,40 MHZ, 869,65 MHz to 869,70 MHz";

Part 4: "Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Metering devices operating in designated band 169,400 MHz to 169,475 MHz".

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

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).

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Introduction

The present document includes improvements to the previous version of the standard that take advantage of technical developments within the SRD industry. It also serves the purpose of providing the requirements and associated measurement methods to improve the intra- SRD co-existence and promote efficient spectrum use.

The attention of the reader is brought on the fact that the present document includes "reference limits" which may be called by harmonised standards but which can also be different if requested for a specific application environment.

The present document is structured as follows:

Clause 2 provides references.

Clause 3 provides definitions of terms and abbreviations used.

Clause 4 provides conformance specifications.

Clause 5 specifies the list of parameters, reference limits and tests.

Annex A (normative): Technical performance of the test equipment.

Annex B (normative): Test Fixture, contains specifications for the test fixture.

Annex C (normative): Test sites and arrangements for radiated measurement, contains specifications concerning radiated measurements.

Annex D (informative): Bibliography.

Annex E (informative): Change History.

1 Scope

The present document specifies technical characteristics and test methods to be used in the conformance assessment of Short Range Device equipment.

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 http://docbox.etsi.org/Reference.

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

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

[1] Recommendation ITU-T O.153: "Basic parameters for the measurement of error performance at bit rates below the primary rate".

[2] ETSI TR 100 028 (all parts) (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[3] Recommendation ITU-T O.41: "Psophometer for use on telephone-type circuits".

[4] Void.

[5] ETSI TS 103 060 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Method for a harmonized definition of Duty Cycle Template (DCT) transmission as a passive mitigation technique used by short range devices and related conformance test methods".

[6] ETSI TR 102 273-2 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 2: Anechoic chamber".

[7] ETSI TR 102 273-3 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 3: Anechoic chamber with a ground plane".

[8] ETSI TR 102 273-4 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 4: Open area test site".

2.2 Informative references

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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] CISPR 16 (2006) (parts 1-1, 1-4 and 1-5): "Specification for radio disturbance and immunity measuring apparatus and methods; Part 1: Radio disturbance and immunity measuring apparatus".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

acknowledgement: brief communication (burst) from the responder to the message initiator confirming successful reception of the message

adaptive frequency agility: capability of an equipment to dynamically change the temporary operational channel within its available frequencies for proper operation

NOTE 1: For the purpose of the present document, non-overlapping channels are used.

NOTE 2: Dynamic change of a channel can be triggered by sensing an occupied channel (e.g. LBT), etc.

adjacent channel: frequency band, of width Operating Channel bandwidth, on either side of the Operating Channel

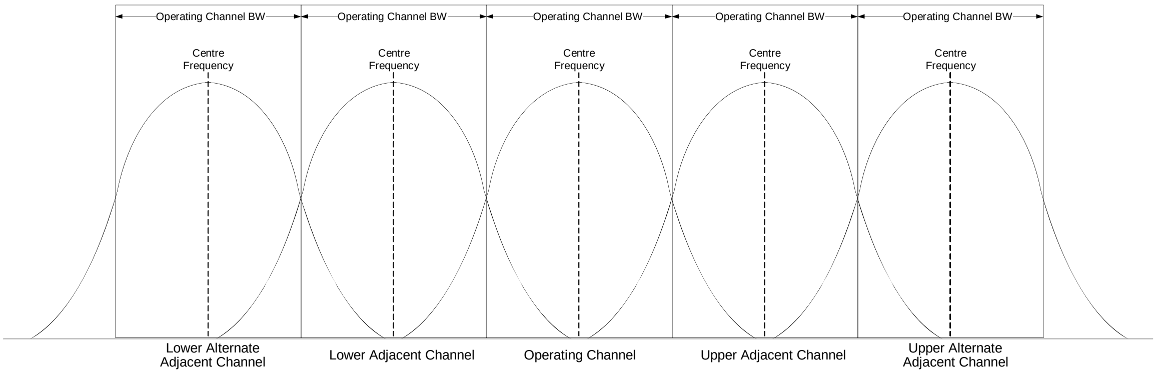


Figure 1: Adjacent Channels definition

alarm device: equipment devices that use radio communication to indicate an alert or danger condition to a distant location

alternate adjacent channels: those two channels offset from the nominal Operating Channel by double the Operating Channel Bandwidth

audio: wideband application where the activity factor is high (e.g. music)

channel adaptivity: ability to adapt device behaviour without change of channel

channel spacing: distance, in hertz, between adjacent nominal Centre Frequencies

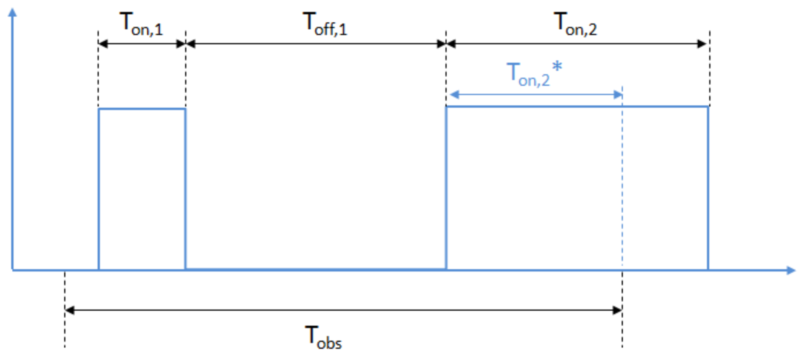
centre frequency: nominal centre frequency of a transmission

clear channel assessment: procedure of sensing the operating channel to determine whether or not it is occupied by a transmission

conducted measurements: measurements which are made using a direct 50 Ω connection to the equipment under test

continuous transmission: transmission without interruption for the period of the test

cumulative on time (T_{on_cum}): sum of T_{on}, within T_{obs}



In this example: $T_{on\_cum} = T_{on,1} + T_{on,2}^{*}$

Figure 2: Illustration for Cumulative On-Time

dedicated antenna: removable antenna supplied and tested with the radio equipment, designed as an indispensable part of the equipment

deferral time: random time a transmission is deferred before a retry to CCA when a channel was not free

disregard time (T_{Dis}): provider declared interval below which two separate radio emissions in an Operating Channel are considered a single continuous transmitted burst

NOTE: See Figure 4.

Duty Cycle (DC): ratio expressed as a percentage, of the cumulative duration of transmissions T_{on_cum} within an observation interval T_{obs}. $DC = \left(\frac{T_{on\_cum}}{T_{obs}}\right)_{Fobs}$ on an observation bandwidth F_{obs}

Duty Cycle Template (DCT): duty cycle respecting the constraint of T_{on_max} and T_{off_min} values for transmissions

frequency adaptivity: capability of a device to avoid using permitted Operating Channels that it has determined are temporarily or permanently unsuitable for its use

frequency agility: capability of a device to dynamically change Operating Channel

Frequency Hopping Spread Spectrum (FHSS): technique in which the transmitter signal occupies a number of frequencies in time, each for some period of time, referred to as the dwell time

NOTE: Transmitter and receiver follow the same frequency hop pattern. The frequency range is determined by the lowest and highest hop positions and the bandwidth per hop.

frequency range: See FHSS above.

integral antenna: permanent fixed antenna, which may be built-in, designed as an indispensable part of the equipment

inter transmission interval: time period between two successive transmissions

listen before transmit: mechanism by which an equipment applies Clear Channel Assessment (CCA) before Transmission (also known as Listen Before Talk)

maintenance: process of external intervention intended to keep equipment operational

NOTE: Maintenance may be scheduled or in response to failure. Automatic processes by the equipment itself are not considered maintenance.

maximum transmission duration (T_{On-Max}): longest permitted transmission T_{on}

Message Initiator (MI): device which generates a message to be transferred to another device, such as a Message Responder

Message Responder (MR): device which receives a message from another device, such as a Message Initiator

minimum inter-transmission interval ($T_{Off-Min}$): minimum interval in a channel between two transmissions by the same device

model control: devices used to control models (e.g. miniature representations of vehicles) in the air, on land or over or under the water surface

non overlapping channels: hopping positions separated by channel bandwidth of 90 % or more below the maximum power as measured with a spectrum analyser

non-specific use: any type of application

observation bandwidth (F_{obs}): bandwidth in which the energy of an equipment is considered for the purposes of assessing transmission timings

observation period (T_{obs}): reference interval of time

Occupied BandWidth (OBW): width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0,5 % of the total mean power of a given emission

NOTE: See Figure 3.

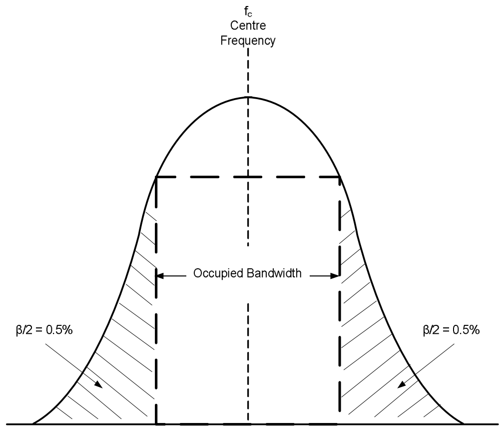


Figure 3: Signal Occupied Bandwidth

off time (T_{off}): time duration between two successive Transmissions

NOTE: See Figure 4.

on time (T_{on}): duration on a Transmission

NOTE: See Figure 4.

Operating Channel (OC): frequency range in which the Transmission from the equipment occurs; defined by two frequency edges values. Declared by manufacturer/provider

Operating Channel Width (OCW): bandwidth between the two frequencies declared as operating channel

operating frequency: nominal centre frequency of Transmission

operational frequency band: frequency band or sub-band within which the device is intended to operate and to perform the intended function of the equipment

Out Of Band domain: spectrum area where Out Of Band Emissions occur

Out Of Band emissions: emission on a frequency or frequencies immediately outside the Operating Channel and which results from the modulation process, but excluding spurious emissions

polite spectrum access: techniques to access spectrum and mitigate interference that employ CCA

provider: manufacturer, or his authorized representative or the person responsible for placing the equipment on the market

radiated measurements: measurements which involve the absolute measurement of a radiated field

signal threshold ($P_{Threshold}$): power level in a given receiver bandwidth that determines the start and the end of a transmission. $P_{Threshold}$ is set at -26 dBc

social alarm devices: devices that allow reliable communication including portable equipment which allows a person in distress in a limited area to initiate a call for assistance by a simple manipulation

spurious emissions: emissions on a frequency or frequencies which are outside the Out Of Band domain and the level of which may be reduced without affecting the corresponding transmission of information

NOTE: Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude Out Of Band emissions.

transmission: continuous radio emission, or sequence of emissions each separated by an interval shorter than T_{Dis}, with a signal level greater than the signal threshold $P_{Threshold}$ in the Operating Channel

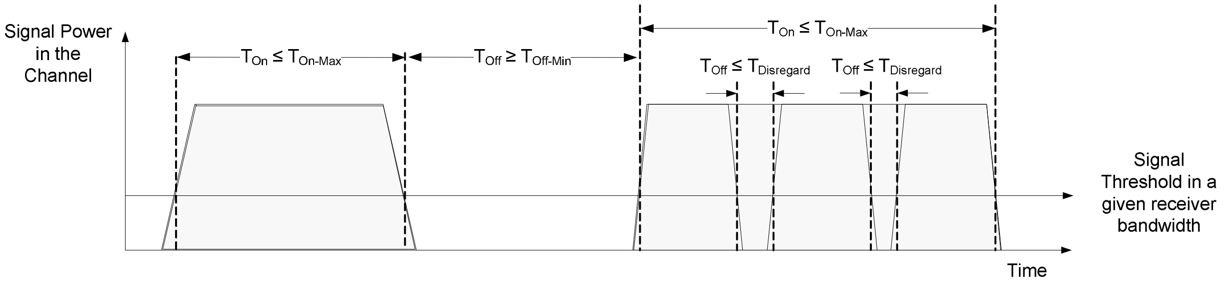


Figure 4: Transmission definitions

3.2 Symbols

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

dB	decibel
E	Electric field strength
NaCl	sodium chloride
R	distance
S	Sensitivity of receiver
λ	wavelength

3.3 Abbreviations

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

AC	Alternative Current
ACK	Acknowledgment
ACP	Adjacent Channel Power
ACS	Adjacent Channel Selectivity
AFA	Adaptive Frequency Agility
APC	Adaptive Power Control
ARQ	Automatic Repeat reQuest
AVG	Average
BER	Bit Error Ratio
BW	BandWidth
CCA	Clear Channel Assessment
CISPR	International Special Committee on Radio Interference
DC	Duty Cycle
DCT	Duty Cycle Template
e.r.p.	effective radiated power
EMC	ElectroMagnetic Compatibility
EU	European Union
EUT	Equipment Under Test

FAR	Fully Anechoic Room
FEC	Forward Error Correction
FHSS	Frequency Hopping Spread Spectrum
IF	Intermediate Frequency
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
LBT	Listen Before Talk
LPDA	Logarithmic Periodic Dipole Antenna
MI	Message Initiator
MR	Message Responder
OATS	Open Area Test Site
OBW	Occupied BandWidth
OC	Operating Channel
OCW	Operating Channel Bandwidth
OFB	Operational Frequency Band
OFDM	Orthogonal Frequency Division Modulation
OOB	Out Of Band
PD	Power Density
PSD	Power Spectral Density
RB	Receiver Bandwidth
RBW	Resolution BandWidth
RBW_{REF}	REFerence Resolution BandWidth
RF	Radio Frequency
RMS	Root Mean Square
RX	Receiver
SA	Spectrum Analyser
SAR	Semi-Anechoic Room
SINAD	Received signal quality based on SND/ND
SR	Switching Range
SRD	Short Range Device
TR	Technical Report
TX	Transmitter
VBW	Video Bandwidth
VSWR	Voltage Standing Wave Ratio

4 Conformance specification

4.1 General performance criterion

For the purpose of the receiver performance tests, the receiver shall produce an appropriate output under normal conditions as indicated below:

- after demodulation, a raw data signal with a Bit Error Ratio of 10^{-3} without correction; or
- after demodulation, a message success ratio equivalent to above Bit Error Ratio;
  - $(1-p)^n$ where p is the probability of single bit error (10^{-3}) and n the number of bits; or
- a SINAD ratio of 20 dB, measured at the receiver output through a telephone psophometric weighting network as described in Recommendation ITU-T O.41 [3].

Where the indicated performance cannot be measured, the performance criterion used to determine the performance of the receiver shall be declared by the provider.

The receiver sensitivity should be measured with any Forward Error Correction (FEC) or Automatic Repeat reQuest (ARQ) function disabled. If it is not practical to disable such error correction, a suitable note shall be made in the test report, together with any alternative test method used.

4.2 Equipment conformance requirements specification

4.2.1 General

Transmitters and receivers may be individual or combination units.

One or more samples of the equipment, as appropriate, shall be tested.

Stand alone equipment shall be tested complete with any ancillary equipment needed for testing.

If an equipment has several optional features, considered not to affect the RF parameters then the tests need only to be performed on the equipment configured with that combination of features considered to be the most critical.

Each equipment submitted for testing, where applicable, shall fulfil the requirements of the present document on all frequencies over which it is intended to operate.

Additionally, technical documentation, sufficient to allow testing to be performed, shall be available.

4.2.2 Transmitter shut-off facility

If the transmitter is equipped with an automatic transmitter shut-off facility, it should be made inoperative for the duration of the test. In the case this not possible, a proper test method shall be described and documented.

4.2.3 Receiver mute or squelch or battery saving circuit

If the receiver is equipped with a mute, squelch or battery-saving circuit, this circuit shall be made inoperative for the duration of the tests. In the case where this not possible, a proper test method shall be described and documented.

4.2.4 Auxiliary test equipment

All necessary test signal sources special to the equipment and set-up information shall accompany the equipment when it is submitted for testing.

If a system includes transponders, these are measured together with the interrogator.

4.2.5 Receiver Category

4.2.5.1 Description

SRDs are used in a wide range of applications; therefore a range of receiver categories is available with different levels of performance. The performance level chosen is related to the ability of the system to operate in the presence of other signals. For the same application, the equipment level of performance may vary in different operational frequency bands.

The product family of short range radio devices is therefore divided based on receiver categories, see Table 1, each having a set of relevant receiver requirements and minimum performance criteria.

The choice of receiver category should be performed paying particular attention to the risk for interference from other systems operating in the same or adjacent bands, in particular where operation of SRD may have inherent safety of human life implications. Where risk assessment shows that equipment may not function in accordance with its intended use, information to users is to be provided.

The receiver categories are listed in Table 1.

Table 1: Receiver categories

Receiver category	Description
1	Category 1 is a high performance level of receiver. In particular to be used where the operation of a SRD may have inherent safety of human life implications.
1.5	Category 1.5 is an improved performance level of receiver category 2.
2	Category 2 is standard performance level of receiver.
3	Category 3 is a low performance level of receiver. Manufacturers have to be aware that category 3 receivers are not able to work properly in case of coexistence with some services such as a mobile radio service in adjacent bands. The manufacturer shall provide another mean to overcome the weakness of the radio link or accept the failure.

NOTE: The receiver category should be stated in both the test report and in the user's manual for the equipment.

4.3 General conditions for testing

4.3.1 Test signals

4.3.1.1 Test signals for analogue speech

Test signals for analogue speech are specified as follows:

- A-M1: a 1 000 Hz tone;
- A-M2: a 1 250 Hz tone.

For angle modulation the normal level of the test signals A-M1 and A-M2 shall be that which produces a deviation of 12 % of the channel separation or any value as declared by the provider as the normal operating level.

In situations where the above is not applicable the test modulation shall be declared by the provider.

4.3.1.2 Test signals for data

For the purposes of this document a test signal is a modulated or unmodulated carrier generated by the EUT to facilitate a particular test. The EUT should be capable of generating the following test signals:

D-M1: A test signal consisting of an unmodulated carrier. This test signal is optional but helps to simplify some tests.

D-M2: A test signal consisting of a modulated carrier representative for normal operation and generating the greatest occupied RF bandwidth. The preferred test signal consists of a pseudo-random bit sequence of at least 511 bits in accordance with Recommendation ITU-T O.153 [1]. This sequence shall be continuously repeated.

D-M2a: A test signal as described in D-M2 but generated intermittently. The generated RF signals shall be the same for each transmission except for the data sequence, occur regularly in time, be accurately repeatable and their timing duration shall represent normal operation of the EUT except for compliance with a duty cycle limit.

D-M3: A test signal representative of normal operation of the EUT. This signal shall be agreed between the test laboratory and the provider in case selective messages are used and are generated or decoded within the equipment.
The agreed test signal may be formatted and may contain error detection and correction.

Test signals may be generated by applying test baseband signals to a modulation port on the device or be generated internally by the device. Operation in a test mode may involve suitable temporary internal modifications of the equipment under test or the use of special software. Details of the method employed shall be declared by the provider and be recorded in the test report.

For each test performed, the test signal used shall be recorded in the test report. Recommended test signals for each test are shown in Table 2.

Table 2: Test signals

Requirement with clause number	Test Signal
5.2	D-M1, D-M2, D-M2a, D-M3
5.3	D-M3
5.4	D-M3
5.5	D-M3
5.6	D-M2, D-M2a, D-M3
5.8	D-M1, D-M2, D-M2a, D-M3
5.8	D-M2, D-M2a, D-M3
5.9	D-M1, D-M2, D-M2a, D-M3
5.10	D-M3
5.11	D-M2, D-M2a, D-M3
5.12	D-M1, D-M2, D-M2a, D-M3
5.14	D-M3
5.15	D-M3
5.16	D-M3
5.17	D-M3
5.18	D-M3
5.19	D-M3
5.20	D-M3
5.21	D-M3

4.3.2 Test power source

4.3.2.0 General

The equipment shall be tested using the appropriate test power source as specified in clauses 4.3.2.1 or 4.3.2.2. Where equipment can be powered using either external or internal power sources, then the equipment shall be tested using the external power source as specified in clause 4.3.2.1. then repeated using the internal power source as specified in clause 4.3.2.2.

The test power source used shall be stated in the test report.

4.3.2.1 External test power source

External test power sources shall be capable of producing normal and extreme test voltages as specified in clauses 4.3.3.2 and 4.3.4.2. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible. For the purpose of the tests, the voltage of the external test power source shall be measured at the input terminals of the equipment. The external test power source shall be suitably de-coupled and applied as close to the equipment battery terminals as practicable. For radiated measurements, any external power leads shall be so arranged so as not to affect the measurements (e.g. use of ferrite on power cables).

During tests, the test power source voltages shall be within a tolerance of $< \pm 1$ % relative to the voltage at the beginning of each test. The value of this tolerance can be critical for certain measurements. Using a smaller tolerance will provide a better uncertainty value for these measurements.

For radiated measurements, any external power leads should be so arranged so as not to affect the measurements.

4.3.2.2 Internal test power source

For radiated measurements on portable equipment with integral or dedicated antenna, fully charged internal batteries shall be used. The batteries used shall be as supplied or recommended by the provider. If internal batteries are used, at the end of each test the voltage shall be within a tolerance of < ±5 % relative to the voltage at the beginning of each test. Where this is not appropriate, clause C.3.1 applies.

If appropriate, for conducted measurements or where a test fixture is used, an external power supply as described in clause 4.3.2.1 at the required voltage may replace the supplied or recommended internal batteries. This shall be stated on the test report.

4.3.3 Normal test conditions

4.3.3.1 Normal temperature and humidity

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 %.

When it is impracticable to carry out tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

4.3.3.2 Normal test power source

4.3.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages, for which the equipment was designed.

The frequency of the test power source corresponding to the ac mains shall be between 49 Hz and 51 Hz.

4.3.3.2.2 Regulated lead-acid battery power sources

When the radio equipment is intended for operation with the usual types of regulated lead-acid battery power source, the normal test voltage shall be 1,1 multiplied by the nominal voltage of the battery (e.g. 6 V, 12 V, etc.).

4.3.3.2.3 Other power sources

For operation from other power sources or types of battery (primary or secondary), the normal test voltage shall be that declared by the equipment provider and agreed by the accredited test laboratory. Such values shall be stated in the test report.

4.3.4 Extreme test conditions

4.3.4.0 General requirement

Unless stated otherwise, tests performed under extreme test conditions shall apply the worst case temperature and voltage conditions simultaneously.

4.3.4.1 Extreme temperatures

4.3.4.1.0 Procedure for tests at extreme temperatures

4.3.4.1.1 General requirements

Before measurements are made the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilizing period.

In the case of equipment containing temperature stabilization circuits designed to operate continuously, the temperature stabilization circuits shall be switched on for 15 minutes after thermal balance has been obtained, and the equipment shall then meet the specified requirements.

If the thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour, or such period as may be decided by the test laboratory, shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

4.3.4.1.1.1 Procedure for equipment designed for continuous operation

If the provider states that the equipment is designed for continuous operation, the test procedure shall be as follows:

- Before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on in the transmit condition for a period of a half hour after which the equipment shall meet the specified requirements.
- For tests at the lower extreme temperature, the equipment shall be left in the test chamber until thermal balance is attained, then switched on for a period of one minute after which the equipment shall meet the specified requirements.

4.3.4.1.1.2 Procedure for equipment designed for intermittent operation

If the provider states that the equipment is designed for intermittent operation, the test procedure shall be as follows:

- before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained in the oven. The equipment shall then either:
  - transmit on and off according to the providers declared duty cycle for a period of five minutes; or
  - if the provider's declared on period exceeds one minute, then:
    - transmit in the on condition for a period not exceeding one minute, followed by a period in the off or standby mode for four minutes; after which the equipment shall meet the specified requirements;
- for tests at the lower extreme temperature, the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for one minute after which the equipment shall meet the specified requirements.

4.3.4.1.2 Extreme temperature ranges

Tests at extreme temperatures shall be made in accordance with the procedures specified in clause 4.3.4.1.1 at the upper and lower temperatures of the operational profile declared by the provider.

Example of range commonly used for equipments:

- General: -20 °C to +55 °C;
- Portable: -10 °C to +55 °C;
- Normal indoor use: +5 °C to +35 °C;
- Automotive: -40 °C to +125 °C.

The test report shall state the range used.

4.3.4.2 Extreme test source voltages

4.3.4.2.1 Mains voltage

The extreme test voltages for equipment to be connected to an AC mains source shall be the nominal mains voltage ±10 %. For equipment that operates over a range of mains voltages clause 4.3.4.2.4 applies.

4.3.4.2.2 Regulated lead-acid battery power sources

When the radio equipment is intended for operation from the usual type of regulated lead-acid battery power sources the extreme test voltages shall be 1,3 and 0,9 multiplied by the nominal voltage of the battery (6 V, 12 V, etc.).

For float charge applications using "gel-cell" type batteries the extreme voltage shall be 1,15 and 0,85 multiplied by the nominal voltage of the declared battery voltage.

4.3.4.2.3 Power sources using other types of batteries

The lower extreme test voltages for equipment with power sources using batteries shall be as follows:

- for equipment with a battery indicator, the end point voltage as indicated;
- for equipment without a battery indicator the following end point voltages shall be used:
    - for the Leclanché or the lithium type of battery:
        - 0,85 multiplied by the nominal voltage of the battery;
    - for the nickel-cadmium type of battery:
        - 0,9 multiplied the nominal voltage of the battery;
- for other types of battery or equipment, the lower extreme test voltage for the discharged condition shall be declared by the equipment provider.

The upper extreme voltage shall be declared by the equipment provider if different from the nominal voltage.

4.3.4.2.4 Other power sources

For equipment using other power sources, or capable of being operated from a variety of power sources, the extreme test voltages shall be those agreed between the equipment provider and the test laboratory. This shall be recorded in the test report.

4.3.5 Testing of frequency agile or hopping equipment

Tests shall be carried out on the highest operating channel and the lowest operating channel. Where appropriate, tests shall also be carried out on one or more intermediate frequencies as agreed between the test laboratory and the provider.

For FHSS equipment, two different tests shall be made under the conditions stated above:

a) The hopping sequence is stopped and the equipment is tested at two different channels as stated above.

b) The hopping sequence is in normal function and the equipment is tested with all hopping channels as declared by the provider.

4.3.6 Testing of equipment with adaptive power levels

If an equipment has adaptive output power levels provided by the use of separate power modules, then it has to be declared. Each module shall be tested in combination with the equipment. As a minimum, measurements of the radiated power (e.r.p.) and TX and/or RX spurious emissions shall be performed for each combination and shall be stated in the test report.

4.3.7 Artificial antenna

Where applicable, tests shall be carried out using an artificial antenna (also called a dummy load) which shall be a substantially non-reactive non-radiating load connected to the antenna connector. The Voltage Standing Wave Ratio (VSWR) at the 50 Ω connector or the provider's specified test fixture shall not be greater than 1,5:1 over the frequency range of the measurement.

4.3.8 Equipment without an external RF connector

4.3.8.0 General conditions

For equipment with an integral antenna or with an antenna connection other than a conventional 50 Ω coaxial connector, conducted measurements may be made on such equipment by:

- access to an internal connector;
- fitting of a temporary connector;
- use of a test fixture.

4.3.8.1 Equipment with an internal connector

Where the EUT has an internal conventional 50 Ω coaxial connector between the antenna and the circuitry, this may be utilized to perform conducted measurements. The means to access the connector shall be stated with the aid of a diagram. The fact that use has been made of the internal antenna connection, to facilitate measurements shall be recorded in the test report.

4.3.8.2 Equipment with a temporary antenna connector

One set of equipment, with the normal antenna connected, may be tested to enable radiated measurements to be made. The provider shall attend the test laboratory at the conclusion of the radiated measurements, to disconnect the antenna and fit the temporary connector. The testing laboratory staff shall not connect or disconnect any temporary antenna connector.

Alternatively, two sets of equipment may be submitted to the test laboratory, one fitted with a temporary antenna connector with the antenna disconnected and another equipment with the antenna connected. Each equipment shall be used for the appropriate tests. There shall be a declaration that the two sets of equipment are identical in all aspects except for the antenna connector.

4.3.8.3 Use of a Test Fixture

A test fixture is a structure for coupling the integral antenna to a 50 Ω RF terminal at all frequencies for which measurements need to be performed.

A test fixture may only be used for relative measurements.

For further information on the test fixture, see annex B.

4.3.9 Conducted and radiated measurements

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.

Where a test method is given using a conducted connection, an equivalent radiated measurement may be used instead. For certain measurements, an equivalent test using a test fixture may be used instead. In such cases, appropriate procedures to establish reference levels shall be used and recorded.

Where a test method specifies a radiated measurement, it is not generally possible to substitute a conducted or a test fixture measurement. A preliminary conducted or test fixture measurement is permissible, for instance to identify at which frequencies a radiated measurement is needed. The results of a preliminary conducted or test fixture measurement may also be used to show that a radiated measurement is not required, for instance if it is clear that spurious emissions are significantly below the specified limits.

For guidance on radiation test sites, see annex C. Detailed descriptions of radiated measurement arrangements are included in annex C.

Table 3 gives guidance as to which measurements may be performed using conducted or test fixture connections.

Table 3: Measurement Options

Description	Conducted with connector on EUT	Test Fixture	Radiated
Operating Frequency	Yes	Yes	Yes
Effective Radiated Power Maximum e.r.p spectral density	Yes	No	Yes
Maximum Occupied Bandwidth	Yes	Yes	Yes
Transmitter Frequency Error	Yes	Yes	No
Tx Out Of Band Emissions	Yes	No	Yes
Unwanted Emissions in the Spurious Domain	Yes	No	Yes
Transient Power	Yes	No	Yes
Adjacent Channel Power	Yes	No	Yes
Tx behaviour under Low Voltage Conditions	Yes	Yes	Yes
Adaptive Power Control	Yes	No	Yes
RX sensitivity	Yes	No	Yes
Adjacent Channel Selectivity	Yes	No	Yes
Blocking	Yes	No	Yes
Receiver saturation	Yes	No	Yes
Spurious response rejection	Yes	No	Yes
Behaviour at high wanted signal level	Yes	No	No
Rx Spurious Radiation	Yes	No	Yes
CCA threshold	Yes	No	Yes

4.3.10 Measuring receiver

4.3.10.0 Description

The term "measuring receiver" refers to a frequency-selective voltmeter or a spectrum analyser. Details are given in clause A.1. Unless stated otherwise, an RMS detector shall be used.

4.3.10.1 Reference bandwidth

In general, the resolution bandwidth of the measuring receiver (RBW) should be equal to the reference bandwidth (RBW_{REF}) given in Table 4.

Table 4: Reference bandwidth for the measurement receiver

Frequency range: (f)	Measuring receiver resolution bandwidth (RBW_{REF})
f < 150 kHz	200 Hz or 300 Hz
150 kHz ≤ f < 25 MHz	9 kHz or 10 kHz
25 MHz ≤ f ≤ 1 000 MHz	100 kHz or 120 kHz
f > 1 000 MHz	1 MHz
NOTE: The frequency ranges and corresponding RBW_{REF} values are derived from CISPR 16 [i.1].	

To improve measurement accuracy, sensitivity and efficiency, RBW may be different from RBW_{REF}.

When $RBW_{measured} < RBW_{REF}$ the result should be integrated over RBW_{REF} for instance according to the formula (1):

$$B = 10 \log \left(RBW_{REF} * \frac{\left(\frac{1}{n}\right) * \sum_{i=1}^{n} \left(10^{\left(\frac{P(i)}{10}\right)} \right)}{RBW_{MEASURED}} \right) \qquad (1)$$

Where:

- P(i) are the measured samples with $RBW_{measured}$;
- n is the number of samples inside RBW_{REF};
- B is the corresponding value at RBW_{REF}.

When $RBW_{measured} > RBW_{REF}$ the result for broadband emissions should be normalized to the bandwidth Ratio according to the formula (3):

$$B = A + 10 \log \frac{RBWref}{RBW_{MEASURED}} \qquad (2)$$

Where:

- A is the measured value at the wider measurement bandwidth $RBW_{measured}$;
- B is the corresponding value at RBW_{REF}.

For discrete emissions, defined as a narrow peak with a level of at least 6 dB above the average level inside the measurement bandwidth) , the above correction is not applicable while integration over RBW_{REF} is still applicable.

4.4 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;
- the recorded value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in Table 5.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated and shall correspond to an expansion factor (coverage factor) k = 1,96 or k = 2 (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028 [2], in particular in annex D of ETSI TR 100 028-2 [2].

Table 5 is based on such expansion factors.

Table 5: Measurement uncertainty

Radio frequency	±0,5 ppm
RF power, conducted	±1,5 dB
Conducted spurious emission of transmitter, valid up to 6 GHz	±3 dB
Conducted emission of receivers	±3 dB
Radiated emission of transmitter, valid up to 6 GHz	±6 dB
Radiated emission of receiver, valid up to 6 GHz	±6 dB
RF level uncertainty for a given BER	±1,5 dB
Occupied BandWidth	±5 %
Temperature	±2,5 °C
Humidity	±10 %

5 Parameters and tests

5.1 Operating frequency

5.1.1 Description

The nominal Operating Frequency is the centre of a channel of width OCW.

5.1.2 Conformance

The information shown in Table 6 shall be recorded in the test report.

Table 6: Information Recorded in the Test Report for Operating Frequency test

Value	Notes
Operational Frequency band or bands	Declared by the provider
Nominal Operating Frequency or Frequencies	Declared by the provider
Operating Channel width(s) - OCW -	Declared by the provider

5.2 Effective Radiated Power

5.2.1 Description

The effective radiated power (e.r.p) is the power radiated in the direction of the maximum field strength under specified conditions of measurements for any condition of modulation. For equipment with a permanent or temporary antenna connection it may be taken as the power delivered from that connector taking into account the antenna gain.

If the equipment is designed to operate with different carrier powers, the rated power for each level or range of levels shall be declared by the provider.

5.2.2 Conformance

5.2.2.1 Effective Radiated Power (conducted measurement)

5.2.2.1.0 General

This method applies only to EUT with a permanent external antenna connector.

5.2.2.1.1 Test conditions

1) The measurement shall be performed on the lowest and the highest Operating Frequencies declared by the provider. Additional frequencies may be tested.

2) If the equipment is designed to operate with different power levels, the rated power for each level or range of levels shall be declared by the provider. These measurements shall be performed at the highest power level at which the transmitter is intended to operate.

3) The transmitter shall be switched on, if possible, without modulation and the measuring receiver shall be tuned to the frequency of the transmitter under test. D-M1 test signal (unmodulated carrier) shall not be used for equipment with non-constant envelope modulation.

4) The RBW of the spectrum analyser shall be wide enough to cover the complete power envelope of the signal of the EUT.

5.2.2.1.2 Measurement procedure

The transmitter shall be connected to a dummy load as described in clause 4.3.7 and the conducted power delivered shall be measured with a measurement receiver according to clause 4.3.10.

In the case of non-constant envelope modulation, a peak detector shall be used.

The maximum gain of the antenna to be used together with the equipment shall be declared by the provider and this shall be recorded in the test report.

The radiated power (e.r.p.) limit applies to the maximum measured conducted power value adjusted by the antenna gain (relative to a dipole).

The information shown in Table 7 shall be recorded in the test report.

Table 7: Information Recorded in the Test Report for conducted Effective Radiated Power

Value	Notes
Test environment	Normal operation or unmodulated carrier
Centre frequency	Nominal Operating Frequency
Measured Effective Radiated Power	maximum measured conducted power value adjusted by the antenna gain (relative to a dipole)
NOTE: In case of a dedicated antenna the antenna gain (in dB, i.e. relative to a dipole) is declared by the provider.	

5.2.2.2 Effective radiated power (radiated measurement)

5.2.2.2.0 General

This measurement method applies to EUT other than those measured using clause 5.2.2.1.

5.2.2.2.1 Test conditions

1) The measurements shall be performed under normal test conditions. Test under extreme temperature conditions is normally not possible.

2) The measurement shall be performed on the lowest and the highest Operating Frequencies declared by the provider. Additional frequencies may be tested.

3) These measurements shall be performed at the highest power level at which the transmitter is intended to operate.

4) The transmitter shall be switched on, if possible, without modulation and the measuring receiver shall be tuned to the frequency of the transmitter under test. D-M1 test signal (unmodulated carrier) shall not be used for equipment with non-constant envelope modulation.

5) The RBW of the spectrum analyser shall be wide enough to cover the complete power envelope of the signal of the EUT.

6) In the case of a removable antenna, the antenna shall be fitted in a manner representative of normal use.

5.2.2.2.2 Measurement procedure

A suitable test site shall be selected from those described in clause C.1 and the radiated power established using the procedures described in clause C.6.

In the case of non-constant envelope modulation, a peak detector shall be used.

The information shown in Table 8 shall be recorded in the test report.

Table 8: Information Recorded in the Test Report for Effective Radiated Power

Value	Notes
Test environment	Normal operation or unmodulated carrier
Centre frequency	Nominal Operating Frequency
Measure of Effective Radiated Power	Larger value from horizontal and vertical measurement equivalent radiated power, plus equipment antenna gain
NOTE: In case of a removable antenna the antenna gain (in dB, i.e. relative to a dipole) is declared by the provider.	

5.3 Maximum Effective Radiated Power spectral density

5.3.1 Description

The maximum e.r.p. spectral density is defined as the highest e.r.p. level in dBm per Hertz generated by the transmitter within the power envelope.

5.3.2 Conformance

5.3.2.1 Test conditions

5.3.2.1.1 General requirements

1) The measurement shall be performed on the lowest and the highest Operating Frequencies declared by the provider. Additional frequencies may be tested.

2) If the equipment is designed to operate with different power levels, the rated power for each level or range of levels shall be declared by the provider. These measurements shall be performed at the highest power level at which the transmitter is intended to operate.

3) The transmitter shall be switched on without modulation and the measuring receiver shall be tuned to the frequency of the transmitter under test.

5.3.2.1.2 Measurement procedure

5.3.2.1.2.1 Option 1: Using a spectrum analyser with an average detector and/or PSD measurement feature

The test procedure contained in this option 1 shall be as follows:

Connect the EUT to the spectrum analyser and use the following settings:

Centre Frequency:	The centre frequency of the Operating Channel under test.
Span:	Wide enough to cover the complete power envelope of the signal of the EUT (≥ Occupied Bandwidth).
Resolution BW:	100 kHz (see note 2).
Video BW:	100 kHz (see note 2).
Sweep time:	1 minute.
Detector:	Average (see note 1).
Trace Mode:	Max Hold.

NOTE 1: The detector mode "Average" is often referred to as "RMS Average" or "Sample" but do not use Video Average.

NOTE 2: In case the regulatory parameter is expressed in dBm/10 kHz, RBW & VBW should be set to 10 kHz.

When the trace is complete, capture the trace, for example using the "View" option on the spectrum analyser.

Find the peak value of the trace and place the analyser marker on this peak. This level is recorded as the highest mean power (spectral power density) D in a 100 kHz band.

Alternatively, where a spectrum analyser is equipped with a facility to measure spectral power density, this facility may be used to display the spectral power density D in dBm/100 kHz.

Where the spectrum analyser bandwidth is non-Gaussian, a suitable correction factor shall be determined and applied.

The maximum e.r.p. spectral density is calculated from the above measured power density (D and the applicable antenna assembly gain "G" in dB relative to an ideal half wave dipole, according to the formula (3). If more than one antenna assembly is intended for this power setting, the gain of the antenna assembly with the highest gain shall be used.

$$PD = D + G \quad (3)$$

5.3.2.1.2.2 Option 2: Using a spectrum analyser with a narrow IF output port

The test procedure contained in this option 2 shall be as follows:

Step 1:

Use the following settings on the spectrum analyser:

- Centre Frequency: The centre frequency of the channel under test.
- Resolution BW: 100 kHz (see note).
- Video BW: 100 kHz (see note).
- Detector mode: Peak.
- Averaging: Off.
- Span: Wide enough to cover the complete power envelope of the signal of the EUT.

NOTE: In case the regulatory parameter is expressed in dBm/10 kHz, RBW & VBW can be set to 10 kHz.

Step 2:

Connect the E.U.T. to the spectrum analyser and switch on the E.U.T.

Step 3:

Adjust the Reference Level of the spectrum analyser so that the peak of the power envelope is between the Reference Level and the Reference Level -10 dB. This assumes a 10 dB/division setting is used on the spectrum analyser.

Step 4:

Use the marker to find the peak value of the power envelope.

Adjust the centre frequency of the analyser to the marker frequency, resulting in the peak of the power envelope being in the centre of the screen.

Step 5:

Change the spectrum analyser settings as follows:

- Resolution BW: Unchanged.
- Video BW: Unchanged.
- Detector mode: Peak.
- Averaging: Off.
- Span: 0 Hz.

Step 6:

Connect a Power Meter to the "Narrow I.F" output port of the spectrum analyser.

NOTE: The IF output of the spectrum analyser may be 20 dB or more below the input level of the spectrum analyser. Unless the power meter has adequate sensitivity, a wideband amplifier may be required.

Adjust the Centre Frequency of the spectrum analyser carefully (fine tune) for maximum indication on the power meter.

The level measured by the power meter shall be recorded as level "A".

It is important to not change any of the settings of the spectrum analyser anymore at this stage.

Step 7:

Switch off the EUT and disconnect the coaxial cable from the EUT.

Connect the cable to the R.F. signal generator and use the following settings for the generator.

- Level: Approx. + 5 dBm (as a starting point).
- Frequency: Equal to the current Centre Frequency of the analyser.

Adjust the frequency of the generator carefully (fine adjustment) for maximum indication on the power meter. This to ensure that the centre frequency of the analyser is 100 % identical to the one of the signal generator noting that there might be a small offset between both reference oscillators used for the frequency measurement.

Adjust the level of the generator to get the same indication (level) on the power meter as the level "A" noted in step 6.

The level of the signal generator is now equal to the measured power density (D). Depending on the accuracy of the level indication on the signal generator, a power meter may be used to accurately measure the current power (density) level (D) of the generator.

The maximum e.r.p. spectral density is calculated from the above measured power density (D), and the applicable antenna assembly gain "G" in dB relative to an ideal half wave dipole, according to the formula (4). If more than one antenna assembly is intended for this power setting, the gain of the antenna assembly with the highest gain shall be used.

$$PD = D + G \quad (4)$$

Where the spectrum analyser bandwidth is non-Gaussian, a suitable correction factor shall be determined and applied.

The information shown in Table 9 shall be recorded in the test report.

Table 9: Information Recorded in the Test Report for Effective Radiated Power

Value	Notes
Centre frequency	Nominal Operating Frequency
Maximum radiated Power density	Maximum radiated power density shall be recorded

5.4 Duty Cycle

5.4.1 Description

Duty cycle is the ratio expressed as a percentage, of the cumulative duration of transmissions $_{Ton\_cum}$ within an observation interval T_{obs}. $DC = \left(\frac{T_{on\_cum}}{T_{obs}}\right)_{Fobs}$ on an observation bandwidth $F_{obs.}$
Unless otherwise specified, T_{obs} is 1 hour and the observation bandwidth F_{obs} is the operational frequency band Each transmission consists of an RF emission, or sequence of RF emissions separated by intervals < T_{Dis}.

An equipment may operate on several bands simultaneously (i.e. multi transmissions), Duty Cycle of each band applies to each transmission.

In case of a multicarrier modulation in a band, the duty cycle applies to the whole signal used for a transmission (e.g. OFDM).

It has to be noted that on some bands Duty Cycle value may depend on the presence of a primary radio service.

Equipment may be triggered manually, by internal timing or by external stimulus. Depending on the method of triggering the timing may be predictable or random.

5.4.2 Conformance

An assessment of the overall Duty Cycle shall be made for a representative period of T_{obs} over the observation bandwidth F_{obs}. Unless otherwise specified, T_{obs} is 1 hour and the observation bandwidth F_{obs} is the operational frequency band.

The representative period shall be the most active one in normal use of the device. As a guide "Normal use" is considered as representing the behaviour of the device during transmission of 99 % of traffic generated during its operational lifetime.

Procedures such as test and development of equipment and setup and configuration during installation and maintenance are not considered part of normal operation.

Where an acknowledgement is used, the additional transmitter on-time from a message responder shall be declared only once whether included in the message initiator Duty Cycle or in the message responder Duty Cycle.

5.5 DCT

5.5.1 Description

Duty Cycle Template is the ratio, expressed as a percentage, of the Cumulative On Time within an observation interval divided by the observation interval. $DCT = \left(\frac{T_{on\_cum}}{T_{obs}}\right)_{Fobs}$ on an observation bandwidth F_{obs} respecting the constraint of T_{on_max} and T_{off_min} values.

NOTE: DCT may be defined for more than one value of $T_{obs.}$

Each Transmission consists of an RF emission, or sequence of RF emissions separated by intervals < T_{Di}.

In case of a multicarrier modulation in a band, the duty cycle applies to the whole signal used for a transmission (e.g. OFDM).

Equipment may be triggered manually, by internal timing or by external stimulus. Depending on the method of triggering the timing may be predictable or random.

5.5.2 Conformance

5.5.2.1 Test conditions

1) The measurement shall be performed on the operating frequency declared by the provider. The frequency shall correspond to a nominal channel centre frequency consistent with the highest and lowest frequencies and channel spacing declared by the provider.

2) The EUT shall be configured to transmit its maximum length transmissions.

3) Unless otherwise specified, the observation period T_{obs} is 1 second.

4) Unless otherwise stated the observation bandwidth is the operational frequency band.

5.5.2.2 Measurement procedure

1) The measurement shall be performed on a frequency declared by the provider. The frequency shall correspond to a channel centre frequency consistent with the highest and lowest frequencies declared by the provider.

2) The EUT shall be configured to transmit its maximum length transmissions.

The measurement setup is described in ETSI TS103 060, clause 5 [5].

This test is performed using a fast power sensing equipment suitable for measurements in the operating frequency band.

Table 10: Power Sensor Settings for short term behaviour measurement

Setting	Value	Notes
Sample rate	≥ 1 M samples/second	Sampling rate for at least 100 µsecond resolution
Trigger		Trigger setting to capture leading edge of first transmission
$P_{Threshold}$		Signal threshold
NOTE: The trigger setting shall be determined by the test laboratory. The threshold power level shall be agreed between the test laboratory and the provider.		

The power sensing equipment shall be configured according to the settings in Table 10.

The EUT signal shall be measured with a power sensor and its levels adjusted according to the power envelope of the EUT transmissions.

Step 1:

The EUT shall be set to operate for not less than 10 transmissions.

The sampled power readings shall be saved.

NOTE 1: For low activity EUT it may be agreed with the test laboratory that a smaller number of transmissions may be accepted.

Step 2:

Using suitable analysis software the start time and stop time of each sequence of samples above $P_{Threshold}$ shall be obtained.

Between the saved start and stop times of each individual burst, the T_{On} time shall be calculated. These T_{On} values shall be saved.

Between the saved stop and start times of two subsequent bursts, the T_{Off} time shall be calculated. These T_{Off} values shall be saved.

NOTE 2: For low activity EUT, a note should be made if only a single transmission occurred.

Step 3:

Within the calculated T_{Off} times, any interval less than T_{dis} shall be discarded. The lowest value of T_{Off} shall be noted.

The transmission duration is the time between two consecutive T_{Off} intervals. The highest value calculated for transmission duration shall be noted.

NOTE 3: If only a single transmission occurred the duration is calculated from the samples directly and the T_{off} time is the duration from the end of the transmission to the end of the sampling interval.

The information shown in Table 11 shall be recorded in the test report.

Table 11: Information Recorded in the Test Report for DCT

Value	Notes
Centre frequency	Nominal Operating Frequency
Measured sequence	$T_{on\ cumulative}$ and $T_{off\ cumulative}$ measured with T_{obs} and F_{obs}
DCT	DCT calculated with above measured parameters

5.6 Occupied Bandwidth

5.6.1 Description

The occupied bandwidth (OBW) is the Frequency Range in which 99 % of the total mean power of a given emission falls. The residual part of the total power being denoted as β, which, in cases of symmetrical spectra, splits up into β/2 on each side of the spectrum. Unless otherwise specified, β/2 is to be taken as 0,5 %. The related measuring method is known as the β/2 method, see Figure 3.

The maximum occupied bandwidth includes all associated side bands above the appropriate emissions level and the frequency error or drift under extreme test conditions.

5.6.2 Reference limits

Limits apply under normal and extreme conditions.

The Operating Channel shall be declared and shall reside entirely within the Operational Frequency Band.

The Occupied Bandwidth at 99 % shall reside entirely within the Operating Channel.

For systems where 99 % OBW cannot be measured, the bandwidth at -23 dBc shall reside entirely within the Operating Channel bandwidth.

5.6.3 Conformance

5.6.3.1 Test conditions

1) The measurement shall be performed on the lowest and the highest Operating Frequencies declared by the provider. Additional frequencies may be tested.

2) The measurement shall be performed with a spectrum analyser.

3) An EUT without a permanent or temporary antenna connector shall be tested according to clause 4.3.8. An EUT with a permanent or temporary antenna connector shall be tested according to clause 4.3.7.

4) For devices with e.r.p. ≤ -30 dBm, OBW may be either measured or taken as equal to the OCW within the operational frequency band.

5.6.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1 and the measurements in clause 5.6.3.4 shall be performed using corresponding radiated measurement methods described in clause C.6.

5.6.3.3 Conducted measurement

The EUT shall be connected to an artificial antenna which shall be connect to the test equipment via an appropriate attenuator.

The measurements in clause 5.6.3.4 shall be performed.

5.6.3.4 Measurement procedure

5.6.3.4.0 General

The spectrum analyser shall be configured as appropriate for the parameters shown in Table 12.

Table 12: Test Parameters for Max Occupied Bandwidth Measurement

Setting	Value	Notes
Centre frequency	The nominal Operating Frequency	The highest or lowest Operating Frequency as declared by the provider
RBW	1 % to 3 % of OCW without being below 100 Hz	For the built in OBW measurement of the spectrum analyser and for the -23 dBc measurement
	3 x approximate emission width	For determining the total channel power
VBW	3 x RBW	Nearest available analyser setting to 3 x RBW
Span	At least 2 x Operating Channel width	Span should be large enough to include all major components of the signal and its side bands
Detector Mode	RMS	
Trace	Max hold	

If the equipment is capable of producing an unmodulated carrier and the test in clause 5.8 is performed, then the OBW measurements need only be performed under normal test conditions. Any required results for Maximum OBW under extreme conditions are obtained by addition and substraction of the upper and lower frequency error results to each bandwidth measurement obtained in this test.

5.6.3.4.1 Method using the build in measurement procedure of the spectrum analyser

Step 1:

Operation of the EUT shall be started, on the highest operating frequency as declared by the provider, with the appropriate test signal.

The signal attenuation shall be adjusted to ensure that the signal power envelope is sufficiently above the noise floor of the analyser to avoid the noise signals on either side of the power envelope being included in the measurement.

Step 2:

When the trace is completed the peak value of the trace shall be located and the analyser marker placed on this peak.

Step 3:

The 99 % occupied bandwidth function of the spectrum analyser shall be used to measure the occupied bandwidth of the signal.

5.6.3.4.2 Method using the -23 dBc measurement procedure

The 23 dB measurement method is a secondary alternative to the 99 % Occupied BW function method. The spectrum analyser is set to a resolution and video bandwidth far greater than the emission bandwidth and the peak of the signal is set to the top line of the analyser.

The spectrum analyser is then set as follows:

- Span: The minimum span to fully display the emission, and able to display the signal at approximately 26 dB below the peak level.
- Resolution BW: Set to 1 % to 3 % of the approximate emission width.
- Video BW: 3 times the Resolution BW.
- Video Averaging: None.
- Sweep time: Coupled.

- Detector: Sample.

Step 1:

Operation of the EUT shall be started, on the highest operating frequency as declared by the provider, with the appropriate test signal.

The signal attenuation shall be adjusted to ensure that the signal power envelope is sufficiently above the noise floor of the analyser to avoid the noise signals on either side of the power envelope being included in the measurement.

Step 2:

The RBW shall be changed to the value for determining the total channel power. The peak value of the trace shall be located and the analyser marker placed on this peak. The marker value represents the total channel power.

Step 3:

The RBW shall be changed to the value for measuring the -23 dBc bandwidth.

The marker is placed on the trace at the lowest frequency point that displays a value that is 23 dB below the value of the total channel power from step 2. The delta marker is evoked and placed at the highest frequency point that displays 0 dB differential. The frequency differential is the Occupied Bandwidth.

Step 4:

Operation of the EUT shall be restarted on the lowest operating frequency, as declared by the provider, with the appropriate test signal. Steps 2 to 3 shall be repeated for the lowest operating frequency.

5.6.3.5 Recording

The information shown in Table 13 shall be recorded in the test report for each test condition.

Table 13: Information Recorded in the Test Report for Occupied Bandwidth

Value	Notes
Test environment	Normal or extreme conditions
Test signal	The test signal used. See Table 3
Centre Frequency	The highest or lowest operating frequency as declared by the provider and any other frequencies used in the test case
Occupied Bandwidth	The value measured with the spectrum analyser
Maximum Occupied Bandwidth	Highest measured OBW value or if the measurement is only performed at normal temperature conditions, the upper and lower frequency error results have to be added and subtracted to measured OBW to calculate the Maximum Occupied bandwidth

5.7 Frequency error

5.7.1 Description

Frequency error is the difference between the measured unmodulated carrier frequency under extreme conditions and the nominal Centre Frequency as stated by the manufacturer. This measurement procedure only applies if the EUT can generate an unmodulated carrier (test signal D-M1).

5.7.2 Conformance

5.7.2.1 Test conditions

1) The measurement shall be made under extreme test conditions.

2) The measurement shall be performed with an unmodulated carrier test signal (D-M1).

3) For frequency agile devices, the measurement shall be repeated in each band.

4) The nominal frequency for the test can be wherever in each sud-bands.

5) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.7.2.3.

6) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.7.2.2.

5.7.2.2 Conducted measurement

The EUT shall be connected to the spectrum analyser. The measurement procedure in clause 5.7.2.4 should be performed.

5.7.2.3 Radiated measurement

The EUT shall be tested according to clause 4.3.8. The measurement procedure in clause 5.7.2.4 should be performed.

5.7.2.4 Measurement procedure

Step 1:

Operation of the EUT shall be started on the nominal frequency as declared by the provider under lower extreme temperature and voltage.

The frequency of the unmodulated carrier shall be measured and noted.

Step 2:

Operation of the EUT shall be started on the nominal frequency as declared by the provider under higher extreme temperature and voltage.

The frequency of the unmodulated carrier shall be measured and noted.

5.7.2.5 Recording

The information shown in Table 14 shall be recorded in the test report for each test condition.

Table 14: Information Recorded in the Test Report For Frequency Error

Value	Notes
Nominal Operating Frequency (N)	Declared by the provider
Carrier frequency (A) under lower extreme test conditions	Measured unmodulated carrier frequency
Carrier frequency (B) under higher extreme test conditions	Measured unmodulated carrier frequency
Frequency error (upper & lower)	A-N and B-N

5.8 Tx Out Of Band Emissions

5.8.1 Description

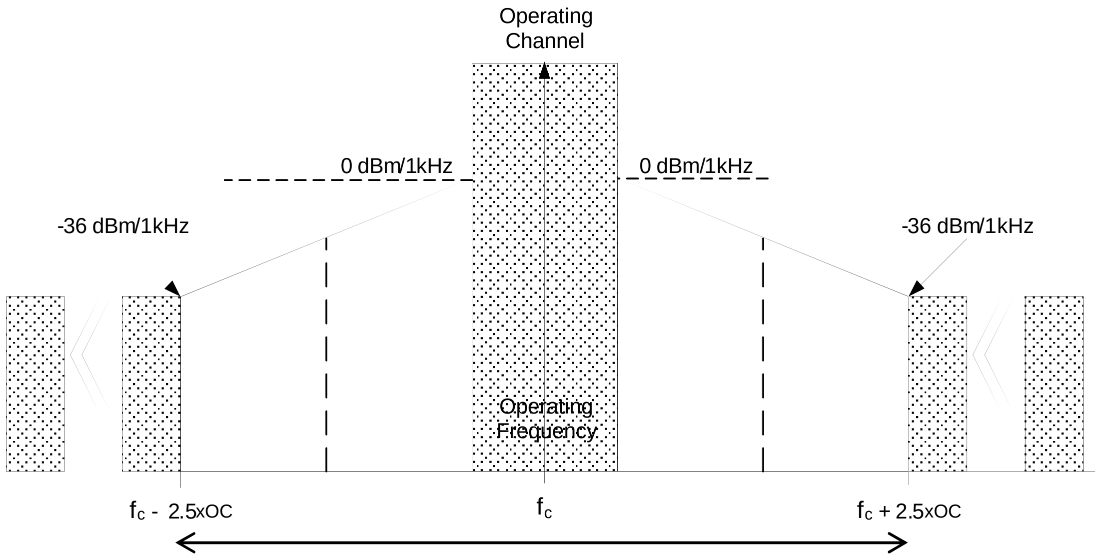


Figure 5: Out Of Band Domain for Operating Channel with reference BW

Unwanted emissions in the Out Of Band domain are those falling in the frequency range immediately below the lower, and above the upper, frequency of the Operating Channel. The OOB domain includes both frequencies outside the Operating Channel within the Operational Frequency Band and frequencies outside the Operational Frequency Band.

The relevant Out Of Band domain is shown in Figure 5 and applies within the Operational Frequency Band.

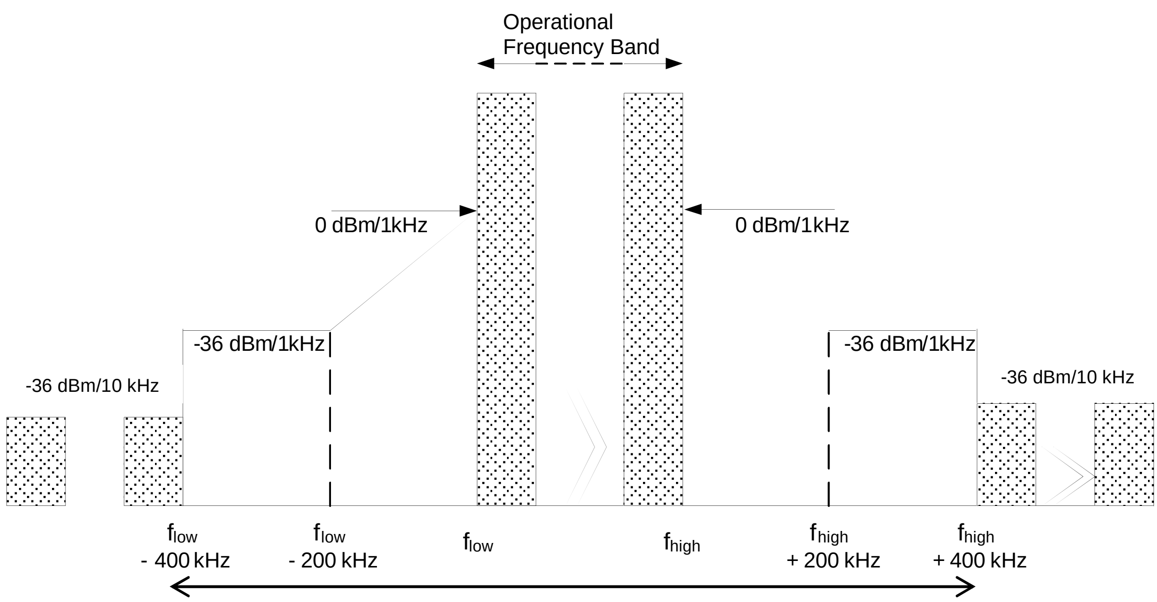


Figure 6: Out Of Band Domain for Operational Frequency Band with reference BW

Specific limits apply at frequencies immediately above and below the Operational Frequency Band as shown in Figure 6.

NOTE: f_{low} is the lower edge of the Operational Frequency Band.

f_{high} is the upper edge of the Operational Frequency Band.

5.8.2 Reference limits

The OOB domain includes both frequencies outside the Operating Channel within the Operational Frequency Band and frequencies outside the Operational Frequency Band.

In the Out Of Band domain, the power level shall be below the spectrum masks given in Table 15.

Table 15: Emission limits in the Out Of Band domains

Domain	Frequency Range	RBW_{REF}	Max power limit
OOB limits applicable to Operational Frequency Band (See Figure 6)	$f \leq f_{low}$ - 400 kHz	10 kHz	-36 dBm
	f_{low} - 400 kHz $\leq f \leq f_{low}$ - 200 kHz	1 kHz	-36 dBm
	f_{low} - 200 kHz $\leq f < f_{low}$	1 kHz	See Figure 6
	$f = f_{low}$	1 kHz	0 dBm
	$f = f_{high}$	1 kHz	0 dBm
	$f_{high} < f \leq f_{high}$ + 200 kHz	1 kHz	See Figure 6
	f_{high} + 200 kHz $\leq f \leq f_{high}$ + 400 kHz	1 kHz	-36 dBm
	f_{high} + 400 kHz $\leq f$	10 kHz	-36 dBm
OOB limits applicable to Operating Channel (See Figure 5)	$f = f_c$- 2.5 x OCW	1 kHz	-36 dBm
	f_c - 2,5 x OCW $\leq f \leq f_c$ - 0,5 x OCW	1 kHz	See Figure 5
	$f = f_c$ - 0,5 x OCW	1 kHz	0 dBm
	$f = f_c$ + 0,5 x OCW	1 kHz	0 dBm
	f_c + 0,5 x OCW $\leq f \leq f_c$ + 2,5 x OCW	1 kHz	See Figure 5
	$f = f_c$+ 2,5 x OC	1 kHz	-36 dBm
NOTE: f is the measurement frequency. f_c is the Operating Frequency. f_{low} is the lower edge of the Operational Frequency Band. f_{high} is the upper edge of the Operational Frequency Band. OCW is the operating channel bandwidth.			

5.8.3 Conformance

5.8.3.1 Test conditions

1) If the clause 5.8 is performed then the measurements may be made under normal test conditions only, with the upper and lower frequency error results added and subtracted to the masks of this test.

2) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.8.3.2.

3) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.8.3.3.

5.8.3.2 Radiated measurement

The measurements shall be performed using the procedure in clause 5.8.3.4 using a suitable test site from those described in clause C.1 and using corresponding radiated measurement methods described in clause C.6.

5.8.3.3 Conducted measurement

The EUT shall be connected to an artificial antenna which shall be connect to the test equipment via an appropriate attenuator.

The measurements in clause 5.8.3.4 shall be performed.

5.8.3.4 Measurement procedure

Table 16: Test Parameters for Out Of Band for Operating Channel Measurement

Spectrum Analyser Setting	Value	Notes
Centre frequency	Operating Frequency	
Span	6 x Operating Channel width	
RBW	1 kHz (see note)	Resolution bandwidth for Out Of Band domain measurements
Detector Function	RMS	
Trace Mode	Linear AVG	An appropriate number of samples should be averaged to give a stable reading
NOTE: If the value of RBW used is different from RBW_{REF} in clause 5.8.2, use clause 4.3.10.1.		

The test equipment shall be configured as appropriate for the parameters shown in Table 16.

Step 1:

Operation of the EUT shall be started, on the highest operating frequency as declared by the provider, with the appropriate test signal.

The signal shape is recorded when stable and shall be below the spectrum mask Out Of Band for operating channel.

Step 2:

The test equipment shall be reconfigured as appropriate for the parameter shown in Table 17.

Table 17: Test Parameter Setting for Lower Out Of Band Measurement

Spectrum Analyser Setting	Value	Notes
Centre frequency	f_{low}	The lowest Operating Frequency in the band
Span	2 x (500 kHz + f_{low} - f_{low} _OFB)	Ensures that the left most mask specification remains within the span

NOTE: f_{low_OFB} is the lower edge of the Operational Frequency Band.

Operation of the EUT is restarted, with the appropriate test signal, on the lowest operating frequency as declared by the provider.

If the equipment is using only one operating Frequency in the operational Frequency Band, measurement shall be performed the nominal operating frequency.

The signal shape is recorded when stable; and shall be below the spectrum mask for operating channel.

Step 3:

The test equipment shall be reconfigured as appropriate for the parameter shown in Table 18.

Table 18: Test Parameter Setting for upper Out Of Band Measurement

Spectrum Analyser Setting	Value	Notes
Centre frequency	f_{high}	the highest Operating Frequency in the band
Span	2 x (500 kHz + f_{high} _OFB-f_{high})	Ensures that the rightmost mask specification remains within the span
NOTE: f_{high_OFB} is the higher edge of the operational frequency Band.		

Operation of the EUT is restarted, with the appropriate test signal, on the highest Operating Frequency as declared by the provider.

If the equipment is using only one Operating Frequency in the Operational Frequency Band, measurement shall be performed the nominal Operating Frequency

The signal shape is recorded when stable and shall be below the spectrum mask for Out Of Band emissions for operational Frequency Band.

Step 4:

For frequency agile devices, the measurement shall be repeated in each Operational Frequency Band.

Step 5:

Where required (see clause 5.8.3.1 condition 1), the measurements in step 1 to step 5 shall be repeated under extreme test conditions.

5.9 Unwanted emissions in the spurious domain

5.9.1 Description

5.9.1.1 Unwanted emissions for a TX mode

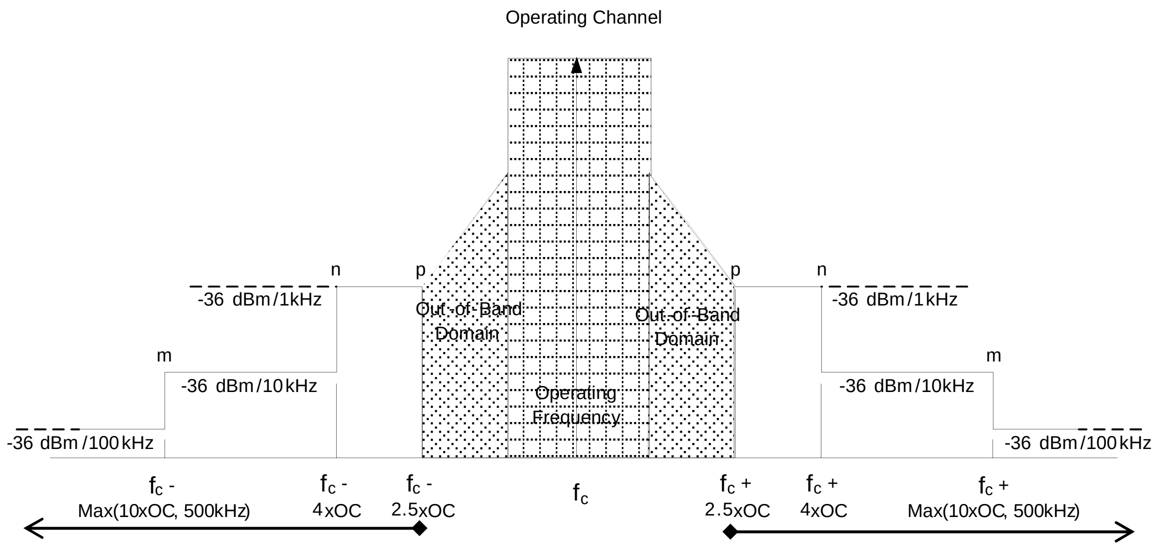


Figure 7: Spectrum Mask for Unwanted Emissions in the Spurious Domain with reference BW

Spurious emissions are unwanted emissions in the spurious domain at frequencies other than those of the Operating Channel and its Out Of Band Domain. The relevant spurious domain is shown in Figure 7.

5.9.1.2 Unwanted emissions for all other modes

Spurious radiations from the EUT are components, at any frequency, radiated by the equipment and antenna.

5.9.2 Reference limits

The power of any unwanted emission in the spurious domain shall not exceed the values given in Table 19.

Table 19: Spurious domain emission limits

Frequency / State	47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 790 MHz	Other frequencies below 1 000 MHz	Frequencies above 1 000 MHz
TX mode	-54 dBm	-36 dBm	-30 dBm
RX and all other modes	-57 dBm	-57 dBm	-47 dBm

5.9.3 Conformance

5.9.3.1 Test conditions

The EUT shall be operated in a mode representative of normal operation.

For EUT without an external conventional 50 Ω coaxial antenna connector, the spurious emissions levels shall be established by the radiated measurement procedure in clause 5.9.3.3.2.

For all other EUT the spurious emissions levels shall be established as both:

i) the conducted measurement procedure in clause 5.9.3.3.1; and

ii) the radiated measurement procedure in clause 5.9.3.3.2, with the antenna port terminated in a dummy load.

5.9.3.2 Test conditions for TX mode

1) The transmitter shall be switched on the lowest and the highest Operating Frequency declared by the provider. Additional frequencies may be tested.

2) The measurement shall be performed with the EUT operating at its maximum operating power level, as declared by the provider, and also with the EUT in powered-on stand-by mode.

3) The RBW of measuring receiver are shown in Table 20.

Table 20: Parameters for TX Spurious Radiations Measurement

Operating Mode	Frequency Range	RBW_{REF} (see note 2)
Transmit mode	9 kHz ≤ f < 150 kHz	1 kHz
	150 kHz ≤ f < 30 MHz	10 kHz
	30 MHz ≤ f < f_c - m	100 kHz
	f_c - m ≤ f < f_c - n	10 kHz
	f_c - n ≤ f < f_c - p	1 kHz
	f_c + p < f ≤ f_c + n	1 kHz
	f_c + n < f ≤ f_c + m	10 kHz
	f_c + m < f ≤ 1 GHz	100 kHz
	1 GHz < f ≤ 6 GHz	1 MHz

NOTE 1: f is the measurement frequency.
f_c is the Operating Frequency.
m is 10 x OC or 500 kHz, whichever is the greater.
n is 4 x OC or 100 kHz, whichever is the greater.
p is 2,5 x OC.

NOTE 2: If the value of RBW used for measurement is different from RBW_{REF}, use clause 4.3.10.1.

5.9.3.3 Measurement procedure

5.9.3.3.1 Conducted measurement

The antenna port of the EUT shall be connected to the dummy load and the output of the dummy load connected to the measuring receiver.

The operation of the EUT shall be started.

For TX mode clause 5.9.3.2 applies.

The measuring receiver shall be tuned over the frequency range shown in Table 21.

Table 21: Spurious Radiations conducted Measurement Frequency Range

Frequency Range
9 kHz to 6 GHz
NOTE: The measurements need only to be performed over the frequency range 4 GHz to 6 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz.

At each frequency at which a spurious component is detected, the power level shall be measured and noted.

5.9.3.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1.

The EUT shall be connected to its normal operating antenna.

The output of the test antenna shall be connected to a measuring receiver. The measurements described shall be performed using appropriate radiated measurement methods described in clause C.6.

The operation of the EUT shall be started.

For TX mode clause 5.9.3.2 applies.

The measuring receiver shall be tuned over the frequency range shown in Table 22.

Table 22: Spurious Radiations radiated Measurement Frequency Range

Frequency Range
25 MHz to 6 GHz
NOTE: The measurements need only to be performed over the frequency range 4 GHz to 6 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz.

At each frequency at which a spurious component is detected within the frequency range in Table 22, the spurious emission power level shall be established using the procedures described in clause C.6 and noted in the report.

For each frequency at which a spurious component is detected the appropriate measurement procedure for the selected test site as described in annex C shall be performed.

The maximum signal level detected by the measuring receiver for vertical and horizontal polarization shall be noted.

The substitution measurement defined in clause C.6.3 shall be performed with the frequency of the calibrated signal generator set to the frequency of the spurious component detected and, if necessary, the input attenuator setting of the measuring receiver adjusted in order to increase the sensitivity of the measuring receiver.

The radiated power for vertical and horizontal polarization, corrected for any change of input attenuator setting of the measuring receiver, shall be noted.

The measure of the effective radiated power of the spurious component is the larger of the two power levels at the input to the substitution antenna.

The power measured shall be recorded in the test report for each spurious component.

5.10 Transient power

5.10.1 Description

Transmitter transient power is power falling into frequencies other than the operating channel as a result of the transmitter being switched on and off.

5.10.2 Reference limits

The transient power shall not exceed the values given in Table 23.

Table 23: Transmitter Transient Power limits

Absolute offset from centre frequency	RBW_{REF}	Peak power limit applicable at measurement points
≤ 400 kHz	1 kHz	0 dBm
> 400 kHz	1 kHz	-27 dBm

5.10.3 Conformance

5.10.3.1 Test conditions

1) The measurements shall be performed under normal conditions.

2) The measurement shall be performed on the lowest and the highest operating Frequency declared by the provider. Additional frequencies may be tested.

3) These measurements shall be performed at the highest power level at which the transmitter is intended to operate.

5.10.3.2 Measurement procedure

The output of the EUT shall be connected to a spectrum analyser or equivalent measuring equipment.

The measurement shall be undertaken in **zero span** mode. The analyser's centre frequency shall be set to an offset from the operating centre frequency. These offset values and their corresponding RBW configurations are listed in Table 24.

Table 24: RBW for Transient Measurement

Measurement points: offset from centre frequency	Analyser RBW	RBW_{REF}
-0,5 x OCW - 3 kHz 0,5 x OCW + 3 kHz Not applicable for OCW < 25 kHz	1 kHz	1kHz
±max (12,5 kHz, OCW)	Max (RBW pattern 1,3,10) ≤ Offset frequency/6	1 kHz
-0,5 x OCW - 400 kHz 0,5 x OCW + 400 kHz	100 kHz	1 kHz
-0,5 x OCW -1 200 kHz 0,5 x OCW + 1 200 kHz	300 kHz	1 kHz

Max (RBW pattern 1, 3, 10) means the maximum bandwidth that falls onto the commonly implemented 1,3,10 RBW filter bandwidth incremental pattern of spectrum analysers.

As an example if OC is 25 kHz then the RBW value corresponding to one OC offset frequency is 3 kHz. The rest of the analyser settings are listed in Table 25.

Table 25: Parameters for Transient Measurement

Spectrum Analyser Setting	Value	Notes
VBW/RBW	10	At higher RBW values VBW may be clipped to its maximum value
Sweep time	500 ms	
RBW filter	Gaussian	
Trace Detector Function	RMS	
Trace Mode	Max hold	
Sweep points	501	
Measurement mode	Continuous sweep	
NOTE: The ratio between the number of sweep points and the sweep time shall be maintained the same as in table 23 if different number of sweep points is used.		

The used modulation shall be D-M3. The analyser shall be set to the settings of Table 25 and a measurement shall be started for each offset frequency. The EUT shall transmit at least five D-M3 test signal. The peak value shall be recorded and the measurement shall be repeated at each offset frequency mentioned in Table 24.

The recorded power values shall be converted to power values measured in RBW_{REF} by the formula in clause 4.3.10.1.

5.11 Adjacent Channel Power

5.11.1 Description

Adjacent channel power is power incidental to proper operation of a transmitter falling into the neighbouring channels.

The adjacent channels and alternate adjacent channels are defined in clause 3.

5.11.2 Reference limits

5.11.2.1 Limits for equipment with operating channel width less than 25 kHz

Where the operating channel width is less than or equal to 25 kHz, the power in the adjacent channels shall not exceed the values given in Table 26.

Table 26: Adjacent channel power limits for transmitters with OCW ≤ 25 kHz

		Adjacent Channel power integrated over 0,7 x OCW	Alternate Adjacent Channel power integrated over 0,7 x OCW
OCW < 20 kHz	Normal test conditions	-20 dBm	-20 dBm
	Extreme test conditions	-15 dBm	-20 dBm
OCW ≥ 20 kHz	Normal test conditions	-37 dBm	-40 dBm
	Extreme test conditions	-32 dBm	-37 dBm

5.11.3 Conformance

5.11.3.1 Test conditions

1) The measurement shall be performed on the lowest and the highest Operating Frequency declared by the provider. Additional frequencies may be tested.

2) These measurements shall be performed at the highest power level at which the transmitter is intended to operate.

3) The Adjacent Channel Power shall be measured with a spectrum analyser which conforms with the requirements given in annex A.

4) For FHSS, the test conditions in clause 4.3.5 apply.

An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.11.3.2. An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.11.3.3.

5.11.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1 and the measurements in clause 5.11.3.4 performed using corresponding radiated measurement methods described in clause C.6.

5.11.3.3 Conducted measurement

The EUT shall be connected to an artificial antenna which shall be connect to the test equipment via an appropriate attenuator.

The measurements in clause 5.11.3.4 shall be performed.

5.11.3.4 Measurement procedure

The spectrum analyser shall be configured as appropriate for the parameters shown in Table 27.

Table 27: Test Parameters for Adjacent Channel Power

Setting	Value	Notes
Centre frequency	The nominal Operating Frequency	
RBW	100 Hz	
VBW	≥ 3 x RBW	
Span	At least 5 x Operating Channel width	Span should be large enough to include Adjacent and Alternate Adjacent Channel
Detector Mode	RMS	
Trace mode	Linear Averaging	An appropriate number of samples should be averaged to give a stable reading
NOTE: The highest and lowest operating frequencies are declared by the provider.		

Step 1:

Operation of the EUT shall be started, on the Operating Frequency as declared by the provider. The modulation used shall be set according to Table 2.

During the test, the transmitter shall be set in continuous transmission mode. If this is not possible, the measurements shall be carried out in a period shorter and fully within the duration of the transmitted burst. It may be necessary to extend the duration of the burst.

The signal attenuation shall be adjusted to ensure that the signal power is not saturating the Spectrum analyser input port.

Step 2:

When the trace is completed, read the integrated power over a bandwidth of **RBW_{REF}** centered to an **offset from centre frequency** as specified in Table 28. The spectrum analyser's ACP personality or an integrating marker may be used. If the spectrum analyser's ACP personality is used any additional filtering over the integrating bandwidth shall be disabled.

Table 28: Offset and RBW_{REF} parameters

Measurement	Offset from centre frequency	RBW_{REF}
Adjacent channel	± OCW	0,7 x OCW
Alternate channel	± 2 x OCW	0,7 x OCW

Take the higher power value from the positive and negative offsets at both the adjacent channel and alternate channel results.

Lin Averaging on the trace is an advanced SA feature. It antilogs the results averages them than takes the log again.

5.12 TX behaviour under Low Voltage Conditions

5.12.1 Description

The frequency stability under low voltage condition is the ability of the equipment to maintain its operating frequency and not produce emissions which exceed any relevant limit when the battery voltage falls below the lower extreme voltage level.

5.12.2 Reference limits

The equipment shall either:

a) remain in the Operating Channel OC without exceeding any applicable limits (e.g. Duty Cycle); or

b) reduce its effective radiated power below the Spurious Emission limits without exceeding any applicable limits (e.g. Duty Cycle); or

c) shut down, (e.g. no emission above EMC levels)

as the voltage falls below the providers declared operating voltage.

5.12.3 Conformance

5.12.3.1 Test conditions

The test shall be performed on Operating Frequency declared by the provider.

5.12.3.2 Measurement procedure

Step 1:

Operation of the EUT shall be started, on Operating Frequency as declared by the provider, with the appropriate test signal and with the EUT operating at nominal operating voltage.

The centre frequency of the transmitted signal shall be measured and noted.

Step 2:

The operating voltage shall be reduced by appropriate steps until the voltage reaches zero.

The centre frequency of the transmitted signal shall be measured and noted.

Any abnormal behaviour shall be noted.

5.13 Void

5.14 Adaptive Power Control

5.14.1 Description

When applicable, Automatic / Adaptive Power Control (APC) modifies the power transmitted by a device when communicating with a neighbour device. APC requires bi-directional communications to exchange information used to manage the transmitted power level. Such information exchange is out of scope of the present document.

5.14.2 Reference limits

The peak power measured when active APC function at its minimum setting shall not exceed the value shown in Table 29.

Table 29: APC power limit

Parameter	Limit
Transmitted e.r.p.	+7 dBm

5.14.3 Conformance

5.14.3.1 Test conditions

1) The measurements shall be performed under normal test conditions.

2) The measurement shall be performed on a frequency declared by the provider. The frequency shall correspond to a nominal channel centre frequency consistent with the highest and lowest frequencies declared by the provider.

3) The measurement shall be performed with the EUT operating at its highest supported maximum transmit power.

4) The EUT and companion device shall operate in normal operating mode.

5) The measurements shall be performed over the APC settling time interval declared by the provider.

NOTE 1: A test mode may be provided to ensure adequate traffic for the EUT APC mechanism to operate.

6) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.14.3.2.

NOTE 2: The path loss between the EUT and its companion device may be controlled by the separation distance between the two device, or by other means, to ensure an equivalent configuration to that shown in Figure 8.

7) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.14.3.3.

5.14.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1 and the measurements in clause 5.14.3.4 performed using corresponding radiated measurement methods described in clause C.6.

5.14.3.3 Conducted measurement

The EUT shall be connected to an artificial antenna which shall be connect to the test equipment via an appropriate attenuator.

The measurements in clause 5.14.3.4 shall be performed.

5.14.3.4 Measurement procedure

Table 30: Test Parameters Settings for Automatic / Adaptive Power Control Measurement

Parameter	Value	Notes
RBW	Operational Frequency Band	Operational Frequency Band
Detector Mode	Peak	

The test equipment shall be configured as appropriate for the parameters shown in Table 30.

Step 1:

Two EUTs shall be interconnected as shown in Figure 8. The attenuation between the two points A and B shall be measured, using an appropriate method, and noted.

Step 2:

The variable attenuator shall be adjusted such that the attenuation between points A and B is 75 dB.

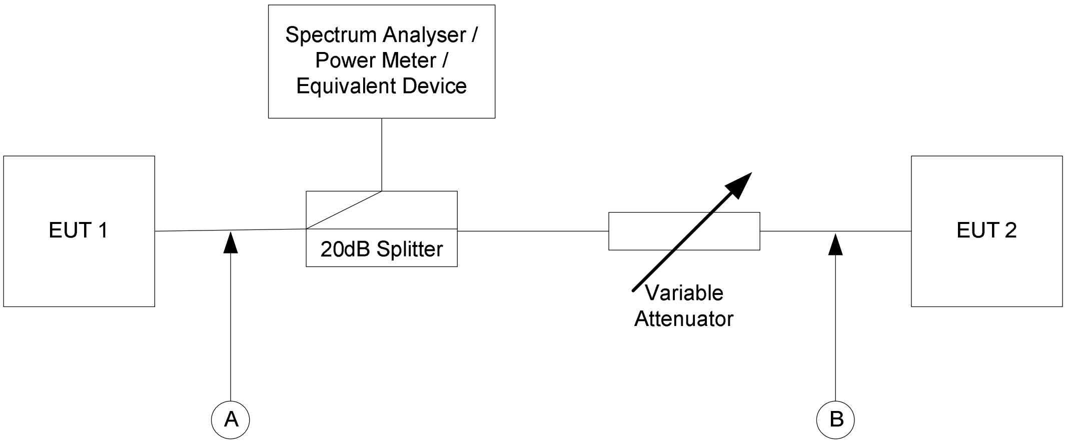


Figure 8: APC Measurement Setup

The EUTs shall be set to communicate with each other for at least the APC settling time.

The test equipment shall then be used to measure power for at least 60 seconds.

NOTE: The power measuring interval should be sufficiently long to capture transmissions from the EUT.

The information shown in Table 31 shall be recorded in the test report.

Table 31: Information Recorded in the Test Report

Value	Notes
Test signal	The test signal used
Operating frequency	Channel centre frequency on which the EUTs operate
Settling time	APC settling time
Tx power level	Peak measured power
NOTE: The APC settling time is declared by the provider.	

5.15 RX sensitivity level

5.15.1 Description

The receiver sensitivity is the minimum signal power input to the receiver which produces the general performance criterion stated in clause 4.1. The test input signal is generated at the nominal operating frequency and modulated with normal modulation.

5.15.2 Reference limits

The sensitivity for receivers shall be below or equal to Table 32 level.

Table 32: Limits for Receiver sensitivity

$$S = 10 \log RB_{kHz} - 4 \quad dB\mu V\ emf$$; or

$$S_P = 10 \log RB_{kHz} - 117 dBm$$

where:

- S_P is the sensitivity in dBm.
- RB is the declared receiver bandwidth in kHz.

The receiver bandwidth RB shall be declared by the manufacturer. RB is the usually 3 dB receiver bandwidth selectivity.

For example, the sensitivity for a 25 kHz Operating Channel equipment with a 16 kHz bandwidth shall be better than +8 dBµV emf for a 50 Ω receiver input impedance. This corresponds to a receiver sensitivity of -105 dBm.

5.15.3 Conformance

5.15.3.1 Test conditions

1) The measurements shall be performed under normal test conditions.

2) The measurements shall be performed on the operating frequency as declared by the provider.

3) If possible the EUT shall be operated with any FEC or automatic retransmission facility disabled.

4) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.15.3.2.

5) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.15.3.3.

5.15.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1.

The output of the signal generator shall be connected to a transmit test antenna with the same antenna polarization as the EUT. The transmit test antenna shall be placed in the test site.

The EUT shall be placed at the location of the turntable at the orientation of the most sensitive position.

The measurement in clause 5.15.3.4 shall be performed using appropriate radiated measurement methods described in clause C.6.4.

5.15.3.3 Conducted measurement

The EUT shall be connected to the output of a signal generator.

The measurements in clause 5.15.3.4 shall be performed.

5.15.3.4 Measurement procedure

The signal generator, modulated with an appropriate test signal, shall be set to Operating Frequency, as declared by the provider.

Step 1:

The operation of the EUT shall be started as a receiver on the Operating Frequency, as declared by the provider.

Step 2:

The level of the input signal to the EUT shall be adjusted until the wanted criterion as described in clause 4.1 is just exceeded.

Step 3:

With the signal generator settings unchanged, the power received by EUT shall be established by appropriate means.

The receiver sensitivity shall be noted.

Step 4:

Steps 1 to 3 shall be repeated for each data rate at which the EUT is able to operate.

Step 5:

The information shown in Table 33 shall be recorded in the test report.

Table 33: Information Recorded in the Test Report

Value	Notes
Test signal	The test signal used
Data rate	EUT data rate
FEC or ARQ state	FEC/ARQ enabled or disabled
Measurement method	BER/message success ratio/other
Measurement description	Description of message success ratio calculation/other measurement method if applicable
Operating frequency	Operating frequency tested
Receiver sensitivity	Measured signal generator power level

5.16 Adjacent channel selectivity

5.16.1 Description

The adjacent channel selectivity is a 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 a channel separation for which the equipment is intended.

5.16.2 Reference limit for receiver category 1

The adjacent channel selectivity shall be equal to or greater than the limit in Table 34.

Table 34: Adjacent channel selectivity

Requirement	Limits
Minimum Adjacent Channel Selectivity (OCW ≤ 25 kHz)	≥ -50 dBm
Minimum Adjacent Channel Selectivity (OCW > 25 kHz)	≥ -44 dBm

5.16.3 Conformance

5.16.3.1 Test conditions

1) The measurement is performed on an operating frequency declared by the provider.

2) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.16.3.2.

3) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.16.3.3.

5.16.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1.

Signal generators A and B together with the combiner, shown in Figure 9, shall be placed outside the test site.

The output of the combiner shall be connected to a transmit test antenna with the same antenna polarization as the EUT. The transmit test antenna shall be placed in the test site.

The EUT shall be placed at the location of the turntable at the orientation of the most sensitive position.

The measurements in clause 5.16.3.4 shall be performed.

5.16.3.3 Conducted measurement

Two signal generators A and B shall be connected to the EUT via a combining network as shown in Figure 9.

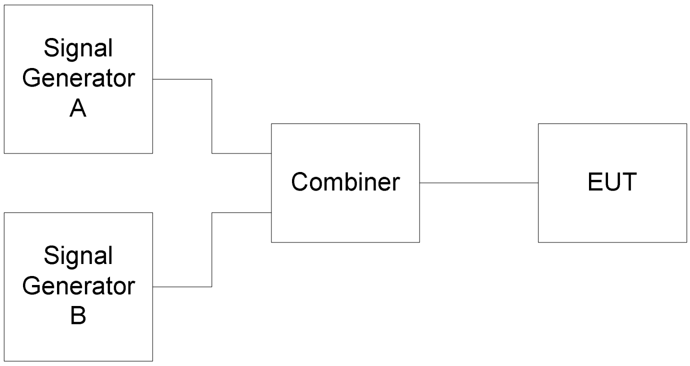


Figure 9: Measurement arrangement

The measurements in clause 5.16.3.4 shall be performed.

5.16.3.4 Measurement procedure

Signal generator A shall be at the operating frequency of the receiver, and configured to generate the wanted signal.

Signal generator B shall be unmodulated and shall be adjusted to the Adjacent Channel centre frequency immediately above the operating channel.

Signal generator B shall be powered off.

Signal generator A shall be set to the minimum level which gives the wanted performance criterion or the reference level in Table 32, whichever is the higher. The output level of generator A shall then be increased by 3 dB. Signal generator B is then switched on and the signal amplitude is adjusted to the minimum level at which the wanted performance criterion is not achieved.

The ACS is then the power received from generator B at the EUT antenna.

This can either be measured on the antenna connector or be calculated (e.g. ACS = Tx power generator B - combiner loss + antenna gain test antenna + appropriate antenna gain EUT - path loss) (see clause C.6.4).

The measurements shall be repeated with signal generator B adjusted to the Adjacent Channel centre frequency immediately below the Operating Channel.

The information shown in Table 35 shall be recorded in the test report for each measured Adjacent Channel.

Table 35: Information Recorded in the Test Report

Value	Notes
Operating Frequency	Nominal centre frequency of the receiver
Upper Adjacent Channel Selectivity	
Lower Adjacent Channel Selectivity	
NOTE: If several Operational Frequency bands are used by the equipment, at least one ACS measurement by bands has to be performed.	

5.17 Receiver saturation at Adjacent Channel

5.17.1 Description

The receiver saturation is a measure of the capability of the receiver to operate as intended in the presence of a strong signal in the wanted channel together with a strong signal in the adjacent channel, which differs in frequency from the wanted signal by an amount equal to the adjacent channel separation for which the equipment is declared.

5.17.2 Reference limit for receiver category 1

The receiver saturation at the adjacent channel shall be equal or greater than limit given in Table 36.

Table 36: Receiver saturation at adjacent channel

Requirement	Limits
Adjacent channel saturation (OCW ≤ 25 kHz)	≥ -20 dBm
Adjacent channel saturation (OCW > 25 kHz)	≥ -10 dBm

5.17.3 Conformance

5.17.3.1 Test Conditions

1) The measurements shall be performed on the operating frequency declared by the provider.

2) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.17.3.2.

3) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.17.3.3.

5.17.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1.

Signal generators A and B together with the combiner, shown in Figure 10, shall be placed outside the test site.

The output of the combiner shall be connected to a transmit test antenna with the same antenna polarization as the EUT. The transmit test antenna shall be placed in the test site.

The EUT shall be placed at the location of the turntable at the orientation of the most sensitive position.

The measurements in clause 5.17.3.4 shall be performed.

5.17.3.3 Conducted measurement

Two signal generators A and B shall be connected to the EUT via a combining network as shown in Figure 10.

The measurements in clause 5.17.3.4 shall be performed.

5.17.3.4 Measurement procedure

The method of measurements is identical to that for Adjacent Channel Selectivity, clause 5.16 except of the use of a wanted signal (generator A) at max usable sensitivity defined in Table 32 or the sensitivity level of the device if above Table 34 values +43 dB level.

Receiver saturation in adjacent channels values shall not be less than the technical requirement.

The information shown in Table 37 shall be recorded in the test report for each measured signal level and unwanted signal offset.

Table 37: Information Recorded in the Test Report

Value	Notes
Operating Frequency	Nominal centre frequency of the receiver
Signal generator A	Power level of signal generator A
Receiver saturation in upper Adjacent Channel	Power level of signal generator B
Receiver saturation in lower Adjacent Channel	Power level of signal generator B
NOTE: If several operational frequency bands are used by the equipment, at least one measurement by bands has to be performed.	

5.18 Spurious response rejection

5.18.1 Description

The spurious response rejection 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 modulated signal at any other frequency, at which a response is obtained.

5.18.2 Reference limit for receiver category 1

The spurious response rejection of the equipment shall be equal to or greater than the limit in Table 38.

Table 38: Spurious response rejection

Requirement	Limits
Spurious response rejection (OCW ≤ 25 kHz)	≥ -44 dBm
Spurious response rejection (OCW > 25 kHz)	≥ -34 dBm
NOTE: For spurious response tests separated from the wanted signal by less than 0,1 % of the Operating Frequency, the limits are relaxed by 25 dB.	

5.18.3 Conformance

5.18.3.1 Test Conditions

1) The measurements shall be performed on operating frequency declared by the provider.

2) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.18.3.2.

3) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.18.3.3.

5.18.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1.

Signal generators A and B together with the combiner, shown in Figure 10, shall be placed outside the test site.

The output of the combiner shall be connected to a transmit test antenna with the same antenna polarization as the EUT. The transmit test antenna shall be placed in the test site.

The EUT shall be placed at the location of the turntable at the orientation of the most sensitive position.

The measurements in clause 5.18.3.4 shall be performed.

5.18.3.3 Conducted measurement

Two signal generators A and B shall be connected to the EUT via a combining network as shown in Figure 10.

The measurements in clause 5.18.3.4 shall be performed.

5.18.3.4 Measurement procedure

To determine the frequencies at which spurious responses can occur the following calculations shall be made:

- Calculation of the "limited frequency range":
  - the limited frequency range is defined as the frequency of the local oscillator signal (f_{LO}) applied to the first mixer of the receiver plus or minus the Intermediate Frequency (IF) or where more than 1 IF is involved, at the image frequency of the first and subsequent frequency conversions;
  - at frequency separation corresponding to half of the first IF from the wanted receive frequency.

For the calculations a) and b) above, the manufacturer shall state the frequency of the receiver, the frequency of the local oscillator signal (f_{LO}) applied to the 1st mixer of the receiver, the intermediate frequencies (f_{I1}, f_{I2}, etc.).

Signal generator A shall be at the nominal frequency of the receiver, and configured to generate the wanted signal.

Signal generator B shall be unmodulated and shall be adjusted to the test frequency as determined above.

Signal generator B shall be switched off. Signal generator A shall be set to the minimum level which gives the wanted performance criterion or the reference level in Table 32, whichever is the higher The output level of generator A shall then be increased by 3 dB. Signal generator B is then switched on and the signal amplitude is adjusted to the minimum level at which the wanted performance criterion is not achieved.

The output level of generator A shall then be increased by 3 dB.

Signal generator B is then switched on and the signal amplitude is adjusted to the minimum level at which the wanted performance criterion is not achieved.

The spurious response rejection is then the conducted power received from generator B at the EUT antenna.

This can either be measured on the antenna connector or be calculated (see clause C.6.4).

Spurious response rejection values shall not be less the requested technical requirement.

The information shown in Table 39 shall be recorded in the test report for each measurement.

Table 39: Information Recorded in the Test Report

Value	Notes
Operating Frequency	Nominal centre frequency of the receiver
Signal generator A	Power level of signal generator A
Spurious response rejection	Power level of signal generator B
NOTE: If several Operational Frequency bands are used by the equipment, measurement have to be performed in each band.	

5.19 Blocking

5.19.1 Description

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 input signal at any frequencies other than those of the spurious responses or the adjacent channels or bands.

5.19.2 Reference limits for receiver category 3

The blocking levels at the specified frequency offsets shall be equal to or greater than the limits Table 40, except at frequencies where spurious responses are found.

Table 40: Blocking level parameters for RX category 3

Requirement	Limits
	Receiver category 3
Blocking at ±2 MHz from OC edge	≥ -80 dBm
Blocking at ±10 MHz from OC edge	≥ -60 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -60 dBm

For equipment using CCA whatever is the receiver category, steps 1 to 4 shall be repeated with signal generator A level adjusted +13 dB higher than in the measurements in clause 5.19.6.4.

5.19.3 Reference limits for receiver category 2

The blocking levels at the specified frequency offsets shall be equal to or greater than the limits Table 41, except at frequencies where spurious responses are found.

Table 41: Blocking level parameters for RX category 2

Requirement	Limits
	Receiver category 2
Blocking at ±2 MHz from OC edge	≥ -69 dBm
Blocking at ±10 MHz from OC edge	≥ -44 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -44 dBm

For equipment using CCA whatever is the receiver category, steps 1 to 4 shall be repeated with signal generator A level adjusted +13 dB higher than in the measurements in clause 5.19.6.4.

5.19.4 Reference limits for receiver category 1.5

The blocking levels at the specified frequency offsets shall be equal to or greater than the limits Table 42, except at frequencies where spurious responses are found.

Table 42: Blocking level parameters for RX category 1.5

Requirement	Limits
	Receiver category 1.5
Blocking at ±2 MHz from OC edge	≥ -43 dBm
Blocking at ±10 MHz from OC edge	≥ -33 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -33 dBm

For equipment using CCA whatever is the receiver category, steps 1 to 4 shall be repeated with signal generator A level adjusted +13 dB higher than in the measurements in clause 5.19.6.4.

5.19.5 Reference limits for receiver category 1

The blocking levels at the specified frequency offsets shall be equal to or greater than the limits Table 43, except at frequencies where spurious responses are found.

Table 43: Blocking level parameters for RX category 1

Requirement	Limits
	Receiver category 1
Blocking at ±2 MHz from Centre Frequency	≥ -20 dBm
Blocking at ±10 MHz from Centre Frequency	≥ -20 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -20 dBm

For equipment using CCA whatever is the receiver category, steps 1 to 4 shall be repeated with signal generator A level adjusted +13 dB higher than in the measurements in clause 5.19.6.4.

Additionally, for category 1 receivers it is necessary to determine the receiver saturation by , steps 1 to 4 with a +40 dB increased level for signal generator A in clause 5.19.6.4.

5.19.6 Conformance

5.19.6.1 Test conditions

1) The measurements shall be performed under normal test conditions.

2) The measurement is performed at an operating frequency declared by the provider.

3) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.19.6.2.

4) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.19.6.3.

5.19.6.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1.

Signal generators A and B together with the combiner, shown in Figure 10, shall be placed outside the test site.

The output of the combiner shall be connected to a transmit test antenna with the same antenna polarization as the EUT. The transmit test antenna shall be placed in the test site.

The EUT shall be placed at the location of the turntable at the orientation of the most sensitive position.

The measurements in clause 5.19.6.4 shall be performed.

5.19.6.3 Conducted measurement

Two signal generators A and B shall be connected to the EUT via a combining network as shown in Figure 10.

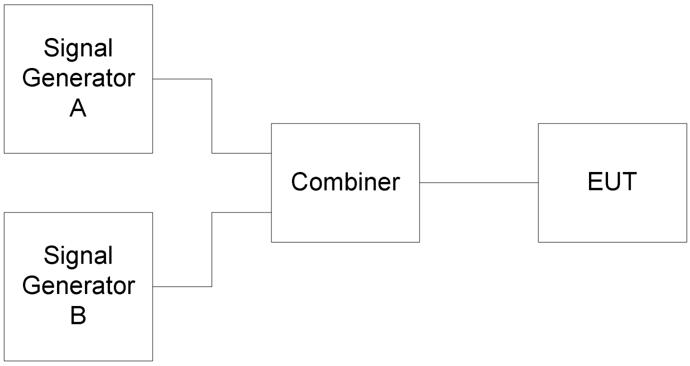


Figure 10: Blocking measurement arrangement

The measurements in clause 5.19.6.4 shall be performed.

5.19.6.4 Measurement procedure

Signal generator A shall be set to the nominal operating frequency of the receiver, modulated with an appropriate test signal.

Signal generator B shall be unmodulated.

Measurements shall be carried out at frequencies of the unwanted signal at approximately the frequency(ies) offset(s) defined in technical requirement avoiding those frequencies at which spurious responses occur. Additional measurement points may be requested by technical requirements clause.

If several operational frequency bands are used by the equipment, at least one blocking measurement by bands has to be performed.

Step 1:

Signal generator B shall be powered off. Signal generator A shall be set to the minimum level which gives the wanted performance criterion or the reference level in Table 32, whichever is the higher The output level of generator A shall then be increased by 3 dB. Signal generator B is then switched on and the signal amplitude is adjusted to the minimum level at which the wanted performance criterion is not achieved.

The output level of generator A shall then be increased by 3 dB unless otherwise specified in technical requirement.

Step 2:

Signal generator B is powered on and set to operate at the nominal operating frequency - offset frequency.

Signal generator B is then switched on and the signal amplitude is adjusted to the minimum level at which the wanted performance criterion is not achieved.

With signal generator B settings unchanged, the receiver shall be replaced with a suitable RF power measuring equipment. The power into the measuring equipment shall be measured and noted.

The blocking level is then the conducted power received from generator B at the EUT antenna.

This can either be measured on the antenna connector or be calculated (see clause C.6.4).

The blocking level shall be higher or equal to the blocking power level requested in the technical requirement clause.

Step 3:

The measurement in steps 1 to 3 shall be repeated with signal offsets at required frequencies.

Step 4:

The information shown in Table 44 shall be recorded in the test report for each measured signal level and unwanted signal offset.

Table 44: Information Recorded in the Test Report

Value	Notes
Operating Frequency	Nominal centre frequency of the receiver
Signal generator A	Power level of signal generator A
Blocking level	Power level of signal generator B

5.20 Behaviour at high wanted signal level

5.20.1 Description

The behaviour at high wanted signal level is a measure of the capability of the receiver to operate as intended in the presence of a strong wanted signal in the operating channel.

5.20.2 Reference limits for receiver category 1

The wanted performance criterion shall be met with a wanted signal at a level of -10 dBm.

5.20.3 Conformance

5.20.3.1 Test Conditions

1) The measurements shall be performed on the highest and lowest frequencies declared by the provider.

5.20.3.2 Measurement procedure

The receiver sensitivity may be established by the procedure in clause 5.15.

The signal level shall be increased until either the wanted performance criterion is no longer met, or the specified test limit is reached.

The signal level into the EUT shall be noted.

5.21 Clear Channel Assessment threshold

5.21.1 Description

The CCA threshold is defined as the received signal level above which the EUT determines that the channel is not available for use.

5.21.2 Reference CCA limits

The CCA threshold shall not exceed the limits given in Table 45.

Table 45: CCA radiated threshold limits

Parameter	Value
CCA threshold for EUT with e.r.p < 100 mW	15 dB above Rx sensitivity level limit as given in Table 32
CCA threshold for EUT with e.r.p from 100 mW to 500 mW	11 dB above Rx sensitivity level limit as given in Table 32
NOTE: The limits are based on an antenna gain of 0 dB relative to a dipole (i.e. +2,15 dBi) maximum. For other antenna gains different to 0 dB the limits shall be adjusted accordingly. EXAMPLE: With antenna gain of -5 dB, the CCA threshold shall be corrected and increased by 5 dB at the RF front end.	

5.21.3 Conformance

5.21.3.1 Test conditions

1) The measurement is performed on an Operating Frequency declared by the provider. The frequency shall correspond to a nominal channel centre frequency consistent with the highest and lowest frequencies and channel spacing declared by the provider.
2) An EUT without a permanent or temporary antenna connector shall be tested according to clause 5.21.3.2.
3) An EUT with a permanent or temporary antenna connector shall be tested according to clause 5.21.3.3.

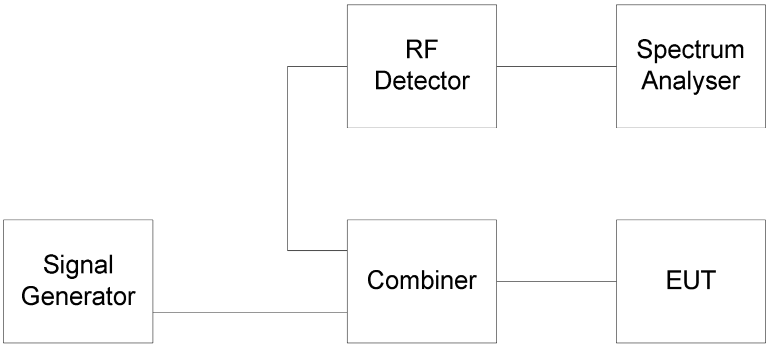


Figure 11: CCA measurement arrangement

5.21.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause C.1.

Signal generators A and B together with the combiner, shown in Figure 11, shall be placed outside the test site.

The output of the combiner shall be connected to a transmit test antenna with the same antenna polarization as the EUT. The transmit test antenna shall be placed in the test site.

The EUT shall be placed at the location of the turntable at the orientation of the most sensitive position.

The measurement in clause 5.21.3.4 shall be performed using appropriate radiated measurement methods described in clause C.6.

5.21.3.3 Conducted measurement

A signal generator and a power meter shall each be combined via appropriate attenuators into the EUT antenna connector as shown in Figure 11.

The measurements in clause 5.21.3.4 shall be performed.

5.21.3.4 Measurement procedure

Table 46: Test Parameters Settings for CCA Threshold Measurement

Setting	Value
Centre frequency	The nominal EUT operating frequency
RBW	Approximately 3 x Operating Channel width OC
VBW	3 x RBW
Span	Zero span
Detector Mode	RMS
Trace Mode	Max. Hold
NOTE: The nominal operating frequency is agreed between the test laboratory and the provider. The nominal operating frequency shall be consistent with the highest and lowest operating frequencies and channel spacing as declared by the provider. Channel Spacing is declared by the provider.	

The spectrum analyser shall be configured as shown in Table 46.

Step 1:

Operation of the EUT as a receiver shall be started with its CCA function active.

The signal generator, with normal test modulation, shall be adjusted to the nominal operating frequency.

The spectrum analyser levels and RBW shall be adjusted to provide satisfactory display of the signal generator signal.

Step 2:

The output power level of the signal generator shall be set to approximately 20 dB above the EUT receiver reference sensitivity.

The EUT shall be instructed to transmit.

NOTE 1: The means of instructing the EUT to transmit is determined by the provider.

The presence of any signal from the EUT detected by the spectrum analyser shall be noted.

Step 3:

The level of the signal generator shall be reduced in steps of 1 dB until the equipment starts to transmit.

NOTE 2: There may be a delay due to collision avoidance operation before the EUT begins to transmit once the CCA threshold has been reached. Ensure that any such delay is taken into account in the rate at which the signal generator level is reduced.

The signal generator level present at the receiver input of the EUT when transmission begins is the CCA threshold and shall be noted.

Step 4:

Step 2 and step 3 shall be repeated.

Step 5:

The information shown in Table 47 shall be recorded in the test report.

Table 47: Information Recorded in the Test Report

Value	Notes
Test signal	The test signal used.
CCA threshold (A)	First CCA threshold power level
CCA threshold (B)	Second CCA threshold power level
Presence of unexpected EUT signal	Any transmission detected at the spectrum analyser in step 2
NOTE: The presence of unexpected EUT transmission is a test failure.	

CCA threshold levels shall not exceed values defined by technical requirements.

5.22 Polite spectrum access

5.22.1 Description

Before transmitting, a polite device senses the channel for at least the Clear Channel Assessment interval to determine if it is free. If the average signal level over the clear channel assessment listening interval is below the CCA threshold the device proceeds with the transmission.

The time between the end of the CCA interval and the start of the transmission is the dead time.

If the average signal level is above the signal threshold, the polite device defers its transmission to a later time. The equipment shall not attempt re-transmission on the same operating frequency until a random interval has expired (multiple of the minimum deferral period). Alternatively, the equipment may select another operating frequency and again start the listen time before Transmission.

A polite spectrum access can be used with channel adaptivity in case the RF channel is not available.

NOTE: The random interval should be consistent with the duration of transmissions of the EUT and may be associated with a contention resolution algorithm provided by medium access protocol specifications.

5.22.2 Reference limits for polite spectrum access

Parameters are shown in Table 48 shall not be exceeded.

Table 48: Reference limits for Polite Spectrum Access Parameters

Parameter	Limit	Notes
Minimum CCA interval	160 µs	Minimum CCA listening period
Minimum deferral period	CCA interval	Minimum value of the deferral interval
Minimum unit of deferral period	See note 1	Smallest interval between two adjacent deferral periods
Dead Time	CCA declared time by the vendor but not exceeding 5 ms	Maximum time between the end of a listening interval and the start of a transmission
Maximum Transmission Duration T_{on} Max	1 s	For a single Transmission
Maximum Transmission Duration T_{on} Max	4 s	For a Transmission dialogue or a polling sequence
Max Cumulative On Time over 1 hour	100 s / 1 h per 200 kHz spectrum	Maximum allowed Cumulative On Time over a 200kHz portion of spectrum per hour.
Minimum Inter Transmission Interval on the same Operating Frequency	100 ms	The minimum TX-off time period where a specific transmitter shall remain off after a transmission on the same Operating Frequency
NOTE 1: The minimum unit of deferral period is declared by the provider. NOTE 2: T_{DIS} is declared by the provider without exceeding 5 ms. NOTE 3: Longer accumulated transmission time is possible by implementing more AFA channels.		

5.22.3 Conformance

The use of polite spectrum access shall be declared by the provider.

The provider shall also declare:

1) The minimum CCA interval employed.

2) The maximum dead time.

3) The method employed to randomize timing of re-transmission attempts.

4) The units of the deferral period.

5) The minimum and maximum values of the deferral random period.

6) The maximum transmission duration time, T_{on} max.

7) The minimum Inter Transmission Interval on the same operating frequency, Tx_{off} min.

The declared parameters shall not exceed the requested values in technical requirements.

5.23 Acknowledge transmissions

5.23.1 Description

An acknowledgement is the transmission and reception of a short message in the return direction so that the sending device knows the forward message has been successfully received.

5.23.2 Conformance

The Message Initiator (MI) and the Message Receiver (MR) shall be configured so that a transmission from the MI reaches the MR at between 10 dB and 20 dB higher level than the sensitivity level of the MR. The coupling mechanism shall be entirely passive so that the reciprocal path loss is the same (conducted or radiated).

NOTE: The sensitivity may be established by the procedure in clause 5.15.

The MI shall have a means of indicating reception of an ACK for each individual forward message.

The MI shall be made to send a series of at least 10 messages to the MR at intervals specified by the provider. The indication of ACK reception shall be noted for each message.

Either the MR shall be disabled or the coupling between the MI and the MR shall be reduced by more than 40 dB. The MI shall be made to send the same series of messages. Indication of an ACK for any message will constitute a failure of this test.

5.24 Adaptive Frequency Agility

5.24.1 Description

Further improvements in shared access can be achieved if polite short control signalling or acknowledgment is combined with LBT and channel adaptivity or agility. Various algorithms may be used to implement channel adaptivity including periodic and event driven decisions to wait or change of speed transmission (Adaptivity) or to change of operating channel (Agility - Also called AFA). Preferred algorithms distribute generated traffic uniformly over available channels and avoid use of channels occupied permanently or temporarily occupied by other devices.

Although no specific timing constraints are imposed, it should be noted that the delays in switching between receive and transmit states, together with the corresponding processing delays of signals through the receiver and transmitter, should be less than the CCA interval in order to avoid losing the channel to another device.

5.24.2 Conformance

The use of adaptive frequency agility shall be declared by the provider

Annex A (normative): Technical performance of the test equipment

A.1 Spectrum analyser

Methods of measurement refer to the use of a spectrum analyser. The characteristics of the spectrum analyser shall meet at least the following requirements:

- the reading accuracy of the frequency marker shall be within ±100 Hz;
- the accuracy of relative amplitude measurements shall be within ±3,5 dB;
- dynamic range greater than 80 dB;
- gaussian RBW shape factor ≤ 12.

It shall be possible to adjust the spectrum analyser to allow the separation on its screen of two equal amplitude components with a frequency difference of 100 Hz.

For statistically distributed modulations, the spectrum analyser and the integrating device (when appropriate) need to allow determination of the power spectral density (energy per time and bandwidth), which has to be integrated over the bandwidth in question.

The average phase noise in the adjacent and alternate channels shall be such that measurement of adjacent and alternate adjacent channel power is not limited by phase noise."

The following functions are needed for certain test procedures:

- OBW;
- ACP;
- Linear power averaging.

NOTE: Linear averaging is a trace averaging method on a spectrum analyser whereby the measured power values are averaged in the linear power domain as opposed to the logarithmic power domain.

Alternative averaging method to linear power averaging: If linear averaging is not available log averaging may be used on the condition the measured results are compensated with the following formula:

$$P\_result = P\_meas + 2,5 \text{ dB} \quad (A.1)$$

where P_result is the result of the measurement and P_mes is the reading from the spectrum analyser.

A.2 Signal Generators and Signal Sources

Care should be taken that the performance of signal generators and signal sources is adequate for the tests undertaken. This is particularly important in respect of the phase noise.

Annex B (normative): Test Fixture

B.0 Description of test-fixture

With equipment intended for use with a small aperture integral antenna, and not equipped with a 50 Ω RF output connector, a suitable test fixture as shown in Figure B.1 shall be used.

Where a test fixture as defined in the present clause is used for measurements on integral antenna equipment, tests on radiated signals shall be carried out using the test fixture. For tests of unwanted emissions in the spurious domain, (clause 5.9), the test fixture bandwidth shall exceed 5 times the operating frequency: If this is not the case, a radiated measurement according to clause 5.9 and annex C shall be used.

This fixture is a radio frequency device for coupling the integral antenna to a 50 Ω RF terminal at all frequencies for which measurements need to be performed.

The test fixture shall be fully described.

In addition, the test fixture may provide:

a) a connection to an external power supply;

b) a method to provide the input to or output from the equipment. This may include coupling to or from the antenna. In case of assessment of speech equipment, an audio interface may be provided by direct connection or by an acoustic coupler or in case of non-speech equipment, the test fixture could also provide the suitable coupling means e.g. for data or video outputs.

The test fixture shall normally be supplied by the provider.

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) adequate bandwidth properties;

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

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

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

f) 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. Normally, the text fixture is in a fixed position and provides a location for the EUT;

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

The attenuation of the test fixture coupling should be such that the received signal at the measuring instrument is at least 10 dB above the measuring instrument noise floor. If the attenuation is too great it can be compensated by linear amplification outside the test-fixture.

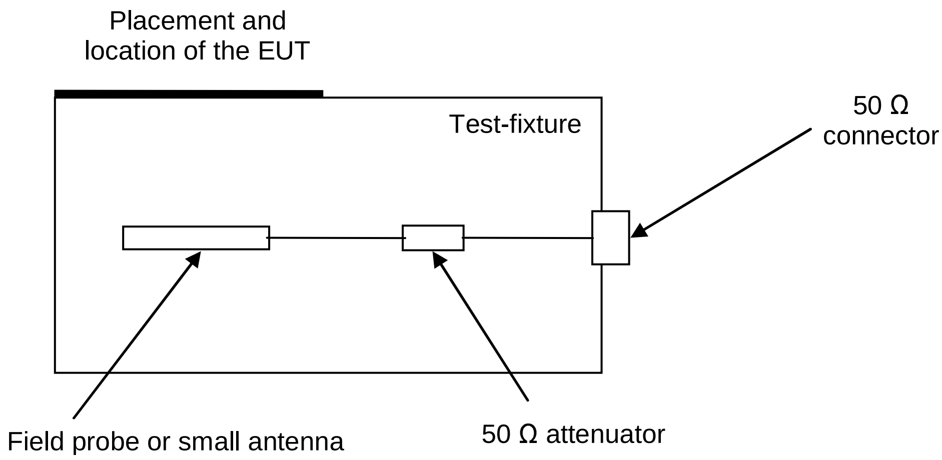


Figure B.1: Test fixture

The field probe (or small antenna) shall be properly terminated.

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

B.1 Validation of the test-fixture in the temperature chamber

This test is only needed if test fixture measurements are performed under extreme temperature conditions.

If it is not possible to use the present method, the method used for calibrating the test fixture over the temperature range shall be agreed with the testing laboratory, and fully documented in the test report.

The test fixture is brought into a temperature chamber.

Step 1:

A transmit antenna connected to a signal generator shall be positioned from the test-fixture at a far field distance of not less than one λ at the frequency. The test fixture consists of the mechanical support for the EUT, an antenna or field probe and a 50 Ω attenuator for proper termination of the field probe. The test fixture shall be connected to a spectrum analyser via the 50 Ω connector. A signal generator has to be set on the EUT's nominal frequency (see Figure B.2). The unmodulated output power of the signal generator has to be set to a value such that a sufficiently high level can be observed with the spectrum analyser. This determined value shall be recorded. The signal generator shall then be set to the upper and the lower band limit of the EUT's assigned frequency band. The measured values shall not deviate more than 1 dB from the value at the nominal frequency. The distance between test antenna and test fixture may be reduced to λ\2 for frequencies below 100 MHz.

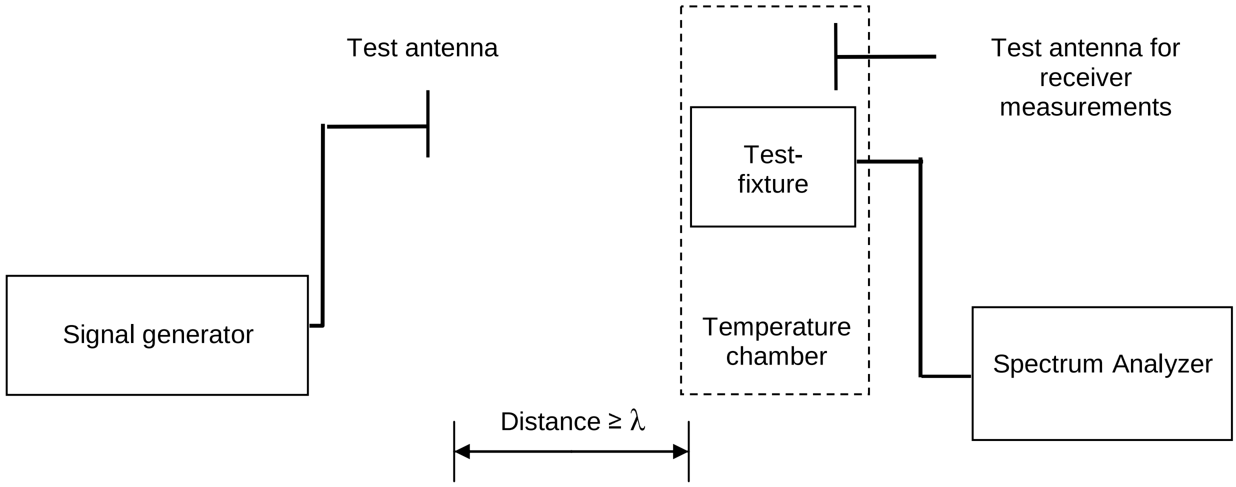


Figure B.2: Validation of test set-up without EUT

If receiver tests under extreme temperature conditions are performed, a receiver test antenna is also brought into the temperature chamber to ensure its influence in the chamber is known.

Step 2:

During validation and testing the EUT shall be fitted to the test fixture in a switched-off mode as shown in Figure B.3. Step 1 shall be repeated, this time with the EUT in place. The measured values shall be compared with those from step 1 and may not vary by more than 2 dB. This shows that the EUT does not cause any significant shadowing of the radiated power.

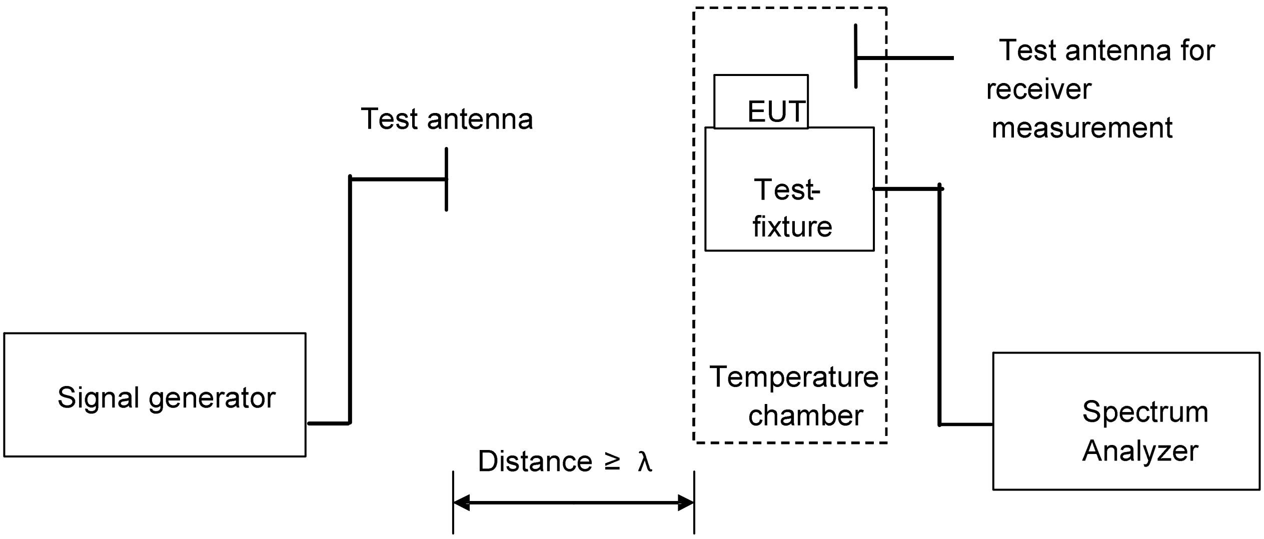


Figure B.3: Validation of test set-up with EUT in place

Step 3:

In case of a battery operated EUT that is supplied by a temporary voltage feed as well as temporary signal- and control line, a decoupling filter shall be installed directly at the EUT in order to avoid parasitic, electromagnetic radiation. See Figure B.4.

In this step the signal generator and the transmit antenna are removed.

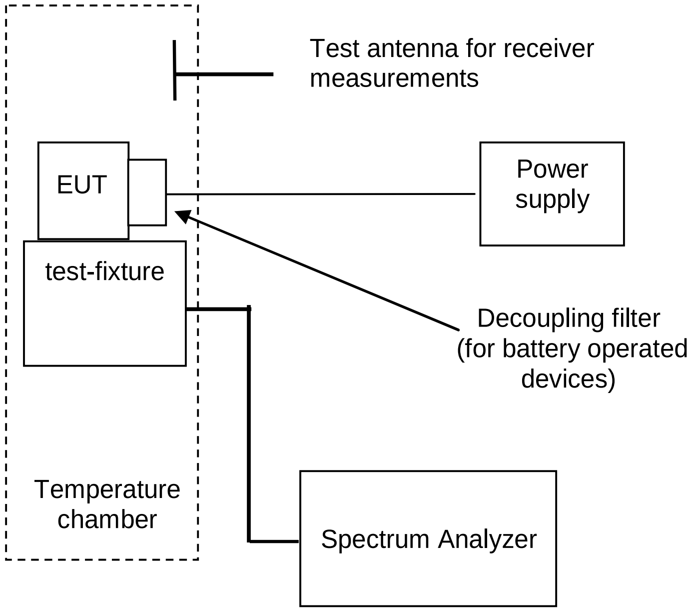


Figure B.4: Test of EUT

B.2 Mode of use

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

It is used particularly for the measurement of the radiated carrier power and usable sensitivity expressed as a field strength under extreme conditions. The measurements under extreme conditions are preceded by calibrated measurements according to annex C.

Annex C (normative): Test sites and arrangements for radiated measurement

C.0 Introduction

This annex introduces three most commonly available test sites and a test fixture, to be used in the radiated measurements in accordance with the present document.

Subsequently the following items will be described:

Open Area Test Site (OATS);

Semi Anechoic Room (SAR);

Fully Anechoic Room (FAR);

The first three are generally referred to as free field test sites. Both absolute and relative measurements can be performed on these sites. They will be described in clause C.1. Clause C.2 describes the antennas used in these test sites. The test fixture can only be used for relative measurements, and will be described in clause C.3.

Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in clause 6 of ETSI TR 102 273-4 [8] for the OATS, in clause 6 of ETSI TR 102 273-3 [7] for the SAR, and in clause 6 of ETSI TR 102 273-2 [6] for the FAR.

Information for calculating the measurement uncertainty of measurements on one of these test sites can be found in ETSI TR 100 028-1 [2] and ETSI TR 100 028-2 [2], ETSI TR 102 273-2 [6], ETSI TR 102 273-3 [7] and ETSI TR 102 273-4 [8].

C.1 Radiation test sites

C.1.1 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, while good conductivity can be achieved, the ground plane size has to be limited. A typical Open Area Test Site is shown in Figure C.1.

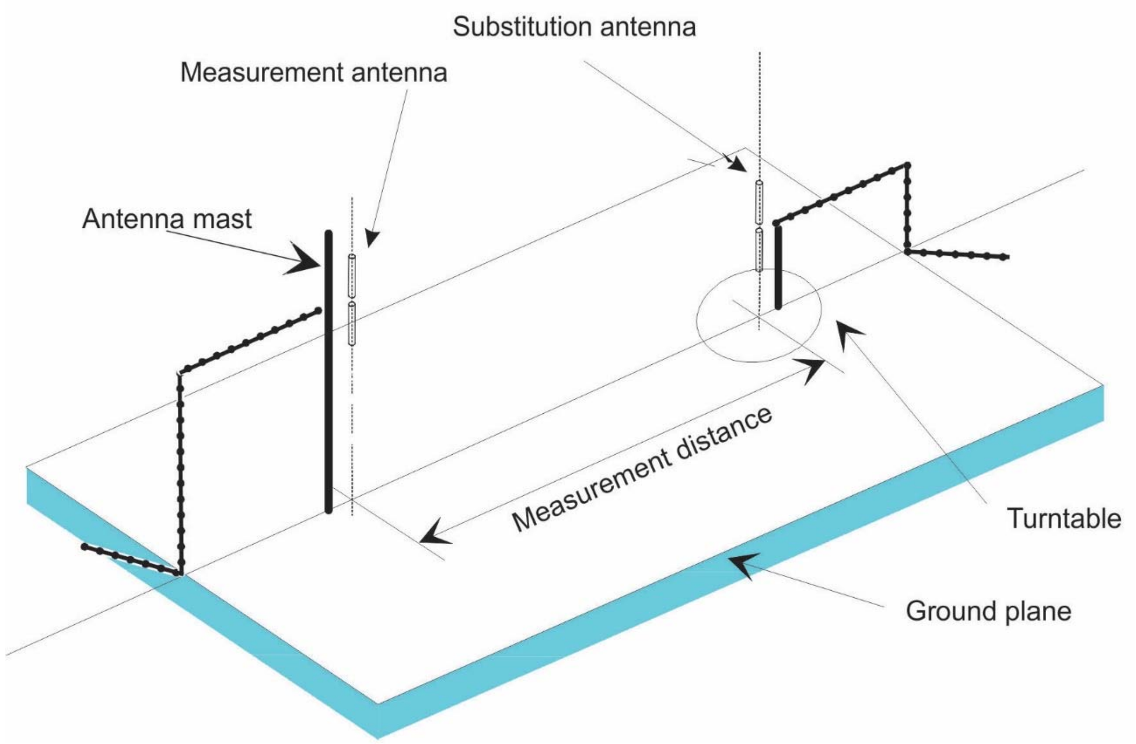


Figure C.1: A typical Open Area Test Site

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 EUT) 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 measurement antenna can be optimized for maximum coupled signal between antennas or between a EUT and the measurement antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane.

The measurement distance and minimum chamber dimensions can be found in clause C.1.4. The distance used in actual measurements shall be recorded with the test results.

Further information on Open Area Test Sites can be found in ETSI TR 102 273-4 [8].

C.1.2 Semi Anechoic Room

A Semi Anechoic Room is - or anechoic chamber with a conductive ground plane - is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material. The floor, which is metallic, is not covered by absorbing material and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other end. A typical anechoic chamber with a conductive ground plane is shown in Figure C.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.

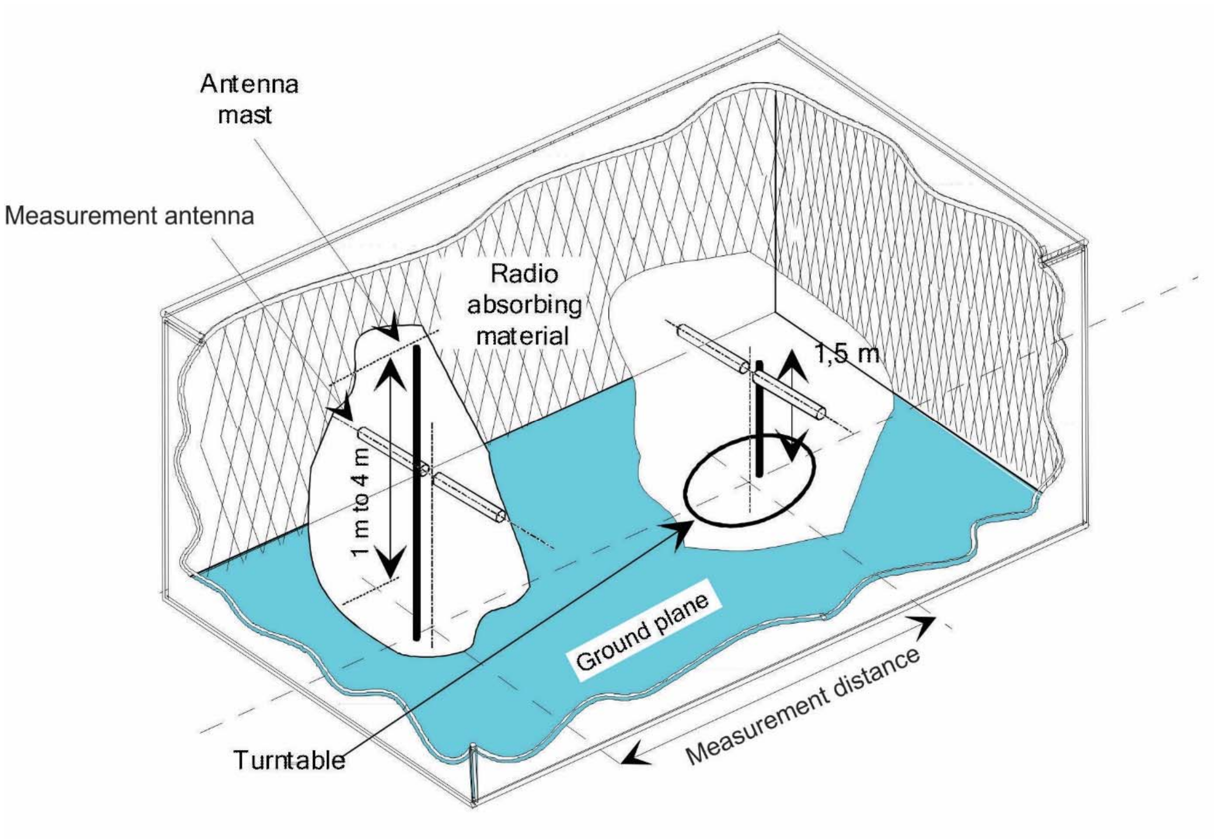


Figure C.2: A typical Semi Anechoic Room

In this facility 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 EUT) 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 measurement antenna can be optimized for maximum coupled signal between antennas or between a EUT and the measurement antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane.

The measurement distance and minimum chamber dimensions can be found in clause C.1.4. The distance used in actual measurements shall be recorded with the test results.

Further information on Semi Anechoic Rooms can be found in ETSI TR 102 273-3 [7].

C.1.3 Fully Anechoic Room (FAR)

A Fully Anechoic Room is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material. The chamber usually contains an antenna support at one end and a turntable at the other end. A typical Fully Anechoic Room is shown in Figure C.3.

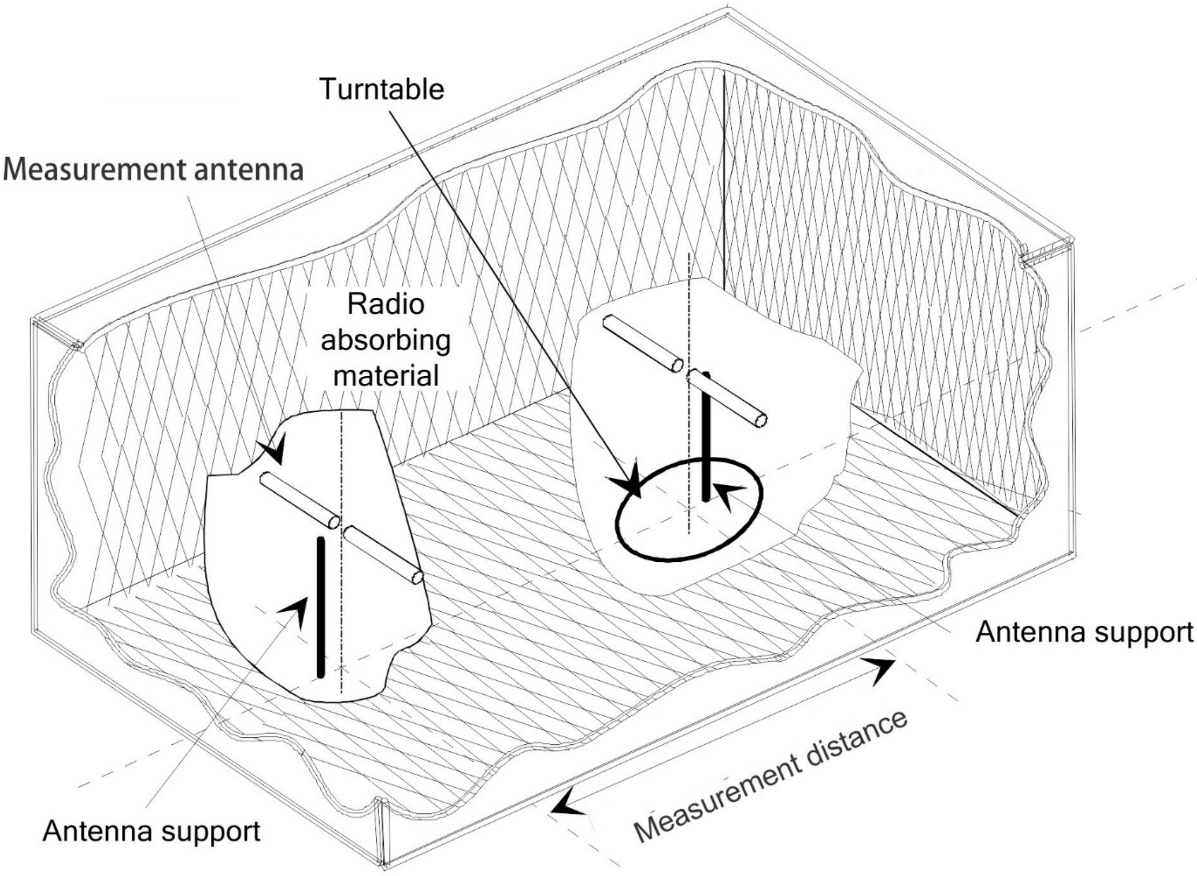


Figure C.3: A typical Fully Anechoic Room

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. The shielding should be sufficient to eliminate interference from the external environment that would mask any signals that have to be measured.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the EUT at as close as possible to a height of 1,5 m above the ground plane.

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.

The measurement distance and minimum chamber dimensions can be found in clause C.1.4. The distance used in actual measurements shall be recorded with the test results.

Further information on Fully Anechoic Rooms can be found in ETSI TR 102 273-2 [6].

C.1.4 Measurement Distance

The measurement distance should be chosen in order to measure the EUT at far-field conditions. The minimum measurement distance between the equipment and the measurement antenna should be λ or $r_m \gg \frac{D^2}{\lambda}$, whichever is the greater.

λ	=	wavelength in m
r_m	=	minimum measurement distance between EUT and measurement antenna in m
D	=	largest dimension of physical aperture of the largest antenna in the measurement setup, in m
D^2/λ	=	distance between outer boundary of radiated near field (Fresnel region) and inner boundary of the radiated far-field (Fraunhofer region) in m, also known as Rayleigh distance

3 m or 10 m are recommended measurement distances, where these conditions cannot be fulfilled and where the measurement distance would result in measurements in the near field (e.g. while measuring spurious emissions), this should be noted in the test report and the additional measurement uncertainty should be incorporated into the results.

C.2 Antennas

C.2.0 General

Antennas are needed for the radiated measurements on the three test sites described in clause C.1. Depending on its use, the antenna will be designated as "measurement antenna" or "substitution antenna".

C.2.1 Measurement antenna

In emission tests the measurement antenna is used to detect the field from the EUT 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, the antenna is used as the transmitting device.

The measurement antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization. Additionally, on an OATS or SAR, the height of the centre of the antenna above the ground should be variable over the specified range (usually 1 m to 4 m).

In the frequency band 30 MHz to 1 000 MHz, biconical or logarithmic periodic dipole antennas (LPDA) are recommended. Above 1 GHz, horn antennas or logarithmic periodic dipole antennas are recommended.

For spurious emission testing, however, a combination of biconical antennas (commonly termed "bicones") and log periodic dipole array antennas (commonly termed "log periodics") could be used to cover the entire 30 MHz to 1 000 MHz band.

The measurement antenna does not require an absolute calibration.

C.2.2 Substitution antenna

The substitution antenna shall be used to replace the equipment under test in substitution measurements.

Shall be suitable for the frequency range and the return loss of the antenna shall be taken into account when calculating the measurement uncertainty.

The phase centre of this antenna shall coincide with the reference point of the test sample it has replaced. Therefore antennas with a phase centre that changes as a function of frequency (such as a LPDA) are not suitable as a substitution antenna.

The reference point of the substitution antenna shall coincide with the volume centre of the EUT when its antenna is internal, or the point where an external antenna is connected to the EUT.

The distance between the lower extremity of the antenna and the ground shall be at least 30 cm.

The substitution antenna shall be calibrated. For below 1 GHz, the calibration is relative to a half wave dipole, while above 1 GHz, an isotropic radiator is the reference.

NOTE: Calibration figures intended for use above a reflective surface cannot be used in an anechoic chamber or vice versa.

C.3 Guidance on the use of radiation test sites

C.3.0 General

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated test are undertaken. These schemes are common to all types of test sites described in clause C.1.

Where necessary, a mounting bracket of minimal size should be available for mounting the EUT on the turntable. This bracket should be made from low conductivity, low relative permittivity (i.e. $\frac{\varepsilon}{\varepsilon_0}$ $\frac{\varepsilon}{\varepsilon_0} < 1,5$) material(s) such as expanded polystyrene, balsawood, etc.

C.3.1 Power supplies for the battery powered EUT

All tests should be performed using power supplies wherever possible, including tests on EUT designed for battery-only use. For battery powered equipment, power leads should be connected to the EUT'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 EUT. 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 EUT and down to the 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).

C.3.2 Site preparation

The cables to the measuring and substitution antenna should be routed horizontally away from the testing area for a minimum of 2 m (unless, in the case 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 other 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 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.

C.4 Coupling of signals

C.4.1 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 coupling).

C.4.2 Data Signals

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

C.5 Void

C.6 Measurement procedures for radiated measurement

C.6.0 General

This annex gives the general procedures for radiated measurements using the test sites and arrangements described in annex C.

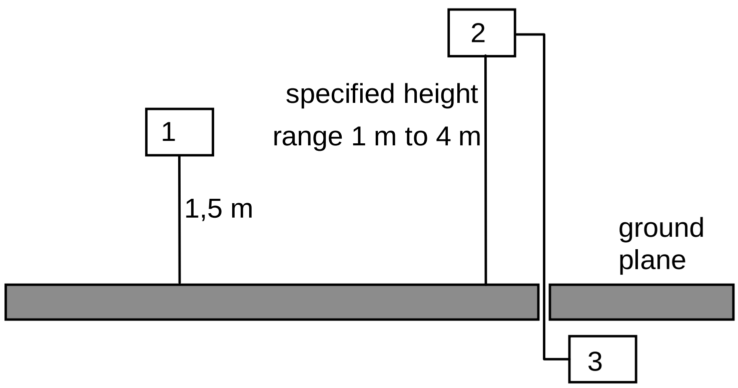
Preferably, radiated measurements shall be performed in a FAR, see clause C.6.2. Radiated measurements in an OATS or SAR are described in clause C.6.1.

C.6.1 Radiated measurements in an OATS or SAR

Radiated measurements shall be performed with the aid of a measurement antenna and a substitution antenna, in test sites described in annex C. The measurement set-up shall be calibrated according to the procedure defined in annex C. The EUT and the measurement antenna shall be oriented such as to obtain the maximum emitted power level. This position shall be recorded in the measurement report:

a) The measurement antenna (device 2 in Figure C.4) shall be oriented initially for vertical polarization unless otherwise stated and the EUT (device 1 in Figure C.4) shall be placed on the support in its standard position and switched on.

b) The measurement equipment (device 3 in Figure C.4) shall be connected to the measurement antenna and set-up according to the specifications of the test.



1) EUT
2) Measurement antenna
3) Measurement equipment

Figure C.4 Measurement arrangement No.1

c) The EUT shall be rotated through 360° in a horizontal plane until a maximum signal is received.

d) The measurement antenna shall be raised or lowered again through the specified height range until a maximum is obtained. This level shall be recorded.

e) This measurement shall be repeated for horizontal polarization.

NOTE: This maximum may be a lower value than the value obtainable at heights outside the specified limits.

C.6.2 Radiated measurements in a FAR

For radiated measurements using a FAR, the procedure is identical to the one described in clause C.6.1, except that the height scan is omitted.

C.6.3 Substitution measurement

To determine the absolute measurement value a substitution measurement is performed. The following steps shall be performed:

1) Replacing the EUT with the substitution antenna that is depicted as device 1 in Figure C.4. The substitution antenna will have vertical polarization.

2) Connect a calibrated signal generator to the substitution antenna, and adjust it to the measurement frequency.

3) If an OATS or a SAR is used, the measurement antenna shall be raised or lowered, to ensure that the maximum signal is received.

4) Subsequently, the power of the signal generator shall be adjusted until the same level is obtained again at the measurement equipment.

5) The radiated power is equal to the power supplied by the signal generator, increased by the substitution antenna gain minus the cable losses (values in dB).

6) This measurement shall be repeated with horizontal polarization.

NOTE: For test sites with a fixed setup of the measurement antenna(es) and a reproducible positioning of the EUT, correction values from a verified site calibration can be used alternatively.

C.6.4 Radiated measurement for receivers

Preferably, radiated measurements shall be performed in a FAR.

Measurements on receiving equipment are essentially the reverse of measurements on transmitters, with a signal generator connected to the measuring antenna. Calibration relies on the principle of replacing the EUT with a substitution antenna and suitable measuring equipment.

Clause C.2.2 Substitution antenna applies. (Note this does not require an actual half wave dipole, only an antenna with known gain relative to a half wave dipole.)

There are two methods:

a) Connect the substitution antenna to a calibrated measuring receiver and read the measurement result directly.

b) Measure the path loss from the measurement antenna to the substitution antenna and subtract this from the signal generator level to reach the measurement result.

For method a) the level received in some measurements is likely to be too low, so it may be necessary to raise the signal generator by a suitable amount and apply an equivalent offset to the measurement result.

Method b) means that one calibration measurement can be used for multiple tests.

C.7 Guidance for testing technical requirements

C.7.0 General

This clause provides guidance on how the various technical requirements can be verified using radiated measurements.

C.7.1 Radio test suites and corresponding test sites

Table C.1 provides guidance on the test site to be used for each of the radio tests when performing radiated measurements on integral antenna equipment.

Table C.1: Radio conformance tests and corresponding test sites

Radio conformance test - Clause number	Corresponding test site - Clause number(s)
5.2	C.1.1, C.1.2, C.1.3
5.3	C.1.1, C.1.2, C.1.3
5.6	C.1.1, C.1.2, C.1.3
5.8	C.1.1, C.1.2, C.1.3
5.8	C.1.1, C.1.2, C.1.3
5.9	C.1.1, C.1.2, C.1.3
5.11	C.1.1, C.1.2, C.1.3
5.15	C.1.1, C.1.2, C.1.3
5.16	C.1.1, C.1.2, C.1.3
5.17	C.1.1, C.1.2, C.1.3
5.18	C.1.1, C.1.2, C.1.3
5.19	C.1.1, C.1.2, C.1.3
5.20	C.1.1, C.1.2, C.1.3
5.21	C.1.1, C.1.2, C.1.3

Annex D (informative): Bibliography

- Ketterling, H-P: "Verification of the performance of fully and semi-anechoic chambers for radiation measurements and susceptibility/immunity testing", 1991, Leatherhead/Surrey.
- ETSI TR 102 313 (V1.1.1): "Electromagnetic compatibility and Radio Spectrum Matters (ERM); Frequency-agile Generic Short Range Devices using listen-Before-Transmit (LBT); Technical Report".

Annex E (informative): Change History

Date	Version	Information about changes
February 2016	3.1.1	First publication of the EN after approval by TC ERM at ERM#58 (22 February - 26 February 2016; Sophia Antipolis)

History

Document history		
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V2.4.1	May 2012	Publication
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