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Electromagnetic compatibility and Radio spectrum Matters (ERM); Network Based Short Range Devices (SRD); Radio equipment to be used in the 870 MHz to 876 MHz frequency range with power levels ranging up to 500 mW; Part 1:Technical characteristics and test methods

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Contents

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Foreword

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

The present document is part 1 of a multi-part deliverable covering Short Range Devices (SRD); Radio equipment to be used in the 870 MHz to 876 MHz frequency range with power levels ranging up to 500 mW, as identified below:

Part 1: "Technical characteristics and test methods";

Part 2: "Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

National transposition dates	
Date of adoption of this EN:	17 October 2014
Date of latest announcement of this EN (doa):	31 January 2015
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 July 2015
Date of withdrawal of any conflicting National Standard (dow):	31 July 2015

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**may not**", "**need**", "**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 is part of a set of standards developed by ETSI and is designed to fit in a modular structure to cover all radio and telecommunications terminal equipment within the scope of the R&TTE Directive [i.2]. The modular structure is shown in EG 201 399 [i.5].

For non EU countries the present document may be used for regulatory (Type Approval) purposes.

The present document describes test and performance requirements for licence exempt Short Range Devices (SRDs) intending to use the frequency range 870 - 876 MHz at power levels up to 500 mW and duty cycle up to 2,5 %. The frequency band is shared with other SRDs intended to support applications with more restrictive power levels and duty cycles as well as ER-GSM [i.6] assigned to the frequency range 873 - 876 MHz. Less restrictive duty cycle limits may apply to certain infrastructure SRDs (Network Relay Points) under individual licence.

The present document defines signal and operating constraints within the frequency band as well as at the band edges and when devices operate within range of ER-GSM [i.6] services operating within 873 - 876 MHz:

- SRDs may operate on a specific frequency or may be channel agile and operate on a number of different frequencies. When operating as a system, frequency control should be sufficiently accurate to promote effective use of the spectrum as required by regulation. Transmitted signals are constrained within defined bandwidth limits. Frequency accuracy limits allow implementers to trade signal bandwidth for frequency accuracy in their designs.

- Channel agile SRDs operate on two or more channels with signals constrained to the same limits as non-agile devices.

- Although no channel raster is defined for either fixed frequency or channel agile SRDs, channel separation is limited by regulation to $\leq$ 200 kHz. A preferred regular channel raster of 200 kHz separation allows sub-divisions of 100 kHz, 50 kHz, etc. for lower data rate applications using narrower bandwidth signals.

- When deployed in locations where GSM-R services are in operation, devices may implement cognitive procedures such as sensing the medium for GSM-R signalling information, or use a priori information from GSM-R operators to determine if additional sharing mechanisms are needed. In such cases, the preferred values of operating frequency should align with the channel raster of ER-GSM [i.6] to minimise potential interference.

- Signal transmissions are constrained in maximum duration and devices are required to wait for specified intervals before again transmitting in a given channel. After transmission limits have been reached on a specific channel, channel agile device operation may continue on a different channel whilst respecting the limits on each channel and overall limits applicable in the operational frequency band.

The present document is intended to promote equitable sharing of the radio resource amongst a variety of devices and intended uses:

- Spectrum sharing is enhanced when transmissions occupy their channel for the shortest time. The specifications included in the present document are not intended for devices operating at low data rates and in narrow channel spacings.

- Specifications are included for devices implementing channel sensing before transmitting.

- Although no specific mechanism is defined, implementations which distribute devices uniformly over the available channels are preferred. Examples of suitable radio specifications and medium access techniques which promote such behaviour can be found in TS 102 887-1 [i.7] and TS 102 887-2 [i.8].

- Other 'polite' spectrum access mechanisms are also described in the present document to emphasise the need to design for effective use of the shared spectrum.

The present document is structured as follows:

- Clauses 1 and 3 provide a general description of the types of equipment covered by the present document and the definitions of terms and abbreviations used.

- Clause 4 provides details on presentation of equipment for testing.

- Clauses 5 and 6 specify the test and general conditions for testing of the device.

- Clause 7 specifies the spectrum utilization parameters of transmitters which are required to be measured. Its sub-clauses provide details on how the equipment should be tested and the conditions which should be applied.

- Clause 8 specifies receiver parameters.

- Clause 9 specifies polite spectrum access parameters.

- Clause 10 gives the maximum measurement uncertainty values.
- Annex A (normative) is Void.
- Annex B (normative) provides specifications concerning radiated measurements.
- Annex C (normative) contains specifications for the test fixture.
- Annex D (normative) is Void.
- Annex E (normative) provides the spectrum analyser specification.
- Annex F (informative) Bibliography covers other supplementary information.

1 Scope

The present document applies to the following radio equipment types:

1) Network Based SRDs which are SRDs intended to operate in association with other SRDs to form network topologies supporting the intended application.

2) Network Relay Points which are specific fixed Network Based SRDs supporting interconnection of a network of SRDs with an external network or service.

Table 1: Frequency bands designated to Network Based Short Range Devices

Network Based SRD frequency bands	
Transmit	870,00 MHz to 875,6 MHz
Receive	870,00 MHz to 875,6 MHz

NOTE 1: It should be noted that Table 1 represents the most widely implemented position within the European Union and the CEPT countries, but it should not be assumed that the designated bands are available in all countries.

NOTE 2: In addition, it should be noted that other frequency bands may be available for networked short range devices in a country. See European Commission Decision on Short Range Devices [i.3] and CEPT/ERC/REC 70-03 [i.1] as implemented through National Radio Interfaces (NRI) or additional NRI as relevant.

NOTE 3: On non-harmonized parameters, national administrations may impose certain conditions such as the type of modulation, frequency, channel/frequency separations, maximum transmitter radiated power, duty cycle, and the inclusion of an automatic transmitter shut-off facility, as a condition for the issue of Individual Rights for use of spectrum or General Authorization, or as a condition for use under "licence exemption" as it is in most cases for Short Range Devices.

The present document covers equipment intended for use in a fixed location, equipment normally fixed in a vehicle and equipment intended to be carried or attached.

2 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 reference 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.

2.1 Normative references

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".

2.2 Informative references

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] CEPT/ERC/REC 70-03: "Relating to the use of Short Range Devices (SRD)".

[i.2] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[i.3] Commission Decision 2006/771/EC on harmonization of the radio spectrum for use by short-range devices as amended by subsequent Commission Decisions.

[i.4] 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".

[i.5] ETSI EG 201 399 (V2.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); A guide to the production of Harmonized Standards for application under the R&TTE Directive".

[i.6] UIC Code 951 (Version 15.3.0, 2012): "European Integrated Railway Radio Enhanced Network, System Requirements Specification".

[i.7] ETSI TS 102 887-1 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Smart Metering Wireless Access Protocol; Part 1: PHY layer".

[i.8] ETSI TS 102 887-2 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Smart Metering Wireless Access Protocol; Part 2: Data Link Layer (MAC Sub-layer)".

[i.9] 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".

[i.10] 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".

[i.11] 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".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

adjacent channel: frequency band, of width channel spacing, on either side of the operating channel

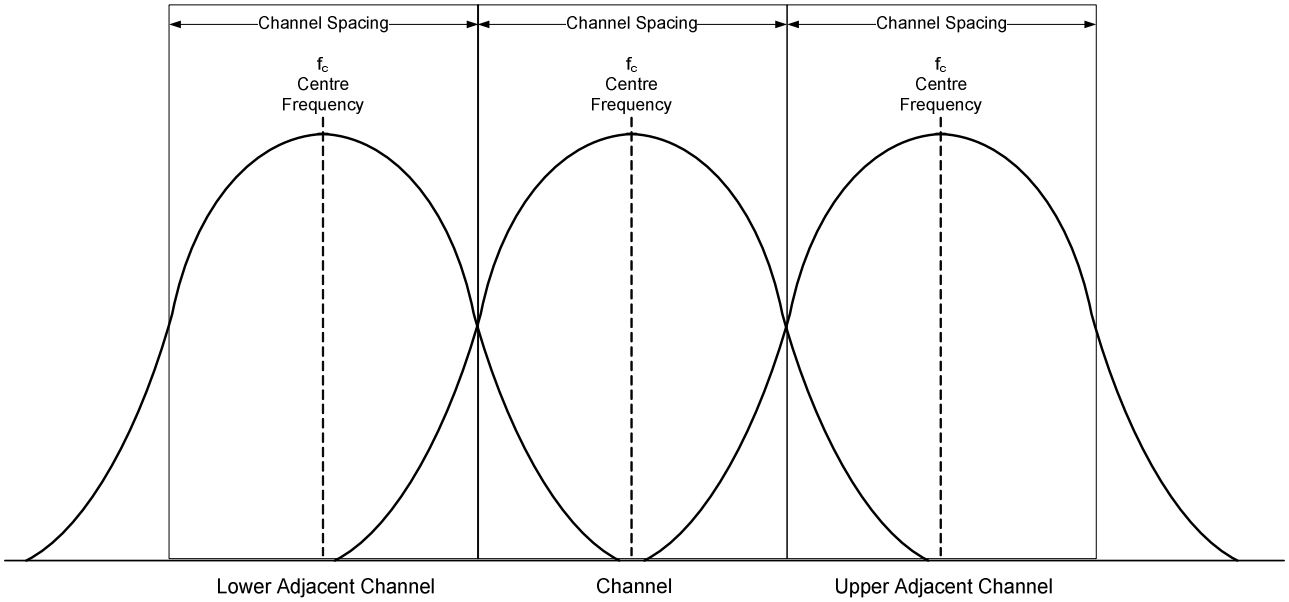


Figure 1: Adjacent channel definitions

centre frequency: nominal centre frequency of a transmission

channel: frequency band, of width channel spacing, the centre of which defines the nominal centre frequency for a given transmission

channel adaptivity: capability of a device to avoid using permitted operating channels that it has determined are temporarily or permanently unsuitable for its use

channel spacing: distance, in hertz, between adjacent nominal centre frequencies

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: modulated transmission without interruption for the period of the test

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

disregard time ($T_{Disregard}$): provider declared interval below which two separate radio emissions in a channel are considered a single continuous transmitted burst

duty cycle: ratio, expressed as a percentage, of the cumulative duration of transmissions in an observation bandwidth within an observation interval divided by the observation interval

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

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

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

network relay point: a class of device intended to provide network infrastructure to support communications between devices and an external communications network or service

occupied bandwidth: 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

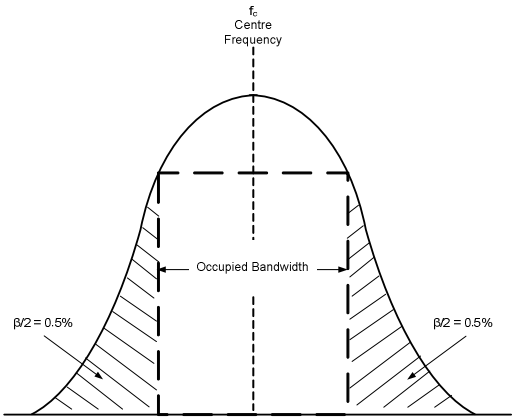


Figure 2: Signal Occupied Bandwidth

operating channel: channel in which transmissions from the device occur

operating frequency: centre frequency

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

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 ($P_{Threshold}$): absolute signal level (in dBm) above which a transmission is considered to exist for a given receiver bandwidth

spurious emissions: emissions on a frequency or frequencies which are outside the occupied bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. 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 < $T_{Disregard}$, with a signal level greater than the signal threshold in a channel

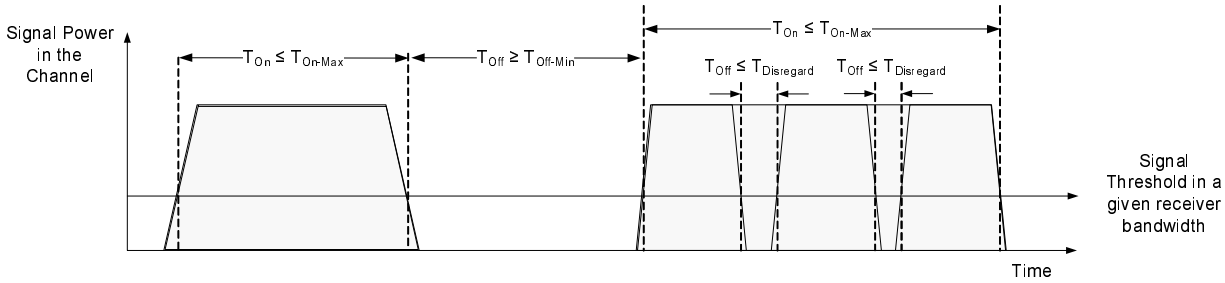


Figure 3: Transmission definitions

3.2 Symbols

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

dB	decibel
S	Sensitivity of receiver
λ	wavelength

3.3 Abbreviations

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

APC	Automatic / Adaptive Power Control
ARQ	Automatic Repeat reQuest
BER	Bit Error Ratio
BW	BandWidth
CCA	Clear Channel Assessment
CEPT	Commission Européenne des Postes et Télécommunications
CISPR	International Special Committee on Radio Interference
CS	Channel Spacing
e.r.p.	effective radiated power
EC	European Commission
EMC	ElectroMagnetic Compatibility
EU	European Union
EUT	Equipment Under Test
FAR	Fully Anechoic Room
FEC	Forward Error Correction
ITU-R	International Telecommunication Union - Radiocommunication
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
LBT	Listen Before Talk
LPDA	Logarithmic Periodic Dipole Antenna
NRI	National Radio Interfaces
NRP	Network Relay Point
OATS	Open Area Test Site
OOB	Out-Of-Band
R&TTE	Radio and Telecommunications Terminal Equipment
RBW	Resolution BandWidth
RBW_{REF}	Reference BandWidth
RF	Radio Frequency
RMS	Root Mean Square
Rx	Receiver
SAR	Semi-Anechoic Room
SCS	Short Control Signalling
SRD	Short Range Device
TR	Technical Report
Tx	Transmitter
VBW	Video Bandwidth
VSWR	Voltage Standing Wave Ratio

4 Technical requirements specifications

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.

The equipment tested shall be designed, constructed and manufactured in accordance with good engineering practice and with the aim of minimizing harmful interference to other equipment and services.

4.1 General performance criteria

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

- after demodulation, a message acceptance ratio better than 80 % for messages of length 20 octets, equivalent acceptance ratio for other message lengths or equivalent BER; or
- an appropriate false alarm rate or sensing criteria as declared by the provider.

Where the indicated performance cannot be achieved, the performance criteria used to determine the performance of the receiver shall be declared and published 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 Presentation of equipment for testing purposes

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

To simplify and harmonize the testing procedures between the different testing laboratories, measurements shall be performed, according to the present document, on samples of equipment defined in clauses 4.2.1 to 4.2.2.

These clauses are intended to give confidence that the requirements set out in the present document have been met without the necessity of performing measurements on all frequencies.

4.2.1 Choice of model for testing

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

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

If an EUT 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 complex.

4.2.1.1 EUT with an external RF connector

Where practicable, an EUT offered for testing shall provide a 50 Ω connector for conducted RF power measurements.

4.2.1.2 EUT without an external RF connector

Conducted measurements on an EUT with an integral antenna or with an antenna connection other than a conventional 50 Ω coaxial connector may be made by:

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

4.2.1.2.1 EUT with an internal connector

Where the EUT has an internal conventional 50 Ω coaxial connector between the antenna and the circuitry, this may be utilised to perform conducted measurements. The means to access the connector, with the aid of a diagram, shall be stated by the provider.

Use of an internal antenna connection shall be recorded in the test report.

4.2.1.2.2 EUT with a temporary antenna connector

One EUT, with the normal antenna connected, may be tested using radiated measurement procedures. The provider shall attend the test laboratory at the conclusion of the radiated measurements to disconnect the antenna and fit the temporary antenna connector. The test laboratory staff shall not connect or disconnect any temporary antenna connector.

Alternatively, two EUTs may be submitted to the test laboratory, one fitted with a temporary antenna connector with the antenna disconnected and another with the antenna connected. The appropriate EUT shall be used for each test case. The provider shall declare that the two EUTs are identical in all respects except for the temporary antenna connector.

Use of an EUT with a temporary antenna connection shall be recorded in the test report.

4.2.1.2.3 Use of a Test Fixture

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

A test fixture may only be used for relative measurements.

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

4.2.2 Testing of modular equipment

If a family of equipment has alternative output power levels provided by the use of separate power modules or add on stages, or additionally has alternative frequency coverage, then all these shall be declared. Each module or add on stage shall be tested in combination with the equipment. The necessary samples and tests shall be based on the requirements of clause 4.2. As a minimum, measurements of the radiated power (e.r.p.) and spurious emissions shall be performed for each combination and shall be stated in the test report.

4.2.3 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.

4.2.4 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.

4.2.5 Marking (equipment identification)

The equipment shall be marked in a visible place. This marking shall be legible and durable. Where this is not possible due to physical constraints, the marking shall be included in the user's manual, packaging or guarantee material.

The marking shall include as a minimum:

- the name of the manufacturer or his trademark;
- the type designation;
- the transmitter duty cycle;
- the operating frequency range.

4.3 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.

A companion device necessary to enable the EUT to operate normally may be provided.

4.4 Provider declared information

The provider shall declare the information shown in Table 2. Additional information may be provided to facilitate testing or operation of the EUT.

Table 2: Provider Declared Information

Parameter	Notes	
Highest operating frequency	The highest nominal operating frequency of the EUT	
Lowest operating frequency	The lowest nominal operating frequency of the EUT	
Channel spacing	Nominal separation of adjacent operating frequencies	
Maximum Tx power	Maximum RF output power If the equipment is designed to operate with different power levels, the rated power for each level or range of levels, frequency or range of frequencies	
Antenna gain	Gain in dB (i.e. relative to a dipole) of the antenna used by the equipment in normal operation	
Worst case modulation and operational mode	The set of modulation and operational parameters which create the worst case results for a specific test	
Maximum data rate	Highest data rate employed by EUT	
Unmodulated carrier	Whether the equipment can generate unmodulated carrier or not	
Frequency agile	Whether the equipment is channel agile or not	
Transmitter duty cycle	Maximum duty cycle	
Disregard Time	Maximum duration of an inter-emission gap in a transmission	
Extreme temperature range	Category I, II or III or specific range (see clause 5.4.1.2)	
APC Settling Time	Time required for the EUT APC mechanism to adjust Tx Power to minimum level under test conditions	
Polite spectrum access mechanisms employed	CCA listen duration	Duration of the CCA channel sampling time
	Dead time	The maximum time between the end of the CCA interval and the start of the transmission at the equipment local antenna
	Deferral period	The method used to randomise re-transmission attempts
	Minimum unit of deferral period	Unit of time slot used in the deferral method
	Maximum SCS transmission	Maximum short control signalling transmission duration
	Channel adaptivity	Whether the equipment employs channel adaptivity or not
	NRP Coordination	Description of any NRP coordination methods employed
Normal use position	Height or other description of normal use of EUT for radiated test measurements	
NOTE: Declaration of antenna gain applies to EUT with permanent or temporary external antenna connector.		

5 Test conditions, power sources and ambient temperatures

5.1 Normal and extreme test conditions

Testing shall be made under normal test conditions, and also, where stated, under extreme test conditions.

5.2 Test power source

The equipment shall be tested using the appropriate test power source as specified in clauses 5.2.1 or 5.2.2. 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 5.2.1 then repeated using the internal power source as specified in clause 5.2.2.

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

5.2.1 External test power source

During testing, the power source of the equipment shall be replaced by an external test power source capable of producing normal and extreme test voltages as specified in clauses 5.3.2 and 5.4.2. 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.

During tests, the test power source voltages shall be within a tolerance of < ±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.

5.2.2 Internal test power source

For radiated measurements on portable equipment with integral 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, a note to this effect shall be appended to the Test Report.

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

5.3 Normal test conditions

5.3.1 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.

5.3.2 Normal test power source

5.3.2.1 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.

5.3.2.2 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.).

5.3.2.3 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.

5.4 Extreme test conditions

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

5.4.1 Extreme temperatures

5.4.1.1 Procedure for tests at extreme temperatures

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.

5.4.1.1.1 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.

5.4.1.1.2 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.

5.4.1.2 Extreme temperature ranges

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in clause 5.4.1.1, at the upper and lower temperatures of one of the following ranges, either:

a) the temperature range as declared by the provider; or

b) one of the following specified temperature ranges:

- Temperature category I (General): -20 °C to +55 °C;
- Temperature category II (Portable): -10 °C to +55 °C;
- Temperature category III (Equipment for normal indoor use): +5 °C to +35 °C.

The test report shall state which range is used.

5.4.2 Extreme test source voltages

5.4.2.1 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 5.4.2.4 applies.

5.4.2.2 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.

5.4.2.3 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.

5.4.2.4 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.

6 General test conditions

6.1 Transmitter test signals

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

D-M1: a test signal consisting of an unmodulated carrier.

D-M2: a test signal representative or normal operation and generating the greatest occupied RF bandwidth. The preferred test signal shall consist 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 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 and shall be representative of normal operation of the EUT.

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 3.

Table 3: Recommended test signals

Requirement	Clause	Test Signal
Frequency error	7.2	D-M1
Average power	7.3	D-M1, D-M2, D-M2a, D-M3
Effective radiated power	7.4	D-M2, D-M2a, D-M3
Transient power	7.5	D-M1, D-M2, D-M2a, D-M3
Occupied bandwidth	7.6	D-M2, D-M2a, D-M3
Out-of-band emissions	7.7	D-M2, D-M2a, D-M3
Tx spurious emissions	7.8	D-M2, D-M2a, D-M3
Frequency stability under low voltage	7.9	D-M1, D-M2, D-M2a, D-M3
Duty cycle	7.10	D-M3
Automatic/adaptive power control	7.11	D-M3
Rx sensitivity	8.2	D-M3
CCA threshold	8.3	D-M3
Blocking	8.4	D-M3
Rx spurious emissions	8.5	N/A
Polite spectrum access	9	N/A

6.2 Conducted measurements

6.2.1 Artificial antenna

Conducted 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 EUT antenna connector and providing a 50 Ω coupling port for connection to test equipment.

6.2.2 Voltage Standing Wave Ratio (VSWR)

The VSWR at the 50 Ω output connector of:

- the artificial antenna
- the provider's specified test fixture

shall not be greater than 1,5:1 over the frequency range of the measurement.

6.3 Radiated measurements

For all radiated measurements a suitable test site, selected from those described in clause B.1, and applicable measurement procedures, as described in clause B.6, shall be used.

When performing radiated transmitter measurements, the EUT shall be configured and antenna(s) positioned (including smart antenna systems and systems capable of beam forming) and oriented for maximum radiated power into the measuring antenna. The measuring antenna shall use the same polarisation as the EUT and be chosen according to the frequency of the transmitter.

When performing radiated receiver measurements, the EUT shall be configured and antenna(s) positioned (including smart antenna systems and systems capable of beam forming) for maximum sensitivity towards the test antenna. The test antenna shall use the same polarisation as the EUT and be chosen according to the frequency of the transmitter.

6.4 Applicable measurement methods

Although the measurement methods in the present document allow conducted measurements to be performed, the EUT together with all its intended antenna assemblies shall comply with the applicable technical requirements.

For any test method described 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. In such cases, appropriate procedures to establish reference levels shall be used and recorded.

Where a test method uses 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.

A summary of the applicable measurement methods for each test suite are shown in Table 4.

Table 4: Applicable test methods

Clause	Requirement	Test method		
		Radiated	Conducted	Test fixture
7.2	Frequency error	Yes	Yes	Yes
7.3	Average power	No	Yes	No
7.4	Effective radiated power	Yes	No	No
7.5	Transient power	Yes	Yes	No
7.6	Occupied bandwidth	Yes	Yes	Yes
7.7	Unwanted emissions in the out-of-band domain	Yes	Yes	No
7.8	Unwanted emissions in the spurious domain	Yes	Yes	No
7.9	Frequency stability under low voltage conditions	Yes	Yes	Yes
7.10	Duty cycle	Yes	Yes	Yes
7.11	Automatic/adaptive power control	Yes	Yes	No
8.2	Receiver sensitivity	Yes	Yes	No
8.3	Clear channel assessment threshold	Yes	Yes	No
8.4	Blocking	Yes	Yes	No
8.5	Receiver spurious radiations	Yes	Yes	No
9	Polite spectrum access	Yes	Yes	Yes
NOTE: See clause 4.2.1 Choice of model for testing.				

6.5 Modes of operation

6.5.1 Test mode

Unless otherwise specified, the measurements shall be performed using normal operation of the equipment in the worst case operational mode. For each of the requirements in the present document, this worst case operational mode shall be declared by the manufacturer and documented in the test report. Special software may be used to operate the equipment in this mode.

NOTE: The worst case operational mode is that mode resulting in the worst results with regard to the requirement.

6.5.2 Transmitter operation

For each transmitter test an appropriate test signal shall be employed and recorded in the test report.

Unless stated otherwise, the transmitter shall be operated at its maximum transmit power level as declared by the provider.

Equipment able to operate with different modulations shall be tested for each modulation separately.

When making transmitter tests on equipment designed for intermittent operation, the maximum duty cycle of the transmitter, as declared by the provider, shall not be exceeded. The actual duty cycle used shall be recorded and stated.

NOTE: The maximum duty cycle of the transmitter should not be confused with the duty cycle of the device under normal operation conditions.

When performing transmitter tests on equipment designed for intermittent operation it may be necessary to exceed the duty cycle associated with normal operation. Where this is the case, care should be taken to avoid heating effects having an adverse effect on the equipment and the parameters being measured. The maximum transmission duration shall be stated by the test laboratory, where applicable. This on-time shall not be exceeded and details shall be stated in the test report.

6.5.3 Testing of multi-frequency or channel agile equipment

Unless stated otherwise, equipment intended to operate on multiple frequencies, or channel agile equipment, shall be tested on the highest operating frequency and lowest operating frequency declared by the provider.

Channel agile equipment should allow specific operating frequencies to be selected manually to facilitate some of the tests to be performed.

6.5.4 Non-uniform maximum transmit power

Where an EUT does not use the same power level on each operating frequency, specific test procedures are required for certain tests. Where the operating frequency does not materially impact the testing of the requirement, the highest and lowest operating frequencies on which the EUT operates at its highest power level shall be used in place of the highest and lowest operating frequencies declared by the provider.

Where the operating frequency does materially impact the testing of the requirement, the tests shall be performed on the highest and lowest operating frequencies declared by the provider. The tests shall then be repeated for each next highest and lowest operating frequency on which a greater power level is used until operating frequencies on which the highest power level is used have been tested.

The result of the test shall be recorded as the worst case of the sets of frequencies tested for the specific test suite.

The test suites where these specific procedures apply are shown in Table 5.

Table 5: Specific Test Procedures

Clause	Requirement	Specific Test Procedures
7.2	Frequency error	No
7.3	Average power	Yes
7.4	Effective radiated power	Yes
7.5	Transient power	No
7.6	Occupied bandwidth	No
7.7	Unwanted emissions in the out-of-band domain	Yes
7.8	Unwanted emissions in the spurious domain	Yes
7.9	Frequency stability under low voltage conditions	No
7.10	Duty cycle	No
7.11	Automatic/adaptive power control	Yes
8.2	Receiver sensitivity	No
8.3	Clear channel assessment threshold	No
8.4	Blocking	No
8.5	Receiver spurious radiations	No
9	Polite spectrum access	No

6.6 Measuring receiver

The term "measuring receiver" refers to a frequency-selective voltmeter or a spectrum analyser. Unless stated otherwise, an RMS detector shall be used.

6.6.1 Reference Bandwidth

In general, the resolution bandwidth of the measuring receiver (RBW) should be equal to the reference bandwidth (RBW_{REF})given in Table 6.

Table 6: Resolution bandwidth for the measuring receiver

Measured 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.4].	

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

When RBW < RBW_{REF} the result should be integrated over RBW_{REF}.

When RBW > RBW_{REF} the result for broadband spurious emissions should be normalised to the bandwidth ratioaccording to the following formula:

$$B = A + 10 \log \frac{RBW_{REF}}{RBW_{MEASURED}}$$

Where:

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

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

6.7 Test equipment

For each test method, appropriate test equipment, configuration settings and operation shall be selected by the test laboratory. The test equipment used, together with relevant settings for the test method, shall be recorded in the test report.

For equipment with pulse modulation, or where it is not possible to make a required measurement in the absence of modulation, the measurement shall be carried out by the use of a measuring receiver with appropriate receiver bandwidth (see clause 6.6).

7 Methods of measurement and limits for transmitter parameters

7.1 General limits

The general limits applying to all parameters in the present document are as shown in Table 7.

Table 7: Maximum radiated power limit, e.r.p., channel spacing, spectrum access and mitigation requirements

Frequency Bands / frequencies	Maximum radiated power, e.r.p.	Channel spacing (CS)	Spectrum access and mitigation requirement)
870 - 875,6 MHz	≤ 500 mW e.r.p.	25 ≤ CS ≤ 200 kHz	≤ 2,5 % duty cycle and APC required (see note 1) For ER-GSM protection (873 - 875,6 MHz, where applicable), the duty cycle is limited to ≤ 0,01 % and a maximum single transmitter on time of 5 ms/1 s (see note 2)
NOTE 1: A duty cycle of up to 10 % may be allowed for network relay points forming part of metropolitan/rural area networks such as for utilities or other applications for the purpose of data acquisition. Network relay points may be individually licensed. NOTE 2: Except if the EUT employs a coordination procedure with the railway operator or a cognitive procedure in order to avoid channels within the ER-GSM bands. A cognitive procedure is the ability to detect ER-GSM transmissions and not transmit within occupied ER-GSM channels.			

7.2 Frequency error

7.2.1 Description

Frequency error is the difference between the measured unmodulated carrier frequency and the nominal centre frequency as stated by the manufacturer.

7.2.2 Test method

This test shall apply to an EUT able to generate, or be modulated by, test signal D-M1. All other EUT shall meet the limits in clause 7.6 under extreme test conditions.

7.2.2.1 Test conditions

1) The measurement shall be made under normal and extreme test conditions.
2) The measurement shall be performed on the highest and lowest operating frequencies declared by the provider.
3) The measurement shall be performed with an unmodulated carrier test signal.
4) An EUT without a permanent or temporary antenna connector shall be tested according to clause 7.2.2.2 or clause 7.2.2.4.
5) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.2.2.3.

7.2.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.1 and the measurements in clause 7.2.2.5 performed using corresponding radiated measurement methods described in clause B.6.

7.2.2.3 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 7.2.2.5 shall be performed.

7.2.2.4 Alternate conducted measurement

The EUT shall be installed in the provider's test fixture which shall be connected to the test equipment via an appropriate attenuator.

The measurements in clause 7.2.2.5 shall be performed.

7.2.2.5 Measurement procedure

Step 1:

Operation of the EUT shall be started using test signal D-M1 on the highest operating frequency as declared by the provider.

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

Step 2:

The operation of the EUT shall be restarted using test signal D-M1 at the lowest operating frequency declared by the provider.

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

Step 3:

The test step 1 and step 2 shall be repeated under extreme test conditions.

Step 4:

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

Table 8: Information Recorded in the Test Report For Frequency Error

Value	Notes
Test environment	Normal or Extreme test conditions
Carrier frequency (high) (A)	Measured unmodulated carrier frequency at highest frequency declared by the provider
Nominal centre frequency (high) (B)	Highest operating frequency declared by the provider
Carrier frequency (low) (A')	Measured unmodulated carrier frequency at lowest frequency declared by the provider
Nominal centre frequency (low) (B')	Lowest operating frequency declared by the provider
Frequency error (high)	Absolute value of (A-B)
Frequency error (low)	Absolute value of (A'-B')
NOTE: The highest and lowest operating frequencies are declared by the provider.	

7.2.3 Limits

The measured frequency shall be within the operating frequency band and the measured frequency error shall not exceed the frequency tolerance given in Table 9.

Table 9: Frequency error

Operating frequency	Frequency tolerance (ppm), see note
870 000 MHz to 875 600 MHz (see note)	±20 ppm or ±10 % of the channel spacing, whichever is the smaller
NOTE: The highest and lowest operating frequencies are declared by the provider.	

7.3 Average power (conducted)

7.3.1 Description

This test measures the average power delivered to the artificial antenna (see clause 6.2.1).

7.3.2 Test method

This test shall apply to an EUT with a permanent or temporary external antenna connector.

7.3.2.1 Test conditions

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

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

NOTE: See clause 6.5.4 for specific test procedures for non-uniform maximum transmit power.

3) In the case of amplitude modulated output, the D-M1 test signal shall not be used.

7.3.2.2 Measurement Procedure

The EUT shall be connected to an artificial antenna which shall be connected to the measuring receiver via an appropriate attenuator.

Table 10: Test Parameters for Average Power Measurement

Setting	Value	Notes
Centre frequency	The nominal channel centre frequency	The highest or lowest operating frequency
Detector Mode	RMS or Peak	RMS if EUT provides unmodulated carrier otherwise Peak
NOTE: The highest and lowest operating frequencies are declared by the provider.		

The test equipment shall be configured as appropriate for the parameters shown in Table 10.

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 average or mean power, as appropriate, delivered to this artificial antenna shall be measured.

Step 2:

The measurement in step 1 shall be repeated for the lowest operating frequency as declared by the provider.

Step 3:

The measurements in step 1 and step 2 shall be repeated under extreme test conditions.

Step 4:

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

Table 11: Information Recorded in the Test Report for Average Power

Value	Notes
Test environment	Normal or Extreme test conditions
Test signal	The test signal used (see clause 6.1)
Centre frequency	Nominal centre frequency
Average output power (conducted)	Measured average or mean power plus equipment antenna gain in dB
NOTE: The nominal centre frequency is declared by the provider. The equipment antenna gain (in dB, i.e. relative to a dipole) is declared by the provider.	

7.3.3 Limits

The average output power (conducted), including applicable antenna gain, shall not exceed the maximum radiated power value given in Table 7.

7.4 Effective radiated power

7.4.1 Description

The effective radiated power is the power radiated in the direction of the maximum field strength under specified conditions of measurements for any condition of modulation.

7.4.2 Test method

This test shall apply to an EUT without a permanent or temporary external antenna connector.

7.4.2.1 Test conditions

1) The measurements shall be performed under normal conditions.

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

NOTE: See clause 6.5.4 for specific test procedures for non-uniform maximum transmit power.

3) In the case of amplitude modulated output, the mean power shall be measured.

7.4.2.2 Measurement procedure

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

Step 1:

Table 12: Test Parameters for Effective Radiated Power Measurement

Setting	Value	Notes
Centre frequency	The nominal channel centre frequency	The highest or lowest operating frequency as declared by the provider
Detector Mode	RMS or Peak	RMS if EUT provides unmodulated carrier otherwise Peak
NOTE: The highest and lowest operating frequencies are declared by the provider.		

The test equipment shall be configured as appropriate for the parameters shown in Table 12.

Step 2:

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

The maximum average or mean power values measured for vertical and horizontal polarisation shall be noted.

Step 3:

The substitution measurement as defined in clause B.6.3 shall be performed.

The equivalent radiated power for vertical and horizontal polarisation shall be noted.

The measure of the effective radiated power is the larger of the two levels recorded at the input to the substitution antenna, corrected for the gain of the substitution antenna and applicable cable losses.

Step 4:

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

Table 13: Information Recorded in the Test Report for Effective Radiated Power

Value	Notes
Test environment	Normal operation or unmodulated carrier
Test signal	The test signal used (see clause 6.1)
Centre frequency	Nominal centre frequency
Measure of effective radiated power	Measured equivalent radiated power, plus equipment antenna gain
NOTE: The nominal centre frequency is declared by the provider. The equipment antenna gain (in dB, i.e. relative to a dipole) is declared by the provider.	

7.4.3 Limits

The measured effective radiated power shall not exceed the maximum radiated power limit given in Table 7.

7.5 Transient power

7.5.1 Description

Transient power is the power due to switching the transmitter on and off during normal operation falling in the out-of-band domain of the operating channel.

7.5.2 Test method

This test shall apply to all EUT.

7.5.2.1 Test conditions

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

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

3) The measurements shall be performed using a measuring receiver (see clause 6.6) employing a quasi-peak detector.

4) An EUT without a permanent or temporary antenna connector shall be tested according to clause 7.5.2.2.

5) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.5.2.3.

7.5.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.1 and the measurements in clause 7.5.2.4 performed using corresponding radiated measurement methods described in clause B.6.

7.5.2.3 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 7.5.2.4 shall be performed.

7.5.2.4 Measurement procedure

Table 14: Test Parameters for Transient Power Measurement

Setting	Value	Notes
RBW	120 kHz	Measuring bandwidth suitable for the operating frequency band
Detector Mode	Quasi-peak	If used, a spectrum analyser is operated in time domain mode (zero span)

The measuring receiver shall be configured as appropriate for the test parameters shown in Table 14.

The EUT shall be configured to operate on the highest frequency as declared by the provider.

The centre frequency of the measuring receiver shall be configured to be 100 kHz above the operating channel of the EUT.

Step 1:

Operation of the EUT shall be started using an appropriate test signal.

Step 2:

Operation of the EUT shall be stopped.

NOTE: When a continuous test signal is used, steps 1 and 2 should be repeated at least 5 times within a maximum period of 60 seconds. The recommended duration for on- and off-time is at least 1s respectively.

When an intermittent test signal is used the operating duration should ensure at least 5 transitions between transmitter on and off states.

Step 3:

The measured power level shall be noted.

Step 4:

Steps 1, 2, and 3 shall be repeated with the centre frequency of the measuring receiver set to 100 kHz below the operating channel of the EUT.

Step 5:

The measurements in steps 1 to 4 are repeated for the EUT configured to operate on the lowest operating frequency as declared by the provider.

The information shown in Table 15 shall be recorded in the test report for each measurement frequency.

Table 15: Information Recorded in the Test Report for Transient Power

Value	Notes
Test modulation	Modulation method
EUT centre frequency	EUT operating frequency
Measuring receiver centre frequency	Transient measurement frequency
Power level (transient)	Measured quasi-peak power (transient power level)

Step 6:

Table 16: Measured Peak Power

Maximum Measured Power
-36 dBm / 250 nW

If the maximum recorded power level exceeds the power limit in Table 16, the procedures in steps 1 to 6 shall be repeated with a test signal providing continuous transmission without switching the EUT on and off, or the measurements made in a period shorter than the duration of the modulated transmitted burst.

Step 7:

The information shown in Table 17 shall be recorded in the test report for each measurement frequency.

Table 17: Information Recorded in the Test Report for Transient Power

Value	Notes
Test modulation	Modulation method
EUT centre frequency	EUT operating frequency
Measuring receiver centre frequency	Transient measurement frequency
Power level (non-transient)	Measured peak power with continuous transmitted signal (non-transient power level)

Step 8:

Measurement steps 1 to 5 shall be repeated with the offset of the centre frequency of the measuring receiver from the channel increased from 100 kHz in steps of 120 kHz until either the maximum measured transient power no longer exceeds the limits in Table 16 or the offset exceeds 2 MHz.

7.5.3 Limits

At all frequencies where the measured transient power level exceeds the limits in Table 18, the measured transient power level shall not exceed the measured non-transient power level by more than 3 dB.

Table 18: Transient Power Limits

Power Limit	Lower Frequency Range	Upper Frequency Range
-9,2 dBm	(f_{low}-200 kHz) to f_{low}	f_{high} to (f_{high}+200 kHz)
-25,2 dBm	(f_{low}-400 kHz) to (f_{low}-200 kHz)	(f_{high}+200 kHz) to (f_{high}+400 kHz)
-35,2 dBm	(f_{low}-2 MHz) to (f_{low}-400 kHz)	(f_{high}+400 kHz) to (f_{high}+2 MHz)

NOTE: f_{low} is the lower channel edge frequency
f_{high} is the upper channel edge frequency
For measurement bandwidths other than 120 kHz, power levels are converted using the formula:
P = A +10log(BW/120)
Where:
P is the equivalent power limit
A is the power limit in 120 kHz
BW is the measurement bandwidth.

7.6 Occupied bandwidth

7.6.1 Description

The occupied bandwidth is the width of the band of frequencies that contain 99 % of the power of the signal.

7.6.2 Test method

This test shall apply to all EUT.

7.6.2.1 Test conditions

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

NOTE: If the frequency error test (see clause 7.2) 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 each frequency measurement obtained in this test.

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

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

4) An EUT without a permanent or temporary antenna connector shall be tested according to clause 7.6.2.2 or clause 7.6.2.4.

5) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.6.2.3.

7.6.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.1 and the measurements in clause 7.6.2.5 performed using corresponding radiated measurement methods described in clause B.6.

7.6.2.3 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 7.6.2.5 shall be performed.

7.6.2.4 Alternate conducted measurement

The EUT shall be installed in the provider's test fixture which shall be connected to the test equipment via an appropriate attenuator.

The measurements in clause 7.6.2.5 shall be performed.

7.6.2.5 Measurement procedure

Table 19: Test Parameters for Occupied Bandwidth Measurement

Setting	Value	Notes
Centre frequency	The nominal channel centre frequency	The highest or lowest operating frequency as declared by the provider. Additional frequencies may be derived from these values using the declared channel spacing
RBW	1 kHz	
VBW	3 x RBW	Nearest available analyser setting to 3x RBW
Span	At least 2x channel spacing	Span should be large enough to include all major components of the signal and its side bands
Detector Mode	RMS	
Trace	Max. hold	
NOTE: The highest and lowest operating frequencies are declared by the provider. The channel spacing is declared by the provider.		

The spectrum analyser shall be configured as appropriate for the parameters shown in Table 19.

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.

Step 4:

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

The measurement in step 2 and step 3 shall be repeated.

The information shown in Table 20 shall be recorded in the test report for each test condition.

Table 20: Information Recorded in the Test Report for Occupied Bandwidth

Value	Notes
Test environment	Normal or extreme conditions
Test signal	The test signal used (see clause 6.1)
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 displayed by the spectrum analyser for the 99 % occupied bandwidth for each centre frequency measured
NOTE: The highest and lowest operating frequencies are declared by the provider.	

7.6.3 Limits

The measured occupied bandwidth in each test condition shall not exceed the limits in Table 21.

Table 21: Occupied bandwidth limits

Requirement	Limit
Occupied bandwidth	≤ Channel spacing
NOTE: The occupied bandwidth shall reside entirely within the operating channel. The operating channel shall reside entirely within the operating frequency band as defined in Table 7. The channel spacing is declared by the provider.	

7.7 Unwanted emissions in the out-of-band domain

7.7.1 Description

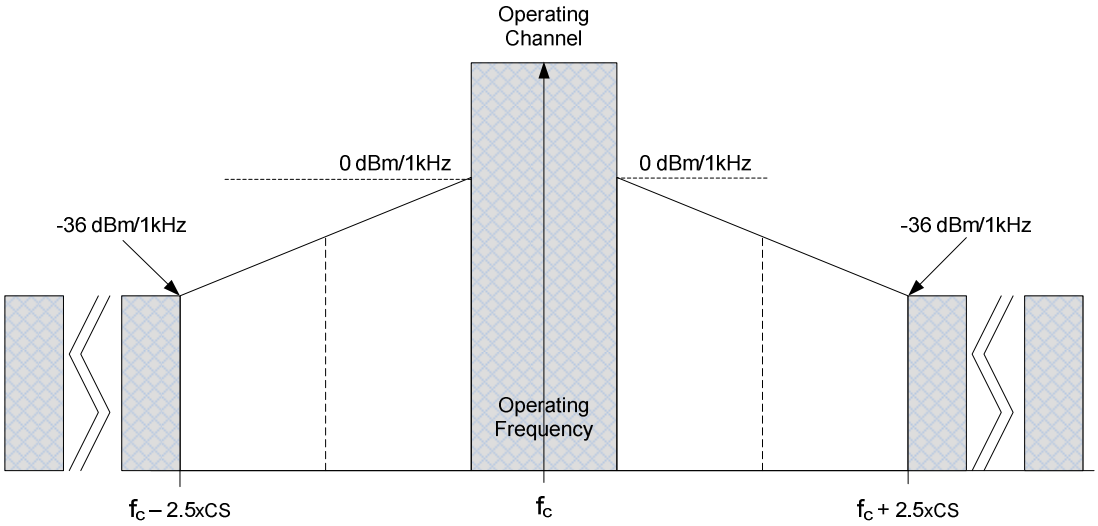


Figure 4: Out-of-Band Domain for Operating Channel

NOTE: In Figure 4, CS is the channel spacing declared by the provider and is equal to the width of the operating channel.

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 relevant out-of-band domain is shown in Figure 4 and applies within the operating frequency band.

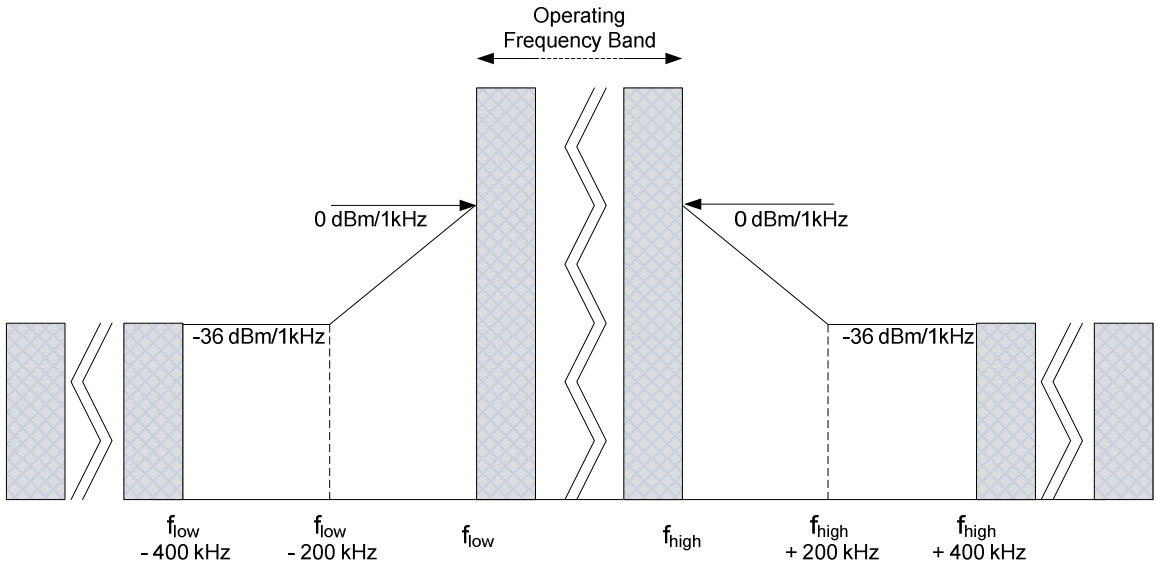


Figure 5: Out-of-Band Domain for Operating Frequency Band

Specific limits apply at frequencies immediately above and below the operating frequency band as shown in Figure 5.

NOTE: f_{low} is the lower edge of the operating frequency band defined in Table 7.

f_{high} is the upper edge of the operating frequency band edge defined in Table 7.

7.7.2 Test method

This test shall apply to all EUT.

7.7.2.1 Test conditions

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

NOTE 1: If the frequency error test (see clause 7.2) 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 each frequency measurement obtained in this test.

2) The measurement shall be performed on the lowest and the highest frequency declared by the provider and an intermediate frequency on which the EUT operates at its maximum transmit power.

NOTE 2: See clause 6.5.4 for specific test procedures for non-uniform maximum transmit power.

The intermediate frequency should be chosen such that the out-of-band domain falls entirely within the operating frequency band.

3) An EUT without a permanent or temporary antenna connector shall be tested according to clause 7.7.2.2.

4) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.7.2.3.

7.7.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.1 and the measurements in clause 7.7.2.4 performed using corresponding radiated measurement methods described in clause B.6.

7.7.2.3 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 7.7.2.4 shall be performed.

7.7.2.4 Measurement procedure

Table 22: Test Parameters for Upper Out-of-Band Measurement

Spectrum Analyser Setting	Value	Notes
Centre frequency	f_{high}	The upper band edge frequency
RBW	1 kHz (see note 2)	Resolution bandwidth for out-of-band domain measurements
Detector Function	Peak	
Trace Mode	Max. Hold	
NOTE 1: f_{low} is the lower band edge frequency defined in Table 7.		
NOTE 2: See clause 6.6 if the value of RBW used is different from RBW_{REF} in Table 27.		

The test equipment shall be configured as appropriate for the parameters shown in Table 22.

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 highest frequency at which the EUT signal power envelope, corrected for attenuator values, equals the peak power limit for the first row of Table 27 is determined and noted.

Step 2:

The test equipment shall be reconfigured as appropriate for the parameter shown in Table 23.

Table 23: Test Parameter Setting for Lower Out-of-Band Measurement

Spectrum Analyser Setting	Value	Notes
Centre frequency	f_{low}	The lower band edge frequency

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

The lowest frequency at which the EUT signal power envelope, corrected for attenuator values, equals the peak power limit for the first row of Table 27 is determined and noted.

Step 3:

Step 1 and step 2 shall be repeated for the peak power limit of the second row of Table 27, adapting the test equipment configuration as required.

Step 4:

The information shown in Table 24 shall be recorded in the test report for each test condition.

Table 24: Information Recorded in the Test Report for OOB Emissions

Parameter	Value Recorded in the Test Report
Test condition	Normal or extreme test conditions
Test signal	The test signal used (see clause 6.1)
Centre frequency	Upper or lower edge of the operating frequency band
Operating frequency	Highest or lowest operating frequency as declared by the provider
Power limit	Peak power limit from the relevant row of Table 27
Upper frequencies	The measured values from step 3 for each row of Table 27
Lower frequencies	The measured values from step 4 for each row of Table 27

Step 5:

The test equipment shall be reconfigured as appropriate for the parameter shown in Table 25.

Table 25: Test Parameter Setting for Lower Out-of-Band Measurement

Spectrum Analyser Setting	Value	Notes
Centre frequency	f_c	Intermediate operating frequency

Operation of the EUT shall be re-started, with the appropriate test signal, on the intermediate operating frequency.

The highest and lowest frequencies at which the EUT signal power envelope, corrected for attenuator values, equals the peak power limit for the third row of Table 27 is determined and noted.

Step 6:

The highest and lowest frequencies at which the EUT signal power envelope, corrected for attenuator values, equals the peak power limit for the fourth row of Table 27 is determined and noted.

Step 7:

The information shown in Table 26 shall be recorded in the test report.

Table 26: Information Recorded in the Test Report for OOB Emissions

Parameter	Value Recorded in the Test Report
Test condition	Normal or extreme test conditions
Test signal	The test signal used (see clause 6.1)
Centre frequency	Test equipment centre frequency
Operating frequency	Intermediate operating frequency
Upper frequencies	The measured highest values from step 5 and step 6
Lower frequencies	The measured lowest values from step 5 and step 6

Step 8:

Where required (see clause 7.7.2.1 condition 1), the measurements in step 1 to step 7 shall be repeated under extreme test conditions.

7.7.3 Limits

The measured lower frequencies in each test condition shall not be less than the corresponding lower frequency, and the measured upper frequencies in each test condition shall not be greater than the corresponding upper frequency given in Table 27.

Table 27: Emission limits in the out-of-band domain

Reference Bandwidth (RBW_{REF})	Peak power limit	Lower frequency	Upper frequency
1 kHz	-36 dBm / 250 nW	f_{low} – 200 kHz	f_{high} + 200 kHz
1 kHz	0 dBm / 1mW	f_{low}	f_{high}
1 kHz	-36 dBm / 250 nW	f_c- 2,5xCS	f_c+ 2,5xCS
1 kHz	0 dBm / 1mW	f_c- 0,5xCS	f_c+ 0,5xCS

NOTE: f_c is the operating frequency.
f_{low} is the lower edge of the operating frequency band defined in Table 7.
f_{high} is the upper edge of the operating frequency band defined in Table 7.
CS is the channel spacing declared by the provider.

7.8 Unwanted emissions in the spurious domain

7.8.1 Description

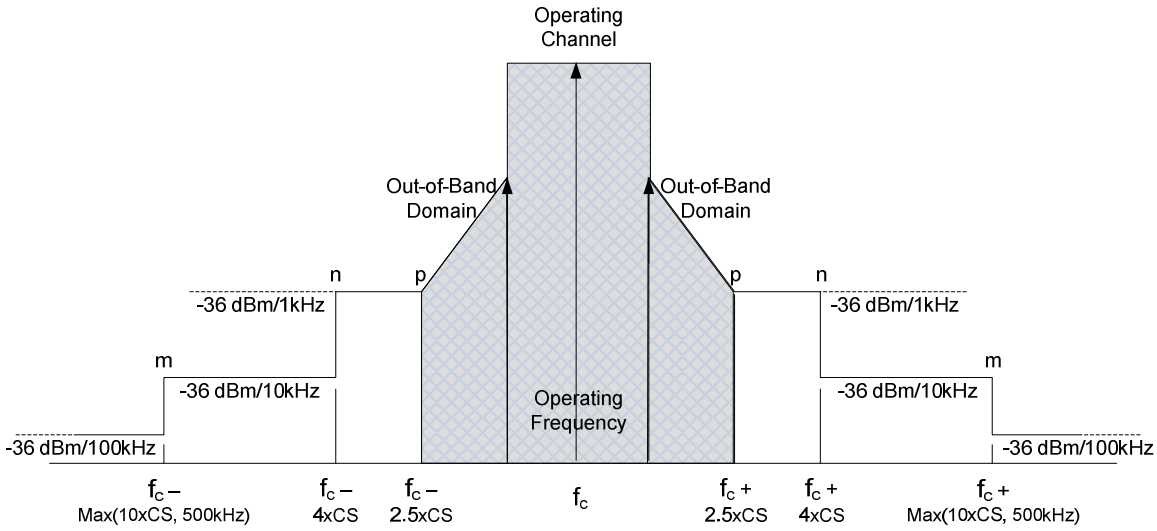


Figure 6: Spectrum Mask for Unwanted Emissions in the Spurious Domain

NOTE: In Figure 6, CS is the channel spacing declared by the provider.

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 6.

7.8.2 Test method

This test shall apply to all EUT.

7.8.2.1 Test conditions

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

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

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

NOTE: See clause 6.5.4 for specific test procedures for non-uniform maximum transmit power.

4) For measurements on transmitters with an e.r.p. exceeding 100 mW, additional external filtering or a spectrum analyzer internal filtering may be used to avoid significant amount of energy from the out-of-band emissions being measured when performing spurious emission measurements close to the out-of-band domain. If additional filtering is used, this shall be stated in the test report.

5) An EUT without a permanent or temporary antenna connector shall be tested according to clause 7.8.2.2.

6) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.8.2.3 and clause 7.8.2.4.

7.8.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.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 in clause 7.8.2.5.2 shall be performed using corresponding radiated measurement methods described in clause B.6.

7.8.2.3 Radiated measurement

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

The EUT shall be connected to an artificial antenna (see clause 6.2.1). The output of the test antenna shall be connected to a measuring receiver.

The measurements in clause 7.8.2.5.2 shall be performed using corresponding radiated measurement methods described in clause B.6.

7.8.2.4 Conducted measurement

The EUT shall be connected to a 50 Ω power attenuator. The output of the power attenuator shall be connected to a measuring receiver. The measurements described in clause 7.8.2.5.1 shall be performed.

7.8.2.5 Measurement procedure

7.8.2.5.1 Conducted measurement

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 measuring receiver shall be tuned over the frequency range shown in Table 28.

Table 28: Conducted Spurious Radiations Measurement Frequency Range

Frequency Range	RBW_{REF} (see note 2)
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 the larger of 10 x channel spacing or 500 kHz. n is 4 x channel spacing. p is 2.5 x channel spacing. The channel spacing is declared by the provider. NOTE 2: See clause 6.6 if the value of RBW used for measurement is different from RBW_{REF}.	

Step 2:

At each frequency at which a spurious component is detected, the spurious emission power level shall be noted as the conducted spurious emission level delivered into the specified load.

Step 3:

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

The measurements in step 2 shall be repeated.

Step 4:

Operation of the EUT shall be restarted with the transmitter in stand-by mode.

Step 2 and step 3 shall be repeated.

Step 5:

The information shown in Table 30 shall be recorded in the test report for each spurious component.

7.8.2.5.2 Radiated measurement

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 measuring receiver shall be tuned over the frequency range shown in Table 29.

Table 29: Radiated Spurious Radiations Measurement Frequency Range

Frequency Range	RBW_{REF} (see note 2)
25 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 the larger of 10 x channel spacing or 500 kHz. n is 4 x channel spacing. p is 2.5 x channel spacing. The channel spacing is declared by the provider. NOTE 2: See clause 6.6 if the value of RBW used for measurement is different from RBW_{REF}.	

Step 2:

For each frequency at which a spurious component is detected the appropriate measurement procedure for the selected test site as described in clause B.1 shall be performed.

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

The substitution measurement defined in clause B.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 polarisation, 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 and shall be noted.

Step 3:

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

The measurements in step 2 shall be repeated.

Step 4:

Operation of the EUT shall be restarted with the transmitter in stand-by mode.

Step 2 and step 3 shall be repeated.

Step 5:

The information shown in Table 30 shall be recorded in the test report for each spurious component.

Table 30: Information Recorded in the Test Report for Unwanted Emissions in the Spurious Domain

Value	Test condition	Notes
Test signal		The test signal used (see clause 6.1)
Frequency	Conducted or radiated	Measured frequency of the spurious component
Power level	Conducted or radiated	Measured conducted or effective radiated power level

7.8.3 Limits

The power of any unwanted emission in the spurious domain shall not exceed the values given in Table 31.

Table 31: 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
Operating	-54 dBm / 4 nW	-36 dBm / 250 nW	-30 dBm / 1 µW
Standby	-57 dBm / 2 nW	-57 dB / 2 nW	- 47 dBm / 20 nW

7.9 Frequency stability under low voltage conditions

7.9.1 Description

The frequency stability under low voltage condition is the ability of the equipment to remain within the operating frequency band when the battery voltage falls below the lower extreme voltage level.

7.9.2 Test method

This test shall apply to all battery operated EUT.

7.9.2.1 Test conditions

1) The measurements shall be performed under normal test conditions.
2) The measurements shall be performed on the highest and lowest frequencies declared by the provider.
3) An EUT without a permanent or temporary antenna connector shall be tested according to clause 7.9.2.2 or clause 7.9.2.4.
4) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.9.2.3.

7.9.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.1 and the measurements in clause 7.9.2.5 performed using corresponding radiated measurement methods described in clause B.6.

7.9.2.3 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 7.9.2.5 shall be performed.

7.9.2.4 Alternate conducted measurement

The EUT shall be installed in the provider's test fixture which shall be connected to the test equipment via an appropriate attenuator.

The measurements in clause 7.9.2.5 shall be performed.

7.9.2.5 Measurement procedure

Table 32: Test Parameters for Frequency Stability under Low Voltage Conditions Measurement

Setting	Value	Notes
Centre frequency	The nominal channel centre frequency	The highest or lowest operating frequency
NOTE: The highest and lowest operating frequencies are declared by the provider.		

The test equipment shall be configured as appropriate for the parameters shown in Table 32.

Step 1:

Operation of the EUT shall be started, on the highest 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 an appropriate step.

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

Step 3:

Step 2 shall be repeated until either the EUT ceases to operate or the voltage reaches zero.

Step 4:

Operation of the EUT shall be restarted, on the lowest 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 5:

Step 2 and step 3 shall be repeated.

Step 6:

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

Table 33: Information Recorded in the Test Report for Frequency Stability Under Low Voltage Conditions

Value	Notes
Test signal	The test signal used (see clause 6.1)
Highest centre frequency	Highest centre frequency valued noted
Lowest centre frequency	Lowest centre frequency value noted

7.9.3 Limits

The measured centre frequencies shall not exceed the limits in Table 34.

Table 34: Frequency Stability under Low Voltage Conditions limits

Requirement	Limit
Highest recorded centre frequency	f_{high} – ½ Channel spacing
Lowest recorded centre frequency	f_{low} + ½ Channel spacing
NOTE: f_{high} is the upper operating frequency band limit. f_{low} is the lower operating frequency band limit. The operating frequency band limits are specified in Table 7. The channel spacing is declared by the provider.	

7.10 Duty cycle

7.10.1 Description

Table 35: Duty Cycle Parameters

Parameter	Value
Duty cycle observation bandwidth	Operating frequency band
Duty cycle observation period	3 600 seconds
Observation bandwidth for short term behaviour	Operating channel
Observation period for short term behaviour	Period for 10 transmissions
NOTE: The operating frequency band is defined in Table 7.	

Duty cycle is expressed with respect to two different observation intervals, aggregate and immediate, which apply to their respective observation bandwidths as shown in Table 35.

7.10.2 Duty cycle

The duty cycle describes the behaviour of transmissions within the aggregate observation frequency band over the aggregate observation period.

7.10.2.1 Test method

This test shall apply to all EUT.

7.10.2.2 Measurement procedure

The maximum duty cycle shall be declared by the provider.

7.10.3 Short term behaviour

Each transmission consists of an RF emission, or sequence of RF emissions separated by intervals < $T_{Disregard}$, in the operating channel. The EUT shall wait a minimum period before beginning a subsequent transmission in the same channel.

The ratio of the longest transmission in the observation period comprised of the sum of the longest transmission + the shortest wait interval (Ton-max/(Ton-max + Toff-min)) defines the short term behaviour in the channel.

7.10.3.1 Test method

This test shall apply to all EUT.

7.10.3.2 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 and channel spacing declared by the provider.

3) This test is performed using a fast power sensing equipment suitable for measurements at 800 - 900 MHz. The test equipment shall be capable of not less than 1M samples/second to provide 1µ second resolution.

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

5) An EUT without a permanent or temporary antenna connector shall be tested according to clause 7.10.3.3 or clause 7.10.3.5.

6) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.10.3.4.

7.10.3.3 Radiated measurement

A suitable test site shall be selected from those described in clause B.1 and the measurements in clause 7.10.3.6 performed using corresponding radiated measurement methods described in clause B.6.

7.10.3.4 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 7.10.3.6 shall be performed.

7.10.3.5 Alternate conducted measurement

The EUT shall be installed in the provider's test fixture which shall be connected to the test equipment via an appropriate attenuator.

The measurements in clause 7.10.3.6 shall be performed.

7.10.3.6 Measurement procedure

Table 36: Test Parameters Settings for Short Term Behaviour Measurement

Setting	Value	Notes
Sample rate	≥ 1M samples/second	Sampling rate for at least 1µ second resolution
Trigger	-	Trigger setting to capture leading edge of first transmission
$P_{Threshold}$	-	Threshold power level indicating presence of EUT transmission
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 as appropriate for the parameters in Table 36 and the power envelope of the EUT transmission.

A suitable value for $P_{Threshold}$ shall be determined.

Step 1:

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

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

The sampled power readings shall be saved.

Step 2:

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

Step 4:

The information shown in Table 37 shall be recorded in the test report.

Table 37: Results Recorded in the Test Report for Short Term Behaviour

Parameter	Value Recorded in the Test Report
Test signal	The test signal used (see clause 6.1)
Highest transmission duration T_{On-Max}	Highest calculated transmission duration
Lowest inter-transmission duration $T_{Off-Min}$	Lowest T_{Off} value

7.10.4 Limits

The declared aggregate duty cycle and the T_{On-Max} and $T_{Off-Min}$ values shall comply with the limits defined in Table 38.

Table 38: Duty Cycle and Transmission Timing Limits

Parameter	Limit	Notes
Duty Cycle	Spectrum access duty cycle limit defined in Table 7	Aggregate duty cycle limit
T_{On-Max}	400 ms	Maximum duration of a transmission from the EUT in the operating channel
$T_{Off-Min}$	400 ms	Minimum interval between transmissions from the EUT in the operating channel

7.11 Automatic / adaptive power control

7.11.1 Description

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.

7.11.2 Test method

This test shall apply to all EUT.

7.11.2.1 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 and channel spacing 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 7.11.2.2.

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 7.

7) An EUT with a permanent or temporary antenna connector shall be tested according to clause 7.11.2.3.

7.11.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.1 and the measurements in clause 7.11.2.4 performed using corresponding radiated measurement methods described in clause B.6.

7.11.2.3 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 7.11.2.4 shall be performed.

7.11.2.4 Measurement procedure

Table 39: Test Parameters Settings for Automatic / Adaptive Power Control Measurement

Parameter	Value	Notes
RBW	Operating frequency band	Operating frequency band as defined in Table 7
Detector Mode	Peak	

The test equipment shall be configured as appropriate for the parameters shown in Table 39.

Step 1:

Two EUTs shall be interconnected as shown in Figure 7. 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.

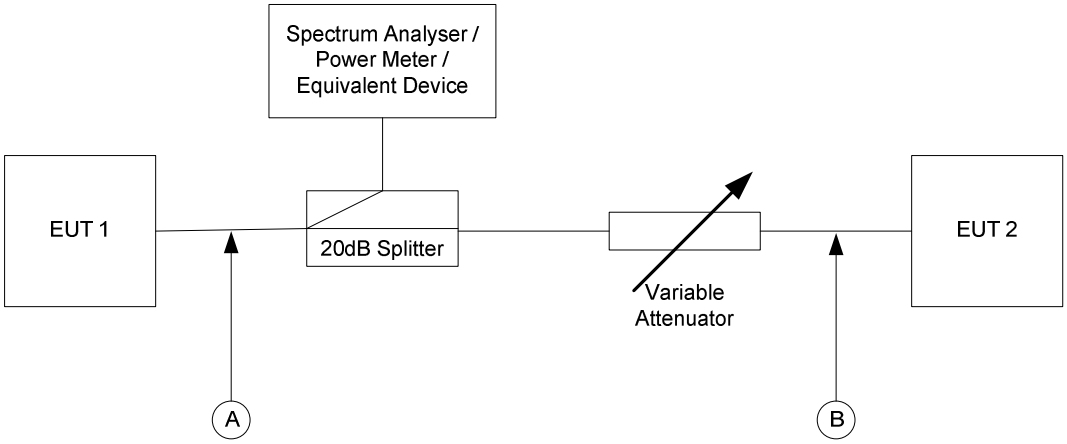


Figure 7: APC Measurement Setup

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 40 shall be recorded in the test report.

Table 40: Information Recorded in the Test Report

Value	Notes
Test signal	The test signal used (see clause 6.1)
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.	

7.11.3 Limits

The peak measured power shall not exceed the value shown in Table 41.

Table 41: APC Power Limit

Parameter	Limit
Transmitted Power	+7dBm / 5mW

8 Methods of measurement and limits for receiver parameters

8.1 General limits

The general limits applying to all receiver parameters in the present document are as shown in Table 7.

8.2 Receiver sensitivity

8.2.1 Description

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

8.2.2 Test method

This test shall apply to EUT with clear channel assessment capability.

8.2.2.1 Test Conditions

1) The measurements shall be performed under normal test conditions.
2) The measurements shall be performed on the highest and lowest operating frequencies as declared by the provider.
3) The EUT shall be operated with any FEC or automatic retransmission facility disabled.
4) The measurements shall be performed for each data rate at which the EUT is able to operate.
5) An EUT without a permanent or temporary antenna connector shall be tested according to clause 8.2.2.2.
6) An EUT with a permanent or temporary antenna connector shall be tested according to clause 8.2.2.3.

8.2.2.2 Radiated measurement

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

The output of a signal generator shall be connected to a transmit test antenna with the same antenna polarisation 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 8.2.2.4 shall be performed using appropriate radiated measurement methods described in clause B.6.

8.2.2.3 Conducted measurement

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

The measurements in clause 8.2.2.4 shall be performed.

8.2.2.4 Measurement procedure

The signal generator, modulated with an appropriate test signal, shall be set to the highest operating frequency, as declared by the provider.

Step 1:

The operation of the EUT shall be started as a receiver on the highest operating frequency, as declared by the provider.

Step 2:

The level of the input signal to the EUT shall be adjusted until the wanted criteria (see clause 4.1) is just exceeded.

Step 3:

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

The receiver sensitivity is the measured signal power.

Step 4:

Steps 1 to 3 shall be repeated with the EUT and signal generator set to the lowest operating frequency, as declared by the provider.

Step 5:

Steps 1 to 4 shall be repeated for each data rate at which the EUT is able to operate.

Step 6:

The information shown in Table 42 shall be recorded in the test report.

Table 42: Information Recorded in the Test Report

Value	Notes
Test signal	The test signal used (see clause 6.1)
Data rate	EUT data rate
FEC or ARQ state	FEC / ARQ enabled or disabled
Operating frequency	Highest or lowest operating frequency
Receiver sensitivity	Measured signal generator power level
NOTE: The highest and lowest operating frequencies are declared by the provider.	

8.2.3 Limits

The receiver sensitivity shall not be higher than the limits given in Table 43.

Table 43: Limits for Receiver Sensitivity

Parameter	Limit
Rx sensitivity	-91 dBm
NOTE: The Rx sensitivity is based on a 50 kbps data rate. For other rates the sensitivity shall be adjusted according to the following formula: $$S = 10\log\frac{R}{R'} - 91 \quad dBm$$ where: • S is the sensitivity in dBm; • R is the EUT data rate in kbps • R' is 50 kbps	

8.3 Clear channel assessment threshold

8.3.1 Description

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

8.3.2 Test method

This test shall apply to EUT with clear channel assessment capability.

8.3.2.1 Test conditions

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

2) 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.

3) An EUT without a permanent or temporary antenna connector shall be tested according to clause 8.3.2.2.

4) An EUT with a permanent or temporary antenna connector shall be tested according to clause 8.3.2.3.

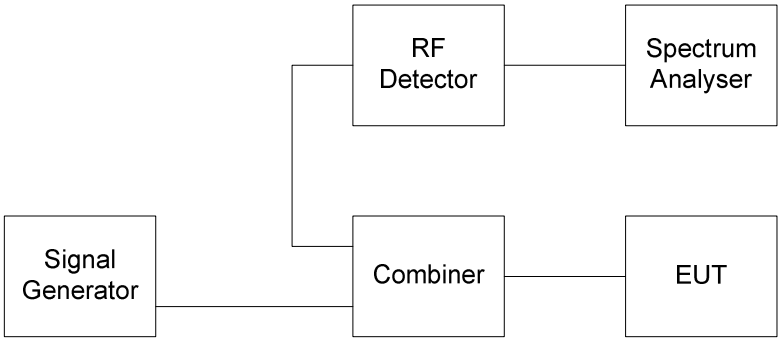


Figure 8: Measurement arrangement

8.3.2.2 Radiated measurement

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

The signal generator together with the combiner, shown in Figure 8, shall be placed outside the test site.

The output of the combiner shall be connected to a transmit test antenna with the same antenna polarisation 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 8.3.2.4 shall be performed using appropriate radiated measurement methods described in clause B.6.

8.3.2.3 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 8.

The measurements in clause 8.3.2.4 shall be performed.

8.3.2.4 Measurement procedure

Table 44: Test Parameters Settings for CCA Threshold Measurement

Setting	Value
Centre frequency	The nominal EUT operating frequency
RBW	Approximately 3 x channel spacing
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 analyzer shall be configured as shown in Table 44.

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 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 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.

Step 4:

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

The measured RF power level is the CCA threshold and shall be noted.

Step 5:

Step 2, step 3 and step 4 shall be repeated.

Step 6:

The information shown in Table 45 shall be recorded in the test report.

Table 45: Information Recorded in the Test Report

Value	Notes
Test signal	The test signal used (see clause 6.1)
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.	

8.3.3 Limits

The CCA threshold shall not exceed the limits given in Table 46.

Table 46: CCA threshold limit

Parameter	Value
CCA threshold	10 dB above Rx sensitivity limit as given in Table 43

8.4 Blocking

8.4.1 Description

Blocking is a measure of the receiver capability 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.

8.4.2 Test method

This test shall apply to EUT with clear channel assessment capability.

8.4.2.1 Test conditions

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

2) 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.

3) An EUT without a permanent or temporary antenna connector shall be tested according to clause 8.4.2.2.

4) An EUT with a permanent or temporary antenna connector shall be tested according to clause 8.4.2.3.

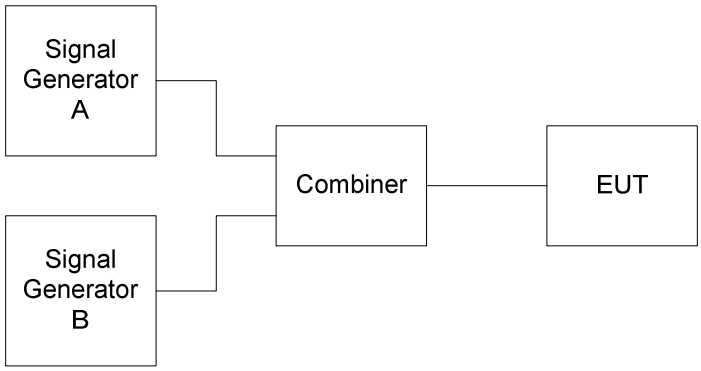


Figure 9: Measurement arrangement

8.4.2.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.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 polarisation 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 8.4.2.4 shall be performed.

8.4.2.3 Conducted measurement

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

The measurements in clause 8.4.2.4 shall be performed.

8.4.2.4 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 ±2 MHz and ±10 MHz, avoiding those frequencies at which spurious responses occur.

Step 1:

Signal generator B shall be powered off.

The level of signal generator A shall be adjusted to the lowest level that gives sufficient response from the EUT.

NOTE: Ensure that the level at the receiver input is not below the sensitivity limit given in clause 8.2.3.

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

Step 2:

Signal generator B is powered on and set to operate at the nominal operating frequency -2 MHz.

Signal generator B level shall be adjusted until the wanted criteria (see clause 4.1) is just exceeded.

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.

With signal generator A settings unchanged its output is connected to the RF power measuring equipment. The power into the measuring equipment shall be measured and noted.

Blocking is the difference between the measured power levels of signal generator B and signal generator A.

Step 3:

For equipment using clear channel assessment the above measurements shall be repeated with the level of signal generator A adjusted +13 dB higher than in the measurements above (this is equal to a level of +16 dB above the sensitivity).

Step 4:

The measurement in steps 1 to 3 shall be repeated with unwanted signal offsets of +2 MHz, -10 MHz and +10 MHz.

Step 5:

The information shown in Table 47 shall be recorded in the test report for each measured signal level and unwanted signal offset:

Table 47: 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
Signal generator B	Power level of signal generator B
Blocking level	Signal generator B – signal generator A
NOTE: The operating centre frequency is declared by the provider.	

8.4.3 Limits

The blocking level shall not be less than the values given in Table 48, except at frequencies on which spurious responses are found.

Table 48: Limits for receiver blocking

Frequency offset	Limit
±2 MHz	35 dB - A
±10 MHz	60 dB - A
NOTE: A = 10 log (R / 50) where R is the data rate in kbps. The limits apply also for the repeated tests in case of equipment using CCA reduced by 13 dB to account for the increased wanted signal level.	

8.5 Receiver spurious radiations

8.5.1 Description

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

8.5.2 Test method

This test shall apply to all EUT.

8.5.2.1 Test conditions

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

2) The EUT shall be operated with normal modulation at its maximum bit rate as declared by the provider.

3) Radiated measurements shall be performed on a test site selected from annex B, with corresponding measurement procedures, which fulfils the measurement requirements for the specified frequency range.

4) An EUT without a permanent or temporary antenna connector shall be tested according to clause 8.5.2.2.

5) An EUT with a permanent or temporary antenna connector shall be tested according to clause 8.5.2.3 and clause 8.5.2.4.

8.5.2.2 Radiated measurement

The EUT shall be placed in a test site selected from those described in clause B.1 using a test antenna of length chosen to correspond to the frequency of the measuring receiver.

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 in clause 8.5.2.5.2 shall be performed using appropriate radiated measurement methods described in clause B.6.

8.5.2.3 Radiated measurement

The EUT shall be placed in a test site selected from those described in clause B.1 using a test antenna of length chosen to correspond to the frequency of the measuring receiver.

The EUT shall be connected to an artificial antenna (see clause 6.2). The output of the test antenna shall be connected to a measuring receiver.

The measurements in clause 8.5.2.5.2 shall be performed using appropriate radiated measurement methods described in clause B.6.

8.5.2.4 Conducted measurement

The EUT shall be connected to a 50 Ω power attenuator. The output of the power attenuator shall be connected to a measuring receiver. The measurements described in clause 8.5.2.5.1 shall be performed.

8.5.2.5 Measurement procedure

8.5.2.5.1 Conducted measurement

Step 1:

The operation of the EUT as a receiver shall be started.

The measuring receiver shall be tuned over the frequency range shown in Table 49.

Table 49: Receiver Spurious Radiations Measurement Frequency Range

Frequency Range
9 kHz - 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.

Step 2:

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

Step 3:

The information shown in Table 50 shall be recorded in the test report for each spurious component.

Table 50: Information Recorded in the Test Report

Value	Notes
Frequency	Frequency of spurious component
Power level	Measured power level of spurious component
NOTE: The power level is the spurious level delivered into the artificial antenna load.	

8.5.2.5.2 Radiated measurement

Step 1:

The operation of the EUT as a receiver shall be started.

The measuring receiver shall be tuned over the frequency range shown in Table 51.

Table 51: Receiver Spurious Radiations Measurement Frequency Range

Frequency Range
25 MHz - 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.

Step 2:

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

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

Step 3:

The substitution measurement defined in clause B.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 polarisation, 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.

Step 4:

The information shown in Table 50 shall be recorded in the test report for each spurious component.

8.5.3 Limits

The power of any spurious emission, radiated or conducted, shall not exceed the values given in Table 52.

Table 52: Spurious Radiation Limits

Frequency range	Maximum Power
< 1 000 MHz	-57 dBm / 2nW
≥ 1 000 MHz	-47 dBm / 20 nW

9 Polite spectrum access

9.1 General limits

The general limits applicable to all polite spectrum access parameters are shown in Table 53.

Table 53: General 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
Longest short control signalling transmission	$< T_{DISREGARD}$ See note 2	Maximum duration of any short control signalling transmission
Dead time	CCA Interval	Maximum time between the end of a listening interval and the start of a transmission
NOTE 1: The minimum unit of deferral period is declared by the provider. NOTE 2: The longest short control signalling transmission is declared by the provider. $T_{DISREGARD}$ is declared by the provider.		

9.2 Listen before talk

9.2.1 Description

In order to make maximum use of the available channels, a polite equipment may use a Listen Before Talk (LBT) protocol with a preferred option of channel adaptivity.

Before transmitting, a device implementing LBT 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 signal 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 LBT device defers its transmission to a later time. The equipment shall not attempt re-transmission on the same channel until a random interval has expired. Alternatively, the equipment may select another channel and again start the listen time before transmission.

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.

For a device with LBT some of the following receiver parameters become essential requirements under the Radio Equipment Directive [i.2]:

- CCA threshold (see clause 8.3)
- Blocking or de-sensitisation (see clause 8.4)

9.2.2 Test method

This test shall apply to all EUT.

9.2.2.1 Measurement procedure

The use of LBT shall be declared by the provider.

If the EUT uses LBT the provider shall also declare:

1) The minimum CCA interval employed.
2) The maximum dead time.
3) The method employed to randomise timing of re-transmission attempts.
4) The units of the deferral period.
5) The minimum and maximum values of the deferral random period.

9.2.3 Limits

The declared listen before talk parameter values shall not exceed the values given in Table 53.

9.3 Short control signalling transmissions

9.3.1 Description

Transmissions may be acknowledged by the receiving device and hence carry information to control whether a transmission should be repeated or considered successful. Since acknowledgement avoids unnecessary re-transmission, it is also considered part of polite spectrum access.

To avoid transmitting long data messages to a destination which is not available to receive them, a device may transmit a short polling message and expect a short confirmation response. If the response is successfully received the long message transmission can be attempted, otherwise the transmission attempt should be re-scheduled for a later time or a different channel. A device may exploit the $T_{Disregard}$ parameter to permit short control signalling messages separated by intervals shorter than the minimum inter-transmission interval.

9.3.2 Test method

This test shall apply to all EUT.

9.3.2.1 Measurement procedure

The use of short control signalling transmissions shall be declared by the provider.

9.3.3 Limits

The declared short control signalling transmission parameter values shall not exceed the values given in Table 53.

9.4 Channel adaptivity

9.4.1 Description

Further improvements in shared access can be achieved if polite short control signalling is combined with LBT and channel adaptivity. Various algorithms may be used to implement channel adaptivity including periodic and event driven decisions to change operating channel. 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.

9.4.2 Test method

This test shall apply to all EUT.

9.4.2.1 Measurement procedure

The use of channel adaptivity shall be declared by the provider.

9.4.3 Limits

No limits are defined for channel adaptivity parameters.

9.5 Coordination of network relay points

9.5.1 Description

Some configurations of network based SRDs may require network relay points to provide interconnection with external networks or services. In such cases, spectrum sharing may be improved by coordination between neighbouring NRPs.

Coordination may be used to manage channel assignments, coordinate traffic or services or determine optimum locations for NRPs as well as other factors which may affect sharing.

The means for coordination may include communications protocols specifically designed for the exchange of coordination and management information or access to, and maintenance of, data bases of NRP information.

9.5.2 Test method

This test shall apply to all EUT.

9.5.2.1 Measurement procedure

The use of NRP coordination procedures shall be declared by the provider.

9.5.3 Limits

No limits are defined for coordination of network relay points parameters.

10 Measurement uncertainty

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

- the measured value related to the corresponding limit shall 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 separately included in the test report;
- the value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in Table 54.

Table 54: Measurement uncertainty

Radio frequency	$\pm 1 \times 10^{-7}$
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
Temperature	±1 °C
Humidity	±10 %

For the test methods, according to the present document the uncertainty figures shall be calculated according to the methods described in the TR 100 028 [2] 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 case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Table 54 is based on such expansion factors.

The particular expansion factor used for the evaluation of the measurement uncertainty shall be stated.

Annex A (normative):
Void

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

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)
- Test fixture for relative measurements

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 B.1. Clause B.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 B.3.

Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in clause 6 of TR 102 273-4 [i.11] for the OATS, in clause 6 of TR 102 273-3 [i.10] for the SAR, and in clause 6 of TR 102 273-2 [i.9] for the FAR.

Information for calculating the measurement uncertainty of measurements on one of these test sites can be found in TR 100 028-1 [2] and TR 100 028-2 [2], TR 102 273-2 [i.9], TR 102 273-3 [i.10] and TR 102 273-4 [i.11].

B.1 Radiation test sites

B.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 B.1.

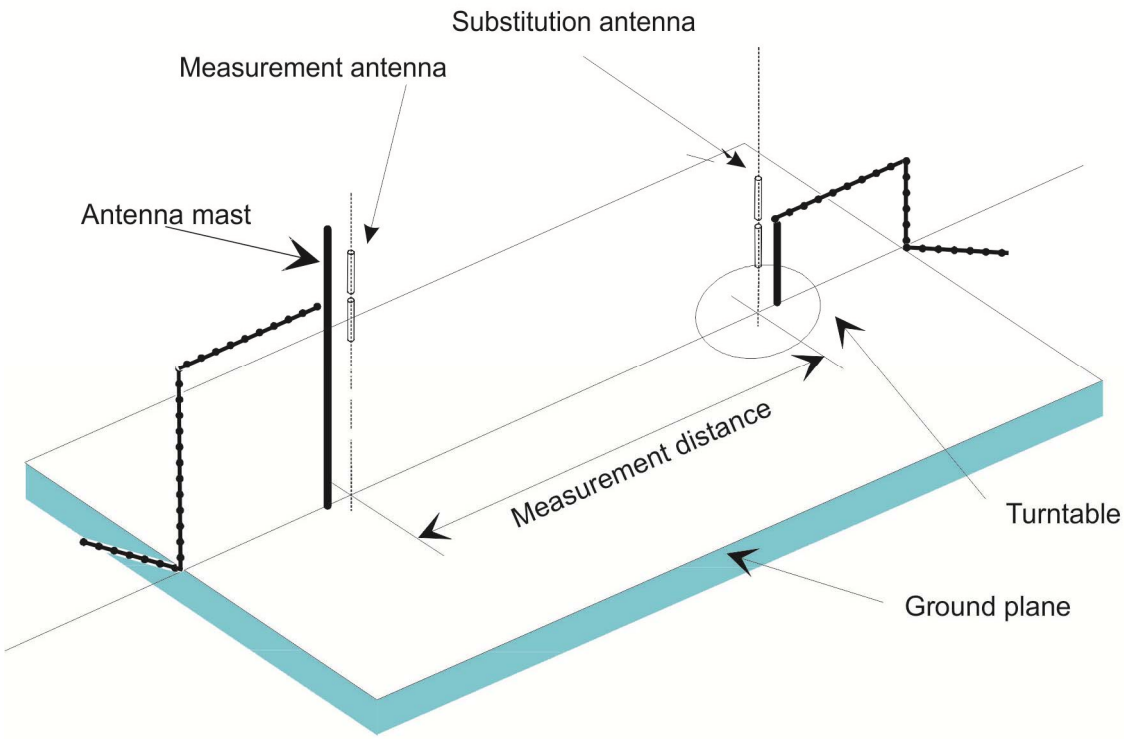


Figure B.1: A typical Open Area Test Site

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 B.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 TR 102 273-4 [i.11].

B.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 B.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.

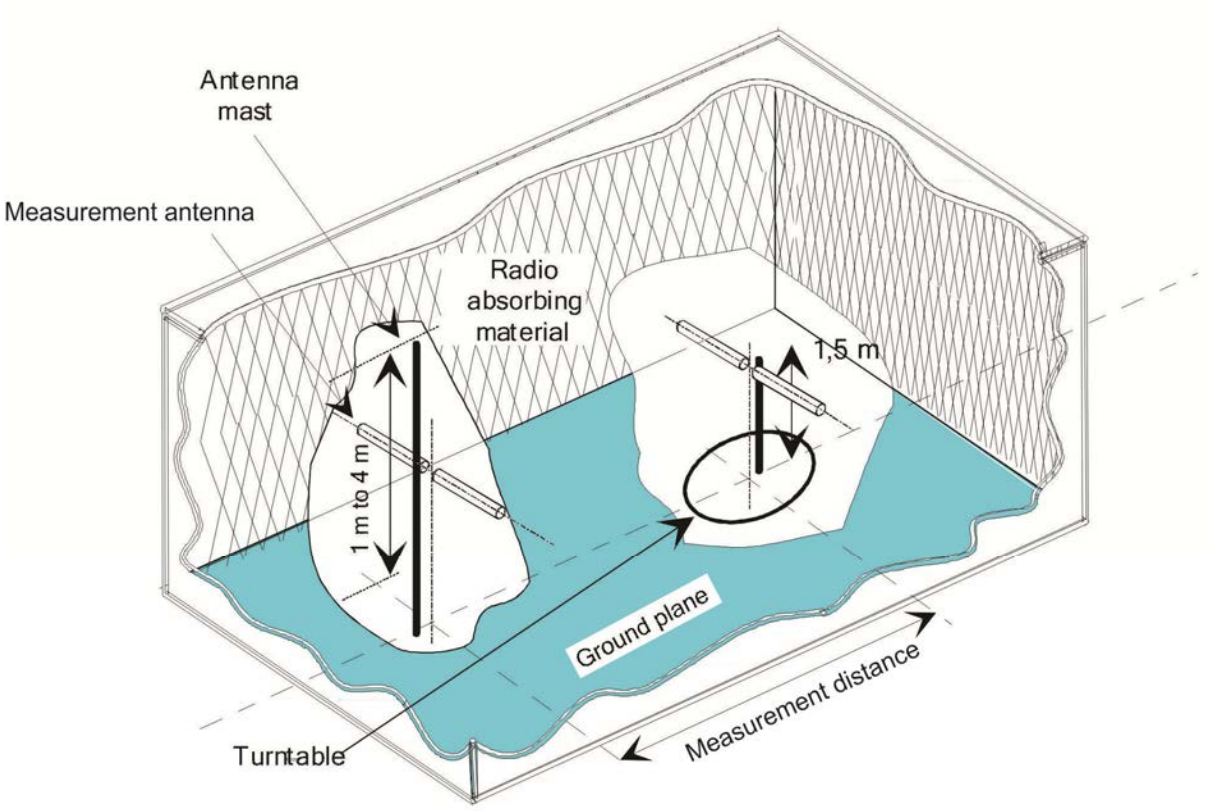


Figure B.2: A typical Semi Anechoic Room

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 B.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 TR 102 273-3 [i.10].

B.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 B.3.

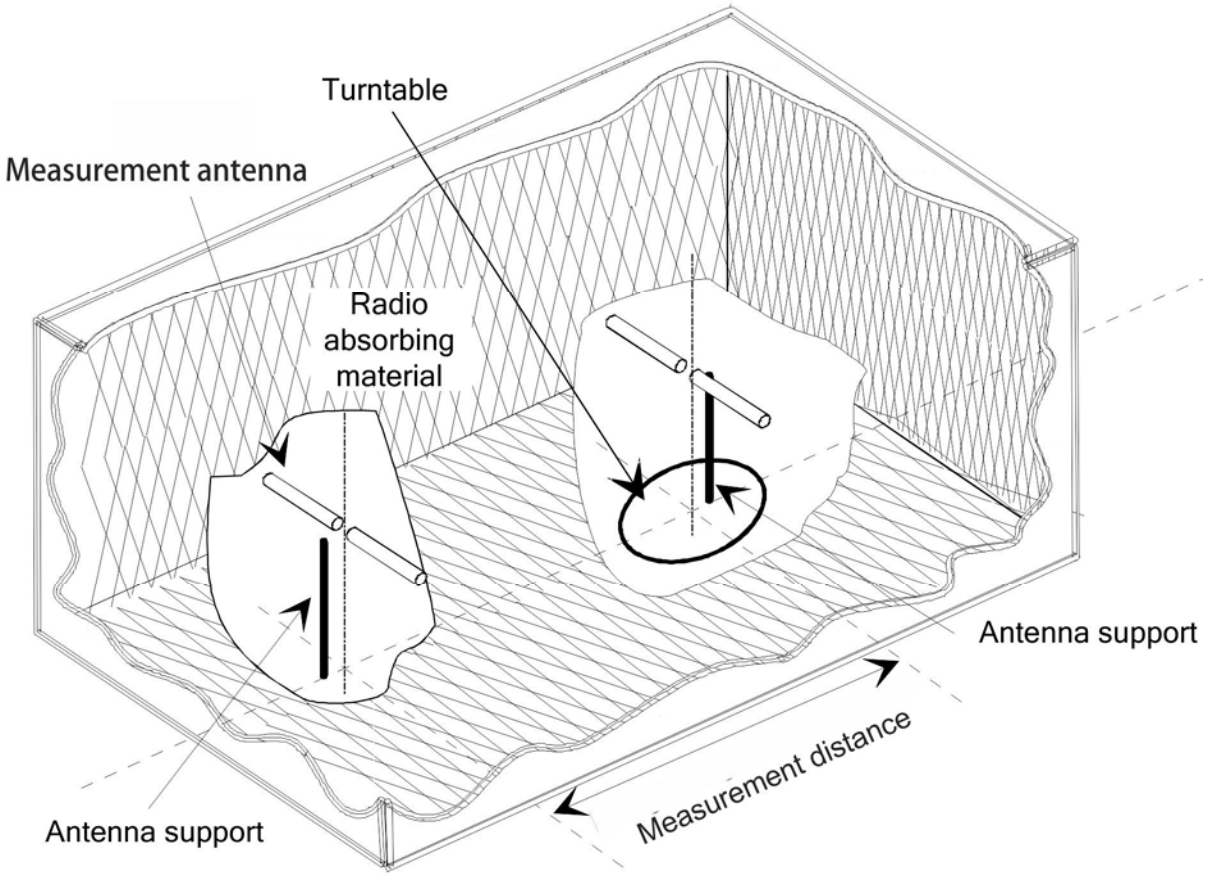


Figure B.3: A typical Fully Anechoic Room

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 shall be measured.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the EUT at a suitable height (e.g. 1 m) above the ground plane.

The measurement distance and minimum chamber dimensions can be found in clause B.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 TR 102 273-2 [i.9].

B.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 $r_{m >>} \frac{D^2}{\lambda}$, 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

$\frac{D^2}{\lambda}$ = 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

For those measurements, 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.

B.2 Antennas

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

B.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.

B.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 the test site (OATS, SAR, FAR) in which it will be used. 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.

B.3 Guidance on the use of radiation test sites

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 B.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. $\frac{\varepsilon}{\varepsilon_0} < 1{,}5$) material(s) such as expanded polystyrene, balsawood, etc.

B.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).

B.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.

B.4 Coupling of signals

B.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).

B.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.

B.5 Void

B.6 Measurement procedures for radiated measurement

This annex gives the general procedures for radiated measurements using the test sites and arrangements described in clause B.1.

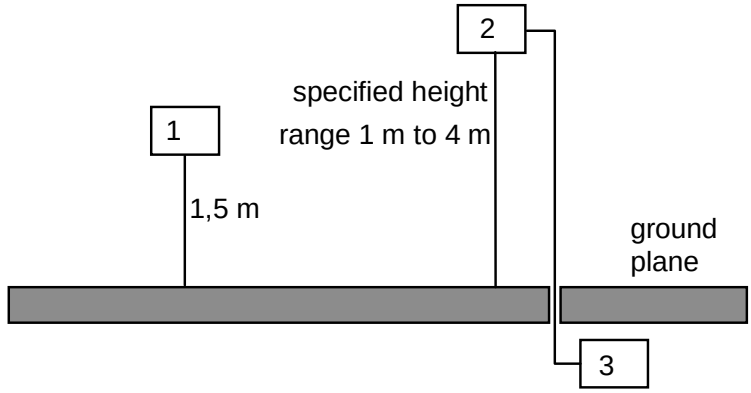
Preferably, radiated measurements shall be performed in a FAR, see clause B.6.2. Radiated measurements in an OATS or SAR are described in clause B.6.1.

B.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 B. The measurement set-up shall be calibrated according to the procedure defined in this annex. 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 B.4) shall be oriented initially for vertical polarization unless otherwise stated and the EUT (device 1 in Figure B.4) shall be placed on the support in its standard position and switched on.

b) The measurement equipment (device 3 in Figure B.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 B.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.

e) Steps c and d shall be repeated. The maximum signal level shall be recorded.

f) 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.

B.6.2 Radiated measurements in a FAR

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

B.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 B.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.

B.7 Guidance for testing technical requirements

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

B.7.1 Essential radio test suites and corresponding test sites

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

Table B.1: Essential radio test suites and corresponding test sites

Essential radio test suite	Clause	Corresponding test site - Clause number(s)
Effective radiated power	7.4	B1.1, B1.2, B1.3
Transient Power	7.5	B1.1, B1.2, B1.3
Tx Spurious Emissions	7.8	B1.1, B1.2, B1.3
Transmitter unwanted emissions in the out-of-band domain	7.7	B1.1, B1.2, B1.3
Rx Sensitivity	8.2	B1.3
Blocking	8.4	B1.3
Rx Spurious Emissions	8.5	B1.1, B1.2, B1.3

Annex C (normative): 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 C.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 7.8), the test fixture bandwidth should exceed 5 times the operating frequency: If this is not the case, a radiated measurement according to clause 7.8 and annex B 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.

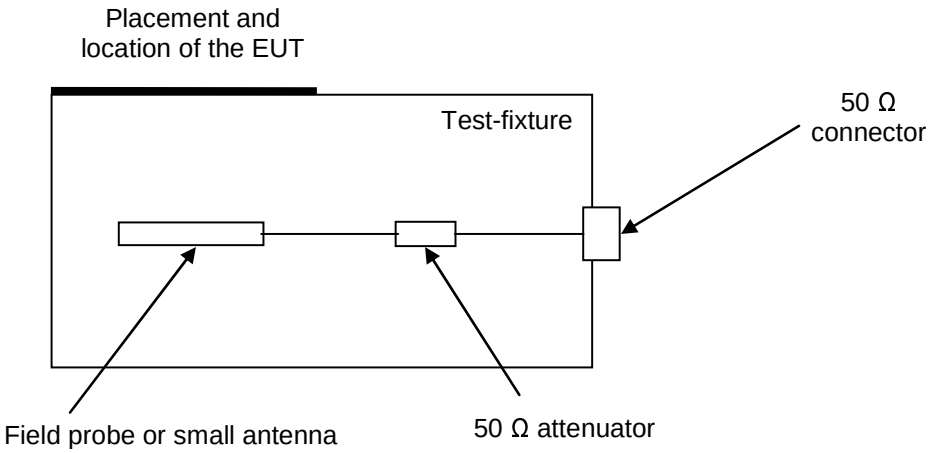


Figure C.1: Test fixture

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

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

C.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 analyzer via the 50 Ω connector. A signal generator has to be set on the EUT's nominal frequency (see Figure C.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 analyzer. 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.

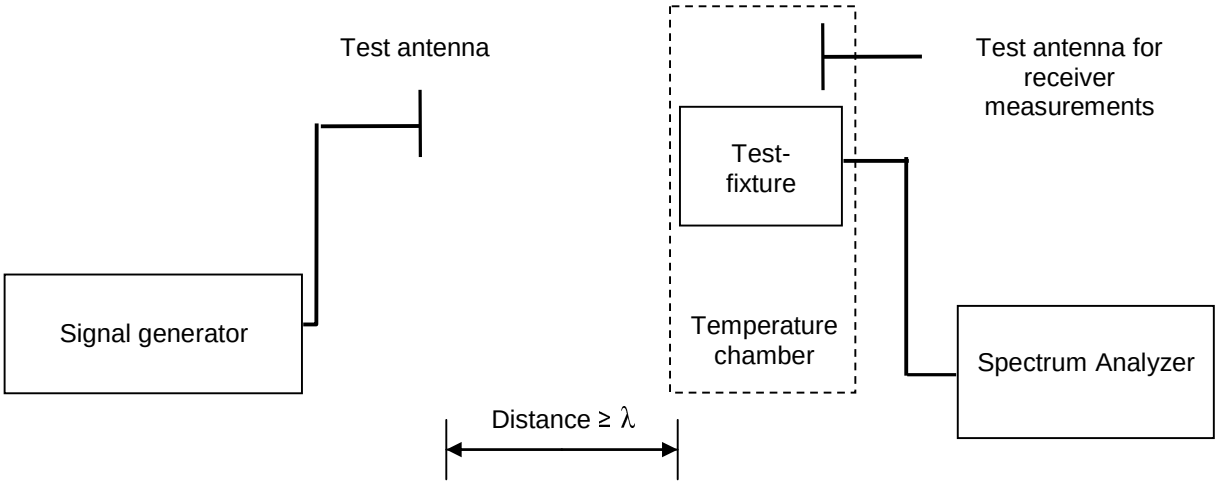


Figure C.2: Validation of test set-up without EUT

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 C.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.

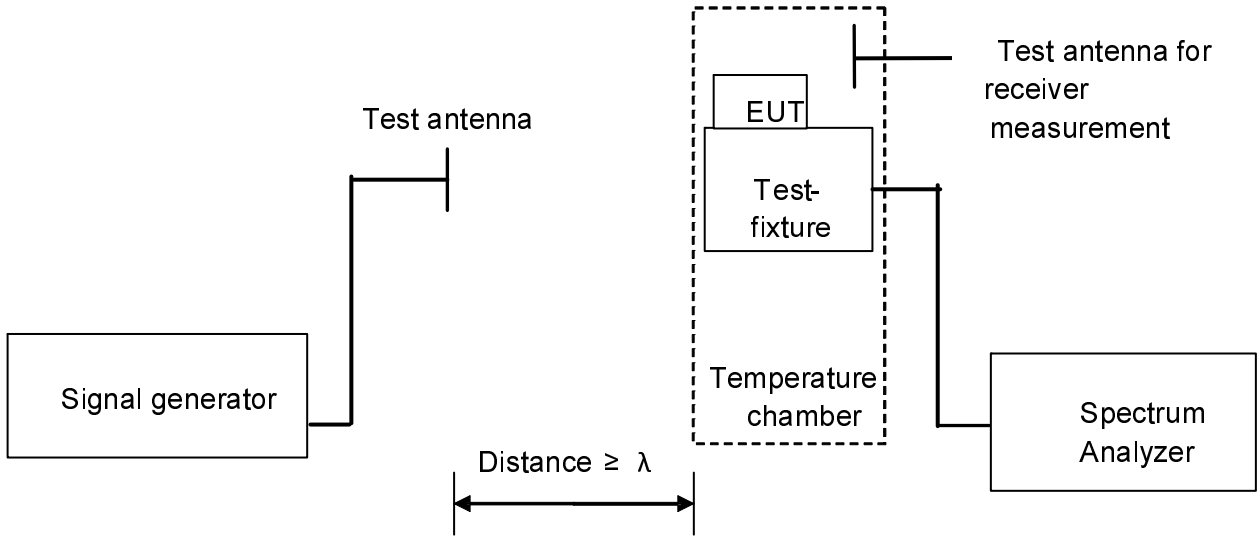


Figure C.3: Validation of test set-up with EUT in place

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 C.4.

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

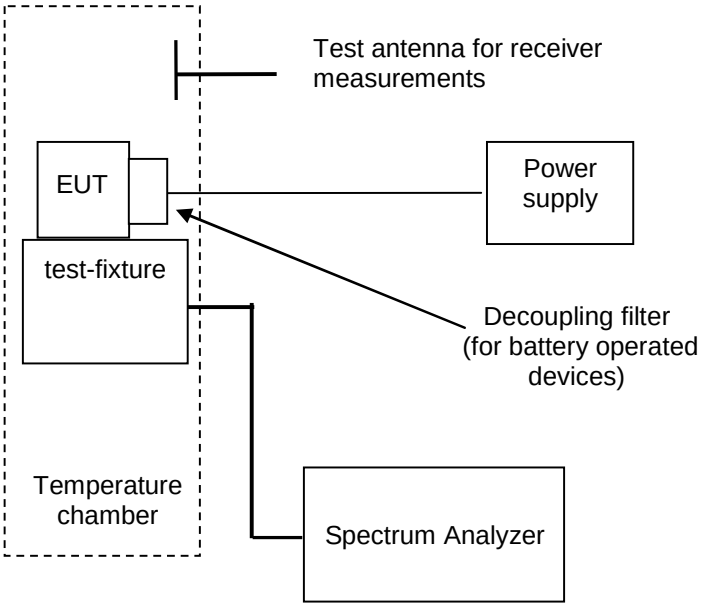


Figure C.4: Test of EUT

C.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 B.

Annex D (normative): Void

Annex E (normative): Technical performance of the 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.

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.

Annex F (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 EN 301 489-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 40 GHz".
- ETSI EN 300 220-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive".
- 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".
- ANSI C63.5 (2006): "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electro Magnetic Interference".
- ITU-R Radio Regulations.

History

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V1.1.1	October 2014	Publication	