

**Electromagnetic compatibility
and Radio spectrum Matters (ERM);
Short range devices;
Radio equipment to be used
in the 1 GHz to 40 GHz frequency range;
Part 1: Technical characteristics and test methods**



Reference

REN/ERM-TG28-0417-1

Keywords

radio, testing, SRD

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Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the Public Enquiry phase of the ETSI standards Two-step Approval Procedure.

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

The present document is part 1 of a multi-part deliverable covering Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range, as identified below:

Part 1: "Technical characteristics and test methods";

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

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

1 Scope

The present document applies to the following Short Range Device major equipment types:

- 1) Generic Short Range Devices, including alarms, identification systems, radio-determination, telecommand, telemetry etc.
- 2) Radio Frequency IDentification (RFID).
- 3) Detecting and movement and alert applications.

These radio equipment types are capable of operating in the permitted frequency bands within the 1 GHz to 40 GHz range as specified in table 1:

- either with a Radio Frequency (RF) output connection and dedicated antenna or with an integral antenna;
- for all types of modulation;
- with or without speech.

Table 1 shows a list of the frequency bands as designated by the European Commission Decision on Short Range Devices and the CEPT ERC Recommendation 70-03 as known at the date of publication of the present document.

Table 1: Short Range Devices within the 1 GHz to 40 GHz permitted frequency bands

	Frequency Bands	Applications	Notes
Transmit and Receive	2 400 MHz to 2 483,5 MHz	Generic use	
Transmit and Receive	2 400 MHz to 2 483,5 MHz	Detecting and movement and alert applications	
Transmit and Receive	(a) 2 446 MHz to 2 454 MHz	RFID	See annex C
Transmit and Receive	(b) 2 446 MHz to 2 454 MHz	RFID	See annex C
Transmit and Receive	5 725 MHz to 5 875 MHz	Generic use	
Transmit and Receive	9 200 MHz to 9 500 MHz	Detecting and movement and alert applications	
Transmit and Receive	9 500 MHz to 9 975 MHz	Detecting and movement and alert applications	
Transmit and Receive	10,5 GHz to 10,6 GHz	For detecting and movement and alert applications	
Transmit and Receive	13,4 GHz to 14,0 GHz	Detecting and movement and alert applications	
Transmit and Receive	17,1 GHz to 17,3 GHz	GBSAR detecting and movement and alert applications	See annex E
Transmit and Receive	24,00 GHz to 24,25 GHz	Generic use and for detecting and movement and alert applications	

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 all designated bands are available in all countries.

In addition, it should be noted that other frequency bands may be available in a country within the frequency range 1 GHz to 40 GHz covered by the present document.

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 an individual or general licence, or as a condition for use under licence exemption

The present document covers fixed stations, mobile stations and portable stations. If a system includes transponders, these are measured together with the transmitter.

When selecting parameters for new SRDs, which may have inherent safety of human life implications, manufacturers and users should pay particular attention to the potential for interference from other systems operating in the same or adjacent bands.

Applications using Ultra Wide Band (UWB) technology are not covered by the present document.

The present document does not require measurements for radiated emissions below 25 MHz.

The present document is intended to cover the provisions of Directive 1999/5/EC [2] (R&TTE Directive), Article 3.2, which states that "..... radio equipment shall be so constructed that it effectively uses the spectrum allocated to terrestrial/space radio communications and orbital resources so as to avoid harmful interference".

In addition to the present document, other ENs that specify technical requirements in respect of essential requirements under other parts of Article 3 of the R&TTE Directive may apply to equipment within the scope of the present document.

NOTE: A list of such ENs is included on the web site <http://www.newapproach.org>.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version 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.

- [1] CISPR 16 (2006) (parts 1-1, 1-4 and 1-5): "Specification for radio disturbance and immunity measuring apparatus and methods; Part 1: Radio disturbance and immunity measuring apparatus".
- [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).
- [3] ITU-T Recommendation O.41: "Psophometer for use on telephone-type circuits".
- [4] ITU-T Recommendation O.153: "Basic parameters for the measurement of error performance at bit rates below the primary rate".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

adjacent and alternate adjacent channels:

- The adjacent channels are those two channels offset from the nominal channel by the nominal channel bandwidth.

- The alternate adjacent channels are those two channels offset from the nominal channel by double the nominal channel bandwidth.

The wanted channel is described by the occupied bandwidth of the wanted emissions, i.e. the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage 0,5 % of the total mean power of a given emission. In addition, the necessary bandwidth of the emissions as defined by the ITU-R radio regulations shall not exceed the wanted channel.

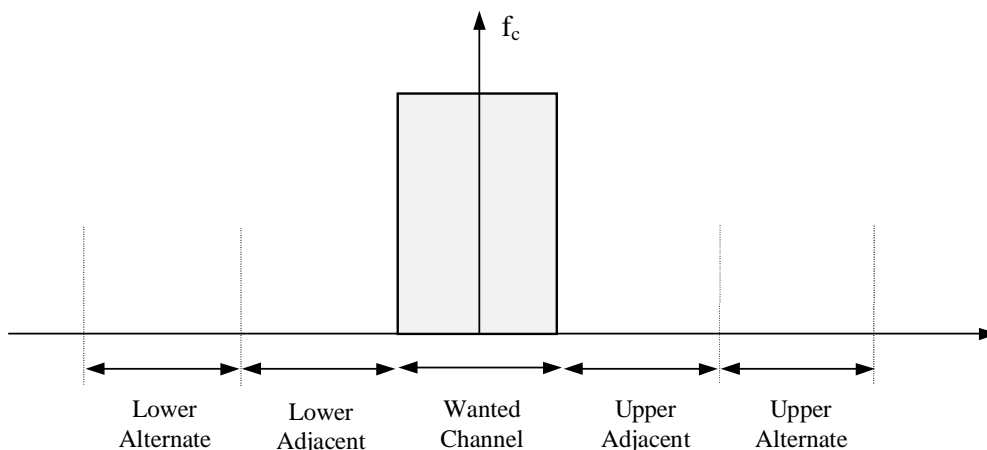


Figure 1: Adjacent and alternate adjacent channel definitions

NOTE: For equipment to be used in a frequency band where channelization is not defined by regulation, the channel spacing of the equipment is defined by the provider.

alarm: use of radio communication for indicating an alarm condition at a distant location

artificial antenna: non-radiating dummy load equal to the nominal impedance specified by the provider

assigned frequency band: frequency band within which the device is authorized to operate and to perform the intended function of the equipment

chip: unit of modulation used in Direct Sequence Spread Spectrum (DSSS) modulation

chip rate: number of chips per second

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

Direct Sequence Spread Spectrum (DSSS): form of modulation where a combination of data to be transmitted and a fixed code sequence (chip sequence) is used to directly modulate a carrier, e.g. by phase shift keying

NOTE: The code rate determines the occupied bandwidth.

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

far-field: tests performed under annex A of the present document are based on far-field measurements for which the far-field is defined by:

$$R \geq 2 D_{\text{ant}}^2 / \lambda \text{ or } \lambda / 2 \text{ whichever is greater}$$

Where D_{ant} is the largest aperture dimension of the radiating antenna or that of the test antenna and R is the measurement distance.

fixed station: equipment intended for use in a fixed location

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

NOTE: Transmitter and receiver follow the same frequency hop pattern. The number of hop positions and the bandwidth per hop position determine the occupied bandwidth.

identification system: equipment consisting of a transmitter(s), receiver(s) (or a combination of the two) and an antenna(s) to identify objects by means of a transponder

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

mobile station: equipment normally fixed in a vehicle or used as a transportable station

necessary bandwidth: width of the emitted frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions

NOTE: The necessary bandwidth including the frequency tolerances shall be accommodated within the assigned frequency band.

Portable station: equipment intended to be carried, attached or implanted

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

operating frequency: nominal frequency at which equipment is operated; this is also referred to as the operating centre frequency

NOTE: Equipment may be able to operate at more than one operating frequency.

operating frequency range: range of operating frequencies over which the equipment can be adjusted through tuning, switching or reprogramming

out of band emissions: emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions

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

radio determination: determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of radio waves

spread spectrum: modulation technique in which the energy of a transmitted signal is spread throughout a large portion of the frequency spectrum

spurious emissions: emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information

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

telecommand: use of radio communication for the transmission of signals to initiate, modify or terminate functions of equipment at a distance

telemetry: use of radio communication for indicating or recording data at a distance

transponder: device which responds to an interrogation signal

Ultra Wide Band technology: technology for short-range radiocommunication, involving the intentional generation and transmission of radio-frequency energy that spreads over a very large frequency range, which may overlap several frequency bands allocated to radiocommunication services as defined in ITU-R Recommendation SM.1755 (see bibliography)

3.2 Symbols

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

D_{ant}	Aperture dimension of the radiating antenna
E	Electrical field strength
E_0	Reference electrical field strength, (see annex A)
f	Frequency
P	Power
R	Distance
R_0	Reference distance, (see annex A)
t	Time
λ	wavelength

3.3 Abbreviations

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

DAA	Detect And Avoid spectrum access technique
dB	Decibel
dB _i	gain in decibels relative to an isotropic antenna
DSSS	Direct Sequence Spread Spectrum
e.i.r.p.	equivalent isotropically radiated power
EMC	ElectroMagnetic Compatibility
ERC	European Radiocommunication Committee
FHSS	Frequency Hopping Spread Spectrum
GBSAR	Ground Based Synthetic Aperture Radar
ITU-R	International Telecommunications Union, Radio Sector
ITU-T	International Telecommunications Union, Telecommunications Sector
LBT	Listen Before Talk spectrum access technique
R&TTE	Radio and Telecommunications Terminal Equipment
RF	Radio Frequency
RFID	Radio Frequency Identification
SND/ND	Signal + Noise + Distortion divided by Noise + Distortion
SRD	Short Range Device
Tx	Transmitter
UWB	Ultra Wide Band
VSWR	Voltage Standing Wave Ratio

4 Technical requirements specifications

4.1 General requirements

4.1.1 Receiver category

The product family of short range radio devices is divided into three receiver categories, see table 2, each having its own set of minimum performance criteria associated to technical requirements as relevant. Each set of requirements is conditional to equipment provider's choice.

The provider shall specify the receiver category of his choice and this shall be declared in the product literature. In particular where an SRD which may have an inherent safety of human life implications, manufacturers and users should pay particular attention to the potential for interference from other systems operating in the same or adjacent bands.

Table 2: Receiver categories

Receiver category	Relevant receiver clauses	Risk assessment of receiver performance
1	8.1, 8.2 and 8.3	Highly reliable SRD communication media; e.g. serving human life inherent systems (may result in a physical risk to a person).
2	8.2 and 8.3	Medium reliable SRD communication media e.g. causing Inconvenience to persons, which cannot simply be overcome by other means.
3	8.3	Standard reliable SRD communication media e.g. Inconvenience to persons, which can simply be overcome by other means (e.g. manual).

If receiver category 1 or 2 is selected this shall be stated in both the test report and in the users manual for the equipment.

4.1.2 General performance criteria

For the purpose of the receiver performance tests, the receiver will produce an appropriate output under normal conditions as indicated below. Where the indicated performance cannot be achieved, the provider shall declare and publish the performance criteria used to determine the performance of the receiver:

- a SND/ND ratio of 20 dB, measured at the receiver output through a telephone psophometric weighting network as described in ITU-T Recommendation O.41 [3]; or
- after demodulation, a data signal with a bit error ratio of 10^{-2} without correction; or
- after demodulation, a message acceptance ratio of 80 %;
- an appropriate false alarm rate or sensing criteria as declared by the provider.

4.2 Presentation of equipment for testing purposes

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.

Where appropriate testing should be carried out on suitable frequencies for the equipment concerned.

If an equipment is designed to operate with different carrier powers, measurements of each transmitter parameter shall be performed at the highest power level at which the transmitter is intended to operate.

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

A test fixture for equipment with an integral antenna may be supplied. (see clause 6.3).

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 4.2.3.2.

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 equipment, as appropriate, shall be tested.

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

If an equipment has several optional features, considered not to affect the RF parameters then the tests need only to be performed on the equipment configured with that combination of features considered to be the most complex. Where practicable, equipment offered for testing shall provide a 50 Ω connector for conducted RF power measurements.

In the case of integral antenna equipment, if the equipment does not have a internal permanent 50 Ω connector then it is permissible to supply a second sample of the equipment with a temporary 50 Ω antenna connector fitted to facilitate testing, see clause 4.2.3.

4.2.2 Testing of equipment with alternative power levels

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.i.r.p.) and spurious emissions shall be performed for each combination and shall be stated in the test report.

4.2.3 Testing of equipment that does not have an external 50 Ω RF connector (integral antenna equipment)

4.2.3.1 Equipment with an internal permanent or temporary antenna connector or using a dedicated test fixture

The means to access and/or implement the internal permanent or temporary antenna connector shall be stated with the aid of a diagram. Alternately, a suitable test fixture may be provided by the provider. The fact that use has been made of the internal antenna connection, or of a temporary connection or a suitable test fixture, to facilitate measurements shall be recorded in the test report.

For further information on the test fixture, see clause 6.3.

4.2.3.2 Equipment with a temporary antenna connector

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

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

4.3 Mechanical and electrical design

4.3.1 General

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.

Transmitters and receivers may be individual or combination units.

4.3.2 Controls

Those controls which, if maladjusted, might increase the interfering potentialities of the equipment shall not be easily accessible to the user.

4.3.3 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.

4.3.4 Receiver mute or squelch

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 this not possible, a proper test method shall be described and documented.

4.3.5 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 users' manual, packaging or guarantee material.

4.3.5.1 Equipment identification

The marking shall include as a minimum:

- the name of the manufacturer or his trademark;
- the type designation;
- receiver category, see clause 4.1.1.

4.3.5.2 Marking

The equipment shall be marked in a visible place. This marking shall be legible and durable. In cases where the equipment is too small to carry the marking, it is sufficient to provide the relevant information in the users' manual.

4.4 Auxiliary test equipment

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

4.5 Interpretation of the measurement results

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

- the measured value relating to the corresponding limit shall be used to decide whether an equipment meets the requirements of the present document;
- the measurement uncertainty value for the measurement of each parameter shall be included in the test report;
- the recorded value of the measurement uncertainty shall, for each measurement, be equal to, or lower than, the figures in the table of measurement uncertainty (see clause 10).

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.

The test conditions and procedures shall be as specified in clauses 5.2 to 5.4.

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 should be so arranged so as not to affect the measurements.

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

5.2.2 Internal test power source

For radiated measurements on portable equipment with integral antenna, fully charged internal batteries should be used. The batteries used should 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 $< \pm 5$ % 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 $+15^{\circ}\text{C}$ to $+35^{\circ}\text{C}$;
- 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

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 accredited 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): 0°C to +55°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 $\pm 10\%$. 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 nominal voltage is considered to be the upper extreme test voltage in this case.

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 conditions

6.1 Normal test signals and test modulation

The test modulating signal is a signal which modulates a carrier, is dependent upon the type of equipment under test and also the measurement to be performed. Modulation test signals only apply to products with an external modulation connector. For equipment without an external modulation connector, normal operating modulation shall be used.

Where appropriate, a test signal shall be used with the following characteristics:

- representative of normal operation;
- causes greatest occupied RF bandwidth.

For equipment using intermittent transmissions the test signal shall be such that:

- the generated RF signal is the same for each transmission;
- transmissions occur regularly in time;
- sequences of transmissions can be accurately repeated.

Details of the test signal shall be recorded in the test report.

Normal operating modulation shall be used, where there is no provision for external test modulation. For narrow band speech (≤ 120 kHz RF bandwidth) an unmodulated signal shall be used.

6.1.1 Normal test signals for data

Where the equipment has an external connection for general data modulation, the normal test signals are specified as follows:

- D-M2: a test signal representing a pseudo-random bit sequence of at least 511 bits in accordance with ITU-T Recommendation O.153 [4]. This sequence shall be continuously repeated. If the sequence cannot be continuously repeated, the actual method used shall be stated in the test report.
- 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.

6.2 Artificial antenna

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

6.3 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 may 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 test 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 coupler attenuation of the test-fixture may amount to a maximum of the noise level of the measurement instrument +10 dB. If the attenuation is too great it can be compensated by linear amplification outside the test-fixture.

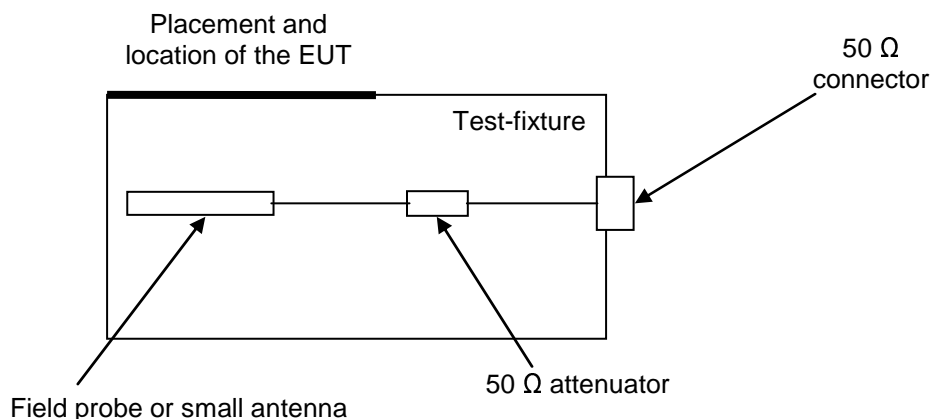


Figure 2: Test fixture

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

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

6.3.1 Validation of the test-fixture in the temperature chamber

The test fixture is brought into a temperature chamber.

Step 1:

A transmit antenna connected to a signal generator will 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 will 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 3). 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 may not deviate more than 1 dB from the value at the nominal frequency.

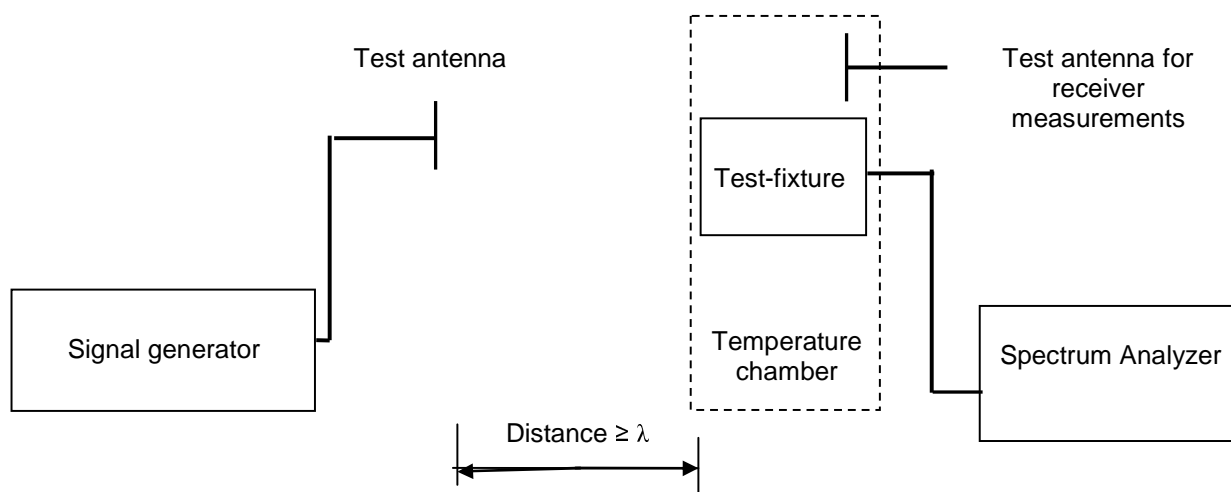


Figure 3: Validation of test set-up without EUT

If receiver tests are needed, 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 has to be fitted to the test fixture in a switched-off mode. Step 1 has to be repeated, this time with the EUT in place. The measured values will 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.

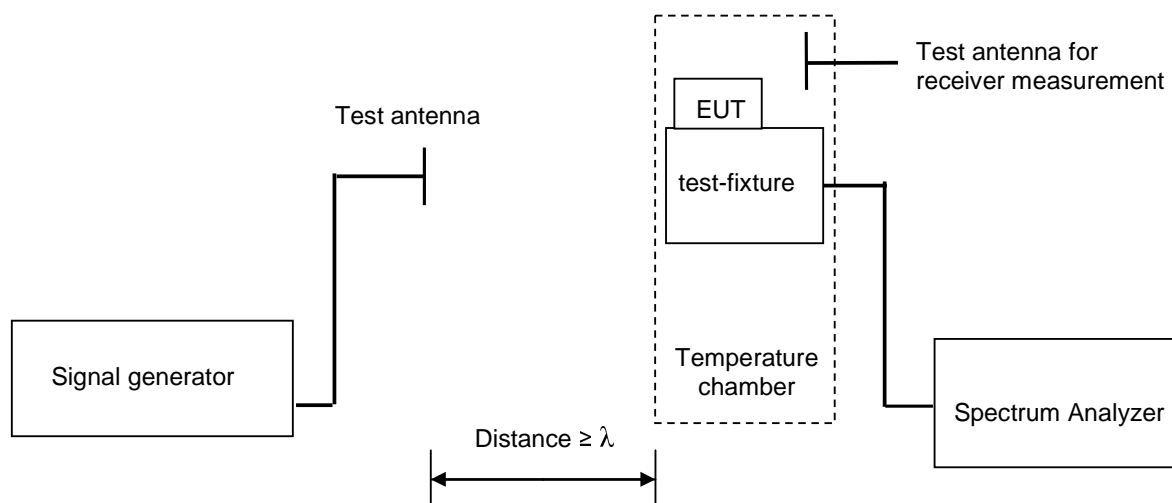


Figure 4: Validation of test set-up with EUT in place

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 5).

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

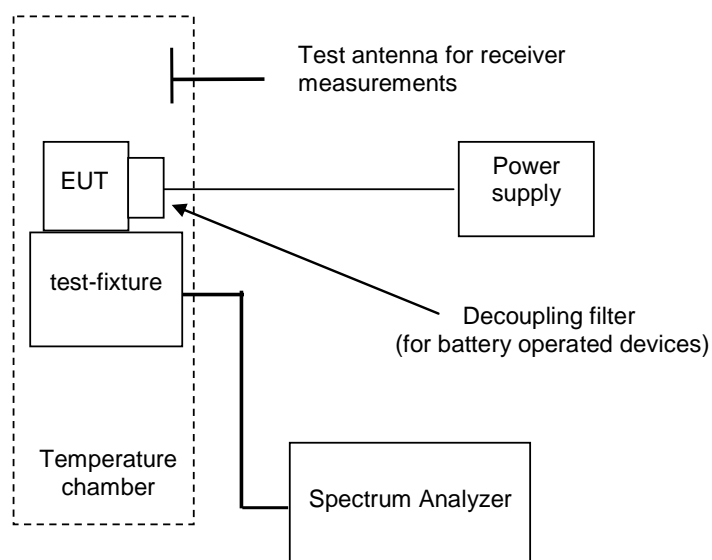


Figure 5: Test of EUT

6.3.2 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 A.

6.4 Test sites and general arrangements for radiated measurements

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

6.5 Measuring receiver

The term "measuring receiver" refers to a frequency-selective voltmeter or a spectrum analyser. The bandwidth of the measuring receiver shall be as given in table 3.

Table 3

Frequency: (f)	Measuring receiver bandwidth
$30 \text{ MHz} \leq f \leq 1\,000 \text{ MHz}$	100/120 kHz
$f > 1\,000 \text{ MHz}$	1 MHz

7 Methods of measurement and limits for transmitter parameters

Where the transmitter is designed with adjustable carrier power, then all transmitter parameters shall be measured using the highest power level, as declared by the provider. The equipment shall then be set to the lowest carrier power setting, as declared by the provider, and the measurements for spurious emissions shall be repeated (see clause 7.3).

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

NOTE: The maximum duty cycle of the transmitter under test should not be confused with the duty cycle of the equipment under normal operating 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 transmit-on time shall be stated and where applicable the test laboratory, this time shall not be exceeded and details shall be stated in the test report.

If the equipment to be tested is designed with a permanent external 50 Ω RF connector and a dedicated or integral antenna, then full tests shall be carried out using this connector. If the RF connector is not 50 Ω a calibrated coupler or attenuator shall be used to provide the correct termination impedance, to facilitate the measurements. The equivalent isotropically radiated power is then calculated from the declared antenna gain.

In addition, the following tests shall be carried out with the dedicated or integrated antenna:

- equivalent isotropically radiated power (see clause 7.1);
- spurious emissions (see clause 7.3).

The equipment shall fulfil the requirements of the stated measurements.

7.1 Equivalent isotropically radiated power (e.i.r.p.)

7.1.1 Definition

The e.i.r.p. is defined as the maximum radiated power of the transmitter and its antenna, and is measured and calculated according to the procedure given in the following clause. See clause 5 for the test conditions.

7.1.2 Method of measurement

Using the applicable measurement procedure as described in annex B, the power output shall be measured and recorded in the test report. The method of measurement shall be documented in the test report.

In order to measure e.i.r.p. it is first necessary to determine the appropriate method of measurement to be used: see clauses 7.1.2.1 and 7.1.2.2. The -6 dB transmitter bandwidth shall be determined using a 100 kHz measuring bandwidth in order to establish which measurement method is applicable.

Measurements shall be performed at normal and extreme conditions (see clauses 5.3 and 5.4).

Where possible, the equipment shall be able to operate in a continuous transmit mode for testing purposes.

7.1.2.1 Non spread spectrum transmitters with a -6 dB bandwidth of up to 20 MHz and spread spectrum transmitters with channel bandwidth of up to 1 MHz

This method of measurement in clauses 7.1.2.1.1 or 7.1.2.1.2 shall only be used for:

- non spread spectrum equipment with a -6 dB bandwidth of 20 MHz or less and a duty cycle above 50 %;
- spread spectrum equipment with a -6 dB channel bandwidth of 1 MHz or less.

For peak power measurements, a spectrum analyser or frequency-selective voltmeter shall be used and tuned to the transmitter carrier at which the highest level is detected.

For FHSS systems, the hop frequency which provides the maximum indicated level shall be used. The frequency shall be indicated in the test report.

Other transmitters are tested according to clause 7.1.2.2.

7.1.2.1.1 Equipment measured as constant envelope modulation equipment

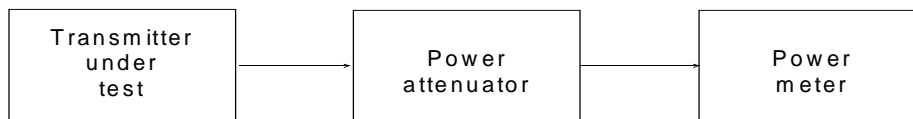


Figure 6: Measurement arrangement

For practical reasons, measurements shall be performed only at the highest power level at which the transmitter is intended to operate. The measurement arrangement in figure 6 shall be used.

The measurement shall be performed preferably in the absence of modulation.

When it is not possible to measure it in the absence of modulation, this fact shall be stated in test reports.

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

The transmitter shall be connected to an artificial antenna (see clause 6.2) and the power delivered to this artificial antenna shall be measured.

The equivalent isotropically radiated power is then calculated from the measured value, the known antenna gain, relative to an isotropic antenna, and if applicable, any losses due to cables and connectors in the measurement system.

7.1.2.1.2 Equipment measured as non-constant envelope modulation equipment

The measurement shall be performed with test signals D-M2 or D-M3 as appropriate.

The transmitter shall be preferably set in continuous transmission mode. If this is not possible, the measurement can be performed in discontinuous mode.

The transmitter shall be connected to an artificial antenna (see clause 6.2) and the power delivered to this artificial antenna shall be measured. The measuring instrument shall have a measurement bandwidth not less than sixteen times the channel bandwidth.

The equivalent isotropically radiated power is then calculated from the measured value, the known antenna gain, relative to an isotropic antenna, and if applicable, any losses due to cables and connectors in the measurement system.

7.1.2.2 Other transmitters than defined in clause 7.1.2.1

This method of measurement shall be used for:

- a) equipment with a -6 dB bandwidth greater than 20 MHz;
- b) equipment with a duty cycle below 50 %;
- c) spread spectrum equipment with a channel bandwidth above 1 MHz.

The equivalent isotropically radiated power shall be determined and recorded.

In case of radiated measurements on smart antenna systems using symmetrical power distribution across the available transmit chains, the EUT should, where possible, be configured so that only one transmit chain (antenna) is activated while the other transmit chains are disabled. Where this is not possible, the method used shall be documented in the test report. If only one transmit chain was tested, the result for the active transmit chain shall be corrected to be valid for the whole system (all transmit chains).

NOTE: The power (in mW) for one transmit chain need to be multiplied with the number of transmit chains to obtain the total power for the system.

The measurement shall be performed using normal operation of the equipment with the test modulation (see clause 6.1) applied.

The test procedure shall be as follows:

Step 1:

- using a suitable means, the output of the transmitter shall be coupled to a matched diode detector;
- the output of the diode detector shall be connected to the vertical channel of an oscilloscope;
- the combination of the diode detector and the oscilloscope shall be capable of faithfully reproducing the envelope peaks and the duty cycle of the transmitter output signal;
- the observed duty cycle of the transmitter (Tx on/(Tx on + Tx off)) shall be noted as x, ($0 < x < 1$) and recorded.

Step 2:

- the average output power of the transmitter shall be determined using a wideband, calibrated RF power meter with a matched thermocouple detector or an equivalent thereof and, where applicable, with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as "A" (in dBm);
- the e.i.r.p. shall be calculated from the above measured power output A, the observed duty cycle x, and the applicable antenna assembly gain "G" in dBi, according to the formula:
 - $P = A + G + 10 \log (1/x)$;
 - P shall not exceed the value specified in clause 7.1.3.

The measurement shall be repeated at the lowest, the middle, and the highest frequency of the stated frequency range. These frequencies shall be recorded. FHSS equipment shall be made to hop continuously to each of these three frequencies separately.

7.1.3 Limits

The transmitter maximum e.i.r.p. under normal and extreme test conditions shall not exceed the values given in table 4.

Table 4: Maximum radiated peak power (e.i.r.p.)

Frequency Bands	Power	Application	Notes
2 400 MHz to 2 483,5 MHz	10 mW e.i.r.p.	Generic use	
2 400 MHz to 2 483,5 MHz	25 mW e.i.r.p.	Detecting and movement and alert applications	
(a) 2 446 MHz to 2 454 MHz	500 mW e.i.r.p.	RFID	See table 4, table 7 and annex C
(b) 2 446 MHz to 2 454 MHz	4 W e.i.r.p.	RFID	See table 4, table 7 and annex C
5 725 MHz to 5 875 MHz	25 mW e.i.r.p.	Generic use	
9 200 MHz to 9 500 MHz	25 mW e.i.r.p.	Detecting and movement and alert applications	
9 500 MHz to 9 975 MHz	25 mW e.i.r.p.	Detecting and movement and alert applications	
10,5 GHz to 10,6 GHz	25 mW e.i.r.p.	For detecting and movement and alert applications	
13,4 GHz to 14,0 GHz	25 mW e.i.r.p.	Detecting and movement and alert applications	
17,1 GHz to 17,3 GHz	400 mW e.i.r.p.	GBSAR detecting, movement and alert applications	See annex E
24,00 GHz to 24,25 GHz	100 mW e.i.r.p.	Generic use and detecting and movement and alert applications	

7.2 Permitted range of operating frequencies

The frequency range of the equipment is determined by the lowest and highest frequencies occupied by the power envelope in accordance with clause 7.1.3, table 4.

F_H is the highest frequency of the power envelope, it is the frequency furthest above the frequency of maximum power where the output power drops below the level of -75 dBm/Hz spectral power density (e.g. -30 dBm if measured in a 30 kHz reference bandwidth) e.i.r.p.

F_L is the lowest frequency of the power envelope; it is the frequency furthest below the frequency of maximum power where the output power drops below the level of -75 dBm/Hz spectral power density (e.g. -30 dBm if measured in a 30 kHz reference bandwidth) e.i.r.p.

The power envelope shall contain the occupied bandwidth representing 99 % of the emissions.

The occupied and necessary bandwidths of the transmitter shall be specified. Where differing modes of emission are available, all modes and their associated bandwidths shall be stated.

7.2.1 Definition

The permitted range of operating frequencies includes all frequencies on which the equipment may operate within an assigned frequency band. The operating frequency range shall be declared by the manufacturer.

The range of frequencies, determined by clause 7.2, shall be specified in the test report.

7.2.2 Method of measurement

The method of measurement for equipment employing FHSS and stepped frequency modulation are given in clause 7.2.3.

Using applicable conducted measurement procedures, as described in annex B, the frequency range(s) shall be measured and recorded in the test report.

Where applicable, during these measurements the test data sequence as specified in clauses 6.1 and 6.1.1 shall be used. The transmitter power level shall be set to the rated power level.

These measurements shall be performed under both normal and extreme operating conditions except for the occupied bandwidth assessment for which measurement at normal operating conditions is sufficient.

The measurement procedure shall be as follows:

- a) put the spectrum analyser in video averaging mode with a minimum of 50 sweeps selected;
- b) select the lowest operating frequency of the equipment under test and activate the transmitter with modulation applied. The RF emission of the equipment shall be displayed on the spectrum analyser;
- c) using the marker of the spectrum analyser, find lowest frequency below the operating frequency at which spectral power density drops below the level given in clause 7.2 This frequency shall be recorded in the test report;
- d) select the highest operating frequency of the equipment under test and find the highest frequency at which the spectral power density drops below the value given in clause 7.2. This frequency shall be recorded in the test report;
- e) the difference between the frequencies measured in steps c) and d) is the operating frequency range. It shall be recorded in the test report.

This measurement shall be repeated for each frequency range declared by the manufacturer.

7.2.3 Method of measurement for equipment using FHSS modulation

Using an applicable conducted measurement procedure as described in annex B the frequency range of the equipment shall be measured and recorded in the test report.

During these measurements the test data sequence, as specified in clause 6.1, shall be used.

The transmitter power level shall be set to the rated power level.

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

The measurement procedure shall be as follows:

- a) put the spectrum analyser in video averaging mode with a minimum of 50 sweeps selected;
- b) select the lowest hop frequency of the equipment under test and activate the transmitter with modulation applied;
- c) find the lowest frequency below the operating frequency at which spectral power density drops below the level given in clause 7.2. This frequency shall be recorded in the test report;
- d) select the highest hop frequency of the equipment under test and find the highest frequency at which the spectral power density drops below the level given in clause 7.2. This frequency shall be recorded in the test report;
- e) the difference between the frequencies measured in steps c) and d) is the frequency range. It shall be recorded in the test report.

This measurement shall be repeated for each operating frequency range declared by the manufacturer.

7.2.4 Limit

The width of the power spectrum envelope is $f_H - f_L$ for a given operating frequency. In equipment that allows adjustment or selection of different operating frequencies, the power envelope takes up different positions in the allowed band. The frequency range is determined by the lowest value of f_L and the highest value of f_H resulting from the adjustment of the equipment to the lowest and highest operating frequencies.

The occupied bandwidth (i.e. the bandwidth in which 99 % of the wanted emission is contained) shall fall within the assigned frequency band.

For all equipment the frequency range shall lie within the frequency band given by clause 7.1.3, table 4. For non-harmonized frequency bands the available frequency range may differ between national administrations.

7.3 Unwanted emissions in the spurious domain

7.3.1 Definition

Unwanted emissions in the spurious domain (spurious emissions) are those at frequencies beyond the limit of 250 % of the necessary bandwidth above and below the center frequency of the emission.

The level of spurious emissions shall be measured as either:

- a)
 - i) their power level in a specified load (conducted emission); and
 - ii) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation); or
- b) their effective radiated power when radiated by the cabinet and the integral or dedicated antenna, in the case of equipment fitted with such an antenna and no permanent RF connector.

7.3.2 Measuring receiver

The term "measuring receiver" refers to either a frequency-selective voltmeter or spectrum analyser. The measurement bandwidth of the measuring receiver shall, where possible, be according to CISPR 16 [1]. In order to obtain the required sensitivity, a narrower measurement bandwidth may be necessary, and in such cases, this shall be stated in the test report form. The maximum bandwidth of the measuring receiver is given in table 5.

Table 5: Measuring receiver bandwidths

Frequency being measured (f)	Measuring receiver bandwidth
f < 1 000 MHz	100 kHz to 120 kHz
f ≥ 1 000 MHz	1 MHz

In case of a narrower measurement bandwidth was used, the following conversion formula has to be applied:

$$B = A + 10 \log \frac{BW_{ref}}{BW_{MEASURED}}$$

Where:

- A is the value at the narrower measurement bandwidth;
- B is the value referred to the reference bandwidth; or

Use the measured value, A, directly if the measured spectrum is a discrete spectral line. (A discrete spectrum line is defined as a narrow peak with a level of at least 6 dB above the average level inside the measurement bandwidth.)

7.3.3 Method of measurement - conducted spurious emission

This method of measurement applies to transmitters having a permanent antenna connector.

Additional requirements for equipment employing FHSS modulation are given in clause 7.3.6.

- The transmitter shall be connected to a measuring receiver through a test load, 50 Ω power attenuator, and if necessary, an appropriate filter to avoid overload of the measuring receiver. The bandwidth of the measuring receiver shall be adjusted until the sensitivity of the measuring receiver is at least 6 dB below the spurious emission limit given in table 6, see clause 7.3.7. This bandwidth shall be recorded in the test report.

For the measurement of spurious emissions below the second harmonic of the carrier frequency, the filter used shall be a high "Q" (notch) filter centred on the transmitter carrier frequency, which attenuates this signal by at least 30 dB.

For the measurement of spurious emissions at and above the second harmonic of the carrier frequency the filter used shall be a high pass filter with a stop band rejection exceeding 40 dB. The cut-off frequency of the high pass filter shall be approximately 1,5 times the transmitter carrier frequency.

Precautions may be required to ensure that the test load does not generate or that the high pass filter does not attenuate, the harmonics of the carrier.

- The transmitter shall be unmodulated and operating at the maximum limit of its specified power range. If modulation cannot be inhibited then the test shall be carried out with modulation (see clause 6.1) and this fact shall be recorded in the test report.
- For carrier frequencies in the range 1 GHz to 20 GHz the frequency of the measuring receiver shall be adjusted over the frequency range 25 MHz to 10 times the carrier frequency, not exceeding 40 GHz. For carrier frequencies above 20 GHz the measuring receiver shall be tuned over the range 25 MHz up to twice the carrier frequency, not exceeding 100 GHz. The frequency and level of every spurious emission found shall be noted. The emissions within the channel occupied by the transmitter carrier and, for channelized systems its adjacent channels, shall not be recorded.

- d) If the measuring receiver has not been calibrated in terms of power level at the transmitter output, the level of any detected components shall be determined by replacing the transmitter by the signal generator and adjusting it to reproduce the frequency and level of every spurious emission noted in step c). The absolute power level of each of the emissions shall be noted.
- e) The frequency and level of each spurious emission measured and the bandwidth of the measuring receiver shall be recorded in the test report.
- f) If a user accessible power adjustment is provided then the tests in steps c) to e) shall be repeated at the lowest power setting available.
- g) The measurement in steps c) to f) shall be repeated with the transmitter in the standby condition if this option is available.

7.3.4 Method of measurement cabinet spurious radiation

This method of measurement applies to transmitters having a permanent antenna connector. For equipment without a permanent antenna connector see clause 7.3.5.

Additional requirements for equipment employing FHSS modulation are given in clause 7.3.6.

- a) A test site selected from annex A which fulfils the requirements of the specified frequency range of this measurement shall be used. The test antenna shall be oriented initially for vertical polarization and connected to a measuring receiver. The bandwidth of the measuring receiver shall be adjusted until the sensitivity of the measuring receiver is at least 6 dB below the spurious emission limit given in table 6, see clause 7.3.7. This bandwidth shall be recorded in the test report.

The transmitter under test shall be placed on the support in its standard position, connected to an artificial antenna (see clause 6.2) and switched on without modulation. If modulation cannot be inhibited then the test shall be carried out with modulation, (see clause 6.1), and this fact shall be recorded in the test report.
- b) For carrier frequencies in the range 1 GHz to 20 GHz the frequency of the measuring receiver shall be adjusted over the frequency range 25 MHz to 10 times the carrier frequency, not exceeding 40 GHz. For carrier frequencies above 20 GHz the measuring receiver shall be tuned over the range 25 MHz up to twice the carrier frequency, not exceeding 100 GHz, except for the channel on which the transmitter is intended to operate and for channelized systems, its adjacent channels. The frequency of each spurious emission detected shall be noted. If the test site is disturbed by interference coming from outside the site, this qualitative search may be performed in a screened room, with a reduced distance between the transmitter and the test antenna.
- c) At each frequency at which a emission has been detected, the measuring receiver shall be tuned and the test antenna shall be raised or lowered through the specified height range until the maximum signal level is detected on the measuring receiver.
- d) The transmitter shall be rotated through 360° about a vertical axis, to maximize the received signal.
- e) The test antenna shall be raised or lowered again through the specified height range until a maximum is obtained. This level shall be noted.
- f) The substitution antenna (see clause A.2.3) shall replace the transmitter antenna in the same position and in vertical polarization. It shall be connected to the signal generator.
- g) At each frequency at which a emission has been detected, the signal generator, substitution antenna, and measuring receiver shall be tuned. The test antenna shall be raised or lowered through the specified height range until the maximum signal level is detected on the measuring receiver. The level of the signal generator giving the same signal level on the measuring receiver as in item e) shall be noted. After corrections due to the gain of the substitution antenna and the cable loss between the signal generator and the substitution antenna, is the radiated spurious emission at this frequency.
- h) The frequency and level of each spurious emission measured and the bandwidth of the measuring receiver shall be recorded in the test report.
- i) Steps c) to h) shall be repeated with the test antenna oriented in horizontal polarization.

- j) If a user accessible power adjustment is provided then the tests in steps c) to h) shall be repeated at the lowest power setting available.
- k) Steps c) to i) shall be repeated with the transmitter in the standby condition if this option is available.

7.3.5 Method of measurement radiated spurious emission

This method of measurement applies to transmitters having an integral antenna.

Additional requirements for equipment employing FHSS modulation are given in clause 7.3.6.

- a) A test site selected from annex A which fulfils the requirements of the specified frequency range of this measurement shall be used. The test antenna shall be oriented initially for vertical polarization and connected to a measuring receiver, through a suitable filter to avoid overloading of the measuring receiver if required. The bandwidth of the measuring receiver shall be adjusted until the sensitivity of the measuring receiver is at least 6 dB below the spurious emission limit given in table 6, see clause 7.3.7. This bandwidth shall be recorded in the test report.

For the measurement of spurious emissions below the second harmonic of the carrier frequency the optional filter used shall be a high "Q" (notch) filter centred on the transmitter carrier frequency and attenuating this signal by at least 30 dB.

For the measurement of spurious emissions at and above the second harmonic of the carrier frequency the optional filter used shall be a high pass filter with a stop band rejection exceeding 40 dB. The cut-off frequency of the high pass filter shall be approximately 1,5 times the transmitter carrier frequency.

The transmitter under test shall be placed on the support in its standard position and shall be switched on without modulation. If modulation cannot be inhibited then the test shall be carried out with modulation (see clause 6.1) and this fact shall be recorded in the test report.

- b) The same method of measurement as steps b) and k) of clause 7.3.4 shall be used.

7.3.6 Additional requirements for equipment employing FHSS modulation

Measurements shall be carried out while the equipment is hopping between two frequencies separated by the maximum hop frequency change declared by the manufacturer, one of which is the lowest hop frequency.

The measurements shall be repeated on two frequencies separated by the maximum hop frequency change declared by the manufacturer, one of which is the highest hop frequency.

7.3.7 Limits

The power of any spurious emission shall not exceed the following values given in table 6.

Table 6: Radiated spurious emissions

State	47 MHz to 74 MHz 87,5 MHz to 108 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other frequencies ≤ 1 000 MHz	Frequencies > 1 000 MHz
Operating	4 nW	250 nW	1 μW
Standby	2 nW	2 nW	20 nW

7.4 Duty cycle

For equipment with Listen Before Talk a duty cycle does not apply.

7.4.1 Definitions

For the purposes of the present document the duty cycle is defined as the ratio, expressed as a percentage, of the maximum transmitter "on" time monitored over one hour, relative to a one hour period. The device may be triggered either automatically or manually and depending on how the device is triggered will also depend on whether the duty cycle is fixed or random.

7.4.2 Declaration

For automatic operated devices, either software controlled or pre-programmed devices, the provider shall declare the duty cycle class or classes for the equipment under test, see table 7.

For manual operated or event dependant devices, with or without software controlled functions, the provider shall declare whether the device once triggered, follows a pre-programmed cycle, or whether the transmitter remains on until the trigger is released or the device is manually reset. The provider shall also give a description of the application for the device and include a typical usage pattern. The typical usage pattern as declared by the provider shall be used to determine the duty cycle and hence the duty class, see table 7.

Where an acknowledgement is required, the additional transmitter on-time shall be included and declared by the provider.

For devices with a 100 % duty cycle transmitting an unmodulated carrier most of the time, a time-out shut-off facility shall be implemented in order to improve the efficient use of spectrum. The method of implementation shall be declared by the provider.

7.4.3 Duty cycle limits

In a period of 1 hour the duty cycle shall not exceed the values given in table 7.

Table 7: Duty cycle limits

Frequency Band	Duty cycle	Application	Notes
2 400 MHz to 2 483,5 MHz	No Restriction	Generic use	
2 400 MHz to 2 483,5 MHz	No Restriction	Detecting and movement and alert applications	
(a) 2 446 MHz to 2 454 MHz	No Restriction	RFID	See annex C
(b) 2 446 MHz to 2 454 MHz	≤ 15 %	RFID	See annex C
5 725 MHz to 5 875 MHz	No Restriction	Generic use	
9 200 MHz to 9 500 MHz	No Restriction	Detecting and movement and alert applications	
9 500 MHz to 9 975 MHz	No Restriction	Detecting and movement and alert applications	
10,5 GHz to 10,6 GHz	No Restriction	For detecting and movement and alert applications	
13,4 GHz to 14,0 GHz	No Restriction	Detecting and movement and alert applications	
17,1 GHz to 17,3 GHz	DAA or equivalent techniques	GBSAR detecting and movement and alert applications	See annex E
24,00 GHz to 24,25 GHz	No Restriction	Generic use and for detecting and movement and alert applications	

7.5 Additional requirements for FHSS equipment

7.5.1 FHSS modulation

FHSS modulation shall make use of at least 20 channels hopping over > 90 % of the assigned frequency band.

The dwell time per channel shall not exceed 1 s. While the equipment is operating (transmitting and/or receiving) each channel of the hopping sequence shall be occupied at least once during a period not exceeding four times the product of the dwell time per hop and the number of channels.

There shall be a declaration of the total number of hops, the dwell time, the bandwidth per hop and the maximum separation of hops.

8 Receiver

8.1 Adjacent channel selectivity

This clause is applicable if the equipment receiver category 1 has been selected, see clause 4.1.1.

8.1.1 Definition

The adjacent channel selectivity is a measure of the capability of the receiver to operate satisfactorily in the presence of an unwanted signal that differs in frequency from the wanted signal by an amount equal to the adjacent channel separation for which the equipment is intended.

8.1.2 Method of measurement

This measurement shall be conducted under normal conditions.

Two signal generators A and B shall be connected to the receiver via a combining network to the receiver, either:

- a) via a test fixture or a test antenna to the receiver integrated, dedicated or test antenna; or
- b) directly to the receiver permanent or temporary antenna connector.

The method of coupling to the receiver shall be stated in the test report.

Signal generator A shall be at the nominal frequency of the receiver, with normal modulation of the wanted signal. Signal generator B shall be unmodulated and shall be adjusted to the adjacent channel center frequency immediately above that of the wanted signal.

Initially signal generator B shall be switched off and using signal generator A the level that still gives sufficient response shall be established. The output level of generator A shall then be increased by 3 dB.

Signal generator B is then switched on and adjusted until the wanted criteria are met. This level shall be recorded.

The measurements shall be repeated with signal generator B unmodulated and adjusted to the adjacent channel center immediately below the wanted signal.

The adjacent channel selectivity shall be recorded for the upper and lower adjacent channels as the level in dBm of the unwanted signal.

For tagging systems (e.g. RF identification, anti-theft, access control, location and similar systems) signal generator A may be replaced by a physical tag positioned at 70 % of the measured system range in metres. In this case, the adjacent selectivity shall be recorded as the level in dBm of lowest level of the unwanted signal (generator B) resulting in a non-read of the tag.

8.1.3 Limits

The adjacent channel selectivity of the equipment under specified conditions shall not be less than the levels of the unwanted signal as stated in table 8.

Table 8: Limit for Adjacent channel selectivity

Equipment category	Limit
1	-30 dBm + k
2	No limit
3	No limit

The correction factor, k , is as follows:

$$k = -20 \log f - 10 \log BW$$

Where:

- f is the frequency in GHz;
- BW is the channel bandwidth in MHz.

The factor k is limited within the following:

- $0 < k < 40$ dB.

The measured adjacent channel selectivity shall be stated in the test report.

8.2 Blocking or desensitization

This clause is applicable if the equipment receiver category 1 or category 2 has been selected, see clause 4.1.1.

8.2.1 Definition

Blocking is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequencies other than those of the spurious responses or the adjacent channels or bands, see clauses 8.1 and 8.2.

8.2.2 Methods of measurement

This measurement shall be conducted under normal conditions.

Two signal generators A and B shall be connected to the receiver via a combining network to the receiver, either:

- a) via a test fixture or a test antenna to the receiver integrated, dedicated or test antenna; or
- b) directly to the receiver permanent or temporary antenna connector.

The method of coupling to the receiver shall be stated in the test report.

Signal generator A shall be at the nominal frequency of the receiver, with normal modulation of the wanted signal. Signal generator B shall be unmodulated and shall be adjusted to a test frequency at approximately 10 times, 20 times and 50 times of the receive channel bandwidth above upper band edge of the receive channel.

Initially signal generator B shall be switched off and using signal generator A the level which still gives sufficient response shall be established. The output level of generator A shall then be increased by 3 dB.

Signal generator B is then switched on and adjusted until the wanted criteria are met. This level shall be recorded.

The measurement shall be repeated with the test frequency for signal generator B at approximately 10 times, 20 times and 50 times of the receive channel bandwidth below the lower band edge of the receive channel.

The blocking or desensitization shall be recorded as the level in dBm of lowest level of the unwanted signal (generator B).

For tagging systems (e.g. RF identification, anti-theft, access control, location and similar systems) signal generator A may be replaced by a physical tag positioned at 70 % of the measured system range in metres. In this case, the blocking or desensitization shall be recorded as the ratio in dB of lowest level of the unwanted signal (generator B) resulting in a non-read of the tag, to the declared sensitivity of the receiver +3 dB.

8.2.3 Limits

The blocking level, for any frequency within the specified ranges, shall not be less than the values given in table 10, except at frequencies on which spurious responses are found in table 9.

Table 9: Limits for blocking or desensitization

Equipment category	Limit
1	-30 dBm + k
2	-45 + k
3	No limit

The correction factor, k , is as follows:

$$k = -20 \log f - 10 \log BW$$

Where:

- f is the frequency in GHz;
- BW is the channel bandwidth in MHz.

The factor k is limited within the following:

- $0 < k < 40$ dB.

The measured blocking level shall be stated in the test report.

8.3 Spurious emissions

These requirements do not apply to receivers used in combination with permanently co-located transmitters continuously transmitting. Co-located is defined as < 3 m. In these cases the receivers will be tested together with the transmitter in operating mode.

8.3.1 Definition

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

The level of spurious radiations shall be measured by either:

- a)
 - i) their power level in a specified load (conducted spurious emission); and
 - ii) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation); or
- b) their effective radiated power when radiated by the cabinet and the integral or dedicated antenna, in the case of portable equipment fitted with such an antenna and no permanent RF connector.

8.3.2 Method of measurement conducted spurious components

This method of measurement applies to receivers having a permanent antenna connector.

A test load, 50 Ω power attenuator, may be used to protect the measuring receiver (see clause 7.3.2) against damage when testing a receiver combined in one unit with a transmitter.

The measuring receiver used shall have sufficient dynamic range and sensitivity to achieve the required measurement accuracy at the specified limit. The bandwidth of the measuring receiver shall be adjusted until the sensitivity of the measuring receiver is at least 6 dB below the spurious emission limit given in clause 8.4.5. This bandwidth shall be recorded in the test report.

- a) The receiver input terminals shall be connected to a measuring receiver having an input impedance of 50 Ω and the receiver is switched on.
- b) For carrier frequencies in the range 1 GHz to 20 GHz the frequency of the measuring receiver shall be adjusted over the frequency range 25 MHz to 10 times the carrier frequency, not exceeding 40 GHz. For carrier frequencies above 20 GHz the measuring receiver shall be tuned over the range 25 MHz up to twice the carrier frequency not exceeding 100 GHz. The frequency and the absolute power level of each of the spurious components found shall be noted.
- c) If the detecting device is not calibrated in terms of power input, the level of any detected components shall be determined by replacing the receiver by the signal generator and adjusting it to reproduce the frequency and level of every spurious component noted in step b). The absolute power level of each spurious component shall be noted.
- d) The frequency and level of each spurious emission measured and the bandwidth of the measuring receiver shall be recorded in the test report.

8.3.3 Method of measurement cabinet radiation

This method of measurement applies to receivers having a permanent antenna connector.

- a) A test site selected from annex A which fulfils the requirements of the specified frequency range of this measurement shall be used. The test antenna shall be oriented initially for vertical polarization and connected to a measuring receiver. The bandwidth of the measuring receiver shall be adjusted until the sensitivity of the measuring receiver is at least 6 dB below the spurious emission limit given in clause 8.1.5. This bandwidth shall be recorded in the test report.

The receiver under test shall be placed on the support in its standard position and connected to an artificial antenna, see clause 6.2.

- b) For carrier frequencies in the range 1 GHz to 20 GHz the frequency of the measuring receiver shall be adjusted over the frequency range 25 MHz to 10 times the carrier frequency, not exceeding 40 GHz. For carrier frequencies above 20 GHz the measuring receiver shall be tuned over the range 25 MHz up to twice the carrier frequency not exceeding 100 GHz. The frequency of each spurious component shall be noted. If the test site is disturbed by radiation coming from outside the site, this qualitative search may be performed in a screened room with reduced distance between the transmitter and the test antenna.
- c) At each frequency at which a component has been detected, the measuring receiver shall be tuned and the test antenna shall be raised or lowered through the specified height range until the maximum signal level is detected on the measuring receiver.
- d) The receiver shall be rotated up to 360° about a vertical axis, to maximize the received signal.
- e) The test antenna shall be raised or lowered again through the specified height range until a maximum is obtained. This level shall be noted.
- f) The substitution antenna (see clause A.3.2) shall replace the receiver antenna in the same position and in vertical polarization. It shall be connected to the signal generator.

- g) At each frequency at which a component has been detected, the signal generator, substitution antenna and measuring receiver shall be tuned. The test antenna shall be raised or lowered through the specified height range until the maximum signal level is detected on the measuring receiver. The level of the signal generator giving the same signal level on the measuring receiver as in step e) shall be noted. This level, after correction due to the gain of the substitution antenna and the cable loss, is the radiated spurious component at this frequency.
- h) The frequency and level of each spurious emission measured and the bandwidth of the measuring receiver shall be recorded in the test report.
- i) Measurements b) to h) shall be repeated with the test antenna oriented in horizontal polarization.

8.3.4 Method of measurement radiated spurious components

This method of measurement applies to receivers having an integral antenna.

- a) A test site selected from annex A which fulfils the requirements of the specified frequency range of this measurement shall be used. The test antenna shall be oriented initially for vertical polarization and connected to a measuring receiver. The bandwidth of the measuring receiver shall be adjusted until the sensitivity of the measuring receiver is at least 6 dB below the spurious emission limit given in clause 8.4.5. This bandwidth shall be recorded in the test report.

The receiver under test shall be placed on the support in its standard position.

- b) The same method of measurement as items b) to i) of clause 8.4.3 shall apply.

8.3.5 Limits

The power of any spurious emission shall not exceed 2 nW in the range 25 MHz to 1 GHz and shall not exceed 20 nW on frequencies above 1 GHz.

The measured spurious emissions shall be stated in the test report.

9 Spectrum access techniques

For the present standard the following access mechanisms are specified:

- Listen before talk (LBT) which is used to share a spectrum between SRD transceiver equipment with similar power and bandwidth; or
- Detect and avoid (DAA) which is used to protect radiocommunication services.

Receiver Category 2 or better for all LBT and DAA applications shall be used.

For equipment with radiated power of less than 100 μ W e.i.r.p., no access technique is specified.

9.1 Principle for Listen Before Talk (LBT)

In order to make maximum use of the available channels, an intelligent or polite equipment may use a Listen Before Talk (LBT) protocol with a preferred option of Adaptive Frequency Agility (AFA). AFA is defined as the capability of an equipment to dynamically change channel within its available frequencies for proper operation.

If an equipment does not use LBT then clause 7.4 applies. Equipment with LBT does not have to comply with the duty cycle conditions as stated in clause 7.4.

For LBT equipment, the device shall listen on the next intended frequency before transmitting. If it is intended to move to a different channel then this channel can be monitored whilst still transmitting at its first channel. If it is not intended to move to a different channel then it should be treated as a single frequency device waiting for a free channel.

The channel occupancy timings refer to the maximum time a device can transmit on a channel, in any one period, and the minimum "listening" period before the device can retransmit either on the same or, for frequency agile equipment, on another channel.

For a device with LBT some of the receiver parameters become essential requirements under the R&TTE Directive [2]. The receiver requirements are the following:

- LBT threshold, for further details, see clause 9.2.
- Blocking or desensitization, for further details, see clause 8.3.

Adjacent channel selectivity, see clause 8.1, is not a mandatory requirement for equipment using LBT. However, it shall be noted that insufficient adjacent channel selectivity may reduce the apparent channel availability.

For spread spectrum systems, LBT may be used if the required timing and threshold limits can be met; if not, then a duty cycle requirement applies, see clause 7.4.

It shall be noted that the use of LBT may be restricted by the dwell time for Frequency Hopping Spread Spectrum systems. In case of fast frequency hopping where the dwell time is shorter than the LBT minimum listening time then a duty cycle requirement applies, see clause 7.4.

9.1.1 LBT timing parameters

9.1.1.1 Minimum transmitter off-time

The minimum TX off-time allows other users with LBT facility to get access to a channel.

9.1.1.1.1 Definition

The minimum TX-off time is defined as the period where a specific transmitter shall remain off after a transmission or a communication dialogue between units or a polling sequence of other units.

9.1.1.1.2 Limit

The limit for the minimum TX-off time is > 25 ms.

The TX-off time shall be declared in the test report by the equipment provider.

9.1.1.2 LBT minimum listening time

9.1.1.2.1 Definition

The minimum listening time is defined as the minimum time that the equipment listens for a received signal at or above the LBT threshold level (see clause 9.2) immediately prior to transmission to determine whether the intended channel is available for use.

The listening time shall consist of the "minimum fixed listening time" and an additional pseudo random part. If during the listening mode another user is detected on the intended channel, the listening time shall commence from the instant that the intended channel is free again. Alternatively, the equipment may select another channel and again start the listen time before transmission.

9.1.1.2.2 Limit for minimum listening time

The total listen time, t_L , consists of a fixed part, t_F , and a pseudo random part, t_{PS} , as the following:

$$t_L = t_F + t_{PS}$$

- a) The fixed part of the minimum listening time, t_F , shall be 5 ms.

- b) The pseudo random listening time t_{PS} shall be randomly varied between 0 ms and a value of 5 ms or more in equal steps of approximately 0,5 ms as the following:
 - If the channel is free from traffic at the beginning of the listen time, t_L , and remains free throughout the fixed part of the listen time, t_F , then the pseudo random part, t_{PS} , is automatically set to zero by the equipment itself.
 - If the channel is occupied by traffic when the equipment either starts to listen or during the listen period, then the listen time commences from the instant that the intended channel is free. In this situation the total listen time t_L shall comprise t_F and the pseudo random part, t_{PS} .

The limit for total listen time for the receiver consists of the sum of a) and b) together.

Algorithmic details and values for a) and b) shall be declared by the provider of the equipment.

9.1.1.3 Acknowledge transmissions

An acknowledge transmission is defined as a receipt for a received message.

There is no requirement for a listen time before an acknowledge can be performed. However, it shall be noted that if the start of an acknowledge is not received before the end of normal fixed part of the listen time (5 ms) then the channel might be taken by an other transmitter.

9.1.1.4 Maximum transmitter on-time

A transmitter shall only be allowed to transmit continuously for a maximum specified period. This will prevent a transmitter from occupying a channel for an extended period.

The maximum on-time shall always be as short as possible for the application since SRD applications are often battery operated.

9.1.1.4.1 Definition

The maximum transmitter on-time is defined as the maximum time the transmitter can be on during:

- a) A single transmission.
- b) Multiple transmissions and acknowledgements for a communication dialogue or polling sequence of other units under the condition that the channel is free.

An equipment intended for very long messages must be capable of switching to a "free" channel before the maximum transmitter on-time is reached for each channel of operation.

9.1.1.4.2 Limit

The limit for a single transmission TX on-time is 2 s and this limit shall be declared by the provider. For further information on measurements of maximum transmitter on-time, see clause 9.2.

The time limit for a transmission dialogue or a polling sequence is 10 s and this limit shall be declared by the provider.

In the case of the above timing, t , reaches the limit then the minimum TX-off time limit shall apply automatically.

9.1.1.5 Declaration of LBT parameters

For automatic operated LBT devices, either software controlled or pre-programmed devices, the provider shall declare all the channel LBT timings for the equipment under test.

9.1.1.6 Equipment with or without LBT using transmitter time-out-timer

For manual operated or event dependant devices, with or without software controlled functions, the provider shall declare whether the transmission once triggered, follows a pre-programmed time-out-timer, or whether the transmitter remains on until the trigger is released or the device is manually reset.

The provider shall also give a description of the application for the device and include a typical usage pattern. The typical usage pattern as declared by the provider shall be used to determine the channel occupancy timings.

9.2 Receiver LBT threshold and transmitter max on-time

The measurements and limits apply to a transceiver that facilitates a receiver with a LBT protocol.

9.2.1 Definitions

The LBT threshold is defined as the received signal level above which the equipment can determine that the channel is not available for use. If the received signal is below the LBT threshold then the equipment can determine that the channel is available for use.

The definition of the maximum transmitter on-time for an equipment with LBT facility is defined in clause 9.1.1.4.1.

9.2.2 Method of measurements

A signal generator and a power meter are each combined via appropriate attenuators into the equipment antenna connector. The following test set-up shall be used:

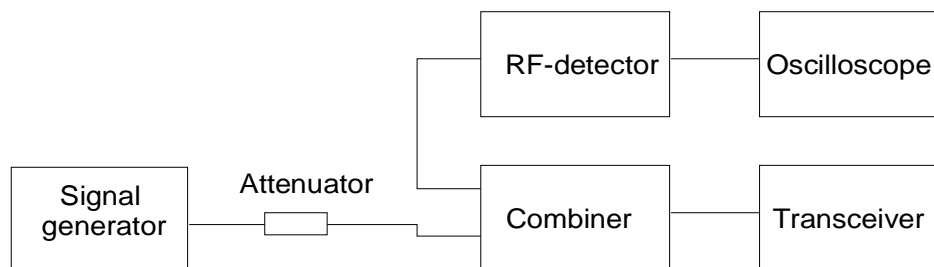


Figure 7: Measurement arrangement

For equipment with integral antenna the connection to the equipment is made either to a temporary 50 ohm antenna connector, see clause 4.2.3.1, or via a calibrated test fixture, see clause 6.3.

- a) the LBT function of the transceiver shall be active;
- b) the attenuator shall provide sufficient attenuation to protect the signal generator from burn-out by the transmitter of the transceiver;
- c) the signal generator with normal test modulation is adjusted to the receiving frequency. The level is increased to approximately 20 dB above the receiver sensitivity;
- d) the equipment is switched to an intended transmit mode. The equipment shall not be transmitting as the transceiver recognizes a busy channel from the signal generator;
- e) the level of the signal generator is reduced in steps of 1 dB until the equipment starts to transmit. This specific signal generator level present at the receiver input of the transceiver is the LBT threshold;

The level of the received LBT threshold shall be recorded in the test report.

- f) the steps c) and d) shall be repeated; and
- g) the level of the signal generator is reduced in steps of 1 dB until the equipment starts to transmit and the duration of the transmit on-time is measured at the oscilloscope.

The transmit on-time is recorded in the test report.

9.2.3 Limits

The maximum LBT threshold for the receiver in the listen mode is given in table 10.

Table 10: Receiver LBT threshold limit versus transmit power and channel spacing

TX power	< 100 mW	500 mW
LBT threshold	-80 dBm + c	-87 dBm + c
NOTE 1: The limit is independent of the receiver Category, see clause 4.1.1.		
NOTE 2: The limits are based on an antenna gain of +2 dBi maximum. For other antenna gains greater than +2 dBi the limits shall be adjusted accordingly.		

The correction factor, c , is given by the following formula:

$$c = 10 \cdot \log BW$$

Where:

- BW is the bandwidth in MHz.

The measured LBT threshold shall be stated in the test report.

9.3 Detect and avoid techniques (DAA)

Detect and avoid provide protection to other radio communication services by the following parameters:

- a) Receiver minimum listen time before the transmitter can be switched on, immediately prior any indented transmission.
- b) Receiver detect and avoid threshold.
- c) An appropriate long listen-time after detection of a service to be protected is detected.
- d) Maximum transmitter on-time without interruption.
- e) Minimum transmitter off-time after a transmitter on-time period.

It shall be noted that DAA can only be applied if the SRD equipment is using a common antenna for both receive and transmit, or the same antenna type is used for both receive and transmit with both antennas pointing in the same direction.

The DAA function and limits are depending of the services to be protected. An example of an equipment using DAA spectrum access method is given in annex E.

9.4 Dynamic Frequency Selection (DFS)

9.4.1 Introduction

SRD equipment with LBT or DAA may employ a Dynamic Frequency Selection (DFS) function to:

- detect interference from other systems and to avoid co-channel operation with these systems;
- where possible, provide on aggregate a uniform loading of the spectrum across all devices.

The equipment shall only use the channels dedicated for the application.

Additionally, the equipment shall either follow the restrictions for LBT given in clause 9.3 or the restrictions for DAA as appropriate.

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:
 - a) the value of the measurement uncertainty for the measurement of each parameter shall be separately included in the test report;
 - b) the value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in table 11.

Table 11: Measurement uncertainty

Parameters	Uncertainty
Radio frequency	$\pm 1 \times 10^{-7}$
RF power (conducted)	± 4 dB
Radiated emission of transmitter, valid to 26,5 GHz	± 6 dB
Radiated emission of transmitter, valid to 80 GHz	± 8 dB
Radiated emission of receiver, valid to 26,5 GHz	± 6 dB
Radiated emission of receiver, valid to 80 GHz	± 8 dB
Temperature	$\pm 1^{\circ}$ C
Humidity	± 5 %
Voltage (DC)	± 1 %
Voltage (AC, < 10 kHz)	± 2 %

NOTE: For radiated emissions above 26,5 GHz it may not be possible to reduce the measurement uncertainties to the levels specified in table 11. In these cases alone it is acceptable to employ the alternative interpretation procedure specified in clause 10.1.

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 (see bibliography) 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 11 is based on such expansion factors.

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

10.1 Measurement uncertainty is greater than maximum acceptable uncertainty

The interpretation of the results when comparing measurement values with specification limits should be as follows:

- a) When the measured value plus the difference between the maximum acceptable measurement uncertainty and the measurement uncertainty calculated by the test technician does not exceed the limit value the equipment under test meets the requirements of the standard.
- b) When the measured value plus the difference between the maximum acceptable measurement uncertainty and the measurement uncertainty calculated by the test technician exceeds the limit value the equipment under test does not meet the requirements of the standard.
- c) The measurement uncertainty calculated by the test technician carrying out the measurement should be recorded in the test report.
- d) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement undertaken. The method used should be recorded in the test report.

Annex A (normative): Radiated measurements

A.1 General requirements for measurements involving the use of radiated fields

Measurements involving radiated fields require a prepared test site, well-characterized antenna equipment, calibrated test instrumentation, appropriate ancillary equipment such as cabling and filters, and appropriate test plans and methods. This annex provides minimum requirements and examples of suitable practice.

Test sites shall be suitable for radiated measurements and shall be designed to eliminate significant effects of objects or materials capable of influencing the interaction between test sample or substitute antenna and test antenna and instrumentation.

Test sites may consist of:

- Outdoor test sites.
- Indoor sites.
- Anechoic test sites.

The nature of the test site, precautions taken and evidence of suitability shall be recorded with the results of the tests.

Principal items of equipment are:

- Equipment under test with associated cabling.
- Antennas:
 - Test antenna.
 - Substitution antenna.
 - Artificial antenna.
- Test equipment:
 - Calibrated measuring receiver, spectrum analyser or other appropriate receiving instrument.
 - Calibrated filtering equipment.
 - Calibrated recording equipment.

The provisions below describe minimum acceptable standards for test sites, test methods and equipment and scope of testing.

The provisions below are appropriate for measurements in the far-field. Test result must record where the near-field conditions are entered and the additional measurement uncertainty shall be evaluated, recorded and added to the test result, see clause A.5.

A.2 Test Sites

A.2.1 Outdoor test site

An outdoor test site shall provide:

- Measured support positions at least 3 m or $\lambda/2$ (at the test frequency) apart for the test item or substitution antenna and the test antenna, and a measured midpoint.
- A clear area greater than a circle of diameter twice the separation of the test item or substitution antenna from the test antenna, centred at the midpoint.
- Substantially level ground surface treated to render its effect either negligible (treatment to minimize reflection) or deterministic (treatment with flat reflecting material) and including the whole of the clear area.
- Sufficient precautions to ensure that reflections from extraneous objects beyond the clear area and within or adjacent to the site do not degrade the measurement results in accordance with CISPR 16 [1].
- Non-conducting supports for the test item or substitution antenna and the test antenna.
- Provision for free-mounting equipment under test to be supported 1,5 m above the ground and rotated through 360° in the horizontal plane.
- Provision for floor-standing equipment to be mounted 100 mm above the ground and rotated through 360° in the horizontal plane.
- Provision for the test antenna to be moved between heights of at least 1 m to 4 m above the treated ground surface and rotated for operation in any plane of polarization.

Key:

- 1) equipment under test;
- 2) test antenna;
- 3) high pass filter (if necessary);
- 4) spectrum analyser or measuring receiver.

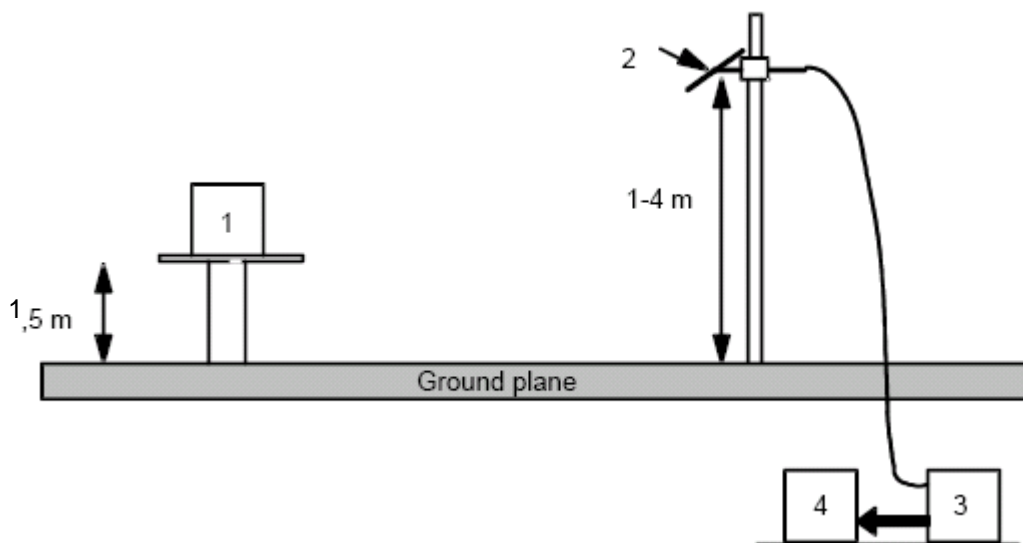


Figure A.1: Outdoor test site

A.2.2 Indoor test site

An indoor site may be used for test frequencies above 80 MHz. If an indoor site is used, this shall be recorded in the test report.

An indoor test site shall provide:

- Floor, ceiling above 2,7 m, test sample wall and test antenna wall separated by at least 7 m and side walls separated by at least 6 m.
- A test antenna providing adequate sensitivity over the range of test frequencies and also providing adequate isolation from the effects of floor, ceiling, test antenna wall and side walls.

EXAMPLE: A corner reflector antenna.

- A test sample wall treated with anechoic material to render its effect negligible.
- Non-conducting supports for the test item or substitution antenna and the test antenna.
- Measured support positions on the long axis of the site and at least 3 m apart for the test item or substitution antenna and the test antenna.
- Sufficient precautions to ensure that the presence of objects within the room does not degrade the measurement results in accordance with CISPR 16 [1].
- Provision for free-mounting test samples to be supported 1,5 m above the ground and rotated through 360° in the horizontal plane.
- Provision for floor-standing equipment to be mounted 100 mm above the ground and rotated through 360° in the horizontal plane.
- Provision for the test antenna to be centred at a height more than 1,35 m above the floor and more than 1,35 m below the ceiling, and to be rotated for operation in any plane of polarization.
- Provision for a substitution antenna to replace the equipment under test and to be moved up to $\pm 0,1$ m in any direction.

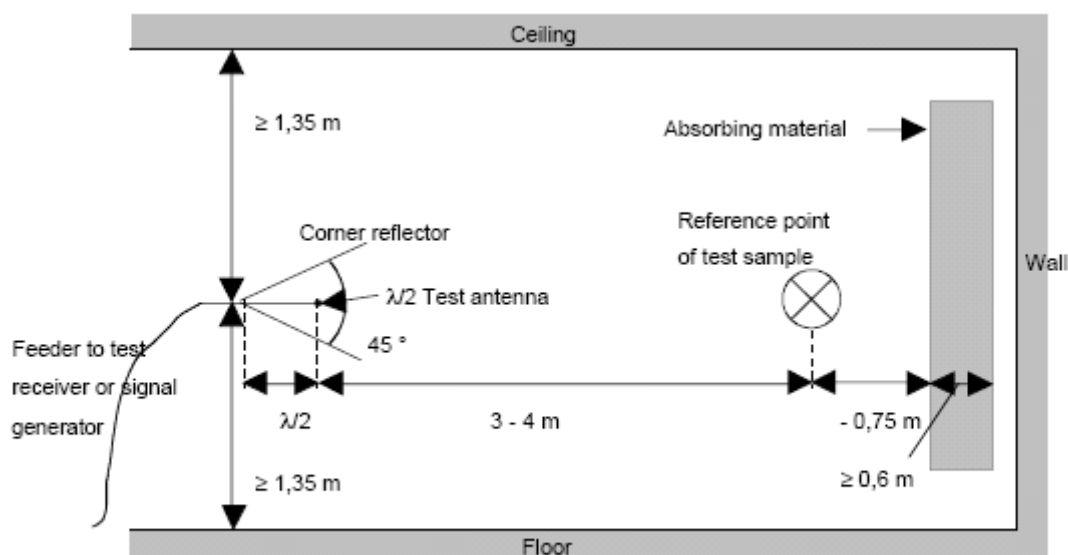


Figure A.2: Indoor site arrangement (shown for horizontal polarization)

A.2.3 Shielded anechoic test site

"Anechoic" means that the walls, floor and ceiling of the enclosed test site are treated to substantially reduce radio reflections.

For radiation measurements under the present document a shielded, calibrated anechoic chamber may be used to simulate a free space environment. Such use shall be frequencies above 100 MHz unless specific treatment and calibration evidence at lower frequencies is provided. Calibration by a competent body shall confirm reflection attenuation at the walls to meet the limits provided in figure A.3. Shielding better than the limits provided by figure A.3 is desirable. An example of the construction of an anechoic chamber is shown in figure A.4.

The chamber shall provide sufficient space to carry out tests as in the general method. If such a chamber is used, this shall be recorded in the test report.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method.

A.2.3.1 Influence of parasitic reflections in anechoic chambers

With an anechoic chamber of the dimensions suggested in clause A.1.3 at low frequencies up to 100 MHz far field conditions are not met and specific calibration procedures will be required. Careful attention is also required to the chamber calibration for frequencies above 1 GHz.

A.2.3.2 Calibration of the shielded RF anechoic chamber

The chamber shall be calibrated over the range 30 MHz to 80 GHz.

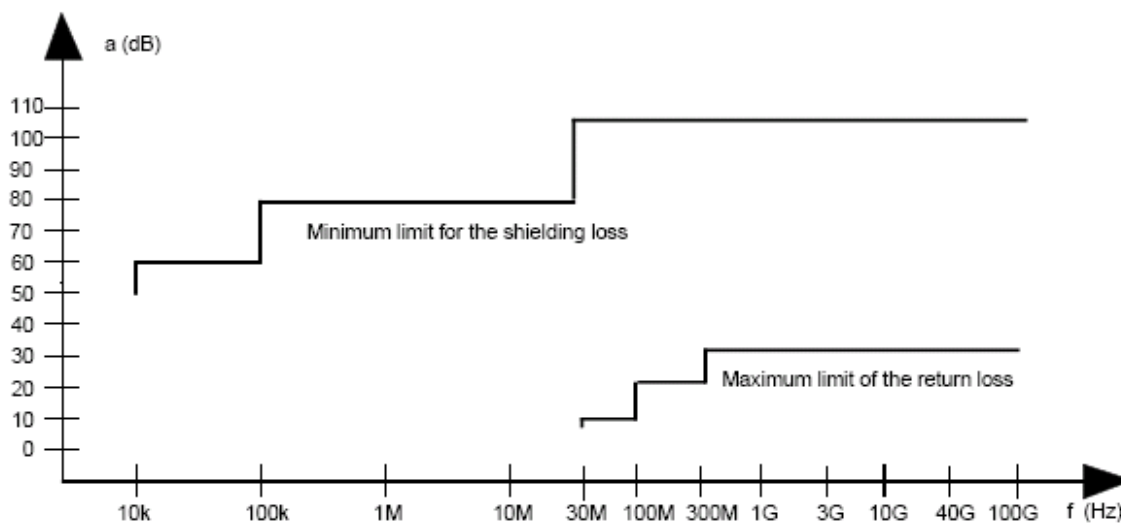


Figure A.3: Specification for shielding and reflections

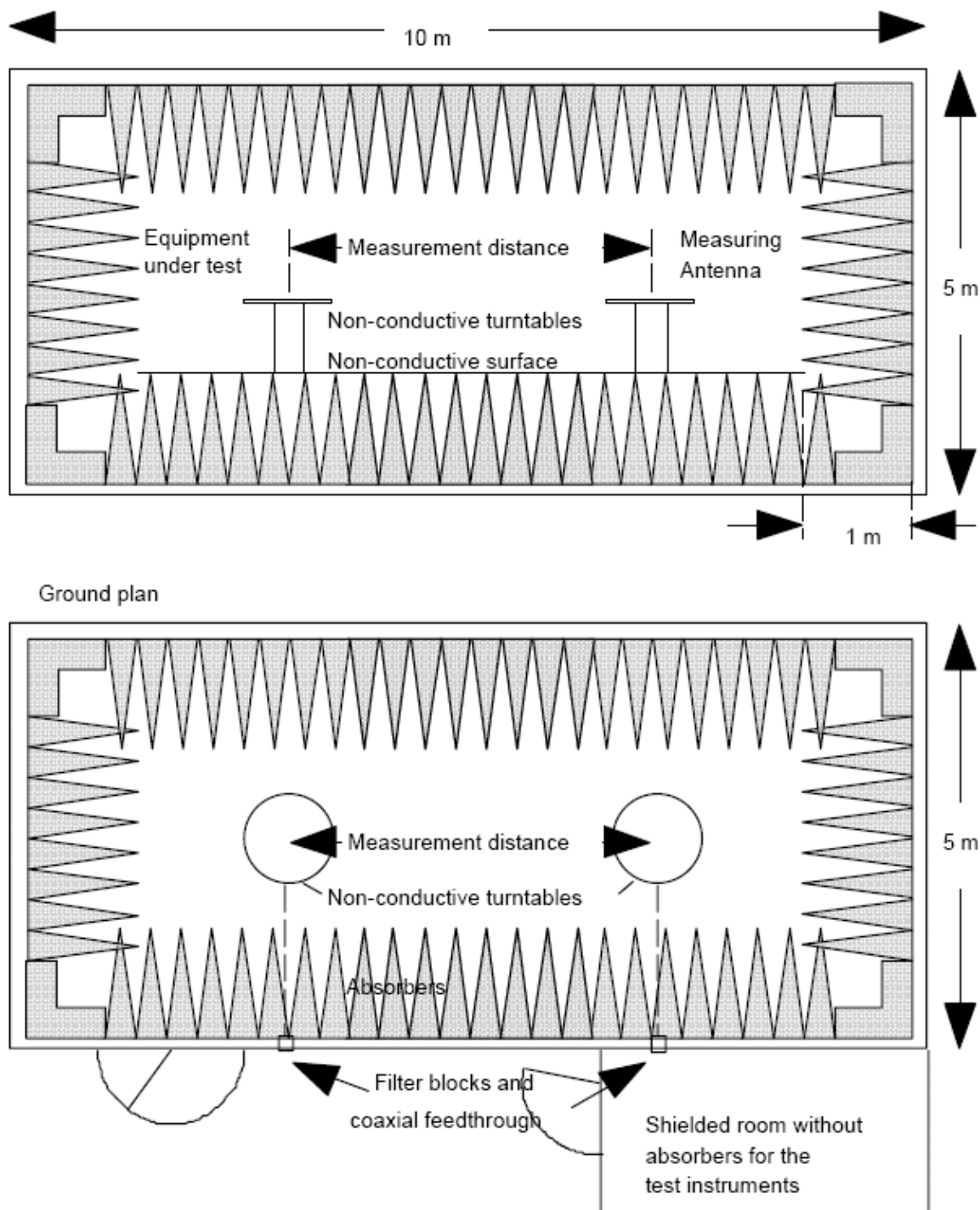


Figure A.4: Example of construction of an anechoic shielded chamber

A.3 Antennas

A.3.1 Test antenna

The test antenna is used to detect the radiation from both the test sample and the substitution antenna for emission measurements. It is used as a transmitting antenna for the measurement of receiver characteristics.

The test antenna support provides for either horizontal or vertical polarization and for the height of its centre above ground to be varied over the range 1 m to 4 m or to the ceiling of an indoor or anechoic chamber, whichever is less. The test antenna shall provide boresight directivity equal to at least half the wall reflectivity limit prescribed in figure A.3. The length of the test antenna along the measurement axis shall not exceed 20 % of the measuring distance.

For emission measurements, the test antenna is connected to a calibrated measuring receiver capable of being tuned to any frequency under investigation.

For receiver sensitivity measurements, the test antenna is connected to a calibrated signal generator capable of being tuned to any frequency under investigation.

Height variation shall be used to find the point at which the radiation is a maximum near the initial position.

A.3.2 Substitution antenna

A substitution antenna may be used in place of the equipment under test when comparing equipment emissions with standard emissions.

When measuring in the frequency range up to 1 GHz the substitution antenna shall be a $\lambda/2$ dipole, resonant at the operating frequency, or a shortened dipole, calibrated to the $\lambda/2$ dipole. When measuring in the frequency range above 4 GHz, a horn radiator shall be used. For measurements between 1 GHz and 4 GHz either a $\lambda/2$ or a horn radiator may be used. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the volume centre of the sample when its antenna is mounted internally, or the phase centre of an external antenna.

The distance between the lower extremity of the dipole and the ground shall not be less than 0,3 m.

The substitution antenna shall be connected to a calibrated signal generator when the site is used for spurious radiation measurements and transmitter effective radiated power measurements. The substitution antenna shall be connected to a calibrated measuring receiver when the site is used for the measurement of receiver sensitivity.

The signal generator and the receiver shall be connected to the antenna through suitable matching and balancing networks.

Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used shall be included with the results of the tests and correction factors shall be taken into account.

The substitution antenna shall be moved through a distance of $\pm 0,1$ m in the direction of the test antenna as well as in the two directions perpendicular to this first direction to find the position of maximum response. If these changes of position cause a signal change of greater than 2 dB, the test sample should be re-sited and measurements repeated until a change of less than 2 dB with the substitution antenna is obtained.

A.3.3 Artificial antenna

An artificial antenna may be connected to the equipment output port when cabinet or enclosure emissions are being tested and shall be substantially non-radiating.

Where possible, a direct connection should be used between the artificial antenna and the test sample. In cases where it is necessary to use a connecting cable, precautions should be taken to reduce the radiation from this cable by, for example, the use of ferrite cores or double screened cables.

A.4 Test Practice and Auxiliary Test Equipment

Antenna characteristics and positions and test equipment settings shall be recorded with each test result.

Test equipment calibration shall be traceable to appropriate European standards. Test equipment, antenna and cable types or characteristics shall be recorded with the results of the tests.

Test methods shall comply with operator instructions for each item of equipment, with the measurements and limits described in the present document, and with the provisions and guidelines given below.

All test equipment shall be calibrated with traceability to European standards and used in accordance with the manufacturer's recommended operating procedures.

A.5 Measuring distance

Under the conditions provided in this annex, measurement frequencies will be above 25 MHz and the measuring distance should be greater than $2D^2/\lambda$ or $\lambda/2$, whichever is greater, at the frequency of measurement where D is the largest transmitting aperture dimension. Outdoor sites will be required for low frequency measurements unless special provisions are made at an indoor, anechoic or near field site.

A.5.1 Standard position

The standard position in all test sites, except for equipment which is intended to be worn on a person, shall be as follows:

- for equipment with an integral antenna, it shall be placed in the position closest to normal use as declared by the manufacturer;
- for equipment with a rigid external antenna, the antenna shall be vertical;
- for equipment with non-rigid external antenna, the antenna shall be supported by a non-conducting support at the initial height of the test antenna.

A.5.2 Auxiliary cables

The position of auxiliary cables (power supply and microphone cables etc.) which are not adequately de-coupled, may cause variations in the measurement results. In order to get reproducible results, cables and wires of auxiliaries should be arranged vertically downwards (through a hole in the non conducting support), or as specified in the technical documentation supplied with the equipment.

Care shall be taken to ensure that test cables do not adversely affect the measuring result.

Annex B (normative): General description of measurement methods

This annex gives the general methods of measurements for RF signals using the test sites and arrangements described in annex A. In addition, this annex gives a simple measurement method for radiated emissions based on a calculated rather than measured path loss.

B.1 Conducted measurements

In view of the low power levels of the equipment to be tested under the present document, conducted measurements may be applied to equipment provided with an antenna connector. Where the equipment to be tested does not provide a suitable termination, a coupler or attenuator that does provide the correct termination value shall be used.

The equivalent isotropically radiated power is then calculated from the measured value, the known antenna gain, relative to an isotropic antenna, and if applicable, any losses due to cables and connectors in the measurement system.

B.2 Radiated measurements

Radiated measurements shall be performed with the aid of a test antenna and measurement receiver as described in annex A. The test antenna and measurement receiver, spectrum analyser or selective voltmeter, shall be calibrated according to the procedure defined in this annex. The equipment to be measured and the test antenna shall be oriented to obtain the maximum emitted power level. This position shall be recorded in the measurement report. The frequency range shall be measured in this position.

Preferably, radiated measurements shall be performed in an anechoic chamber. For other test sites corrections may be needed (see annex A).

- a) A test site which fulfils the requirements of the specified frequency range of this measurement shall be used.
- b) The transmitter under test shall be placed on the support in its standard position (clause A.1.2) and switched on.
- c) The test antenna shall be oriented initially for vertical polarization unless otherwise stated. The test antenna shall be raised or lowered, through the specified height range until the maximum signal level is detected on the measuring receiver.

The test antenna need not be raised or lowered if the measurement is carried out on a test site according to clause A.3.

- d) The transmitter shall be rotated through 360° about a vertical axis to maximize the received signal.
- e) The test antenna shall be raised or lowered again, if necessary, through the specified height range until a maximum is obtained. This level shall be recorded.

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

- f) This measurement shall be repeated for horizontal polarization.
- g) The substitution antenna, shall replace the transmitter antenna in the same position and in vertical polarization. The frequency of the signal generator shall be adjusted to the transmitter (carrier) frequency.
- h) Steps c) to f) shall be repeated.
- i) The input signal to the substitution antenna shall be adjusted in level until an equal or a known related level to that detected from the transmitter is obtained in the test receiver.
- j) This measurement shall be repeated with horizontal polarization.

- k) The radiated power is equal to the power supplied by the signal generator, increased by the known relationship if necessary and after corrections due to the gain of the substitution antenna and the cable loss between the signal generator and the substitution antenna.

Annex C (normative): Power limits for RFID systems operating in the 2,45 GHz ISM band

The present annex specifies the requirements for RFID systems operating in the 2,45 GHz ISM band.

C.1 Power limits and frequency band

The parameter limits for RFID equipment operating in the 2,45 GHz band are defined in table C.1.

Table C.1: Parameters for 2,45 GHz RFID systems

Frequency band	Power limit, e.i.r.p. (note 1)	Use of equipment	Comments
2 446 MHz to 2 454 MHz	+27 dBm	No restriction	FHSS or unmodulated carrier (CW) only
2 446 MHz to 2 454 MHz	+36 dBm (see note 2)	In-building only	FHSS only
NOTE 1: e.i.r.p. including an antenna with the following data: a) equal or less than ± 45 degrees horizontal beamwidth; b) equal or more than 15 dB sidelobe attenuation; c) physical protection (e.g. antenna dome) which dimension limits a power transfer from the RFID antenna to a quarter wave matched dipole at positioned at an extreme close proximity to $\leq +15$ dBm. NOTE 2: The use of power levels above +27 dBm (e.i.r.p.) shall by technical means be restricted to in building use only and shall have a duty cycle less than or equal to 15 % averaged over any 200 msec period. (30 msec on/170 msec off).			

C.1.1 Additional requirements for 2,45 GHz 4 W e.i.r.p. indoor RFID equipment

Indoor 4W e.i.r.p. RFID equipment shall be constructed with 2 power levels as described below:

The default power level is 500 mW e.i.r.p. or less.

The 4 W e.i.r.p. level is only enabled by a secure software code built in into the equipment and which is only accessible by the manufacturer or his representative. They way the software code controls the power level shall be as below:

- Fixed mounted RFID equipment shall be mounted inside a building and shall have a tamper proof function, which shall ensure self-destruction of the special software code if the RFID equipment is removed from its fixed mounting position. Such action shall reduce the power automatically to the default value of to 500 mW e.i.r.p. or less.
- Portable RFID equipment shall, via an inside building short range link, have a continuously update of the special software code. This code is generated by a fixed mounted control unit installed in the same indoor room or area in which the RFID equipment is to be used. Without a signal from this control unit, the RFID equipment shall reduce its power automatically to the default level of 500 mW e.i.r.p. or less. The control unit shall have a tamper proof function, which shall ensure self-destruction of the special software code if the unit is removed from it fixed, in building, mounting position.

Further information related to the above requirement is given in annex D.

C.1.2 Spectrum mask

The spectrum mask shall be declared by the provider and shall comply with the limits in table C.2.

Table C.2: Stair-case spectrum mask for RFID systems operating in the 2,45 GHz band

Frequency off-set, f ($f_0 = 2\,450\text{ MHz}$)	Limit	Measurement resolution Bandwidth
$f \leq f_0 - 4,20\text{ MHz}$ and $f \geq f_0 + 4,20\text{ MHz}$	-5 dBm	30 kHz
$f \leq f_0 - 6,83\text{ MHz}$ and $f \geq f_0 + 6,83\text{ MHz}$	-30 dBm	300 kHz
$f \leq f_0 - 7,53\text{ MHz}$ and $f \geq f_0 + 7,53\text{ MHz}$	-30 dBm	1 MHz

Annex D (informative):

Example of implementation for restriction of 4 W RFID to in-building use only

This annex provides guidance for RFID manufacturers to design an automatic inside/outside building power control, thus in order to meet the essential requirement as stated in EN 300 440-2, clause 4.1.1 and table 2 (see bibliography) power classes 12 and 14a as relevant of the present document. Any other technical design may be implemented to achieve the same result.

The present annex describes an automatic inside/outside building power control scheme. A special, permanently fixed in-building mounted, System Control Unit (SCU) restricts the higher power of 4W RFID to an operation inside a building only. In case the same RFID reader is moved outside the building or the RF beam is turned away from the in-building fixed installed SCU, e.g. towards windows or doors, then the power is automatically reduced to a default power level of 500 mW.

The SCU has a very short communication range (up to approx. 4 m) and transmits an access code to the RFID reader to obtain the higher power of 4 W. The RFID SCU is required to be installed at a permanent fixed position inside a building where the higher power (4 W) is needed.

The above-mentioned schemes will prevent an RFID reader to transmit the higher power when moved outside the range of the SCU. The result of such action is the reader loses its high power access code and consequently the power is automatically reduced to 500 mW. Furthermore, the user of the RFID system does not need to do anything special.

To enforce the use of 4 W inside a building only, the following design options are suggested for SCUs, either:

- SCU units are equipped with a tamper switch to prevent these units from being removed together with its high power access code from their fixed mounting position inside a building. Any tampering with these units causes permanent loss of the access code for the higher power level. This prevents the user from moving the SCU functionality to a position outside the building. It is further suggested that only a manufacturers representative can obtain the necessary tools to generate new high power access code; or
- SCUs are mounted by a special tool that is not for general sale; or
- SCUs are designed to be installed once, if removed, they are permanently destroyed.

An example for 2,45 GHz RFID installation using this principle is shown in figure D.1.

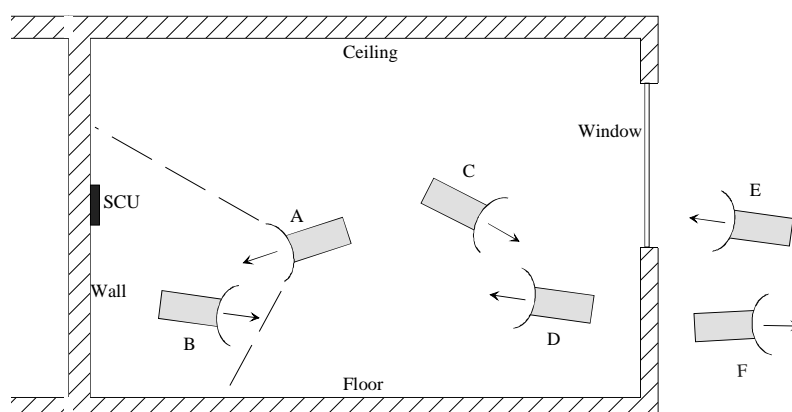


Figure D.1: Example for RFID system with an automatic RF power control for in- and outside building operation

RFID readers, A to F in figure D.1, are all of same type having both 4 W and 500 mW radiated power (e.i.r.p.) with a default power level of 500 mW. Only reader A is able to communicate with the System Control Unit (SCU) via its antenna main beam at close distance and is therefore allowed to radiate with the higher power of 4 W e.i.r.p. All other readers, B to F, are either out of range or outside the antenna main beam concerning the SCU and are therefore forced to radiate with the default power level of 500 mW e.i.r.p.

As an example, the SCU may be passive (without any transmitter) if control communication system is based on radio. In this case, the SCU is only re-modulating and reflecting reader transmitted signals like a normal RFID tag. As the reader receiver sensitivity is limited to approx -62 dBm the SCO to reader range is limited to approximately 3 m and 5 m for reader radiated power of 500 mW and 4 W respectively. This will effectively limit the maximum distance between the reader and the SCU to approximately 3 m in order to turn-on the 4 W power level.

Annex E (normative): Limits for GBSAR operating in the frequency range 17,1 GHz to 17,3 GHz

E.1 Introduction

The present annex specifies limits for Ground Based Synthetic Aperture Radar (GBSAR) based Stepped Frequency CW (SF-CW) radar operating in the frequency range 17,1 GHz to 17,3 GHz.

GBSAR system is used for detection of movement and its scope is limited to radar equipment operated as a short range device. The GBSAR applications considered in the present document are intended exclusively for detection of movement related to structures potentially effecting the protection of workers and the general public. A few examples of applications are given below:

- static and dynamic load analyses of constructions like bridges and buildings;
- landslide monitoring;
- volcano and earthquake movement detection;
- urban area subsidence detection.

Method of measurements and other limits than given in clause E.2 are in accordance with the present document.

E.2 Effective radiated power (e.i.r.p.)

E.2.1 Definition

See clause 7.1.

E.2.2 Method of measurement

See clause 7.2.

E.2.3 Limits

The radiated power shall not exceed +26 dBm e.i.r.p.

E.3 Permitted range of operating frequencies

See clause 7.2.

E.4 Principles of Detection And Avoid (DAA)

In order to avoid any interference of GBSAR towards other radar systems operating in the same frequency range, a GBSAR equipment shall use a Detection And Avoid (DAA) spectrum access method.

The principle of DAA is that GBSAR shall sense the channel within its operative bandwidth, in order to detect the possible presence of other radar systems. If a radar system is detected GBSAR shall avoid the transmission until the other radar system disappears.

The DAA threshold and timing requirements are defined in clauses E.4.3 and E.4.4 respectively.

Equivalent or better techniques than DAA may be used, providing that they meet the DAA essential requirements.

E.4.1 General DAA test set-up

The following DAA test set-up shall be used.

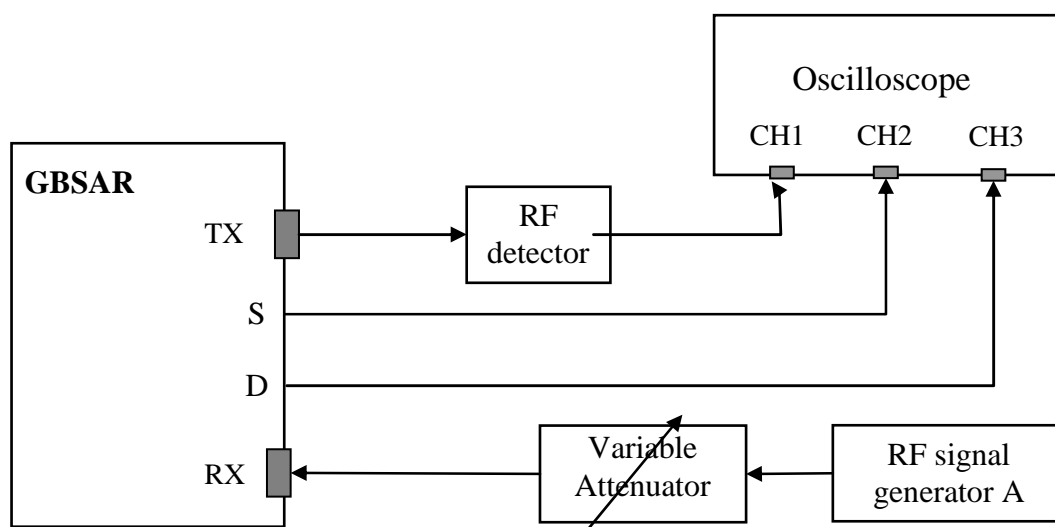


Figure E.1: DAA measurement arrangement

The DAA test set-up is composed by:

- An RF signal generator, A, is connected to GBSAR receiver antenna connector via appropriate attenuator. A variable attenuator is used to vary the output power of signal generator A into to the GBSAR receiver.
- GBSAR transmitter antenna connector is connected to channel 1 of a three channel oscilloscope via an RF detector. The detected RF signal measured by the oscilloscope will show when GBSAR is actually transmitting.
- GBSAR shall provide an output logic test signal, S, indication when the intended operation command of GBSAR is started and stopped respectively. This signal is connected to channel 2 of the oscilloscope.
- GBSAR shall provide an output logic signal, D, indication when the level from the signal generator A is detected above and below the GBSAR receiver DAA threshold respectively. This signal shall be connected to channel 3 of the oscilloscope.

The signal generator A shall be able to generate all the test signals defined in clause E.4.2, table E.1.

The variable attenuator shall provide a range of at least 20 dB of attenuation in 1 dB steps.

For equipment with integral antennas the connection with GBSAR receiver and transmitter shall be made with a temporary antenna connector or an appropriate test fixture, (see clauses 4.2.3 and 6.3).

E.4.2 Test signals

For validation of the DAA function the necessary characteristics of four RF test signals and their related test modulation are defined in table E.1.

Table E.1: Characteristics of RF test signals for different types of radar systems

Parameter	Unit	Type 1	Type 2	Type 3	Type 4
Modulation		Linear FM pulse	Linear FM pulse	Frequency Hopping	Linear FM pulse
Frequency range	GHz	17,1 to 17,3	17,1 to 17,2	17,1 to 17,3	17,1 to 17,3
Chirp bandwidth	MHz	200	100	30	3
Signal generator	dBm/MHz	-71,0	-66	-35,0	-50,0
Peak Power	dBm	-48,0	-46	-20,2	-45,2
Pulsewidth	μs	15,3	40,6	0,1	17
PRR, Pulse repetition rate	pps	2 041	900	1 333	3 140

E.4.3 DAA threshold

E.4.3.1 Definition

The DAA threshold is defined as the received signal power level at GBSAR antenna connector above which the equipment shall determine the presence of a radar system.

Different DAA thresholds are defined according to the actual radar system signal characteristics, see clause E.4.2, table E.1.

E.4.3.2 Method of measurement

The test set-up in figure E.1 shall be used. The following procedure shall be used:

- The attenuator is set at the minimum attenuation (ideally 0 dB).
- A test signal according to clause E.4.2, table E.1 with a power level +10 dB above the DAA threshold limit is applied by the RF signal generator A.
- The time, t_0 , at which the transmitter is intended to be switched-on shall be noted at the oscilloscope on channel 2 of the oscilloscope.
- It shall be noted that a DAA level above its threshold is detected at channel 3 at the oscilloscope.
- The RF power level from the RF generator A is reduced in 1 dB steps by the increasing the attenuation of attenuator until a signal is not anymore detected on channel 3 of the oscilloscope.
- The resulting RF power level at GBSAR RX antenna connector is calculated as the difference between the signal generator power level in dBm minus the attenuator value in dB. The final level (the DAA threshold) is noted and recorded in the test report.

The procedure a) to f) shall be made for each type of the four test signals according the clause E.4.2, table E.1.

E.4.3.3 Limit

The maximum DAA threshold for GBSAR in listen mode are given in table E.2.

Table E.2: Maximum DAA thresholds

Test signal type	DAA maximum threshold
1	-81 dBm/MHz
2	-76 dBm/MHz
3	-45 dBm/MHz
4	-60 dBm/MHz

As an option a manufacturer may select to test only one DAA threshold, in this case the lowest limit value shall apply.

E.4.4 DAA timing parameters

E.4.4.1 Minimum listen Time

E.4.4.1.1 Definition

Prior to any GBSAR operation a minimum listen time applies. The minimum listen time, t_D , is defined as the minimum time that GBSAR listens within its bandwidth immediately prior any indented transmission to determine if one or more radar systems are transmitting within range. If a radar system is detected, then clauses E.4.5 and E.4.7 apply.

E.4.4.1.2 Method of measurement

The test set-up in figure E.1 shall be used. The following test procedure shall be used:

- Set the attenuator at the maximum attenuation (at least 20 dB).
- A test signal according to clause E.4.2, table E.1 is applied by the RF signal generator A. The signal generator is switched on. The received power level at GBSAR RX antenna connector shall be at least 10 dB below the DAA threshold limit, see clause E.4.3.3, table E.2.
- The GBSAR is intentionally switched on and the time, t_0 , is noted at channel 2 of the oscilloscope.
- The time, t_t , when the actual transmission is automatically switched-on is noted at channel 1 of the oscilloscope. The minimum listen time is calculated as:

$$t_D = t_t - t_0$$

The minimum listen time measured is illustrated at figure E.2.

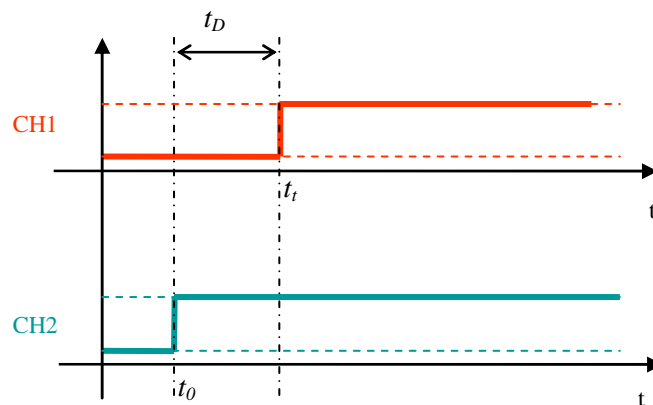


Figure E.2: Minimum listen time , t_D , measurement

E.4.4.1.3 Limit for minimum listen time

The limit for the minimum listen time t_D is $> 15s$.

The value of t_D shall be noted in the test report by the equipment provider.

E.4.5 Minimum listen time after detection

E.4.5.1 Definition

If a radar signal which is not generated by GBSAR is detected then GBSAR shall sense the channel for a time interval defined as minimum listen time after detection t_L , before starting or continuing any transmission. If during this interval a radar system is detected t_L is reset.

E.4.5.2 Method of measurement

The test set-up in figure E.1 shall be used. The following test procedure shall be used:

- Set the attenuator at the minimum attenuation (ideally 0 dB).
- A test signal according to clause E.4.2, table E.1 is applied by the RF signal generator A. The power level at GBSAR RX antenna connector shall be at least 10 dB above the DAA threshold. (The DAA threshold is defined in clause E.4.3, table E.2).
- The time, t_0 , at which the intended transmitter command is switch-on shall be noted at channel 2 of the oscilloscope, see figure E.3.
- Note that a DAA level above the DAA threshold is detected at channel 3 at the oscilloscope and that no transmission is present by monitoring channel 1 at the oscilloscope, see figure E.3. These facts shall be noted in the test report.
- By increasing the value of variable attenuator in steps of 1 dB, the power from the signal generator A to the GBSAR receiver antenna connector is reduced.
- Note the time, t_S , when the power from the signal generator A at RX antenna connector is reduced to 3 dB below the DAA threshold, see figure E.3. The value of the attenuation shall be noted.
- It shall be noted that a DAA level below the DAA threshold is detected at channel 3 at the oscilloscope.
- Note the time, t_r , when the transmitter is automatically switched-on at channel 1 of the oscilloscope.

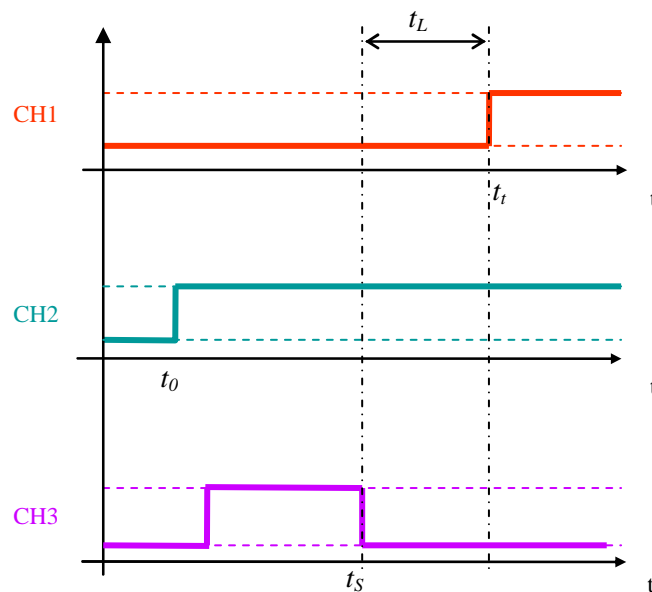


Figure E.3: Minimum listen time after detection , t_L , measurement

E.4.5.3 Limit

The minimum listen time after detection, t_L , is calculated as:

$$t_L = t_t - t_S$$

The limit for the minimum listen time after detection is $t_L > 120$ s.

The value of t_L shall be noted in the test report.

E.4.6 Maximum transmitter on-time

GBSAR shall only be allowed to transmit continuously for a maximum specified period. This will prevent GBSAR to transmit for an extended time without noticing the presence of a RL system.

E.4.6.1 Definition

The maximum transmitter on-time, t_{on} , is defined as the maximum time GBSAR can transmit continuously without interruption.

E.4.6.2 Method of measurement

The test set-up in figure E.1 shall be used. The following test procedure shall be used:

- Set the attenuator at the maximum attenuation (at least 20 dB).
- A test signal according to clause E.4.2, table E.1 is applied by the RF signal generator A and the generator is switched on. The received power level at GBSAR RX antenna connector shall be at least 10 dB below the DAA threshold, see clause E.4.3.3, table E.2.
- GBSAR is switched on, The time, t_0 , at the intended switch-on command shall be noted at channel 2 of the oscilloscope, see figure E.4.
- Note the time, t_t , when the transmitter is actually switched-on (channel 1 of the oscilloscope).
- Note the time, t_e , when the transmitter is automatically switched-off at channel 1 of the oscilloscope.

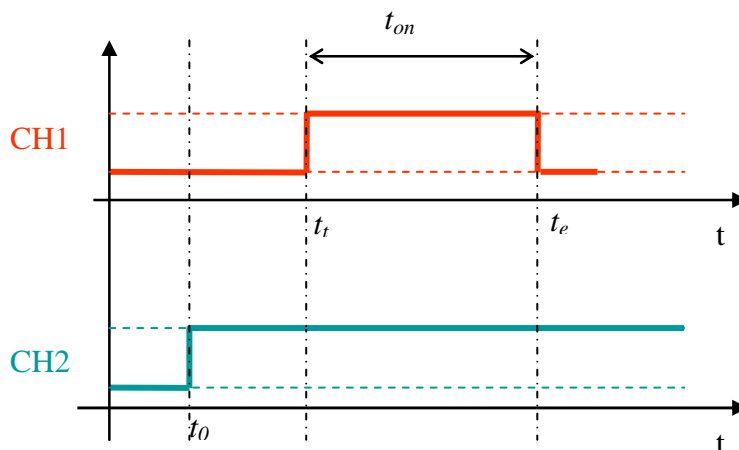


Figure E.4: Maximum transmit on time , t_{on} , measurement

E.4.6.3 Limit

The maximum transmitter on-time, t_{on} , is calculated as:

$$t_{on} = t_e - t_t$$

The limit for maximum TX-on time, t_{on} is < 40 s.

The value of t_{on} shall be noted in the test report.

E.4.7 Minimum transmitter off-time

E.4.7.1 Definition

The minimum TX-off time, t_{off} , is defined as the period where GBSAR shall remain off after a transmission period. During TX-off time GBSAR shall again sense the channel in order to detect the presence of a radar system.

If during t_{off} GBSAR detects the presence of a radar system then clause E.3.5 applies.

E.4.7.2 Method of measurement

The test set-up in figure E.1 shall be used. The following test procedure shall be used:

- Set the attenuator at the maximum attenuation (at least 20 dB).
- A test signal according to clause E.4.2, table E.1 is applied by the RF signal generator A and the generator is switched on. The power level at GBSAR RX antenna connector is at least 10 dB below the DAA threshold, see clause E.4.3.3 table E.2.
- The time, t_0 , at the intended transmitter switch-on command shall be noted at channel 2 of the oscilloscope, see figure E.5.
- The time, t_t , when the transmitter is actually switched-on shall be noted at channel 1 of the oscilloscope, see figure E.5.
- Note the time, t_e , when the transmitter is automatically switched-off at channel 1 of the oscilloscope see figure E.5.
- Note the time, t_r , when the transmitter is automatically switched-on at channel 1 of the oscilloscope, see figure E.5.

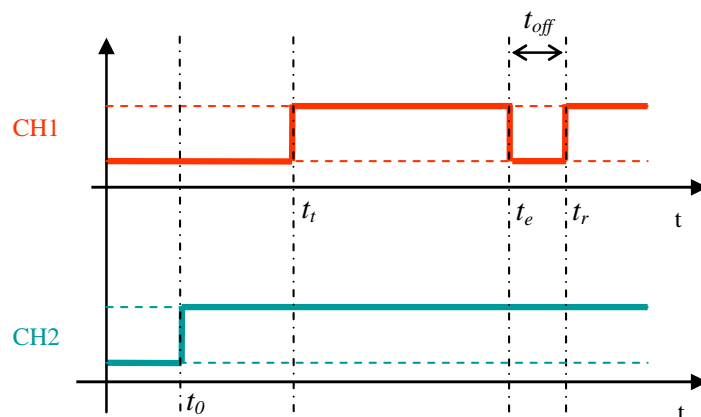


Figure E.5: Maximum transmit off time, t_{off} measurement

E.4.7.3 Limit

The minimum TX-off time, t_{off} is calculated as:

$$t_{off} = t_r - t_e$$

The limit for minimum TX-off time t_{off} is ≥ 40 ms.

The value of t_{off} shall be noted in the test report.

Annex F (informative): Bibliography

- Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.
- Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations.
- ETSI EN 301 489-3 (V1.2.1): "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".
- ITU-R Recommendation SM.1755: "Characteristics of ultra-wideband technology".
- European Commission Decision (2006/771/EC) of 9 November 2006 on harmonization of the radio spectrum for use by short-range devices.
- CEPT/ERC Recommendation 70-03 (2007): "Relating to the use of Short Range Devices (SRD)".
- CEPT/ERC Recommendation 74-01 (2005): "Unwanted emissions in the spurious domain".
- ETSI EN 300 440-2 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".
- ETSI TR 100 028 (V1.4.1) (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

History

Document history		
Edition 1	December 1995	Publication as I-ETS 300 440
Corrigendum 1	April 1996	Corrigendum 1 to 1 st Edition of I-ETS 300 440
V1.3.1	September 2001	Publication
V1.4.1	August 2007	Public Enquiry PE 20071130: 2007-08-01 to 2007-11-30