

**Electromagnetic compatibility
and Radio spectrum Matters (ERM);
Short Range Devices (SRD);
Radio equipment to be used in the 25 MHz to 1 000 MHz
frequency range with power levels ranging up to 500 mW;
Part 1: Technical characteristics and test methods**



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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 includes improvements to the previous version of the standard that take advantage of technical developments within the SRD industry.

The present document is part 1 of a multi-part deliverable covering the Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW, as identified below:

Part 1: "Technical characteristics and test methods";

Part 2: "Harmonized EN covering essential requirements under 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

Introduction

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

Clause 4 provides a guide as to the number of samples required in order that type tests may be carried out, and any markings on the equipment which the provider should provide.

Clauses 5 and 6 give guidance on the test and general conditions for testing of the device.

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

Clause 8 specifies receiver parameters which are only required to be measured in cases where:

- a Listen Before Talk (LBT) protocol is used to control the transmitter; or
- an enhanced protection of the receiver is required, e.g. for special applications such as fire alarms or social alarms.

The present document describes a generic classification of receiver performance in clause 4.1.1.

Clause 10 gives the maximum measurement uncertainty values.

Annex A (normative) provides specifications concerning radiated measurements.

Annex B (normative) contains specifications for a filter for transmitter measurement arrangements.

Annex C (normative) provides information on the spectrum analyser specification.

Annex D (normative) covers normative requirements for social alarms.

Annex E (normative) covers supplementary requirements for receivers.

Annex F (informative) Bibliography covers other supplementary information.

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) Detection, movement and alert applications.

These radio equipment types are capable of operating in the permitted frequency bands within the 25 MHz to 1 000 MHz 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 to Short Range Devices and the CEPT/ERC/REC 70-03 [8] as known at the date of publication of the present document.

Table 1: Short Range Devices within the 25 MHz to 1 000 MHz permitted frequency bands

	Frequency Bands/frequencies	Applications
Transmit and Receive	26,995 MHz, 27,045 MHz, 27,095 MHz, 27,145 MHz, 27,195 MHz, 34,995 MHz to 35,225 MHz, 40,665 MHz, 40,675 MHz, 40,685 MHz, 40,695 MHz	Model control
Transmit and Receive	26,957 MHz to 27,283 MHz	Generic use
Transmit and Receive	40,660 MHz to 40,700 MHz	Generic use
Transmit and Receive	138,200 MHz to 138,450 MHz	Generic use
Transmit and Receive	169,400 MHz to 169,475 MHz	Tracking, tracing and data acquisition and meter reading
Transmit and Receive	169,475 MHz to 169,4875 MHz	Social alarms
Transmit and Receive	169,5875 MHz to 169,6000 MHz	Social alarms
Transmit and Receive	433,050 MHz to 434,790 MHz	Generic use
Transmit and Receive	863,000 MHz to 870,000 MHz	Generic use
Transmit and Receive	864,800 MHz to 865,000 MHz	Wireless audio applications
Transmit and Receive	868,000 MHz to 868,600 MHz	Generic use
Transmit and Receive	868,600 MHz to 868,700 MHz	Alarms
Transmit and Receive	868,700 MHz to 869,200 MHz	Generic use
Transmit and Receive	869,200 MHz to 869,250 MHz	Social alarms
Transmit and Receive	869,250 MHz to 869,300 MHz	Alarms (0,1 % duty cycle)
Transmit and Receive	869,300 MHz to 869,400 MHz	Alarms (1 % duty cycle)
Transmit and Receive	869,400 MHz to 869,650 MHz	Generic use
Transmit and Receive	869,650 MHz to 869,700 MHz	Alarms
Transmit and Receive	869,700 MHz to 870,000 MHz	Generic use

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

NOTE 2: In addition, it should be noted that other frequency bands may be available in a country within the frequency range 25 MHz to 1 000 MHz covered by the present document.

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

The present document covers fixed stations, mobile stations and portable stations.

Applications using Ultra- WideBand (UWB) technology are not covered by the present document.

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

2 References

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.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
 - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
 - for informative references.

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For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

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

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

- | | |
|-----|---|
| [1] | ITU-T Recommendation O.153: "Basic parameters for the measurement of error performance at bit rates below the primary rate". |
| [2] | ETSI TR 100 028 (all parts) (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics". |
| [3] | 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". |
| [4] | ITU-T Recommendation O.41: "Psophometer for use on telephone-type circuits". |
| [5] | ETSI TR 102 273 (all parts) (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties". |
| [6] | ANSI C63.5 (2006): "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electro Magnetic Interference". |

- [7] 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).

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

- [8] CEPT/ERC/REC 70-03 (2007): "Relating to the use of Short Range Devices (SRD)".
- [9] ITU-R Radio Regulations.
- [10] ITU-R Recommendation SM.1755: "Characteristics of ultra-wideband technology".
- [11] IC RSS-Gen (2007-06): "General requirements and information for the certification of radio communication equipment".
- [12] CEPT/ERC/REC 74-01 (2005): "Unwanted emissions in the spurious domain".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

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

adjacent channels: channels on either side of the nominal channel separated by the nominal channel bandwidth

alternate adjacent channels: those two channels offset from the nominal channel by double the channel bandwidth

The wanted channel is described by the occupied bandwidth (see definition below) 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 [9] shall not exceed the wanted channel.

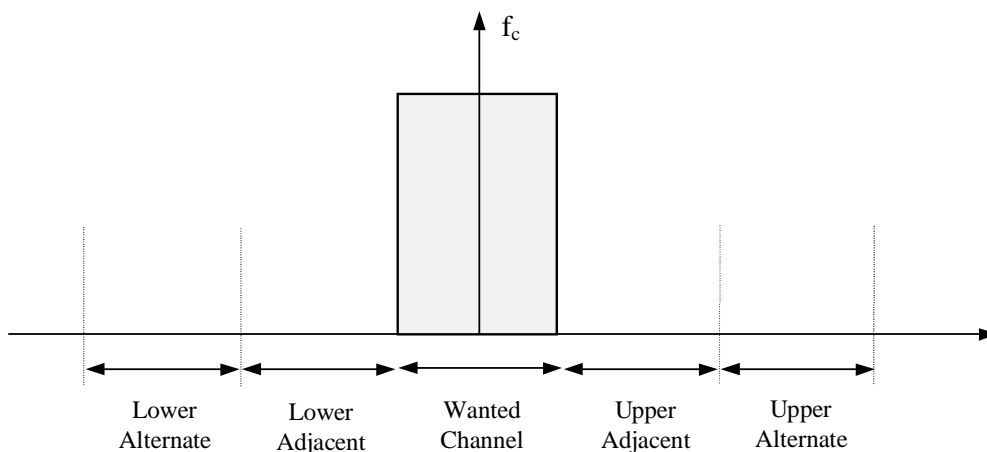


Figure 1: Adjacent and alternate adjacent channel definitions

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.

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

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

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

fixed station: equipment intended for use in a fixed location

frequency agility: ability to determine an unoccupied sub-band or channel of operation in order to minimize interference with other users of the same band

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

listen before talk: combination of the listen mode followed by the talk mode

listen mode: action taken by an interrogator to detect an unoccupied sub-band or channel prior to transmitting

mobile station: equipment normally fixed in a vehicle

narrowband: equipment to be used in a non-channelized continuous frequency band with a channel spacing of equal or less than 25 kHz, or equipment to be used in a channelized frequency band with a channel spacing of equal or less than 25 kHz

NOTE: For equipment to be used in a non-channelized frequency band by the regulation the channel spacing of the equipment is defined by the provider.

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.

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

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.

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

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

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

social alarm devices: are used to assist elderly or disabled people living at home when they are in distress

spurious emissions: emissions 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.

talk mode: transmission of intentional radiation by a transmitter

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 that 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 [10]

wanted channel: occupied bandwidth of the wanted emissions

wideband: equipment having an occupied bandwidth of more than 25 kHz

3.2 Symbols

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

dB	decibel
E	Electric field strength
FR _C	Centre of Frequency Range
FR _H	Higher end of Frequency Range
FR _L	Lower end of Frequency Range
NaCl	sodium chloride
R	distance
S	Sensitivity of receiver
t _L	Total listen time
t _F	Fixed part of listen time
t _{PS}	Pseudo random part of listen time
λ	wavelength

3.3 Abbreviations

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

ac/AC	alternating current
AFA	Adaptive Frequency Agility
BW	BandWidth
DSSS	Direct Sequence Spread Spectrum
EMC	ElectroMagnetic Compatibility
emf	electromotive force
e.i.r.p.	equivalent isotropically radiated power
e.r.p.	effective radiated power
EUT	Equipment Under Test
FHSS	Frequency Hopping Spread Spectrum
IC RSS	Industry Canada Radio Standard Specification
IF	Intermediate Frequency
ITU-R	International Telecommunications Union - Radio Communication
ITU-T	International Telecommunications Union - Telecommunications Standardization Sectors
LBT	Listen Before Talk
NRI	National Radio Interfaces
OATS	Open Area Test Site
R&TTE	Radio and Telecommunications Terminal Equipment
RF	Radio Frequency
SINAD	Received signal quality based on SND/ND (see below)
SND/ND	Signal + Noise + Distortion divided by Noise + Distortion
SR	Switching Range
SRD	Short Range Device

TX	Transmitter
UWB	Ultra Wide Band
VSWR	Voltage Standing Wave Ratio

4 Technical requirement 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 a set of relevant receiver requirements and minimum performance criteria. The set of receiver requirements depends on the choice of receiver category by the equipment provider.

The provider shall specify the receiver category of his choice and this shall be declared in the product literature provided to the user. 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	8.3, 8.4 and 8.5	Highly reliable SRD communication media; e.g. serving human life inherent systems (may result in a physical risk to a person).
2	8.4 and 8.5	Medium reliable SRD communication media e.g. causing Inconvenience to persons, which cannot simply be overcome by other means.
3	8.5	Standard reliable SRD communication media e.g. Inconvenience to persons, which can simply be overcome by other means (e.g. manual).

If the receiver is intended for two way communication, the receiver category 1, 2 or 3 shall be stated in both the test report and in the user's manual for the equipment.

4.1.2 General performance criteria

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

- a SINAD ratio of 20 dB, measured at the receiver output through a telephone psophometric weighting network as described in ITU-T Recommendation O.41 [4]; 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.

Where the indicated performance cannot be achieved, the performance criteria used to determine the performance of the receiver shall be declared and published by the provider.

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 an 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 user's manual, packaging or guarantee material.

The marking shall include as a minimum:

- the name of the manufacturer or his trademark;
- the type designation.

Additional information shall be included in the user manual:

- receiver category, see clause 4.1.1;
- transmitter duty cycle, if used;
- receiver LBT, if used.

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

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

5.3.2 Normal test power source

5.3.2.1 Mains voltage

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

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

5.3.2.2 Regulated lead-acid battery power sources

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

5.3.2.3 Other power sources

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

5.4 Extreme test conditions

5.4.1 Extreme temperatures

5.4.1.1 Procedure for tests at extreme temperatures

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

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

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

5.4.1.1.1 Procedure for equipment designed for continuous operation

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

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

5.4.1.1.2 Procedure for equipment designed for intermittent operation

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

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

5.4.1.2 Extreme temperature ranges

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

- a) the temperature range as declared by the provider, or
- b) one of the following specified temperature ranges:
 - Temperature category I (General): -20 °C to +55 °C;
 - Temperature category II (Portable): -10 °C to +55 °C;
 - Temperature category III (Equipment for normal indoor use): +5 °C to +35 °C.

The test report shall state which range is used.

5.4.2 Extreme test source voltages

5.4.2.1 Mains voltage

The extreme test voltages for equipment to be connected to an ac mains source shall be the nominal mains voltage $\pm 10\%$. 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.

6.1.1 Normal test signals for analogue speech

Normal test signals for analogue speech are specified as follows:

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

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

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

6.1.2 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 [1]. 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.

6.1.3 Testing of frequency agile or hopping equipment

Where possible, tests shall be carried out on a frequency within ± 50 kHz of the highest frequency hop and of the lowest frequency hop.

For frequency hopping equipment specifically, two different tests shall be made under the conditions stated above:

- a) The hopping sequence is stopped and the equipment is tested at two different channels as stated above.
- b) The hopping sequence is in function and the equipment is tested with two hopping channels as stated above, the channels shall be visited sequentially and the number of visits to each shall be equal.
- c) The hopping sequence is in normal function and the equipment is tested with all hopping channels as declared by the provider.

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.

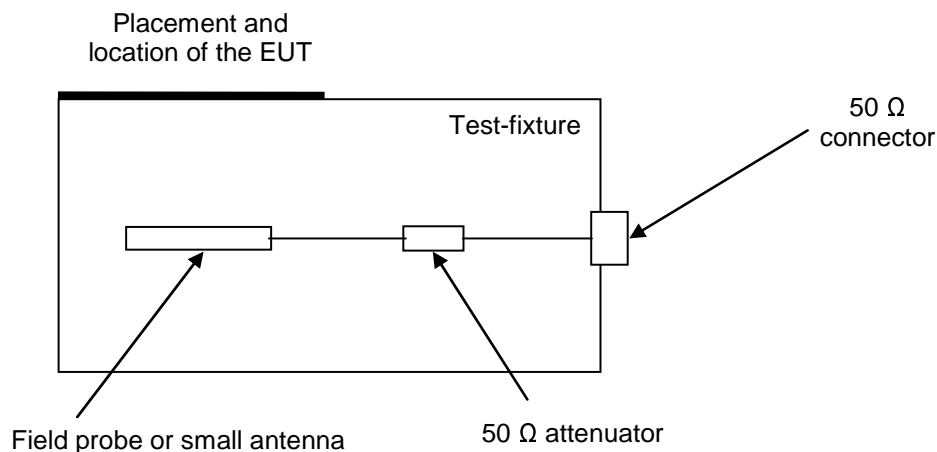


Figure 2: Test fixture

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

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

The test fixture is brought into a temperature chamber.

Step 1:

A transmit antenna connected to a signal generator shall be positioned from the test-fixture at a far field distance of not less than one λ at the frequency. The test fixture consists of the mechanical support for the EUT, an antenna or field probe and a 50 Ω attenuator for proper termination of the field probe. The test fixture shall be connected to a spectrum analyzer via the 50 Ω connector. A signal generator has to be set on the EUT's nominal frequency (see figure 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 shall not deviate more than 1 dB from the value at the nominal frequency. The distance between test antenna and test fixture may be reduced to $\lambda/2$ for frequencies below 100 MHz.

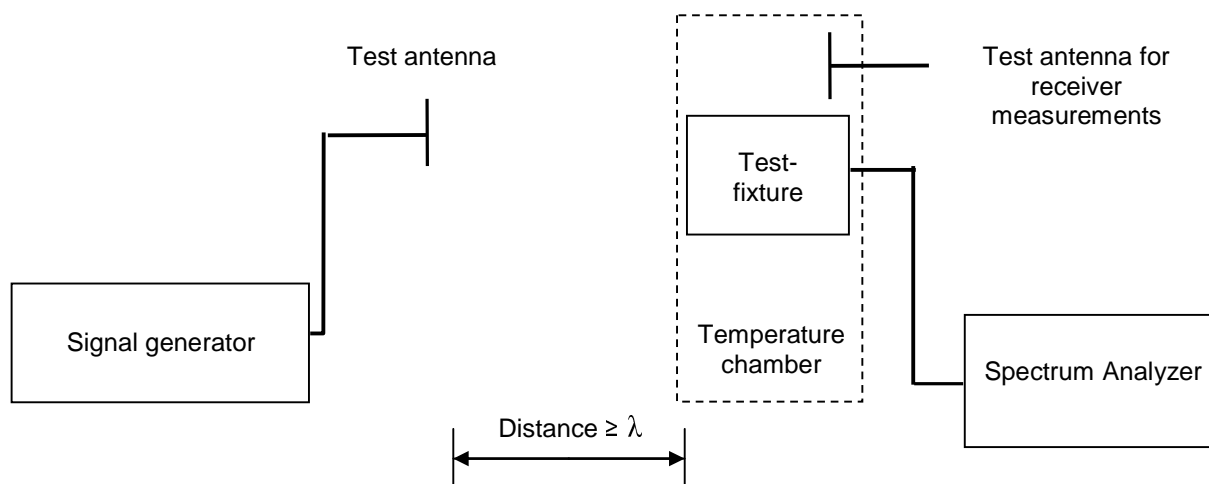


Figure 3: Validation of test set-up without EUT

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

Step 2:

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

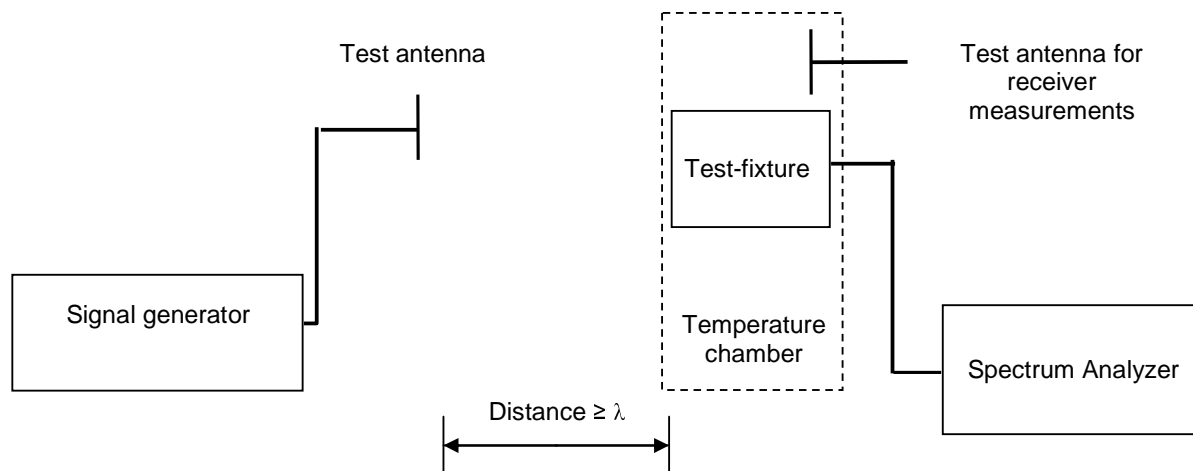


Figure 4: Validation of test set-up with EUT in place

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.

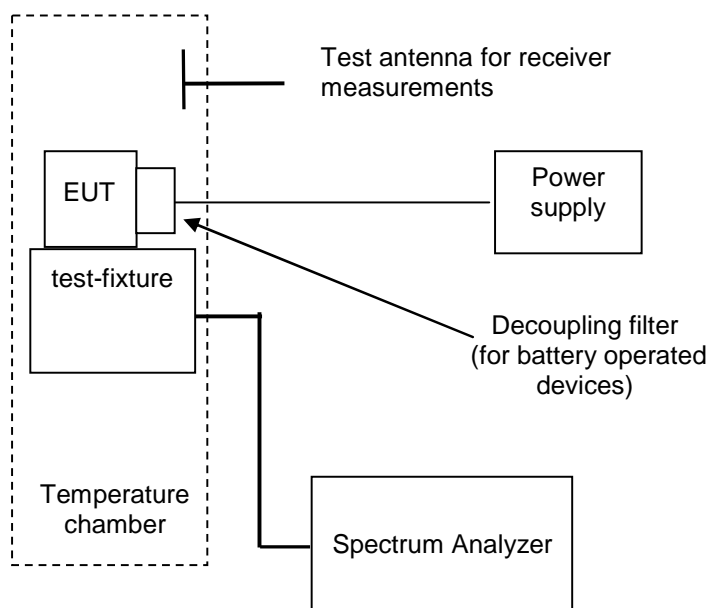


Figure 5: Test of EUT

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 Modes of operation of the transmitter

For the purpose of the measurements according to the present document, there should be a facility to operate the transmitter in an un-modulated state. The method of achieving an un-modulated carrier frequency, or special types of modulation patterns may also be decided by the provider and where applicable the test laboratory, the details of which modulation patterns shall be described and stated. It may involve suitable temporary internal modifications of the equipment under test. If it is not possible to provide an un-modulated carrier then this shall be stated.

For purposes of testing, the normal test signal (see clause 6.1) shall be applied to the input of the transmitter under test with the normal input device (e.g. microphone) disconnected.

6.6 Measuring receiver

The term "measuring receiver" refers to a frequency-selective voltmeter or a spectrum analyser. An RMS detector is used if not defined otherwise for a specific measurement. The measurement bandwidth of the measuring receiver shall, where possible, be according to CISPR 16 [3]. 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 bandwidth of the measuring receiver shall be as given in table 3.

Table 3: Reference bandwidth for the measurement receiver

Frequency range: (f)	Measuring receiver bandwidth
$f < 150 \text{ kHz}$	200 Hz/300 Hz
$150 \text{ kHz} \leq f < 25 \text{ MHz}$	9 kHz/10 kHz
$25 \text{ MHz} \leq f \leq 1\,000 \text{ MHz}$	100 kHz/120 kHz
$f > 1\,000 \text{ MHz}$	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 Methods of measurement and limits for transmitter parameters

Where the transmitter is designed with an 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 7.8).

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

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

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

For frequency hopping spread spectrum (FHSS) the equipment shall be programmed so that measurements can be performed on selected single carrier or hop frequencies as described in clause 6.1.3.

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

The occupied bandwidth of the equipment under test shall be assessed by using the values of IC RSS-Gen [11] for the resolution and video bandwidth of the spectrum analyzer.

The submitted equipment shall fulfil the requirements of the stated measurement.

7.1 Frequency error

Frequency error is normally measured with an unmodulated carrier. If the equipment is not capable of producing an unmodulated carrier, then the adjacent channel power (see clause 7.6 for narrowband equipment) or modulation bandwidth (see clause 7.7 for wideband equipment) shall be measured under extreme test conditions (see clause 5.4) and the limits in clause 7.6.3 or 7.7.3 shall be met.

7.1.1 Definition

Frequency error is the difference, under normal and extreme conditions, between the measured unmodulated carrier frequency and the nominal frequency as stated by the manufacturer.

7.1.2 Method of measurement

7.1.2.1 Method of measurement for equipment with unmodulated carrier test mode

The provider shall state whether the frequency error or adjacent channel power measurement is applicable, see clause 7.1.

The carrier frequency shall be measured (in the absence of modulation) with the transmitter connected to an artificial antenna. A transmitter without a 50 Ω output connector may be placed in the test fixture (see clause 6.3) connected to a frequency measuring device via an artificial antenna.

The measurement shall be made under normal test conditions (see clause 5.3) and extreme test conditions (see clause 5.4) For the latter, the worst case combination of extreme temperature (see clause 5.4.1) and extreme supply voltage (see clause 5.4.2) are applied simultaneously.

7.1.3 Limits

The frequency error shall not exceed the values given in table 4a for systems with bandwidth less or equal to 25 kHz, or table 4b for systems with bandwidth above 25 kHz, under normal and extreme conditions (see specific bands in clause 7.2.3, table 5).

Table 4a: Frequency error for narrowband systems with bandwidth less or equal to 25 kHz

Channelization	Frequency error limit (kHz), see note				
	< 47 MHz	47 MHz to 137 MHz	> 137 MHz to 300 MHz	> 300 MHz to 500 MHz	> 500 MHz to 1 000 MHz
Channelized systems	$\pm 10,0$	$\pm 10,0$	$\pm 10,0$	$\pm 12,0$	$\pm 20,0$
NOTE: Adjacent channel power as defined in clause 7.6.1 shall not exceed the limit in clause 7.6.3.					

Table 4b: Frequency error for wideband systems with bandwidth above 25 kHz

Operating frequency	Frequency error limit (ppm), see note
$\leq 1\ 000\ \text{MHz}$	± 100
NOTE: Adjacent band power as defined in clause 7.7.1 shall not exceed the limit in clause 7.7.3.	

Additionally, it shall be noted that the transmitter frequency shall always be inside any allocated sub-band, for further information see CEPT/ERC/REC 70-03 [8] as implemented through National Radio Interfaces (NRI) and additional NRI as relevant.

7.2 Carrier power (conducted)

This method applies only to equipment with a permanent external antenna connector. For equipment with an external antenna connector and supplied with a dedicated antenna, clause 7.3 applies.

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

7.2.1 Definition

The carrier power is the average power delivered to the artificial antenna (see clause 6.2) during one radio frequency cycle in the absence of modulation.

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

7.2.2 Method of measurement

The transmitter shall be connected to an artificial antenna (see clause 6.2) and the carrier or mean power delivered to this artificial antenna shall be measured under normal test conditions (see clause 5.3).

In the case of amplitude modulated output, the mean power is measured.

In the case of pulse modulation equipment where it is not possible to make the measurement in the absence of modulation, the measurement shall be carried out by the use of a measuring receiver with bandwidth as stated in clause 6.6 and peak detector and max hold.

For Direct Sequence Spread Spectrum (DSSS) and other non-Frequency Hopping Spread Spectrum (FHSS) equipment, the maximum power density in a 100 kHz resolution band shall be measured by means of a spectrum analyzer and recorded in the test report.

For equipment using FHSS, the additional test conditions in clause 6.1.3 shall be used.

The measurement shall be repeated under extreme test conditions (see clauses 5.4.1 and 5.4.2 applied simultaneously).

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

7.2.3 Limits

Under normal and extreme test conditions (see clauses 5.3 and 5.4), the carrier output power (conducted) shall not exceed the power class value given in table 5.

Table 5: Carrier power limit, e.r.p. - spectrum density vs. Channel spacing

Frequency Bands/frequencies	Applications	Radiated power, e.r.p.	Channel spacing
26,995 MHz, 27,045 MHz, 27,095 MHz, 27,145 MHz, 27,195 MHz. 34,995 MHz to 35,225 MHz. 40,665 MHz, 40,675 MHz, 40,685 MHz, 40,695 MHz	Model control	< 100 mW	10 kHz 10 kHz 10 kHz
26,957 MHz to 27,283 MHz	Generic use	< 10 mW	No specific
40,660 MHz to 40,700 MHz	Generic use	< 10 mW	No specific
138,200 MHz to 138,450 MHz	Generic use	< 10 mW	No specific
169,400 MHz to 169,475 MHz	Tracking and tracing	< 500 mW	≤50 kHz
169,400 MHz to 169,475 MHz	Meter Reading	< 500 mW	≤50 kHz
169,475 MHz to 169,4875 MHz	Social alarms	< 10 mW	12,5 kHz
169,5875 MHz to 169,6000 MHz	Social alarms	< 10 mW	12,5 kHz
433,050 MHz to 434,790 MHz	Generic use	< 10 mW (10 % duty cycle)	No specific
433,050 MHz to 434,790 MHz	Generic use	< 1 mW (100 % duty cycle)	No Specific For bandwidth greater than 250 kHz the power density limited to -13 dBm/10 kHz
434,040 MHz to 434,790 MHz	Generic use	< 10 mW (100 % duty cycle)	≤25 kHz
863,000 MHz to 870,000 MHz	Generic use	< 25 mW (see note)	≤ 100 kHz for 1 or more channels and allowing for a subdivision into 50 kHz or 25 kHz. For a bandwidth of 200 kHz, the frequency band is limited to 865,5 MHz - 867,5 MHz
864,800 MHz to 865,000 MHz	Wireless audio applications	< 10 mW	50 kHz
868,000 MHz to 868,600 MHz	Generic use	< 25 mW	No specific channel spacing, for 1 or more channels, however the whole stated frequency band may be used
868,600 MHz to 868,700 MHz	Alarms	< 10 mW	25 kHz The whole stated frequency band may be used as 1 wideband channel for high speed data transmission
868,700 MHz to 869,200 MHz	Generic use	< 25 mW	No specific channel spacing, for 1 or more channels, however the whole stated frequency band may be used
869,200 MHz to 869,250 MHz	Social alarms	< 10 mW	25 kHz
869,250 MHz to 869,300 MHz	Alarms	< 10 mW (0,1 % duty cycle)	25 kHz
869,300 MHz to 869,400 MHz	Alarms	< 10 mW (1 % duty cycle)	25 kHz
869,400 MHz to 869,650 MHz	Generic use	< 500 mW	≤25 kHz for 1 or more channels. The whole stated frequency band may be used as 1 wideband channel for high speed data transmission
869,650 MHz to 869,700 MHz	Alarms	< 10 mW	25 kHz
869,700 MHz to 870,000 MHz	Generic use	< 5 mW	No specific channel spacing for 1 or more channels, however the whole stated frequency band may be used

NOTE: The power density limits, channel arrangement and duty cycle for FHSS equipment are given in clause 7.4.1.2; for DSSS and other non-FHSS spread spectrum equipment are given in clause 7.4.1.3.

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

NOTE 2: In addition, it should be noted that other frequency bands may be available in a country within the frequency range 25 MHz to 1 000 MHz covered by the present document.

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

7.3 Effective radiated power

This measurement applies to equipment with an integral antenna and to equipment supplied with a dedicated antenna.

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

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

7.3.1 Definition

The effective radiated power is the power radiated in the direction of the maximum level under specified conditions of measurements in the absence of modulation.

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

Information on specific modulation schemes is given clause 7.4.

7.3.2 Methods of measurement

On a test site, selected from annex A, the equipment shall be placed at the specified height on a support, as specified in annex A, and in the position closest to normal use as declared by the provider.

The test antenna shall be oriented initially for vertical polarization and shall be chosen to correspond to the frequency of the transmitter.

The output of the test antenna shall be connected to the measuring receiver.

The transmitter shall be switched on, if possible, without modulation and the measuring receiver shall be tuned to the frequency of the transmitter under test.

In case of pulse modulation equipment where it is not possible to make the measurement in the absence of modulation, the measurement shall be carried out by the use of a measuring receiver with bandwidth as stated in clause 6.6 and peak detector set in accordance with the specification of CISPR 16 [3], section one for the bands C and D.

For equipment using FHSS, the additional test conditions in clause 6.1.3 shall be used.

The test antenna shall be raised and lowered through the specified range of height until a maximum signal level is detected by the measuring receiver.

The transmitter shall then be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver.

The test antenna shall be raised and lowered again through the specified range of height until a maximum signal level is detected by the measuring receiver.

The maximum signal level detected by the measuring receiver shall be noted.

The transmitter shall be replaced by a substitution antenna as defined in clause A.1.5.

The substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of the transmitter.

The substitution antenna shall be connected to a calibrated signal generator.

If necessary, the input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver.

The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received. When a test site according the clause A.1.1 is used, the height of the antenna shall not to be varied.

The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the transmitter radiated power was measured, corrected for the change of input attenuator setting of the measuring receiver.

The input level to the substitution antenna shall be recorded as power level, corrected for any change of input attenuator setting of the measuring receiver.

The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.

The measure of the effective radiated power is the larger of the two levels recorded at the input to the substitution antenna, corrected for gain of the substitution antenna if necessary.

The measurement shall be carried out under normal test conditions only (see clause 5.3).

7.3.3 Limits

The effective radiated power shall not exceed the power limit given in table 5.

The power density limits for DSSS and other non-FHSS spread spectrum equipment is given in clause 7.4.2.2.

The permitted carrier power in different SRD frequency bands are given in table 5; as implemented through National Radio Interfaces (NRI) and additional NRI as relevant.

NOTE: Further information can be found in CEPT/ERC/REC 70-03 [8].

7.4 Spread spectrum modulation

An equipment shall be tested with its intended modulation. If a product can operate with several modulation types it is considered to be a multi-mode equipment, which shall be tested in each of the modulation modes. For example, if an equipment can operate in both FHSS and non-FHSS then both modes shall be tested.

7.4.1 Frequency Hopping Spread Spectrum devices (FHSS)

In order to maximize the use of the available channels and to minimize the potential of interference to other users, the minimum number of channels, the maximum dwell time on a channel and the maximum return time to a channel are stated in clause 7.4.1.2.

7.4.1.1 FHSS definitions

The following specific definitions for FHSS apply:

- a) The number hopping channels is defined as the number of non-overlapping channels used by the FHSS equipment.
- b) The dwell time is defined as the period the equipment stays on channel before hopping to the next hop channel.
- c) Maximum return time to a hop channel is the maximum period within which a specific hop channel shall be reused.

7.4.1.2 FHSS declarations

The following declarations for FHSS shall be made by the provider:

- a) The provider shall declare the number of non-overlapping channels or hopping positions separated by the declared hop channel bandwidth. The minimum number of channels shall be greater than or equal to the limit given in clause 7.4.1.3, indent a).

- b) The provider shall declare the dwell time per channel, which shall not exceed the time stated in clause 7.4.1.3, indent b).
- c) The provider shall declare the maximum return time to a hop channel which shall not exceed the time stated in clause 7.4.1.3, indent c).
It shall be noted that 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 hop channels.
- d) The provider shall declare transmit duty cycle for the entire transmission, if LBT is not used.

7.4.1.3 Limits

- a) The number of FHSS hopping channels shall not be less than the values given in table 6.

Table 6: Minimum of hop channels and other requirements for FHSS

Sub-band	Number of hop channels/bandwidth (BW)	Other requirements
865 MHz to 868 MHz	≥ 58 at ≤ 50 kHz BW each	LBT or < 1 % TX duty cycle (see note 1)
863 MHz to 870 MHz (see note 2)	≥ 47 at ≥ 100 kHz BW each	LBT or < 0,1 % TX duty cycle (see note 1)
NOTE 1: The duty cycle applies to the entire transmission (not at each hopping channel).		
NOTE 2: The frequency bands for alarms are defined in tables 1, 5 and 6.		

- b) The maximum dwell time per channel shall be equal to or less than 400 ms.
- c) The maximum return time to a hopping channel shall be equal or less than the product of 4 x dwell and the number of hopping channels and must not exceed 20 s.
- d) Each channel of the hopping sequence shall be occupied at least once during a period not exceeding the product of 4 x dwell time and the number of hopping channels.
- e) In case of LBT being used for FHSS, this function shall be used at each hop channel.
- f) In the case of FHSS with a dwell time less than the LBT listen time defined in clause 9.1.1.2.2, a 0,1 % duty cycle restriction applies for the entire FHSS transmission mode.
- g) Using the additional test conditions for FHSS in clause 6.1.3, the conducted power, clause 7.2.3, or radiated power limit, clause 7.3.3, shall not be exceeded.
- h) Using the additional test conditions for FHSS in clause 6.1.3, the adjacent channel power, see clause 7.6.3 or 7.7.3 and spurious emissions, see clause 7.8.5 shall not be exceeded.

7.4.2 Direct sequence or spread spectrum other than FHSS

7.4.2.1 Definition

The maximum spectral power density is defined as the highest level in watts per hertz generated by the transmitter within the power envelope.

7.4.2.2 Limits

For Direct Sequence Spread spectrum or spread spectrum modulation other than FHSS the following limits given in table 7 apply in addition to the conducted power, clause 7.2.3, or radiated power limit, clause 7.3.3.

Table 7: Maximum radiated power density, bandwidth and duty cycle limits for other spread spectrum than FHSS

Sub-band	Occupied bandwidth	Max radiated power density e.r.p.	Requirements
865 MHz to 868 MHz	0,6 MHz	6,2 dBm/100 kHz	1 % TX duty cycle
865 MHz to 870 MHz	3,0 MHz	-0,8 dBm/100 kHz	0,1 % TX duty cycle
863 MHz to 870 MHz	7,0 MHz	-4,5 dBm/100 kHz	0,1 % TX duty cycle

The spurious emissions outside the allocated sub-band, see clause 7.8.5, shall not be exceeded.

7.5 Void

7.6 Adjacent channel power

These measurements are applicable for a given narrowband channel spacing equipment where channel spacing is defined by regulation, see specific bands in clause 7.2.3, table 5.

7.6.1 Definition

The adjacent channel power is defined as the amount of the modulated RF signal power which falls within a given adjacent channel, clause 3.1 definitions.

This power is the sum of the mean power produced by the modulation, hum and noise of the transmitter.

7.6.2 Method of measurement

This test measures the power transmitted in the adjacent channel(s) during continuous modulation. This measurement is complemented by alternate adjacent channel power measurements.

The adjacent channel power shall be measured with a spectrum analyzer which conforms with the requirements given in annex C.

For FHSS, the test conditions in clause 6.1.3 apply.

When using the test fixture (see clause 6.3) for this measurement, it is important to ensure that direct radiation from the transmitter to the spectrum analyzer does not affect the result or the loss introduced by the test fixture.

The following procedure shall be used:

The transmitter shall be modulated with test modulation as appropriate, (see clause 6.1). The modulation used shall be recorded in the test report. During the test, the transmitter shall be set in continuous transmission mode. If this is not possible, the measurements shall be carried out in a period shorter than the duration of the transmitted burst. It may be necessary to extend the duration of the burst. Averaging measurements with 100 samples are possible for constant and non-constant envelope modulated equipment.

The output of the transmitter shall be connected to the input of the spectrum analyser by a 50 Ω power attenuator, to ensure that the impedance presented to the transmitter is 50 Ω and the level at the spectrum analyser input is appropriate.

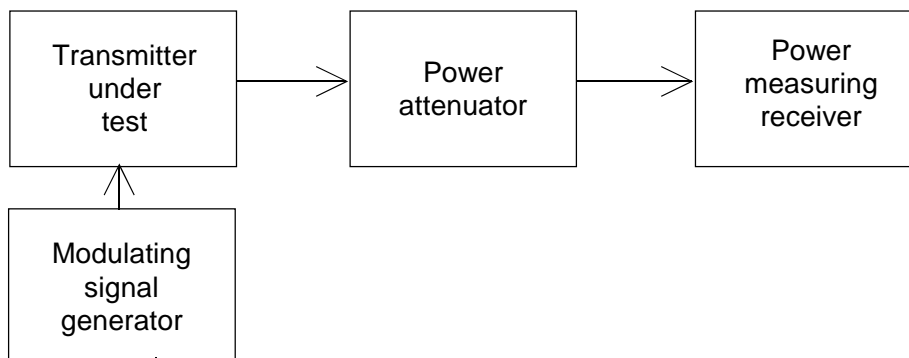


Figure 6: Measurement arrangement

The adjacent channel power may be measured, as follows, with a power measuring receiver which conforms to annex B (referred to in this clause as the "receiver"):

- a) the transmitter shall be operated at the carrier power determined under normal test conditions. The output of the transmitter shall be linked to the input of the "receiver" by a connecting device such that the impedance presented to the transmitter is 50 Ω and the level at the "receiver input" is appropriate;
- b) with the transmitter unmodulated, the tuning of the "receiver" shall be adjusted so that a maximum response is obtained. This is the 0 dB response point. The "receiver" attenuator setting and the reading of the meter shall be recorded. If an unmodulated carrier cannot be obtained, then the measurement shall be made with the transmitter modulated with the normal test signal as appropriate, in which case this fact shall be recorded in test reports;
- c) the frequency of the "receiver" shall be adjusted above the carrier so that the "receiver" -6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency as given in table 8;

Table 8: Frequency displacement (channel spacing variable)

Channel separation (kHz)	Specified necessary bandwidth (kHz)	Displacement of the -6 dB point from the nominal carrier frequency (kHz)
10/12,5	8,5	8,25
20	14	13
25	16	17

- d) the transmitter shall be modulated by a normal test signal as appropriate;
- e) the "receiver" variable attenuator shall be adjusted to obtain the same meter reading as in step b), or a known relation to it;
- f) the ratio of the adjacent channel power to the carrier power is the difference between the attenuator settings in steps b) and e), corrected for any differences in the reading of the meter.

For each adjacent channel, the adjacent channel power shall be recorded.

- the measurement shall be repeated with the frequency of the "receiver" adjusted below the carrier so that the "receiver" -6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency as given in table 8;
- the adjacent channel power of the equipment under test shall be expressed as the higher of the two values recorded in step f) for the upper and lower channels nearest to the channel considered;
- when it is not possible to perform the measurement of frequency error in the absence of modulation, this measurement shall be repeated under extreme test conditions.

7.6.3 Limits

The power in the adjacent channel shall not exceed the maximum values given in table 9.

Table 9: Adjacent channel power limits where channelization is defined by regulation

	Channel separation < 20 kHz	Channel separation \geq 20 kHz
Normal test conditions	10 μ W	200 nW
Extreme test conditions	32 μ W	640 nW
NOTE: These limits also apply to spread spectrum equipment.		

7.7 Bandwidth for non-channelized equipment

7.7.1 Definition

Non channelized equipment is defined as operating inside one or more dedicated sub-bands, in which no channels are defined.

7.7.2 Measurement applicability

This measurement applies to equipment with an occupied bandwidth exceeding 25 kHz, including Direct Sequence Spread Spectrum modulation and FHSS systems measured under the conditions defined in clause 6.1.3 a), and is performed using a spectrum analyser. The range of occupied bandwidth includes all associated side bands above the 0,5 % level and the frequency error and drift under extreme test conditions. In addition, if measured under extreme conditions, then the frequency error tests under clause 7.1 can be omitted.

7.7.3 Method of measurement

In case of equipment with integral antenna, the equipment shall be placed in the test fixture (see clause 6.3). The RF output of the equipment or the test fixture shall be connected to a spectrum analyser via a 50 Ω connector and attenuator.

The transmitter shall be operated at the carrier power measured under normal test conditions in clause 7.2 or 7.3. The attenuator shall be adjusted to an appropriate level displayed on the spectrum analyser screen.

For FHSS, the test conditions in clause 6.1.3 a) apply.

The transmitter shall be modulated by the normal test signal (see clause 6.1).

In case of equipment with intermittent transmission and a duty cycle < 1 % a quasi- peak detector in accordance with CISPR 16 [3] shall be applied

The power density, at the edges of the dedicated sub-band, shall be measured in an appropriate bandwidth, e.g. 1 kHz. The measured result shall be referred to a 100 kHz bandwidth by calculation as given in CEPT/ERC/REC 74-01 [12].

7.7.4 Limits

Including the frequency error as measured in clause 7.1.3, the emission shall at all times be within the limits of the designated sub-band. A limit of -36 dBm/100 kHz at subband edge frequencies shall not be exceeded.

This limit also applies to spread spectrum equipment.

7.8 Unwanted emissions in the spurious domain

In the case of pulse modulation equipment the measurement shall be carried out by the use of a measuring receiver with bandwidth as stated in clause 6.6 and quasi-peak detector set in accordance with the specification of CISPR 16 [3].

For measurements above 1 000 MHz the peak value shall be measured using a spectrum analyser. The "max hold" function of a spectrum analyser shall be used.

7.8.1 Definition

Unwanted emissions in the spurious domain are emissions at frequencies other than those of the wanted carrier frequency and its sidebands associated with normal test modulation.

For FHSS modulation the above definition is valid at any time and at any hopping channel.

For FHSS, the test conditions in clause 6.1.3 apply.

The level of spurious emissions shall be measured as:

- a) either:
 - 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);
- b) or:
 - their effective radiated power when radiated by the cabinet and the integral antenna, in the case of portable equipment fitted with such an antenna and no external RF connector.

7.8.2 Method of measuring the power level in a specified load, clause 7.8.1 a) i)

This method applies only to equipment with an external antenna connector.

For FHSS, the test conditions in clause 6.1.3 apply.

The transmitter shall be connected to a 50 Ω power attenuator. The output of the power attenuator shall be connected to a measuring receiver.

- In the case of pulse modulation, the transmitter shall be switched on with test modulation D-M2.
- If this is not possible then the measurements shall be made with the transmitter modulated by the normal test signal D-M3 (see clause 6.1.2) in which case this fact shall be recorded in the test report.

The measuring receiver, (see clause 6.6) shall be tuned over the frequency range:

- a) 9 kHz to 4 GHz for equipment operating on frequencies below 470 MHz, or
- b) 9 kHz to 12,75 GHz for equipment operating on frequencies above 470 MHz.

To improve the accuracy of the measurement, a RF preselector may be added in order to avoid harmonic components being introduced by the mixer in the receiver.

At each frequency at which a spurious component is detected, the power level shall be recorded as the conducted spurious emission level delivered into the specified load, except for the channel on which the transmitter is intended to operate and the adjacent channels.

The measurements shall be repeated with the transmitter on stand-by.

7.8.3 Method of measuring the effective radiated power, clause 7.8.1 a) ii)

This method applies only to equipment with an external antenna connector.

For FHSS, the test conditions in clause 6.1.3 apply.

On a test site, selected from annex A, the equipment shall be placed at the specified height on a non-conducting support and in the position closest to normal use as declared by the provider.

The transmitter antenna connector shall be connected to an artificial antenna (see clause 6.2). The test antenna shall be orientated for vertical polarization and the length of the test antenna shall be chosen to correspond to the instantaneous frequency of the measuring receiver. The output of the test antenna shall be connected to a measuring receiver.

In the case of pulse modulation the transmitter shall be switched on with test modulation D-M2.

If this is not possible, then the measurements shall be made with the transmitter modulated by the normal test signal D-M3 (see clause 6.1.2) in which case the fact shall be recorded in the test report.

The measuring receiver shall be tuned over the frequency range:

- a) 25 MHz to 4 GHz, for equipment operating on frequencies below 470 MHz, or
- b) 25 MHz to 12,75 GHz for equipment operating on frequencies above 470 MHz.

Tests are made on all frequencies except for the channel on which the transmitter is intended to operate and its adjacent channels.

At each frequency at which a spurious component is detected, the test antenna shall be raised and lowered through the specified range of heights until a maximum signal level is detected on the measuring receiver.

The transmitter shall then be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver and the test antenna height shall be adjusted again for maximum signal level.

The maximum signal level detected by the measuring receiver shall be noted.

The transmitter shall be replaced by a substitution antenna as defined in clauses A.1.4 and A.1.5.

The substitution antenna shall be orientated for vertical polarization and calibrated for the frequency of the spurious component detected.

The substitution antenna shall be connected to a calibrated signal generator.

The frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected. The input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver, if necessary.

The test antenna shall be raised and lowered through the specified range of heights to ensure that the maximum signal is received. When a test site according to clause A.1.1 is used, the height of the antenna need not be varied.

The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for any change of input attenuator setting of the measuring receiver.

The input level to the substitution antenna shall be recorded as a power level, corrected for any change of input attenuator setting of the measuring receiver.

The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.

The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the substitution antenna if necessary.

If applicable, the measurements shall be repeated with the transmitter on standby.

7.8.4 Method of measuring the effective radiated power, clause 7.8.1 b)

This method applies only to equipment without an external antenna connector. The method of measurement shall be performed according to clause 7.8.3, except that the transmitter output shall be connected to the integral antenna and not to an artificial antenna.

For FHSS, the test conditions in clause 6.1.3 apply.

7.8.5 Limits

The power of any spurious emission, conducted or radiated, shall not exceed the following values given in table 10.

Table 10: Limits

Frequency State	47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other frequencies below 1 000 MHz	Frequencies above 1 000 MHz
Operating	4 nW	250 nW	1 μ W
Standby	2 nW	2 nW	20 nW

7.9 Frequency stability under low voltage conditions

This test is for battery operated equipment only.

7.9.1 Definition

The frequency stability under low voltage condition is the ability of the equipment to remain on channel, for channelized equipment, or within the assigned operating frequency band, for non-channelized equipment, when the battery voltage falls below the lower extreme voltage level.

7.9.2 Method of measurement

The carrier frequency shall be measured, where possible in the absence of modulation, with the transmitter connected to an artificial antenna. A transmitter without a 50 Ω output connector may be placed in a test fixture (see clause 6.3) connected to an artificial antenna. The measurement shall be made under normal temperature and humidity conditions (see clause 5.3.1), the voltage from the test power source shall be reduced below the lower extreme test voltage limit towards zero. Whilst the voltage is reduced the carrier frequency shall be monitored.

7.9.3 Limits

The equipment shall either:

- remain on channel, for channelized equipment within the limits stated in clause 7.1.4, or within the assigned operating frequency band, for non-channelized equipment, whilst the radiated or conducted power is greater than the spurious emission limits; or
- the equipment cease to function below the providers declared operating voltage.

7.10 Duty Cycle

For frequency agile devices the duty cycle applies to the total transmissions unless Listen-Before-Talk (LBT) is used. For LBT devices without frequency agility (AFA), the duty cycle applies.

7.10.1 Definitions

For the purposes of this 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.

7.10.2 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 11.

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 11.

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.

7.10.3 Duty cycle limits

In a period of 1 hour the duty cycle shall not exceed the values given in table 11.

Table 11: Duty cycle limits

Frequency Bands/Frequencies	Applications	Duty Cycle
26,995 MHz, 27,045 MHz, 27,095 MHz, 27,145 MHz, 27,195 MHz, 34,995 MHz to 35,225 MHz, 40,665 MHz, 40,675 MHz, 40,685 MHz, 40,695 MHz	Model control	No restriction
26,957 MHz to 27,283 MHz	Generic use	No restriction
138,200 MHz to 138,450 MHz	Generic use	$\leq 1\%$
169,400 MHz to 169,475 MHz	Tracking, tracing and data acquisition	$\leq 1\%$
169,400 MHz to 169,475 MHz	Meter Reading	$\leq 10\%$
169,475 MHz to 169,4875 MHz	Social alarms	$\leq 0,1\%$
169,5875 MHz to 169,6000 MHz	Social alarms	$\leq 0,1\%$
433,050 MHz to 434,790 MHz	Generic use	$\leq 10\%$ @ < 10 mW
433,050 MHz to 434,790 MHz	Generic use	$\leq 100\%$ @ ≤ 1 mW or -13 dBm/10 kHz for bandwidth greater than 250 kHz
434,040 MHz to 434,790 MHz	Generic use	$\leq 100\%$
863,000 MHz to 870,000 MHz	Generic use	$\leq 0,1\%$ or LBT+AFA
864,800 MHz to 865,000 MHz	Wireless audio applications	No restriction
868,000 MHz to 868,600 MHz	Generic Use	$\leq 1\%$ or LBT+AFA
868,600 MHz to 868,700 MHz	Alarms	$\leq 1\%$
868,700 MHz to 869,200 MHz	Generic Use	$\leq 0,1\%$ or LBT+AFA
869,200 MHz to 869,250 MHz	Social alarms	$\leq 0,1\%$
869,250 MHz to 869,300 MHz	Alarms	$\leq 0,1\%$
869,300 MHz to 869,400 MHz	Alarms	$\leq 1\%$
869,400 MHz to 869,650 MHz	Generic Use	$\leq 10\%$ or LBT+AFA
869,650 MHz to 869,700 MHz	Alarms	$\leq 10\%$
869,700 MHz to 870,000 MHz	Generic Use	No restriction

8 Receiver parameters

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.

8.1 Maximum usable sensitivity (conducted)

8.1.1 Definition

The usable sensitivity is the minimum level of signal (electromotive force (emf)) at the receiver input, produced by a carrier at the nominal frequency of the receiver, modulated with the normal test signal modulation (see clause 6.1), which produces:

- a SINAD ratio of 20 dB, measured at the receiver output through a telephone psophometric weighting network as described in ITU-T Recommendation O.41 [4]; or
- after demodulation, a data signal with a bit error ratio of 10^{-2} , provided that forward error correction, where provided, is disabled; or
- after demodulation, a message acceptance ratio of 80 %.

Where the indicated performance cannot be achieved, the provider shall declare and publish the performance criteria used to determine the performance of the receiver.

8.1.2 Method of measurement with continuous bit streams

The following test setup shall be used.

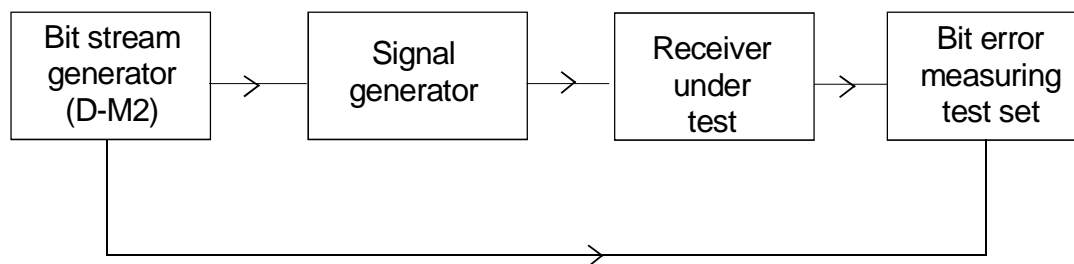


Figure 7: Measurement arrangement

The measurement procedure shall be as follows:

- a) an input signal with a frequency equal to the nominal frequency of the receiver, modulated by the normal test signal as appropriate (see clause 6.1), shall be applied to the receiver input terminals.
For equipment with integral antenna the connection to the equipment is made either to a temporary 50 Ω antenna connector or via a validated test fixture, see clause 6.3;
- b) the bit pattern of the modulating signal shall be compared to the bit pattern obtained from the receiver after demodulation;
- c) the level of the input signal to the receiver is adjusted until the bit error ratio is 10^{-2} or better. (When the value of 10^{-2} cannot be reached exactly, this shall be taken into account in the evaluation of the measurement uncertainty (TR 100 028 [2]);

the maximum usable sensitivity is the emf of the input signal to the receiver;

This value shall be recorded.

- d) the measurement shall be repeated under extreme test conditions (see clauses 5.4.1 and 5.4.2 applied simultaneously).

The limit(s) corresponding to this parameter can be found in clause 8.1.4.

8.1.3 Method of measurement with messages

The following test setup shall be used.

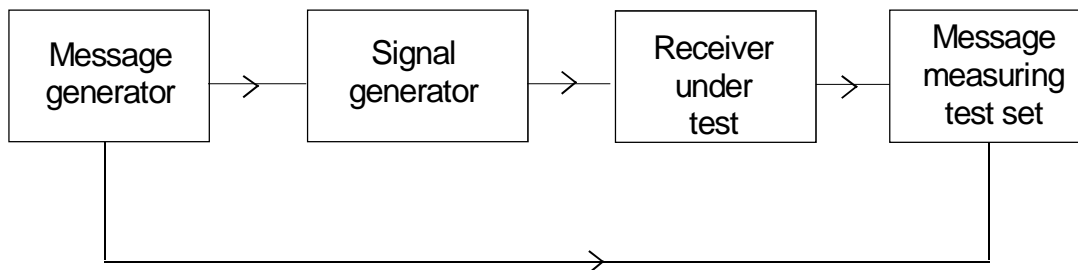


Figure 8: Measurement arrangement

The measurement procedure shall be as follows:

- a) an input signal with a frequency equal to the nominal frequency of the receiver, having normal test modulation (see clause 6.1), in accordance with the instructions of the manufacturer (and accepted by the testing laboratory), shall be applied to the receiver input terminals;

for equipment with integral antenna the connection to the equipment is made either to a temporary 50 Ω antenna connector or via a validated test fixture, see clause 6.3;

- b) the level of this signal shall be such that a successful message ratio of less than 10 % is obtained;
- c) the normal test signal (see clause 6.1) shall then be transmitted repeatedly whilst observing in each case whether or not a message is successfully received;

the level of the input signal shall be increased by 2 dB for each occasion that a message is not successfully received;

the procedure shall be continued until three consecutive messages are successfully received;

the level of the input signal shall then be noted;

- d) the level of the input signal shall be reduced by 1 dB and the new value noted;

the normal test signal (see clause 6.1) shall then be transmitted 20 times. In each case, if a message is not successfully received the level of the input signal shall be increased by 1 dB and the new value noted;

if a message is successfully received, the level of the input signal shall not be changed until three consecutive messages have been successfully received. In this case, the level of the input signal shall be reduced by 1 dB and the new value noted;

no level of the input signal shall be noted unless preceded by a change in level;

the maximum usable sensitivity is the average of the values noted in steps c) and d) (which provides the level corresponding to the successful message ratio of 80 %).

This value shall be recorded in the test report.

The limit(s) corresponding to this parameter can be found in clause 8.1.4.

8.1.4 Limits

Under normal test conditions, the usable sensitivity for a 25 kHz channel spacing equipment with a 16 kHz bandwidth shall not exceed +6 dB μ V emf for a 50 Ω receiver input impedance. This corresponds to a sensitivity of -107 dBm which shall not be exceeded.

The limit for usable sensitivity for other receiver bandwidths than 16 kHz is given by:

$$S = +6 + 10 \log \frac{BW}{16} \text{ dB}\mu\text{V emf} ; \text{ or}$$

$$S_P = 10 \log \frac{BW}{16} - 107 \text{ dBm}$$

where:

- S is the sensitivity in dBμV emf;
- S_P is the sensitivity in dBm;
- BW is the bandwidth in kHz.

For further information on field strength sensitivity for equipment with integral antenna, see clause E.2.

For equipment using a Listen Before Talk (LBT) protocol, see clause 8.2.

8.2 Receiver LBT threshold and transmitter max on-time

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

8.2.1 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.

8.2.2 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:

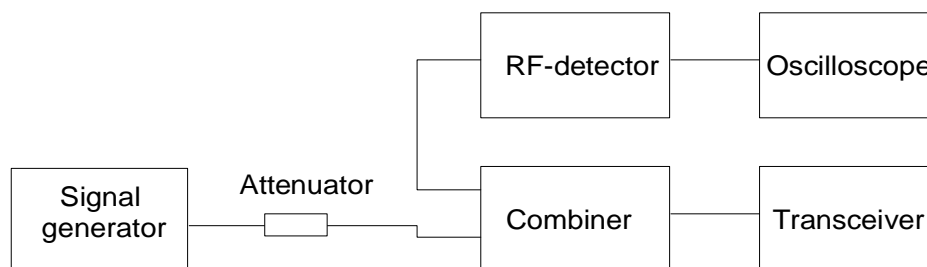


Figure 9: Measurement arrangement

For equipment with integral antenna the connection to the equipment is made either to a temporary 50 ohm antenna connector or via a validated test fixture, see clause 6.3. The spectrum analyzer is operated in zero span mode and the resolution bandwidth shall be approximately 3 times the channel bandwidth.

- 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;

NOTE: The equipment will 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 spectrum analyzer.

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

8.2.3 Limits

The maximum LBT threshold for the receiver in the listen mode is given in table 12.

Table 12: Receiver LBT threshold limit versus transmit power and channel spacing

<div>TX power</div>	< 100 mW	500 mW	Maximum TX on-time
Receiver bandwidth			
6,25 kHz	-102 dBm	-106 dBm	< 1 s
12,5 kHz	-99 dBm	-103 dBm	
20/25 kHz	-96 dBm	-100 dBm	
50 kHz	-93 dBm	-97 dBm	
100 kHz	-90 dBm	-94 dBm	
200 kHz	-87 dBm	-91 dBm	
500 kHz	-83 dBm	-	
600 kHz	-82 dBm	-	
NOTE 1: The limit is independent of the receiver category, see clause 4.1.1.			
NOTE 2: For intermediate channel spacings, a straight line interpolation shall be used.			
NOTE 3: 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.			
NOTE 4: Limits for receiver bandwidth not mentioned in the table shall be adjusted to the maximum usable sensitivity +9 dB, see clause 8.1. However, limits can be also obtained by a simple interpolation between values in table 12.			

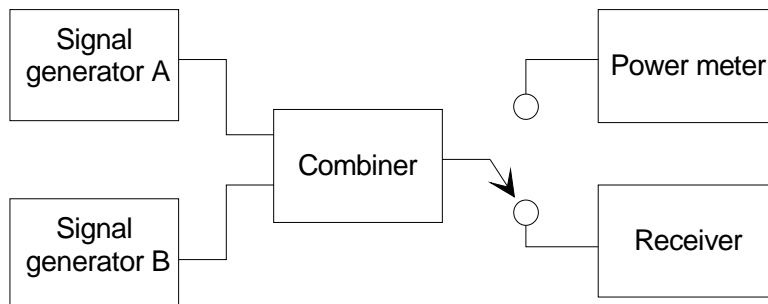
8.3 Adjacent channel selectivity

8.3.1 Definition

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

8.3.2 Method of measurement

This measurement shall be conducted under normal conditions. The following test set-up shall be used.



NOTE: The power meter may be replaced by a measurements receiver or spectrum analyzer.

Figure 10: Measurement arrangement

Two signal generators A and B shall be connected to the receiver via a combining network to the receiver antenna connector.

For equipment with integral antenna the connection to the equipment is made either to a temporary antenna connector, see clause 4.2.13, or via a validated test fixture, see clause 6.3.

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 the wanted channel.

Initially signal generator B shall be switched off and using signal generator A the level which still gives sufficient response shall be established, however, the level at the receiver input shall not be below the sensitivity limit given in clause 8.1.4. The output level of generator A shall then be increased by 3 dB.

Signal generator B is then switched on and the signal amplitude is adjusted until the wanted criteria, see clause 8.1.1, is just exceeded.

With signal generator B settings unchanged the power into the receiver is measured by replacing the receiver with a power meter or a spectrum analyzer. This power level shall be recorded.

The measurements shall be repeated immediately below the wanted channel.

For special protection requirements for receiver it may be necessary to determine the receiver saturation. In this case the above measurements are repeated with a +40 dB increased level for signal generator A.

8.3.3 Limits

8.3.3.1 Limit for adjacent channel selectivity

The adjacent channel selectivity of the equipment under specified conditions shall be equal to or greater than the unwanted signal as stated in table 13.

Table 13: Limit for adjacent channel selectivity

Receiver category	Channel spacing ≤ 25 kHz	Channel spacing > 25 kHz
1	≥ -50 dBm	≥ -44 dBm
NOTE: The limits are based on an antenna gain of +2 dBi. For other antenna gains greater than +2 dBi the limits shall be adjusted accordingly.		

8.3.3.2 Limit for receiver saturation at adjacent channel

8.3.3.2.1 Definition

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

8.3.3.2.2 Method of measurements

The method of measurements is identical to clause 8.3.2 except of the use of a fixed wanted signal equal to the sensitivity +43 dB.

8.3.3.2.3 Limits

The receiver saturation at the adjacent channel shall be equal or greater than limit given in table 14.

Table 14: Limit for receiver saturation at adjacent channel

Receiver category	Channel spacing 12,5 kHz ≤ 25 kHz	Channel spacing > 25 kHz
1	≥ -20 dBm	≥ -10 dBm
NOTE 1: Measured at a wanted receiving signal at +43 dB above the sensitivity.		
NOTE 2: The limits are based on an antenna gain of +2 dBi. For other antenna gains greater than +2 dBi the limits shall be adjusted accordingly.		

8.4 Blocking or desensitization

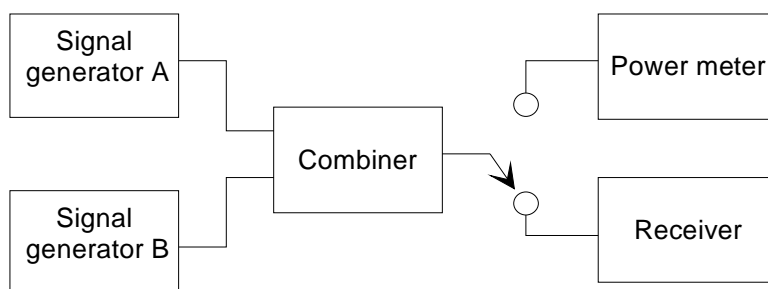
8.4.1 Definition

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 8.3.

8.4.2 Method of measurement

This measurement shall be conducted under normal conditions.

The following test set-up shall be used.



NOTE: The power meter may be replaced by a measurements receiver or spectrum analyzer.

Figure 11: Measurement arrangement

Two signal generators A and B shall be connected to the receiver via a combining network to the receiver antenna connector.

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

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 test frequencies at approximately 2 MHz/10 MHz above and below the nominal frequency of the receiver

Initially signal generator B shall be switched off and using signal generator A the level which still gives sufficient response shall be established, however, the level at the receiver input shall not be adjusted below the sensitivity limit given in clause 8.1.4. 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 (see clause 8.1.1) is just exceeded.

With signal generator B settings unchanged the power into the receiver is measured by replacing the receiver with a power meter or spectrum analyzer. This level shall be recorded.

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

Additionally, for category 1 receivers it is necessary to determine the receiver saturation by repeating the above measurements with a +40 dB increased level for signal generator A.

8.4.3 Limit for blocking

The blocking level shall not be less than the values given in table 15, except at frequencies on which spurious responses are found.

Table 15: Limits for receiver blocking

Receiver category	Frequency offset	Limit
1	± 2 MHz	≥ -20 dBm
2	± 2 MHz	≥ -69 dBm
	± 10 MHz	≥ -44 dBm
NOTE: The limits are based on an antenna gain of +2 dBi. For other antenna gains greater than +2 dBi the limits shall be adjusted accordingly.		

8.5 Receiver spurious radiation

8.5.1 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:

- a) either:
 - 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 antenna, in the case of portable equipment fitted with such an antenna and no external RF connector.

8.5.2 Method of measuring the power level in a specified load, clause 8.5.1 a) i)

This method applies only to equipment with an external antenna connector.

The receiver shall be connected to a 50 Ω attenuator.

The output of the attenuator shall be connected to a measuring receiver. The receiver shall be switched on, and the measuring receiver shall be tuned over the following frequency range:

- a) 9 kHz to 4 GHz for equipment operating on frequencies below 470 MHz, or

- b) 9 kHz to 12,75 GHz for equipment operating on frequencies above 470 MHz. For equipment operating on frequencies above 470 MHz the measurements need only to be performed over the frequency range 4 GHz to 12,75 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz.

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

8.5.3 Method of measuring the effective radiated power, clause 8.5.1 a) ii)

NOTE: This method applies only to equipment having an external antenna connector.

For digital equipment that supports adaptive rates, testing is only required at the maximum bit rate that the manufacturer declares is compliant to the present document.

The measurement procedure shall be as follows:

- a) a test site which fulfils the requirements for the specified frequency range of this measurement shall be used (see annex A);

the equipment shall be placed at the specified height on a non-conducting support and in the position closest to normal use as declared by the manufacturer;
- b) the receiver antenna connector shall be connected to an artificial antenna (see clause 6.2):
 - the test antenna shall be orientated for vertical polarization and the length of the test antenna shall be chosen to correspond to the frequency of the measuring receiver;
 - the output of the test antenna shall be connected to a measuring receiver;
- c) radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 25 MHz to 4 GHz. For equipment operating on frequencies above 470 MHz the measurements shall also be performed over the frequency range 4 GHz to 12,75 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz;
- d) at each frequency at which a component is detected the test antenna shall be raised and lowered through the specified range of height until a maximum signal level is detected by the measuring receiver;

when a test site according to clause A.1.1 or A1.2 is used, there is no need to vary the height of the antenna;
- e) the receiver shall then be rotated through 360° in the horizontal plane until the maximum signal level detected by the measuring receiver;

the maximum signal level detected by the measuring receiver shall be noted;
- f) the receiver shall be replaced by a substitution antenna as defined in clause A.1.5;

the substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of the spurious component detected;
- g) the substitution antenna shall be connected to a calibrated signal generator;

the frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected;
- h) the input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver if necessary;
- i) the test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received;

the input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for the change of input attenuator setting of the measuring receiver;

the input level of the substitution antenna shall be recorded as a power level, corrected for the change of input attenuator setting of the measuring receiver;

- j) the measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization;
- k) the measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the antenna if necessary.

8.5.4 Method of measuring the effective radiated power, clause 8.5.1 b)

This method applies only to equipment without an external antenna connector.

For digital equipment that supports adaptive rates, testing is only required at the maximum bit rate that the manufacturer declares is compliant to the present document.

The method of measurement shall be performed according to clause 8.5.3, except that the receiver input shall be connected to the integral antenna and not to an artificial antenna.

8.5.5 Limits

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

The limits are applicable to all receiver categories:

- 2 nW below 1 000 MHz;
- 20 nW above 1 000 MHz.

9 Spectrum access techniques

For the present standard the following access mechanism is specified:

- Listen before talk (LBT) which is used to share a spectrum between SRD transceiver equipment with similar power and bandwidth;

Receiver category 2 or better for all LBT applications shall be used.

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 with AFA then clause 7.10 applies. Equipment with LBT and AFA does not have to comply with the duty cycle conditions as stated in clause 7.10.

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 [7]. The receiver requirements are the following:

- LBT threshold, for further details, see clause 8.2.
- 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 7.10.

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 7.10.

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 > 100 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 8.2) 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 1 s and this limit shall be declared by the provider. For further information on measurements of maximum transmitter on-time, see clause 8.2.

The time limit for a transmission dialogue or a polling sequence is 4 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.

10 Measurement uncertainty

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

- the measured value related to the corresponding limit shall be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be separately included in the test report;
- the value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in table 16.

Table 16: Measurement uncertainty

Radio frequency	$\pm 1 \times 10^{-7}$
RF power, conducted	$\pm 1,5$ dB
Maximum frequency deviation:	
- within 300 Hz and 6 kHz of audio frequency	± 5 %
- within 6 kHz and 25 kHz of audio frequency	± 3 dB
Adjacent channel power	± 3 dB
Conducted spurious emission of transmitter, valid up to 12,75 GHz	± 3 dB
Conducted emission of receivers	± 3 dB
Radiated emission of transmitter, valid up to 12,75 GHz	± 6 dB
Radiated emission of receiver, valid up to 12,75 GHz	± 6 dB
RF level uncertainty for a given BER	$\pm 1,5$ dB
Temperature	$\pm 1^{\circ}$ C
Humidity	± 10 %

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

Table 16 is based on such expansion factors.

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

Annex A (normative): Radiated measurement

This annex has been drafted so that it could be used as well for the assessment of speech, data or equipment providing a specific response.

It covers test sites and methods to be used with integral antenna equipment or equipment having an antenna connector.

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

This clause introduces three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in the relevant parts of TR 102 273 [5] or equivalent.

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

A.1.1 Anechoic Chamber

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

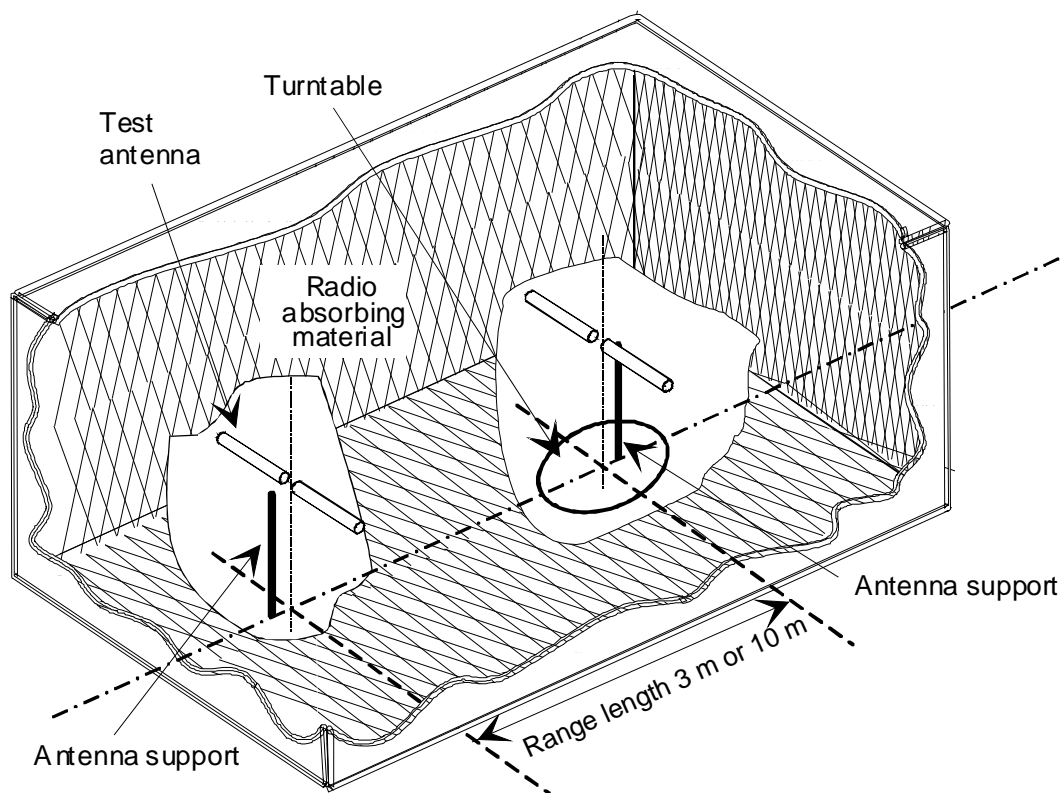


Figure A.1: A typical Anechoic Chamber

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

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

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a suitable height (e.g. 1 m) above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2 / \lambda$ (m), whichever is greater (see to clause A.2.5). The distance used in actual measurements shall be recorded with the test results.

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

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

A.1.2 Anechoic Chamber with a conductive ground plane

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

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

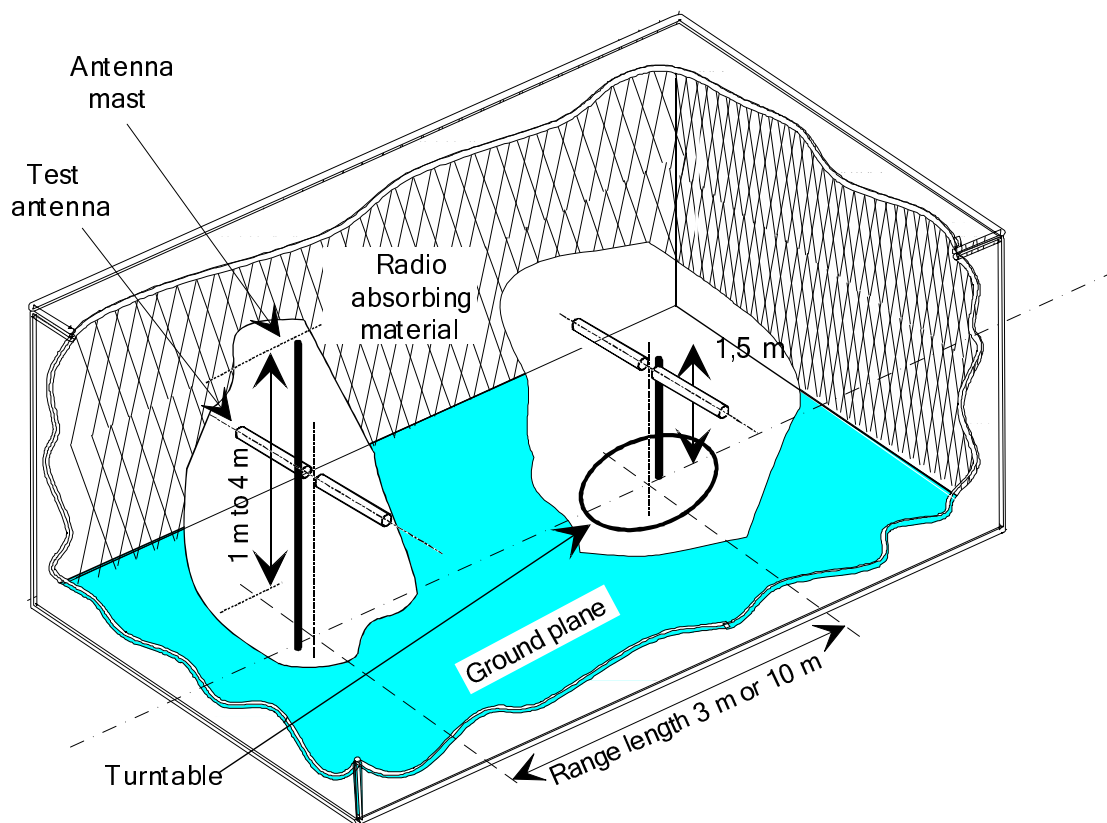


Figure A.2: A typical Anechoic Chamber with a conductive ground plane

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

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

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2 / \lambda$ (m), whichever is greater (see clause A.2.5). The distance used in actual measurements shall be recorded with the test results.

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

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

A.1.3 Open Area Test Site (OATS)

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

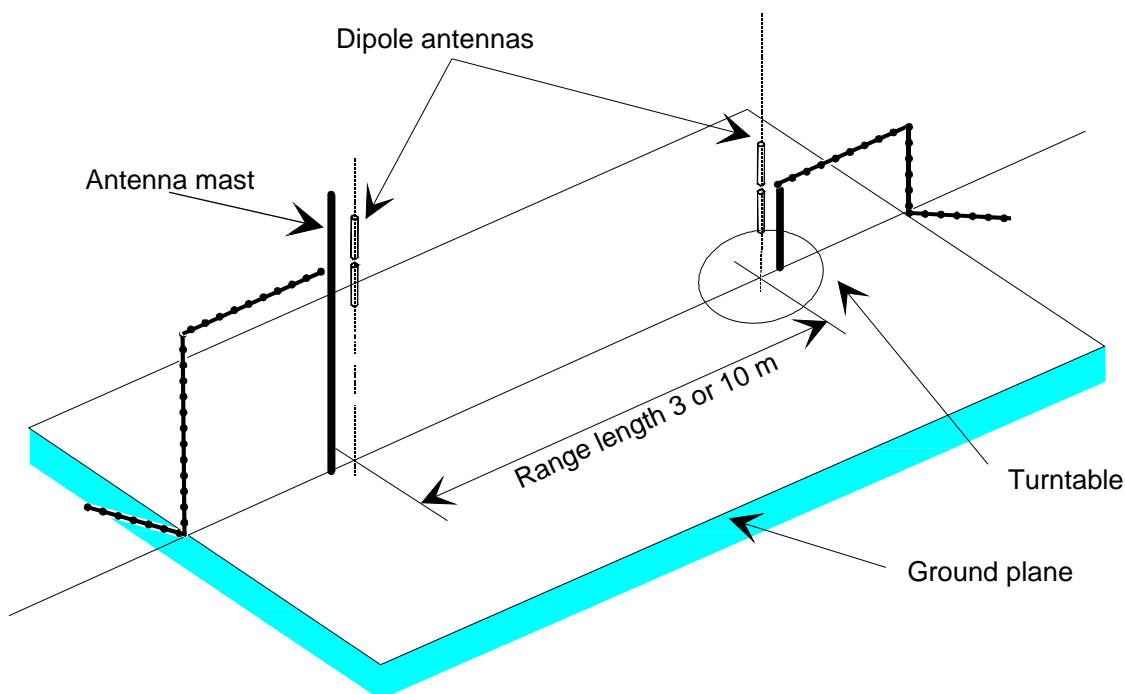


Figure A.3: A typical Open Area Test Site

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

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

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

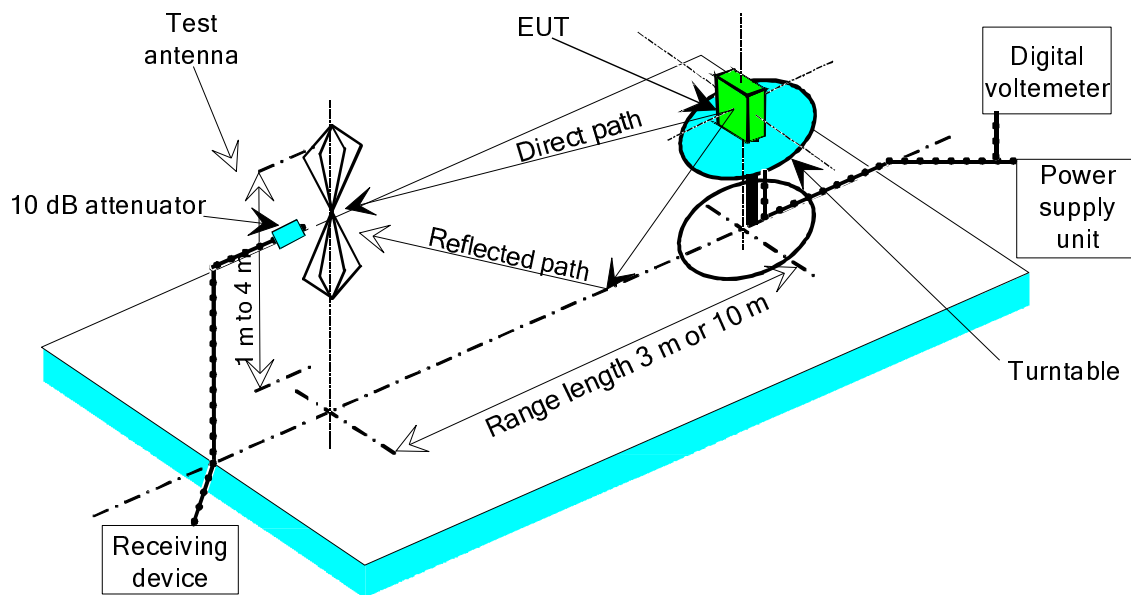


Figure A.4: Measuring arrangement on ground plane test site (OATS set-up for spurious emission testing)

A.1.4 Test antenna

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

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

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [6] are generally recommended. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For spurious emission testing, however, a combination of bicones and log periodic dipole array antennas (commonly termed "log periodic") could be used to cover the entire 30 MHz to 1 000 MHz band. Above 1 000 MHz, waveguide horns are recommended although, again, log periodic could be used.

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

A.1.5 Substitution antenna

The substitution antenna is used to replace the EUT for tests in which a transmitting parameter (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) is being measured. For measurements in the frequency band 30 MHz to 1 000 MHz, the substitution antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [6] is generally recommended). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For measurements above 1 000 MHz, a waveguide horn is recommended. The centre of this antenna should coincide with either the phase centre or volume centre.

A.1.6 Measuring antenna

The measuring antenna is used in tests on a EUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric field strength in the vicinity of the EUT. For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [6] is generally recommended). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT.

A.2 Guidance on the use of radiation test sites

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

A.2.1 Verification of the test site

No test should be carried out on a test site which does not possess a valid certificate of verification. The verification procedures for the different types of test sites described in annex A (i.e. anechoic chamber, anechoic chamber with a ground plane and Open Area Test Site) are given in the relevant parts of TR 102 273 [5] or equivalent.

A.2.2 Preparation of the EUT

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

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

A.2.3 Power supplies to the EUT

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

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

A.2.4 Volume control setting for analogue speech tests

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

A.2.5 Range length

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

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

where:

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

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

λ is the test frequency wavelength (m).

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

$$2\lambda$$

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

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

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

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

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

A.2.6 Site preparation

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

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

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

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

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

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

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

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

A.3 Coupling of signals

A.3.1 General

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

A.3.2 Data Signals

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

A.3.3 Speech and analogue signals

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

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

A.3.3.1 Acoustic coupler description

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

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

A.3.3.2 Calibration

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

A.4 Standard test position

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

- a) for equipment with an internal antenna, it shall be placed in the position closest to normal use as declared by the provider;
- b) for equipment with a rigid external antenna, the antenna shall be vertical;
- c) for equipment with a non-rigid external antenna, the antenna shall be extended vertically upwards by a non-conducting support.

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

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

The container shall have the following dimensions:

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

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

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

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

Annex B (normative):

Specification for measurement filter

Methods of measurement in clauses 7.5 and 7.6 refer to the use of a filter. The IF filter shall be within the limits of the selectivity characteristic of figure B.1.

An alternative measuring method shall consist in using, in place of the IF filter, a spectrum analyser with a resolution bandwidth of 100 Hz and integrating the power of all the 100 Hz sub-band measurements, over a total bandwidth of $\pm D2$ (see table B.1).

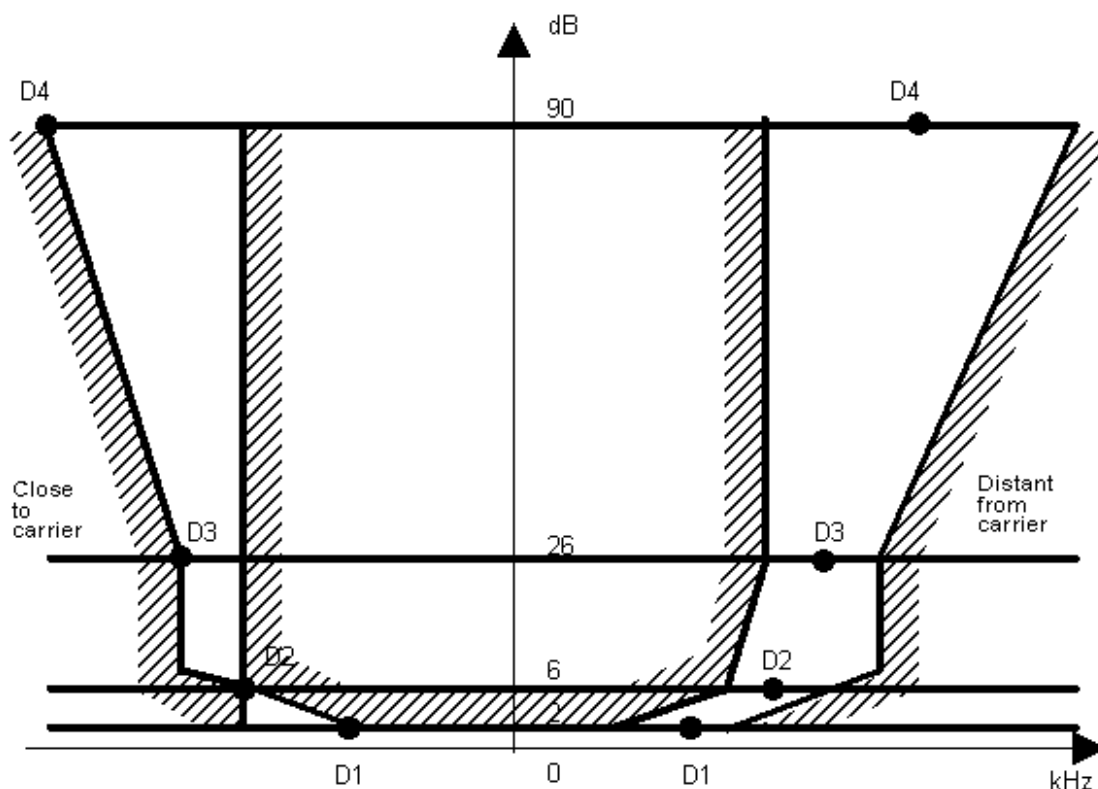


Figure B.1: IF filter

Depending on the channel separation, the selectivity characteristic shall keep the frequency separations from the nominal centre frequency of the adjacent channel as stated in table B.1.

Table B.1: Selectivity characteristics of IF filter

Channel separation (kHz)	Frequency separation of filter curve from nominal centre frequency of adjacent channel (kHz)			
	D1	D2	D3	D4
10/12,5	3	4,25	5,5	9,5
20	4	7,0	8,25	12,25
25	5	8,0	9,25	13,25

Depending on the channel separation, the attenuation points shall not exceed the tolerances as stated in tables B.2 and B.3.

Table B.2: Attenuation points close to carrier

Channel separation (kHz)	Tolerances range (kHz)			
	D1	D2	D3	D4
10/12,5	+1,35	$\pm 0,1$	-1,35	-5,35
20	+3,1	$\pm 0,1$	-1,35	-5,35
25	+3,1	$\pm 0,1$	-1,35	-5,35

Table B.3: Attenuation points distant from the carrier

Channel separation (kHz)	Tolerance range (kHz)			
	D1	D2	D3	D4
10/12,5	$\pm 2,0$	$\pm 2,0$	$\pm 2,0$	+2,0 -6,0
20	$\pm 3,0$	$\pm 3,0$	$\pm 3,0$	+3,0 -7,0
25	$\pm 3,5$	$\pm 3,5$	$\pm 3,5$	+3,5 -7,5

The minimum attenuation of the filter, outside the 90 dB attenuation points, shall greater than or equal to 90 dB.

Annex C (normative):

Technical performance of the spectrum analyser

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

- the reading accuracy of the frequency marker shall be within ± 100 Hz;
- the accuracy of relative amplitude measurements shall be within $\pm 3,5$ dB.

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

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

The spectrum analyser should have a dynamic range greater than 80 dB and the average phase noise in the adjacent and alternate channels shall be such that measurement of adjacent and alternate adjacent channel power (see clause 7.6) is not limited by phase noise. In order to confirm this the selected measurement technique for clause 7.6.2 shall be used to measure the adjacent and alternate channel power with a unmodulated signal source with phase noise of less than -110 dBc/Hz at one channel spacing offset and -120 dBc/Hz at two channel spacing offset. The maximum adjacent channel power observed with these conditions shall not exceed -60 dBc, and the maximum alternate channel power measured with these conditions shall not exceed -70 dBc.

Annex D (normative): Application: Social alarm systems

D.1 General

This annex covers equipment operating in a domestic or residential environment. It covers fixed, mobile or portable transmitters working into fixed receivers.

This annex assumes a certain path loss if the equipment has to operate with adequate reliability. The minimum power level recommended in this annex takes into account the effects of:

- non uniform radiation patterns of the transmitter and receiver antennas;
- reflections caused by the construction of the building, moveable objects and persons;
- attenuation by commonly used building materials;
- path loss assuming a distance of typically 10 m;
- operating frequency;
- interference by other transmitters.

D.2 Classification of effective radiated power levels

There are four classes of effective radiated power (e.r.p.) as detailed in table D.1.

Table D.1: Classification of effective radiated power (e.r.p.) for social alarms

Power Class	e.r.p.
A	≥ 2 mW to 10 mW
B	≥ 100 μ W to 2 mW
C	≥ 10 μ W to < 100 μ W
D	< 10 μ W
NOTE: In environments in which interference from co-located or nearby high power transmitters may be expected power category A equipment is recommended category.	

D.3 Receiver parameters and limits

The receiver parameters and limits are stated in clause 8 of the present document. This clause also contains the method of measurement of the receiver parameters.

Social Alarm receivers shall meet the following requirements for category 1 receivers of the present document as stated in table D.2.

Table D.2: Requirements for Social Alarm receivers

Receiver parameter	≤ 200 MHz	> 200 MHz	Receiver category
Adjacent channel selectivity	See clauses 8.3.3.1 and 8.3.3.2	See clause 8.3.3.1	Category 1
Blocking and desensitization	See clause 8.5.3.1	See clause 8.5.3.1	Category 1

Additional information for field strength sensitivity and other supplementary receiver parameters, see annex E.

Annex E (normative): Supplementary parameters for receivers

E.1 Maximum usable sensitivity (conducted)

For details see clause 8.

E.2 Average usable sensitivity (field strength)

This measurement only applies to equipment with an integral or dedicated antenna.

The average, E_{mean} , is calculated from eight measurements of field strength, where the receiver is rotated in 45° increments, starting at an arbitrary orientation.

$$E_{\text{mean}} = 20 \log_{10} \sqrt{\frac{8}{\sum_{i=1}^8 \frac{1}{x_i^2}}}$$

Where x_i represents the eight field strengths in $\mu\text{V/m}$.

E.2.1 Definition

The average usable sensitivity of the receiver is the average field strength at the antenna, expressed in $\text{dB}\mu\text{V/m}$, produced by a carrier at the nominal frequency of the receiver, modulated with the normal test signal which produces:

- 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 [4]; or
- after demodulation, a data signal with a bit error ratio of 10^{-2} , provided that forward error correction, where provided, is disabled; or
- after demodulation, a message acceptance ratio of 80 %.

E.2.2 Limits

The average radiated usable sensitivity for a receiver intended for 25 kHz channel spacing or 16 kHz bandwidth is given in table E.1. For other receiver bandwidths the sensitivity shall be corrected by the following formula:

$$S_A = (\text{value of table F.1}) + 10 \log \frac{BW}{16} \quad \text{dB}\mu\text{V} / \text{m}$$

where:

- S_A is the average sensitivity in $\text{dB}\mu\text{V/m}$;
- BW is the bandwidth in kHz.

Table E.1: Limits for average radiated usable sensitivity

Frequency range (MHz)	Average usable sensitivity dBµV/m
Integral antenna fully within the case	
30 to 400	27,0
> 400 to 750	28,5
> 750 to 1 000	30,0
Integral or dedicated antenna with an external length ≤ 20 cm to the case	
30 to 130	18,0
> 130 to 300	19,5
> 300 to 440	21,5
> 440 to 600	23,5
> 600 to 800	25,5
> 800 to 1 000	28,0
Integral or dedicated antenna with an external length > 20 cm to the case	
30 to 130	18,0 - k
> 130 to 300	19,5 - k
> 300 to 375	21,5 - k
> 375 to 440	21,5
> 440 to 600	23,5
> 600 to 800	25,5
> 800 to 1 000	28,0

Where:

- $k = 20 \log_{10} ((l + 20) / 40)$; and
- l is the length of the external part of the antenna in cm.

Annex F (informative): Bibliography

Ketterling, H-P: "Verification of the performance of fully and semi-anechoic chambers for radiation measurements and susceptibility/immunity testing", 1991, Leatherhead/Surrey.

ETSI EN 301 489-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 40 GHz".

ETSI EN 300 220-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive".

European Commission Decision (2006/771/EC) of 9 November 2006 on harmonization of the radio spectrum for use by short-range devices.

ETSI TR 102 313 (V1.1.1): "Electromagnetic compatibility and Radio Spectrum Matters (ERM); Frequency-agile Generic Short Range Devices using listen-Before-Transmit (LBT); Technical Report".

ITU-R Recommendation SM.328: "Spectra and bandwidth of emissions".

History

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