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European Standard (Telecommunications series)

**Electromagnetic compatibility and Radio spectrum Matters (ERM);
Short Range Devices (SRD);
Technical characteristics for SRD equipment using
Ultra Wide Band technology (UWB);
Building Material Analysis and Classification equipment
applications operating in the frequency band
from 2,2 GHz to 8 GHz;
Part 1: Technical characteristics and test methods**

Reference

DEN/ERM-TG31C-001-1

Keywords

radar, radio, SRD, testing, UWB

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Contents

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Foreword

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

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

The present document is part 1 of a multi-part deliverable covering Ultra-Wide Band Location Tracking applications operating in the frequency range from 2,2 to 8 GHz, as identified below:

Part 1: "Technical characteristics and test methods";

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

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

Clauses 4 and 5 provide the technical requirements for the conduction of the tests and information for equipment to be presented.

Clauses 6 and 7 give guidance on the general conditions for testing of the device and the interpretation of results and maximum measurement uncertainty values.

Clause 8 specifies the transmitter spectrum utilization parameters. The clause provides details on how the equipment should be tested and the conditions which should be applied.

Clause 9 provides receiver parameters.

Annex A (normative) provides specifications concerning radiated measurements.

Annex B (normative) provides information on the design requirements.

Annex C (informative) gives information for the measurement antenna and the preamplifier specifications.

Annex D (normative) provides a wall definition for emission measurements and LBT function.

Annex E (informative) Bibliography covers other supplementary information.

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

1 Scope

The present document specifies the requirements for Building Material Analysis and Classification (BMA&C) Applications operating in all or part of the frequency band from 2,2 GHz to8 GHz. Reduced emissions in the range from 0,96 GHz to 2,2 GHz and 8 GHz to 10,6 GHz are permitted and defined in clause 8.

The document applies to:

a) UWB building material analysis and classification equipment for imaging and object detection applications;

b) equipment fitted with an integral antenna;

c) handheld devices;

d) equipment with an activation switch which allows emissions only when the equipment is in direct contact to the material to be investigated.

The document does not apply to:

- UWB communication applications; and
- Ground and wall probing and through-wall equipment.

The present document specifies the equipment which is designed to not radiate into the free air. It is designed to function only when positioned such that it radiates directly into the absorptive material such as walls and other building materials which absorb emissions. Any leakage or residual emissions appearing, e.g. behind the wall or outside the directed and backwards and sideways screened antenna, is defined as undesired emission.

The present document does not necessarily include all the characteristics which may be required by a user, nor does it necessarily represents the optimum performance achievable.

The present document contains all technical characteristics and test methods for Building Material Analysis and Classification equipment operated in accordance with the ECC Decision ECC/DEC/(06)xy [4] for imaging devices.

2 References

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

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

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

[1] ECC/DEC/(06)xy: Decision of xx 2006 on the frequency band 2.2 GHz to 8.0 GHz to be designated for the use of UWB Imaging systems.

[2] CISPR 16-1 (2003): "Specification for radio disturbance and immunity measuring apparatus and methods".

[3] ANSI C63.5 (1998): "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration of Antennas (9 kHz to 40 GHz)".

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

[5] 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".

[6] CENELEC EN 55022: "Information technology equipment - Radio disturbance characteristics - limits and methods of measurement".

[7] Antenna Pattern Measurement, Theory and Equations, Michael D. Foegelle, ETS Lindgreen, Compliance Engineering, Annual Reference Guide 2002.

NOTE: See http://www.etslindgren.com/manuals/768CE.pdf.

[8] ITU-R SG1 Draft New Recommendation SM.1/BL/10 (2006): "Measurement techniques of ultra-wideband transmissions", document 1/83.

[9] Fraunhofer Institut Bauphysik, IPG Report GB 174e/2006: Typical Wall constructions in Germany, England and France.

[10] ETSI TR 102 070-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guide to the application of harmonized standards to multi-radio and combined radio and non-radio equipment; Part 2: Effective use of the radio frequency spectrum".

[11] CEPT/ERC/REC 74-01: "Spurious Emissions".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

Pulse Repetition Frequency (PRF): inverse of the Pulse Repetition Interval, averaged over a sufficiently long time to cover all PRI variations

activity factor: reflects the effective transmission time ratio, actual on-the-air time divided by active session time or actual on-the-air emission time within a given time window

clutter: undesired radar reflections (echoes) e.g. from inhomogenities, interfaces, gravel stones, cavities in building material structures

Listen Before Talk (LBT): mechanism to avoid signal transmission in the presence of other radio service signals

spatial resolution: ability to discriminate between two adjacent targets

Total Power (TP): is the integration of the undesired emissions in the whole area around the BM&A-scenario.

NOTE: The integration is over a sphere (same procedure as for Total Radiated Power (TRP) [7]). This value is comparable to an equivalent isotropic radiator.

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

undesired emissions: any emissions into free space during operation of the equipment when equipment is faced to a wall or other material to be investigated. Undesired emissions are:

- leaked emissions from the side or backside of the antenna; and/or
- scattered/reflected emissions from the building material to be investigated; and/or
- residual emissions through the building material.

3.2 Symbols

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

E	Electrical field strength
Eo	Reference electrical field strength (see annex A)
f	Frequency
f_c	Frequency at which the emission is the peak power at maximum.
f_H	Highest frequency of the frequency band of operation
f_L	Lowest frequency of the frequency band of operation
P	Power
R	Distance
Ro	Reference distance (see annex A)
RWB	Resolution bandwidth of a measurement
t	Time
λ	wavelength
c	velocity of light in a vacuum
δR	range resolution
δt	time interval between the arrivals of two signals from targets separated in range by δR
E_R	relative dielectric constant of earth materials
T_P	pulse rise time

3.3 Abbreviations

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

BMA&C	Building Material Analysis and Classification
CEPT	Conference Europeenne des administrations de Postes et des Telecommunications
dB	deciBel
dBi	gain in deciBels relative to an isotropic antenna
dBm	deciBel reference to 1mW
DUT	Device under test
ECC	European Communication Committee
EMC	ElectroMagnetic Compatibility
ERC	European Radiocommunication Committee
e.i.r.p	effective isotropic radiated power
LBT	Listen-Before-Talk
LNA	Low Noise Amplifier
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
RBW	Resolution BandWidth
RF	Radio Frequency
R&TTE	Radio and Telecommunications Terminal Equipment
SRD	Short Range Device
TRP	Total Radiated Power
TP-UE	Total Power of Undesired (UWB) Emissions
TUE	Total Undesired Emissions
UE	Undesired (UWB) Emissions
USE	Undesired Spurious Emissions
UWB	Ultra Wide Band
VBW	Video BandWidth
VSWR	Voltage Standing Wave Ratio

4 Technical requirement specifications

4.1 General requirements

Equipment supplied for testing against this standard shall be fitted with an integral antenna.

4.2 Presentation of equipment for testing purposes

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

The provider shall provide one or more samples of the equipment, as appropriate for testing.

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

The performance of the equipment submitted for testing shall be representative of the performance of the corresponding production model. In order to avoid any ambiguity, the present document contains instructions for the preparation of equipment for testing purposes (clause 4.2), conditions of testing (clause 5) and the measurement methods (clause 8).

Equipment shall be offered by the provider complete with any ancillary equipment needed for testing. The provider shall declare the frequency range(s), the range of operation conditions and power requirements, as applicable, in order to establish the appropriate test conditions.

4.2.1 Choice of model 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, as proposed by the provider and agreed by the test laboratory.

4.2.2 Auxiliary test equipment

All necessary set-up information, means for activation and hardware necessary (e.g. standardized wall structure for testing, see annex D) shall accompany the equipment when it is submitted for testing.

4.2.3 Declarations by the provider

The provider shall declare the necessary information regarding the equipment with respect to all technical requirements set by the present document.

4.2.4 Marking and equipment identification

The equipment shall be marked in a visible place. This marking shall be legible and durable.

The marking shall include as a minimum:

- the name of the manufacturer or his trademark;
- the type designation. This is the manufacturer's numeric or alphanumeric code or name that is specific to a particular equipment.

4.3 Mechanical and electrical design

4.3.1 General

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

4.3.2 Controls

- The device has to be equipped with a non locking activation switch.
- The device has to be equipped with a switch facility which detects the direct mechanical contact of the equipment with the material under investigation. If there is no contact the transmitter shall not transmit even when the activation is triggered.
- The device has to be equipped with a movement detector which switches the transmitter automatically off after maximum 10 sec where no movement has occurred.

4.3.3 Transmitter shut-off facility

For the automatic transmitter shut-off facility it shall be possible to disable this feature for the purposes of testing.

Controls for testing purposes, which, if maladjusted, may increase the interfering potential of the equipment, shall not be easily accessible to the user.

4.4 Other device emissions

The equipment may contain digital circuit elements, radio circuit elements and other elements whose performance is not covered by the present document. These elements of the equipment shall meet the appropriate performance requirements for those components, as specified in other standards.

For example the requirements of a standard for EMC compatibility of IT equipment, such as EN 55022 [6] (for the elements of the device which are not concerned with radio communications but are considered to be IT equipment).

NOTE: For further information on this topic, see ETSI document TR 102 070-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guide to the application of harmonized standards to multi-radio and combined radio and non-radio equipment; Part 2: Effective use of the radio frequency spectrum" [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 equipment shall be tested using the external test 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 recorded and stated.

5.2.1 External test power source

During tests, the power source of the equipment shall be replaced by an external test power source capable of producing normal test voltages as specified in clause 5.3.2. 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 external test power source voltages shall be within a tolerance < ±1 % relative to the voltage at the beginning of each test.

5.2.2 Internal test power source

For radiated measurements on portable equipment with integral antenna, fully charged internal batteries shall be used. The batteries used 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 < ±5 % relative to the voltage at the beginning of each test.

If appropriate, the external test power source may replace the supplied or recommended internal batteries at the required voltage - this shall be recorded and stated. In this case, the battery should remain present, electrically isolated from the rest of the equipment, possibly by putting tape over its contacts.

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 recorded and stated.

5.3.2 Normal test power source

5.3.2.1 Internal battery power source

The normal test voltage for equipment shall be a regulated battery power source. 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.

When the radio equipment is intended for operation with the usual types of regulated 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.).

5.3.2.2 Regulated lead-acid battery power sources

When the radio equipment is intended for operation from 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 (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. Such values shall be recorded and stated.

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 not be switched off during the temperature stabilizing period.

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

5.4.1.2 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 limits:

- Temperature range : -20 °C to +55 °C.

5.4.2 Extreme test source voltages

5.4.2.1 Mains voltage

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

5.4.2.2 Regulated lead-acid or gel-cell type batteries

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 test voltages 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 other than those in clause 5.4.2.2 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 voltage shall be used:
  - for the Leclanché or the lithium type of batteries:
    - 0,85 multiplied by the nominal voltage of the battery;
  - for the nickel-cadmium type of batteries:
    - 0,9 multiplied by the nominal voltage of the battery;
  - for other types of batteries, 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 that declared by the provider. These shall be recorded in the test report.

6 General conditions

6.1 Radiated measurement arrangements

For guidance on radiation test sites and general arrangements for radiated measurements, see annex A.

Detailed descriptions of radiated measurement arrangements for UWB devices can be found in ITU-R Document 1/83 (Rev.1)-E : "Measurement techniques of ultra-wideband transmissions" [8].

All reasonable efforts should be made to clearly demonstrate that emissions from the UWB transmitter do not exceed the specified levels, with the transmitter in the far field. To the extent practicable, the device under test should be measured at the distance specified in annex A and with the specified measurement bandwidths. However, in order to obtain an adequate signal-to-noise ratio in the measurement system, radiated measurements may have to be made at distances less than those specified in annex A and/or with reduced measurement bandwidths. The revised measurement configuration should be stated on the test report, together with an explanation of why the signal levels involved necessitated measurement at the distance employed or with the measurement bandwidth used in order to be accurately detected by the measurement equipment, and calculations demonstrating compliance.

Where it is not practical to further reduce the measurement bandwidth (either because of limitations of commonly-available test equipment or difficulties in converting readings taken using one measurement bandwidth to those used by the limits in tables 2 and 3) , and the required measurement distance would be so short that the device would not clearly be within the far field, the test report shall state this fact, the measurement distance and bandwidth used, the near field/far field distance for the measurement setup (see clause A.1.4), the measured device emissions, the achievable measurement noise floor and the frequency range(s) involved.

6.2 Modes of operation of the transmitter

For the purpose of the measurements according to the present document, there shall be a facility to operate the transmitter in a continuous state, whereby a normal test signal (see clause 6.1) is transmitted repeatedly.

If pulse gating is employed where the transmitter is quiescent for intervals that are long compared to the nominal pulse repetition interval, measurements shall be made with the pulse train gated on.

6.3 Measuring receiver

The term measuring receiver refers to a spectrum analyser. The reference bandwidth of the measuring receiver as defined in CISPR 16 [2] shall be as given in table 1.

Table 1: Reference bandwidth of measuring receiver

Frequency being measured: f	Spectrum analyser bandwidth (3 dB)
30 MHz ≤ f < 1 000 MHz	100 kHz
1 000 MHz ≤ f	1 MHz

7 Interpretation of results

7.1 Measurement uncertainty

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 s in table 2.

Table 2: Measurement uncertainty

Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-7}$
RF power, radiated	±6 dB
Temperature	±1 K
Humidity	±5 %

Accuracy of azimuth and elevation adjustment during TRP measurement ±1°.

For the test methods, according to the present document the uncertainty figures shall be calculated according to the methods described in TR 100 028 [5] 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 cases where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Table 2 is based on such expansion factors.

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

NOTE: Information on uncertainty contributions, and verification procedures are detailed in TR 102 273 [4].

7.1.1 Measurement uncertainty is equal to or less than maximum acceptable uncertainty

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

e) When the measured value does not exceed the limit value the equipment under test meets the requirements of the standard.

f) When the measured value exceeds the limit value the equipment under test does not meet the requirements of the standard.

g) The measurement uncertainty calculated by the test technician carrying out the measurement should be recorded in the test report.

h) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement untaken. The method used should be recorded in the test report.

7.1.2 Measurement uncertainty is greater than the maximum acceptable uncertainty

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

i) When the measured value plus the difference between the maximum acceptable measurement uncertainty and the measurement uncertainty calculated by the test technician does not exceed the limit value the equipment under test meets the requirements of the standard.

j) When the measured value plus the difference between the maximum acceptable measurement uncertainty and the measurement uncertainty calculated by the test technician exceeds the limit value the equipment under test does not meet the requirements of the standard.

k) The measurement uncertainty calculated by the test technician carrying out the measurement should be recorded in the test report.

l) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement untaken. The method used should be recorded in the test report.

7.2 Other emissions from device circuitry

UWB transmitters emit very low power radio signals, comparable with the power of spurious emissions from digital and analog circuitry. If it can be clearly demonstrated that an emission from an ultra-wideband device is unintentional and is not radiated from the transmitter's antenna (e.g. by disabling the device's UWB transmitter or internally disconnecting the UWB antenna), such emissions shall be considered as emitted from the receiver or from other digital or analog circuitry.

8 Methods of measurement and limits for transmitter parameters

Where the transmitter is designed with adjustable carrier power, then all transmitter parameters shall be measured using the maximum average power density.

All measurements shall be performed using normal modulation representing normal operation of the equipment.

If the transmitter is equipped with an automatic transmitter shut-off facility, it should be made inoperative for the duration of the test.

8.1 Permitted range of operating Frequencies

8.1.1 Definition

The permitted range of operating frequencies is the frequency range over which the equipment is authorized to operate.

8.1.2 Method of measurement

The minimum and maximum frequencies outside of the permitted range of frequencies of 8.1.3 shall be measured using the method shown in figure 1.

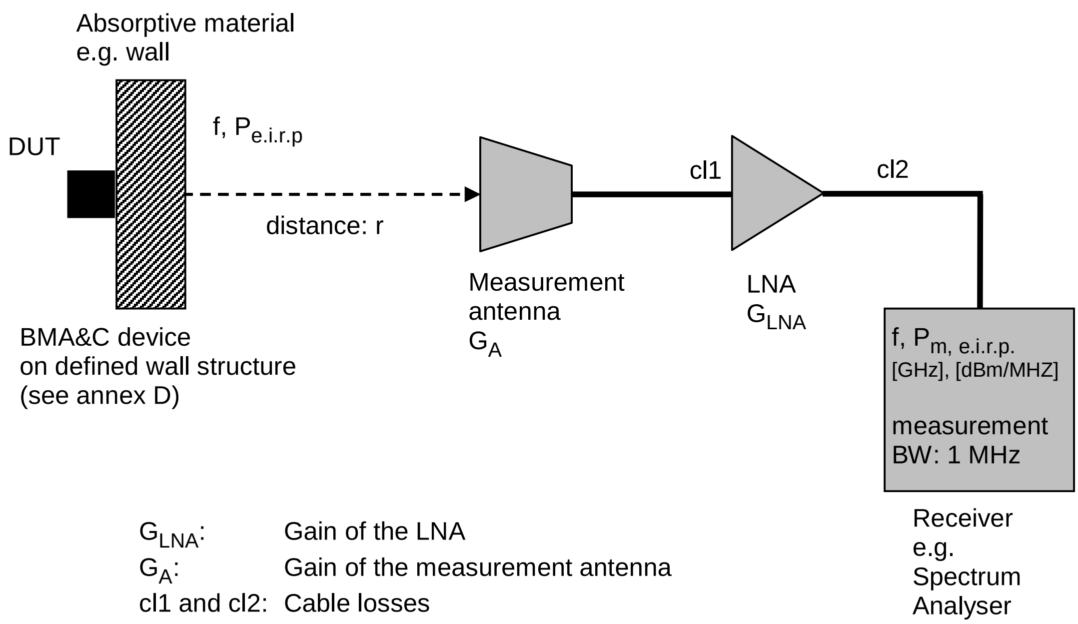


Figure 1: Test set-up for measuring the operating frequency range

8.1.3 Limits

The permitted range of operating frequencies is 2,2 GHz to 8 GHz with reduced emissions from 0,96 GHz to 2,2 GHz and 8 GHz to 10,6 GHz.

8.2 Emissions

8.2.1 Total maximum UWB emission of the equipment (UE)

Any emissions radiated from the equipment into the free air are defined as undesired emissions. The total measured undesired emissions (TUE) of the equipment are the sum of:

1) UWB Emissions (UE) from the transmitter.

2) Undesired and Spurious Emissions (USE) from the transmitter, receiver and other analog or digital circuitry.

The UWB emissions (UE) cannot be measured directly because the undesired emissions as spurious and the analog or digital control circuitry emissions are simultaneously present and emitted.

The UWB and other emissions from the equipment for the purpose of the test are defined as the total undesired emissions (TUE).

The undesired emissions as spurious and the analog or digital control circuitry emissions (USE) can be determined by disabling the transmitter UWB emissions. Both USE and TUE are measured as digital datasets.

The difference of TUE and USE represent the UWB transmitter emissions UE.

8.2.1.1 Definition

The maximum mean undesired UWB emission (UE) is the UWB emission into the material under investigation and measured around a sphere (see clause 8.2.1.2).

UE [dBm/MHz] = TUE [dBm/MHz] – USE [dBm/MHz]

8.2.1.2 Method of measurement

In order to define the UWB Emissions (UE) as specified under limits in clause 8.2.1.3, the total undesired emissions including the UWB signal and the spurious and other emissions (TUE) shall be measured.

In a second step the non-UWB emissions shall be measured by disabling the UWB transmitter or switching off the antenna.

The total maximum UWB transmission (UE) is the total measured undesired emission of the equipment (TUE) minus the spurious and other emissions from the equipment. (USE).

In order to be able to conduct all the measurements for a longer period of time, the implemented mechanisms to avoid continuous emission shall be deactivated for test purposes (e.g. timeout, movement sensor, manual push button action), (see clause 6.2).

8.2.1.2.1 Method of measurement of the total undesired emissions including the UWB signal and the spurious and other emissions (TUE)

The DUT shall be tested on a defined normalized building material structure as defined in normative annex D.

In all measurements the normal operational signal according to clause 6.2 is used.

Using a spectrum analyser with rms average detector the following settings are applicable:

m) Set the centre frequency of the spectrum analyzer to the frequency of interest.

n) Set the frequency span to examine the spectrum across a convenient frequency segment.

o) Set the RBW to 1 MHz and the VBW to 3 MHz.

p) Set the detector to rms

q) Set the sweep time so that there is no more than a one msec or less integration period per measurement point.

Other applicable measurement methods are described in [7].

In order to obtain the required sensitivity for the lowest levels to be measured, a narrower bandwidth setting may be necessary. This shall be stated in the test report form.

During the measurement, the DUT is placed on the building structure with its antenna pointing directly into the structure and the test antenna is placed 1,5 m away from the device under test.

The polarization of the measurement antenna must meet the polarization of the main field component at each measurement point. Therefore the measurement antenna can be rotated at each point until the highest value is obtained. Another possible method is to use a measurement antenna with two orthogonal polarization directions.

The relevant measurement value is the maximum value over the sphere and over all polarization angles.

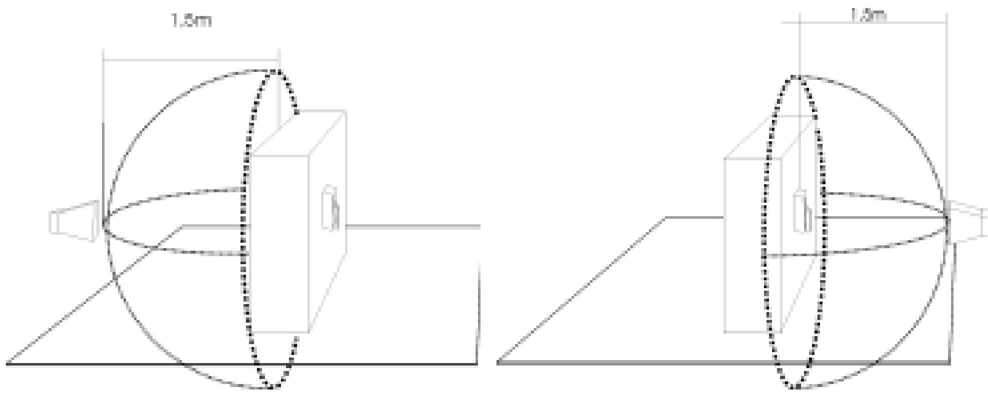


Figure 2: Measurement arrangement for all emission measurements (TUE, USE, UE, UE-TP)

The measuring receiver configuration uses a low noise preamplifier and a dipole antenna (for frequencies below 1 GHz) or horn antenna (for frequencies above 1 GHz). For the spurious emission measurements, outside the permitted range of frequencies, a combination of bicones and log periodic dipole array antennas (commonly termed "log periodic") could also be used to cover the entire 30 MHz to 1 000 MHz band. The test set-up is shown in figure 3.

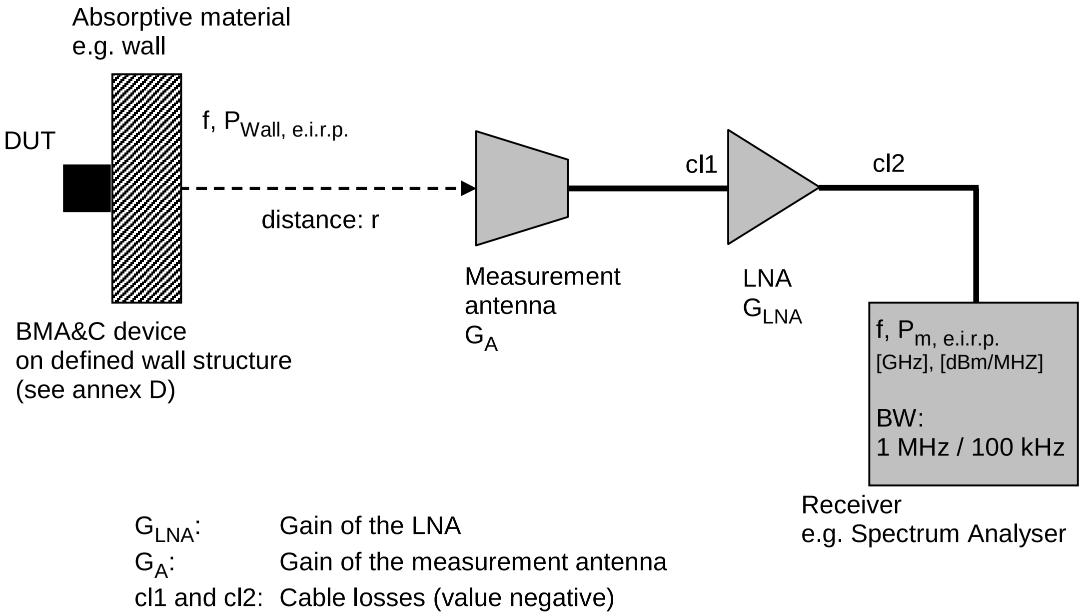


Figure 3: Test set-up for e.i.r.p measurements

The $P_{wall,eirp}$ is the power density referenced to the surface of the wall taking the frequency depending free space attenuation and the measurement equipment into account.

$$P_{Wall,e.i.r.p.} = \frac{\left(P_{m,eirp} - G_{LNA} - cl1 - cl2\right) \times \left(4\pi r\right)^2}{G_A \times \lambda^2} \qquad [dBm/MHz]$$

A test site such as one selected from annex A (i.e. indoor test site or open area test site), which fulfils the requirements of the specified frequency range and undisturbed lowest specified emission levels of this measurement shall be used.

The bandwidth of the measuring receiver shall be set to a suitable value to correctly measure the undesired emissions. This bandwidth shall be recorded in the test report.

The total undesired emission (TUE) level of the DUT shall be measured and recorded. For these measurements it is recommended to use a LNA (low noise amplifier) before the spectrum analyser input to achieve the required sensitivity.

The frequency of the measuring receiver shall be adjusted over the frequency range from 30 MHz to 26 GHz (according to CEPT/ERC/REC 74-01 [11]). The frequency of each spurious component shall be noted. If the test site is disturbed by radiation coming from outside the site, this qualitative search may be performed in a screened room with reduced distance between the transmitter and the test antenna if necessary.

Proper pre-select filtering can be incorporated to protect the measurement system low-noise pre-amplifier from overload. In addition, all ambient signals can be detected prior to the activation of the transmitter in order to remove the ambient signal contributions present in the measured spectra. This will require post-processing of the measurement data utilizing a computer and data analysis software.

The value in dBm/MHz of the spurious emissions (USE-measurement) shall be stored as a digital dataset as function of the measured frequencies in the range of 960 MHz to 10,6 GHz.

8.2.1.2.2 Method of measurement of the spurious and other non-UWB emissions from the equipment (USE)

The UWB signal transmission is disabled and /or the antenna is switched off.

The method of measurement for USE is identical to clause 8.2.1.2.1.

The value in dBm/MHz shall be stored as a digital dataset as function of the measured frequencies in the range of 960 MHz to 10,6 GHz.

8.2.1.2.3 Method of calculation of the total maximum undesired UWB emission of the equipment (UE)

The recorded e.i.r.p limits of clause 8.2.1.2.1 shall be reduced by the limits of clause 8.2.1.2.2 and represent the values of the total maximum undesired UWB emissions from the equipment (UE).

The calculation of the measured E-Field into the e.i.r.p. shall be done with the following equation:

$$e.i.r.p. = \frac{|E_{rms}|^2 \times 4 \times \pi \times R^2}{Z_{Fo}}$$

where R is the distance in metres between the equipment under test and the measurement point.

and $$Z_{F0} = 120\pi\ \Omega$$

8.2.1.3 Limits

e.i.r.p limits of undesired UWB emissions (UE).

Table 3: Limits for undesired UWB emissions

Frequency range [GHz]	Limit values UWB emissions [dbm/MHz]
below 0,96	-85
0,96 to 1,73	-70
1,73 to 2,2	-61.3
2,2 to 8	-50
8 to 9,6	-70
above 10,6	-85

8.2.2 Transmitter spurious emissions (USE)

8.2.2.1 Definition

Spurious emissions are emissions radiated by the antenna of the DUT or its cabinet on a frequency, or frequencies, outside the permitted range of frequencies occupied by the transmitter. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products.

8.2.2.2 Method of measurement

The method of measurement is identical to clause 8.2.1.2.1.

8.2.2.3 Limits

The equivalent isotropically radiated power of any spurious emission shall not exceed the values given in table 5 a in accordance to CEPT/ERC/REC 74-01 [11].

Table 4: Limits of radiated spurious emissions

Frequency range	Limit values for spurious radiation
47 MHz to 74 MHz	-54 dBm / 100 kHz
87,5 MHz to 118 MHz	-54 dBm / 100 kHz
174 MHz to 230 MHz	-54 dBm / 100 kHz
470 MHz to 862 MHz	-54 dBm/ 100 kHz
otherwise in band 30 MHz to 1 000 MHz	-36 dBm / 100 kHz
1 000 MHz to 100 000 MHz (see note)	-30 dBm / 1 MHz
NOTE: Not applicable within the permitted range of frequencies.	

8.2.3 Total Power (UE-TP)

8.2.3.1 Definitions

The Total Power of undesired UWB emissions (UE-TP) is the integration of the time-averaged power density of the undesired UWB emissions (UE) from clause 8.2.1 across the entire spherical surface enclosing the UWB sensor under test (DUT).

8.2.3.2 Method of measurement

The measurement procedure is identical to clause 8.2.1.2.1.

The Total Power of undesired UWB emissions (UE-TP) is the integrating time-averaged power density of the undesired emissions (UE) from clause 8.2.1 across the entire spherical surface enclosing the UWB sensor under test (DUT). The calculation in annex E should be used.

Measurements have to be done every max 15° (for both angles) on the spherical surface in a distance of max 1,5 m (far field distance of the used measurement antenna is necessary).

8.2.3.3 Limits

The e.i.r.p. limit of the total power spectral density (UE-TP) shall be 5 dB below the limits of clause 8.2.1.3.

Table 5: Limits of Total Power (UE-TP)

Frequency range [GHz]	TP-UWB emissions [dbm/MHz]
below 0,96	-90
0,96 to 1,73	-75
1,73 to 2,2	-66
2,2 to 8	-55
8 to 9,6	-77
above 10,6	-90

8.3 Pulse Repetition Frequency (PRF)

8.3.1 Definitions

For the purposes of the present document the Pulse Repetition Frequency (PRF) is defined as the minimum number of UWB pulses transmitted per second by the device when it is continuously transmitting.

8.3.2 Declaration

The provider shall give a description of the timing of pulses transmitted by the device when it is transmitting the normal test signal (as given in clause 6.1) and shall declare the PRF for the transmitter.

8.3.3 Limits

The PRF of the device under test shall not be less than 5 MHz.

8.4 Listen Before Talk (LBT)

8.4.1 Definition

Listen before talk is a mechanism to protect other operating services in the same band. The receiver of the equipment has to monitor the frequency band of clause 8.4.3.

The equipment initially and then intermittently checks the permitted frequency range of operation for an active use by other services prior to release the UWB transmitter emissions, see figure 4.

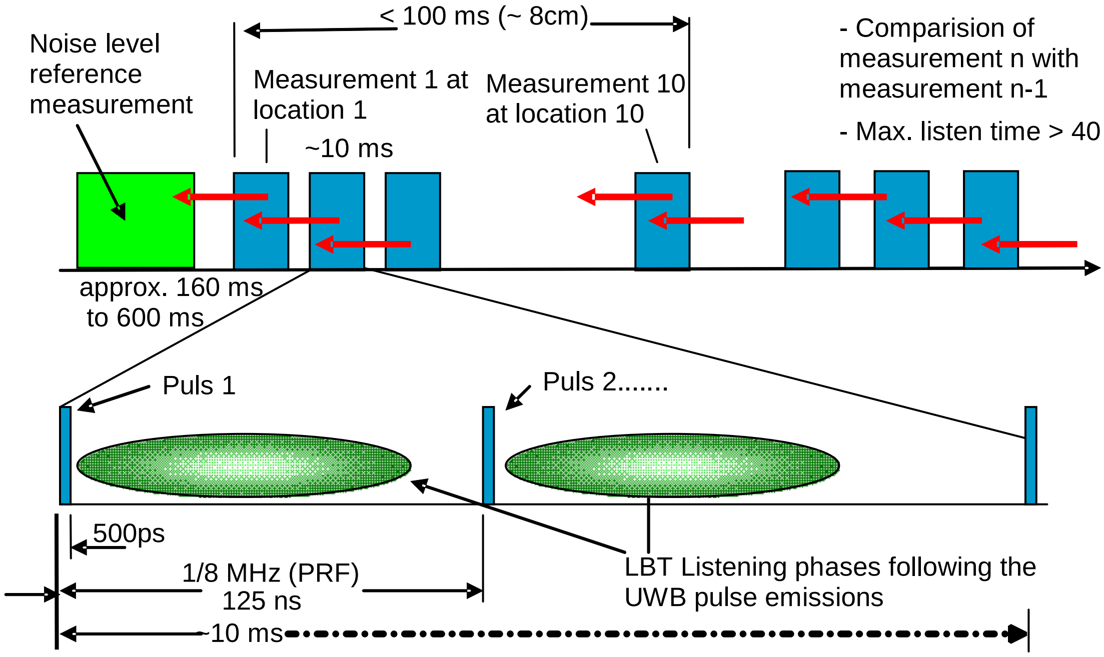


Figure 4: Listen Before Talk (LBT) function

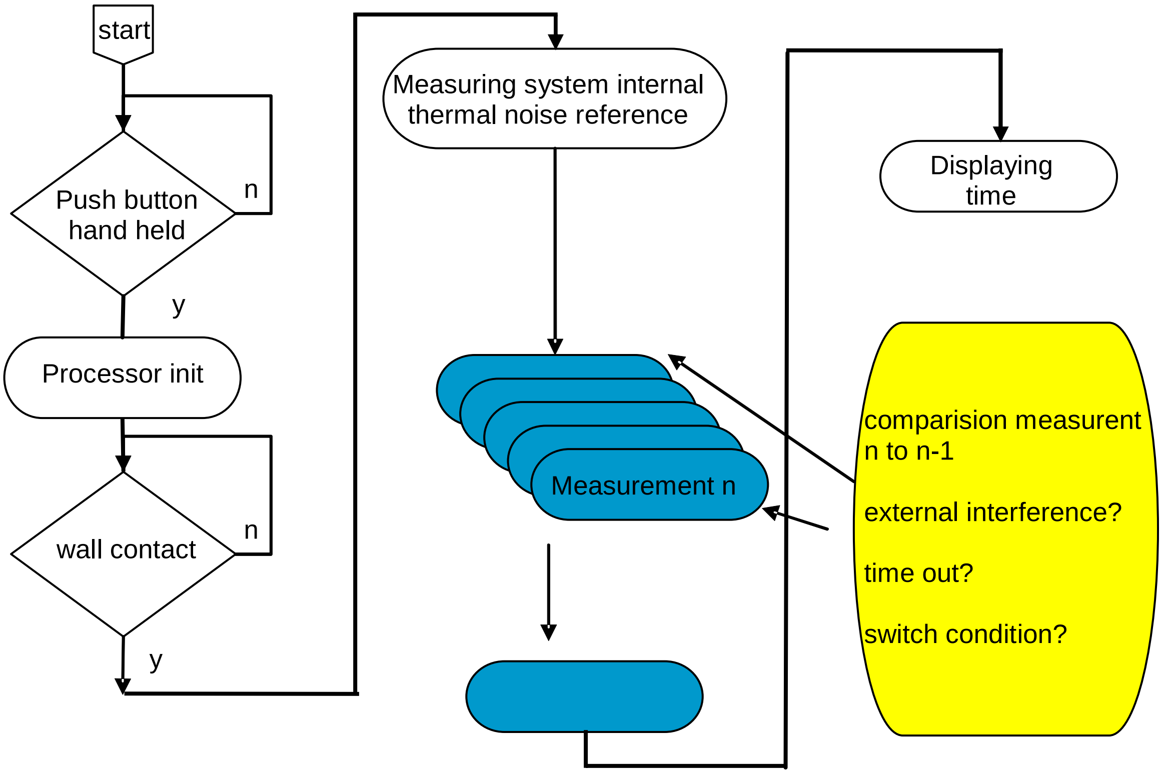


Figure 5: Flow diagram of LBT mechanism

8.4.2 Method of measurement

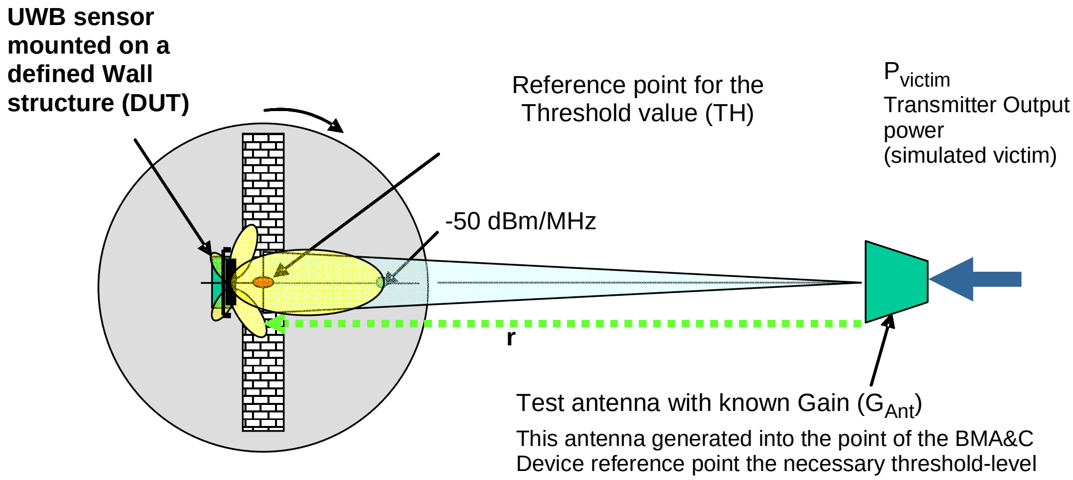
8.4.2.1 Measurement procedure

A test transmitter simulating the victim (e.g. UMTS) transmits a calibrated signal of the field strength levels of clause 8.4.3 towards the UWB DUT receiver.

With the equipment operated in a continuous mode, the individual frequency ranges and levels according to clause 8.4.3 shall be applied to the DUT.

For each frequency range and around the sphere (as per figure 2), the DUT has to be tested for the deactivation threshold to stop UWB emissions at the defined sensitivity limits of clause 8.4.3.

8.4.2.1 Test set-up



$$TH = \frac{P_{to} \times G_{(f)}}{4 \times r^2 \times \pi}$$

Figure 6: Test set-up for LBT function

8.4.3 Limits

The sensitivity of the UWB receiver has to meet the minimum sensitivity levels of table 5 over the frequency range within a max. receiving time of 40 msec.

In case the UWB equipment covers only part of the frequency range of table 6, the LBT function shall only cover the actually used UWB range.

Table 6: Frequency and sensitivity limits of the LBT function

Frequency range [GHz]	LBT sensitivity Limits [dbm/MHz]
0,96 to 1,35	-17
1,35 to 1,73	-43
1,73 to 2,2	-43
2,2 to 8	-43
8 to 9,6	-17

8.5.5 Design requirements

The equipment shall comply with the design requirements as defined in annex B.

9 Methods of measurement and limits for receiver parameters

9.1 Receiver spurious emissions

Separate radiated spurious measurements need not be made on receivers co-located with transmitters.

Annex A (normative): Radiated measurements

This annex covers test sites and methods to be used with integral antenna equipment.

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

This clause introduces two commonly available test sites, an anechoic chamber and an anechoic chamber with a ground plane, 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 [3] 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.

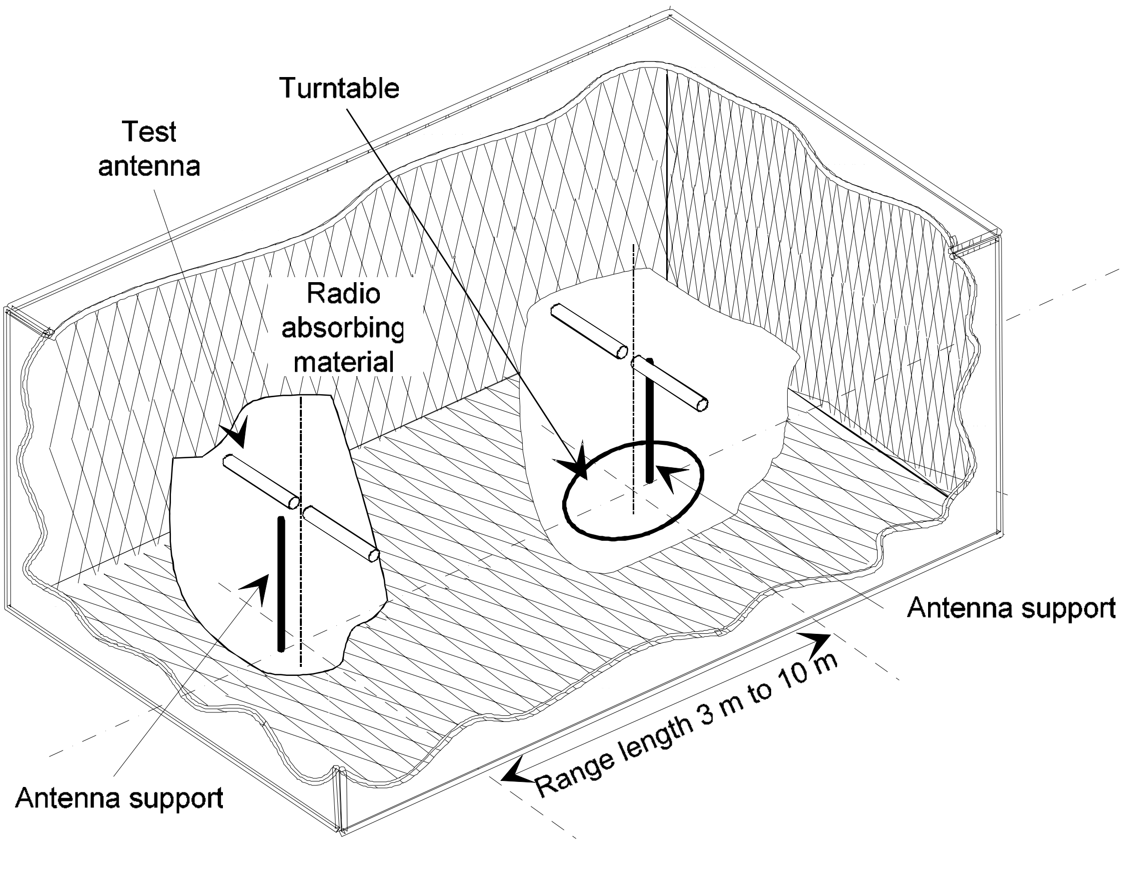


Figure A.1: A typical Anechoic Chamber

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

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

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

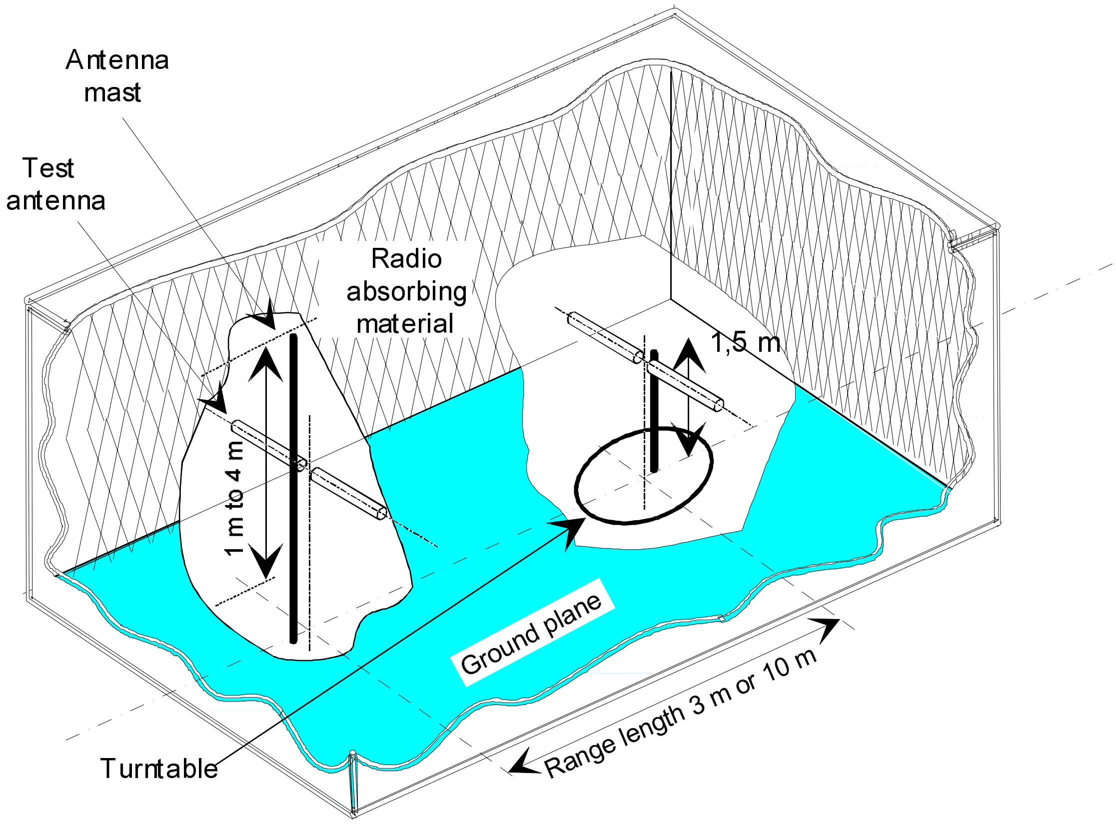


Figure A.2: A typical Anechoic Chamber with a conductive ground plane

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 DUT) and the receiving antenna above the ground plane.

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

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (DUT) at a specified height, usually 1,5 m above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2 /\lambda$ (m), whichever is greater (see clause 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 DUT by raising and lowering the receiving antenna on the mast (to obtain the maximum constructive interference of the direct and reflected signals from the DUT) and then rotating the turntable for a "peak" in the azimuth plane. At this height of the test antenna on the mast, the amplitude of the received signal is noted. Secondly the DUT is replaced by a substitution antenna (positioned at the DUT's phase or volume centre) which is connected to a signal generator. The signal is again "peaked" and the signal generator output adjusted until the level, noted in stage one, is again measured on the receiving device.

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

A.1.3 Test antenna

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

The test antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization which 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 [3] 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.1.4 Measuring antenna

The measuring antenna is used in tests on a DUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric field strength in the vicinity of the DUT. For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [3]. 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 DUT.

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 tests are undertaken. These schemes are common to all types of test sites described in annex A.

A.2.1 Verification of the test site

Verification procedures, as far as applicable, for different types of test sites are given in TR 102 273 [4], clause A.2.2 Preparation of the DUT.

The manufacturer should supply information about the DUT covering the operating frequency, polarization, supply voltage(s) and the reference face. Additional information, specific to the type of DUT should include, where relevant, carrier power and 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 minutes off).

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

A.2.3 Power supplies to the DUT

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

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

A.2.4 Range length

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

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

where:

- d_1 is the largest dimension of the DUT/dipole after substitution (m);
- d_2 is the largest dimension of the test antenna (m);
- λ is the test frequency wavelength (m).

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

$$2\lambda$$

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

A.2.5 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 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.

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 logbook results sheet for the specific test.

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

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

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

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

A 2.6 General requirements for RF cables

Due to the low power levels involved in the measurements, all RF cables including their connectors at both ends used within the measurement arrangements and set-ups shall be of coaxial type featuring within the frequency range they are used:

- a nominal characteristic impedance of 50 Ω;
- a VSWR of less than 1,2 at either end;
- a shielding loss in excess of 60 dB.

NOTE: Further details are provided in TR 102 273 [4].

Annex B (normative): Design requirements

The following design requirements shall be implemented in order to comply with the ECC Decision ECC/DEC/(06) xy [4].

- The equipment shall be equipped with a non locking manual activation switch.
- The equipment shall have a switch which upon sensing the mechanical contact of the equipment with the material under investigation (e.g. ground or wall) enables the activation of the UWB transmissions.
- The device shall be equipped with a movement detector to automatically cease transmission after a time of 10 seconds has elapsed after the last movement has occurred.
- Only handheld equipment allowed.

The time duration after which an active radio service has to be detected at a power density given in clause 8.4.3 should be < 40 ms.

Annex C (informative): Measurement antenna and preamplifier specifications

The radiated measurements set-up in section 8 specifies the use of the wide-band horn antenna and a wide-band, high gain preamplifier in order to measure the very low radiated power density level from the DUT.

Table C.1 gives examples of recommended data and features for the horn antenna and preamplifier to be used for the test set-up.

Table C.1: Recommended performance data for preamplifier and horn antenna.

Pre-amplifier	
Parameter	**Data**
Bandwidth	< 1 GHz to > 15 GHz
Noise figure	< 2 dB
Output at 1 dB compression	> +10 dBm
Gain	> 30 dB
Gain flatness across band	±1,5 dB
Phase response	Linear across frequency range
Impulse response overshoot	< 10 %
Impulse response damping ratio	0,3 to 0,5
VSWR in/out across band	2:1
Nominal impedance	50 Ω
Horn antenna	
Parameter	**Data**
Gain	> 4 dBi
1 dB bandwidth	< 1 GHz to > 15 GHz
Nominal impedance	50 Ω
VSWR across band	< 1,5:1
Cross polarization	> 20 dB
Front to back ratio	> 20 dB
Tripod mountable	Yes
Robust precision RF connector	Yes

Measuring the complete emission spectrum of the operating frequency range, several measurement antennas will be required, each optimized over a distinct frequency range:

Table C.2: Recommended measurement antennas

Antenna type	Frequency range
λ/2 - dipole or biconical	30 MHz to 200 MHz
λ/2 - dipole or log periodic	200 MHz to 1 000 MHz
Horn	> 1 000 MHz

Annex D (normative): Wall definition for measuring the emissions and LBT function

Based on a study from Fraunhofer Institute [9] a wall which represents the material used in European building constructions will be used as a reference for all emission measurements.

The wall shall be consisted of 240 mm bricks, covered and on both sides with 15 mm of plaster.

The size shall be minimum of 1 x 1 m.

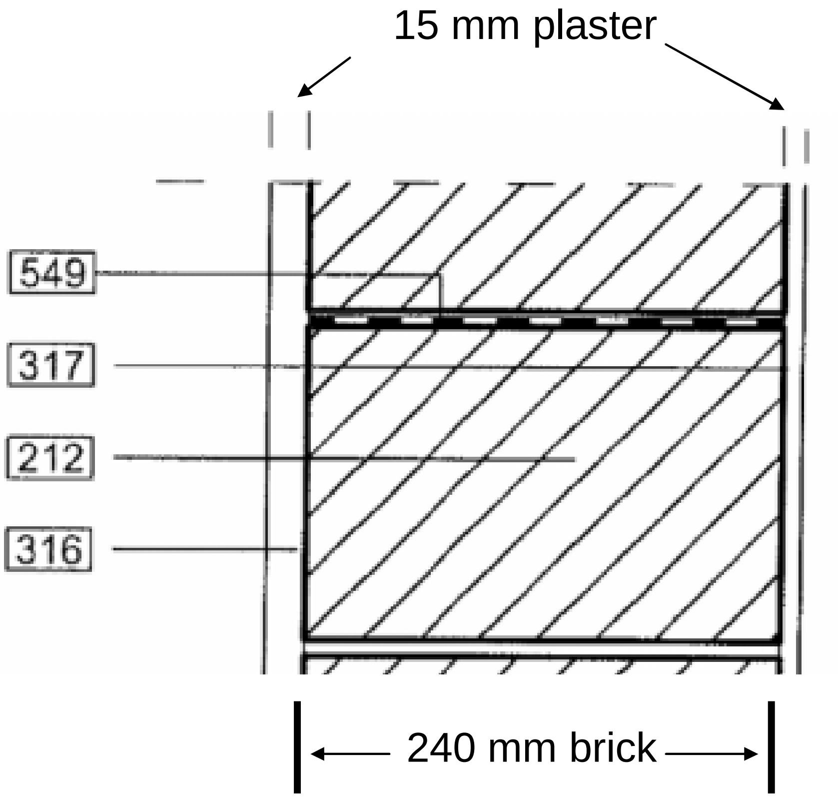


Figure D.1: Crossection of a reference wall for emission measurements

Annex E (informative): Definition for Total Power (TP-UE)

The Total Power (TP) is defined as the undesired UWB emission that is radiated around the DUT. The result can be obtained by measuring the time-averaged power density S around the sphere and their integration.

Measuring the field strength of the electric field, the power density is given by:

$$S = \frac{|E_{rms}|^2}{Z_{F0}}$$

where $Z_{F0} = 120\pi\Omega$ represents the wave impedance of free air.

The RMS value of the field strength can be obtained using:

$$E_{rms} = \frac{|E|}{\sqrt{2}}$$

where $|E|$ is the amplitude the electric field.

Measuring the power using a spectrum analyser, the power density is given by:

$$S = \frac{P_r}{A_r}$$

where P_r is the power at the connector of the receiving antenna and A_r is the effective area of the receiving antenna.

The Total Power is then given by:

$$TP = \int_{\Theta=0}^{\pi} \int_{\Phi=0}^{2\pi} S \times r^2 \times \sin(\Theta) d\Theta d\Phi$$

where r is the radius of the sphere, Θ is the elevation angle, and Φ is the azimuth angle.

For both the measurement of the electric field strength as well as for the measurement of the power the RBW must be set to 1 MHz and the VBW to 3 MHz.

Annex F (informative): Bibliography

1) CISPR 22: "Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement", including proposed modification of CISPR 22 on emission limits and methods of measurement from 1 GHz to 6 GHz from December 2003".

2) Fraunhofer Institut Bauphysik, IPG Report GB 174e/2006: "Typical Wall constructions in Germany, England and France".

3) Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB); System Reference Document Part 1: Building material analysis and classification applications operating in the frequency band from 2,2 GHz to 8 GHz.

History

Document history		
V1.1.1	May 2006	Public Enquiry PE 20060922: 2006-05-24 to 2006-09-22