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Harmonized European Standard (Telecommunications series)

Electromagnetic compatibility and Radio spectrum Matters (ERM); Ultra WideBand (UWB) technologies for communication purposes; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive

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Foreword

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

The present document has been produced by ETSI in response to a mandate from the European Commission issued under Council Directive 98/34/EC (as amended) laying down a procedure for the provision of information in the field of technical standards and regulations.

The present document is intended to become a Harmonized Standard, the reference of which will be published in the Official Journal of the European Communities referencing the 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 ("the R&TTE Directive ").

NOTE: A list of such Harmonized European Standards is included on the web site http://www.newapproach.org.

Technical specifications relevant to Directive 1999/5/EC are given in annex A.

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):	18 months after doa

Introduction

The present document is part of a set of standards developed by ETSI and is designed to fit in a modular structure to cover all radio and telecommunications terminal equipment within the scope of the R&TTE Directive. The modular structure is shown in EG 201 399 (see bibliography).

UWB Technologies

The present document provides a generic set of technical requirements covering many different types of UWB technologies used for short range communications. These technologies can be broken down into two groups:

1) Impulse based technologies; and

2) RF carrier based technologies.

The following clauses give a brief overview of these UWB technologies and their associated modulation techniques.

Impulse technology

Impulse derived UWB technology consists of a series of impulses created from a dc voltage step whose risetime can be modified to provide the maximum useful number of spectral emission frequencies. This derived impulse can then be suitably modified by the use of filters to locate the resulting waveform within a specific frequency spectrum range. This filter can be a stand alone filter or incorporated into an antenna design to reduce emissions outside the designated frequency spectrum.

Modulation techniques include pulse positioning in time, pulse suppression and other techniques to convey information. The transmitted energy is summed at the receiver to reproduce the transmitted pulse.

This technology is suitable for direct and non-direct line of sight communications, any reflected or time delayed emissions being suppressed by the receiver input circuits.

RF carrier based technology

RF carrier based UWB technology is based upon classical radio carrier technology suitably modulated by a baseband modulating process. The modulating process must produce a bandwidth in excess of 50 MHz to be defined as UWB.

Different modulating processes are used to transmit the data information to the receiver and can consist of a series of single hopping frequencies or multi-tone carriers.

This technology can be used for both direct and non-direct line of sight communications, any reflected or time delayed emissions being suppressed by the receiver input circuits.

Test and measurement limitations

The ERA report 2006-0713 (see bibliography) has shown that there are practical limitations on measurements of RF radiated emissions. The minimum radiated levels that can be practically measured in the lower GHz frequency range by using a radiated measurement setup with a horn antenna and pre-amplifier are typically in the range of about -70 dBm/MHz to -75 dBm/MHz (e.i.r.p) to have sufficient confidence in the measured result (i.e. UWB signal should be at least 6 dB above the noise floor of the spectrum analyser and the measurement is performed under far-field conditions at a one meter distance). However, RF conducted measurements with a pre-amplifier can be carried out to somewhere around -100 dBm/MHz.

For equipment that have detachable antennas and provide a 50 Ω antenna port, measurements can be made providing suitable antenna calibrations can be provided.

For integrated antenna equipment, previous ETSI testing standards have allowed equipment modification to provide a 50 Ω adaptor to be added to provide the necessary test port. However, UWB integral equipment and particularly impulse based technology does not use classical radio techniques and as such is unlikely to have matched 50 Ω antenna port impedances.

The present document therefore recognizes these difficulties and provides a series of test methods suitable for the different UWB technologies.

1 Scope

The present document applies to transceivers, transmitters and receivers utilizing Ultra WideBand (UWB) technologies and used for short range communication purposes.

The present document applies to impulse, modified impulse and RF carrier based UWB communication technologies.

The present document applies to fixed (indoor only), mobile or portable applications, e.g.:

- stand-alone radio equipment with or without its own control provisions;
- plug-in radio devices intended for use with, or within, a variety of host systems, e.g. personal computers, hand-held terminals, etc.;
- plug-in radio devices intended for use within combined equipment, e.g. cable modems, set-top boxes, access points, etc.;
- combined equipment or a combination of a plug-in radio device and a specific type of host equipment;
- equipment for use in road and rail vehicles.

The present document does not cover UWB transmitter equipment to be installed at a fixed outdoor location or for use in flying models, aircraft and other forms of aviation as per the ECC/DEC/(06)04 (see bibliography).

The present document applies to UWB equipment with an output connection used with a dedicated antenna or UWB equipment with an integral antenna.

These radio equipment types are capable of operating in all or part of the frequency bands given in table 1.

Table 1: Radiocommunications frequency bands

	Radiocommunications frequency bands
Transmit	3,4 GHz to 4,8 GHz
Receive	3,4 GHz to 4,8 GHz
Transmit	6,0 GHz to 8,5 GHz
Receive	6,0 GHz to 8,5 GHz

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

[2] ANSI C63.5 (2006): "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electro Magnetic Interference".

[3] ITU-R Recommendation SM 329-10 (2003): "Unwanted emissions in the spurious domain".

[4] ETSI TS 102 321 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Normalized Site Attenuation (NSA) and validation of a fully lined anechoic chamber up to 40 GHz".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

combined equipment: any combination of non-radio equipment and a plug-in radio device that would not offer full functionality without the radio device

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

effective radiated power (e.r.p): product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction (RR 1.162)

equivalent isotropically radiated power (e.i.r.p): product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain) (RR 1.161)

gating: transmission that is intermittent or of a low duty cycle referring to the use of burst transmissions where a transmitter is switched on and off for selected time intervals

hopping: spread spectrum technique whereby individual radio links are continually switched from one subchannel to another

host: host equipment is any equipment which has complete user functionality when not connected to the radio equipment part and to which the radio equipment part provides additional functionality and to which connection is necessary for the radio equipment part to offer functionality

impulse: pulse whose width is determined by its dc step risetime and whose maximum amplitude is determined by its dc step value

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

narrowband: See test in clause 5.8.5.

plug-in radio device: radio equipment module intended to be used with or within host, combined or multi-radio equipment, using their control functions and power supply

pulse: short transient signal whose time duration is nominally the reciprocal of its -10 dB bandwidth

rf carrier: fixed radio frequency prior to modulation

stand-alone radio equipment: equipment that is intended primarily as communications equipment and that is normally used on a stand-alone basis

wideband: emission whose occupied bandwidth is greater than the test equipment measurement bandwidth

3.2 Symbols

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

f	frequency
f_H	highest frequency of the power envelope
f_L	lowest frequency of the power envelope
R	Distance
Ω	ohm
λ	wavelength

3.3 Abbreviations

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

AC	Alternate Current
ATT	ATTenuator/ATTenuation
dB	deciBel
dBi	gain in decibels relative to an isotropic antenna
dBm	gain in decibels relative to one milliwatt
DC	Direct Current
e.i.r.p.	equivalent isotropically radiated power
e.r.p.	effective radiated power
EUT	Equipment Unter Test
LDC	Low Duty Cycle
LNA	Low Noise Amplifier
OFDM	Orthogonal Frequency Division Multiplexing
PRF	Pulse Repetition Frequency
RBW	Resolution BandWidth

R&TTE	Radio and Telecommunications Terminal Equipment
RF	Radio Frequency
RMS	Root Mean Square
RR	Radio Regulations
Rx	Receiver
SNR	Signal to Noise Ratio
SRD	Short Range Device
TPC	Transmit Power Control
Tx	Transmitter
UWB	Ultra WideBand
VBW	Video BandWidth
VSWR	Voltage Standing Wave Ratio

4 Technical requirements specification

4.1 Technical requirements

4.1.1 Operating bandwidth

4.1.1.1 Definition

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 percentage of 0,5 % of the total mean power of a given emission.

For the purposes of the present document the measurements are made at the -23 dB points.

4.1.1.2 Test procedure

This test shall be performed using a radiated or conducted test procedure (see clause 5.8.4).

4.1.1.3 Limit

The operating bandwidth shall be greater than 50 MHz (at -23 dB relative to the maximum spectral power density).

4.1.1.4 Measurement uncertainty

See table 9.

NOTE: The operating bandwidth is calculated from the two measured frequencies for which the uncertainty figure for frequency applies. However, the uncertainty of either radiated or conducted power will need to be taken into account when deriving the uncertainty value for frequency measurements at the -23 dB points.

4.1.2 Maximum value of mean power spectral density

4.1.2.1 Definition

The maximum mean power spectral density (specified as e.i.r.p.) of the device under test, at a particular frequency, is the average power per unit bandwidth (centred on that frequency) radiated in the direction of the maximum level under the specified conditions of measurement.

4.1.2.2 Test procedure

This test shall be performed using a radiated or conducted test procedure (see clause 5.8.2) for the frequencies as shown in table 2.

This test shall be repeated at the frequencies as shown in table 3 including the frequency band edges at 1,6 GHz, 2,7 GHz, 3,4 GHz, 3,8 GHz, 4,2 GHz, 4,8 GHz, 6,0 GHz and 8,5 GHz and 10,6 GHz as shown in table 3.

4.1.2.3 Limit

The maximum mean power spectral density measured using the above test procedure shall not exceed the limits given in tables 2 and 3.

Table 2: Maximum value of mean power spectral density limit

Frequency (GHz)	Maximum value of mean power spectral density (dBm/MHz)
3,4 < f ≤ 4,8	≤ -41,3 (see note 1)
4,2 < f ≤ 4,8	≤ -41,3 (see note 2)
6 < f ≤ 8,5	≤ -41,3 (see note 2)
NOTE 1: LDC is required (see clause 4.1.7). If LDC is not implemented then the following applies: - 3,4 GHz to 3,8 GHz ≤ -80 dBm/MHz; - 3,8 GHz to 4,2 GHz ≤ -70 dBm/MHz. NOTE 2: In case of devices installed in road and rail vehicles, operation is subject to the implementation of Transmit Power Control (TPC) with a range of 12 dB with respect to the maximum value of mean power spectral density. If TPC is not implemented then the following applies: - 4,2 GHz to 4,8 GHz ≤ -53,3 dBm/MHz; - 6 GHz to 8,5 GHz ≤ -53,3 dBm/MHz.	

Table 3: Maximum value of mean power spectral density limit at frequency band edges

Frequency (GHz)	Maximum value of mean power spectral density (dBm/MHz)
f ≤ 1,6	-90
1,6 < f ≤ 2,7	-85
2,7 < f ≤ 3,4	-70
3,4 < f ≤ 3,8 (applies for equipment not using LDC)	-80
3,8 < f ≤ 4,8 (applies for equipment not using LDC)	-70
4,8 < f ≤ 6	-70
8,5 < f ≤ 10,6	-65
f > 10,6	-85

4.1.2.4 Maximum allowable measurement uncertainty

See table 9.

4.1.3 Maximum value of peak power

4.1.3.1 Definition

The power specified as e.i.r.p. contained within a 50 MHz bandwidth at the frequency at which the highest mean radiated power occurs, radiated in the direction of the maximum level under the specified conditions of measurement.

4.1.3.2 Test procedure

This test shall be performed using a radiated or conducted test procedure (see clause 5.8.3).

4.1.3.3 Limit

The maximum peak power limit measured using the above test procedure shall not exceed the limits given in table 4.

Table 4: Maximum peak power limit

Frequency (GHz)	Maximum peak power (dBm, measured in 50 MHz)
3,4 < f ≤ 4,8	0 (see note 1)
4,2 < f ≤ 4,8	0 (see note 2)
6 < f ≤ 8,5	0 (see note 2)
NOTE 1: LDC is required (see 4.1.7). If LDC is not implemented then the following applies: - 3,4 GHz to 3,8 GHz ≤ -40 dBm, measured in 50 MHz; - 3,8 GHz to 4,2 GHz ≤ -30 dBm, measured in 50 MHz. NOTE 2: In case of devices installed in road and rail vehicles, operation is subject to the implementation of Transmit Power Control (TPC) with a range of 12 dB with respect to the maximum value of peak power. If TPC is not implemented then the following applies: - 4,2 GHz to 4,8 GHz ≤ -12 dBm, measured in 50 MHz; - 6 GHz to 8,5 GHz ≤ -12 dBm, measured in 50 MHz.	

The power reading on the spectrum analyser can be directly related to the peak power limit when a spectrum analyser resolution bandwidth of 50 MHz is used for the measurements. If a spectrum analyser resolution bandwidth of X MHz is used instead, the maximum peak power limit shall be scaled down by a factor of 20 log (50/X), where X represents the measurement bandwidth used.

EXAMPLE: If the maximum peak power in a particular frequency band is 0 dBm/50 MHz, and a 3 MHz resolution bandwidth is used in case of an impulsive technology, then the measured value shall not exceed -24,4 dBm (see annex D).

For rf carrier based modulation using multi-tone carriers and not having gating techniques implemented, the maximum peak power limit shall be scaled down by a different factor of 10 log(50/X), where X represents the measurement bandwidth used.

4.1.3.4 Maximum allowable measurement uncertainty

See table 9.

4.1.4 Transmit Power Control

4.1.4.1 Definition

Transmit Power Control (TPC) is a mechanism to be used to ensure an interference mitigation on the aggregate power from a large number of devices. The TPC mechanism shall provide the full range from the highest to the lowest power level of the device and is required for UWB devices intended to be used in road or rail vehicles.

4.1.4.2 Test procedure

TPC tests to assess the highest and lowest power spectral density level shall be measured using a radiated or conducted test procedure (see clauses 5.8.2).

4.1.4.3 Limit

The maximum value of power spectral density when configured to operate at the highest level of the TPC range shall not exceed the levels given in table 5a.

Table 5a: Limits for maximum value of power spectral density at the highest level of the TPC range

Frequency range (MHz)	Power spectral density limit (e.i.r.p.) (dBm/MHz)
4 200 to 4 800	- 41,3
6 000 to 8 500	- 41,3

The maximum value of power spectral density when configured to operate at the lowest level of the TPC range shall not exceed the levels given in table 5b.

Table 5b: Limits for maximum value of power spectral density at the lowest level of the TPC range

Frequency range (MHz)	Power spectral density limit (e.i.r.p.) (dBm/MHz)
4 200 to 4 800	- 53,3
6 000 to 8 500	- 53,3

4.1.4.4 Maximum allowable measurement uncertainty

See table 9.

4.1.5 Receiver spurious emissions

4.1.5.1 Definition

Receiver spurious emissions are emissions at any frequency when the equipment is in receive mode.

4.1.5.2 Test procedure

See clause 5.8.5.

4.1.5.3 Limit

The narrowband spurious emissions of the receiver shall not exceed the values in tables 6 and 7 in the indicated bands.

Table 6: Narrowband spurious emission limits for receivers

Frequency range	Limit
30 MHz to 1 GHz	- 57 dBm (e.r.p.)
above 1 GHz to 40 GHz	- 47 dBm (e.i.r.p.)

The above limit values apply to narrowband emissions, e.g. as caused by local oscillator leakage. The measurement bandwidth for such emissions may be as small as necessary to get a reliable measurement result.

Wideband spurious emissions shall not exceed the values given in table 7.

Table 7: Wideband spurious emission limits for receivers

Frequency range	Limit
30 MHz to 1 GHz	- 47 dBm/MHz (e.r.p.)
above 1 GHz to 40 GHz	- 37 dBm/MHz (e.i.r.p.)

4.1.5.4 Maximum allowable measurement uncertainty

See table 9.

4.1.6 Pulse Repetition Frequency (PRF)

This test only applies to impulse and modified impulse UWB transmitters.

4.1.6.1 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 a normal test signal as defined in clause 5.

4.1.6.2 Declaration

The provider shall give a description of the timing of pulses transmitted by the device and shall declare the minimum PRF for the transmitter under any transmitting condition.

4.1.6.3 Limits

The PRF of the UWB transmitter shall be equal or greater than 1 MHz.

4.1.7 Low Duty Cycle (LDC)

This test only applies to UWB devices with LDC implemented and operating in the frequency band 3,4 GHz to 4,8 GHz.

4.1.7.1 Definitions

Tx on is the duration of a transmission burst and Tx off is the time interval between two consecutive transmission bursts.

4.1.7.2 Test procedure

The manufacturer shall provide sufficient information for determining compliance with the limits given in table 8.

4.1.7.3 Limits

Table 8: LDC limits

LDC parameter	Value
Maximum Tx on	≤ 5 ms
Minimum Mean Tx off	≥ 38 ms (mean value averaged over one (1) second)
Accumulated minimum Tx off (Σ Tx off)	≥ 950 ms in one (1) second
Maximum accumulated transmission time (Σ Tx on)	18 s in one (1) hour

4.1.8 Transmitter timeout

4.1.8.1 Definition

The time after which the transmitter shall cease transmitting data not having established a communication link with another transmitter/receiver combination. This requirement does not apply to network control and management information.

4.1.8.2 Test procedure

The manufacturer shall declare compliance with the requirement of this clause.

4.1.8.3 Limit

The limit for communications traffic transmitter timeout without an acknowledgement response from an associated receiver is a maximum of 10 s.

5 Essential radio test suites

5.1 Product information

The following product information shall be provided by the manufacturer:

- the type of UWB technology implemented in the equipment (e.g. carrier-based, impulse, modified impulsed, etc.);
- the type of modulation schemes available (e.g. OFDM modulation, pulsed modulation or any other type of modulation, etc.);
- the operating frequency range(s) of the equipment (see clause 4.1.1);
- the type of the equipment (e.g. stand-alone equipment, plug-in radio device, combined equipment, etc.) (see also clause 5.5);
- the intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p. levels (see also clause 5.4);
- the nominal power supply voltages of the stand-alone radio equipment or the nominal power supply voltages of the host equipment or combined equipment in case of plug-in devices;
- the test modulation to be used for testing (see also clause 5.2);
- the implementation of features such as gating or hopping;
- the implementation of any mitigation techniques.

5.2 Requirements for the test modulation

The test modulation used should be representative of normal use of the equipment and which results in the highest mean transmit power spectral density.

Where the equipment is not capable of continuous RF transmission, the test modulation shall be such that:

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

The same test modulation shall be used for all measurements on the same equipment. For transmitters that have multi-modulation schemes incorporated, the manufacturer shall declare the modulation scheme to be used for the tests.

Implemented transmitter timeout functionality (such as the implemented transmitter timeout as defined in clause 4.1.8) shall be disabled for the sequence of the test suite.

Where devices are equipped with LDC, the LDC operation will be disabled for the duration of the test.

The manufacturer shall provide the means to operate the transmitter during the tests.

5.3 Test conditions, power supply and ambient temperatures

5.3.1 Test conditions

Testing shall be performed under normal test conditions.

The test conditions and procedures shall be performed as specified in the following clauses.

5.3.2 Power sources

5.3.2.1 Power sources for stand-alone equipment

During testing, the power source of the equipment shall be replaced by a test power source capable of producing normal test voltages as specified in clause 5.3.3.2. The internal impedance of the test power source shall be low enough for its effect on the test results to be negligible. For the purpose of tests, the voltage of the power source shall be measured at the input terminals of the equipment.

For battery operated equipment the battery may be removed and the test power source shall be applied as close to the battery terminals as practicable.

During tests the power source voltages shall be maintained within a tolerance of ±1 % relative to the voltage at the beginning of each test. The value of this tolerance is critical to power measurements; using a smaller tolerance will provide better measurement uncertainty values.

5.3.2.2 Power sources for plug-in radio devices

The power source for testing plug-in radio devices shall be provided by a test fixture or host equipment.

Where the host equipment and/or the plug-in radio device is battery powered, the battery may be removed and the test power source applied as close to the battery terminals as practicable.

5.3.3 Normal test conditions

5.3.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature: +15 °C to +35 °C;
- relative humidity: 20 % to 75 %.

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

The actual values during the tests shall be recorded.

5.3.3.2 Normal power source

5.3.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the voltage(s) 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.

5.3.3.2.2 Lead-acid battery power sources used on vehicles

When radio equipment is intended for operation from the usual, alternator fed lead-acid battery power source used on vehicles, then the normal test voltage shall be 1,1 times the nominal voltage of the battery (6 V, 12 V, etc.).

5.3.3.2.3 Other power sources

For operation from other power sources or types of battery (primary or secondary), the nominal test voltage shall be as stated by the equipment manufacturer. This shall be recorded.

5.4 Choice of equipment for test suites

5.4.1 Choice of model

The tests shall be carried out on one or more production models or equivalent preliminary models, as appropriate. If testing is performed on (a) preliminary model(s), then the corresponding production models shall be identical to the tested models in all respects relevant for the purposes of the present document.

If an equipment has several optional features that are considered to affect directly the RF parameters then tests need only be performed on the equipment configured with the considered worst case combination of features as declared by the manufacturer.

Some radiated RF power measurements are difficult to carry out at the limits described in the present document, and therefore conducted measurements may be used in accordance with the specified test procedures. Equipment used for testing may be provided with a suitable 50 Ω connector for conducted RF power measurements. If a 50 Ω impedance cannot be provided at the test point for conducted testing then the test shall be performed as a radiated test using the radiated test procedure presented in the relevant test procedure in the following clauses.

5.4.2 Presentation

Stand-alone equipment shall be tested complete with any ancillary equipment.

Plug-in radio devices may be tested together with a suitable test fixture and/or typical host equipment (see clause 5.5).

5.4.3 Operating bandwidth

Where equipment has more than one operating bandwidth, a minimum of two operating bandwidths shall be chosen such that the lower and higher limits of the operating range(s) of the equipment are covered (see clause 4.1.2.3). All operating bandwidths of the equipment shall be declared by the equipment manufacturer.

5.4.4 Test sites and general arrangements for radiated measurements

The test site, test antenna and substitution antenna used for radiated measurements shall be as described in clause A.1.

For guidance on use of radiation test sites, coupling of signals and standard test positions used for radiated measurements, see clauses A.2 to A.4.

Detailed descriptions of radiated measurement arrangements for UWB devices can be found in ITU-R Recommendation SM.1754.

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 shall be measured at the distance specified in clause A.2.4 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 clause A.2.4 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 to 4, 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.2.4), the measured device emissions, the achievable measurement noise floor and the frequency range(s) involved.

5.5 Testing of host connected equipment and plug-in radio devices

For combined equipment and for radio parts for which connection to or integration with host equipment is required to offer functionality to the radio, different alternative test approaches are permitted. Where more than one such combination is intended, testing shall not be repeated for combinations of the radio part and various host equipment where the latter are substantially similar.

Where more than one such combination is intended and the combinations are substantially dissimilar, one combination shall be tested against all requirements of the present document and all other combinations shall be tested separately for radiated spurious emissions only.

5.5.1 The use of a host or test fixture for testing plug-In radio devices

Where the radio part is a plug-in radio device which is intended to be used within a variety of combinations, a suitable test configuration consisting of either a test fixture or a typical host equipment shall be used. This shall be representative for the range of combinations in which the device may be used. The test fixture shall allow the radio equipment part to be powered and stimulated as if connected to or inserted into the host or combined equipment. Measurements shall be made to all requirements of the present document.

NOTE: For further information on this topic, see TR 102 070-2 (see bibliography).

5.5.2 Testing of combinations

5.5.2.1 Alternative A: General approach for combinations

Combined equipment or a combination of a plug-in radio device and a specific type of host equipment may be used for testing according to the full requirements of the present document.

5.5.2.2 Alternative B: For host equipment with a plug-in radio device

A combination of a plug-in radio device and a specific type of host equipment may be used for testing according to the full requirements of the present document.

For radiated emission tests the most appropriate harmonized EMC standard shall be applied to the host equipment. The plug-in radio device shall meet the radiated emissions requirements as described in clause 4.1.5.

5.5.2.3 Alternative C: For combined equipment with a plug-in radio device

Combined equipment may be used for testing according to the full requirements of the present document.

For radiated emissions the requirements of the most appropriate harmonized EMC standard shall be applied to the non-radio equipment. The plug-in radio device shall meet the radiated emissions requirements as described in clause 4.1.5. In the case where the plug-in radio device is totally integrated and cannot operate independently, radiated emissions for the combination shall be tested using the most appropriate harmonized standard with the radio part in receive and/or standby mode. If the frequency range is less than the one defined in the present document, additional measurements shall be performed to cover the remaining parts of the frequency range. With the radio in transmit mode, the radiated emissions requirements of the present document shall be applied.

5.6 Interpretation of the measurement results

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

1) the measured value related to the corresponding limit shall be used to decide whether an equipment meets the requirements of the present document;

2) the measurement uncertainty value for the measurement of each parameter shall be recorded;

3) the recorded value of the measurement uncertainty shall be wherever possible, for each measurement, equal to or lower than the figures in table 9, and the interpretation procedure specified in clause 5.6.1 shall be used.

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

Table 9 is based on such expansion factors.

Table 9: Maximum measurement uncertainty

Parameter	Uncertainty
Radio Frequency	$\pm 1 \times 10^{-5}$
All emissions, radiated	± 6 dB (see note)
All emissions, conducted	± 4 dB
Temperature	± 1 °C
Humidity	± 5 %
DC and low frequency voltages	± 3 %
NOTE: For radiated emissions measurements below 2,7 GHz and above 10,6 GHz it may not be possible to reduce measurement uncertainty to the levels specified in table 9 (due to the very low signal level limits and the consequent requirement for high levels of amplification across wide bandwidths). In these cases alone it is acceptable to employ the alternative interpretation procedure specified in clause 5.6.2.	

5.6.1 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:

a) When the measured value does not exceed the limit value the equipment under test meets the requirements of the present document.

b) When the measured value exceeds the limit value the equipment under test does not meet the requirements of the present document.

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

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

5.6.2 Measurement uncertainty is greater than maximum acceptable uncertainty

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

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

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

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

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

5.7 Other emissions from device circuitry

UWB transmitters emit very low power radio signals, comparable with the power of spurious emissions from digital and analogue circuitry. If it can be clearly demonstrated that an emission from the ultra-wideband device is not the ultra-wideband emission identified in clause 4.1.1 (e.g. by disabling the device's UWB transmitter), that emission shall be considered against the receiver spurious emissions limits (see clause 4.1.5.3).

5.8 Test procedures for essential radio test suites

5.8.1 General

This clause describes methods of measurement for the following transmitter and receiver parameters:

- the maximum mean power spectral density (e.i.r.p.);
- the maximum peak power (e.i.r.p.);
- the operating bandwidth(s); and
- the receiver spurious emissions.

The following methods of measurement shall apply to the testing of stand-alone units and to the equipment configurations identified in clause 5.5.

5.8.2 Maximum mean power spectral density

See clause 5.3 for the test conditions.

The maximum mean power spectral density shall be determined and recorded.

The following shall be applied to the combination(s) of the radio device and its intended antenna(e). In the case that the RF power level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.

When measurements are made using conducted methods, the characteristic of the radiating antenna shall be applied to give the value of e.i.r.p.

Radiated measurements shall be made using one of the techniques presented in clause B.4.

Measurements shall be carried out over the frequency ranges as shown in clause 4.1.2.3, tables 2 and 3.

When measuring maximum mean power spectral density from the device under test, the spectrum analyser or equivalent shall be configured as follows unless otherwise stated:

- Resolution bandwidth: 1 MHz.

NOTE 1: To the extent practicable, the device under test is measured using a spectrum analyser configured using the setting described above. However, in order to obtain an adequate signal-to-noise ratio in the measurement system, radiated measurements may have to be made using narrower resolution bandwidths where it is practical. In these cases, the revised measurement configuration should be stated in the test report, together with calculations which permit the measurements taken to be compared with the appropriate limits and an explanation of why the signal levels involved necessitated measurement using the resolution bandwidth employed in order to be accurately determined by the measurement equipment.

- Video bandwidth: Not less than the resolution bandwidth.
- Detector mode: RMS.

NOTE 2: RMS average measurements can be accomplished directly using a spectrum analyser which incorporates an RMS detector. Alternatively, a true RMS level can be measured using a spectrum analyser that does not incorporate an RMS detector (see ITU-R Recommendation SM.1754 for details).

- Average time (per point on spectrum analyser scan): 1 ms or less.
- Frequency Span: Equal to or less than the number of displayed samples multiplied by the resolution bandwidth. The measurement results shall be determined and recorded over the frequency ranges as shown in clause 4.1 (tables 2 and 3).

The measurements shall be repeated at the frequency band edges at 1,6 GHz, 2,7 GHz, 3,4 GHz, 3,8 GHz, 4,2 GHz, 4,8 GHz, 6,0 GHz and 8,5 GHz and 10,6 GHz. The measurements at the frequency band edges shall be performed at the frequency offsets as shown in table 10.

Table 10: Frequency offsets for band edge measurements

Band edge frequency (GHz)	Frequency with frequency offset applied
1,6	1,6 GHz - 20 MHz
2,7	2,7 GHz - 20 MHz
3,4	3,4 GHz - 20 MHz
3,8	3,8 GHz - 20 MHz
4,2	4,2 GHz - 20 MHz
4,8	4,8 GHz + 20 MHz
6	6 GHz - 20 MHz
8,5	8,5 GHz + 20 MHz
10,6	10,6 GHz + 20 MHz

This frequency offset that is shown in table 10 is necessary since measurements at the exact frequency edges with a spectrum analyser may integrate energy from both sides of the respective band edge frequency. This is caused by the filter bandwidth of the test equipment.

The measurements shall be repeated for devices with TPC implemented within the UWB device configured at the lowest power spectral density level.

5.8.3 Maximum peak power

See clause 5.3 for the test conditions.

For all UWB modulations the maximum peak power (e.i.r.p.) shall be measured at the frequency of the maximum mean power spectral density as recorded under clause 5.8.2.

When measurements are made using conducted methods, the characteristic of the radiating antenna shall be applied to give the value of e.i.r.p.

Radiated measurements shall be made using one of the techniques presented in clause B.4.

When measuring maximum peak power from the device under test, the spectrum analyser used should be configured as follows:

- Frequency: The measurement shall be centred on the frequency at which the maximum mean power spectral density occurs.
- Resolution bandwidth: Equal to or greater than 3 MHz but not greater than 50 MHz for impulsive technology or equal or greater than 10 MHz but not greater than 50 MHz for rf carrier based technology.

NOTE 1: For peak power measurements, the best signal to noise ratio is usually obtained with the widest available resolution bandwidth.

- Video bandwidth: Not less than the resolution bandwidth.
- Detector mode: Peak.

- Display mode: Max. Hold.
- Measurements shall be continued with the transmitter emitting the normal test signal (see clause 5.2) until the displayed trace no longer changes.

NOTE 2: To the extent practicable, the device under test is measured using a spectrum analyser configured using the settings described above. However, in order to obtain an adequate signal-to-noise ratio in the measurement system, radiated measurements may have to be made using narrower resolution bandwidths. In these cases, the revised measurement configuration should be stated in the test report, together with calculations which permit the measurements taken to be compared with the appropriate limits and an explanation of why the signal levels involved necessitated measurement using the resolution bandwidth employed in order to be accurately determined by the measurement equipment.

5.8.4 Operating bandwidth

Using the following measurement procedure the frequency range (see clause 4.1.2) of the equipment shall be measured and recorded.

During these measurements the test modulation as specified in clause 5.2 shall be used.

The measurement procedure shall be as follows:

- place the spectrum analyser in video averaging mode and max hold mode with a minimum of 50 sweeps selected and activate the transmitter with modulation applied;
- find lowest frequency below the operating bandwidth at which spectral power density decreases to the level given in clause 4.1.1. This frequency shall be recorded;
- find the highest frequency at which the spectral power density decreases to the level given in clause 4.1.1. This frequency shall be recorded;
- the difference between the lowest frequency and highest frequency measured is the frequency range which shall be recorded.

This measurement shall be repeated for each operating bandwidth as declared by the manufacturer.

The results obtained shall be compared to the limit in clause 4.1.1.3.

5.8.5 Receiver spurious emissions

See clause 5.3 for the test conditions.

The level of spurious emissions radiated by cabinet and antenna shall be measured.

The following method of measurement shall apply:

- Above 1 GHz a full anechoic test site as described in clause B.1.1 is preferred for measurement. The spurious emissions as defined in clause 4.1.5.1 shall be measured and recorded.
- Where an anechoic chamber is not available, the test site described in clause B.1.2 may be used with suitable anechoic material placed on the floor of the chamber.
- Below 1 GHz the method and site characteristics described in ITU-T Recommendation SM 329-10 [3] shall be used (see clause B.1.2). The spurious emissions as defined in clause 4.1.5.1 shall be measured and recorded.

The measurement procedure shall be as follows:

- With the equipment in the receive mode, the applicable spectrum shall be searched for emissions that exceed the limit values given in clause 4.1.5.3 or that come to within 6 dB below the limit values given in clause 4.1.5.3. Each occurrence shall be recorded.

Measurements shall be carried out over the frequency range from 30 MHz to 40 GHz.

The measurements shall be performed only under the following conditions:

- The equipment shall be tested in the standby/ receive mode among frequencies as defined in clauses 5.8.4.

Where these measurements are made with a spectrum analyser, the following settings shall be used for narrowband emissions:

- resolution BW: 100 kHz;
- video BW: 300 kHz;
- detector mode: positive peak;
- averaging: off;
- span: 100 MHz;
- amplitude: adjust for middle of the instrument's range;
- sweep time: 1 s.

For measuring emissions that exceed the level of 6 dB below the applicable limit, the resolution bandwidth shall be switched to 30 kHz and the span shall be adjusted accordingly. If the level does not change by more than 2 dB, it is a narrowband emission; the observed value shall be recorded. If the level changes by more than 2 dB, the emission is a wideband emission and its level shall be measured and recorded.

The results obtained shall be compared to the limits in clause 4.1.5.3 in order to prove compliance with the requirement.

5.8.6 Low Duty Cycle

The performance of the implementation shall be declared by the manufacturer. Sufficient information about the performed LDC tests shall be provided.

5.8.7 Transmitter timeout

The performance of the implementation shall be declared by the manufacturer. Sufficient information about the performed transmitter timeout tests shall be provided.

Annex A (normative): HS Requirements and conformance Test specifications Table (HS-RTT)

The HS Requirements and conformance Test specifications Table (HS-RTT) in table A.1 serves a number of purposes, as follows:

- it provides a statement of all the requirements in words and by cross reference to (a) specific clause(s) in the present document or to (a) specific clause(s) in a specific referenced document;
- it provides a statement of all the test procedures corresponding to those requirements by cross reference to (a) specific clause(s) in the present document or to (a) specific clause(s) in specific referenced document(s);
- it qualifies each requirement to be either:
  - Unconditional: meaning that the requirement applies in all circumstances; or
  - Conditional: meaning that the requirement is dependant on the manufacturer having chosen to support optional functionality defined within the schedule.
- in the case of Conditional requirements, it associates the requirement with the particular optional service or functionality;
- it qualifies each test procedure to be either:
  - Essential: meaning that it is included with the Essential Radio Test Suite and therefore the requirement shall be demonstrated to be met in accordance with the referenced procedures;
  - Other: meaning that the test procedure is illustrative but other means of demonstrating compliance with the requirement are permitted.

Table A.1: HS Requirements and conformance Test specifications Table (HS-RTT)

Harmonized Standard EN 302 065 The following technical requirements and test specifications are relevant to the presumption of conformity under Article 3.2 of the R&TTE Directive						
Essential Requirement			**Requirement Conditionality**		**Test specification**	
No	**Description**	**Reference: clause No**	**U/C**	**Condition**	**E/O**	**Reference: clause No**
1	Operating bandwidth	4.1.1	U	.	E	5.8.4
2	Maximum value of mean power spectral density	4.1.2	U		E	5.8.2
3	Maximum value of peak power	4.1.3	U		E	5.8.3
4	Transmit Power Control	4.1.4	C	Applies only to equipment having TPC implemented.	E	5.8.2
5	Receiver spurious emissions	4.1.5	U		E	5.8.5
6	Pulse Repetition Frequency (PRF)	4.1.6	C	Applies only to equipment having impulsive UWB modulation.	X	
7	Low Duty Cycle	4.1.7	C	Applies only to equipment with LDC implemented and operating in the frequency band 3,4 GHz to 4,8 GHz.	O	5.8.6
8	Transmitter timeout	4.1.8	C	Does not apply to network control and management information	O	5.8.7

Key to columns:

Essential Requirement:

No Table entry number.

Description A textual reference to the Essential Requirement.

Clause Number Identification of clause(s) defining the essential requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

U/C Indicates whether the requirement is to be *unconditionally* applicable (U) or is *conditional* upon the manufacturers claimed functionality of the equipment (C).

Condition Explains the conditions when the requirement shall or shall not be applicable for a technical requirement which is classified "conditional".

Test Specification:

E/O Indicates whether the test specification forms part of the *Essential Radio Test Suite* (E) or whether it is one of the *Other Test Suite* (O).

NOTE: All tests whether "E" or "O" are relevant to the requirements. Rows designated "E" collectively make up the Essential Radio Test Suite; those designated "O" make up the Other Test Suite; for those designated "X" there is no test specified corresponding to the requirement. The completion of all tests classified "E" as specified with satisfactory outcomes is a necessary condition for a presumption of conformity. Compliance with requirements associated with tests classified "O" or "X" is a necessary condition for presumption of conformity, although conformance with the requirement may be claimed by an equivalent test or by manufacturer's assertion supported by appropriate entries in the technical construction file.

Clause Number Identification of clause(s) defining the test specification in the present document unless another document is referenced explicitly Where no test is specified (that is, where the previous field is "X") this field remains blank.

Annex B (normative): Radiated measurements

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

This annex introduces the test site which may be used for radiated tests. The test site is generally referred to as a free field test site. 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 TS 102 321 [4].

B.1.1 Anechoic chamber

An anechoic chamber is the preferred test site to be used for radiated testing in accordance with the present document above 1 GHz. However, an anechoic chamber with ground plane as described in clause B.1.2 may be used above 1 GHz providing that suitable anechoic material is placed on the chamber floor to suppress any reflected signal.

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 B.1.

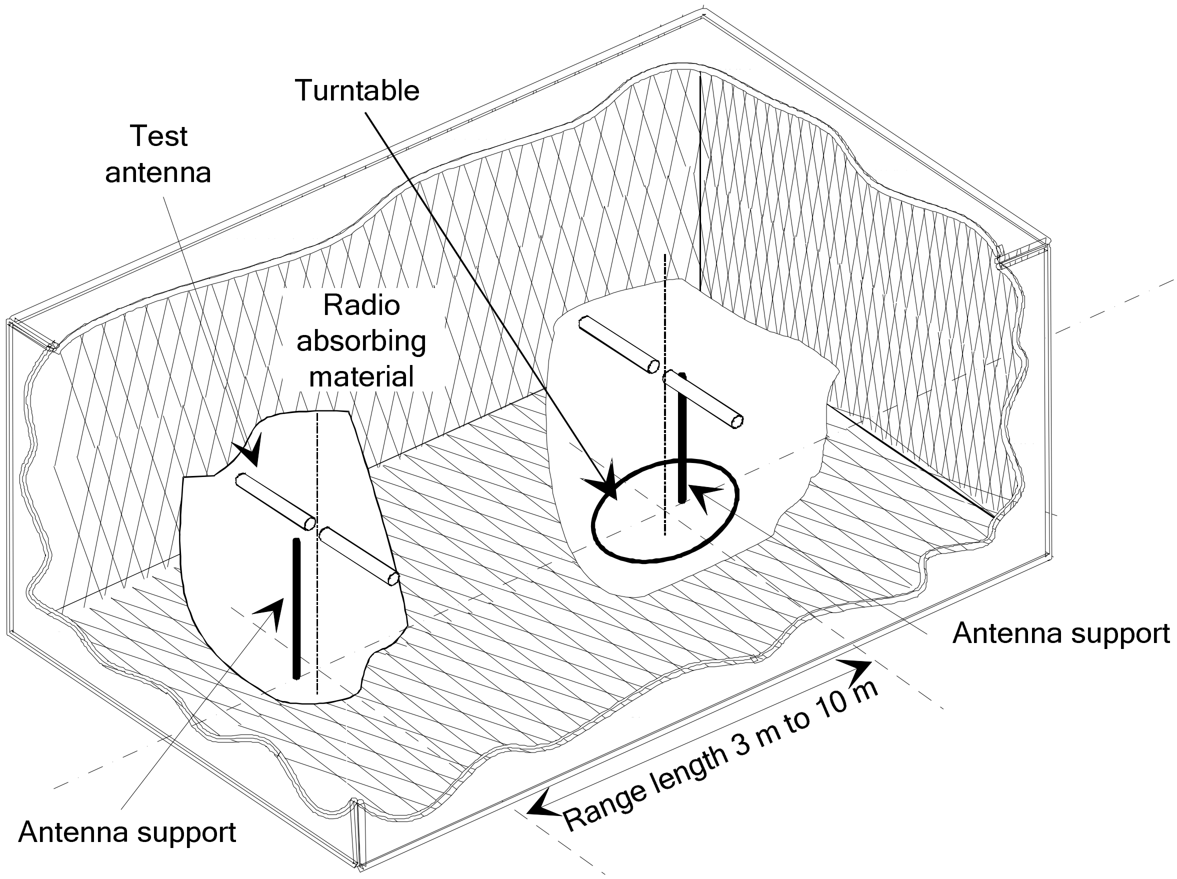

Figure B.1: A typical anechoic chamber

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 metre) above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 metre or $2(d_1 + d_2)^2/\lambda$ (m), whichever is greater (see clause B.2.5). However, it shall be noted that due to the low radiated power density for UWB equipment its transmit spectrum can be measured at approximately 1 metre to improve measurement sensitivity. 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 testing can be carried out within an anechoic chamber without limitation.

B.1.2 Anechoic chamber with a conductive ground plane

An anechoic chamber with a conductive ground plane shall be used for radiated testing in accordance with the present document below 1 GHz.

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 B.2.

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

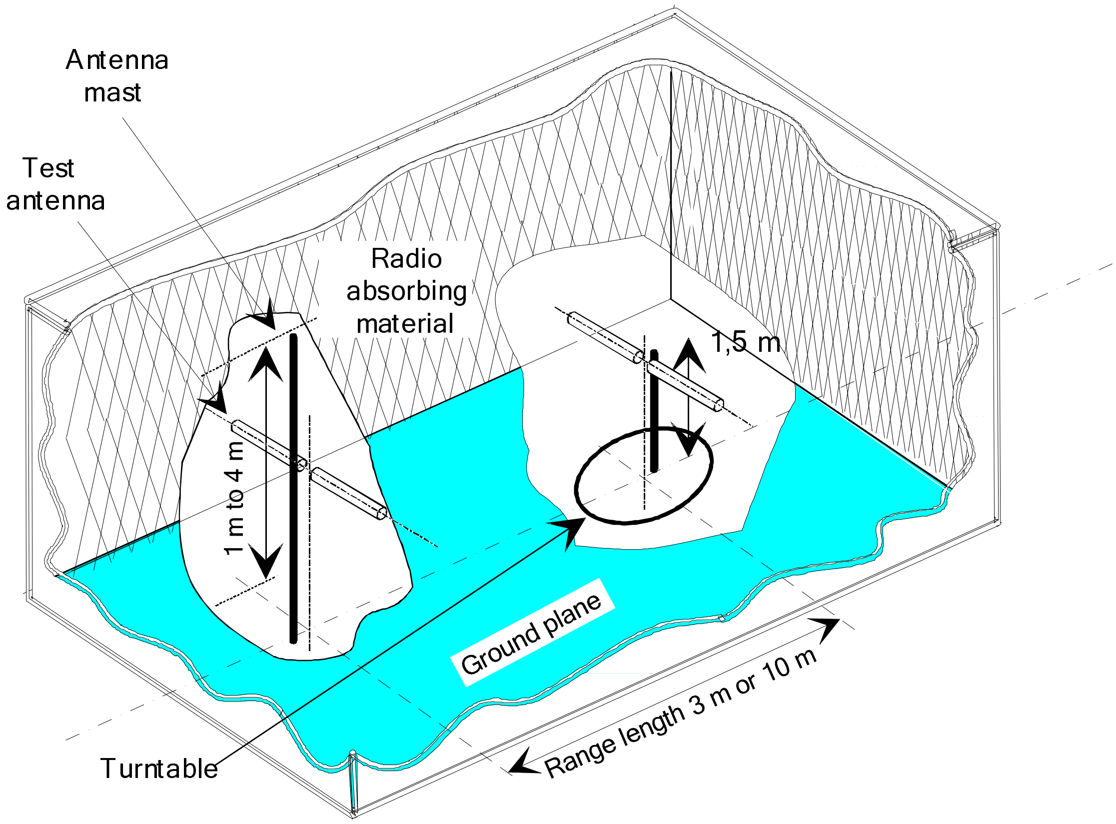

Figure B.2: A typical anechoic chamber with a conductive ground plane

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 metre above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 metre or $2(d_1 + d_2)^2 / \lambda$ (m), whichever is greater (see clause A.2.5). However, it shall be noted that due to the low radiated power density for UWB equipment its transmit spectrum can be measured at approximately 1 metre. 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.

B.1.3 Test antenna

A test antenna is always used in radiated test methods. In emission tests (i.e. effective radiated power, spurious emissions) 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 plane) should additionally allow the height of its centre above the ground to be varied over the specified range (usually 1 metre to 4 metres).

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [2]) 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 periodics") 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 periodics could be used.

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

B.1.4 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 [2]). 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.

B.1.5 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 [2]). 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.

B.2 Guidance on the use of a radiation test site

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated tests are undertaken.

B.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 and anechoic chamber with a ground plane) are given in the relevant parts of TR 102 273 or equivalent.

B.2.2 Preparation of the EUT

The manufacturer 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 minutes 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, balsawood, etc.

B.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 either the screen, ground plane or facility wall (as appropriate) by the shortest possible paths. Precautions should be taken to minimize pick-up on these leads (e.g. the leads could be twisted together, loaded with ferrite beads at 0,15 m spacing or otherwise loaded).

B.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 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 test reports 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/manufacturer. 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.

B.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 measurement uncertainty they exhibit should be known along with the distribution of the uncertainty.

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

B.3 Coupling of signals

B.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).

B.3.2 Data Signals

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

B.4 Standard test methods

Two methods of determining the radiated power of a device are described in clauses B.4.1 and B.4.2.

B.4.1 Calibrated setup

The measurement receiver, test antenna and all associated equipment (e.g. cables, filters, amplifiers, etc.) shall have been recently calibrated against known standards at all the frequencies on which measurements of the equipment are to be made. A suggested calibration method is given in clause B.5.

On a test site according to clause B.1, the equipment shall be placed at the specified height on a support, 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 spectrum analyser via whatever (fully characterized) equipment is required to render the signal measurable (e.g. amplifiers).

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

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

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

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

The maximum signal level detected by the spectrum analyser shall be noted and converted into the radiated power by application of the pre-determined calibration coefficients for the equipment configuration used.

B.4.2 Substitution method

On a test site, selected from clause B.1, the equipment shall be placed at the specified height on a support, as specified in clause B.1, 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 spectrum analyser.

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.

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

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

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

The maximum signal level detected by the spectrum analyser shall be noted.

The transmitter shall be replaced by a substitution antenna as defined in clause B.1.4.

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 spectrum analyser shall be adjusted in order to increase the sensitivity of the spectrum analyser.

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 clause B.1.1 is used, the height of the antenna shall not be varied.

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

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

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

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

B.5 Standard calibration method

The calibration of the test fixture establishes the relationship between the detected output from the test fixture, and the transmitted power (as sampled at the position of the antenna) from the EUT in the test fixture. This can be achieved (at higher frequencies) by using a calibrated horn with a gain of equal to or less than 20 dB, fed from an external signal source, in place of the EUT to determine the variations in detected power over frequency.

The calibration setup is shown in figure B.3.

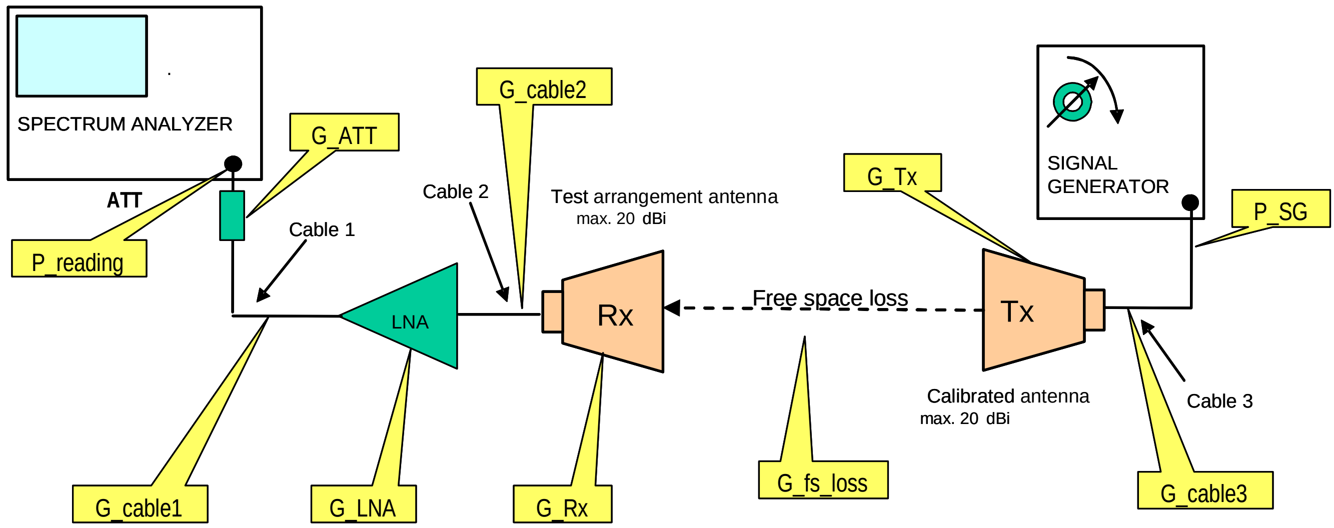

Figure B.3: Calibration set-up configuration

The calibration of the test fixture shall be carried out by either the provider or the accredited test laboratory. The results shall be approved by the accredited test laboratory.

It is the responsibility of the tester to obtain enough measurement accuracy. The following description is an example of a proven and accurate calibration method:

a) Calibrate all instruments using usual calibration routines.

b) Remove the EUT from the test fixture and replace the EUT by a calibrated antenna. Carefully orientate the calibration antenna in the test fixture towards the test arrangement antenna. The reference plane of the calibration antenna shall coincide with the EUT reference plane. The distance between the calibration antenna and the test arrangement antenna shall be between 0,5 m to 1 m.

c) Connect a signal generator to the calibrated antenna in the test fixture.

d) Connect a 10 dB attenuator to the test arrangement antenna to improve the VSWR. If SNR of the test arrangement is low it might be necessary to omit the attenuator.

e) Connect a power meter to the test arrangement antenna including a 10 dB attenuator, if required, and apply, by means of a signal generator, a frequency and power level to the same as the expected value from the EUT output to the calibration antenna in the test fixture.

f) Take into account the gain from both the calibration and the test arrangement antenna, the losses from the attenuator and all cables in use and the gain of a LNA, if required.

g) Note the absolute reading of the power meter.

h) Replace the power meter with a spectrum analyser. Adjust the frequency and power level of the signal generator to the same as the expected value from the EUT output. Apply this signal to the calibration antenna.

i) Take into account the gain from both the calibration and the test arrangement antenna, the losses from the attenuator and all cables in use and the gain of a LNA, if required. Instead of an external attenuator the built-in attenuator of the spectrum analyser may be used.

j) Set the spectrum analyser detector in RMS mode with a RBW and VBW at least as large as the signal generator output signal bandwidth with an appropriate spectrum analyser sweep rate. Note the absolute reading of the spectrum analysers input signal.

k) The noted absolute power reading of the power meter and the spectrum analyser shall not differ more than the specified uncertainty of the used measurement equipments.

l) Calculate the total attenuation from the EUT reference plane to the spectrum analyser as follows:

P_reading = the absolute power level noted from the power meter/spectrum analyser.

G_Tx = antenna gain of the calibrated antenna in the test fixture.

G_Rx = antenna gain of the test arrangement antenna.

G_ATT = the 10 dB attenuator loss (0 dB, if attenuator not used).

G_cable = the total loss of all cables used in the test setup.

G_LNA = the gain of the low noise amplifier (0 dB, if LNA not used).

G_fs_loss = the free space loss between the calibrated antenna (Tx) in the test fixture and the test arrangement antenna (Rx).

C_ATT = calculated attenuation of all losses with referenced to the EUT position.

P_abs = the absolute power of the EUT (e.i.r.p.).

C_ATT = G_fs_loss - G_Rx + G_cable2 - G_LNA + G_cable1 + G_ATT.

P_abs = P_reading - C_ATT.

The calibration should be carried out at a minimum of three frequencies within the operating frequency band.

Annex C (informative): Measurement antenna and preamplifier specifications

The radiated measurements set-up in annex B specifies the use of a horn antenna and a wide-band, high gain preamplifier above 1 GHz in order to measure the very low radiated power density level from UWB equipment.

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 (see note)
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	> 10 dBi (see note)
3 dB bandwidth	< 1 GHz - > 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
NOTE: The combination of preamplifier and horn antenna should give a overall equivalent gain of about 40 dB without overloading the spectrum analyser. The noise floor of the combined equipment should be at least 6 dB below the limits specified in the radiated tests given in the present document.	

Annex D (informative): Calculation of peak limit for 3 MHz measurement bandwidth

For impulsive modulation schemes the present document specifies a fixed maximum limit for average power in a 1 MHz bandwidth. The relationship between the PRF and the peak power to average power ratio is given in figure D.1.

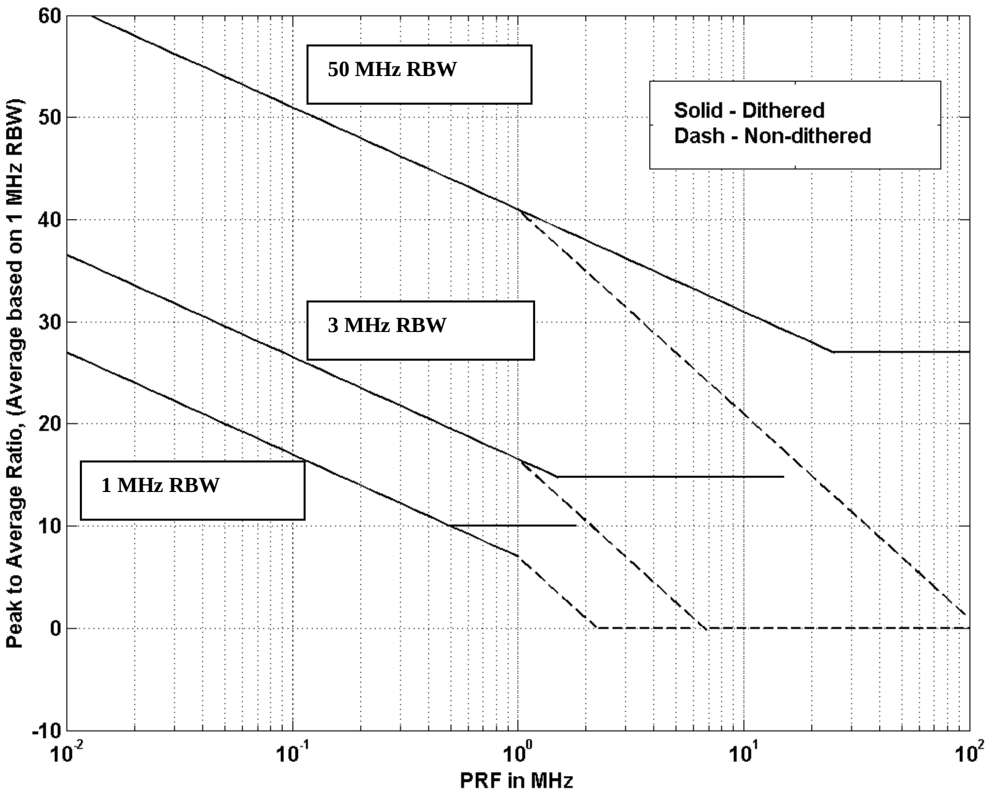

Figure D.1: Peak to average power versus PRF

For a noise like signal (e.g. dithered pulses) the roll-off rate is -10 dB/decade with a break point at half of the resolution bandwidth. Consequently, the breakpoints for 50 MHz, 3 MHz and 1 MHz resolution bandwidths are 25 MHz, 1,5 MHz and 0,5 MHz respectively.

As a peak measurement using a 50 MHz resolution bandwidth is difficult to impossible to conduct, the peak power is measured with a 3 MHz resolution bandwidth.

The curve for 3 MHz resolution bandwidth is 20 log(BW 50 MHz/BW 3 MHz) = 24,4 dB lower than for a 50 MHz resolution bandwidth. A peak limit of 0 dBm at 50 MHz will consequently be reduced correspondingly by 24,4 dB to -24,4 dBm.

As the dithered limit values are almost identical below and above 1 MHz PRF (within ±1 dB). For a 3 MHz measuring bandwidth the peak limit is adjusted to -25 dBm within the entire range for PRF.

The resulting Peak limit is shown in figure D.2.

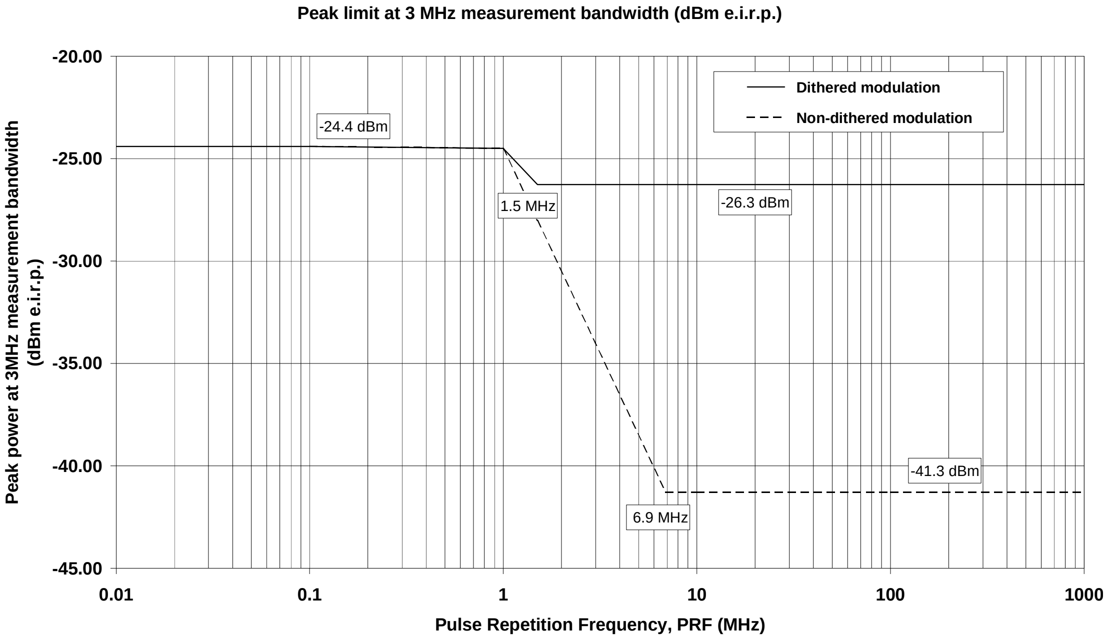

Figure D.2: Peak power limit in a 3 MHz bandwidth

Non-dithered modulation does not have the characteristics of a noise like spread spectrum but contains instead higher-level non-spread spectrum lines. To protect against these non-dithered spectrum lines the Peak limit is reduced further for PRF frequencies above 1 MHz by an additional -20 dB/decade roll-off until the peak to average ratio is zero. The resulting peak limit at 3 MHz is identical to the average limit in 1 MHz bandwidth for PRF above approximately 6,9 MHz.

Annex E (informative): Bibliography

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- ITU-R Recommendation SM.1754 (2006): "Measurement techniques of ultra-wideband transmissions".
- Ketterling, H-P: "Verification of the performance of fully and semi-anechoic chambers for radiation measurements and susceptibility/immunity testing", 1991, Leatherhead/Surrey.

Annex F (informative): The EN title in the official languages

Language	EN title
Bulgarian	
Czech	
Danish	
Dutch	
English	Electromagnetic compatibility and Radio spectrum Matters (ERM); Ultra WideBand (UWB) technologies for communication purposes; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive
Estonian	
Finnish	
French	
German	
Greek	
Hungarian	
Icelandic	
Italian	
Latvian	
Lithuanian	
Maltese	
Norwegian	
Polish	
Portuguese	
Romanian	
Slovak	
Slovenian	
Spanish	
Swedish	

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