ETSI EN 302 066 V2.1.1 (2017-01)

Short Range Devices (SRD);
Ground- and Wall- Probing Radar applications (GPR/WPR) imaging systems;
Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU

Reference
REN/ERM-TGUWB-138

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Contents

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Foreword

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

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.5] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

National transposition dates	
Date of adoption of this EN:	23 December 2016
Date of latest announcement of this EN (doa):	31 March 2017
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 September 2017
Date of withdrawal of any conflicting National Standard (dow):	30 September 2018

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document specifies the requirements for Ground- and Wall- Probing Radar imaging systems applications. Ground Probing Radars (GPR) and Wall Probing Radars (WPR) are used in survey and detection applications.

The scope is limited to GPR and WPR radars, in which the system is in close proximity to the materials being investigated. It does not include radars operated from aircraft or spacecraft.

The GPR/WPR applications in the present document are not intended for communications purposes, and the intended signal is not radiated into free space.

NOTE: Equipment covered by the present document is intended to be used by competent professional personnel.

The present document applies to:

1) Ground Probing Radars (GPR) operating in the frequency range 30 MHz to 12,4 GHz radiating directly downwards into the ground.

2) Wall Probing Radars (WPR) operating in the frequency range 30 MHz to 12,4 GHz radiating directly into a "wall". The "wall" is a building material structure, the side of a bridge, the wall of a mine or another physical structure that absorbs a significant part of the signal transmitted by the radar.

These equipment can either:

1) be fitted with integral antennas and without antenna connector; or

2) use different imaging heads (antennas) with an antenna connector, to allow operation at different operating bandwidths frequencies.

Equipment covered by the present document operates in accordance with ECC/DEC(06)08 "ECC Decision of 1 December 2006 on the conditions for use of the radio spectrum by Ground- and Wall- Probing Radar (GPR/WPR) imaging systems" [i.2].

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

Table 1: Permitted ranges of operation

Permitted range of operation	
Transmit	30 MHz to 12,4 GHz
Receive	30 MHz to 12,4 GHz
NOTE 1: Limits in table 2, clause 4.3.4 are to be met. NOTE 2: The frequency usage conditions for GPR/WPR are not fully harmonised in the EU and CEPT. Some National Regulatory Authorities (NRAs) may not have a general frequency allocation for GPR/WPT and may have established individual licensing requirements (e.g. registration of the user). Annex 2 of [i.2] gives some guidance to administrations.	

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

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

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 303 883 (V1.1.1) (09-2016): "Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques".

[2] ETSI TS 103 361 (V1.1.1) (03-2016): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Receiver technical requirements, parameters and measurement procedures to fulfil the requirements of the Directive 2014/53/EU".

[3] CISPR 16 (2014) (parts 1-1, 1-4 and 1-5): "Specification for radio disturbance and immunity measuring apparatus and methods; Part 1: Radio disturbance and immunity measuring apparatus".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Directive 2014/53/EU of the European Parliament and of the council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.2] ECC Decision of 1 December 2006 on the conditions for use of the radio spectrum by Ground- and Wall- Probing Radar (GPR/WPR) imaging systems, ECC/DEC/(06)08.

[i.3] ANSI C63.5-2004: "American National Standard for Electromagnetic Compatibility-Radiated Emission Measurements in Electromagnetic Interference (EMI) Control-Calibration of Antennas (9 kHz to 40 GHz)".

[i.4] ETSI TR 102 273 (V1.2.1) (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".

[i.5] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in ETSI EN 303 883 [1] and the following apply:

exterior limits: regulatory limits defined and measured around a specific setup or measurement scenario

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

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

user manual: end user documentation to be included with the device

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI EN 303 883 [1] and the following apply:

dB	deciBel
dBi	gain in decibels relative to an isotropic antenna
E	Electrical field strength
f_c	Frequency at which the emission is the peak power at maximum
λ	wavelength

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 303 883 [1] and the following apply:

CEPT	European Conference of Postal and Telecommunications Administrations
DT	DwellTime
DUT	Device Under Test
e.r.p.	effective radiated power
GPR	Ground Probing Radar, Ground Penetrating Radar
OATS	Open Area Test Site
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
RNSS	Radio Navigation Satellite Service
SA	Spectrum Analyser
ST	ScanTime
WPR	Wall Probing Radar

4 Technical requirements specifications

4.1 Environmental conditions

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the declared operational environmental profile. The normal test conditions are defined in clause 5.4.3 of ETSI EN 303 883 [1].

4.2 General

UWB devices in the scope of the present document can operate in a broad permitted range of frequencies from 30 MHz to 12,4 GHz, as defined in table 1.

In order to clearly identify the required limits and thus measurement procedures it is essential to define the operational bandwidth of the UWB equipment under test, The operating bandwidth of the UWB equipment under test shall be the -10 dBc bandwidth of the intended UWB signal under normal operational conditions as defined in clause 4.3.1.

A single UWB device can have more than one operational bandwidth. All UWB related emissions shall be measured in the identified operational bandwidth of the UWB device under test. The required mitigation techniques are only valid in the operational bandwidth.

The RX interference signal handling deals with the performance of the receiver and is focused on interference signals in the operational bandwidth and on some clearly identified frequencies outside the operational bandwidth(s), see clause 4.4.3.

4.3 Transmitter Conformance Requirements

4.3.1 Operating Bandwidth

4.3.1.1 Applicability

This requirement shall apply to all DUT.

4.3.1.2 Description

The operating bandwidth(s) of GPR/WPR is/are the -10 dBc bandwidth(s) of effective emissions radiated into the air by the equipment.

4.3.1.3 Limits

Any operating bandwidth of all the DUT shall lie within the permitted frequency range of operation of the device (see table 1) and shall be > 50 MHz.

4.3.1.4 Conformance

The conformance test suite for operating bandwidth shall be as defined in clause 6.5.3 of the present document.

Conformance shall be established under normal test conditions (see clause 4.1).

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.3.

4.3.2 Maximum value of mean power spectral density

Intentional emissions can't be tested due to the nature of the GPR/WPR applications and thus only unintentional emissions into the air will be tested (see clause 4.3.4 on exterior limit).

4.3.3 Maximum value of peak power

Intentional emissions cannot be tested due to the nature of the GPR/WPR applications and thus only unintentional emissions into the air will be tested (see clause 4.3.4 on exterior limit).

4.3.4 Exterior Limits

4.3.4.1 Applicability

This requirement shall apply to all DUT.

4.3.4.2 Description

The emissions into the air resulting from the operation of GPR/WPR imaging systems are defined as those emissions radiated in all directions above the ground from the GPR/WPR equipment, including direct emissions from the housing/structure of the equipment and emissions reflected or passing through the media under inspection; they are therefore dependent on the operational conditions and are meaningful only if the GPR/WPR are coupled with the material being investigated.

4.3.4.3 Limits

The effective radiated power of any emission from GPR/WPR shall not exceed the values given in table 2.

Table 2: Power limits of radiated emissions [i.2]

Frequency range (MHz)	Peak power limit values for emission
30 to 230	-44,5 dBm/120 kHz (e.r.p)
> 230 to 1 000	-37,5 dBm/120 kHz (e.r.p)
> 1 000 to 18 000	-30 dBm/MHz (e.i.r.p.)

The maximum mean e.i.r.p. spectral density shall not exceed the values in table F.1 ([i.2]) and shall be calculated as set out in annex F.

4.3.4.4 Conformance

The conformance test suite for Exterior Limit shall be as defined in clause 6.5.6.

The maximum mean e.i.r.p. spectral density which is based on the peak values measured according to clause 6.5.6 shall be calculated as set out in annex F and shall not exceed the values in table F.1 ([i.2]).

Conformance shall be established under normal test conditions (see clause 4.1).

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.3.

4.3.5 Total Power

This requirement does not apply to any DUT.

4.3.6 Other Emissions

This requirement does not apply to any DUT.

4.3.7 Transmitter unwanted emissions

This requirement does not apply to any DUT.

4.4 Receiver Conformance Requirements

4.4.1 General

Detailed description for related UWB receiver requirements, see ETSI TS 103 361 [2].

4.4.2 Receiver spurious emissions

Receiver spurious emissions are measured as part of the emissions resulting from the operation of GPR/WPR imaging systems, see clause 4.3.4.

4.4.3 Receiver interference handling

4.4.3.1 Applicability

This requirement shall apply to all DUT.

4.4.3.2 Description

Interferer signal handling, defined as the capability of the device to operate as intended in coexistence with interferers, is the receiver parameter for UWB applications.

Operation as intended is evaluated using a performance criterion. For common applications, recommended performance criteria and test cases are defined in clause 9.4 of ETSI TS 103 361 [2]. The performance criterion shall be stated in the user manual (see clause 9.2.2 of ETSI TS 103 361 [2]).

4.4.3.3 Limits

The level of performance of the chosen performance criterion shall meet the minimum requirement defined in the recommended test case, see ETSI TS 103 361 [2].

4.4.3.4 Conformance

The conformance tests for Interference Signal Handling shall be as defined in clause 6.6.2.

Conformance shall be established under normal test conditions see clause 4.1.

4.5 Requirements for spectrum access

4.5.1 Detect and Avoid (DAA)

This requirement does not apply to any DUT.

4.5.2 Listen-before-talk (LBT)

This requirement does not apply to any DUT.

4.5.3 Low Duty Cycle (LDC)

This requirement does not apply to any DUT.

4.6 Antenna Requirements

This requirement does not apply to any DUT.

4.7 Other Requirements and Mitigation techniques

4.7.1 Adaptive/Transmit Power Control (TPC)

This requirement does not apply to any DUT.

4.7.2 Activity factor

This requirement does not apply to any DUT.

4.7.3 Frequency Domain Mitigation

This requirement does not apply to any DUT.

4.7.4 Shielding effects

This requirement does not apply to any DUT.

4.7.5 Thermal Radiation

This requirement does not apply to any DUT.

4.7.6 Site registration

This requirement does not apply to any DUT.

4.7.7 Deactivation mechanism

GPR/WPR applications are not intended for communications purposes. Their intended usage excludes radiation into the free space and this should be avoided due to a proper mechanism that deactivates the equipment when normal use is interrupted.

The deactivation mechanism requirements are defined in annex D.

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

Tests defined in the present document shall be carried out at one or more representative point(s) within the boundary limits of the declared operational environmental profile.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the declared operational environmental profile) to give confidence of compliance for the affected technical requirements.

5.2 General conditions for testing

5.2.1 Product information

The requirements for the product information shall be as given in ETSI EN 303 883 [1], clause 5.2.

A application form for DUT testing is provided in annex B.

5.2.2 Requirements for the test modulation

This requirement does not apply to any DUT.

5.2.3 Test conditions, power supply and ambient temperatures

The test conditions, power supply and ambient temperatures shall be as given in ETSI EN 303 883 [1], clause 5.4.

5.2.4 Choice of equipment for test suites

The choice of the equipment for the test suites shall be as given in ETSI EN 303 883 [1], clause 5.5.

5.2.5 Multiple Operating bandwidths and multiband equipment

This requirement does not apply to any DUT.

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

Testing of host connected equipment and plug-in radio devices measurements shall be as given in ETSI EN 303 883 [1], clause 5.6.

5.3 Interpretation of the measurement results

5.3.0 General

Interpretation of the measurement results shall be as given in ETSI EN 303 883 [1], clause 5.7.

5.3.1 Measurement uncertainty is equal or less than maximum acceptable uncertainty

If measurement uncertainty is equal to or less than maximum acceptable uncertainty the interpretation shall be as given in ETSI EN 303 883 [1], clause 5.7.2.

5.3.2 Measurement uncertainty is greater than maximum acceptable uncertainty

If measurement uncertainty is greater than maximum acceptable uncertainty the interpretation shall be as given in ETSI EN 303 883 [1], clause 5.7.3.

5.3.3 Emissions

This clause does not apply any DUT.

6 Conformance test suites

6.1 Introduction

In this clause the general setup of a test bed for the test of UWB equipment will be described.

GPR/WPR shall be compliance-tested under conditions that are representative of normal operating conditions.

A detailed introduction shall be considered as in ETSI EN 303 883 [1], clause 6.1.

6.2 Initial Measurement steps

In initial measurement steps shall be done as described in ETSI EN 303 883 [1], clause 6.2.

6.3 Radiated measurements

6.3.1 General

Detailed descriptions of the radiated measurement arrangements are included in annex C.

Absolute power measurements shall be made using an appropriate method to ensure that the wave front is properly formed (i.e. operating in far field conditions). The test site shall meet the appropriate requirements as defined in published guidelines/standards.

It may not be possible to measure at the power limits without low-noise amplification to reduce the overall noise figure of the overall measurement system at a separation of approximately 3 meters in an RF quite environment. A lower separation distance may be required since the instrumentation noise floor should be at least 10 dB above the limit within the instrument bandwidth.

6.3.2 Test sites and general arrangements for measurements involving the use of radiated fields

Test sites and general arrangements for measurements shall be as described in clause C.1.

6.3.3 Guidance on the use of a radiation test site

6.3.3.1 General

Guidance is given clause C.2.

6.3.3.2 Range length

Range length shall be as in clause C.2.4.

6.3.4 Coupling of signals

This requirement does not apply to any DUT.

6.3.5 Standard test methods

6.3.5.1 Generic measurement method

6.3.5.1.1 Calibrated setup

The DUT shall be tested over a dry sand pit (i.e. emission of GPR/WPR is to be directed towards the sand pit) which is 50 cm deep and which is greater in area than the DUT, set into the ground with a thin plastic sheet or other suitable barrier to preserve sand condition.

During the measurement, the DUT shall be placed on the testbed of sand with its antenna pointing directly into the sand and the test antenna is placed three metres away from the boresight (vertical centre axis) of the DUT.

Measurements shall be taken at a sufficient number of radials and polarizations to ensure that the maximum emission is measured.

An alternative method for testing GPR/WPR devices is to place the DUT at a height of 80 cm on a non-conducting support with the emitter directed downwards. If the DUT emissions are expected to have components below 500 MHz, a layer of ferrite tile should be placed directly on the floor below the DUT. Pyramidal or wedge-shaped RF absorbers not less than 60 cm in height should be placed directly below the DUT. Some sections of absorber may be inverted and placed over other absorbers to form a solid block. Care shall be taken not to place any RF absorber between the device and the search antenna, as this would prevent energy not directed downwards from reflecting from the ground screen. The placement of the absorber shall not be disturbed when the device is rotated. This arrangement prevents energy directed downwards from consideration in the measurement. A search in azimuth and elevation for indirect emissions may now be performed.

6.3.5.1.2 Substitution method

This requirement does not apply to any DUT.

6.3.6 Standard calibration method

The provisions of ETSI EN 303 883 [1], clause 6.3.6 shall apply.

6.4 Conducted measurements

6.4.1 General Setup

This requirement does not apply to any DUT.

6.4.2 Specific Setup

This requirement does not apply to any DUT.

6.5 Conformance methods of measurement for transmitter

6.5.1 General

The DUT shall be measured for:

- the operating bandwidth(s);
- the exterior limits.

The following methods of measurement shall apply to the testing of stand-alone units and to the equipment configurations identified in clause 5.2.6.

6.5.2 Method of measurements of the Ultra Wideband Emissions from GPR/WPR

Where the transmitter is designed with adjustable carrier power, then all transmitter parameters shall be measured using the highest peak power level, as declared by the provider. When making transmitter tests on equipment designed for intermittent operation, the duty cycle of the transmitter, as declared by the provider, shall not be exceeded. The actual duty cycle used shall be recorded and stated in the test report.

NOTE: The maximum duty cycle of the transmitter under test should not be confused with the duty cycle of the equipment under normal operating conditions.

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

6.5.3 Operating Bandwidth(s)

The DUT shall be tested with the setup described in clause 6.3.5.1.1.

The dimensions of the DUT and the setup used shall be recorded in the test report.

In both measurements for the lower and upper frequency bound f_L and f_H, there shall be no point in the emission below f_L and above f_H where the level increases above the level recorded at f_L and f_H. This ensures that peaks and valleys occurring near f_C are not used prematurely as the upper and lower bounds of the emission.

The peak of the radiated emission shall be determined by a peak power measurement, that indicates the maximum of the emission, f_C.

The peak power of the emission shall be measured by:

- Set the spectrum analyser detector to positive peak.

- Centre the span on the peak of the emission and set the span to a value large enough to display the full emissions spectrum.
- Set the RBW to no less than 1 MHz and the VBW to no less than the RBW.
- A VBW of three times the RBW is preferred to eliminate video averaging.

The DUT shall be tested by directly coupling the normal operational transmitted signal, via a free-line-of-sight towards the measuring test antenna in a manner to ensure the test antenna receives a sufficient signal.

For the lower frequency bound f_L, the emission shall be searched from a frequency lower than the peak that has, by inspection, a much lower PSD than the peak PSD -10 dB and increasing in frequency towards the peak until the PSD indicates a level of 10 dB less than at the peak of the radiated emission.

The process shall be repeated for the upper frequency bound f_H, beginning at a frequency higher than the peak that has, by inspection, a much lower PSD than the peak PSD -10 dB.

The results for f_L, f_H, the operating bandwidth and f_C shall be reported in the test report.

6.5.4 Mean power spectral density measurements

This requirement does not apply to any DUT.

6.5.5 Peak power measurements

This requirement does not apply to any DUT.

6.5.6 Exterior limit measurement

The DUT shall be tested with the setup described in clause 6.3.5.1.1.

The dimensions of the DUT and the setup used shall be recorded in the test report.

It may be necessary for specific DUTs to perform this measurement by inserting a low noise amplifier in the measuring arrangement to ensure sufficient signal level.

In all measurements the normal operational signal shall be used.

For measurements below 1 GHz, a CISPR 16-1 [3] quasi peak detector shall be used. For measurements above 1 GHz, a peak detector shall be used.

Using a spectrum analyser the following settings shall be applied:

a) Set the RBW below 1 GHz to 120 kHz and above 1 GHz to 1 MHz and the VBW to be at least equal or greater than the RBW.

b) Record over the frequency range f_L to f_H (see clause 6.5.3) the maximum level P_m received by the test antenna in the direction of the maximum emission of the DUT.

c) Calculate and record the peak power according the following formula:

$$\text{Power}_{\text{peak}} = P_m - G_R + L_C + L_{Atten} - G_{Amp} + 20 \text{ Log } (4 \pi \frac{D}{\lambda}) \quad (1)$$

where

P_m = measured power

G_R = gain of the receive (measurement) antenna, in dBi

L_C = signal loss in the measurement cable, in dB

L_{Atten} = value of external attenuation (if used), in dB

G_{Amp} = value of external amplification (if used), in dB

D = measurement distance, in meters

λ = wavelength computed on the centre frequency of radiated DUT signal

d) The maximum observed values for the peak power and the maximum mean e.i.r.p. spectral density computed according to annex F, shall be recorded in the test report.

NOTE: Limits in clause 4.3.4.3 may be converted to a peak field strength level at 3 meters (see annex C). e.r.p. limits in clause 4.3.4.3 can be converted to e.i.r.p. limits using e.i.r.p. = e.r.p.+ 2,15 dB.

In order to obtain the required sensitivity a narrower bandwidth may be necessary, this shall be stated in the test report form.

The measurement shall be repeated in the frequency bands 1 164 MHz to 1 215 MHz and 1 559 MHz to 1 610 MHz measured in a 1 kHz resolution bandwidth. Using a spectrum analyser the following is applicable:

a) Search for the highest narrowband emission/spectral line and record the frequency.

b) Set the RBW to 1 kHz and the VBW to 3 kHz.

c) Set the centre frequency of the SA to the frequency recorded in a).

d) Measure and record the level of the emission recorded in step a).

The measuring receiver configuration shall use a low noise preamplifier and a dipole antenna (for frequencies below 1 GHz) or horn antenna (for frequencies above 1 GHz). Details are given in annex E. For the emission measurements, a combination of bicones and log periodic dipole array antennas (commonly termed "log periodics") could also be used to cover the entire 30 MHz to 1 000 MHz band.

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

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.

Proper pre-select filtering can be incorporated to protect the measurement system low-noise pre-amplifier from overload. In addition, persistent ambient signals can be detected 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.

6.5.7 Total Power

This requirement does not apply to any DUT.

6.5.8 Transmitter unwanted emissions

This requirement does not apply to any DUT.

6.6 Conformance methods of measurement for receiver

6.6.1 Receiver spurious emissions

Receiver spurious emissions are measured as part of the emissions by GPR/WPR, see clause 6.5.6.

6.6.2 Receiver interference handling

Interference signal handling measurements shall be as given in clause 9 of ETSI TS 103 361 [2].

The interferer test frequency range, interferers and interferer power levels, test scenario, performance criterion and level of performance shall be recorded in the test report.

6.7 Conformance test suits for spectrum access

6.7.1 Detect and Avoid (DAA)

This requirement does not apply to any DUT.

6.7.2 Listen Before Talk

This requirement does not apply to any DUT.

6.7.3 Low Duty Cycle

This requirement does not apply to any DUT.

6.8 Conformance test suites for antenna requirements

This requirement does not apply to any DUT.

6.9 Other test suites

6.9.1 Transmit Power control

This requirement does not apply to any DUT.

6.9.2 Activity factor

This requirement does not apply to any DUT.

6.9.3 Frequency domain mitigation

This requirement does not apply to any DUT.

6.9.4 Shielding Effects

This requirement does not apply to any DUT.

6.9.5 Thermal Radiations

This requirement does not apply to any DUT.

6.9.6 Installation requirements/site registration

This requirement does not apply to any DUT.

6.9.7 Deactivation mechanism

Verification of the deactivation mechanism according to the requirements defined in annex D shall be performed.

The result shall be recorded in the test report.

Annex A (normative): Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.5] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

Table A.1: Relationship between the present document and the essential requirements of Directive 2014/53/EU

Harmonised Standard ETSI EN 302 066 The following requirements are relevant to the presumption of conformity under the article 3.2 of Directive 2014/53/EU [i.1]				
Requirement			**Requirement Conditionality**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**
1	Operating bandwidth(s)	4.3.1	U	
2	Exterior limits	4.3.4	U	
3	Deactivation mechanism	4.7.7	U	
4	Receiver spurious emissions	4.4.2	U	
5	Receiver interference handling	4.4.3	U	

Key to columns:

Requirement:

No A unique identifier for one row of the table which may be used to identify a requirement.

Description A textual reference to the requirement.

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

Requirement Conditionality:

U/C Indicates whether the requirement shall be unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

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

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (informative): Application form for testing

B.1 Introduction

The form contained in this annex may be used by the manufacturer to comply with the requirement contained in clause 4 to provide the necessary information about the equipment to the test laboratory prior to the testing. It contains product information as well as other information which might be required to define which configurations are to be tested, which tests are to be performed as well the test conditions.

This application form should form an integral part of the test report.

B.2 General Information by ETSI EN 302 066, clause 5.2.1

B.2.1 Type of Equipment (stand-alone, combined, plug-in radio device, etc.)

☐ Stand-alone

☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

☐ Plug-in radio device (Equipment intended for a variety of host systems)

☐ Other.....

B.2.2 The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices

Details provided are for the:

☐ stand-alone equipment

☐ combined (or host) equipment

☐ test jig

Supply Voltage:

☐ AC mains State AC voltage …….. V

☐ DC State DC voltage …….. V

In case of DC, indicate the type of power source:

☐ Internal Power Supply

☐ External Power Supply or AC/DC adapter

☐ Battery

☐ Other: .....

B.3 Signal related Information by ETSI EN 302 066, clause 4.3

B.3.1 Introduction

In accordance with ETSI EN 302 066, clause 4.3, the following information is provided by the manufacturer.

B.3.2 Operational bandwidth(s) of the equipment

- Operational Bandwidth 1: ..... MHz to ..... MHz
- Operational Bandwidth 2: ..... MHz to ..... MHz

NOTE: Add more lines if more Frequency Ranges are supported.

B.3.3 The worst case mode for each of the following tests

NOTE: In this clause specify the Operational mode and not the measured value. E.g. test mode 1, etc.

- Operational bandwidth(s)

  .....

- Exterior Limits

  .....

B.4 RX test Information by ETSI EN 302 066, clause 4.4

B.4.1 Introduction

In accordance with ETSI EN 302 066, clause 4.4, the following information is provided by the manufacturer.

B.4.2 Performance criterion and level of performance

- performance criterion (e.g. accuracy, sensitivity)

  ……..

- level of performance (e.g. for accuracy ±10 %, level of sensitivity)

  …….

B.4.3 Interfering signals

Frequency [MHz]	Power [dBm]	Type of signal (e.g. CW, CW with DC, other modulation)

B.5 Additional information provided by the applicant

B.5.1 About the DUT

☐ The equipment submitted are representative production models.

☐ If not, the equipment submitted are pre-production models?

☐ If pre-production equipment are submitted, the final production equipment will be identical in all respects with the equipment tested.

☐ If not, supply full details:

.....

.....

B.5.2 Additional items and/or supporting equipment provided

☐ Spare batteries (e.g. for portable equipment)

☐ Battery charging device

☐ External Power Supply or AC/DC adapter

☐ Test Jig or interface box

☐ RF test fixture (for equipment with integrated antennas)

☐ Host System Manufacturer: .....

Model #: .....

Model name: .....

☐ Combined equipment Manufacturer: .....

Model #: .....

Model name: .....

☐ User Manual

☐ Technical documentation (Handbook and circuit diagrams)

Annex C (normative): Radiated measurements

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

C.1.0 General

Both, an Open Area Test Site (OATS) or indoor test site may be used for radiated tests.

The distance used in actual measurements shall be recorded with the test results.

Test sites shall be flat, with no artificial ground plane and clear of underground obstructions. The test bed shall be constructed such that the surface is flat with the surrounding test site. The DUT shall be deployed in the manner of intended use as described in the manufacturer's literature.

The method of measurement shall be in accordance with that described in CISPR 16-1 [3], as far as possible.

Near noise correction (radiometric) methods can also be used to perform accurate measurements at and below the noise floor of a spectrum analyser. The radiometer consists of a band pass filter, a low noise amplifier and a spectrum analyser. The DUT is set 3 metres away from the measuring test antenna and remotely operated from a measurement room.

To minimize coupling loss, the test antenna, filter and LNA shall be connected directly.

When the measurement equipment combines a spectrum analyser with an oscilloscope (i.e. the SA puts the IF signal as external output signal which is measured by the oscilloscope), the oscilloscope input bandwidth shall be over 500 MHz.

C.1.1 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 metre to 4 metres).

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [i.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 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.

C.1.2 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 [i.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.

C.2 Guidance on the use of radiation test sites

C.2.0 General

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 C.

C.2.1 Verification of the test site

Verification procedures, as far as applicable, for different types of test sites are given in the relevant part of ETSI TR 102 273 [i.4] or equivalent.

C.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.

C.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).

C.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:

$$\frac{2(d_1 + d_2)^2}{\lambda} \qquad \text{(C.1)}$$

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.

C.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.

C.2.6 Conversion of field strength to power limits

The limits in clause 4.3.4.3 are given as power limit. In order to do the conversion of a field strength level to a power level, the following equation shall be used:

$$E = \frac{\sqrt{30 \times e.r.p.}}{R} \qquad (C.2)$$

where R is the distance in metres between the equipment under test and the measurement point, e.r.p. is the effective radiated power in Watts of the equipment.

Annex D (normative): Deactivation mechanism

The deactivation mechanism of the equipment is a function which deactivates the equipment when normal use is interrupted.

The following requirements shall be fulfilled:

- Manually operated GPR and WPR, which is intended to be used as handheld equipment, shall contain a manually operated non-locking switch (e.g. it may be a sensor for the presence of the operators hand or a movement sensor) which ensures that the equipment de-activates (i.e. the transmitter switches off) within 10 seconds of being released by the operator.
- In the case of remotely/computer controlled imaging equipment, the equipment shall be de-activated via the control system provided that de-activation takes place within 10 seconds of the control system being switched off or released by the operator.
- GPR and WPR equipment shall be designed to operate while in contact with, or in close proximity, or within one meter of, to the ground or the wall, and their emissions being directed into the ground or wall (e.g. measured by a proximity sensor or imposed by the mechanical design). Manufacturers shall provide instruction manuals for the equipment which include a description for its use and deployment (positioning) during operation.
- There are particular cases where the equipment is mounted in a vehicle for the collection of data where the de-activation time required is 60 seconds.

Annex E (informative): Measurement antenna and preamplifier specifications

The radiated measurements set-up in clause 6.3 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 E.1 gives examples of recommended data and features for the horn antenna and preamplifier to be used for the test set-up.

Table E.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 E.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 F (normative): Calculation of the Mean Power Density

F.0 General

Maximum mean power densities and peak power densities of any emission emanating from GPR/WPR imaging systems are defined below. For pragmatic reasons and for taking the mitigation factors into account, the mean power density shall be determined by formula (F.1) or (F.2) and the peak values shall be measured according to clause 6.5.6.

NOTE: GPR/WPRs operate across a wide range of spectrum where established radio services operate. These services have diverse bandwidths, some may be susceptible to peak signal levels and others to average signal levels. There are technical and practical issues, related to bandwidth, the effective loading of the GPR/WPRs radiation by earth materials and the limitations of instrumentation. Peak signal levels are measured according to clause 6.5.6 and average signal levels calculated based upon the duty cycle of the GPR/WPR.

a) The mean power density of any emission emanating from GPR/WPR imaging systems shall be kept to a minimum and not exceed the limits in table F.1.

Table F.1: Maximum mean e.i.r.p. of any emission emanating from GPR/WPR imaging systems [i.2]

Frequency range (MHz)	Maximum mean e.i.r.p. density (dBm/MHz)
< 230	-65
230 to 1 000	-60
1 000 to 1 600	-65 (see note)
1 600 to 3 400	-51,3
3 400 to 5 000	-41,3
5 000 to 6 000	-51,3
> 6 000	-65
NOTE: In addition to the maximum mean e.i.r.p. density given above, a maximum mean e.i.r.p density of -75 dBm/kHz applies in the RNSS bands 1 164 MHz to 1 215 MHz and 1 559 MHz to 1 610 MHz in case of spectral lines in these bands. Peak power shall be measured according to clause 6.5.6 of the present document and mean power density shall be determined from formula (F.1) or (F.2) set out below.	

b) The measured radiated peak power of any emission emanating from GPR/WPR imaging systems shall not exceed the limits as given in clause 4.3.4.3 (table 2), measured according to clause 6.5.6.

c) The time domain architecture of GPR/WPRs and patterns of use imply that there is wide variation in the total power emitted in any time period. For pulsed systems this includes the duration of pulses compared to the time between pulses, the time between bursts of pulses when the system is being moved to the next measurement position and other operational factors. This should be taken into account when considering the mean power that may be incident upon a vulnerable radio service. In order to accommodate all these factors a conversion factor shall be used to evaluate the mean power that should be compared to the limits in table F.1. This conversion factor has been established as a simple and practical way to assess mean power levels based on the measurement of peak power levels.

When determining mean power values, for pulsed systems, to be compared with the values in table F.1 the following formula shall be used:

$$Power_{mean} = Power_{peak} + conversion\_factor \quad (F.1)$$

with:

$$conversion\ factor = 10 \log(PRF \times \tau)$$

where:

τ is the pulse width of the GPR/WPR transmitter measured at the 50 % amplitude points of the envelope at boresight with an UWB probe and a suitable oscilloscope. When performing this measurement, care should be taken that the pulse is properly gated, i.e. no reflectors should be allowed to influence the pulse while travelling from the GPR/WPR transmitter to the UWB probe. The UWB probe/antenna shall have a bandwidth wide enough to capture the UWB signal from the GPR/WPR properly.

PRF is the pulse repetition frequency.

For systems using step-frequency waveforms, the wideband signal is formed by transmitting a sequence of discrete frequencies each having a DwellTime (DT). The length of the total sequence is referred to as the ScanTime (ST). The Scan Time is identical to the Cycle Time in frequency hopping systems, and it is the interval between each time the transmitter is hopping back to the first frequency in the sequence.

For calculating the mean power value for a step-frequency system, the following formula shall be used:

$$Power_{mean} = Power_{peak} + conversion\_factor \quad (F.2)$$

with:

$$conversion\_factor = 10 \log(DT/ST)$$

where:

DT is measured at the 50 % amplitude points of the envelope at boresight with an UWB probe and a spectrum analyser in zero-span mode at a frequency near the maximum of the radiated spectrum using 1 MHz resolution bandwidth. ST is measured in the same way using a spectrum analyser in zero-span mode and 1 MHz resolution bandwidth.

F.1 Measurement of τ, transmit pulse width

There are two ways of measuring τ, time domain and frequency domain methods.

1) Time domain

The GPR antenna is lifted off the ground and pointed directly towards the measurement antenna, see figure F.1. The distance between the DUT and receive antenna shall be greater than one wavelength (at the lowest frequency radiated). Care shall be taken so that there are no unwanted multipath reflections included in the time interval where the pulse width measurement is carried out. The non-dispersive antenna/UWB-probe shall have a fractional bandwidth wide enough to represent the UWB, signal (GPR/WPR typically have a fractional bandwidth greater than 100 %).

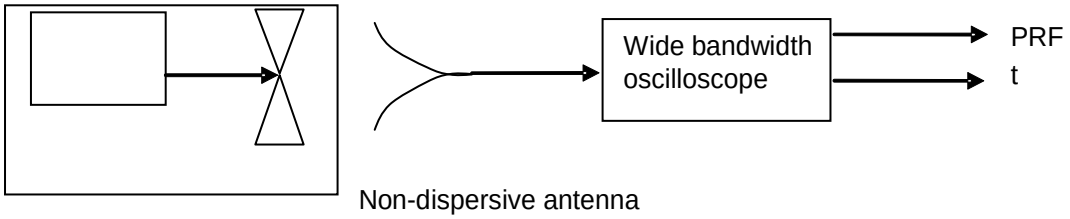

Figure F.1: Test setup 1

2) Frequency domain

The RF bandwidth of a single pulse modulated carrier is approximately $=1/_{\tau}$. By measuring the occupied bandwidth an equivalent pulse width is calculated. There is no need to have a non-dispersive antenna or oscilloscope any more, the measurement is done with the same antenna and spectrum analyser as for the peak power measurement as per clause 6.5.3, but with the GPR and measurement antenna facing each other, see figure F.2.

To avoid multipath reflections distorting the measurement, this test shall be carried out in an open test area or in an anechoic room.

$$T = 1/(F_H - F_L), \text{ -10 dB measurement points (see clause 6.5.3).} \quad \text{(F.3)}$$

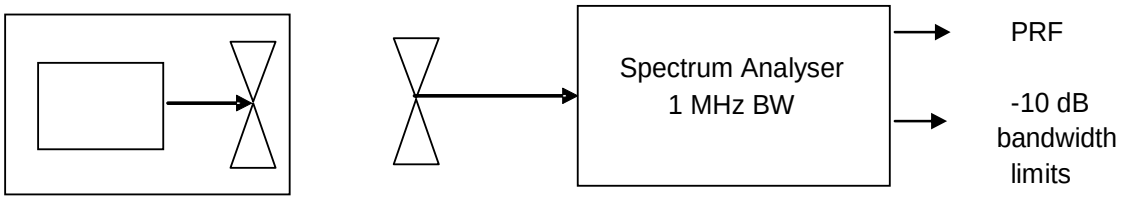

Figure F.2: Test setup 2

Annex G (informative): Bibliography

ETSI EN 301 489-33 (V2.1.1): "ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Harmonised Standard covering the essential requirements of article 3.1b of the Directive 2014/53/EU; Part 33: Specific conditions for Ultra Wide Band (UWB) devices".

EC Decision 2014/702/EU: Commission Decision of 7 October 2014 amending 2007/131/EC on allowing the use of the radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community.

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

Annex H (informative): Change History

Table to cover paragraph 2 of Article 5 of the Standardization request.

Date	Version	Information about changes
February 2008	1.2.1	Last publication as HS under RTT&E
October 2016	2.1.1	• Revision for compliance with Directive 2014/53/EU • Out-sourcing of standard measurement procedures into a separate ETSI EN 303 883 (V1.1.1) • New requirement on Interferer signal handling • New annex B "Application form for testing"

History

Document history				
V1.1.1	September 2005	Publication as ETSI EN 302 066 part 1 and part 2		
V1.2.1	February 2008	Publication as ETSI EN 302 066 part 1 and part 2		
V2.1.0	April 2016	EN Approval Procedure	AP 20160705:	2016-04-06 to 2016-07-05
V2.1.1	October 2016	Vote	V 20161223:	2016-10-24 to 2016-12-23
V2.1.1	January 2017	Publication		