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Short Range Devices (SRD) and Ultra Wide Band (UWB); Part 1: Measurement techniques for transmitter requirements

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Foreword

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

The present document is part 1 of a multi-part deliverable covering Short Range Devices (SRD) and Ultra Wide Band (UWB), as identified below:

Part 1: **"Measurement techniques for transmitter requirements";**

Part 2: "Measurement techniques for receiver requirements".

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Modal verbs terminology

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Introduction

Ultra Wide Band (UWB) radio technology enables a new generation of high-speed data devices for short-range communication purposes as well as location tracking and Sensor devices and opens new markets with a variety of innovative applications.

UWB devices may form an integral part of other portable electronic equipment such as future generation cellular phones or laptops equipped with UWB enabled short-range air interfaces.

In addition, UWB devices with an operating frequency range of several hundreds of MHz up to several GHz allow tens of centimetre-level accuracy real time localization and positioning even in the presence of severe multipath effects caused by walls, furniture or any other harsh radio propagation environments.

Based on the broad variety of different applications and the broad possible frequency range of operation the number of possible deployed physical signal formats can be very large. The existing range of physical signal and modulation formats range from traditional carrier based systems like OFDM over spread spectrum based system to carrier less systems based on base band pulses. The frequency regulation on the other side only defines a single set of transmission limits and values, which have to be fulfilled by all systems under the UWB regulation. Furthermore, the very high channel bandwidth of a UWB signal gives a specific challenge to the needed measurement setup and the procedures. Existing measurement methods need to be extended and new possible techniques should be described in the present document.

The present document is structured as follows:

- Clauses 1 through 3 provide a general description on the types of equipment covered by the present document and the definition of terms, symbols and abbreviations used.
- Clause 4 provides an overview on the technical and technology basics which were considered during the preparation of the present document.
- Clause 5 specifies EUT TX requirements and the related conformance procedure.
- Annex A provides information on test conditions, used test sites and procedures.
- Annex B provides necessary information on radiated test procedures.
- Annex C provides information on TX signal types.
- Annex D provides information on the all emission concept.
- Annex E provides information for a pre-scan radiated power measurement test procedure.
- Annex F provides information on differences between the different emission power measurements.
- Annex G provides a change history table containing the major technical changes.

1 Scope

The present document summarizes the available information of possible measurement techniques and procedures for the conformance measurement of various signal formats (e.g. Ultra Wide Band) in order to comply with the given transmission limits given in the current regulation.

The present document could be used as a reference for existing and future ETSI standards covering UWB and other technologies.

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 https://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 TS 102 754: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics of Detect And Avoid (DAA) mitigation techniques for SRD equipment using Ultra Wideband (UWB) technology".

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

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] ETSI TS 103 060: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Method for a harmonized definition of Duty Cycle Template (DCT) transmission as a passive mitigation technique used by short range devices and related conformance test methods".

[i.2] ITU Radio Regulations.

NOTE: Available at https://www.itu.int/pub/R-REG-RR/en.

[i.3] ECC/DEC/(06)04: "ECC Decision of 24 March 2006 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz, amended 9 December 2011 and amended 8 March 2019".

[i.4] ECC/DEC/(07)01: "ECC Decision of 30 March 2007 on the harmonised use, exemption from individual licensing and free circulation of Material Sensing Devices using Ultra-Wideband (UWB) technology, amended on 26 June 2009, corrected on 18 November 2016 and amended on 8 March 2019".

[i.5] 2019/785/EC: "Commission Implementing Decision (EU) 2019/785 of 14 May 2019 on the harmonisation of radio spectrum for equipment using ultra-wideband technology in the Union and repealing Decision 2007/131/EC (notified under document C(2019) 3461)".

[i.6] ECC/DEC/(11)02: "ECC Decision of 11 March 2011 on industrial Level Probing Radars (LPR) operating in frequency bands 6-8.5 GHz, 24.05-26.5 GHz, 57-64 GHz and 75-85 GHz", updated on 17 November 2017 and amended on 5 July 2019.

[i.7] ERC/REC 70-03: "ERC Recommendation of 1997 on relating to the use of Short Range Devices (SRD)".

NOTE: Available at https://efis.cept.org/sitecontent.jsp?sitecontent=srd_regulations.

[i.8] 2019/1345/EC: "Commission Implementing Decision (EU) 2019/1345 of 2 August 2019 amending Decision 2006/771/EC updating harmonised technical conditions in the area of radio spectrum use for short-range devices (notified under document C(2019) 5660)".

[i.9] ERC/REC 74-01: "ERC Recommendation of 1998 on unwanted Emissions in the Spurious Domain, latest amendment on 29 May 2019".

[i.10] Recommendation ITU-R SM.329-12 (09/2012): "Unwanted emissions in the spurious domain".

[i.11] 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", updated on 26 October 2018.

[i.12] ETSI EN 302 372: "Short Range Devices (SRD); Tank Level Probing Radar (TLPR) equipment operating in the frequency ranges 4,5 GHz to 7 GHz, 8,5 GHz to 10,6 GHz, 24,05 GHz to 27 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.13] ECC/DEC/(04)03: "ECC Decision of 19 March 2004 on the frequency band 77-81 GHz to be designated for the use of Automotive Short Range Radars".

[i.14] ETSI TR 103 181-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB);Transmission characteristics Part 2: UWB mitigation techniques".

[i.15] ETSI TR 103 181-1: "Short Range Devices (SRD) using Ultra Wide Band (UWB); Technical Report Part 1: UWB signal characteristics and overview CEPT/ECC and EC regulation".

[i.16] ECC Report 120 (07/2008): "Technical requirements for UWB DAA (Detect and Avoid) devices to ensure the protection of radiolocation services in the bands 3.1 - 3.4 GHz and 8.5 - 9 GHz and BWA terminals in the band 3.4 - 4.2 GHz".

[i.17] ETSI EG 203 367: "Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the Directive 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment".

[i.18] ETSI TR 100 028 (all parts) (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[i.19] Recommendation ITU-R SM.1754-0 (05/2006): "Measurement techniques of ultra-wideband transmissions".

[i.20] ANSI C63.5-2017/Cor 1-2019: "American National Standard for Electromagnetic Compatibility-Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration and Qualification of Antennas (9 kHz to 40 GHz) - Corrigendum 1".

[i.21] ETSI TR 102 273 (all parts) (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

[i.22] ETSI TR 102 215: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Recommended approach, and possible limits for measurement uncertainty for the measurement of radiated electromagnetic fields above 1 GHz".

[i.23] ECC Report 064: "The protection requirements of radiocommunications systems below 10.6 GHz from generic UWB applications".

[i.24] Recommendation ITU-R SM.1755-0 (05/2006): "Characteristics of ultra-wideband technology".

[i.25] ETSI TR 102 347: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Equipment for Detecting Movement; Radio equipment operating around e.g. 5,8 GHz, 10 GHz, 25 GHz, 61 GHz, 77 GHz; System Reference Document for Tank Level Probing Radar (TLPR)".

[i.26] ECC Report 139: "Impact of Level Probing Radars (LPR), using Ultra-Wideband Technology on Radiocommunications Services".

[i.27] Recommendation ITU-R SM.1541-6 (08/2015): "Unwanted emissions in the out-of-band domain; SM Series".

[i.28] ETSI EN 303 446-1: "ElectroMagnetic Compatibility (EMC) standard for combined and/or integrated radio and non-radio equipment; Part 1: Requirements for equipment intended to be used in residential, commercial and light industry locations".

[i.29] ETSI EN 303 446-2: "ElectroMagnetic Compatibility (EMC) standard for combined and/or integrated radio and non-radio equipment; Part 2: Requirements for equipment intended to be used in industrial locations".

[i.30] RBW influence on peak or mean power measurement of pulsed signals, Application Note 6.2019-1EF106-1E, 06.06.2019.

NOTE: Available at https://www.rohde-schwarz.com/pk/applications/rbw-influence-on-peak-or-mean-power-measurement-of-pulsed-signals-application-note_56280-648522.html.

[i.31] ETSI EN 302 729-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Level Probing Radar (LPR) equipment operating in the frequency ranges 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Part 1: Technical characteristics and test methods".

[i.32] 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 (RED).

[i.33] CISPR 16-1-6:2014: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-6: Radio disturbance and immunity measuring apparatus - EMC antenna calibration".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

All Emissions (AE): related UWB Emission of the transmitter (RP), Transmitter Unwanted Emissions (TXUE) and Other Emissions (OE) of the EUT

NOTE: See emission concept in clause 5.1.2.1.

antenna cycle: one complete sweep of a mechanically or electronically scanned antenna beam along a predefined spatial path

antenna scan duty factor: ratio of the solid angle of the antenna beam (measured at its 3 dB point) to the total solid angle scanned by the antenna

associated antenna: antenna and all its associated components which are designed as an indispensable part of the equipment

avoidance level: maximum amplitude to which the UWB transmit power is set for the relevant protection zone

burst: emitted signal whose time duration (T_{on}) is not related to its bandwidth

co-located receiver: receiver is located in the same device housing as the transmitter

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

default avoidance bandwidth: portion of the victim service bandwidth to be protected if no enhanced service bandwidth identification mechanisms are implemented in the DAA enabled devices

detect and avoid time: time duration between a change of the external RF environmental conditions and adaptation of the corresponding UWB operational parameters

Duty Cycle: the ratio, expressed as a percentage, of $\Sigma(T_{on})/(T_{obs})$ where T_{on} is the "on" time of a single transmitter device and T_{obs} is the observation period, see ETSI TS 103 060 [i.1]

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 isotopically 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)

NOTE: See ITU Radio Regulations [i.2], RR 1.161.

far field measurement: measurement at a distance from an antenna sufficient to ensure that the electro-magnetic field approximates a plane wave (see clause B.2.1)

frequency span: frequency range between the start and stop frequency of the RP measurement set-up

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

hopping cycle: number of hopping positions for a full frequency hopping sequence

host equipment: 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

indirect emissions: emissions radiated in all directions in a specified scenario (see clause 5.7, including direct emissions from the housing/structure of the equipment and emissions reflected or passing through a media under inspection or through a scenario)

NOTE: These emissions are sometimes also named an exterior limit or unwanted emissions.

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

main beam direction: direction of maximum gain of a directional antenna

NOTE: EUT may have different main beam direction for TX and RX antennas.

mean power: power during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation envelope

minimum avoidance bandwidth: portion of the victim service bandwidth requiring protection

minimum initial channel availability check time: minimum time the UWB radio device spends searching for victim signals after power on, Parameter: $T_{avail,\ Time}$

Non-Interference Mode operation (NIM): operational mode that allows the use of the radio spectrum on a non-interference basis without active mitigation techniques

operating frequency range: frequency range over which the EUT is intentionally transmitting

NOTE 1: The operating frequency range of the EUT is determined by the lowest (f_L) and highest frequency (f_H).

NOTE 2: For analogue or discrete frequency modulated systems (FSK, FMCW) the operating frequency range covers the difference between minimum and maximum of all carrier frequencies on which the equipment can be adjusted.

peak power: power measured with the peak detector using a filter the width and shape of which is sufficient to accept the signal bandwidth (see Recommendation ITU-R SM.1541-6 [i.27])

permitted frequency range(s): frequency range(s) within which the device is authorized to operate

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

Power Spectral Density (PSD): ratio of the amount of power within a specified bandwidth

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

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

Pulse Repetition Interval (PRI): time between the rising edges of the transmitted (pulsed) output power

Radar Cross Section (RCS): cross-sectional area of a perfectly reflecting sphere that would produce the same strength reflection as would the object in question

rf carrier: fixed radio frequency prior to modulation

scanning (steerable) antenna: directional antenna which can move its beam along a predefined spatial path

NOTE: Scanning can be realized by mechanical, electronical or combined means. The antenna beamwidth may stay constant or change with the steering angle, dependent on the steering method.

second (2^{nd}) harmonic: twice the frequency of the fundamental (e.g. 48 GHz for a 24 GHz device)

signal detection threshold set: set of amplitudes of the victim signal which defines the transition between adjacent protection zones

signal off time (T_{off}): one or more time periods within the signal repetition time, where no transmission occurs

signal repetition time: length of the time between subsequent transmission patterns of the system

NOTE: Also known as cycle time, frame repetition time or frame duration.

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

transmission: sequence of emissions separated by intervals shorter than T_{dis}, ETSI TS 103 060 [i.1]

transmitter timeout functionality: internal functionality that switches off the system in order to reduce power consumption or for regulatory reasons

victim signal: signal(s) of the service to be detected and protected by the DAA mitigation technique

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:

Ω	ohm
λ	wavelength
σ	standard deviation
Θ	elevation angle
Φ	azimuth angle
B_{wrel}	relation of the bandwidth
$C_{ATT\ total}$	attenuation from the EUT reference plane to the spectrum analyser
D	detection threshold
dB	decibel
dBc	decibel below the maximum
dBi	gain in decibels relative to an isotropic antenna
dBm	gain in decibels relative to one milliwatt
f	frequency
f_c	centre frequency for the filter
f_L	lowest frequency of the operating frequency range
f_H	highest frequency of the operating frequency range
f_C	centre frequency of the operating frequency range
f_M	frequency for peak power measurement
f[t]	filter coefficients at time *t*, centred on f_M
G	gain
G_{ATT}	attenuator loss
G_{LNA}	gain low noise amplifier
I	isolation in dB
P	power in dBm
P_{av}	mean e.i.r.p. power spectral density
$P_{peak,filtered}$	peak power in filter bandwidth
$P_{peak,max}$	maximum peak power in filter bandwidth
P_{pk}	peak e.i.r.p. spectral density power
R	distance
$T_{avail\_time\_min}$	minimum initial channel availability check time
T_{avoid}	detect and avoid time

NOTE: Actual Detect and Avoid time of a EUT, can be negative.

T_{avoid_max}	maximum allowed Detect and avoid time
T	time
t	discrete time variable
T_{dis}	time interval below which interruptions within a transmission are considered part of T_{on} (disregard time), ETSI TS 103 060 [**i**.1]
T_{obs}	reference interval of time (observation period, ETSI TS 103 060) [i.1]
T_{off}	time interval between two consecutive bursts when the UWB emission is kept idle

NOTE: T_{off} is defined as "the time duration between two consecutive transmissions", ETSI TS 103 060 [i.1].