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Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques

Reference

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Foreword

This draft European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

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
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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 bandwidth 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.

1 Scope

The present document summarizes the available information of possible measurement techniques and procedures for the conformance measurement of various UWB signal formats in order to comply with the given transmission limits given in the current regulation.

The present document will be used as a reference for existing and future ETSI standards covering UWB 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 http://docbox.etsi.org/Reference.

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

[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] 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".

[4] ETSI TS 102 754 (V1.2.1): "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".

2.2 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 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.2] ETSI EN 302 065-1: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU Part 1: Requirements for Generic UWB applications".

[i.3] Recommendation ITU-R SM.1754 (2006): "Measurement techniques of ultra-wideband transmissions".

[i.4] ETSI TR 102 070-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guide to the application of harmonized standards to multi-radio and combined radio and non-radio equipment; Part 2: Effective use of the radio frequency spectrum".

[i.5] EU Project WALTER (Project Number 216312): "Project Deliverable: WALTER report on limitations of test methods to include calibration and measurement uncertainties", July 2009.

[i.6] 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.7] Recommendation ITU-R SM 329-10 (2003): "Unwanted emissions in the spurious domain".

[i.8] ETSI EN 302 065-2: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU Part 2: Requirements for UWB location tracking".

[i.9] ETSI EN 302 065-3: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU Part 3: Requirements for UWB devices for ground based vehicular applications".

[i.10] ETSI EN 302 065-4: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU Part 4: Material Sensing devices using UWB technology below 10,6 GHz".

[i.11] ETSI EN 302 066: "Short Range Devices (SRD); Ground- and Wall- Probing Radar applications (GPR/WPR) imaging systems; Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.12] ETSI EN 302 372: "Short Range Devices (SRD); Equipment for Detection and Movement; Tank Level Probing Radar (TLPR) operating in the frequency bands 5,8 GHz, 10 GHz, 25 GHz, 61 GHz and 77 GHz; Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.13] ETSI EN 302 729: "Short Range Devices (SRD); Equipment for Detection and Movement; 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; Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.14] ETSI TR 103 365: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Time Domain based Peak Power Measurement Procedure".

[i.15] ETSI TR 103 366: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Time Domain based Low Duty Cycle Measurement Procedure".

[i.16] ETSI TR 103 181-2 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB); Transmission characteristics Part 2: UWB mitigation techniques".

[i.17] ECC/DEC/(06)04: "The harmonised conditions for device using Ultra-Wideband (UWB) technology in bands below 10.6 GHz", ECC Decision of 24 March 2006 amended 9 December 2011 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz.

[i.18] 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.19] ETSI EN 301 489-33: "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".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

burst: emitted signal whose time duration (Ton) is not related to its bandwidth

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

cycle time: length of time between subsequent transmissions of the same system at full load

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

detection probability: probability that the DAA enabled UWB radio device reacts appropriately to a signal detection threshold crossing within the detect and avoid time

duty cycle: percentage of the transmitter sum of all burst duration "on" relative to a given period

dwell time: duration of a transmission on a particular sub-channel

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

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

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

maximum avoidance power level: UWB transmit power assuring the equivalent protection of the victim service

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

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

signal detection threshold: amplitude of the victim signal which defines the transition between adjacent protection zones, Parameter: D_{thresh}

NOTE: The threshold level is defined to be the signal level at the receiver front end of the UWB DAA radio device and assuming a 0 dBi receive antenna.

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

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

sweep time: time to tune the LO across the selected span

transmission: sequence of emissions separated by intervals shorter than T_{dis} [i.18]

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

zone model: flexible DAA concept based on the definition of different zones as defined in ETSI TS 102 754 [4]

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
D	detection threshold
dB	decibel
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 bandwidth
f_H	highest frequency of the operating bandwidth
f_C	centre frequency of the operating bandwidth
f_M	frequency for peak power measurement
f[t]	filter coefficients at time t, centred on f_M
G	gain of the filter
I	isolation in dB
P	power in dBm
$P_{peak,filtered}$	peak power in filter bandwidth
$P_{peak,max}$	maximum peak power in filter bandwidth
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 DUT, 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)" [i.18]
T_{obs}	reference interval of time (observation period) [i.18]
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" [i.18].

T_{on}	duration of a burst irrespective of the number of pulses contained

NOTE: T_{on} is defined as "the duration of a transmission".

$V_{peak,filtered}$	peak voltage in filter bandwidth
Z_0	characteristic impedance

3.3 Abbreviations

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

AC	Alternating Current
ADC	Analogue-to-Digital
BW	BandWidth
BWA	Broadband Wireless Access
CON	Connector
DAA	Detect And Avoid
DC	Direct Current
DEC	DECision
DUT	Device Under Test
EC	European Commission
ECC	European Communication Committee
EIRP	Equivalent Isotropically Radiated Power also called e.i.r.p., eirp, E.I.R.P.
EMC	Electro Magnetic Compatibility
EN	European Norm
ERM	Electromagnetic compatibility and Radio spectrum Matters
ESA	Economy Spectrum Analyzer®
ESD	Electro Static Discharge
ETSI	European Telecommunications Standards Institute
EUT	Equipment Under Test
FC	Centre Frequency
FCC	Federal Commission for Communications
FH	Frequency Hopping
FH-UWB	Frequency Hopping-UWB
FMCW	Frequency Modulated Continuous Wave
HS	Harmonised Standard
IF	Intermediate Frequency
ITU	International Telecommunications Union
LDC	Low Duty Cycle
LNA	Low Noise Amplifier
LO	Local Oscillator
NIM	Non-Interference Mode operation
OBW	Operating BandWidth
OE	Other Emissions of the radiated emissions
OFDM	Orthogonal Frequency Division Multiple Access
PEP	Peak Envelope Power
PPM	Part Per Million
PRF	Pulse Repetition Frequency
PSA	Power Spectrum Analyser®
PSD	Power Spectral Density
RBW	Resolution BandWidth
REC	RECommendation
RF	Radio Frequency
RMS	Root Mean of Squares

RX	Receiver
SNR	Signal to Noise Ratio
TE	Total Emission
TPC	Transmit Power Control
TX	Transmitter
UE	User Equipment
UUT	Unit Under Test
UWB	Ultra Wide Band
VBW	Video BandWidth
VSWR	Voltage Standing Wave Ratio

4 Overview

4.1 Basic information

In this clause a short overview over the existing and known UWB signal formats will be given. Based on the presented signal format the main issues of the needed measurement techniques will be derived. A more detailed description of the presented signal formats can be found in the ETSI TR 103 181-1 [i.1].

The present document describes measurements for many different types of UWB technologies used for a variety of different applications. The UWB technologies used for these applications can be broken down into two main groups:

1) Impulse derived (carrier-less) technologies.

2) Frequency modulated/carrier-based.

In general combinations of these systems are possible.

4.2 Impulse derived (carrier-less)

Impulse derived UWB technology consists of a series of impulses. These impulses are created from a pulsed oscillator, or a dc voltage step whose rise time 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 or other techniques to convey information. The receiver either senses the individual pulses, or sums the energy from multiple pulses to reproduce the transmitted information.

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.

Simple short pulses whereby one can modify/modulate by:

- pulseform/pulseshape;
- pulse duration;
- pulse trains (i.e. number of pulses per burst);
- pulse amplitude;
- pulse position/spacing, time/pulse hopping, random pseudo-noise generation, dithering (intentional jitter);
- direct sequence (generates UWB when performed quickly, typically pre-programmed).

Or combinations of the above. In figure 1 some examples of pulse shapes in the time domain and the corresponding spectrum is depicted.

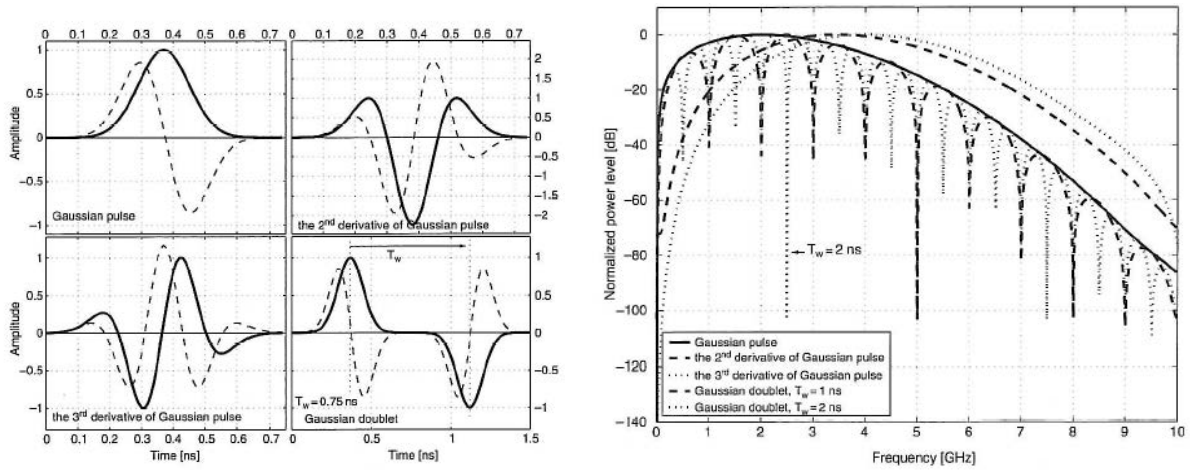

Figure 1: Example of Pulse shapes in time domain and the corresponding spectra

4.3 Frequency modulated/carrier-based

Under this category the following systems can be covered:

- phase shift keying;
- frequency hopping/stepping;
- FMCW, can also be intermittent, i.e. pulsed or gated;
- OFDM and similar (i.e. having multiple carriers/sub-carriers);
- random pseudo-noise generation, dithering or intentional pre-programmed direct sequencing can apply on all these carrier-based modulation schemes.

Or combinations of the above, including complex time- and frequency modulated combinations.

Due to the possible combinations, the above categories are not exhaustive.

5 General Consideration and test requirements

5.1 Overview

In this clause all general considerations for the testing of UWB devices will be given. These considerations and requirements are related to the presentation of the products to be tested (see clause 5.2); the used test modulation (see clause 5.3) and the general test conditions (see clause 5.4).

Details included in following clause:

- Product information (see clause 5.2).
- Test modulation (see clause 5.3).
- Specific Test setup (see clause 5.4).

An overview over the basic flow from a UWB application or device to the right certification measurement is given in figure 2. Based on the UWB application the manufacturer will chose a harmonised standard used for the certification of the devices. In this harmonised standard the regulatory requirements will be covered with a link to the relevant standardization document describing the used mitigation factor, the UWB signal format used and then the corresponding measurement setup for the given specific UWB application. The regulatory limits will be included in the relevant harmonised standard including the requirements for the additional mitigation techniques and factors.