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**Naprave kratkega dosega (SRD), ki uporabljajo ultra širok frekvenčni pas (UWB) - Merilne tehnike**

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

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# ETSI EN 303 883 V1.1.1 (2016-09)



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

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# Contents

|   |    |
|---|----|
| Intellectual Property Rights .....  | 6  |
| Foreword.....   | 6  |
| Modal verbs terminology.....  | 6  |
| Introduction .....  | 6  |
| 1 Scope .....   | 8  |
| 2 References .....  | 8  |
| 2.1 Normative references .....  | 8  |
| 2.2 Informative references.....   | 8  |
| 3 Definitions, symbols and abbreviations .....  | 10 |
| 3.1 Definitions .....   | 10 |
| 3.2 Symbols.....  | 11 |
| 3.3 Abbreviations .....   | 12 |
| 4 Overview .....  | 13 |
| 4.1 Basic information .....   | 13 |
| 4.2 Impulse derived (carrier-less).....   | 13 |
| 4.3 Frequency modulated/carrier-based .....   | 14 |
| 5 General Consideration and test requirements.....  | 15 |
| 5.1 Overview .....  | 15 |
| 5.2 Product information.....  | 16 |
| 5.3 Requirements for the test modulation.....   | 16 |
| 5.4 Test conditions, power supply and ambient temperatures .....                                      | 17 |
| 5.4.1 Test conditions.....  | 17 |
| 5.4.2 Power sources .....   | 17 |
| 5.4.2.1 Power sources for stand-alone equipment.....  | 17 |
| 5.4.2.2 Power sources for plug-in radio devices .....   | 17 |
| 5.4.3 Normal test conditions .....  | 17 |
| 5.4.3.1 Normal temperature and humidity .....   | 17 |
| 5.4.3.2 Normal power source .....   | 18 |
| 5.4.3.2.1 Mains voltage .....   | 18 |
| 5.4.3.2.2 Lead-acid battery power sources used on vehicles .....                                      | 18 |
| 5.4.3.2.3 Other power sources .....   | 18 |
| 5.5 Choice of equipment for test suites .....   | 18 |
| 5.5.1 Choice of model.....  | 18 |
| 5.5.2 Presentation.....   | 18 |
| 5.5.3 Multiple operating bandwidths .....   | 18 |
| 5.6 Testing of host connected equipment and plug-in radio devices.....                                | 18 |
| 5.6.1 General.....  | 18 |
| 5.6.2 The use of a host or test fixture for testing plug-In radio devices.....                        | 19 |
| 5.7 Interpretation of the measurement results .....   | 19 |
| 5.7.1 General points on interpretation of the measurement results .....                               | 19 |
| 5.7.2 Measurement uncertainty is equal to or less than maximum acceptable uncertainty.....            | 19 |
| 5.7.3 Measurement uncertainty is greater than maximum acceptable uncertainty.....                     | 20 |
| 5.8 Other emissions .....   | 20 |
| 6 Test setups and procedures.....   | 20 |
| 6.1 Introduction .....  | 20 |
| 6.2 Initial Measurement steps.....  | 20 |
| 6.3 Radiated measurements .....   | 21 |
| 6.3.1 General.....  | 21 |
| 6.3.2 Test sites and general arrangements for measurements involving the use of radiated fields ..... | 21 |
| 6.3.2.1 General .....   | 21 |
| 6.3.2.2 Anechoic chamber.....   | 21 |
| 6.3.2.3 Anechoic chamber with a conductive ground plane.....  | 22 |

|           |   |    |
|-----------|---|----|
| 6.3.2.4   | Test antenna .....  | 23 |
| 6.3.2.5   | Substitution antenna .....  | 24 |
| 6.3.2.6   | Measuring antenna .....   | 24 |
| 6.3.3     | Guidance on the use of a radiation test site.....   | 24 |
| 6.3.3.1   | General on guidance on the use of a radiation test site .....   | 24 |
| 6.3.3.2   | Verification of the test site .....   | 24 |
| 6.3.3.3   | Preparation of the EUT .....  | 24 |
| 6.3.3.4   | Power supplies to the EUT.....  | 25 |
| 6.3.3.5   | Range length .....  | 25 |
| 6.3.3.6   | Site preparation .....  | 25 |
| 6.3.4     | Coupling of signals .....   | 26 |
| 6.3.4.1   | General .....   | 26 |
| 6.3.4.2   | Data Signals .....  | 26 |
| 6.3.5     | Standard test methods .....   | 26 |
| 6.3.5.1   | General information on test methods .....   | 26 |
| 6.3.5.2   | Calibrated setup.....   | 26 |
| 6.3.5.3   | Substitution method .....   | 27 |
| 6.3.6     | Standard calibration method .....   | 27 |
| 6.4       | Conducted measurements.....   | 30 |
| 7         | Test procedures for essential radio test suites .....   | 30 |
| 7.1       | General .....   | 30 |
| 7.2       | Definitions .....   | 31 |
| 7.2.1     | Introduction.....   | 31 |
| 7.2.2     | Operating bandwidth.....  | 31 |
| 7.2.3     | Maximum mean power spectral density .....   | 31 |
| 7.2.4     | Maximum peak power .....  | 31 |
| 7.2.5     | Emissions.....  | 31 |
| 7.2.6     | Receiver spurious emissions.....  | 32 |
| 7.2.7     | Power control.....  | 32 |
| 7.2.8     | Detect and avoid .....  | 32 |
| 7.2.9     | Duty Cycle.....   | 32 |
| 7.3       | Method of measurements of the UE.....   | 33 |
| 7.3.1     | Introduction.....   | 33 |
| 7.3.2     | Emission Measurements steps .....   | 33 |
| 7.3.2.1   | First step.....   | 33 |
| 7.3.2.2   | Second step .....   | 33 |
| 7.4       | Detailed measurement procedure .....  | 34 |
| 7.4.1     | Introduction.....   | 34 |
| 7.4.2     | Operating bandwidth.....  | 34 |
| 7.4.3     | Mean power spectral density measurements.....   | 35 |
| 7.4.3.1   | General on mean power spectral density measurement.....   | 35 |
| 7.4.3.2   | Mean power spectral density measurement: Method 1 .....   | 36 |
| 7.4.3.3   | Mean power spectral density measurement: Method 2 .....   | 37 |
| 7.4.3.4   | Mean power spectral density measurement: Method 3 .....   | 38 |
| 7.4.4     | Peak power measurements.....  | 39 |
| 7.4.4.1   | General on peak power measurement .....   | 39 |
| 7.4.4.2   | Peak power measurement: Method 1 .....  | 40 |
| 7.4.4.3   | Peak power measurement: Method 2 .....  | 41 |
| 7.4.4.4   | Peak power measurement: Method 3 .....  | 42 |
| 7.4.4.4.1 | Description .....   | 42 |
| 7.4.4.4.2 | Signal acquisition .....  | 43 |
| 7.4.4.4.3 | Post-Processing.....  | 43 |
| 7.4.4.4.4 | Limit .....   | 44 |
| 7.4.5     | Receiver spurious emissions .....   | 44 |
| 7.4.6     | Power control.....  | 45 |
| 7.4.7     | Test procedures for detect and avoid mechanisms.....  | 45 |
| 7.4.7.1   | Introduction .....  | 45 |
| 7.4.7.2   | Initial start-up test .....   | 47 |
| 7.4.7.2.1 | Start-up procedure .....  | 47 |
| 7.4.7.2.2 | Test without a victim test signal during the <i>Minimum Initial Channel Availability Check</i><br><i>Time, T<sub>avail_time_min</sub></i> ..... | 47 |

|   |   |           |
|---|---|-----------|
| 7.4.7.2.3   | Test with a victim test signal at the beginning of the <i>Minimum Initial Channel Availability Check Time</i> , $T_{\text{avail\_time\_min}}$ ..... | 48        |
| 7.4.7.2.4   | Test with a victim test signal at the end of the <i>Minimum Initial Channel Availability Check Time</i> , $T_{\text{avail\_time\_min}}$ .....       | 50        |
| 7.4.7.3   | In-operation test .....   | 52        |
| 7.4.7.3.1   | General points for In-operation test .....  | 52        |
| 7.4.7.3.2   | In-operation test procedure .....   | 53        |
| 7.4.8   | Test procedures for Low Duty Cycle .....  | 54        |
| 7.4.8.1   | Test procedure for $T_{\text{on}}/T_{\text{off}}$ , Method 1 .....  | 54        |
| 7.4.8.2   | Test procedure for $T_{\text{on}}/T_{\text{off}}$ , Method 2 .....  | 56        |
| 7.4.8.2.1   | Description .....   | 56        |
| 7.4.8.2.2   | General test setup .....  | 56        |
| 7.4.8.2.3   | Time domain procedure for DC measurement .....  | 56        |
| 7.5   | Limits .....  | 58        |
| 7.6   | Maximum allowable measurement uncertainty .....   | 59        |
| <b>Annex A (normative): Frequency domain measurements using spectrum analyser .....</b> |   | <b>60</b> |
| A.1   | Spectrum analyser internal operation .....  | 60        |
| A.2   | UWB power measurement procedures .....  | 61        |
| A.2.1   | Introduction .....  | 61        |
| A.2.2   | Maximum mean power spectral density .....   | 61        |
| A.2.2.1   | General.....  | 61        |
| A.2.2.2   | Average mean power: Finding highest .....   | 62        |
| A.2.3   | Maximum peak power (e.i.r.p.) measurement procedure .....   | 63        |
| A.3   | Calculation of peak limit for 3 MHz measurement bandwidth .....   | 65        |
| A.4   | Detailed Information to standard test methods.....  | 66        |
| A.4.1   | Spherical scan with automatic test antenna placement .....  | 66        |
| A.4.1.1   | General.....  | 66        |
| A.4.1.2   | Calibrated setup .....  | 67        |
| A.4.1.3   | Substitution method .....   | 67        |
| A.4.1.4   | Spherical scan with rotating device .....   | 68        |
| A.4.1.4.1   | General .....   | 68        |
| A.4.1.4.2   | Calibrated setup.....   | 69        |
| A.4.1.4.3   | Substitution method .....   | 69        |
| A.4.1.5   | Spherical scan other methods.....   | 70        |
| <b>Annex B (informative): Measurement antenna and preamplifier specifications .....</b> |   | <b>71</b> |
| <b>Annex C (informative): Bibliography .....</b>  |   | <b>72</b> |
| History .....   |   | 75        |

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## Foreword

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

| National transposition dates   |                   |
|--|-------------------|
| Date of adoption of this EN:   | 12 September 2016 |
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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.

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# 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.

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## 2 References

### 2.1 Normative references

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- [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

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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 the 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 the 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 the 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 the 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 the essential requirements of article 3.2 of the Directive 2014/53/EU".
- [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] ETSI EN 302 729: "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; Harmonised Standard covering the 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 for UWB Devices".
- [i.15] ETSI TS 103 366: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Time Domain based Low Duty Cycle Measurement for UWB".
- [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; Part 33: Specific conditions for Ultra-WideBand (UWB) devices; Harmonised Standard covering the essential requirements of article 3.1(b) of the Directive 2014/53/EU".

## 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 ( $T_{on}$ ) 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:  $D_{\text{thresh}}$

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  $T_{\text{dis}}$ , ETSI TS 103 060 [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

SIST EN 303 883 V1.1.1:2016

<https://standards.iteh.ai/catalog/standards/sist/8507eba6-183a-45c1-9b43-9225261ca13e-01-303-883-v1-1-2016>

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

|                            |   |
|----------------------------|---|
| $\Omega$                   | ohm   |
| $\lambda$                  | wavelength  |
| $\sigma$                   | standard deviation  |
| $\Theta$                   | elevation angle   |
| $\Phi$                     | azimuth angle   |
| $C_{\text{ATT total}}$     | attenuation from the EUT reference plane to the spectrum analyser |
| $D$                        | 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  |
| $G_{\text{ATT}}$           | attenuator loss   |
| $G_{\text{LNA}}$           | gain low noise amplifier  |
| $I$                        | isolation in dB   |
| $P$                        | power in dBm  |
| $P_{\text{peak,filtered}}$ | peak power in filter bandwidth                                    |
| $P_{\text{peak,max}}$      | maximum peak power in filter bandwidth                            |

|                               |   |
|-------------------------------|---|
| R                             | distance  |
| $T_{\text{avail\_time\_min}}$ | minimum initial channel availability check time |
| $T_{\text{avoid}}$            | detect and avoid time                           |

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

|                         |   |
|-------------------------|---|
| $T_{\text{avoid\_max}}$ | maximum allowed Detect and avoid time   |
| $T$                     | time  |
| t                       | discrete time variable  |
| $T_{\text{dis}}$        | time interval below which interruptions within a transmission are considered part of $T_{\text{on}}$ (disregard time), ETSI TS 103 060 [i.18] |
| $T_{\text{obs}}$        | reference interval of time (observation period, ETSI TS 103 060 [i.18])   |
| $T_{\text{off}}$        | time interval between two consecutive bursts when the UWB emission is kept idle   |

NOTE:  $T_{\text{off}}$  is defined as "the time duration between two consecutive transmissions", ETSI TS 103 060 [i.18].

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

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

|                            |                                  |
|----------------------------|----------------------------------|
| $V_{\text{peak,filtered}}$ | 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 Converter           |
| 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 |

NOTE: 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 Analyser®                               |
| ESD    | Electro Static Discharge                                 |
| ETSI   | European Telecommunications Standards Institute          |
| EU     | European Union   |
| 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    |
| PEP  | Peak Envelope Power                       |
| PPM  | Part Per Million                          |
| PRF  | Pulse Repetition Frequency                |
| PSA  | Power Spectrum Analyser <sup>®</sup>      |
| 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   | UWB Emissions                             |
| UUT  | Unit Under Test                           |
| UWB  | Ultra Wide Band                           |
| VBW  | Video BandWidth                           |
| VSWR | Voltage Standing Wave Ratio               |

## 4 Overview STANDARD PREVIEW (standards.iteh.ai)

### 4.1 Basic information

SIST EN 303 883 V1.1.1:2016

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.