ETSI TS 103 085 V1.1.1 (2012-10)

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB) for Location and Tracking railroad applications; RF conformance testing

Reference
DTS/ERM-TGUWB-020

Keywords
DNS, enum, IMS

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://ipr.etsi.org).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Introduction

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

UWB devices with an operating bandwidth of several GHz allow tens of centimetre-level accuracy within real time localization and positioning applications even in the presence of severe multipath effects caused by harsh radio propagation environments.

The specified requirements covered in the present document describe UWB Location and Tracking applications which may use either ultra-short pulse base band modulation or FMCW and SFCW modulation.

The background and related applications to the railway environment have been described in TR 101 538 [i.1] where these applications are considered either indoor-like and outdoor systems, which may include ground-based terminals and infrastructures at fixed locations wayside.

The UWB regulations [i.4] and [i.5] define two different sets of transmission limits and values applicable, respectively, to the generic case of indoor/vehicular usage of UWB terminals and to the specific case of infrastructures intended for Location and Tracking (Type 2: LT2) outdoor/indoor applications, using mobile/vehicular and fixed terminals transmitting UWB signals.

Measurement methods and techniques are described in the present document and should be seen as feasible test methods to prove regulation compliance of UWB Location and Tracking systems in railway environment, according to the general provisions on UWB measurement techniques already defined in [5].

1 Scope

The present document specifies the requirements of measurement techniques and procedures for the RF conformance test of location and tracking systems for railroad application outdoor and indoor-like, using UWB technology operating in the 3,1 GHz to 8,5 GHz frequency range.

2 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 reference 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.

2.1 Normative references

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

[1] CISPR 16-1 (2003): "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus".

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

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

[4] ANSI C63.5 (2006): "American National Standard for Electromagnetic Compatibility - Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration of Antennas (9 kHz to 40 GHz)".

[5] ETSI TS 102 883: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques".

[6] 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

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 101 538: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); UWB location tracking devices in the railroad environment".

[i.2] ECC Report 167: "on practical implementation of registration/coordination mechanism for LT2 systems".

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

[i.4] Last amendment of ECC DEC (06)04: "The harmonised conditions for devices using UWB technology in bands below 10.6 GHz".

[i.5] ECC REC(11)09: "UWB LOCATION TRACKING Systems TYPE 2 (LT2)".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

activity factor: effective transmission time ratio, actual on-the-air time divided by active session time or actual on-the-air emission time within a given time window

distance: Euclidean distance between two objects, i.e. real distance

duty cycle: ratio of the total on time of the transmitter to the total time

emissions: signals that leaked or are scattered into the air within the frequency range (that includes harmonics) which depend on equipment's frequency band of operation

equivalent isotropically radiated power (e.i.r.p.): total power transmitted, assuming an isotropic radiator

EUT: UWB device with its antenna

fixed equipment: UWB location tracking device on a fixed position

Frequency Modulated Continuous Wave (FMCW): transmitter power is fairly constant but possibly zero during periods giving a big duty cycle (such as 0,1 to 1)

NOTE: The frequency is modulated in some way giving a very wideband spectrum with a power versus time variation which is clearly not pulsed.

mobile equipment: UWB location tracking device to be used while in motion or during halts at specified points

operating frequency (operating centre frequency): nominal frequency at which equipment is operated

pulsed transmitter: transmitter signal has a microwave power consisting of short RF pulses

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

radiation: signals emitted intentionally inside a tank for level measurements

range: measured distance between two objects, i.e. erroneous distance

range resolution: ability to resolve two targets at different range

Stepped Frequency Continuous Wave (SFCW): transmitter sequentially generates a number of frequencies with a step size

NOTE: At each moment of transmission, a monochromatic wave is emitted. It is distinguished from FMCW that has the instantaneous frequency band rather than a single frequency wave. The SFCW signal bandwidth is synthesized by signal processing to achieve required resolution bandwidth.

3.2 Symbols

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

c	velocity of light in a vacuum
cl1	cable loss 1
cl2	cable loss 2
dB	deciBel
dBi	gain in deciBel relative to an isotropic antenna
dBm	decibel relative to 1 mW
Δh	transmission interval

Δt	transmission on
D_{data}	data rate
δR	range resolution or multipath rejection resolution
E	electrical field strength
E_R	relative dielectric constant of earth materials
E_{rms}	average electrical field strength measured as root mean square
f	frequency
f_c	frequency at which the emission is the peak power at maximum
G	efficient antenna gain of radiating structure
G_{LNA}	gain of the measurement LNA
G_A	gain of the measurement antenna
$G_{(f)}$	antenna gain over frequency
f_H	highest frequency of the frequency band of operation
f_L	lowest frequency of the frequency band of operation
k	Boltzmann constant
P	Power
$P_{e.i.r.p.}$	power spectral density
P_m	measured spectral power
r	range of UWB device
R_{data}	ranging packet length
rms	root mean square
t	time
T	Temperature
T_p	pulse width
U_r	Update rate
Z_{F0}	free space wave impedance
λ	wavelength

3.3 Abbreviations

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

AF	Activity Factor
BSS	Board SubSystem
BW	Bandwidth
CISPR	Comité International Spécial des Perturbations Radioélectriques/ Special international committee on radio interference
DAA	Detect-And-Avoid
DC	Direct Current
e.i.r.p.	equivalent isotropically radiated power
ECC	Electronic Communications Committee
EUT	Equipment Under Test
FM	Frequency Modulation
FMCW	Frequency Modulated Continuous Wave
GSS	Ground SubSystem
IT	Information Technology
LDC	Low Duty Cycle
LNA	Low Noise Amplifier
OATS	Open Area Test Site
OBU	OnBoard Unit
OE	Other Emissions
PC	Physical Contact
RF	Radio Frequency
RMS	Remote Management system
SFCW	Stepped Frequency Continuous Wave
SMA	SubMiniature version A (connectors)
TGUWB	Task Group Ultra-wide Band
TP	Total Power

TPC	Transmission Power Control
UE	User Equipment
UWB	Ultra WideBand
VSWR	Voltage Standing Wave Ratio

4 General equipment requirements for testing

4.1 Presentation of product equipment for testing purposes

The manufacturer shall submit one or more samples of the product equipment as appropriate for testing.

Additionally, technical documentation and operating manuals, sufficient to allow testing to be performed, shall be supplied.

The performance of the equipment submitted for testing shall be representative of the performance of the corresponding production model. In order to avoid any ambiguity in that assessment, the present document contains instructions for the presentation of equipment for testing purposes (see clause 4), conditions of testing and interpretation of results (see clause 5), test setups and methods of measurements (see clause 6) and test procedures for essential radio test suites (see clause 7).

The manufacturer shall offer equipment complete with any auxiliary equipment needed for testing.

4.2 Choice of model for testing

One or more samples of the EUT, as described in the following clause 5.5, shall be tested.

4.2.1 Declarations by the manufacturer

The manufacturer shall submit the necessary information regarding the equipment with respect to all technical requirements set by the present document.

- relevant harmonized standard and environmental conditions of use/intended use;
- the type of UWB technology implemented in the equipment (e.g. impulse, carrier-based, FMCW, SFCW, etc.);
- the type of modulation schemes available (e.g. pulsed modulation, FM modulation, etc.);
- for all modulation schemes the modulation parameters need to be provided: for example modulation period, frequency deviation, modulation bandwidth;
- the operating frequency range(s) of the equipment;
- the type of the equipment (e.g. stand-alone equipment, plug-in radio device, combined equipment, etc.);
- the intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p. levels;
- the nominal power supply voltages of the stand-alone radio equipment or the nominal power supply voltages of the host equipment or combined equipment in case of plug-in radio devices;
- the test modulation to be used for testing;
- the inclusion and any necessary implementation details of any mitigation or equivalent mitigation techniques;
- in case of conducted measurements, the antenna impedance as well as maximum antenna gain characteristics (frequency response) over the relevant frequency range covered in the related harmonized standard.

4.2.2 Marking and equipment identification

The equipment shall be marked in a visible place. This marking shall be legible and durable.

The marking shall include as a minimum:

- The name of the manufacturer or his trademark.
- The type designation. This is the manufacturer's numeric or alphanumeric code or name that is specific to particular equipment.

4.3 Design, manufacturing and usage requirements

4.3.1 General requirements

The equipment submitted by the manufacturer shall be designed, constructed and manufactured in accordance with good engineering practice and with the aim of minimizing harmful interferences to other equipments and services.

4.3.2 Unlicensed UWB transmitters (indoor and vehicular transmitters only)

Such UWB technology, using indoor and vehicular transmitters only, intended for short-range **unlicensed** and unprotected radio communications, shall be designed, manufactured and used according to the general harmonized conditions defined in [i.4], the last amendment of ECC/DEC(06)04, which allows emissions of UWB terminals in indoor usage and in the installations on-board rail and road vehicles for the frequency bands below 10,6 GHz.

This amended ECC decision [i.4] is primarily intended for regulating either UWB emitters indoor usage and also any generic vehicular application, where UWB emissions directed towards outside the vehicle comply with the specifically regulated ([i.4], annex 5) "exterior limit".

It is worth to underline that any indoor/vehicular application of UWB technology for Location and Tracking in railroad, complying with [i.4], shall not require license and is not subjected to any registration/coordination or authorization like, for instance, the procedure proposed in ECC Report 167 (see [i.2]).

Table 1: Maximum e.i.r.p. limits for train application, all UWB transmitters (fixed/vehicular) only indoor/underground environment

Frequency range	Maximum mean e.i.r.p. spectral density	Maximum peak e.i.r.p. (defined in 50 MHz)
Below 1,6 GHz	-90 dBm/MHz	-50 dBm
1,6 GHz to 2,7 GHz	-85 dBm/MHz	-45 dBm
2,7 GHz to 3,4 GHz (Notes 1 and 2)	-70 dBm/MHz	-36 dBm
3,4 GHz to 3,8 GHz (Notes 1 and 2)	-80 dBm/MHz	-40 dBm
3,8 GHz to 4,2 GHz (Notes 1 and 2)	-70 dBm/MHz	-30 dBm
4,2 GHz to 4,8 GHz (Notes 1 and 2)	-70 dBm/MHz	-30 dBm
4,8 GHz to 6 GHz	-70 dBm/MHz	-30 dBm
6 GHz to 8,5 GHz	-41,3 dBm/MHz	0 dBm
8,5 GHz to 10,6 GHz (Note 2)	-65 dBm/MHz	-25 dBm
Above 10,6 GHz	-85 dBm/MHz	-45 dBm
NOTE 1: Within the band 3,1 GHz to 4,8 GHz, devices implementing **Low Duty Cycle (LDC) mitigation technique** (see annex 2) are permitted to operate with a maximum mean e.i.r.p. spectral density of -41,3 dBm/MHz and a maximum peak e.i.r.p. of 0 dBm defined in 50 MHz. NOTE 2: Within the bands 3,1 GHz to 4,8 GHz and 8,5 GHz to 9 GHz, devices implementing **Detect And Avoid (DAA) mitigation technique** (see annex 3) are permitted to operate with a maximum mean e.i.r.p. spectral density of -41,3 dBm/MHz and a maximum peak e.i.r.p. of 0 dBm defined in 50 MHz.		

Table 2: Maximum e.i.r.p. limits for generic train applications, UWB transmitter on the train vehicle only (indoor and outdoor usage), no fixed outdoor UWB transmitters

Frequency range	Maximum mean e.i.r.p. spectral density	Maximum peak e.i.r.p. (defined in 50 MHz)
Below 1,6 GHz	-90 dBm/MHz	-50 dBm
1,6 GHz to 2,7 GHz	-85 dBm/MHz	-45 dBm
2,7 GHz to 3,4 GHz (Notes 1 and 2)	-70 dBm/MHz	-36 dBm
3,4 GHz to 3,8 GHz (Notes 1 and 2)	-80 dBm/MHz	-40 dBm
3,8 GHz to 4,2 GHz (Notes 1 and 2)	-70 dBm/MHz	-30 dBm
4,2 GHz to 4,8 GHz (Notes 1 and 2)	-70 dBm/MHz	-30 dBm
4,8 GHz to 6 GHz	-70 dBm/MHz	-30 dBm
6 GHz to 8,5 GHz (Notes 1 and 3)	-53,3 dBm/MHz	-13,3 dBm
8,5 GHz to 10,6 GHz (Note 2)	-65 dBm/MHz	-25 dBm
Above 10,6 GHz	-85 dBm/MHz	-45 dBm

NOTE 1: Within the band 3,1 GHz to 4,8 GHz and 6 GHz to 8,5 GHz, devices implementing Low Duty Cycle (LDC) mitigation technique (see annex 2) are permitted to operate with a maximum mean e.i.r.p. spectral density of -41,3 dBm/MHz and a maximum peak e.i.r.p. of 0 dBm defined in 50 MHz. Operation is in addition subject to the implementation of an exterior limit (see annex 5) of -53,3 dBm/MHz.

NOTE 2: Within the bands 3,1 GHz to 4,8 GHz and 8,5 GHz to 9 GHz, devices implementing Detect And Avoid (DAA) mitigation technique (see annex 3) are permitted to operate with a maximum mean e.i.r.p. spectral density of -41,3 dBm/MHz and a maximum peak e.i.r.p. of 0 dBm defined in 50 MHz. Operation is in addition subject to the implementation of Transmit Power Control (TPC) mitigation technique (see annex 4) and an exterior limit (see annex 5) of -53,3 dBm/MHz.

NOTE 3: Within the band 6 GHz to 8,5 GHz devices implementing Transmit Power Control (TPC) mitigation technique (see annex 4) and an exterior limit (see annex 5) of -53,3 dBm/MHz are permitted to operate with a maximum mean e.i.r.p. spectral density of -41,3 dBm/MHz and a maximum peak e.i.r.p. of 0 dBm defined in 50 MHz.

4.3.3 Registered UWB fixed outdoor transmitters

According to [1] it is possible to deploy UWB terminals and infrastructures, specifically intended for Location and Tracking applications (Type 2 - LT2), including outdoor transmitting terminals installed at fixed locations.

National registration/coordination procedure [i.2] is needed in this case, as UWB terminals for railroad Location and Tracking applications (Type 2: LT2, [i.5]) shall comply with limits and provisions specified in the following tables 3 and 4, which are less stringent than limitations relevant to generic unlicensed applications [i.4].

Table 3: Maximum e.i.r.p. for fixed outdoor terminals

Frequency range	Maximum mean e.i.r.p. spectral density	Maximum peak e.i.r.p. (defined in 50 MHz)
Below 1,6 GHz	-90 dBm/MHz	-50 dBm
1,6 GHz to 2,7 GHz	-85 dBm/MHz	-45 dBm
2,7 GHz to 3,4 GHz	-70 dBm/MHz (Note 1)	-36 dBm
3,4 GHz to 4,8 GHz	-41,3 dBm/MHz (Notes 2 and 3)	0 dBm
4,8 GHz to 10,6 GHz	-70 dBm/MHz	-30 dBm
Above 10,6 GHz	-85 dBm/MHz	-45 dBm

NOTE 1: Within the band 3,1 GHz to 3,4 GHz, terminals implementing Detect-And-Avoid (DAA) mitigation technique (see technical parameters for DAA in the band 3,1 GHz to 3,4 GHz as defined in ECC/DEC/(06)04) [i.4] may be permitted to operate with a maximum mean e.i.r.p. spectral density of -41,3 dBm/MHz and a maximum peak e.i.r.p. of 0 dBm defined in 50 MHz. A maximum duty cycle of 5 % per transmitter per second and a maximum Ton = 25 ms also apply.

NOTE 2: A maximum duty cycle of 5 % per transmitter per second and a maximum Ton = 25 ms apply.

NOTE 3: The maximum mean e.i.r.p. spectral density in the band 4,2 GHz to 4,4 GHz for emissions that appear 30° or greater above the horizontal plane should be less than -47,3 dBm/MHz.

Table 4: Maximum e.i.r.p. for mobile terminals and fixed indoor terminals

Frequency range)	Maximum mean e.i.r.p. spectral density	Maximum peak e.i.r.p. (defined in 50 MHz)
Below 1,6 GHz	-90 dBm/MHz	-50 dBm
1,6 GHz to 2,7 GHz	-85 dBm/MHz	-45 dBm
2,7 GHz to 3,4 GHz	-70 dBm/MHz (Note 1)	-36 dBm
3,4 GHz to 4,8 GHz	-41,3 dBm/MHz (Note 2)	0 dBm
4,8 GHz to 10,6 GHz	-70 dBm/MHz	-30 dBm
Above 10,6 GHz	-85 dBm/MHz	-45 dBm
NOTE 1: Within the band 3,1 GHz to 3,4 GHz, terminals implementing Detect-And-Avoid (DAA) mitigation technique (see technical parameters for DAA in the band 3,1 GHz to 3,4 GHz as defined in ECC/DEC/(06)04) may be permitted to operate with a maximum mean e.i.r.p. spectral density of -41,3 dBm/MHz and a maximum peak e.i.r.p. of 0 dBm defined in 50 MHz. A maximum duty cycle of 5 % per transmitter per second and a maximum Ton = 25 ms also apply. NOTE 2: A maximum duty cycle of 5 % per transmitter per second and a maximum Ton = 25 ms apply. The duty cycle should also be limited to 1,5 % per minute or equipment should implement an alternative mitigation technique that provides at least equivalent protection.		

5 Conditions of testing and interpretation of results

5.1 Normal test conditions

All testing shall be made under normal test conditions in terms of temperature and humidity, as specified in [5] clause 5.4.3 and relevant sub-clauses.

5.2 Power sources

During tests, the power source of the equipment shall be compliant to the provisions specified in [5], clause 5.4.2 and relevant sub-clauses.

Normal power sources (mains voltage, other power sources) shall be as specified in [5], clause 5.4.3.2.

The test power source used shall be stated in the test report.

5.3 Requirements for the test modulation

The test modulation used should be representative of normal use of the equipment and result in the highest mean transmit power spectral density which would be available in normal operation, as specified in [5], clause 5.3.

5.4 Choice of equipment model for test suites

The tests should be carried out on one or more production models or equivalent preliminary models, as duly appropriate, as specified in [5], clause 5.5 and relevant sub-clauses.

5.5 Radiated measurement arrangements

The test site, test antenna and substitution antenna used for radiation measurements shall be as described in [5], clause 6.3.2 and relevant sub-clauses.

For guidance on radiation test sites and general arrangements for radiated measurements, see [5] from clause 6.3.3 to 6.3.5 and relevant sub-clauses.

Detailed descriptions of radiated measurement arrangements for UWB devices can be found, as informative reference, in ITU-R Recommendation SM.1754 [i.3].

5.6 Modes of operation of the transmitter

For the purpose of the measurements according to the present document, there shall be a facility to operate the UWB transmitter in a continuous state, whereby the signal is transmitted repeatedly and any gating techniques switched off.

For combined equipment and for radio parts, for which connection to or integration with host equipment is required to offer functionality to the radio, different alternative test approaches are permitted, as specified in [5], clause 5.6 and relevant sub-clauses.

5.7 Interpretation of the measurement results

Interpretation of the results recorded in the test report for the measurements described in the present document shall be performed according criteria specified in [5], clause 5.7 and relevant sub-clauses.

NOTE: Information on uncertainty contributions, and verification procedures are detailed in TR 102 273 [3].

5.8 Other emissions

UWB transmitters emit very low power radio signals, comparable with the power of spurious emissions from digital and analogue circuitry. If it can be clearly demonstrated that an emission from the ultra-wideband radio device is not the ultra-wideband emission identified in [5], clause 7.6 (e.g. by disabling the radio device's UWB transmitter or disconnecting and terminating, internally or externally the antenna of the device) or it can clearly be demonstrated that it is impossible to differentiate between other emissions and the UWB transmitter emissions, then emission or aggregated emissions shall be considered against the receiver spurious emissions limits defined in the relevant harmonized standard.

5.9 Measuring receiver

The term measuring receiver refers to a spectrum analyser. The reference bandwidth of the measuring receiver as defined in CISPR 16-1 [1] shall be as given in table 5.

Table 5: Reference bandwidth of measuring receiver

Frequency being measured: f	Spectrum analyser bandwidth
30 MHz ≤ f < 1 000 MHz	100 kHz
1 000 MHz ≤ f	1 MHz

6 Test setups and methods of measurement

6.1 General

The railways Location and Tracking system covered by the present document uses an onboard unit (OBU) as UWB terminal equipped with a conformal array antenna (a printed circuit microstrip antenna) to transmit the UWB signal from the rail vehicle towards several ground-based equipments (Fixed Units) belonging to the infrastructure which is part of the wayside railroad environment, as described into [i.1].

NOTE: Just in case these Fixed Units operate outdoor and include UWB emitters, then they shall comply with [i.5], otherwise – in any other application case, where indoor and vehicular UWB emitters are concerned, using purely passive Fixed Units (e.g. UWB receivers and/or passive UWB reflectors) - they may operate as unlicensed UWB devices according to the applicable regulation [i.4].

The system is functionally emitting UWB radio communication signals either in indoor and in outdoor environments, while the rail vehicle is running and/or manoeuvring along the railroad. The measurements described below aim to measure the worst case of such UWB emissions in order to check their compliance to the limits, which refer to the applicable standards: either the generic regulations [i.4] for unlicensed short-range UWB equipments or the specific LT2 regulations [i.5] for Location and Tracking (Type 2) UWB applications.

In this clause, the general setup of a test bed for the test of UWB equipment are described referring to [5].

Three procedures of test shall be duly considered according to the following specifications:

- Initial measurements as specified in [5], clause 6.2.
- Radiated measurements as specified in [5], clause 6.3 and relevant sub-clauses.
- Conducted measurements as specified in [5], clause 6.4.

7 Test procedures for essential radio test suites

7.1 General

This clause refers to [5] describing the methods of measurement for the transmitter and receiver parameters, as follows:

- the operating bandwidth(s) as specified in [5], clauses 7.2.2 and 7.4.2;
- the maximum mean power spectral density (e.i.r.p.) as specified in [5], clauses 7.2.3 and 7.4.3;
- the maximum peak power (e.i.r.p.) as specified in [5], clauses 7.2.4 and 7.4.4;
- Other Emissions (OE) as specified in [5], clauses 7.2.5 and 7.4.5;
- the receiver spurious emissions as specified in [5], clauses 7.2.6 and 7.4.5;
- power control as specified in [5], clauses 7.2.7 and 7.4.6;
- detect and avoid as specified in [5], clauses 7.2.8 and 7.4.7.

7.2 Limits

7.2.1 Introduction

In this clause the limits for the measured parameter are specified. These limits are split into two main categories:

- Generic limits which are valid for all unlicensed devices using UWB technologies, as specified in [i.4].
- Specific limits which are valid only for UWB Location and Tracking LT2 applications, as specified in [1].

7.2.2 Operation bandwidth

The operating bandwidth shall be greater than 50 MHz (at -13 dB relative to the maximum spectral power density).

7.2.3 Maximum mean power spectrum density

The limits are given in the relevant harmonized standard.

7.2.4 Maximum Peek power

The limits are given in the relevant harmonized standard.

7.2.5 Other emissions

The equivalent isotropically radiated power of any of these unwanted emissions in the spurious domain shall not exceed the values given in table 6, which refers to [5], clause 7.8.5.

Table 6: Other Emission limits (radiated)

Frequency range	Limit values for OE
47 MHz to 74 MHz	-54 dBm/100 kHz
87,5 MHz to 118 MHz	-54 dBm/100 kHz
174 MHz to 230 MHz	-54 dBm/100 kHz
470 MHz to 862 MHz	-54 dBm/100 kHz
otherwise in band 30 MHz to 1 000 MHz	-36 dBm/100 kHz
1 000 MHz to 40 000 MHz (see note)	-30 dBm/1 MHz
NOTE: Not applicable for UE emissions within the permitted range of frequencies.	

7.2.6 Receiver spurious emissions

The narrowband spurious emissions of the receiver shall not exceed the values in the indicated bands. Narrowband spurious emission limits for receivers are given in table 7.

Table 7: Narrowband spurious emission limits for receivers

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

The above limit values, which refers to [5], clause 7.8.6, apply to narrowband emissions, e.g. as caused by local oscillator leakage.

Wideband spurious emissions shall not exceed the values given as follows.

Table 8: Wideband spurious emission limits for receivers

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

7.2.7 Power control

The limits are given in the relevant harmonized standard.

7.2.8 Detect and avoid

The limits, test patterns and test parameters are given in the relevant harmonized standard.

7.3 Maximum allowable measurement uncertainty

In all cases the maximum allowable measurement uncertainty is given in table 9, as follows.

Table 9: Maximum measurement uncertainty

Parameter	Uncertainty
Radio Frequency	±1 x 10^{-5}
all emissions, radiated	±6 dB (see note)
Conducted	±3 dB
temperature	±1 °C
Humidity	±5 %
DC and low frequency voltages	±3 %
NOTE: For radiated emissions measurements below 2,7 GHz and above 10,6 GHz it may not be possible to reduce measurement uncertainty to the levels specified in this table 9 (due to the very low signal level limits and the consequent requirement for high levels of amplification across wide bandwidths). In these cases alone it is acceptable to employ the alternative interpretation procedure specified in [5], clause 5.7.2.	

Annex A (normative): Radiated measurements

This annex has been drafted so it covers test sites and methods to be used with integral antenna equipment or dedicated antenna for equipment having an antenna connector.

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

This annex complements Radiated measurement provisions as specified into [5], clauses 6.3 and relevant sub-clauses, dealing with three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in the relevant parts of TR 102 273 [3] or equivalent, as TS 102 321 [6].

A.2 Installation requirements for Onboard Unit (OBU) and for Ground-based equipments in UWB railroad applications

This annex provides the information for manufacturers and for installers to design the equipment and the installation in such a way, that the requirements as stated in [i.4] or [i.5] on UWB emissions are fulfilled.

UWB terminals are included into Onboard Units (OBU) as parts of the train Board Subsystem (BSS), while several Ground Subsystem (GSS) UWB terminals are deployed, as shown in figure A.1, at fixed locations.

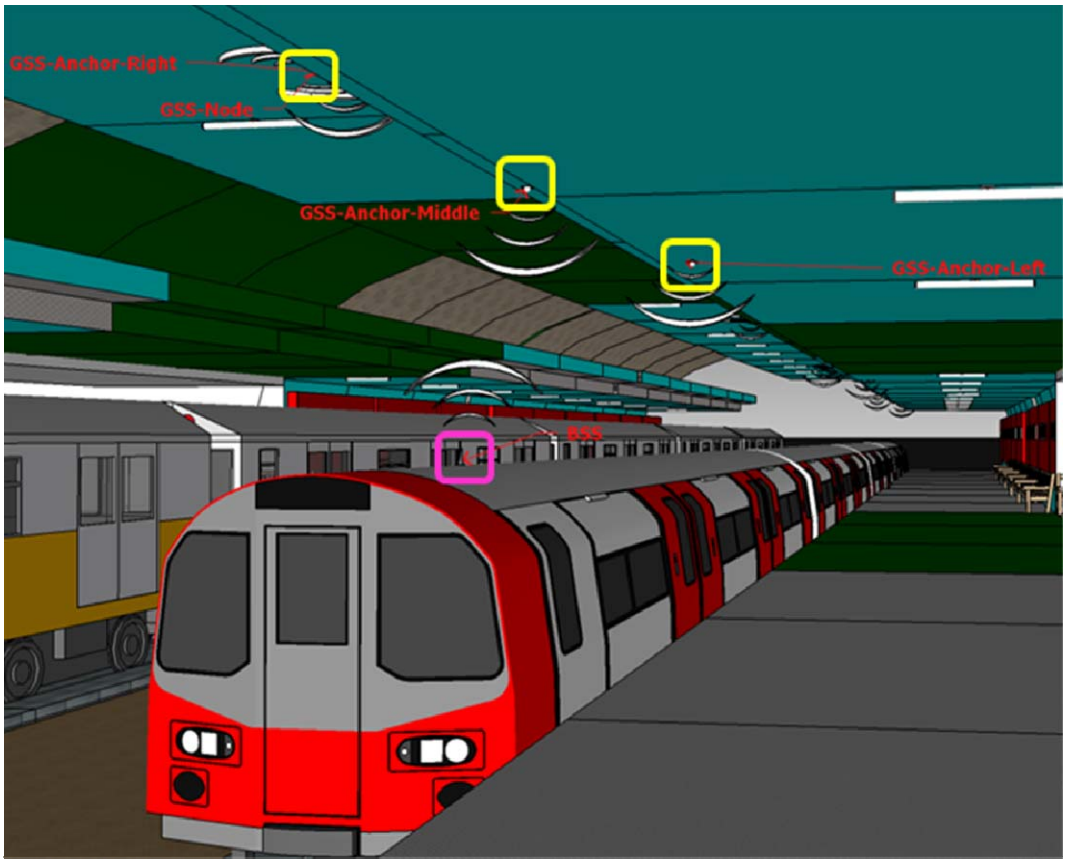


Figure A.1: Installation of UWB devices

The following installation requirements shall be fulfilled:

1) Each Onboard Unit (OBU) is required to be installed on-board the train with its corresponding antenna mounted in a permanent fixed position on the external surface of the car, according to the special instructions provided by the manufacturer for BSS installation.

2) Connectors and attachments of the OBU to the corresponding conformal antenna, mounted on the external surface of the train car, shall provide the necessary microwave sealing by design.

3) Installation and maintenance of the OBU and relevant conformal antenna equipments shall be performed by professionally trained individuals only.

4) Each Ground-based equipment is required to be installed on its supporting structure at the railroad wayside together with its antenna, mounted in a permanent fixed position, according to the special instructions provided by the manufacturer for GSS installation.

5) Connectors and attachments of the Ground-based equipment to the corresponding antenna, mounted on the supporting structure, shall provide the necessary microwave sealing by design.

6) Installation and maintenance of Ground-based equipment and of the relevant antenna shall be performed by professionally trained individuals only.

The manufacturer is required to inform the users and installers about the installation requirements and, if applicable, the additional special instructions for antenna mounting and for correct antenna pointing (e.g. by putting them in the product manual).

Annex B (normative): Requirements on testing UWB conformal antennas

B.1 General

These requirements shall apply for testing the UWB antenna, which conforms with the external surface of the train:

- the test antenna shall have the same dimensions and the same electrical characteristics of the conformal antenna to be mounted on the external surface of the train car;
- the test antenna shall be conformally mounted on a metallic surface sample which is realistically representative of the mounting configuration of the UWB antenna on the train car external surface;
- the dimensions of such metallic sample of external surface shall be large enough to minimize diffraction effects or its minimum dimension shall be at least ten times the wavelength at the UWB center frequency.

The mechanical setup for UWB conformal antenna, shown in figure B.1, is used as a worst-case scenario for measuring the total emission outside the train car and is included in the test-range, as shown in figure B.2.

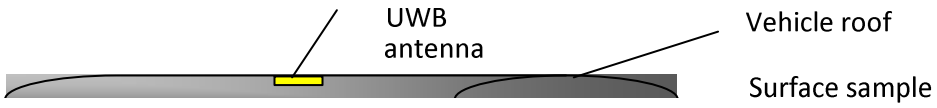
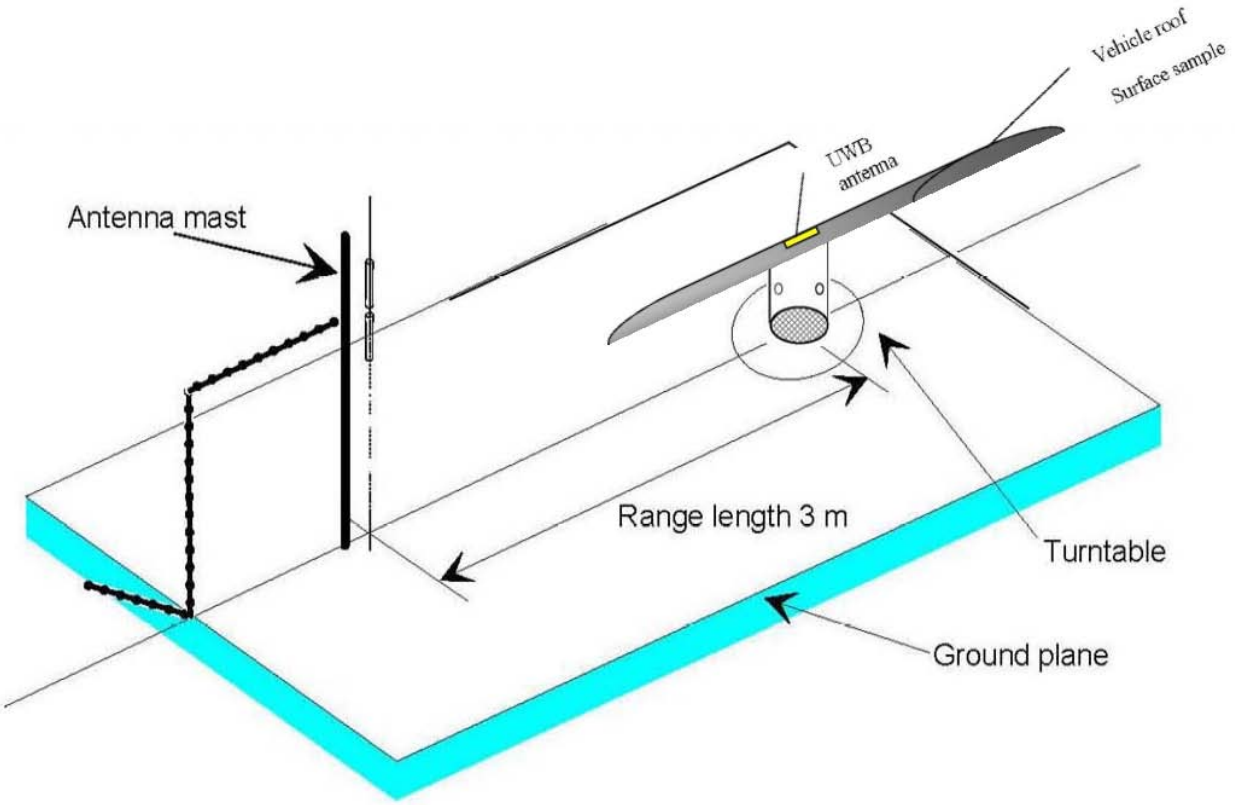


Figure B.1: Exemplary set-up for measuring an UWB antenna conformal with the train roof

B.2 Measurement setup



NOTE: Should the sensitivity not be sufficient, the measurement distance can be reduced to 1 m.

Figure B.2: Test set-up example for measurements with a UWB antenna in an OATS

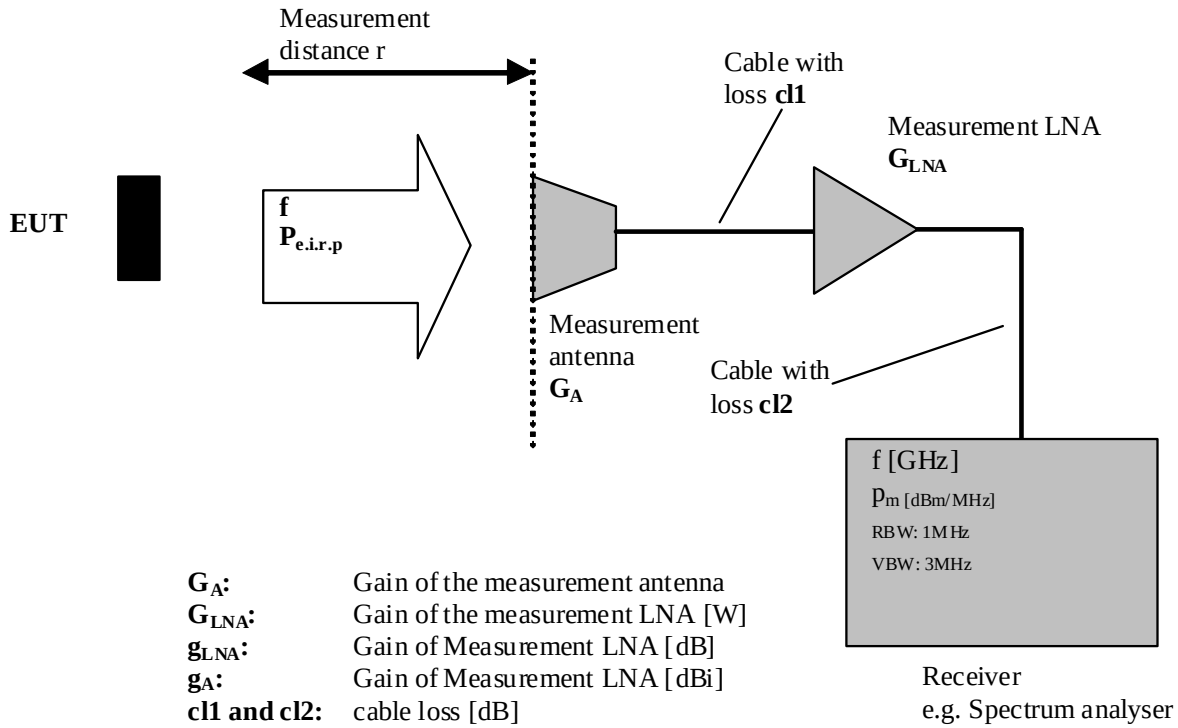


Figure B.3: Test set-up for emission measurements

Conversion:

$$g_{LNA} = 20\log(G_{LNA})$$

$$g_A = 10\log(G_A)$$

$$cl_x = 10^{\left(\frac{Cl_x}{20}\right)}$$

Equation (Values [dB]):

$$p_{e.i.r.p} = p_m - g_A - cl1 - cl2 - g_{LNA} + 20 \cdot \log\left(\frac{4\pi r}{\lambda}\right) \quad \text{[dBm/MHz]}$$

The values of the cable loss Cl1 and Cl2 are smaller than one. Consequently the logarithmic values cl1 and cl2 are negative!

A test site selected from annex A, which fulfils the requirements of the specified frequency range and undisturbed lowest specified emission levels of this measurement shall be used.

Annex C (informative): Measurement antenna and preamplifier specifications

The radiated measurements set-up in clause 8 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 spectral density level from the EUT mounted in a still pipe.

Table C.1 gives examples of minimum recommended data and features for the horn antenna and preamplifier to be used for the test set-up.

Table C.1: Recommended minimum performance data for preamplifier and antenna

Pre-amplifier	
Bandwidth	30 MHz to 22,5 GHz
Noise figure	< 3 dB
Output at 1dB compression	5 dBm
Gain	27 dB
Gain flatness across band	±2,5 dB
Phase response	Linear
VSWR in/out across band	2,5:1
Nominal impedance RF Connector Or waveguide size	50 Ω

Antenna	
Type of Antenna	**Log. Periodic/Horn**
Bandwidth	30 MHz to 22,5 GHz
Gain	8,5 dBi
Nominal Impedance	50 Ω
VSWR across band	< 2,5:1
Connector or waveguide connection	PC 3,5 (SMA)

Measuring the complete emission spectrum, several measurement antennas will be required, each optimized over a distinct frequency range:

Table C.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

History

Document history		
V1.1.1	October 2012	Publication