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Naprave kratkega dosega - Merilne tehnike za avtomobilsko in nadzorno radarsko opremo

Short Range Devices - Measurement Techniques for Automotive and Surveillance Radar Equipment

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Short Range Devices; Measurement Techniques for Automotive and Surveillance Radar Equipment

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Foreword

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

It is intended to be used in conjunction with an appropriate harmonised standard for the purposes of assessing conformity with the Radio Equipment Directive [i.3].

National transposition dates	
Date of adoption of this EN:	5 December 2016
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Modal verbs terminology

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

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Introduction

Automotive and surveillance radar equipments are low power millimetre wave devices that are able to detect and characterize targets in their environment.

The following use cases are included (but are not limited to):

- automotive Advanced Driver Assistance Systems (ADAS) applications, such as Adaptive Cruise Control (ACC), Blind Spot Detection (BSD), parking aid, backup aid, autonomous braking and Pre-Crash Systems (PCS);
- surveillance radars for other kind of ground based vehicles, such as trains, trams, aircrafts while taxiing;
- fixed infrastructure radars for traffic monitoring;
- railway/road crossings obstacle detection radars;

- helicopter obstacle detection radars.

Detailed information about use cases can be found in the related Harmonised Standards (ETSI EN 301 091-1 [i.7], ETSI EN 301 091-2 [i.8], ETSI EN 301 091-3 [i.9], ETSI EN 302 264 [i.10], ETSI EN 302 858 [i.11]).

The current generation of radars uses mainly FMCW modulations, such as slow-ramp and fast-ramp (chirp or pulse compression) modulations. Radars may have multiple transmitting antennas and receiving antennas to enable adaptive field-of-views or digital beam forming. Scanning systems, electronically or mechanically, also exist on the market.

1 Scope

The present document describes possible measurement techniques and procedures for the conformance measurements applicable to automotive and surveillance radar equipments.

The present document will be used as a reference for existing and future ETSI standards covering automotive and surveillance radar equipments.

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] CISPR 16-1-1 (2006), CISPR 16-1-4 (2010) and CISPR 16-1-5 (2014): "Specification for radio disturbance and immunity measuring apparatus and methods; Part 1: Radio disturbance and immunity measuring apparatus".

[2] 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".

[3] 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".

[4] 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".

[5] 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)".

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.

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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] CEPT/ERC/Recommendation 74-01: "Unwanted emissions in the spurious domain".

[i.2] ITU Radio Regulations.

[i.3] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.4] Recommendation ITU-R SM.329-12 (2012): "Unwanted emissions in the spurious domain".

[i.5] Recommendation ITU-R SM.328-11 (2006): "Spectra and Bandwidth of Emissions".

[i.6] Recommendation ITU-R SM.1754 (2006): "Measurement techniques of ultra-wideband transmissions".

[i.7] ETSI EN 301 091-1: "Short Range Devices; Transport and Traffic Telematics (TTT); Radar equipment operating in the 76 GHz to 77 GHz range; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Ground based vehicular radar".

[i.8] ETSI EN 301 091-2: "Short Range Devices; Transport and Traffic Telematics (TTT); Radar equipment operating in the 76 GHz to 77 GHz range; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: Fixed infrastructure radar equipment".

[i.9] ETSI EN 301 091-3: "Short Range Devices; Transport and Traffic Telematics (TTT); Radar equipment operating in the 76 GHz to 77 GHz range; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 3: Railway/Road Crossings obstacle detection system applications".

[i.10] ETSI EN 302 264: "Short Range Devices; Transport and Traffic Telematics (TTT); Short Range Radar equipment operating in the 77 GHz to 81 GHz band; Harmonised Standard covering essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.11] ETSI EN 302 858: "Short Range Devices; Transport and Traffic Telematics (TTT); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Radar equipment operating in the 24,05 GHz to 24,25 GHz or 24,05 GHz to 24,50 GHz range".

[i.12] ECC Recommendation (07)01: "Frequency Measurements Using Fast Fourier Transform (FFT) Techniques".

[i.13] ETSI TR 103 366: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Time Domain based Low Duty Cycle Measurement Procedure".

[i.14] ETSI EG 203 367 (V1.1.1): "Guide to the application of harmonised standards covering article 3.1b and 3.2 of the Directive 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

averaging time: time interval on which a mean measurement is integrated

blanking period: time period where no intentional emission occurs

boresight: direction of maximum gain of a directional antenna

NOTE: EUT may have different boresights for TX and RX antennas.

bumper: (automotive) generally 3D shaped plastic sheet normally mounted in front of the radar device

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

cycle time: length of the time between periodic transmission patterns of the system

NOTE: In case of a random pattern, a default value of 1 minute is used.

duty cycle: $\sum(T_{on})/t\_o$ where T_{on} is the ON time of a single transmission and t_o is the observation period. T_{on} is measured in an observation frequency band (BW_o)

dwell time: in general, time interval for which a certain frequency range is occupied

NOTE: "Cumulated dwell time" is the sum of individual dwell times within a measurement time frame and in a defined frequency range.

"Absolute dwell time" is the time from first entrance into a defined frequency range until last exit from a defined frequency range.

Equipment Under Test (EUT): radar sensor including the integrated antenna together with any external antenna components which affect or influence its performance

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)

NOTE 1: See ITU Radio Regulations [i.2], RR 1.161.

NOTE 2: e.i.r.p. may be used for peak or mean (average) power and peak or mean (average) spectral power density. If not otherwise noted, e.i.r.p. refers to the mean (average) power.

far field measurement: measurement at a distance from an antenna sufficient to ensure that the electro-magnetic field approximates a plane wave (see clause 5.3.2.3)

illumination time: (for equipment with scanning antennas) time for which a given point in the far field is within the main beam(s) of the antenna(s)

maximum power: maximum mean power with respect to azimuth and elevation (typically measured at antenna boresight)

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

NOTE 1: See ITU Radio Regulations [i.2], RR 1.158.

NOTE 2: For pulsed systems the mean power is equal to the peak envelope power (see ITU Radio Regulations [i.2], RR 1.157) multiplied by the time gating duty factor. For CW systems without time gating the mean power is equal to the transmission power without modulation.

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

NOTE: Equipment may be able to operate at more than one operating frequency.

operating frequency range: range of operating frequencies over which the equipment can be adjusted through switching or reprogramming or oscillator tuning

NOTE 1: For pulsed or phase shifting systems without further carrier tuning the operating frequency range is fixed on a single carrier line.

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: highest instantaneous power of the EUT

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

power envelope: power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions

NOTE: See ITU Radio Regulations [i.2], RR 1.157.

power flux density: radiated power per unit area normal to the direction of the electromagnetic wave propagation

Power Spectral Density (PSD): ratio of the amount of power to the used radio measurement bandwidth

pulse radar: EUT which determines distance (range) by the time-of-flight of short radar pulses which are not frequency modulated

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

quiescent period: time instant where no intentional emission occurs

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

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

spread spectrum modulation: modulation technique in which the energy of a transmitted signal is spread throughout a relatively large portion of the frequency spectrum

ultra-wideband bandwidth: equipment using ultra-wideband technology means equipment incorporating, as an integral part or as an accessory, technology for short-range radiocommunication, involving the intentional generation and transmission of radio-frequency energy that spreads over a wider frequency range

3.2 Symbols

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

λ	wavelength
B	(pulse) bandwidth
B_{FH}	Bandwidth used for frequency hopping systems
d	largest dimension of the antenna aperture
dB	decibel
d_{FF}	Far Field Distance
E	Field strength
f_c	Carrier frequency
f_H	highest frequency
f_L	lowest frequency
F	Permitted frequency bandwidth
F_1	Low boundary between OOB and Spurious domains
F_2	High boundary between OOB and Spurious domains
σ	Radar Cross Section
BW_o	Observation bandwidth
f_max	Maximum frequency range of interest
f_mod	Modulation frequency range
P_min	Minimum relevant signal power
P_{CORR}	Measured power corrected with regard to the RBW
$P_{MEASURED}$	Measured power

RBW	Resolution Bandwidth
RBW_{REF}	Reference Resolution Bandwidth
$RBW_{MEASURED}$	Resolution Bandwidth used for the measurements
S	Power Flux Density
T_C	Chip period
t_d1,2,3	Individual dwell time contributions
t_d	Dwell time
t_o	Observation time
t_r	Repetition time
TP	Total Power

3.3 Abbreviations

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

AC	Alternating Current
ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance Systems
ATT	ATTenuator
BSD	Blind Spot Detection
BW	BandWidth
CEPT	European Conference of Postal and Telecommunications administrations
CISPR	Comité International Spécial des Perturbations Radioélectriques
CW	Continuous Wave
DC	Direct Current
e.i.r.p.	equivalent isotropically radiated power
EC	European Commission
ECC	Electronic Communications Committee
EMC	Electro Magnetic Compatibility
ERC	European Radiocommunication Committee
EUT	Equipment Under Test
FFT	Fast Fourier Transform
FH	Frequency Hopping
FMCW	Frequency Modulation Continuous Wave
FSK	Frequency Shift Keying
HS	Harmonised Standards
IF	Intermediate Frequency
LNA	Low Noise Amplifier
OBW	Occupied BandWidth
OOB	Out-Of-Band
PCS	Pre-Crash System
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PSD	Power Spectral Density
RBW	Resolution BandWidth
RCS	Radar Cross Section
RE-D	Radio Equipment Directive
RF	Radio Frequency
RMS	Root Mean Square
RR	ITU-R Radio Regulations
Rx	Receiver (Receive)
SNR	Signal to Noise Ratio
SRD	Short Range Device
SRR	Short Range Radar
TTT	Transport & Traffic Telematics
Tx	Transmitter
UWB	Ultra Wide Band
VBW	Video BandWidth
VSWR	Voltage Standing Wave Ratio

4 General Considerations for performing the tests

4.1 Overview

In this clause, all general considerations for the testing of short-range radar devices will be given. These considerations and requirements are related to the presentation of the products to be tested (see clause 4.2), the requirement for the EUT (see clause 4.3), the general test conditions (see clause 4.4), the reference bandwidth for the measurements (see clause 4.5) the interpretation of test results (see clause 4.6) and the test report (see clause 4.7).

4.2 Product information

The following product information may be needed in order for the tests to be performed adequately and should be provided by the manufacturer, such as:

- relevant harmonised standard and environmental conditions of use/intended use;
- 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 type of technology/modulation implemented in the equipment (e.g. pulse, pulse-Doppler, FMCW, etc.);
- for all modulation schemes, the modulation parameters need to be provided: for example modulation period, ramp sweep time, modulation bandwidth;
- high and low power modes;
- the equipment power duty cycle;
- the operating frequency range(s) of the equipment (see clause 6.3.2);
- the normal installation orientation of the EUT;
- the antenna polarization for both transmit and receive antennas;
- the antenna boresight direction, as well as the antenna beamwidth, horizontal and vertical 3 dB points for both transmit and receive antennas;
- details of any antenna switching or electronic or mechanical scanning. Where such features are present, information about whether they can be disabled for testing purposes should also be supplied;
- the desired range of temperature (see clause 4.4.4.1.2), including the necessary warm-up settling time of the EUT;
- information about equipment function to establish wanted performance criteria (clause 6.3.12).

See related HS for more information (ETSI EN 301 091-1 [i.7], ETSI EN 301 091-2 [i.8], ETSI EN 301 091-3 [i.9], ETSI EN 302 264 [i.10] and ETSI EN 302 858 [i.11]).

4.3 Requirements for the EUT

4.3.1 EUT version and configuration

Testing may be carried out on production or on equivalent versions of the equipment.

NOTE: It is the responsibility of the manufacturer to ensure that the equipment that is put into service meets the relevant requirements of the applicable legislation, including the RE-D [i.3].

If an equipment has optional features that are considered not to affect directly the RF parameters then tests need only be performed on the equipment configured with the considered worst case combination of features as declared by the manufacturer.