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

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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.

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].

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
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## Modal verbs terminology

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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.

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# 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.

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## 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.

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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 (Edition of 2012).
- [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; Harmonized 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; Harmonized 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 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".

## 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 (as measured at its 3 dB point)

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

**average 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:**  $\sum(T_{on})/T_{obs}$  where  $T_{on}$  is the ON time of a single transmission and  $T_{obs}$  is the observation period.  $T_{on}$  is measured in an observation frequency band ( $F_{obs}$ )

**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.):** The 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), (see ITU Radio Regulations [i.2], RR 1.161).

NOTE: 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.

**equivalent pulse power duration:** duration of an ideal rectangular pulse which has the same content of energy compared with the pulse shape of the EUT with pulsed modulation or time gating

**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, (see ITU Radio Regulations [i.2], RR 1.158).

NOTE: 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, (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 (in  $W/m^2$ )

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

NOTE: It is expressed in units of dBm/Hz or as a power in unit dBm with respect to the used bandwidth. In case of measurement with a spectrum analyser the measurement bandwidth is equal to the RBW.

**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 (2<sup>nd</sup>) 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:

$\lambda$	wavelength
B	(pulse) bandwidth
$B_{FH}$	Bandwidth used for frequency hopping systems
BW	BandWidth
d	largest dimension of the antenna aperture
$d_{FF}$	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
$\sigma$	Radar Cross Section
BW <sub>o</sub>	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 <sub>d1,2,3</sub>	Individual dwell time contributions
t <sub>d</sub>	Dwell time
t <sub>o</sub>	Observation time
t <sub>r</sub>	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
BPSK	Binary Phase Shift Keying
BSD	Blind Spot Detection
CEPT	European Conference of Postal and Telecommunications administrations
CISPR	Comité International Spécial des Perturbations Radioélectriques
CW	Continuous Wave
dB	decibel
DC	Direct Current
DSB	Double Sideband
DSS	Direct Sequence Signal
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
FMICW	Frequency Modulated Interrupted 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
PN-ASK	Pseudo-Noise Amplitude Shift Keying
PN-PSK	Pseudo-Noise coded Phase Shift Keying
PPM	Pulsed Position Modulation
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
SPM	Staggered Pulse Position Modulated
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