SLOVENSKI STANDARD
SIST EN 302 729-1 V1.1.2:2011

01-julij-2011

Elektromagnetna združljivost in zadeve v zvezi z radijskim spektrom (ERM) - Naprave kratkega dosega (SRD) - Oprema radarjev za ugotavljanje ravni tekočine (LPR), ki delujejo v frekvenčnih območjih od 6 GHz do 8,5 GHz, 24,05 GHz do 26,5 GHz, 57 GHz do 64 GHz in od 75 GHz do 85 GHz - 1. del: Tehnične karakteristike in preskusne metode

Electromagnetic compatibility and Radio spectrum Matters (ERM) - 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 - Part 1: Technical characteristics and test methods

Ta slovenski standard je istoveten z: **EN 302 729-1 Version 1.1.2**

ICS:

33.060.01	Radijske komunikacije na splošno	Radiocommunications in general
33.100.01	Elektromagnetna združljivost na splošno	Electromagnetic compatibility in general

SIST EN 302 729-1 V1.1.2:2011 **en**

ETSI EN 302 729-1 V1.1.2 (2011-05)

European Standard

Electromagnetic compatibility and Radio spectrum Matters (ERM); 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; Part 1: Technical characteristics and test methods

Reference
DEN/ERM-TGTLPR-0114-1

Keywords
EHF, radar, regulation, SHF, short range, SRD, testing, UWB

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Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

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

For non-EU countries, the present document may be used for regulatory (Type Approval) purposes.

The present document is part 1 of a multi-part deliverable covering Electromagnetic compatibility and Radio spectrum Matters (ERM); 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, as identified below:

Part 1: "Technical characteristics and test methods";

Part 2: "Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

National transposition dates	
Date of adoption of this EN:	9 May 2011
Date of latest announcement of this EN (doa):	31 August 2011
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	29 February 2012
Date of withdrawal of any conflicting National Standard (dow):	29 February 2012

Introduction

Clauses 1 and 3 provide a general description on the types of equipment covered by the present document and the definitions and abbreviations used.

Clause 2 provides the information on normative and informative reference documentation.

Clause 4 provides a guide as to the number of samples required in order that tests may be carried out, and any markings on the equipment which the provider should provide. It also includes the general testing requirements and gives the maximum measurement uncertainty values.

Clauses 5 and 6 give guidance on the test and general conditions for testing of the LPR device.

Clause 7 specifies the LPR spectrum utilization parameters which are required to be measured. The clauses provide details on how the equipment should be tested and the conditions which should be applied. It also includes information on applicable interference mitigation techniques for LPR.

- Annex A (normative) provides specifications concerning radiated measurements.
- Annex B (normative) provides specifications concerning conducted measurements.
- Annex C (informative) provides specifications concerning the installation requirements for LPR.
- Annex D (informative) covers information on recommended Measurement antenna and preamplifier specifications.
- Annex E (informative) contains information on the practical test distances for accurate measurements.
- Annex F (normative) provides the range of modulation schemes for LPR.
- Annex G (informative) contains information on atmospheric absorptions and material dependent attenuations In the frequency range between 40 GHz and 246 GHz.
- Annex H (informative) Bibliography covers other supplementary information.

Test and measurement limitations

The ERA report 2006-0713 [i.7] has shown that there are practical limitations on measurements of RF radiated emissions. The minimum radiated levels that can be practically measured in the lower GHz frequency range by using a radiated measurement setup with a horn antenna and pre-amplifier are typically in the range of about -70 dBm/MHz to -75 dBm/MHz (e.i.r.p.) to have sufficient confidence in the measured result (i.e. EUT signal should be at least 6 dB above the noise floor of the spectrum analyser and the measurement is performed under far-field conditions at a onemetre distance).

The present document therefore recognizes these difficulties and provides a series of radiated test methods suitable for the different LPR technologies.

1 Scope

The present document specifies the requirements for Level Probing Radar (LPR) applications based on pulse RF, FMCW, or similar wideband techniques.

LPR radio equipment types are capable of operating in all or part of the frequency bands as specified in table 1.

Table 1: Frequency bands designated to Level Probing Radars (LPR)

	Frequency Bands/frequencies (GHz)
Transmit and Receive	6 to 8,5
Transmit and Receive	24,05 to 26,5
Transmit and Receive	57 to 64
Transmit and Receive	75 to 85

Table 1 shows a list of the frequency bands as designated to Level Probing Radars in the draft CEPT ECC Decision on harmonised deployment conditions for industrial Level Probing Radars (LPR) [i.1] as known at the date of publication of the present document.

LPRs are used in many industries concerned with process control to measure the amount of various substances (mostly liquids or granulates). LPRs are used for a wide range of applications such as process control, custody transfer measurement (government legal measurements), water and other liquid monitoring, spilling prevention and other industrial applications. The main purposes of using LPRs are:

- to increase reliability by preventing accidents;
- to increase industrial efficiency, quality and process control;
- to improve environmental conditions in production processes.

LPR always consist of a combined transmitter and receiver and are used with an integral or dedicated antenna. The LPR equipment is for professional applications to which installation and maintenance are performed by professionally trained individuals only.

NOTE: LPR antennas are always specific directive antennas and no LPR omnidirectional antennas are used. This is also important in order to limit the illuminated surface area as well as to control and limit the scattering caused by the edges of the surface.

The scope is limited to LPRs operating as Short Range Devices.

The LPR applications in the present document are not intended for communications purposes.

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] 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".

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

[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 Calibration of Antennas Used for Radiated Emission Measurements in Electro Magnetic Interference".

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] Draft CEPT ECC Decision of [Day Month Year] on industrial Level Probing Radars (LPR) in frequency bands 6-8.5 GHz, 24.05-26.5 GHz, 57-64 GHz and 75-85 GHz (ECC/DEC/(11)BB).

[i.2] ITU-R Recommendation SM.1755: "Characteristics of ultra-wideband technology".

[i.3] CEPT/ERC/REC 74-01 (2005): "Unwanted emissions in the spurious domain".

[i.4] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[i.5] ITU-R Recommendation SM.1754: "Measurement techniques of Ultra-wideband transmissions".

[i.6] Void.

[i.7] ERA Report 2006-0713: "Conducted and radiated measurements for low level UWB emissions".

[i.8] FCC: "Revision of part 15 of the Commission's Rules Regarding Ultra- Wideband Transmission Systems", ET Docket No. 98-153, First Report and Order, April 2002.

[i.9] ITU-R Recommendation P.526-10 (02/07): "Propagation by diffraction".

[i.10] ETSI TS 103 052: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radiated measurement methods and general arrangements for test sites up to 100 GHz".

[i.11] ITU-R Recommendation P.676-5: "Attenuation by atmospheric gases", 2001.

[i.12] CEPT ECC Report 139: "Impact of Level Probing Radars Using Ultra-Wideband Technology on Radiocommunications Services", Rottach-Egern, February 2010.

[i.13] ETSI TR 102 601: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System reference document; Short Range Devices (SRD); Equipment for Detecting Movement using Ultra Wide Band (UWB) radar sensing technology; Level Probing Radar (LPR)-sensor equipment operating in the frequency bands 6 GHz to 8,5 GHz; 24,05 GHz to 26,5 GHz; 57 GHz to 64 GHz and 75 GHz to 85 GHz".

[i.14] European Commission Decision 2009/343/EC Commission Decision 2009/343/EC amending Decision 2007/131/EC on allowing the use of the radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community.

[i.15] ETSI TR 102 215: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Recommended approach, and possible limits for measurement uncertainty for the measurement of radiated electromagnetic fields above 1 GHz".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Activity Factor (AF): See annex F for definition and explanation.

Adaptive Power Control (APC): automatic function implemented to offer a dynamic power control that delivers maximum power only during deep fading; in this way for most of the time the interference is reduced

dedicated antenna: antenna that is designed as an indispensable part of the equipment

Duty Cycle (DC): See annex F for definition and explanation on duty cycle.

Equipment Under Test (EUT): LPR under test

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

NOTE: e.i.r.p. is conventionally the product of "power into the antenna" and "antenna gain". e.i.r.p. is used for both peak and average power.

Frequency Modulated Continuous Wave (FMCW) radar: radar where the 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.

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

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

power spectral density (psd): amount of the total power inside the measuring receiver bandwidth expressed in dBm/MHz

pulsed radar (or here simply "pulsed LPR"): radar where the transmitter signal has a microwave power consisting of short RF pulses

Pulse Repetition Frequency (PRF): inverse of the Pulse Repetition Interval, averaged over a sufficiently long time to cover all PRF variations

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

radiation: signals emitted intentionally for level measurements

3.2 Symbols

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

f	Frequency
f_C	Frequency at which the emission is the peak power at maximum
f_H	Highest frequency of the frequency band of operation
f_L	Lowest frequency of the frequency band of operation
t	Time
k	Boltzmann constant
T	Temperature
G	Efficient antenna gain of radiating structure

G_a	Declared measurement antenna gain
d	Largest dimension of the antenna aperture of the LPR
d_1	Largest dimension of the EUT/dipole after substitution (m)
d_2	Largest dimension of the test antenna (m)
D	Duty cycle
λ	Wavelength
dB	deciBel
dBi	antenna gain in deciBels relative to an isotropic antenna

3.3 Abbreviations

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

AF	Activity Factor
APC	Adaptive Power Control
DC	Duty Cycle
DUT	Device Under Test
e.i.r.p.	equivalent isotropically radiated power
ERC	European Radiocommunication Committee
EUT	Equipment Under Test
FH	Frequency Hopping
FMCW	Frequency Modulated Continuous Wave
FSK	Frequency Shift Keying
FSL	Free Space Loss
IF	Intermediate Frequency
LNA	Low Noise Amplifier
LO	Local Oscillator
LPR	Level Probing Radar
OATS	Open Area Test Site
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PSD	Power Spectral Density
R&TTE	Radio and Telecommunications Terminal Equipment
RBW	Resolution BandWidth
RF	Radio Frequency
RMS	Root Mean Square
SFCW	Stepped Frequency Carrier Wave
SRD	Short Range Device
Tx	Transmitter
UWB	Ultra-WideBand
VBW	Video BandWidth
VSWR	Voltage Standing Wave Ratio

4 General requirements specifications

4.1 Presentation of equipment for testing purposes

Equipment submitted for testing, where applicable, shall fulfil the requirements of the present document on all frequencies over which it is intended to operate.

The provider shall submit one or more samples of the 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 (clause 4), conditions of testing (clauses 5 and 6) and the measurement methods (clause 7).

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

The provider shall declare the frequency range(s), the range of operation conditions and power requirements, as applicable, in order to establish the appropriate test conditions.

4.2 Choice of model for testing

If an equipment has several optional features, considered not to affect the RF parameters then the tests need only to be performed on one sample of the equipment configured with that combination of features considered to create the highest unintentional emissions.

In addition, when a device has the capability of using different dedicated antennas or other features that affect the RF parameters, at least the worst combination of features from an emission point of view as agreed between the provider and the test laboratory shall be tested.

Where the transmitter is designed with adjustable output power, then all transmitter parameters shall be measured using the highest maximum mean power spectral density level, as declared by the provider. The duty cycle of the transmitter as declared by the provider shall not be exceeded. The actual duty cycle used during the measurements shall be recorded in the test report.

The choice of model(s) for testing shall be recorded in the test report.

4.3 Mechanical and electrical design

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

4.3.1 Marking (equipment identification)

The equipment shall be marked in a visible place. This marking shall be legible and durable. Where this is not possible due to physical constraints, the marking shall be included in the user's manual.

4.3.1.1 Equipment identification

The marking shall include as a minimum:

- the name of the manufacturer or his trademark;
- the type designation.

4.4 Auxiliary test equipment and product information

All necessary set-up information shall accompany the LPR equipment when it is submitted for testing.

The following product information shall be provided by the manufacturer:

- the type of modulation technology implemented in the LPR equipment (e.g. FMCW or pulsed);
- the operating frequency range(s) of the equipment;
- the intended combination of the LPR transceiver and its antenna and their corresponding e.i.r.p. levels in the main beam;
- the nominal power supply voltages of the LPR radio equipment;

- for FMCW, FH and FSK or similar carrier based modulation schemes, it is important to describe the modulation parameters in order to ensure that the right settings of the measuring receiver are used. Important parameters are the modulation period, deviation or dwell times within a modulation period, rate of modulation (Hz/s);
- the implementation of features such as gating, hopping or stepped frequency hopping;
- the implementation of any mitigation techniques;
- for pulsed equipment, the Pulse Repitition Frequency (PRF) is to be stated.

4.5 General requirements for RF cables

All RF cables including their connectors at both ends used within the measurement arrangements and set-ups shall be of coaxial or waveguide type featuring within the frequency range they are used:

- a VSWR of less than 1,2 at either end;
- a shielding loss in excess of 60 dB.

When using coaxial cables for frequencies above 40 GHz attenuation features increase significantly and decrease of return loss due to mismatching caused by joints at RF connectors and impedance errors shall be considered.

All RF cables and waveguide interconnects shall be routed suitably in order to reduce impacts on antenna radiation pattern, antenna gain, antenna impedance. Table 2 provides some information about connector systems that can be used in connection with the cables.

Table 2: Connector systems

Connector System	Frequency	Recommended coupling torque
N	18 GHz	0,68 Nm to 1,13 Nm
SMA	18 GHz (some up to 26 GHz)	~ 0,56 Nm
3,50 mm	26,5 GHz	0,8 Nm to 1,1 Nm
2,92 mm	40 GHz (some up to 46 GHz)	0,8 Nm to 1,1 Nm
2,40 mm	50 GHz (some up to 60 GHz)	0,8 Nm to 1,1 Nm
1,85 mm	65 GHz (some up to 75 GHz)	0,8 Nm to 1,1 Nm

4.6 RF waveguides

Wired signal transmission in the millimeter range is preferably realized by means of waveguides because they offer low attenuation and high reproducibility. Unlike coaxial cables, the frequency range in which waveguides can be used is limited also towards lower frequencies (highpass filter characteristics). Wave propagation in the waveguide is not possible below a certain cutoff frequency where attenuation of the waveguide is very high. Beyond a certain upper frequency limit, several wave propagation modes are possible so that the behaviour of the waveguide is no longer unambiguous. In the unambiguous range of a rectangular waveguide, only H10 waves are capable of propagation.

The dimensions of rectangular and circular waveguides are defined by international standards such as 153-IEC for various frequency ranges. These frequency ranges are also referred to as waveguide bands. They are designated using different capital letters depending on the standard. Table 3 provides an overview of the different waveguide bands together with the designations of the associated waveguides and flanges.

For rectangular waveguides, which are mostly used in measurements, harmonic mixers with matching flanges are available for extending the frequency coverage of measuring receivers. Table 3 provides some information on waveguides.