ETSI TR 102 601 V1.1.1 (2007-12)

Technical Report

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

Reference

DTR/ERM-RM-254

Keywords

SRD, radar

ETSI

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Foreword

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

Introduction

The request for harmonized European spectrum for tank level probing radars (TLPR) as defined in TR 102 347 [4] has resulted in an addition of identified frequencies for TLPR in CEPT/ERC Recommendation 70-03 [1], annex 6. ETSI, in parallel, has published the Harmonized European Standard EN 302 372 [2] for TLPR. ITU-R Recommendation SM.1538 [3] also covers TLPR.

The present document covers the request for harmonized European spectrum for Level Probing Radar-sensors (LPR) applications not installed in closed metallic or similar (e.g. concrete) enclosure structures. LPR use a similar technology as TLPR, however due to the different installation conditions, different technical requirements are envisaged for the Harmonized Standard.

Commercially, sales of LPR are currently limited due to lack of a Harmonized Standard and regulation. License exempt European harmonized conditions for the availability and use of radio spectrum for LPR could lead to an increase of the total addressable market for TLPR and LPR applications.

NOTE: From a regulatory point of view, TLPR may not be considered a subset of LPR. Since the majority of radar level sensor products currently on the market are TLPR, and LPR is closely technology related, TLPR are mentioned in the present document mainly for marketing clarifications (see annex A).

Status of pre-approval draft

The present document has been created and approved by ERM_TG TLPR. The document has been revised and approved by TG TLPR. It has been sent to ERM for approval.

Final approval for publication as ETSI Technical Report was achieved at ERM#33 (26-30 Nov. 2007).

Target version	Pre-approval date version (see note)				
V1.1.1	**a**	**s**	**m**	**Date**	**Description**
V1.1.1	2.0.0			24 August 2007	Approved by ERM to send to CEPT; result of one month consultation between all radio groups in ETSI; stable and mature document suitable for CEPT to use for considerations and studies
V1.1.1	2.1.2			5 November 2007	Approved by TG TLPR and send to ETSI ERM for approval
V1.1.1	3.0.0			30 November 2007	Approved by ETSI ERM for publication and for transmission to CEPT, RSCom, and TCAM
NOTE: See clause A.2 of EG 201 788 [12].					

1 Scope

The present document provides information on the intended applications, the technical parameters and the radio spectrum requirements for LPR proposed to be operated in one or more of the following frequency bands:

- 6,0 GHz to 8,5 GHz;
- 24,05 GHz to 26,5 GHz;
- 57 GHz to 64 GHz; and
- 75 GHz to 85 GHz.

LPR covered by the present document are always installed in a fixed position and pointing downwards to achieve maximum reflection. They use highly directive antennas and the antenna footprint can be defined accurately, i.e. the area of their emissions is well defined, and any reflections outside of the area can be controlled to not exceed a maximum limit by using Adaptive Power Control (APC).

The present document describes LPR devices that measure substance levels via short ranges with an accuracy in the millimeter range. LPR use carrier-based Ultra Wide Band technology for this purpose.

The present document provides information to aid in the development of general, non-individual, preferably licence exempt European harmonized conditions for the availability and use of radio spectrum for level probing radar (LPR) sensor systems.

Additional information is given in the following annexes:

- Annex A: Detailed market information;
- Annex B: Detailed technical information;
- Annex C: Expected sharing and compatibility issues.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
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  - for informative references.

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NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Informative references

[1] CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".

[2] ETSI EN 302 372 (parts 1 and 2): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Equipment for Detection and Movement; Tanks Level Probing Radar (TLPR) operating in the frequency bands 5,8 GHz, 10 GHz, 25 GHz, 61 GHz and 77 GHz".

[3] ITU-R Recommendation SM.1538: "Technical and operating parameters and spectrum requirements for short range radiocommunication devices".

[4] ETSI TR 102 347: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Equipment for Detecting Movement; Radio equipment operating around e.g. 5,8 GHz, 10 GHz, 25 GHz, 61 GHz, 77 GHz; System Reference Document for Tank Level Probing Radar (TLPR)".

[5] CEPT/ECC Report 64: "The protection requirements of radiocommunications systems below 10.6 GHz from generic UWB applications".

[6] CEPT/ECC Report 23: "Compatibility of automotive collision warning Short Range Radar operating at 24 GHz with FS, EESS and Radio Astronomy".

[7] CEPT/ECC Report 56: "Compatibility of automotive collision warning Short Range Radar operating at 79 GHz with radiocommunication services".

[8] CEPT/ERC Report 25: "The European table of frequency allocations and utilisations covering the frequency range 9 kHz to 275 GHz" Lisboa January 2002 - Dublin 2003 - Turkey 2004 - Copenhagen 2004 - Nice 2007.

[9] CEPT/ECC Report 114: "Compatibility studies between multiple GIGABIT wireless systems in frequency range 57-66 GHz and other services and systems".

[10] EC/EFTA Mandate M/407: "Ultra-Wideband Equipment".

[11] Andrzej Kraszewski: "Microwave Aquametry" from IEE press 1994.

[12] ETSI EG 201 788 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guidance for drafting an ETSI System Reference Document".

3 Definitions and abbreviations

3.1 Definitions

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

beat frequency: frequency difference between the transmitted and instantaneously received signal in FMCW

duty cycle: total accumulated transmitter activity time within one hour within any specific bandwidth of 1 MHz

FMCW radar: carrier- based radar system using a frequency modulated continuous wave

pulse radar: carrier- based radar system transmitting and receiving short RF pulses

range resolution: ability to resolve two targets at different ranges

3.2 Abbreviations

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

APC	Adaptive Power Control
CEPT	European Conference of Post and Telecommunications
dB	decibel
dBc	decibel relative to carrier power
e.i.r.p.	equivalent isotropically radiated power
EC	European Commission
ECC	Electronic Communications Committee
ERC	European Radiocommunications Committee
ETSI	European Telecommunications Standards Institute
FMCW	Frequency Modulated Continuous Wave
ITU	International Telecommunications Union
LPR	Level Probing Radar-sensor for use outside metallic and similar shielding tanks
LR	Level Radar category including both LPR and TLPR
RF	Radio Frequency
SRD	Short Range Device
SRDoc	System Reference Document
TLPR	Tank Level Probing Radar-sensor
UWB	Ultra Wide Band

4 Comments on the System Reference Document

No statements have been received on the present document after the ETSI ERM correspondence approval procedure.

5 Executive summary

5.1 Background information

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.

LPRs are the preferred measurement tool to achieve the above goals for the following reasons:

- due to the requirement of having non- contact measurement means because of large level variations, aggressive substances or extreme temperature/conditions;
- since other alternative solutions (e.g. ultra- sonic or optical) are too sensitive to contamination or other process conditions;
- since metallic coating of enclosure structure is not possible (e.g. plastic or glass tanks) because of chemical reactions by aggressive substances.

5.2 Market information

There is already an established LPR market and certain level measurements cannot be performed by other means than LPR.

LPR represent an industrial niche market and should not be considered as a mass market. They cannot be used for communications purposes. An economic benefit results from the introduction of LPR devices in industrial processes.

From a marketing point of view, the Level Radar (LR) market consists of both LPR and TLPR. Sales of LPR are low at this moment since certification is a major problem due to lack of both an appropriate harmonized standard and regulation. Therefore, there is an increase of about 20 % of the total European addressable market for level probing radars, if suitable European harmonized conditions for the availability and use of radio spectrum for LPR could be found in Europe. A harmonized approach would greatly facilitate installation of LPR throughout Europe.

As Level Radar (LR) is a non-contacting level measurement technology, it has proven to be a robust, reliable and accurate in many industrial environments. For this reason, Level Radar is replacing traditional contacting level measurement technology at a rapid pace. The world wide market in 2005 for Level Radar was Euro 250 million and is projected to grow to Euro 660 million by 2015 (approximately 450 000 units). It is expected that Europe comprises 40 % of the worldwide market. Additionally, LPR will be 10 % to 20 % of the total market. In 2015 the installed base of LPR units covered by the present document is projected to be approximately 36 000 units.

Detailed market information is given in annex A.

5.3 Radio Spectrum requirements and justification

Currently, there are no European harmonized conditions for availability and use of radio spectrum for LPR. So far, LPR have been operated under individual licence and notifications (article 6.4 of the R&TTE Directive).

The applications for LPR are very diverse. From a radar signal reflection point of view, it ranges from highly absorptive low dielectric granulates to well reflective liquids such as water. The application circumstances vary from smooth surfaces to very rough and scattering surfaces. Therefore, the wide variety of applications demands the use of several frequency bands. From a radar sensor resolution and accuracy point, a wide frequency band is required. This results in the request of use for LPR of the following 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.

Detailed technical information is given in annex B.

5.4 Current Regulations

The current general position on the common spectrum designation for TLPR for countries within the CEPT is given by CEPT/ERC Recommendation 70-03 [1], annex 6. However, for LPR, no current European harmonized conditions for availability and use of radio spectrum are in existence.

So far, LPR have been operated under individual licence and notifications which vary from country to country, if possible at all in a specific country. So far, no reported cases of interference to other spectrum users are known.

6 Foreseen limits in the Harmonized Standard

Under all circumstances LPR-sensors are expected to be designed to meet the emission limits proposed in this clause and to reduce the risk of interference with other spectrum users by use of Adaptive Power Control to match the highly variable application circumstances and in essence always are pointed downwards. Additionally, the duty cycle is extremely low, and an aggregation effect of LPR-sensors is unlikely.

6.1 Radiated power (e.i.r.p.) in the LPR main lobe

The radiated power (e.i.r.p.) is defined as the downwards emitted power of the LPR including antenna gain. The limits in table 6.1 for radiated power (e.i.r.p.) in the LPR main lobe (i.e. in front of the LPR antenna) are planned to be added to the ETSI Harmonized Standard:

Table 6.1: Radiated peak and mean power limits in the LPR main lobe

Frequency band of operation (see note 1)	Peak radiated power (e.i.r.p.) (see note 3)	Mean radiated power (mean e.i.r.p.) (see note 2)
6 GHz to 8,5 GHz	+24 dBm	+1 dBm
24,05 GHz to 26,5 GHz	+43 dBm	+20 dBm
57 GHz to 64 GHz	+43 dBm	+23 dBm
75 GHz to 85 GHz	+43 dBm	+23 dBm

NOTE 1: -20 dBc bandwidth.
NOTE 2: The mean power is determined as the conducted power (dBm) as measured with a true RMS power meter, (e.g. bolometer etc), during normal operating conditions. The measured value is corrected by adding the LPR antenna peak gain (dB).
NOTE 3: The peak power is determined by adding the duty cycle factor 10 log ($1/D_X$) to the measured mean power value.

NOTE: Notes 2 and 3 in table 6.1 are assuming that the LPR is designed for use in petrochemical, chemical or gas industry hazardous atmospheres. The design therefore meets an intrinsic safety specification which includes a power supply made for very low currents only. In this case it is not possible to disable the duty cycle of the equipment.
However, in cases where the hardware allows the duty cycle to be disabled (i.e. continuous transmitter signal) the peak power can be measured with disabled duty cycle.

6.2 Maximum Emission (e.i.r.p.) outside a defined half sphere area

Due to huge variations in the environment, it is envisaged that the Harmonized Standard will include requirements to control the LPR emission levels by an Adaptive Power Control (APC) to avoid interference to other services and applications. This concept allows for coexistence with radio services and applications by controlling the maximum interference levels by using a geometry defined in figure 6.1 in combination of an adaptive power control.

The effective power level limits in the different bands that are needed for reliable radar operation with state of the art technology are summarized in table 6.2.

Table 6.2: Proposed parameters outside the half sphere

Frequency band (-20 dB bandwidth)	Maximum -3 dB antenna beam-width	Adaptive Power Control (APC)	Max Duty cycle	Max. emission (power spectral density) outside the half sphere area in 1 MHz bandwidth (mean e.i.r.p.) (see note)
6 GHz to 8,5 GHz	± 15°	Yes	0,5 %	-41,3 dBm
24,05 GHz to 26,5 GHz	±8°	Yes	0,5 %	-41,3 dBm
57 GHz to 64 GHz	±4°	Yes	1 %	-41,3 dBm
75 GHz to 85 GHz	±4°	Yes	1 %	-41,3 dBm

NOTE: The reference point for the limit includes:
a) The reflected power spectral density from the target.
b) Emitted side lobes through the virtual boundary see figure 6.1.