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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band technology (UWB); Part 2: Ground- and Wall- Probing Radar applications; System Reference Document

Reference
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Foreword

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

The present document is part 2 of a multi-part deliverable covering Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band technology (UWB), as identified below:

Part 1: "Communications applications";

Part 2: "Ground- and Wall- Probing Radar applications; System Reference Document".

Introduction

Ultra Wide Band is a new emerging SRD technology with potential benefits for security applications, consumers and businesses. There are at least three separate groups of probing radar applications:

- Ground Probing Radars (GPR);
- Wall Probing Radars (WPR); and
- Through-Wall Probing Radars (TWPR).

The emphasis in the present document is clearly put on the commercial use of Ground Probing Radars and Wall Probing Radars. The market information and figures in annex A of the present document apply only to GPR and WPR.

Ground Probing Radars or also named Ground Penetrating Radars, as both terms are accepted and used internationally, operate only when in contact with or within close proximity of the ground for the purpose of detecting or obtaining the images of buried objects. Wall-Probing Radars or also named Wall Penetrating Radars, are designed to detect the location of objects contained within a wall. This includes examining a concrete structure, e.g. the side of a bridge or the wall of a mine.

Commercial application of UWB technology for Ground Probing Radars and Wall Probing Radars are expected to operate between 30 MHz and 12,4 GHz with a very high bandwidth and a very low radiated power density. In addition, some applications for e.g. glacier sounding or usage in hydrogeology additionally use frequencies down to 1 MHz.

Through-Wall Probing Radar applications are only included in the present document as a matter of completeness. These are normally only considered for military agencies and governmental services usage. Through-Wall Probing Radars can detect the location or movement of persons or objects that are located on the other side of a structure such as a wall. Possible commercial use of this application or its usage by the public is not described and addressed in the present document. Therefore, Through-Wall Radars should be recognized as a unique class of device distinct from GPR/WPR. For Through-Wall Probing Radars (TWPR) the band of operation is from 3,1 GHz to 10,6 GHz. Post-911, there are also some low-frequency TWPR activities which are not addressed in the present document as it is believed that this work is being undertaken under military regime.

In addition, GPRs are also used in underground excavations, mines and drill holes where leakage of signal into the air is virtually impossible. Higher powers for equipment which intended use is not to be operated in the open air can be beneficial. This should also be taken into account.

The present report includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT) for amending the ERC Recommendation 70-03 [1].

1 Scope

The present document provides information on the intended applications, the technical parameters and the radio spectrum requirements for UWB Ground- and Wall Probing Radar equipment operating in the frequency band from 30 MHz to 12,4 GHz. It describes Ground Probing (GPR) and Wall Probing (WPR) systems that are used in survey and detection applications. These applications require wide frequency bandwidths that cannot be provided by alternative technologies and/or at spot frequencies.

The scope is limited to radars operated as short range devices (because of their usage and design), in which the system is in close proximity to the materials being investigated. It does not include radars operated from aircraft or spacecraft which may sometimes be referred to as GPRs but do not fall into the category of short range devices.

The radar applications in the present document are not intended for communications purposes. Their intended usage excludes radiation into the free space, unlike for UWB communications equipment.

Additional information is given in the following annexes:

- annex A: detailed market information;
- annex B: technical information;
- annex C: expected 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.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

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

[2] ITU-R SG1 TG1-8 Report from the 1st meeting of ITU-R SG1 TG 1-8, Geneva 21-24 January 2003 (Document 1-8/047).

[3] FCC 03-03: "Revision of Part 15 of the Commission's Rules Regarding UWB Transmission Systems".

[4] CENELEC EN 55022 (1998): "Limits and methods of measurement of radio disturbance characteristics of information technology equipment".

[5] ITU-R Radio Regulations.

[6] Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-personnel Mines and on their Destruction, available via http://www.mineaction.org/.

[7] CISPR/I/105/CDV: "EMC of information technology, multimedia equipment and receivers", date of circulation 2004-04-30, closing date for voting 2004-10-01.

[8] CISPR/I/106/CDV: "EMC of information technology, multimedia equipment and receivers", date of circulation 2004-04-23, closing date for voting 2004-09-24.

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

[10] ETSI EN 302 065: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band technology (UWB) for communications purposes".

[11] ETSI EN 302 066: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band technology (UWB) for purposes other than communications".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

deactivation switch: function of the equipment which deactivates the equipment when normal use is interrupted

range resolution: ability to resolve two targets at different ranges

3.2 Symbols

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

c	velocity of light in a vacuum
δR	Range resolution
δt	time interval between the arrival of two signals from targets separated in range by δR
E_R	relative dielectric constant of earth materials
T_P	pulse rise time

3.3 Abbreviations

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

A/D	Analogue to Digital Converter
APMBC	Antipersonnel Mine Ban Convention
BW	Bandwidth
CEPT	European Conference of Post and Telecommunications Administrations
dB	decibel
ECC	Electronic Communications Committee
Euro-GPR	The European GPR Association
GPR	Ground Probing Radar, Ground Penetrating Radar, Sub-surface Radar or Ground Radar
ISM	Industrial, Scientific and Medical
PRF	Pulse Repetition Frequency
SRD	Short Range Device
TEM	Transverse Electromagnetic wave
TWPR	Through-Wall Probing Radar
UWB	Ultra Wide Band
VHF	Very High Frequency
WPR	Wall Probing Radar

4 Executive summary

The present document provides a basis for a general, non-individual, licensing arrangement for probing radar systems, replacing the system of temporary or experimental licences that has been in use in parts of Europe for many years.

Despite the restriction that these licences have placed upon the development of such systems, they are now internationally used for a wide range of applications where information about objects is not readily obtainable by other means. Apart from reducing risk and accidents, GPR often has a pivotal role in the economic direction of major infrastructure projects. It also has a major potential role in areas like detection of anti-personnel mines.

The objective of designers and operators of radar equipment is to direct signals into earth materials and not to allow radiation into the air where reflections cause unwanted responses. The required signals necessarily demand a high bandwidth to provide sufficient depth resolution. Earth materials act as low pass filters and in order to maximize the information from the ground, equipment are designed and selected to match local ground conditions. This leads to a wide variation in equipment bandwidth.

Given the similarity in bandwidth and the unwanted nature of radiations into the air, the present document proposes that a general EMC standard should be used to specify the radiation from GPR and other probing radar systems. This essentially follows the situation that has been carefully implemented and monitored in the UK by the Radiocommunications Agency/OFCOM and the European GPR Association (Euro-GPR).

GPR and other probing radar equipment does not communicate any information via the radar signal to any other equipment, therefore no protocol communications standard is required for all probing radars.

Market information, technical information including the required spectrum, and a discussion of compatibility issues are presented in the annexes of the present document.

4.1 Status of the present document

Draft version 1.1.1_1.0.1, prepared by ERM TG31A, was discussed at ERM RM # 27. The preliminary draft V1.1.1_1.0.4 was forwarded to the ECC for information. An ERM-RM approval by correspondence was initiated. Comments received during part of the ERM-RM initial collection of comments (until July 15th, 2004) were discussed at ERM TG31A#8bis meeting, July 6th, 2004. The version 1.1.1_2.0.8 was approved by ERM-RM and forwarded to ECC-TG3.

The present document was amended by ERM#33 in November 2007.

4.2 Market information

For detailed market information, see annex A.

4.3 Technical system description

For detailed technical UWB information, see annex B.

5 Current regulations

There are no current regulations permitting the operation of UWB in Europe.

Article No. 4.4 of the Radio Regulations [5] has been relied upon by national administrations (and CEPT as well) in many contexts to authorize applications not conforming with the Table of Frequency Allocations in the Radio Regulations (e.g. Short Range Devices which are operated in ISM frequency bands). UWB equipment, as described in the present document, might also be operated under Article RR No. 4.4.

The status of radio licensing of GPR within Europe is highly variable between different member states. This has been a major hindrance to the EC's investment in GPR for anti-personnel mine detection.

In the UK GPRs operate on a temporary use licence and temporary arrangements negotiated by the European GPR Association (Euro-GPR) for its members. These were implemented on the basis of allowing limited and supervized use while working out a more regular arrangement.

The U.S.A has specified radiation limits for Through-Wall Probing Radars in FCC 03-03 [3].

6 Main conclusions

The systems described in the present document have a major role to play in security and sustainability of life, including civil engineering, environmental management and anti-personnel mine detection.

These systems are diverse because of the range of applications. In particular the GPR systems do not readily fit into established radio licensing requirements.

The users of GPR and WPR are normally professional service providers, scientists, and engineers.

7 Expected ECC actions

Mandate M/329 covering UWB calling for completion of Harmonized Standards for UWB by the end of the year 2004 was received by ETSI. ETSI accepted this mandate (see EN 302 065 [10] and EN 302 066 [11]).

Therefore, ETSI requests ECC to consider the present document, which includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT) for amending the CEPT Recommendation 70-03 [1].

Therefore, ETSI asks CEPT-ECC to perform the relevant studies to determine whether the emissions described in the present document are appropriate to protect all the other radio services and to provide the practical measures to ensure the protection of all other radio services in the band from 30 MHz to 12,4 GHz.

ETSI believes that procedures for administrating and ensuring adherence to regulations should be kept minimal both for the regulator as well as for the users of GPR and WPR. A possible way of managing proper use is to mandate that user training occur and/or to limit usage to trained/professional providers.

It should be stressed that the present document contains information not yet considered in the currently on-going co-existence studies within CEPT-ECC spectrum engineering project team SE24.

Annex A: Detailed market information

A.1 Range of applications

The use of GPR has grown exponentially since the early 1980's, and the technology is now central to security and sustainability aspects of civil engineering, environmental management and humanitarian mine clearance and for purposes associated with, for example, law enforcement, fire fighting , emergency rescue, scientific research, commercial mining and construction.

The total value of surveys using GPR may seem relatively low in comparison with other users of the radio spectrum, but the impact of the technique in safety critical applications, and the impact of investigations on the planning and execution of very high value construction and development projects should be considered.

Advanced systems, often linked to radionavigation systems data, enable unrivalled options for inspection and assessment of major infrastructure such as highways, bridges, railways, tunnels and airports. The technique delivers safety, technical, economic, environmental, and humanitarian benefits. A number of example applications are summarized below.

Highway inspection

Applications include:

- Determining highway pavement construction type and thickness.
- Mapping defects such as voids, moisture or cracking.
- Quality assurance on construction projects, such as checking the effectiveness of new sustainable practices such as pavement material recycling and soil stabilization, which greatly reduce energy use and landfill demand.

This information is widely used by government agencies, local authorities, and the consultants responsible for highways. At least 10 000 km of highway are surveyed per year within Europe. Surveys can be conducted from vehicles driven at a traffic speed that does not disrupt traffic flows and does not require road closures. Such closures are required for alternative methods such as core drilling and are known to multiply the risk of road traffic accidents by a factor of 10. Other key benefits are:

- Effective targeting of funding for maintenance and repair.
- More accurate analysis of other test data.
- Reduced waste of construction materials: accurate knowledge of existing materials enables selection of what to leave intact, what to remove, and what to overlay.
- Reduced damage to the structure, such as that caused by core drilling or "trial holes".
- Determination of materials suitable for recycling.

Airport runway inspection

Applications include:

- Recording runway and taxiway pavement construction type and thickness.
- Mapping defects such as voids, moisture, or cracking.
- Targeting funding for maintenance and repair.