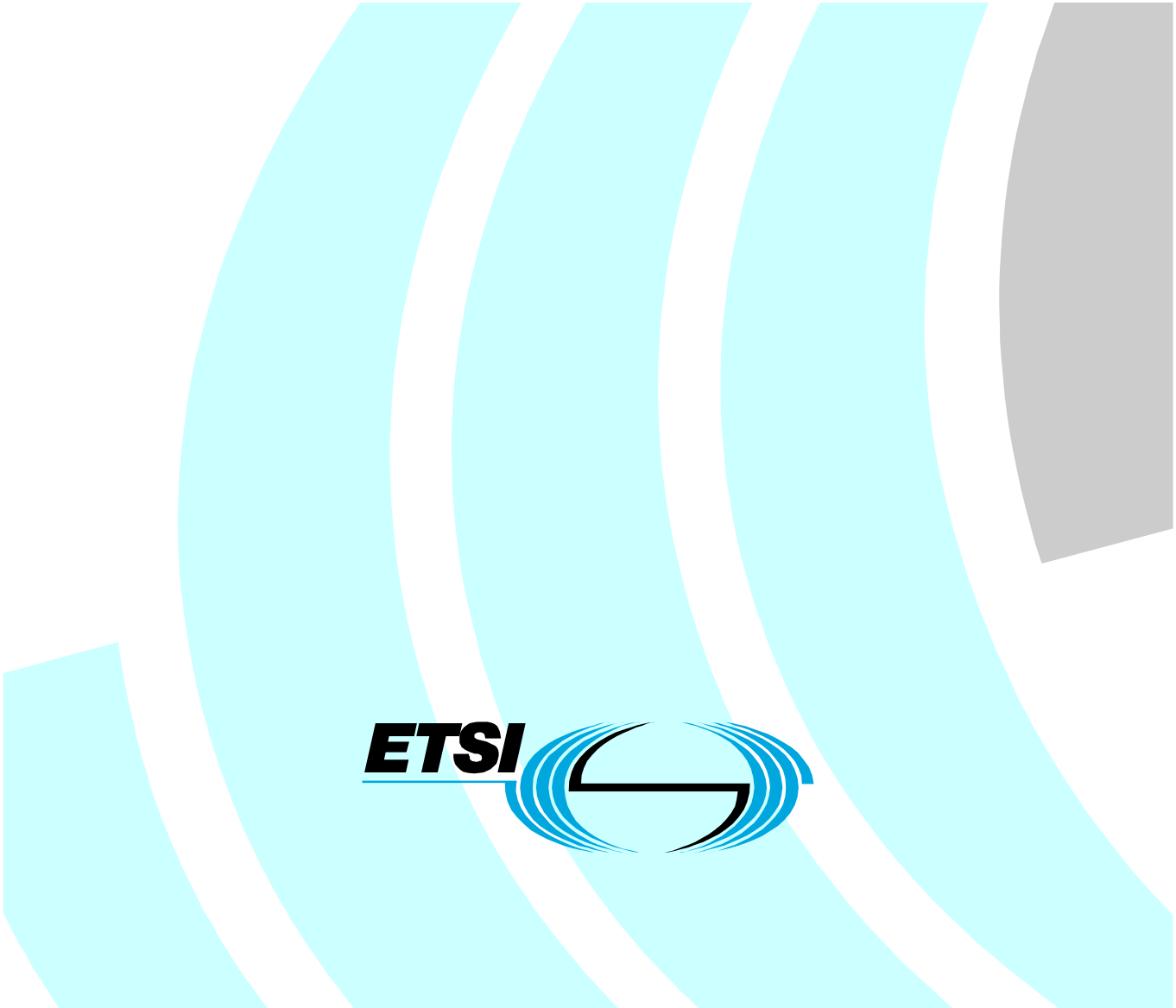
ETSI TR 102 495-2 V1.1.1 (2006-05)

Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB); System Reference Document Part 2: Object discrimination and characterization applications operating in the frequency band 2,2 GHz to 8 GHz



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Contents

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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) System Reference Documents; Technical characteristics for SRD equipment using Ultra Wide Band technology (UWB) for sensor applications as identified below:

Part 1: "Building material analysis and classification applications operating in the frequency band from 2,2 GHz to 8 GHz";

Part 2: "Object Discrimination and Characterization applications operating in the frequency band from 2,2 GHz to 8 GHz";

Part 3: "Location tracking applications operating in the frequency range from 6 GHz to 9 GHz";

Part 4: "Object identification for surveillance applications operating in the frequency band from 2,2 GHz to 8 GHz".

Introduction

Ultra wide band sensors enable a new generation of devices, allowing the identification and classification of objects, in addition to detecting their presence and position. The operation is contactless and can work over a short distance, even if the object is hidden by an obstacle.

Applications for such devices are widespread. The following list gives an overview:

- Position detection and identification of human extremities for safety devices in potentially dangerous tools.
- "Break through" protection and direct contact avoidance for building work.
- Detection of weapons and explosives (handheld operation for detection at short distances).
- Short distance material classification applications in an industrial environment.

Frequencies in the lower GHz range are prerequisite for such a kind of object classification, allowing the electromagnetic wave to penetrate objects like cloth or human tissue. The wave penetrating an object returns much more information (such as inhomogenities, object composition, dielectricity, etc.) about the object than just the surface reflection. A certain bandwidth is required to receive a characteristic response from the target and to ensure sufficient resolution needed for target separation.

The present document is intended to include necessary information to be forwarded to the Electronic Communications Committee (ECC) under the MoU between ETSI and the ECC.

1 Scope

The present document provides information on the intended applications, the technical parameters and the radio spectrum requirements for UWB object classification equipment operating in the frequency band from 2,2 GHz to 8 GHz.

The applications which will operate in close proximities can be divided in 3 different categories:

Category 1: User-safety relevant application

- Sensing and position detection of human tissue (extremities) for user- safety applications, e.g. for tooling equipment (table top saw).
- Measure the thickness of materials and penetrate materials for "Break through" protection and avoid direct contact for building, construction type work (e.g. drilling machine); pre-impact detection.
- Medical applications such as heart beat and breathe sensing.

Category 2: Material analysis in industrial environments

Category 3: Detection of weapons and explosives in public environments

- Body scan using handheld devices.
- For weapons and explosives in public buildings (body scan using handheld devices).

The present document includes necessary information to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT), including:

- Detailed market information (annex A).
- Technical information (annex B).
- Expected compatibility issues (annex C).

The present document does not cover through-wall, building material analysis and classification and ground probing radar devices.

2 References

For the purposes of this Technical Report (TR) the following references apply:

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

[2] CEPT/ERC Report 25: " The European table of frequency allocations and utilisations covering the frequency range 9 kHz to 275 GHz".

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

[4] ETSI TR 102 495-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB); System Reference Document Part 1: Building material analysis and classification applications operating in the frequency band from 2,2 GHz to 8 GHz".

[5] DIN EN 45694: "Mechanical vibration - Guideline for the assessment of exposure to hand-transmitted vibration based on information provided by manufacturers of machinery".

[6] Sachs J.; Peyerl P.; Zetik R.; Crabbe S.: "M-Sequence Ultra-Wideband-Radar: State of Development and Applications," Radar 2003, Adelaide (Australia), pp. 6, September 2003.

[7] Egil S. Eide: "Radar Imaging of Small Objects Closely Below the Earth Surface", PhD from Norwegian University of Science and Technology, NTNU, Trondheim, 2000.

[8] "Visible Human Project". http://www.nlm.nih.gov/research/visible/

[9] "U.S. Consumer Product Safety Commission". http://www.cpsc.gov/

[10] "Final report of the safety Working Group on road safety"; Directorate-General for the Information Society of the European Commission.

[11] Federal Communications Commission: "Supplement 5 to OET Bulletin 65". http://www.fcc.gov

[12] Holzberufsgenossenschaft Deutschland.

3 Definitions and abbreviations

3.1 Definitions

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

activity factor: reflects the effective transmission time ratio

clutter: undesired radar reflections (echos) e.g. from inhomogenities, interfaces, etc.

pre-impact detection: "Break through" protection and direct contact avoidance for building work

spatial resolution: ability to discriminate between two adjacent targets

3.2 Abbreviations

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

CEPT	Conference Europeenne des Administrations de Postes et des Telecommunications
CW	Continuous-Wave
dB	DeciBel
dBm	DeciBel relative to 1 mW
e.i.r.p.	equivalent isotropic radiated power
e.r.p.	Effective Radiated Power
ECC	Electronic Communications Committee
ITU-R	International Telecommunications Union-Radio sector
MoU	Memorandum of Understanding
PN	Pseudo Noise
PSD	Power Spectral Density (dBm/Hz)
RF	Radio Frequency
SRD	Short Range Device
UWB	Ultra Wide Band

4 Executive summary

The present document describes a new generation of devices using Ultra Wide Band technology for object classification applications operating in close proximity to objects at distances up to 40 cm.

Such devices will lead to significant user-safety improvements in critical areas e.g. manual operation and material handling close to potentially dangerous tools, public building security, enhanced quality assessment, and to provide potentials savings in medical applications. In consequence, a significant socio-economic benefit results from the introduction of these devices.

A reliable object discrimination and characterization is required. This can be achieved by using UWB technology. A high bandwidth provides the required accuracy in combination with sufficient radiated power to receive characteristic responses from objects.

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

4.1 Status of the present document

The present document was first presented as RM30(05)38r1 and reviewed since in view of the sensor technology updates and compatibility studies based on ECC TG3 work.

The present document was finally adopted at ERM RM#32 in Dublin in January 2006. It will be submitted to ERM#28 for approval for publication.

4.1.1 Comment from MINEFI - France

MINEFI-France favours the compliance of UWB with the general regulation currently developed by CEPT and would prefer to avoid the multiplication of specific regulations for sub-sets of UWB application.

4.1.2 Comment from France Telecom

France Telecom suggests that ETSI UWB task groups fully take the work carried out by ECC-TG3 into consideration. At this stage, France Telecom expresses its reservations concerning certain emission powers levels, proposed frequency ranges and potential of interference of systems operating in other bands.

4.2 Market information

For detailed market information, see annex A.

4.3 Technical system description

For detailed technical information, see annex B.

5 Current regulations

There are no current regulations permitting the operation of these new short range applications in Europe.

The present draft ECC decision for UWB communications is not applicable since lower frequencies are needed (> 2,2 GHz) to penetrate the objects, e.g. human body or wet materials.

The FCC has released an UWB regulation in 4/2002 and the last revision was published in 04/2005 [3].

6 Proposed regulations

Based on the needs of the intended applications described in the scope of the present document, the following limits are proposed as input values for the ongoing discussions and considerations in ECC-TG3.

Table 6.1: Proposed regulation

Frequency (GHz)	Maximum average PSD (e.i.r.p.) [dBm/MHz]	PRF [MHz]	Category
2,2 to 8	-50	> 5	1 and 3
2,2 to 8	-60	> 5	2
NOTE 1: For more details see clause B.1.1. NOTE 2: PRF is applicable for pulsed UWB devices.			

The proposed regulation should be a general (non-individual) licensing arrangement for category 1 and 3, whereas individual licensing/notification requirements may be possible for category 2. It is also proposed that the regulation may contain appropriate mitigation requirements.

The mitigation factors to be considered for the different categories are:

All categories:

- Very short operating range, usage only in close proximity to the object.
- Presence and position detection of different materials (i.e. triggered by a separate detection technology such as a light beam).
- Integral antenna only.
- Listen-before-transmit functionality (LBT) as well as duty cycle restrictions which are in line with the operational requirements of the application requirements may be employed.

NOTE 1: Possible Listen-before-talk and duty cycle restriction need to be investigated in ECC TG 3.

Category 1 (user safety relevant applications):

- Handheld or portable operation only (fixed or combined with the tools to be used).
- Focused emissions for close proximity operation with possible shielding.
- Fixed installation in tooling type equipment only.
- Additional for the applications: Proximity Sensing of Human tissue and "break through" protection and direct contact avoidance for building and construction type work:
  - usage in noisy environment;
  - activation only when the tool is activated simultaneously.

Category 2 (industrial environment):

- Fixed installation only.
- Focused emissions for close proximity operation.
- Shielding is mandatory.

NOTE 2: Higher unit numbers within restricted industrial areas could be expected.

Category 3 (weapon and explosive detection application):

- Handheld and manual operation.

7 Main conclusions

The systems described in the present document offers a unique way for contactless gathering of information about one or several objects. Such information include:

- position, distance and size;
- material characteristics like complex permittivity.

Such devices will lead to significant improvements in areas like the operation of dangerous tools, to enhance user-safety, public building security, enhanced quality assessment, and provide saving potentials in medical applications. In consequence, a socio-economic benefit results from the introduction of these devices.

8 Expected ECC and ETSI actions

Mandate M/329 was received by ETSI, calling for release of candidate Harmonized European Standards for UWB.

ECC-TG3 continues the work under revised ToR. This work includes UWB imaging devices such as UWB sensors.

ETSI requests ECC to consider the present document, which includes necessary information under the MoU between ETSI and the ECC for a regulatory framework.

ETSI asks CEPT-ECC to perform the relevant compatibility studies to determine whether the emissions and mitigation factors described in the present document are appropriate to protect all the other radio services.

It is proposed that ECC will create a new ECC decision for these applications.

A draft Harmonized European standard for the equipment covered by the present document is under development in ETSI ERM TG31C.

Annex A:
Detailed market information

A.1 Range of applications

Ultra wideband sensors enable a novel class of applications, allowing the identification and classification of objects, additionally to detecting their presence and position. Such sensors also allow the monitoring of the status of an object or a person. A number of examples for applications are summarized below.

Category 1:

Application A: Proximity Sensing of Human tissue

- Detection of small objects like a finger or other extremities in the presence of obstacles (e.g. wood), positioned close to a hazard like a saw blade.
- Applications typically for consumer market, like safety devices for power tools or dangerous machines.
- Usage in close proximity to hazard area (0 cm to 40 cm).

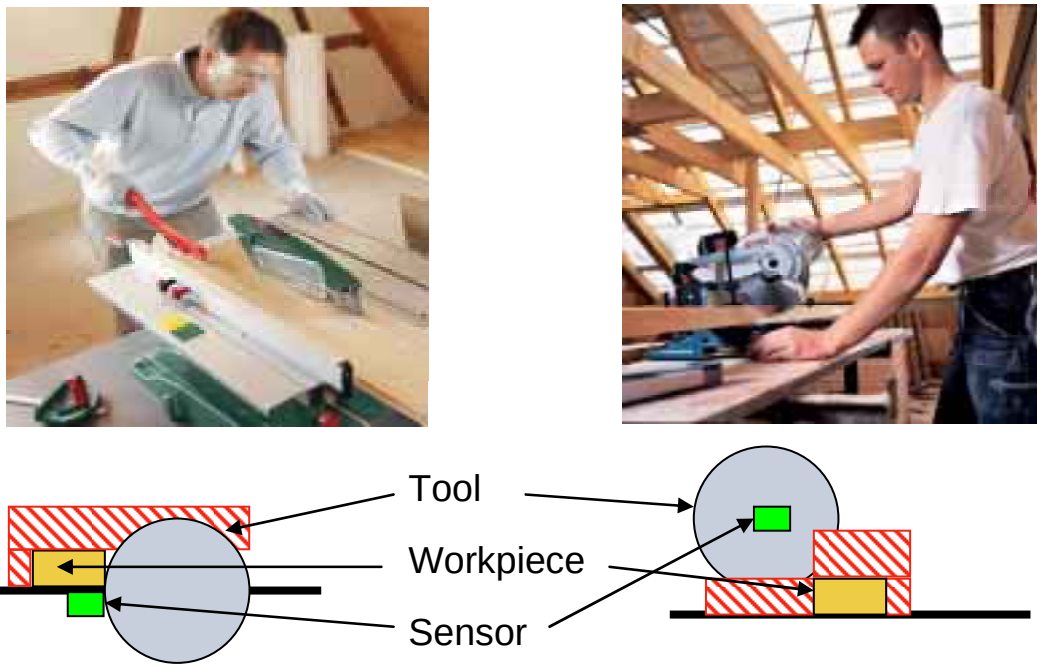


Figure A.1.1: Saw Scenario

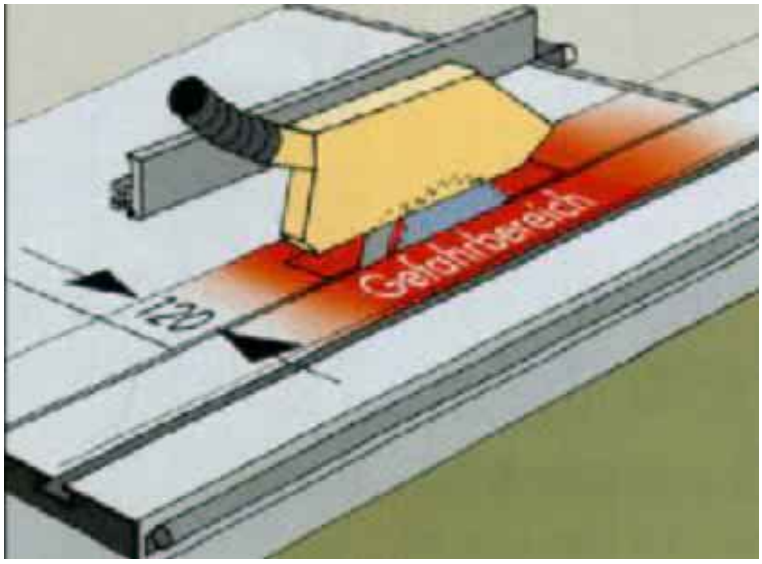


Figure A.1.2: Table top saw blade

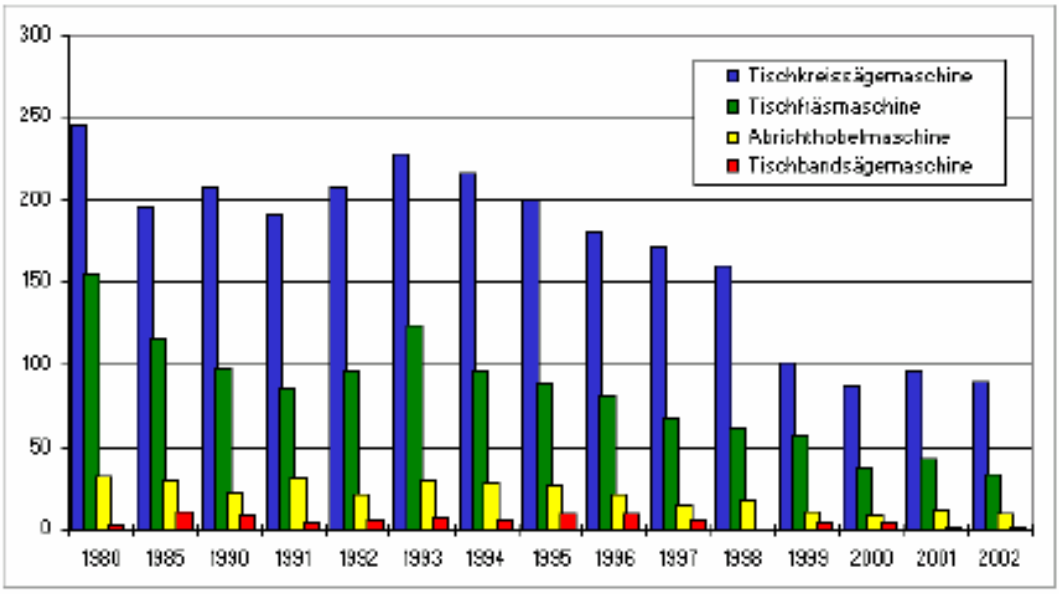


Figure A.1.3: Injuries from accidents in Germany [12]

U.S. hospitals treated an estimated 37 000 injuries resulting from table saw use in 2003 alone. More than three-quarters of injuries resulted from contact with the blade, including 4 100 amputations, according to the Consumer Product Safety Commission. The agency estimated the cost of table saw injuries in 2001 at nearly $2 billion [9].

Application B: "Break through" protection and direct contact avoidance for building work

The application will be used for high end drilling and percussion drilling machines. It is planned to mount it directly to the tool. A parallel usage is possible. The UWB sensor application monitors the drilling process and controls the drilling machine also depending on the inhomogenities in the material. The user will be warned acoustical or optical if a collision with unexpected objects inside the material (e.g. gas- water pipes or electric cables) may happen.

The UWB application may be active synchronously to the operation of the drilling machine which will be supported by this application.

Figure A.1.4: "Break through" situation

Application C: Life sign monitoring in a clinical environment

Medical applications such as heart beat and breathe sensing.

Possible application scenarios can be:

- Child protection inside the bed (cot death).
- In-patient monitoring inside bed.
- Monitoring of the unborn child.
- Monitoring of persons at risk (sensor on the human body).

Figure A.1.5: Monitoring for medical applications

Category 2 : Material Analysis in industrial environments

- Analysis of mass, water and ingredient concentration.
- Applications like quality control in industrial packaging for food or medical goods.
- Sensoring area screened against surrounding area.
- Usage in close proximity to sample (< 40 cm).

Figure A.1.6: Material Analysis for Packaging

Figure A.1.7: Sensor scenarios / industrial environment

Category 3: Detection of weapons and explosives

- Entrance surveillance in public building like airports.
- Applications for professional market.
- Indoor use and limited outdoor use at the entrance of a building or public area.
- Operating range < 40 cm for close by manual inspection.

Figure A.1.8: Handheld metal detection / airport

A.2 Market size and value

There is a certain demand for such devices in the European and global markets. The largest markets are driven by consumer applications such as proximity sensing as safety devices and object identification for security surveillance.

Category 1:

Application A: Proximity Sensing of Human tissue (benchtop tools)

Table A.2.1: Total Market size per year in Million Euro

Benchtop tools Market (in mio EUR) (see note)			
Year	2004	2009	2014
Europe	579	665	746
World	1 410	1 608	1 807
NOTE: Market analysis Bosch GmbH 2005.			

The price range is between 300 € and 700 €/device depending of feature class. An average of 500 € is taken into account.

Table A.2.2: Total Market size per year in Million devices

Benchtop tools value (in mio devices)			
Year	2004	2009	2014
Europe	1 160	1 330	1 490
World	2 820	3 210	3 650

It is assumed that only the high end product range (30 %) will be equipped with this application. This leads to 400 000 devices/year in whole Europe.

Table A.2.3: Trades in the building sector

In 2004	Germany (see note)	Europe (extrapolated)
a. Construction trades	7 300	44 000
b. Building industry	8 500	52 000
total	15 800	96 000
NOTE: http://www-ec.destatis.de.		

It is assumed that 30 % of the devices will be used by DIY (130 000). The remaining 270 000 will lead to approximately 3 devices per enterprise.

The stock of such tools in Europe is approximately 4 millions. Replacement per year 35 %. Market grow about 3 %/year. The Lifetime of devices is in minimum between 50 h and 200 h.

Application B: Pre-impact/"Break through" protection and direct contact avoidance for building work

Drilling machine market volume in Europe (2004)

- Hammer drill 2-4 kg (weight of the hammer): 1 018 000
- Hammer drill 5 kg (weight of the hammer): 328 000
- Percussion drill: 1 200 000
- Total: 2 546 000
- Thereof 30 % premium range tools which are considered here: 760 000

The typical life time of the drilling machines is between 50 h and 200 h.

Loudness level (Noise level): acoustic pressure between 90 dB and 99 dB; acoustic power between 100 dB and 112 dB.

Category 2: Material analysis in industrial environments

Material flow supervision on an assembly line in a fixed installation.

- < 100 sensors per production hall.
- ~ 10 000 production halls.
- ~ 1 000 000 screened sensor units expected.

Category 3: Detection of weapons and explosives

The market for professional use consists of body scan applications for the detection of weapons and explosives in safety areas (borders, custom, airports, public buildings) using handheld devices.

A.3 Traffic evaluation

Category 1:

Application A: Proximity sensing of human tissue and material analysis

The daily usage is assumed to be 0,4 h which leads to 500 days lifetime or 2,5 years (5 days/week). This is also the replacement time of such a tool. It is assumed that the DIYs will have the same "activity factor" as the professionals.

0,4 h/ usage time during 12 h leads to an activity factor of 3 %.

Application B: Pre-impact application

- Activity: - operation time of 0,4 h/day.
- Others: - range < 40 cm

Table A.3.1: Daily usage [4]

Type of machine	Craft enterprise [h/day]	Light industry [h/day]
Drilling < 4 kg	0,25	0,5
Drilling ≥ 4 kg	0,25	0,5
Percussion drill	0,15	-
Total average	0,25	0,5

Table A.3.2: Drilling velocity [cm/s]

Type / drill bit diameter [mm]	8	14	18	20	25	30	35	40	55	100
Type 1	70	38	24	-	-	-	-	-	-	-
Type 2	-	-	-	29	24	15	12	7	-	-
Type 3	-	-	30	29	24	23	21	13	6	4

An average using time of 20 min/12 h is assumed.

The activity factor is comparable to the TR 102 495-1 [4] Building Material analysis with 0,28 %.

Category 2: Material analysis in industrial environments

Activity: (= total operation time) up to 24 h/day

Activity factor ≤ 100 % -

Range ≤ 40 cm

- Indoor usage.
- Controlled environment.
- Licensing possible.
- Electromagnetic shielding in the sensor application area is possible.

Category 3: Detection of weapons and explosives

- Activity: - operation time 24 h/day
- Activity factor - 5 min/h = 8 %

Annex B:
Technical information

B.1 Detailed technical description

The short range classification applications described in the present document can be realized using different approaches. For example a direct pulse-based base band method can be used. Other approaches may be a PN coded digital modulation with a certain mid frequency.

A simple block diagram of a generic UWB sensor system.

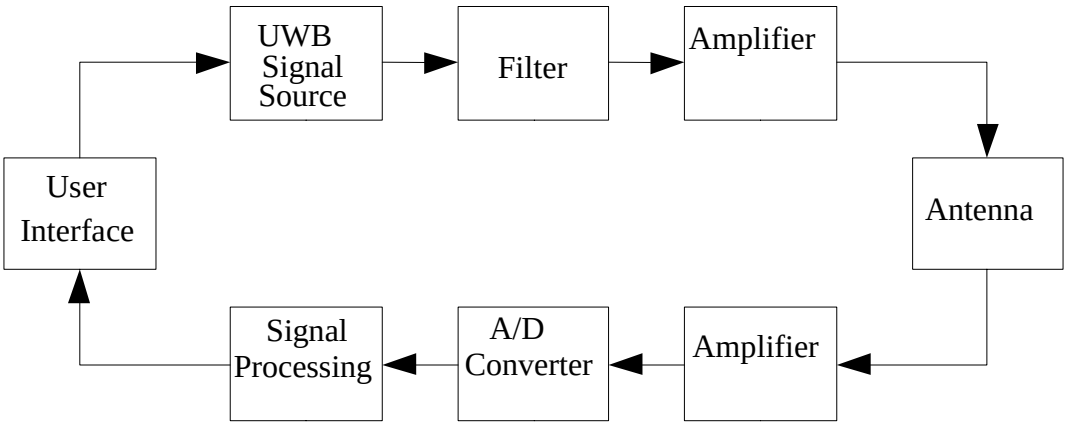


Figure B.1.1: Block diagram of an UWB Sensors system

The system is designed to radiate a broadband signal and capture a return signal caused by a remote object. A single measurement does not allow the objects to be characterized. Typically the device is operated at repeated intervals and a sequence of return signals is recorded to build up a pattern of waveforms and to allow movement information to be decoded. The following digital signal processing steps create a result, which may be further processed by an external device or presented to an operator.

The block diagram in figure B.1.1 shows the user interface triggering the UWB signal source. Therefore, the signal source will just be switched on, when the user actively starts a measurement. The signal source is followed by a filter ensuring compliance with the spectrum mask. After sufficient amplification, the antenna will transmit the signal into free space. A target object will reflect fractions of the signal. These reflected signals are received by the antenna. After amplification of the received analogue signal it is converted into a digital data stream. This data stream is then processed and the result is either transmitted to an external device or displayed on the user interface.

B.1.1 UWB Sensor Types

There are several alternative approaches for realizing UWB-sensor devices, see annex D [6] and [7]. Different applications require waveforms that can provide the most suitable measurement data of the targets of interest. When designing a UWB-sensor, the choice of waveform must take into account the waveform's possible advantages and disadvantages for the specific application, and evaluate the cost and complexity of implementing the waveform.

The key to a powerful UWB-sensor is the use of an appropriate stimulation signal because the whole device structure and the sensor efficiency depend upon it. With regards to this point, the most important aspects may be summarized in what follows:

- The stimulus must be generated in a stable manner by simple means up to several GHz bandwidth.
- Using repetitive stimuli, cost effective under-sampling methods for signal gathering can be employed. It is allowed to work with a certain degree of under sampling without data loss since the time variation of targets is comparatively smaller with respect to its settling time.

- The Signal/Noise Ratio can be improved by averaging over several samples.

Pulsed UWB Sensor Systems

The most obvious and straightforward UWB sensor waveform is the impulse or short pulse. The time duration of these impulses is usually 0,1 ns to 1 ns. The typical pulse repetition frequency is > 5 MHz. If the pulses are transmitted without carrier, they are often termed carrier less impulses or base band video pulses. In many cases, it is advantageous to remove the DC content of the pulses by differentiation or high pass filtering. The resulting pulses are often called monocycle pulses. A popular short duration waveform is the Ricker wavelet that can be described mathematically as the negative of a second derivative of a Gaussian pulse. All short impulses can be generated using different high-voltage impulse sources that are based on the principle of rapid discharge of stored energy in a short transmission line. Transistors (or semiconductors in general) operated in the avalanche mode provide the rapid discharge of energy giving rise and fall times in the order of 100 ps.

Continuous-Wave (CW) UWB Sensor Systems

A sensor system that transmits continuously is termed a Continuous-Wave (CW) sensor. There are mainly two types of CW UWB sensors:

- Sine wave UWB sensors.
- Pseudo Noise UWB sensors.

Sine wave UWB sensors

A sine wave which stimulates the test objects is swept or stepped over the frequency band of interest. Usually a heterodyne receiver, based on fundamental or harmonic mixing, captures the scattered return signal. It provides the characteristic complex transfer function of the sensor arrangement at every frequency point. This principle is certainly the most sensitive method due to the excellent noise rejection and suppression of intermodulation products by the narrow band IF filters. The low crest factor of the sine waves promotes the handling of signals rich in energy resulting in large SINAD-values. Furthermore, highly sophisticated synthesizer sources provide for stable operational conditions so that effective methods can be applied to remove systematic errors. Stepped frequency radars are typical devices applying this approach.

Pseudo Noise UWB-sensors

Pulse compression sensors traditionally apply phase-coded long duration pulses to increase the pulse energy while maintaining the resolution. Various code sequences have been developed and applied, and the Barker code is maybe the most well-known. The development of spread-spectrum techniques for communications and navigation has led to new sensor systems based on these techniques. Maximum length Pseudo Noise (PN) sequences with high bit-rates generate a wideband noise-like signal that is suitable for range measurement. In a PN sensor system, the received echoes are correlated with an internally delayed replica of the transmitted signal, and the resulting output has a peak response when the internal delay equals the target delay. By pushing a digital shift register with a stable single tone RF-oscillator, PN sequences can be generated up to tenths of GHz of bandwidth. These signals have a high energy even at small amplitudes. Small voltage signals are suitable to be handled by integrated circuits and they may be switched extremely fast. Thus low crest factor signals promote a high bandwidth and an excellent jitter performance.

B.2 Technical justification for spectrum

Present sensing technologies are inaccurate, have insufficient resolution and cannot meet the requirements for the needed applications, Therefore UWB sensor technology can be applied for all applications as noted under clause A1.

Only frequencies in the lower GHz range (i.e. below 3 GHz) provide the needed penetration into materials usually having low pass characteristics, otherwise no usable return signals are received and no object classification can be performed.

Especially human tissue shows a large increase in electrical conductivity over frequency, leading to a high attenuation [8] and [11].

Table B.2.1: Relative permittivity ε_r and conductivity σ of head and body tissue [11]

Target Frequency (MHz)	Head		Body	
	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52,3	0,76	61,9	0,80
300	45,3	0,87	58,2	0,92
450	43,5	0,87	56,7	0,94
835	41,5	0,90	55,2	0,97
900	41,5	0,97	55,0	1,05
915	41,5	0,98	55,0	1,06
1 450	40,5	1,20	54,0	1,30
1 610	40,3	1,29	53,8	1,40
1 800 to 2 000	40,0	1,40	53,3	1,52
2 450	39,2	1,80	52,7	1,95
3 000	38,5	2,40	52,0	2,73
5 800	35,3	5,27	48,2	6,00

Many organic substances exhibit a large and frequency dependent attenuation, which leads to the requirement of a low frequency band edge for such UWB applications.

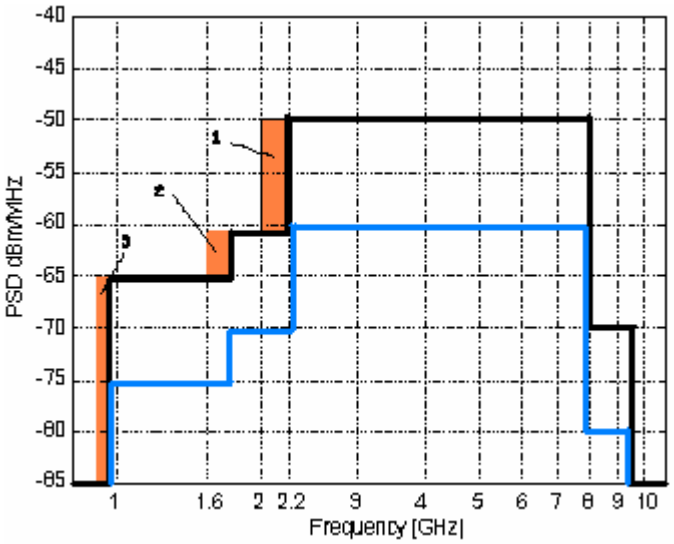
B.2.1 Power

There are several factors having a negative influence on the received signal:

- the large and material dependent attenuation;
- a large amount of noise due to the large bandwidth;
- clutter caused by surrounding objects.

The power spectral density given in clause 6, "Proposed Regulations", is needed in order to receive a signal that contains the necessary information for the signal processing to achieve reliable object identification.

B.2.2 Frequency mask



Notes 1 to 3 adaptions related to TG3 contributions on TR 102 495-1 [4].
Black curve: category 1 and 3 applications.
Blue curve: category 2 applications.

Figure B.2.1: Spectral mask

Table B.2.2: Emissions

Frequency range (MHz)	Power limit values for undesired emission (e.r.p.) Category 1 and 3 applications	Power limit values for undesired emission (e.r.p.) Category 2 applications
< 960	- 85 dBm/MHz	- 95 dBm/MHz
> 960 to 1 730	-65,3 dBm/MHz	- 75,3 dBm/MHz
1 730 to 2 200	-61,3 dBm/MHz	-71,3 dBm/MHZ
2 200 to 8 000	- 50 dBm/MHz	-60 dBm/MHz
8 000 to 9 600	-70 dBm/MHz	-80 dBm/MHz
> 9 600	- 85 dBm/MHz	-95 dBm/MHz

B.2.3 Bandwidth requirement

- Frequencies in the lower GHz range are prerequisite for object classification applications, allowing the electromagnetic wave to penetrate objects. The wave penetrating an object must contain the needed information for the proper functioning of the application, especially for the proximity sensing of human extremities for safety critical devices in dangerous tools or detection of weapons and explosives.

- A large bandwidth is required to ensure sufficient resolution needed for object separation. This is extremely important to discriminate between the actual object of interest and other sources of reflection that falsify the result if not detected properly.

- For object characterization, measuring the complex permittivity (dielectric constant and conductivity) over a broad frequency range is necessary to achieve unambiguous and reliable results.

Annex C:
Expected compatibility issues

C.1 Coexistence issues

Possible coexistence problems need to be investigated in ECC TG3. The ECC Report 64 [1], although focussing on UWB for communications equipment, should also be considered as a source of information for the purpose of new compatibility studies for UWB sensors.

C.2 Current ITU-R allocations

There is no current ITU-R allocation corresponding to these devices. The present document assumes operation according to a provision of the Radio Regulations (RR4.4) that does not require any new allocation (i.e. on a non-protected basis and causing no harmful interference).

Due to the broad range of frequencies covered, an excerpt of the European Common Allocation Table [2] is not reproduced here. Please see [2] for further details.

C.3 Sharing issues

Sharing will be required with all services within the proposed frequency ranges.

The following technical aspects (mitigation factors) need to be taken into account as these will decrease the probability of interference with the existing radio services in a suitable manner.

Mitigation factors are e.g.:

- usage in close proximity to object only;
- manual operation in conjunction with tools or handheld device only;
- no aggregation for this type of devices;
- integrated antenna element excites emissions with directivity combined with shielding provisions, as described in clause 6.

History

Document history		
V1.1.1	May 2006	Publication