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System Reference document (SRdoc);
Short Range Devices (SRD) using Ultra Wide Band (UWB);
Technical characteristics and spectrum requirements for UWB based vehicular access systems for operation in the 3,4 GHz to 4,8 GHz and 6 GHz to 8,5 GHz frequency ranges

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Foreword

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

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The present document 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).

Ultra Wide Band (UWB) technologies enable security-critical vehicular access control applications. The deployment of UWB in the modern automobile will significantly enhance the security of existing Passive Keyless Entry and Start Systems (PKES), also known as Keyless-Go and/or PASE (PAssive Start and Entry).

PKES systems represent the state-of-the-art technology for vehicle access and security systems on its long-term evolution from mechanical locks to electronic access systems and beyond. Highly convenient, the system allows car owners to open and start their vehicle by smart detection of the presence of the key in proximity of the car (less than 2 meters) and also inside the car. The system typically operates when pulling the door handle to open or pushing a START button to start the engine.

UWB technology for PKES

In order to further enhance the security of PKES systems (and access systems in general), UWB technology plays an important role with respect to proximity detection. More precisely, UWB-based PKES will prevent a number of attacks on current PKES systems - namely the so-called "relay attack" - by measuring the true time-of-flight distance between the car and the key and therefore make the cars significantly more secure and safer, without reducing the availability of the access or start function (due to false alarms).

UWB technology enables low-power, precise and secure time-of-flight (ToF) distance measurement between the key fob and the car in order to make a bullet-proof secure open and engine start. Unlike other technologies for distance measurement, UWB can provide a high precision even under Non-Line-Of-Sight (NLOS) conditions, which gives this technique a unique advantage if high reliability is required. Therefore, UWB is appropriate for highest security, system intelligence and convenience.

For car owners, UWB technology brings the highest security and safe operation for a car access system. For automakers, UWB technology enables the highest security grade compliant with existing and future regulations.

Beyond the core access functionality, UWB will support the automakers' effort towards smart cars where centimetre-precise location of the keyfob around and in the car enables new services.

The present document has been created by ERM TGUWB.

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1 Scope

The present document provides information on the use of UWB technology in vehicular access control applications, the technical parameters, the relation to the existing spectrum regulation and additional new radio spectrum requirements for UWB equipment for the operation in vehicular access control applications in the band below 10 GHz.

The applications can be divided in 3 different categories:

- **Category A:** Vehicular access systems using triggered UWB transmission for **proximity verification**
- **Category B:** Extended vehicular access systems using triggered UWB transmission for **proximity monitoring**
- **Category C:** Vehicular access systems using periodic UWB beacons for **proximity detection**

The present document includes necessary information to support the **co-operation betwee**n 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).
- Relation to existing spectrum regulation (annex C).

2 References

2.1 Normative references

As informative publications shall not contain normative references this clause shall remain empty.

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.

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

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] ECC Report 170, Tallinn, October, 2011: "Specific UWB applications in the bands 3.4 - 4.8 GHz and 6 - 8.5 GHz Location tracking Applications for Emergency Services (LAES), Location Tracking applications type 2 (LT2) and location tracking and sensor applications for automotive and transportation environments (LTA)".

[i.2] ETSI EN 302 065-1 (V2.1.0) (2016-04): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Requirements for Generic UWB applications".

[i.3] ETSI EN 302 065-3 (V2.1.0) (2016-04): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 3: Requirements for UWB devices for ground based vehicular applications".

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[i.4] Commission Decision 2009/343/EC of 21 April 2009 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.5] Commission Decision 2007/131/EC of 21 February 2007 on allowing the use of the radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community.

[i.6] ECC/DEC/(06)04: "UWB technology in bands below 10.6 GHz".

[i.7] IEEE P802.15-08-0576-00-0006, H. Sawada: "Channel Models between body surface and wireless access point for UWB Band".

[i.8] Zhang et. al.: "UWB Systems for Wireless Sensor Networks", March 2009.

[i.9] D. Pozar: "Directivity of omnidirectional antennas", Article in IEEE Antennas and Propagation Magazine vol.35(5), pages 50 - 51 November 1993.

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

range resolution: ability to resolve two targets at different ranges

3.2 Abbreviations

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

CAN	Controller Area Network
CEPT	Conference Europeenne des Administrations de Postes et des Telecommunications
dBm	deciBel relative to 1 mW
DC	Duty Cycle
ECC	Electronic Communications Committee
EIRP, e.i.r.p.	equivalent isotropically radiated power
EN	European Norm
ERM	Electromagnetic compatibility and Radio spectrum Matters
HPBW	Half Power Beam Width
ID	Identification Device
LDC	Low Duty Cycle
LF	Low-Frequency
LOS	Line Of Sight
LTA	Location and Tracking Applications
NLOS	Non-Line-Of-Sight
PASE	PAssive Start and Entry
PKE	Passive Keyless Entry
PKES	Passive Keyless Entry and Start
PSD	Power Spectral Density
RF	Radio Frequency
RSSI	Receive Signal Strength Indication
RX	Receiver
SRD	Short Range Device
TGUWB	Task Group Ultra-wide Band
ToF	Time-of-Flight
Ton	Transmitter on time
TPC	Transmit Power Control

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TRX	Transceiver
TX	Transmitter
UWB	Ultra Wide Band

4 Comments on the System Reference document

Void.

5 Presentation of the system or technology

5.1 Background information: Vehicular Access Functionalities

Today's vehicular access systems appear with different embodiments and functionality:

- The **classic Passive Access System** is triggered by the user pulling the door handle. The car starts the communication and sends a message to wake up the key - typically Low-Frequency (LF) signals (e.g. at 20 kHz or 125 kHz) are used for that. The received LF field strength (RSSI) at the key is also used to locate the key inside or outside the vehicle. The key response is typically transmitted via RF (e.g. 434 MHz) and may include subsequent bidirectional RF communication. The system response times are often enhanced by using capacitive sensors in the door handles to start the communication flow even before the user pulls the handle.

- **Advanced Passive Access Systems** do detect the presence of the user already in advance and at distances up to 5-10 m, in order to realize functions like "Welcome Lighting" or "Approach Unlock". This "presence detection" is realized by the car periodically transmitting an LF wake-up message, in order to trigger a key response. Systems using RF wake-up messages instead of LF are also conceivable.

- The **vehicle Passive Start** is always triggered by the user pushing the START button. The communication for key authentication then follows the classic Passive Access flow (LF Wake-Up, RF Response). Passive Start is a very basic functionality that is being widely introduced in order to replace the mechanical steering lock (enhanced security and comfort). It appears also in vehicles that are not equipped with Passive Access.
  The "Passive Start" functionality should not be confused with the " automatic start-stop system" (as described e.g. in https://en.m.wikipedia.org/wiki/Start-stop_system), which is used to reduce fuel consumption. The "automatic start-stop system" does not require additional authentication and thus will be neglected for the purpose of the present document.

- ***Extended functions*** in the context of vehicle access are (re-)using the authentication and localization capabilities to provide or enhance user safety and security:

  - "**Comfort Open**" and "**Comfort Closing**" are used to open or close vehicle windows or convertible tops. The user starts the action with a button press and needs to keep the button pressed to keep it going. The action stops immediately once the user releases the button. Furthermore, the function is only activated if the user is in the vicinity of the car (e.g. 5 m). This supports the intention that the user is monitoring the action and can stop it at any time.

  - The upcoming function "**Remote (Control) Parking**" (also known as "Piloted Parking") enables the user to move the car without being inside, in order to park it into narrow parking lots or garages. The user still is obliged to monitor and start/stop the action by actively operating a remote control, e.g. the key, within a limited range around the vehicle. In particular, this function requires to start the engine from outside the vehicle, which is done by the user pushing a key button (or button combination) instead of the START button inside the car.

  - "**Walk Away Locking**" automatically locks the vehicle once the user leaves the vicinity of the car.

  - "**Door Lock Warning**" is a function that warns the user if he leaves the car unlocked, or an open door or window prevents safe locking of the car. To do this, the vehicle transmits the locking status (e.g. along with other vehicle status information) to the user, as long as the user is in the vicinity of the car.

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5.2 Vehicular access systems using UWB

5.2.1 Introduction

In this clause, a set of access control applications using UWB technologies will be presented. The goal of this presentation will be the identification of the key requirements and features of the applications. Furthermore, the operational environment for the specific application will be identified and analysed in order to understand the potential interference behaviour and the corresponding mitigation factors.

For the purpose of the present document, the vehicular access systems are clustered into three categories:

1) **Category A:** Vehicular access systems using triggered UWB transmission for **proximity verification**.
These systems are characterized by short (single) UWB transmissions after a user triggered event.

2) **Category B:** Extended vehicular access systems using triggered UWB transmission for **proximity monitoring**.
These systems are characterized by periodic UWB transmissions for a limited time.
The initialization is a user triggered event. The duration is either based on a user interaction and/or a pre-defined time-out and/or connection loss.

3) **Category C:** Vehicular access systems using periodic UWB beacons for **proximity detection**.
These systems are characterized by periodic UWB transmissions ("beacons"), which are sent by the vehicle in order to trigger an ID device action ("Wake-Up"). Typically, no ID device is in range and thus no response is sent after a vehicle beacon.
Once a response from an ID device is received by the vehicle, the subsequent communication can be viewed as "triggered communication".

5.2.2 Category A: Triggered UWB transmission for proximity verification

5.2.2.1 Introduction

This clause applies to systems where UWB communication is used to **verify the proximity** (or position) of an ID-device carried by the user.
The core characteristic of these systems is that **UWB transmissions are triggered by the system following a user event** and the **communication time is very short** (e.g. just a single or few UWB transmissions).

In general, those systems may still include non-UWB communication links (like LF or RF). For example, the Wake-Up message for the key is still transmitted via an LF-link.

The (triggered) UWB communication will be used to perform:

- distance bounding (to avoid relay attacks); and/or
- all or parts of the data exchange for authentication; and/or
- localization of the key.

The following functions from clause 5.1 can be realized using this category:

- Classic Passive Access;
- Advanced Passive Access (using non-UWB beacons for ID-device wake-up);
- Passive Start;
- Remote Start (e.g. for Piloted Parking).

All functionalities have in common that the UWB communication is triggered only if there has been a successful (uni- or bidirectional) communication on a non-UWB link before and/or there was a specific (intentional) user action.

With respect to the "Advanced Passive Access" function it is pointed out that, in the context of this clause, the **periodic wake-up messages ("beacons") are not using UWB technology**, but conventional LF or RF technology.

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The UWB communication may be initiated on either side:

1) Triggered UWB communication, initiated by key: Key is being activated by the car (e.g. LF beacon after user touching the door handle), and is triggering the UWB transmission (see figure 1).

2) Triggered UWB communication, initiated by car: Car system is activated by the key (e.g. user pushing a key button), and is triggering the UWB transmission (see figure 1).

UWB communication ("UWB link") may comprise the exchange of several frames.

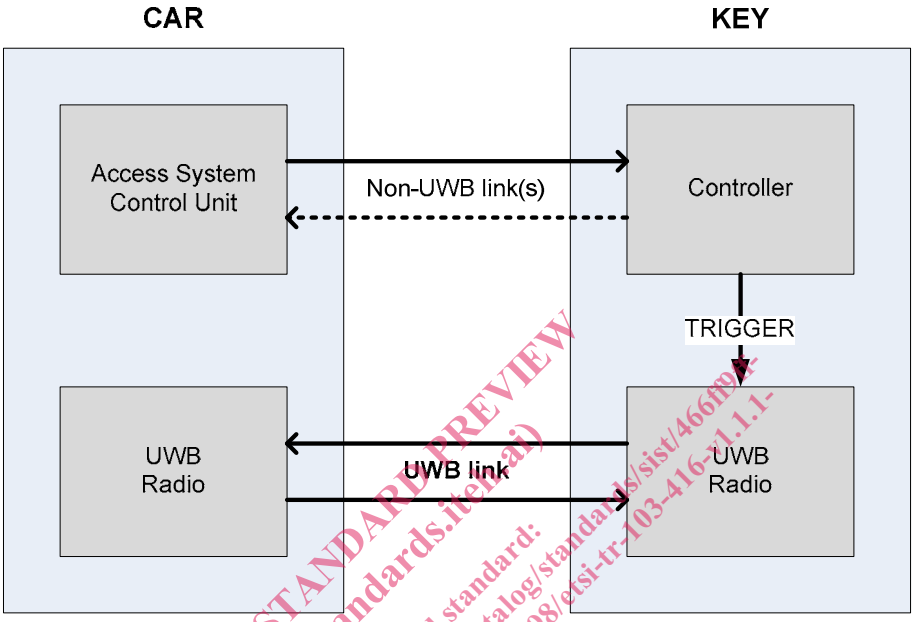


Figure 1: Triggered UWB communication, initiated by key

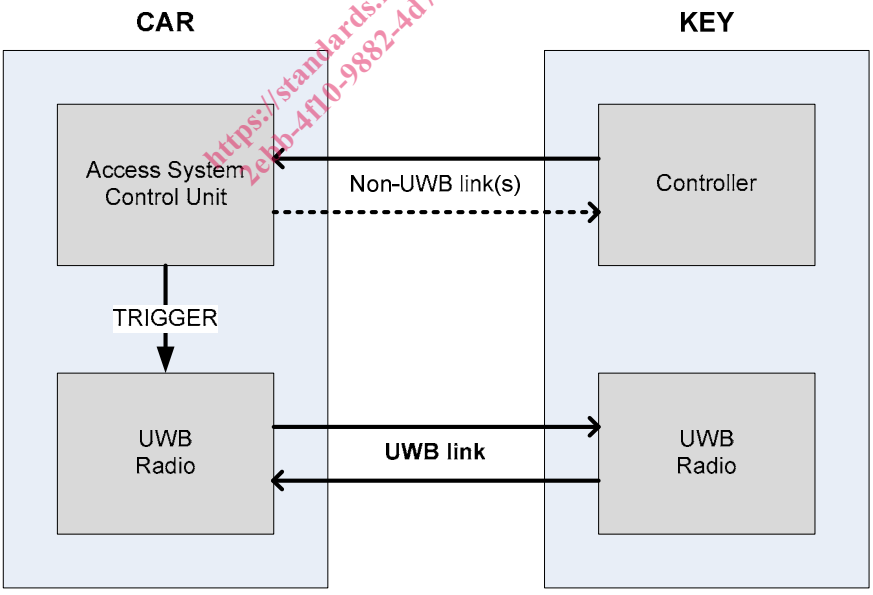


Figure 2: Triggered UWB communication, initiated by car

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5.2.2.2 System requirements (UWB)

The basic system requirements for UWB can be summarized as follows:

- Several independent channels.