

## RFID APPLICATION FOR ELECTRIC CAR IDENTIFICATION AT CHARGING STATION

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**Abstract.** Over the last five years the transportation and logistics world has rapidly developed strong interest in electric car use as ordinary road transport; as a result several issues related to the appropriate charging station infrastructure were raised, including systems for electric car identification during charging. The research was done to evaluate the Radio Frequency Identification Device (RFID) systems for this purpose. Special license plate design for electric cars was developed, introducing RFID passive transponders as a part of the plate. The research goal was to make sure that the RFID application has possibilities to identify an electric vehicle approaching the charging station and separate those which are charged from those which just pass by. Studies have shown that the RFID system active operation field has particular shape with vertical and horizontal components, which must be taken in account when a charging station with the RFID system is being created. The proper RFID receiver antenna and transponder placement ensure high quality communication.

**Keywords:** RFID, electric car, identification, charging station.

### Introduction

Passive information transmission and communication techniques hit everyday life more and more often. Recent developments in these systems allowed to minimize the size of the transmitting devices, as they do not need an internal energy source, which usually is the largest space consumer in the device.

Radio Frequency Identification Device (RFID) is the system, which has rather long history, but got boost in applications recently. RFID principle has been developed since 1935, when the Scottish physicist Robert Alexander Watson-Watt discovered the radar principle [1]. One of such passive transmission of information and identification systems is a. Radio Frequency Identification principle has existed since 1935, the Scottish physicist Robert Alexander Watson-Watt discovered the radar principle and raised the question about the detected object identification [1]. Within a short time period RFID was introduced in industry – it was combined with the radar system, and was used for military aircraft and their component identification from distance [2]. Currently, RFID systems are being applied all around, ranging from luggage tracking and follow-up at the airport, to instant access to a detailed patient medical history in the hospital.

The research identifies advantages and disadvantages of RFID applications. The most commonly mentioned advantages are the following:

- No internal source of energy needed – no need for maintenance, battery replacement, charging, etc.;
- RFID transponder can be placed in a hidden place, without need to track it optically – as it could be needed with barcode systems [3];
- RFID transponder can store substantial amounts of information and can provide calculations based on outside transferred information;
- RFID system can track the location of the transponder;
- Technology allows to create different sizes and modifications of RFID transponders – they can be in a size of a needle;
- RFID application improves profitability of the delivery chain in the company [4].

Main disadvantages are the following:

- Programming of RFID is a time and money consuming process;
- RFID systems can be easily tracked, decoded and modified illegally [3];
- Active RFID systems are rather expensive due to power supply requirements;
- Lack of norms and regulations as to RFID applications – intrusion in private life, and person anonymity breaking (public voice was raised in the US discussing whether Wal-Mart company is breaking the human rights if it introduces RFID in the products sold in its shops and uses the gathered information to follow up the purchasing habits of its customers [5]);

At the same time, relatively little research has been conducted to find the RFID transponder and transmitting antennae mutual positioning on the impact on the quality of the signal reading [6-10]. This study aims to find out the RFID system interaction and stable location field shape, depending on the position of the transmitting antenna in a horizontal and vertical plane.

Experiments took place in laboratory using just a car plate with the RFID transponder introduced and in the field using the electric car with a plate as the carrier of the RFID transponder.

## Materials and methods

Instruments used in the research (Figure 1):

- Leica Disto D5 distance measuring device, measuring error  $\pm 0.001$  m for the distance diapason 0-10 m;
- UHF Industrial Reader CX 2CH R-IN-UHF-5346U. Technical parameters – max. output power 1W (30 dBm), operating frequency range 840-960 MHz, operation distance up to 8 m, max.number of antennas connected – 2, energy consumption – up to 15 W (with output power 1W), supported standards - Standard ISO 18000-6C (EPC Class 1 Generation 2);
- iDTRONIC BLUEBOX UHF Long-Range Antenna R-IN-UHF-9126U. Technical parameters – operating frequency range 865–867MHz (EU), operation distance up to 12 m, antenna amplification ratio 8.5 dBic, axial coefficient 1 dB, supported standards - ISO 18000-6C (EPC Class 1 Generation 2) and ISO 18000-6B, circular polarization, beam angle – 69°/69°.
- NXP G2iL series transponder, incorporated in the license plate of an electric car. Technical parameters – operating frequency range 840-960 MHz, chip output power 18 dBm (without external power applied), and 27 dBm (with external power applied), supported standard EPCglobal v1.2.0, memory size 128 bit EPC memory, working temperature from -40 °C up to +85 °C.
- iDTRONIC BLUEBOX™ “Software development kit” was used for the RFID system control and data registration and storage.

Transponder memory was split in four sections for experiment purposes:

- the first block – ACCESS and KILL passwords;
- the second block – EPC code (size 128 bits);
- the third block – particular producer information;
- the fourth block – transponder ID information.

All devices and instruments are certified by the CE (Conformité Européenne) standard.

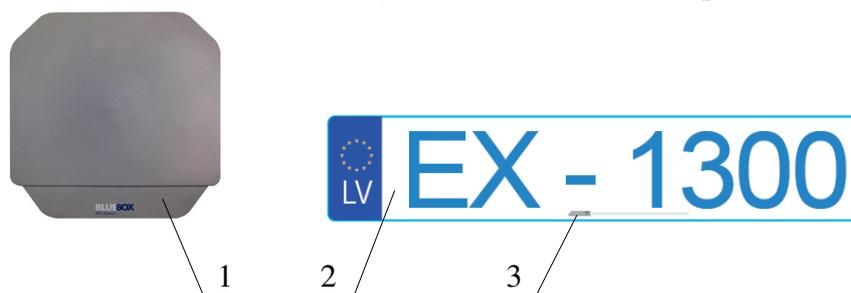


Fig. 1. **Devices used in the experiments:** 1 – RFID BLUEBOX UHF Long-Range Antenna; 2 – car license plate; 3 – RFID transponder

All measurements were performed in the laboratory with special equipment without any metallic objects located nearby in order to minimize the disturbances on the RFID transponder introduced in the car registration plate (see Figure 1). It is well-known in RFID industry [6] that metallic objects located in a close proximity to the RFID transponder substantially affect the electromagnetic wave propagation and reflection properties, so in order to achieve accurate results it was very important to exclude or at least minimize the impact of metallic objects.

Real-life experiments with the electric car, which is built at most part from ferromagnetic materials, may interfere with the signal sent by the RFID antenna, and may change the maximum operating range as well as the angle between the antenna and the transponder.

The measurements were done in three stages, each time shifting the license plate position in a vertical plane, i.e. the plate with the transponder was moved up relative to the ground, and its angle was changed as well. During this study the license plate height was positioned by 20, 40 and 60 cm from the ground, while the angle was changed from 90° to 45°. RFID reader was positioned at the height of 40cm from the ground.

Measurements were obtained by moving the license plate positioned at particular height and angle towards the RFID reader, thus obtaining the positions where stable RFID reader and transponder mutual communication field is formed.

In real life environment a number of RFID transponders can be present in the RFID reader operating range at the same time. If the number of active transponders (those who respond to the RFID reader inventory command) is too large, then the reader can be overloaded with information and cannot process all data received, thereby switching to the emergency mode, or even restart, and interrupting the communication.

Such type of problem was faced by researchers carrying out the tests with the BMW i3 electric vehicle. It turned out that this electric car has a number of built-in RFID transponders (exact number of transponders was not known, but during the experiment, it was found out that there are at least 8 RFID transponders in the car). In this case accurate information receiving from the license plate was not possible – the RFID reader was not able to handle extensive data flow. The problem was solved by making the following changes in RFID transponders introduced in the car license plate and the receiver operating software:

- EPC code and its length of the transponder introduced in the license plate were changed to 8 byte, and the transponder ID was introduced there. Standard EPC field length is 12 byte;
- The RFID reader settings were changed – it was set to the status in Tag Select step, where it is receiving information flow only from the RFID transponders, which have 8 byte EPC field. This allowed to exclude all other RFID transponders from communication with the RFID reader.
- All unique transponder ID (TID) codes were stored in the database. During the Tag Inventory process, when all data are read, the received EPC and TID are compared with the ones in the database. When the transponder is recognized, further process with the car user identification starts.

## Results and discussion

The laboratory experiments were conducted in a room without any metal object, which could cause the transmission field deformation. Each measurement point was calculated as the mean value from five results obtained, with standard deviation and the polar coordinate angle calculated.

The measurement results are presented graphically as the RFID antenna and transponder safe (stable) communication field in Figure 1 and Figure 2.

RFID antenna and transponder stable communication fields show the best performance if the license plate is located on the height of 60 cm from the ground, and the angle between the movement direction and the plate is 90° – the plate plane and RFID antenna plane are parallel (Figure 1). Decreasing the height or changing the angle between the RFID antenna and the transponder (Figure 2) also the communication field size and shape decrease.

The RFID system field experiments were provided in real environment with a special electric vehicle license plate (see Figure 1) connected to it.

RFID readers were placed in front of the charging station. According to the results obtained, it can be concluded that the RFID reader placement near to the charging equipment, as it is presented in Figure 4, provides sufficient communication field for two electric cars approaching the charging station. The setup allows to cover the field up to 6 m in distance. However, when the RFID antenna is

positioned perpendicularly to the parking, the RFID reader and the transponder active communication field is too small, and communication is unstable.

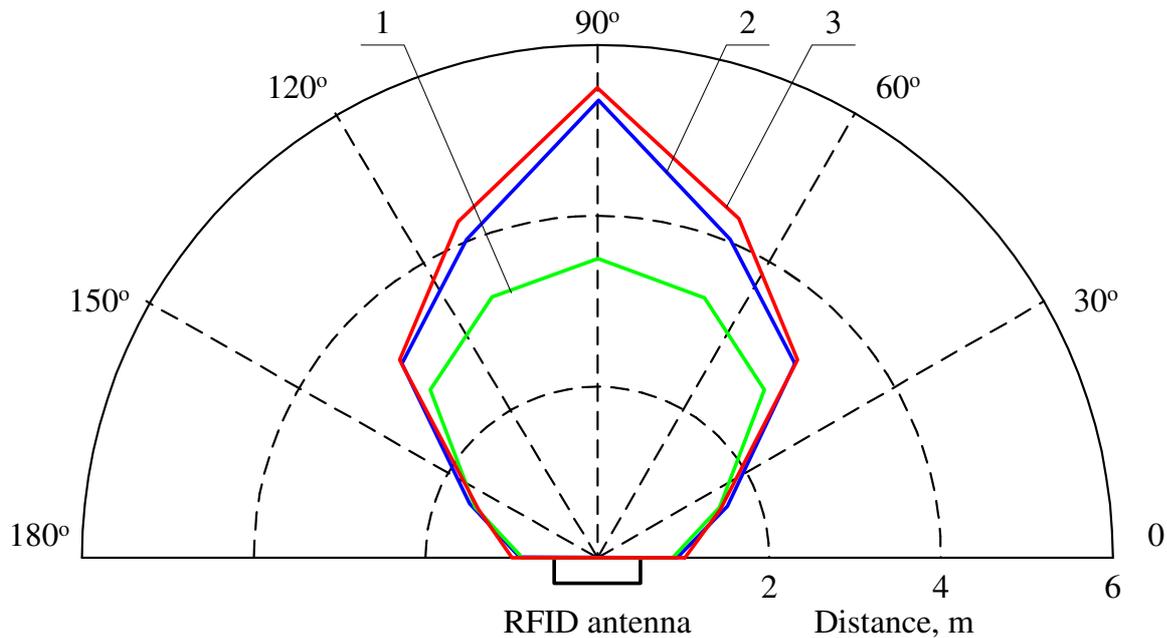


Fig. 2. RFID antenna and transponder safe communication field, angle 90°: RFID transponder height above the ground: 1- 20cm, 2- 40cm, 3- 60cm.

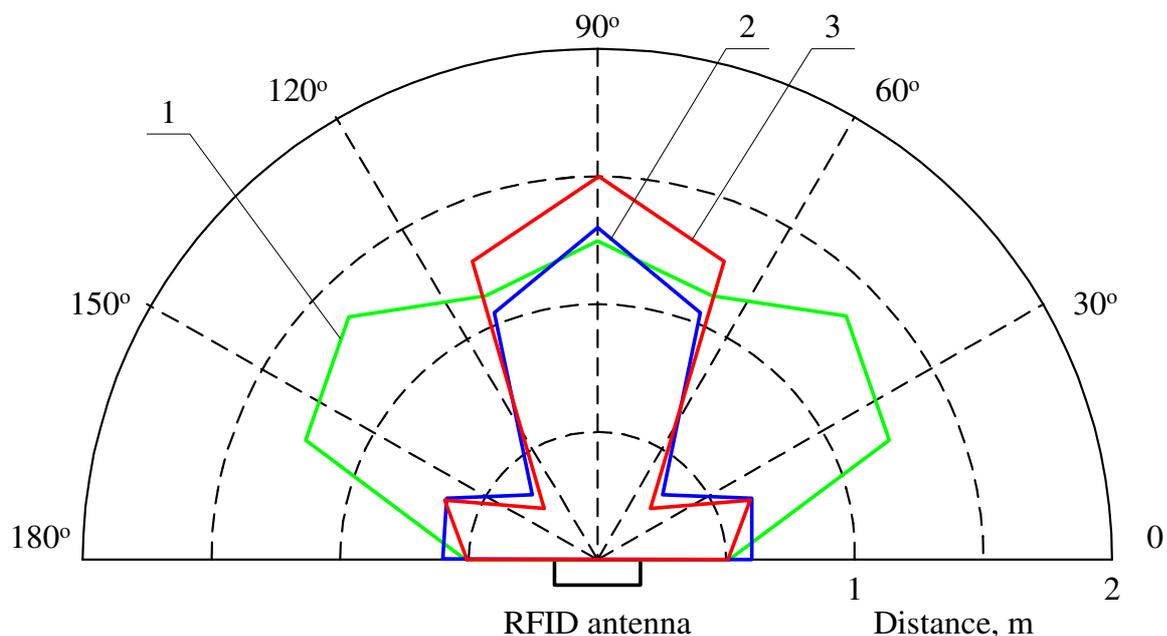


Fig. 3. RFID antenna and transponder safe communication field, angle 45°, RFID transponder height above the ground: 1 – 20 cm, 2 – 40 cm, 3 – 60 cm

Analyzing the possible configurations of RFID antenna positioning when two cars are approaching and must be identified and also taking in account the fact that car parking is not perfect (depends on the driver experience and skills, as well as the situation in the parking place), the most universal design of RFID antenna positioning was developed. The stable communication field configuration in the situation when the two cars are coming under angle to the charging station was established with antennas turned by 30° to both directions (Figure 5.). Such configuration allowed to park cars in parallel and perpendicularly, and still to get sufficient communication.

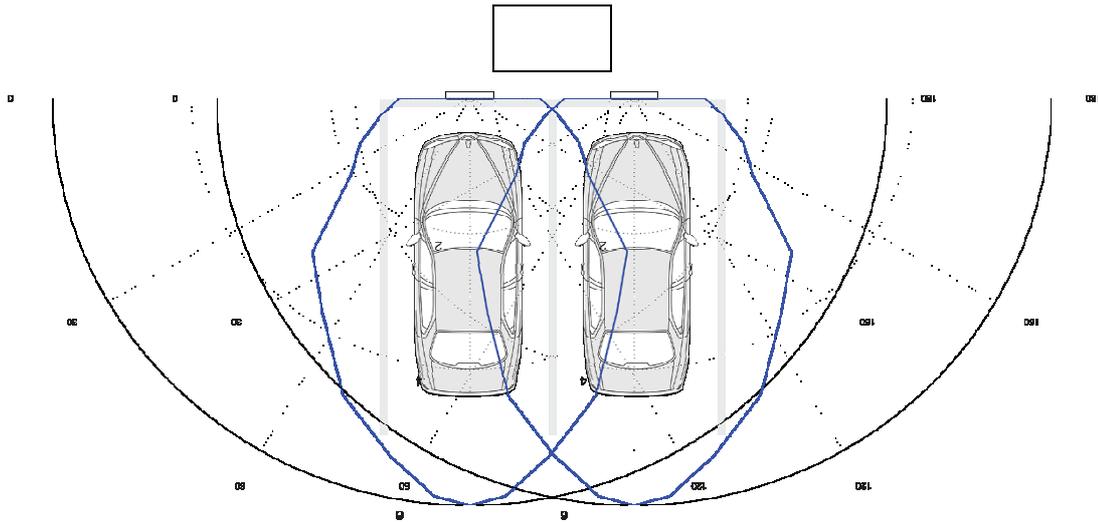


Fig. 4. Electric cars positioned in front of charging station (transponder in the licence plate is parallel to the antenna plane)

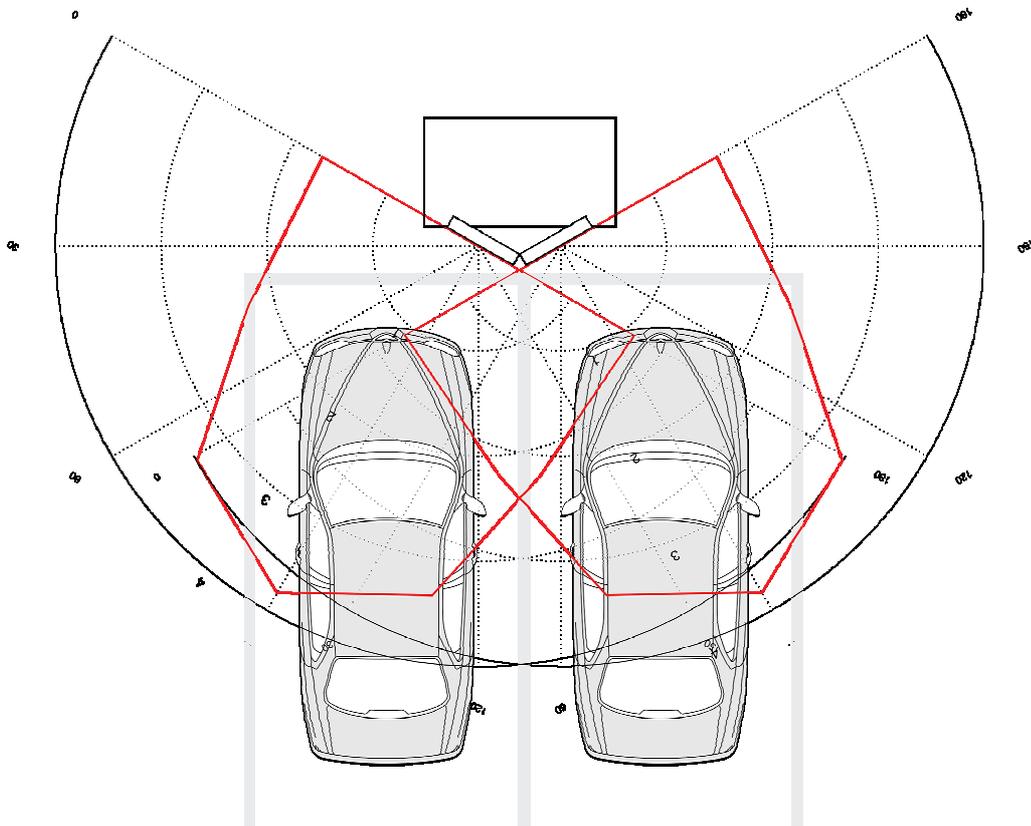


Fig. 5. RFID antennas turned by 30°, cars parked forward

If the electric cars are parked forward, the secure communication field distance is 3.7 m and the width 3.5 m (Figure 5).

In the case when the electric cars approach the charging station from both sides and are parked sideward, the communication field distance is 2.5 m, and the field width is 1 m for each car (Figure 6).

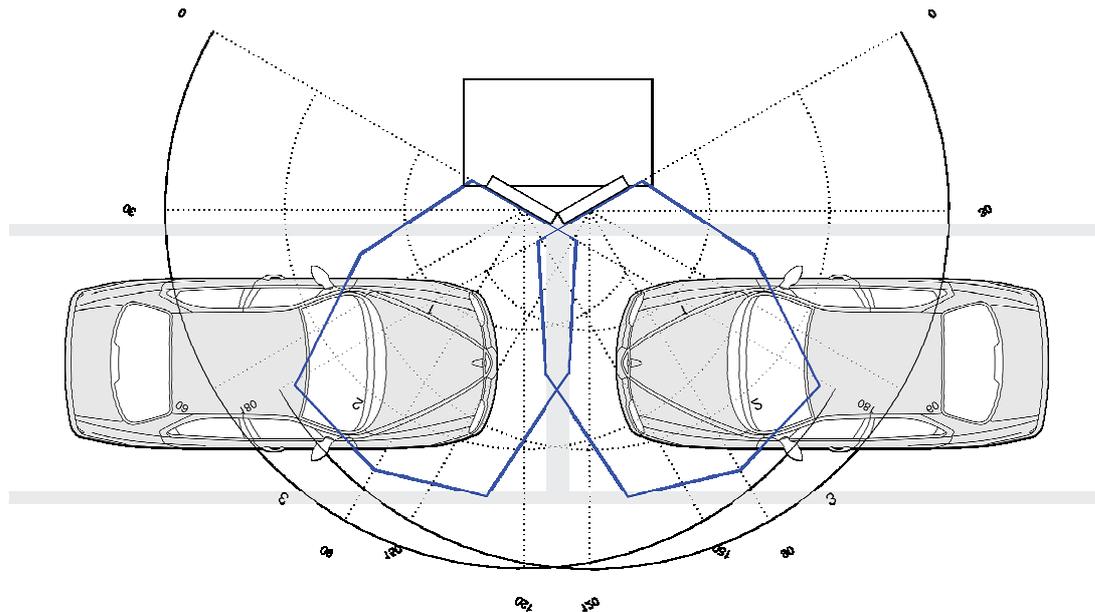


Fig. 6. RFID antennas turned by 30°, cars parked sideward

### Conclusions

1. RFID reader and transponder stable communication fields show the best performance if the license plate is located on the height of 60 cm from the ground, and the angle between the license plate plane and the RFID reader plane is 0°.
2. Any change in transponder positioning (height, angle) reduces the stable communication field size.
3. If the RFID antenna plane is perpendicular to the transducer plane, communication is unstable.
4. For industrial installations, the optimal angle of RFID readers is 30° against the charging station face plan. This allows to establish good communication between the RFID reader and the transponder in different electric car license positions, thus reducing the necessity for high accuracy of car parking.
5. RFID system developers for electric car service must take into account the potential impact of other RFID devices already introduced in modern car systems, as well as to any RFID device, which may occur nearby. Interference reduction between different RFID transponders may become a very serious task in future.

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