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Analysis of Location Tracking and Speed Measurements for Moving Objects by using Radio Frequency Identification Systems

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Introduction

- Performance evaluation of an ultra-high frequency (UHF, 865-945 MHz) RFID system
- Radiated emissions measurements according to EN 55022 standard
- Speed measurements methods based on Time of Arrival (TOA) and Angle of Arrival (AOA)
- Experimental Results
- Conclusions

1. Performance evaluation

- UHF (865-945 MHz) RFID system

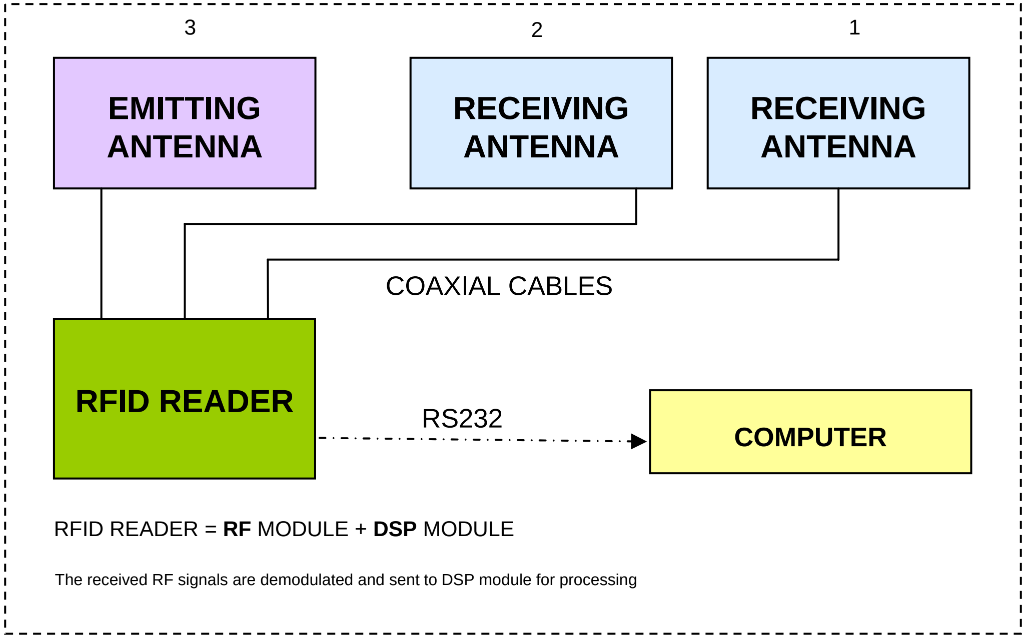


Fig. 1 – UHF RFID system (configuration)

1. Performance evaluation

- UHF (865-945 MHz) RFID system

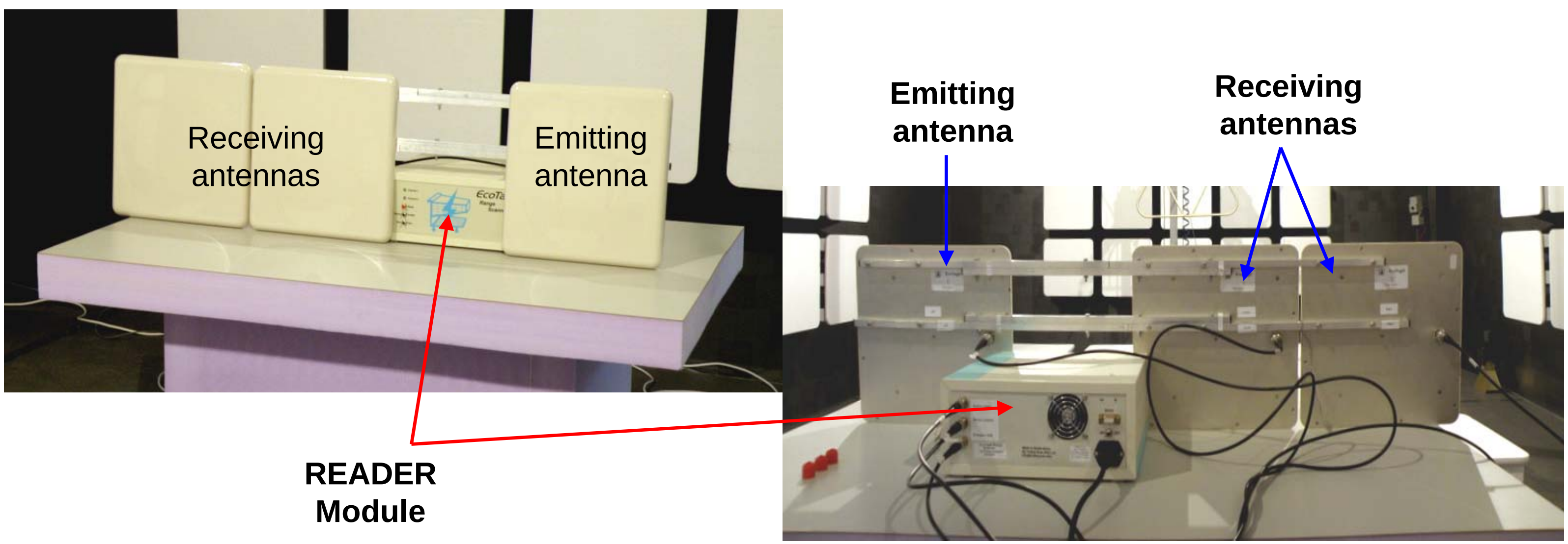


Fig. 2 – UHF RFID system (photos)

1. Performance evaluation

- UHF (865-945 MHz) RFID system

Fig. 3 - UHF RFID system - transponders

2. Radiated Emissions Measurements

- Test setup

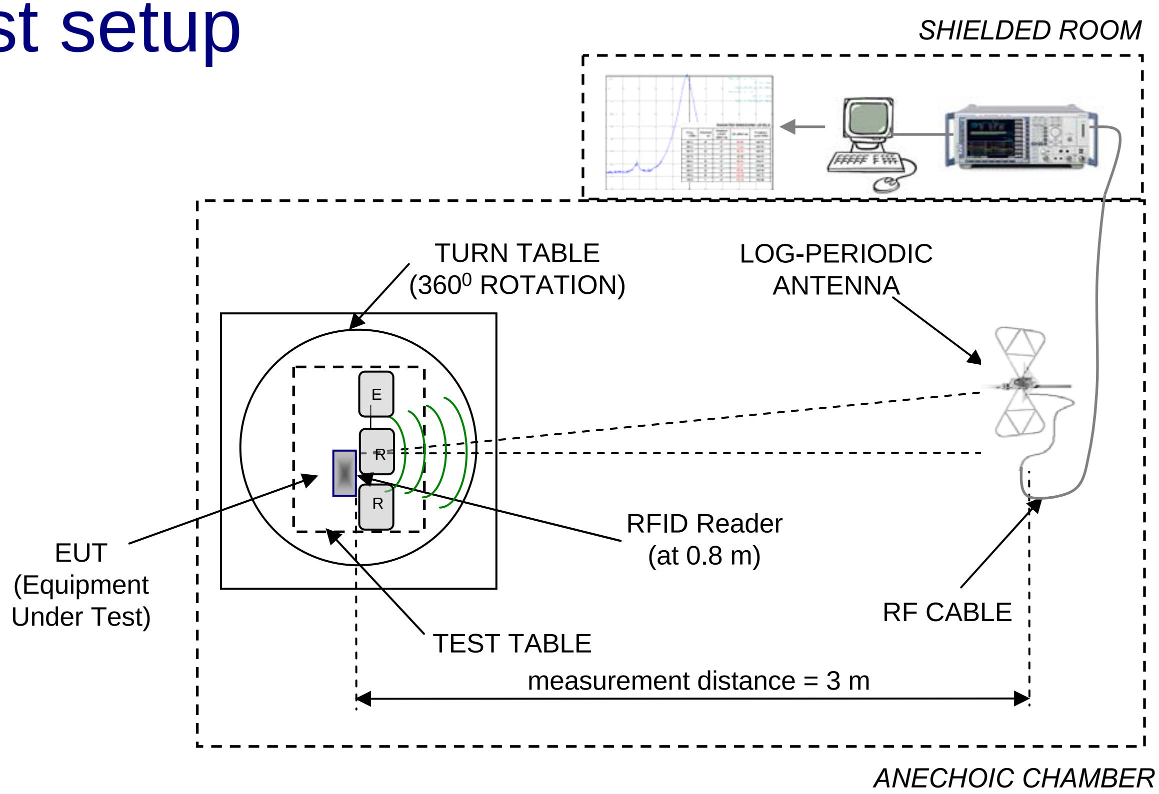


Figure 4 – Test Setup for Radiated Emissions Measurements (anechoic chamber)

2. Radiated Emissions Measurements

- The CISPR22 standard limit = 47 dB(uV/m)

Radiated emission levels >> 47 dB(uV/m)

measurement distance = 3 m

Freq. (MHz)	Polarization	Table Angle (deg)	QP dB(uV/m)	Frequency peak (MHz)	QP Margin (dB)
865.2	H	18.2	89.00	869.91	42.00
865.2	V	153.2	72.54	869.91	25.54
867.0	H	17.7	88.70	869.92	41.70
867.0	V	150.5	42.38	869.92	-4.62
868.3	H	18.5	80.43	869.97	33.43
869.3	H	17.4	72.57	870.00	25.57
869.3	V	150.9	55.89	870.00	9.11
869.9	H	18.8	89.46	869.90	42.46
869.9	V	152.0	72.85	869.90	25.85
945.6	H	12.6	133.10	945.75	86.10
945.8	V	62.0	117.61	945.80	70.61

Table 1 – Example of radiated emissions levels (30-1000 MHz frequency band)

2. Radiated Emissions Measurements

■ Experimental results

The RFID Radar radiated emissions levels (measured in the anechoic chamber)

LIMIT (dBuV/m)	QP (dBuV/m)	Frequency peak (MHz)
47	89.00	869.91
47	72.54	869.91
47	88.70	869.92
47	42.38	869.92
47	80.43	869.97
47	72.57	870.00
47	89.46	869.90
47	133.10	945.75

The limit defined in EN 55022 standard for the 230 MHz - 1000 MHz frequency band

Table 2 - Radiated Emissions Levels (30-1000 MHz frequency band)

As we might see in table 1, the radiation emissions levels measured using the test setup described in figure 4, exceed the limits defined in EN 55022 standard (CISPR22).

Therefore, the RFID system considered has relatively high emission levels for the main operating frequency band.
This leads to electromagnetic interferences for electrical equipments operating nearby and raises human safety issues.

3. The K-band radar

- **Bushnell Velocity Speed Gun**

Figure 5 - The K-band radar

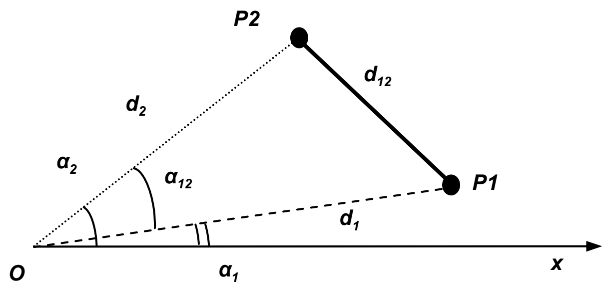
Technical specifications

Accuracy	+/- 1 MPH
Auto racing range	6 to 200 mph (1,500 feet away)
Size (inches/mm)	4.3 x 8.4 x 6 / 109 x 213 x 152
Weight (oz/g)	19 / 539 without batteries
Battery Type	C (2) (Alkaline recommended)
Battery Life	Up to 20 hours if Alkaline batteries are used
Display Type	Large LCD / Reads and Displays in MPH only
Processor	Locks in Fasted Speed of trigger pull

4. Speed Measurements

- The method for measuring the transponder speed is based on the Time of Arrival and Angle of Arrival information provided by the RFID radar

$$v \approx \frac{d_{12}}{t_{12}} = \frac{\sqrt{d_1^2 + d_2^2 - 2d_1 d_2 \cos(\alpha_2 - \alpha_1)}}{t_2 - t_1}$$

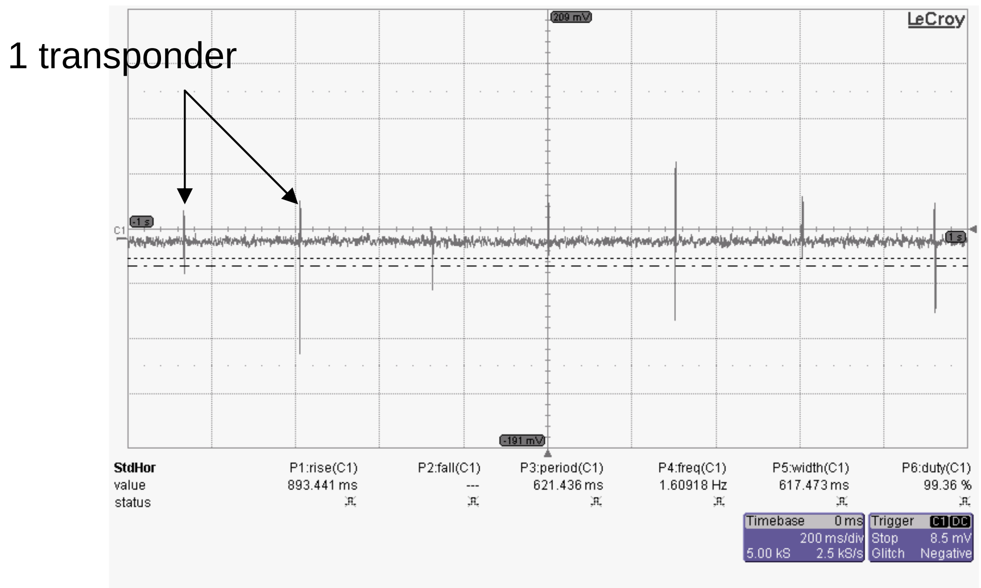


(d1, α1, t1) and (d2, α2, t2) = (distance, angle, time) information provided by the radar for two consecutive readings P1 and P2 of a transponder in range

Fig. 6 - Speed measurements

4. Speed Measurements

- The signal transmitted between the receiving antennas preprocessor and the digital processing board located inside the reader



the time spacing between two transponder transmissions is about 333 milliseconds

Fig. 7 - The signal received by the RFID Radar when only one transponder unit is in the active area

4. Speed Measurements

- The signal transmitted between the receiving antennas preprocessor and the digital processing board located inside the reader

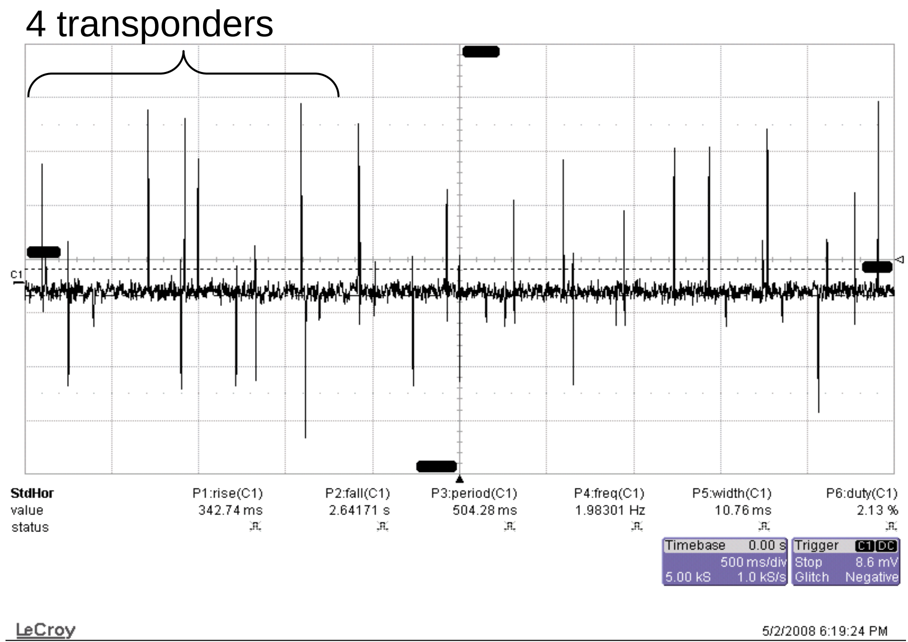
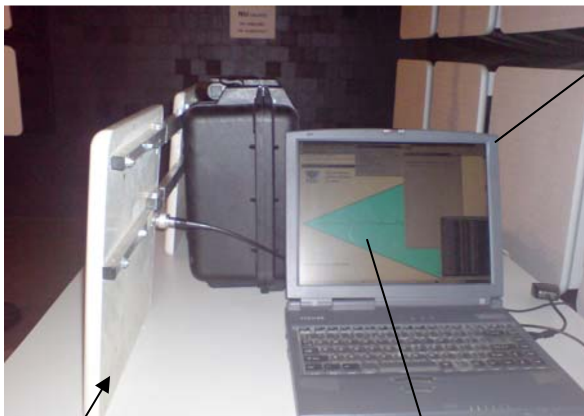


Fig. 8 - The signal received by the RFID Radar when four transponder units are in the active area

4. Speed Measurements

- The speed measurement system was tested using also passive and active transponders

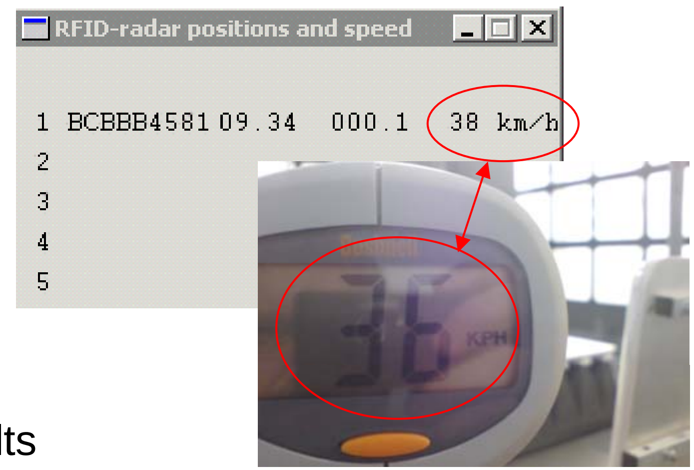


Computer
(system command)

Emission
antenna

Speed measurement
(software)

The speed measured using our software (38 km/h) is almost equal with the K-band Radar indication (36 km/h)



K-band Radar

Fig. 9 – Experimental results

4. Speed Measurements

The repeatability of the measurements was tested outdoor by performing 50 measurements of the transponder moving with 10 km/h for each of the following distances: 20m, 30m and 40m

Distance to the antenna system (m)	10	20	30	40	50
Speed (km/h)	6	24	32	36	n/a

Table 3: Maximum measured speed as a function of the distance between the transponder and the antenna system

Distance to the antenna system (m)	20	30	40
Number of speed measurements within 10% error for the RFID Radar (%)	84	72	64
Number of speed measurements within 10% error for the K-Band Radar (%)	96	84	78

Table 4: Repeatability of the measurements

Conclusions

- We presented a performance evaluation of an ultra-high frequency (UHF, 865-945 MHz) RFID system with respect to location tracking of moving objects

- Several radiated emissions measurements were made in order to point out the high perturbations levels of UHF RFID radar

- We developed a method for measuring the transponder speed - based on the Time of Arrival (TOA) and Angle of Arrival (AOA) information provided by the RFID radar

- The RFID Radar method performed reasonable well when compared against classical K-band Radar, and proved that an additional capability could be added to the current RFID system that mainly focus on transponder localization and information transfer

Thank You !

CONTACT

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