How fast is fast?

RFID identifies objects up to 200 km/h

How quickly may an object move to be reliably identified with a UHF RFID system? The HARTING RFID team conducted a high speed test on an airfield together with the Ignition Racing team. The racing car passed an antenna at 200 km/h and the EPC (unique number of the tag) was read nine times – leaving lots of room for higher velocities.

Keywords: high speed, UHF, RFID, railway, rolling stock, logistics, asset tracking

1 Introduction

How can an object or vehicle be reliably identified at high speed? And how fast may the vehicle go? Radio Frequency Identification (RFID) is the technology of choice in many applications for example for automated warehouses, identification of fast moving tools, and the identification of trains.

A typical RFID system is shown in figure 1.

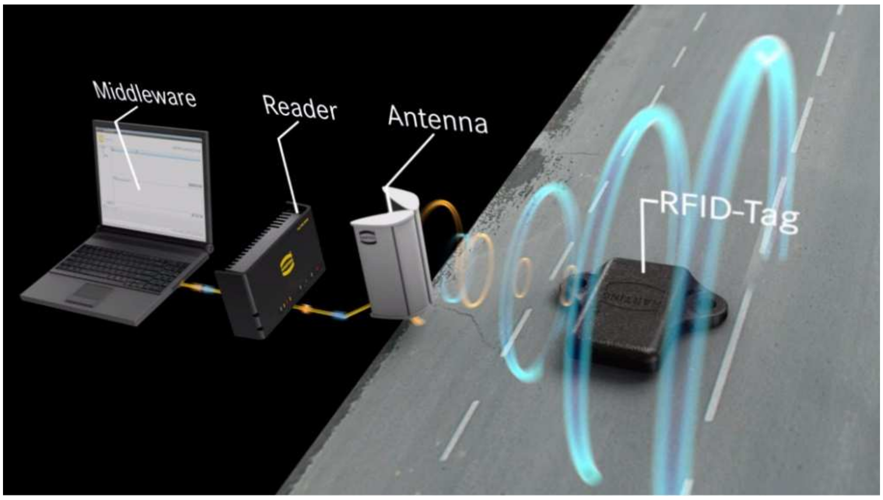

Figure 1 General setup: the RFID tag passes the antenna. The antenna emits a radiowave (blue lines). The tag draws energy from the radiowave and transmits its unique identifier EPC (electronic product code) (orange lines).

The RFID tag (also called RFID transponder) enters the electromagnetic field emitted by an RFID reader with its antenna. The RFID tag absorbs the energy and answers with his unique number, the so called EPC (electronic product code). The reader receives the analog signal, converts it from analog to digital and in the end the Ha-VIS Middleware collects all data and generates a report with the information needed.

The advantages of RFID at a glance:

1) Identifies up to 330 objects per second
2) No line of sight required
3) Reading distance from few millimeters to 15 m (without a battery)
4) Rewriteable user memory

Because HARTING has a strong focus on railway, from heavy duty connectors, over Ethernet switches for rolling stock, to RFID systems for track side identification and applications on rolling stock, the question came up, how fast a train may move so that the EPC could reliably be detected and written into a database. HARTING provides complete systems from RFID tags for special applications, over antennas, readers up to the Middleware, so we decided to make a high speed test, where different combinations of available standard products, always together with the Middleware, could prove their high speed capabilities.

In order to set the boundaries of the test, we checked how fast objects are moving in different applications:

1) Boxes and parts on conveyer belts for logistics: up to 30 km/h
2) High speed transport systems in automated warehouses: 50 km/h
3) High speed robots for manufacturing: up to 50 km/h
4) Cargo trains: 120 to 160 km/h (depending on country)

2 Setup

Three different configurations were installed on a taxi way at the Airport Porta Westfalica, Germany.

Figure 2 Sketch of the taxi way, the vehicle and the three reading points along the taxi way.

	Reading point 1	Reading point 2	Reading point 3
Reader	Ha-VIS RF-R200 (PoE)	Ha-VIS RF-R500-c-EU	Ha-VIS RF-R500-p-EU
Coax Cable	Ha-VIS Coax LL240flex, 10 m	Ha-VIS Coax LL240flex, 10 m	Ha-VIS Coax LL240flex, 10 m
Antenna	Ha-VIS RF-ANT-MR20-EU	Ha-VIS RF-ANT-WR30-EU	Ha-VIS RF-ANT-WR80-30-EU
Software	Ha-VIS Middleware	Ha-VIS Middleware	Ha-VIS Middleware

Table 1 Along the taxi way of the airfield, three independent reading points were installed with a distance between each station of at least 15 m.

The exact configuration of the RFID reader is described in table 2.

	Reading point 1	Reading point 2	Reading point 3
Reader	Ha-VIS RF-R200 (PoE)	Ha-VIS RF-R500-c-EU	Ha-VIS RF-R500-p-EU
Power	0.5 W	1.6 W	2 W with power splitter 1 W without power splitter
Antenna gain	4 dBic	8.5 dBic	11 dBic
Emitted power at antenna	0.2 W ERP	2 W ERP	2 W ERP
Mode	Host Mode	Host Mode	Host Mode
Persistence Reset time	0 ms	0 ms	0 ms

Table 2 Reader configuration for every reading point. For the Ha-VIS RF-R200, the maximum power was configured that the reader can emit. For reading points 2 and 3, the reader was configured such that the attached antenna emitted only the legally allowed 2 W ERP.

The Ha-VIS Ha-VIS Middleware operated and controlled the readers, collected the data and generated XML reports with a listing of all identified tags and how often they were read while being in the antenna field. If not mentioned differently, the 96 bit EPC was read.

Concerning Reading Point 3, we tested two configurations. If not mentioned differently, two Ha-VIS RF-ANT-WR80-30-EU antennas were connected to a power splitter, and the power splitter was connected to antenna port 1 of the RFID reader. The hypothesis was that by combining two antennas to one “logical” antenna, the tag will be longer in the antenna field and therefore the number of read events should increase. The results for this test are discussed in chapter 3.4.

Each vehicle was equipped with only one tag (see pictures and chapter 3 for details) when passing the three reading points.

3 High speed test

Motivated by the different classes of applications and speeds involved, we chose four different vehicles for the test:

1) E-bike with a speed of up to 50 km/h
2) E-Racing car from Ignition Racing team for Formula Student (Season 2013) with speed up to 120 km/h
3) Gasoline racing car from Ignition Racing team for Formula Student (Season 2010) with speed up to 160 km/h
4) High speed street car for speed up to 200 km/h (the car can drive faster, but the length of the taxi way limited the maximum speed due to needed distance for acceleration and stopping)

Vehicle	Tag	Maximum speed in test	Chapter
E-bike	FT89	52 km/h	3.1
E-Racing car	VT86s	87 km/h	3.2
Gasoline racing car	SL89	114 km/h	3.4
High speed street car	SL89	200 km/h	3.3

Table 3 Overview of which vehicle was equipped with which tag.

3.1 E-bike with FT89 tag

Figure 3 E-bike with FT89 tag.

The FT89 tag is a flexible transponder that can be glued onto any non-conducting surface (versions for conducting surfaces are available as well). Therefore, the tag was placed on the right side of the plastic cover (below the large HARTING logo). The E-bike passed with a constant speed of 51 km/h all three reading points. The figures in the columns for each reading point represent how often the 96 bit EPC was read by the reader and Middleware.

Tag	Velocity	Distance tag-antenna	Reading point 1	Reading point 2	Reading point 3
FT89	51 km/h	2.5 m	1	5	39

Table 4 Results of the test with E-bike and FT89 tag. At reading point 1, the EPC (unique identifier of the tag with 96 bit) was read once, at reading point 2 it was read 5 times and at reading point 3 it was read 39 times.

Figure 4 E-Racing car with VT86s tag.

The VT86s is transponder optimized for small size, maximum robustness and best function on metal. Therefore, the tag was placed on a metal plate (see figure 4, green metal plate mounted on to roll cage).

Tag	Velocity	Distance tag-antenna	Reading point 2
VT86s	59 km/h	2.5 m	4
VT86s	87 km/h	2.5 m	1

Table 5 Results of the test with E-racing car and VT86s.

3.3 High speed street car with SL89 tag

The SL89 set was fixed at the rear right car wing of the car (see figure 5 for the SL89 set). The car drove with a constant velocity of 200 km/h on the taxi way and passed all three reading points.

Figure 5 SL89 set with metal bracket. The metal bracket with the slot is the antenna. Ideal for high speed applications and harsh environments.

Tag	Velocity	Distance tag-antenna	Reading point 1	Reading point 2	Reading point 3
SL89	200 km/h	2.5 m	./.	1	9

Table 6 Results of the test with high speed street car and SL89 tag. The tag was read nine times at 200 km/h.

At a speed of 200 km/h, the combination of Ha-VIS Middleware, RF-R500-p-EU and the WR80-30 antenna was able to read the 96 bit EPC of the SL89 nine times!

3.4 Gasoline Racing car with SL89 tag – technical details

Figure 6 Gasoline racing car with SL89 tag.

Each transponder has different memory banks. In bank 1 the TID is stored with 32 bit. This a unique number generated and stored in the RFID IC during fabrication and can typically not be changed. In bank 2, the electronic product code is stored with 96 bit. This number can be changed. Once it is set, it can be secured by a password.

So far, only the EPC with 96 bit was read, when a vehicle passed all three reading points. In some applications, where authentication is important, it is useful to read EPC and TID. With the gasoline racing car it was verified how often the EPC and TID can be read, while the car passes reading point 2 (see table 7). As expected, the number of read events is reduced. However, at a speed of 114 km/h the EPC+TID (96 bit + 32 bit = 128 bit) can be read five times.

Tag	Velocity	Distance tag-antenna	Read Data	Reading point 2
SL89	114 km/h	2.5 m	EPC	8
SL89	114 km/h	2.5 m	EPC+TID	5

Table 7 Comparison of how often EPC+TID can be read compared to EPC only.

Finally, we compared the arrangement with the two WR80-30 antennas with the power splitter and 2W emitted by the reader (this results in 2 W ERP emitted at each antenna) to a single antenna. As a preliminary result, the option with a single antenna without power splitter delivered comparable results to the arrangement with two antennas connected with the power splitter.

4 Summary

We demonstrated that a car at 200 km/h can be reliably identified with standard UHF RFID components. The SL89 tag was read 9 times at 200 km/h. Consequently, the SL89 is the best recommendation for high speed applications beyond velocities of 100 km/h.

The Ha-VIS RF-R500 RFID reader in combination with the Ha-VIS RF-ANT-WR80-30 turned out to be the optimal choice for velocities above 120 km/h.

The Ha-VIS Middleware proved its capabilities for high speed and high throughput applications. Without any programming, the Ha-VIS Ha-VIS Middleware bridges the gap between hardware and software and delivers exactly the data the customer needs – by simple configuration.

Since there is much room for improvements, the HARTING RFID team looks for the next challenge.

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