Archives of Transport System Telematics

Volume 6

Issue 4

November 2013

Tracing and tracking using RFID tags in logistic systems of transport and storage

S. KWAŚNIOWSKI[a], **P. ZAJĄC**[a]
[a] WROCLAW UNIVERSITY OF TECHNOLOGY, Faculty of Mechanical Engineering, I. Lukasiewicza, 50-371 Wroclaw, Poland
EMAIL: pawel.zajac@pwr.wroc.pl

ABSTRACT

The paper presents the results of laboratory tests of passive RFID tags, which were conducted at the laboratory in order to determine the application area of this technology. The study was conducted in three stages: transponders reviews, that involved reading parameters such as the positional relationship between the transponder antenna and the maximum reading distance. The influence of typical packaging materials such as cardboard, foil, etc. on the correctness of reading was also taken into account, dynamic tests of transponders that involved reading tags in a linear or rotary motion at different speeds. Reading more moving transponders, which are also close to each other, was carried out, and transponders research programme, which was to determine the possibility of writing such information and programming during movement.

KEYWORDS: optimization of logistic system, RFID

1. Introduction

The radio-frequency identification (RFID) is a term defining the system, which transmits a unique serial number designating a person or an object wirelessly, using radio waves. There are two basic solutions in this area: energy consumption and simultaneous or alternate transmission. In the case of alternate transmission, the energy is absorbed and a while later the information is transmitted by the transponder. The RFID monitoring systems are made of two fundamental parts: a transponder, the base station (antenna). The base station emits the energy that is accumulated by the electronic tag and used for a return transmission. As a standard, the chip stores approx. 2000 bytes. This amount is sufficient to use these tags to monitor loads in supply chains and the tags may be in the form of cards, capsules or disks.

Passive devices are not equipped with transmitters and reflect the radio waves back to the reader. Active tags transmit the information that is stored in the internal microchip. This paper concentrates on passive tags, which are cheaper than active ones, but offer a shorter range. A passive tag is made of a microchip connected to an antenna and operates at low, high and ultra-high frequencies. Tags working at low frequency are used in areas, where a tag must be read from a short distance (e.g. in proximity cards, pallets). This paper presents the results of tests on such tags.

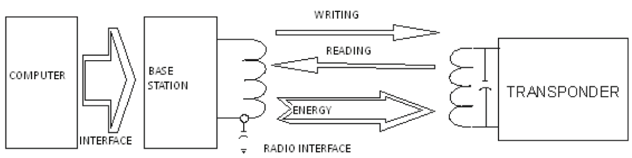

Fig. 1. RFID systems operation

Figure 1 presents the operation of the RFID systems. The computer was equipped with the MIDDLEWARE software which collects the data from the readers, formats and sends the data to the end system. The middleware often plays a key role in the RFID systems. The base station is connected to an external computer through a wired interface. The base station uses a radio interface to communicate with the transponder. This interface works at a specific frequency range. The base station system usually comprises a series resonant circuit and the tags are equipped with a parallel resonant circuit and both these circuits are aligned to work at the same frequency.

2. 125 kHz transponder test

The test was performed on the UNIQUE - TRD-DESK RS232 device (Fig. 2).

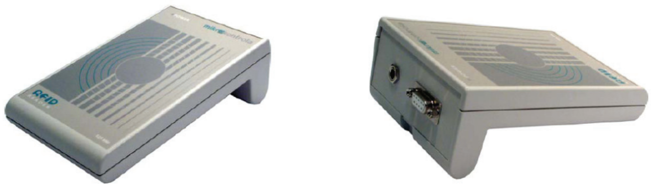

Fig. 2. UNIQUE - TRD-DESK RS232 [4]

The manufacturer's technical data presented at www.mikrokontrola.pl [4] have been adopted. The transponder is brought closer to the reader to read the code. A correct reading is signalled by a short beep. Simultaneously, the transponder code is transmitted through the RS232 link to the computer. Five bytes of the code are read as follows: the oldest byte of the code is sent first (transmission parameters: speed 2400/8 data bits/no parity bit/one stop bit).

The tests were carried out in three areas:

- I static tests
- II dynamic tests
- III transponder software tests.

The purpose of tag tests is to develop the conditions of correct operation. They help to define the application area and related issues.

2.1 Static tests

Stage I defines the maximum transponder reading distance and the optimum positioning of the tag against the reader's antenna. Figure 3 presents the test station diagram.

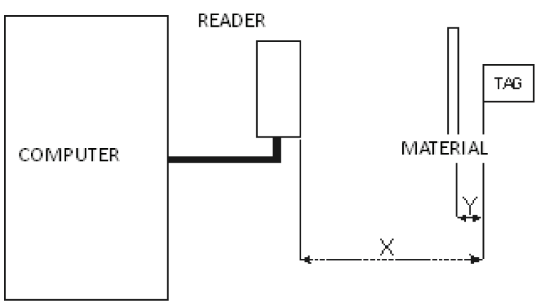

Fig. 3. Diagram of transponder static tests

The reader (2) was connected to the computer (1) using a wired interface (3) and the RS 232 socket. The reader was powered by a power supply unit. To measure the maximum reading range of the tag, the card (4) was slowly brought close to the reader. When the sound was emitted, the computer read test data. There was no material (5) in the test. The results are presented in table 1.

Table 1. Maximum reading distance results

	Perpendicular	Parallel I	Parallel II
Maximum reading distance [mm]	85	25	40

Based on these results it was concluded that the perpendicular configuration is best for the reader and the transponder. This optimum configuration was used in further tests (widest reading range).

The most frequently used packaging materials were selected, which included: foil (PE-LD) – Y1; plastic (PP) – Y2; cardboard – Y3; envelope – Y4; fabric (50% cotton /50% polyacrylonitrile) – Y5; wood – Y6; metal (2 mm thick) – Y7 and Y8 for the reading distance. Figure 4 presents the test station. The transponder was positioned at the maximum reading distance determined in test 1, i.e. 85 mm. Material Y1 was placed at 0 mm from the reader, then the tag was slowly brought closer to the reader along a straight line. After the signal the maximum reading range was recorded.

Material Y1 was moved 5 mm away from the reader and the maximum reading range was tested. Then the material was moved by another interval, up to 80 mm. The materials were used in sequence to obtain results. The speed of moving the tag to the reader was insignificant and made no impact on the results.

The reader was connected with the computer as in the previous test (see Fig. 3). Other materials (Y1-Y5) were put between the reader and transponder to test how various materials influence the reading range. The materials used for testing were selected based on the frequency of application in collective or transport packaging. The test results are presented in Fig. 4.

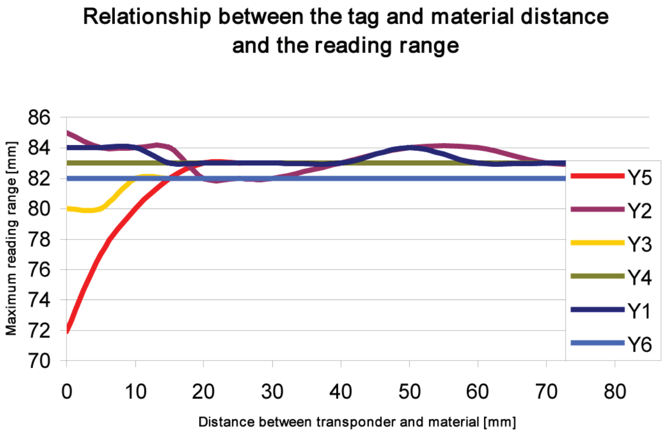

Fig. 4. Static test chart

The materials demonstrated an impact on radio waves. The test results show that most materials have no impact on the reading range of transponders operating at 125 kHz. However, a dense fabric made an impact, but only in the initial stage, when the transponder was close to the fabric. The 50% polyacrylonitrile content affected the reading quality. However, the range is reduced by no more than 15 %, therefore the 125 kHz tag may be used with this type of material. Using tags on natural fabrics, e.g. cotton or linen had no impact on the reading distance.

The major problem with 125 kHz transponders is the use in close proximity to metal. If the tag is applied directly to metal, the reading will not be made. The tag must be moved from the metal by at least 1 mm to gain a range of 10 mm. If the transponder is used further than 12 mm from the metal, the maximum reading range, i.e. 85 mm remains unaffected.

2.2 Dynamic tests

In this case the test comprises: the speed at which the tag is moved against the reader and the reading of several transponders. To avoid test errors, the set rate of rotation was stabilised each time. Figure 5 presents the test station diagram, where the inverter (1)

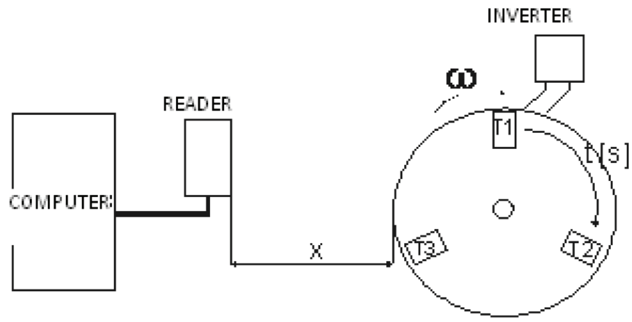

Fig. 5. Test station diagram

was connected to a device with a dial (2), the rate of rotation of the dial, to which the transponders were connected (3), was set by changes in the inverter's voltage. The measuring device (4) was positioned close to the rotating dial. The zero point is at the transponder's level and thus direct results will be obtained. The reader and the antenna (5) were placed over the rotating dial so that tag 1 is within the antenna range. During the test the reader was moved towards the rotating dial with the transponders.

To avoid disturbances of measurements, the entire assembly was calibrated. Tag 1 was placed on the dial with the radius of 150 mm. The linear velocity was approx. 1 m/s. The reading distance was 40 mm.

Then the 2nd and 3rd tag was added. The test results are presented in Table 2.

Table 2. Results of the calibration of the assembly

No.	Number of tags [pcs]	Linear velocity [m/s]	Distance between tags [mm]	Reading distance [mm]
1.	1		-	38
2.	2	1.0	250	39
3.	3		180	38

No disturbances of measurements were recorded at the reading distance. The distance between 3 tags was 180 mm and could not disturb the reading of individual transponders. Disturbances might occur if the distance between tags was shorter than the maximum reading range.

The reader was connected with the computer in the same manner as in item 1.1. The tags were mounted on the dial, the rotations of which were adjusted by the inverter. Initially the first tag was set by the rotation and mounted on the dial. It was concluded that the maximum rate for 125 kHz transponders was approx. 140 rotations per minute.

Similar tests were performed for 3 tags mounted at 180 mm from one another.

Moreover, additional tests were carried out for 1 and 2 tags mounted on a shorter arm.

Fig. 6. Dynamic test chart

2.3 Transponder programming

The tests pertained to the possibility to save data on the transponders in various conditions of positioning and motion, for the following cases: 1, 2 or 3 tags.

Standard UniqueMaker v1.2 software working under Windows XP OS and connected to the computer via RS 232 port was used for programming.

The transponders offer 10 fields, which may be filled in as follows: in each field a digit (0-9) or a letter (A, B, C, D, E, F) may be entered and no field may be left empty. Any combination of digits and letters is acceptable.

The data writing time per tag is approx. 1.5 – 2 s. This time is invariable even if the distance between the tag and the transponder or the number of tags within the antenna range varies.

If a single tag is programmed, it must remain within the antenna range during programming. To assure a 100 % correct recording, the tag must be stationary. If the tag is moving, the recording may be incorrect. If the recording is incorrect, the transponder will not be visible for the reader.

Should 2 transponders be within the antenna range, the tag with a wider range will be read. During programming, however, the same new code will be saved on both tags. The reading and programming will not be possible if 2 tags are aligned axially and if they adjoin one another closely. In the case of 2 tags aligned axially, the minimum distance must be at least 10 mm and if the tags adjoin one another, they should be moved away to disrupt the coaxial alignment.

The 3 transponders within the antenna range will be programmed if the tags are positioned axially and perpendicularly to the antenna, with the minimum distance of at least 15 mm, if the transponders are not aligned, even if they adjoin one another.

The chart (Fig. 8) shows that the optimum linear velocity for the tags, in which case neither the number of transponders nor the distance between tags is relevant, is approx. 0.5 m/s. The lower the speed the larger the reading distance is and the higher the linear velocity, the closer the reader must be.

The maximum reading distance is related to the number of tags in proximity. With 1 tag the maximum reading distance is 80 mm at 0.2 m/s. With 2 tags the maximum reading distance is 74 mm at 0.4 m/s and with 3 tags the distance drops to 60 mm at 0.5 m/s.

The maximum speed at which tags are read is 2.1 m/s at a very short distance between the reader and the tag.

Series 2 comprises 1 tag at the arm of 80 mm and series 3 involved 2 tags at the same arm positioned 170 mm from each other. It may be seen that the rate of reading 2 tags at the same reading distance decreases. This occurs only at a speed higher than 0.63 m/s. One may intuitively conclude that at lower speeds 1 tag should be read faster than 2 tags, but it is the other way round – 2 tags are read faster than 1 tag. 2.5.

3. Conclusion

This paper discusses RFID tags working at the frequency of 125 kHz. Despite the fact that they operate at a low frequency, the penetration through materials analysed above is 100 %. The only exception is metal and applications in very close proximity to metal objects.

In the case of application on packaging in motion as it is the case with, e.g. a parcel sorting facility, there may be problems with the proper place to put the tags. To avoid errors or failure to read, antennas should be installed around moving parcels. The contents of parcels: liquids, foil and metals absorb and reflect radio waves. Unfortunately, the so-called "smart labels" must be carefully placed on such items as foil-packed crisps, liquid detergents and tinned goods. In such cases, the best solution is to apply RFID labels working at a higher frequency, e.g. 13.56 MHz. It is often the case that the possible area of label application is very limited, therefore it requires continuous experiments.

Dynamic tests show that the maximum linear velocity of 125 kHz tag amounts to 2.2 m/s. The optimum positioning of the tag against the reader is perpendicular, i.e. radio waves strike the tag perpendicularly. Therefore, the tag should be positioned at 90 degrees against the reader.

During programming, the tags must remain stationary against the antenna for approx. 2 s. For 125 kHz chips 10 fields are written, in combination of digits 0-9 and letters A-B-C-D-E-F. In the case of combining the transponder reading and writing programme with, e.g. a spreadsheet, the area of application may be expanded.

However, to apply the RFID systems in practice, a series of tests is required. It will help producing results, which will translate into the most efficient application in supply chains.

Bibliography

[1] KWAŚNIOWSKI S., ZAJĄC P.: „Automatyczna identyfikacja w systemach logistycznych", Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2004

[2] TI-RFID Product Manuals Terms & Abbreviations, Technical Application Report, Texas Instruments

[3] www.bcspolska.pl (accessed 19.08.2013)

[4] www.mikrokontrola.pl (accessed 19.08.2013)

[5] www.selmar.com.pl (accessed 19.08.2013)

[6] www.softex.com.pl (accessed 19.08.2013)

[7] www.symbol.com (accessed 19.08.2013)

[8] www.ti-rfid.com (accessed 19.08.2013)