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INFLUENCE OF SELECTED MATERIALS ON RFID – PRACTICAL TESTING

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ABSTRACT:
Radio frequency identification, shortly RFID is potential upcoming technology of the future item lifecycle tracking. As every technology also RFID has its limitations. The most serious factors can even disable tag from reading. This article shows practical experiments with various materials attached to the RFID tag and measurement of read distances.
KEYWORDS:
RFID, physical attributes, testing

1. INTRODUCTION

Radio frequency identification - RFID is technology of objects or person identification by use of radio frequency transmission. Principles of this technology have been used during World War 2 by British army (Identification Friend or Foe, shortly IIF). RFID system consists of two basic components: RFID readers (or interrogators) and RFID tags, also known as transponders. RFID readers are providing energy to the passive RFID tags and are reading information contained in memory of RFID tag. According to the type of RFID tag, RFID readers can also store information on the tags.

There are 2 basic types of RFID tags:

- active RFID tags (contain battery, therefore they can be read from longer distances)
- passive RFID tags (tags are supplied by energy transmitted by RFID reader)

RFID tags can be divided also according to operating frequency to (Lewis, 2005):

- **LF** → less than 135 kHz → mostly passive, biggest antenna of all RFID tags, no or poor anticollision algorithm
- **HF** → 13,56 MHz → mostly passive, cheaper than LF RFID tags, used in Smart Cards
- **UHF** → 860 - 930 MHz → in large volumes cheaper than LF and HF RFID tags, longer read distance than LF and HF, good readability of multiple tags, can be passive or active
- **Microwave** → 2,45 GHz → similar properties as UHF RFID tags, but with higher read speed, can be passive or active, typically used in electronic toll systems or location tracking

There are many specifications of RFID tags, nowadays mostly of used are working on LF 125 kHz and HF 13,56 MHz, but recently also UHF tags 860 – 930 MHz (according to location) are going to take large part of the market. Therefore, core of this paper is focused on LF and HF tags.

One of the important issues in radio frequency identification is transmission of data through air and energy propagation. Energy from the reader's antenna can be absorbed, reflected or can be detuned. It depends on environment and surrounding materials, frequency of RFID reader, amount of energy that reader propagates and from distance and type of RFID tag. All these factors are influencing tag-reader communication at the same time. To demonstrate and verify the influence of various materials on tag-reader communication, we used four types of RFID readers:

- Phidget 125 kHz (see FIG. 1) and
- Stronglink SL015B 13,56 MHz (see FIG.2)
- Stronglink SL018 13,56 MHz (see FIG.3)
- Stronglink SL030 13,56 MHz (see FIG.4)

together with 3 different types of material:

- two hard electric conductive materials
- two electric conductive and magnetic non-conductive materials
- three electromagnetic materials

and 4 different types of RFID tags.

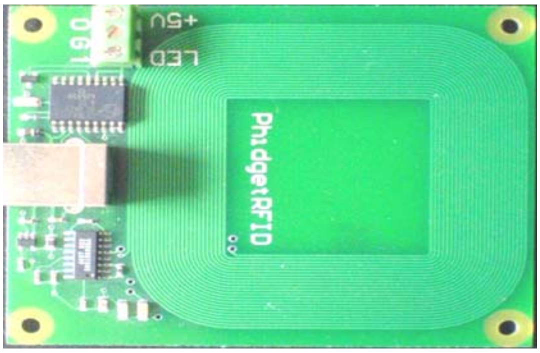

FIGURE1. PHIDGET 125 kHz - RFID READER

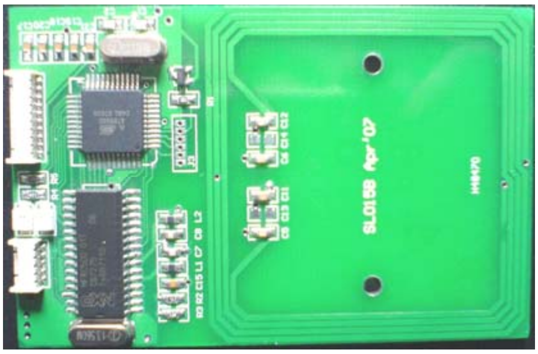

FIGURE 2. STRONGLINK SL015B - 13,56 MHz RFID READER

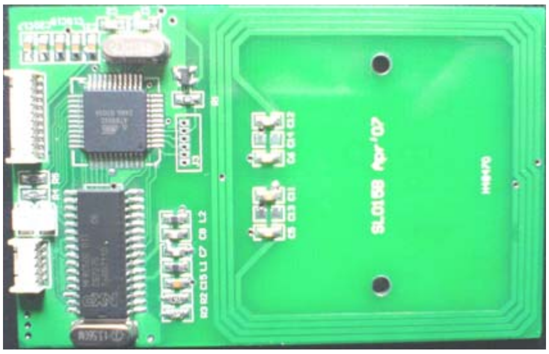

FIGURE 3. STRONGLINK SL018 - 13,56 MHz RFID READER

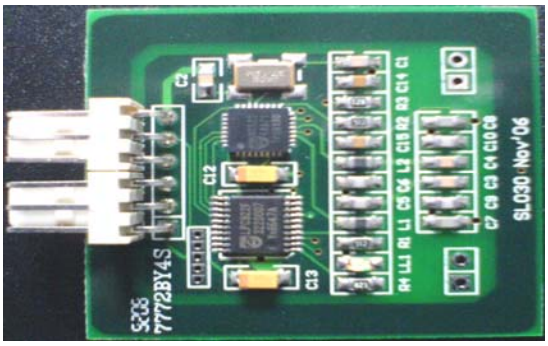

FIGURE 4. STRONGLINK SL030 - 13,56 MHz RFID READER

Because electromagnetic radiation differs in every environment and reading range is dependent also on tag, reader type and antenna, maximum read values have been measured for each type of reader and tag separately (see Table 1) to set comparison values. As we expected, these values were different than manufacturer specification of maximum reading ranges. In order to make testing results comparable, all materials used for testing had the same dimension – 90x130x1 mm. It is essential for testing of reading range and its dependence on type of material in the same surrounding environment.

2. PRACTICAL TESTING OF RFID

Testing of reading range was performed by use of two RFID readers with different work frequencies and correspondent RFID tags along with various materials, which were inserted between tag and reader. After tag was recognized by reader, measured value was written down. Each measurement was performed three times and average of these values was counted as representative value of measurement.

First of all, reference reading range values without any material between tag and reader have been measured (see Table 1). These values represent maximal reading values in measured environment of correspondent RFID reader and type of RFID tag. As we can see from Table 1, the worst reading range have SL018 and SL030 readers, because they contain

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smaller antennas in compare with SL015B and Phidget 125 kHz. From that reason all following measurements have been made just with Phidget 125 kHz and Stronglink SL015B 13,56 MHz in order to compare suitability of each reader type according to nearby material. Tag was put on the corresponding material from direct sight of view and indirect sight of view to the reader. Every measurement was performed three times and average measured values are shown in the table 2, 3, 4, 5, 6 and 7.

Table 1: Maximal reference values of tested RFID readers

Phidget 125 kHz		Stronglink SL015B – 13,56 MHz	
Tag type	Read range [mm]	Tag type	Read range [mm]
Card	137	Card	80
Rectangle sticker	95	Round sticker Ø 30 mm	43
Round sticker	90	Sticker 75x17 mm	55
SLG01 – under skin	50	Sticker 30x30 mm	50
Stronglink SL018 – 13,56 MHz		**Stronglink SL030 – 13,56 MHz**	
Tag type	Read range [mm]	Tag type	Read range [mm]
Card	52	Card	45
Round sticker Ø 30 mm	30	Round sticker Ø 30 mm	35
Sticker 75x17 mm	30	Sticker 75x17 mm	35
Sticker 30x30 mm	30	Sticker 30x30 mm	30

Table 2: Hard electric conductive materials – Phidget 125 KHz

Phidget 125 kHz				
Hard electric conductive materials	Material			
	wood		cardboard	
	direct sight	indirect sight	direct sight	indirect sight
Tag type	Read range [mm]			
Card	126	125	135	130
Rectangle sticker	90	85	90	90
Round sticker	90	8,5	90	90
SLG01 – under skin	35	30	35	25

Table 3: Hard electric conductive materials – Stronglink SL015B 13,56 MHz

Stronglink SL015B – 13,56 MHz				
Hard electric conductive materials	Material			
	wood		cardboard	
	direct sight	indirect sight	direct sight	indirect sight
Tag type	Read range [mm]			
Card	80	75	80	75
Round sticker Ø 30 mm	40	40	40	35
Sticker 75x17 mm	53	50	53	50
Sticker 30x30 mm	50	45	50	50

Table 4: Electric conductive and magnetic non-conductive materials – Phidget 125 kHz

Phidget 125 kHz				
Electric conductive and magnetic non-conductive material	Material			
	copper		brass	
	direct sight	indirect sight	direct sight	indirect sight
Tag type	Read range [mm]			
Card	40	0	10	0
Rectangle sticker	10	0	5	0
Round sticker	15	0	20	0
SLG01 – under skin	40	35	45	40

Table 5: Electric conductive and magnetic non-conductive materials – Stronglink SL015B 13,56 MHz

Stronglink SL015B – 13,56 MHz				
Electric conductive and magnetic non-conductive material	Material			
	copper		brass	
	direct sight	indirect sight	direct sight	indirect sight
Tag type	Read range [mm]			
Card	0	0	0	0
Round sticker Ø 30 mm	0	0	0	0
Sticker 75x17 mm	0	0	0	0
Sticker 30x30 mm	0	0	0	0

Table 6: Electromagnetic materials – Phidget 125 kHz

Phidget – 125 kHz						
Electromagnetic material	Material					
	type 1		type 2		type 3	
	direct sight	indirect sight	direct sight	indirect sight	direct sight	indirect sight
Tag type	Read range [mm]					
Card	50	0	70	35	55	0
Rectangle sticker	35	0	45	0	40	0
Round sticker	45	0	50	0	50	0
SLG01 – under skin	50	30	40	35	45	35

Table 7: Electromagnetic materials - Stronglink SL015B 13,56 MHz

Stronglink SL015B – 13,56 MHz						
Electromagnetic material	Material					
	type 1		type 2		type 3	
	direct sight	indirect sight	direct sight	indirect sight	direct sight	indirect sight
Tag type	Read range [mm]					
Card	0	0	0	0	0	0
Round sticker Ø 30 mm	0	0	0	0	0	0
Sticker 75x17 mm	0	0	0	0	0	0
Sticker 30x30 mm	0	0	0	0	0	0

As we can see from above results of measurements, 125 kHz reader is more suitable than 13,56 MHz reader when reading near liquids or metals. Despite this, the difference is very small because most of the reading attempts were unsuccessful. Reading range depends mainly on distance of metal or liquid from the tag and transmission power of the reader and antenna, which is directly connected with the dimension of the antenna.

3. CONCLUSION

Energy transmitted by reader is obviously very small and every metal or liquid with surface greater than antenna makes reading of the tag impossible. This can be significantly improved by special tags that have special cover which ensures sufficient distance from metals or liquids. Second way how to read near such materials is to use active RFID tags or even different frequencies. Generally LF readers are more suitable than HF readers, but UHF readers with special metal tags are emerging. These UHF tags can be in large volumes very cheap and therefore they can provide very good solution and alternative way how to identify metal goods or liquids by RFID technology.

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