Data hardware protection of electronic identifiers

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Abstract—Data protection of personal information contained in electronic identifiers is one of the most important tasks in RFID technology development. This paper is focused on design and development of data hardware protection of electronic identifiers. New developed textile materials based on metallic and polymeric fibers reach electromagnetic shielding efficiency of tens of decibel in a wide frequency spectrum. The paper describes a development of specific application and its testing.

Keywords-RFID, EMC, Shielding, Shielding textile, ESE, Planar Material.

I. INTRODUCTION

A development of contact and non-contact personal and object identification systems and their applications for electronic payment is affected by risks of illegal modifications, alienation or duplication. Nowadays more and more scientific publications describe different attacks to electronic identification systems, which character is in principle non-invasive (from the involved owner point of view). Non-invasive attack means, attacker does not have to have physical identifier available and nevertheless he can read saved data in identifier for a long distances. Methods for solving these attacks belong to cryptography branch.

This paper is focused on data hardware protection of electronic identifiers based on RFID technology or systems with data magnetic field. Applications of new shielding textiles enable prevent from unauthorized reading of data content saved in electronic identifiers.

II. RFID

RFID (Radio Frequency Identification) technology is based on well-known radar principle. Tags are active or passive. Passive tags use an energy sent from the reader as a power source. This paper is focused on passive RFID tags, Fig. 1.

A reader sends an electromagnetic wave on its carrier frequency and the wave is received by antenna tag. A generated voltage produces electric current, which is rectified and charges a condensator. A saved energy in condensator is used for electric power supply of logical and radio circuits of tag.

When the condensator receives a minimum voltage level, logic controller or microprocessor (i.e. control circuits inside the tag) is started and tag sends an answer to the reader. Data sending is based on ASK (Amplitude Shift Keying) modulation, which is realized by change of antenna tag terminating impedance (aerial matching or short-circuit termination). Reflections, which are produced by antenna impedance change, are detected and interpreted like logical 1 and logical 0. Control of communication and individual conditions of communication circuit is defined by ISO (International Organization for Standardization) standard [1].

Sufficient energy for condensator charge in tag and a detection ability to receive the answer of tag by reader are main hardware conditions of RFID system operation. A quality of RFID signal is decreased with increasing distance between reader and tag. An increasing level of noise in basic signal leads to impossibility of successful detection of received message. It is also possible to write the information to the tag from the reader by modulation of wave.

The necessary condition of successful identification process is the ability of external reader to add sufficient energy to the RFID tag.

RFID tags are power supplied by two main methods:

- Communication in near field uses inductive coupling between RFID reader antennas (coils) and tags (low frequency and high frequency range)
- Communication in far field uses antenna systems with dimensions comparable with carrier wave length (very high frequency and ultra high frequency range)

The principle of RFID technology operation shows that decreasing level of useful signal leads to decreasing reading distance. In the worst case it is impossible to communicate between RFID tag and reader.

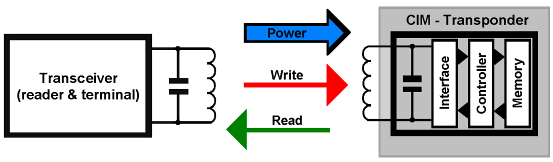

Figure 1. Basic RFID communication.

III. GENERAL ANTENNA COUPLING

Equation (1) shows a power accepted by RFID tag.

$$P_{CHIP} = P_{READER} \cdot C \cdot \tau \text{ [W]} \quad (1)$$

P_{CHIP} is the power accepted by RFID tag, P_{READER} is a power sent by RFID reader, C is the coupling coefficient (the power transmission loss) between reader and tag antennas and τ is matching coefficient [2].

Coupling coefficient is in the ideal case equals to 1. In this case RFID chip is connected directly by wire to the output of the reader and impedance match is maintained. Coupling coefficient can be expressed in the real case as shown in equation (2).

$$C = L_{PATCH} \cdot G_t \cdot G_r \cdot p \text{ [-]} \quad (2)$$

L_{PATCH} is a loss of transmission environment and it represents loss caused by diversion of reader and RFID tag antennas from ideal polarization plane. G_t is the reader antenna gain, G_r is the receiving tag antenna gain and p is the polarization mismatch loss [2].

L_{PATCH} is generally defined by attenuation of electromagnetic wave with certain wave length (λ) and at distance (d) propagated in free space (wireless data transmission) (3) [3].

$$L_{PATCH} = (\lambda / 4 \cdot \pi \cdot d)^2 \text{ [dB]} \quad (3)$$

It is necessary to increase L_{PATCH}, if it is required to limit reading distance and block RFID tag reading. New attenuation is L^*_{PATCH} and it adds to the L_{PATCH} additional obstruction $ESE_{ABSORBER}$ (4).

$$L^*_{PATCH} = (\lambda / 4 \cdot \pi \cdot d)^2 + ESE_{ABSORBER} \text{ [dB]} \quad (4)$$

Undesirable electromagnetic signals are attenuated by electromagnetic shielding or absorber of electromagnetic field in EMC (Electromagnetic compatibility) branch.

IV. Electromagnetic Shielding Efficiency

ESE (Electromagnetic shielding efficiency) is a parameter, which describes an ability of specific material to limit a penetration of high frequency signal over certain barrier.

Shielding ability, i.e. reduction of intensity of electromagnetic field, is based on originating reflections of electromagnetic wave and its absorption in specific material. A heating is generated during absorption of high frequency energy like a product of transformation electromagnetic field energy to thermal energy. Shielding principle is shown in Fig. 2. A part of the incident electromagnetic wave is reflected from the barrier (reflection). The other part of incident energy is attenuated by reflections inside the barrier (re-reflection) and the last part of the energy is transmitted through barrier (transmission) [4]. The shielding effectiveness is possible to describe by equation (5).

$$SE = R + A + B \text{ [dB]} \quad (5)$$

R is single-reflection loss, A is absorption through the shielding and B is multiple-reflection coefficient.

Values of specific parameters, which correspond to a specific material and a construction of used barrier, have an effect to resulting value of ESE. The ESE describes a difference between intensities of electromagnetic field, which limp and pass through the barrier. As a consequence it is possible to express ESE by logarithm of quotient intensities of electric or magnetic component of electromagnetic wave or also by power levels (6).

$$ESE = 20 \cdot \log \left| \frac{E_i}{E_t} \right| = 20 \cdot \log \left| \frac{H_i}{H_t} \right| = P_i - P_t \, [dB] \quad (6)$$

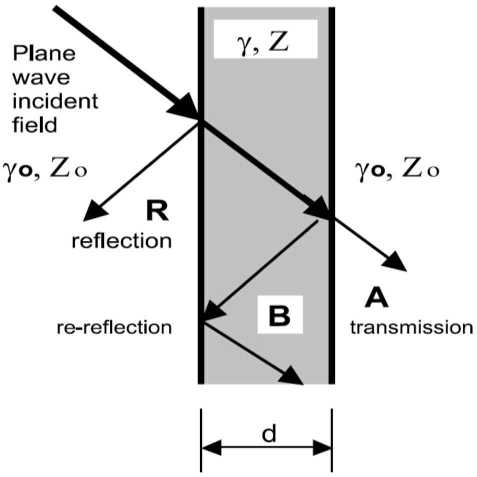

Figure 2. Shielding principle [6].

V. Measurement of Shielding Materials

New shielding materials based on yarn with silver nanoparticles were designed and produced within the scope of BE-TEX project. Equation (6) shows the principle of ESE measurement, which is called comparing measurement. Intensities of electromagnetic field of sent and received signals are compared with and without shielding material. Realized sample of shielding cover is shown in Fig. 3.

Figure 3. Shielding cover.

VI. ESE Measurement of Planar Textiles in RFID Frequency Ranges

A. ESE Measurement using capacitive coupling

This chapter is focused on realization of measuring device of electromagnetic shielding efficiency of planar textiles in frequency range 100 kHz – 1.5 GHz. This measurement uses ASTM D4935 standard [5] adapter.

The goal of the measuring device is to realize reproducible measurement based on comparison of reference sample and measured sample. The method accuracy is ensured by used measuring apparatus. In this case circuit analyzer with accuracy +/- 0.5 dB was used.

The size of measuring device was minimized by using capacity coupling systems. It also supports minimization of environment influence. This is very useful feature, which does not require measuring in anechoic chamber. This is a great advantage in comparison with e.g. electromagnetic compatibility measuring. Measuring device is shown in Fig. 4.

Figure 4. Measuring device.

B. Low frequency, high frequency

RFID technology in frequency ranges 125 kHz and 13.56 MHz uses a communication in near field by inductive coupling. The cover, restricting communication of tags, creates shading coil, which absorbs magnetic component of electromagnetic field generated by RFID reader. Results of measurement of these frequency ranges are shown in Fig. 5. Measurement is realized with modified ASTM D4935 coaxial adapter [5]. Samples of textiles with nanoparticles of silver and continuous rustless yarn are used. Measurement of 10 µm thick aluminum sheet is also realized with respect to ESE comparison (noise background definition). A structure and material of sample in woof and warp, sett of fabric and produced type of textile are parameters, which affect ESE of specific sample.

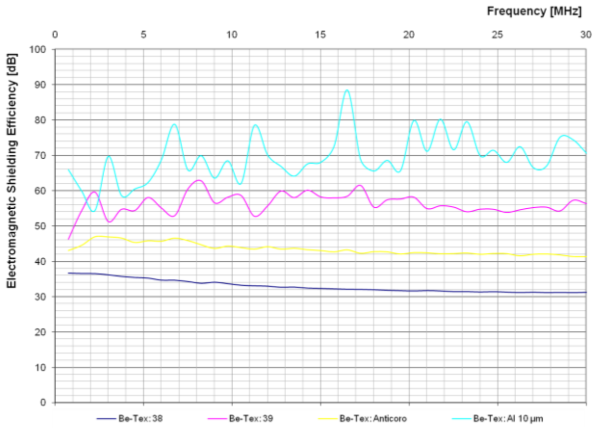

Figure 5. ESE of planar material samples in frequency range 100 kHz – 30 MHz.

C. Very high frequency, ultra high frequency

RFID tags in these frequency ranges communicate with the aid of back-scatter modulation. Measurement of frequency ranges from 30 MHz to 1.5 GHz was realized also by comparing measurement. A circuit analyzer and a gauging fixture ASTM D4935 [5] were used. The results of the same samples of planar materials are shown in Fig. 6.

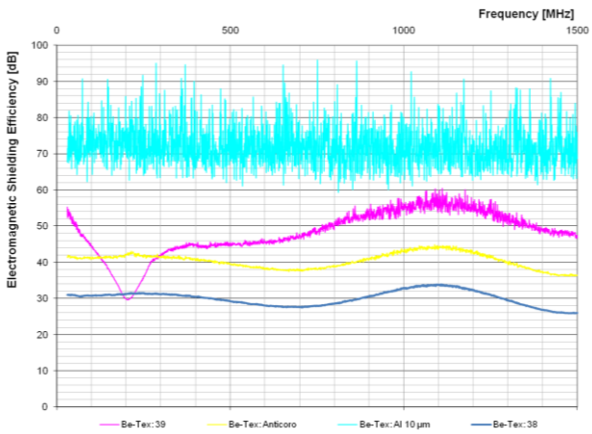

Figure 6. ESE of planar material samples in frequency range 30 MHz – 1.5 GHz.

VII. Absorber Testing in RFID System

A practical testing procedure of three absorber prototypes was realized for three common RFID frequency ranges. Prototypes were produced in single-layer and two-layer configuration. Tab. 1 shows the results of the reading ability of tags placed inside the absorbers.

Absorber testing was realized on the measuring desk, which consists of standard RFID reader for specific frequency range (Elatec models TWN3 OEM PCB modul Multi 125 and TWN3 OEM PCB modul Multi ISO), RFID tag and absorber. The RFID tag was placed in specific absorber type. The RFID reader and tag were very closely located and control computer evaluated individuals detection operations.

The best results were achieved by shielding material Be-Tex Anticoro in application with one layer. It was not possible to identify the tag placed in Anticoro one layer application in any of 50 realized tests.

TABLE I. RFID ABSORBERS UNDER TEST

Material	**125 kHz**	**13. 56 MHz**	**868 MHz**
Be-Tex nr. 38, single	signal	signal	no signal
Be-Tex nr. 38, double	signal	no signal	no signal
Be-Tex nr. 39, single	signal	signal	no signal
Be-Tex nr. 39, double	signal	no signal	no signal
Be-Tex Anticoro, single	no signal	no signal	no signal

VIII. FUTURE RESEARCH

Future research is focused on prototype development of designed hardware protection and its testing in laboratory environment from following points of view.

- Efficiency of data protection of RFID electronic identifiers
- Robustness of prototypes
- ESE stability testing in using prototypes

IX. CONCLUSION

This paper describes the prototype development of hardware data protection of RFID electronic identifiers. The production of prototype, ESE measurement of specific materials in RFID frequency ranges was designed and realized. The function of cover protection sample based on modern textile materials with silver nanoparticles was confirmed.

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