ACCESS CONTROL SYSTEM USING A CAPSULE TYPE RFID BIOMEDICAL IMPLANT

Lecturer PhD. Eng., Marian IONESCU, "Constantin Brâncuși" University from Tîrgu-Jiu, ROMANIA, i_marian_19@yahoo.com
Assoc. Prof. Ph.D. Eng., Ilie BORCOSI, "Constantin Brâncuși" University from Tîrgu-Jiu, ROMANIA, ilieborcosi@yahoo.com

ABSTRACT: *This paper presents the development of an access system for a secure space that can be accessed based on an RFID biomedical implant in the form of a capsule implanted in the hand. Biomedical RFID (Radio Frequency Identification) capsule implants are small devices, usually in the form of a capsule or microchip, that are inserted into the human body for medical purposes and that use RFID technology to transmit and receive information. These implants are generally used to monitor or control various vital parameters of the body's general health, but also for smart cards or RFID cards with the aim of providing fast and secure access in a convenient and efficient way.*
KEYWORDS: RFID biomedical implant, access system, RFID technology, RFID card, Arduino Nano

1. INTRODUCTION

Access control through RFID implants represents a modern and effective solution in the field of security. These implants include miniaturized chips and antennas, inserted under the skin, which communicate with specialized readers. They allow for fast and accurate user authentication, providing a convenient and personalized way of accessing different areas or systems. This eliminates the need to use and maintain external devices such as access cards or passwords [1]. Access control with RFID implants offers high levels of security, as they are unique to each user and can be programmed and reprogrammed to adapt to individual needs and rights. In addition, this technology can be easily integrated into various environments, such as office buildings, transportation systems or even personal devices, ensuring effective protection and a simpler and more convenient experience for users. At the same time, radio frequency identification (RFID) technology is increasingly being used in the medical field to help improve patient care and safety [2].

2. PROBLEM FORMULATION

RFID medical implants are small devices that are inserted into the human body to help track a patient's medical information and improve their overall health. They use a small chip that can store and transmit data wirelessly using radio waves [3]. These devices are typically implanted under the skin and are designed to be permanent. They can be used to monitor vital signs, track medication adherence, and provide doctors with real-time information about a patient's health status. Access control with RFID implants is an innovative and secure approach to security. This technology provides users with personalized and convenient control over access to various areas or systems, eliminating the need to carry or maintain other external devices, such as access cards or passwords [4]. RFID implants provide high levels of security because they are unique to each user and can be programmed and reprogrammed to adapt to individual needs and rights. However, this technology raises certain concerns regarding security and privacy. Careful management of personal data is essential, as is preventing unauthorized access to medical information stored in RFID implants. In addition, respect for the individual's autonomy and maintaining

control over their own body must be taken into account. By adopting a prudent and responsible approach, the use of RFID implants for access control can support improved patient care and contribute to a more efficient and safer medical environment.

3. SUBCUTANEOUS IMPLANTS WITH RFID MICROCIPPS

Biomedical RFID (Radio Frequency Identification) capsule implants shown in Figure 1 are small devices, usually in the form of a capsule or microchip, that are inserted into the human body for medical purposes and that use RFID technology to transmit and receive information [5]. These implants are generally used to monitor or control various aspects of human health, or to control access to certain secure spaces. An electronic device implanted under the skin, commonly known as a human microchip, is usually inserted by injection. It may include an RFID module with an integrated circuit, sealed in a silicate glass container and placed in the person's body. Subdermal implants typically contain a unique identification code that can be linked to an external database, allowing access to information such as identity, criminal history, medical records, treatments administered, appointments, and other possible uses.

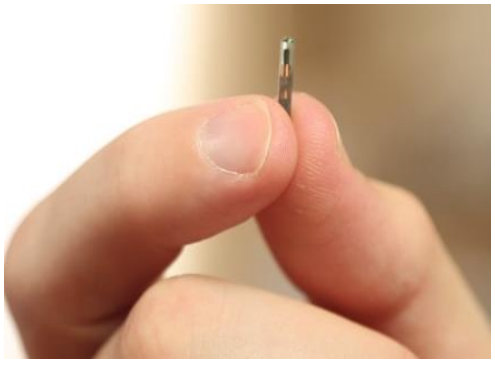

Fig. 1. Capsule-type RFID biomedical implant

Capsule RFID implants are typically small and compact, about the size of a medical capsule or a grain of rice. They are made of biocompatible materials, such as titanium or silicone, to minimize adverse reactions or rejection by the body. Implants use RFID technology to interact with external devices. An RFID system includes a microchip containing a unique identification code and an antenna that allows the transmission and reception of radio signals. These implants can be read and configured using dedicated devices, such as RFID readers [6]. Most capsule-type RFID biomedical implants do not require an external power source, as they use the energy transmitted by the RFID reader or electromagnetic fields in the vicinity. Thus, there is no need to replace batteries. A key element in the use of RFID biomedical implants is data protection and ensuring confidentiality. Medical information must be protected from unauthorized access, and implementing robust security measures is crucial to prevent potential cyber threats.

4. DEFINITION OF RFID TECHNOLOGY

The term RFID stands for "Radio Frequency Identification" and refers to several systems that together allow objects to be identified automatically. The easiest way to imagine the RFID system is to think of a barcode that is capable of transmitting information via radio and updating itself over time [7]. Many believe that RFID is the technology that will allow for the creation of the "Internet of Things", or rather a large network in which not only people, but also objects will be connected to each other [8,9]. For supply chain professionals, i.e. goods management, RFID technology is a useful tool because it provides extraordinary control over boxes and products. With the help of RFID technology, management accounts can be reduced, as well as improving the efficiency of warehouses and the entire supply chain. For sellers, RFID technology is an opportunity, because it leads to improvements in the way buyers interact with the products they intend to purchase. Finally, for those who produce, integrate and sell RFID technology, it is one of the most promising markets, because tags and antennas, which are two basic elements of a radio frequency identification system, are developing worldwide with surprising speed.

Figure 2 below shows the operating principle of a passive RFID. Identification

occurs using an antenna to read a digital chip (called a tag or transponder) that has been applied to an object (a person or a vehicle) that needs to be identified. The tag contains a certain amount of information regarding the object on which it was applied (such as a code, production date, manufacturer), which can be static, or can change over time. Tags do not need power sources (electricity) to function: when "illuminated" by the magnetic field of the antenna to which it is exposed, the tag is actually able to accumulate that small amount of energy that it needs to transmit, over a short distance, the information it contains. This type of tag is called "passive". If it is necessary to transmit information over a long distance, more energy is needed and the tag must be powered by an electrical power source, such as a battery. In this second case the tag is called "active" [10].

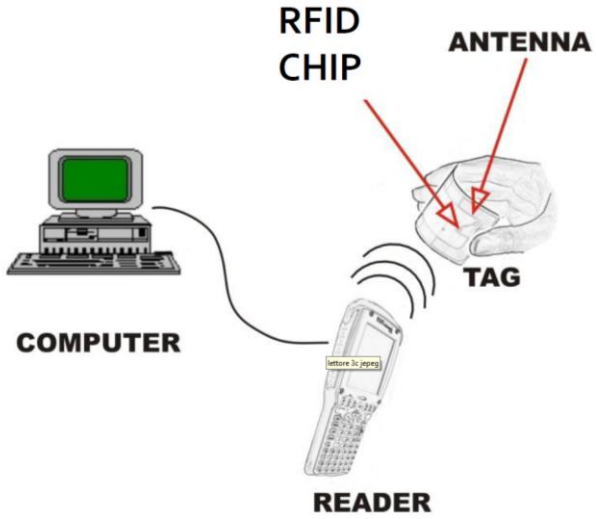

Fig. 2. The operating principle of a passive RFID [10]

The tag shown in Figure 3 below consists of a chip and a small antenna assembled on a small support. While the chip incorporates various types of information into memory and is responsible for managing all tag activities, the antenna allows communication with the RFID system readers. Antennas integrated into chips can be of two types: circular ones that allow tags to be read in any orientation of the antenna, while linear ones allow better tag reading depending on the orientation. The chip contains a unique universal number written in silicon and offers the ability to store additional data. There are three types of tags, namely: passive tags, semi-passive tags, and active tags. Passive tags do not require power, have a short reading distance and do not have the ability to integrate auxiliary sensors. They have a low acquisition cost. Semi-passive tags are powered by their own energy, have a long reading distance, and can integrate auxiliary sensors. They have an average acquisition cost. Active tags have their own power, have a long reading distance and can integrate auxiliary sensors. They have a high acquisition cost.

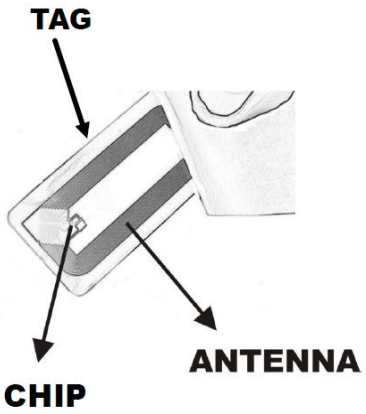

Fig.3 Schematic diagram of an RFID TAG [10]

The principle by which an RFID tag is able to receive and transmit the information contained in the chip is electromagnetic in nature. Figure 4 below shows the operating principle of a tag. [10].

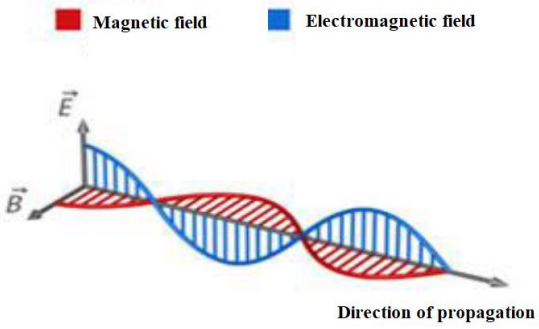

Fig.4 The operating principle of a TAG [10]

The coupling phenomenon between the tag antenna and that of the reader is achieved according to different physical principles (magnetic or due to magnetic field

propagation) independent of the frequency at which the tag and reader operate. At low or high frequencies, the magnetic coupling effect predominates, and at ultra-high frequencies, the electric field propagation effect predominates. When it enters the field of action of a reader (from a few cm to a few meters) the tag is activated by the electromagnetic field generated by the reader and responds by "reflecting" the modulated signal. The modulated response signal is then received by the reader which decodes it. This type of tag, called passive, is the most widespread on the market due to its price, which makes it affordable for many applications. Some types of passive tags, if specifically designed, offer great resilience in extreme industrial conditions. The performance limit of passive tags is the reading distance and the impossibility of integrating auxiliary sensors. In addition, the fact that they only activate when they are in the magnetic field of a reader makes them unsuitable for real-time location services (RTLS) applications [10].

4. ACCESS SYSTEM FOR A TECHNICAL SPACE ACCESSED BASED ON AN RFID MICROCHIP IMPLANTED IN THE HAND

The proposed method consists of developing an access system for a technical space that can be accessed only based on the passive RFID chip implanted in the hand or a card intended for authorized personnel. Figure 5 below shows the technical access space that is secured by a locking system controlled by a servomotorn[10]. The servomotor control system is composed of an Arduino Nano motherboard [11], RDM6300 RFID module [12], reed switch and 5V power supply.

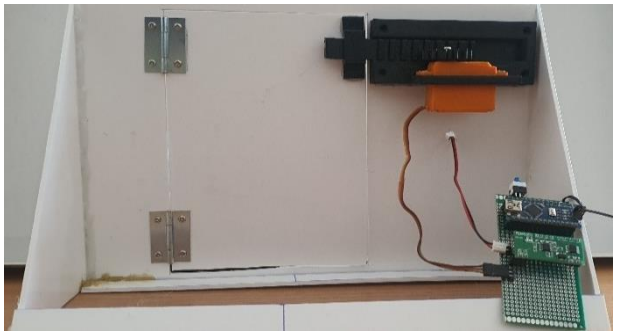

Fig. 5. Proposed access system for the technical space accessed by a passive RFID [13]

Figure 6 below shows the connection diagram of the electronic components of the access system. The RDM6300 module is a card reader with a working frequency of 125 Khz, with a serial UART (TTL) interface and uses radio frequency technology to read passive RFID tags and cards. This module is compact and easy to use, being frequently used in access control applications. This RDM6300 card reader can also read capsule-type RFID implants. The module will notify when the capsule-type implant is nearby, and the serial code will be sent through the IO pins and saved through the UART port. It is compatible with read-only tags (e.g. EM4100) and can read their UID from a distance of up to 5 cm, depending on the shape of the antenna and tag.

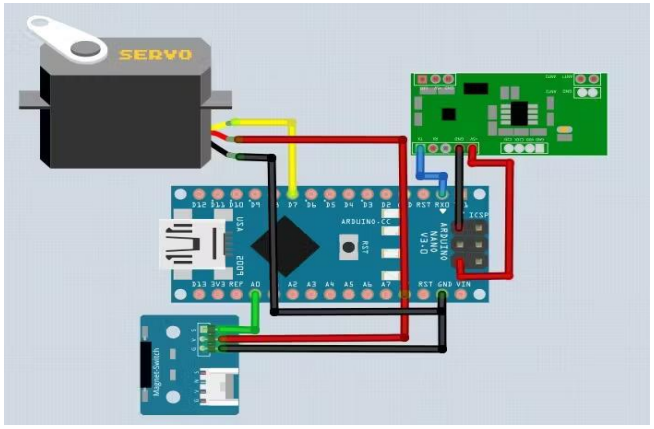

Fig. 6. Connection diagram of the electronic components of the access system [14]

The reed switch is responsible for keeping the locking system in the open position as long as the door is open. When the door is closed, the reed relay sends an impulse to the access system so that it can close the access door.

5. CONCLUSIONS

The RFID implant can be used as one of the components of a high-security system, increasing the functionality and security of the entire system. But to guarantee strong security standards, RFID implants must also be combined with other security measures. These can include encryption of transmitted data, strict chip authentication and the use of secure communication protocols. One of the main risks is the interception of data transmitted between the RFID chip and its reader. Since communication is via radio waves, an attacker can use special equipment to intercept and decode this data, which could allow unauthorized access to the information stored on the chip. Another risk associated with implantology is allergic reaction to materials used for implants, such as metals or fixation materials. It is important to perform allergy tests beforehand and to use materials that are compatible with the patient. Capsule-type RFID biomedical implants can be used in various medical fields, including patient monitoring, medication administration, health monitoring, implant or prosthesis tracking, patient identification, and more.

REFERENCES

[1] Aubert, H., *RFID technology for human implant devices*, Journal of Biomedical Engineering & Technology, 2011, pp.675-683.

[2] Abugabah, A., Ahmad AL Smadi, Luke Houghtonb, *RFID in healthcare: A review of the real-world application in hospitals,* The 14th International Conference on Ambient Systems, Networks and Technologies, March 15-17, 2023, Leuven, Belgium, pp.8-15.

[3] Grofu Florin, Cercel Constantin, Drăguţ Gheorghe, *„Wireless Application For Mechanical Transmission Study",* 15th International Multidisciplinary Scientific GeoConference SGEM 2015, www.sgem.org, SGEM2015 Conference Proceedings, ISBN 978-619-7105-34-6 / ISSN 1314-2704, June 18-24, 2015, Book2 Vol. 1, 415-424 pp DOI: 10.5593/SGEM2015/B21/S7.052 WOS:000371599500052.

[4] Grofu Florin, Cercel Constantin, *"Access control system using iButton"* , 15th WSEAS International Conference on Automatic Control, Modelling & Simulation (ACMOS13), Brasov, Romania, June 1-3, ISBN: 978-1-61804-189-0, pg. 232-237,2013.

[5] Aubert, H., *RFID technology for human implant devices*, Comptes Rendus Physique, Nanoscience and nanotechnologies: hopes and concerns, Volume 12 (2011) no. 7, pp. 675-683.

[6] Malik, N. A., Sant, P., Ajmal, T. and Ur Rehman, M., *Implantable antennas for bio-medical applications*, IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology, 2020, doi:10.1109/JERM.2020.3026588).

[7] Cercel Constantin, Grofu Florin, Runceanu Adrian,*"System for Reading Barcodes",* Annals of the „Constantin Brancusi" University of Tirgu Jiu, Engineering Series, No.3/2010, pag. 250-259, Editura „Academica Brâncuşi", Tg-Jiu, Cod CNCSIS 718, ISSN 1842 – 4856.

[8] Gheorghe GÎLCĂ, *Smart home system application based on internet of things*, National Scientific Conference with international participation "CONFERENG 2018", Tîrgu-Jiu, November 23-24, Annals of the „Constantin Brâncuşi" University from Tg. Jiu, Engineering Series, No 4, 2018, pp. 101-106, ISSN 1842-4856.

[9] Gheorghe GÎLCĂ, *Applications developed with the objects from the field of internet of things*, National Scientific Conference with international participation "CONFERENG 2017", Tîrgu-Jiu, December 08-09, Nr. 4, 2017, pp. 102-107, ISSN 1842-4856, Annals of the „Constantin Brâncuşi" University from Tg. Jiu, Engineering Series.

[10] https://www.leghorngroup.ro/wp-content/uploads/2020/04/ce-inseamna-rfid-2007.pdf

[11] Cercel Constantin, Grofu Florin, Nebunu Dana *"Modern system for access security"* Annals of the „Constantin Brancusi" University of Tirgu Jiu, Engineering Series, No.3/2011, pag. 66-75, Editura „Academica

Brâncuşi", Tg-Jiu, Cod CNCSIS 718, ISSN 1842 – 4856.
[12] https://store.arduino.cc/en-ro/products/arduino-nano?srsltid=AfmBOoq3RcuAJxeauwghuO5C8RM_AIlCOsArUuE9sQMR-uS7HGVXBhHN
[13] https://sigmanortec.ro/modul-rfid-125khz-rdm6300-uart
[14]https://www.dzduino.com/125-khz-module-lecteur-rfid-rdm6300-uart-fr?srsltid=AfmBOorSEIlpwpt4pVlPsu3K2lWw64_JgnvaBkKUHI2PvWBSjD9TrgJ1