Design of a Tag Antenna for IoT Applications in the Healthcare Field

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Abstract: RFID Radio Frequency Identification is a method of remotely memorizing and retrieving data. The system is activated by a transfer of electromagnetic energy between a radio tag and an RFID transmitter. The radio tag, made up of an electronic chip and an antenna, receives the radio signal emitted by the reader, also equipped with RFID technology. This technology is useful in a wide variety of processes. The uses that can be attributed to it are many and varied as well as the sectors where it can be applied. In this paper we will study the use of RFID in the healthcare sector. Wireless technology is evolving more and more in the world of healthcare applications among these technologies we find the Internet of Things, sensor networks, RFID technologies. Radiofrequency identification (RFID) technology is a new technology that improves the quality of life of patients and offers several technological solutions and involves several fields application, we find the field of healthcare with the ability to track or locate equipment and people in real-time, and also provides efficient access to medical data for physicians and other medical professionals. The use of RFID technology in healthcare has become more popular due to its unique characteristics compared to other technologies. In this article, we discuss the state of the art and the relationship between RFID technology and the Internet of Things. after that, we introduce healthcare system monitoring using RFID technology. Finally, we offer our RFID body sensor tag design suggestion we present an RFID antenna used for healthcare application; we made many simulations in order to get an idea about the behaviour of the antenna with the patient.

1 INTRODUCTION

The rapid growth in population density requires services and new infrastructure that are provided to meet the needs of the inhabitants which necessitates Thus, we have seen an increase in demand for onboard devices, such as sensors, actuators, and smartphones, which has given rise to the tremendous business potential for the new field of the Internet of Things (IoT), in which all devices are able to connect and communicate with each other over the Internet.

The use of the Internet of Things and new technologies solves several problems that exist in the health system. IoT technology capable of providing real-time remote health monitoring while preserving the quality of life of patients.

The healthcare system has undergone a great change in recent years due to the use of new technologies due to the development of Internet of Things applications which allows the healthcare sector to administer automatically with efficiency and effectiveness. accurately services to patients not only in hospitals, but also in their daily life, and provide several advantages.

The key concept of smart health is getting the right information in the right place and on the right device to make patient decisions easily and to help them faster. To develop the concept of smart health, we have deployed several wireless sensors on the patient's body, surveillance cameras, emergency buttons in hospitals and other fixed devices.

The use of IoT technologies such as sensor networks, RFID and on-board systems will help hospital patients to move freely within the hospital without having to enter certain rooms and be connected to certain machines, while avoiding the problems of moving doctors and nurses from one ward to another for examinations and analyses. Indeed, this will help caregivers in the performance

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of their work, while allowing them to monitor the patient's condition remotely and help them to cooperate for the diagnosis of the patient's condition between the different disciplines. This will help them respond quickly to emergencies and allow them to cooperate with international hospitals to monitor a patient's condition.

RFID is a technology providing a communication interface with marked objects through wireless data transmission to retrieve relevant information. Radio Frequency Identification (RFID) enables automatic identification and data capture using radio waves, a tag and a reader. The tag is basically used for encoding the data whereas the reader has an antenna along with the digital and RF section for extraction of tag encoded data.

RFID can help the healthcare industry and also hospitals to improve their inventory management, identify patients and keep medical records. By using RFID, healthcare organizations can also have a fully automated solution for information delivery, reducing human error and improving efficiency. Although RFID has the potential to play a vital role in providing effective and efficient healthcare.

To this end, this paper is structured as follows: Section II present the related works. Section III present the Radio Frequency Identification (RFID) system and his application. Section IV details some application in healthcare fields that use the RFID system. Section V describes our application using RFID system in healthcare as well as the results of our practical evaluations. Finally, Section VII concludes this chapter.

2 RESEARCH MOTIVATION

The evolution of RFID technology in the medical field promises a new world in healthcare IT applications. Healthcare applications using RFID technologies are exploding as patients monitor themselves through telemedicine, people track their activity, and “the hospital of the future” uses these technologies to track patients, staff and equipment. We find several applications in the health field are developed using RFID technology.

Awarepoint, a real-time tracking system provider, which offers patients an RFID tag after checking in in the emergency department.

Hospitals and laboratories are adopting refrigerated cabinets with built-in RFID tags that are able to track and monitor very expensive drugs.

Pharmaceutical companies use RFID tags to detect counterfeit, falsified or unacceptable products.

Hospitals use RFID tags attached to x-ray aprons to track where they move throughout the hospital and when inspections are carried out on aprons themselves.

RFID tags can be placed on sponges and surgical towels to track their location so they are not left inside patients during surgery.

3 RELATED WORK

In this section, we are going to discuss the main research areas considered by most surveys published in the field of the Internet of Things and RFID technologies in Health-care. Many articles exist in the literature using RFID technologies in Internet of Things applications and more specifically in the health field. Some of these works are given below:

Mark and Jason (Mark,2016) present a framework to aid in the integration of sensor and RFID device into IT applications. This framework is applied for healthcare applications using a theory-based approach, illustrated with examples from the healthcare industry.

We also find the work of Sarfraz (Sarfraz, 2017) which describes and propose monitoring existence cycle and effective healthcare monitoring system using the loT and RFID tags. This system comprises of association between microcontroller, actuator, and sensors to measure the different parameters like as Blood Glucose, blood pressure, Body temperature, and Motion. The experimental results of this work show the robust output against various medical emergencies.

Leema (Leena,2013) developed a new system for predicting glucose concentration in diabetic patients using GlucoSim software to analyse patient information, the aim of this system is to avoid hyperglycaemia and complications. severe diabetes.

Nada and Sabri (Nada,2016) presented an implanted antenna RFlD in the human body, the authors made many simulations by the CST (computer simulation technology) software and studied the performance of a UHF tag operating in tissues similar to the human body in order to have an idea about the behaviour of the antenna in the human body.

Abhinav and his colleagues (Singh, 2016) Proposed and designed an array-based RFID reader antenna made on FR4 epoxy substrate using ANSYS HFSS v.15 software at a frequency of 2.4 GHz. The simulation results indicate that the antenna fulfils all the requirements of RFID reader antenna for healthcare applications as well as in wireless communication. In (Alain, 2015), the authors aim to extend existing work by integrating the unified theory of acceptance and use of technology to predict the adoption of RFID in the healthcare supply chain. The research model was tested by employing neural network analysis. The authors applied of a predictive analytic approach (i.e., neural network) to study RFID adoption. In (Xiao, 2015), the authors compare and discuss the performance of several machine learning algorithms for predicting the long and short-term length of stay of hospitalized diabetic patients using implantable sensor micro-system based on RFID for real-time glucose monitoring.

In our article, we will talk about RFID technology and its application for the monitoring and surveillance of patients. we will also mention the healthcare system applications based on the use of RFID system. finally, we will describe the design of our proposed antenna for application in healthcare using RFID and then we will discuss the results of our practical evaluations.

4 RFID TECHNOLOGY

Radio-identification, most often referred by the acronym RFID, is a method of memorizing and retrieving data remotely using markers called "radio tags".

RFID is part of automatic identification technologies; this technology makes it possible to identify an object or a person, to follow the path and to know the characteristics at a distance thanks to label emitting radio waves, attached to or incorporated into the object or person. RFID technology allows reading of labels even without direct line of sight and can cross thin layers of materials (Sangwan, 2005) (Wei,2015).

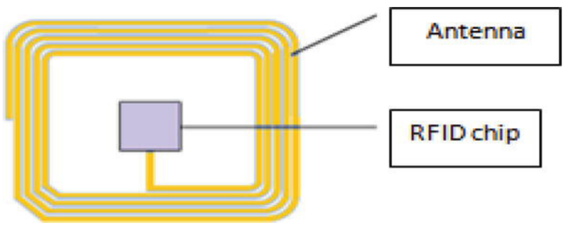

Figure 1: Block diagram of RFID.

These electronic chips contain an identifier and possibly additional data. This identification technology can be used to identify:

- objects, as with a barcode (this is called an electronic label).
- people, by being integrated into passports, transport cards, payment cards (we speak of a contactless card).
- domestic carnivores (cats, dogs and ferrets) whose RFID identification is mandatory in many countries, by being implanted under the skin. This is also the case in a non-compulsory way for other working, companion or production animals (we speak of a subcutaneous flea).

4.1 Components and Operation of the RFID System

RFID includes labels, readers, encoders, and middleware which allow integrating the flow of data in the information system of the company.

4.1.1 The Tag

One of the most used identification methods is to house a serial number or a sequence of data in a chip and connect it to a small antenna. This couple (chip + antenna) is then encapsulated in a support. These “tags” can then be incorporated in objects or be glued on products, Figure 1. The format of the data on the labels is standardized at the initiative of electronic product code (EPC) Global.

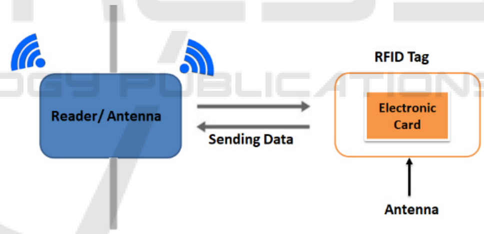

Figure 2: Tag Antenna.

4.1.2 The Reader

The reader/recorder is constituted of a circuit that emits electromagnetic energy through antenna and electronics that receives and decodes the information sent by the transponder and sends them to the data collection device. Not content to read RFID tags, he is able to write their content. The RFID reader is the element responsible for reading radiofrequency labels and transmitting the information they contain (EPC code or other, status information, cryptographic key, etc.) to the next level of the system (middleware). This communication between the reader and the label takes place in four stages:

- The reader transmits by radio the energy necessary for the activation of the tag.

- It launches a query querying the tags nearby.
- It listens to answers and eliminates duplicates or collisions between answers.
- Finally, it transmits the results obtained to the applications concerned.

4.2 The Different Types of Tags and Their Technical Specificities

4.2.1 Active Tags and Passive Tags

To exploit the information contained in these labels, it is imperative to have the appropriate reader. This one emits radio waves toward the capsule which allows supplying it with energy (electromagnetic induction feed); in other words, to activate it, these chips are not able to perform dynamic treatments.

4.2.2 Passive Tags (Without Battery)

Without any external power supply, they depend on the electromagnetic effect of receiving a signal emitted by the reader. It is this current that allows them to power their microcircuits. They are inexpensive to produce and are generally reserved for volume productions. They are the ones we find especially in logistics and transport. They use different radio frequency bands according to their capacity to transmit remotely more or less important and through different substances (air, water, metal). The reading distance is less than 1 m. Low and high frequencies are standardized worldwide. These chips are stuck on the products for a follow-up. They are disposable or reusable depending on the case.

4.2.3 Semi-passive Tags

These tags are similar to passive ID cards. They use similar technologies but with some important differences. They also have a small battery which works constantly, which frees the antenna for other tasks, in particular the reception of return signals. These tags are more robust and faster in reading and transmission than passive tags, but they are also more expensive.

4.2.4 Active Tags

Active tags are the most expensive because they are more complex to produce and provide transmission functions, functions of capture or processing of the captured information, and either or both. Thereby, they need an onboard power supply you have to know that these labels prove particularly well adapted to certain functions, including the creation of authentication systems, security, anti-theft, etc. Short, they are ideal for triggering an alert or alarm. They can emit several hundred meters.

4.3 Frequencies Used in RFID

RFID systems generate and reflect electromagnetic waves. In particular, RFID systems must be careful not to disrupt the operation of other radio systems. We cannot, in principle, use only the frequency ranges specifically reserved for industrial, scientific, or medical applications. These frequency ranges are called industrial-scientific-medical (ISM). The main frequency ranges used by RFID systems are the low frequencies (125 and 134.5 kHz) and ISM frequencies: 6.78, 13.56, 27.125, 40.68, 433.92, 869.0, 915.0 MHz (not in Europe), 2.45, 5.8, and 24.125 GHz.

5 HEALTHCARE AND IoT

The Internet of Things will play an essential role in developing smart services, supporting and strengthening the activities of society and people. These services allow people to live independently and improve their health. For this, the Internet of Things offers many advantages: monitoring of objects and people (staff and patients), monitoring and administration of medical parameters, identification and authentication of people, automatic data collection and remote sensing.

In healthcare, there is patient flow tracking and monitoring to improve workflow in hospitals and tracking movement through choke points, such as access to designated areas. It also includes patient identification to reduce incidents that could harm them (e.g. wrong dose / dose / time / procedure), complete and current electronic maintenance of medical records (outpatient and outpatient), and identification of infants in hospitals. In this sense, there are other relevant applications regarding the identification of medical materials and instruments like the application of smart labels which will ensure accurate tracking of objects in order to avoid loss or theft of material, or the presence of material inside a patient during an operation.

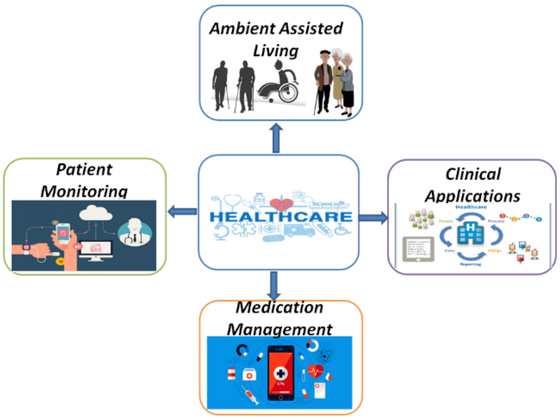

Figure 3: Healthcare application in IoT.

5.1 Ambient Assisted Living

Ambient Assisted Living is based on Ambient Intelligence. AAL gives the possibility to the elderly and the disabled to remain independent. The semantics will allow by reasoning to assist the elderly in their daily routine by understanding their activities. Its aim is to improve the quality of life of people with special needs (such as the elderly or disabled) using different types of technology. To achieve these goals, several sensors and smart devices are typically used. These devices can be placed at home (called Smart Home), in the body (implementation of WBAN networks), as portable sensors, or even in phones (Smartphones). (Reem,2012) (Amine,2016).

5.2 Patient Monitoring

The vision of connected healthcare is growing due to the availability of new technological tools. By applying IoT and new technologies, it is possible to create a health app that pops up every morning to request blood glucose readings and automatically collect patient data. In the vision of connected healthcare, patients are the ones who take responsibility for monitoring their health. The IoT with its applications will help doctors react quickly in an emergency and allow them to cooperate with international hospitals to monitor the condition of such a patient. With advancements in Internet of Things technology, sophisticated sensors can be used to monitor patients with real-time updates (Solans, 2014).

5.3 Clinical Application

Among the applications of the Internet of Things, we can find electronic monitoring applications made primarily to set up a system of patient-centered remote consultation services and continuous monitoring aimed at helping critically ill patients. IoT sensors will help inpatients move freely within the hospital without having to enter certain rooms and be connected to certain machines while avoiding the hassle of moving doctors and nurses around the hospital. 'pavilion to pavilion for reviews and analysis. Indeed, it will help caregivers in the performance of their work, while allowing them to monitor the patient's condition remotely and help them to cooperate for the diagnosis of the patient's condition between the different disciplines (Khan, 2010).

5.4 Medication Management

IoT applications enable patients and their families to manage medication therapy well. It is often observed that patients forget to take their medications on time and that doctors do not receive this information correctly. The use of IoT applications solves drug management problems, an application to remind the patient to use their drugs, and also to specify the time for and the dose of each drug (Trin, 2021).

5.5 RFID Technology in Healthcare

RFID technologies can be used in the health field to improve the quality of life of patients and also to help health workers to work in good conditions. RFID can be used to locate, identify and monitor the location and condition of equipment used in hospitals. This leads to a substantial improvement in operating costs, proactive maintenance and inventory levels. Using RFID tags and the RFID wristband to monitor patient movements to ensure they are receiving the right treatments where a mobile point of care is more convenient for physicians. RFID systems could have an indirect impact on the safety productivity of hospitals by monitoring their workflow and processing time (Yao, 2010).

6 PROPOSED INTEGRATED RFID TAG FOR IOT APPLICATION

6.1 Study and Design of the Printed Dipole Antenna

The identification of objects using radio waves (RFID), is systems based on two-way remote and contactless identification technology. This type of application makes it possible to extract information stored in RFID Tags. The principle of operation of RFID Tags is to backscatter information by modulation to ensure full communication with readers.

To design an antenna that meets the expected characteristics, in particular low cost, optimal dimensions, and a good reflection coefficient, it is necessary to have a precise idea of the choice of antenna components. For this purpose, we have studied the folded dipole antenna.

The parametric study will determine the impact on the resonant frequency, radiated field and gain. We will then present the results obtained using the HFSS simulation tool.

The main types of antennas used for RFID applications are:

- Patch antennas
- Dipole antennas
- PIFA antennas

In this paper we have chosen the dipole antenna which has many advantages:

Dipole antennas are the most used in RFID technology, thanks to several characteristics, in particular their symmetry, their ease of integration and especially their low cost. They have omnidirectional radiation and linear polarization. We have shown in the previous chapter, that to obtain a maximum of power supplied to the load. However, most commercial RFID Tags are based on dipole antennas. Figure 4 shows the antenna proposed for this work. This is the design of the folded planar half-wave dipole antenna, length l = 75mm and width W = 3mm under HFSS software. It operates on a resonant frequency of 2.45 GHz. The substrate was chosen as the epoxy FR4 having a relative permittivity ε_r = 4.6 and a height of 1.6 mm.

The proposed antenna as shown in Fig. 4 has been modelled and analyzed by using Ansoft HFSS 2015 software that is used for optimization and simulation of the designed antenna. The antenna performance has been obtained through a frequency swept range from 2- 2.80 GHz. The simulation of the planar dipole antenna that operates on the 2.45 GHz resonance frequency gives the following results. Figure 5 shows a minimal reflection at the resonance frequency equal to -41dB.

Figure 6 shows the SWR of the planar dipole antenna, SWR<2.

Figure 7 represents the 3D radiation pattern shows that the antenna is omnidirectional according to the angle phi, and bidirectional according to angle Theta.

Another essential feature for knowing the antenna parameters is the two-dimensional radiation pattern in the E planes and the H plane which is illustrated in Figure 6, and which represents 2 main lobes.

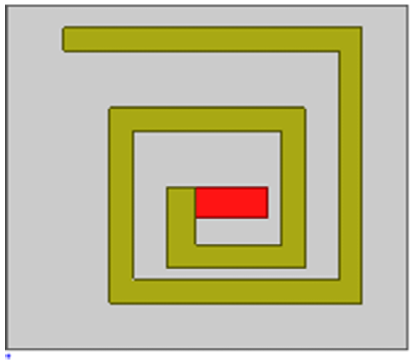

Figure 4: Planar Dipole Antenna.

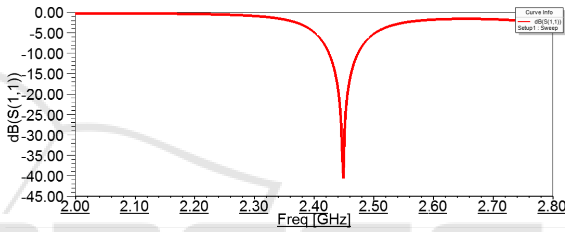

Figure 5: Return Loss of the Planar Dipole

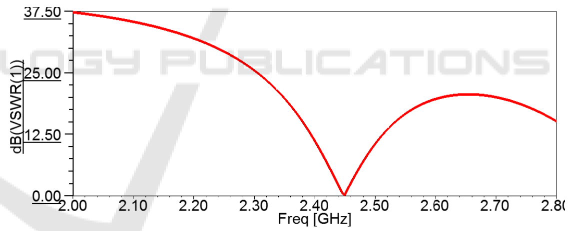

Figure 6: SWR of the Planar Dipole Antenna.

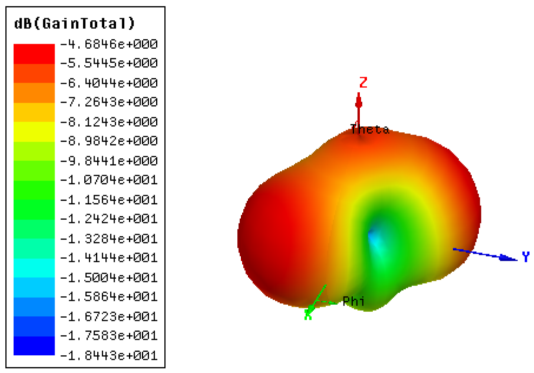

Figure 7: Radiation pattern of the Dipole antenna.

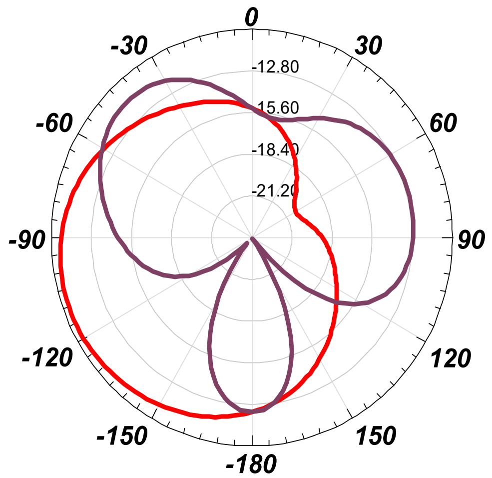

Figure 8: 2D radiation pattern in the E&H plane.

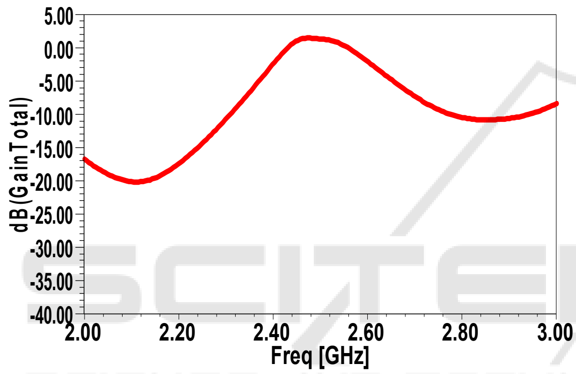

Figure 9: Gain of the Dipole antenna.

As we notice in figure 9 that our antenna has a gain equal to 3dB.

7 CONCLUSIONS

The integration of the two new emerging technologies RFID and IoT in healthcare applications offers several advantages for patients and also for healthcare professionals. With the use of RFID and IoT we can improve healthcare applications, and monitor patient medical equipment continuously. In this paper an array-based RFID reader antenna has been proposed. The design is made on substrate using ANSYS HFSS v.15 software at a frequency of 2.45 GHz. The simulation results indicate that the antenna fulfils all the requirements of RFID reader antenna for healthcare applications as well as in wireless communication. In future work, we will try to add other parameters to improve the gain of the antenna. other thing that interests us is to reduce the size of the antenna and also to choose the best substrate, because its permittivity has a significant effect on the performance of the antenna. Moreover, we are going to implement it for weigh control (Lopes, 2011) and children continuous ehealth monitoring (Lloret, 2017) purposes.

REFERENCES

A. Anny Leema, M. Hemalatha, (2013). Proposed prediction algorithms based on hybrid approach to deal with anomalies of RFID data in healthcare, *Egyptian Informatics Journal,* Vol.14, Issue 2, pp: 135-145.

A. K. Singh. ;Tanmaya K. D. ;Santanu K. B.(2016). Design of RFID reader antenna for healthcare applications, *7th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT)*.

Alain Y. C.; Martin L.; Jun L.; Ooi K. B. (2015). Predicting RFID adoption in healthcare supply chain from the perspectives of users, *International Journal of Production Economics,* Vol.159, pp: 66-75.

Al-attas, R., Yassine, A., and Shirmohammadi, S. (2012). Tele-medical applications in home-based health care. *IEEE International Conference On Multimedia And Expo Workshops*. pp. 441-446.

F. H. Khan, Z. H. Khan. (2010). A Systematic Approach For Developing Mobile Information System Based On Location Based Services, *Network Protocols And Algorithms*, Pp. 54-65.

IM Lopes, BM Silva, JJPC Rodrigues, J Lloret, ML Proença, (2011). A mobile health monitoring solution for weight control, *International Conference on Wireless Communications and Signal Processing (WCSP),* 9-11.

J Lloret, L Parra, M Taha, J Tomás, (2017). An architecture and protocol for smart continuous eHealth monitoring using 5G, *Computer Networks* vol.129, pp: 340-351.

J. Wei, P. Lowry, and S. Seedorf, (2015). The assimilation of RFID technology by Chinese companies: A technology diffusion perspective, *Inf. & Manag.* Vol.52 pp; 628–642.

M. Gaynora, J. Waterman, (2016). Design framework for sensors and RFID tags with healthcare applications, *Health Policy and Technology Vol.5, Issue 4, pp 357-369.*

Nada J.; Sabri B.; Ali G. (2016). RFID antennas implanted for pervasive healthcare applications, *7th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT)*.

R.S.Sangwan,; R.G.Qiu,; D. Jessen. (2005). Using RFID tags for tracking patients, charts and medical equipment within an integrated health delivery network, *Networking, Sensing and Control, 2005. Proceedings. IEEE,* p p: 1070- 1074, 19-22.

Sarfraz K. (2017). Health care monitoring system in Internet of Things (IoT) by using RFID, *International*

Conference on Industrial Technology and Management (ICITM).

Xiao Z; Tan X.; Chen X.; Chen S.; Zhang Z.; Zhang H.; Min H. (2015). An implantable RFID sensor tag toward continuous glucose monitorin. *IEEE journal of biomedical and health informatics*.

Trina D.; Subhadeep P., Prateeti K. (2021). Chapter 2 - IoT for healthcare industries: a tale of revolution", *Healthcare Paradigms in the Internet of Things Ecosystem,* pp: 21-45.

W. Yao, C. H. Chu, Z. Li, (2010). The use of RFID in healthcare: Benefits and barriers, *IEEE International Conference on RFID-Technology and Applications,* pp.2-4.