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Read Range Investigation of RFID Tag on Human Chest

Ba-Saleh Ammar Nabil Salem[1,3], **Raimi Dewan**[1,2,3*], **Osman Ayop**[1] and **Amirudin Ibrahim**[4]

[1]Advanced RF & Microwave Research Group, Faculty of Electrical Engineering,
Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia.
[2]IJN-UTM Cardiovascular Engineering Centre, Institute of Human Centered Engineering,
Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia.
[3]Department of Biomedical Engineering and Health Sciences, Faculty of Electrical Engineering,
Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia.
[4]Electrical Engineering Studies, College of Engineering, Universiti Teknologi MARA,
Pulau Pinang Branch, Permatang Pauh Campus 13500 Pulau Pinang, Malaysia.

*Corresponding Author: raimi.dar@utm.my

Abstract: Radio Frequency Identification (RFID) technology for automatic identification, tracking, and monitoring of human is in great demand by the healthcare industry. The existence of passive tag with proximity to human body in general, represents an intrinsic challenge because of the high losses of body tissues A commercial passive ultra-high frequency (UHF) RFID tag with 860 MHz-960 MHz operating frequency range is modelled to study and analyze the effect on the read range parameter by placing the RFID tag in proximity to human body model (the chest) with respect to the placement of pocket position of any shirt The body model of the chest is consisting of three layers which are skin, fat and muscle. The commercial RFID tag that has been used for this study was INLAY-9662. The measurement is done on the commercial tag prior to modelling and simulation in the CST. Furthermore, the simulation was carried on two conditions: (1) in free-space, and (2) in proximity to human body. In addition, 1 mm, 3 mm and 10 mm have been set as the gap between the modelled tag and the chest model to examine the impacted read range at different distances. The results obtained have shown some variations when the distances are varied from the human chest. The read range were achieved at 0.5 m, 1.3 m and 2.4 m for 1 mm, 3 mm and 10 mm respectively. This study has shown the capabilities of human body to reduce the efficiency of the read range whenever RFID tags are placed in proximity to human body.

Keywords: Radio Frequency Identification (RFID), Passive UHF RFID, Read Range, Human Tissue, Simulation

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1. INTRODUCTION

Radio Frequency Identification (RFID) is a wireless data collection technology that uses the RF component of the electromagnetic spectrum to provide wireless identification and tracking of targets and objects [1]. The technology was first widely used in the 1980s, when the industry classified it appropriately for identifying high-value products as they moved through the manufacturing and assembly process [1]. Following this successful implementation, RFID systems were expanded to include supply chains, commercial products, and animals. Recent advances in the evolution of RFID have been to include humans as a target for applications. These applications have served a variety of purposes, including access, tracking, and communication.

Furthermore, it might have been noticed that RFID devices have been carried in people's hands, wallets, and clothes. Now, a possibility exists to maintain the technology on their bodies. However, the efficiency of an RFID tag can be significantly impacted in the presence of metallic or liquid materials, as well as by human proximity that degrades the tag antenna's radiation efficiency and gain.

RFID is an automated technology that uses radio waves to help machines or computers recognize objects, record metadata, and monitor individual targets. When an RFID reader is connected to an Internet terminal, the readers can identify, track, and monitor tags-attached objects globally, automatically, and in real-time, if necessary. This is known as the "Internet of Things" (IoT). RFID is sometimes regarded as a need for the Internet of Things [1].

A tag, a reader, and a reader antenna are the three main components of an RFID system. Moreover, RFID tags are classified into three categories: passive, semi-passive, and active. A small antenna and a silicon chip are the main components. The frequency range that will be used play major role in the RFID tag designing and shape, as well as other factors [2]. An RFID identification system's operation begins first at reader's stage. The reader antenna receives an instruction to emit electromagnetic waves from the RFID reader. The waves that are collected by the RFID tag that is beyond the antenna's radiation range. The energy of the received electromagnetic waves is converted into power by a small antenna on the tag, which is used to activate the chip. The chip then returns the electromagnetic signal to the reader antenna, allowing the reader to recognize the tag. Figure 1.1 shows the different components of an RFID system, including the reader, the reader antenna, and the RFID tag.

This project investigates the current applications associated with the RFID direct contact to a human body concerning human pocket position and characteristics. It aims to analyze the existing technical knowledge and speculation as to future uses. This investigation of RFID is designed based on using a commercial RFID tag with its database simulated with CST studio suites 2020 student version.

There are two objectives for the project. The first is to model and simulate the commercial RFID tag antenna with electromagnetic simulation software on the human body and in free space condition. Second objective is to study and analyse the effect on read range parameter by placing the RFID tag into a chest placement on the human body with respect to the pocket's positions.

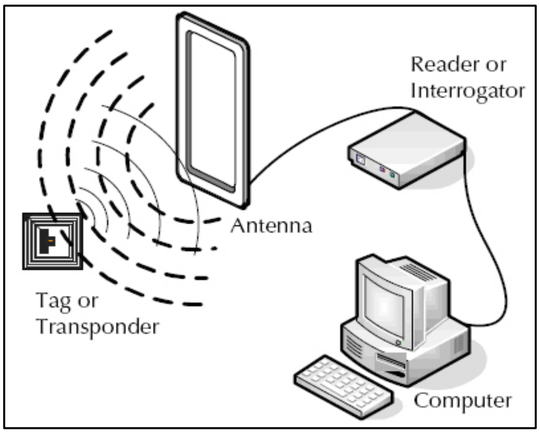

Figure 1.1 RFID system components

1.1 Problem Statement

In body-centric systems, the fundamental challenges in RFID development arise from the proximity of the human body, where the dielectric biological matter shows notable electrical conductivity and polarizability [3]. This leads to reduced antenna radiation performance through energy consumption in the interaction between the antenna electromagnetic (EM) fields and the body.

Practical experiments and recent researches show that the presence of an RFID tag at the proximity to the human body results in a variation of its performance. The tag impedance matching, radiation efficiency and directivity change accordingly [4]. Therefore, this project is a simulation-based and investigates the commercial RFID tag performance on the human body concerning pockets position of a human chest area.

1.2 Scope of Study

This project investigates and analyses an RFID tag antenna with close contact to the human body concerning pocket placement of the chest area by simulating one commercial RFID tag in the condition of free space and in proximity to human body. Moreover, the simulation is carried out on flat-surface only, and it is not including human curve-surface and bending-surface. In this project, a passive UHF RFID tag antenna is used for the simulation, and the standard frequency range used follows the European standards, which is (860-960MHz). However, due to the limitation of the software and the availability of the student version, this project cannot be simulated with a human body model which only available in full version with paid license. Therefore, human body part parameters of the chest are extracted from the reputable journals and available datasheets.

1.3 Significance of Study

The existence of passive tag with the human body or with living matters, in general, represents an intrinsic challenge because of the high losses of tissues, where integrated part of the tag consisting of an antenna is susceptible to the specific position over the body and to the human variability, which strongly degrades the radiation efficiency of the RFID system and, accordingly, the read range of the communication link. This problem has been widely addressed by researchers on wearable antenna incorporated devices [5]. However, through this project, it is expected that the results of the simulated commercial passive UHF RFID tag indicate the impact of the human body effect on the read range performances based on the specific position of the RFID passive concerning the pocket position of chest area.

1.4 Human Body Characteristics

Recent and ongoing advancements in low-power wearable and epidermal electronics are being used to investigate personal health around the human body. Flexible, stretchable, lightweight, and wireless devices have recently been introduced that can be conformed and incorporated with the body. They can collect biophysical information while providing the user with a high comfortability [6].

An essential feature of these RFID tags is that they are being applied to operate on the human body, making them face more challenges. One of the main challenges that the implementation of RFID tag faces is the stable performance of the human body [7]. As these RFID antennas are located near human tissues under various deformation conditions. These tissues have a high dielectric nature, affecting RFID performance parameters such as read range, reflection coefficient (S11), bandwidth, gain (dBi), and radiation characteristics [7].

Human tissues have a dielectric nature which effecting RFID antenna performance parameters [7]. When a living organism is exposed to a static RF field or a non-radiating source in the area, it will usually extract energy from the emitting source. At higher frequencies, however, the quantitative explanations of these processes by which this extraction occurs are very different [8]. It is well understood that at higher frequencies, the skin effect becomes even more noticeable and important for humans [8, 9].

1.4.1 Properties of Human Body

Individual differences exist in the electrical properties of the human body [9]. Factors such as skin thickness, which is determined by the environment and ethnicity, affect the electrical characteristics of the body [10, 11]. The electrical properties of the body can also be affected by the density of the underlying fat tissues, muscles, and bone in the area under consideration. The influence of general lossy dielectric substances on the resonance frequency of RFID antennas was studied [12]. According to measurements taken in an experiment [4] people with more fat on their arms had lower permittivity and conductivity levels than the other participants. Individuals with higher muscle density in their arms exhibited higher permittivity and conductivity levels than those with fatty tissues.

1.5 RFID in Healthcare

Every year, over 42.7 million adverse events are caused by medical and human errors in hospitals [13], demonstrating the crucial need for enhanced patient safety. RFID has a lot of potential in terms of enhancing patient care by decreasing human errors during interactions between patients and healthcare professionals [14]. However, hospitals have been in slow to implement RFID technology, owing to high prices and difficulty justifying the investment. RFID offers a variety of uses in healthcare, according to the literature. Patient tracking, identification, and monitoring, drug tracking, identification, and administration, blood transfusion, equipment and asset tracking, and sensor-derived data collecting are examples of these uses [15]. The following are the findings on RFID applications in healthcare, as well as the most common challenges and barriers regarding RFID adoption in healthcare.

1.5.1 Patient Identification

Misidentification of patients is a problem that hospitals encounter on a regular basis. Patient misidentification is one of the most common causes of medical errors in hospitals and is seen as a threat to patient safety [16]. A smart wristband with a passive RFID tag that can be scanned to identify patients and reveal information such as date of birth, name, insurance information, allergies, blood type, and medication requirements are examples of positive patient identification (PPI) applications using RFID technology [17]. According to several studies, hospitals should endeavor to prevent these errors by developing a reliable patient identification system that can improve hospital safety processes [18-20]. Similarly, [21]suggests that smart RFID technologies may be able to reduce errors caused by patient misidentification. Other studies propose using RFID-based patient identification to query and retrieve correct associated medical data from various existing healthcare information systems, and potentially reducing patient-handling errors [22]. For surgical patients, RFID identification may be utilized to ensure that the surgery operation is performed on the correct patient [23].

1.5.2 Patient Tracking

One of the most common applications of RFID in healthcare is the management of supply chains, as well as the monitoring of medical inventory, supplies, and assets [24]. However, these aren't the only uses of RFID in hospitals for tracking purposes. RFID is currently being seen as a device for improving medical care and safety by tracking vulnerable patients [21, 25] rather than only as an asset tracker. This could entail following the movements of elderly or disoriented patients, as well as infants, in order to prevent baby snatching [26]. RFID patient tracking has also been used to quickly locate and identify patients in emergency care so that medical assistance may be provided quickly [27]. The majority of time spent in hospitals, according to [28], is spent in waiting. Thus, RFID patient tracking capabilities have the ability to reduce waiting times by automatically displaying the phase in which a patient is in, which can help enhance patient flow and reduce wait times by providing transparency for patients and staff in the surgical trajectory. RFID tracking can also be used to identify patients who are ready to leave the hospital, allowing for more efficient resource allocation by reducing unnecessary protracted stays. It can also be used to track chronically ill elderly individuals at their homes [29]. The movement tracking of visitors, personnel, and patients is another tracking tool used to locate and identify those who have come into touch with people who are infected with contagious diseases. Several Asian hospitals used RFID for this purpose during the Severe Acute Respiratory Syndrome (SARS) epidemic. The hospitals were able to identify and find those who had been in contact with the SARS-infected patient before the diagnosis was made using data from RFID technology [17, 23].

1.5.3 Patient Monitoring

RFID can also be used to monitor patients and collect sensor-derived data. Implantable RFID is recommended for patient monitoring since it functions as a portable medical record. During the SARS outbreak, Taiwan's Show Chan Hospital launched the "Intelligent digital health network" initiative, which used active RFID tags to measure the body temperature of potentially contagious patients with a fever [10]. Later, the remote data link RFID feature was used in a senior citizen home to broadcast the movements and physiological data of disabled or bedridden patients remotely. This allowed medical personnel to keep an eye on patients and intervene if necessary [17]. Furthermore, combining RFID with a healthcare information system (HIS) may improve decision-making and diagnosis by allowing medical professionals to rapidly obtain accurate patient data and thus make the best judgments possible [30].

RFID can also assist in emergency circumstances and occurrences such as patient falls or cardiac abnormalities when combined with other IoT technologies such as sensors, mobile networks, or wireless sensor networks (WSN) [31]. Based on a case study conducted in Saudi Arabia, which suggested and tested a prototype for home-staying elderly patients with chronic conditions that uses RFID wristbands and sensors for tracking and wireless ECG sensors to monitor vital signs and communicate data remotely [31].

Another study looked at the present technological applications of RFID in body-centric systems for patient monitoring, as well as the use of IoT sensors to gather information about the patient's living environment. While the study suggests that RFID applications in healthcare are mostly still in the experimental stage, recent advances in biomaterial engineering have paved the way for tattoo-like thin surface electronic devices that are fully biocompatible and self-dissolvable within a certain time frame, and could thus be used as temporary wireless wearable sensors for patient monitoring [32] Other researchers believe that using RFID-enabled smart bandages to monitor the after-surgery patient's status by detecting temperature and monitoring damaged tissues and the healing process could be beneficial.

1.5.4 Patient Drug Compliance

In order to improve drug compliance, RFID technologies could be applied and used. By combining RFID wristbands on patients with barcodes on drug containers, the Wisely Aware RFID Dosage (WARD) system for hospitals can reduce the risk of medication errors and create a safe and effective patient care environment [33]. Furthermore, a comparable but slightly more advanced system is demonstrated, which combines active and passive RFID tags to localize a patient in a specific region and detect the correct doze of prescribed medication. After leaving the hospital, patient drug compliance solutions can be utilized at home by attaching an RFID tag to the medicine container, which records each time it is opened. Doctors can obtain this RFID data via a connected information system and so monitor patient drug compliance [23]. Similarly, a study presented a prototype that uses RFID tags on drugs, as well as an RFID reader and a web-based system to track medication use [14]. If the drugs have expired, the system will notify healthcare workers. RFID-enabled smart bandages can also help with regulated drug distribution for post-surgery patients based on wound monitoring data.

Another study [34] reported the use of RFID technologies for blood sample management via a blood bank management system at a Greek hospital. The outcomes of the study suggest that using RFID in conjunction with barcodes can help manage blood samples better and reduce the risk of misidentification and blood product waste [34]. Similarly, RFID technologies can help transfusion departments better organize blood samples and make it easier to identify and transfuse blood products to the right patient.

1.5 RFID Effect on Human Body

Normally RFID readers function to radiate magnetic fields and electromagnetic field near the tag. This leads to the activation of circuitry on the tags and retransmission of the stored tag data to the reader in a frequency that match the read range. A number of studies conducted to find out the consequence of these electromagnetic radiations on the human body. However, there are no dependable outcomes reported for such radiations in the frequency ranges being employed by RFID. Moreover, research was mainly performed to observe the radiation effects on the drug products that utilize RFID tags for marketing [15]. The findings demonstrated that the energy liberated by these radiations is not adequate to induce a chemical alteration. Moreover, passive RFID tag is a low powered device. Hence, currently, there is no appropriate confirmation of the likely health risks. Similarly, The FDA has also not reported any adverse events linked to RFID. Nevertheless, there is one major challenge in the use of RFID tag on the human body and it is its stable performance since RFID antennas are placed adjacent to the human tissues. These human tissues possess a high dielectric nature and this causes disruption in the RFID performance parameters, for example, radiation characteristics, bandwidth, reflection coefficient (S_{11}), and gain (dBi) [7].

Although, RFID technology offers various benefits to healthcare, there is still a need of better planned RFID systems to augment approval and appropriate utilization of RFID in healthcare. However, with advancement in RFID technology and its implementation in patient care sphere, some concerns regarding safety have been arisen. This is due to the emission of radiation even though at very low levels from the equipment. Even though no injuries have been reported in patients, this equipment still holds a possibility of unfavorable events in patients with implants or pacemakers.

1.6 Fundamental Parameters of RFID Tags and Design Considerations

On-body antennas face greater challenges and difficulties in designing due to the electromagnetic properties of the human body. The fundamental affects the performance of the antenna such as return loss, radiation efficiency and radiation pattern.

1.6.1 Read Range

One of the most critical performance factors of RFID tags is read range. The maximum distance at which the tag receives enough power to switch on and scatter back is one of the read range restrictions. The other critical factor is the maximum distance at which the reader can detect the scattered signal. Because the reader sensitivity is strong enough, the read range is generally governed by the former distance [22].

Several factors influence the read range of an RFID tag, including:

- Antenna for passive or active RFID tags.
- RFID frequency: low-frequency, high-frequency, or ultra-high-frequency.
- Surrounding materials.
- Type of tag.
- Type of reader.
- Time to read.
- The number of tags that are being read.
- Density of tags.

The power gathered by an RFID antenna is calculated using the Friis free-space transmission formula, as illustrated in Equation 1.2 [16]:

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi\, r)^2} \tag{1.2}$$

where P_t is the reader's transmitted power, G_t is the reader's antenna gain, G_r is the tag antenna's received gain, r is the distance between the reader and the tag antenna, and λ is the wavelength.

The tag range bandwidth is defined as the frequency range in which the tag provides an acceptable minimum detectable read range. Equation 1.3 gives the maximum feasible read range r assuming the tag is perfectly matched to the chip [16].

$$r_{max} = \frac{\lambda}{4\pi}\sqrt{\frac{P_t G_t G_r \lambda}{P_{th}}} \qquad (1.3)$$

where P_{th} is the minimum threshold power required to turn on the chip.

2.1 Tools and Software

INLAY-9662 is the proposed commercial passive RFID tag that will be modelled and simulated to show the influence of the body's distance and properties on the RFID tag as shown in Figure 2.1(a). CST Microwave Studio Software is used to model and simulate the structure Figure 2.1(b). The commercial RFID tag is proposed to be modelled in proximity to human body with a specific permittivity and thickness for body layers. The simulation will be based on the placement of human chest with concerning to pockets positions.

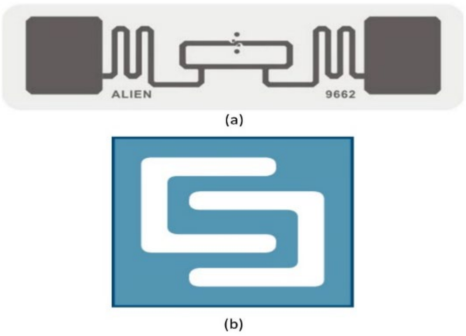

Figure 2.1 (a) INLAY-9662 passive RFID tag, (b) CST software

2.2 Data of Body Part Properties

Each part of the body has different electrical properties such as conductivity σ and permittivity ε_r. Human body layer is a lossy medium and the performance of antenna is affected by dielectric characteristics of human body. Human body model is made up with 3 layers of human body tissues consists of skin, fat, and muscle. The human body have its own electrical properties consist of conductivity and permittivity. The high dielectric nature of these tissues has an impact on antenna performance factors like reflection coefficient (S_{11}), bandwidth, gain (dB), and radiation properties. Table 2.1 shows the human electrical properties that have been extracted from the journals.

2.3 Body Part Model – (Chest)

In this section, the data of the body part that have been collected to find the valid data of human body electrical properties based on pocket position. Chest is the body part that has been chosen after analysing the data that were extracted from the journal papers and available datasheet. Based on the Table 2.1 the average value of the chest part for the conductivity and permittivity is calculated and presented which have been extracted from reputable journals [18, 25, 35-37] before modelling the body model in CST as shown in Figure 2.3.

Table 2.1 Average of thickness, permittivity and conductivity

Body Part (Chest)	**Conductivity (S/m)**	**Permittivity (ε)**	**Thickness (mm)**
(A) Skin	1.49	37.95	2
(B) Fat	0.11	5.27	5
(C) Muscle	1.77	52.27	20

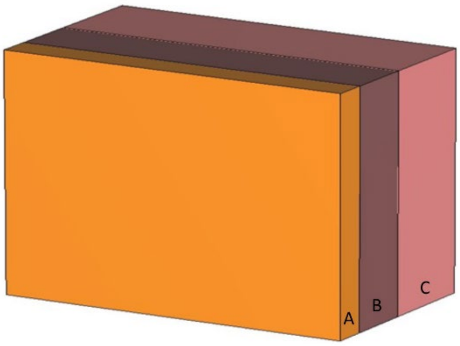

Figure 2.3 Body model of chest layers cosists of A = Skin, B = Fat and C = Muscle layer

2.5 RFID Tag Design Components

This project was carried on modeling and simulation a type of passive commercial RFID tag. INLAY-9662 was chosen as the commercial RFID tag based on a comparison with some other types regards the availability, cost and datasheet provided. The modeling process of the tag started by drawing the substrate and antenna. Figure 2.4 shows the elements of INLAY-9662.

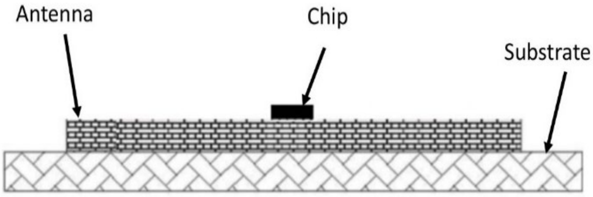

Figure 2.4 Elements of INLAY-9662 [52]

2.5.1 Substrate

The substrate has three main parameters which are permittivity (ε_r), loss tangent (tan δ), and the thickness. The effective wavelength is reduced with the use of any dielectric constant substrate. The most sensitive factor in antenna's performance is the dielectric constant of the substrate material ε_r [38]. Figure 2.5 shows the front and back side of the commercial RFID tag.

PET stands for Polyethylene Terephthalate is one of the most used materials as a substrate for an RFID tag. PET substrate with dielectric constant 2.8, loss tangent of 0.003 and thickness of 0.053 mm are used for the commercial RFID tag in this project.

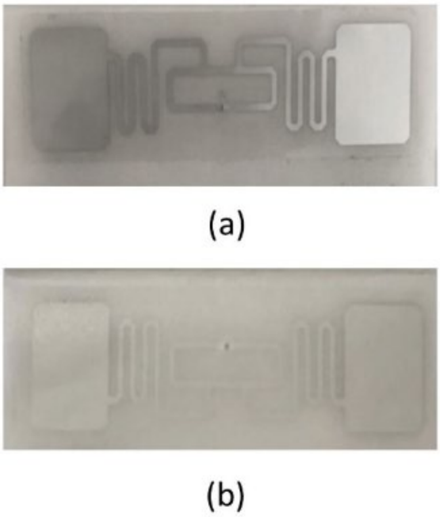

Figure 2.5 RFID INLAY-9662 front side (a), back side (b)

The process of drawing the substrate started by taking the actual measurement of the purchased commercial RFID tag INLAY-9662. Next, the substrate was designed in CST software with respect to dimensions taken manually, then, PET material was added. Figure 2.6 shows the substrate dimension in CST.

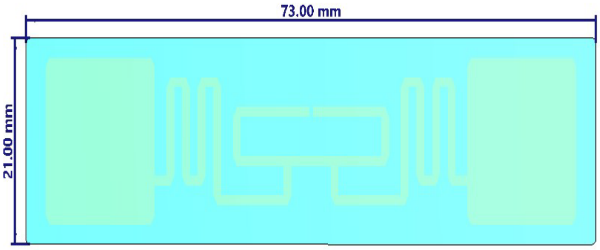

Figure 2.7 PET substrate model in CST

2.5.2 Antenna in Commercial RFID Tag

At first the measurement of actual dimensions of the physical commercial RFID tag was taken as previously shown in Figure 2.6. However, the dimensions are only approximations and variance are to be expected in measurements. Thus, the measured dimensions of the tag are taken and modelled in approximate range from the actual dimensions. Figure 2.8 shows the physical INLAY-9662, antenna elements definition and the structure modelled in CST software.

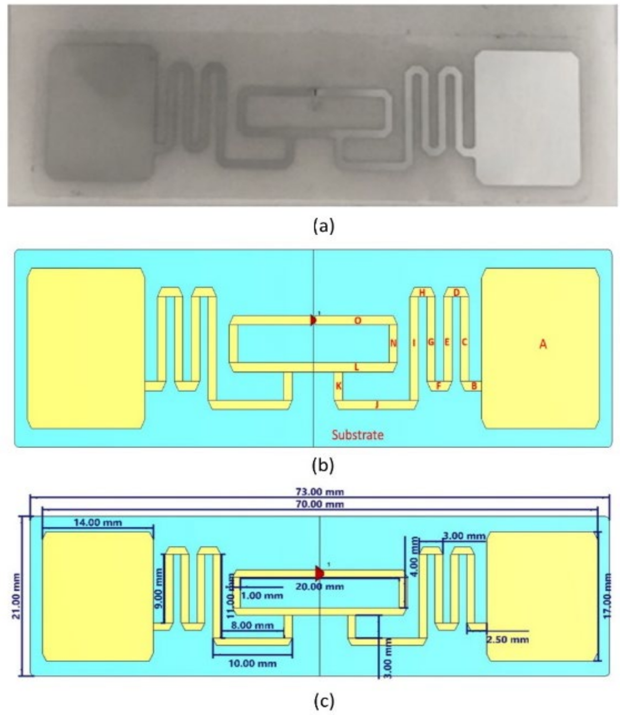

Figure 2.8 Physical INLAY-9662 (a), antenna elements definition (b) structure modelled in CST (c) with its corresponding dimension

3. RESULTS & DISCUSSIONS

Among 30 data of body from different parts, the chest has been chosen to perform the analysis and examine the effect of placing the RFID tag in proximity.

3.1 Pre-Read Range Analysis

Before moving to the analysis of placing the RFID tag on human body, it is necessary to ensure that the model is functioning efficiently. The modelled INLAY-9662 did not show good results based on gain and reflection coefficient. However, the way to get the claimed read range of the tag and ensure as accurate as the commercial RFID tag is by performing an optimization and taking the best value of S_{11} where the antenna is functioning perfectly. Thus, parametric sweep was performed on some elements to see the optimum value at which the model will show a good S_{11} results to proceed to next step of analysis.

Consequently, 3 elements were chosen to perform the par-sweep. the setting of minimum and maximum values was selected to be in tolerance since the measurement of actual dimensions has been taken manually, so a variance would be expected. Table 3.1 represent the linear of elements, while Figure 3.1 shows the S_{11} graph obtained based on par-sweep analysis.

Table 3.1 Linear for parameters

LA	LC =LE=LG= LI=LK= LN	LL = LO
14mm	1.0 mm	10mm
15.5mm	0.9mm	11.5mm
17mm	0.8mm	13mm
18.5mm	-	-
20mm	-	-

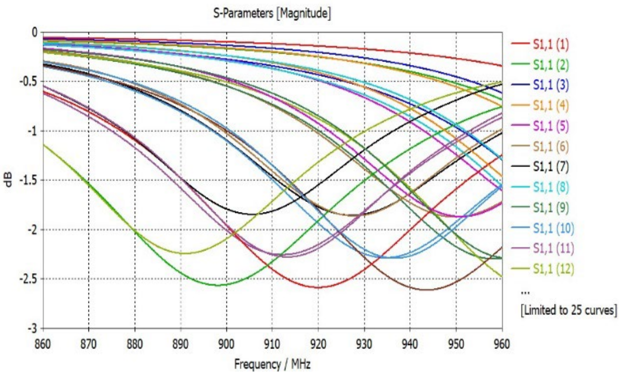

Figure 3.1 S_{11} based on par-sweep

The best and optimum value was selected after obtaining the results of par-sweep, where it is noticed at Figure 3.2 The best S_{11} slope is at $f = 920$MHz and the S_{11} is below -2.5dB which consider acceptable. Table 3.2 shows the optimum values of elements.

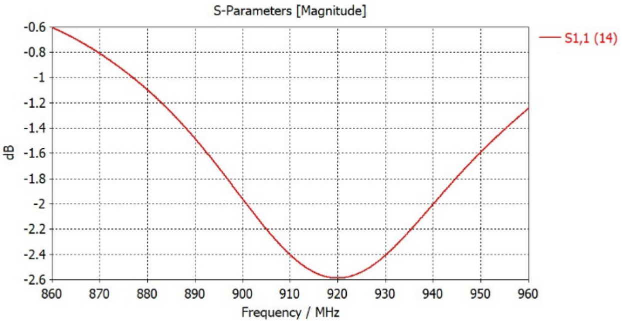

Figure 3.2 Best S_{11} slope shape at f=920MHz

Table 3.2 Optimum values obtained

LA	LC=LE=LG=LI=LK=LN	LL=LO
14mm	1mm	10mm
15.5mm	0.9mm	11.5mm
17mm	0.8mm	13mm
18.5mm	-	-
20mm	-	-

3.2 Read Range Analysis

After obtaining the functional model, the analysis of read range came next. As above mentioned in section 1.1 the analysis of read range would be done in two conditions: (1) in Free-Space condition, (2) in proximity to human body.

In free space condition, the simulation was set to measure the read range of the model without disturbance of any proximity of high loss objects. As shown in Figure 3.3 the read range was achieved. It can conclude that, the claimed read range by distributor of the manufacturer was met as the range of the meters obtained was from 4-8 meter and at $f = 920$ MHz the read range was 7.5 meter.

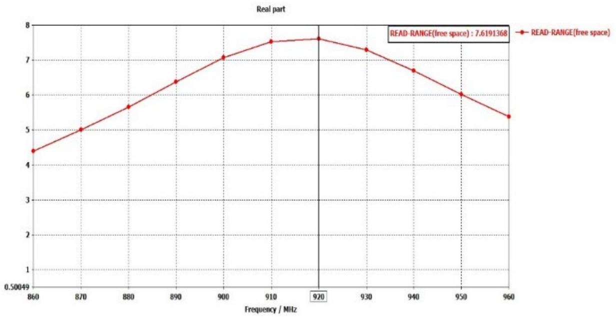

Figure 3.3 Read range at free space condition

On the other hand, in proximity to human body condition. The simulation was set to place the modelled INLAY-9662 in proximity to the body model of chest layers as shown in Figure 3.4. The obtained results showed variance whenever the tag is placed close to human body. The more the tag is placed close to human body the more the read range is being affected by human body properties. Figure 3.5 shows the read range results of 3 different placements of the model with considering the cloths and body movement as a gap between the body and RFID tag model. The gap was set to be at 1 mm, 3 mm and 10 mm.

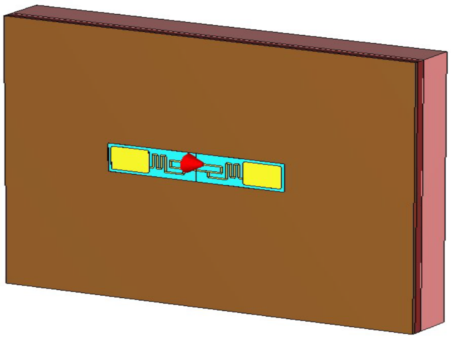

Figure 3.4 On human body condition placement

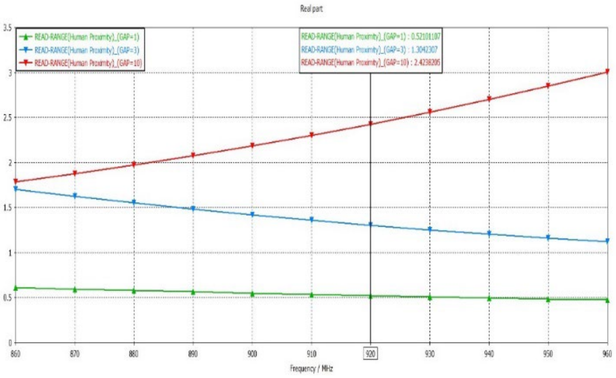

Figure 3.5 Read range in proximity to human body

Figure 3.6 shows the combination of slopes for both conditions. Furthermore, the difference can be spotted between both conditions, and it can be concluded that placing an RFID tag in proximity to human body results in a variation of its performance due to the dielectric biological matter of human body and because it is an object with high loss dielectric constants that leading to tag detuning and radiation efficiency reduction.

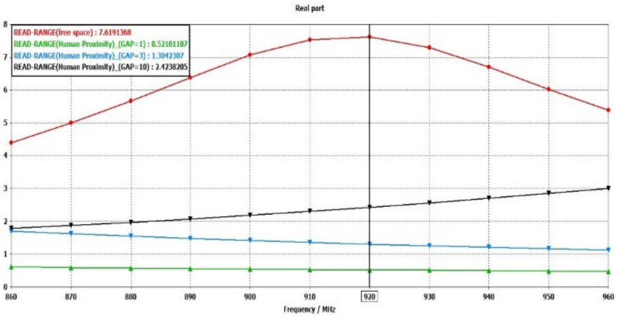

Figure 3.6 Comparison between free space and human proximity condition

4. CONCLUSION

In conclusion, the fundamental challenges in RFID development arise from the proximity of the human body tissues. These tissues have a high dielectric nature, affecting RFID performance parameters such as reflection coefficient (S_{11}), bandwidth, gain (dBi), and radiation characteristics. Thus, this project was planned to identify the effects of human body nature on the performance of RFID tags in proximity to human body concerning the placement of the chest pocket position.

The objectives of this project have been achieved by modelling the commercial INLAY-9662 RFID tag at the frequency of 860Mhz-960Mhz with proximity to human chest model and examines the effects based on the read range parameters. The simulation was carried on flat surface by placing the model of RFID tag in proximity to human chest model and in free space condition. 1mm, 3mm and 10mm have been set as the gap between the modelled tag and the chest model to examine the read range at different distances. As a result, simulating and analyzing the commercial INLAY-9662 RFID tag using CST simulation software showed an effect on the read range performances based on the placement of the tag whenever it gets closer to human body.

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