# Smart Room Design: A Pilot Project

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***Abstract***
*The increasing advancement in technology and science has shaped how human lives and more applications are visible in the society, from public, business and educational institutions. However, there are still lesser applications in Indonesia educational institutions, particularly in the Faculty of Engineering UNHAS. This paper aims to focus on development of a particular technology and its real application, which is to develop a smart room which implements smart access door utilizing one of the three features available, which are RFID Tag-based. This project is simplified into a small miniature that contains a magnetic-based lock mechanism, RFID Tag Reader, an infra red-based button for internal door opening feature and a power supply centre. A sequence of testing scenarios are designed to measure the performance of the RFID Tags, the RFID reader and the infrared button with respect to the time of opening and closing the solenoid-based lock door mechanism. The results show that the Tag can be detected at a maximum of 2 cm with 21 ms for detection time, activation time for the solenoid-based lock mechanism is 124 ms and deactivation time is 525 ms. The angle placement also affect the card readability, with the maximum angle of placement is 80º which takes a bit longer time for detection, 19 cm compared to the angle of 45º and 0º which require 16 ms and 18 ms respectively. For the infrared-based opening button, the maximum distance for detection is 10.5 cm, with detection time is 24 ms and the time for solenoid activation is 25 ms and deactivation time is 107 ms. The time data requires to activate the door opening mechanism cards is relatively low and takes a shorter period of time which gives a positive impact on the user-friendly feature of the miniature of the smart room.*

*Keywords: RFID Tag card, Reader, miniature, infrared button, solenoid*

## INTRODUCTION

The growth and development of educational institutions, particularly at the tertiary level in Indonesia which covers the number of universities and the variety of field of studies, have shown an increasing trend in the last decade. This trend has a direct association with the development of science and technology in which those institutions should have become the pioneer in knowledge advancement, knowledge transfer and direct implementation into real applications. There are still very few Indonesia educational institutions which are making real implementations of these technology advancement. Faculty of Engineering, UNHAS, for example, with its new facilities and the vision to be the centre of technology should have been prioritizing the use of advanced technology to support the functionality and operation-ability of the institution. It is reported that two advanced equipment that have been for the building operational, which are the utilization of solar cell panel to generate electric power and security cameras for security purposes. Regardless this achievement, the utilization of advanced technology equipments should have been maximized. Some potential implementations that can be developed such as room access which is still using manual lock system-based, lighting activation and air conditioning systems which consume electric power wastefully.

This paper aims to develop a smart room which implements smart access door utilizing one of the three features available, which are RFID Tag-based. A room miniature is designed and the door mechanism is installed onto the miniature which has been equipped with the RFID Tag Reader and an automatic solenoid-based lock for opening and closing functions. Two factors are to be measured in order to assess the design performance, which are the distance between the RFID card with respect to the tag reader and the angle of placement. It can be summarized that the average time of identification is very low within an acceptable RFID card distance placement towards the reader. Future work will involve the integration of more resources to be controlled, such as lighting and air conditioning systems.

Paper presentation is divided into several sections, first section covers the background of the study and a brief overview of the work and important experimental findings. Section two focuses on related studies which elaborate some studies in the field. The next section centres on the details of the methodology for project design and implementation, followed by experimental findings and discussions on the experimental outcomes. Finally, the last section, concludes the overall achievements and projections of future development of the project.

## RELATED STUDIES

RFID Tag technology has been widely available in many applications particularly in high technology applications, such as smart door application. There are some applications that have been recognized through the US patent. Tuttle (1995) proposed the application of RFID-based system in detecting the opening of containers and baggage. Later, a patent reported in (Duhame & Meyvis 1996), utilizes this technology in the building access. Further works such as (Posamentier & Burr 2006), (Humbel 2007) and (Higham 2008) have also developed applications which utilise RFID technology and the US Patent has acknowledged their works. A later project proposed by Verma & Tripathi (2010) develop a digital security door using RFID technology.

### RFID Technology

The most common Radio Frequency Identification (RFID) technology being used do not have any internal power supply source. RFID technology can be divided into two components, the reader, which contains a transceiver with an antenna, and an the tag. The transceiver generates low power radio signal which can travel from short distance in centimeter until few kilometers away. This signal is used for tag activation and it is transmitted through an antenna, where the signal can serve as a power source for the tag. The transponder as part of RFID tag functions as a radio frequency converter during sending and receiving message processes. A transponder receives radio wave which oscillates according to the length of the transceiver at a certain frequency. During this situation, RFID has sufficient energy to function and activate the transponder mechanism. When activated, the transponder radiates all stored energy and this process occurs instantly, around few milliseconds. RFID tag system can be divided into two categories, active and passive tags. Active tags have a internal power source with the advantage of the reader can be located far away, while the passive tags must be powered externally. Active RFID devices are designed to last relatively around 10 years, however, the more they are being used the shorter the lifetime. In contrast, passive RFID devices have no internal power source, the size is relatively smaller and the life time is considerably unlimited. This passive devices, however, can only be used for 1024 Byte data storage (1KByte). Regardless its small size, information is stored in text format can be represented in about 130 Byte. Hence, in average with an amount of 1KByte, the memory is already sufficient for the system to function. Compared to barcode systems or other optic-based technology, RFID tags can be identified by various reading mechanism, Besides, tags are not necessarily placed on the surface of the object and the reading process can be done simultaneously.

## METHODS

As the paper focuses on the RFID Tag implementation, this project is simplified into a small miniature that contains a magnetic-based lock mechanism, RFID Tag Reader, an infra red-based button for internal door opening feature and a power supply centre. An overall design is depicted in Figure below.

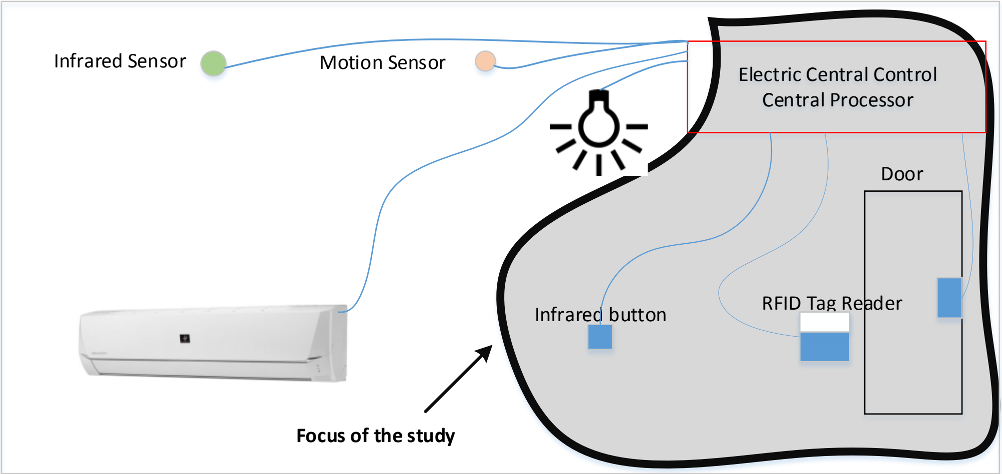


**Figure 1. Overall Design of Smart Room and the Grey Area is the Focus of the Study**

For the opening process from outside, RFID tags are used during experiments and for users inside, infra red button is used as to avoid limit sensor which is prone to physical failure due to mechanical problems.

A sequence of testing scenarios are designed to measure the performance of the RFID tags, the RFID reader and the infrared button with respect to the time of opening and closing the solenoid-based lock door mechanism. The physical design of the RFID-based door miniature can be seen in Figure 2 below.

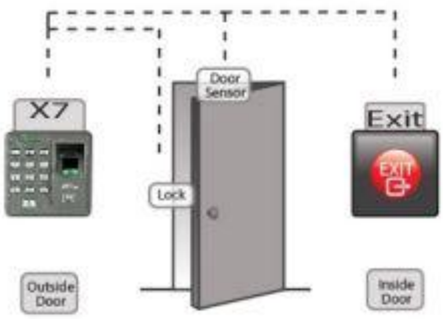


**Figure 2 Design RFID Tag-based Door Mechanism**

After designing and constructing the project prototype, scenario of experiments are conducted on the project miniature and five RFID tags are used in the experiment, as shown in the following figures.

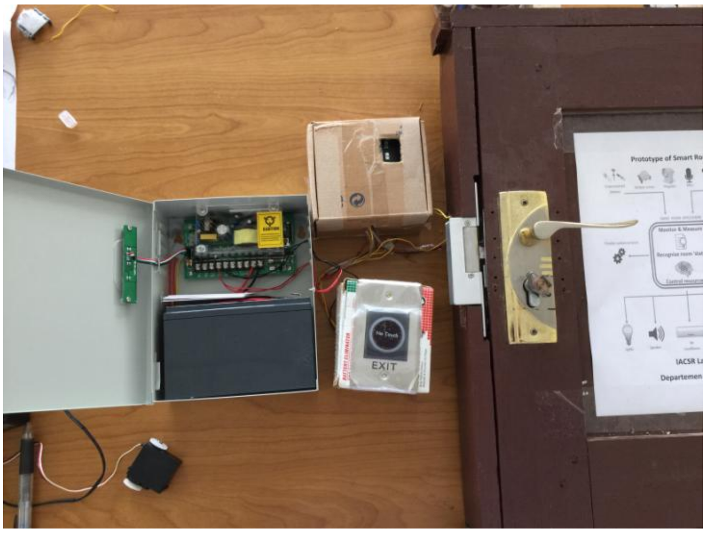


**Figure 3 Overall RFID Tag-based Door Mechanism**

The kind of RFID tags being used is RFID Tag card, 125 KHz, EMID IC card, made of PVC, ABS materials. dimension 86*54*1.8 mm, chip TK4100. Each tag card has a unique identification number as shown in Table 1 below and five different distances are used to assess the response time.

**Table 1 RFID Tag Unique Number**

| RFID Reader Test | |
|---|---|
| No | Tag ID |
| 1 | 000 74 764 39 114,053 35 |
| 2 | 000 74 842 67 114,131 63 |
| 3 | 000 17 987 00 027,292 28 |
| 4 | 000 75 128 39 114,417 35 |
| 5 | 000 75 239 26 114,528 22 |


**Figure 4 Five RFID-Tags Used for Experiments**

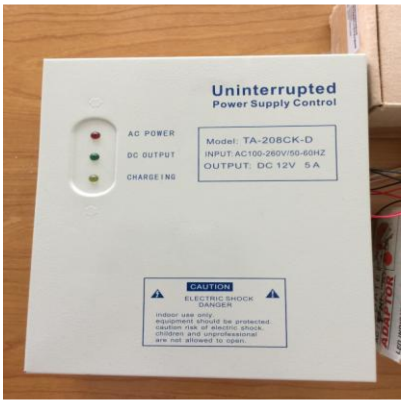


**Figure 5 Uniterrupted Power Supply**

## RESULT AND DISCUSSION

This section presents the outcome of the experiments followed by a breakdown and discussion which provide an overall analysis of experiments' results.

### *RESULT*

First scenario is to measure the RFID tags angle of activation and the results are shown in Table 2 below.

**Table 2 Angle of Activation RFID-Tags**

| RFID Reader Test | | | |
|---|---|---|---|
| ANGLE | T read RFID (ms) | T solenoid open (ms) | T open-closed (ms) |
| 0 | 16 | 130 | 505 |
| 45 | 18 | 122 | 495 |
| 80 | 19 | 131 | 510 |
| 90 | | | |

Second scenario is to measure the RFID tags distance of activation and the results are shown in Table 3 below.

**Table 3 Distance Test Scenario**

| RFID Reader Test | | | |
|---|---|---|---|
| DISTANCE (CM) | T read RFID (ms) | T solenoid open (ms) | T open-closed (ms) |
| 1 | 16 | 121 | 525 |
| 2 | 21 | 124 | 550 |
| 2.5 | | | |

Third scenario is designed to measure the response time of the magnetic-based locking system with respect to the exit door button which utilises infrared mechanism. Five different distances are introduced and the results of the experiments can be seen in Table 4 below.

**Table 4 Infra Red Distance Testing Scenario**

| Infra Red Test | | | |
|---|---|---|---|
| DISTANCE (cm) | T read hand (ms) | T solenoid open (ms) | T open-closed (ms) |
| 2 | 20 | 16 | 86 |
| 5 | 21 | 24 | 102 |
| 7 | 24 | 18 | 76 |
| 9 | 21 | 28 | 63 |
| 10.5 | 24 | 25 | 107 |
| 11 | | | |

### *DISCUSSION*

In average of five tag cards being tested and the results show similarity in pattern, hence the discussion will only cover one data pattern per scenario.

In RFID Tag scenario, the performance is measured based on the angle of RFID Tag placement against the RFID Reader and four data is acquired. At angle 0º, the reader requires 16 ms to detect the card and this detection time tends to increase for every different angle placement. The maximum angle in which the card can still be detected is 80º with detection time is 19 ms. Hence, the detection time in average is about 17.67 ms. Above the maximum angle, the reader can no longer detect the cards that are being used. Figure 6 depicts the pattern of detection time with respect to the angle placement of the cards.

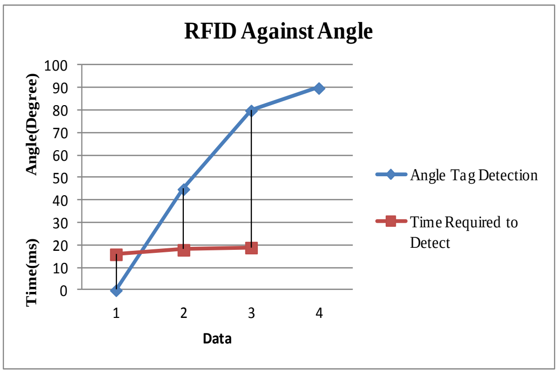


**Figure 6 RFID Tag with Respect to Angle**

From the time of being detected, the solenoid-based lock mechanism requires 130 ms to be active and this active condition lasts for 375 ms. In other words, the lock is deactivated around 505 ms after its activation. When the angle of placement is 45º, the lock takes 122 ms to be activated and its deactivation time is 495 ms. At the angle of 80º, 131 ms is the time used to activate the lock and 510 ms is the deactivation time. Overall, activation time of the lock mechanism is about 127.67 ms and deactivation time takes around 503.33 ms (see Figure 7 below for the overall data pattern).

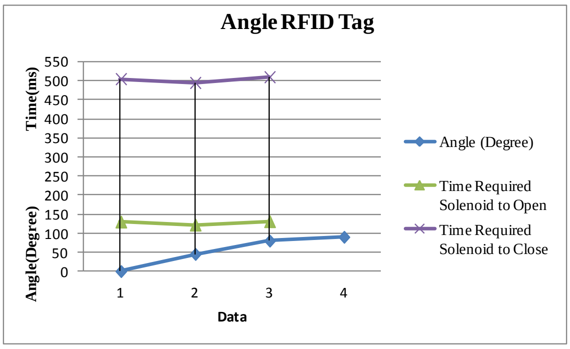


**Figure 7 RFID Tag and Angle Overall**

With respect to distance, the detection time of the RFID is 16 ms when the placement is 1 cm from the surface of the reader. There is a slight increase of detection time, 19 ms at the distance of 2 cm. The reader can no longer detect the RFID Tag cards when the distance of placement of card is higher than 2. The overall figure of this testing scenario can be depicted in Figure 8.

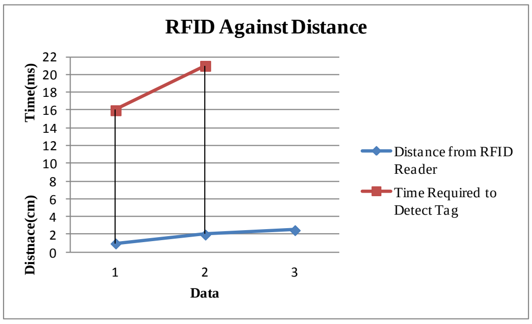


**Figure 8 RFID Tag and Distance Testing**

Activation time of solenoid-based lock measured from the time of detection is also collected and at the distance of 1 cm, the lock requires 121 ms to activate and 525 ms for deactivation time. Activation and deactivation times increase slightly, 124 ms and 550 ms respectively (see Figure 9 for the overall achievement).

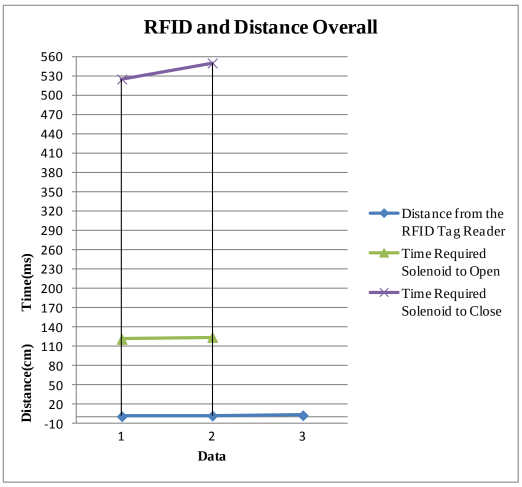


**Figure 9 Overall RFID Tag and Distance Experiment**

For the infrared exit button, six data are obtained and the average of hand user detection is 22 ms, where the maximum distance of detection is 10.5 cm. Figure 10 depicts the detection time of infrared sensor in different distance experiment.

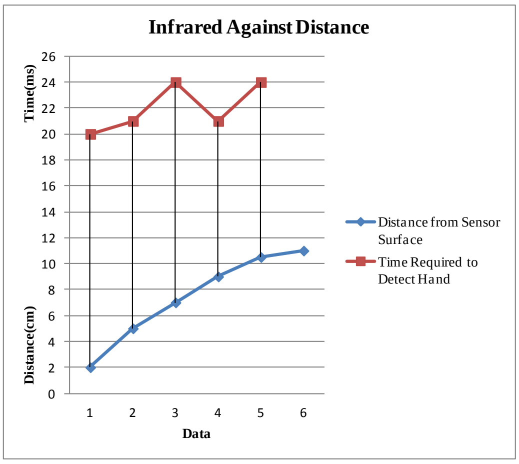


**Figure 10 Infrared Data Measured Respect to Distance**

For the activation and deactivation times of solenoid-based lock, at distance 2 cm, activation time is 16 ms and deactivation time is 86 ms. The maximum distance, 10.5 cm, requires 25 ms for activation time and 107 ms for deactivation time. In overall, both activation and deactivation times fluctuate where the average of activation time is 22.2 ms and deactivation time is 86.8 ms (the result pattern can be seen in Figure 11).

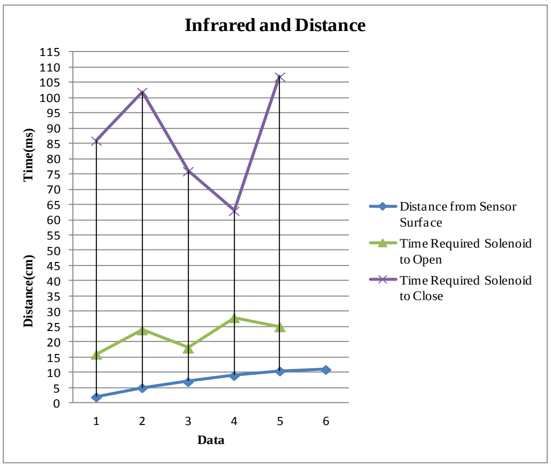


**Figure 11 Infrared and Distance Overall**

## CONCLUSION

The experiment results shows that the RFID Tag cards can be detected and identified at a maximum distance of 2 cm which requires 21 ms for detection time and activation time for the solenoid-based lock mechanism is 124 ms and deactivation time is 525. The angle placement also affect the RFID Tag card readability, with the maximum angle of placement is 80º which takes a bit longer time for detection, 19 cm compared to the angle of 45º and 0º which require 16 ms and 18 ms respectively. For the infrared-based opening button, the maximum distance that the user hand is detected is 10.5 cm, with detection time is 24 ms and the time for solenoid activation is 25 ms and deactivation time is 107 ms. The obtained data is fluctuative due to manual timing used during data collection for both testing scenario, which are RFID Tag testing and Infrared button testing. Overall, the time data requires to activate the door opening mechanism using RFID Tag cards is considerably low. Similarly, for the infrared button, the opening mechanism only takes shorter period of time which gives a positive impact on the user-friendly feature of the miniature of the smart room. Besides, with the miniature of the RFID Tag-based door opening system, it can be further implemented on real application in various door access mechanisms at Engineering Faculty UNHAS, particularly, the Department of Electrical Engineering.

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