Relationship between RFID Readers' Output Power and Detected Transponder Distance – A Preliminary Study for 3D RFID Library Search System

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***Abstract*— A RFID reader emits electromagnetic wave in order to detect any transponders within the reading distance of the reader or interrogation zone. This reading distance can be increase or decrease by adjusting the output power of the reader. To investigate the relationship between the readers' output power and detected transponder distance, this study was conducted in relation with a propose development of a search system called *3D RFID Library Search System* and is presented in this paper.**

I. Introduction

Most common RFID readers available in the market have built in function which granted system developers to adjust the readers' output power in order to either increase or decrease the readers' interrogation zone. This capability is meant for developers to have the ability to control the readers' output power according to their respective needs.

Ideally saying the higher the output power of the reader, the greater the coverage of the interrogation zone. This also dictates that if a transponder is placed at a distance where it is out of the original coverage of the interrogation zone, system developers need only increase the readers' output power in order to achieve successful detection of transponder.

However, this is not as simple as for real condition where RFID system commonly is being deployed, such as supermarkets, warehouses and etc where interference as discussed in [1] will affect the coverage of the readers' interrogation area.

In this paper, the relationship between the readers' output power and detected transponder distance is presented. This study was conducted in relation with the propose development of a search system called *3D RFID Library Search System* [2]. The purpose of this search system is to provide library users with the capability to track and locate a book in a library regardless it has been misplaced by other users or relocate to another location. The development of this system employs the used of RFID technology along with a localization technique described in [3]. This localization technique takes advantage of the readers' capability to control its output power to form a localization function by manipulating the relationship between readers' output power and detected transponder distance.

The balance of this paper is organized as follows: Methodology is described in section II. In section III, the experiment results are presented and discussed while the last section provides conclusion.

Manuscript received April 14, 2009. This work was supported in part by Universiti Malaysia Sabah Fundamental Research Grant FRG2007-TK-112.

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II. Methodology

A. Experiment layout

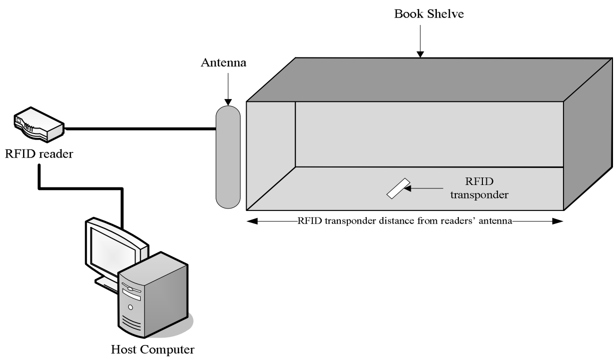

Fig. 1. The experiment layout consisting of a reader, RFID antenna, host computer, section of a bookshelf and RFID transponder

In order to investigate the relationship between RFID reader output power and detected transponder distance, an experiment layout was set up in order to measure the readers' output power along with the corresponding detected transponder distance. The experiment layout is depicted in Figure 1.

The layout consists of a section of a five-tire book shelf, a host computer, a RFID reader, an antenna and a transponder. The host computer is connected to the RFID reader through RS232 connection to provide control of the readers' output power by the use of a program that was developed specifically for this experiment.

The antenna which is connected to the reader is placed on the left side near the third level of the five-tier book shelve. A transponder is placed within the book shelves and its position is changed according to the experiment needs. A portion of the experiment layout physical appearance is shown in Figure 2.

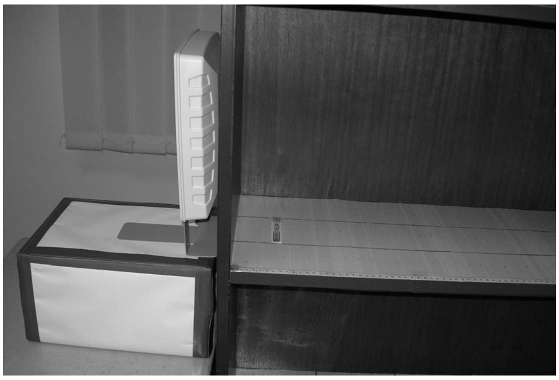

Fig. 2. Physical appearance of the experiment Layout

Figure 3, 4 and 5 shows the reader, antenna and transponder used in this experiment measurement respectively. The reader is an Ultra High Frequency (UHF) reader from *CAEN RFID* which has a long range detection capability (approximately 5-6 meters depending on transponder type) with operating frequencies spanning from

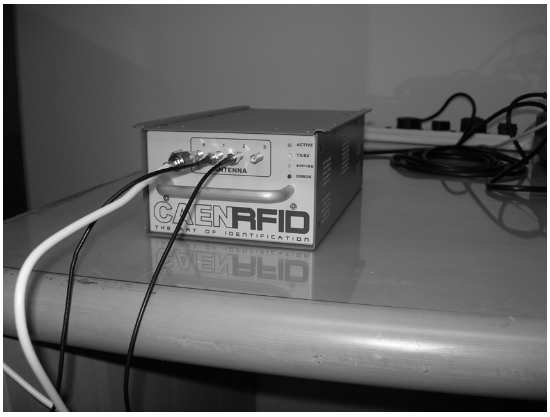

Fig. 3. CAEN RFID Long Range UHF reader

865.6 MHz till 867.6MHz. This reader also has 1.2W (31dBm) of maximum programmable output power and compliance with ISO 18000-6B, Philips UCODE EPC 1.19 and EPCC1G2 standards.

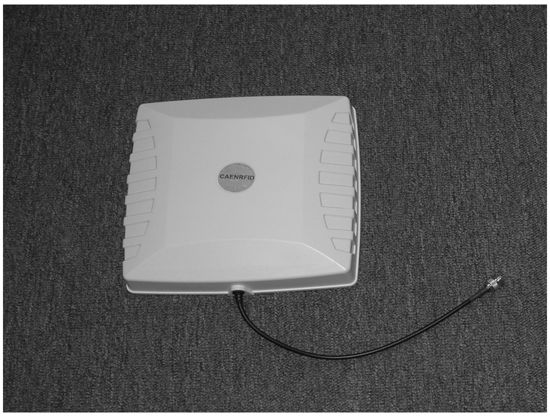

Fig. 4. CAEN RFID UHF circular Polarized antenna

The antenna, also from *CAEN RFID* is a circular polarization UHF type antenna with 6 to 8dBi gain while the transponder is a passive UHF transponder from *Rafsec.*

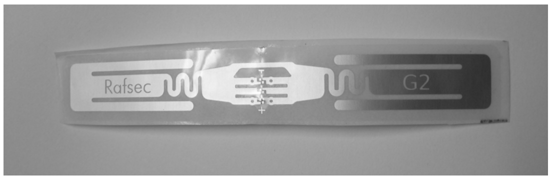

Fig. 5. Rafsec's UHF EPCC1G2 transponder

B. *Measurement Program*

To provide control for the readers' output power, a simple program was developed by using Visual C# along with *CAEN RFID* provided libraries. The programs' graphical user interface as depicted in Figure 6, allow user to configure various increment step sizes by inputting the appropriate value into the measurement program. The minimum output power in this experiment is pre-fixed at 1mW.

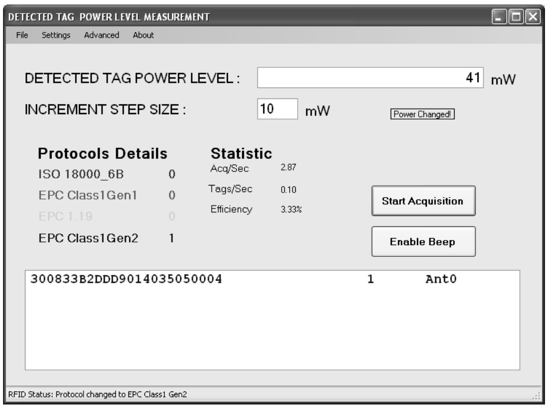

Fig. 6. Measurement program

C. *Experiment Measurement*

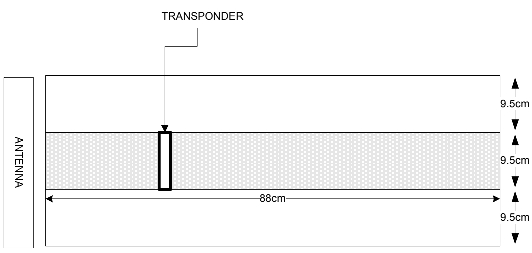

Fig. 7. Experiment setup plan view

Figure 7 illustrates the plan view of the third level of the book shelf and the antenna. The shaded area is the area where the different placement of the transponder was made, starting from left side of the bookshelf near where the antenna was positioned until towards the far end side of the bookshelf. The length of the shaded area is 88cm while depth is 9.5cm.

To measure the corresponding transponder distance and readers' output power, the following steps are taken:

Step 1: Determine the readers' output power increment step size and enter the value into the measurement program.

Step 2: Place the transponder at a determined distance from the antenna.

Step 3: Start the measurement program by clicking the "Start Acquisition" button. The reader will then start the acquisition process by interrogating the surrounding area. The reader will sets its' output power starting from the initial value of 1mW and increase progressively according to the increment step size entered at step 1. The interrogation zone coverage will increase for each increment of the readers' output power. If the transponder is detected, the reader will stop increasing its' output power and the final value of the output power will be recorded in the "DETECTED TAG POWER LEVEL" field.

Step 4: Record the readers' final output power

III. MEASUREMENT RESULT

This study has conducted ten experiments using increment step sizes ranging from 1 to 10mW. However, only the results from experiments using 1, 5 and 10mW are shown here in this paper which can be found in Figure 8, 9 and 10 respectively. The reason being similar result observed using increment step sizes ranging from 1 to 4mW and 5 to 9mW with no significant difference respectively.

As can be seen from the results obtain from the three experiments conducted, the relationship between readers' output power and transponder distance behave in a similar trend despite using various increment step sizes, where, as a general deduction the farther the distance of the transponder is placed away from the antenna, the higher the readings of the readers' output power.

This also validate that the larger the distance of the transponder from the antenna, the more the reader needs to increase its output power in order to ensure successful detection and communication with the transponder.

However, the results also showed that at distances between 2cm to 6cm, the readings of the readers' output power is very high even though at these distances where the transponder was placed were considerably near the antenna. This indicates that the system detection efficiency is low if the transponder is placed too near the antenna.

The system detection efficiency again fluctuated at distances between 58cm to 70 cm where the readers' sudden increased and decreased of output power as can be seen from the results.

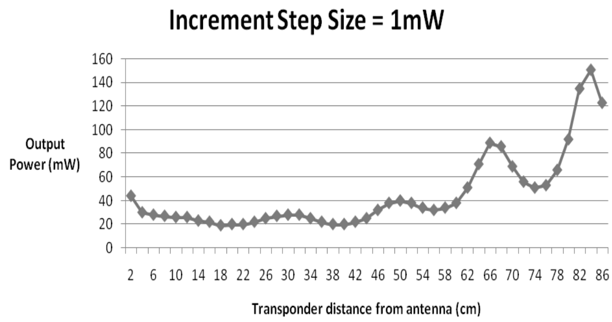

Fig. 8. Readers' output power (mW) against transponder distance from antenna (cm) with increment step size of 1mW

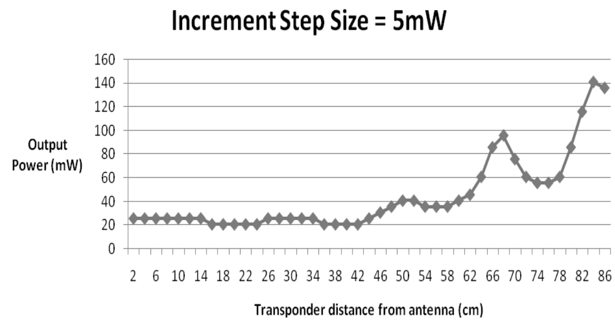

Fig. 9. Readers' output power (mW) against transponder distance from antenna (cm) with increment step size of 5mW

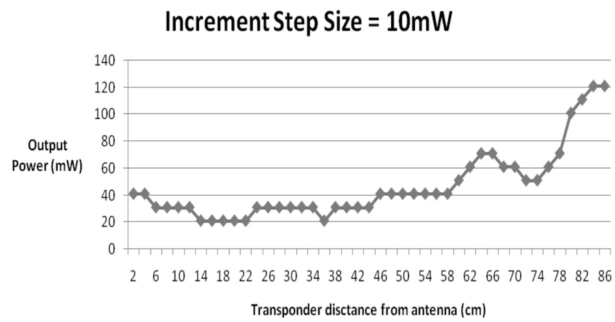

Fig. 10. Readers' output power (mW) against transponder distance from antenna (cm) with increment step size of 10mW

IV. CONCLUSION

In this paper, the relationship between RFID readers' output power and detected transponder distance is investigated. Generally the farther the distance of the transponder is positioned away from the antenna, the more the reader needs to increase its output power.

However, at certain distances this relationship does not applied due to the system detection efficiency as described in previous section. Recommendation for future works with more increment step sizes variation and improve system detection efficiency to further investigate the studied relationship.

ACKNOWLEDGMENT

This research is supported by Universiti Malaysia Sabah Fundamental Research Grant FRG2007-TK-112.

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