Journal of Mobile Multimedia, Vol. 11, No. 1&2 (2015) 021–033

EVALUATION AND MEASUREMENTS OF MAIN FEATURES OF A TABLE TYPE RFID READER

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RFID system is one of the key technology to bring efficiency to library services such as the automatic rental of book and return. In this paper, we evaluate the performance of table type RFID reader. Furthermore, when RFID reader is on the metallic plate (which affected the performance of RFID), we investigate the relation between the reading rate and the distance between metallic plate and RFID reader. From the experiments, it is clearly shown that communication area decreases and becomes near the center of reader's antenna as the distance between the tag and the reader increases. The influence of the metallic plate to the reader depends on the gap between the metallic plate and the reader.

Keywords: RFID System, Wireless Communication, Automatic Rental and Return, Library services

1 Introduction

The progress of the radio technology allow us to use many wireless services, for example, TV, Radio, mobile phone, etc. These services changed our life dramatically and enabled us to use the network services (telephone, web, mail...) anytime and anywhere. The wireless communication began as a technique to realize long-distance communications. However, people are recently interested in the near filed wireless communication technique such as Radio Frequency Identification (RFID) technique [1], because it easily enables the non-contact data exchange.

The RFID technique uses electromagnetic coupling for data exchange between the reader/writer and the tag. The RFID system using this technique enables us to manage the goods efficiently in the case that a large quantity of goods is managed. For example, in the library, by using RFID system, we expect the efficiency of the following services: 1) rental of book and the return, 2) collection inventory, 3) search of the book, 4) access control of users [2, 3]. Furthermore, if RFID system is integrated with smartphones and wireless sensor networks [4, 5], as a new service, the library system can trace books and user in the library, and the system may send useful information to users.

A lot of applications using RFID are proposed [6, 7, 8, 9]. Moreover, the development of RFID device and performance evaluation using RFID system are performed to realize a reliable RFID system [10, 11, 12, 13, 14, 15, 16, 17].

At Kyushu University Library, we have implemented a RFID system. For the evaluation of usefulness of RFID system, we carried out experiments at Chikushi Library of Kyushu University, as a joint study with Mitsubishi Materials Corp. and Checkpoint Systems Inc. [2].

In these experiments, we found that the performance depends on the reading range of RFID system. Especially, when tags get too close, the performance largely decreased. The performance of the tag system changed by the distance of bookshelf or desk. The main reason of this problem is the shift of the resonant frequency by the influence of other things. To confirm this situation, we evaluated the influence that paper or another RFID tag give to the resonant frequency of RFID tag [10].

When using the tag in the library, it is not easy to change the size and shape of tag because the tag is stuck on a book. Therefore, the improvement of the tag is difficult. On the other hand, the improvement of the reader is possible because there are few limits to the shape. As a first step of the development of the reader which is most suitable for the use in library, we evaluate the performance of table type RFID reader using 13.56MHz. Furthermore, when RFID reader is on the metallic plate (which affected the performance of RFID), we investigate the relation between the reading rate and the distance between metallic plate and RFID reader.

The structure of this paper is as follows. In section 2, the RFID system is presented. In section 3, the experimental method is shown. In section 4, the performance of table type RFID reader is evaluated. In section 5, the effect of metallic plate to the performance of table type RFID reader is discussed. In section 6, we conclude this paper.

2 RFID System

An RFID system is contactless ID system using wireless communication. It is one of the technique on the automatic identification. Automatic identification means to "automatically input bar-code, magnetic-card, RFID data, etc. with the use of hardware and software and not human intervention in order to recognise the content of the data [18]". Biometrics, OCR, the machine vision are included in this technique, too.

The RFID system is made up of two components as shown in Fig. 1 [1]. One is the RFID tag, which is located on the object to be identified, and another is the reader/writer. The RFID tag normally does not have the power supply to work, so the reader/writer not only exchange the data, but also supply the power and clock signal to the RFID tag.

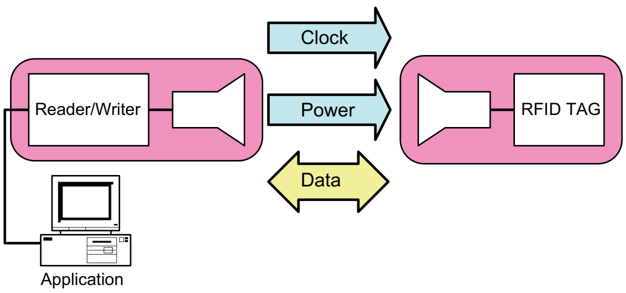

Fig. 1. RFID system.

3 Experimental Method

In this experiment, as the table type RFID reader, ST-RW01 produced by SOFEL was used. The size of this reader is 25 cm × 35 cm. The probe and the spectrum analyzer used for the measurement of the magnetic field are EM-6993 of ELECTRO-METRICS Corp. having loop antenna of 6 cm in diameter and HP8560E of HEWLETT PACKARD Corp., respectively. The photo of ST-RW01 and EM-6993 are shown in Fig. 2. The photo on the right side in Fig. 2 is the inside part of the reader. An approximately 20 cm square loop is the antenna of the reader. In the experiments, we measured the power based on the intensity of magnetic field and evaluated the reading performance.

Fig. 2. Photo of ST-RW01 and EM-6993.

We defined the axis and the height of probe as shown in Fig. 3 for the observation and measured the intensity of magnetic field on the reader at 1 cm intervals in 25 cm square.

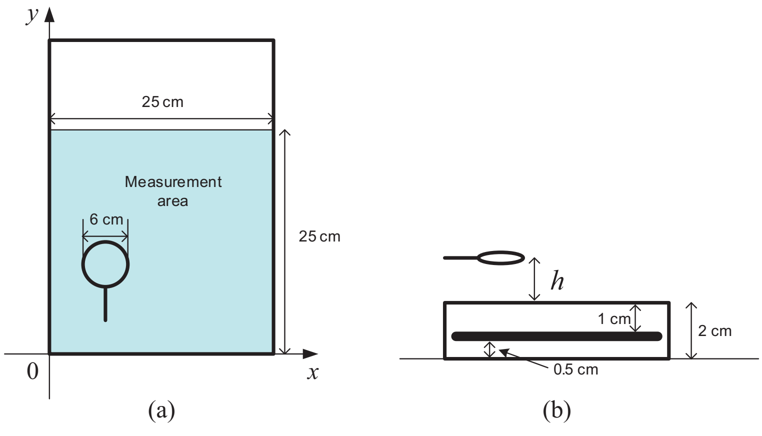

Fig. 3. Measurement setup and observation area.

Figure 4 shows an example of observed signal power at the spectrum analyzer. The peak point gives the intensity of received signal power at 13.56 MHz. This value can be changed

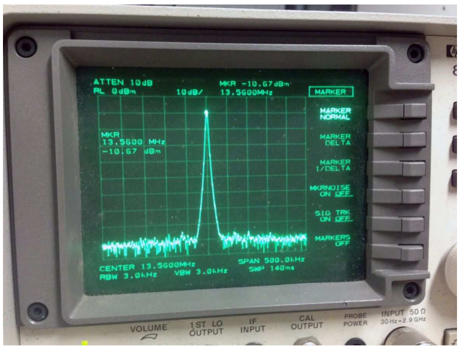

Fig. 4. Example of observed signal at the spectrum analyzer.

by changing the probe position.

4 Measurement and Evaluation

4.1 Observed Power

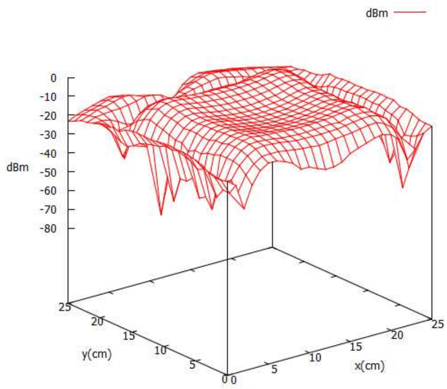

Fig. 5. Observed power at each point and height ($h = 0$ cm).

Figures 5 to 7 show the observed power at each point and height. From these figures, we see that the observed power decreases as the probe height increases, but the attenuation of the power near the center of the antenna is lower than that of the other areas. To show this situation clearly, we evaluated the distribution of the observed power of the x-axis direction in the case of $y = 5$ cm and 10 cm. The results as shown in Figs. 8 and 9. When the distance between the probe and the reader is about 10 cm, compared with the results of h=0cm, the observed power near the center of antenna is about $1/10 \sim 1/30$ (10 dB $\sim$ 15 dB) and the edge of antenna is 1/100 (20 dB).

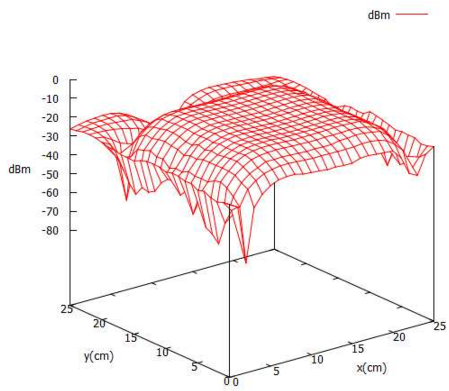

Fig. 6. Observed power at each point and height ($h = 2$ cm).

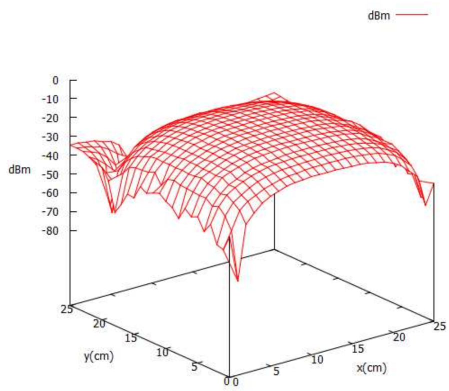

Fig. 7. Observed power at each point and height ($h = 6$ cm).

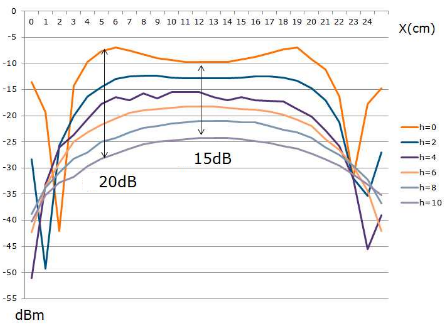

Fig. 8. Observed power at $y = 5$ cm.

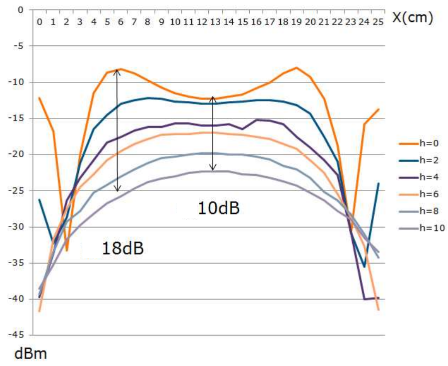

Fig. 9. Observed power at $y = 10$ cm.

4.2 Communication Area

Next, we evaluate the communication area on the reader. When the influence of outside can be ignored, the power more than -25 dBm is necessary for the communication with tag. So, the threshold of -25 dBm was evaluated. The results are shown in Figs. 10∼13. In these figures, the symbols '+' means the points where the reader can communicate with the tag.

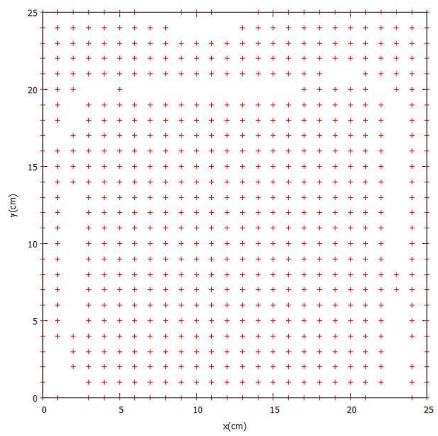

Fig. 10. Evaluation when reader can communicate with tag in case of $h = 0$ cm.

As shown in these figures, communication area decreases and becomes near the center of antenna of reader as the distance between the tag and the reader increases. Figure 14 shows the relation between the ratio of point where communication is possible on the reader and the distance between the reader and the tag.

5 Influence of Metallic Plate on Communication Performance of Reader

When RFID reader is put on the metallic desk, the performance of RFID system decreases. Here, we investigate the relation between the reading rate and the distance between metallic

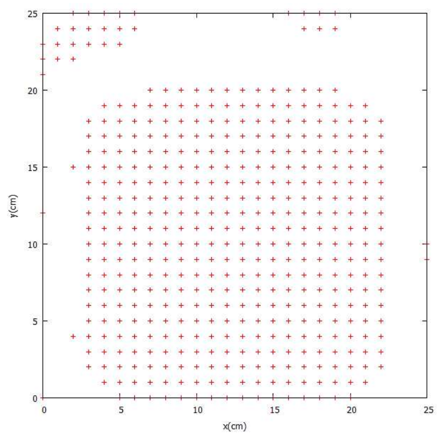

Fig. 11. Evaluation when reader can communicate with tag in case of $h = 2$ cm.

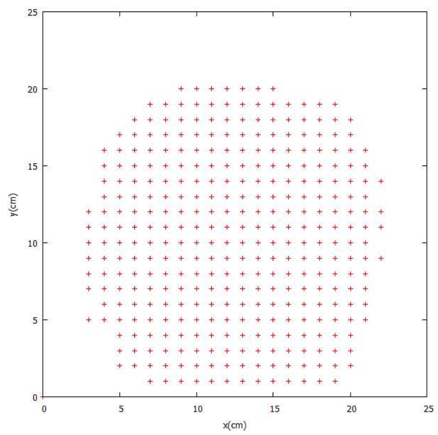

Fig. 12. Evaluation when reader can communicate with tag in case of $h = 6$ cm.

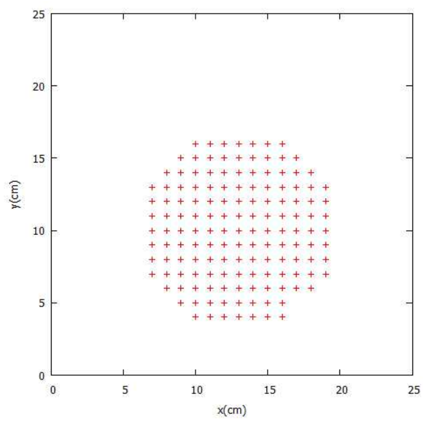

Fig. 13. Evaluation when reader can communicate with tag in case of $h = 7$ cm.

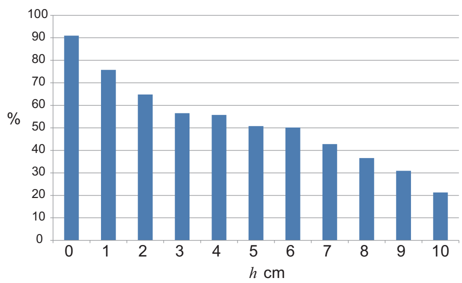

Fig. 14. Ratio when communication is possible vs distance between reader and tag.

plate and RFID reader. Figure 15 shows the measurement setup of the influence of the metallic plate on communication performance of the reader. As shown in this figure, we changed the space between the metallic plate and the reader. Then, we observed the readable point on the reader by using a tag and evaluated the ratio of points where communication is possible as shown in Fig. 16. When the reader is on the metallic plate ($h_m = 0$ cm), the readable point is about 20% in the case of $h = 0$ cm and when h is 1 cm or larger the readable point disappear. Figure 17 shows the observed power in the case $h_m = h = 0$ cm. Compared with Fig. 5, the power decreases but it seems that the result has a similar characteristic. Figure 18 is the communication area which was evaluated using a tag. On the other hand, in Fig. 19 the evaluation is based on the observed signal level as shown in Fig. 15. In this case, about 60 % of area becomes readable points and it has a large difference compared with Fig. 18.

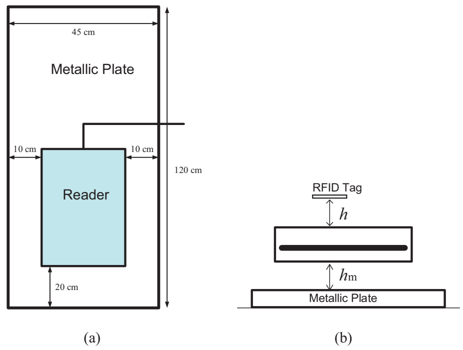

Fig. 15. Setup to measure metallic plate influence on communication performance of reader.

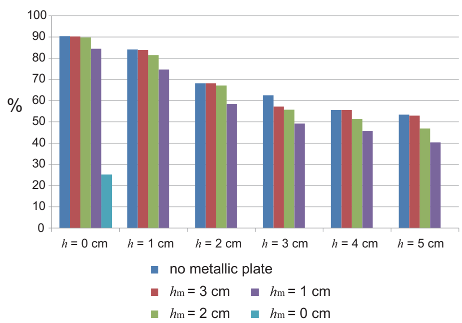

Fig. 16. Ratio when communication is possible vs distance between reader and tag.

When a metallic plate is near the coil, the electromagnetic field produced by coil is reflected by the metallic plate. As a result, there is interference between reflected electromagnetic field and original electromagnetic field. When the interference becomes large the tag can not communicate with reader because of largely distorted signal. The effect of the reflected electromagnetic field to the performance depends on the gap between the metallic plate and the reader. If the gap increases then the effect is decreased.

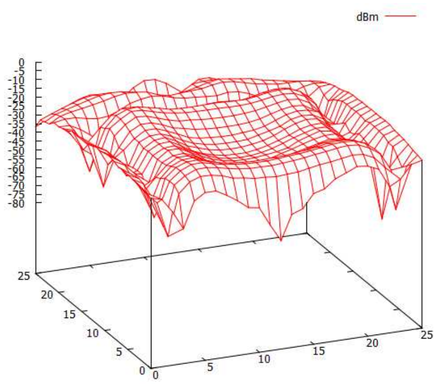

Fig. 17. Observed power at each point in the case of $h = 0$ cm and $h_m = 0$ cm.

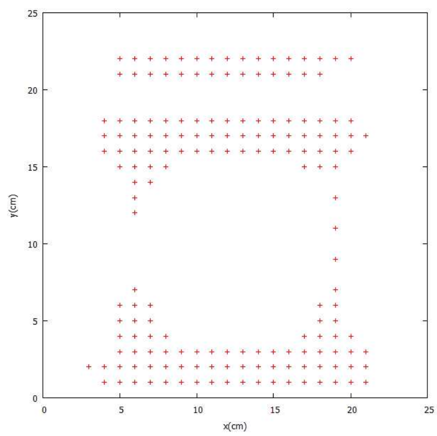

Fig. 18. Evaluation when reader can communicate with tag in case of $h = 0$ cm and $h_m = 0$ cm.

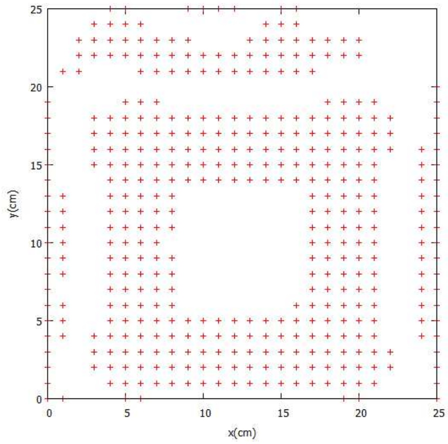

Fig. 19. Evaluation when reader can communicate with tag based on observed power on reader in case of $h = 0$ cm and $h_m = 0$ cm.

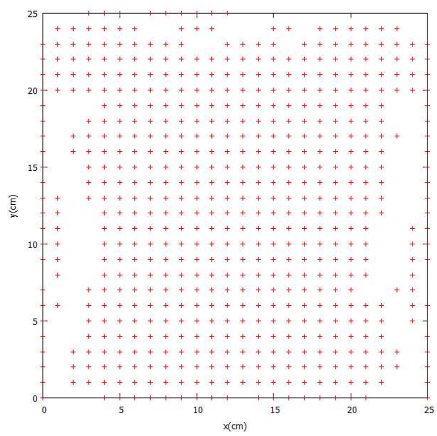

Fig. 20. Evaluation when reader can communicate with tag in case of $h = 0$ cm and $h_m = 1$ cm.

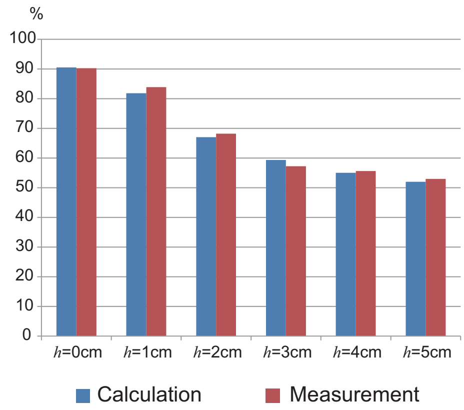

Fig. 21. Ratio when communication is possible vs distance between reader and tag in case of h_m = 3 cm.

Figure 20 shows the results when the distance h_m is 1 cm. Compared with Fig. 18, the readable points are increased. From Fig. 16, the influence of the metallic plate to the reader can be ignored if the gap between the metallic plate and reader becomes more than 3 cm. To show more clearly this result, we calculate the readable rate from observed power in the case of $h_m = 3$ cm and compare with the measurement one (see Fig. 21). This result clearly explains that to avoid the influence of the metallic plate to reader more than 3 cm gap is needed.

6 Conclusions

In this paper, we evaluated the performance of a table type RFID reader using 13.56MHz. When RFID reader was on the metallic plate, we investigated the relation between the reading rate and the distance between metallic plate and RFID reader. It is clearly shown that communication area decreases and becomes near the center of reader's antenna as the distance between the tag and the reader increases. Furthermore, the influence of the metallic plate to the reader depends on the gap between the metallic plate and the reader. If the gap becomes more than 3 cm, the influence to the reader can be ignored.

In the future work, we want to examine which shape of the reader is most suitable for using in the library.

Acknowledgements

I am indebted to Takeru Niimi and Kento Maeda for there assistance in experiments. My thanks also go to the staff of Kyushu University Library.

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