A Dead Spot Analysis in Simultaneous Read of Multiple RFID Tags

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1. Introduction

RFID (Radio Frequency Identification) systems consist of RFID tags and readers and this technology uses the electromagnetic radiation to provide contact-less recognition. It has the unique advantage that it can provide simultaneous read of multiple tags, but we have observed that either a maximum read range or recognition rate becomes low during this operation. Especially, we are here concerned with the mechanism of the low recognition rate called dead spot and studied this by the experiment and simulation.

A dead-spot of RFID tag means that a recognition rate is quite low within the maximum read range. In the case of reading only one tag, the mechanisms of the dead spot are well studied by the previous works. In one study, it is reported that the recognition error may occur when tags are close to the reader antenna which consists of four patch antennas[1]. In another work, it is also reported that the recognition error is caused by impedance miss-match between a tag antenna and a load at a certain distance, because a input impedance of a load depends on the power of the incident wave [2],[3]. However, there is no previous works on the dead spots analysis in the case of the simultaneous read of multiple tags so far.

In this paper, we first conducted experiments on the simultaneous read of multiple tags using 2.45GHz band RFID tags and present the phenomenon of the half-wavelength period dead spots. And then, we next analyzed the mechanism of the dead spot by the method of moment simulation.

2. Dead spots in simultaneous read of multiple tags

We have evaluated the recognition rate in the simultaneous read of eight tags by experiment as a function of distance R between the reader and the tags as shown in Fig. 1. The spacing between the tags is 20mm. The tags are μ-chip inlet COA (produced by Hitachi Ltd.) and the reader has the directivity of 12dBi and transmission power of 300mW (24.8dBm). The reader antenna consists of the circularly polarized four patch antennas. This experiment was conducted in an anechoic chamber. The operating frequency is 2.45GHz band. Fig 2 shows the experimental results in term of the recognition rate. From these results, we can see that the dead-spot occurs in the period of half-wavelength at the operating frequency.

3. Analysis of load power by the method of moment

3.1 Analysis model

In general, tags can be recognized when enough power which is required to activate the tags is provided. Therefore, we have calculated load power of each tag by the method of moment. EEM-MOM [4] is used to calculate the load powers. A simulation environment is almost the same as the experimental setup shown in Fig. 1. Fig. 3 (a) and (b) respectively show the reader and tag antenna geometry.

The reader antenna consists of circularly polarized four patch antennas. The transmitting power is 300mW, directivity is 11.8dBi, axial ratio is 0.5dB and VSWR is 1.05. On the method of moment, the wire radius is 0.31mm, the number of segments of the ground plane and patches are 54 by 54 and 32 by 32, respectively. Each patch has two feed ports and these are respectively excited by in-phase and quadrature-phase voltages to radiate circularly polarized electro-magnetic field.

The tag antenna is the dipole antenna with feeder line as shown in Fig. 3(b) and its input impedance is 52.8-j8.1 ohm. The terminal is loaded by 50 ohm.

3.2 Evaluation results on load power

Using the analysis model as shown in Fig 3, the currents of the tags are calculated and the load power of each tag is determined by the following equation

$$P_{tag} = |I|^2 \cdot R_L . \qquad (1)$$

Where I is the effective value of current at the terminal and R_L is the real part of load impedance.

We calculated P_{tag} of the eight tags with 10mm spacing between 10mm and 300mm. The results are shown in Fig 4. The corves of the load power are almost symmetrical for the RFID tag array center and the load power of the tag placed around the edge of the RFID tag array decays compared to that around the center. We can see that the load powers vary with the period of half wavelength at 2.45GHz. This phenomenon is probably caused the mutual coupling effect between the reader and the tags.

4. Comparative study between experimental and simulation results

Fig 5 (a), (b) and (c) respectively compare the experimental results and the simulation results of the tags A, G and H. The dotted line in the upper trace indicates the minimum threshold power of μ-chip and its value is 3.5dBm (2.2mW) [5].

These results confirm that the dead spots are caused by the drop in load power from the minimum threshold level (3.5dBm). We can see good agreement between the experimental results and simulation results.

5. Influence of the number of RFID tags

To evaluate the influence of the number of tags, we compare the load power both in the case of only one tag and eight tags. Fig 6 shows the comparison of load power of the tag at the coordinate E.

It is clearly confirmed that the sinusoidal variation in the case of eight tags is larger than that of the one tag case. This means that the probability of the dead spots will increase with increasing the number of tags in the simultaneous read of multiple tags.

6. Conclusion

In this paper, first we have conducted experiments on the simultaneous read of multiple tags using 2.45GHz band RFID tags and presented the phenomenon of the half-wavelength period dead spots. And then, we have analyzed the mechanism of the dead spot by the method of moment simulation.

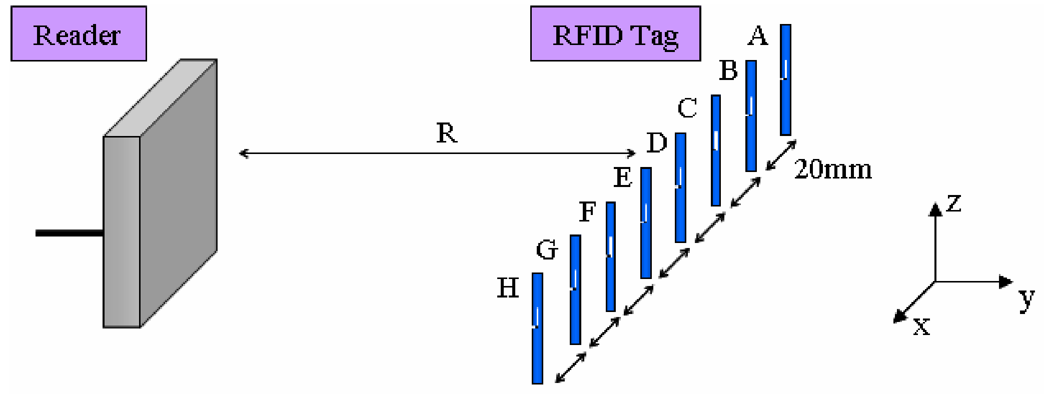

Fig.1 Experimental setup.

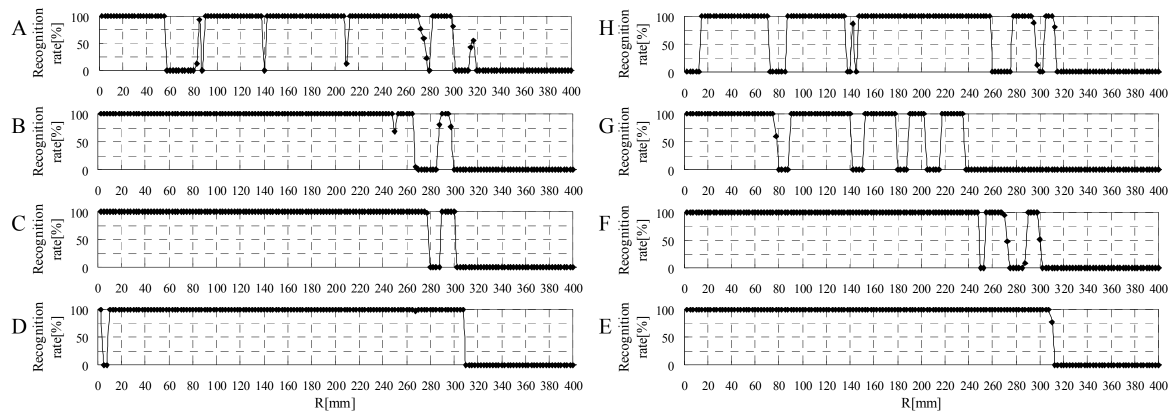

Fig.2 Experimental result in terms of recognition rate.

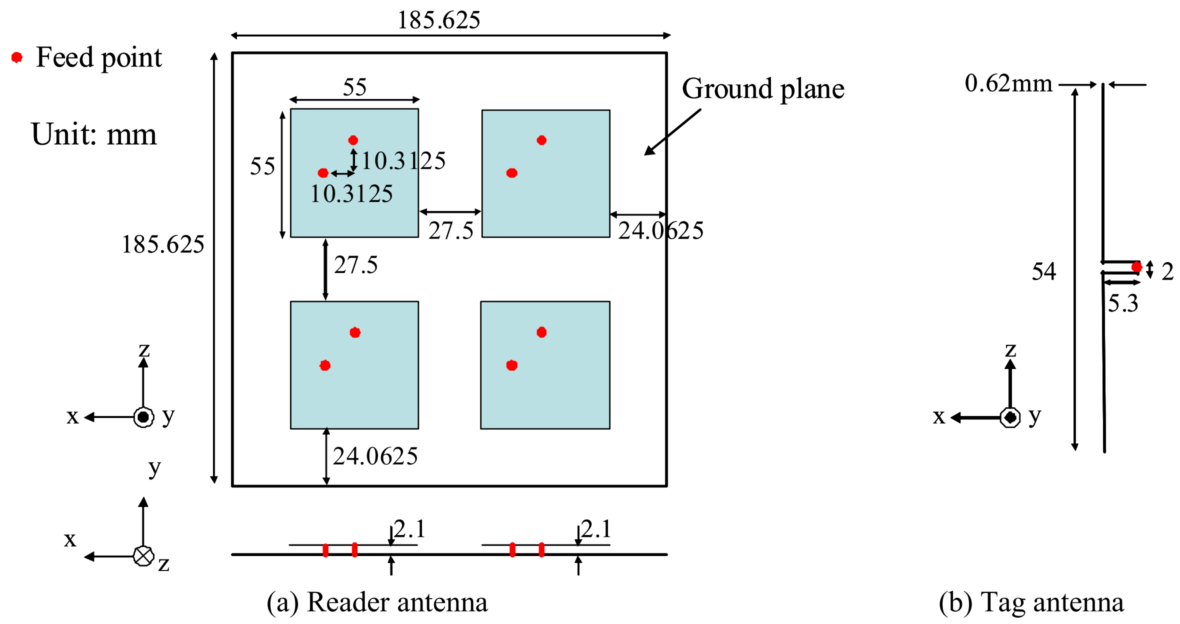

Fig.3 Antenna geometry in the simulation.

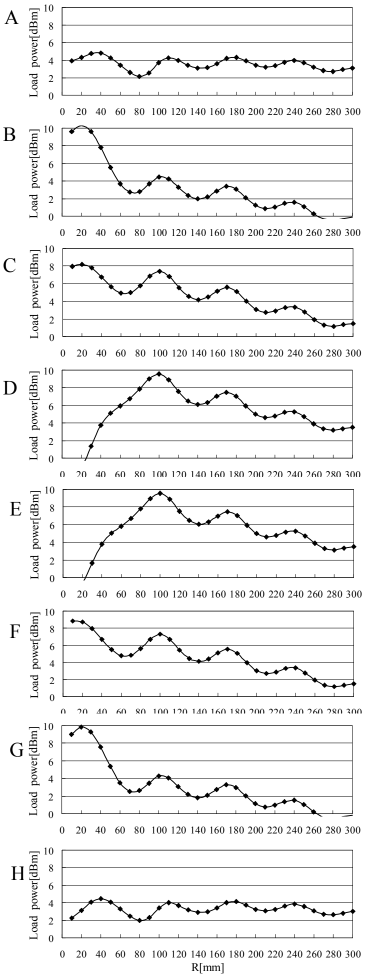

Fig.4 Load power of tag.

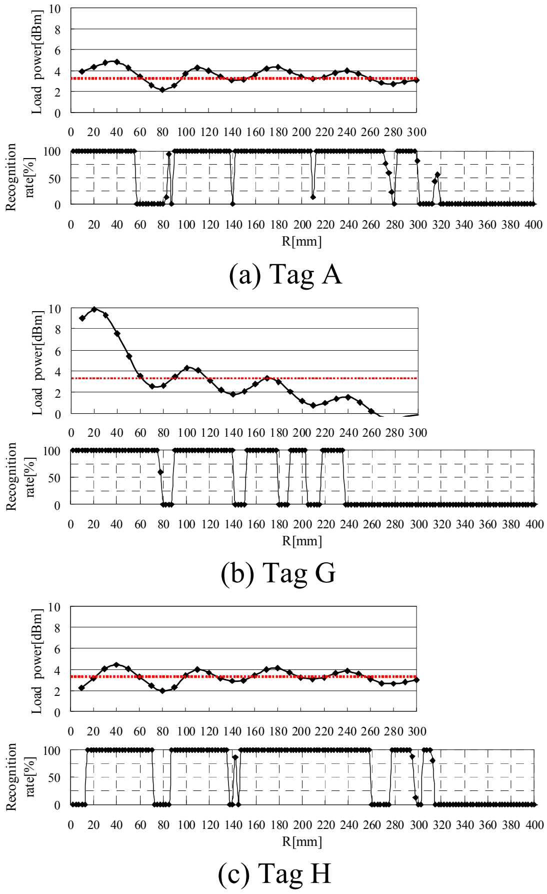

Fig.5 Comparison between the experimental results and simulation results (Upper trace : Load power obtained by the simulation, Lower trace : Recognition rate obtained by the experiment).

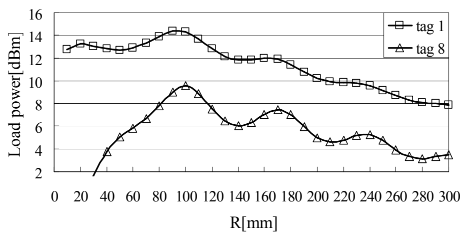

Fig.6 Comparison of load powers between the simultaneous read of eight tags and only one tag.

References

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