Study on objects storage position detector with UHF-RFID system

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Abstract:
RFID (Radio Frequency IDentification) system is expected to serve as the distribution management system of the alternative to bar-codes in recent years. If objects storage location detection equipment with RFID technology is introduced in the distribution management system, work efficiency and safety improvement are predicted. The system that can identify massed RF-tags has already been proposed, though it is required to mounting dedicated tags. On the other hand, the massed RF-tag location detection system which can use the ordinary and low-priced tag is proposed in this report.

Keywords: RFID, UHF band, RF-Tag, detector, the leaky coaxial cable.

Classification: Antennas and propagation

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1 Introduction

RFID (Radio Frequency IDentification) systems are expected to serve as the distribution management system of the alternative to bar-codes in recent years. RF-ID systems are widely used in the distribution management field because it can perform multifaceted inspection and recognition in a non-contact manner with wireless technologies [1]. If a system that extract objects position from information of RF-ID's reader / writer is put to practical use, it is expected to improving the accuracy and safety in especially medicine distribution management field [2]. Currently, there are two types of RFID systems (the electromagnetic coupling use type and the microwave-use type). The electromagnetic coupling use type system (HF-RFID) has the property to which the identification precision is steady for environmental changes. Therefore, this system is suitable for the detection of closely spaced RF-tags. However, it is unsuitable for few meters distance or movement RF-Tag detection. In contrast, the microwave-use type system (UHF-RFID) is suitable for few meters distant or traveling RF-tags detection, because the detection signal transmission efficiency is high [3]. It becomes widely used around the apparel industry because of UHF-RFID tags have above mentioned features, and as results the cost reduction of UHF-RFID tags has been accomplished compared with HF-RFID tags. It is thought that small tag profile is also advantageous to attach it to small objects. On the other hand, when ordinary UHF-RFID reader / writer systems are used to closely spaced RF-tags, appearance of the electromagnetic interference is worried. Accordingly, the suppression technology of electromagnetic interference is necessary for the detection of closely spaced RF-tags. A reader / writer unit capable of constant monitoring of massed tag with UHF-RFID has been proposed [4] [5]. In this report, above mentioned units are structured like the lattice, and the practical use of the system which detects the object's stored position is verified. Fig.1 shows the system configuration. The following chapters, the attachment object of tag is assumed to the test tube, because of accurate storage position detection unit achievement of the medicine ampoule with the UHF-RFID system.

2 Configuration of the proposed system

The tag detector for medicine is required to accurately read closely spaced RF-tags. The tags detector proposed in this paper referred to the leaky coaxial cable [6]. The proposal tag detector has flat shape that suitable for storage is considered though general leaky coaxial cable's form is a cylindrical shape. The proposed unit structure is shown in Fig.1 (a) in detail. A flat shape cable is called shielded type microstrip-line. This is composed with putting slot apertures on the outside metal layer of shielded microstrip-line. Furthermore, in those units are arranged in matrix form as shown in Fig.1 (b). This structure enables to detect the tag location with extracted information from "row" and "column" units shown in Fig.1 (d).
FDTD (Finite Difference Time Domain) method is used for the design and the performance evaluation of the proposal massed-tag detector. Electric properties of the substrate (relative permittivity $\varepsilon_r$ and the conductivity $\sigma$) which composes the shielded microstrip-line are set to $\varepsilon_r = 3$ and $\sigma = 0.0005$ [S/m] respectively.

Fig. 1. Configuration of the proposed system. (a) Configuration of the tag detector unit. (b) Configuration of the matrix tag detector unit. (c) Slot parameters. (d) Schematic views of the proposed system.
3 Evaluation of the tag detection

In this chapter, the results of evaluating the possibility of target tags storage position detection with the proposal system is shown. The target tag detection possibility is evaluated due to the insertion loss between the tag antenna model and proposal system. Tag antenna model is appropriated with a short dipole (element length: 50 mm) loaded with a 1 Ω resistor shown in Fig.2 (a) and located on the proposed unit as shown in Fig. 2 (b). To evaluate the possibility of the tag detection with the tag search rack, an insertion loss is evaluated as relative $S_{21}$. Relative $S_{21}$ is normalized with the insertion loss between the long-range detector antenna (it is composed with the high gain antenna that has around 7 dBi) and 2 m distant tag antennas. Many of antennas for long-range Reader/Writer are enabled for tag to be detected by 90 % or more if the distance between it and a target tag is within 2 m. Furthermore, Fig.2 (c) shows relative $S_{21}$ between each tag antenna model and the closest Vertical or Bottom unit. Relative $S_{21}$ between Bottom or Vertical unit and each tag has exceeded 0db. Those results predicts that target tags adequately can be found with the proposal detector system. Moreover, because sensitivity is better than those models for the evaluation, actual RFID-tag is thought that the positional detection possibility will be higher than these evaluation results.

![Fig.2. Evaluation of the tag detection. (a) Tag antenna model. (b) Arrangement of the tag antenna model. (c) Relative $S_{21}$ between tag antenna model and proposed unit](image)
4 Measurement results

In this chapter, the actually manufactured tag detector is evaluated. Manufactured tag detector is composed with the glass cloth Teflon substrate of relative permittivity $\varepsilon_r = 3$ (see Fig.3 (a)). Since the side of the tag detector needs to be shorted, the metal layer putting slot aperture and ground plane are shorted with rivets. The comparison between simulated and measured S parameter characteristics of Vertical unit is shown in Fig. 3(b) (c). Vertical unit exhibited agreement between simulation result and measurement result. Thus, Vertical unit is considered to be sufficiently capable of detecting tags from simulation result in previous chapter. Similarly, the performance of the bottom unit is shown in Fig.3 (d) (e). Bottom unit's measured $S_{11}$ as the function of the frequency is observed to shift for the lower frequency region. However, it is thought that its practical performance is enough.

![Fig.3. S parameter. (a)The prototype of tag detector. (b)Comparison of measurement and simulation of $S_{11}$ in Vertical unit. (c) Comparison of measurement and simulation of $S_{21}$ in Vertical unit. (d)Comparison of measurement and simulation of $S_{11}$ in Bottom unit. (e)Comparison of measurement and simulation of $S_{21}$ in Bottom unit.](image-url)
5 Conclusion

In this report, the massed tag detection units are assembled like the lattice, and the practical use of the system which detects the object's stored position is verified. Concretely, insertion loss between a short dipole and tag position detector was analyzed. As a result, it was confirmed that tag position detector is to be able to identify the target tag's location. Moreover, the actually manufactured tag detector was compared to the simulation. The measurement results showed good agreement with simulation results. In the future, tag detectors will be arranged in matrix form and experimented with tag location detection.