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The characteristics of the RFID antenna by poses of human body for urination sensing

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1. Introduction

Radio frequency identification (RFID) system has been developed to use in various scenes, for instance, individual authentication, logistics, etc [1]. An RFID system is consisted of RFID tag and Reader/Writer. The electromagnetic wave transmitted from the Reader/Writer antenna is received by RFID tag antenna and the integrated circuit (IC) chip of the tag can be excited. In addition, the information of the IC chip is return to Reader/Writer by the electromagnetic wave. In this system, the RFID tag antenna is very important because the size and the communication area of the RFID tag depend on the tag antenna [2].

Recent year, this system has been expected to use in medical field because the heavy care burden of nursing staffs is a serious problem in many developed countries. One of hard work for health care personnel is changing diapers. It is hard for the health care personnel to know urination of his care-receivers without taking off the pant. Then this paper presents a sensing system for urination by RFID system (Fig. 1). In our system, the urination is detected by whether the RFID tag embedded into a paper diaper can communicate with Reader/Writer or not. If the paper diaper is dry, the tag can communicate with Reader/Writer. In contrast, if it is wet, the tag cannot communicate with Reader/Writer because the urination prevents the electromagnetic wave. By use of this system, the health care personnel can know urination of his care-receivers without taking off the pant. Therefore it is possible to reduce his or her loading. In order to realize this system, the RFID tag antenna needs to be designed and analyzed. In addition, there are many poses when the care-receiver lies in bed. Therefore the characteristics of the antenna are evaluated by some human models of different poses.

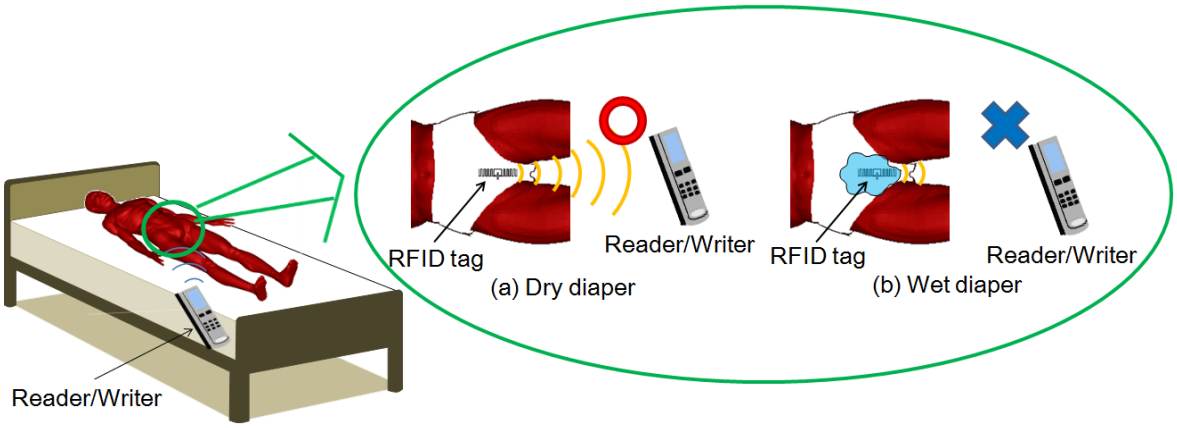


Fig. 1 Sensing system for urination.

2. Antenna Design and Human Models

The proposed antenna is shown in Fig. 2. This antenna is embedded into the paper diaper as shown in Fig. 3. In order to reduce the size and to match the IC chip, we used meander and loop structures in our antenna design.

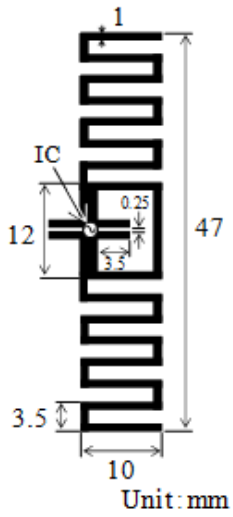


Fig. 2 Antenna structure.

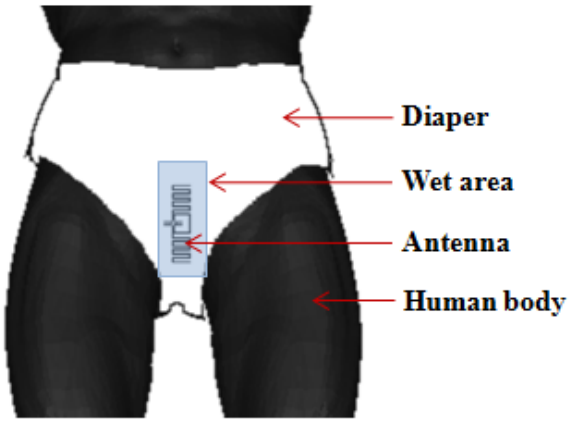
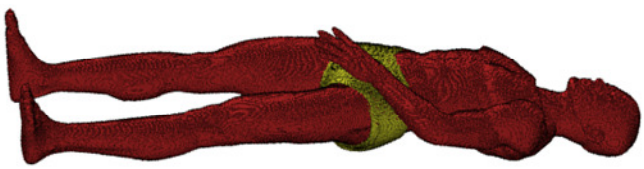


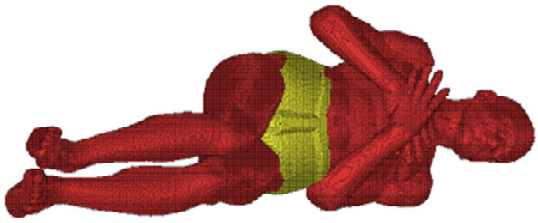
Fig. 3 Position of the antenna.

Figure 4 presents the human body wears the paper diaper with the proposed antenna in different poses. Pose 1 is dorsal position, Pose 2 is dorsal position with the hand near the RFID tag and Pose 3 is decubitus position. The thickness of the diaper is 6 mm and the antenna embedment depth is 3 mm. In our calculation model, the reflection coefficients and radiation patterns of the antenna in dry and wet are analyzed. In calculation, the wet diaper is defined by changing the electrical properties of a part of dry diaper to that of wet one. The electrical properties of human body, paper diaper in dry and wet are listed in Table 1. In our research, 2/3 muscle-equivalent phantom is used on the human model in order to measure. The electrical properties of the proposed phantom of 950 MHz were found to be ε_r=36.6, σ=0.64 S/m [3]. It is common for evaluation purposes that the averaged electric constant of the human body is 2/3 of the muscles [4]. In addition, the measured relative permittivity and conductivity of the paper diaper on dry and wet are measured by network analyzer. The measuring instrument is an HP-85070B dielectric-probe measurement system (Agilent Technology Company, Palo Alto, CA). The characteristics of the antenna were calculated by Finite-Difference Time-Domain (FDTD) method.

(a) pose 1.



(b) pose 2.



(c) pose 3.

Fig. 4 Numerical human models in different poses.

Table 1 Electrical property of human model and paper diaper

	Relative permittivity	Conductivity[S/m]
Human (2/3 muscle)	36.6	0.64
Paper diaper (dry)	1.3	0.01
Paper diaper (wet)	61.4	1.54

3. Calculated Results

Figure 5 shows the reflection coefficients of the proposed antenna embedded into the paper diaper model in Fig. 4 (a). These results are standardized by the impedance of the IC chip. The operated frequency of the proposed antenna is 950 MHz in the paper diaper. From these results, the proposed antenna has a good impedance matching with IC chip at 950 MHz when the diaper is dry. In contract, when paper diaper is wet, the proposed antenna has poor impedance matching at 950 MHz. In addition, the reflection coefficients are good agreement regardless of posing.

Figure 6 shows the calculated radiation patterns with different poses in dry and wet paper diapers. From the results, the proposed antenna has higher direction gain in the dry paper diaper. In addition, the pose of the human body also affects the shape of the radiation patterns. From these results, it could be possible to detect urination because the influence from the urination is more than that from the poses.

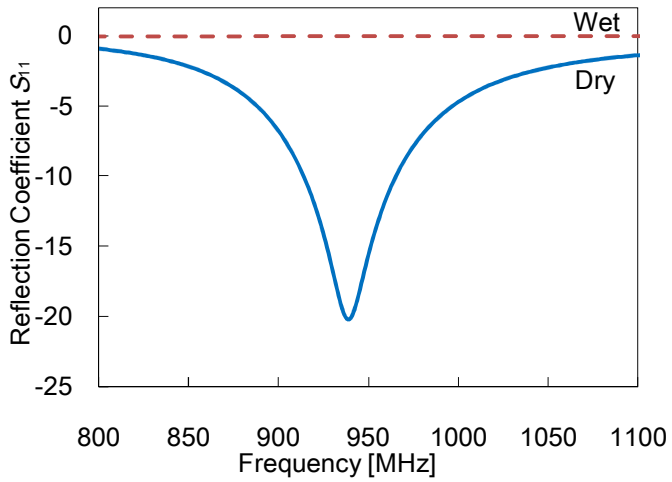
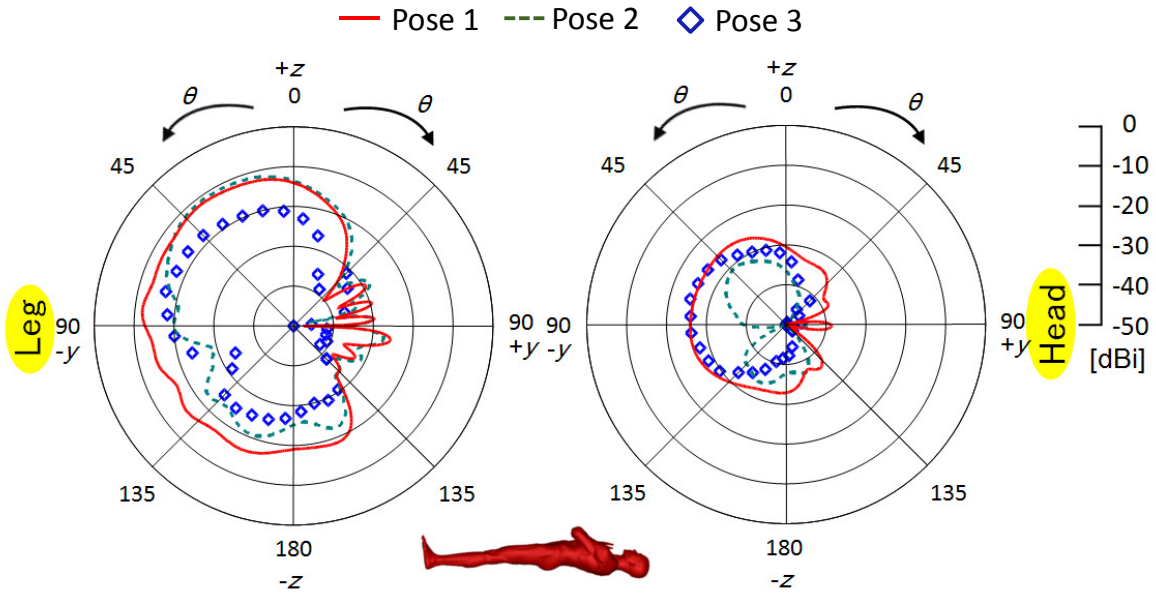


Fig. 5 Reflection coefficient.



(a) Dry diaper. (b) Wet diaper.

Fig. 6 Radiation patterns.

4. Conclusion

An RFID tag antenna with meander and loop structures for detecting urination system is studied in this paper. The impedance of this antenna is also designed to match the IC chip. In our study, we discussed the characteristics of the proposed antenna embedded into each dry and wet diaper. In addition, we also analyzed the radiation patterns in different poses. From the results, the proposed antenna has good impedance matching in dry diaper. Hence, the influence from the urination is bigger than that from the poses, so that it could be possible to detect urination by change of the antenna characteristics regardless of their poses.

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