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A Warning System Based on the RFID Technology for Running-Out of Injection Fluid

Chi-Fang Huang and Jen-Hung Lin

***Abstract*— For providing an automatic warning system of running-out of injection fluid, RFID technology is applied in this work to propose an infrastructure with low cost to help nurses and patient's company. Specially, a RFID tag is designed and attached on a bag of intravenous drip to demonstrate the benefits in the present system. The main idea of this system is that, tag is disabled when the bag is not empty because of the EM loading due to the liquid contained. The bag can be any kind in the current market and be without any electronic attachment or modification. LAN (Local Area Network) is also applied as a part of this infrastructure for data transmission.**

***Keywords*— RFID, Tag antenna, RFID reader, intravenous drip LAN (Local Area Network)**

I. Introduction

INTRAVENOUS drip is a normal means in treating patents as a slow injection process of medial fluid. Usually, when the fluid inside the drip bag is about to run out, the nurses can be aware of the situation only either by themselves going to wards to check from time to time, or by the requesting signal from the patient's company by the bed. Such a kind of checking procedure is resulted in frequent interruption of nurses' tasks and in increase of personnel cost. Consequently, recently, the need of automatically monitoring the running-out of intravenous drip has caused much attention for developing workable systems [1]-[2]. Among these developed systems, either a functionally dedicated bag of the injection fluid or a special circuitry connection between the bag and monitoring electronic equipment is needed. One way or the other, they are of higher complexity in hardware and higher cost system wise.

Since its invention after World War II, RFID (Radio Frequency IDentification) [3] has been applied in diverse areas which are more related to people routine life other than the scientific and industrial purpose. RFID tags play an important role when they are attached on objects to be identified with a wireless manner.

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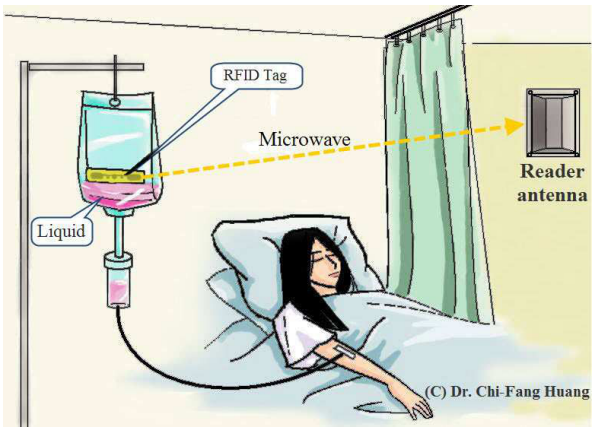


Fig. 1 The proposed system by RFID technology

The tags are classified into two sorts, namely, passive and active ones depending on using battery or not. The former is that designed and used in the present system.

There is a "drawback" being associated with the RFID tags, especially those in UHF and microwave bands, that is, they are quite easy affected by the electromagnetically lossy objects. When a tag is attached on or near by such a kind of materials, for example, bottles containing liquid, metals and fruits, etc., it will be not able to echo the RF signal from the RFID reader. In this work, this "weakness" is turned to be a design feature being a triggering mechanism when constructing an intravenous drip monitoring system.

The idea of this work is to attach a RFID tag on the bag of intravenous trip, referring to Fig. 1. Specially, the tag is on the lowest position of the bag which is made of plastic or rubber materials. When the fluid is full or is not about empty, the tag is disabled to respond to the distant RFID reader. However, when the fluid level inside the bag is below the tag, then the tag works normally again and echoes to the reader to signal an empty status.

A procedure of designing a RFID tag by considering the material parameters of the bag of intravenous trip is described in the following text. In this work, the prototype of tag is designed based on the concept of complex conjugated match in between the chip on RFID tag and the associated antenna, and is fabricated on a PCB. Such a design offers a low-cost solution of RFID tags which are supposed to be used in a mass volume when the present monitoring system is installed in

hospitals widely. Furthermore, these tags are even recyclable and environment-friendly to the hospital circumstances.

II. System Structure

Referring to Fig. 2, which is the whole system structure of the present design in terms of signal control. In a ward, there are possibly several intravenous drips working for more than one bed, and a RFID reader with a single one or multiple antenna serves to communicate with these tags on bags. Through the middleware [4], the controller (or control PC) takes the data from tags in the room to communicate with the PC in nursing station through the network either by a wire or a wireless way. Of course, the PC at nursing station can further communicate with the hospital data center.

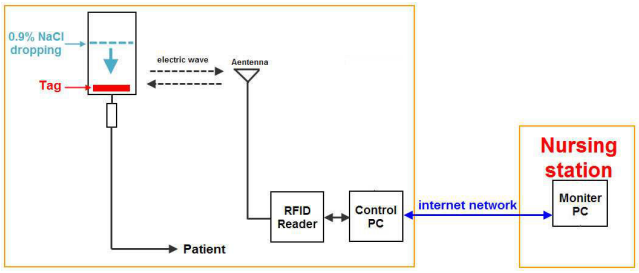


Fig. 2 system structure of the present design

When the nurse takes a new bag at the station, she can register it to have an update of the stock database in hospital. The system will "know" that this new bag will be used by which patent bed. It is worth to mention that, the used bags can be of general types in current market without specially being designed and manufactured for this system, and the tag can be attached at the hospital.

III. Tag Design

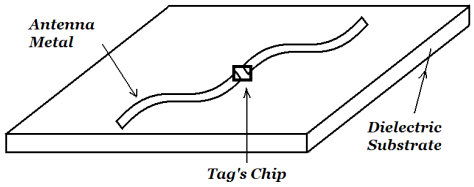


Fig. 3 The general structure of a RFID tag [5]

Referring to the illustration in Fig. 3, a RFID tag is composted of a chip and tag antenna [5]. In design phase, the input impedance both of chip and antenna should follow the concept of complex conjugated matching for optimal transfer efficiency [6]. Currently, most of the tags used in the industry are with the form of planar dipole, and are manufactured by the PCB technology. However, recently the introduction of printing technology [7] into the tag production has caused much attention because of the consideration of low cost.

The electromagnetic simulation tool CST [8] is employed in this work, and Fig. 4 shows the simulation model. For the purpose of making a complete modeling for tag simulation, both of bag (PVC) and liquid materials are taken into account in addition to the tag itself. The tag is attached near the bottom of the bag.

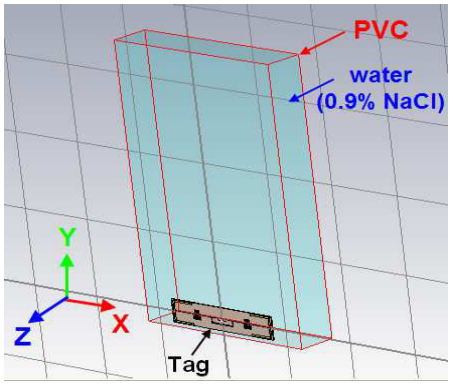
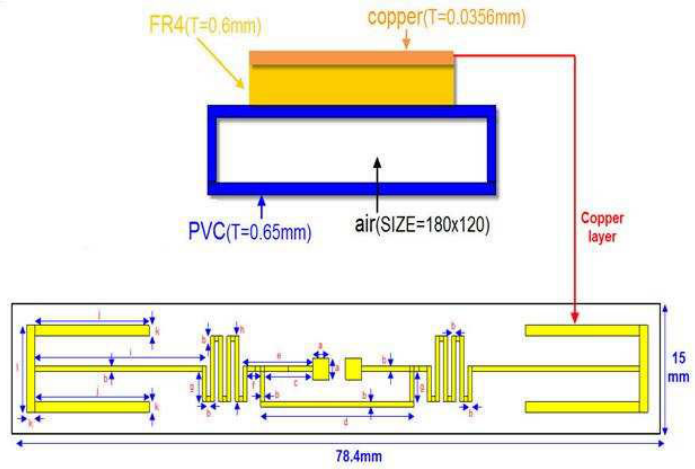


Fig. 4 CST simulation model including bag, liquid and the tag itself



a	b	c	d	e	f	g	h	i	j	k
2	0.5	5	17	14.5	9	2.75	6	15	14	1

單位：mm

Fig. 5 The structural and dimensional details of designed tag

The Fig. 5 shows the structural and dimensional details of the designed tag, and all numbers are in unit of mm. It is worth to note that, in terms of the structure of tag in simulation model, the tag itself is made of a PCB, yet which is on a PVC bag model. That means the effect due to the bag's material and structure on the tag antenna's performance has been considered in the simulation work before realization. As mentioned above, the tag antenna designed in this work is still a dipole-like one which even looks a little complex in shape.

In simulation, Fig. 6 shows the current distribution on the antenna, and shows also that this antenna is workable for a RFID tag.

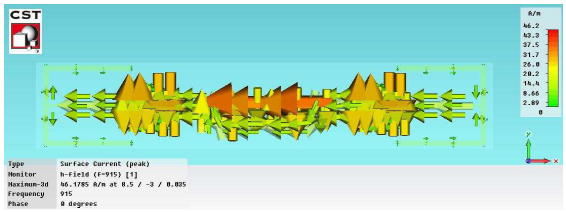


Fig. 6 Current distribution on the tag antenna

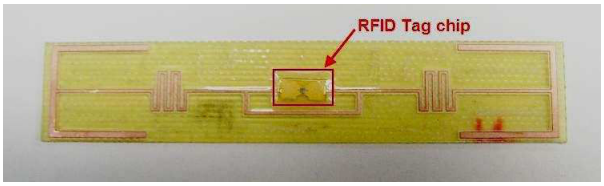


Fig. 7 The realized tag

The Fig. 7 shows the realized passive tag which is fabricated on a PCB and is with a chip IC. This tag is further attached on a bag of intravenous trip as shown in Fig. 8 to function as a triggering device in this aimed system. It is worth to note that the tag's performance has been optimized by considering the material effect of bag in design phase.

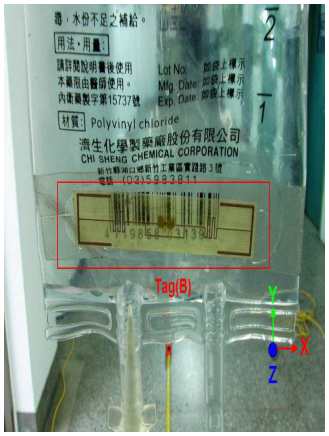


Fig. 8 The designed tag is attached on a bag of intravenous trip

IV. System Test

To have a functional test for the whole system as shown in the Fig. 2, a real system is implemented as shown in the Fig. 9 in which, a bag with a tag designed in this work for intravenous trip is hung on a stand and a RFID reader with antenna is apart from it. The control PC functions as the RFID reader in which the associated middleware is included. "Monitor PC" plays the role of the terminal at the nurse station waiting for the messages from wards. In between the control PC and Monitor PC, the LAN is employed, that is supposed to have been widely deployed in the current hospitals.

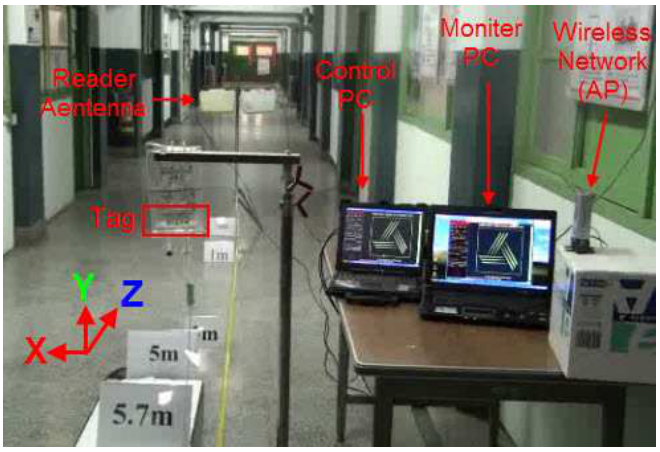


Fig. 9 A test system for evaluating the present RFID infrastructure as an automatic warning system of running-out of injection fluid

Consequently, the effort of implementation for the proposed system is not paid much, only the reader with antennas is necessary to be installed in each ward. By the way, one single RFID reader can serve for several, say, three beds, in a ward. On the other hand, the reader's performance can be enhanced by using multiple antennas based on the diversity technique [9]. When the work for a nurse to attach a RFID tag on a new bag is carried, a registration will be done, and the bag stock is to be updated simultaneously. This is a very important feature of this infrastructure.

In the test in Fig. 9, the reading distance of evaluation can be up to 5.7m, which is practical enough inside a ward, not mentioning the potential implementation with multiple antennas for a larger space. The communication in between the monitor PC and control PC is working well too.

V. Conclusion

This paper has demonstrated results of a warning system of running-out of intravenous drip in hospitals. RFID technology is adopted as a means of triggering device of the whole system. A RFID tag is designed and fabricated as a demonstration, and the tag can be attached on any kinds of bag of intravenous drip in market. The main theory of this system is that, when the bag is not empty the tag is disabled because of the liquid loading to the tag antenna; however, the tag is to work again normally when the bag is about empty. The warning signal is sent to the nurse by the RFID reader in that ward.

The access function of RFID of this system in one ward can be a part of stock control system of bag of intravenous drip in a hospital through the LAN facility. System test is also presented as well in this paper.

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