A Smart Shelf, An Efficient Object Identification System By Blinking LED With Batteryless Passive Low Frequency RFID Tag

Wireless charging to a passive RFID tag for making it active

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***Abstract*— A smart shelf is an object identification system that uses Radio Frequency Identification (RFID) and LED indicators to quickly locate a specific object. The RFID is a powerful technology, which is vastly used for object identification. However, this system comes with challenges such as noise, interference from collocated RFID modules and higher power consumption for the passive RFID. This paper describes a system that uses an RFID module to harvest energy from an incoming radio signal both to power the circuitry in order to identify the object and to power an indicator LED. Also it describes how interferences between collocated tags can be minimized through the innovative use of aluminum and magnetic shielding.**

Keywords-Smart Shelf; passive RFID; transponder; wireless charging

I. INTRODUCTION

The object identification is a widely used concept in user oriented and ubiquitous networking system. Almost all those systems use ID, password or biometric data for human identification to deliver personal information or accessing restricted data. These systems are useful for different kinds of applications where unavoidable gap is presented between the physical objects and its virtual world such as asset tracking, automated inventory etc. An object identification system makes a seamless connection between a physical object and its virtual world.

An object identification system faces challenge if multiple objects are present at the same time. There are many identification techniques are available [1] – [9] with some limitations. For example, a barcode is a widely used object identification technique. However, a line of sight between the reader device and the tag is required to read a barcode, however, it often does not work without human intervention. Presently the RFID tags are also being used widely for an object identification, which has an active tag using battery and it consumes high power and moreover it is an expensive system and not ecological.

In this paper I am proposing a new RFID object identification system, which has the following advantages: a)It is battery less, b) A LED indicating identification, c) It can identify multiple objects at the same time, d) An automated inventorying by the response of the tags, e) As there is no battery, LED ON/blink time is not limited, f) Cheaper than other available RFID object identification systems available at present g) It come with an easy and simple installation system, h) It consumes low power, i) It is ecological , j) ID can be written on the tags more than 1 Million times.

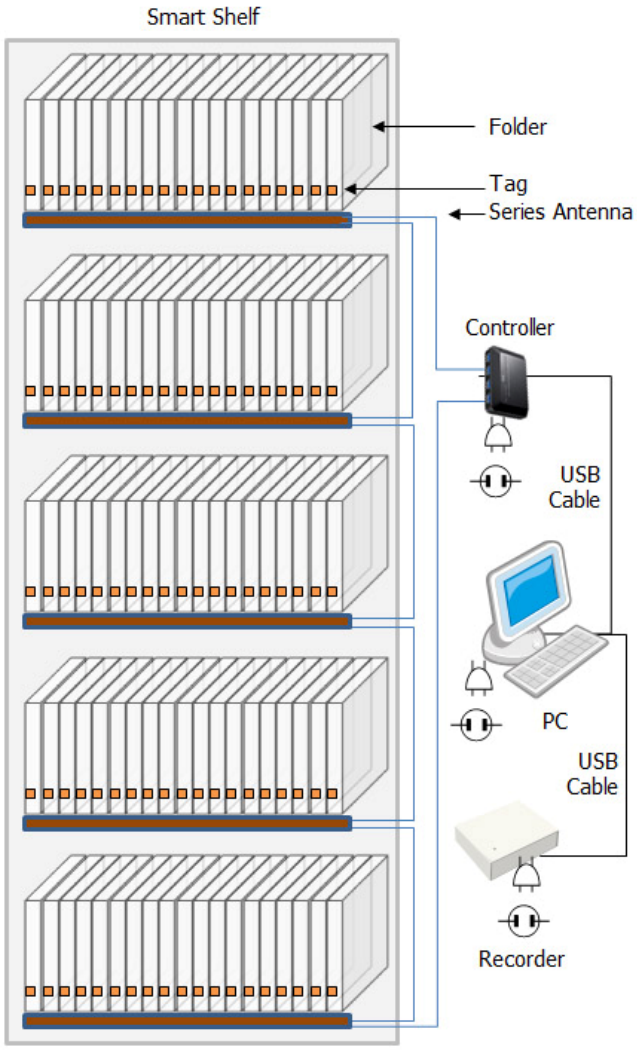

Figure 1. Image of a Smart Shelf with Series Antennas

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II. SYSTEM'S DESCRIPTION

Figure 1 shows an image of the Smart Shelf.
Essential parts:

1. PC
   A computer is used to store a database for the object. A computer application is used to control the Smart Shelf system by using the database that is available in the computer.
2. Smart Shelf
   In Figure 1, only one Smart Shelf is shown, though a dozen of Smart Shelf can be added to a single computer depending on the total numbers of objects in the system. A Smart Shelf which is a size of 2100mm height × 900mm width × 450mm depth, contains six racks having the capacity of storing about 650 folders. Each folder contains a RFID tag with a LED. The racks are connected with a series of antennas, controlled by a single Controller.
3. Controller
   The controller is a set of Texas Instruments' RF Module and Control Module. The Control Module receives the command from computer and converts the command in order to send it to the tags via the RF Module wirelessly.
4. Tag
   Every folder of this system contains a RFID tag. A schematic diagram of RFID tag is shown in Figure 2. The tag contains mainly a RF chip, a transponder coil, a microprocessor (CPU) and a LED. Size of a tag is 20mm × 30mm × 4mm, and an aluminum sheet and a magnetic sheet are attached on the tag to avoid effect of collocated tags.

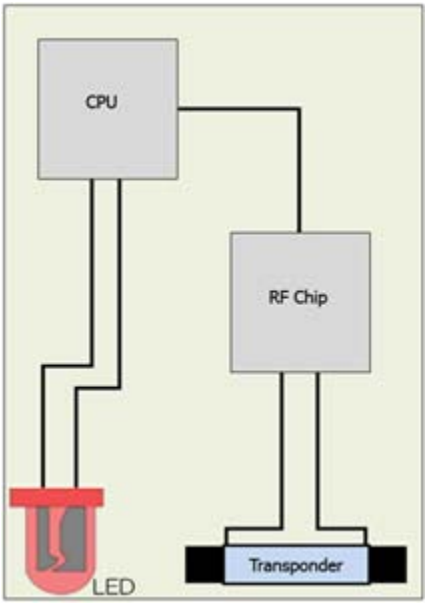

Figure 2. Schematic Diagram of a RFID Tag

5. Recorder
   Recorder is used to write tag's self ID on the RFID tag's EEPROM. A 5 digit ID from 00001 to 99999 can be chosen and written easily. Duplicate ID writing is prohibited by the application.

III. COMMANDS COMMUNICATIONS

Different types of commands are passed wirelessly between the PC and RFID tags.

A. Wireless Charging Command

The tags are battery less, but each tag contains a microprocessor (CPU) and a LED. Since the tag is battery less, an alternate power source is needed to turn ON the CPU and to ON the LED. Wireless charging command is being sent from a computer with this system, which is received by the tag with transponder coil. The receiving wave signal is converted into power (DC Voltage) by RF chip [10], and stored in a couple of capacitors.

B. ID Registration / Writing Command

The RF chip of the tag contains an EEPROM to store self ID. This object identification system uses 5 digits ID. As a result, at most 99,999 objects can be used in this system. An object registration command with an ID is sent from the computer by the Recorder (see Figure 1). For ID registration, a single tag is put on the recorder. The RF chip receives the command via transponder and writes the ID on an EEPROM. ID can be written more than 1 Million times on a single tag. So, a tag can be used several years using same ID or different ID.

C. Object Search Command

An object search command is sent from PC to tags including an ID. The tag of a sending ID blinks if it is available on the Smart Shelf system.

IV. IDENTIFYING TECHNIQUES

A broadcasting technique is used to identify a specific tag. In this process, the collocated tags affect the performances of the wireless communication. An innovative use of aluminum and magnetic shielding can minimize the interference between collocated tags. Moreover, wireless communication is working at a low frequency of 134.2 kHz, which is reduced by environmental noise. Both the antennas of the controller and the tags are kept close to each other to avoid the effect of noise.

A. Tag Identifying

To identify an object on the system, an object identifying command including an ID is broadcasting to all the racks of the Smart Shelf connecting with the system. Every single tag that is presented on the racks will receive the command and process. Individual tag will compare the receiving tag ID with its self-ID stored on the EEPROM. If the receiving tag ID is equal to the stored self-ID, then only that tag will response back to the PC via the Controller. The tag also ON/blinks the LED connected with it. All other tags whose stored ID is not same with the receiving ID, will not take any action.

B. *Effects of Collocated Tags*

As many tags are kept in a line on the racks of a Smart Shelf, radio wave will be contaminated by the wave propagating from collocated tags. Figure 3 shows an image of contaminated wave propagation. An aluminum sheet and a magnetic sheet are attached to every RFID tag which work as a shield to prevent wave contamination between collocated tags. Figure 4 shows an image of wave shielding to prevent wave contamination.

C. *Effects of Noise*

This system uses a low frequency at 134.2 kHz for wireless communication. Transmitting data signal is very weak and sensitive to environmental noise and other propagated waves near the system. As a result, there is a possibility that data can be changed during the time of transmission. To avoid this super-imposing noise, the tags are kept closely to the controller antennas. Figure 5 shows an image of shielded tags on controller antenna.

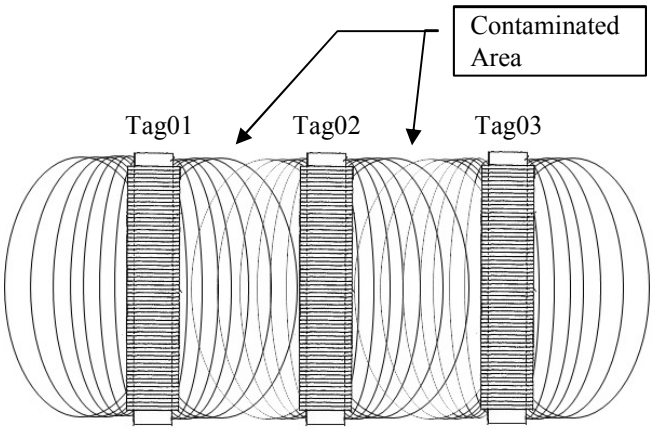

Figure 3: Wave contaminated by neighboring tags

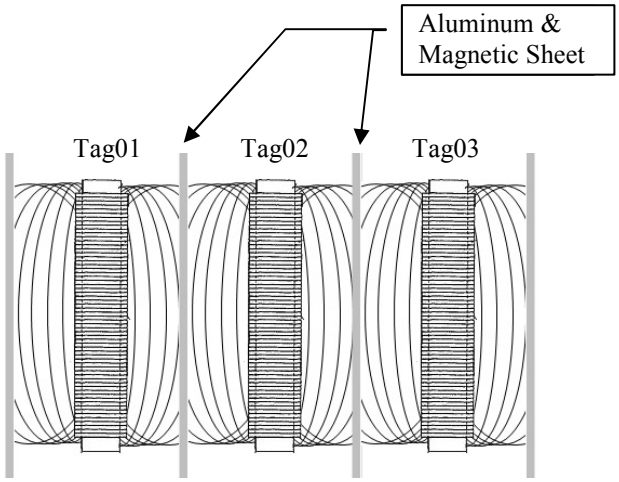

Figure 4: Wave contamination is protecting by aluminum sheet and magnetic sheet

V. APPLICATIONS

This Smart Shelf system is widely used where hundreds of folders are kept tighter, like the folders of patients in a hospital or the folders of students in a car driving school. In a hospital, hundreds of folders which are used to keep patient's information are kept together in a shelf. When an existing patient comes to a hospital, the hospital authority needs to find the patient's folder which has patient's information on it. If hospital needs to do it manually, it will be a time consuming and boring task. However, in this situation, if the hospital uses the Smart Shelf system, the authority only has to use the system to read the patient's ID from the patient's card. The system automatically sends a tag identifying command from the computer using the patient's ID. The folder can be indicated by the LED ON/blinking. This can save valuable time for both the patient and the hospital authority and make the overall identification much faster and efficient. Similar way, the Smart Shelf system can be used in a Post Office for letters or parcel tracing, in an office for folder tracing, in a driving school for students' folder tracing and so on. Figure 6 shows a set of pictures of the Smart Shelf system. Price of the system is about JPY 2,200,000 (about AUD 25,000), which includes 1 PC with tag search application and database, 1 Smart Shelf, 650 Folders, 650 Tags, 1 Recorder, 1 Controller, a series of 6 antennas and 1 card reader. Transportation, settings and other costs related to it are not included on the above price.

VI. CONCLUSION

This paper describes an efficient, cheap, easy and ecologically acclaimed application of RFID object identification. A simple effective technique to prevent propagated wave contamination between tags is also described in this paper. The proper use of this application of RFID technique in the right environment will make object identification tasks easier for various types of users.

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http://www.ti.com/lit/ds/swrs083a/swrs083a.pdf

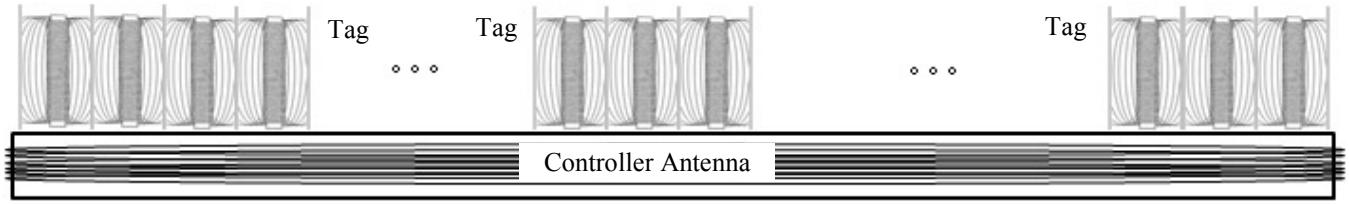

Figure 5: Tags on controller antenna

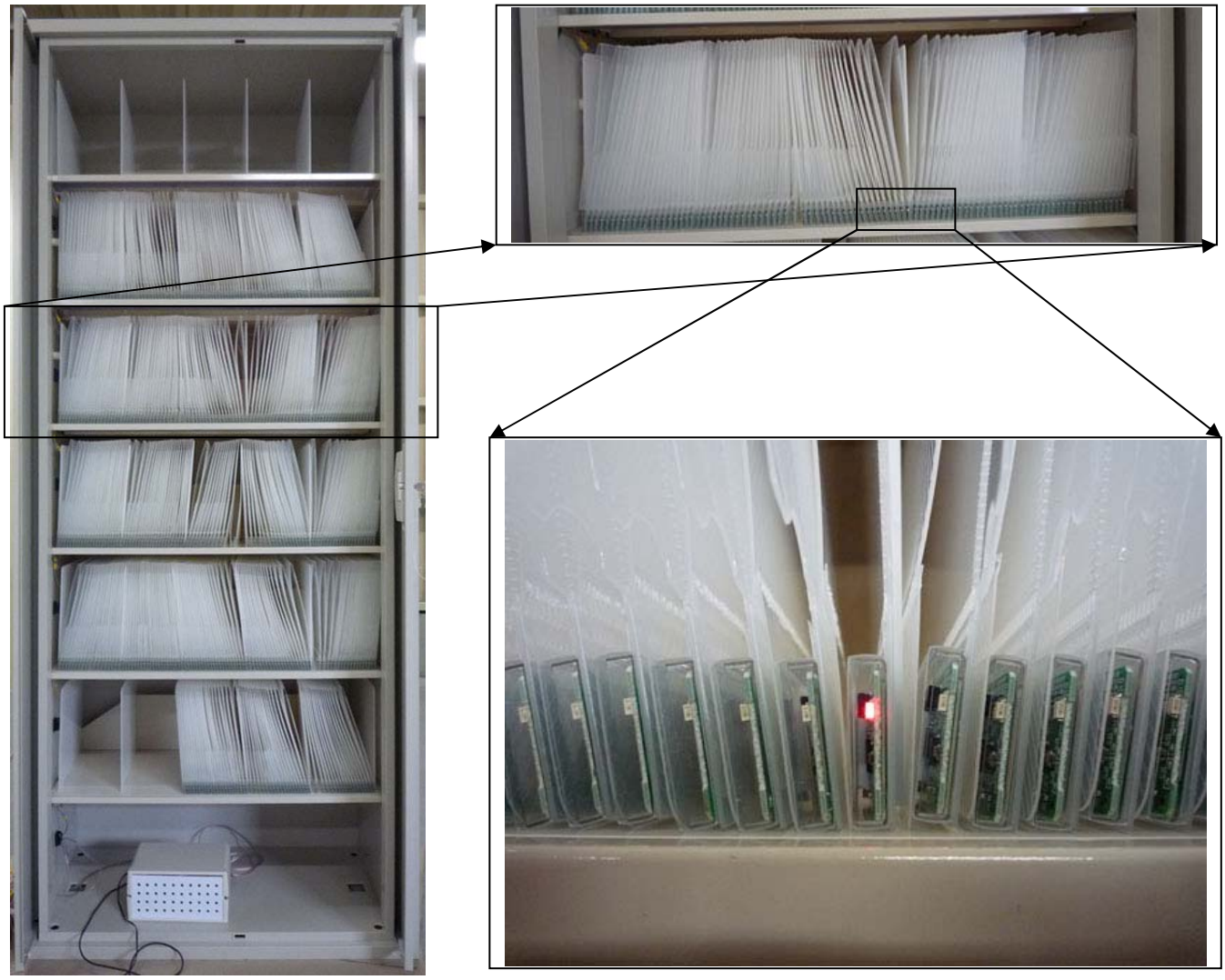

Figure 6: Pictures of a Smart Shelf System