Manufacturing Feasibility Evaluation of RFID chips embedded in Artificial Organs

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Abstract - Advances in medical technology rely heavily on the collection and analysis of measured data to facilitate patient diagnosis and business decisions. The healthcare industry, particularly pharmaceuticals and diagnostic processes, has an ongoing need to improve item tracking and data collection to improve the quality of care while reducing cost. This paper primarily focuses on integrating Radio Frequency Identification (RFID) inside of artificial organs to provide doctors and nurses a better synopsis of the embedded organ. The remote, non-invasive characteristics of RFID can facilitate the information needs of healthcare without imposing additional burden onto the patient or staff. Properly deployed RFID enabled devices is envisioned to provide convenient and accurate data for artificial organs conditions, and critical information that may be necessary for medical specialist to better serve patients with these organs. This paper describes an all-encompassing RFID tracking system that begins with compliance documentation from implementation duration of the patient's life. This RFID system can provide data for decision-making and facilitate compliance with FDA imposed e-pedigree requirements. This transcript introduces healthcare trends in order to motivate the need for a biocompatible RFID system. The overall goal of the pending research is to develop biocompatible RFID tag components for use with systems implemented inside artificial organs and continued through the duration of the device as mentioned above. It is envisioned that successful implementation of this technology could improve life expectancy of patients with artificial organs by ten percent.

Index Terms – Micro manufacturing, Micro RFID tags, Feasibility, Artificial Organ

I. Introduction

Radio Frequency Identification (RFID) technology has the ability to operate without the restrictions of line of sight. RFID systems are very popular and useful tools in manufacturing, supply chain management, and inventory control. RFID systems consist of two main components, the radio frequency tags (transponders), and the Radio Frequency (RF) reader (transceivers). The RFID tag reader interrogates the tag providing information, which is stored on the digital memory chip, which contains detailed descriptions such as location, price, color, date, and age by beaconing a specific RF signal. The RF tags responds to this signal by transmitting back a unique serial number or electronic product code. RFID tags have numerous advantages such as; reasonable data storage capacity, Read/Write/Rewrite capability, ability to operation in harsh environments, and high scan rates. Since RFID tags are equipped with microchips embedded inside of them, their functionality can range from integrated sensors, to read/write storage, to supporting encryption and access control.

RFID memory chip can provide a channel to communicate with the staff, which cannot be accessed after implanting a RFID tag. After the artificial organ is embedded in the living body, the activities and condition of the embedded artificial organ is critical for the life of the patient. For this reason, the functionalities and condition of the artificial organ has much interest by researchers and doctors. The utilization of RFID system embedded inside artificial organ presents an effectual and feasible solution.

From a current publication by Jones et al he describes the advantages and limitations of utilizing RFID technology to track pharmaceutical drug. He beginning from the manufacture lot and continues through distribution to the point of interest within the patient's body. Jones et al also demonstrates medical tracking strategies for patients, staff members, equipment, and information that could be implemented to increase the efficiency of health care, as well as facilitate better patient outcomes. Studies have been performed to demonstrate the opportunity for resource utilization and efficiency increases when equipment location is facilitated with an RFID system [1]. Sangwan [2] proposes an RFID system for patients, charts, and equipment location within a multi-level hospital setting. This system includes an alert system to notify staff members when a tracked item is removed from defined boundaries. Cypack has embedded RFID chips into pharmaceutical packaging to track patient compliance by monitoring when the package is opened, but has not integrated it into the actual medication [3]. For surgical procedures, RFID tags have been tested for tracking and tracing surgical sponges in order to eliminate errors due to manual counting at the completion of a procedure [4]. It is envisioned that the same concept and technology can be utilized to address the concept of integrating RFID technology in artificial organs. The overall goal of the pending research is to utilize the same

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concepts addressed above which has the ability to lead to the development of a biocompatible RFID tag for use, beginning with the manufacturer and continuing through distribution to the point of interest within the patient's body.

In Choi's et al research [5], a RFID tag system was created to store biological information by body signal detection. The main block diagram of the proposed RFID tag system is shown below in Fig. 1.

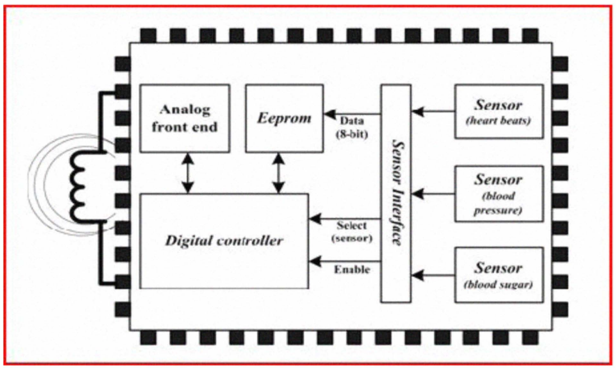

Fig. 1 Block Diagram of the RFID tag system.[5]

Figure.1 above displays an integrated circuitry tag chip which is composed of a seven block system consisting of: analog front end, digital controller, Electrical Erasable Programmable Read-Only Memory abbreviated as (EEPROM), heart beat sensor sensor interface, blood pressure sensor, and blood sugar sensor. The tag has the ability to detect vital information pertaining to heartbeats, blood pressure and blood sugar levels by the way of sensors. Once captured the information is stored inside an embedded memory component. From this point the information can be transmitted from the tag to the reader. There are two critical components that the RFID tag builds upon; these components are known as the data transaction block and sensor interfaces. The data transaction circuitry which specifically describes an event contains a command interpreter, error detection and collision avoidance circuits, while the sensor interface comprises resistance deviation-to-pulse width converter and interface circuit. The command interpreter application confines stored data inside the flash memory; the error detection has the ability to recognize transmission errors during the activity of data exchange between the RFID reader and the tags; the collision avoidance circuitry application is to reduce the chance of data shortages when the tags are in the process transmitting a Unique Item Identifier (UID) to a reader at the same time. The resistance deviation-to-pulse width converter in the sensor interface has the ability to detect minor resistance change of the resistive sensors having a high fixed offset resistance, while the sensor interface circuit with RFID tag is to transfer generated Pulse Width Modulation (PWM) signals to the RFID tag system.

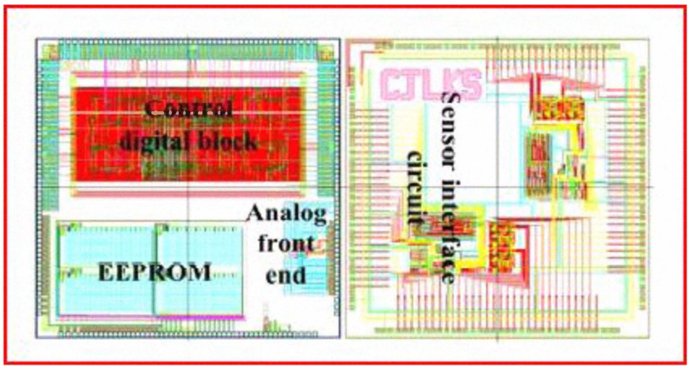

Fig. 2 Integrated Circuit chip layout (4.5mm x 4.5mm).[5]

After implementation, it was proved that the novel RFID tag system with sensors can detect and store vital information such as blood pressure and body temperature. In addition, the novel tag can be expanded to obtain other bio-information by adding more sensors. The layout of an integrated RFID tag chip and its size is shown in Fig. 2. The size of this type of chips is 4.5mm x 4.5mm using Hynix 0.18-µm CMOS and the size is regular and normal.

The RFID systems utilized in the embedded artificial organ must be small enough to be ignored by the living body except storing the bio-information. As lectured by Hitachi, micro RFID tag (wireless tag) IC measuring only 0.05 x 0.05 x 0.005mm was achieved in 2007. [6] The IC was manufactured using 90-nm CMOS technology using Silicon on Insulator (SOI) substrates. The size of CMOS used in Hitachi micro RFID tag IC is as small as 1/2 in Choi's research, and the size of tag IC is much smaller than Choi's. Hitachi super micro RFID tag IC features a three-layer metal wiring layer and a 21 x 32µm memory chip capable of recording 128-bit data, but the antenna is separated with the tag IC and maximum communication range with the reader is 300mm.

II. Methods

This paper discusses biocompatible concerns such as how a micro-RFID system can be designed and incorporated into an artificial organ to provide critical information of the device. This paper also discuss concerns such as how RFID technology integrated into a artificial organ can provide accurate information for doctors and nurses assisting patients in critical need or regular checkups to make sure the device is operating correctly.

Reducing the size of the RFID tag and antenna by using micro-manufacturing technology and providing a cost effective manufacturing process will be a feasible solution for reducing the cost and increasing the performance. Some researchers believe that manufacturing of electrostatic devices such as antennas may not be prudent a levels of 40 nano-meters and below because serious miniaturization problems may be expected in the next six to ten years [7]. The testing and design at the proposed 100 micron meter level is cost effective and prudent level to test RFID technologies.

The long-term research objective is to design a reliable RFID system that can be manufactured at the micro scale level to provide better performance and feasibility to be integrated inside artificial organs. The research objective is to test and evaluate the manufacturing design of antennas for RFID tags at the micro scale level. These effects can be evaluated after testing of antennas designed from micro manufactured process such as Electro Discharge Machining (EDM).

III. Discussion And Conclusion

By literature research, the design of RFID system for detecting and storing biological information and micro RFID tag IC have been developed by predecessors. The concept of using RFID tags implanted in the artificial organ to detect and store biological information and the organ's description is feasible, which can make the jobs and task of doctors easier when assisting a patient as well to check for any internal abnormal conditions.

The best design for micro RFID system is to make the tag and antenna together as one single-cell to reduce its size, and the micro manufacturing needs to be utilized in the process. This research intends to meet the proposed objectives by completing the following specific objectives:

Specific Objective #1: Evaluate manufacturing processes that reduce RFID passive tag size. Incorporate a new antenna design to reduce the size of the tag without sacrificing the performances. These tags can be utilized for tagging individual items at the item level and in the future to promote less obtrusive tagging in small items such as microprocessors

Specific Objective #2: Evaluate processes that reduce RFID passive tag cost. Develop a manufacturing methodology to make the RFID tags at reduced cost. This development process will identify the manufacturing issues of the new antenna designed from Specific Objective #1 and select a set of efficient manufacturing techniques and the process sequence.

Specific Objective #3: Evaluate and test Micro-RFID chip. Manufacture a Radio Frequency Identification (RFID) chip imbedded in artificial organs to provide doctors and nurses critical information to better serve patients. A unique chip that has the correct polarization, and tag reflection is novel for an integrated RFID chip. The goal is to develop a chip that supports this critical information.

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