

Design of the RFID for Storage of Biological Information

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ABSTRACT

Recent advances in RFID (radio frequency identification) technology promises to create a wireless circuitry capable of interfacing with biological systems for acquisition, identification and processing of biological data based on radio frequency interaction. Thus, the RFID tag can be attached not only to consumer products and form part of the supply chain, but also to animals, plants and in particular human body. This paper describes the strategy for the design of a novel RFID tag, which stores vital biological information such as body temperature and blood pressure and heartbeat in accordance with the EPC global Class-1 standard. Biological data is obtained from a sensor technology that is based on resistance deviation-to-pulse width converter. The integrated chip consists of an analog front end, command interpreter, collision avoidance block, data storage, sensors, and interface circuitry. The system is capable of supporting heartbeats in the range of 40~200 beats per a minute and blood pressure 0~300mmHg. The proposed system employs collision free algorithm that supports access to single tag within a multiple tag environment. The approach facilitates intelligent management of patients in hospitals as part of an integrated healthcare management system.

Keywords: RFID, collision avoidance, error detection, sensor, tag, healthcare

1. INTRODUCTION

The generic form of RFID system consists of a reader and multiplicity of tags. There are two approaches in implementation of tags. The first entail an active tag where a battery is utilized to power the circuitry. The second utilizes a passive tag whereby power for the circuitry is derived from external sources either through magnetic interaction such as near field coupling or by the way of frequency conversion. Passive tags receive both information and operating energy from the reader through the allocated 13.56 MHz band reserved for commercial service.

RFID can be used in a variety of real-time applications for data storage and communication of biological information within it to the digital block. The RF signal includes energy for internal power, reset signal to initialize circuit, clock signal to operate control logic, and data that are transmitted to the digital controller. The controller returns UID to the reader and obtains

ubiquitous sensor networks. A particular application environment is for control and identification and administration of correct quantity of drugs in the health industry whereby accidental drug usage and incorrect administration of drugs and medication can be avoided. The technology is capable of preventing medical accidents in the health industry and in case of an emergency an effective and rapid interaction between patient/medical practitioners become possible through critical medical data transmission.

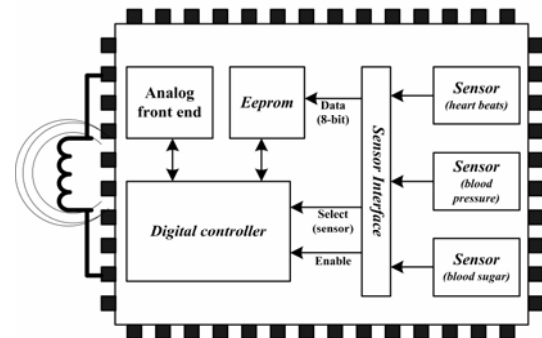


Fig. 1 Block diagram of the RFID tag system

This paper is organized as follows: In Section 2, the proposed architecture for the RFID tag system is introduced. Section 3, discusses the approach in the design of data transaction and sensor interface circuit and presents the detailed design of RFID system. Section 4 presents the implemented results. Finally, Section 5 provides the conclusion.

2. RFID SYSTEM

The block diagram of the proposed RFID tag system for body signal detection is shown in Fig. 1. The integrated circuit tag chip is composed of seven blocks: analog front end, digital controller, EEPROM, sensor interface, heart beats sensor, blood pressure sensor, and blood sugar sensor. The RFID tag is aimed at to monitor vital information heartbeats, blood pressure, and blood sugar and to store them into an embedded memory. The tag obtains RF signal from antenna and transfers

data from blood pressure and blood sugar sensors. Personal vital information stored in the memory can be checked in real-time through this non-invasive approach.

3. DESIGN OF RFID TAG

The RFID tag is divided into data transaction block and sensor interfaces. The data transaction circuit contains a command interpreter, error detection, and collision avoidance circuits. The sensor interface comprises resistance deviation-to-pulse width converter and interface circuit with the RFID tag.

3.1 Data transaction

The digital controller shown in Fig. 2 handles data to communicate with the reader and the sensors. It consists of a channel decoder, a command decoder, a CRC/Parity checker and generator, data encoder, and state sequencer. The essential functions preferred by this circuit are data transfer to the embedded memory, error detection, and collision avoidance.

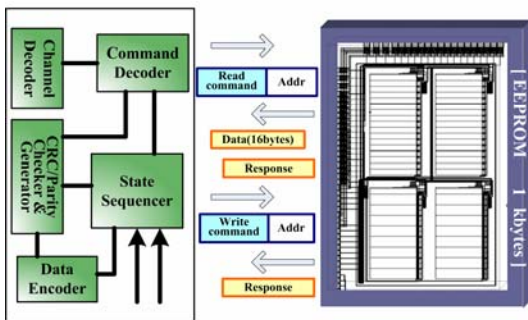


Fig. 2 Operation concept of the digital controller

Command interpreter

The decoder interprets the commands that controls stored data in the flash memory. The state sequencer transfers multiple data from vital sensors to the memory. The RFID tag is operated in five states: idle state, ready-1 state, ready2 state, active state, and halt state. The operation sequence is shown in Fig. 3.

All the commands REQA, WUPA, Anti-collision cascade-1, Select cascade-1, Anti-collision cascade-2, Select cascade-2, Read, Write, and Halt are based on ISO 14443A standard. The command format consists of start bit, end bit, data, and parity bits for each byte, 16-bit CRC per block, and bit count that checks for UID.

After Power on Reset (POR), the RFID chip enters into the Idle state. The chip can be left with either a REQA command or a WUPA command in the Idle state. If the chip receives any other commands, it remains in the Idle state waiting for arrival of other signals. In the ready-1 state, the first part of UID (3-byte) with an Anti-collision cascade-1 command is transmitted to the reader and a Select cascade-1 command is resolved. This occurs in this state only. The reader with Select cascade-1 command brings the RFID chip into the ready-2 state. In the ready-2 state, the second part of UID (4-byte) with an Anti-collision cascade-2 command is finally transmitted to the reader. This state is left with a Select cascade-2 command. Anti-collision loop repeats is utilized for identification of the UID (Unique Identification) in the Ready-1 or Ready-2 state.

In the Active state, either a Read command or a Write command will be executed after the final process selecting an

individual UID is passed. In this state, the vital information can be stored with a Write command from address 0 to 1023 in regular sequence.

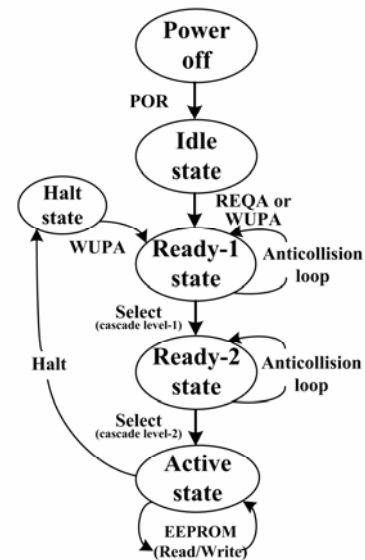


Fig. 3 State diagram of the tag

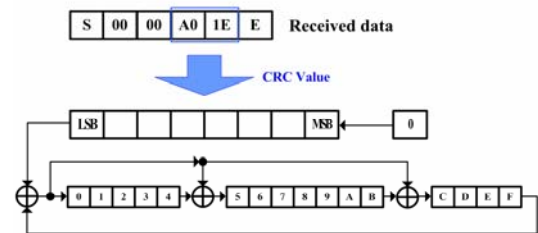


Fig. 4 CRC check with shift register

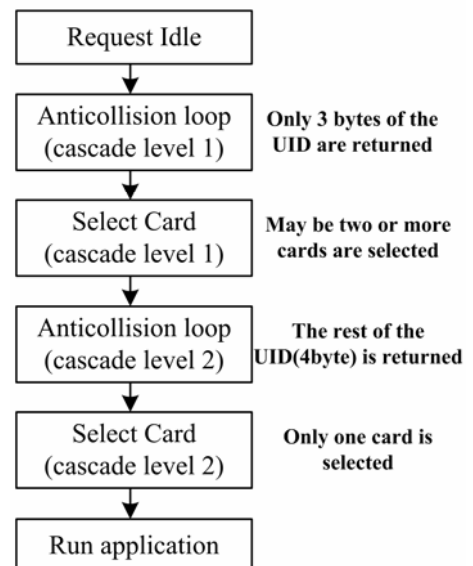


Fig. 5 Select process of the one card

Also, a Read command can obtain the vital information from the flash memory. For transmission results of a Write or Read command the RFID chip returns either Acknowledged (ACK) or Negative Acknowledged (NAK).

The Halt command is sent to leave this state and the chip returns to the waiting state that is the Idle state or the Halt state. If the RFID chip has no response during a specified period, it enters the Halt state upon which it can exit with a WUPA command.

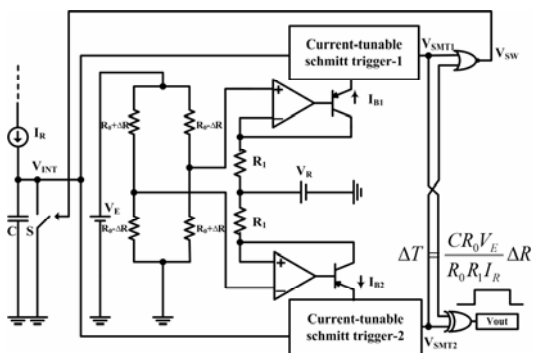


Fig. 6 Resistance deviation-to-pulse width converter

Error detection

The tag chip detects errors through a two-step process. The CRC-16/CCITT block and parity block shown in Fig. 2 detects transmission errors during exchange of data between RFID reader and the tags. When the CRC/Parity checker reports errors, the RFID reader will retransmit the original data. The parity generator based upon even or odd counting the number of one in 8-bit data that decides on transmission success or failure. Based on odd parity strategy, if the calculated value is even then a transmission error has occurred. However, if the transmission is successful the calculated value is odd. The CRC algorithm detects errors in data transfer continuously. The CRC-16/CCITT generating polynomial is composed of shift registers and XOR gates. Fig. 4 shows principle operation. The system compares the calculated CRC and the received CRC after the shift register initialized with '6363' that calculates CRC of the received data. The compared result is the same that the communication was successful.

Collision avoidance

The collisions among tags occur when the tags are going to transmit UID to a reader at the same time. The binary tree search algorithm based on Manchester coding is used to identify a serial number of the tag called UID. The direction of the bit transition of Manchester coding is what carries the data, with a low-to-high transition indicating one binary value, and a high-to-low transition indicating the other. The response signal that transmits to a reader has no transition when the same tags respond at once. In this case, the reader recognizes collision of the tags. The tags have three data types for UID: single, double or triple. The cascade level changes with the UID size.

The proposed system avoids the collision by two cascade levels as shown in Fig. 5. The tag has UID 7-byte. First, the tag transmits UID 3-byte only that is level-1. In level-2, the rest of 4-byte UID is transmitted. The anti-collision loop shown in Fig. 5

selects only one tag by the cascade level.

3.2 Sensor interface

The sensor interface circuits are designed using the resistive bridge sensor approach that detects the vital information such as blood pressure from a body. The conventional approach uses two methods: the first one counts oscillation frequency of a square wave oscillator or alternatively the phase angle of the oscillator. The second utilizes pulse width converter that compares the amplitude of voltage. The approach pursued in the conventional circuit for transmission of resistance value is influenced by a high offset, which means it is unable to provide the needed resolution to satisfy the standards.

Our sensor interface circuit using current-tunable Schmitt trigger is simpler than the conventional circuit and is able to provide high-resolution data under low operating voltage.

Resistance deviation-to-pulse width converter

The resistance deviation-to-pulse width converter detects small resistance change of the resistive sensors having a high fixed offset resistance. Fig. 6 shows the proposed resistance deviation-to-pulse width converter. The converter consists of the resistive sensor bridge using one sensor, two V/I converter, a ramp generator, two current-tunable Schmitt triggers, and glue logic. The output voltage of bridge is converted into two direct currents that control the threshold voltage of the Schmitt trigger. The threshold voltage of the Schmitt trigger is compared with Ramp voltage having a regular slope and hence converts it into pulse width. Thus, the sensor interface circuit obtains digitalized output data from counting the pulse width using an external clock.

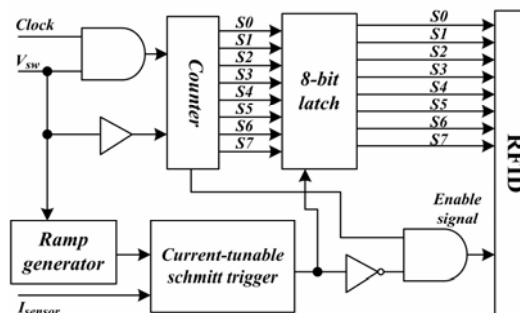


Fig. 7 Sensor interface transferring the vital information

Sensor interface circuit with RFID tag

The proposed sensor interface circuit connects RFID tag generates a PWM signal transferred to the RFID tag system. Voltage difference of the resistive bridge sensor results in PWM pulse signal with current-tunable Schmitt trigger. The interface circuit takes 8-bit digital data from body temperature and blood pressure.

The circuit also has control signals that enable the output data. Fig. 7 shows the sensor interface circuits connecting the RFID tag. The interface circuit has several functions: heart beats measurement 40~200 beats per a minute, blood pressure measurement 0~300mmHg and transition recognition every 0.5 Ω unit in the reference resistance.

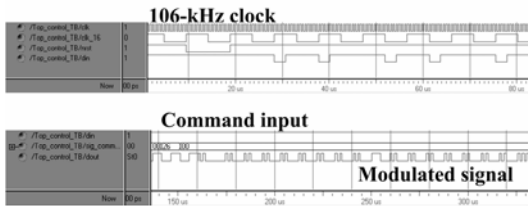


Fig. 8 Data output of the digital controller

4. IMPLEMENTATION RESULTS

Fig. 8 shows the simulation results of the output signal. The system clock 1.695-MHz is divided into 106-kHz blocks. When the valid command is generated, the modulated data by the sub carrier 847-kHz is activated. Fig. 9 shows the pulse width deviation of the sensor output signal. Increasing the output voltage of the sensor changes the pulse width linearly in range of 0 to 60-mV. Fig. 10 presented 8-bit data output current from the sensor, obtained from the resistance deviation-to-pulse width converter circuit. Fig. 10 shows the measured bit per current value. Fig. 11 is the Integrated Circuit chip layout for the tag using Hynix 0.18-um CMOS process that occupies an area of 4.5mm x 4.5mm.

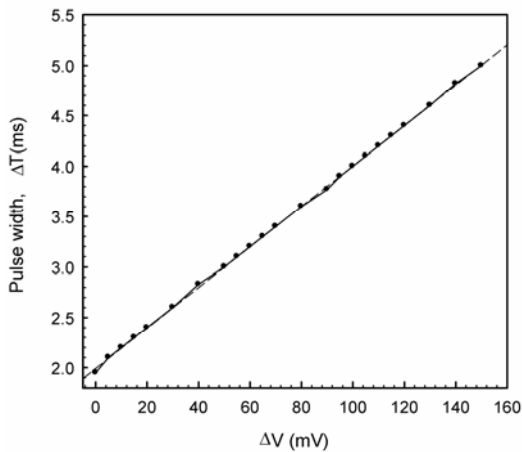


Fig. 9 Pulse width deviations by output voltage of the sensor

5. CONCLUSION

We have presented a novel RFID chip with a sensor interface circuit and sensors. The proposed RFID tag system is able to obtain and store vital data such as blood pressure and body temperature. The system supports heartbeats measurement in the range of 40~200 beats per minute and blood pressure measurement 0~300mmHg. The system is easy to expand to include other bio-information by additional sensors. The tag system will help the management of the patients in hospital environment and it is useful for implementation within the future healthcare system.

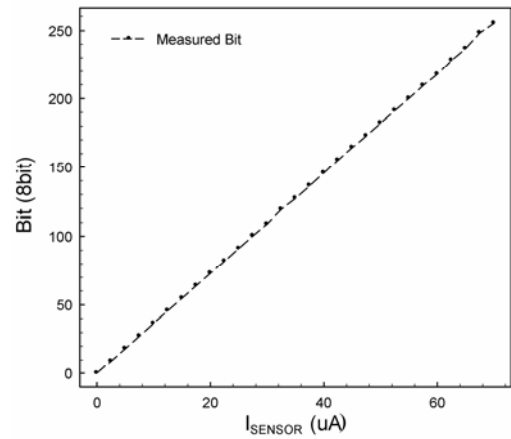


Fig. 10 8-bit data of current of the sensor

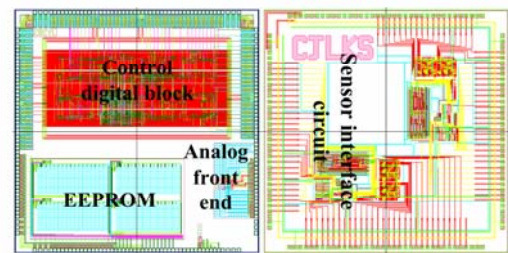


Fig. 11 Chip layout (4.5mm x 4.5mm)

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