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NOVEL BIO-ELECTRODE FOR HUMAN BODY SIGNAL DETECTION

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ABSTRACT

The current paradigm in healthcare is the notion of continuous remote patient monitoring using a network of wireless sensors. These healthcare sensor network systems, consisting of human body area networks (HBAN) and infrastructure area networks avoid the need for a manual self-administered health system and may enable users to take control of their health disorders in future. HBAN technology envisions miniaturized sensors worn or implanted on the body, continuously monitoring health parameters and acting to prevent the onset of critical health events. For example, diabetics now have access to an automatic insulin pump which monitors glucose levels and administers insulin when glucose levels are high. Similar technologies will one day result in devices which can minimize incidences of heart attack or stroke. They could prevent frequent hospital visits and save costs for both the individual patient and a nation's healthcare system. Radio frequency (RF) wireless technology has been successfully deployed in most HBAN implementations; they consume a lot of battery power, susceptible to electromagnetic interference (EMI) and have security issues. The key issue with RF propagation in portable devices is that it consumes battery life quickly. For example zigbee has the maximum data rate of 250 kb/s at 26.5mW resulting in 106nJ per received bit but IBC consumes an order of magnitude less energy at data rates up to 10Mb/s which makes it an attractive communication method for HBAN applications.

KEYWORDS: *Wireless, Healthcare, Radio Frequency, Human Body, Networks, Security*

Article History

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INTRODUCTION

Intra body communication (IBC) is an alternative wireless communication technology which uses the human body as the signal propagation medium [1]. IBC has characteristics that could naturally address the issues with RF for BAN technology. This survey examines the on-going research in this area and highlights IBC core fundamentals [2], current mathematical models of the human body, IBC transceiver designs, and the remaining research challenges to be addressed. IBC has exciting prospects for making BAN technologies [4] more practical in the future**.** The IBC system is a protected and private communication network which provides natural security and interference free communication. The required operating frequency of IBC is much lower compared to RF system. This means signals are confined to the person's proximity since reading data requires body contact. There is no signal leakage through the skin in IBC method and environmental noise has less effect on communication. At higher frequencies (300MHz to several gigahertz) the signal wavelength becomes comparable to the human body channel length and body radiates energy acting as an antenna. Since transmitter and receiver contain small size electrodes instead of antennas, the larger wavelength of the carrier signal compared to the electrode size results in interference free IBC below 300MHz. IBC forms a short range communication network inside and around human body and therefore allows the same frequency band to be reused by HBAN on other users with minimal interference. This property potentially allows designs to focus on improving data rates, reducing power consumption and integrating smaller form factors. IBC is classified into two basic coupling types called capacitive and galvanic coupling. For both coupling types the transceiver needs two pair of electrodes. In capacitive coupling only one of the electrodes of transmitter and receiver side is attached to the body, while other electrode is floating whereas in galvanic coupling both are attached to human body. The signal is generated between the body channel transceiver [6] by making a current loop through the external ground. The signal electrode of the transmitter induces the electric field into the human body which is controlled by the electric potential and body act as a conductor with the ground as the return path [7]. It is achieved by coupling AC current into human body. Here electrical signal is applied differentially between electrodes and a largely attenuated signal is received by the two receiver electrode [8]. In general, the ion content in the human body is the carrier of information in this method [9].

Electrical Properties of Human Body Tissues

The two major properties are relative permittivity and electrical conductivity [10, 11]. Tissue types, the operational frequency range, temperature, intactness of cellular membranes and tissue water content are some of the major factors which determine the tissue electrical properties in the human body. Dielectric properties of living tissue vary differently with frequency dispersion which refers to the behavior of tissues at various frequency range; low frequency range[5], RF ranges and gigahertz frequency ranges, which are referred as alpha, beta and gamma distribution. Permittivity strongly declines, whereas conductivity increases within the frequency dispersion. The polarization of water molecules creates the gamma dispersion in the gigahertz region where the dispersion is not strong and has minimal effect on the electrical properties of body tissues. The polarization of cellular membranes is an obstacle for an ion to flow in or out of the cell and leads to the beta dispersion. The transport of ions across a biological membrane is related to the alpha dispersion where increase in tissue conductivity is rarely evident and permittivity shows a significant decrease. The existing systems used to improve security are biometric and password based systems. The wireless technology is used as a medium. This wireless data communication is based on radio frequency (RF) which have been successfully developed using popular protocols such as Bluetooth, Zigbee. A major drawback of wireless RF propagation for miniaturized monitoring devices is the high power consumption which limits the practical duration of an operation. Most current research claim that Zigbee and ANT has a battery life of three years, but this is at a low operating data rate, e.g., 1B transmitted per 5min. The IEEE 802.15.4 standard for low power Zigbee protocol indicates a transmission power output of 0dbm (1mW). Continuous operation at the maximum data rate of 250 kbps generally consumes a normal lithium ion battery in a matter of hours. It is evident that new approaches to ultralow power wireless technology are required for improving next generation BAN technology. The proposed system is used to improve the security using bio signals to access the door using a non-RF wireless data communication technique which uses human body as transmission medium for electrical signals which prevents energy being dissipated into the environment. It uses surface electrodes, microcontrollers and driver circuit. The data from the controller is converted to the electrical signal by using a driver circuit. The resultant signal is allowed to transmit through the body using surface electrodes. Another electrode is placed at different place of the body. It collects input from the human body and feeds the driver circuit. Driver and signal inducing circuit converts the electrical signal to the binarized input. The binarized input feeds the controller and it sends the command to the driver circuit. Depending upon the controllers command, devices will be switched on using driver circuit.

EXPERIMENTAL SET UP

The system consists of two nodes such as Transmitter and receiver node. The transmitter part consists of microcontroller, driver circuit, switches and electrode. The data are transmitted to the driver circuit by pressing the switch. Then the data's are transmitted through the human body by surface electrodes. Switches which are interfaced with the microcontroller are used to start up the operation of transmission of data. The receiver part consists of microcontroller, driver circuit, relay and motor. This part is used to receive data from the human body by the surface electrodes. The data's are received by the microcontroller using driver circuit. Depend upon the data from the microcontroller; driver circuit will give power supply to motor by using the relay

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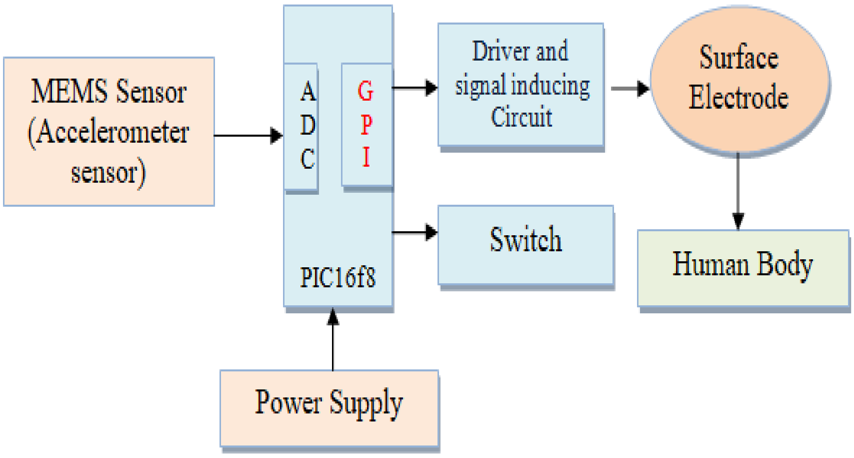

Figure 1: Transmitter Block Diagram.

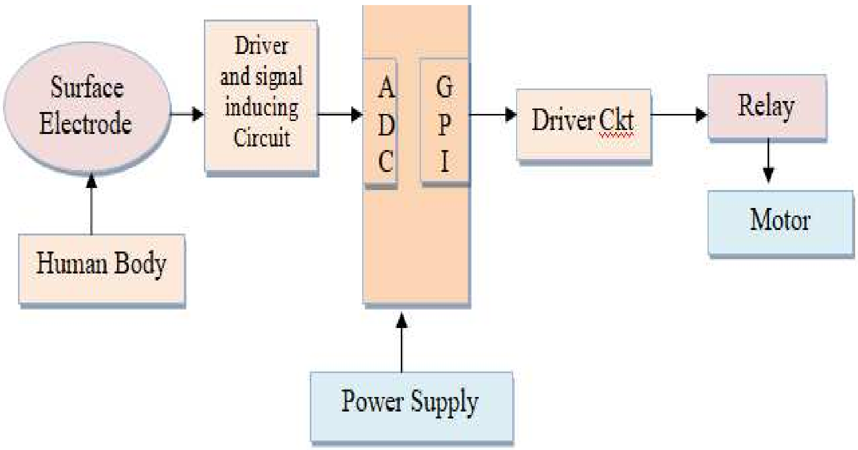

Figure 2: Receiver Block Diagram.

Mems Accelerometer Adxl330

The MEMS accelerometer contains a tiny cantilever beam with a proof / seismic mass. The sensor sends an analog signal as the proof mass deflects from its neutral position under the influence of external acceleration. MEMS accelerometer made by Analog Devices Inc., ADXL330 is used. This model already deploys multi-axes sensor in three-dimensional space. This provides a great advantage for the current interest since one does not need to set up at least two small MEMS accelerometers perpendicularly to obtain two dimensional orientations. Using ADXL330, it is able to measure the inclinations of object relative to two dimensional planes simultaneously. TAhe devise is also small in size, 4 x 4 x 1.45 (mm) and consumes low power and integrates three-axes sensor in a single circuit. It also can measure both dynamic and static accelerations with enough accuracy that is within -3g and +3g, and sensitivity equal to 320 mV / 1 gr.

Asynchronous Receiver Transmitter (Usart)

The Universal Synchronous Asynchronous Receiver Transmitter (USART) module is one of the two serial I/O modules. (USART is also known as a Serial Communications Interface or SCI). Bit SPEN and bits TRISC<7:6> have to be set in order to configure pins RC6/TX/CK and RC7/RX/DT as the Universal Synchronous Asynchronous Receiver Transmitter.

USART Baud Rate Generator (BRG)

The BRG supports both the Synchronous Asynchronous modes of the USART. It is a dedicated 8-bit baud rate generator. The SPBRG register controls the period of a free running 8-bit timer. In Synchronous Asynchronous mode, bit BRGH also controls the baud rate. Given the desired baud rate and FOSC, the nearest integer value for the SPBRG register can be calculated. From this, the error in baud rate can be determined. It may be advantageous to use the high baud rate (BRGH = 1), even for slower baud clocks. This is because the FOSC/ (16(X + 1)) equation can reduce the baud rate error in some cases. Writing a new value to the SPBRG register causes the BRG timer to be reset (or cleared). This ensures the BRG does not wait for a timer overflow before outputting the new baud rate.

The USART transmitter block diagram is shown in Figure 3.5. The heart of the transmitter is the transmit (serial) shift register (TSR). The shift register obtains its data from the read/write transmit buffer, TXREG. The TXREG register is loaded with data in software. The TSR register is not loaded until the STOP bit has been transmitted from the previous load. As soon as the STOP bit is transmitted, the TSR is loaded with new data from the TXREG register. Once the TXREG register transfers the data to the TSR register (occurs in one TCY), the TXREG register is empty and flag bit TXIF is set. This interrupt can be enabled / disabled by setting/clearing enable bit, TXIE

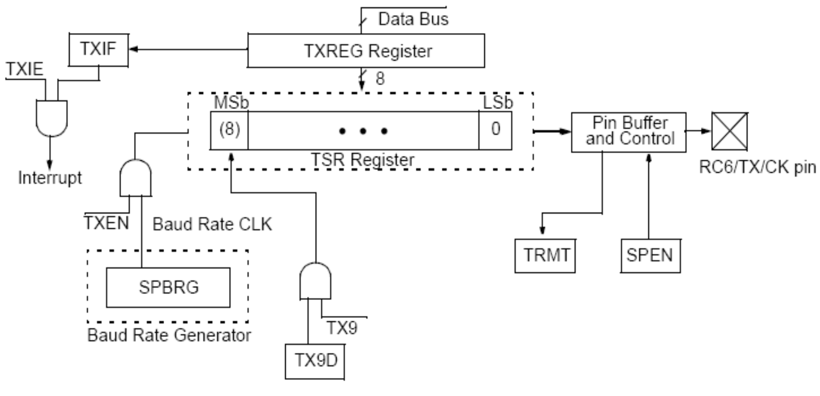

Figure 3: USART Baud Rate Generator.

USART Receiver

The data is received on the RC7/RX/DT pin and drives the data recovery block. Once Synchronous Asynchronous mode is selected, reception is enabled by setting bit CREN. The heart of the receiver is the receive (serial) shift register (RSR). After sampling the STOP bit, the received data in the RSR is transferred to the RCREG register (if it is empty). If the transfer is complete, flag bit RCIF is set.

The actual interrupt can be enabled/ disabled by setting/clearing enable bit RCIE. Flag bit RCIF is a read only bit, which is cleared by the hardware. It is cleared when the RCREG register has been read and is empty. The RCREG is a double buffered register (i.e., it is a two deep FIFO). It is possible for two bytes of data to be received and transferred to the RCREG FIFO and a third byte to begin shifting to the RSR register. On the detection of the STOP bit of the third byte, if the RCREG register is still full, the overrun error bit OERR will be set. The word in the RSR will be lost. The RCREG register can be read twice to retrieve the two bytes in the FIFO. Overrun bit OERR has to be cleared in software. This is done by resetting the receive logic (CREN is cleared and then set).

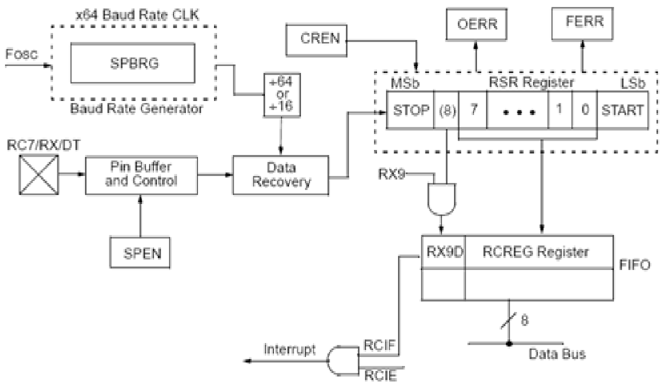

Figure 4: USART Receiver Block Diagram.

Synchronous Asynchronous Reception

When setting up a Synchronous Asynchronous Reception, follow these steps:

- Initialize the SPBRG register for the appropriate baud rate. If a high speed baud rate is desired, set bit BRGH.

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Surface Electrode

The purpose of an electrode is to act as a connector between the subject's skin (where electrical signals are easier to detect) and the MP40 acquisition unit (via the 40EL cable). If an electrode makes good contact with the skin, the signals that are generated will be relatively accurate.

Electrodes are very simple devices that consist of a small piece of metal designed to make indirect contact with the skin and a larger adhesive plastic disk. Each electrode is about 1inch (2.5cm) in diameter and is sticky on one side so it will adhere to the skin. There is a small piece of plastic mesh filled with a bluish gel. Since gel conducts electricity (better than your skin) and is more flexible than the metal part of the electrode, the skin can flex and change shape somewhat without losing the electrical connection with the metal part of the electrode. BIOPAC disposable electrodes are standard electrodes which are widely used in clinical, research and teaching applications. These electrodes come in strips of ten and you should not remove an electrode from the backing until you are ready to use it.

Electrode Placement

There are two basic methods of electrode placement: monopolar and bipolar. In a monopolar recording, an active electrode is placed over the region of interest and a reference electrode is attached to a more distant part of the body. In a bipolar recording the voltage difference between two electrodes is measured with respect to the third "reference" electrode. Leads I, II, III are standard bipolar electrode configurations. The standard bipolar limb leads are

Lead I = right arm (-), left arm (+)

Lead II = right arm (-), left leg (+)

Lead III = left arm (-), left leg (+)

Preparing Electrode Site

If signals are erratic, one way to improve electrode connections is to gently rub the area where the electrode is to be placed. This is known as abrading the skin and removes a thin layer of dead skin from the surface of the skin. Since dead skin doesn't conduct electricity very well removing it improves the connection between the electrode and the skin. The skin site can be lightly abraded with a clean dry cloth.

Attaching Electrodes

To attach an electrode, peel the electrode from its backing and place it on the area. Once in place press down firmly on the electrode with two fingers and rock the electrode back and forth for a few seconds. This will ensure that it is adhering to the skin as much as possible.

To help insure that the electrode will make good electrical contact with the skin, you may want to squeeze a drop or two of electrode gel onto either the surface of the skin or onto the electrode without allowing any to get on the adhesive.

Connecting the Electrode Lead

Each electrode lead cable is a different color and each pinch connector on the end of the cable needs to be attached to a specific electrode. The connector is polarized and needs to be clipped on such that the metal extensions inside the clip are on the down side to make surface contact with the electrode.

Removing Electrodes

Disconnect the electrode cable pinch connectors; peel the electrode off the skin and dispose of the electrodes. Wash the electrode gel residue from the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours. This is normal and does not indicate that anything is wrong.

RS232 Communication

RS232 is an asynchronous serial communication protocol widely used in computers and digital systems. It is called asynchronous because there is no separate synchronizing clock signal as there are in other serial protocols like SPI and I2C. The protocol is such that it automatically synchronizes itself. RS232 is easily used to create a data link between our MCU based projects and standard PC.

Basics of Serial Communication

In serial communication the whole data unit, say a byte is transmitted one bit at a time. While in parallel transmission the whole data unit, say a byte (8bits) are transmitted at once. Obviously serial transmission requires a single wire while parallel transfer requires as many wires as there are in our data unit. So parallel transfer is used to transfer data within short range while serial transfer is preferable in long range. In RS232 there are two data lines RX and TX. TX is the wire in which data is sent out to other device. RX is the line in which other device put the data it need to sent to the device. The arrow indicates the direction of data transfer. In addition to RX/TX lines there is a third line i.e. Ground (GND) or Common. As there is no “clock” line so for synchronization accurate timing is required so transmissions are carried out with certain standard speeds. The speeds are measured in bits per second. No of bits transmitted is also known as baud rate. Some standard baud rates are 1200, 2400, 4800, 9600.

Rs232 Data Channels

The data transfer is done in following ways, We make use of the following components PIC 16F877A Microcontroller, ULN2003, Relay, Surface electrodes, HD 74LSI4B.

Figure 5 shows Using MEMS accelerometer the password (data) is sensed and with the axis value it enters the microcontroller. Switches interfaced with microcontroller start up the transmission operation only if the axis value is above the threshold range that is programmed in the controller. Crystal oscillator is used to provide clock frequency to microcontroller. Data are transmitted to the driver circuit by pressing the switch which converts binary to electrical signal, then transmitted through human body through surface electrodes. Since body has the electrical property it transmits it to the receiver side which receives data from the human body through the t surface electrodes which is placed at the other side of the body. Microcontroller receives data using driver circuit. Depending on the data, driver circuit will switch on/off the motor using relay. Here we make use of a device called ULN2003 between controller and relay because it needs 12V power supply to operate but the actual power obtained from the microcontroller will be of 5V. This device amplifies the power from 5V to 12V. Thus from the output of the relay the motor switches on/off which indicates the opening or closing of the door.

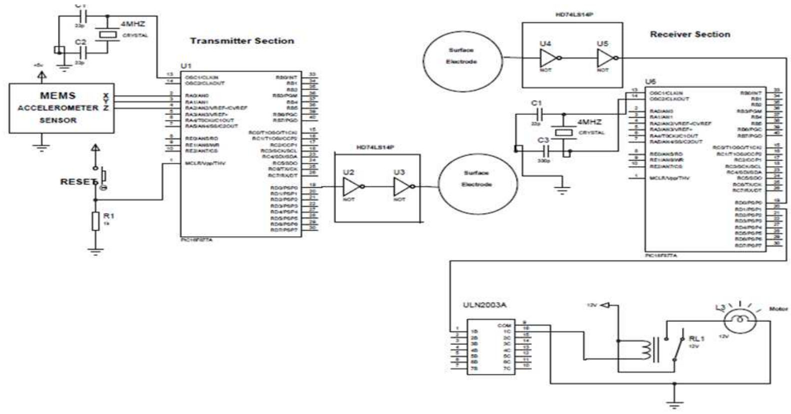

Figure 5: Architecture Diagram.

Implementation Using Software

We make use of an embedded C language to program in the controller. The compiler used is CCS.

Transmitter Simulation

When the axis of the character is above 250, data will be transmitted. Transmission of the data is indicated by a LED (high).

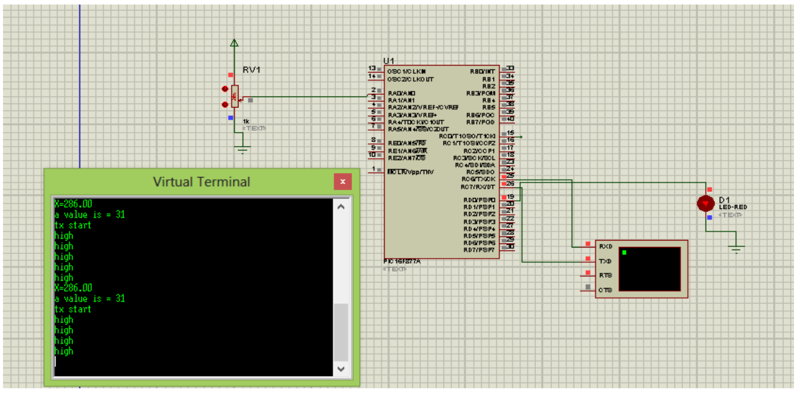

Figure 6: Transmitter Simulation 1.

When the axis of the character is below 250, data will not be transmitted.

- LED will not glow.
- It indicates the user to check the axis.

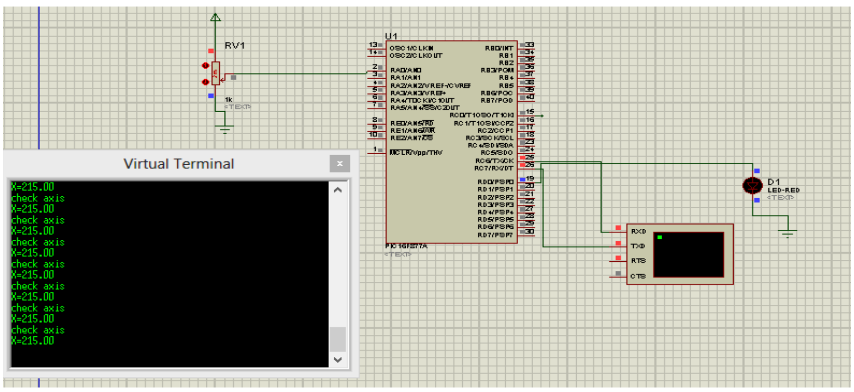

Figure 7: Transmitter Simulation 2.

CONCLUSIONS

This project has satisfactorily overcome the issues addressed by the RF wireless technology used in existing system. As we make use of human body as a medium the system becomes more efficient and advantageous. The security system is improved by making use of this concept since it provides natural security. As it consumes less power it increases the practical duration of the system. It provides an interference free communication and also there will be no signal leakage and it uses a lower frequency ranges. Due to all these reasons the security has been improved and its implementation is also simple.

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