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DoS Transmission of Vital Biomedical Data Via the Intercommunication System of an MRI

M. Jyothendra Bushan Rao[1], S .Yuvaraj[2], KR. Mahadevan[3] and V. Dikshit[4]

[1]*Electronics and Communication Engineering, SRM Institute of Science and Technology, India*
[2] *Electronics and Communication Engineering, SRM Institute of Science and Technology, India*
[3] *Electronics and Communication Engineering, SRM Institute of Science and Technology, India*
[4] *Electronics and Communication Engineering, SRM Institute of Science and Technology, India*

Abstract
Without using any hazardous radiation, magnetic resonance imaging (MRI) enables a high-resolution scan of the body's soft tissue components. A person typically has 1.5 MRI scans over their lifespan. The inability to accurately measure a patient's vital signs or other medical data during scans is a downside. While it is tricky to measure these values with non-disturbing antimagnetic equipment, it is even more difficult to convey the results to the MRI operator, preferably in real time. To stop the magnetic field of the tomograph from disturbing other medical equipment, shielding is needed around the scanner. A microcontroller that digitizes analog patient parameters and a connected sonography transmitter is utilized to get around the data transfer problem. On the receiver side, graphs of the patient parameters can be plotted and analyzed in Visual Basic Software for current status in real-time.

Keywords:
Data over Sound (DoS), Force sensing resistors (FSR), Beats per minute (BPM), Breath Rate Per Minute (BRPM), and millimeters of mercury (mmHg).

1. INTRODUCTION

A powerful magnetic field and radio waves are used in the non-invasive medical imaging procedure known as an MRI (Magnetic Resonance Imaging) to provide precise images of the inside organs and tissues of the body. A variety of injuries, illnesses, and anomalies in the brain, spine, joints, and other regions of the body can all be detected and tracked with MRI technology. Basic examinations that concentrate on a single body part, such as the knee or shoulder, can be finished in 15 to 30 minutes. It may take an hour or longer for more complicated exams that entail imaging various body areas or using several imaging sequences. Depending on the complexity of the exam and the body area being examined, an MRI scan might take more than an hour in some instances. A full-body MRI or a cardiac MRI, for example, may require more time than an hour to complete.

To maintain patient safety and produce high-quality images during an MRI scan, biological data must be monitored. Strong magnetic fields and radio waves used by MRI equipment to produce images of the body's internal structures may have an impact on a patient's vital signs, including heart rate, blood pressure, and respiration.

As a result, keeping an eye on the patient's biological data during the MRI scan can aid in identifying any negative effects of the treatment on the patient's health and enable timely intervention, if necessary. For instance, medical personnel can respond right away to stabilize the patient if the patient's heart rate or blood pressure dramatically lowers while the scan is being performed.

2. SENSORS and DATA COLLECTION

In the proposed system to send the vital biomedical data for live monitoring, the following sensors were used:

2.1 TEMPERATURE SENSOR (DHT11)

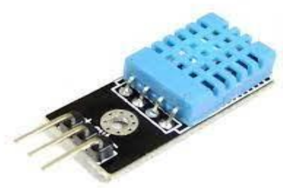

Fig. 1: Temperature sensor.

A digital temperature and humidity sensor with a reasonable cost is referred to as the DHT11. Any microcontroller, including Arduino, Raspberry Pi, etc., may easily interface with this sensor to instantly monitor humidity and temperature.

The DHT11 has a temperature range of 0 to 50 degrees Celsius with a 2-degree precision. It has four pins: a not-connected pin, VCC, GND, and a data pin. For communication between the sensor and microcontroller. This temperature sensor is used to measure the body temperature of the patient.

2.2 PRESSURE SENSOR (FSR 406)

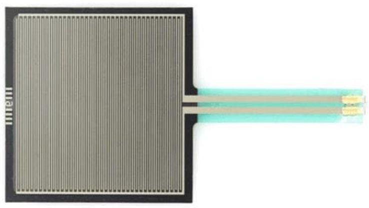

Fig. 2: Pressure sensor.

FSRs are sensors that can recognize weight, squeezing and physical pressure. They are cost-effective and simple to use. This sensor has a 38mm square detecting zone and is an Alpha MF02A-N-221-A01 FSR.

FSRs are resistors that adapt to pressure by changing their resistance value (measured in ohms). The resistance of Force Sensing Resistors (FSR), a polymer thick film (PTF) device, decreases as the force applied to the active surface increases. Its force sensitivity is designed for use in touch-sensitive electronic device control by humans. This sensor is utilized to measure the patient's blood pressure.

2.3 HEARTRATE SENSOR (KY-039)

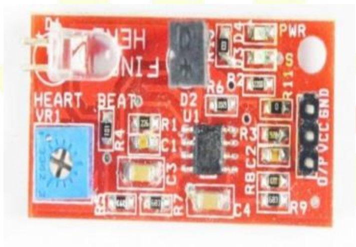

Fig. 3: Heart rate sensor.

This sensor tracks your heart rate via electrical detection. When a finger is placed on a heartbeat sensor, a digital output of the heartbeat is intended to be produced. The beat LED glows in time with each heartbeat while the heartbeat detector is functioning. The Beats Per Minute (BPM) rate may be measured by simply connecting this digital output to a microcontroller. It operates on the idea that each pulse causes a change in the amount of light that is modulated.

2.4 RESPIRATORY SENSOR

Fig. 4: Respiratory sensor.

A respiratory sensor is an instrument or system that monitors and analyzes the depth, rhythm, and rate of breathing. It is frequently employed in medical settings to keep an eye on patients who are undergoing mechanical breathing, are receiving anesthesia, or are at risk of experiencing respiratory distress. During an MRI scan, respiratory sensors are crucial instruments for monitoring a patient's respiratory function because they can be used to spot variations in breathing patterns that might point to a lung function issue.

3. SYSTEM DESIGN

Step down transformer is used to convert 230V AC to 12V DC, as Arduino Uno 328 Microcontroller requires 12V, and vital biomedical parameters are collected through sensors. The following sensors are used to collect vital biomedical parameters from patients during MRI scans. Heart rate sensor, Respiratory sensor, Temperature sensor, and FSR 406 Pressure sensor are used to monitor the patient’s biomedical data. Each of these sensors has 3 terminals, namely 5V, Ground, and the input. The input of each sensor goes to the analog ports of the Arduino Uno Board. All four parameters are shown on the LCD screen that has been soldered to the Arduino Uno board.

The AT Mega 328 Microcontroller, which is wired to the L298N motor driver, receives the digital output from the Arduino Uno board. This microcontroller operates at a voltage of 5V and receives a supply voltage of 12V from the Arduino Uno module's J13 pin. The AT Mega 328p microcontroller receives data from the Arduino Uno via serial connection in the form of ASCII characters, with each character's associated waveform provided by the microcontroller. The L298N Motor driver then receives these ASCII characters together with the digital data, which is transmitted via the UART connection. These values are now provided with the aid of the L298N Motor driver, the microcontroller of the AT Mega 328 will convert the p values of information from the Arduino 328 into a wavelength with certain frequencies for information transfer via a wireless intercommunication system. It is also known as an H-bridge, and it is used to magnify the data output from a microcontroller to a transmitter that runs on 12 volts. The ground, the two inputs, the two positive high and low threshold pins, the two negative high and low threshold pins, and the voltage supplies for the motor driver are all connected. The two output pins of the motor driver are linked to the DoS transmitter module. The data is transmitted from the information source to the channel coder, where it is encoded.

The calibration amplifier, which also serves as the signal conditioner, ensures that the data stays on the same channel. As a result, this cycle of data between the information source, coder, and calibration amplifier continues until the desired frequency is established. The frequency tracker now receives this and keeps the frequency stable so that the receiver may identify the registered frequency and transmit it through the transmitter. As ultrasound waves are used, it requires a medium to propagate with. These waves would be higher than the audible frequency range. As ultrasound waves are used, it does not require any antenna for propagation. The system has been tested and 3 to 4 feet of distance between the DoS Tx and Rx gives accurate output in the PC.

Block Diagram:

Transmission Side:

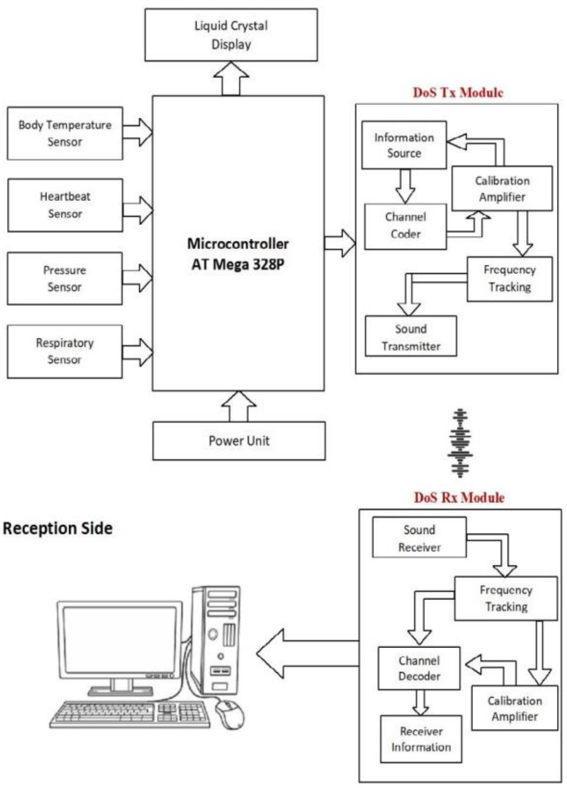

Fig. 5: Process flow of Data over Sound Transmission.

At the DoS Receiver side, the exact opposite operation takes place. The DoS receiver and PC interface use an RS-232 standard pin. For continuous value monitoring, the characters are transformed into numbers and shown in Visual Basic 6.0.

4. System Specification

4.1 HARDWARE USED

a. Microcontroller ATMega328(DoS Module)
b. Arduino Uno 328
c. Temperature Sensor (DHT11)
d. Heart rate sensor (KY-039)
e. Respiratory Sensor
f. Pressure Sensor (FSR 406)
g. LCD Display
h. DoS Transmission Module
i. DoS Receiver Module
j. Transformer

4.2 SOFTWARE USED

a. Arduino IDE
b. Embedded C
c. Visual Basic Database

5. Working Principle

An Arduino Uno 328 step-down transformer that is rated for 12 volts provides the required voltage. The four sensors that are employed are the respiration sensor, heart rate sensor, temperature sensor, and pressure sensor. These sensors' three terminals are linked, respectively, to the analog input, ground, and 5 V.

The LCD that is soldered above the Arduino Uno board shows the monitor's constantly changing settings. The Arduino Uno board is powered by the AT Mega 328 Microcontroller, which is linked via the J13 pin.
The Arduino Uno board's output is sent to the microcontroller's input pin. The UART interface is currently being used to connect the L298N driver to the DoS Transmitter Module.

The receiver module's RS232 pin is used to establish a connection with the computer, and Visual Basic 6.0 is used to display the data. The graphs for each appropriate parameter are displayed with the numerical values for each sensor.

Table. 1: Normal range for parameters.

Parameters	Range
Heart rate	70-100 bpm
Temperature	Greater than 34 °C
Respiratory	7-15 brpm
Pressure	147-157 mmHg (converted)

Table. 2: Distance of DoS Module to send and receive Data.

Distance (inch)	Sent and receive data
3	Success
4	Success
5	Success
6	Failed

6. RESULTS and DISCUSSION

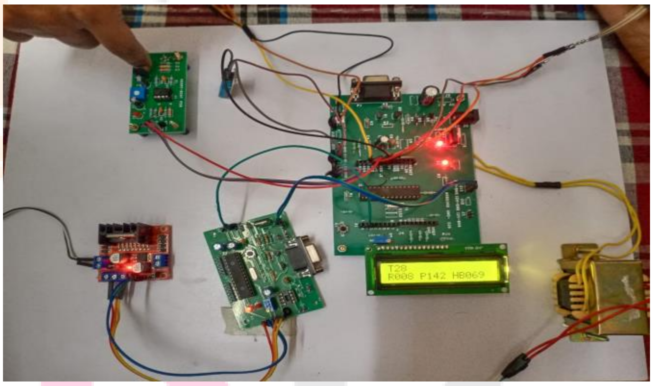

Fig. 6: LCD Output and Transmission Setup.

The above figure portrays the hardware setup on the transmission side with LCD displaying the sensor values.

Fig. 7: Simulation Output by Visual Basics 6.0.

The above figure shows the output in Visual Basics 6.0.It can be observed clearly that the four parameters are displayed. Celsius, mmHg, bpm, and O2 Level are the units of the parameters.

The numerical values from each of the sensors were successfully received at the PC end. Visual Basic 6.0 software was used to check each of the values. The 16X2 LCD shows each of the values.

7. Conclusion

The proposed system has four parameters that will be measured during an MRI scan. The wireless transmission would take place without affecting the MRI scan. The Arduino Uno compatible with 12 V is used and interfaced with the AT Mega Microcontroller which gives advantages on low electronic equipment used and low power consumption. The thickness of the shield during the MRI scan would be a maximum of 4 inches, hence the proposed system's range would be more than enough for data transmission successfully. The sensors used here are prototypes, just to showcase that the data can be monitored in real-time at the PC end. The ultrasound transmission makes sure not to interfere with the MRI scan and transmit the biomedical data through the shield.

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