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Wireless Biomedical Parameter Monitoring System Using ZigBee CC2500 RF Module

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ABSTRACT
This paper proposes a systembased on Zigbee wireless communication and sensors for biomedical parameters monitoring. The system can used to measure body temperature and heart rate. With the help of sensors patient's vital signs are monitored continuously. The system use wireless technology to transmit vital parameters of human body to any host computer. Due to enhancement in wireless technologies and sensor devices patient monitoring has become convenient and cost effective. The device used for data transmission and receiving is zigbeeCC2500(Radio Frequency) module[4]. Applications of device can be used in broader aspects like industrial, scientific and medical fields.

KEYWORDS
LM35, LDR, Zigbee CC2500RF,
Arduino, Photodiode.

1.INTRODUCTION

In recent times sensors networks and wireless transmission networks are playing greater role in electrical and electronics fields.Though sensors are available from previous decade but the wireless sensors network has emerged as new area of research and development which have wide area of applications. One of the major role of sensors is in biomedical field.As we know world's population is increasing rapidly but the medical facilities are not reached to everyone.In developing countries citizens get very low quality of medical facilities and to monitor every patient is a difficult task for medical staff. Now the hospitals and nursing homes are adopting sensor devices to monitor their patient and wireless transmission techniques of patient data. With the help of wireless sensor network patient monitoring and care taking has become easier. Due to advancement of technology speed,accuracy, intelligence, can be achieved in sensors which results in development of smart sensing devices. Due to increased cost of patient health care devices which are cost effective are in demand. ZigBee based system are latest in biomedical patient monitoring. Indoor vital signs can be easily measured through sensor devices and transmission of these signals carrying information of sensors can be easily done with the help of radio frequency transmission. Indeed, co-locating computational power and radio frequency (RF) communication within the sensor unit itself is a distinct feature of wireless sensing. The data collected can be easily transmitted to a host computer which stores the data. This stored data can be analyzed and necessary actions can be taken.

2. RELATED WORKS

Previously wireless patient monitoring systems that used wireless communication consisted of WAP based telemedicine system that further consisted of GSM network, short message system or SMS, circuit switched data

(CSD) or general packet radio system (GPRS). They provided typical data rates ranging from 9.6 kb/s to 171.2 kb/s[1].

Other ways of wireless data transmission from patient's room to doctors cabin or local host computer included Bluetooth network which can provide normal sampling rates up to 295 Hz for 4 channel signal transmission or could use radio transmission and reception module for communication in RF range[2].

But the power consumption in these wireless communication methods is high and rate of data transmission uselessly higher than what we have proposed in our paper.

As the need for adaptation of wireless based patient monitoring systems is high and dire therefore it is of utmost importance that these systems should be feasible in terms of power consumption, data transfer rates and ease of use.

3. PROPOSED APPROACH

The system will consist of patient signal recording system which in our case we are measuring the temperature through LM35 temperature sensing module and a customized heart rate sensor comprising of LDR, LED and related circuit that we will discuss later; alongside wireless data transmission system which consist of RF data communication through a low power module which is ZigBee CC2500 RF module[6].

Firstly the parameters which we are measuring which are temperature and heart rate are send to the arduino microcontroller whose function is to process the analog signals and convert them into digital using in-built ADC's and process them using the algorithm fed in it in the form of a program which is designed such that it process the signals, calculates the required output which is temperature in °C, heart beat in beats or minute or BPM and then forwards it to the LCD display prior to the transmitter module[3].

The LCD interfacing is done to check the calculated values from the microcontroller which are the original with the ones received by the receiver module. The transmitter and receiver ZigBee modules are mounted on the CC2500 ZigBee. The module is designed to work in the frequency range of 2400-2483.5 MHz.

The system also fitted with the signal conditioning circuit in the heart rate sensor for the amplification and noise filtering of the data from the heart rate sensor. The circuit is designed keeping in mind the low power consumption wherever possible and sufficient data transfer rate for the transmission of data through the transceiver system. The data collected by the receiver module is transferred to the computer through the TTL cable. In the computer the arduino software is used to process the information and display it on the monitor which can be easily read by the user or the doctor[7].

4. LM-35 TEMPERATURE SENSOR

LM-35 sensors are precision integrated sensors of which output is linearly proportional to centigrade temperature. LM-35 sensor[4] has an advantage over other conventional temperature sensors which are calibrated in terms of Kelvin,as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. LM-35 temperature sensor does not require any external calibration to obtain accurate results. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single

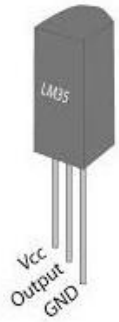

Figure.1.LM35 Temperature Sensor

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power supplies, or with plus and minus supplies. This sensor generates output higher than conventional thermocouples so amplification of output is not required.

LM-35 has accuracy of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Since the calibration is not required device is of lower cost.

Sensor has low power consumption. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range.

5. HEART RATE SENSOR

For heart/pulse rate measurement we are using LDR(light dependent resistor).

The sensor consists of a super bright red LED and light detector. The LED needs to be super bright as the maximum light must pass spread in finger and detected by detector. Now, when the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal.

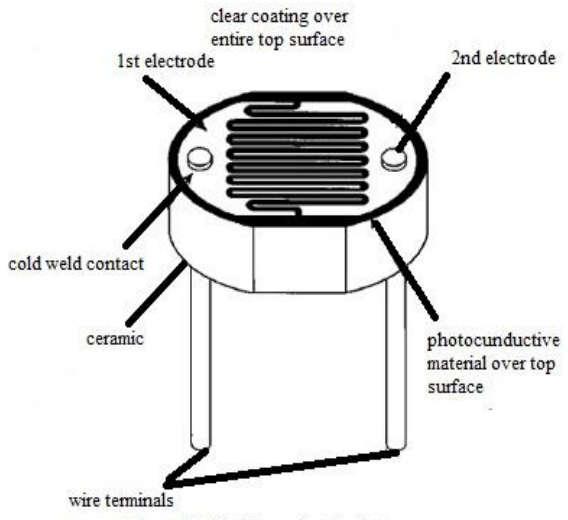

Figure2. Light Dependent Resistor

Electrical characteristics of LDR are shown in following table

Para-meters	Conditions	Min.	Typ.	Max.	Units
Cell resistance	1000 lux 10 lux	- -	400 9	400 9	Ω
Dark resistance	-	1	-	-	MΩ
Dark capacitance	-	-	3.5	-	pF
Rise time 1	1000 lux 10 lux	-	2.8 18	-	Ms Ms
Fall time 2	1000 lux 10 lux	-	48 120	-	Ms Ms

Photocells or LDR's are nonlinear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves. Also, LDR's are less sensitive than photo diodes and photo transistor. LDR or photocells can be classified according to the material used. It is of two types.

Intrinsic photocells are pure semiconductor devices using silicon or germanium. Electrons get excited from valance band to conduction band when photons of enough energy falls on it and number charge carriers increases

Extrinsic photocells these are semiconductor materials doped with impurities which are called as dopants. Theses dopants create new energy bands above the valence band which are filled with electrons. Hence this reduces the band gap and less energy is required in exciting them. Extrinsic photo resistors are generally used for long wavelengths.

6. ZIGBEECC2500TRANSCEIVER SYSTEM

The ZigBee transceiver system consist of two ZigBee modules, one for transmitting and other for receiving along with their respective ZigBee module bases on which they are mounted[3].

The ZigBee used here which is CC2500[6] module is a low power consumption, low cost

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wireless networking protocol targeted towards remote control application. The ZigBee based wireless devices are expected to transmit 10-75 meters depending upon RF environment and the obstruction in the path of transmission. The module which we are using here has a range of 30 meters in the line of sight of transmitter and receiver[5].

Figure 3. A Zigbee CC2500 chip

We have selected the CC2500[6] module because it is cost efficient and meets our requirement although it can be replaced with other high end modules which we do not require and have greater range. The features of this module include- High sensitivity (–104 dbm at 2.4 KBaud1% packet error rate). Hence low output error is expected from the communication channel.Low current consumption(13.3 mA in RX, 250 KBaud).Also Programmable output power up to +1 dbm. It has excellent receiver selectivity and noise blocking performancealongwith Programmable data rate from 1.2 to 500 KBaud.

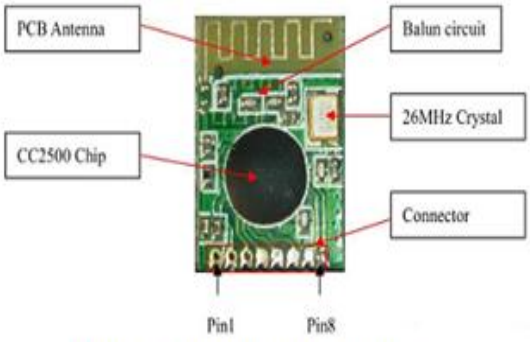

Figure 4. Zigbee CC2500 chip design

7. CIRCUIT DESIGN

While designing the system to get the required output multiple steps and precautions have to be kept in mind. Various fluctuations and errors have to be terminated so as to get the result as close to the expected outcome. Keeping in mind the nature of power supply for various elements used in the circuit transformer and rectifier circuits will be used. Figure 5 shows the block representation of the system. The entire system can be divided into following blocks:

1. Power Supply
2. Sensing Module
3. Processing Unit or Microcontroller
4. LCD
5. Other Elements

7.1 Power Supply

The system is supplied with a 220V 50Hz AC. However various elements that will be used in the system such as ATmega328,sensors, LCD work only with DC signal. Also power supply required by them is in the range of 3-10 volts. The PCB containing elements is connected to host computer and guest computer through USB TTL cable which provide desired power to the elements.

7.2 Sensing Module

The sensing module will consist of temperature sensor LM35 and custom designed heart rate sensor using LDR. First by placing finger on temperature sensor it will sense the body temperature and then placing finger on heart rate sensor which will sense the heart rate.

7.3 Microcontroller Unit

Arduino microcontroller ATmega328 will be used to control the circuit and get the desired output. It has features like 32KB flask memory, SRAM 2KB EEPROM 1KB, Analog pins 8, Digital I/O pins 14, operating voltage 5 V. The main function of the MCU is to read the output from the temperature and heart rate sensors convert the analog signal into digital signal and process the signal and transmit the information to transmitting module. It will

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also be programmed to display the output on LCD.

7.4 LCD

LCD module used is a 16X2 LCD[7]. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data character is displayed on the LCD.

7.5 Other Elements

Other elements consist of a host computer and a guest computer. Data collected from transmitting module is stored in host computer and using protocols data is transmitted to guest computer where receiving module is connected to the USB port. The readings are displayed on the guest computer using Arduino IDE software.

8.CIRCUIT OPERATION

Temperature measurement of subject is to be done by placing LM 35 over the patient's hand after covering its other surface by insulator. This covering will isolate the LM 35 from surrounding and will not be affecting by outside temperature variations.

The LM 35 will give its output in analog form which must be converted into digital in order to transmit data over a distance. AtMega16, microcontroller, is used in arduino-16 which provide a wide range of parameters connection. Arduino has inbuilt library which provide easy way to program.

First, start with LCD-16*2 interfacing by microcontroller at transmitter end to get temporary data to check weather the final output receive at distance end is correct or not. We have selected the liquid crystal from library and then find out the pins D4 D5 D6 D7 E and RS and connect these to pins of AtMega16 microcontroller.Select the columns and row of LCD over which the data has to display and also the baud rate to communicate it with arduino.Use print command to display "Body Temperature" over the LCD and also choose (0,1) which shows that output of this must display at 0^{th} row and 1^{st} column.Now, interfacing LM 35 with microcontroller by taking analog input of it to A0 pin of AtMega16.Sensor value is directly multiplied by numerical value to convert voltage output into degree centigrade.

Sensor Value = Sensor Value*.488281

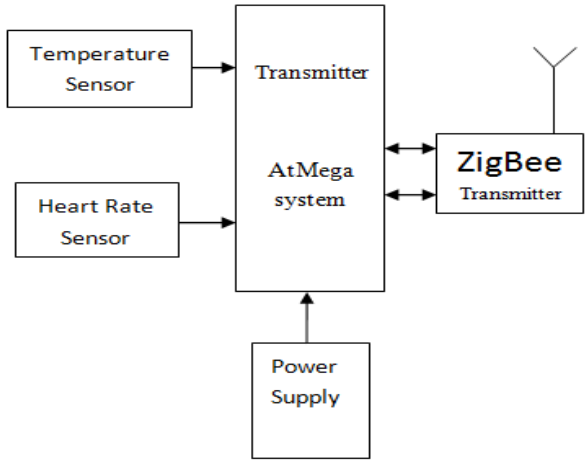

Figure.5. Block diagram of transmitting section

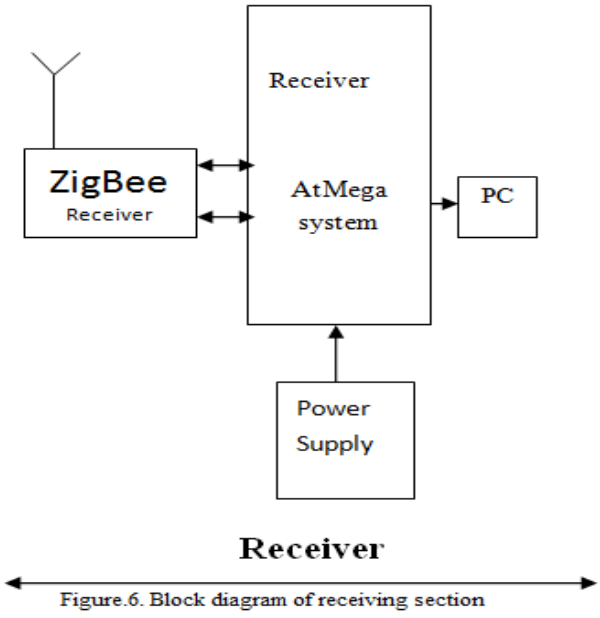

Figure.6. Block diagram of receiving section

9.RESULT

The output below displayed on a distant host computer which is placed nearly 15 meters away from the guest computer. The output reading displayed at the rate of 1 second. The readings shows the body temperature in degree centigrade and heart rate of the patient in pulse per minute. This data can be send to other different computer systems using WLAN.

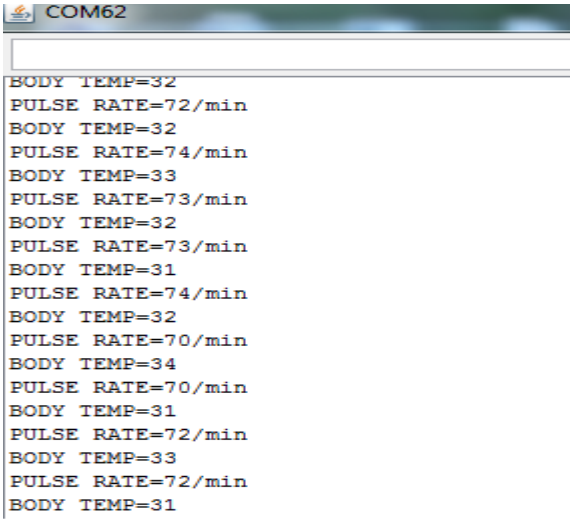

Figure.7.Output on distant host computer

10. CONCLUSION

In this paper, we have presented the research, of applied nature, done to monitor physiological parameters such as skin temperature, heart rate.

A prototype was successfully developed and tested to establish the proof of concept. The readings were tested and found to be accurate and reliable at this developed/development stage.An important aspect of the design was miniaturization, so that the system was as nonintrusive as possible to the wearer. This was achieved by the use of surface-mounted devices on the PCBs designed. Low-power operational amplifiers were used in ZigBee to minimize battery consumption. The major cost comes from the use of ZigBee modules in the current design.With some modification, the system can be made available commercially.The design of the LDR sensors could be improved to decrease its susceptibility to noise,

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