International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Continuous Health Monitoring System for Patients Using IoT

Mr. Y Jeevan
Asst. professor Dept of ECE
Guru Nanak Institute of Technology,
Hyderabad, India.
yjeevanece@gmail.com

P Meghana, V S S Lalitha, S Balaji
Dept of ECE
Guru Nanak Institute of Technology
Hyderabad, India

Abstract

Internet of Things (IoT) can be used to monitor health conditions of patients after major surgeries. Information from various sensors is processed by PIC16F877A microcontroller which sends data to GSM Networkwith the help of IoT module. A relay is used to switch between IoT module and GSM module based on the output voltage of the sensors. The data transmitted from the microcontroller is stored on the cloud for long term storage and access. The address of the webpage used should be configured in the IoT module. Alert signal is sent to caretaker in case of emergency. This system is easy to setup with low power consumption and high performance. This system uses GSM network so can beused even in rural areas where broadband facility is not available.

1. Introduction

In today's world it is very difficult to carry patients from home to hospitals for regular checkup. There are lot of challenges like waiting in the queue, travelling time and patient may be prone to various infections moving in this polluted environment. So the health care industry is focussing on in-home health care services where the patient can undergo medical check-ups in the comfort of his home environment. Health care industry is working together with Information and communication technology industry to develop models that reduces the time consumption, increasing accuracy and interoperable on any platform that can be beneficial to both hospitals and patient[1]. Nowadays Internet of Things is attaining development on a rapid pace and experts estimate that about 50 billion devices will be connected to the internet by 2020. It is a technology in which all the devices like vehicles, buildings, sensors etc. are connected to the internet through the existing infrastructure.

Biotelemetry is the electrical technique for conveying biological information from a living organism and its environment to location where the information can be observed or recorded. A wireless health monitoring device will be attached to the patient and physicians can monitor the patient from anywhere across the world2. Typically the patient health monitoring system con- sists of various sensors that measure the physiological information from the patient and transfer them to the microcontroller as electrical signals. The microcontroller processes this physiological data and transmits them to associated website that is linked to the IoT module. The doctor or the care taker can access the website by typ- ing the unique id given to the patient. As we are storing the data in the cloud it can be accessed anywhere, any- time over the internet. The patient need not carry all the medical reports for the check-up. The doctor can directly access the medical reports by typing the patient's id on that website.

In the existing system the transmission of data received from sensors is intermittent. If any critical parameter is recorded it sends an alert message through GSM technology to the registered caretaker. There is a drawback in the existing system is that the continuous monitoring of patient health is not possible. Even though the patient is taken to the hospital in time the doctor may not come to conclusion with which critical health condition the patient has comeback without further testing of patient. Hence it is a time consuming process.

*Author for correspondence

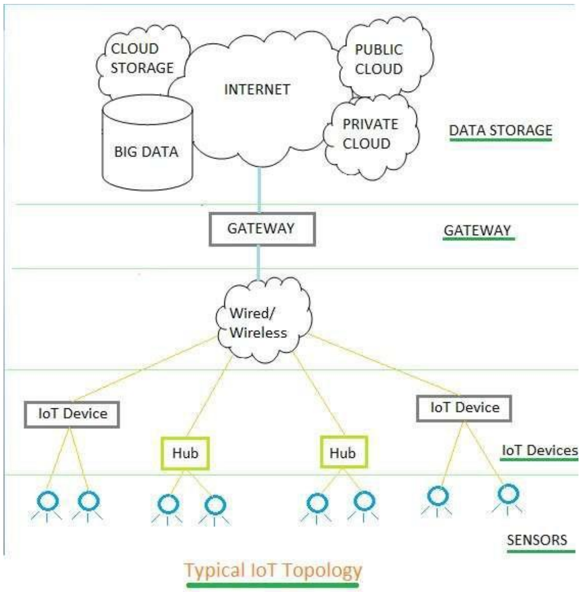

Figure 1. Typical IoT topology.

2. Methods and Materials

IoT based devices can exchange information with each other and are uniquely addressed and identifiable anytime and anywhere using the Internet. Remote health monitoring systems using IoT based devices can automatically exchange information with health institutes through the Internet. Aautomatic alarm can be sent to the nearest healthcare institute in the event of a critical accident for a patient.

2.1 Hardware and Software Description

The Hardware and software used in designing our project are described below.

2.1.1 Power Supply Unit

PIC16F877A works on 5 V DC power supply. The power supply for domestic applications is about 230 V AC. This 230 V AC supply is step down to the required 5 V using an IC7805 voltage regulator. The power supply setup consists of a transformer whose primary coils are connected to the mains supply. The secondary of the transformer is connected to the bridge rectifier and is step down to 12 V DC supply. The efficiency of bridge rectifier is high. But the output of the bridge rectifier is not exactly a DC signal and it contains ripples. A capacitor is connected to the diode so as to filter the ripples present in the output and a pure DC signal is obtained. The output can be further reduced to 5 V using 7805 voltage regulator.

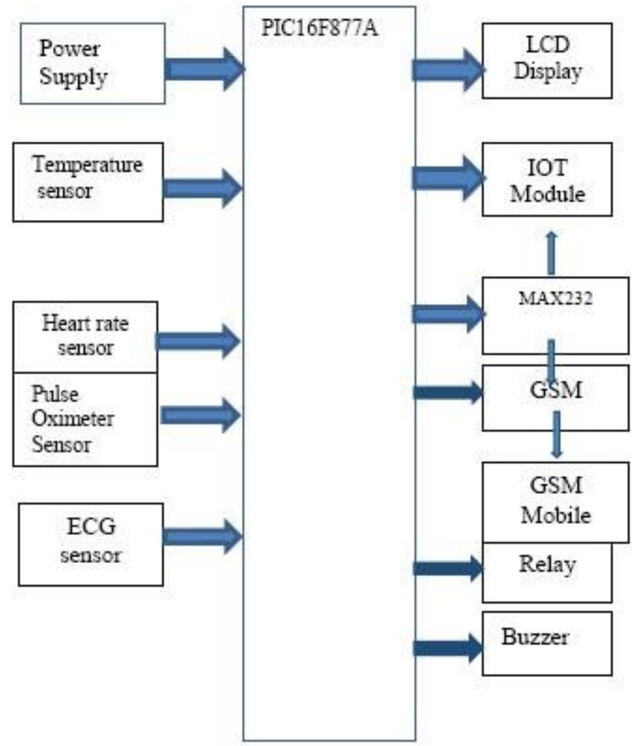

Figure 2. Architecture of health monitoring system based on IoT.

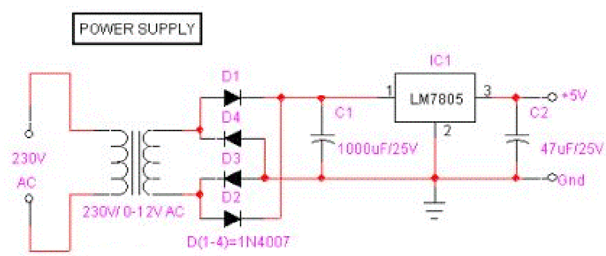

Figure 3. Circuit diagram of power supply system.

2.1.2 PIC16F877A Microcontroller

PIC16F877A microcontroller is 8-bit microcontroller. It consists of 40 pins in dual in line package and works on CMOS technology. It has 8 channels of Analog to Digital converter. It consists of analog comparator module with two analog comparators, programmable on-chip voltage reference (Vref) module. It supports incircuit serial programming via two pins. It has Watch Dog Timer (WDT) with its own on-chip RC oscillator for reliable opera- tion. It supports power saving sleep mode. It has fully static design and operating voltage range between 2 Vto 5 V[3].

2.1.3 Temperature sensor

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The output of this temperature sensor is calibrated in centigrade. It operates in the range of 4-30 V and suitable for low power consumption applications. It exhibits an accuracy of 0.5^0C at 25^{o}C and operates between -55^{o}C to 150^{o}C. The linear scale factor is about 10 mv/^{o}C[4].

The general equation used to convert output voltage to temperature is: Temperature (1^{o}C) = V (out)* (100^{o}C/V) so if V (out) is 1V, then Temperature = 100^{o}C[5].

2.1.4 Pulse Oximeter Sensor

A pulse oximeter is a non-invasive device used to measure the oxygen carrying capacity of hemoglobin, instead of measuring directly from blood sample. It is very help-ful for continuous measurement of oxygen saturationof blood. The pulse oximeter may be incorporated intoa multi-parameter patient monitor. Most monitors also display the pulse rate.

2.1.5 ECG Sensor

The ECG sensor attached to the patient measures electrical activities of heart over a period of time. The sensor out-puts are converted to digital signal. The data acquisition is carried out using microcontroller and is transmitted through IoT module.

2.1.6 Heart Beat Sensor

Heart beat sensor uses a pair of LED, LDR and microcontroller[6,7]. Light is passed using LED from one side of the finger and intensity of light is measured on the other side using an LDR. As the heart rate increases intensity decreases. As a result there will be a change in resistance value of LDR. The output voltage is amplified and detected using microcontroller.

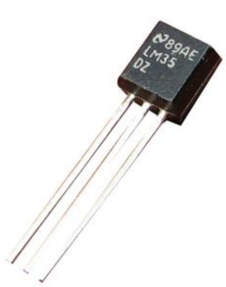

Figure 4. Temperature sensor.

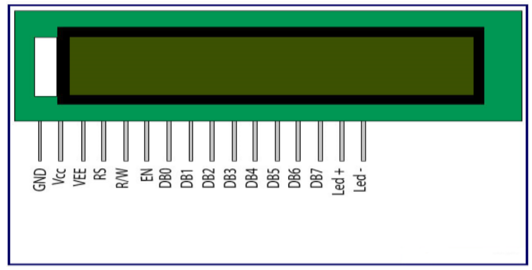

Figure 5. LCD module.

2.1.7 LCD Display

A 16X2 display module is employed to display 16 characters in 2 rows. LCD has two registers namely command and data. The command instruction stores the command instructions given to LCD. Data register stores data to be displayed on LCD. It has totally 16 pins. 8 Bi-directional data pins D7-D0.3 control lines RS, RW, EN.VCC-power supply, VEE-Contrast Adjustment, Ground, Backlightled (0 V) and Backlight LED (5 V). The data that is being transmitted can be read from LCD module.

2.1.8 MAX 232

MAX232 is an essential component in serial communica-tion. It is used to convert the CMOS logic levels to RS232 levels and vice versa[8,9]. It acts as a bidirectional driver/ receiver circuit. It reduces the noise and prevents from external short circuits. It operates at a speed of 120 kbits/s. It supplies a very low current of 8 mA.

2.1.9 GSM Module

A GSM module is a communication medium used for sending or receiving the data over the existing mobile architecture. It operates on a 5 V power supply. A sim-card of any cellular operated should be inserted in it and the charges are levied on the user for availing the services provided by the cellular operator. It is operated on frequencies like 800/900/1800/1900 MHz. It can be interfaced with the computer or microcontroller through attention commands. The data can be transmitted as SMS or MMS and voice messages. We can also avail internet access with the help of GSM/GPRS module. It supports various software features such as FTP/HTTP, SSL, TCP/ UDP protocol and jamming detection.

2.1.10 IoT Module

Iota module is useful for the transmission of data collected from the sensors to the internet by using Hyper

Text Transfer Protocol (HTTP) through a GSM modem. The data is displayed over a webpage which can be viewed from anywhere all over the world. The data collected from this is stored on the cloud for continuous monitoring of patient health over a long period of time.

2.1.11 Relay

Anything connected to the 220 V mains supply can be switched on and off by using a relay enabled low voltage circuit. Here we are using JQC-3FC (T73) DC12V in our project. The typical usage of relay in our project is to switch the power supply between the Iota module and GSM module.

2.1.12 Buzzer

A piezoelectric buzzer is an electrical device which produces sound on the arrival of input voltage signal. This is used to alert the care taker in case of emergency condition.

2.1.13 Programming using Embedded C

Code speed of embedded programs is governed by processing power and timing constraints. Code size of embedded programs is governed by program memory and use of programming languages. Processing power and memory is limited in embedded devices.

2.1.14 MPLAB IDE

MPLAB Integrated Development Environment (IDE) is a free, integrated toolset for the development of embedded applications employing Microchips PIC microcontrollers. MPLAB IDE runs as a 32-bit application on Microsoft Windows, is easy to use and includes a host of free software components for fast application development and super-charged debugging. It supports various programming languages like embedded c and java. It has a graphical project manager.

Figure 6. IOT module.

2.2 Configuration

2.2.1 PIC Microcontroller

The PIC microcontroller is placed on a PIC development board. Power supply system is connected to it and all the necessary code for accessing various features like analog to digital conversion (ADC), USART, LCD for accessing the sensors are written in embedded C language in MPLAB and is loaded into PIC controller using PIC KIT 3.

2.2.2 Sensor Interfacing

All the required four sensors are connected to the general purpose input/output pins of Pic microcontroller. Each sensor is given a particular threshold value.

2.2.3 IoT Module

The PIC microcontroller transmitter pin (RC6/TX) is connected to the IoT module receiver pin (RX). A sim card has to be inserted into the module so that it can access the mobile network of that particular network operator. The IoT module has a Leds that glow on receiving the signal from the mobile network and indicates whether the strength of the signal is strong or weak. The PIC microcontroller is connected to this IoT module using RS232 cable. It has an antenna pad. The website address in which the results have to be displayed has to be linked to the IoT module.

2.2.4 LCD and Buzzer

LCD and buzzer are connected to the GPIO pins of PIC microcontroller.

2.2.5 Relay

In this project the relay driver is connected to the GPIO pins of the microcontroller, IoT module and GSM modem. It switches the power supply between IoT module and GSM modem based on the delay time set in the microcontroller. Because of this the results gets updated in the internet and the message is sent to the registered mobile number.

2.3 Working

2.3.1 Data Acquisition

Data acquisition is carried out by the sensors that measure the various physiological data and carries these bioelectrical signals to the microcontroller.

2.3.2 Data Transmission

Typically the data collected by the microcontroller is transmitted to the internet using IoT module and an SMS can be sent to the caretaker if any critical parameter is recorded. The mobile number of the caretaker is written in the program. Individual sensor's data can be accessed via computer or mobile connected to internet.

2.3.3 Cloud based Processing

Diagnoses and prognosis of a number of health conditions and diseases can be done using the sensor data. Long term storage of patient's health information can be done and the health information can be accessed using internet. In this project we are displaying the results in the website www.iotclouddata.com.

3. Results

In the Figures 7-10 we have shown the software simulation of sensors used in our prototype using proteus 8 ISIS software. The code has been written in MPLAB and tested in proteus.

We have fixed a particular threshold value for each sensor and if there is any change in the reading it dis- play the abnormality in the LCD screen, updates in the internet and sends SMS to the care taker and sounds the buzzer. The following Tables 1-4 indicates the thresholdvalues used for sensors and changes found during soft- ware simulation. We have also successfully implemented

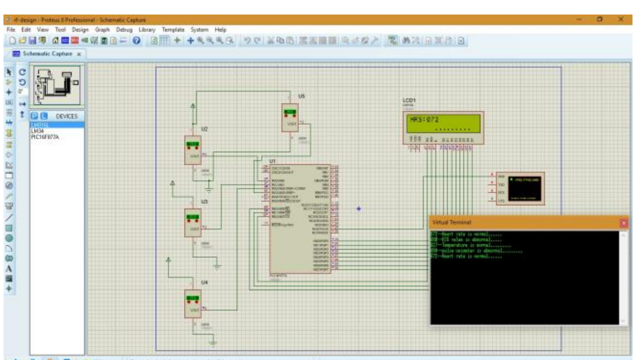

Figure 7. Simulation of heart rate sensor.

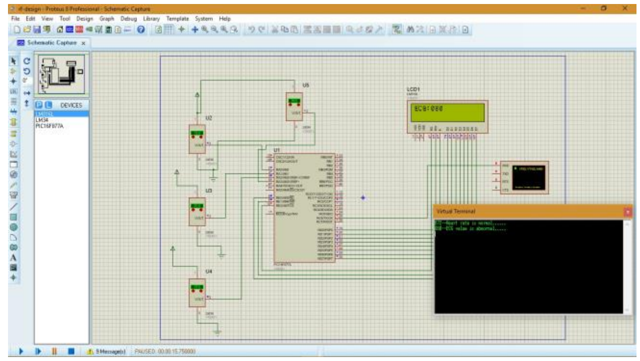

Figure 8. Simulation of ECG sensor.

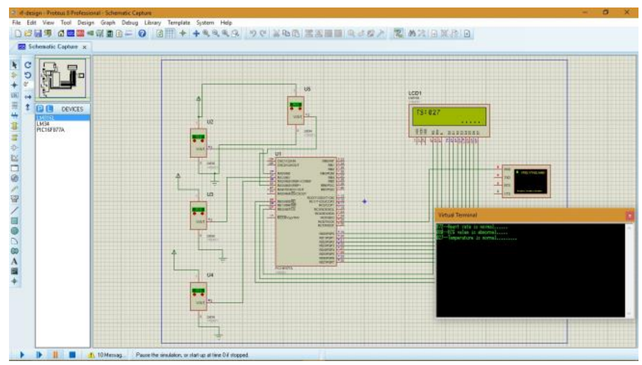

Figure 9. Simulation of temperature sensor.

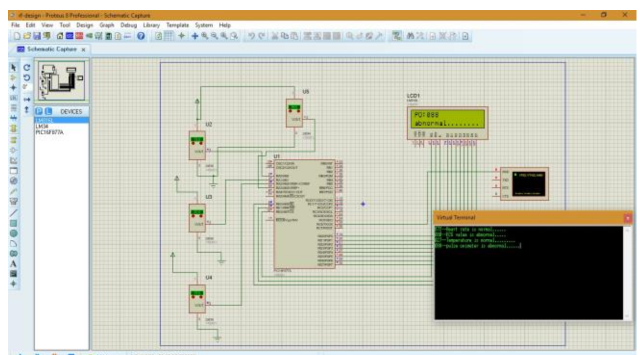

Figure 10. Simulation of pulse oximeter sensor.

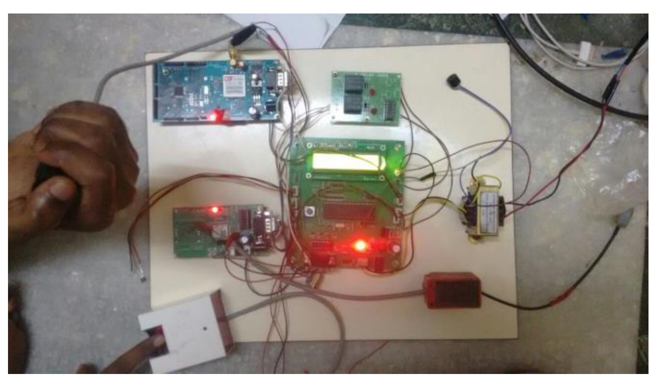

Figure 11. Working model of health monitoring system.

the hardware prototype of our project as shown in Figure 11. The results were displayed in the internet as shown in Figure 12 and SMS has been sent to the care taker as shown in Figure 13.

102	HB_036	05/03/2016	06:47:11
103		05/03/2016	06:47:53
104	HB_037	05/03/2016	06:48:26
105	TEMP_024	05/03/2016	06:49:00
106	HB_037	05/03/2016	06:49:35

Figure 12. Results of patient health condition displayed in the website www.iotclouddata.com.

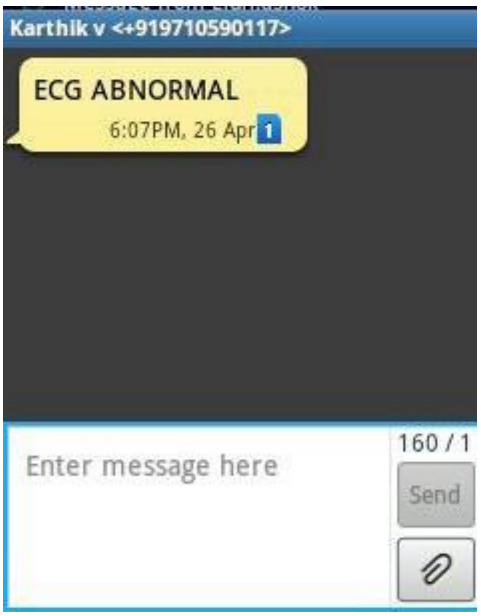

Figure 13. Emergency SMS sent to the caretaker.

Table 1. Characteristics of heart rate sensor

Heart beat sensor	Characteristic
Greater Than 90	Abnormal
Less than 90	Normal

Table 2. Characteristics of ECG sensor

ECG sensor	Characteristic
Greater than 60 bpm	Normal
Less Than 60 bpm	Abnormal

Table 3. Characteristics temperature sensor

Temperature	Characteristic
Greater than 42^0C	Temperature is High
Less Than 42^0C	Temperature is Normal

Table 4. Characteristics of pulse oximeter sensor

Pulse Oximeter Sensor	Characteristic
Greater Than 90	Normal
Less Than 90	Abnormal

4. Conclusion

In this model the continuous monitoring of patient can be achieved by collecting the physiological information from various sensors, processing them using PIC micro-controller, transmitting the data through GSM and IoT module and storing the results in the internet you can access the data anywhere and there is no problem even you forgot any report while consulting a physician. He can access the details by typing the particular id given to the patient.

The future scope of this project is to integrate all the sensors into single chip by the use of fabrication in nano-scale and by making it as bio patch that can be attached to the skin and transmit the data through wireless medium, so that the mobility of the patient increases.

5. Acknowledgement

We would like to express our gratitude to our project in-charge Mrs. K. Haripriya for guiding us in publish- ing this paper and helping us in successful competitionof project.

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