

IoT Based Patient Health Monitoring System Using LabVIEW and Wireless Sensor Network

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Abstract: Patient Health Monitoring is the one of the field that is rapidly growing very fast nowadays with the advancement of technologies many researchers have come with different designs for patient health monitoring systems as per the technological development. With the widespread of internet, Internet of things is among of the emerged field recently in which many have been able to incorporate it into different applications. In this paper we introduce the system called Iot based patient health monitoring system using LabVIEW and Wireless Sensor Network (WSN). The system will be able to take patients physiological parameters and transmit it wirelessly via Xbees, displays the sensor data on LabVIEW and publish on webserver to enable other health care givers from far distance to visualize, control and monitor continuously via internet connectivity.

Keywords: Iot, Temperature Sensor, Heartrate Sensor, ECG, WSN, GUI

1. Introduction

With rapid development of economies, growth of aging population and the prevalence of chronic diseases across the world, there is an urgent need to find new ways to improve patient outcomes, increase access to care, and reduce the cost of medical care. Advancements in sensor technology, the ubiquitous availability of cellular technology, and falling costs of embedded communication devices are opening up new channels for improving patient care and quality of life. A health care monitoring system is necessary to constantly monitor patient's physiological parameters. The tele-medical system focuses on the measurement and evaluation of vital parameters e.g. temperature, electrocardiogram (ECG), heart rate variability, fall detection etc. This project presents a monitoring system that has the capability to detect the specific abnormality of cardiac function, measure the temperature of patient instantly, measure the heartbeat rate and will have the capability of notifying the doctor by messaging him/her if the current health condition of the patient is abnormal. The system can analyze the signal detect the normal or abnormal conditions like arrhythmia and with the help of Arduino Mega and LabVIEW, the signals from all sensors will be processed using Arduino Mega and transmitted wirelessly using Xbee, at the receiving end the signals are received on receiver Xbee and get processed and viewed on LabVIEW. On LabVIEW the signals are viewed and sent to web server via LabVIEW web publishing tool. The main advantage of this system is the result can be viewed at any time at any place and the doctors can be notified using mobile phones messages if patient health is abnormal. Also this project will enable doctors and care givers to observe patients without having to be physically present at their bedside, be it in the hospital or in their home [3].

2. Related Approaches

Several comprehensive reviews about the subject of health monitoring with wearable sensors have been previously presented in the literature. Many such reviews focus on

giving a global overview of the topic. Studies on health monitoring systems include wearable, mobile and remote systems [2]. One of the related approach was automatic wireless health monitoring system where by an automatic wireless health monitoring system was used to measure patient's body temperature and heartbeat by using embedded technology. The system was using both the sensors like heartbeat sensor and temperature sensor.

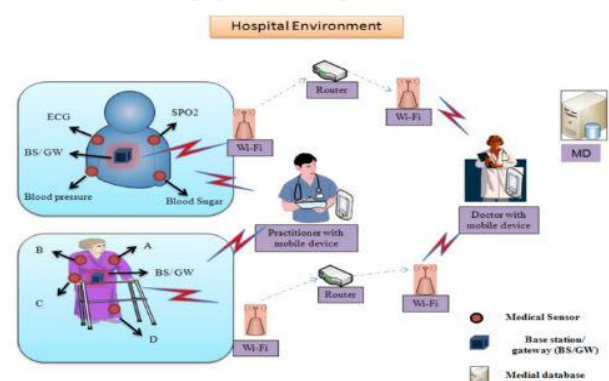


Figure 1: Automatic wireless health monitoring system block diagram

The second related work was a Hospital Healthcare Monitoring System Using Wireless Sensor Networks. In that system a coordinator node has attached on patient body to collect all the signals from the wireless sensors and sends them to the base station. The attached sensors on patient's body form a wireless body sensor network (WBSN) and they are able to sense the heart rate, blood pressure and so on [5]. The system was able to detect the abnormal conditions, issue an alarm to the patient and send a SMS to the physician.

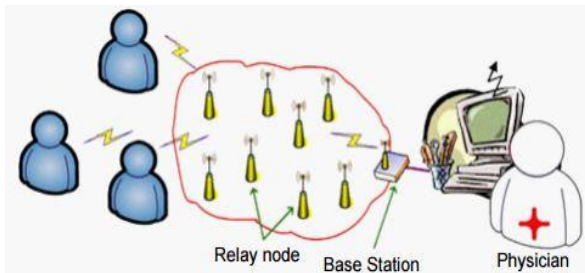


Figure 2: A hospital healthcare monitoring system using wireless sensor networks block diagram

3. Proposed System

The proposed system consists of two major parts Hardware and Software.

3.1. Hardware

The hardware part comprises two big sections transmitter and receiver section.

a) Transmitter section

The transmitter section consists of analog sensors to measure patient physiological parameters, Arduino Mega 2560, Heart rate amplifier circuit, ECG amplifier circuit, I2C LCD 2004 display, GSM modem to alert the care givers, power supply and Xbee module to transmit signals from transmitter to receiver section. Below is the transmitter block diagram of the proposed system.

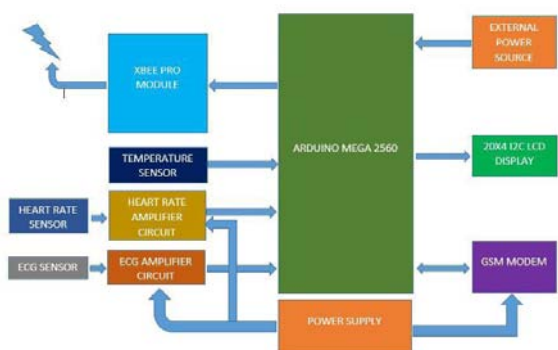


Figure 3: Transmitter section block diagram

b) Temperature Sensor LM35

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With **LM35**, temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1 °C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every °C rise/fall in ambient temperature, i.e., its scale factor is 0.01V/°C. The LM35 has been used to measure human body temperature and pin 2 OUT connected to Arduino mega 2560 analog pin A0.

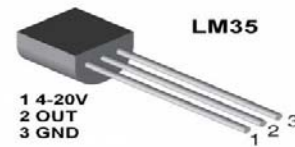


Figure 4: Temperature Sensor LM35

c) Heart rate sensor and heartrate amplifier circuit

The heartrate amplifier circuit consist amplifier and fingertip sensor/heart rate sensor. In which the heartbeat is measured with the help of fingertip sensor which consists of an infra-red (IR) light emitting diode transmitter and an IR photo detecting receiver. The photodiode detects the infra-red light reflected by the finger. It detects the variation in the blood volume with respect to the heartbeat and finally generates a pulse at the output of the photodiode. The signal produced from photodiode is very weak and small which is required to be increased in magnitude. This signal is very weak that it cannot be detected by the Arduino mega 2560 microcontroller directly. Thus, the signal is amplified using an operational amplifier. The operational amplifier used for this purpose is LM324. The output of the amplifier circuit is send directly to Arduino mega 2560 microcontroller analog pin A1 for further processing.

Calculating heartrate: Formula used

$$P5 = t2 - t1$$

$$P1 = P5 / 5$$

$$\text{Rate} = 60000 / P1;$$

Where t1 is first pulse counter value t2 is list pulse counter value, P5 is five pulse counter and P1 is single pulse counter

Rate is final heart rate

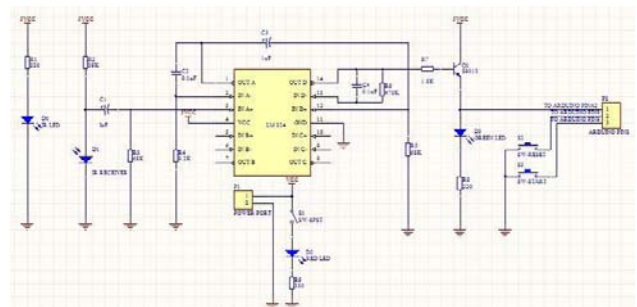


Figure 5: Heart rate amplifier circuit designed on altium designer software

d) ECG sensor and ECG amplifier circuit

Electrocardiography (ECG/EKG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on the skin. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle's electro physiologic pattern of depolarizing and repolarizing during each heartbeat.

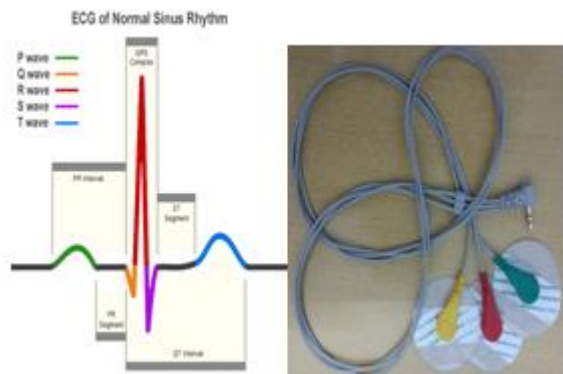


Figure 6: ECG waveform of normal sinus rhythm and ECG Sensors

The amplifier circuit has been used to amplify the signal coming from electrodes placed to patient during measurements. The operational amplifier used for this circuit is LM324. First LM324 has been used at the pre amplifier stage and the second LM324 used at the post amplifier stage. The amplified signal output from this circuit is sent directly to Arduino mega 2560 pin A2 for further processing. The circuit was designed on altium designer software and tested on multisim software. Below is the circuit diagram of ECG amplifier circuit.

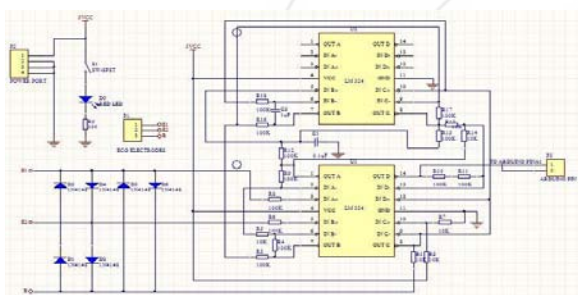


Figure 7: ECG amplifier circuit designed on altium designer software

e) Power Supply Circuit

The power supply circuit designed is to help to power the heart rate circuit, ECG circuit and GSM modem. The input of the power supply ranges 9-18Vdc and the output is 5Vdc. The regulator LM7805 has been used to regulate the voltage for this purposes. The power supply or external power source has been used to power the Arduino mega 2560 too so there is no need to worry about it because the Arduino boards normally has inbuilt power supply with regulating circuitry.

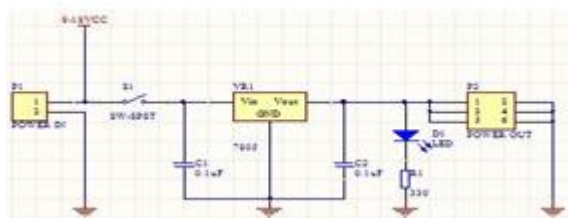


Fig 8: Power Supply circuit designed on altium designer software.

f) Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. The Mega 2560 has more memory and

more I/O pins than any other Arduino. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.



Figure 9: Arduino mega 2560 board

g) GSM/GPRS Modem

GSM/GPRS module is a breakout board and minimum system of SIM900 Quad-band/SIM900A Dual-band GSM/GPRS module. It can communicate with controllers via AT commands (GSM 07.07, 07.05 and SIMCOM enhanced AT Commands). This module supports software power on and reset. The module has been used to alert the care givers in casethe temperature or heart rate of the patient is abnormal.

Features of the module:

- Quad-Band 850/ 900/ 1800/ 1900 MHz
- Dual-Band 900/ 1900 MHz
- GPRS multi-slot class 10/8GPRS mobile station class B
- Compliant to GSM phase 2/2+Class 4 (2 W at 850/ 900 MHz)
- Class 1 (1 W at 1800/1900MHz)
- Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands)
- Low power consumption: 1.5mA(sleep mode)
- Operation temperature: -40°C to +85 °C



Figure 10: GSM/GPRS module

h) ZigBee or Xbee modules

This is the very popular 2.4GHz XBee XBP24-AWI-001 module from Digi. The Pro series have the same pinout and command set of the basic series with an increase output power of 60mW. These modules take the 802.15.4 stack (the basis for ZigBee) and wrap it into a simple to use serial

command set. These modules allow a very reliable and simple communication between microcontrollers, computers, systems, really anything with a serial port. Point to point and multi-point networks are supported. This module has been used to both side transmitter section and receiver section.

Features of the xbees module:

- 3.3V at 215mA
- 250kbps Max data rate
- 60mW output (+18dBm)
- 1 mile (1500m) range
 - Built-in antenna
 - Fully FCC certified
 - 6 10-bit ADC input pins
 - 8 digital IO pins
 - 128-bit encryption
 - Local or over-air configuration
 - AT or API command set

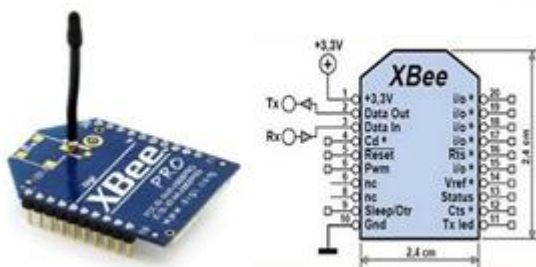


Figure 11: XBee module and Xbee pinout

i) I2C LCD2004 Display

I2C LCD2004 module is a cool LCD with a high speed I2C serial bus. With this I2C interface LCD module, you only need 2 lines (I2C) to display the information. It is a monochromatic 20x4 alphanumeric LCD. 20x4 means that 20 characters can be displayed in each of the 4 rows of the 20x4 LCD, thus a total of 80 characters can be displayed at any instance of time. The display has been used to show the heart beat rate and temperature of the patient. The blue electronic item or variable resistor used to adjust the light intensity to the LCD screen.



Figure 12 (a): I2C LCD 2004 front view



Figure 12 (b): I2C LCD 2004 backside view

j) Receiver section

The receiver section consists of receiving Xbee module, Usb-Xbee FTDI connector and PC/Laptop acting as a server. The physiological parameter signals are received and visualized on LabVIEW then published to webserver to enable far distance care givers to visualize via internet connectivity.

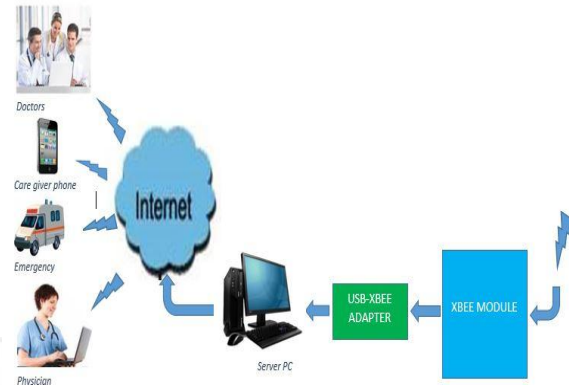


Figure 13: Receiver section block diagram

k) USB-XBEE adapter board

This is a low cost XBee USB Adapter Board comes in partially assembled kit form and provides a cost-effective solution to interfacing a PC or micro-controller to any Xbee or Xbee Pro module. The PC connection can be used to configure the XBee Module through Digi's X-CTU software. Works with XBee series 1 and 2 as well as Pro modules. The Xbee is placed on top of this module below and the Usb wire connected to the PC Usb port.

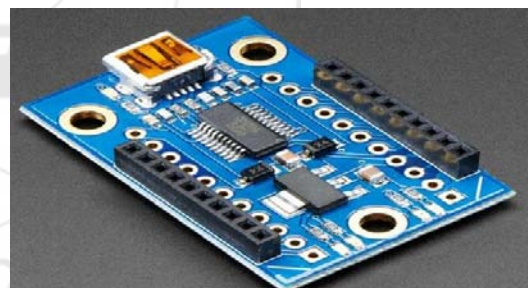


Figure 14: Usb-Xbee adapter board

l) The Server PC/Laptop

The signals received then observed on the designed LabVIEW Graphical User Interface (GUI). Temperature, heart rate and ECG waveform of the patient is visualized by care giver. The signals then sent to webserver to enable far distance physicians and doctors to observe them too.

3.2 Software

The software's used to accomplish this work are XCTU-software, Arduino IDE software and LabVIEW.

a) XCTU-Software

XCTU is a free, multi-platform application compatible with Windows, Mac-OS and Linux. It is designed to enable developers to interact with Digi RF modules through a simple-to-use graphical interface. It includes new tools that

make it easy to set-up, configure and test XBee/RF modules. API Frame Builder is a simple development tool for quickly building XBee API frames. XCTU software has been used to configure the Xbee modules so that they can communicate each other wirelessly.

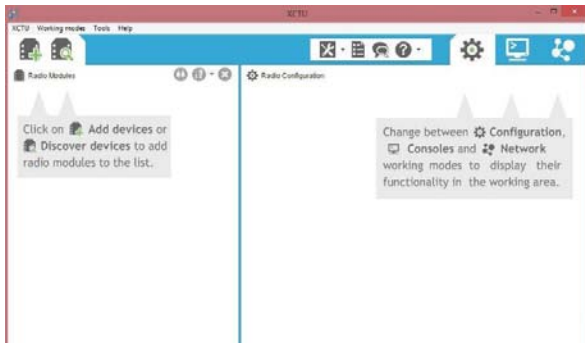


Figure 15: XCTU-Software panel

b) Arduino IDE Software

The Arduino IDE is a cross platform developer tool written in Java. It allows you to control all of the software functions of your Arduino. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino.

The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

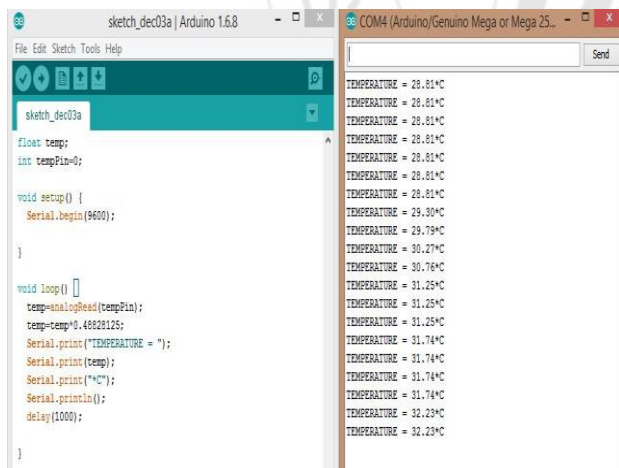


Figure 16: Arduino IDE Software

c) LabVIEW Software

LabVIEW is an integrated development environment designed specifically for engineers and scientists building measurement and control systems. With a native graphical programming language, built-in IP for data analysis and signal processing, and an open architecture that enables integration of any hardware device and any software approach. LabVIEW is the software you need to build the optimal solution that can meet your custom requirements and solve the challenges at hand. LabVIEW integrated

development environment has two window view front panel and block diagram.



Figure 17: LabVIEW icon

d) LabVIEW Web Publishing Tool

LabVIEW Software has its own Web publishing tool in which the design created can be published on webserver to enable other viewers to access it with the help of internet connectivity, the viewers from far distance they should have the link in order to help them visualize the data obtained. It has three options as explained below

- The **Embedded** option embeds the front panel of the VI so clients can view and control the front panel remotely using a browser. The VI must be in memory on the server computer so clients can view and control the front panel.
- The **Snapshot** option displays a static image of the front panel in a browser. **Snapshot** does not allow you to interact with the controls of the VI from the browser.
- The **Monitor** option displays an animated snapshot that updates continuously. **Monitor** does not allow you to interact with the controls of the VI from the browser.

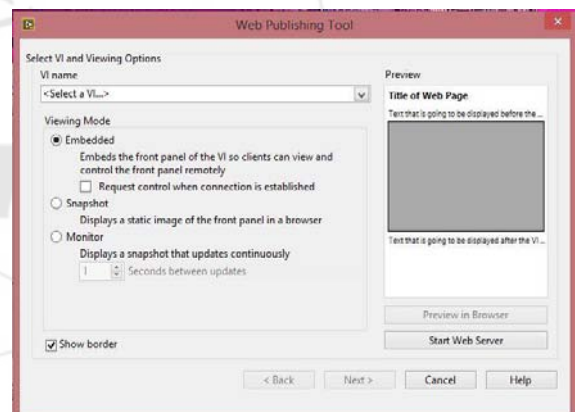


Figure 18: LabVIEW Web Publishing Tool

4. Significance of the Research

The importance of this research to the society are as follows,

a) Benefits for patients

1. Improved health outcomes and quality of life especially for aging population.
2. Real-time support and interventions.
3. Extension of care at home after discharge, helping to prevent emergencies and re-admissions.
4. Reduced hospital stays.

b) Benefits for Care providers and public health authorities

1. Access to increased frequency of patient health data.
2. Ability to continue monitoring patient health, regardless of patient's location, even when not at home.

3. Support an increased level of accuracy for clinical monitoring readings, particularly readings that would otherwise be provided by the patient themselves.
4. Increase the level of trust and reliance that physicians place in data. This is particularly important when there are a few outlying readings, which may potentially indicate an underlying problem, but which might be attributed to errors in measurement.
5. Reduced costs from re-admissions and reduced hospital stays.

c) Benefits for Insurance Payer's

1. Better visibility on patient compliance practices
2. More accountability from patients and care providers
3. Reduced costs of care

5. Results and Discussion

The result from this research was successfully obtained temperature of the patient, ECG and heart rate. Whenever there is an increase of patient body temperature and heartbeat rate the authorized care givers get message so that they can take some immediate measures. Below are some results obtained and can be visualized on GUI created on LabVIEW and also far distance physicians can see also with help of internet but they should have link to access it. The LabVIEW GUI was designed on LabVIEW 2014.



Figure 19: LabVIEW GUI

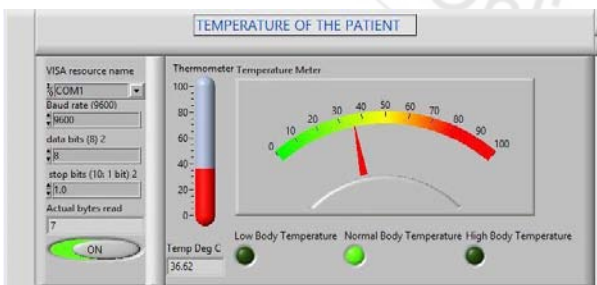


Figure 20: Cropped LabVIEW GUI displaying the temperature of the patient taken was 36.67 degree centigrade and it is normal human body temperature

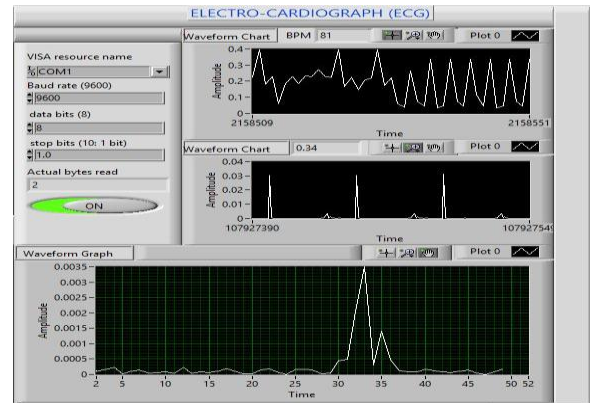


Figure 21: ECG measurements of the patient the BPM shows he has 81 which is normal to the human blood pressure per minute.

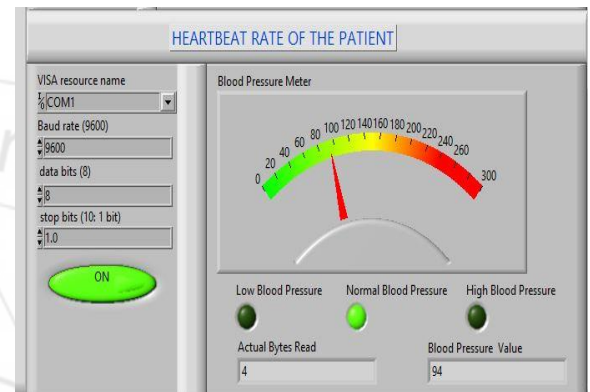


Figure 22: Heart rate of the patient shows 94 blood pressure value and green led is on indicating it is normal blood pressure

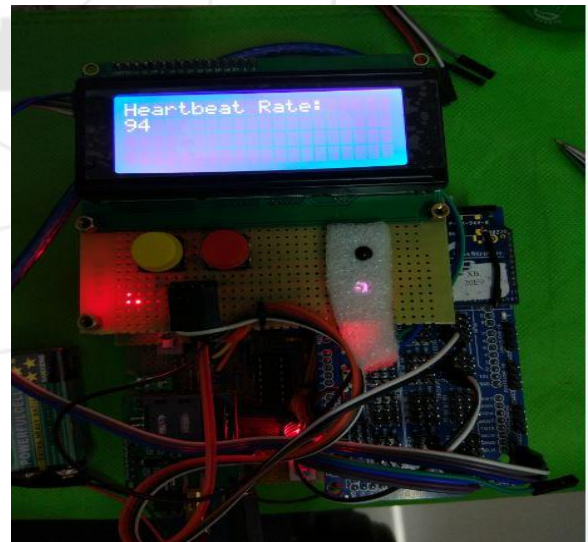


Figure 23: Transmitter section, I2C LCD 2004 displaying the heart beat rate of the patient is 94

6. Conclusion

In conclusion we can say, patient monitoring systems are very useful tools to enable monitoring patient health much attention to the development of this topic should be taken into consideration in order to enhance access to care and improve patient health. This project can be developed by increasing number of sensors so that all physiological

parameters can be observed instead of some few that I managed to work on it.

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Technology and Education. He made the experiment on devices controlled by single chip computer and FPGA a few years ago, and a lot of them have been sold to another University. He also likes to do research on automatic control system and "The Internet of Things". His research interests are on Digital image processing, Embedded systems, Digital signal processing and Radio Frequency Identification.

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