BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE416(January 2022) B1
Microprocessor and Embedded Systems Laboratory

Final Project Report

Biomedical IoT Device for Self-Monitoring Applications

Evaluation Form:

STEP	DESCRIPTION	MAX	SCORE
1	Report (Format, Reference)	10	
2	Design Method and Complete Design (Hardware Implementation)	15	
3	Video Demonstration	10	
4	Novelty of Design	15	
5	Project Management and Cost Analysis	10	
6	Considerations to Public Health and Safety, Environment and Cultural and Societal Needs	10	
7	Assessment of Societal, Health, Safety, Legal and Cultural issues relevant to the solution	10	
8	Evaluation of the sustainability and impact of designed solution in societal and environmental contexts	10	
9	Individual Contribution (Viva)	20	
10	Team work and Diversity	10	
	TOTAL	120	

Signatureof Evaluator: ____

AcademicHonestyStatement:

IMPORTANT!Please carefully read and sign the Academic Honesty Statement, below.Type the student ID and Write your name in your own handwriting. ***You will not receive credit for this project experiment unless this statement is signed in thepresenceofyourlabinstructor.***

"Insigningthisstatement,Weherebycertifythattheworkonthisproject isour ownand that we have not copied the work of any other students (past or present), and cited all relevant sources while completing thisproject.We understand that if we fail to honor this agreement, We will each receive a score of ZERO for this project and be subjecttofailure of this course."

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1 Abstract

With the increase in medical expenses in our country, it is becoming increasingly difficult to ensure medical help to everyone. The development of IoT devices can mitigate this issue. The once expensive sensors are becoming more and more affordable day-by-day. Our objective is to make a device that can provide some important health parameters at a cheap rate without going to the hospital.
This report presents the design and implementation of a health monitoring system using the Internet of things (IoT).This system can deliver a working prototype that can accurately and reliably track a person's some health parameters such as patient's body temperature, heartbeat, and oxygen saturation (SpO2) levels, ECG stats, blood pressure etc.This device can also able to send an email/SMS alert whenever those readings go beyond critical values. These measured readings are recorded over Thing Speak and Google sheets so that patient health can be monitored from anywhere in the world over internet. The parameters will be shown in a mobile app and the data will be saved for further monitoring. A panic has also been attached so that patient can press it on emergency to send email/SMS to their relatives. The main objective of this project to increase affordability for regular people. Besides sustainability in the context of finance, patients will have easy access to personal healthcare.

2 Introduction

Biomedical Signals play an essential role in IoT-based Healthcare monitoring systems. The integration of these different signals allows us to a better healthcare monitoring system and detect other health-related issues. Healthcare IoT is predominantly a resonant concept in medicine to connect a person, device, or virtually any place as it evolves to change the very concept of care. Healthcare with IoT and remote patient monitoring has transformed healthcare during the past few decades due to the field's technological revolution. The application of IoT in the medical domain, referred to as the Internet of Medical Things (IoMT) paved the way for telemedicine, telecare, and remote health services. It encompasses the collection of various medical devices, systems, or applications that can connect to a computer network and further comprising of the collection of health data, its analysis, and transmission through the Internet in consort with connected medical devices and medical applications.The future of IoMT has potential as a result of cloud computing that allows connected devices to store the data on the cloud in order to provide uninterrupted availability, thus opening new opportunities in the field of healthcare. Further, IoMT is the first generation of wireless healthcare IT systems and thus is an essential milestone in developing smart healthcare systems and medical devices. The various IoMT applications in hospitals and clinics include intelligent apps to connect patients and doctors in remote locations.
There are several technological solutions for remote patient monitoring (RPM) that offer various services and devices. Resultantly, RPM gains traction in the front line of healthcare with the introduction of IoMT technologies. When a doctor monitors patient remotely using IoT based medical devices, there is enhanced scope for specialized and tailored treatments. This is achieved as a result of enhanced access to remote patient data in the future.

3 Design

For better visualization we can present our design by dividing some part that is given below-

- **Input**: In our design different kind of sensorlike ECG measurement module kit, pulse oximeter, accelerometer etc. which takes data from patient body behaves like input.

- **Processing unit:**Here we use Node MCU (ESP8266) as processor where Wi-Fi module is integrated. It process data according to our programming.

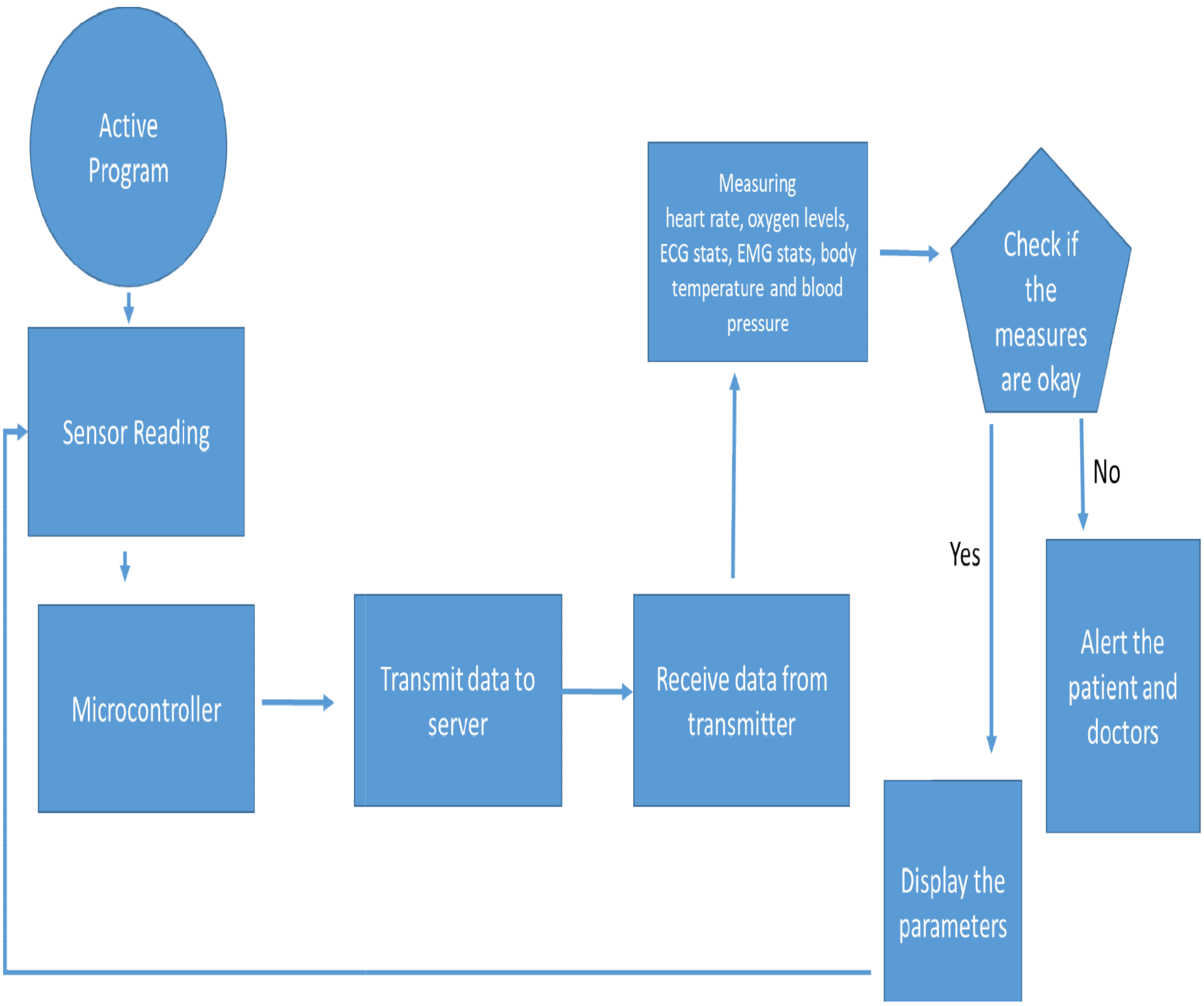
- **Decision& coding**: Using Arduino software we programmed for the input data. We programed and define threshold for the decision (like when it should be consider emergency situation, when alarm message should be given etc.)

- **Output:**alarm system for any emergency situation and giving notification to the doctor and relative. Also LCD monitor is also act like output device.
- **Iot:** Storing patient information in the website and saved the information for future diagnosis. We use ubidots as the IoT platform.

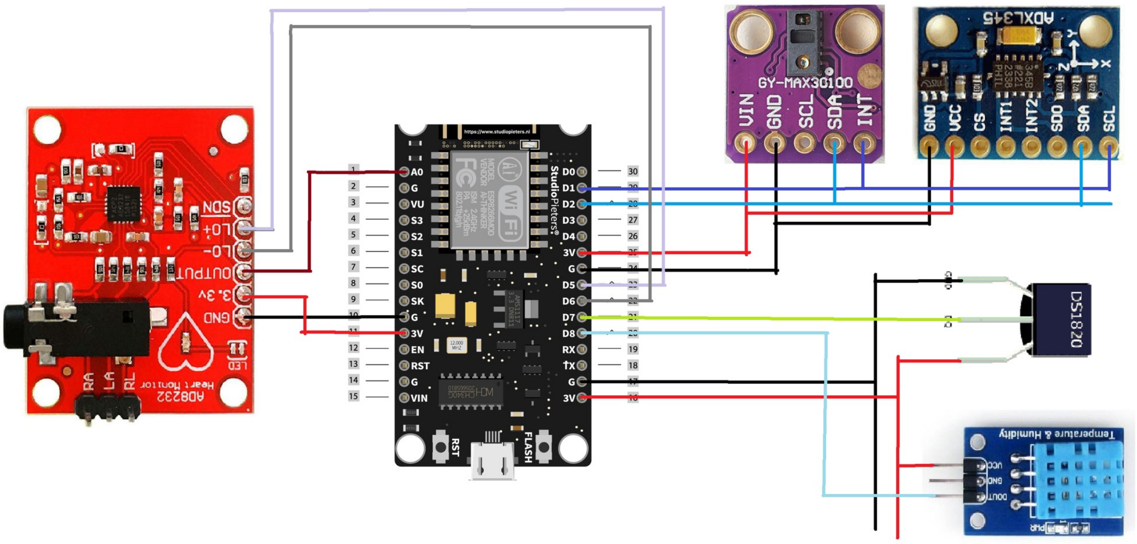
Using flow diagram and circuit diagram we can easily present our design precisely. Flow diagram and circuit diagram is given below:

3.1Design Method

Flow Diagram of our design:



3.2Circuit Diagram



3.3Full Source Code of Firmware

Coding for pulse oximeter to website

```
/*
MAX30100 update current 4.4 mA and 10 sampling
*/
#include <Wire.h>
#include "MAX30100.h"
#include "MAX30100_PulseOximeter.h"
#include "Ubidots.h"
#define REPORTING_PERIOD_MS     2000
const char* UBIDOTS_TOKEN = "BBFF-
zqTiPNdVa059CSNG8pNPXKjigHdSW9";  // Put here your
Ubidots TOKEN
const char* WIFI_SSID = "BUET-Free-WiFi";      // Put
here your Wi-Fi SSID
const char* WIFI_PASS = "";      // Put here your Wi-Fi
password
Ubidotsubidots(UBIDOTS_TOKEN, UBI_HTTP);


PulseOximeter pox;
float a,b;
inti = 10;
float c = 0;
uint32_t tsLastReport = 0;


void onBeatDetected()
{
    Serial.println("STAY STILL Measuring...");
}


void setup()
{
    Serial.begin(115200);
    ubidots.wifiConnect(WIFI_SSID, WIFI_PASS);
    Serial.print("Initializing pulse oximeter..");


    if (!pox.begin()) {
        Serial.println("FAILED");
        for(;;);
    } else {
        Serial.println("SUCCESS");
    }
```

```
    // The default current for the IR LED is 50mA and
it could be changed
    //   by uncommenting the following line. Check
MAX30100_Registers.h for all the
    //   available options.
    pox.setIRLedCurrent(MAX30100_LED_CURR_4_4MA);


    // Register a callback for the beat detection
    pox.setOnBeatDetectedCallback(onBeatDetected);

}


void loop()
{
     pox.update();


    if (millis() - tsLastReport> REPORTING_PERIOD_MS) {
      a = pox.getHeartRate();
      b = pox.getSpO2();
          if( a == 0 || b == 0)
            {
              return;
            }
              if (i>0)
              {
                c = ((c+a)/2);
                i = i-1;
                Serial.println(i);
              }
             if (i==0)
              {
                i=10;
                Serial.print("Heart rate: ");
                Serial.print(c);
                Serial.print(" bpm & SpO2: ");
                Serial.print(b);
                Serial.println("%");
                c=0;
              }
        tsLastReport = millis();
    }
    ubidots.add("Heart Rate", c);
    ubidots.add("SPO2", b);
    bool bufferSent = false;
  bufferSent = ubidots.send();  // Will send data to a
device label that matches the device Id


  if (bufferSent) {
    // Do something if values were sent properly
    Serial.println("Values sent by the device");
  }
}
```

Table: Source Code for the main program

4 Implementation

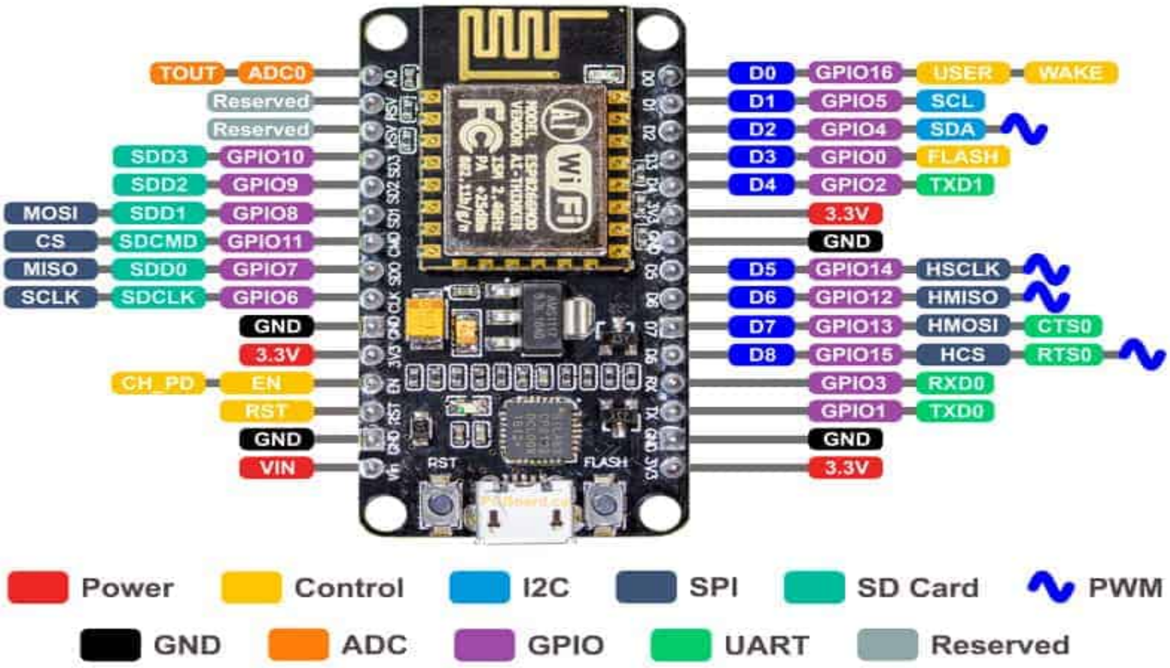
4.1Description

We used Node MCU as microcontroller and use five sensor like Pulse Oximeter, Accelerometer, ECG measurement Kit, DHT11, LM35. The description of the components are given below-

Node MCU: The NodeMCU (Node MicroController Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds. It has 128kBytes

SRAM and4Mbytes memory storage

Node MCU pinout:



Pulse Oximeter: Pulse oximetry sensors use red and infrared LEDs to measure deoxygenated and oxygenated hemoglobin. LED contamination can affect the oximeter calibration, resulting in inaccurate SpO_2 readings below 80%. PureSAT technology uses intelligent pulse-by-pulse filtering to provide precise oximetry measurements—even in the presence of motion, low perfusion, or other challenging conditions. PureSAT signal processing uses advanced algorithms to separate pulse signals from artifacts and interference, leaving only the true pulse. Using smart averaging technology, PureSAT automatically adjusts to each patient's condition to provide fast and reliable1 readings.

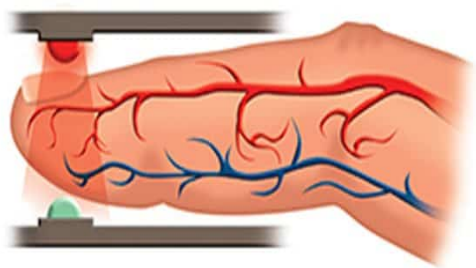
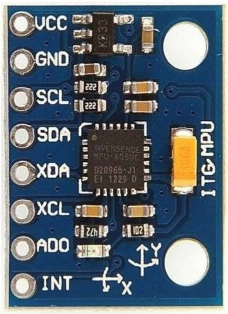


Fig: Pulse oximeter sensor& operation

Accelerometer: An accelerometer sensor is a tool that measures the acceleration of any body or object in its instantaneous rest frame. It is not a coordinate acceleration. Accelerometer sensors are used in many ways, such as in many electronic devices, smartphones, and wearable devices, etc. The MPU6050 consist 3-axis Accelerometer with Micro Electro Mechanical (MEMs) technology. It used to detect angle of tilt or inclination along the X, Y and Z axes as shown in below figure.



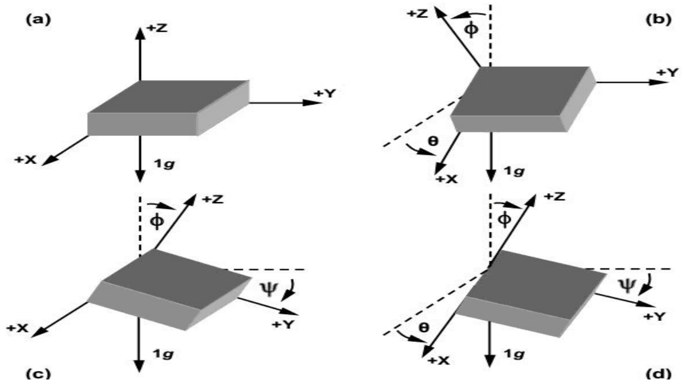


Fig: Accelerometer and its principle

- Acceleration along the axes deflects the movable mass.
- This displacement of moving plate (mass) unbalances the differential capacitor which results in sensor output. Output amplitude is proportional to acceleration.
- 16-bit ADC is used to get digitized output.
- The full-scale range of acceleration are +/- 2g, +/- 4g, +/- 8g, +/- 16g.
- It measured in g (gravity force) unit.
- When device placed on flat surface it will measure 0g on X and Y axis and +1g on Z axis.

DHT11: The DHT11 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.
The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%.

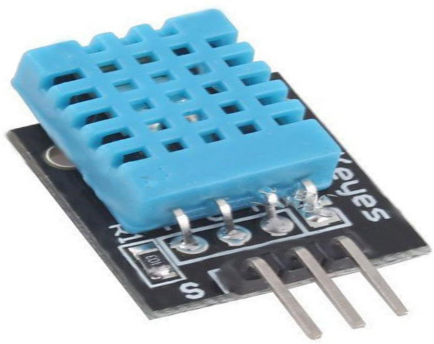


Fig: DHT11

LM30:LM35 is a temperature sensor that outputs an analog signal which is proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. The advantage of lm35 over thermistor is it does not require any external calibration. LM35 can measure from -55 degrees centigrade to 150-degree centigrade. The accuracy level is very high if operated at optimal temperature and humidity levels. The conversion of the output voltage to centigrade is also easy and straight forward. The input voltage to LM35 can be from 4 volts to 30 volts.

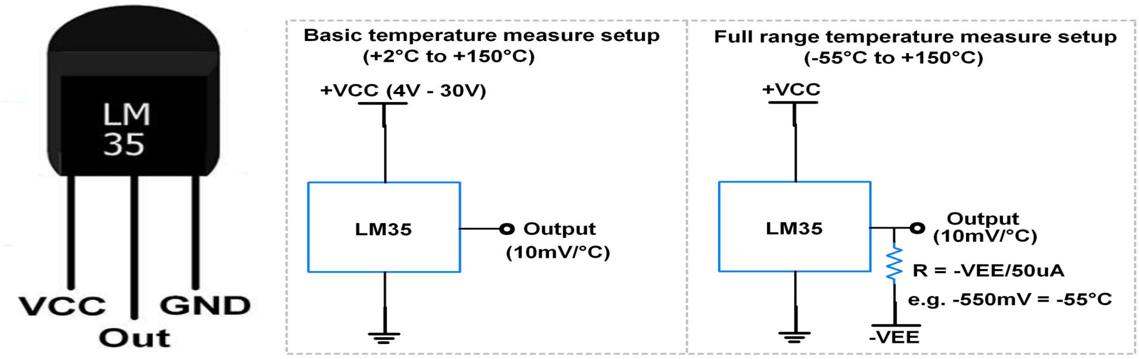


Fig: LM 35 and its operation diagram

4.2 PCB Design

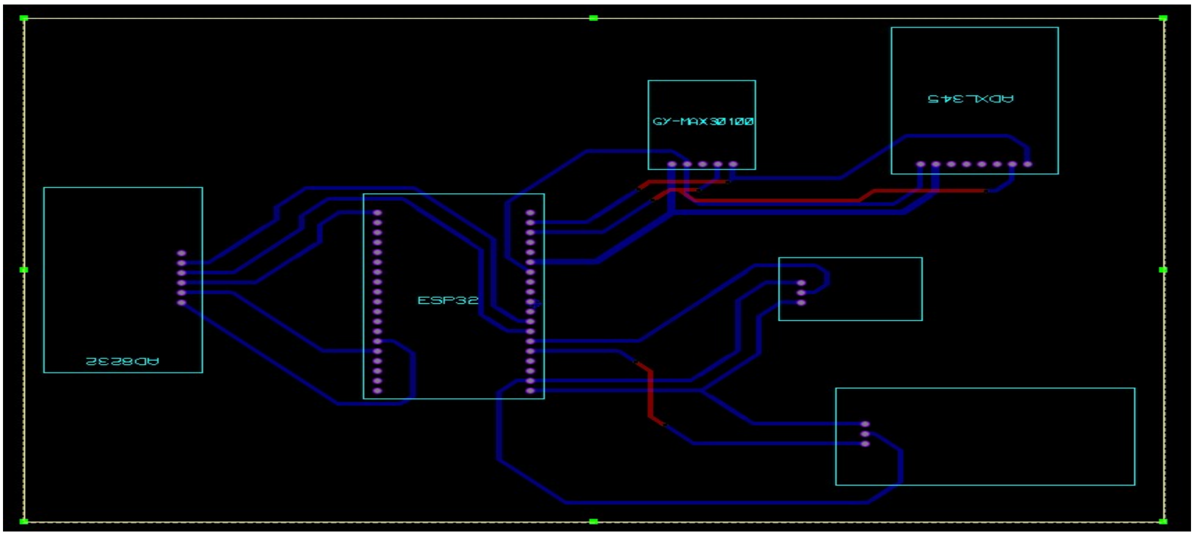


Fig: PCB Layout

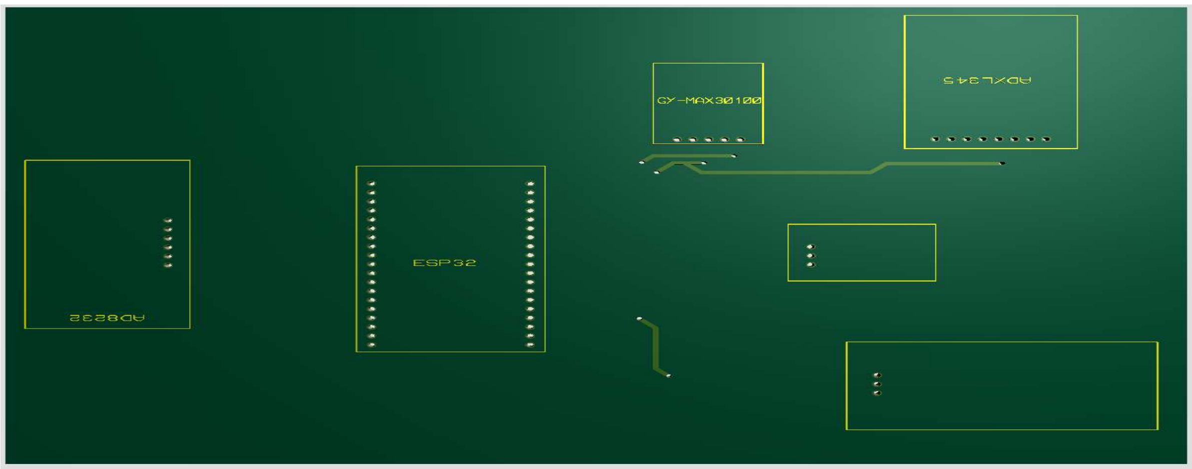


Fig: PCB design

4.3 Results

We have successfully taken different health parameters and shown in both offline and online system. We have compared our results with MAXIM30001 board which takes ECG and Bioimpedence in consideration. But this device was unable to send the data to cloud. So our device is more convenient providing two step verification system(both online and offline) for the users.

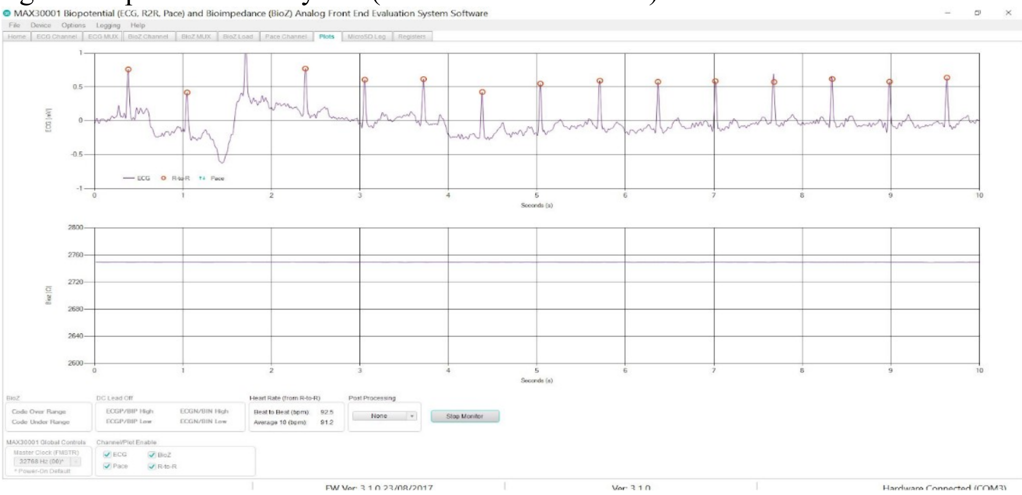
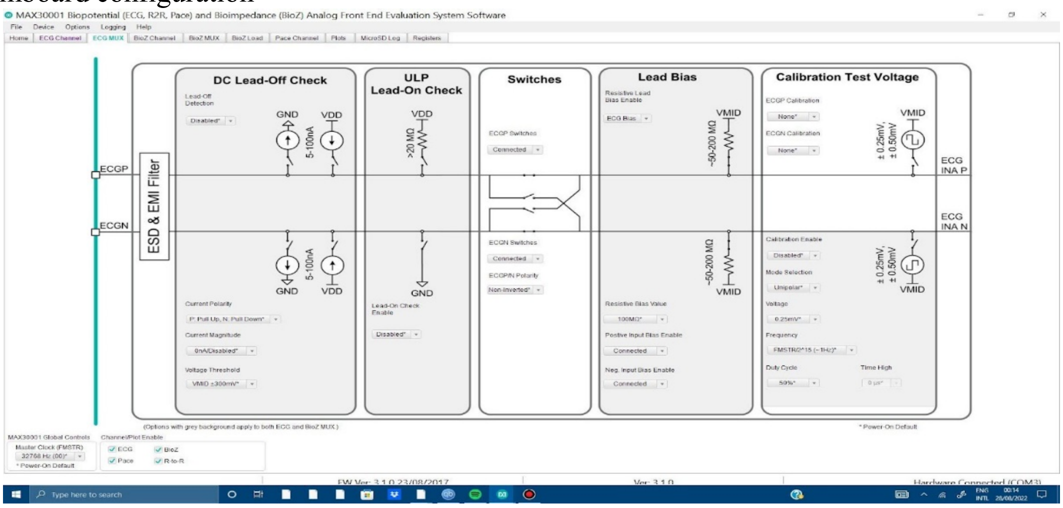


Figure: Reference device ECG(offline)

Maximboard configuration



4.4 GithubLink

https://github.com/tasnimislam/MircoProcessor_4_1_project?fbclid=IwAR1hpTp8SOt6j2GbYR0kRNXUS1IDuBfU-VAHHRt1qzV8CYv3dvRXtVVKIAI

5 Design Analysis and Evaluation

5.1 Novelty

There were lots of IOT healthcare devices proposed in various times. Here we have used the sensors optimal for heart conditions, the reference device we have used(Maxim30001)has redundant sensor bio impedance and ECG both, when any of them could be suffice. We have made it cost efficient and handy and portable so that it could be mass produced for the rural area people. It provides two step verification process both offline and online(can be sent to the doctors) that ensures full health monitoring ensured to the patients. Our device is a one of a kind device incorporating various sensors. We have created a system that can transmit all the data to cloud and the data is saved in the cloud indefinitely if the patient chooses so.

5.2 Project Management and Cost Analysis

5.2.1 Bill of Materials

Serial No	Product name	Quantity(piece)	Price (one piece)	Item total price(BDT)
1	Bread board	3	90	270
2	Node -MCU(ESP8266)	2	450	900
3	ESP -01	1	250	250
4	Pulse Oximeter(GY-30100)	2	450,250	700
5	Accelerometer(ADXL-345)	1	350	350
6	DHT11	1	250	250
7	LM35	2	75,150	225
8	Arduino	1	1100	1100
9	Male to male wire	30	2	60
10	Male to female	20	2	40
11	Vero board	2	50	100
12	AD8232 ECG Measurement Module Kit)	1	750	750
13	Data cable	1	120	120
14	Soldering Iron	1	350	350
Grand total				**BDT 5465**

5.2.2 Calculation of Per Unit Cost of Prototype

Variable cost per unit:

Product name	Quantity(piece)	Price (one piece)	Item total price(BDT)
Node -MCU(ESP8266)	1	450	450
ESP -01	1	250	250
Pulse Oximeter(GY-30100)	1	250	250
Accelerometer(ADXL-345)	1	350	350
DHT11	1	250	250
LM35	1	150	150
Arduino	1	1100	1100
Jumper wire	30	2	60
Vero board	1	50	50
AD8232 ECG Measurement Module Kit)	1	750	750

Total variable cost	BDT 3660

Fixed cost for per unit:

Transportation cost	100
Soldering cost	350
Cable & others	Approx. 200
Total fixed cost	**BDT 650** (approx..)

Per unit cost of the product= total variable cost for per unit +total fixed cost for per unit

=BDT 3660+ BDT 650

=**BDT 4310**

5.2.3 Calculation of Per Unit Cost of Mass-Produced Unit

Assume, we produce 100 unit of our product for mass use. So the per unit cost calculation will be follows:

Variable cost for 100 unit:

Product name	Price (avg. unit price)	Item total price(BDT)
Node -MCU(ESP8266)	350	35000
Pulse Oximeter(GY-30100)	200	20000
Accelerometer(ADXL-345)	250	25000
DHT11	150	15000
LM35	80	8000
Arduino	500	50000
Vero board	30	3000
AD8232 ECG Measurement Module Kit)	600	60000
Total variable cost for 100 unit		**BDT 216000**

So the **per unit fixed cost for mass production is** $=\dfrac{\textbf{BDT 216000}}{\textbf{100}}$ **=BDT 2160**

Fixed cost calculation for 100 units:

Transportation cost	Approx. 5,000
Soldering related cost	Approx. 10,000
Jumper wire	Approx. 2,000
Cable & wire	Approx. 2,000
Storage cost	Approx. 1,000
Others	Approx. 10,000
Total fixed cost for 1000 unit	**Approx. 30,000**

So the **per unit fixed cost for mass production is** $=\dfrac{\textbf{BDT 30000}}{\textbf{100}}$ **=BDT 300(approx.)**

So the final per unit cost for mass production is= BDT 2160+BDT 300
=BDT 2460 (approx.)

Actually, for mass production in dedicated industry the total cost might be reduce again. In that case the device can be affordable under BDT 2000.

5.2.4 Timeline of Project Implementation

For design and implement this project we spent approximately **45 days** totally. We can’t give time regularly to implement this project for our personal business and regular study of other courses. So we need many days for implement

5.3 Practical Considerations of the Design to Address Public Health and Safety, Environment, Cultural, and Societal Needs

During design of our product we consider how our design can address public health and safety, environment, cultural, and societal needs. The consideration are discuss below -

5.3.1 Considerations to public health and safety

Our design product is directly related to public health and safety. Since the main purpose of our design to monitoring the health parameter such as blood pressure, body temperature,heartbeat, and oxygen saturation (SpO_2) levels, ECG stats, of a people, so it is obviously beneficial for public health and safety. One can easily share their health parameter data instantly within one application with the doctor. As we know, the IoT is now considered one of the most desirable solutions in health monitoring. It makes sure that the parameter data is secured inside the cloud, and the most important thing is that any doctor can monitor the health of any patient at any distance.

5.3.2 Considerations to environment

Our design is safe for environment in this way that by using our device one can take doctor advice accurately by staying at home. So no transportation is needed for meeting with doctor. Transportation severely hamper our environment by producing carbon dioxide, carbon monoxide and different toxic gases of nitrogen and sulfur which might be reduced for less use of transportation.

5.3.3 Considerations to cultural and societal needs

Better and reliable health service is one of the important parameter of a developed country that attract people in the way of immigration to a developed country. Our device is really helpful and can reduce complexity for reliable health service by reducing complexity and time of a people. It might be helpful for our cultural enrichment and societal needs. The use of these device as support tools by the general public in a certain situation could have a big impact on their own lives.

5.4 Assessment of the Impact of the Project on Societal, Health, Safety, Legal and Cultural Issues

5.4.1 Assessment of Societal Issues

Our device is mainly monitoring the health parameter of a patient and update data in server and anyone can see the health condition of this patient staying anywhere of the world. This is really helpful for the patients (pregnant woman, paralysis patient, physically disable patient, heart diseases and diabetics patient etc) whose need the continuous monitoring of their health condition. Using our device they can easily measure their blood pressure, ECG signal, body temperature, etc. Seeing data using a smart phone or laptop thedoctor can easily distinguish their patient condition and can give proper solution without via online. For rural aria where medical service is difficult and not available for everyone, but using our device they can be beneficial and take treatment from the doctor staying at home.

5.4.2 Assessment of Health and Safety Issues

Our IoT based self-monitoring device is small, light and easy to carry. A patient can easily carry it like a smartphone. We use a microcontroller and some small sensors that is safe for a human body. So our design is healthy and don’t violate safety issues.

5.4.3 Assessment of Legal Issues

Our device measure data and store it in a website that is secured. Only permitted people can access it. We ensure safety for our patient information. For our design we only use legal and permitted device and sensor.

5.4.4 Assessment of Cultural Issues

For a developing country like Bangladesh Iot based health service is very important parameter for the improvement of medical services. Online health services and doctor consultation is not available in our country especially for rural area. To make online health services reliable and easy for everyone Iot based health monitoring system like our device is very important.

5.5 Evaluation of the Sustainability the and Impact of the Designed Solution in the Societal and Environmental Contexts

5.5.1 Evaluation of Sustainability

In the perspective of sustainability we think that our device will be sustainable. There is no limitation for using this device. If a problem is arise in one sensor then it can be easily replace by a new one without changing the whole device. Also there is a scope to add more sensor in this device to fulfill customer desired requirement.

5.5.2 Evaluation of Impact of Design in Societal Context

For online health services and consultancy with doctor via online, Iot based health monitoring system might be a powerful tool.As a person enters old age, it becomes increasingly vital for them to undergo standard medical health checkups. Since it may be time-consuming and difficult for most people to get regular health checkup appointments, IoT-based arrangements can be beneficial to individuals for routine health checkups. IoT technology has developed into an imperative innovation with applications in numerous areas. Specifically, it refers to any system of physical devices that obtain and exchange information over wireless systems without human mediation.

5.5.3 Evaluation of Impact of Design in Environmental Context

Our design is environment-friendly since there is not use any device that is harmful for our environment. A small size microcontroller and some sensor is the main part of our product. Waste of this Microcontroller and sensor is very insignificant for the pollution of environment. Again recycling the unusable material of our product makes it more environment friendly and sustainable and reduce product cost.

6 Reflection on Individual and Team work

Our project is implemented by doing both individual and teamwork. We have individually tested 5 sensors and tried debug it on our own. The final project finishing and the report was done as a team. And the discussion on course of action was done based on a democratic method.

6.1 Individual Contribution of Each Member

The contribution of each member:

Student Id	Contribution
1706091	Used Arduino Uno, Node MCU device and work with sensor and design
1706092	Coding part, integrating different sensors

	reading and updating offline and online system
1706093	Report writing and coding part with id 92
1706094	Used Arduino Uno, Node MCU device and work with sensor, and buying components
1706097	Report writing and works together for sensor and MCU device

6.2Mode of TeamWork

The coding problems were solved mostly in online or individually. The hardware integrations were done in library and hall sometimes. So the mode of work is both online and offline. Sometimes all of us can’t give time equally. Most of the time we meet in the BUET central library for implement our design.

6.3Diversity Statement of Team

The diversity among each member arises because of many reasons. Some of us are resident in hall again we are resident in different hall and some are attached, two female and three male student in our group. So for doing teams work we face some problem because of timing of the hall. During work in the night there is a problem for female member.

6.4Log Book of Project Implementation

Date	Milestone achieved	Individual Role	Team Role	Comments
	proposal completion		All have searched different aspects of this project and stuck to this particular one	
July 3	Collection of Reference device and preliminary elements collection	92, 93 have contacted TnR Lab from NSU 91,94,97 have bought the components preliminarily	All have cooperated in the application process	
July 15	Sensors working individually	94 has done the primary assemblies 91 has cross checked and the sensors were working smoothly	All have been searching on the ensembling of different devices	
July 20	Pulse oximeter not working	91, 94, 97 have combinedly build the assembled prototype, but the pulse oximeter was not working 92 and 93 was building the code for online	The preliminary prototype is already in hand	
July 30	The sensors were fine,	All were trying to fix the		

	but the synchronization is the issue	issue		
August 10	Sensor Synchronization error	Tried matlab, ubidots, thinkspeak, local server		
August 20	Sensor Synchronization offline solved	Understood the loop error in Arduino (timing)		
August 30	Server synchronization online solved	Understood proper transmission in ubidots		

7 References

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