Visvesvaraya Technological University
Belagavi, Karnataka-590 018

A Project Report on

"Design and development of a wearable vitals monitoring system for smart health care "

A project report submitted in partial fulfilment of the requirement for the award of the degree of

Bachelor of Engineering
In
Electrical & Electronics Engineering

Submitted by

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CMR INSTITUTE OF TECHNOLOGY

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Certificate

Certified that the project work entitled **"Design and development of a wearable vitals monitoring system for smart health care"** carried out by **Ms. Nandini Gupta (1CR17EE036), Ms. Nekkanti Manaswini (1CR17EE037), Nethra Balasubramnaiyam (1CR17EE038), Mr. Nishanth V R (1CR17EE039)** are bonafide students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belagavi during the academic year 2020-2021. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library.The project report has been approved as it satisfies the academic requirements in respect of project work as prescribed for the said Degree.

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DECLARATION

We, **[Ms. Nandini Gupta (1CR17EE036), Ms. N Manaswini (1CR17EE037), Nethra Balasubramnaiyam (1CR17EE038), Mr. Nishanth V R (1CR17EE039)],** hereby declare that the report entitled **"Vitals Monitor"** has been carried out by me under the guidance of **Ms. Lokasree B S, Assistant Professor**, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfilment of the requirements for the degree of **Bachelor of Engineering in Electrical & Electronics Engineering** of Visvesvaraya Technological University, Belagavi during the academic year 2020-2021. The work done in this report is original an it has not been submitted for any other degree in any university.

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Abstract

The purpose of this paper is to develop a health monitoring system that can measure human vital signs and recognise human activity based on body sensor network (BSN). Design/ methodology/approach – The system is mainly composed of electrocardiogram (ECG) signal collection node, blood oxygen signal collection node, inertial sensor node, receiving node and upper computer software. The three collection nodes collect ECG signals, blood oxygen signals and motion signals. And then collected signals are transmitted wirelessly to receiving node and analysed by software in upper computer in real-time. Findings – Experiment results show that the system can simultaneously monitor human ECG, heart rate, pulse rate, SpO 2 and recognise human activity. A classifier based on coupled hidden Markov model (CHMM) is adopted to recognise human activity. The average recognition accuracy of CHMM classifier is 94.8 percent, which is higher than some existent methods, such as supported vector machine (SVM), C4.5 decision tree and naive Bayes classifier (NBC). Practical implications – The monitoring system may be used for falling detection, elderly care, postoperative care, rehabilitation training, sports training and other fields in the future. Originality/value – First, the system can measure human vital signs (ECG, blood pressure, pulse rate, SpO 2 , temperature, heart rate) and recognises some specific simple or complex activities (sitting, lying, go boating, bicycle riding). Second, the researches of using CHMM for activity recognition based on BSN are extremely few. Consequently, the classifier based on CHMM is adopted to recognise activity with ideal recognition accuracies in this paper.

Acknowledgement

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people, who are responsible for the completion of the project work and who made it possible, because success is the outcome of hard work and perseverance, but steadfast of all is encouraging guidance. So with gratitude, We acknowledge all those whose guidance and encouragement served us to motivate towards the success of the project work.

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LIST OF ABBREVIATIONS AND SYMBOLS

WHD	Wearable Health Devices
ADC	Analog to Digital converter
FTDI	Future Technology Devices International
USB	Universal Serial Bus
DTR	Data Terminal Ready
OLED	Organic Light Emitting Diode

CHAPTER 1 :

INTRODUCTION

1.1 Brief Background of the Research

Vital signs are measurements of the body's most basic functions. The three main vital signs routinely monitored by medical professionals and health care providers include the following; Body Temperature, Pulse Rate and Respiration Rate. Vital signs are useful in detecting or monitoring medical problems. These signs can be measured in a medical setting, at home, at the site of a medical emergency, or elsewhere. There are many sensors for measuring vitals of the human body which are essential for a doctor or a medic to know the health problems. We all know that doctor first checks Heart Rate to know Heart Rate Variability (HRV) and body temperature. Currently, modern wearable devices are the most feasible alternative to instantly check a person’s vital signs. These wearable bands and devices however fail in the accuracy and repeatability of the measured data. This mostly happens due to miss alignment of fitness tracker, erroneous reading etc. Most use the LED and Photodiode based Photo Plethysmography (PPG) sensors for the heart rate measurement. In today’s pandemic world, these wearables have become less of a luxury and more of a necessity.

1.2 Vital Signs

Vital signs are measurements of the body's most basic functions. The four main vital signs routinely monitored by medical professionals and health care providers include the following:

- Body Temperature
- Pulse Rate
- Respiration Rate (Rate of Breathing)
- Oxygen Saturation (SpO_2)

1.2.1 Body Temperature

The normal body temperature of a person varies depending on gender, recent activity, food and fluid consumption, time of day, and, in women, the stage of the menstrual cycle.

Normal body temperature can range from 97.8 degrees F (or Fahrenheit, equivalent to 36.5 degrees C, or Celsius) to 99 degrees F (37.2 degrees C) for a healthy adult. A person's body temperature can be taken in any of the following ways :

- **Orally** : Temperature can be taken by mouth using either the classic glass thermometer, or the more modern digital thermometers that use an electronic probe to measure body temperature.
- **Rectally :** Temperatures taken rectally (using a glass or digital thermometer) tend to be 0.5 to 0.7 degrees F higher than when taken by mouth
- **Axillary :** Temperatures can be taken under the arm using a glass or digital thermometer. Temperatures taken by this route tend to be 0.3 to 0.4 degrees F lower than those temperatures taken by mouth.
- **By ear :** A special thermometer can quickly measure the temperature of the ear drum, which reflects the body's core temperature (the temperature of the internal organs).
- **By skin :** A special thermometer can quickly measure the temperature of the skin on the forehead.

1.2.2 Pulse Rate

The pulse rate is a measurement of the heart rate, or the number of times the heart beats per minute. As the heart pushes blood through the arteries, the arteries expand and contract with the flow of the blood. Taking a pulse not only measures the heart rate, but also can indicate the following:

- Heart rhythm
- Strength of the pulse

The normal pulse for healthy adults ranges from 60 to 100 beats per minute. The pulse rate may fluctuate and increase with exercise, illness, injury, and emotions. Females ages 12 and older, in general, tend to have faster heart rates than do males. Athletes, such as runners, who do a lot of cardiovascular conditioning, may have heart rates near 40 beats per minute and experience no problems.

1.2.3 Respiration Rate

The respiration rate is the number of breaths a person takes per minute. The rate is usually measured when a person is at rest and simply involves counting the number of breaths for one minute by counting how many times the chest rises. Respiration rates may increase with fever, illness, and other medical conditions. When checking respiration, it is important to also note whether a person has any difficulty breathing. Normal respiration rates for an adult person at rest range from 12 to 16 breaths per minute.

1.2.4 Oxygen Saturation (SpO_2)

SpO_2, also known as oxygen saturation, is a measure of the amount of oxygen-carrying haemoglobin in the blood relative to the amount of haemoglobin not carrying oxygen. The body needs there to be a certain level of oxygen in the blood or it will not function as efficiently. In fact, very low levels of SpO2 can result in very serious symptoms. This condition is known as hypoxemia. There is a visible effect on the skin, known as cyanosis due to the blue (cyan) tint it takes on. Hypoxemia (low levels of oxygen in the blood) can turn into hypoxia (low levels of oxygen in the tissue). This progression and the difference between the two conditions is important to understand.

1.3 Contribution

Wearable Health Devices (WHDs) are an emerging technology that enables continuous ambulatory monitoring of human vital signs during daily life (during work, at home, during sport activities, etc.) or in a clinical environment, with the advantage of minimising discomfort and interference with normal human activities.

WHDs are part of personal health systems, a concept introduced in the late 1990s, with the purpose of placing the individual citizen in the center of the healthcare delivery process, managing its own health and interacting with care providers—a concept that is commonly referred to as “patient empowerment. The aim was to raise people interest about their health status, improving the quality of care and making use of the new technology capabilities. These devices create a synergy between multiple science domains such as biomedical technologies, micro and nanotechnologies, materials engineering, electronic engineering and information and communication technologies.

The use of WHDs allows the ambulatory acquisition of vital signs and health status monitoring over extended periods (days/weeks) and outside clinical environments. This feature allows acquiring vital data during different daily activities, ensuring a better support in medical diagnosis and/or helping in a better and faster recovering from a medical intervention or body injury. WHDs are also very useful in sport activities/fitness to monitor athlete's performance or even in first responders or military personnel to evaluate and monitor their body response in different hazardous situations and to better manage their effort and occupational health. These devices can be for both medical and/or activities/fitness/wellness purposes, always targeting the human body monitoring. Taking this in account, the best terminology is "health", leading to WHDs. WHDs denomination can be more specific referring to which areas they are applied to. Independently of WHDs purpose, there are four main requirements on their design: low power consumption, reliability and security, comfort and ergonomics.

The wearable devices market is currently having a worldwide revenue of around $26 billion, and is expected to reach almost $34 billion in 2019. Regarding healthcare and medical environments, it is expected to grow almost to $15 billion worldwide value in 2019.

This project aims to design a wearable health care monitoring device to measure temperature, pulse rate and heart rate. The project caters to the need of social distancing and remote healthcare monitoring in the absence of physical assistance.

1.3 Objectives of the Thesis

- A device to measure real-time heart rate (bpm) and SpO2.
- A device to measure real-time body temperature.
- A device that is battery driven.
- A device that gives precise values.
- An affordable device.

CHAPTER 2 :

LITERATURE REVIEW

- One of the monitoring systems that are widely designed is the temperature monitoring system. LM35 temperature sensors are often used in system design to read ambient temperature automatically.-Predict the Percentage Error of LM35 Temperature Sensor Readings using Simple Linear Regression Analysis- (Tigor Hamonangan- Nasution Universitas Sumatera Utara, Medan, Indonesia, Lukman Adlin Harahap -Chulalongkorn University, Bangkok, Thailand).
- IOT is the major market player in terms of network of technology. These devices can work on various devices including cellular, wi-fi, bluetooth etc. (Design Architecture and comparison of smart button using HE05 and ESP8266 - RK Yadav, Himanshu Vohra DTU)
- Building a wireless heart rate monitoring system that allows patients to be mobile in the surrounding environment is the aim of the system. It can receive signals from body and send SMS to the doctor or family, so that treatment can be provided during emergencies without any delay. (Heart rate monitoring system - Minal Patel, Abhishek Madenkar, Dr. P D Khandait - Nagpur India)
- Vital signs monitors facilitate communication between providers at a disaster situation, medical professionals at local hospitals and specialists available for consultation from distant facilities. (Vital Sign Monitoring and patient tracking over a wireless network - Tia Gao, Dan Glenspan, Matt Welsh, Redford R Tuang and Alex Alan)
- Understanding the working of PPG sensor and realizing it to measure heart rate. (Saquib, N., Papon, M. T. I., Ahmad, I., & Rahman, A. (2015). Measurement of heart rate using photoplethysmography. 2015 International Conference on Networking Systems and Security (NSysS). doi:10.1109/nsyss.2015.7043525)
- Usage of PPG graph in identifying different ailments in heart by the method of signal processing. (M. Elgendi. On the Analysis of Fingertip Photoplethysmogram Signals. Current Cardilology Reviews, 2012.)

- Consider revising medium temperature used LM35 temperature sensor, what is an economic and feasible method. – The application of soil temperature measurement by LM35 temperature sensors (Cuihong Liu, Wentao Ren, Benhua Zhang, Changyi Lv-College of Engineering, Shenyang Agricultural University, Shenyang, P.R.China).
- Percentage of Oxygen in blood plays a vital role as a parameter in determining one's health condition (MAX30100 Based Heart Rate and SPO2 Monitoring using IoT- Alan Roddick, Manoj Kumar, Karthik, Ragul and P. Aravind-Saranathan College of Engineering, Tamil Nadu, India)
- Based on the principle of oxygen saturation measurement, this paper introduces a blood oxygen saturation detection system design scheme based on the integrated chip MAX30100, which can simplify the circuit design, reduce system footprint, reduce the designing time and system power consumption. (Reflective type blood oxygen saturation detection system based on MAX30100- Jiaxi Wan, Yuhua Zou, Ye Li, Jun Wang- Shenzhen, China)
- In this paper we have designed an intelligent wearable device and developed the corresponding algorithm, for COVID-19 positive patients that is capable of predicting and notifying the increase in severity of the virus. The device uses ESP 32: Node MCU, MAX 30102: Pulse Oximeter and Heart rate sensor, LM35: Temperature sensor and a vibration sensor.- Severity Monitoring Device for COVID-19 Positive Patients (Aman Dhadge-Maharashtra Institute of Technology, Pune, India, Girish Tilekar-Cranfield University, Hyderabad, India).
- The tri-wavelength MAX30101 sensor and bi-wavelength MAX30102 sensor were evaluated on the forehead, in a truly non-obtrusive wearable friendly position.- Comparison of Bi-Wavelength and Tri-Wavelength Photoplethysmography Sensors Placed on the Forehead (Sally K. Longmore-MARCS Institute for Brain, Behaviour and Development, Western Sydney University, Penrith, Australia, Bin Jalaludin-Ingham Institute of Applied Medical Research, University of New South Wales, Liverpool, Australia, Paul. P. Breen-MARCS Institute for Brain, Translational Health Research Institute, Western Sydney University, Penrith, Australia, Gaetano D. Gargiulo-School of Computing, Engineering and Mathematics, Translational Health Research Institute, Western Sydney University, Penrith, Australia).

CHAPTER 3 :

PROPOSED MODEL WITH THEORETICAL BACKGROUND

3.1 Monitoring System

PIC12F683 is an 8-bit PIC micro-controller that has 8-pin interface. It falls under the category of CMOS controllers and comes with nano Watt technology. The figure 1 depicts the pin diagram of PIC12F683 micro-controller.

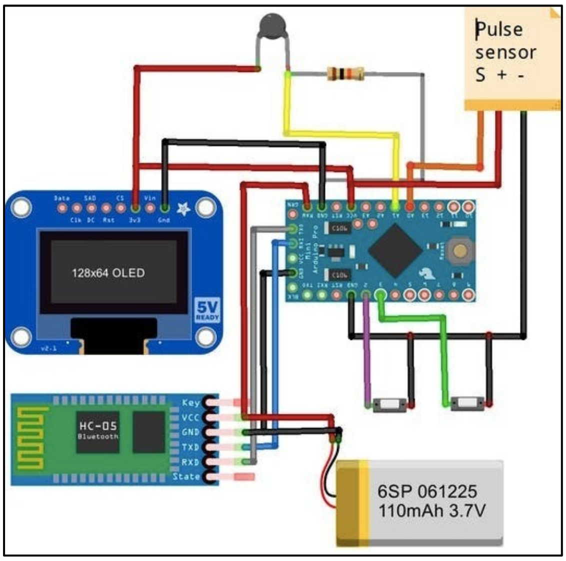


Fig.1 Proposed Model

3.2 Control System

3.2.1 Arduino Mega

The Arduino board is an open-source micro-controller board which is based on Atmega 2560 micro-controller. The growth environment of this board executes the processing or wiring language. These boards have recharged the automation industry with their simple to utilise platform wherever everybody with small otherwise no technical backdrop can start by discovering some necessary skills to program as well as run the Arduino board.The micro-controller board like “Arduino Mega” depends on the ATmega2560 micro-controller. It includes digital input/output pins-54, where 16 pins are analog inputs, 14 are used like PWM outputs hardware serial ports (UARTs) – 4, a crystal oscillator-16 MHz, an ICSP header, a power jack, a USB connection, as well as an RST button. This board mainly includes everything which is essential for supporting the micro-controller. So, the power supply of this board can be done by connecting it to a PC using a USB cable, or battery or an AC-DC adapter. This board can be protected from the unexpected electrical discharge by placing a base plate.

The SCL & SDA pins of Mega 2560 R3 board connects to beside the AREF pin. Additionally, there are two latest pins located near the RST pin. One pin is the IOREF that permit the shields to adjust the voltage offered from the Arduino board. Another pin is not associated & it is kept for upcoming purposes. These boards work with every existing shield although can adjust to latest shields which utilise these extra pins.

Specifications of Arduino include :

- The ATmega2560 is a Micro-controller
- The operating voltage of this micro-controller is 5volts
- The recommended Input Voltage will range from 7volts to 12volts
- The input voltage will range from 6volts to 20volts
- The digital input/output pins are 54 where 15 of these pins will supply PWM o/p.
- Analog Input Pins are 16
- DC Current for each input/output pin is 40 mA
- DC Current used for 3.3V Pin is 50 mA
- Flash Memory like 256 KB where 8 KB of flash memory is used with the help of boot-loader
- The static random access memory (SRAM) is 8 KB
- The electrically erasable programmable read-only memory (EEPROM) is 4 KB
- The clock (CLK) speed is 16 MHz
- The USB host chip used in this is MAX3421E
- The length of this board is 101.52 mm

- The width of this board is 53.3 mm
- The weight of this board is 36 g

Fig.2 Arduino Mega

3.2.2 MAX 30100 Sensor

The MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It combines two LEDs, a photodetector, optimised optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

Benefits and Features of MAX 30100 sensor includes :

- The Complete Pulse Oximeter and Heart-Rate Sensor Solution Simplifies Design Integrated LEDs, Photo Sensor, and High-Performance Analog Front -End
- Tiny 5.6mm x 2.8mm x 1.2mm 14-Pin Optically Enhanced System-in-Package
- Ultra-Low-Power Operation Increases Battery Life for Wearable Devices
- Programmable Sample Rate and LED Current for Power Savings
- Ultra-Low Shutdown Current (0.7µA, typ)
- Advanced Functionality Improves Measurement Performance

- High SNR Provides Robust Motion Artefact Resilience
- Integrated Ambient Light Cancellation
- High Sample Rate Capability
- Fast Data Output Capability

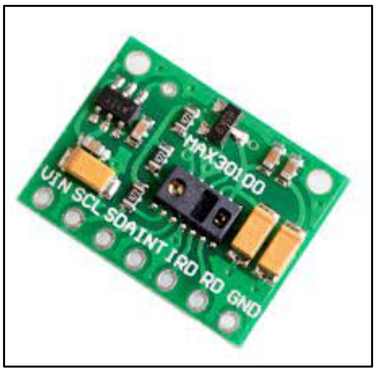


Fig.3 MAX 30100 Sensor

System Block Diagram

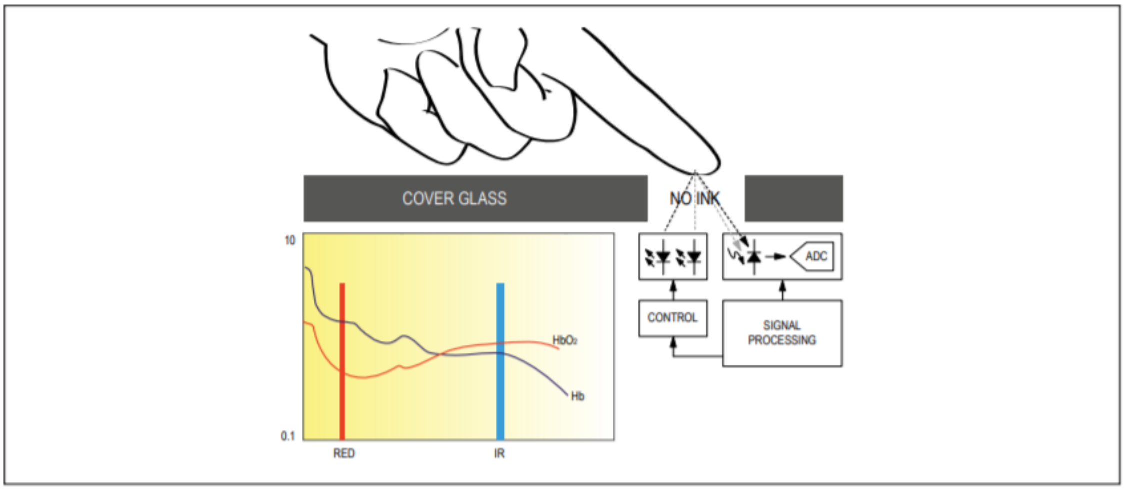


Fig.4 MAX 30100 Sensor System Block Diagram

3.2.3 LM 35

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. 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 power supplies, or with plus and minus supplies. 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, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

The features of LM 35 include :

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates from 4 V to 30 V

- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

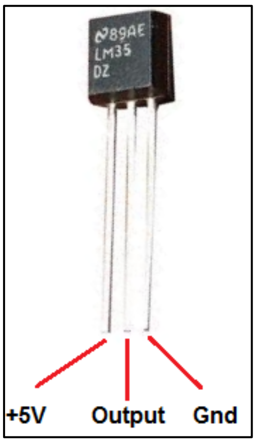


Fig.5 LM 35

3.2.4 Rechargeable Battery

A rechargeable battery, storage battery, or secondary cell, (or archaically accumulator) is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction. Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilise an electrical distribution network. Several different combinations of electrode materials and electrolytes are used, including lead–acid, zinc-air, nickel–cadmium (NiCd), nickel–metal hydride (NiMH), lithium-ion (Li-ion), Lithium Iron Phosphate (LiFePO4), and lithium-ion polymer (Li-ion polymer).

Fig.6 Rechargeable Battery

3.2.5 HC-05 Module

HC−05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module designed for transparent wireless serial connection setup.The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication.This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Blue-core 04−External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

Hardware features include :

- Typical -80dBm sensitivity
- Up to +4dBm RF transmit power
- Low Power 1.8V Operation ,1.8 to 3.6V I/O
- PIO control
- UART interface with programmable baud rate
- With integrated antenna
- With edge connector

Software features include :

- Default Baud rate: 38400, Data bits:8, Stop bit:1,Parity:No parity, Data control: has. Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.
- Given a rising pulse in PIO0, device will be disconnected.

- Status instruction port PIO1: low-disconnected, high-connected.
- PIO10 and PIO11 can be connected to red and blue led separately. When master and slave are paired, red and blue led blinks 1time/2s in interval, while disconnected only blue led blinks 2times/s.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PIN-CODE : ”0000” as default.
- Auto-reconnect in 30 min when disconnected as a result of beyond the range of connection.

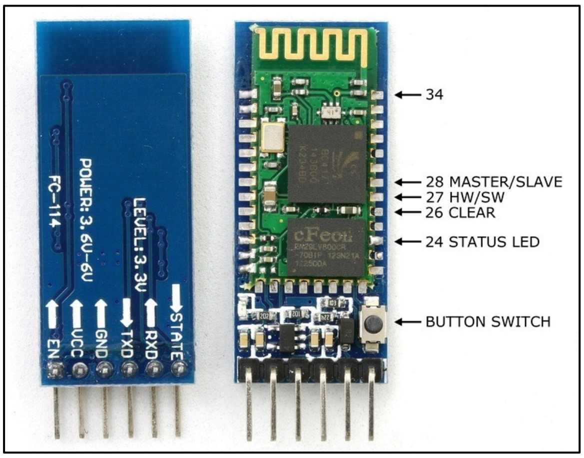


Fig.7 HC-05 Module

3.2.6 128 X 64 OLED Display

OLED (Organic Light-Emitting Diode) is a self light-emitting technology composed of a thin, multi-layered organic film placed between an anode and cathode. In contrast to LCD technology, OLED does not require a backlight. OLED possesses high application potential for virtually all types of displays and is regarded as the ultimate technology for the next generation of flat-panel displays. OLEDs basic structure consists of organic materials positioned between the cathode and the anode, which is composed of electric conductive transparent Indium Tin Oxide (ITO). The organic materials compose a multi-layered thin film, which includes the Hole Transporting Layer (HTL), Emission Layer (EML) and the Electron Transporting Layer (ETL). By applying the appropriate electric voltage, holes and electrons are injected into the EML from the anode and the cathode, respectively. The holes and electrons combine inside the EML to form excitons, after which electro luminescence occurs. The transfer material, emission layer material and choice of electrode are the key factors that determine the quality of OLED components.

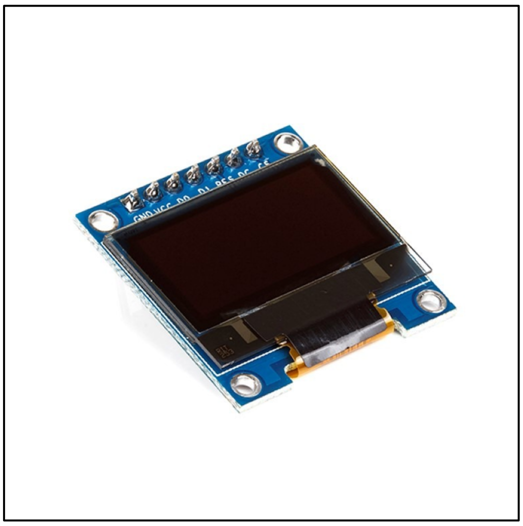


Fig.8 OLED Display

CHAPTER 4 :

METHODOLOGY AND DESIGN

The LM-35 is a temperature sensor that gives an analog signal as output which is proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. The advantage of LM-35 over thermistor is that it does not require any external calibration. The coating of LM-35 protects it from self-heating or ambient heating. The formula to convert the voltage to centigrade temperature for LM35 is Centigrade Temperature = Voltage Read by ADC / 10 mV(mills Volt). We are dividing the analog output value by 10mV because the linear scale of lm35 is +10mV per degree centigrade.

For the detection of SpO2, MAX 30100 sensor is used. One LED is red, with wavelength of 660 nm, and the other is infrared with a wavelength of 940 nm. Absorption of light at these wavelengths differs significantly between blood loaded with oxygen and blood lacking oxygen. In human body, the red blood cells contain a pigment called haemoglobin. Oxygenated haemoglobin absorbs more infrared light and allows more red light to pass through. Deoxygenated haemoglobin allows more infrared light to pass through and absorbs more red light. The amount of light that is transmitted is measured. The ratio of the red light measurement to the infrared light measurement is then calculated by the processor and this ratio is then converted to SpO2 by the processor via a look up table based on the Beer-Lambert Law.

The pulse oximeter operates on the principle of absorption of light by the solutes in a solution. The Beer-Lambert law states that the amount of light absorbed by a solute is proportional to the concentration of the solute and the distance the light is transmitted through the solution. $I_{trans} = I_{inc}$ e - dCε

- I_{trans} – Intensity of transmitted light
- I_{inc} – Intensity of incident light
- e – Base of natural logarithm
- d – Distance traveled by the light
- C – Concentration of the dissolved substance
- ε – Extinction coefficient of the solute

The Pulse-oxy sensor MAX 30100 which is used to measure the heart rate and SpO$_2$ levels, and LM35 sensor used for measuring the temperature in integrated with Arduino where the data received from the sensors are processed and the processed data is sent to OLED display and the mobile app through HC 05 Bluetooth module.

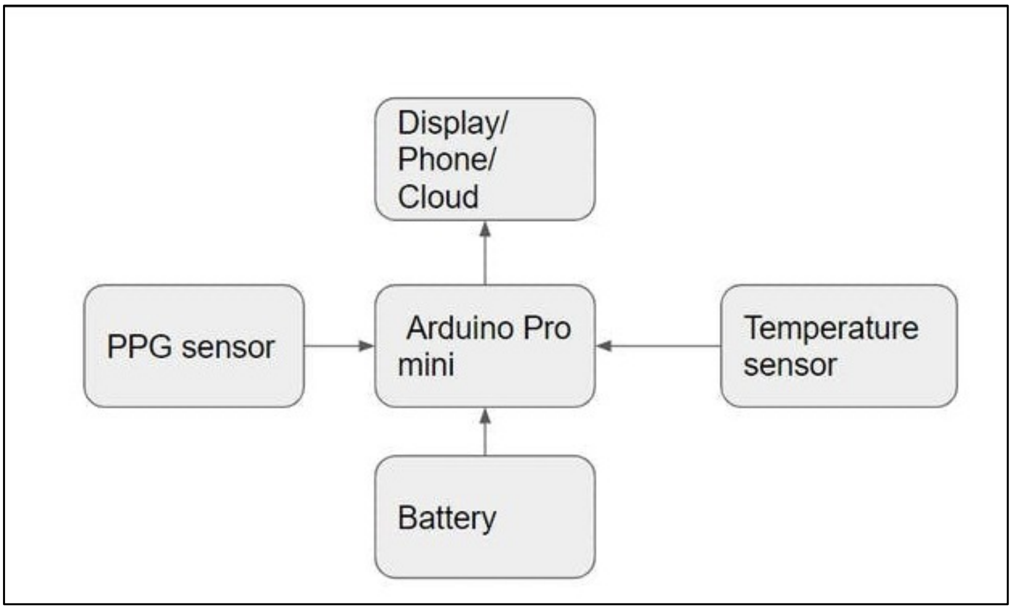


Fig.9 Block Diagram of Arduino based vitals monitor

CHAPTER 5 :

CODE

4.1 Software Used - Arduino IDE

The Arduino Integrated Development Environment **(IDE)** is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2.The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.[By default, avrdude is used as the uploading tool to flash the user code onto official Arduino boards.

Arduino IDE is a derivative of the Processing IDE,[10] however as of version 2.0, the Processing IDE will be replaced with the Visual Studio Code-based Eclipse Theia IDE framework.

With the rising popularity of Arduino as a software platform, other vendors started to implement custom open source compilers and tools (cores) that can build and upload sketches to other micro-controllers that are not supported by Arduino's official line of micro-controllers.

4.2 Application Software - MIT App Inventor

The MIT App Inventor is an intuitive, visual programming environment that allows everyone even children to build fully functional apps for smartphones and tablets. Those new to MIT App Inventor can have a simple first app up and running in less than 30 minutes. And what's more, our blocks-based tool facilitates the creation of complex, high-impact apps in significantly less time than traditional programming environments. The MIT App Inventor project seeks to democratise software development by empowering all people, especially young people, to move from technology consumption to technology creation.

4.3 Source Code

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#include <DFRobot_MAX30102.h>

DFRobot_MAX30102 particleSensor;

#include<SoftwareSerial.h>                    // Software serial library

#define RX_Pin 8
```

```
#define TX_Pin 9

SoftwareSerial bt(RX_Pin,TX_Pin);
#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels



#define OLED_RESET     4
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire,
OLED_RESET);

#define temperature_sensor A0

int lm35_adc_value = 0;
float voltage;
float temperature;

int32_t SPO2; //SPO2
int8_t SPO2Valid; //Flag to display if SPO2 calculation is valid
int32_t heartRate; //Heart-rate
int8_t heartRateValid; //Flag to display if heart-rate calculation is valid

int spo2_value=0,heart_rate_value=0;

void setup()
{
 Serial.begin(115200);
 Serial3.begin(9600);
 pinMode(temperature_sensor, INPUT);

 if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) { // Address 0x3D for 128x64
   Serial.println(F("SSD1306 allocation failed"));
   for(;;); // Don't proceed, loop forever
```

```
 }

 while (!particleSensor.begin())
 {
   Serial.println("MAX30102 was not found");
   delay(1000);
 }



  display.clearDisplay();
  display.setTextSize(2);            // Normal 1:1 pixel scale
  display.setTextColor(WHITE,BLACK);       // Draw white text
  display.setCursor(0,0);             // Start at top-left corner
  display.println("Heart Rate& SpO2    Monitoring");
  display.display();
  delay(2000);

  display.clearDisplay();
  display.setTextSize(2);            // Normal 1:1 pixel scale
  display.setTextColor(WHITE,BLACK);       // Draw white text
  display.setCursor(0,0);             // Start at top-left corner
  display.println("Sensor    Data      Reading..");
  display.display();

      particleSensor.sensorConfiguration(/*ledBrightness=*/60,   /*sampleAverage=*/
SAMPLEAVG_4, \
                  /*ledMode=*/MODE_MULTILED, /*sampleRate=*/SAMPLERATE_100,
\
                                             /*pulseWidth=*/PULSEWIDTH_411,  /*adcRange=*/
ADCRANGE_4096);
}

void loop()
```

```
{
 read_spo2();
 read_temperature();
 display_data_oled();
 bt_send();
}

void read_temperature()
{
 lm35_adc_value = analogRead(temperature_sensor);
 voltage = lm35_adc_value * (5.0/1023);
 temperature = voltage *100;
 Serial.print("Temperature : ");
 Serial.println(temperature);
}

void read_spo2()
{
 Serial.println(F("Wait about four seconds"));
    particleSensor.heartrateAndOxygenSaturation(/**SPO2=*/&SPO2,  /**SPO2Valid=*/
&SPO2Valid, /**heartRate=*/&heartRate, /**heartRateValid=*/&heartRateValid);
 //Print result
 Serial.print(F("heartRate="));
 Serial.print(heartRate, DEC);
 Serial.print(F(", heartRateValid="));
 Serial.print(heartRateValid, DEC);
 Serial.print(F("; SPO2="));
 Serial.print(SPO2, DEC);
 Serial.print(F(", SPO2Valid="));
 Serial.println(SPO2Valid, DEC);

 if(heartRateValid == 1)
 {
```

```
    heart_rate_value = heartRate;
    Serial.println("Heart rate Valid");
  }
  if(SPO2Valid == 1)
  {
    spo2_value = SPO2;
    Serial.println("Spo2 Valid");
  }

}
void bt_send()
{
  String data = String(temperature);
  data += ",";
  data += String(heart_rate_value);
  data += ",";
  data += String(spo2_value);

  Serial3.println(data);
}
void display_data_oled(void)
{
  display.clearDisplay();
  display.setTextSize(2);             // Normal 1:1 pixel scale
  display.setTextColor(WHITE,BLACK);        // Draw white text
  String data_1 = "Temp:";
  data_1 += String(temperature);
  display.setCursor(0,0);             // Start at top-left corner
  display.println(data_1);
  String data_2 = "HR:";
  data_2 += String(heart_rate_value);
  display.setCursor(0,25);             // Start at top-left corner
  display.println(data_2);
```

```
  String data_3 = "Spo2 :";
  data_3 += String(spo2_value);
  display.setCursor(0,50);             // Start at top-left corner
  display.println(data_3);

  display.display();

}
```

CHAPTER 5 :

RESULT AND DISCUSSION

The necessary circuit along with simulation has been implemented and partial output of temperature, SpO$_2$ and Heartbeat has been achieved. The established hardware and output along with screenshots of application display and serial monitor are shown below.

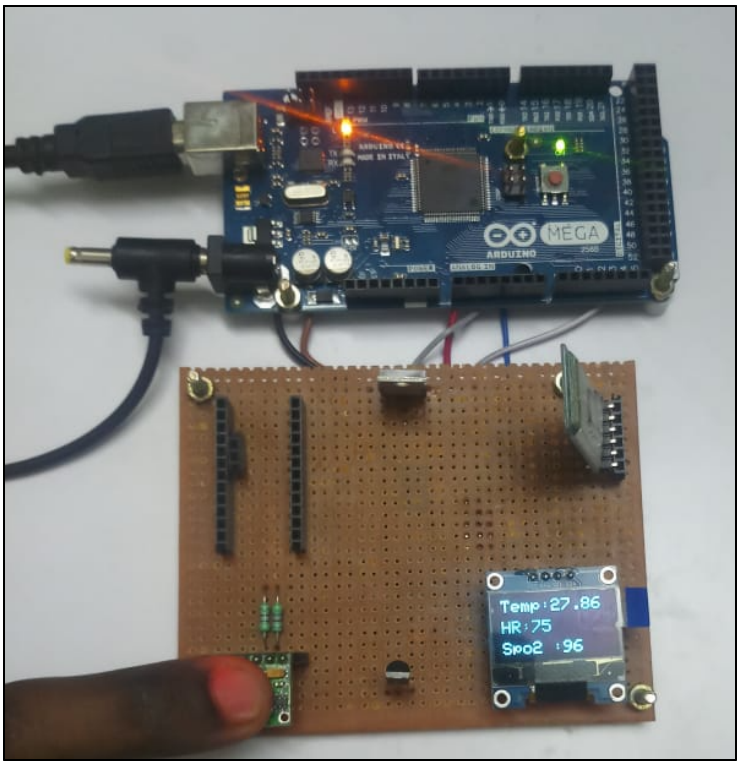


Fig.10 Established Hardware

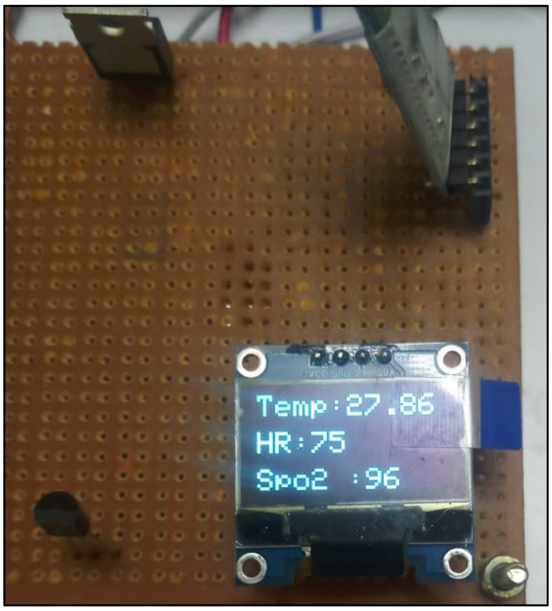
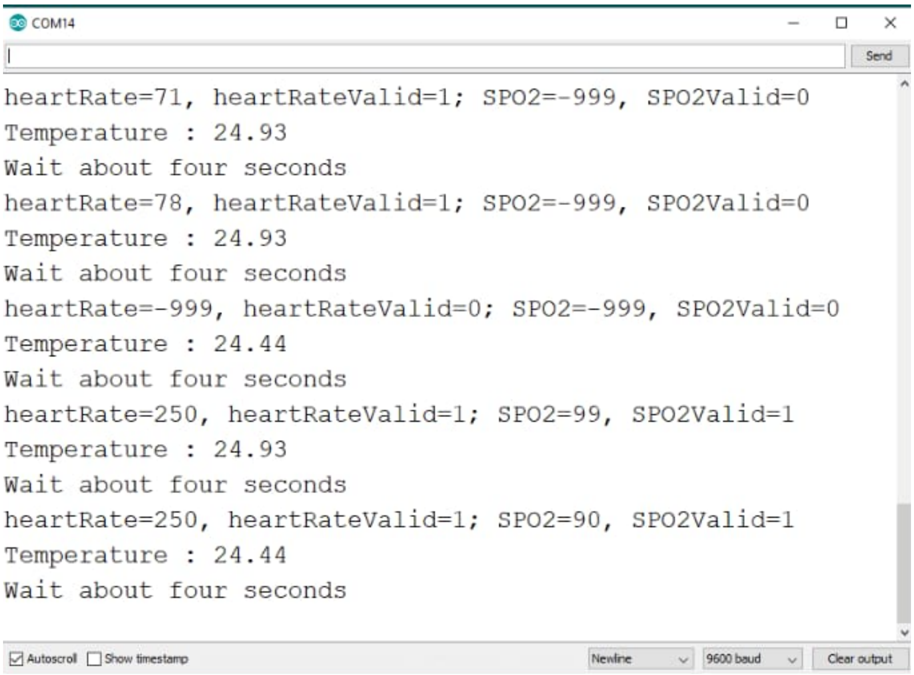
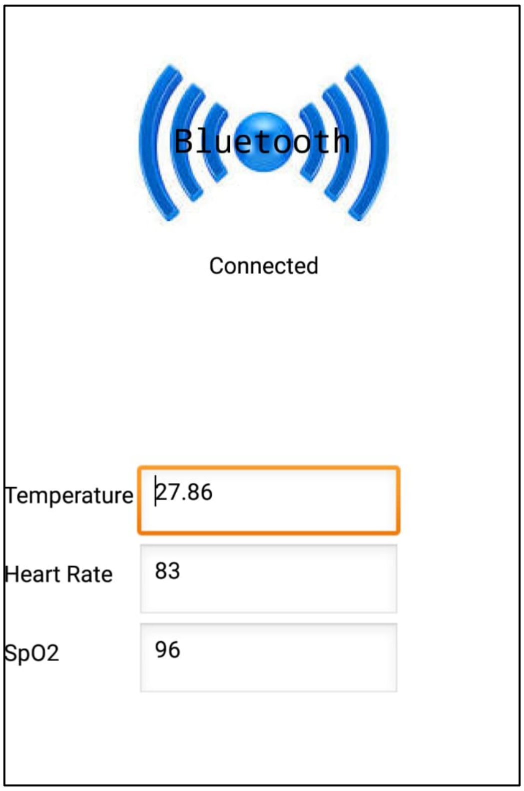


Fig.11 OLED displaying the Vitals



```
heartRate=71, heartRateValid=1; SPO2=-999, SPO2Valid=0
Temperature : 24.93
Wait about four seconds
heartRate=78, heartRateValid=1; SPO2=-999, SPO2Valid=0
Temperature : 24.93
Wait about four seconds
heartRate=-999, heartRateValid=0; SPO2=-999, SPO2Valid=0
Temperature : 24.44
Wait about four seconds
heartRate=250, heartRateValid=1; SPO2=99, SPO2Valid=1
Temperature : 24.93
Wait about four seconds
heartRate=250, heartRateValid=1; SPO2=90, SPO2Valid=1
Temperature : 24.44
Wait about four seconds
```

Fig.12 Serial Monitor displaying the Vitals



Temperature 27.86
Heart Rate 83
SpO2 96

Fig.12 App displaying the vitals

CHAPTER 6 :

CONCLUSIONS AND FUTURE DIRECTIONS

- A vital signs monitoring device can be implemented using small, cost effective components that detect the real time heart rate in beats per minute and SpO2 along with body temperature through the skin.
- Without requiring any elaborate hardware changes, the software controls can be modified easily for additional features or for altering the applications.
- Thus a low cost, multipurpose device can be designed and simulated. This kit can be used for testing without a second person intervention, thus promoting social distancing and contact-less testing, adapting to the global pandemic.
- Future work includes miniaturisation of the existing hardware so that it is in the form of a wearable device.
- Miniaturisation can be established by choosing a smaller yet efficient controller with a good memory.
- The hardware can be accommodated in a wearable case by soldering the components one above the other such that there is no shorting of wires.
- The simulation can be made more memory friendly by creating efficient libraries.

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