Health Monitoring Smart Device for Firefighters

By

Asif Muhammed Pervez
18221016
Abid Mustakem Ahmed
18221021
Iffat Ara Diba
18221028
Shahriar Azad
17121040

A thesis submitted to the Department of Electrical and Electronic Engineering
in fulfillment of the requirements for the degree of
Bachelors of Science in Electrical and Electronics Engineering

Department of Electrical and Electronic
Engineering BRAC University
January 2023

Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing a degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

Academic Technical Committee (ATC) Panel member:

Dr. Mohammed Belal Hossain Bhuian (Chair)
Associate Professor, Department of EEE, BRAC University

Md. Mahmudul Islam
Lecturer, Department of EEE, BRAC University

Abdullah Hil Kafi
Lecturer, Department of EEE, BRAC University

Department of Electrical and Electronic
Engineering BRAC University
January 2023

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

Student's Full Name & Signature:

Asif Muhammed Pervez 18221016	**Abid Mustakem Ahmed** 18221021
Iffat Ara Diba 18221028	**Shahriar Azad** 17121040

Approval

The thesis/project titled "Health Monitoring Smart Device for Firefighters" submitted by

1. [Asif Muhammed Pervez (18221016)]
2. [Abid Mustakem Ahmed (18221021)]
3. [Iffat Ara Diba (18221028)]
4. [Shahriar Azad (17121040)]

of [Fall], [2022] has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on 15-12-22.

Examining Committee:

Academic Technical Committee (ATC): (Chair)

Dr. Mohammed Belal Hossain Bhuian
Associate Professor,
EEE Department,
BRAC University

Final Year Design Project Coordination Committee: (Chair)

Abu S.M. Mohsin, PhD
Associate Professor,
EEE Department,
BRAC University

Department Chair:

Md. Mosaddequr Rahman, PhD
Professor and Chairperson, EEE Department, BRAC University

Ethics Statement

The presented article/journal/thesis/project/report has been thoroughly checked and revised multiple times under teamwork supervision, using authentic anti-plagiarism tools and cross-checking system. The plagiarism found in this paper found to be very low (13%).All sources taken to remodel this paper are biased. Hence any similar work found in this paper matching with any other web materials is non-intentional and purely coincidental.

Abstract/ Executive Summary

“Health Monitoring Smart Device for Firefighters” is a new research project with ideas consisting of some older research projects which were carried out by several independent researchers. In this research, our main goal or objective is to design a smart portable health monitoring system that would consistently measure key health components of firefighters during evacuation or rescue events. In order to perform suitable operations and accurate data analysis, we have used Arduino IDE software to implement Arduino-based designs for our convenience. Saving the lives of firefighters is very much important since they play the key role of saving other humans, animals, and socio-economic properties. The first two designs proved to be obsolete because they only measure a single health factor. In response to these problems we then devised another design and the final design now measures some key health features of firefighters. Even though in reality we didn’t implement our device on firefighters, we made several experiments; that is implementing the device on our colleagues with several environmental conditions both indoor and outdoor.

Keywords: Health Monitoring; Firefighters; Smart; Portable; Software; Data analysis.

Acknowledgment

First and foremost, glory is to the Great Allah, with whose help we were able to finish writing our thesis without too many setbacks.

Second, we would like to thank our Academic Teaching Committee advisors including, Dr. Mohammed Belal Hossain Bhuian sir, Md. Mahmudul Islam sir and last but not least Abdullah Hil Kafi sir for their kind assistance and suggestions throughout FYDP. They came to our aid anytime we needed it.

Thirdly, to all my teammates, friends and colleagues who helped us, and supported us for our immense hard work on the project.

And ultimately, without our parents' ongoing support, it might not be possible. We are currently preparing to graduate thanks to their thoughtful support and prayers.

Table Contents

Chapter 1: Introduction [CO1, CO2, CO3,CO10]

1.1 Introduction:

Over the past ten years, experts have paid a lot of attention to healthcare monitoring systems. The fundamental aim was to create a reliable patient monitoring system that would allow medical professionals to keep an eye on their patients when they were either in hospitals or engaged in routine activities. With the use of TFT modules, we present in this study a wireless healthcare monitoring system that can provide real-time online data on a patient's physiological condition. In order to accurately assess a patient's state of health and fitness, our system must measure and track the patient's essential physiological data. The suggested system also has the ability to provide warnings about the patient's critical medical information. The medical expert can use the information in the communication to provide the necessary medical advice. The majority of the system is composed of software, sensors, and a device that collects data, together with a microcontroller (such an Arduino). The patient's temperature, heart rate, blood oxygen level, and stress level are all tracked by our system and shown. Field testing has been done on the suggested technology to ensure its durability and correctness. The test findings show that our system is capable of taking precise physiological measurements of the individual.

In this research, a brand-new wearable system for firefighter safety is suggested. The wearer's physiological state is measured by a number of integrated sensors in a portable box, and a microcontroller allows for the collection of all measured data on the wearer's health, stress, and fatigue levels, among other things. Using the chosen sensors, the proposed wearable system may continually monitor important health characteristics. For assuring the wearer's comfort and close proximity of the sensors to the body to improve signal quality. A local decision support system for connecting tiredness or stress levels to the detected physiological signals has been developed following the stages of data preprocessing and data fusion by learning from the measurements of the sensors built into the box. In this approach, the command center may receive this high level of information, enabling it to make appropriate, nationwide decisions for improving the protection of firefighters.

1.1.1 Problem Statement:

One of the biggest problems facing humanity is its health. The World Health Organization (WHO founding)'s principles state that everyone has a fundamental right to the best possible level of health. The workload on public safety networks, governmental (or non-governmental) organizations, including hospitals, clinics, and medical experts is also reduced by healthy individuals. A smart healthcare system is necessary to keep people healthy and effective and easily accessible. Better healthcare services should be accessible to individuals at any time, from any location, and in an affordable, patient-friendly way under a modernized healthcare system. A cultural change is currently taking place in the healthcare sector.

Firefighters are characterized by a wide range of health risks in the course of their employment, and as a result, they have a heightened chance of being injured or died in the line of duty.
In addition to the hazards associated with operating in such an environment, fire fighters must also contend with extremes of noise, temperature, and the presence of potentially harmful gasses in the air. As an added downside, the individual's protective gear may reduce his or her productivity. These conditions are linked to measures of physical capabilities considered to lessen the chance of accident, disability, or death on the job. Firefighters have been advised to engage in health and fitness programs that focus on preventing cardiovascular disease and musculoskeletal problems. Both of these types of training are crucial for every modern fire department.

One of the primary chronic health issues for firefighters is heart disease. Heart disease is a problem for firemen who are frequently exposed to dangerous chemicals, high temperatures, and physical strain. In fact, according to a 2013 study of 478 active-duty firefighters conducted by National Volunteer Fire Council, 73% of respondents said that they are more concerned about dying from a heart attack than in the line of duty both from artery disease as well as from irregular heartbeats.
On the job, firefighters run the risk of suffering from heat exhaustion, burns, and physical and mental stress. Additionally, they frequently come into contact with harmful risks like high quantities of carbon monoxide. This type of employment provides a risk for numerous diseases because of these hazardous exposures. Even more at risk are firefighters who smoke or practice other hazardous lifestyle behaviors.

For firefighters, heart attacks are the primary cause of mortality in 45% of cases. During the actual firefighting process, this risk is increased. It may be caused by strenuous work close to hot fires, exposure to carbon monoxide, and other workplace pressures. These hazards are increased by being physically unfit, being overweight, and smoking.

Smoking increases the risk of CO and other respiratory diseases among firefighters. The heart needs more oxygen when under intense physical and mental strain, but breathing in more CO lowers the amount of oxygen a firefighter receives. Heart attacks may result from both coronary heart disease and this.

1.1.2 Background study:

The impact of self-contained breathing apparatus (SCBA) and other risk variables on three forms of injury at the site of a fire was examined in this case-control research within a metropolitan fire department (smoke inhalation,burns, and falls). Telephone interviews and departmental data were used to collect information on 144 controls and 75 wounded firefighters. The two groups of uninjured firefighter controls were matched to incidents (n = 72) or cases based on job status and the kind and size of fires (n = 72). In terms of SCBA use, cigarette smoking, prior fires during the shift, or injury history, cases of smoke inhalation were not statistically different from controls. Nozzle operator, engine officer, and forcible entry personnel in first-due companies were among the occupations with a high risk of burns

(OR = 20.1). Additional risk factors for burns included the fire starting in the basement (OR = 10.2), having received prior firefighting training from a department other than the current one (same fire: OR
= 11.2; similar fire: OR = 3.9), and having been injured while on the job within the previous 12 months (same fire: OR = 4.3; similar fire: OR = 3.5). Consistent SCBA use was linked to falls but not to burns when other risk factors were taken into account (same fire: OR = 11.8; comparable fire: OR = 4.3). Members of truck companies (OR = 17.7) and firefighters without children (same fire: OR = 8.4; comparable fire: OR = 7.4) both had higher fall risk. When cases were compared to controls attending similar fires, on-duty injury in the previous 12 months was associated with falls (OR = 5.5), but not with controls attending the same fire.

1.1.3 :Related work

A real-time mobile healthcare system has been proposed for keeping an eye on elderly patients from outside or inside areas. The system's two major parts are a smartphone and a biosignal sensor. A smart server receives the data gathered by the bio-signal sensor through a GPRS/UMTS network. The device enables remote monitoring of the elderly patient's mobility, whereabouts, and vital signs.
A smart shirt has been designed in [3] . The patient's health can be continuously monitored by the shirt using acceleration signals and electrocardiogram (ECG) measurements. To gather the body signal, the shirt is mostly made of sensors and conductive materials. Through an IEEE 802.15.4 network, the measured body signals are sent to a base station and server PC. The wearable gadgets are small enough to fit inside a shirt and have low battery consumption. In this work, an adaptive filtering method has also been presented in order to lessen the noise present in the ECG signal.

A method for tracking bodily parameters that runs on Windows Mobile has been introduced. The suggested system uses a network of body sensors to assess and gather physiological data. Data from the sensor network has been dependable and robust.
The outcomes of the experiments demonstrate the capability of the suggested system to track patients' physiological data while they are moving around.

1.1.4 Relevance to current and future industry:

Future Industry: We take into account a number of commercial, business, and engineering factors when implementing the system, including cost, ease of use, efficiency, low energy consumption, and environmental friendliness for future use.

- **YoctoKnob device:**
  The Yocto-Knob gadget provides simple USB reading of five input knobs, contacts, switches, or buttons. It is an analog-to-digital converter of some sort (ADC). Any analog resistive sensor, including photodiodes, can be read with it. The values of the five inputs are displayed continuously on the gadget by five small LEDs. A design is made simpler by using five micro switches wired in parallel to the inputs. A YoctoHub-Ethernet or YoctoHub-Wireless can be used to connect this device directly to an Ethernet or Wi-Fi network, respectively. The Valarm Pro v1.1.0 application for Android supports the Yocto-Knob sensor. Without any programming, we can utilize these sensors to send out alerts and/or log the state of a range of things that need to be tracked. In order to monitor, record, and broadcast alerts based on environmental and weather parameters like CO2, VOCs (Volatile Organic Compounds), ambient temperature, relative humidity, barometric pressure, ambient light, electrical resistance, water levels, and flood alerts, the Valarm Pro application integrates Yoctopuce sensors.

1.2 Objective,Requirements,Specifications:

1.2.1 Objectives:Our aim is to build a wearable system may continually monitor important health characteristics for firefighters.The following are the objectives of our project:

- Monitor health condition in real time
- Establish a reliable observation system
- Healthcare professionals could keep an eye on their patients while they are on duty.
- In the case of an emergency, provide suggestions and take immediate action.

1.2.2 Functional and non-Functional Requirements:

The Specification of the system can be classified into subcategories.These would be divided into Functional and Non-Functional part according to the user end Requirements:

User-End Requirements	Functional	Health condition monitoring
		Emergency condition detection
		Provide Immediate action
		On duty monitoring by doctors
		Remote monitoring
		Wireless communication
	Non-Functional	Light weight
		Comfortable

Table 01: Functional and Non-Functional Requirements

1.2.3 Specification:

This section will cover our system's requirements and specifications as well as provide a detailed analysis of each component used.

Requirement

Requirement	Specification	Components
Can detect pulse rate, Sp02, Body temperature	Sensors	MAX30100 Heart Rate and Sp02 Module

Able to detect Fall and Position	Sensor	MPU6050, GPS
Can detect Excessive sweating through skin conductance	Sensor	GSR Sensor (Galvanic Skin Response)
Displays User Data	Display	3.5” inch TFT Display
Capable of showing data of multiple firefighter’s data	Microcontroller Unit and corresponding Wifi Module	ESP-32 in devices Arduino for Base station
Able to detect Toxic and Flammable Gas	Sensor	MQ-2

Table 02: System Requirements

1.2.4 Technical and Non-Technical Considerations and constraints in the design process:

Limitations/ Constraints of our design	Technical constraints	Sensitivity issue
		To prevent a hang, the sensor must be restarted.
		Circuit-related risks could cause the item to experience water damage.
	Non-Technical Constraints	Making the watch band's color to the user's preference

Table 03: Technical and non-technical restrictions and concerns involved in the design process

1.2.5 : Applicable Compliance, standards and codes:

- **IEEE Std 11073-10404-2008:**
  This standard establishes a normative definition of communication between personal telehealth pulse oximetry devices and compute engines (such as cell phones, personal computers, personal health appliances, set top boxes) in a way that facilitates plug-and-play (PnP) interoperability within the context of the ISO/IEEE 11073 family of standards for device communication. It makes effective use of the vocabulary, information models, application profile standards, and transport standards specified in ISO/IEEE 11073. It limits the optionality in basic frameworks in favor of interoperability by requiring the usage of certain word codes, formats, and behaviors in remote monitoring situations. The common core of communication capabilities for personal telehealth pulse oximeters is defined by this standard.

1.3 Systematic overview /Summary of the project:

In this work, a watch-based health monitoring system has been introduced. The method allows emergency doctors to constantly monitor and act quickly on behalf of their patients.
Real-time physiological data display. As a result, the physician can always keep an eye on their patients from a range. Our system is easy to use. As a result our smart device will create an impact on our medical technology sector .Overall, it will improve our firefighters' performance tremendously and raise their productivity.

1.4 Conclusion:

An efficient health monitoring system must be able to capture and alert doctors to a patient's condition in real time. A modern health monitoring device should be able to take, display, and send the patient's physiological data from the body to a distant location at any time, taking full advantage of the benefits of modern bioinstrumentation technology. An alarm system should be built into the device(panic button) to ensure prompt, efficient, and emergency medical attention. The device duty is not only to keep tabs on and display the critical patient's data, but also to send out emergency alerts to the patient and their doctors if any of those numbers start to go outside of their predetermined parameters.

Chapter 2: Project Design Approaches [CO5, CO6]

2.1 Introduction:

Our system for monitoring firefighters' health is based on a few goals, which allowed us to evaluate how crucial it was when developing the methods. We looked through a number of research review papers and software in order to identify the three potential design methods to achieve the major objectives of our project.

2.2 Identify Multiple Design Approaches:

2.2.2 Design Approach 1:

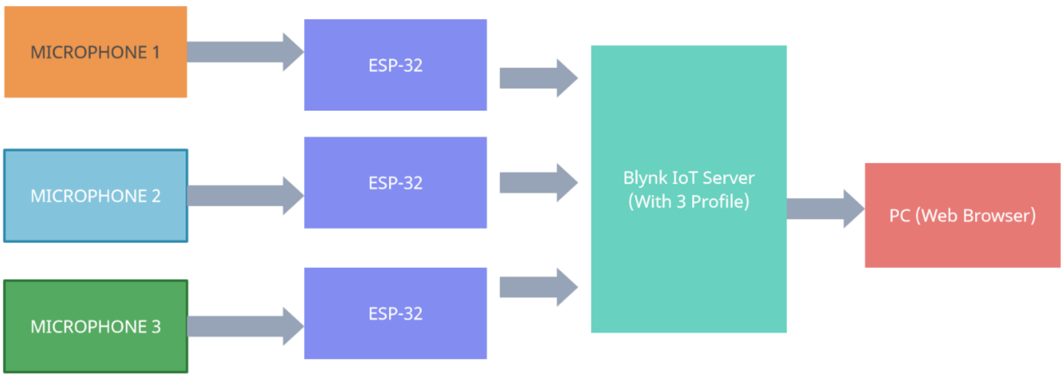


Figure: Block Diagram of the Design 1

- Each microphone can detect heartbeat as a form of audio signals
- Each ESP-32 detects audio intensity separately
- Blynk to show heart rate and its condition

2.2.3 Design Approach 2:

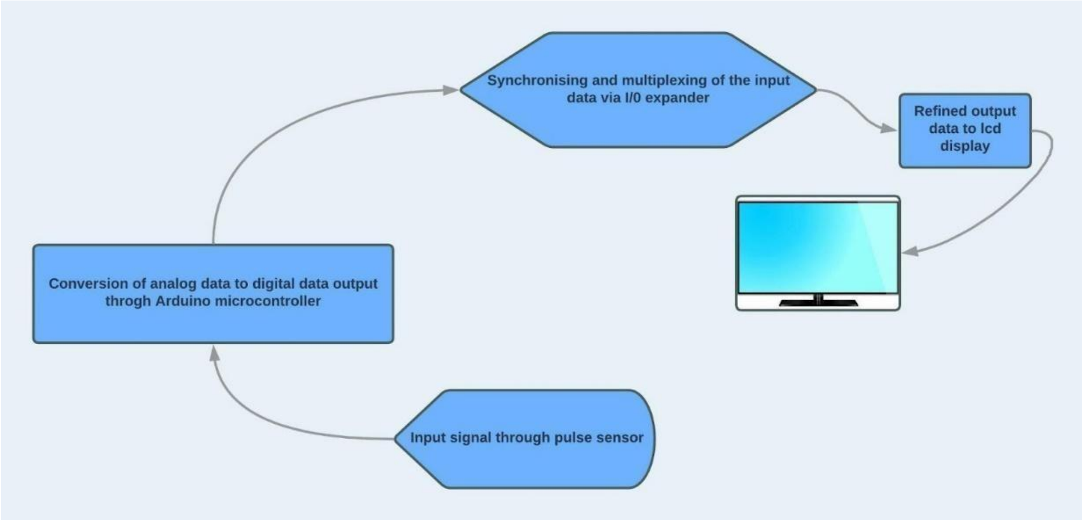


Figure : Block Diagram of the Design 2

2.2.1 Design Approach 3:

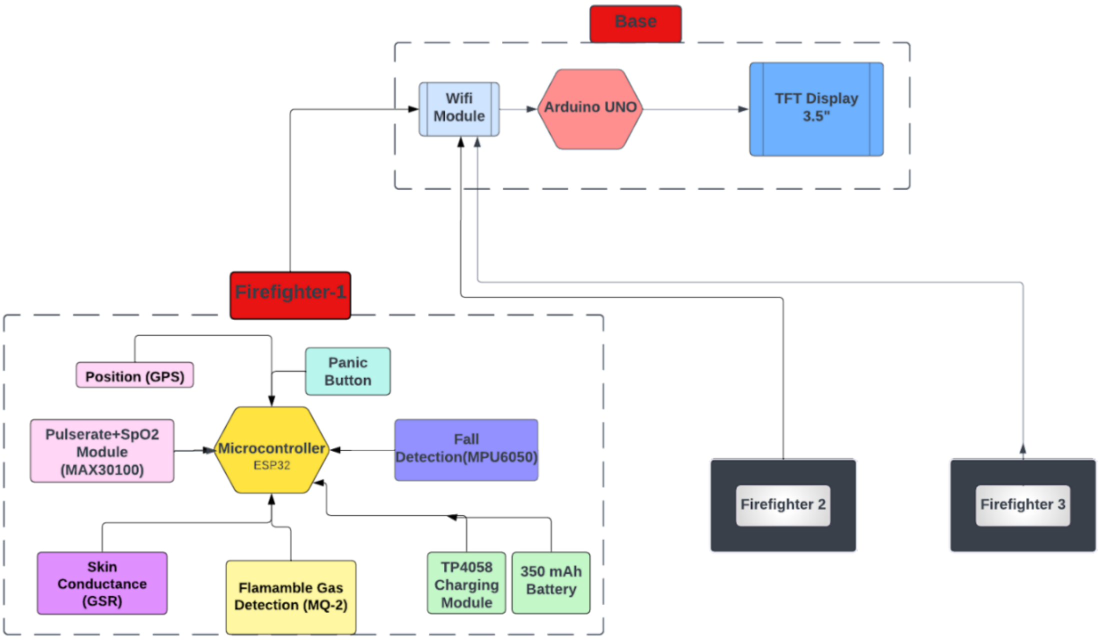
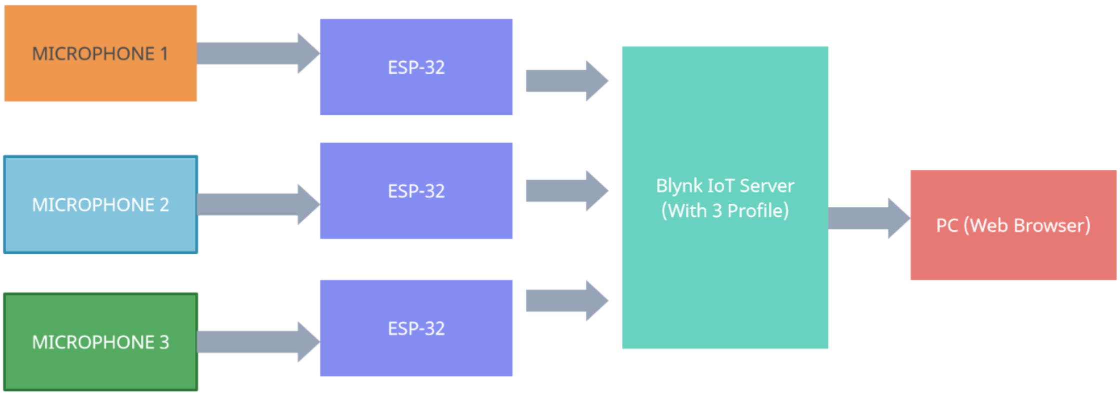


Figure : Block Diagram of the Design 3

2.3 Describe multiple design approaches:

Design Approaches 01:



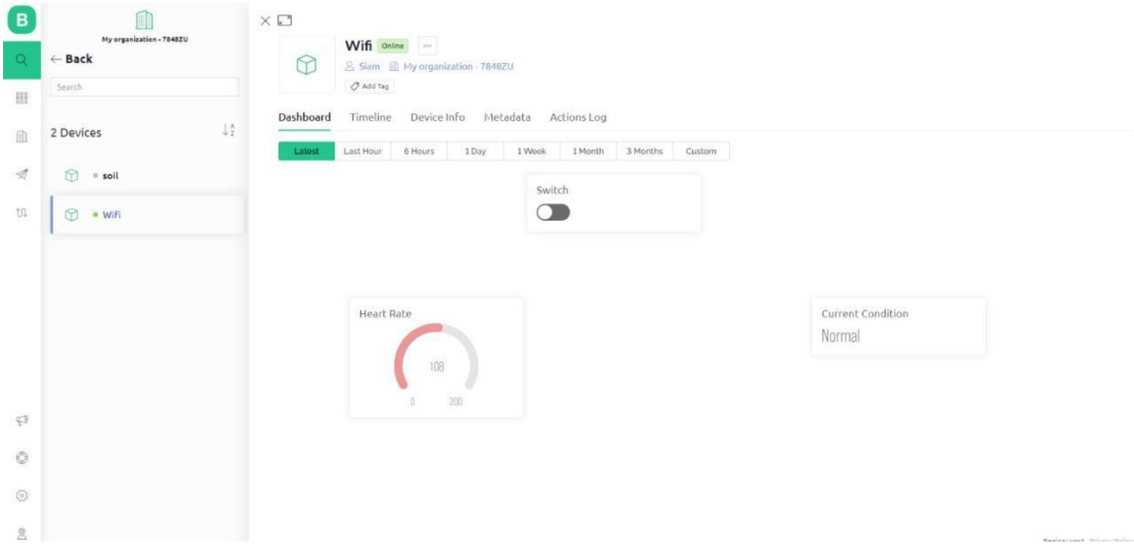


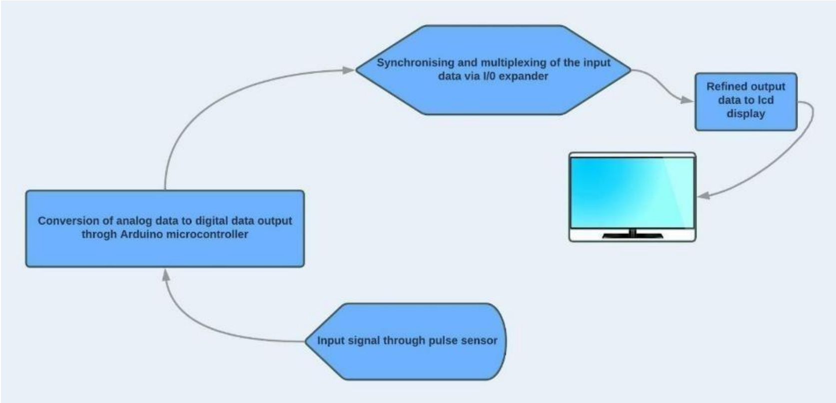
Figure : Block Diagram design 1

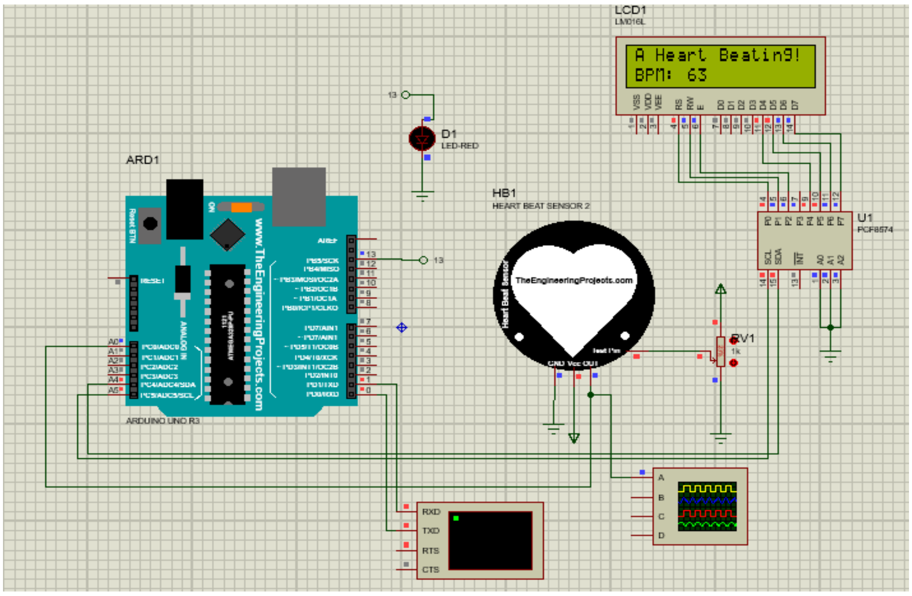
Blynk is a cloud IoT platform which we can connect with ESP-32 to visualize data and personal information. Blynk supports up to 3 profiles (Free) where we can monitor up to 3 esp-32 monitor at a time.

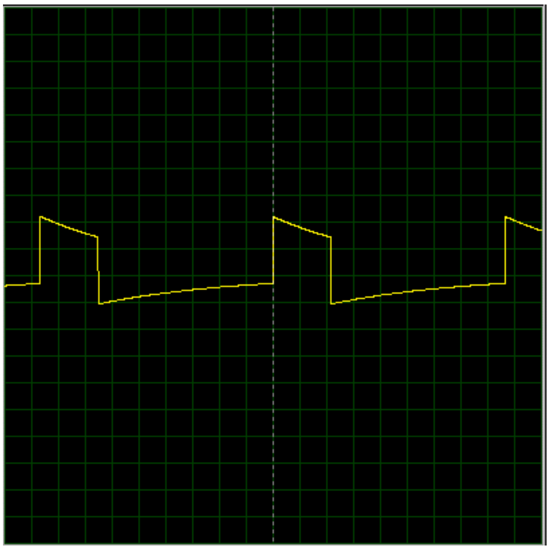
In this solution we can take heart signals from the microphone and we don't need any additional PC to manipulate signals; rather MCU(ESP-32) will take and manipulate signals and transmit data to Blynk.

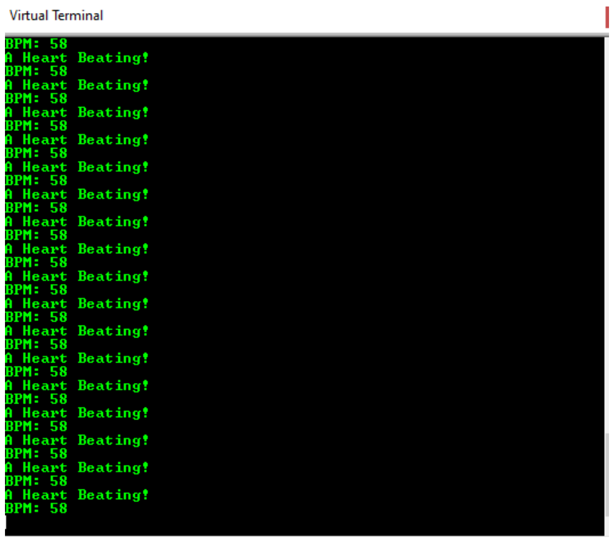
In the blynk server we can monitor heartbeat and their condition as well

Design Approach 2:



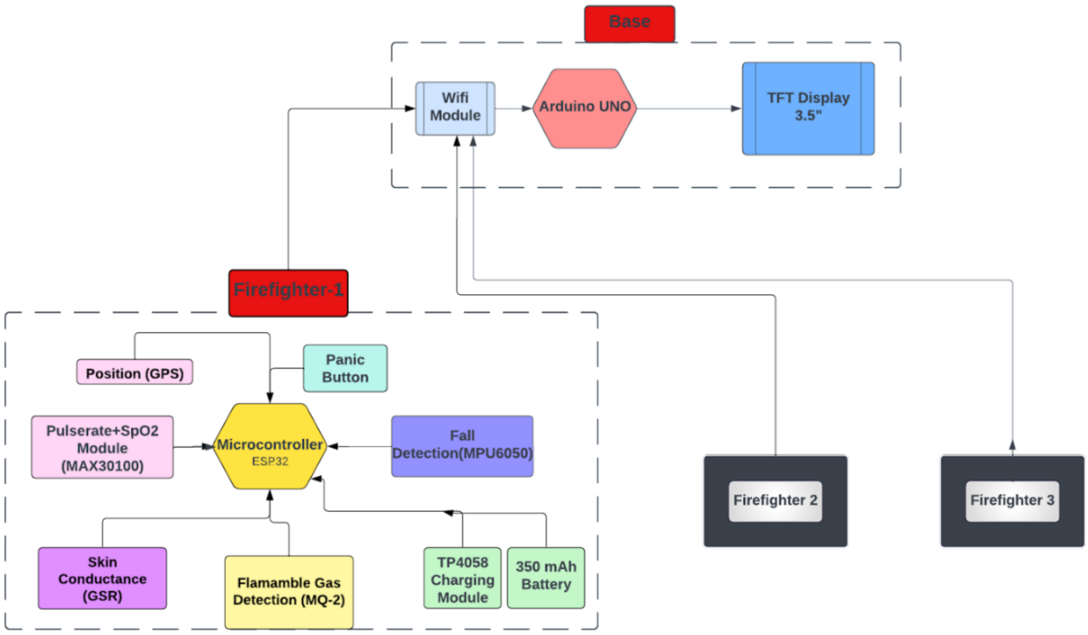






This simple design shows us the heart rate and at the same time shows the heart rate pattern of a person suffering heart rate complications. The design can be divided into three segments; (1) Input of data through heart beat sensor (2) Signal processing through Arduino microcontroller (3) Output data at alphanumeric display. In this design, we used a heartbeat sensor which is easily available in the market and commonly known as Pulse Sensor or SEN-11574 model. Photoplethysmography is a technique used today to monitor the patient's pulse rate. The sensor used for this task is Pulse sensor (SEN-11574), very small, worn or wrapped around your index finger or earlobe. This sensor module consists of a light source photo detector and Infrared LEDs (Light Emitting Diode). microcontroller-based board which is used here in this design to read the ac analog signal from the sensor and to convert the input data into digital form using mathematical algorithms. The output data from the pulse sensor is converted to continuous digital pulsating dc signals by means of numerous mathematical functions.

Design Approaches 03:



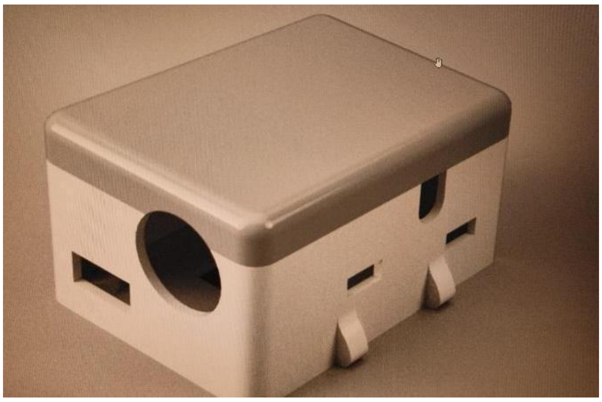


Figure : Block Diagram and 3D model of the Design

In this design we mainly proposed a hand watch type solution which can detect necessary data related to health like SPO2, Sweat, Pulse rate, Skin Conductance etc. to know the physiological condition of our targeted group of people. In this project, health related data will be sent wirelessly to a base station (A MCU which can receive multiple data) where an expert will monitor data for any kind of abnormal or normal state.

Additionally, this project can also detect if a person felled or not and position of a person.it also has a panic button for emergency notice.

2.4 Analysis of multiple design approaches:

Here to compare the three design approaches we have assessed them on several criteria and the results are tabulated below:

	Design 1	Design 2	Design 3
Component Efficiency	Uses multiple MCU and sensors to measure data in real-time	Uses multiple MCU and sensors to measure data in real-time	Uses a single Arduino UNO and sensors to measure data in real- time
Data Accuracy	Error rate 17.28% Low error rate	Error rate 14.28% High error rate	Error rate 7.28% High error rate
Manufacturability	The components are available, can be built easily.	This system based on Microphone, an analog sensor that has a high Error rate	This design has a sensor that is available but it is quite sensitive
Maintainability	Maintenance is bit difficult and sometimes sensor needs to calibrate.	Maintenance is difficult as it has an analog sensor which is not so accurate	Maintenance is easy as it has only one sensor to implement
Feasibility	This design has complexity. There are both nano and uno as MCU. And the code implementation is quite challenging		Yes Feasible

After the comparison, we have come to the decision to elect Design 1 to be our optimal design Solution.

2.5 Conclusion:

To conclude, we have gone through several aspects of mathematical reasoning, analytical skills, and complex engineering problem issues. In order to choose the best design approach (Design Approach-1) for our system, we compared the functionality phases of the 3 separate design approaches we came up with after completing these tasks

CHAPTER 3: Use of Modern Engineering and IT Tool [CO9]

3.1 Introduction:

In the engineering community, the term "modern Engineering Tools" is commonly used. The best methods for selecting a "modern" engineering tool include research, analysis, and comparison. In order to choose the best modern engineering tool for the job, the user must conduct comprehensive research before using it. Therefore, to choose the Modern Engineering tools (Hardware, Software, Simulation) for our "Heath Monitoring System for Firefighters" project, we undertook various forms of research, literature reviews, and comparisons.

3.2 Selection of appropriate Engineering and IT tools:

In order to select the suitable current Engineering Tools for any complex engineering challenge, we must conduct study and evaluate a number of criterions. As a result, we have identified some cutting-edge engineering tools for the hardware and software phases of our complex engineering project.

3.2.1 Software and comparison:

Proteus: This software integrates circuit simulation, PCB design, and single-chip simulation. By providing the best real-time display effects, it also supports the compiling, editing, and source-level simulation of the assembly language of the microcontroller, with built-in assembly compilers of 8051, AVR, PIC, etc. However, insufficient data calculation of the circuit is the limitation of it. As it is more compatible than any other software for us, we've selected Proteus software for our project simulation

LabVIEW: LabVIEW (Laboratory Virtual Instruments Engineering Workbench) is a system engineering software for applications that require measurement, testing, and control with rapid access to hardware and data insights. The LabVIEW software offers a graphical programming approach that helps to visualize every aspect of the application, including hardware configuration, measurement data, and debugging. This visualization makes it simple to integrate measurement hardware from any vendor, represent complex logic on the diagram, develop data analysis algorithms, and design custom engineering user interfaces. LabVIEW is the best tool available in the market for real-time control. It can connect with multiple devices to acquire data from sensors and control actuators based on processed data.

PSpice: It is a general-purpose analog circuit simulator that is used to verify circuit designs and predict circuit behavior. However, it has so many limitations. Such as, it is restricted to circuits with 10 transistors only, doesn't support iterative methods, unavailability of distortion analysis, cannot be used to synthesize the circuit elements, and so on. As it has so many limitations, we are not using this software.

Software Name	Portable	PC Specs Moderate	Import facilities	Free to use	Crash issue	Graphs	Pulse	Component Naming	Library Resources
Proteus	√	√	√	×	√	√	√	√	High
Sci-lab	×	×	×	×	×	√	√	√	Moderate
LabVIEW	√	√	√	×	×	√	√	√	High
TINKERCAD	×	√	√	√	×	×	×	√	Moderate
PSpice	×	√	×	×	×	×	×	√	Moderate

Comparing a number of factors reveals that Proteus provides the best accessible information and user- friendly online forums. Therefore, we have chosen Proteus 8 Professional (v8.11) for the simulation project.

3.2.2 Hardware and Coding:

ESP-32 Microcontroller: This is the microcontroller that reads sensor data and processes it by incorporating code. This MCU contains 32 Mbits of memory capacity and works at 3.3V.

Arduino UNO: Arduino Uno is a microcontroller board based on the ATmega328P. We used it to interface the TFT display and a WIFI module to take data from the sensor.

Biomedical Sensors: 2 Types of Biomedical Sensors used for monitoring in total of 3 kinds of parameters are MAX30100 and GSR sensor. They can show pulse rate, SPO2, and Skin conductance

- **MAX30100 (Pulse Rate and SP02):** It is a sensor solution that offers pulse oximetry and heart rate monitoring. Pulse oximetry and heart-rate signals are obtained using two LEDs, a photodetector, optimized optics, and low-noise analog signal processing.
- **GSR Sensor (Excessive sweat detection):** GSR, which stands for galvanic skin response, is a technique for measuring the skin's electrical conductivity. Strong emotion can stimulate the sympathetic nervous system, causing the sweat glands to produce more perspiration. By attaching two electrodes to two fingers on one hand, Grove - GSR enables the detection of such powerful emotions.

Additional Sensors: This project also incorporates MPU60500, GPS, Gas Sensor and a Panic Button. This are not directly related to the health but very useful if we want take a precautionary step in monitoring health

- **MPU60500 (Fall Detection):** MPU60500 sensor module is a six-axis motion tracking system. It combines a 3-axis Gyroscope, a 3-axis Accelerometer, and a Digital Motion Processor into a compact unit.it enables to detect the position of a person
- **Panic Button:** An additional SPST switch is added for emergency communication
- **GPS:** GPS Sensor to incorporate with fall detection for more accurate result
- **MQ2:** MQ2 can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide

TFT Display: A 3.5" Color display will show all the data's given by the sensors.

3.3 Use of modern Engineering and IT tools:

3D Modeling:

The process of constructing three-dimensional representation of an object or surface is known as 3D modelling. It is useful if we want to show simulate as well as 3D printing

- **Autodesk Fusion 360:** Fusion 360 is available for free download and use by students. Its cloud-based design management makes it an indispensable team resource. Fusion allows modelling in Freeform modeling & sculpting, Solid modeling, Parametric modeling and

Coding:

Arduino IDE refers to the Arduino development environment. It is a rapid and efficient open source tool that facilitates the development and submission of code to the device. This application is compatible with all Arduino, ESP, etc. versions. The software contains numerous user-friendly tools for coding, including a text editor for generating code. Connecting to the Arduino or ESP hardware, the software29 uploads programs and communicates with them. Instead of Arduino, we have utilized ESP32 as a microcontroller capable of both offline and online data transmission.

PCB Design:

For PCB designing we used Proteus because it is simple and Easy to use. and it will be alright for our project

3.4 Conclusion:

To conclude, we combed through a number of research articles and assessments to select the proper modern engineering techniques for the hardware and software component of our "Health monitoring system for firefighters" project. We have chosen sensors and other equipment available on the regional market.

CHAPTER 4: Optimization of Multiple Design and Finding the Optimal Solution. [CO5, CO6, CO7]

4.1 : Introduction:

To select the best design approach from our project's multiple design approaches, we used a few criteria. Our main goal here was to find the most appropriate and suitable proposed solution.

4.2 Optimization of Multiple Design Approaches 1: (Block diagram)

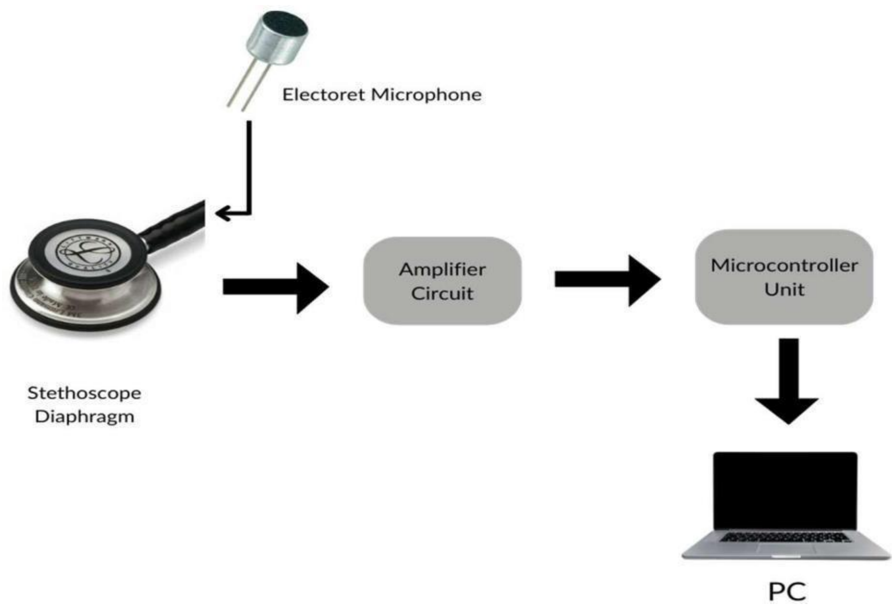


Figure : Block Diagram of the Design 1

1. Collect audio signals using a microphone. We are using a stethoscope Diaphragm to make an environment to collect heart signal.
2. Amplify the audio signal using popular LM386 audio Amplifier.
3. Amplified signals sent to microcontroller where it will be preprocessed and transmitted to PC or Web server
4. We can process, To Analyze and Visualize signals in PC we tasted in MATLAB

4.2.2Simulation design approach 1: (Amplifier Circuit)

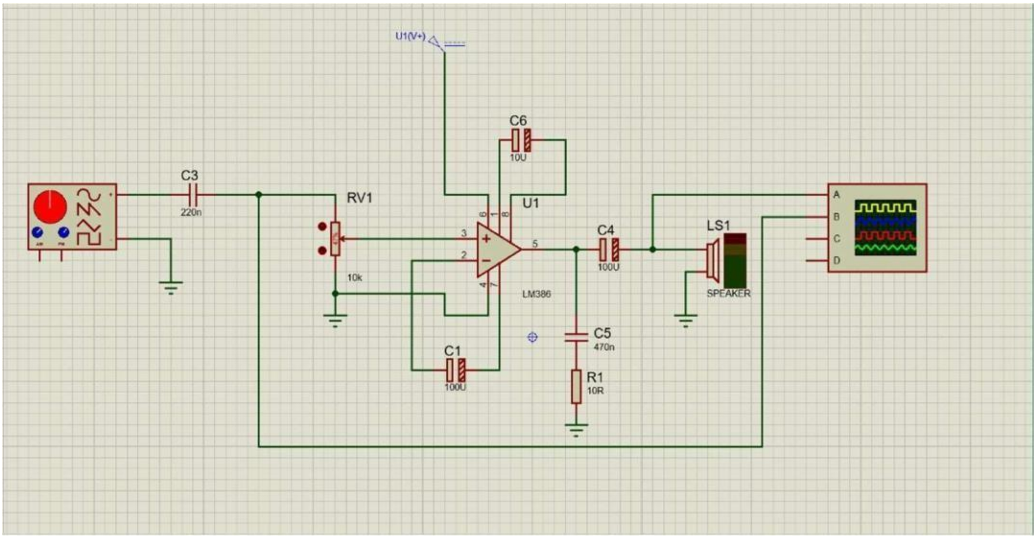
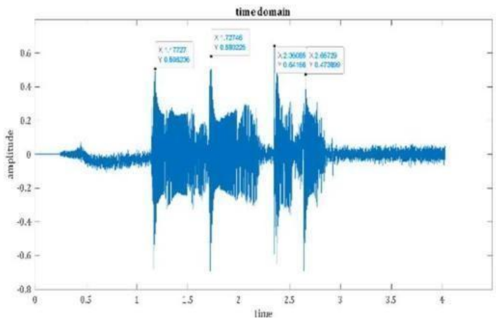
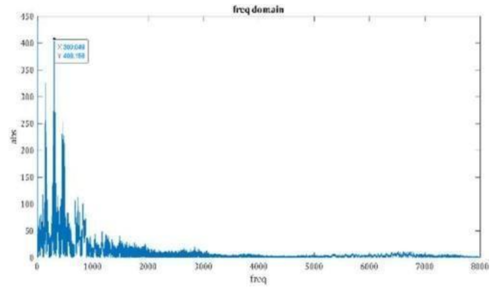
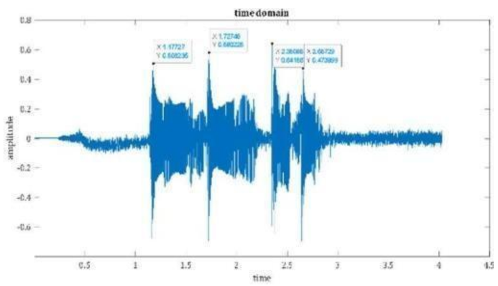
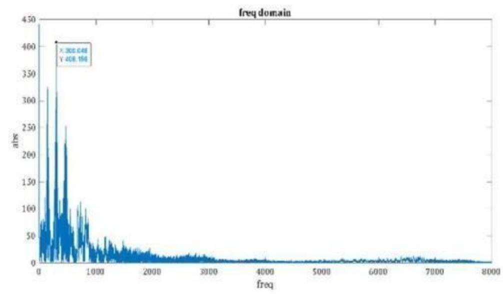
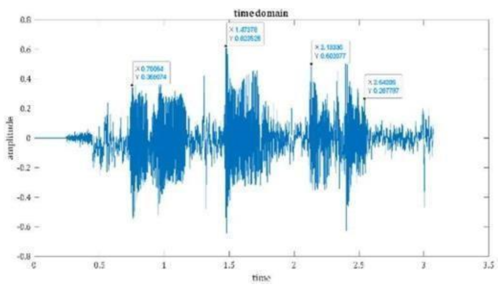
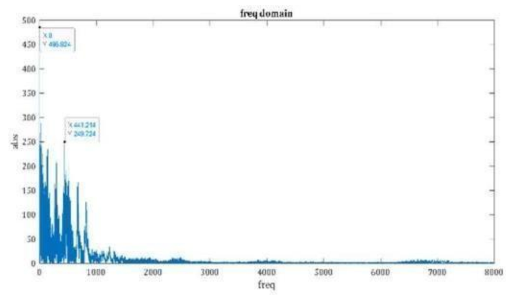


Fig: Amplifier circuit before sending to MCU

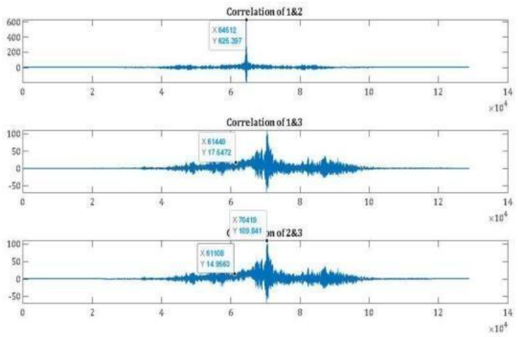
The integrated chip LM386 is a low power audio frequency amplifier requiring a low-level power supply (most often batteries). It comes in an 8-pin mini-DIP package. The IC is designed to deliver a voltage amplification of 20 without external add-on parts. But this voltage gain can be raised up to 200 (Vu = 200) by adding external parts.

As the heart signal has a very low amplitude. This audio amplifier circuit will amplify for better signal analysis. It has a variable potentiometer which can provide gain up to 20 times more than the original signal. We checked this circuit using the original heartbeat audio file and it was working Fine

4.2.3Visualizing Heartrate audio Using MATLAB:

Time domain graph for Audio 1: 	**Frequency domain graph for audio 1:** 
Time domain graph for audio 2: 	**Frequency domain graph for audio 2:** 
Time domain graph for audio 3: 	**Frequency domain graph for audio 3:** 

Correlation between audio 1&2, 1&3, 2&3:



Audio file read in MATLAB:

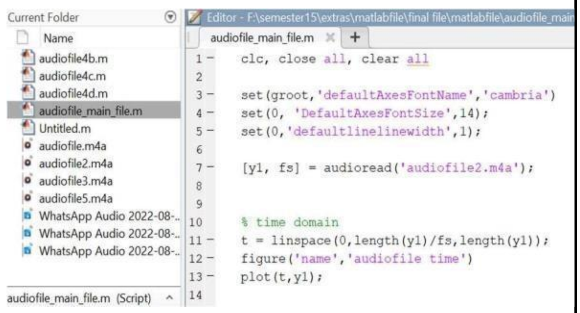


Figure: Visualization of Audio file

4.2.4Description:

At first, we took three audio files recorded on our phone. Then in MATLAB we read all our audio files. After that, using code (given in details later) we got the time domain and frequency domain value of the audio files. We named them as (Audio1, Audio2, and Audio3) files. Then we did correlation of Audio file (1&2), (1&3), (2&3). Here we can observe from the correlation graph, Audio file 1 and 2 are almost the same, so their correlation (Audio 1&2) is identically the same and their pick points and amplitudes are also the same. Whereas Audio3 is different from Audio (1 & 2). That's why the correlation graphs of Audio (1&3), (2&3) are not the same. Their amplitude, pick points are different.

4.2.5Blynk platform to monitor heart rate:

Blynk is a cloud IOT platform which we can connect with ESP-32 to visualize data and personal information. Blynk supports up to 3 profiles (Free) where we can monitor up to 3 esp-32 monitor at a time.

In this solution we can take heart signals from microphone and we don't need any additional PC to manipulate signals rather MCU(ESP-32) will take and manipulate signals and transmit data to Blynk.

In the blynk server we can monitor heartbeat and their condition as well

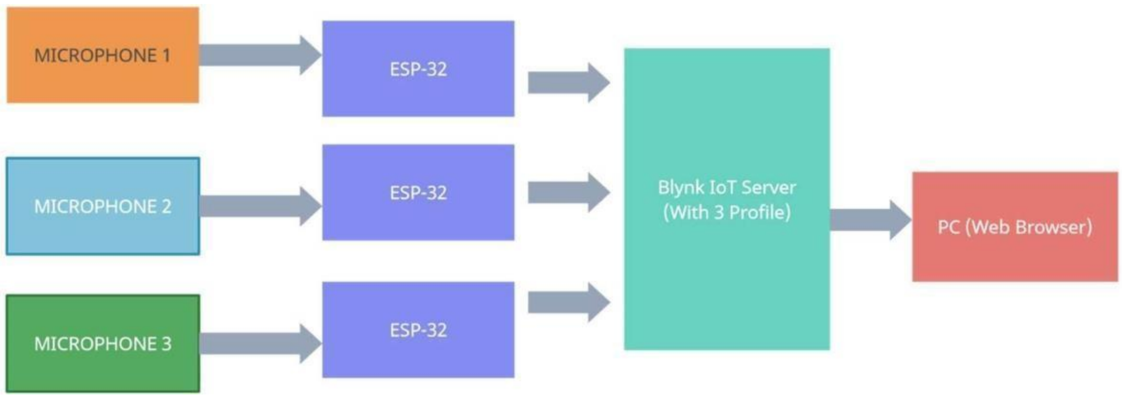


Fig: Block diagram for IOT based solution.

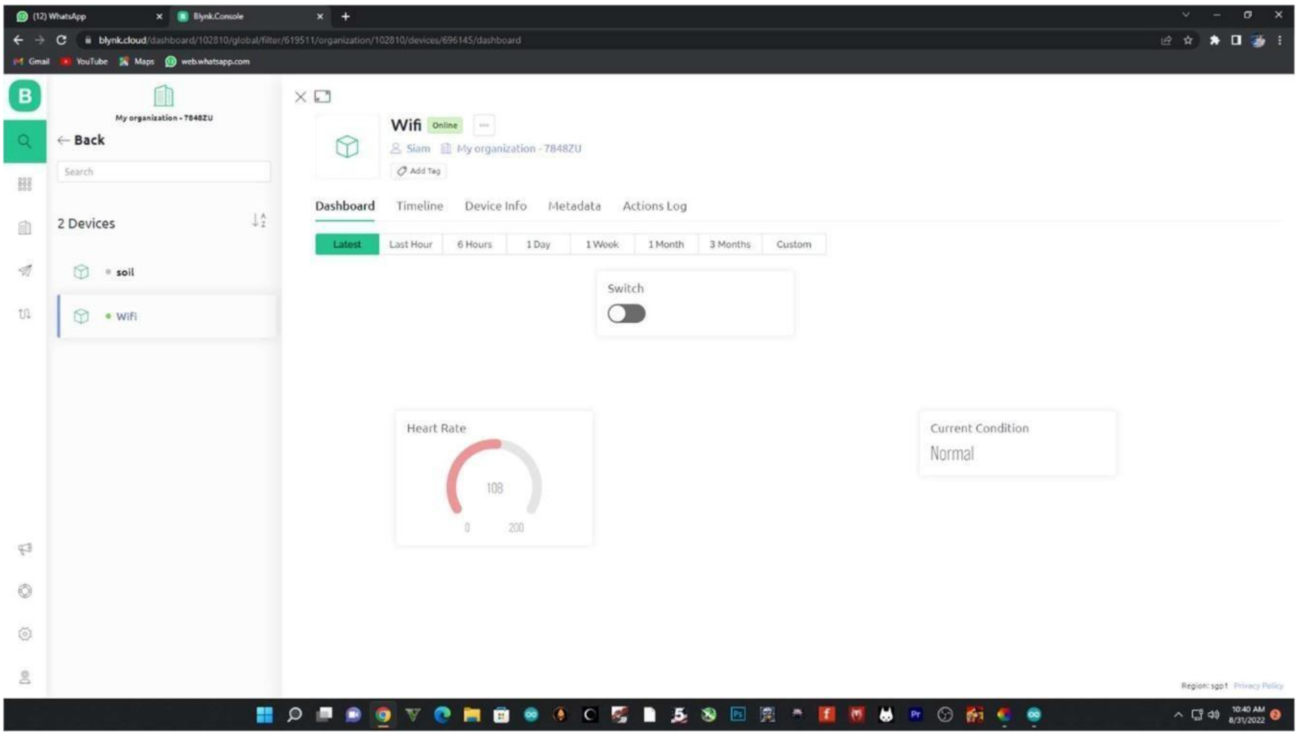


Fig: Interface of blynk IoT

Platform (Normal)

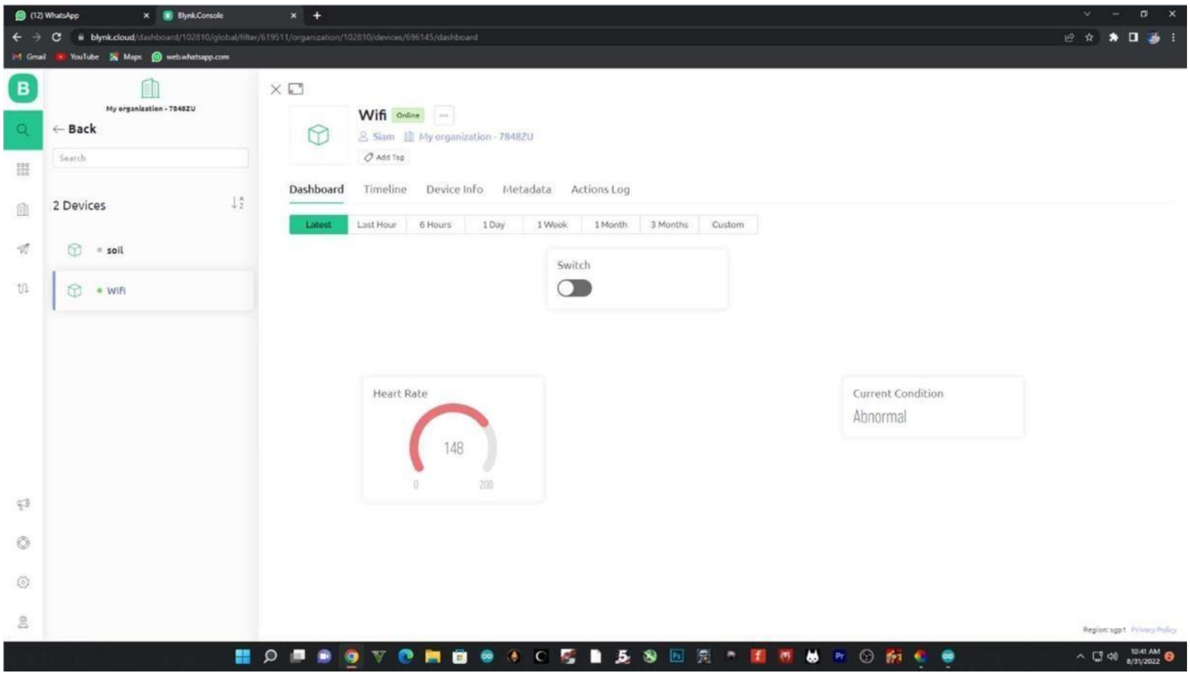


Fig: Interface of blynk IoT

Platform (Abnormal)

4.2.6Design

Approaches 2:

Block Diagram:

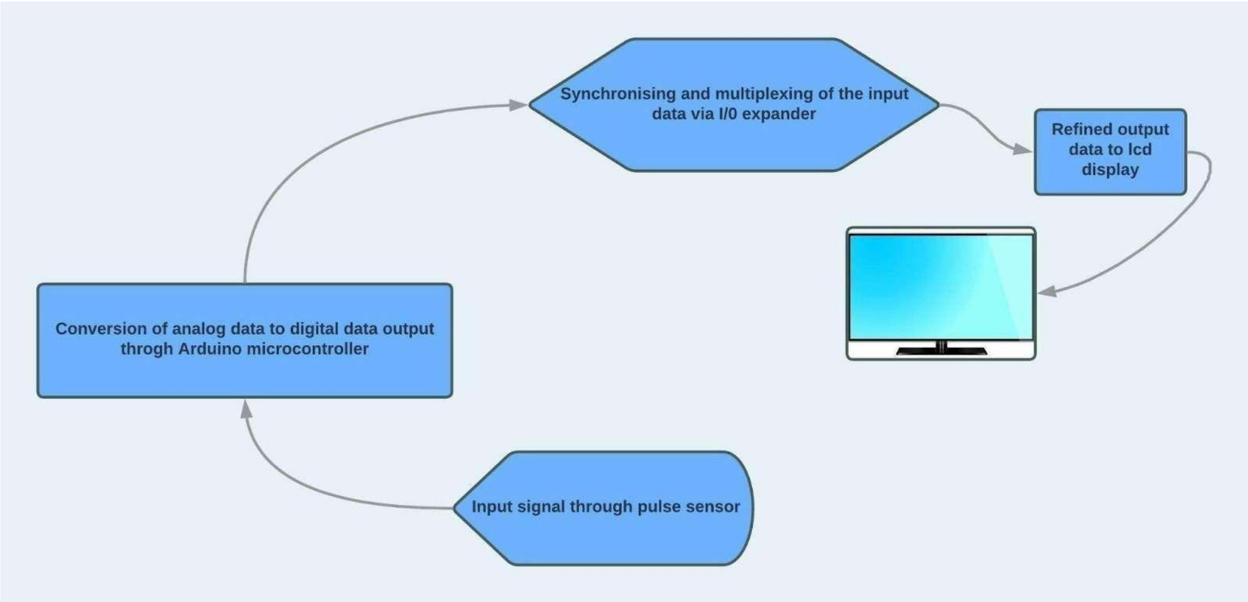


Fig: Block diagram of design

4.2.7Simulation of design approach 2:

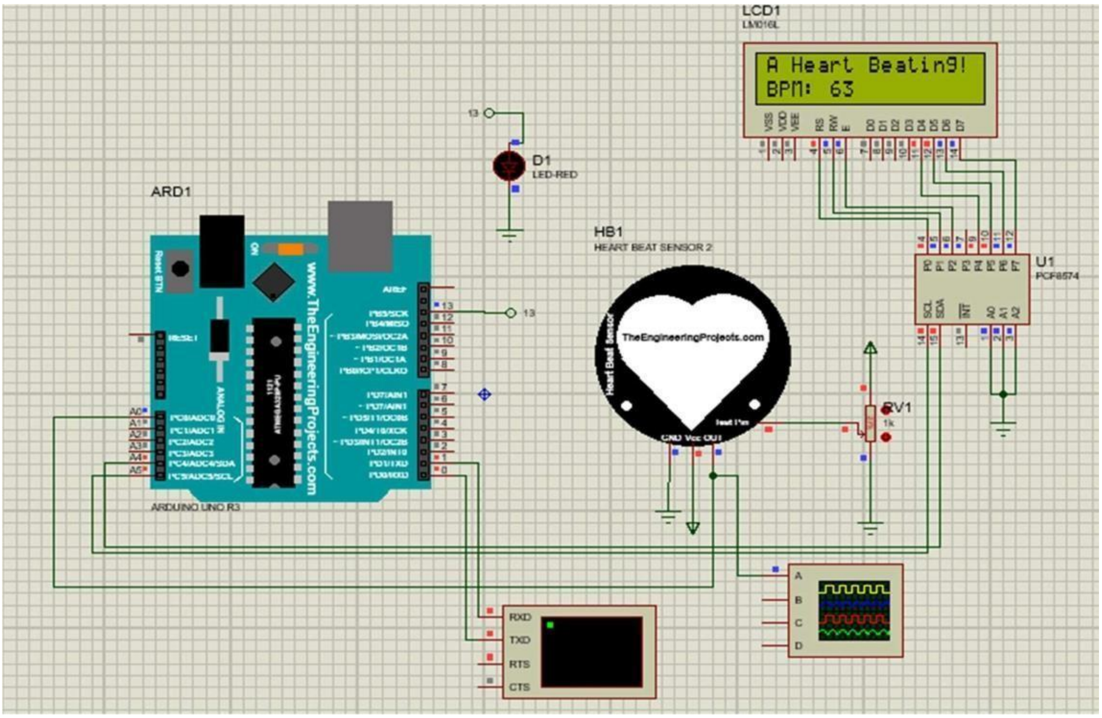
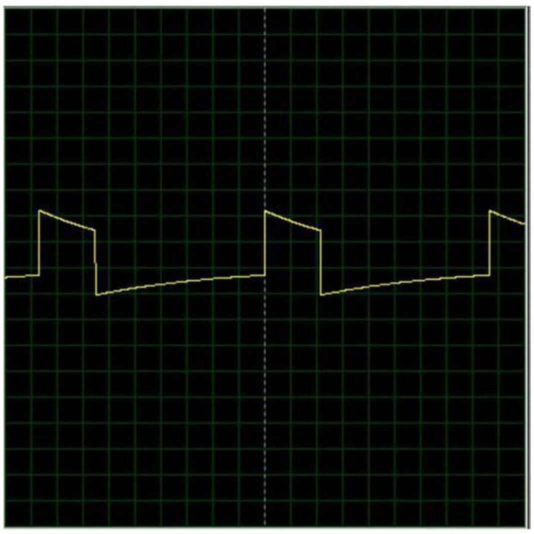
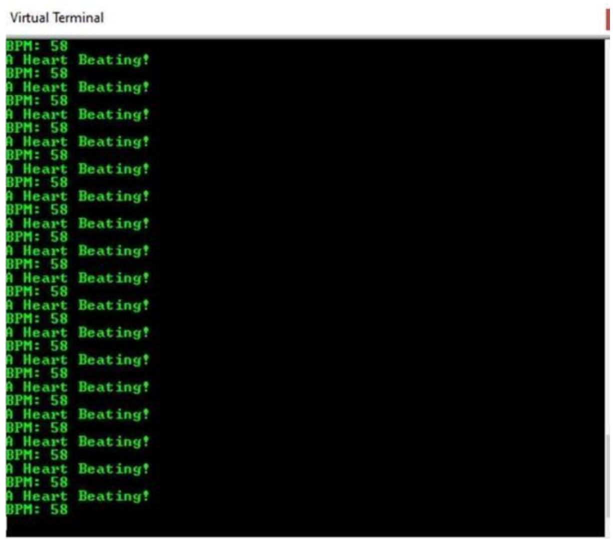


Figure: Schematic diagram of Arduino microcontroller simple heart rate monitoring system.





This simple design shows the heart rate as well as the heart rate pattern of a person suffering from heart rate complications. The design is divided into three sections:

(1) data input via heartbeat sensor,

(2) signal processing via Arduino microcontroller, and

(3) data output via alphanumeric display.

We used a heartbeat sensor, also known as a Pulse Sensor or SEN-11574 model, in this design. Photoplethysmography is a technique used today to monitor a patient's pulse rate. The sensor used for this task is the Pulse sensor (SEN-11574), which is very small and can be worn or wrapped around your index finger or earlobe. This sensor module is made up of a light source photo detector and Infrared LEDs (Light Emitting Diodes). A microcontroller-based board is used in this design to read the ac analog signal from the sensor and convert the input data into digital form using mathematical algorithms. Several mathematical functions are used to convert the pulse sensor output data to continuous digital pulsating dc signals.

4.2.8Design approach 3 (New Design):

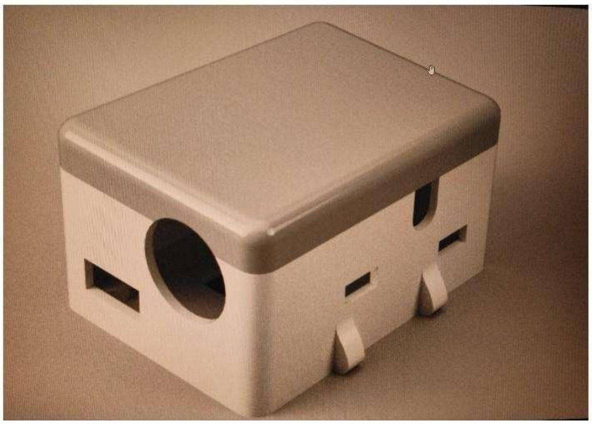


Figure : Block Diagram and 3D model of the Design

4.2.9Design 3 Summary:

we can see that there are two portions. The first is the base section, and the second is the firefighter section. In the firefighter portion, we have used 5 sensors in total. GPS (location), pulse rate + SpO2 (MAX30100), skin conductance (GSR), flammable gas detection (MQ2), and fall detection (MU5060) are all available, and they are all linked by a microcontroller called ESP32. There is a charging module, TP4058 (350 mAh battery). We have also provided a panic button here. Then we can say there is a base station where we will get the data sent from the firefighters' end. A Wi-Fi module is located in the base section, and the Arduino Uno is linked to a display (TFT display, 3.5"). We connected Firefighter 2 because we wanted to collect data from multiple firefighters. As a result, we are sending data from firefighter 1 and firefighter 2 to the base display via the Wi-Fi module.

Key Features:

- **Multiple Communication System:** This design ca connects multiple devices into one device (Base station) wirelessly
- **Base Station:** Here we can show all the data of multiple firefighters in a display
- **Wearable Solution:** It will be wearable solution and
- **Additional Features:** Besides monitoring heath It can detect Fall, Position and also incorporates a Panic Button
- **Rechargeable:** It has battery and charging option

4.3: Identify the Optimal Design Approach:

4.3.1 **: Problems and Findings in Design 1 and Design 2:**There are multiple reasons we need to propose another design (Design 3) for our project.

Feasibility: Heart rate is not the only measure of health monitoring we also need to monitor more parameters for our design like Pulse oximeter, Sweat, etc. these features play vital role while implementing a project related to health monitoring.

Results and Accuracy: At First, While Implanting Design1 and Design 2 in hardware we found that Design 1 and Design 2 are not giving the desired result and results are not even close to what we have expected so we chose Design 3. For example, in Design 1 when we implemented, we found that heart rate is not detected. not even after calibrating them.

Fig: Design 1 Showing wrong result. [Red boxed area shows low amplitude of Heart rate]

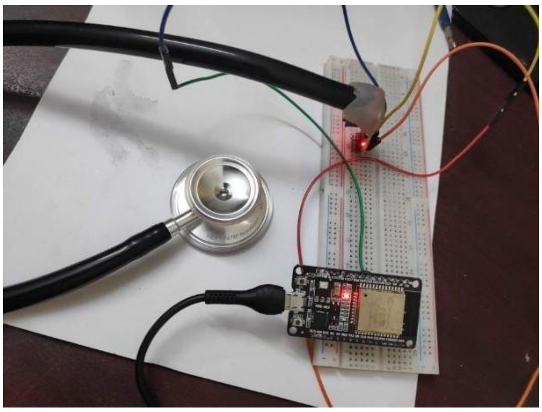


Fig: Chest Piece we tried to implement to detect Heart rate.

Component Efficiency: The sensor we used in Design 1 and design 2 are very sensitive and not really effective for project while working in a harsh condition. in that case design 3 would be the best choice for project

4.3.2 Reasons to Choose Design 3 (New Design):

After going several documents and revising our requirement we found that Design 3 is much more promising and capable to serve our requirement.

- **Multiple Sensors:** It has Multiple sensors implementation for collecting various kinds of data.
- **Better Accuracy:** The accuracy rate is much higher than other two designs.
- **Feasibility:** Design 3 is feasible with our requirement.
- **Cost Efficient:** Design is much more Efficient

As a result, we chose Design 3 as our optimal design.

4.4 Performance evaluation of developed solution:

We had to make some changes to the hardware section in order to adopt the best design solution because we learned about numerous alternate devices that perform better, are more affordable, and include a variety of built-in systems.

4.4.1 Implement the selected design solution:

In our design we selected ESP-32 for multiple communication. 2 Device will be made one has all the sensor we needed and another one has only some essential sensor and in the base station we implemented a 3.5'' TFT Color display. we used a WIFI module We designed PCB for get rid out of bread board

At first, we chose PIC-32 Microcontroller for our design but it came out that we don't need that much Power rather a ESP32 will be enough for our design.

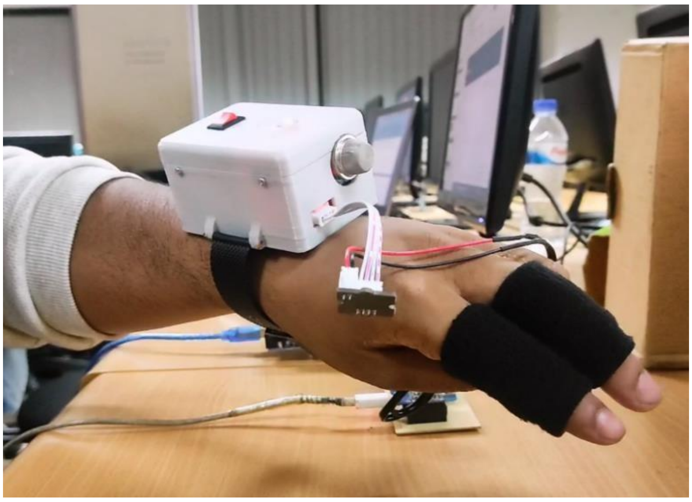


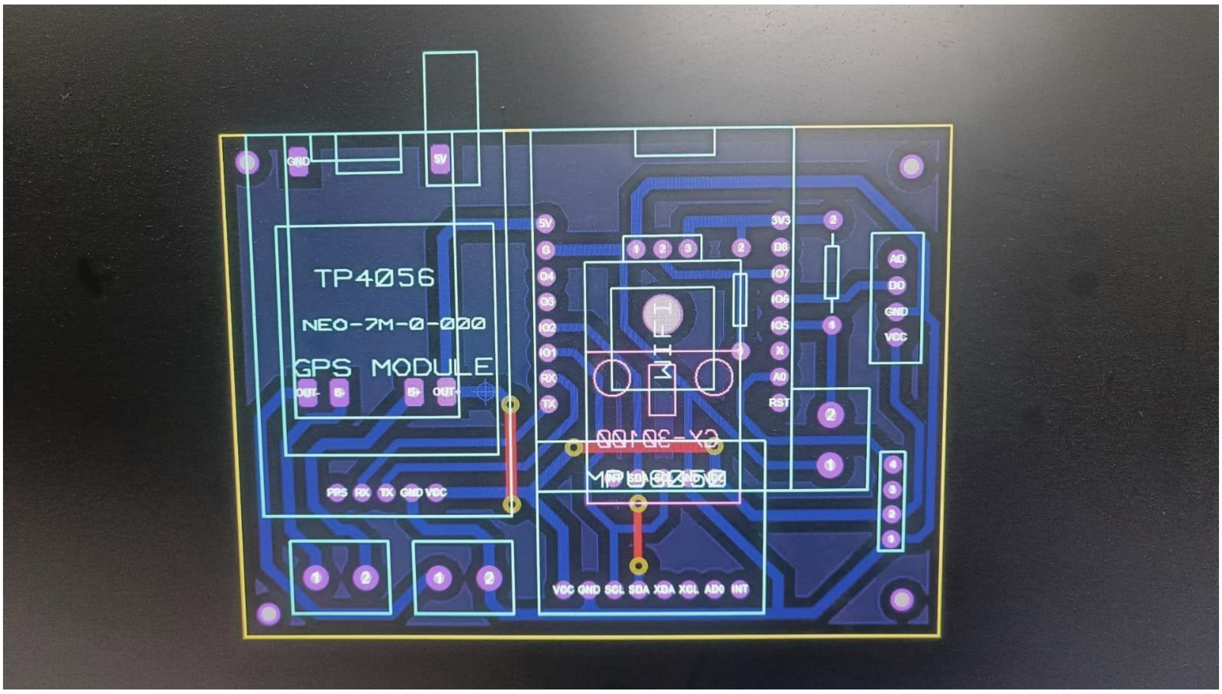
Fig: Implementation of Design.

		PIC -32	ESP32 DevKit
General	Dimensions	2.7¨ x 2.1¨	2¨ x 1.1¨
	Pricing	2500 tk	1400 tk
Connectivity	I/O Pins	14	36
	PWM Pins	25	16
	Analog Pins	35	Up to 18 *
	Analog Out Pins (DAC)	45	2
Computing	Processor	MPS322	Xtensa Dual-Core 32-bit LX6 microprocessor
	Flash Memory	2048 kB	4 MB
	SRAM	512kB	520 kB
	EEPROM	1 kB	-

Table: Difference of choosing MCU.

For our application ESP32 MCU would be enough .and for the base station we chose an Arduino UNO.

PCB Design: Printed circuit board (PCB) design gives physical form to your electronic circuits. PCB design involves component placement and routing using layout software to define electrical connectivity on a manufactured circuit board. We built a single layer PCB using Eagle PCB design suite
This is where we placed all the sensor needed



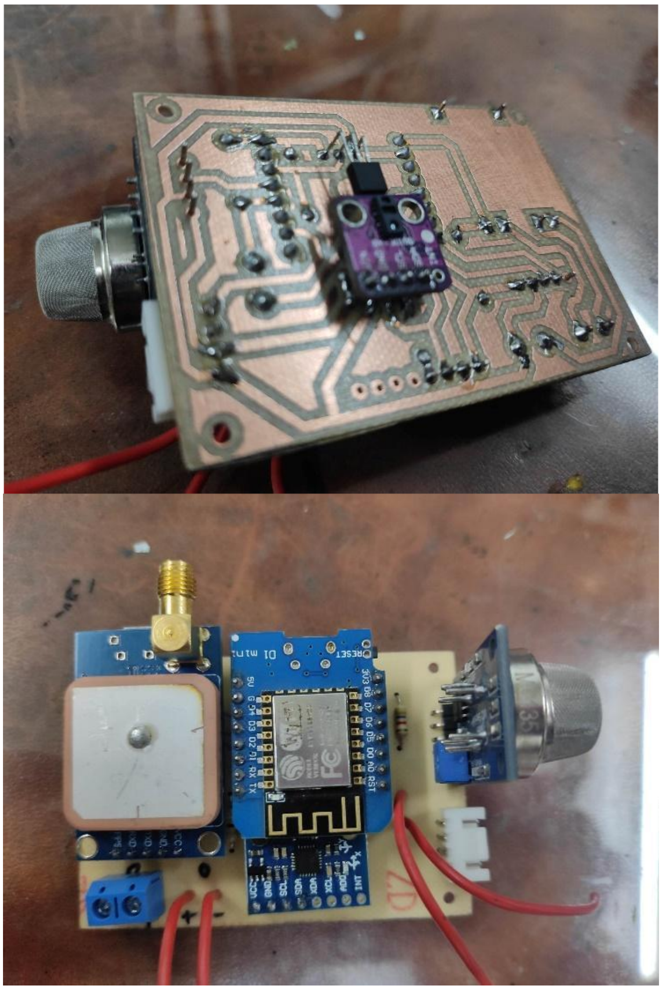


Fig: PCB Design and sensor placement

4.4.3 Evaluate the performance of the implemented solution:

In design 3 we observed that, GPS (location), pulse rate + SpO2 (MAX30100), skin conductance (GSR), flammable gas detection (MQ2), and fall detection (MPU60500) are working well and we are getting all the data as we have wanted. The data we are getting has the accuracy of 70%.To test our result, we used pulse oximeter and Mi Band for testing our design.

Fig: Mi Band (Left) and Pulse Oximeter (Right)

Conclusion:

A number of modifications to the final design were required as a result of the market analysis, and certain components were changed for more efficient ones. The sensors were calibrated, and test results were compared with those from equipment that was actually utilized or in practical situations to make sure we were getting reliable data for our monitoring system.

Chapter 5: Completion of Final Design and Validation

5.1 Introduction:

In order to improve workflow, we divided the tasks involved in finishing the health monitoring gadget into many categories. We read some published studies and evaluated the datasheets of the components we are using before calibrating individual sensors and system components. We eventually worked to connect the system with a platform so that patients could be monitored remotely after moving on to complete system connection.

5.2 Completion of final design

5.2.2 Verifying Spo2 AND HEART RATE

SpO2 (%)	Status
95 – 100	Normal
91 – 94	Mild
86 – 90	Moderate
<85	Severe

Age	Heart Rate (BPM)	Status
Minimum 15 years	< 60	Bradycardia
Minimum 15 years	60 - 100	Normal
Minimum 15 years	> 100	Tachycardia

We use this range to compare our heart rate to actual cases. To automatically display the result as Normal or Abnormal on the TFT display, we code this range into the device.

Age (Years)	History of Disease	Indicated Hypoxemia	SpO2	HR	Prediction	Comparisons of Disease and Prediction
21	GERD	Yes	97.60	91	Normal	Invalid
21	Skizofrenia Paranoid	Yes	91.99	90	Mild	Valid

40	Asthma	Yes	96.88	62	Hipoksemia	Invalid
55	Gastritis/Maag	Yes	93.79	63	Normal	Valid
67	Hyper	Yes	93.83	68	Mild	Valid
21	Normal	No	95.93	67	Hipoksemia	Valid
38	Cholesterolemia	No	98.63	90	Normal	Valid
55	Normal	No	97.03	69	Normal	Valid
22	Normal	No	99.34	74	Normal	Valid
21	Normal	No	99.44	80	Normal	Valid

Here, we collect data from a variety of individuals of all ages, check their blood oxygen levels and heart rates using our devices, and measure the data in challenging scenarios, like when someone is walking or cycling, to see if our system can provide us with reliable data. Then we compile all the data, confirm with the datasheet, compare our findings to previously published data, and work to validate our results using the information from the paper. Most of the time, our device is successful at detecting disease, although it has failed twice.

We are trying to validate our sensor by further experiment and validate our device result by accumulating with the sensor.

CHAPTER 6: Impact Analysis and Project Sustainability. [CO3,CO4]

6.1 Introduction:

Our project is important to society and will have an impact on a number of areas, including the economics, ecology, and more, like all projects do. We have made an attempt to assure the users' safety when using our product in their offices, keeping in mind the impacts it would have on their life. We have also thought about how to sustain this endeavor.

6.2 Assess impact:

The following list includes many categories of the effects of our endeavor.

Economic impact:

Smart monitoring systems also help the environment, the manufacturing firm, and the user. The likelihood of a mistake is reduced by this system. It delivers precision in cost estimation and offers health monitoring usage transparency. Users can also monitor their key health conditions in real-time, spot waste, and manage their spending.

Environmental impact:

Taking as an example the world is frequently affected by wildfires, which can take the shape of bushfires, vegetation fires, forest fires, heath and grass fires. The world has been made aware of the devastation that uncontrolled fire may inflict by recent high-profile disasters in Chile , Australia , and California , respectively. The threat is much closer to home; in Europe alone, there are an average of 70 000 forest fires each year. Although they primarily occur in nations with warmer climates like Portugal and Greece, wildfires—defined as the uncontrolled burning of vegetation—do occur more frequently in the UK, but they don't always involve entire forest fires. Over 58 000 grass and heathland fires occurred in Great Britain in 2010–2011, according to the Fire Statistics Branch of the Department for Communities and Local Government. So Our system's goal is to alert firefighters to their usage of our project so they can modify their precautions and reduce any further human and economic casualties.

Safety impact:

Our device has a very low power consumption. Our project's primary objective is to remotely measure our firefighters of their daily health check-ups and pre-health conditions , so they won't need to physically check their physical health status by approaching any nearby medical station. And our prototype design is very portable, and is very integrated so there is no possible damage that our device can do to the human body. Also there is a very low or negligible possibility that our device will produce electric shocks to the users which might harm them

Social impact:

As our system alerts the user about usage and assists in getting out of a dangerous situation during a rescue event, It limits the expense as a result, which is good for society. And on the other hand the components that we used in our device are easily found in local electric workshops. And the components are also cheap in our local market compared to foreign markets. Hence by assisting customers in using this energy more effectively, our project will help close the supply- demand imbalance.

Health impact:

Unless the lithium battery we used in our project gets fire and produces toxic gasses such as fluoride and smoke in the environment, there is a high possibility that the device will heat up during operation and there is also a low possibility that device will harm our primary users.

6.3 Evaluate the sustainability

The system we have developed should last a couple of years, such as 1 to 5 years, according to us. By implementing the proper safety measures and carrying out regular inspections, we can make sure the system is operating properly and capable of generating results with a low level of error. We tested the product longevity and conducted surveys of the existing systems before structuring the project to maximize user benefit. Examples of this include:

Economic:

Our device which the firefighters use rely on electricity, an expensive resource, to carry out their daily operations. However, there is no such firefighting system that is now in use in our nation that enables users to keep track of their daily health monitoring. Our project on the other keeps track of this data in real-time and helps users assess their health and environment conditions. Our device will save firefighters and hence will reduce economic burdens caused by human casualties and damaged resources.

Environment:

By enabling customers to utilize their device and using fewer electrical components more efficiently, we are lowering E-waste, which can have an adverse influence on the environment. Therefore, the device can benefit the environment. Additionally, users will be able to lessen the amount of power wasted by altering their behaviors, which will lower carbon emissions in the atmosphere.

Social:

Our device overall consumes less energy and is portable for the firefighters to carry out during intense operation. And the aim of our project was to provide the maximum benefits to firefighters within a medium range budget. Hence we expect that in near future the Government of Bangladesh can easily adopt our project so that each and every firefighter gets treated well enough.

6.4 Conclusion:

In this section, we've looked at how our project might affect the environment, society, user safety, and their health. The economic and environmental aspects of sustainability have also been covered in our discussions. We can extend the project's lifespan, advance society, and so look toward a brighter future for our country by evaluating the sustainability of this project according to a number of factors.

CHAPTER 7: Engineering Project Management [CO11, CO14]

7.1 : Introduction:

The primary objective of engineering project is to maintain the tasks on track, under budget, and in compliance with all applicable standards. Here, we researched and reviewed a variety of engineering project management-related issues, created a Gantt chart, assigned work equally among group members, and evaluated the project's effectiveness based on a set of parameters.

7.2 : Define, plan and manage Engineering project:

Every engineering project has a management area in which the work, time, and duties are allocated in accordance with the plan. The same is true for our FYDP (Final Year Design project) system.

7.2.1 : Definition of Project Management:

The engineering management process includes planning and stakeholder engagement, as well as the identification of project goals, needs, and specifications. The primary objective of engineering project management is to ensure and finish the work on schedule, within budget, and in accordance with consumer requirements. Listed below are the fundamental criteria/skills required to execute the project by the deadline:

1. Risk management
2. Stakeholder management
3. Procurement
4. Quality assurance Process
5. Process integration
6. Timing, cost, and scope of the project
7. Communications

7.2.2 : Planning of the Engineering project:

Our " Health monitoring system smart device for firefighters" has been planned using a Work Breakdown Structure. This procedure allowed us to accomplish our project in three phases on time.

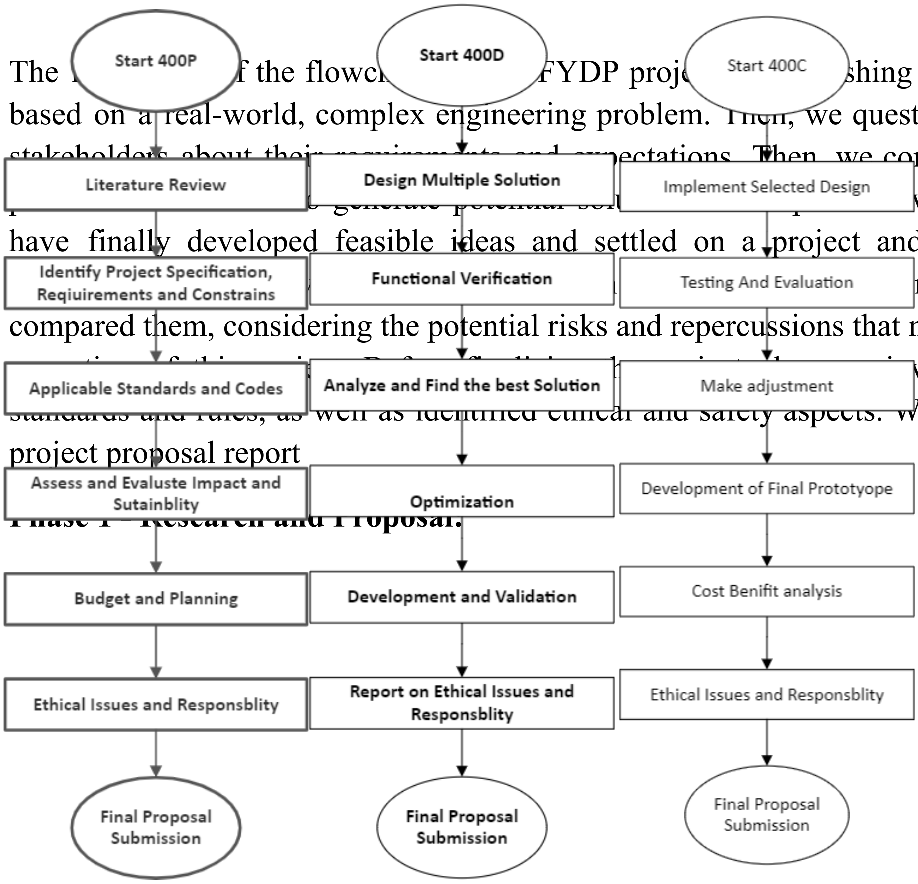
Phase 1 - Research and Proposal;

Phase 2 - Simulation and

Adjustment Phase 3 -

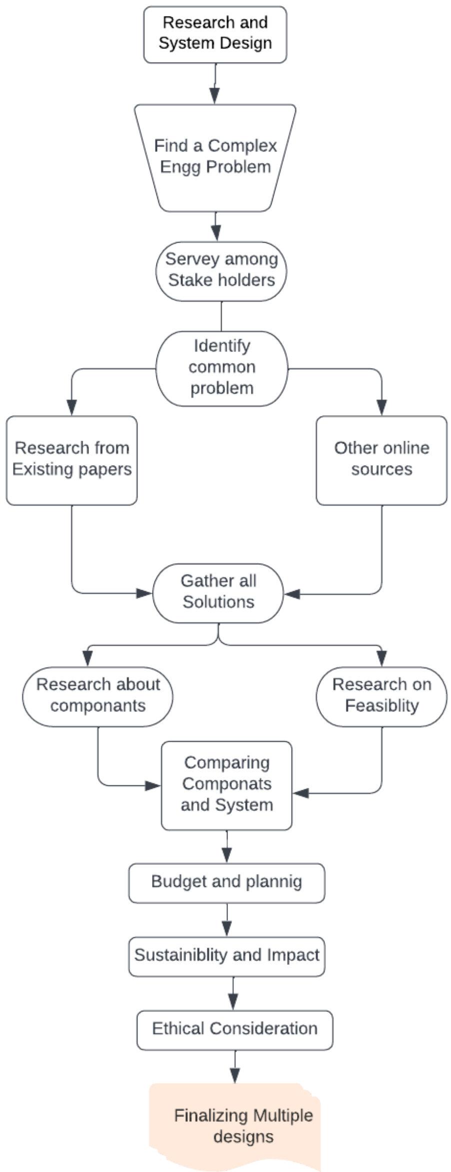
Implementation

Flowchart:



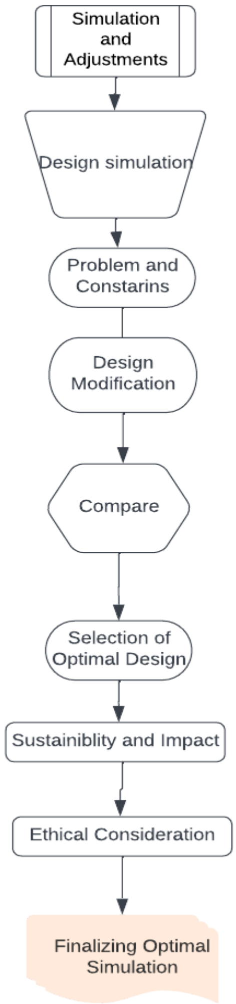
The ... f the flowc... FYDP proj...shing the problem statement based on a real-world, complex engineering problem. Then, we questioned potential project stakeholders about their requirements and expectations. Then, we combed through research ... we are addressing. We have finally developed feasible ideas and settled on a project and problem description. ... r project solution and compared them, considering the potential risks and repercussions that may develop during the ... vestigated the relevant standards and rules, as well as identified ethical and safety aspects. We finally submitted our project proposal report

Phase 1 - Research and Proposal:



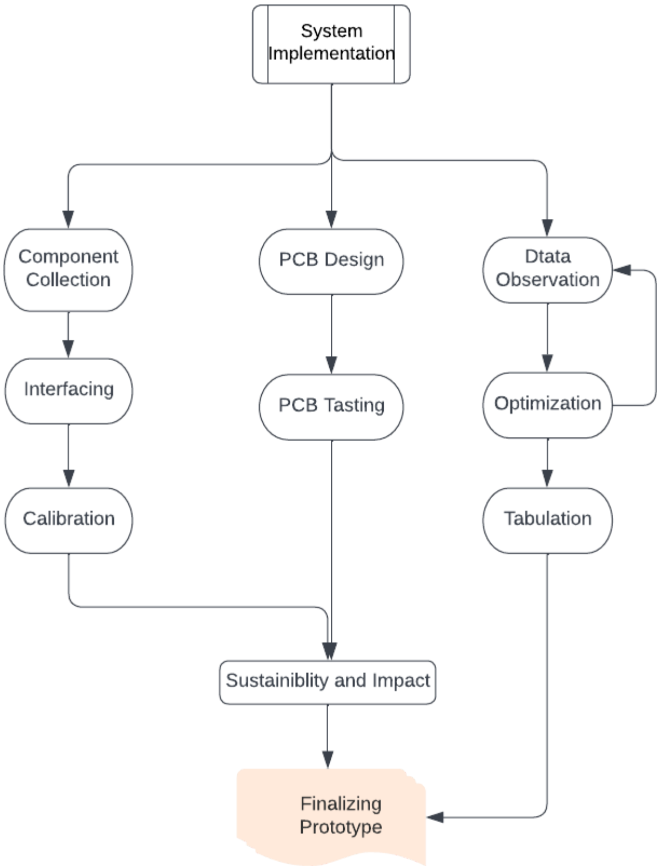
During this part of our project, we have conducted extensive literature reviews to identify a complex engineering problem. Then, we spoke with the stakeholders about the nature of the challenges they were experiencing and sought out existing remedies. After comparing components and design systems, we developed three system designs.

Phase 2 - Simulation and Adjustment:



We will simulate and change our designs during this time. Then, we will identify issues and limitations with each of our designs. Following that, we will adjust our designs based on the highlighted issues. Then, we will compare our designs and choose the best one. Now, we will initiate the simulation of the initial step.

Phase 3 – Implementation:

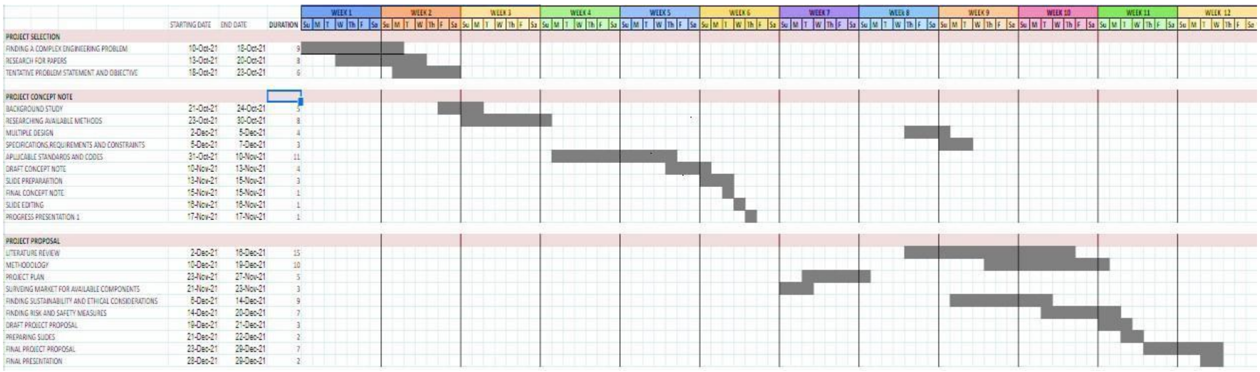


In this third phase of the project, the system will be implemented and real-time data will be monitored. Then, we will compare the data prior to and after the system's adoption.

7.2.3 : Project planning/Gantt chart

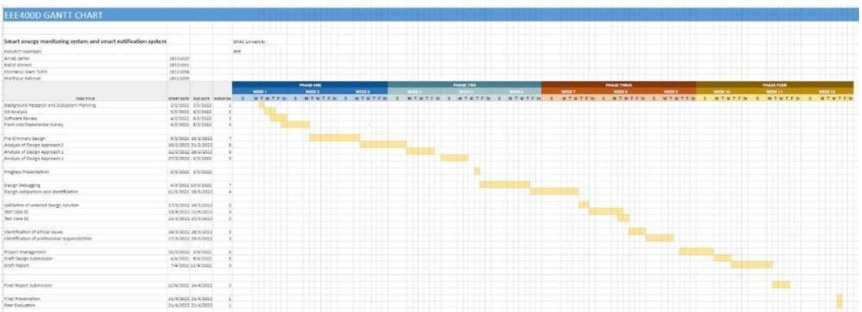
For each semester of our project, we have prepared a Gantt Chart. In general, Gantt Chart is a method for allocating work for the entire semester among group members and dates.

400P:



400D

400C:



7.3 : Evaluate project progress:

SHARIAR	ABID	DIBA	ASIF
Report Writing	Sensor Interfacing	Sensor Interfacing	Report Writing
Video, Photo for prototype	Sensor Calibration	Sensor Calibration	PCB Testing
3D Model	Communication with ATC	Printing Prototype	Paper Reviewing And referencing
Log book	PCB Design	Communication with ATC	Logbook, Stakeholder’s survey
	Referencing	Real time data collection and Tabulation	

7.4: Conclusion:

In conclusion, we have examined project management abilities and criteria and applied them into our FYDP (Final Year Design project) Consequently, by keeping a Logbook, Gantt Chart, and Peer review form, we have allocated the project's work fairly in order to accomplish it on time and within budget.

Chapter 8

Economic Analysis [CO12]

8.1 Introduction:

Economic analysis is the process of weighing costs and benefits to determine whether a project, business opportunity, event, or other situation is viable. In other words, it entails figuring out, assessing, and contrasting costs and advantages. According to a general definition, economic analysis assesses plans, hypotheses, activities, subjects, or decisions to determine their viability or unfavorable effects. It demonstrates a connection to the research of figuring out the opportunity cost of any undertaking. Management uses it in a variety of commercial situations. Businesses might use it, for instance, when identifying new products or when expanding or integrating existing products. The analysis process weighs the advantages and disadvantages and clarifies the situation.

The U.S. Bureau of Economic Analysis (BEA), established in 1972 by Richard Milhous Nixon, the 37th president of the United States, has since assisted American investors in understanding the country's economy through the use of pertinent data and statistics. The government, corporations, researchers, and the American people were all able to follow and comprehend the performance of the country's economy because of the fast and reliable information.

8.2 Economic Analysis:

In projects related to the health monitoring conditions of firefighters, an economic analysis plays an important part in terms of judging or evaluating health conditions of firefighters. It includes the creation of a situation where firefighters are engaged in rescue events such as in households, fields, oil depots or port areas etc. almost anywhere and at any time. By so far out of many jobs or professions, firefighting is one of the most stressful jobs one a trained firefighter has to tolerate in his entire career. And just like any structural or integral part in our environment, which directly or indirectly contributes to nations' economies, firefighters too play an important role for benefiting our society and ultimately a nation as a whole. And so people are directly or indirectly dependent on firefighters provided a given situation. So therefore it is necessary to protect the firefighters while in a rescue event. Hence, our research project is to make a prototype based health conditioned smart monitored device for firefighters to get an idea about some key health conditions while in operation duty. And by using our prototype device we aimed for, we can scale and monitor the changes in their health from time to time. After some deep insight reviews from the literatures, by applying economic validation, we found that our project has a potential well known market value; as well as benefits. And which is why it wouldn't be a much difficult to convince people to invest in such kind of projects. In a well-capitalized city where every citizen dreams of living and invest money for future benefits, firefighters can save millions of lives and can save properties worth of million dollars. And firefighters also play an important role in wildlife conservation and protection. So fortunately many citizen in today's world understands moral and ethical values of firefighters. So keeping in mind our project economic analysis should be performed in such a way, so that it becomes beneficial outcome for the society and health of firefighters. As we know that economic analysis mainly consists of costs and benefits, so our challenge is to build the project prototype and conduct a survey analysis so that people associated will get maximum benefits at minimum cost. But on the other hand we cannot apply a project prototype which has a low cost but then fail to operate for a longer period of time and also having low or unsatisfied efficiencies. Otherwise we may not ensure economic sustainability of our project. Hence it will be duty that we must confirm each product is of best possible quality affordable in market before implementing it or purchasing it by using. We also may need to perform some routine based maintenance on every component, such as batteries, Wi-Fi modules and sensors. By this routine check we can tell that if a component is not working well or not we can change or repair it before causing damage. Hence this may also increase the long-term viability of our project.

8.3 Cost-benefit Analysis:

In our neighboring country India, Brihanmumbai Municipal Corporation (BMC) has allotted a sum of 44179490.50$ or 44 million usd (₹365 crore) to the Mumbai Fire Brigade (MFB) in its budget 2022 to upgrade its facilities and existing infrastructure, and impart basic fire and life safety training to Mumbaiites. This is 55% more than what it was allotted to the MFB in 2021.Out of the total money allotted, 36311910$ or 36 million usd (₹300 crore) have been earmarked for technical upgradation of machinery, and the rest 7867580.50$ or 7.8 million usd (₹65 crore) will be used for the construction of new fire stations during the FY 2022-23. Also the National Disaster Management Authority (NDMA) projected a requirement of 847277900$ or 847.277 million usd (₹7000 crore) to the 13th Finance Commission for revamping Fire and Emergency Services in the country.In United States of America (USA), recently on May 28, President Joe Biden released his Fiscal Year (FY) 2022 budget request which includes allocation of 53.212 million usd in U.S. Fire Administration (an 8% increase).A sum of 370 million usd for assistance to Firefighters Grants Program.A sum of 370 million usd (an 2.8% increase) has been allocated in Staffing for Adequate Fire and Emergency Response (SAFER) grant program.And additionally a budget of volunteer fire assistance worth of 19 million usd has also been included.It is also to be noted that according to NIFC (National Interagency Fire Center) in 2021 approximately around 4.389 billion usd were spent for 58,985 fire cases including wildfire involving 7125643 acres of land in USA.On the other hand, when it all comes to Bangladesh, allocated money for firefighting service is much more lower than India and USA.As for very recently for fiscal year 2022-2023, the total annual budget for FSCD (Fire Service and Civil Defence) has been set at 93507025.30$ or 93.507 million usd (Tk962 crores) from 114599566.35$ or 114.599 million usd (Tk1,179 crores) in the previous fiscal year, accounting for a 17% decrease.And recently our honorable Prime Minister Sheikh Hasina has given around 1.94 million usd (Tk 20 crore) to the welfare fund of the fire service employees and announced to give another 1.94 million usd (Tk 20 crore). Also the government of Bangladesh has purchased a huge number of high-powered modern world standard fire dousing and rescue equipment to enhance the capacity of the Fire Service and Civil Defence. So from this we can see that investment in the firefighting sector is increasing every year in different countries but we see a decreased trend for Bangladesh. Due to the global crisis arising from COVID-19 pandemic and the Ukraine-Russia war the pace of development in the firefighting sector has been slowed. Nowadays, the whole world is going through a serious climate change and socio-political issues such as the Ukraine-Russia war. And as a developing country, Bangladesh is also facing serious economic trouble. The value of our national currency Tk has become weaker against the United States dollar(USD). According to ICAB (Institute of Chartered Accountants of Bangladesh) due to the ongoing Russia-Ukraine war and related sanctions are impacting all economies in the world,the euro has fallen below the dollar for the second time after 20 years when the first time it traded below the dollar was in December 2002. Similarly, BDT and Rupee also lost value against the dollar by 10.08% and 7.02% respectively whereas Russian Rouble gained 34.14% by July this year. Here we can see that BDT fell more than 3.78% than its counterpart Rupee in the same year followed by war. Judging this even though there is potential good enough market value of our project, due to the downfall of our economy, people and stakeholders might lose interest. So right now it will be impossible to construct a vast autonomous project because our budget for the project is limited. Hence we are suggesting a project that has a limited range budget that the civil service department of Bangladesh can afford easily. At the same time we need to motivate our stakeholders in such a way that they should adopt the project's visions in order to minimize the risks associated with firefighting.So far we have made three prototype designs, one that measures only variable and the other measures several health conditions. But the first prototype design cannot be used since this will not be viable and does not meet our expectations.

Table 1: Cost Analysis of multiple prototype designs

Design	Functionality	Time	Cost
1.Smart wearable heart rate monitoring system for firefighters using SEN-11574 sensor.	**1.** Sample of pulsation detection.	10 seconds/person.	25.60$/person
2.Smart wearable Heart rate monitoring system for firefighters.	**1.** Sample of pulsation detection.	10-15 seconds/person.	46.54$/person
3.Smart wearable Health monitoring system for firefighters.	**1.**Heart rate detection. **2.**Ambient body temperature detection. **3.**Fall or movement detection. **4.**GPS detection.	20 seconds/person.	125.18$/person

	5. Sweat detection system. **6.** Toxic gas detection system.		

Here we can see the third prototype design approach gives us the best possible solution. But the problem is that the design has high hardware cost compared to the first and second prototype design. But apart from that scenario, the third approach measures some important key health conditions, enough to analyze the mental and physical phenomena in firefighters. The cost could have been decreased, but due to the current climatic and geo-political crisis prices of commodities have risen up in our country, including daily day-day required things. Typically, Bangladesh employs project finance to fund construction and infrastructure projects. The infrastructure projects in Bangladesh are normally done by the government or the (PPP) model whilst industrial are mostly carried out by private sector. The bulk of PPP infrastructure projects leveraging project finance employ Build Operate and Transfer (BOT) and Build Own and Operate (BOO) formats. In addition to corporate and asset finance, several projects utilize quasi-projects financing as well. Examples of notable infrastructure improvements include toll roads, ports, metro rail, liquefied natural gas (LNG) facilities and energy. In addition to infrastructure, project finance is also utilized in the education, healthcare and telecommunication industries. To give an example, a recent US$210 million loan extended by the Asian Development Bank, the International Financing Corporation and the Islamic Development Bank for setting up a 341 Megawatt (MW) combined cycle gas fired project at Bibiyana. The investment was done by U.S based company Chevron which was worth 500$ million. And Bangladesh is an ideal place for investment where a large number of foreign companies are investing. And so for us it would be an easy job to find financing partners and investors which would be interested in investing in our project. The cost of our design is much lower compared to the ones that are being carried out in our country. The price of the project is 13058.2BDT. If the same project would have been built in other countries, the cost would go up. Our functionality of the system is not so world class ranking and results might not be world class ranking, but it can still do the health monitoring process with a medium range budget. Because of budget limitations, COVID-19 Pandemic and ongoing Ukraine-Russia war, and availability of devices in local markets we avoided making a more complicated design. But if the

FSCD (Fire Service and Civil Defence) can exceed the budget, following all government protocols, then it will be a much more integrated design and would give more information about firefighter's health.

8.4 Evaluate economic and financial aspects:

Firefighters represent more than just a livelihood to many people in developed and developing countries. According to a report issued by NFPA (National Fire Protection Agency) there were estimated 1,041,200 career and volunteer firefighters in the United States of America in 2020. And of the total number of firefighters 364,300 (35%) were career firefighters and 676,900 (65%) were volunteer firefighters. In 2020 there were 24,452 fire departments in the United States. 18% were mostly career departments and the rest 705 protected the population. Also Nationwide 37% of fire departments provided no emergency medical services, 46% provided basic life support (BLS), and 17% provided advanced life support (ALS). The firefighters in the United States also have access to health and dental insurance also including disability payments should they be injured on the job. After further finding it is reported that from 2018-2020,in the highest work week(52-60) hrs the lowest rate of firefighters per 1000 for all-career departments to protect a population of 1,000,000 or more is 0.86 and for 25,000- 49,999 population protected, the rate was found to be a maximum of 1.62. While talking about wages , the US firefighters earn more than other firefighters in the rest of the world. The average firefighter salary in the USA is 47,595$ per year (48.91966 lakh BDT) or 22.88$ (2343.46 BDT) per hour. Entry level positions start at 37,929$ (38.98463 lakh BDT) per year while most experienced workers make up to 70,598$ (72.56288.35 lakh BDT) per year. On the other hand A person working as a firefighter in Bangladesh typically earns around 14,600 BDT (142.05$) per month. Salaries range from 6,710 BDT (65.28$) (lowest) to 23,200 BDT (225.72$) (highest). In a recent report Ali Ahmed Khan, former head of the Bangladesh Fire Service and Civil Defense, shed light on the state of fire safety in the country. According to his statements, the capacity of Bangladesh's fire department FSCD (Fire Service and Civil Defence) is poorer compared to other departments in west and europe. The FSCD has 480 stations across the country, with one headquarter in the capital and only having 13000 active personnel against a population of 165 million.Also there are multiple reports suggesting that, Bangladeshi fire fighters often perform duties without safety gear and adequate training amid a rise in factory fires in the

South Asian nation. Recently 12 firefighters died when a fire broke out at a chemical depot in Chattogram on 4th of june, Bangladesh's main port. The casualties recorded were the highest in the Fire Department since 1981. Pannu Miah, father of Rana Miah ; one of the firefighters who died in the 5th june chemical depot fire claimed that his son got only six months of training. There was no medical or health insurance coverage but a risk allowance with a merge amount. His father only received a cheque of 2 lakh BDT (1945.84$). Rana Miah who joined the fire service in november 2020 made only 16000 BDT (155.67$) as his salary. And during the COVID-19 pandemic his father lost the only rented shop in Keraniganj. According to Ali Ahmed Khan, FSCD lacked engineering management and investigation skills and so they were unaware of what dangerous chemicals were moved in or out from the depot and so FSCD couldn't take any initial measurement precautions before cursing any further casualty. The most alarming fact is that according to a recent assessment of the Fire Department, 90% of buildings in seven city corporations in the country lacked fire safety arrangements, and more than 40% of the hospitals and healthcare centers in Dhaka had no fire-fighting capabilities. Which means that despite there being an allocation of budget for FSCD in recent years, the basic measurements to avoid fire incidents are absent. For a population of 165 million in a country, it is almost impossible for our government to reduce the fire incident casualties in each and every part of our country unless and until the basic protections are implemented. And right now Bangladesh is currently facing some serious economic troubles in 2022. Thinking about these problems we are not so sure whether we will see light in our project. So considering the global climate change and economic conditions, our firefighter service will be in grave danger in the coming years. So it is the high time to protect our firefighters. Therefore our research report will not only help our Fire Service and Civil Defence (FSCD) department management authority but can also be used to inform the general people about the importance of firefighters' health and use of basic fire protection measures through mass campaigning. So it is the crucial time now for the Civil authorities to take some necessary steps to prevent any firefighter deaths, so that the lives of common people could be saved.

8.5 Conclusion:

So overall from the above discussions, we have seen that most of the foreign countries have invested a huge amount of money in their respective firefighting departments. Modern technologies such as autonomous fire dousing systems and thermal imaging systems etc are invented day by day to monitor the health of firefighters. But at the same time this increases the budget while making the monitoring system easier. At the lots health awareness programs are made annually which make people conscious of their firefighters safety. But compared to the economy of our country, it is hard to invest in the firefighter sector. And hence we tried to make a solution from which we will get maximum possible benefits at a medium lower cost. So comparing the two solutions that we analyzed, provides a more efficient and effective output which also ensures the sustainability of our project; hence saving the precious time, labor and money making our project long term viable and project friendly economic.

Chapter 9: Ethics and Professional Responsibilities [CO13, CO2]

9.1 Introduction:

Ethics and professional obligations are well-known concepts in engineering projects, where specific criteria are measured to establish the project's acceptability from this side of the engineering project sector. Therefore, we looked at a number of criteria for our FYDP (Final Year Design Project). Like, for instance, professional conduct, obligations, applicable laws, and standards. Throughout the three semesters of our FYDP, these criteria allowed us to more precisely develop our project (Final Year Design project).

9.2 Identify ethical issues and professional responsibility:

When assessing the ethical issues that are pertinent to the stakeholder's expectations, every engineering project should consider a few key factors. The creator of an engineering project should consider user security and privacy, sustainability, and safety issues.

Any engineering project's developer should take into account a few characteristics in the professional responsibility area to satisfy the needs of the stakeholders. The manufacturer must adhere to all essential standards, professional codes, and legal criteria to make sure the project complies with the appropriate authorities.

As a result, we considered these factors while choosing our "smart energy monitoring system" projects since they relate to moral concerns and obligations throughout the system's creation and use.

9.3 Apply ethical issues and professional responsibility:

We examined the criteria required to choose the relevant ethical issues and professional duties for our project in our FYDP (Final Year Design Project).

- **Ethical consideration:**

  The consumption of electricity and power is essential to the energy and power sector. We therefore determined how much power would be consumed by our system in order to monitor the electricity and power usage. We did additional research for our device and also enlisted the aid of some local technicians to make the project entirely computerized and power consumption friendly, which ultimately helped to improve the efficiency of working output of our project. This is because we cannot place any power source in our device without any prior research and in-depth knowledge. But as a result, several issues come up that cast doubt on their ability to use the system. We have examined a few of these issues.

- **Securing relevance for businesses and society:**

  In our project design, we make use of a power source that is relatively tiny (5V, 2A), globally known as a smartphone charger, and well-liked by smartphone users all over the world. Additionally, the 10W charger, often known as a 5V 2A power source, is affordable, portable, and practically universally used. As a result, this power supply ensures easy communication between customers and electric utilities. If this system is used, there is no risk to the source. The project will benefit society and business by ensuring greater benefits.

- **No compromise of personal security:**

  We will treat everyone's data as confidential, thus we'll make sure it's secure to protect privacy. The only data that the design may access is that which is specifically coded for a given firefighter. Data access will be prohibited without correct admin authority.

- **Minimizing human and animal harm:**

Since we will be employing sensors and covering connections with plastic components, this project will not endanger any life. Additionally, we'll be using genuine hardware and wiring. Therefore, neither humans nor animals will be in danger.

Applicable standards and codes:

- **ISO 10993-1(2018) :**

According to ISO 10993-1, biological testing must come before any description of the chemical elements of medical devices and consideration of material characterisation, including chemical characterization. Based on ISO 10993-1:2018,

- The overall category of devices based on the type and length of their contact with the body;
- The general rules controlling the biological evaluation of medical devices within a risk management procedure;
- The assessment of current pertinent facts from all sources;
- A risk analysis-based gap analysis of the data set that is currently accessible;
- The determination of additional data sets required for the analysis of the medical device's biological safety; the evaluation of the medical device's biological safety.

- **IEEE 802.11ba (2021):**

With the use of this standard, stationary, mobile, and portable stations would all have wireless connectivity within a small region. Additionally, this standard gives regulatory authorities a way to uniformly provide local area communication users access to one or more frequency bands.

- **IEC 62133-2 (2021):**

One of the most significant standards for exporting lithium-ion batteries into international markets is IEC 62133. These batteries are utilized in consumer electronics, laboratory, IT equipment, tools, and medical equipment. It outlines the specifications and testing needed to ensure that portable, sealed secondary cells and batteries produced from them operate safely. IEC 62133 2nd Edition and IEC 62133-2 1st Edition are the two current editions. Depending on the market we want to reach, several versions with varied battery needs have names that appear to be similar.

9.4 Conclusion:

Finally, through the three phases of our complex engineering project, we have gathered knowledge and information to identify the ethical concerns and professional obligations where we prioritize the needs, safety, and privacy of the client in order to assist them in creating an environment that is eco-friendly and less polluted.

CHAPTER 10: Conclusion and Future work:

10.1 : Project summary/Conclusion:

As the human race advances and develops in the modern era, critical situations become increasingly difficult, but it is essential to maintain basic health patterns. Certainly, this project is advantageous for our targeted stakeholders However, we are having trouble collecting sufficient data from sensors, resulting in various effects and problems. Furthermore, there are additional opportunities to enhance this device so that it serves more effectively. Here, we have selected a few objectives and requirements, and in order to meet them, we have completed the development of a project that will benefit both our society and the nation as a whole.

Therefore, after the completion of this project, the following advantages will accrue to the users:

- Real Time health tracking
- Emergency Notification to appropriate parties
- Tracking of a group of firefighters
- Getting alert for flammable gas
- Tracking firefighter’s exact position

10.2 : Future work:

As science is an aspect that is constantly evolving, the term "Future work" is closely associated with every complex engineering problem. Consequently, every project may include Future Works, where hardware and software components can be updated and modified. Our 'Health monitoring smart device for firefighters' project has potential work scopes that will make the device more user-friendly and up-to-date.

10.2.1 : introduce our project’s future work possibilities:

1. **Implementation of Long Range (LoRa):** Long Range or LoRa is a communication module which can sent data up to 10KM LOS (Line of Sight). This can be helpful for our project as currently it can only cover up to 100 Meters only.
2. **Storing Health related data over cloud:** Currently there is no option for visualizing data, we can we do that if we can implement Cloud database servers

like Firebase. where we can store data and use them for future health related visualization. It can provide more freedom to analyze data

3. **More Portability:** Currently the main device is much heavier to wear it in practical scenario. if we can implement industry grade sensors it would be much more portable and user friendly.
4. **Implementation of better algorithm:** We can use both pulse rate and GSR value and develop an algorithm which can take decisions more efficiently and accurately
5. **Blood Toxicity:** There is a method available termed a blood toxicity measurement which can be measured from SpO2 values. if we get more accurate data, it can be very useful.

Chapter 11: Identification of Complex Engineering Problems and Activities.

11.1 : Identify the attribute of complex engineering problem (EP)

During the project, we faced some attributes for complex engineering problems. Now here's what we are going to explain briefly about each of them.

- **Depth of knowledge required:** At the beginning of starting any project, we must have access to some proper knowledge about the relevant field. It is impossible to have an in-depth idea without having proper knowledge. So in order to do a research based project it is compulsory to have almost precise knowledge about the particular problem.

- **Range of conflicting requirements:** After getting some in-depth knowledge, when we start to do a project, we then face many conflicting issues that arise automatically. Our motive should be to overcome these conflicting issues and hence provide a feasible solution so that the project becomes completely effective against all odds. While we were starting our project lots of conflicting issues such as legal issues, technical issues and environmental issues etc. So it will be a target to solve them and provide a beneficial solution.

- **Depth of analysis required:** Another necessary aspect of complex engineering problems. It is mandatory to have proper in-depth analysis in order to make a successful project. Without this attribute many problems will occur in our project and hence we wouldn't be able to solve them.

- **Familiarity with issues:** It is obvious that when a new project is proposed or is going to be implemented the general people will not be familiar with it. Moreover issues may arise from the project if we want to add something new to the old ones.

- **Extent of applicable codes:** When making a complex engineering project, lots of other engineering protocols arise. So we need to follow the international codes and standards to run our project smoothly and efficiently. Otherwise the project will lose its international acceptance.

- **Extent of stakeholder involvement and needs:** Extent of stake holder involvement and needs talks about the demands of stakeholders. It means that we need to ensure that the targeted group of people of our project gets the benefits from our solution.

- **Interdependence:** In a situation where an issue is dependent on another issue and hence the problem should be solved to get the final solution.

Attributes of Complex Engineering Problems (EP)

	Attributes	Put tick (√) as appropriate
P1	Depth of knowledge required	✔
P2	Range of conflicting requirements	✔
P3	Depth of analysis required	✔
P4	Familiarity of issues	
P5	Extent of applicable codes	
P6	Extent of stakeholder involvement and needs	
P7	Interdependence	

Note: Project must have P1, and some or all from P2-P7

11.2 : Provide reasoning how the project address selected attribute (EP):

Out of all the attributes our project has fulfilled some of them. Now we will explain each of them.

First of all, to conduct a project we had to go through lots of pre-research. So we can select the optimum solution that will provide maximum benefit with minimum cost. And so to be careful we have done the entire project step by step. For that we had to go through some previous research papers related to our project and it helped us to get an idea about our work. We also gained knowledge about relevant fields which helped us to make decisions on how we can run our project. Then later in the hardware section, assembling the sensors, microcontroller and wifi module and display screen we went through several previous research papers about the selection of the devices and device assembling. We have tested each of the sensors to see whether they are functionable or not. We selected our device and its associated parts considering modern technology. To keep that in mind we did not use any sensor that is unavailable in our local market and gives low efficiency. We ran through each of the detailed analysis for each of the steps of our project. While selecting the multiple designs ,we have also shown the pros and cons of each of the solutions briefly; ultimately helping us to find the best design for our project. In the software section, we have analyzed our data in such a way that can produce clear output about the health properties of firefighters. We have shown all detailed results of our data analysis that can produce the proper outcome for our project. So the depth of analysis required for our project has been completely established. The attribute of conflicting requirements has also been shown in our project while doing multiple design analysis. We had chosen two multiple design solutions for the health monitoring system. Then we analyzed each design to see which one fulfills our requirements more effectively and efficiently. For all of them we found some positive sides and negative sides. We then further analyzed and sorted down and finally found the optimum design which can fulfill our desired requirements to produce desired output.

11.3 Identify the attribute of complex engineering activities (EA):

The attributes of complex engineering activities (EA) are described below.

- **Range of resources:** The range of resources includes components that are necessary for successful project implementation. This includes people, time, money, knowledge and anything etc that is required from the project planning to the project delivery phases are under the resources.

- **Level of interaction:** Includes all kinds of communication and interaction with the people related to the project such as technicians, engineers, stakeholders and even communication within the team.

- **Innovation:** By definition, innovation is another aspect of an engineering project as we can invent something new from our research project that might be helpful; for others. And So the solution needs to be beneficial for the targeted group and should give a proper level of accuracy.

- **Consequences for society and environment:** A complex engineering project must have some consequences related to the environment and society. And so this attribute talks about it. Therefore we need to find them out and sort them if possible.

- **Familiarity:** While we are doing research on a topic, or doing a project lots of things may come up which are new to us and that they make the project much more difficult to understand. That is why we need to solve them with proper research and teamwork.

And among these attributes, only three of them were applied in our project. Below they are given in the box.

Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	✔
A2	Level of interaction	✔
A3	Innovation	
A4	Consequences for society and the environment	✔
A5	Familiarity	

Note: Project must have some or all of the characteristics from attributes A1 to A5

11.4 Provide reasoning how the project address selected attribute (EA):

Our project required plenty of resources in every step, from planning to execute we had to use various types of resources depending on the project requirement. And project resources are components that are necessary for successful project implementation. And it includes people, equipment, money, time, knowledge and anything that is required from the project planning to the project delivery phases. From the beginning or first semester of our final year design project, we have almost gone through lots of articles, papers and journals that are relevant to our project. Those were also part of the resources. Then we used multiple software such as eagle PCB , proteus and arduino. Finally for the hardware implementation we assembled the required sensors, and cameras and prepared the entire device by ourselves. We also had to prepare the budget and work accordingly, which was also part of the resources. We discussed with our ATC for his suggestion and discussed among ourselves and shared our thoughts which in turn helped us to make further decisions and to make a successful project. So, therefore it can be said that a wide range of resources has been used to complete the entire project successfully. The process interactions can be in several different forms in which the basic project management processes, such as initiating, planning, executing, monitoring, and controlling as well as closing can too interact with each other during conducting project activities. All of our group members interacted with each other and shared our thoughts and ideas. We maintained our weekly meetings and fulfilled our weekly tasks carefully. We also respected each other's opinions and discussed them among ourselves and also got advice from our honorable ATC. A good level of interaction is always required for a project to be successful. From the selection of project topics to the implementation of our project all of us shared our ideas and after discussion , we then selected the final decisions. And finally in this way, we have completed our project.

Overall, the effects or impacts of any project on the environment are one of the vital sides of project management. Since our project is to monitor firefighters' health conditions, we had to keep an eye on the consequences for society and the environment of our project. It is because while conducting our project or collecting data, our device could harm the firefighters and that could have created negative consequences. So, we maintained the highest possible safety standards to avoid such kinds of consequences. On the other hand, we have done our monitoring in our homes with different persons; measuring different key health conditions successfully, giving us maximum possible correct results without any physical harm.

References:

[1] D. L. Tate, L. Sibert and T. King, "Using virtual environments to train firefighters," in IEEE Computer Graphics and Applications, vol. 17, no. 6, pp. 23-29, Nov.-Dec. 1997, doi: 10.1109/38.626965.

[2] A. M. Naghsh, J. Gancet, A. Tanoto and C. Roast, "Analysis and design of human-robot swarm interaction in firefighting," RO-MAN 2008 - The 17th IEEE International Symposium on Robot and Human Interactive Communication, Munich, Germany, 2008, pp. 255-260, doi: 10.1109/ROMAN.2008.4600675.

[3] F. E. Schneider and D. Wildermuth, "Using robots for firefighters and first responders: Scenario specification and exemplary system description," 2017 18th International Carpathian Control Conference (ICCC), Sinaia, Romania, 2017, pp. 216-221, doi: 10.1109/CarpathianCC.2017.7970400

[4] L. T. Nascimento, M. E. M. Araujo, M. W. A. Santos, P. D. Boina, J. V. F. Gomes, M. K. Rosa, T. F. Bastos-Filho, K. S. Komati, and R. J. M. G. Tello, "A smart wearable system for firefighters for monitoring gas sensors and vital signals," *SpringerLink*, 01-Jan-1970. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-030-70601-2_198.

[5] X. Chai, B.-G. Lee, M. Pike, R. Wu, and W.-Y. Chung, "A smart wearable fall detection system for firefighters using V-RNN," *SpringerLink*, 01-Jan-1970. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-030-98404-5_12.

[6] G. B. Tayeh, C. Guyeux, A. Makhoul, J. M. Bahi and S. Freidig, "A Personal LPWAN Remote Monitoring System," 2021 International Wireless Communications and Mobile Computing (IWCMC), Harbin City, China, 2021, pp. 80-85, doi: 10.1109/IWCMC51323.2021.9498794.

[7] F. Jibril, S. A. Adeshina, S. Thomas, A. N. Obadia, O. Sala and O. E. Aina, "A Microcontroller Based Heart Rate Monitoring and Conditions Detection System," 2019 15th International Conference on Electronics, Computer and Computation (ICECCO), Abuja, Nigeria, 2019, pp. 1-4, doi: 10.1109/ICECCO48375.2019.9043190.

[8] M. Z. Dini, A. Rakhmatsyah, and A. A. Wardana, "Detection of oxygen levels (SpO2) and heart rate using a pulse oximeter for classification of hypoxemia based on Fuzzy Logic," Jurnal Ilmiah Teknik Elektro Komputer dan Informatika. [Online]. Available: http://dx.doi.org/10.26555/jiteki.v8i1.22139.

[9] Ariel Roguin, MD, PhD. (Clin Med Res. 2006September; 4(3): 230–235.). Rene Theophile HyacintheLaënnec (1781–1826): The Man Behind theStethoscope. Retrievedfrom http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1570491/

[10] Z. Wadud and F. Y. Huda, "Fire safety in the readymade garment sector in Bangladesh: Structural inadequacy versus management deficiency - fire technology," *SpringerLink*, 18-May-2016. [Online]. Available: https://link.springer.com/article/10.1007/s10694-016-0599-x.

[11] M. M. Mahboob, "Characteristics of fire incidents in Asian countries particularly in Bangladesh," *Fire Science and Technology*, 01-May-2013. [Online]. Available: https://www.jstage.jst.go.jp/article/fst/31/3/31_159/_article/-char/ja/.

[12] D. Bankov, E. Khorov, A. Lyakhov and E. Stepanova, "IEEE 802.11ba — Extremely Low Power Wi-Fi for Massive Internet of Things — Challenges, Open Issues, Performance Evaluation," 2019 IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom), 2019, pp. 1-5, doi: 10.1109/BlackSeaCom.2019.8812785.

[13] Raimundo, A. M., & Figueiredo, A. R. (2009). *Personal protective clothing and safety of firefighters near a high intensity fire front. Fire Safety Journal, 44(4), 514–521.* doi:10.1016/j.firesaf.2008.10.007

[14] H. Park, J. Park, S.-H. Lin, and L. M. Boorady, "Assessment of firefighters' needs for personal protective equipment," *Fashion and Textiles*, vol. 1, no. 1, 2014.

[15] T. Barboni, M. Cannac, E. Leoni, and N. Chiaramonti, "Emission of biogenic volatile organic compounds involved in eruptive fire: Implications for the safety of firefighters," CSIRO PUBLISHING, 14-Feb-2011. [Online]. Available: https://www.publish.csiro.au/wf/WF08122. [Accessed: 24-Jan-2023].

[16]M. N. Kirubakaran1, S. A. Kumar1, S. Sasikala1, S. Gohithmugilan1, and M. Muralidhar1, "IOPscience," Journal of Physics: Conference Series, 01-Aug-2021. [Online]. Available: https://iopscience.iop.org/article/10.1088/1742-6596/1997/1/012040. [Accessed: 24-Jan-2023].

[17] A. C. Eastlake, B. S. Knipper, X. He, B. M. Alexander, and K. G. Davis, "Lifestyle and safety practices of firefighters and their relation to cardiovascular risk factors," *Work*, 01-Jan-2015. [Online]. Available: https://content.iospress.com/articles/work/wor01796.

[18] J. J. Roldán-Gómez, E. González-Gironda, and A. Barrientos, "A survey on robotic technologies for Forest Firefighting: Applying drone swarms to improve firefighters' efficiency and safety," MDPI, 01-Jan-2021. [Online]. Available: https://doi.org/10.3390/app11010363.

[19] F. Perroni, L. Guidetti, L. Cignitti, and C. Baldari, "Psychophysiological responses of firefighters to emergencies: A review.," *THE OPEN SPORTS SCIENCES JOURNAL*, 22-Oct-2022. [Online]. Available: https://iris.unito.it/handle/2318/141943.

[20] P. Castillejo, J. -F. Martinez, J. Rodriguez-Molina and A. Cuerva, "Integration of wearable devices in a wireless sensor network for an E-health application," in IEEE Wireless Communications, vol. 20, no. 4, pp. 38-49, August 2013, doi: 10.1109/MWC.2013.6590049.

Appendix A: Source codes

GSR:

```
#include
<SkinConductance.h>
#include <TinyGPSPlus.h>
#include
<DallasTemperature.h>
#include
<MAX30100_PulseOximeter.h>
#include <Adafruit_MPU6050.h>
#include <ESP8266WiFi.h>

const char* ssid = "server";
const char* password =
"12345678"; const char* host =
"192.168.4.1"; const uint16_t
port = 1000;

#define tempPin
D7 #define button
D5 #define gsrPin
A0 #define
smokePin D6

WiFiClient client;
Adafruit_MPU6050 mpu;
PulseOximeter oximeter;
SkinConductance gsr(gsrPin);
OneWire oneWire(tempPin);
DallasTemperature
dallas(&oneWire); TinyGPSPlus
gps;

double lati, longi,
gsrVal; double temp,
heart, spo2; double x,
y, z;
bool isSmokeDetect,
isPressed; bool
isConnected;
bool
isFall;
long
prevMs;

void setup() {
  Wire.begin(D2,
  D1);
  Serial.begin(960
  0);

  pinMode(LED_BUILTIN, OUTPUT);
  pinMode(smokePin, INPUT);
  pinMode(button,
  INPUT_PULLUP);

  WiFi.mode(WIFI_STA)
  ; WiFi.begin(ssid,
  password);
  while (WiFi.status() !=
    WL_CONNECTED) { delay(500);
    digitalWrite(LED_BUILTIN, !digitalRead(LED_BUILTIN));
  }
  digitalWrite(LED_BUILTIN,
  0); Serial.print("IP=");
  Serial.println(WiFi.localIP())
  ;

  if (!mpu.begin()) Serial.println("MPU
  Fail!"); else {
    mpu.setHighPassFilter(MPU6050_HIGHPASS_0_63_H
    Z); mpu.setMotionDetectionThreshold(1);
    mpu.setMotionDetectionDuration(20);
    mpu.setInterruptPinLatch(true);
    mpu.setInterruptPinPolarity(true);
```

MAX30100:

```
#include <Wire.h>
#include
<MAX30100_PulseOximeter.h>
#include <ESP8266WiFi.h>

const char* ssid = "server";
const char* password =
"12345678"; const char* host =
"192.168.4.1"; const uint16_t
port = 1000;

#define button D5
#define smokePin
D6

WiFiClient client;
PulseOximeter
oximeter;

double heart, spo2;
bool isSmokeDetect,
isPressed; bool
isConnected;
long prevMs;

void setup() {
  Wire.begin(D2,
  D1);
  Serial.begin(960
  0);

  pinMode(LED_BUILTIN, OUTPUT);
  pinMode(smokePin, INPUT);
  pinMode(button,
  INPUT_PULLUP);

  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid,
  password);
  while (WiFi.status() !=
    WL_CONNECTED) { delay(500);
    digitalWrite(LED_BUILTIN, !digitalRead(LED_BUILTIN));
  }
  digitalWrite(LED_BUILTIN,
  0); Serial.print("IP=");
  Serial.println(WiFi.localIP())
  ;

  if (!oximeter.begin()) {
    Serial.println("Oximeter Fail!");
    ESP.restart();
  }
  oximeter.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
  digitalWrite(LED_BUILTIN, 1);
}

void loop() {
  oximeter.update(
  );

  if (millis() - prevMs >=
    1000) {
    oximeter.shutdown();
    isSmokeDetect =
    !digitalRead(smokePin); isPressed =
    !digitalRead(button);

    heart =
    oximeter.getHeartRate();
    spo2 = oximeter.getSpO2();

    if (client.connect(host, port) && !isConnected) {
      isConnected = 1;
      Serial.println("Connected");
```

mpu.setMotionInterrupt(true);
}
dallas.begi
n();
gsr.reset();
if (!oximeter.begin()) {
Serial.println("Oximeter Fail!");
ESP.restart();
}
	} else if (!client.connected() && isConnected) isConnected = 0;
	
	if (isConnected == 1) {
	client.printf("ID2=0,%.2f,%.2f,0,%d,%d,0,0,0,$",
	heart, spo2, isSmokeDetect, isPressed);
	}

```
  oximeter.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
  digitalWrite(LED_BUILTIN, 1);
}

void loop() {
  oximeter.update(
  ); gsr.update();

  if (millis() - prevMs >= 1000) {
    oximeter.shutdown();
    dallas.requestTemperatures();
    isSmokeDetect =
    !digitalRead(smokePin); isPressed =
    !digitalRead(button); checkGPS();

    float tmpF = dallas.getTempFByIndex(0);
    if (tmpF != DEVICE_DISCONNECTED_F) temp = tmpF;

    if
      (mpu.getMotionInterruptStatus()
      ) { sensors_event_t a, g, temp;
      mpu.getEvent(&a, &g, &temp);
      x                   =
      a.acceleration.x;
      y                   =
      a.acceleration.y;
      z                   =
      a.acceleration.z;
      if (x < 0 && z < 0 || x < 0 && y < 0) isFall
      = 1; else isFall = 0;
    }

    gsrVal = gsr.getSCL();
    heart =
    oximeter.getHeartRate();
    spo2 = oximeter.getSpO2();

    if (client.connect(host, port) && !isConnected) {
      isConnected = 1;
      Serial.println("Connected");
    } else if (!client.connected() && isConnected) isConnected

    = 0; if (isConnected == 1) {

client.printf("ID1=%.2f,%.2f,%.2f,%.2f,%d,%d,%d,%.6f,%.6f,$",
                  temp, heart, spo2, gsrVal, isSmokeDetect,
                  isPressed, isFall, lati, longi);
    }

    oximeter.resum
    e(); prevMs =
    millis();
  }
}

void checkGPS() {
  while (Serial.available() >
    0) { if
    (gps.encode(Serial.read()))
    { if (gps.location.isValid())
    {
        lati =
        gps.location.lat();
        longi =
        gps.location.lng();
      }
    }
  }
}
```

```
    oximeter.resum
    e(); prevMs =
    millis();
  }
}
```

ESP:	TFT:

ESP:

```
#include
<ESP8266WiFi.h>
#include
<ESPAsyncTCP.h>
#include
<vector>

#define SSID
"server"
#define PASSWORD
"12345678"
#define TCP_PORT 1000

static std::vector<AsyncClient*>
clients;

static void handleData(void* arg, AsyncClient*
client, void* data, size_t len)
{ Serial.write((uint8_t*)data,
len);
}

static void handleNewClient(void* arg,
AsyncClient* client)

{
clients.push_back(clie
nt); client->onData(&handleData,
NULL);
}

void setup()

{
Serial.begin(960
0);

while (!WiFi.softAP(SSID, PASSWORD, 6, false,
3))
{
Serial.print("
.");
delay(50
0);
}
Serial.print("IP
=");
Serial.print(WiFi.softAPIP
());
Serial.println();

AsyncServer* server =
new AsyncServer(TCP_PORT);
server->setNoDelay(tr
ue); server->onClient(&handleNewClient,
```

TFT:

```
#include <SoftwareSerial.h>
#include
<MCUFRIEND_kbv.h>

MCUFRIEND_kbv tft;
SoftwareSerial wifi(10,
11);

// temp, heart, spo2, gsr, smoke, butt, x, y, z, lati, longi
#define COUNT 9
const char label[][COUNT] = { "Temp", "Heart", "SpO2", "GSR",
"Gas", "Alarm", "Fall", "Lati",
"Longi" }; double value[COUNT][2];

void setup() {
  Serial.begin(9600);
  wifi.begin(9600);

  uint16_t ID = tft.readID();
  if (ID == 0xD3D3) ID = 0x9481;
  tft.begin(ID);
  tft.setRotation
  (1);
  tft.fillScreen(TFT_LIGHTGREY);


  tft.fillRoundRect(5, 5, 230, 310, 10, TFT_CYAN);
  tft.fillRoundRect(245, 5, 230, 310, 10, TFT_GREEN);

  tftPrint(45, 10, TFT_BLACK, TFT_WHITE, 2, "Person-001");
  tftPrint(295, 10, TFT_BLACK, TFT_WHITE, 2, "Person-002");
}

void
  loop() {
  checkDat
  a();
}

void checkData() {
  if (wifi.available()) {
    String data = wifi.readStringUntil('$');
    Serial.println(data);
    if (data.indexOf("ID1=") != -1) printData(data, 0, 10,
TFT_NAVY, TFT_CYAN);
    else if (data.indexOf("ID2=") != -1) printData(data, 1,
250, TFT_NAVY, TFT_GREEN);
  }
}

void printData(String &data, byte c, int x, uint16_t fg, uint16_t
  bg) { int i = data.indexOf("ID1=");
  data.remove(0, i + 4);
  for (byte k = 0; k < COUNT;
    k++) { parse(data, value[k][c]);
    String valStr = "";
    if (k == 4 || k == 5 || k == 6) {
      valStr = (String)label[k] + ": " + (value[k][c] == 0 ? "NO " :
"YES!");
    } else {
      if (k == 7 || k == 8) valStr = (String)label[k] + ": " +
String(value[k][c], 6) + " ";
      else valStr = (String)label[k] + ": " + value[k][c] + " ";
    }

    tftPrint(x, (25 * k) + 40, fg, bg, 2, valStr);
```

server);
server->begin();
}
 	
void loop()
 	
{
ESP.wdtFeed();
}	

```
        if (k ==
    COUNT - 1) { k
    = COUNT;
          valStr = "   ";
          if (value[1][c] > 100) valStr = "Abnormal";
      else if (value[1][c] > 60 && value[1][c] < 100)
valStr = "Normal";
          tftPrint(x, (25 * k) + 40, fg, bg, 2, valStr);
        }
    }
  }

  void tftPrint(int x, int y, uint16_t fg, uint16_t bg, uint8_t s, char
*txt)
  {
     tft.setCursor(x,
 y);
 tft.setTextColor(fg,
 bg);
 tft.setTextSize(s);
 tft.print(txt);
  }

  void tftPrint(int x, int y, uint16_t fg, uint16_t bg, uint8_t s,
String &txt) {
     tft.setCursor(x,
 y);
 tft.setTextColor(fg,
 bg);
 tft.setTextSize(s);
 tft.print(txt);
  }

   void parse(String &data, double
 &val) { int i = data.indexOf(",");
     val =
 data.toFloat();
 data.remove(0, i
 + 1);
  }
```

FYDP (C) Fall/2022 Summary of Team Log Book/ Journal

	Final Year Design Project (P/D/C) Spring/Summer/Fall 202_		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Abid-18221021	abid.mustakem.ahmed@g.bracu.ac.bd	01521104897
Member 2	Diba-18221026	iffat.ara.diba@g.bracu.ac.bd	01406100606
Member 3	Shahriar-17121040	shahriar.azad@g.bracu.ac.bd	
Member 4	Asif-18221016	asif.muhammed.pervez@g.bracu.ac.bd	01733760054
ATC Details:			
ATC 4			
Chair	Dr. Mohammed Belal Hossain Bhuian	belal.bhuian@bracu.ac.bd	
Member 1	Md. Mahmudul Islam	mahmudul.islam@bracu.ac.bd	
Member 2	Abdullah Hil Kafi	abdulla.kafi@bracu.ac.bd	

Date/Time/Place	**Attendee**	**Summary of Meeting Minutes**	**Responsible**	**Comment by ATC**
19/10/2022	1.Abid 2.Diba 3.Asif 4.Azad	1. Need to finalize the design. 2.Need to finalize the problem statement. 3.Need to prepare a draft design concept note	All	Completed

20/10/22	1. Abid 2. Diba 3. Asif 4 .Azad	1. Knowing deeply about the proposed design	All	Done
1/11/22	1. Abid 2. Diba 4 .Azad	1. ATC meeting 2. Proposed design show	All	1. Complete 2. Obsolete design
3/11/22	1. Abid 2. .Azad	1. Finding the way to design approach -2	All	1.Completed
8/11/22	1. Abid 2 .Diba 4.Azad	1. ATC meeting 2. Proposed idea of design approach-2	All	1.Completed 2. On going process
11/11/22	1. Abid 2. Diba 3. Asif 4.Azad	1. Giving critical thoughts about design approach -2	All	Completed
15/11/22	1. Abid 2. Diba 4. Azad	1. ATC meeting 2. theoretical analysis about design approach-2	All	1.Completed 2.Positive feedback
17/11/22	1. Abid 2. Diba 3. Asif 4 .Azad	Finding the problems in design 2	All	Completed
22/11/22	1. Abid 2. Diba 3. Asif 4 .Azad	1.ATC meeting 2.Identifying problem analysis in design approach-2	All	1.Completed 2. Positive feedback
28/11/22	1. Abid 2. Diba 3. Asif 4 .Azad	1.Identifying components 2.Mapping a complete flowchart of final design	All	Completed
29/11/22	1. Abid 2. Diba 3. Asif 4 .Azad	1.ATC meeting 2.Final version of design approach-2 shown	All	1.Completed 2.Approval for the final design was given
2/12/22	1. Abid 2. Diba 3. Asif 4 .Azad	1.FYDP C progress presentation, & giving update till mid to ATC 2.Completing hardware based final design.	All	Partially completed
6/12/22	1. Abid 2. Diba 3. Asif 4 .Azad	FYDP C draft report making	All	Completed
10/12/22	1. Abid 2. Diba 3. Asif 4 .Azad	Final design hardware	ALl	Completed
11/12/22	1. Abid 2. Diba 3. Asif 4 .Azad	FYDP C report making	All	partially completed

FYDP (C) Fall/2022 Summary of Team Log Book/ Journal

15/12/22	1. Abid 2. Diba 3. Asif 4 .Azad	1.FYDP C defense given 2.Project showcasing	All	1.Completed 2.Positive feedback from project showcasing
18/12/22	1. Asif 2 .Azad	Project report making	All	Completed
19/07/22	1. Abid 4 .Diba	Project report making	All	Completed
22/07/22	1. Abid 2. Diba 3.Asif 4.Azad	Organizing project report	All	Completed
25/12/22	1. Abid 2. Diba 3.Asif 4 .Azad	Submission of project report to ATC	All	Completed