Technical Design (TD)

Project Integration

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Version 1.0

Made by: **Group: 10**

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Content

Abbreviations

Abbreviation	Description
GUI	Graphical User Interface

1. Introduction

The elaboration of the technical design for the electronic and software aspects of the heartbeat measurable device is by the component that have been chosen to fulfill the functional design of the system. Each of the fields of engineering used in this project have been combined in such a way as to function together to make the complete heartbeat measurable device.

The following document will describe the technical design of the complete heartbeat measurable device. This complete device consists of a mobile device that work together with a stationary device which has a state-of-the-art communication interface. Which means the following document will describe the technical details of not only one, but two devices.
This technical design document starts with a short abstract of the functional design document where the analysis of the requirement is stated, and key-parameters are created. To fulfill the requirements of each key-parameter a selection between alternative concepts must be weighted by a criterion table. In chapter 2 this information is described.

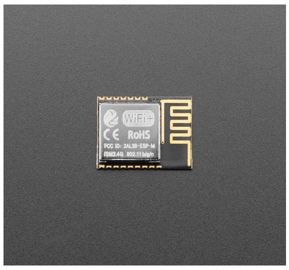
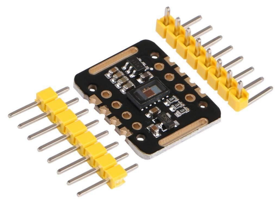
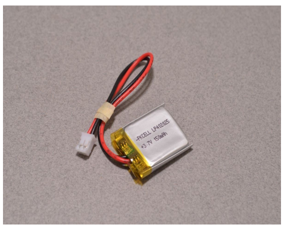
After a short abstraction of the functional design, the description of the technical design start. The functional design document end with the elaboration of the concept design in electrical, electronic and software by using the chosen concept to fulfill the requirements of key-parameters. The description of the technical design start with the approach on how the component were chosen and why were they chosen based on the elaboration of the concept design. After the component are chosen, the next step is to show the hardware and the software design by using the selected component where the hardware design is the schematic and the Printed Circuit Board (PCB) and the software is the flowchart. Chapter 3 describe this in more detail.

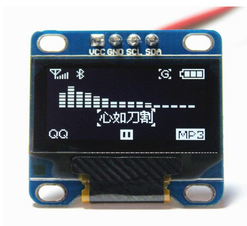
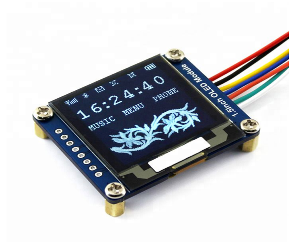
2. Summary from functional

2.1 Analysis of requirements

The final product will be a heartbeat measuring device which can be control with a voice assistant device. The sensor, oled display, ESP32 are designed to be small enough to wear as a watch and ensure device is safe when using. The target of this device are patient and nurse/doctor. The GUI need to be clear and friendly with user. The device must be measure heartbeat signal and send data to cloud.

2.2 Concept principles

Categories\Options	Option 1	Option 2	Option 3
MCU (Microcontroller Unit)	 ESP32	 ESP8266	 ESP8285
Heartbeat Sensor	 Pulse sensor	 MAX30100	 MAX30102
Voice Assistant	 Alexa Echo Dot 1st Edition	 Alexa Echo Dot 2nd Edition	 Alexa Echo Dot 3rd Edition
Battery lithium types	 Lithium prismatic battery	 Lithium polymer battery	 Lithium 18650 battery

Development coding language (Microcontroller)	C programming	Arduino	MicroPython
Development coding language (Database)	Microsoft SQL server	MySQL	SQLite
Development coding language (Server + GUI)	C#	JavaFX	Python
SSD OLED types	 SSD1331	 SSD1306	 SSD1327
Cloud database	Google Cloud	IBM Cloud	DynamoDB Amazon DynamoDB

Weigh criterias of concepts

MCU (Microcontroller Unit)

Criteria\Concepts	ESP32	ESP8266	ESP8285
System Specifications (10%)	+		+
IC Version (20%)	+		
Applications (25%)	+	+	+
Implementation (20%)	+	+	+
Knowledge (25%)	+	+	
Total	100%	70%	55%

ESP32 is the best MCU choice in this case as the main processing platform for the device due to the knowledge about it of the team is much more than other MCU. Moreover, this is a new version of ESP8266, with bluetooth supported, it can be applied in many case, applications. Last but not least, as the requirement of the project, ESP32 is the 1st priority choice to implement the project. The complexity about implementing is not that hard, that’s why the team decided dig deep into it and chose it for the project .

Heartbeat sensor

Criteria\Concepts	Pulse sensor	MAX30100	MAX30102
Cost (10%)		+	+
Output data (15%)	+	+	+
Accuracy (15%)	+	+	+
Implementation (30%)	+		
Knowledge (30%)	+		
Total	90%	40%	40%

Despite of a bit expensive price, pulse sensor is worth than other type of heartbeat sensor because of its complexity of implementation and the ability to handle it of the team. Only require 3 basic pins: power, ground and 1 analog pin, this is an ideal sensor for software engineers and electrical engineers staff work with.

Voice assistant

Criteria\Concepts	Alexa Echo Dot 1st Edition	Alexa Echo Dot 2nd Edition	Alexa Echo Dot 3rd Edition
Development Library (20%)	+	+	
Features (10%)	+	+	+
Implementation (40%)		+	
Knowledge (30%)	+	+	
Total	60%	100%	10%

It is a smart home voice assistant from Amazon, the Alexa Echo Dot now is available with 3 generation. The team had decided to choose the 2nd generation as firstly as the project requirement. Besides, the second version has a lot of implementation which mean that it is the most common version to be implemented in projects. Support libraries and available document resources are also another reason for the team to choose the Alexa Echo Dot 2nd Edition.

Battery lithium types

Criteria\Concepts	Lithium prismatic battery	Lithium polymer battery	Lithium 18650 battery
Safety (40%)		+	
Performance (30%)	+	+	
Cost (10%)			+
Life-pan (20%)	+	+	
Total	50%	90%	10%

Lithium polymer battery is polymer electrolyte instead of liquid electronic, with a high conductivity and these battery can provide a stable energy and continuously for mobile devices. The life-span of Lithium polymer battery is enduring among the other type of battery due to it rechargeability and extensive battery capacity. Although the cost of this type of battery are higher than the others but along that it can bring a various alternative benefits for our devices.

Development coding language (Microcontroller)

Criteria\Concepts	C programming	Arduino	MicroPython
Compatibility (20%)		+	+
Knowledge required (30%)			+
Knowledge available (30%)	+	+	+
Interface (20%)	+	+	+
Total	50%	70%	100%

Working with an MCU, so the best choice for development and implementation an MCU is micropython as this programming language is mostly used for programming MCUs. Furthermore, it is also not too hard or complicated to understand and work with it. Also with simple syntax, micropython is the best ideal language to program an MCU .

Development coding language (Database)

Criteria\Concepts	Microsoft SQL server	MySQL	SQLite
Compatibility (20%)	+	+	+
Knowledge required (30%)	+	+	+
Knowledge available (30%)		+	
Safety (20%)	+	+	+
Total	70%	100%	70%

MySQL might be the best selection for the database as its knowledge. The team worked with it before and of course, all team members have experiences about it. That is the reason to pick it.

Development coding language (Server + GUI)

Criteria\Concepts	C#	JavaFX	Python
Compatibility (20%)	+	+	+
Knowledge required (25%)	+	+	+
Knowledge available (25%)	+		+
Reliability (10%)	+	+	
Associability (20%)	+	+	+
Total	100%	75%	90%

In this case, C# is the team's choice because mostly member on the team (Applied Computer Sciences) ACS students know and understand it a lot, more than the other two programming language and also easy to connect to MySQL database. So the team decided to go for that.

OLED

Criteria\Concepts	SSD1331	SSD1306	SSD1327
Implementation (20%)	+	+	+
Connection types (25%)	+	+	+
Number of pins (5%)		+	
Knowledges (50%)		+	
Total	70%	100%	70%

Ssd1306 oled is an monocolor OLED display which is mostly used for arduino. In this case, it can also be used for the ESP32 by the I2C serial connection by connect sdl and sda pin in the display to I2C pin of the ESP32. Also with available library for implementation in the device, so ssd1306 is the best choice to visible information for users.

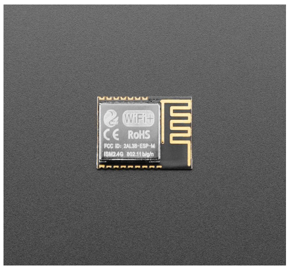
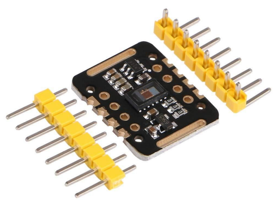
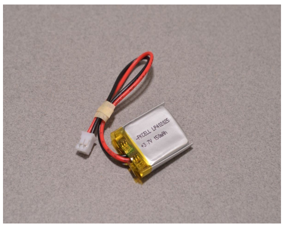
Cloud database

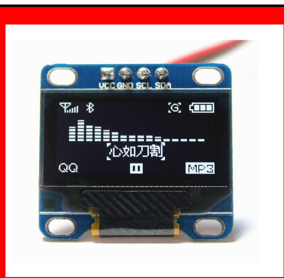
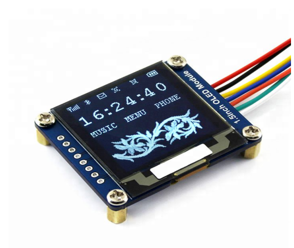
Criteria\Concepts	Google Cloud	IBM Cloud	Amazon DynamoDB
Capacity (10%)	+	+	+
Safety (15%)	+	+	+
Knowledge required (20%)	+	+	+
Knowledge available (20%)	+	+	
Performance (15%)		+	
Reliability (20%)	+	+	+
Total	85%	100%	65%

Comparing with the Google Cloud, IBM and Amazon cloud can be used as free. Moreover, the team also have the experiences about IBM cloud and it reliability and safety as well.

2.3 Comparison of concept principles

After weighed all concepts based on related criterias, all selected technical concepts are demonstrated as the table below:

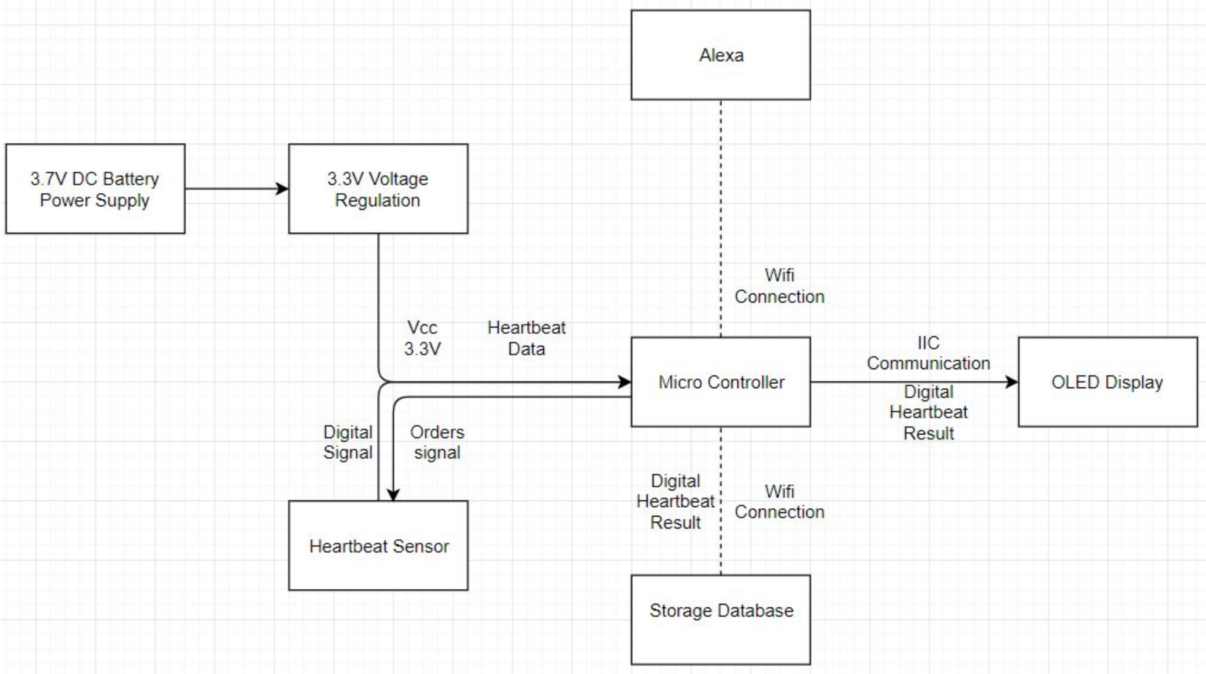
Categories\Options	Option 1	Option 2	Option 3
MCU (Microcontroller Unit)	 ESP32	 ESP8266	 ESP8285
Heartbeat Sensor	 Pulse sensor	 MAX30100	 MAX30102
Voice Assistant	 Alexa Echo Dot 1st Edition	 Alexa Echo Dot 2nd Edition	 Alexa Echo Dot 3rd Edition
Battery lithium types	 Lithium prismatic battery	 Lithium polymer battery	 Lithium 18650 battery

Development coding language (Microcontroller)	C programming	Arduino	MicroPython
Development coding language (Database)	Microsoft SQL server	MySQL	SQLite
Development coding language (Server + GUI)	C#	JavaFX	Python
OLED size	 SSD1331	 SSD1306	 SSD1327
Cloud database	Google Cloud	IBM Cloud	Amazon DynamoDB

3. Technical Design

3.1 Overview of Technical design

The overview of technical design is showed in the block diagram below:



- The Micro Controller will receive the order from Alexa to trigger the Heartbeat Sensor. As soon as the Sensor is trigger, it will measure user's heart rate and transfer it back to Micro Controller. After that, Micro Controller will show the value on the Display. Eventually, all the measured information will be transferred to Cloud(Storage Database) through Wifi and Micro Controller continue to receive the order from Alexa.

3.2 Elaboration of technical design

3.2.1 The technical design of the mobile device

This section starts off with an explanation of the component selection for achieve the electrical concept design of the device. Next alternative component would be chosen by a weight criterion table to achieve the electronic concept design of the device and finally the schematics and the PCB of the device is placed based on the selection of the component and the concept design of the device.

In this chapter, we will focus on the mobile device design.

3.2.1.1 Electrical

The power of the mobile device will depend on two main inputs which work harmonically to supply the circuit. The following figure show the electrical concept design for this device (Note: This figure comes from the functional design document).

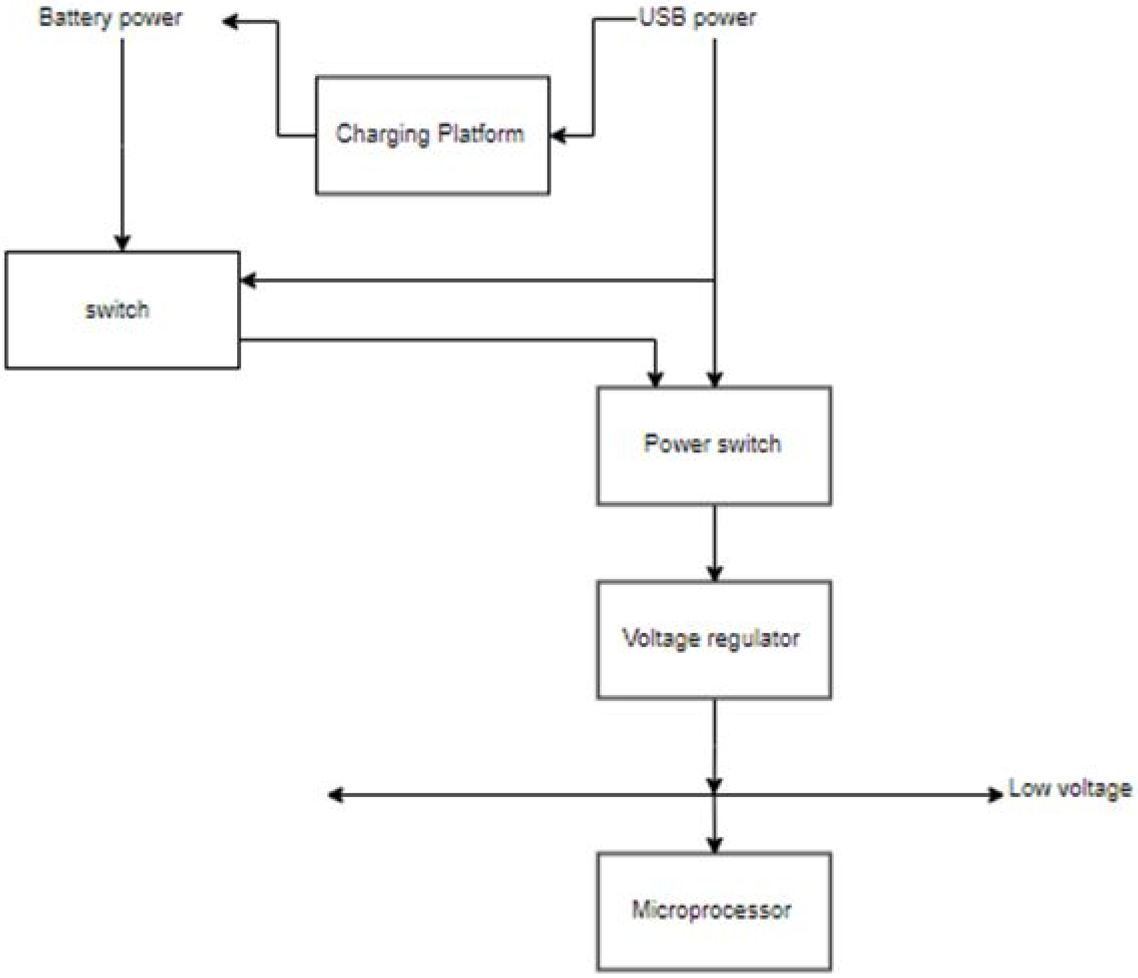


Figure 2: Electrical concept design

When the USB port is connected to the mobile device it will have two functions, the first one is to supply the battery line (battery – charging circuit) with 5 volts on the charging platform connected on parallel will give a 4.2 Vout to the battery for charging which is done by a special IC "MCP73831" that will transform 5 volts to 4.2 volts to charge it. Secondly it will disconnect the battery from the device while charging using a MOSFET switch and the device will be powered directly from the USB port 5 volts which will go to the linear regulator to make it a 3.3 volt to power up the esp32 module.

When battery is charged, and the USB port is not connected the Vout of the battery will go to the converter and the Vout of the converter 3.3 volts will power up the esp32 module and the rest of the circuit.

3.2.1.2 Electronic

Now that our mobile device is powered up; after getting a measurement signal from the sensor, it will be transferred to the esp32 module to be sent via Wi-Fi connection to the Database/User

Interface and at the same time it will be displayed as numbers on the OLED display of the esp32 module on the mobile device. This illustrate in figure 3.

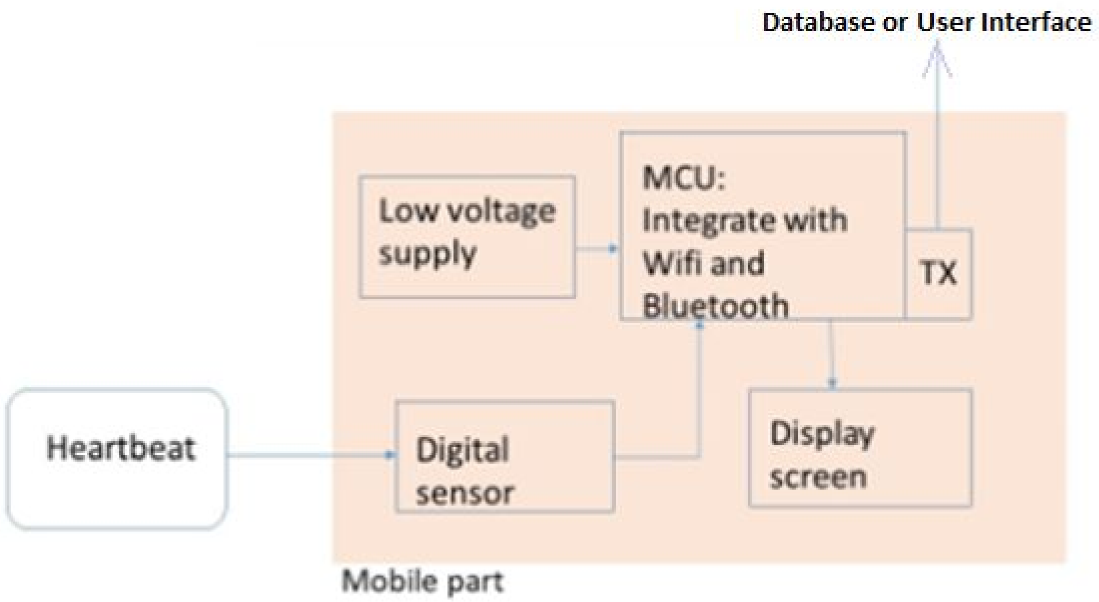


Figure 3: Electronics concept design mobile device

Based on figure 3 electronic architecture of the device alternative component would be compare in a weight criterion table. Each table would have a brief explanation about the component.

Low Voltage Supply	Cost	Efficiency	Hardware Simplicity	Total
	33.3%	33.3%	33.3%	99.9%
Linear Voltage regulator 3.3V	+		+	66.6%
Buck converter 3.3V		+		33.3%

*Note: The power loss of the linear voltage source is mostly cause by the difference of the input voltage and the output voltage. When the difference is high, then the power loss increase. This is where the efficiency of the buck converter overcome the linear voltage regulator. However, because we are using a 3.3v-3.6V battery source for the mobile, the difference of the input and the output voltage would be low, causing the power loss to be low. The hardware of the linear voltage regulator is simpler than the buck converts and the cost of it is lower than the buck converter makes the final choose to be the linear voltage regulator.

Heartbeat sensor	Cost	Size	Efficiency	Hardware simplicity	Total
	25%	25%	25%	25%	100%
MAX30102 (Digital Sensor)		+	+		50%
TCRT1010 (Analog/Pulse Sensor)	+			+	50%

*Note: The comparison is between a digital sensor and an analogue sensor. Since, they have certain advantages and disadvantages which makes equally percentage between them. It also creates the ability that the main control board would be separated from the sensor. The main control board need to have to ability to read data from an analogue sensor and a digital sensor.

Display Screen	Cost	Resolution	Efficiency	Total
	20%	40%	40%	100%
OLED Display Module 0.96 inch (SSD1306)		+	+	80%
OLED Display Module 0.95inch (SSD1331)	+		+	60%

*Note: OLED display module with 0.96-inch (26.7 x 19.26mm) communication interface are I2C. The final chosen display is 0.96-inch OLED Display based on the chapter 2.2 Oled.

MCU: Integrated with Wi-Fi and Bluetooth	Cost	Performance	Hardware simplicity	efficiency	Total
	25%	25%	25%	25%	100%
ESP8285	+	+			50%
ESP8266	+		+		50%

ESP32 Wroom		+	+	+	75%

Note: ESP32 Wroom is a chip that have the ESP 32 inside it, making the performance to be the same as the ESP32. The hardware simpler than the ESP32 chip, because it has also an internal antenna on it. For ESP8266 the price may be lower than the ESP32 wroom, but the efficiency is lower than the ESP32 wroom. At the end, we all agree to use ESP32 Wroom as a heart of the mobile device.

By selecting specific component for the mobile device and that it needs to be as small as possible makes the mobile device to have separated boards. These board are the main board, the input board and the output board. On the main board the Microcontroller (ESP32 Wroom) and linear voltage regulator is connected. The input board would be the digital sensor board or the analog sensor board which they are connected in different pin from the main board. The output board would be the OLED Display module. The following figure would illustrate the explanation. The schematics and the PCB of the board are placed in Appendix.

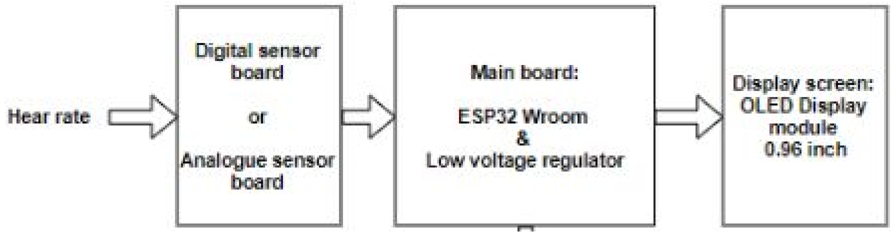
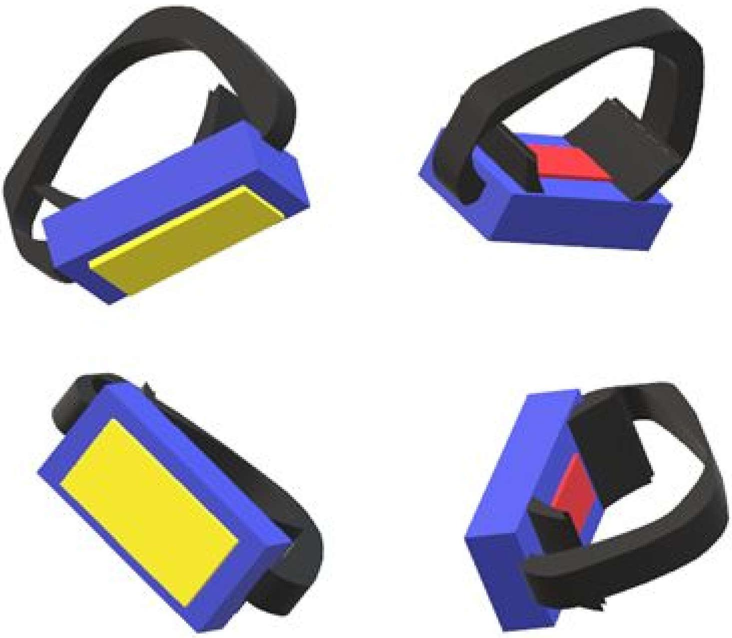


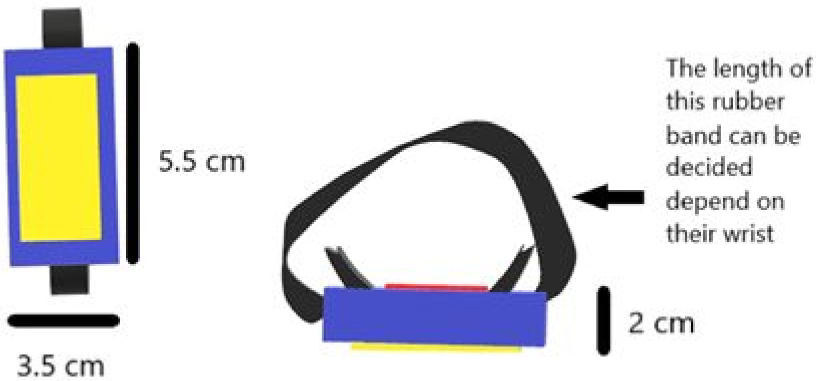
Figure 4: The PCB board design concept

3.2.1.3 Mechanical

The wristband design overview



3D design of the devices

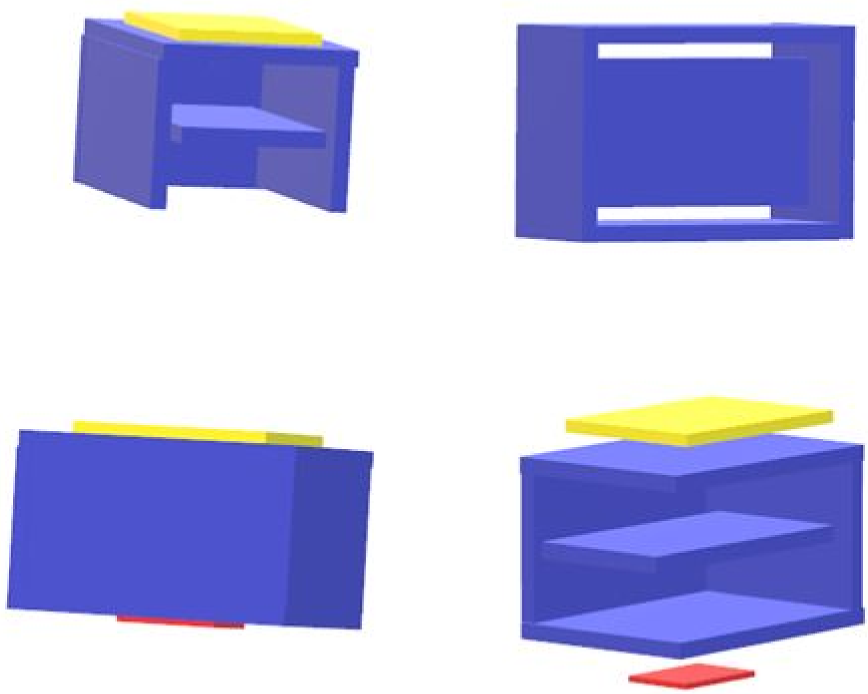


This is the model design of the devices that we concern about, with all the components will be place in the purple part (the container) with the thickness around 2 mm, the upper part (the yellow part) is where the monitor should be placed and the bottom part (the red part) is the sensor which should be placed as near as skin surfaces so it can precisely detect the heart beats of patience. Following this , the black part which is attached beneath the purple part and close to two sides of the sensor and it was designed in other to keep the devices stable on the wrist.

Rubber band

- The 2 red dots will be connected with sensor and placed beneath the wrist of patience to keep track the hearth pulse.

The Watch Box



- The Watch Box will have two layer , the top layer will hold the components and circuit for the monitor (the yellow part) while the bottom layer will hold the piece of electronics which is connected with the sensor (the red part).

3.2.4 Software

Graphical User Interface(GUI)

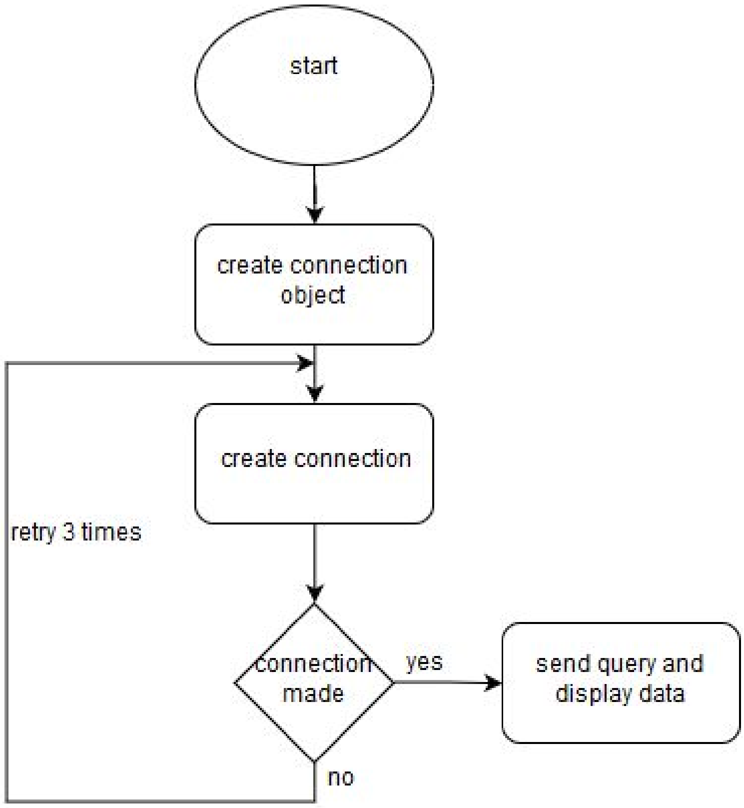
The GUI will be written in the programming language C# with visual studio IDE the reasoning for this is that the IDE is highly user friendly and easy to use..

The GUI will be displayed on as windows. The control will be handled by four different user control panels.They are:
1.Log in
2.Register
3.Forgot Password
4.Logging version

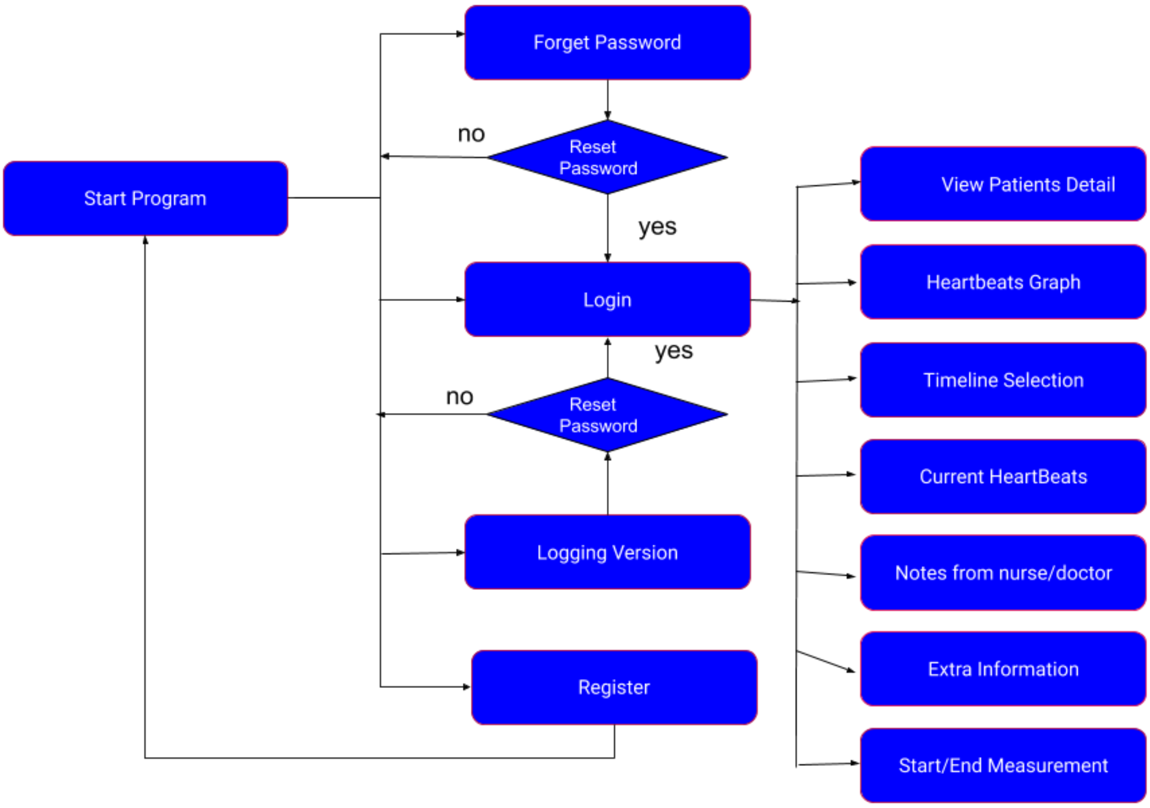
After successful login user can see 7 different parts in windows panel.They are as follows:
1.Patients Detail
2.Graphs
3.Timeline selection
4.Current Heartbeats
5.Notes Box
6.Extra Information
7.Start/end button

Connection Database

The connection will be made using the C# because it has header system which is well tested and old method of making connection.Another reason to choose C# is that we used it to make GUI.



Pic: Flow-diagram of Database connection



Picture: Flow diagram of GUI

Appendix: Mobile device (The first prototype)

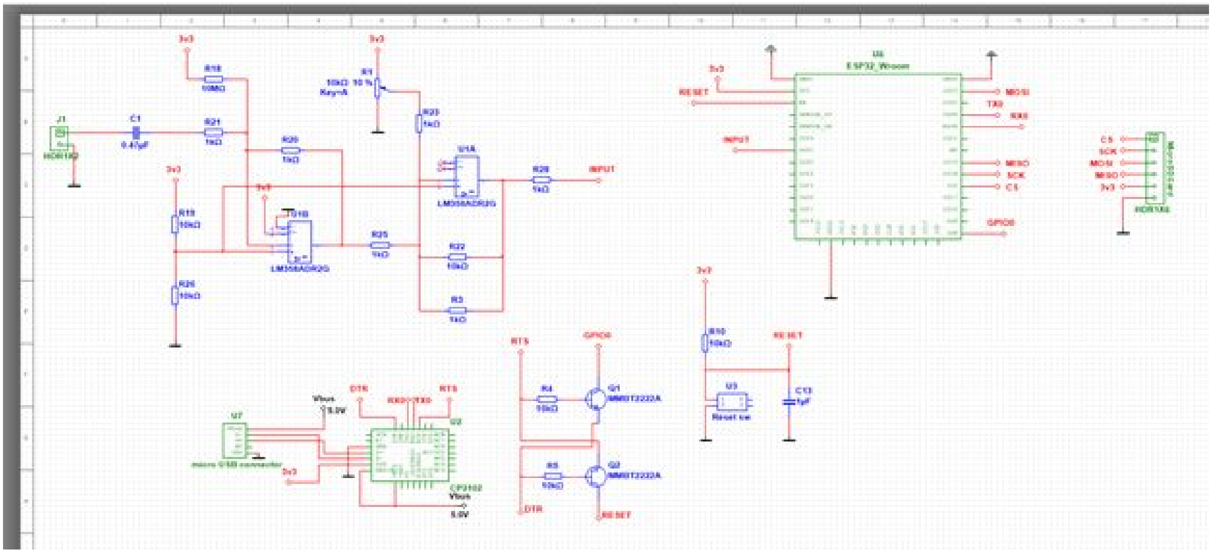


Figure: Mobile device schematic

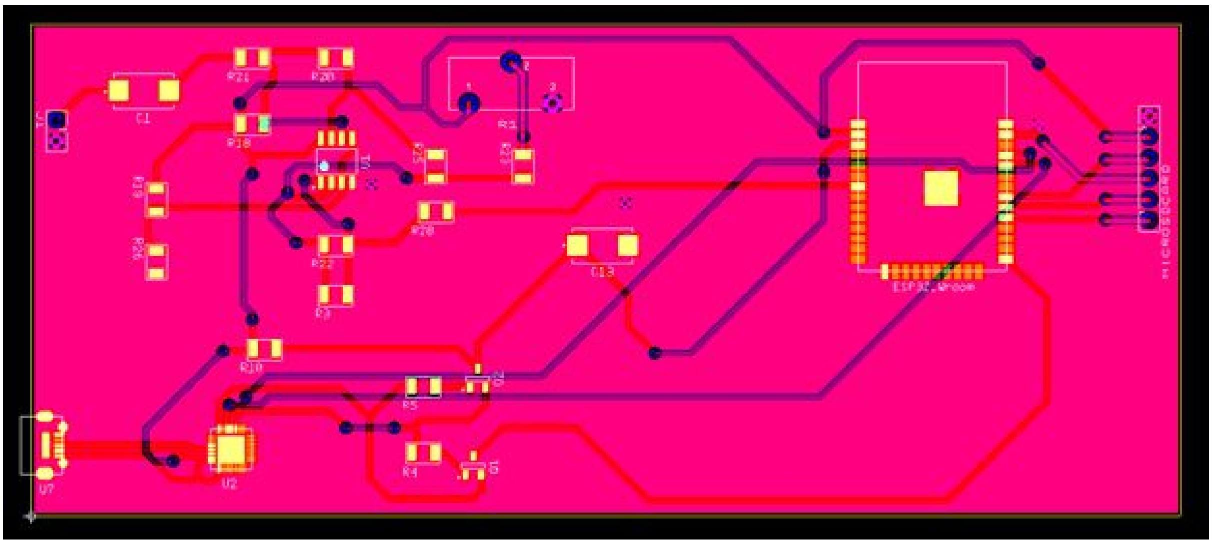


Figure: Mobile device PCB Design

Appendix: Pulse Sensor (The first prototype)