POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

DEVELOPMENT AND IMPLEMENTATION OF A CLOUD-INTEGRATED PULSE OXIMETER FOR REAL-TIME HEALTH MONITORING

VICTOR HENG JUN HANG

(08DEU22F1002)

ELECTRICAL ENGINEERING DEPARTMENT

SESSION I: 2024/2025

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This final report is submitted to the Electrical Engineering Department in fulfilment of the requirements for the award of the Diploma in Electronic Engineering (Medical)

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SESSION I: 2024/2025

DECLARATION OF PROJECT REPORT AND COPYRIGHT

DEVELOPMENT AND IMPLEMENTATION OF A CLOUD-INTEGRATED PULSE OXIMETER FOR REAL-TIME HEALTH MONITORING

1. I, **VICTOR HENG JUN HANG (08DEU22F1002)** is final semester in **Diploma in Electronic Engineering (Medical)**, **Department of Electrical, Politeknik Sultan Salahuddin Abdul Aziz Shah**, address **Persiaran Usahawan, Seksyen U1, 40150 Shah Alam, Selangor**. (After this as 'As Polytechnic').

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NOR KHARUL AINA BINTI MAT DIN	)	………………………………
(As a project supervisor at (date): 22.11.2024	)	**NOR KHARUL AINA BINTI MAT DIN**

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ABSTRAK

Projek ini meneroka pembangunan oksimeter nadi bersepadu awan yang memanfaatkan teknologi IoT untuk meningkatkan oksimetri tradisional. Dengan memanjangkan fungsi oksimeter nadi standard, peranti ini membolehkan pemantauan jarak jauh berterusan dan paparan data masa nyata pada peranti pintar, menjadikannya lebih mudah untuk menjejak tahap oksigen darah dengan kebolehcapaian dan ketepatan yang lebih tinggi. Objektif kajian ini adalah untuk menyiasat kaedah untuk merekod paras oksigen darah melalui aplikasi dalam talian, mereka bentuk dan membangunkan peranti oksimeter nadi dengan keupayaan awan, dan menilai kefungsian peranti dalam penggunaan harian. Menggunakan mikropengawal dan Arduino IDE, pengekodan dipermudahkan untuk pengaturcaraan yang cekap dan muat naik ke peranti. Aplikasi Blynk disepadukan untuk menangkap dan memaparkan data daripada oksimeter nadi pada peranti pintar melalui Wi-Fi, membolehkan pemantauan lancar dan kebolehcapaian data. Sambungan mikropengawal ke Blynk membolehkan pemindahan data dan storan dalam talian, yang berpotensi meningkatkan kebolehgunaan peranti untuk pemantauan kesihatan jauh. Walau bagaimanapun, projek itu menghadapi cabaran yang ketara, termasuk isu penderia yang menghalangnya daripada merakam data dan menyala seperti yang dijangkakan, serta masalah ketersambungan dengan Blynk, yang tidak dapat mengesan peranti walaupun ketika tempat liputan mudah alih digunakan. Kesukaran ini menyekat keupayaan untuk mendapatkan hasil yang boleh digunakan dan menguji peranti sepenuhnya dalam senario praktikal. Kesimpulannya, aplikasi IoT boleh memajukan teknologi perubatan dengan ketara dengan menyediakan pengurusan data yang boleh diakses, tahan gangguan dan selamat untuk rekod perubatan. Walaupun prototaip ini menghadapi batasan, konsep ini menunjukkan potensi berharga untuk peranti kesihatan yang berkaitan dengan awan, membuka jalan untuk aplikasi yang lebih luas melangkaui pulse oximetry, menawarkan peningkatan dalam kebolehcapaian data dan pemantauan pesakit untuk penyelesaian perubatan masa hadapan.

ABSTRACT

This project explores the development of a cloud-integrated pulse oximeter that leverages IoT technology to enhance traditional oximetry. By extending the function of a standard pulse oximeter, this device enables continuous remote monitoring and real-time data display on smart devices, making it easier to track blood oxygen levels with greater accessibility and precision. The objectives of this study are to investigate methods for recording blood oxygen levels through an online application, design and develop a pulse oximeter device with cloud capabilities, and evaluate the device's functionality in everyday use.Using a microcontroller and Arduino IDE, the coding is simplified for efficient programming and uploading to the device. The Blynk application is integrated to capture and display data from the pulse oximeter on a smart device via Wi-Fi, allowing for seamless monitoring and data accessibility. The microcontroller's connection to Blynk enables data transfer and online storage, potentially enhancing the usability of the device for remote health monitoring.However, the project encountered significant challenges, including sensor issues that prevented it from recording data and lighting up as expected, as well as connectivity problems with Blynk, which could not detect the device even when a mobile hotspot was used. These difficulties restricted the ability to obtain usable results and fully test the device in practical scenarios.In conclusion, the application of IoT can significantly advance medical technology by providing accessible, tamper-resistant, and secure data management for medical records. Although this prototype faced limitations, the concept demonstrates a valuable potential for cloud-connected health devices, paving the way for broader applications beyond pulse oximetry, offering improvements in data accessibility and patient monitoring for future medical solutions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 Introduction

The Development and Implementation of a Cloud-Integrated Pulse Oximeter for Real-Time Health Monitoring used IoT connection to extend the function of a traditional oximeter. It increases it accessibility, enable remote monitoring and data display on a smart device to better keep track of a person’s blood oxygen meter more accurately.

1.2 Project Background

Pulse oximetry is a non-invasive method for monitoring the oxygen saturation levels of arterial blood, as well as the pulse rate, typically through a sensor attached to a patient's fingertip, earlobe, or other peripheral site. This technology has become an essential tool in various clinical settings, including hospitals, clinics, emergency medical services, and home care, due to its simplicity, accuracy, and real-time monitoring capabilities.

This project is made to combat the problem of how the data can be easily lost and falsely altered. With this new system, the blood oxygen meter of a person can be stored. It allows the person to easily will be able to look back at the past data, significantly decrease the human error that might occurs. With the use of the Blynk application, the data collected can be view on any smart devices with the Blynk app installed.

1.3 Problem Statement

The increasing demand for continuous health monitoring in both clinical and home settings has highlighted the need for accessible, real-time data on vital signs. Traditional pulse oximeters, while effective in measuring blood oxygen levels and heart rate, are limited by their lack of connectivity and real-time data-sharing capabilities. In critical situations, such as managing chronic respiratory diseases, post-surgery monitoring, or tracking COVID-19 patients, timely data transmission to healthcare providers can significantly impact patient outcomes.

However, current pulse oximeters are not equipped to automatically relay this data to cloud-based platforms for remote access by medical professionals. This creates a gap in care where patients may not receive timely intervention, and healthcare providers cannot monitor or respond to deteriorating conditions in real time. Thus, there is a pressing need to develop a cloud-integrated pulse oximeter that can transmit real-time oxygen saturation and heart rate data to a secure, accessible platform for continuous monitoring, early detection of health risks, and improved patient outcomes.

This project aims to address this gap by developing a Development and Implementation of a Cloud-Integrated Pulse Oximeter for Real-Time Health Monitoring that enhances real-time health monitoring, improves data accessibility, and provides actionable insights for healthcare providers.

1.4 Project Objective

The objectives of this project are:

(a) To study the way to record blood oxygen meter using online application.

(b) To design and develop a pulse oximeter device with cloud integration.

(c) To test how well cloud connected pulse oximeter works in everyday use

1.5 Project Scope

This Project is focusing on measuring and record the blood oxygen meter of a person. The emphasis is to take the data and display in on a smart device with the Blynk application. The main parts of the product consist of ESP8266 microcontroller, OLED screen and MAX30100 sensor.

1.6 Problem Significance

The significance of an IoT-connected pulse oximeter project lies in its potential to revolutionize remote health monitoring and improve patient outcomes through continuous, real-time monitoring, data analytics, and proactive healthcare management. (Sidhartha Giridhar and Dwarakanath K C, 2021)

IoT-connected pulse oximeters have the potential to improve access to healthcare services, particularly for individuals in remote or underserved areas. Patients can receive high-quality monitoring and care regardless of their geographical location, socioeconomic status, or mobility limitations, thereby promoting health equity and reducing disparities in healthcare access. (Nookala Venu, 2022)

1.7 Definition of Term or Operation

The project itself is connected on a breadboard, where is have a ESP8266 microcontroller, OLED screen, MAX30100 oximeter sensor and many jumper wires that connect all the components together. Once the code is uploaded from Arduino.IDE to the ESP microcontroller, the patient put their finger on the sensor and the bpm and Sp02 of the patient will be displayed on the OLED screen. In the coding itself, the microcontroller is written to connected to the Blynk app on a smart device. In the Blynk app, there are two gauges configured that collect data of both the bpm and Sp02 meter from the OLED screen. If there is no connection issue, the bpm and Sp02 of the patient will display the same value as it is on the OLED screen and the Blynk app.

1.8 Summary

This chapter stated the fundamental concept of my project and the ideas behind it. It emphasizes the problem statement and objectives of making this project, as well as the scope and limitations of it, highlighting the significance of this project and serving as an introduction to my project and this proposal. It also cites research on similar topic in the past that serve as a foundation for my projects.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

The purpose of this literature review is to examine the current state of knowledge on blood oximetry. In recent years, there has been a growing interest in blood oximetry due to its importance, especially regarding the amount of people suffer from disease cause by abnormal Sp02 meter, like Hypoxemia. This review will begin by providing a brief overview of the history of research on blood oximetry, followed by a summary of the key findings from previous studies. The review will then explore into the current debates and controversies surrounding blood oximetry and will identify gaps in the existing research. By producing the available literature, this review aims to provide a comprehensive overview of the current state of knowledge on blood oximetry and to identify areas for future research.

2.2 IoT in Healthcare (Literature Review Topic 1)

Sp02 refers to the oxygen saturation in a person’s blood. Medical data like a person’s Sp02 level can be easily lost, that is why the use of IoT can solve this issue as IoT allows devices to interconnect, collect data, and exchange information in real-time, which can improve health monitoring, diagnosis, and disease management in a more effective way. (Dito Anurogo, 2024)

IoT is crucial for the electronic shift in medicine since it provides novel business models to empower and evolve transformations in practice procedures, controlling the budget, enhancing performance, and improving patient satisfaction. (Rehab A Rayan, 2021)

2.3 Control System (Literature Review Topic 2)

Control System theory has played an important role in cloud based computing system. The development of cloud computing in computer science has become an enabler for the widely used controller in control systems to migrate to the cloud and has created a new field of research in cloud-based control systems (CCS). (Santo Wijaya, 2023)

There are different types of control system, two of the more common and prominent one is the closed-loop and open-loop control system. The diagram below will display the basic working of both systems.

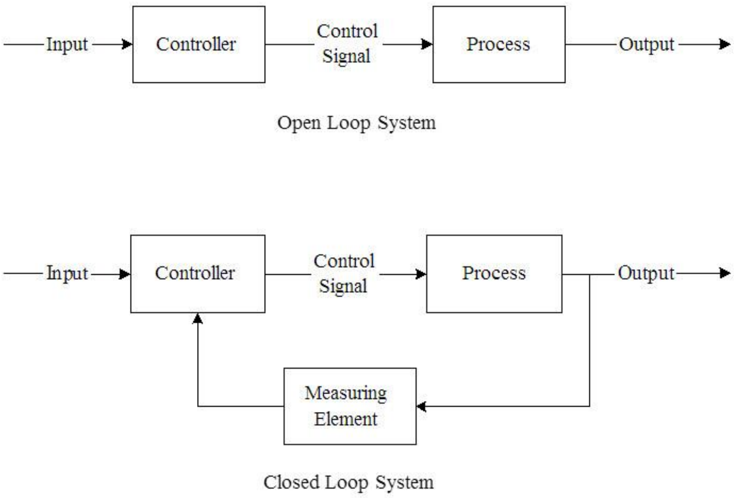

Figure 2.1 Block diagram of open loop and closed loop system

2.3.1 Microcontroller (Literature Review Topic 2)

A microcontroller is a compact integrated circuit (IC) that contains a processor core, memory, and various peripherals, all housed within a single chip. It's essentially a small computer optimized for embedded applications. They are favoured for their small size, low power consumption, and cost-effectiveness, making them ideal for controlling simple to moderately complex tasks in real-time.

2.4 Arduino and ESP8266 (Literature Review Topic 3)

Arduino is an open-source electronics platform that consists of both hardware and software components. It's designed to make it easy for beginners and professionals alike to create interactive projects and prototypes. Its simplicity, versatility, and affordability have made it a popular choice for both beginners and experienced makers alike.

The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems. It can be used as a standalone device, or as a UART to Wi-Fi adaptor to allow other microcontrollers to connect to a Wi-Fi network.

With the use of the Arduino.IDE program, the code can be compiled and upload to any microcontroller via a USB port. After connecting to the microcontroller, it can run the program uploaded to any connected hardware.

2.5 Related Project

Despite the information so far, similar project has been found using different methodology and different approaches. For example, there are already wireless pulse oximetry made using a Wi-Fi connected oximeter that can be connected to a dedicated website that shows all the relevant information. However, both the oximeter and the right to own the website is highly expensive and can't be afforded by most students.

2.5.1 The Development and Implementation of a Cloud-Integrated Pulse Oximeter for Real-Time Health Monitoring (Project 1)

In Project 1, an attempt was made find a template to a website, downloaded it, change its interior design to suit the project. However, this comes with several disadvantages. Firstly, The oximeter. An expensive wireless oximeter would need to be bought an to connected to the website, this would cause the project to end up costing way more than it should.

Secondly, the lack of innovation. If the oximeter bought was used, no change would need to be made in any way as the oximeter already comes with a full package. This would cause the innovation of the project to be way too minimal, defeating the point of making the own project.

Thirdly, the website itself. The interior of the website is way too complicated to be changed other than the wording used. The graphics, interface, videos and customer support of the websites is very difficult to change. This cause the use of a website abandoned entirely as it is way too much effort than to just use a website with only a monitoring purpose like Blynk.

2.5.2 IoT connected Pulse Oximeter (Project 2)

In project 2, a more traditional method to achieve the objective, that being, buying the components necessary individually and assemble the oximeter itself on a breadboard. Components like the core one such as the ESP8266 microcontroller, MAX30100 pulse oximeter sensor and the OLED screen; also, with supporting components like microbus cable, breadboard and jumper wires. The components itself are rather cheap compared to an actual oximeter and way more innovation was present with the project itself.

As for the connection issue, Blynk application was used to monitor the data receive by the project. Blynk itself is easy to configure and can connect with the microcontroller via Wi-Fi. This way, it can display the data shown on the OLED screen.

Since the configuration in Blynk is ready to use at any time, the bpm and Sp02 meter don’t have to be coded in manually.

2.6 Comparison of Project

When comparing both project, Project 2 is cheaper in comparison because each individual components are cheaper than the entire commercially available wireless pulse oximeter. Not only that the website domain is also something that needs to be paid monthly like a subscription. Unlike Blynk application which is free to use if signed up.

Project 1 also use an Arduino based microcontroller for connection, but it is already built into the oximeter itself along with the sensor and the display. The oximeter used in Project 1 is perfect is every way because it is a commercially available oximeter that anyone can buy. Comparatively, Project 2 uses ESP8266 microcontroller for connection. The jumper wire is used to connect all the other core components on the breadboard.

Project 1 is built using industry grade machinery and is built to maximize user comfort, such equipment that no students have access to. Therefore, the oximeter in Project 1 is very compact and lightweight. In comparison, Project 2 is built using individual components making the entire oximeter looks more robust as it has an odd shape.

Finally, Project 1 is battery-powered and needs to be charged regularly to function, like a smartphone. Project 2 however, obtain power right from the microbus cable that is connected to the device that uploaded the code from Arduino.IDE (in this case, a laptop). Project 2 overall uses more electricity because it does not have a built-in battery.

Table 2.1 Comparison between previous projects

Comparison	Project 1	Project 2	Proposed Project
Microcontroller	None	ESP8266	ESP8266
Cost	~RM 1600	RM 80	RM 80
Size	100cm x 60cm x 30cm	80cm x 40cm x 30 cm	30cm x 15cm x 15cm
Sustainability to the environment	Using Battery	Using Direct Power Supply	Using Direct Power Supply

2.7 Summary

This section focuses on two different sections, the first is the main technology that is being utilize in the project, that being the background research of the usage and advantages of IoT technology and cloud-based platform in healthcare.

The second is the control system as well as the PIC and electronic platform that will be used in the making of this project. The system used will allow the project to function as intended and make computing the information easier overall.

This section also highlights the different between Project 1 and Project 2, mainly the core components used and the methodology of how the objective of this project is completed.

CHAPTER 3
METHODOLOGY

3.1 Introduction

To realize this Project as a product that ready to use with safety characteristic, a very comprehensive plan is undertaking. A step-by-step procedure is done so that the Project can be completed in time. This includes collecting data of patient's finger, design the mechanical part, circuit design testing and verification.

3.2 Project Design and Overview

As mentioned in the previous chapter, the designed controller uses a closed-loop system with Arduino as the main controller. The design of the controller circuit using Arduino is realized using Arduino.IDE Software and then convert to PCB circuit. The other main component is the MAX30100 Oximeter Sensor, OLED screen and ESP8266 microcontroller. The process flow of the project is visualized in Figure 3.1 below.

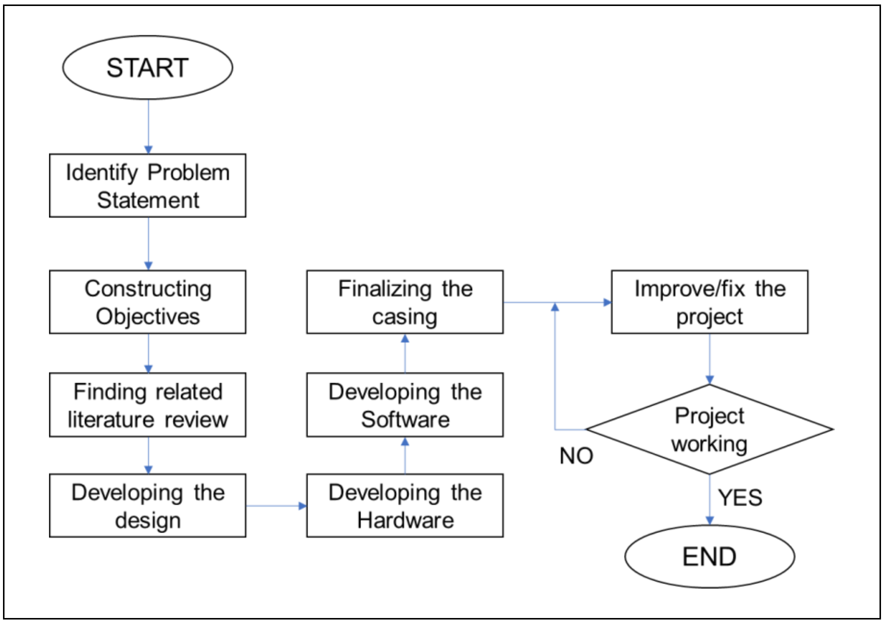

Figure 3.1 Process flow of the project

Below is Figure 3.2 which show the Gantt Chart that represents the planning and early implementation of my project. Figure 3.3 shows a second Gantt Chart that goes over the actual development of the project.

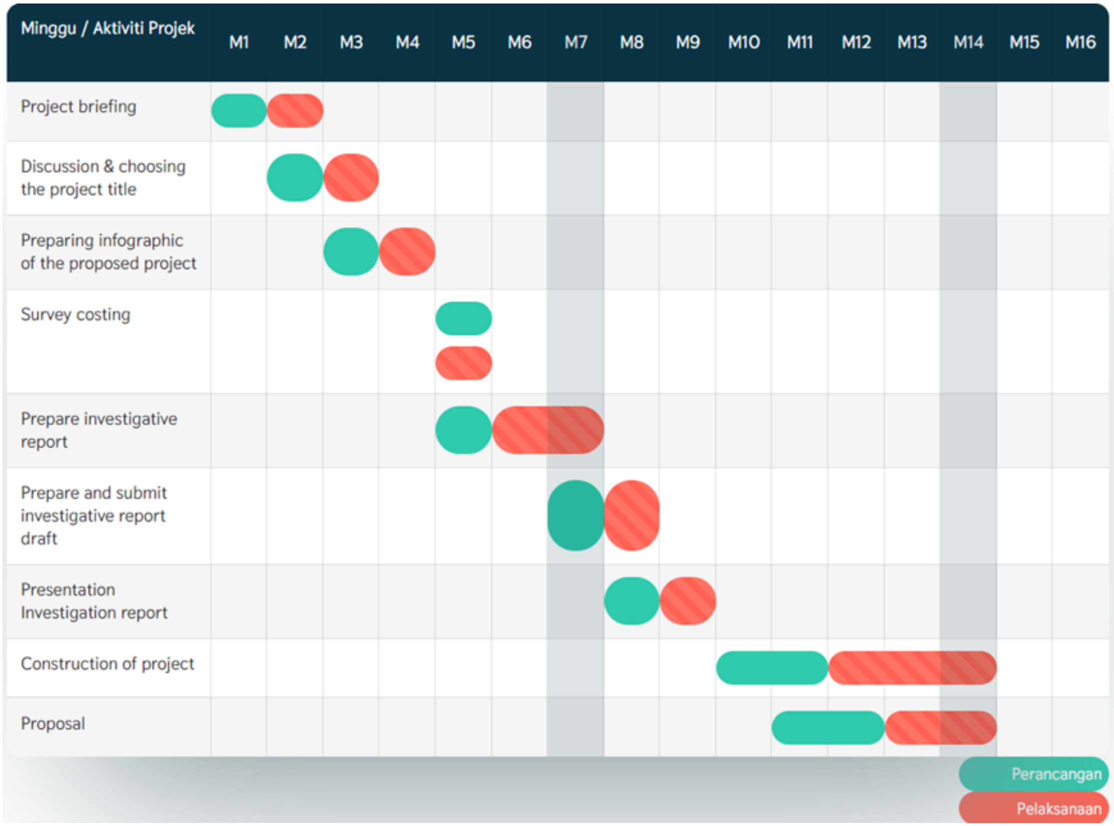

Figure 3.2 Gantt Chart (Project 1)

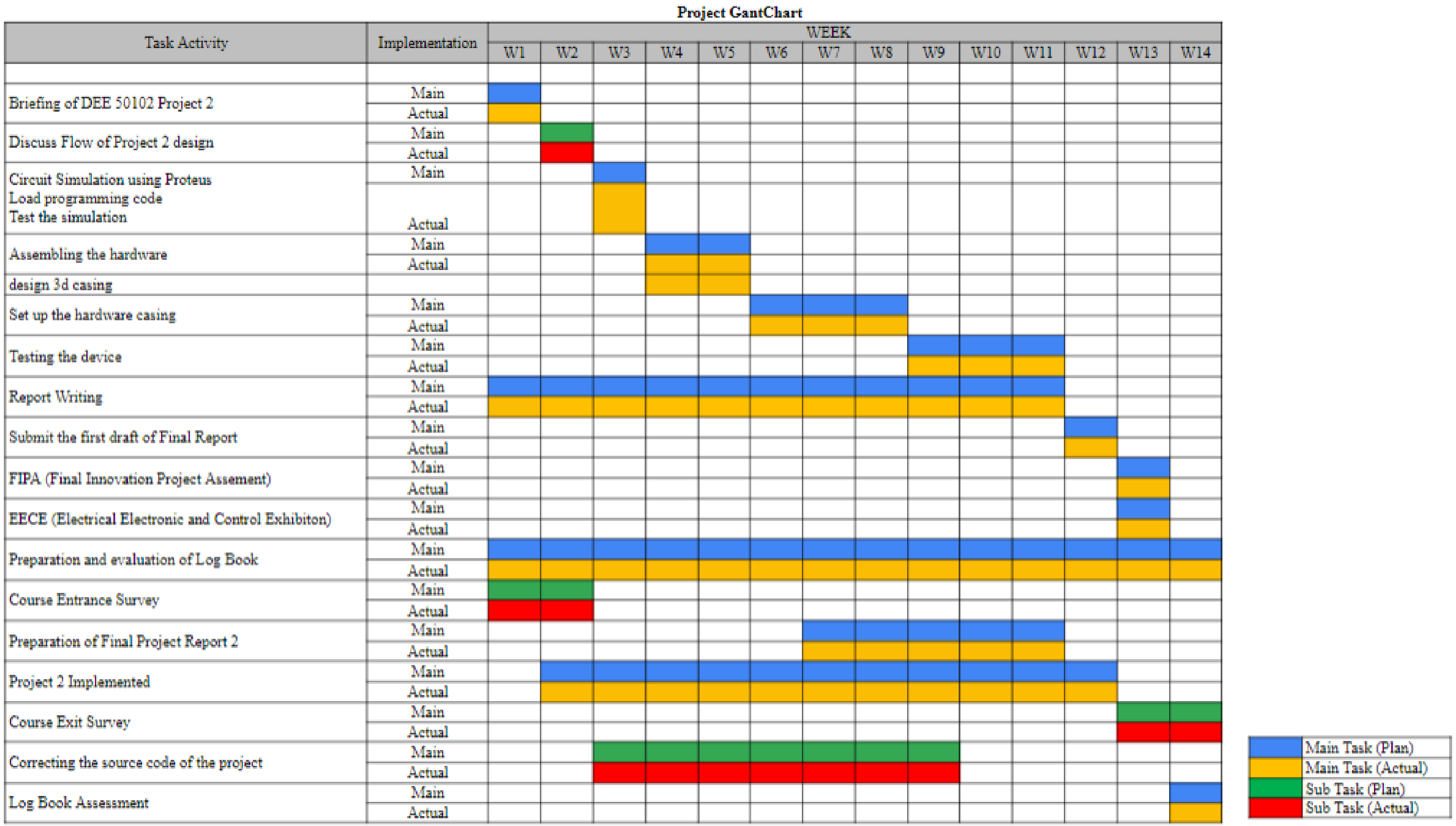

Figure 3.3 Project Gantt Chart

The first Gantt Chart represents Project 1, where the planning over the overall design and inner working of the project is still undergoing. During Project 1, there is only a vague idea of what the final product is going to be like. Nonetheless, an idea was developed until there is a solid foundation for the project. Such as the materials used, the final design, the connection issue, the power sources as well as the software implementation.

The second Gantt Chart represents Project 2, where the plan was acted on and started the acquisition of the necessary components needed to build the project. Not only the hardware, but the software programming and connection as well.

3.2.1 Block Diagram of The Project

3.4 Shows the block diagram of the project. This block diagram explains the connection between each core components and how the product is supposed to function.

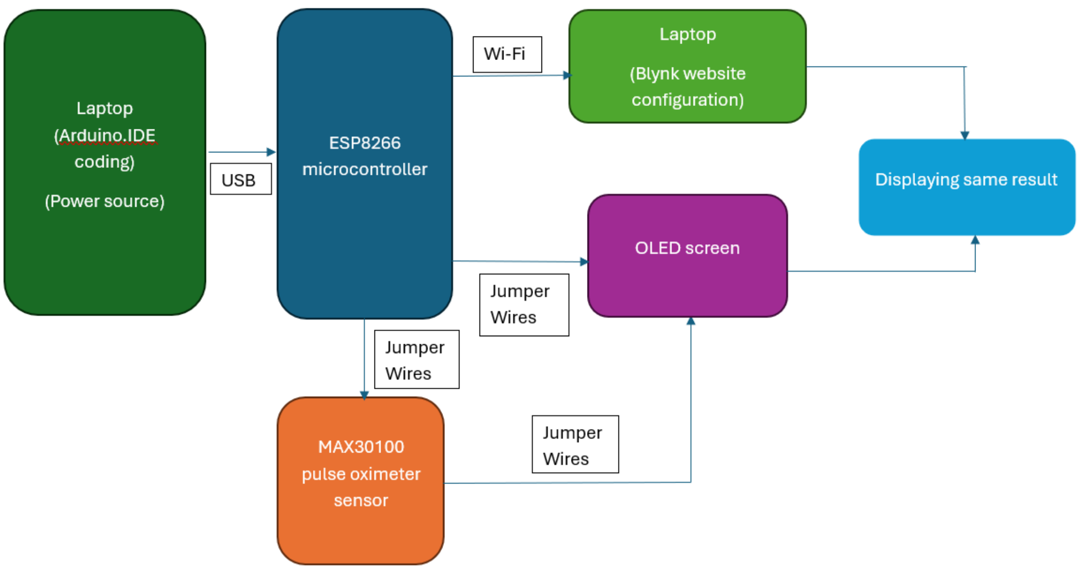

Figure 3.4 Block Diagram of the module

3.2.2 Project Flow Chart

Figure 3.5 is the flowchart of the module. When the product is connected to the power source, all the LED lights up to indicate the circuit is functioning. When a finger is placed on the MAX30100 sensor. If there is incorrect input, the data on the OLED screen remains zero. If the input is correct, the Sp02 and bpm of the patient is taken and will display on the OLED screen. Through the Wi-Fi connection to the Blynk website, the same data will also display on the configuration there on the laptop.

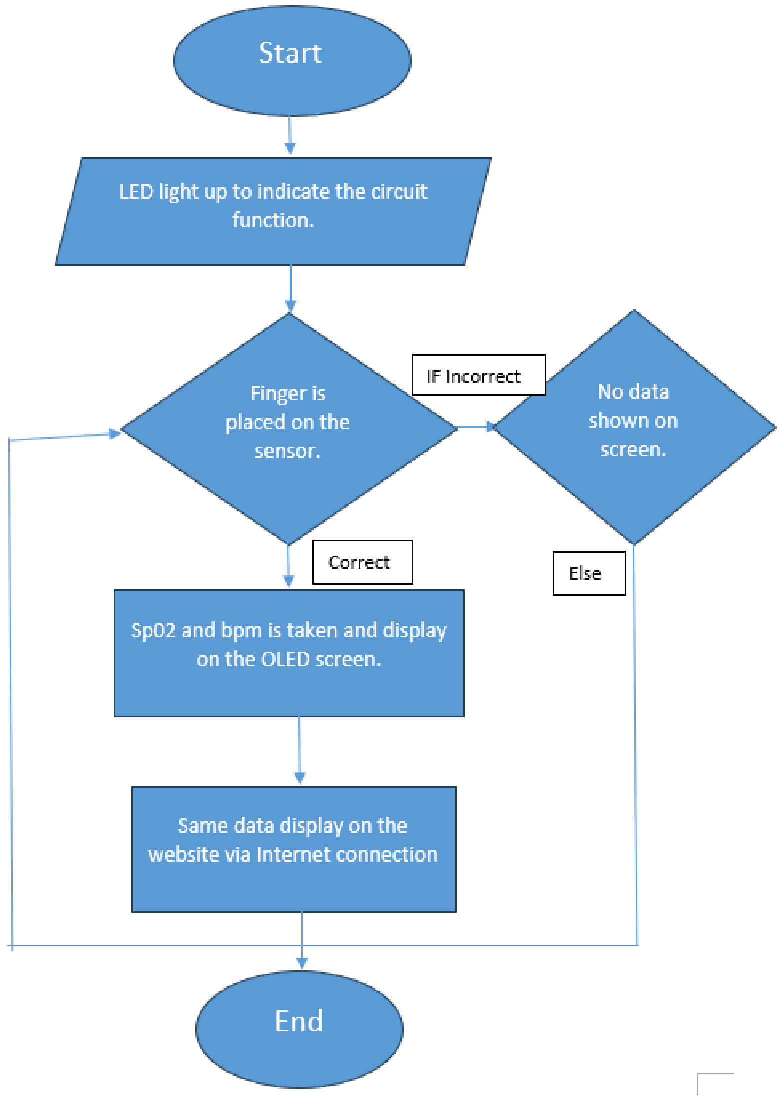

Figure 3.5 Flow chart of the module/system

3.3 Project Hardware

This section provides the information regarding the hardware of the project. The project itself contain 3 core components that being the ESP8266 microcontroller, MAX30100 pulse oximeter sensor and OLED screen. Figure below shows the circuit diagram of each component.

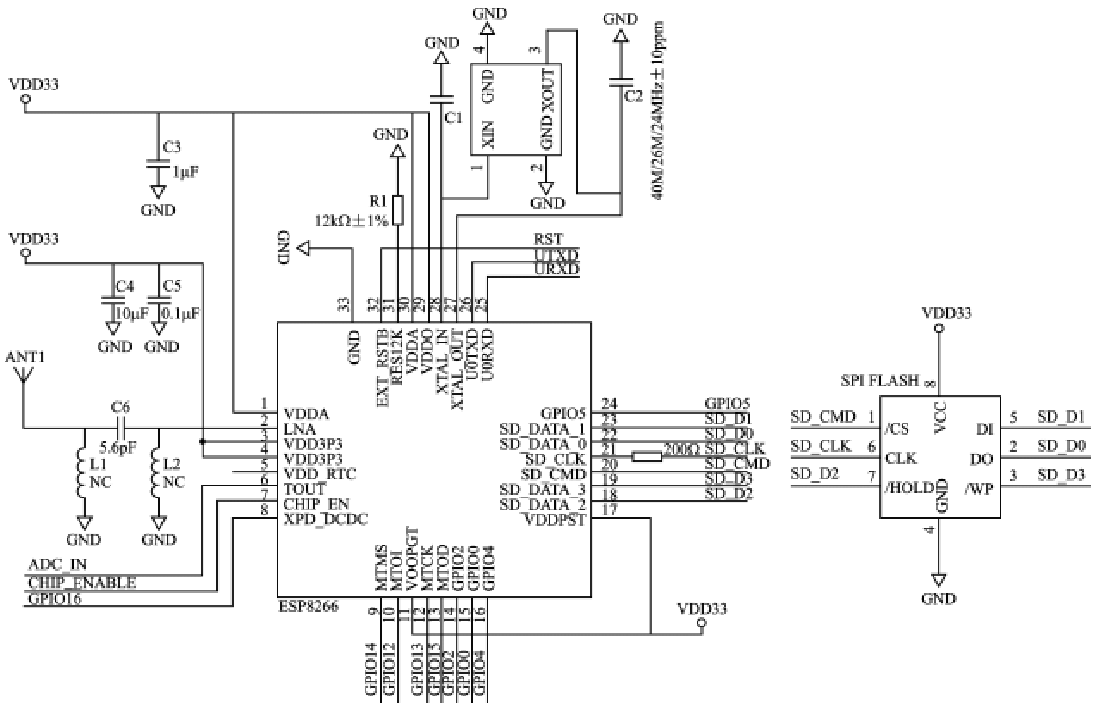

Figure 3.6 Circuit diagram of the ESP8266 microcontroller

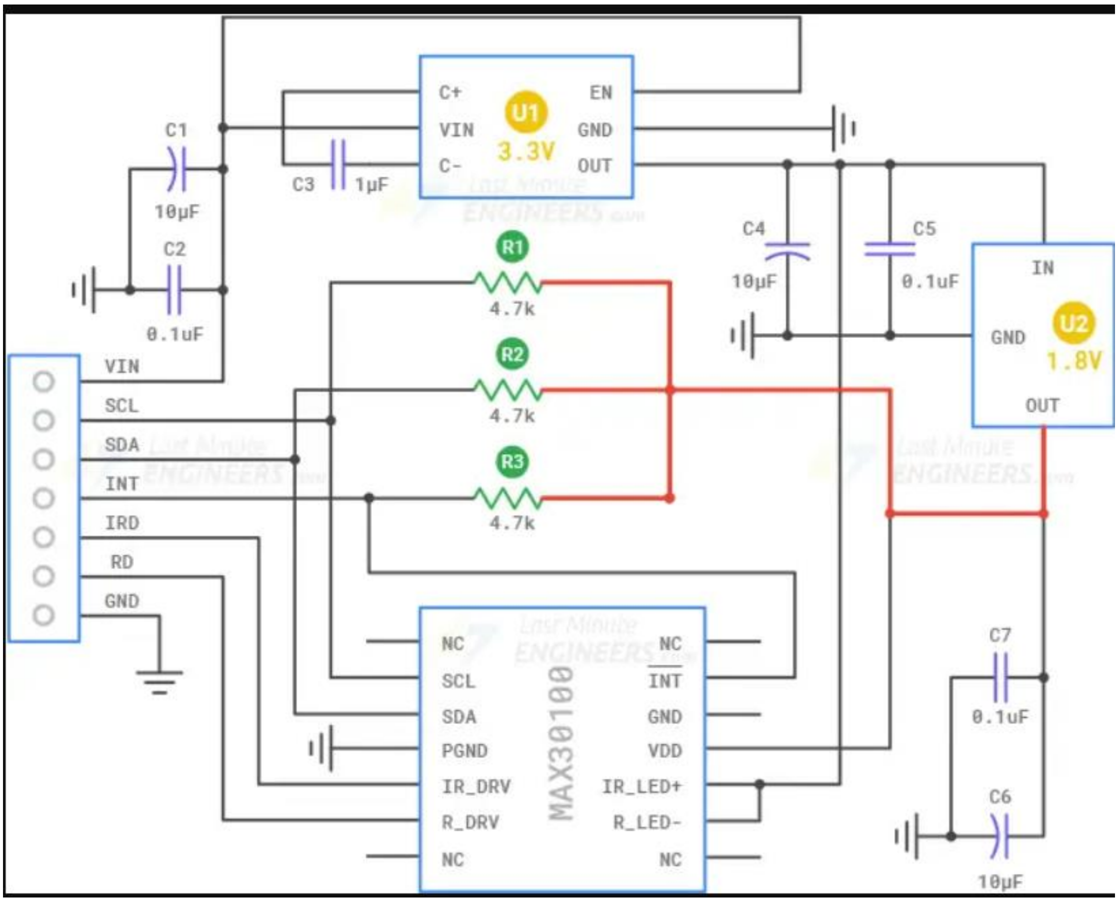

Figure 3.7 Circuit diagram of the MAX30100 Sensor

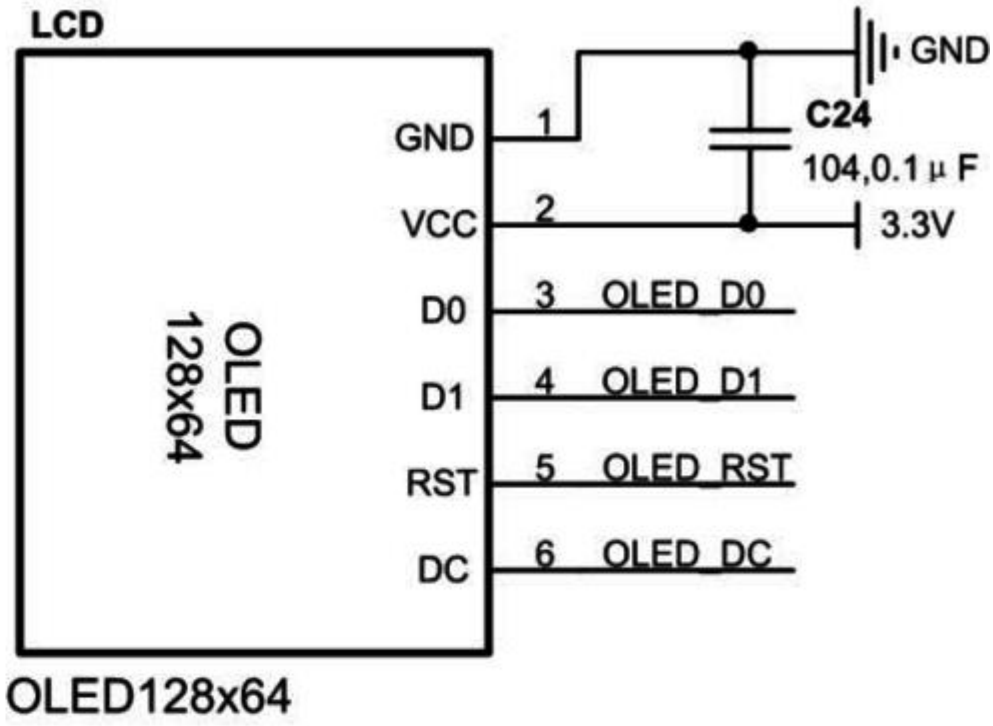

Figure 3.8 Circuit diagram of the OLED display

3.3.1 Schematic Circuit

The schematic circuit is shown in Figure 3.8.

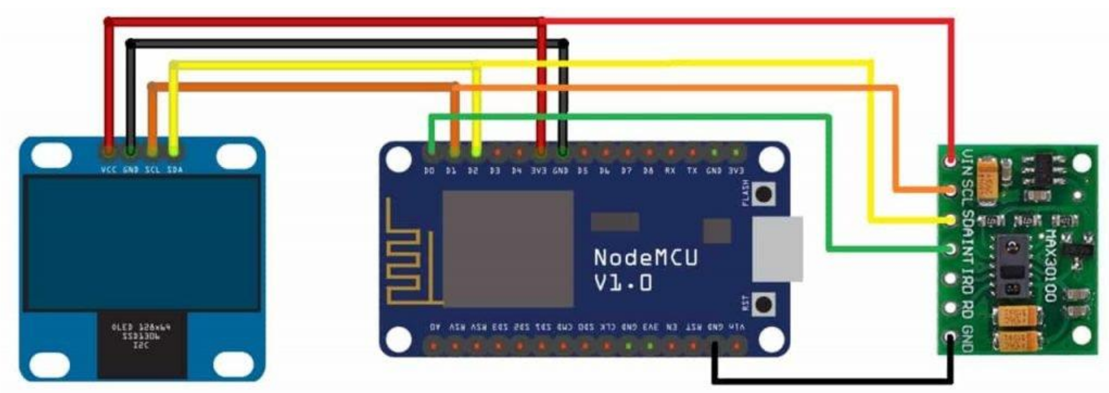

Figure 3.9 Schematic circuit of Cloud connected pulse oximeter

3.3.2 Description of Components

NodeMCU v1.0 (The ESP8266 microcontroller) development board comes with the ESP-12E module containing the ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency.

MAX30100 sensor is an integrated pulse oximetry and heart- rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals.

OLED display use LED technology and use an organic material as a light emitting layer. Organic LEDs can produce high quality displays with high contrasts, high viewing angles and true blacks.

3.3.3 Circuit Operation

Both OLED display and MAX30100 Oximeter Sensor works with the I2C bus. So, Interface the I2C pins (SCL &SDA) of both modules with D1 and D2 pins of NodeMCU. Connect the INT pin of the MAX30100 oximeter sensor to the NodeMCU D0 pin. Similarly, provide 3.3V power to the VCC and Ground the GND pin of both sensors.

3.4 Project Software

This section provides the information regarding the software of the project. First the flowchart of the software.

The project is designed using and Blynk application. It will be stored in the Blynk app and installed into the laptop. Next, when the oximeter is turned on, it automatically connects to the oximeter configuration in the Blynk app via the NodeMCU microcontroller. When the patient's data is taken, the Sp02 and BPM will then display on both the OLED screen and the configuration on the Blynk app.

3.5 Prototype Development

The prototype of this project consists of a fully functional wireless pulse oximeter that can be purchase. This is due to the different idea that was in Project 1. However, that idea was abandoned for the fact that there is minimal innovation in the development of the project, as well as the inability to create a website for the project. Therefore, a more hand-on method was used for the project, that being purchasing each individual components and assemble them.

3.6 Summary

In summary, this chapter discuss the intricacies that goes into making this project. It discusses the main components used and how it is used in the circuit, as well as the flowchart of how the circuit functions. It also discusses the type of programming is needed to use to develop the software for the ESP8266 microcontroller, every step that need to be taken to make it work. It allows evaluation that need to be taken and the step that is needed to finish constructing the project.

CHAPTER 4
RESULT AND DISCUSSION

4.1 Introduction

The result of the pulse oximeter would be displayed on the OLED screen as well as the Blynk application configuration. However, due to multiple error and failure, the project is incomplete. Only a portion of the components can function, causing this overall to lack its core function. This chapter will discuss the problem encountered during the making of the project.

4.2 Results and Analysis

The main component that failed to function is the MAX30100 Pulse Oximetry Sensor. The LED on the sensor cannot light up, even though any other components can. A multimeter is used to test the connection between the sensor, microcontroller and display to make sure all components are connected. The result is positive; however, the sensor cannot function for unknown reason. Even a way to fix this common problem was used, but that only ended with a broken sensor due to the inexperience of altering the wiring in the PCB circuit.

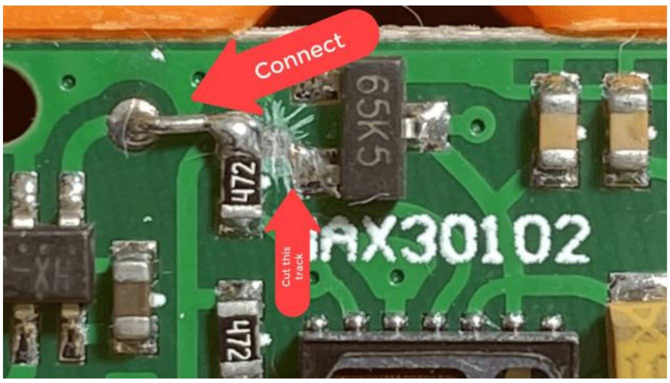

Figure 4.1 Visual image of the fixed oximetry sensor

Another problem is the inability of the microcontroller to connect to the Blynk application. The configuration in Blynk is constantly offline, not even using a mobile hotspot on a smartphone can solve this issue. On the Blynk website, every setting is already set for it to connect to the mobile hotspot. However, the device remains offline and unable to connect for unknown reasons.

This however is not a total failure, as the device did manage to go online one time, this allows the Blynk website to connect to my project. Although, there is no data to be shown due to the sensor not functioning properly. The Blynk application never manage to go online ever since that one time. That one time unfortunately is not photographically recorded and has no visual prove of that incident.

4.3 Discussion

This project, however, is not a complete failure. Even if the connection was only made once, this proves that with the use of IoT technology, medical data like Sp02 meter and BPM can be recorded and save in an online website. Although a commercially sold pulse oximeter has the same function of IoT connection, this project reinforced the study of using IoT to its fullest capabilities to record and preserve medical data. If the oximetry sensor can function, this project would not have been a half-complete product.

4.4 Summary

Though it is regrettable that this project must end like this due to the problems that was encountered and the inability to solve the issues. This is completely because of the lack of knowledge and inexperience of troubleshooting this kind of issue. The coding, wiring, components status all has no problems whatsoever, in the end the problem fail to be identified where it lies and was unable to complete the project because of it.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This project may not have been completed due to numbers of reasons, but it still proved its point by connecting to the Blynk application at least once. This is enough to make a connection between IoT and medical data.

5.2 Conclusion

a) Objective 1

To study the way to record blood oxygen meter using online application.

Although the sensor cannot function and thus cannot record the blood oxygen meter of the patient, but using simulation data in Arduino.IDE, the data can be shown in the Blynk application. Adding a few lines in the coding to simulate Sp02 data during the time the configuration is online can display the exact same data in the Blynk application. This proves that objective 1 is a success, because the data is displayed and recorded in the Blynk application, although the data has been deleted after the configuration went offline again afterward. Since a connection is made and the simulation data can be seen on Blynk application, this completes the objective.

b) Objective 2

To design and develop a pulse oximeter device with cloud integration.

This objective a success. The pulse oximeter device is successfully built with online integration, even though the device only went online once, and this is not supposed to be a one-time use device. There are unknown design flaws that caused the sensor to not function, so the product itself is flawed and not complete. When it comes to cloud integration, the simulation data did successfully record and stored in the Blynk application and by extension cloud, the project did successfully integrate with cloud.

c) Objective 3

To test how well cloud connected pulse oximeter works in everyday use

This objective is unfortunately a failure, due to the malfunction of the sensor, it is unable to record actual data from a patient. Even if a simulation data is used to test the connection to Blynk application, it is still a failure if it cannot record the Sp02 and BPM of an actual human. Since it cannot function to record data from a patient, it is unusable in everyday life, making this objective a failure. Not to mention the need of a constant power source, the lack of a battery system, and the overall clunky and awkward shape making it very hard to carry around.

5.3 Future Recommendations

If there is more time and perhaps an expert's opinion, the problem may be identified and solved. May be the attempt at fixing the sensor using soldering and cutting the PCB wire may not end in failure. But in the end, the problem with the sensor was not fixed so was the connection to Blynk application so that it doesn't just connect that one time. If both of those problems are solved, the device would be able to function normally. Afterward, adding a chassis making it more visually appealing and have a more comfortable shape to carry around. Adding a battery system too so that it does not need to rely on a constant power source.

REFERENCES

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APPENDICES

```
//IoT Based Pulse Heart Rate BPM and Oxygen SpO2 Monitor
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define BLYNK_PRINT Serial
#define BLYNK_TEMPLATE_ID "TMPL6d8Y5tcK7"
#define BLYNK_TEMPLATE_NAME "IoT Based Oximeter "
#define BLYNK_AUTH_TOKEN "u7r4_ToQ4q_aY6cP-SPHjeNZD9FYckNe"
#include <Blynk.h>
#include <BlynkSimpleEsp8266.h>
#include <ESP8266WiFi.h>
#include "Adafruit_GFX.h"
#include "OakOLED.h"
#define REPORTING_PERIOD_MS 1000
OakOLED oled;

char auth[] = "u7r4_ToQ4q_aY6cP-SPHjeNZD9FYckNe";             // Authentication Token Sent by Blynk
char ssid[] = "Redmi Note 10";        //WiFi SSID
char pass[] = "88brpyftjbxfaai";        //WiFi Password
//Connections : SCL PIN - D1 , SDA PIN - D2 , INT PIN - D0
PulseOximeter pox;
float BPM, SpO2;
uint32_t tsLastReport = 0;
const unsigned char bitmap [] PROGMEM =
{
  0x00, 0x00, 0x00, 0x00, 0x01, 0x80, 0x18, 0x00, 0x0f, 0xe0, 0x7f, 0x00, 0x3f, 0xf9, 0xff, 0xc0,
  0x7f, 0xf9, 0xff, 0xc0, 0x7f, 0xff, 0xff, 0xe0, 0x7f, 0xff, 0xff, 0xe0, 0xff, 0xff, 0xff, 0xf0,
  0xff, 0xf7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0, 0x7f, 0xdb, 0xff, 0xe0,
  0x7f, 0x9b, 0xff, 0xe0, 0x00, 0x3b, 0xc0, 0x00, 0x3f, 0xf9, 0x9f, 0xc0, 0x3f, 0xfd, 0xbf, 0xc0,
  0x1f, 0xfd, 0xbf, 0x80, 0x0f, 0xfd, 0x7f, 0x00, 0x07, 0xfe, 0x7e, 0x00, 0x03, 0xfe, 0xfc, 0x00,
  0x01, 0xff, 0xf8, 0x00, 0x00, 0xff, 0xf0, 0x00, 0x00, 0x7f, 0xe0, 0x00, 0x00, 0x3f, 0xc0, 0x00,
  0x00, 0x0f, 0x00, 0x00, 0x00, 0x06, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00
};
```

```
void onBeatDetected()
{
  Serial.println("Beat Detected!");
  oled.drawBitmap( 60, 20, bitmap, 28, 28, 1);
  oled.display();
}
void setup()
{
  Serial.begin(115200);
  oled.begin();
  oled.clearDisplay();
  oled.setTextSize(1);
  oled.setTextColor(1);
  oled.setCursor(0, 0);
  oled.println("Initializing pulse oximeter..");
  oled.display();
   Blynk.begin(auth, ssid, pass);
  if (!pox.begin())
  {
    Serial.println("FAILED");
    oled.clearDisplay();
    oled.setTextSize(1);
    oled.setTextColor(1);
    oled.setCursor(0, 0);
    oled.println("FAILED");
    oled.display();
    for (;;);
  }
  else
  {
    oled.clearDisplay();
    oled.setTextSize(1);
    oled.setTextColor(1);
    oled.setCursor(0, 0);
    oled.println("SUCCESS");
    oled.display();
    Serial.println("SUCCESS");
    pox.setOnBeatDetectedCallback(onBeatDetected);
  }

  // The default current for the IR LED is 50mA and it could be changed by uncommenting the following line.
  pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
}
void loop()
{
    pox.update();
    Blynk.run();
    BPM = pox.getHeartRate();
    SpO2 = pox.getSpO2();

    if (millis() - tsLastReport > REPORTING_PERIOD_MS)
    {
        Serial.print("Heart rate:");
        Serial.print(BPM);
        Serial.print(" SpO2:");
        Serial.print(SpO2);
        Serial.println(" %");
        Blynk.virtualWrite(V1, BPM);
        Blynk.virtualWrite(V2, SpO2);

```

```
            // Clear and update OLED display with formatted output
            oled.clearDisplay();
            oled.setTextSize(1);
            oled.setTextColor(1);
            oled.setCursor(0, 0);
            oled.println("Heart BPM:");
            oled.setTextSize(2);  // Larger size for BPM
            oled.setCursor(0, 10);
            oled.println(BPM);

            oled.setTextSize(1);
            oled.setCursor(0, 40);
            oled.println("SpO2:");
            oled.setTextSize(2);  // Larger size for SpO2
            oled.setCursor(0, 50);
            oled.println(SpO2);

            oled.display();
            tsLastReport = millis();
        }
}
```