



Palestine Polytechnic University  
College of IT and Computer Engineering  
Computer System Engineering Department

**Graduation Project Name:**

**Wearable Safety Device for Children**

**Team Members:**

**Batool suliman. & Baraa dababseh.**

**Supervisor:**

**Dr.Elayan Abu Gharbyeh.**

**2024**

## الإهداء

الحمد لله حباً ورضاً وامتناناً على البدء والختام

(وَآخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ)

بدايةً لم تكن الرحلة قصيرة ولا طريقاً محفوفاً بالتسهيلات ولكننا فعلناها فالحمد لله حمداً كثيراً.

نهدي مشروع تخرجنا إلى رمز الفداء إلى العظيمة فلسطين و إلى من زكوا بدمائهم أرض هذا الوطن الحبيب إلى الأبلغ منا جميعاً إلى شهداء فلسطين أنتم البوصلة والعنوان الأول والأخير لا شيء سيضاهي تضحياتكم الجليلة.

إلى من وهبوا الحياة ، والأمل ، والنشأة على شغف الإطلاع والمعرفة ومن علمونا أن نرتقي سلم الحياة بحكمة وصبر، برأ، وإحساناً، ووفاء لهما.  
(آبائنا الأعزاء)

إلى معلمين افتخرنا بهم وأحببنا تواضعهم وقدرنا جهودهم اكتسبنا معرفتنا بفضل الله ثم بفضلهم.

(أساتذتنا الكرام)

وأيضاً نهدي هذا البحث إلى كل من تُلَفِّظ مَبْتَسِماً متمنياً لنا التوفيق وداعياً لنا بالنجاح.

## **Abstract**

Child safety and improving kids wellbeing are the prime concern in this project. Child security is the foremost common issue emerging around the world. There are numerous issues to youngster security and this work primarily manages kid security from the dangers. This gadget empowers association between the youngster and parent through the WIFI module cooperation utilizing IoT. The data is stored into a cloud permanently to keep the track record of old data of the children for further reference.

In this project, the wearable device incorporates a variety of sensors, including a temperature monitor, vital signs monitor, and an acceleration-tracking sensor to detect any fall or any sudden change in acceleration values.. These sensors enable precise measurement of the child's body temperature, monitoring of vital signs such as blood oxygen levels and heart rate, and detection of sudden movements or potential falls. In emergency situations, an integrated alarm system, comprising a buzzer and an SOS light, enhances visibility and alerts parents promptly. In addition, MQTT technology is used to transmit data in real time and firebase technology to adjust acceleration values.

Also, determine the child's location through the mobile phone application and send the location coordinates to the parents automatically.

## Abbreviations

|          |                                      |
|----------|--------------------------------------|
| MAX30100 | Pulse Oximeter and Heart-Rate Sensor |
| DS18B20  | Dallas Semiconductor                 |
| SCL      | Serial Clock                         |
| SDA      | Serial Data                          |
| USB      | Universal Serial Bus                 |
| MQTT     | Message Queuing Telemetry Transport  |
| IoT      | Internet of Things                   |
| GPIO     | General Purpose Input/output         |
| VCC      | Voltage, Common Collector            |
| GND      | Ground                               |
| PC       | Personal Computer                    |
| MPU6050  | accelerometer and gyroscope          |
| IDE      | integrated development environment   |
| ISP      | Internet Service Provider            |
| Sos      | Save Our Souls                       |
| Esp32    | Espressif modules                    |
| TX       | Transmit                             |
| RX       | Receive                              |

Table 1:abbreviation

# Table of Contents

|   |    |
|---|----|
| Abstract .....  | 2  |
| Abbreviations .....   | 3  |
| Chapter 1: Introduction .....                               | 9  |
| 1.1 Preface .....   | 9  |
| 1.2 Project aims and objectives .....                       | 10 |
| 1.3 Problem Statement.....                                  | 10 |
| 1.3.1 Problem definitions .....                             | 10 |
| 1.3.2 Problem significance & motivation.....                | 11 |
| 1.4 List of Requirements .....                              | 12 |
| Functional Requirements:.....                               | 12 |
| Non Functional Requirements:.....                           | 12 |
| 1.5 Limitation/Constraints .....                            | 13 |
| 1.6 Project Gantt char .....                                | 14 |
| CHAPTER 2: THEORETICAL BACKGROUND .....                     | 15 |
| 2.1 Preface .....   | 15 |
| 2.2 Theories .....  | 15 |
| 2.3 Literature Review .....                                 | 16 |
| □ Child safety wearable device.....                         | 16 |
| □ Child Monitoring System .....                             | 16 |
| 2.4 Hardware System Components .....                        | 18 |
| □ ESP32 Microcontroller.....                                | 18 |
| □ DS18B20 sensor.....                                       | 19 |
| □ Blood oxygen and heart rate sensor (MAX30100) .....       | 20 |
| □ MPU6050 accelerometer and gyroscope.....                  | 21 |
| □ Piezo Buzzer.....   | 21 |
| □ Sos light.....  | 22 |
| □ Esp2866 microcontroller .....                             | 23 |
| Difference between Raspberry Pi VS Arduino VS ESP32 : ..... | 24 |
| Difference between DS18B20 & DHT11 : .....                  | 25 |
| Difference between ADXL345 & MPU6050 : .....                | 26 |

|   |    |
|---|----|
| Difference between MAX30100 & Pulse Rate : .....    | 27 |
| 2.5 System Software Component .....                 | 28 |
| □ App Inventor.....                                 | 28 |
| □ Fritizing.....                                    | 28 |
| 2.6 Software technologies.....                      | 30 |
| □ MQTT protocol .....                               | 30 |
| □ Firebase.....                                     | 30 |
| CHAPTER 3: SYSTEM DESIGN.....                       | 31 |
| 3.1 Preface .....                                   | 31 |
| 3.2 Block Diagram.....                              | 32 |
| 3.3 Flowcharts.....                                 | 33 |
| 3.4 System Wiring Diagrams.....                     | 35 |
| 3.5 System Schematic diagram.....                   | 40 |
| CHAPTER 4: Software & Hardware Implementation ..... | 41 |
| 4.1 Overview.....                                   | 41 |
| 4.2 Software Implementation .....                   | 42 |
| 4.3 Hardware Implementation .....                   | 45 |
| 4.4 Implementation challenges .....                 | 47 |
| Chapter 5: Validation & Testing.....                | 48 |
| 5.1 Overview.....                                   | 48 |
| 5.2 Validation.....                                 | 48 |
| 5.3 Software Testing(mobile app) .....              | 49 |
| 5.4 Hardware Testing.....                           | 52 |
| Chapter 6 :Conclusion & Future work.....            | 53 |
| 6.1 Overview.....                                   | 53 |
| 6.2 Final Result.....                               | 53 |
| 6.3 Future work.....                                | 54 |

|                      |    |
|----------------------|----|
| 6.4 Conclusion ..... | 54 |
| References.....      | 55 |

## List of Figures:

|   |    |
|---|----|
| Figure 1:Project Gantt char .....                       | 14 |
| Figure 2: ESP32 Microcontroller.....                    | 18 |
| Figure 3: DS18B20 sensor .....                          | 19 |
| Figure4 : Blood oxygen and heart rate sensor .....      | 20 |
| Figure 5:MPU6050 accelerometer .....                    | 21 |
| Figure 6: Piezo Buzzer .....                            | 22 |
| Figure 7: Sos light.....                                | 22 |
| Figure 8: Esp8266 .....                                 | 23 |
| Figure 9:block diagram .....                            | 32 |
| Figure 10:flowchart foe ESP32.....                      | 33 |
| Figure 11:flowchart for ESP8266 .....                   | 34 |
| Figure 12:wiring diagram between ESP32&DS18B20 .....    | 35 |
| Figure 13:wiring diagram between ESP32&MAX30100 .....   | 36 |
| Figure 14:wiring diagram between ESP8266 &MPU6050 ..... | 37 |
| Figure 15:wiring diagram between ESP32&Buzzer.....      | 38 |
| Figure 16:wiring diagram between ESP32&sos light .....  | 38 |
| Figure 17: Wiring diagram for all systems .....         | 39 |
| Figure 18: schematic diagram.....                       | 40 |
| Figure 19:login page .....                              | 42 |
| Figure 20:main page .....                               | 43 |
| Figure 21:main page for location.....                   | 44 |
| Figure 22: hardware (esp32 connect DS18B20 ).....       | 45 |
| Figure 23: hardware (esp8266 connect MPU6050 ).....     | 46 |
| Figure 24: hardware (esp32 connect MAX30100 ) .....     | 46 |
| Figure 25: mobile application testing .....             | 49 |
| Figure 26: threshold values testing .....               | 50 |
| Figure 27: location test.....                           | 51 |
| Figure 28: hardware testing .....                       | 52 |

## List of Tables:

|   |    |
|---|----|
| Table 1:abbreviation .....                      | 3  |
| Table 2:RPi VS Arduino VS ESP32.....            | 24 |
| Table 3:Difference between DS18B20 & DHT11..... | 25 |
| Table 4: ADXL345 VS MPU6050 .....               | 26 |
| Table 5: MAX30100 VS Plus rate .....            | 27 |
| Table 6:ESP32 connect with DS18B20 .....        | 35 |
| Table 7:ESP32 connect with max30100.....        | 36 |
| Table 8:ESP8266 connect with MPU6050 .....      | 37 |
| Table 9:ESP32 connect with BUZZER .....         | 38 |
| Table10:ESP32 connect with SOS light .....      | 38 |

# Chapter 1:Introduction

## 1.1 Preface

Supervising children in public places or nurseries be paramount importance, it plays a pivotal role in ensuring to safety well being, and development. Children are naturally curious and energetic and public spaces can present a myriad of potential risks and hazards. A bustling park a crowded shopping mall or dedicated nursery facility effective supervision crucial to prevent accidents and injuries that compromise a child's security.

This project deals with a smart wearable device which is a wrist and foot bracelet that tracks the child from time to time to ensure his safety. In case of any problem, it alerts the parents through the mobile phone so that they can take immediate action. The wristband will detect the body temperature as well as the child's heartbeat and blood oxygen level. In case of emergency, the device will have some measures like an alarm bell and SOS light that will notify passersby to help the child. So this project is all about the safety and security of the child to help him recover from any kind of difficulty. The main goal is to provide parents with comprehensive information in real time. The device includes a sensor to accurately monitor the child's body temperature, providing parents with an instant view of their child's health status. Additionally, a sensor is used to measure vital signs like blood oxygen levels and heart rate, and the accelerometer sensor is adjusted based on the first threshold values. If it is above a certain value, the child is diagnosed as having fallen. If it is below, the child is running. As for the second threshold values, if it is above a certain value, the child is rolling, and if it is below, he is playing. The device is equipped with a bell and light to increase visibility in emergency situations. The device is installed on the foot to give better and more accurate results, especially for the acceleration sensor.

This project uses MQTT technology, to transmit child data in real time, promoting instant and continuous communication between parents and their children's safety measures and firebase technology to adjust acceleration values. Also, determine the child's location through the mobile phone application and send the location coordinates to the parents automatically.

## **1.2 Project aims and objectives**

- ◆ provide parents with precise real-time information.
- ◆ measurement of the child's body temperature.
- ◆ use sensor for measuring vital signs, include blood oxygen levels and heart rate.
- ◆ acceleration tracking sensor into the device ,to detection sudden movements or potential falls .
- ◆ Integrate an alarm system, comprising a buzzer and an SOS light, to alert parents .
- ◆ MQTT technology for real-time data transmission, ensuring a continuous and immediate connection between parents and children .
- ◆ Develop mobile application for parents.
- ◆ Use firebase technology to adjust acceleration values.
- ◆ determine the child's location through the mobile phone.

## **1.3 Problem Statement**

### **1.3.1 Problem definitions**

To truly understand the challenges and solutions of the safety of children in our community, we should be willing to embrace its complexity. Child safety itself goes further than some might conceive, encompassing the prevention of all types of injury: physical, emotional and psychological as well as interventions to promote resilience to harm. Current methods of ensuring child safety often rely on manual supervision, which can be prone to lapses and delays.

Moreover, the existing wearable devices in market may lack integration of essential sensors and technologies required a holistic approach to child safety. Inconsistencies in location accuracy limited health monitoring capabilities and lack of immediate alerts during emergencies contribute to the existing gaps in ensuring security of children in various environments.

### **1.3.2 Problem significance & motivation**

The significance addressing these problems lies in paramount importance of safeguarding children particularly in dynamic and potentially hazardous settings. The increasing pace of life coupled with growing complexity of public spaces, necessitates a robust and technologically advanced solution for child safety. Parents and caregivers are increasingly seeking tools that offer not only real time location tracking but also comprehensive health monitoring and immediate alerts in emergency situations.

The motivation for the project stems from earnest desire to bridge the gaps in child safety solutions. The lack of holistic integrated and user friendly wearable device coupled with absence of accompanying application that provides real time insights underscores the pressing need for this innovative approach. By addressing these issues the project aims to empower parents with reliable technologically advanced tool that not only ensures the physical safety of children but also contributes to their overall well being .The motivation lies in creating a solution that brings peace of mind to parents and caregivers allowing them to confidently navigate the challenges of ensuring the safety of children in diverse environments.

## **1.4 List of Requirements**

### **Functional Requirements:**

- ◆ The wearable device must integrate sensor to monitor the child body temperature in real-time.
- ◆ The system should measure vital signs including blood oxygen levels and heart rate.
- ◆ Track the child acceleration .
- ◆ Implement an alarm system including a buzzer and SOS light to alert parents in emergency situations.
- ◆ Utilize MQTT technology for real time data transmission between the wearable device and parents mobile application and use firebase technology to adjust acceleration values.
- ◆ Development a user friendly mobile application for parents to access real time data .
- ◆ Determine the child's location through the mobile phone

### **Non Functional Requirements:**

- ◆ Performance :The system should provide real time data to ensure timely updates for parents.
- ◆ Scalability : Design the system to scalable accommodating additional features or sensors in future.
- ◆ Reliability : Ensure the systems reliability by minimizing downtime .
- ◆ Data Accuracy :The sensors must provide accurate and reliable data.

## **1.5 Limitation/Constraints**

Limitations/Determinations The success of the system depends on the child's continued desire to wear the device, which leads to the possibility of situations where the child may take off the device or refuse to wear it. Environmental factors such as crowded areas or high temperatures can affect the performance of the systems by interfering with Wi-Fi signals and affecting sensor readings. Another challenge we faced was the difficulty in determining the location accuracy due to the occupation's interference with communication towers, especially with the current situation due to the war. Despite efforts to reduce latency, occasional delays in data transmission may occur, which compromises the true nature of some information. Furthermore, emergency response options are limited and users should not be aware of alternative measures in critical situations. These limitations emphasize the need for a balanced consideration of technological capabilities and practical challenges in the design and implementation of a wearable safety device for children.

# 1.6 Project Gantt char

| Task                                       | Duration (week) |   |   |   |    |    |    |                 |   |   |   |    |    |    |
|--|-----------------|---|---|---|----|----|----|-----------------|---|---|---|----|----|----|
|  | First semester  |   |   |   |    |    |    | Second semester |   |   |   |    |    |    |
|  | ۲               | ۴ | ۶ | ۸ | ۱۰ | ۱۲ | ۱۴ | ۲               | ۴ | ۶ | ۸ | ۱۰ | ۱۲ | ۱۴ |
| <b>Planning</b>                            | █               | █ |   |   |    |    |    |                 |   |   |   |    |    |    |
| <b>Project requirements</b>                |                 |   | █ | █ |    |    |    |                 |   |   |   |    |    |    |
| <b>Analyzing and design</b>                |                 |   |   | █ | █  | █  | █  |                 |   |   |   |    |    |    |
| <b>Project development</b>                 |                 |   |   |   |    |    |    | █               | █ | █ | █ | █  |    |    |
| <b>Project and testing and maintenance</b> |                 |   |   |   |    |    |    |                 |   | █ | █ | █  | █  | █  |
| <b>Documentation</b>                       | █               | █ | █ | █ | █  | █  | █  | █               | █ | █ | █ | █  | █  | █  |

Figure 1:Project Gantt char

# **CHAPTER 2: THEORETICAL BACKGROUND**

## **2.1 Preface**

This chapter provides a short review of some related systems and introduces a theoretical background of the project, including a description of the hardware and software components used in the system .

## **2.2 Theories**

The theoretical foundation of this project draws from diverse fields to build a comprehensive solution for child safety. The core of this is to integrate principles from wireless communications involving theories of signal transmission, modulation and coding. Sensor technology and health monitoring theories contribute to the implementation of body temperature, vital signs and acceleration sensors based on the principles of signal conversion and processing. Internet of Things (IoT) principles guide the integration of MQTT technology involving the concepts of device communication data transfer protocols, cloud-based communications, and the use of Firebase technology to adjust acceleration values, and locate the child through a mobile phone. The project design adheres to the theories of human-computer interaction (HCI) with a focus on user experience, interface design and usability. Emergency response and safety theories support the inclusion of an alarm system, ensuring rapid response and effective communication during critical situations.

## **2.3 Literature Review**

### **❏ Child safety wearable device**

The concept of a smart wearable device for little children. The major advantage of this wearable over other wearable is that it can be used in any cellphone and doesn't necessarily require an expensive smartphone and not a very tech savvy individual to operate. The purpose of this device is to help parents locate their children with ease. At the moment there are many wearable's in the market which help track the daily activity of children and also help find the child using Wi-Fi and Bluetooth services present on the device. But Wi-Fi and Bluetooth appear to be an unreliable medium of communication between the parent and child. Therefore, the focus of this paper is to have an SMS text enabled communication medium between the child's wearable and the parent as the environment for GSM mobile communication is almost present everywhere. The parent can send a text with specific keywords such as "LOCATION", the wearable device will reply back with a text containing the real time accurate location of the child which upon tapping will provide directions to the child's location on Google maps app and will also provide the surrounding temperature, UV radiation index so that the parents can keep track if the temperature or UV radiation is not suitable for the child.[1]

### **❏ Child Monitoring System**

This project aims to build a system that monitors children from the age of 7-10 years. The main purpose is to help parents monitor and track children within the school by locating them and following the educational process within the school where teachers collect all the information for each child (classroom schedules, homework, exam schedules..... etc.), using devices such as smartphones where an application linked between school and mother has been created to send information about each child to his mother. It is designed with

GPS, sound sensors and a device to learn how to navigate (walk or car). The government's efforts to improve the health of women and children are a reality.[2]

### **The importance of the project compared to previous studies**

All previous studies focused on the importance of determining the child's location without considering the importance of knowing the child's vital signs such as temperature, heart rate, and oxygen level. Previous studies did not care about the importance of measuring the child's acceleration to know if the child was exposed to a sudden fall or a high change in acceleration values ,The acceleration sensor is adjusted based on the first threshold values. If it is higher than a certain value, the child is diagnosed as having fallen. If it is lower, the child is running. As for the second case of the threshold values, if it is higher than a certain value, the child is rolling, and if it is lower, he is playing. Hence, this child safety project was created to monitor children in public places and know the most important vital signs of the child and send them to the parents' mobile phone application.

## 2.4 Hardware System Components

This section describes all hardware used in our project, it presents a figure for each one with short description about its work principle and why it is used in the system.

### ► ESP32 Microcontroller

The ESP32 is a versatile microcontroller that belongs to the ESP (Espressif Systems Products) family specifically designed for IoT (Internet of Things) applications. The ESP32 is manufactured by Espressif Systems a semiconductor company based in Shanghai China. It features a dual core Xtensa LX6 microprocessor, which is a 32 bit RISC (Reduced Instruction Set Computing) architecture. And one of key features of ESP32 is its built in Wi-Fi and Bluetooth capabilities, making it suitable for a wide range of IoT applications [3].

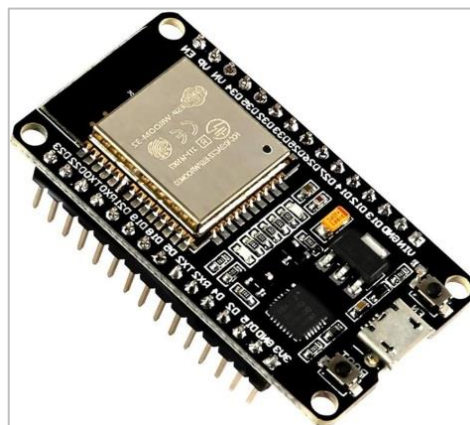


Figure 2: ESP32 Microcontroller

## ► DS18B20 sensor

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply.[4]

### **Specifications:**

1. Power supply: 3.0V to 5.5V.
2. Temperature measurement level:  $-55^{\circ}\text{C} + 125^{\circ}\text{C}$ .
3. Accuracy:  $-10^{\circ}\text{C} + 85^{\circ}\text{C}$ .
4. It communicates with the controllers through one wire.

### **Applications that can be implemented:**

1. Temperature sensor system.
2. In control systems.
3. In industrial projects.
4. Heat systems.



Figure 3: DS18B20 sensor

## ► Blood oxygen and heart rate sensor (MAX30100)

MAX30100 based pulse oximetry and heart rate monitoring sensor breakout board. The MAX30100 sensor combines two LEDs, a photodetector, enhanced optics, and low-noise analog signal processing to detect pulse oximetry and heart rate signals.

The system uses this device to measure blood oxygen level and heart rate. It integrates two LEDs (infrared and red), a photodetector (red), improved optics, and low-noise analog signal processing to detect pulse oximetry and heart rate signals.[5]

### Features:

1. Built-in LEDs, image sensor, and high-performance analog front.
2. Complete solution for pulse oximeter and heart rate sensor simplifies design:
  - a. Built-in LEDs, image sensor and high-performance analogue front.
  - B. An optically enhanced 5.6mm x 2.8mm x 1.2mm 14-pin mini system is included in the package.
3. Ultra-low power operation increases battery life for wearable's:
  - a. Programmable sample rate and LED current for power saving.
  - B. Ultra-low shutdown current (0.7  $\mu$ A, type).
4. Improved advanced functions.



Figure 4: Blood oxygen and heart rate sensor

### ► MPU6050 accelerometer and gyroscope

The MPU6050 is a popular integrated circuit that combines a three-axis accelerometer and a three-axis gyroscope in a single package. The MPU6050 is manufactured by InvenSense, now a part of TDK Corporation. It is a 6-DOF (Degrees of Freedom) motion-tracking device, combining a 3-axis accelerometer and a 3-axis gyroscope. The accelerometer measures linear acceleration along three axes: X, Y, and Z. Typical applications of the accelerometer include tilt sensing, motion detection, and vibration monitoring. Various libraries and example codes are available for interfacing the MPU6050 with popular microcontroller platforms, including Arduino and Raspberry Pi. [6]



Figure 5: MPU6050 accelerometer

### ► Piezo Buzzer

A piezo buzzer is a sound-producing device that relies on the piezoelectric effect to generate audible signals. It consists of a piezoelectric crystal or ceramic element positioned between two metal plates within a housing acting as a resonator. When an alternating voltage is applied to the piezoelectric element, it undergoes rapid expansion and contraction, resulting in mechanical vibrations that produce sound waves. Piezo buzzers operate at relatively low voltages, typically between 3 to 30 volts, making them energy-efficient. They are available in various frequencies, influencing the pitch of the produced sound. [7]



Figure 6: Piezo Buzzer

### ► Sos light

An SOS light is a signaling method that utilizes Morse code to convey the universally recognized distress signal "SOS." The Morse code representation for SOS is "...---...," with each dot representing a short signal ("dit") and each dash indicating a longer signal ("dah"). Typically implemented with flashlight beams, LED lights, or visual signaling devices, an SOS light flashes the Morse code pattern to communicate an urgent need for help or assistance. Recognized internationally, the SOS signal is widely used in emergency situations, such as distress signaling in outdoor environments, maritime distress calls, and other critical scenarios. The effectiveness of an SOS light relies on its visibility, making high-intensity and long-range light sources preferable for emergency signaling. Established as the international maritime distress signal in 1905, the SOS light serves as a straightforward and universally understood means of seeking assistance during emergencies.[9]



Figure 7: Sos light

## ► Esp8266 microcontroller

The ESP8266 module enables microcontrollers to connect to 2.4 GHz Wi-Fi, using IEEE 802.11 bgn. It can be used with ESP-AT firmware to provide Wi-Fi connectivity to external host MCUs, or it can be used as a self-sufficient MCU by running an RTOS-based SDK. The module has a full TCP/IP stack and provides the ability for data processing, reads and controls of GPIOs.

ESP8266 has many applications when it comes to the IoT. Here are just some of the functions the chip is used for:

- **Networking:** The module's Wi-Fi antenna enables embedded devices to connect to routers and transmit data
- **Data Processing:** Includes processing basic inputs from analog and digital sensors for far more complex calculations with an RTOS or Non-OS SDK
- **P2P Connectivity:** Create direct communication between ESPs and other devices using IoT P2P connectivity
- **Web Server:** Access pages written in HTML or development languages.

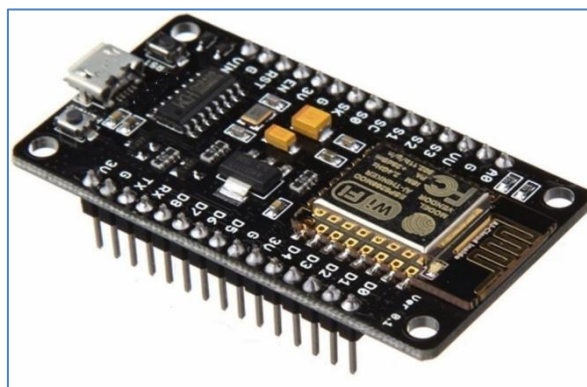


Figure 8: Esp8266

## Difference between Raspberry Pi VS Arduino VS ESP32 :

Comparing ESP32 and Arduino and Raspberry Pi involves considering their features and applications and use cases. Each of these platforms has strengths and weaknesses making them suitable for different type project. compare them based on various criteria to determine which one might be best choice for the project :




| Component        | Arduino   | Raspberry Pi   | ESP32   |
|------------------|---|--|---|
| Ease of Use      | beginners and for quick prototyping.  | requires some basic knowledge of Linux and programming                               | especially for IoT projects. relatively easy to use.                                  |
| Processing Power | limited processing power  | dual-core processor  | single-board computer   |
| Connectivity     | limited connectivity options.   | built-in Wi-Fi and Bluetooth capabilities  | Ethernet, USB, Wi-Fi ,Bluetooth connectivity  |
| Cost             | 10-20\$   | 40-55\$  | 20-25\$   |
| Speed            | 16MHz.  | 1.4GHz.  | 240MHz.   |
| I/O Connectivity | SPI I2C UART<br>GPIO  | SPI DSI UART<br>SDIOCSI GPIO   | UART, GPIO  |
| Best choose      | ☒   | ☒  | ✓   |
| Image            |  |  |  |

Table 2:RPI VS Arduino VS ESP32

If project requires simplicity basic hardware interaction and ease of use Arduino might be the best choice. If need wireless connectivity more processing power and IoT capabilities ESP32 is a strong contender. However if project involves advanced computing tasks running complex software and multimedia applications Raspberry Pi would be the most suitable option.

- ❖ Therefore, in our project we will use the ESP32 controller because it meets the project requirements that we need.

### Difference between DS18B20 & DHT11 :

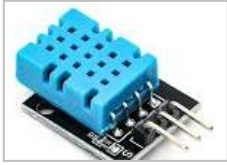

| Component               | DHT11   | DS18B20  |
|-------------------------|---|--|
| Temperature Measurement | 1.Measures temperature along with humidity.<br>2. temperature accuracy of $\pm 2^{\circ}\text{C}$ . | 1.Specialized for temperature measurement.<br>2. temperature accuracy, typically $\pm 0.5^{\circ}\text{C}$ . |
| Humidity Measurement    | humidity sensor in addition to temperature.   | Does not include a humidity Sensor   |
| Operating Voltage       | Operates at a voltage of 3.3V to 5V.  | Typically operates in the range of 3V to 5.5V.   |
| Cost                    | 5-1\$   | 5-10\$   |
| Speed                   | About 2 seconds   | milliseconds to 1 second 750   |
| Best choose             | <input checked="" type="checkbox"/>   | ✓  |
| Image                   |                  |                         |

Table 3:Difference between DS18B20 & DHT11

While both sensors are valuable in their own right the choice between DHT11 and DS18B20 depends on the specific requirements of project. If accurate temperature readings paramount and humidity data is not crucial the DS18B20 is a more suitable choice due to higher temperature accuracy and faster response time.

- ❖ Therefore, in our project we will used because it meets the project requirements that we need.

### Difference between ADXL345 VS MPU6050 :


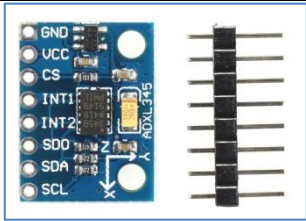
| Component           | MPU6050   | ADXL345   |
|---------------------|---|---|
| Type                | Accelerometer and Gyroscope   | Accelerometer only  |
| Acceleration Range  | $\pm 2g, \pm 4g, \pm 8g, \pm 16g$   | $\pm 2g, \pm 4g, \pm 8g, \pm 16g$   |
| Interface           | I2C (and sometimes SPI)   | I2C and SPI   |
| Resolution          | 16-bit  | 13-bit  |
| Power Consumption   | Medium power consumption  | Low power consumption   |
| Additional Features | Digital Motion Processor (DMP), Temperature Sensor                                  | Shock detection, Auto-sleep, Activity and Inactivity detection                        |
| Price               | \$3 - \$10  | \$2 - \$10  |
| Common Applications | Robotics, Drones, Motion Tracking, Interactive Games                                | Wearable Devices, Smartphones, Games, Medical Devices                                 |
| Best choose         | ✓   | ☒   |
| Image               |  |  |

Table 4: ADXL345 VS MPU6050

- ❖ MPU6050 is a multi-function sensor that contains accelerometer and gyroscope, and contains a digital motion processing unit, the MPU6050 is the best choice for your project wearable safety device for children.

### Difference between MAX30100 VS Pulse Rate :



| Component           | MAX30100  | Pulse Rate  |
|---------------------|---|---|
| Type                | Pulse Oximeter and Heart Rate Sensor  | Heart Rate Sensor   |
| Measurement         | SpO2, Heart Rate  | Heart Rate  |
| Optical Sensors     | Red and Infrared LEDs   | Green LED   |
| Interface           | I2C   | Analog output   |
| Power Consumption   | Low   | Low   |
| Additional Features | Built-in Temperature Sensor   | None  |
| Output              | Digital   | Analog  |
| Ease of Use         | Requires I2C communication setup  | Simple analog signal  |
| Applications        | Wearable Health Monitors, Fitness Trackers, Medical Devices                         | Wearable Health Monitors, Educational Projects  |
| Best choose         | ✓   | ☒   |
| Image               |  |  |

Table 5: MAX30100 VS Plus rate

- ❖ MAX30100 Ideal for applications that need to measure heart rate and blood oxygen, such as advanced health monitors and wearables. It offers more functionality and digital output but requires more complex integration due to the I2C interface. It is a better choice than a pulse rate sensor for this project.

## 2.5 System Software Component

This section will provide some information about the main programs used in our project.

### **Arduino IDE**

Arduino code is written in C++ with an addition of special methods and functions. C++ is a human-readable programming language. The Arduino Integrated Development Environment (IDE) is the main text editing program used for Arduino programming. It is where you'll be typing up your code before uploading it to the board you want to program. Arduino code is referred to as sketches, It is processed and compiled to machine language, and Arduino sketch code is used to program wemos microcontrollers.[9]

### **App Inventor**

App Inventor was founded in 2007 by educators and researchers at MIT and Google with the vision of enabling anyone—including those who may not think of themselves as coders—to create mobile apps for real, effective change in their communities. The App Inventor Foundation is a 501(c)(3) nonprofit organization established by the same team, and expands upon the educational initiatives of the MIT App Inventor project by offering additional resources for teachers and students across the globe .Our platform was intentionally designed to be free, open source, and easy-to-learn with an intuitive graphical interface, making it approachable for first-time programmers and veteran developers alike.[10]

### **Fritzing**

It is an open source initiative to support designers, artists, researchers and hobbyists to take the step from physical prototypes to actual product. We make this software in the spirit of processing and Arduino, developing a tool that allows users to document their Arduino and other electronic models, and create a PCB layout for manufacturing. The complementary website helps users share and

discuss drafts and experiences as well as reduce manufacturing costs. Fritizing is essentially electronic design automation software with a low barrier to entry, suitable for the needs of designers and artists. It uses the metaphor of a breadboard, so that it is easy to transfer your hardware drawing to the software. From there, it is possible to create PCB layouts to turn them into a robust PCB on your own or with the help of a manufacturer.[12]

### **Characteristics and features of the Fritizing program**

1. User-friendly interface for quick and easy workflow.
2. Window panel: Provides parts, tools and information.
3. The Part Creator: A tool to modify parts or create new parts for Fritizing.
4. Easily build your virtual circuit the way your real circuit looks, avoiding errors that may occur while transitioning from physical breadboard to circuit diagram.
5. Allows you to design and export the documents needed to produce a printed circuit board. The PCB display features AutoRoute function, which saves great time.
6. Shows the circuit you created in breadboard view as a circuit diagram, useful for those who are used to or want to be familiar with standard circuit symbols.

## 2.6 Software technologies

This section will provide some information about the main software technologies used in our project

### **MQTT protocol**

The MQTT Dashboard utilizes the HiveMQ MQTT broker. You can use any MQTT client or library to publish to the broker. Testing and usage is for free but please do not use it for sensitive information because everybody is allowed to subscribe to every topic, including wildcard. Feel free to play with MQTT and the HiveMQ broker. Please consider to add a reconnect logic to your client because we may update the underlying HiveMQ instance at any time, so we cannot promise 100% uptime. With our free, fully managed MQTT Cloud Platform HiveMQ Cloud you can create reliable, scalable and secure MQTT cloud-broker clusters that are built for production. [11]

MQTT broker [/https://broker.hivemq.com](https://broker.hivemq.com)

### **Firebase**

Firebase evolved from Envolv, a prior startup founded by James Tamplin and Andrew Lee in 2011. Envolv provided developers an API that enables the integration of online chat functionality into their websites. After releasing the chat service, Tamplin and Lee found that it was being used to pass application data that were not chat messages. Developers were using Envolv to sync application data such as game state in real time across their users. Tamplin and Lee decided to separate the chat system and the real-time architecture that powered it. They founded Firebase as a separate company in 2011 and it launched to the public in April 2012. Firebase's first product was the Firebase Realtime Database, an API that synchronizes application data across iOS, Android, and Web devices.[13]

# CHAPTER 3: SYSTEM DESIGN

## 3.1 Preface

In this chapter we delve into the intricacies of the design process for the advanced child safety wearable device. The primary focus is on the system design encompassing the various components, their interconnections, and overall architecture that ensures the safety and well-being of children. This chapter provides a comprehensive overview of the design considerations, methodologies, and technologies employed to achieve the goals set.

In further exploration of system design, it is essential to highlight the underlying principles guiding the development of this child safety wearable device. The preface serves as a compass steering the project towards harmonious convergence of technological innovation and the paramount concern for children safety. Emphasizing the significance of this initiative, the preface underscores commitment to providing parents with an invaluable tool that not only monitors vital aspects of a child's health but also addresses unforeseen challenges navigating public spaces. The preface sets the tone for a journey into a realm where cutting-edge technology meets the fundamental human need for safeguarding the well-being of the youngest members of our society.

This chapter unveils the meticulous planning and design considerations that have gone into creating a sophisticated child safety wearable device. The combination of advanced sensors, real-time communication technology, and emergency response features demonstrates a holistic approach to child safety. The subsequent chapters will delve into the implementation and testing and validation phases, ensuring the proposed system is not only well-designed but also robust in ensuring the safety and well-being of children in various environments.

### 3.2 Block Diagram

Figure 9, shows the schematic diagram serves as a visual representation of the architecture of a child safety wearable, showing the main functional blocks and interconnections. The core component includes sensors for temperature, blood oxygen levels, heart rate, and acceleration detection, as well as a buzzer and light for emergencies. The diagram shows data between the components, MQTT technology that facilitates real-time communication, and firebase technology to adjust acceleration values.

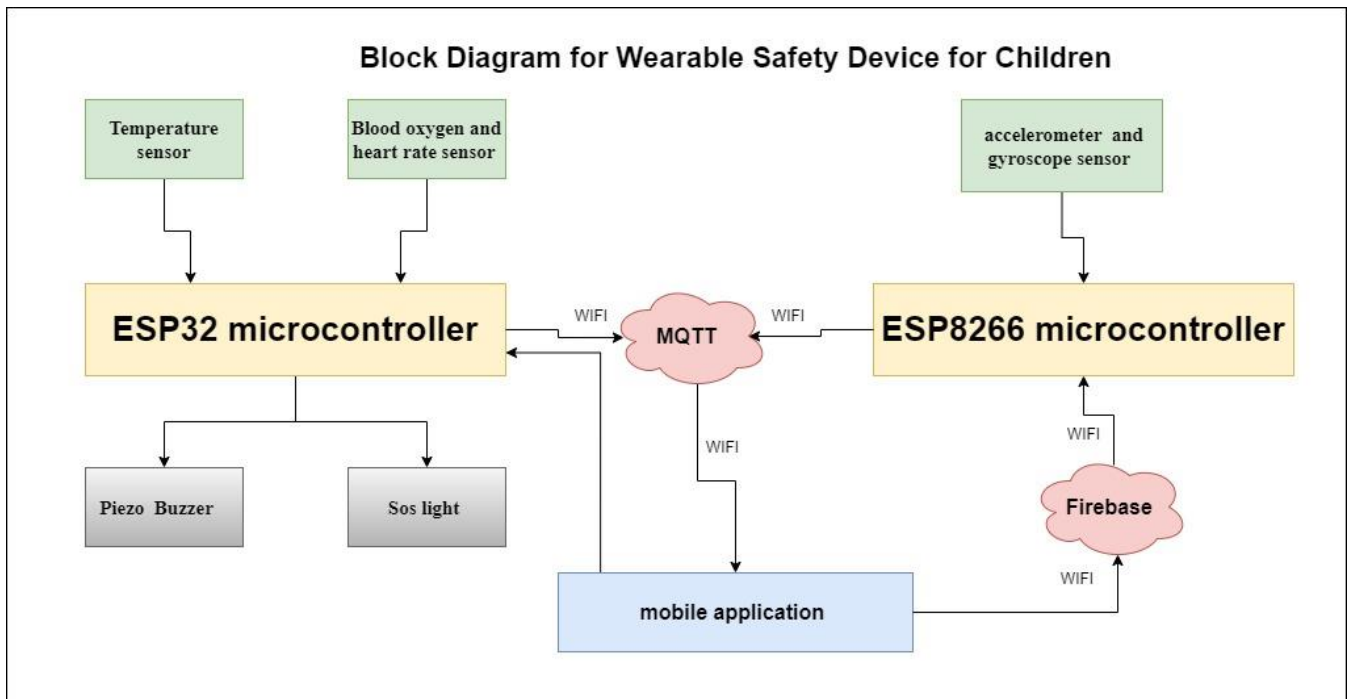


Figure 9:block diagram

### 3.3 Flowcharts

Figure 10, shows to ensure clarity in understanding the devices operation detailed flowcharts are presented. These flowcharts delineate the logical sequence of actions starting from sensor data acquisition to the transmission of information via MQTT. The flowcharts cover normal operation as well as emergency scenarios providing a comprehensive view of how system responds to various inputs and conditions.

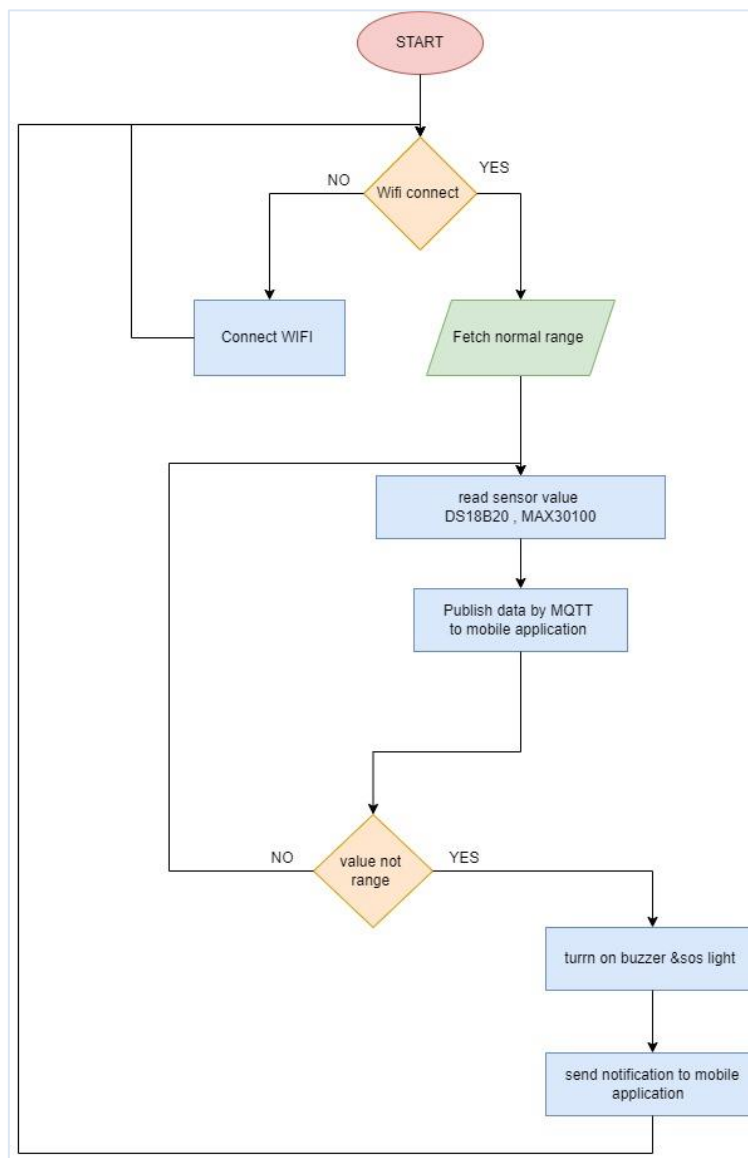


Figure 10:flowchart for ESP32

The following figure 11, shows a diagram of the mechanism of the acceleration sensor, obtaining threshold values from the firebase, reading the acceleration sensor, and sending them via the MQTT protocol in order to activate the alarm.

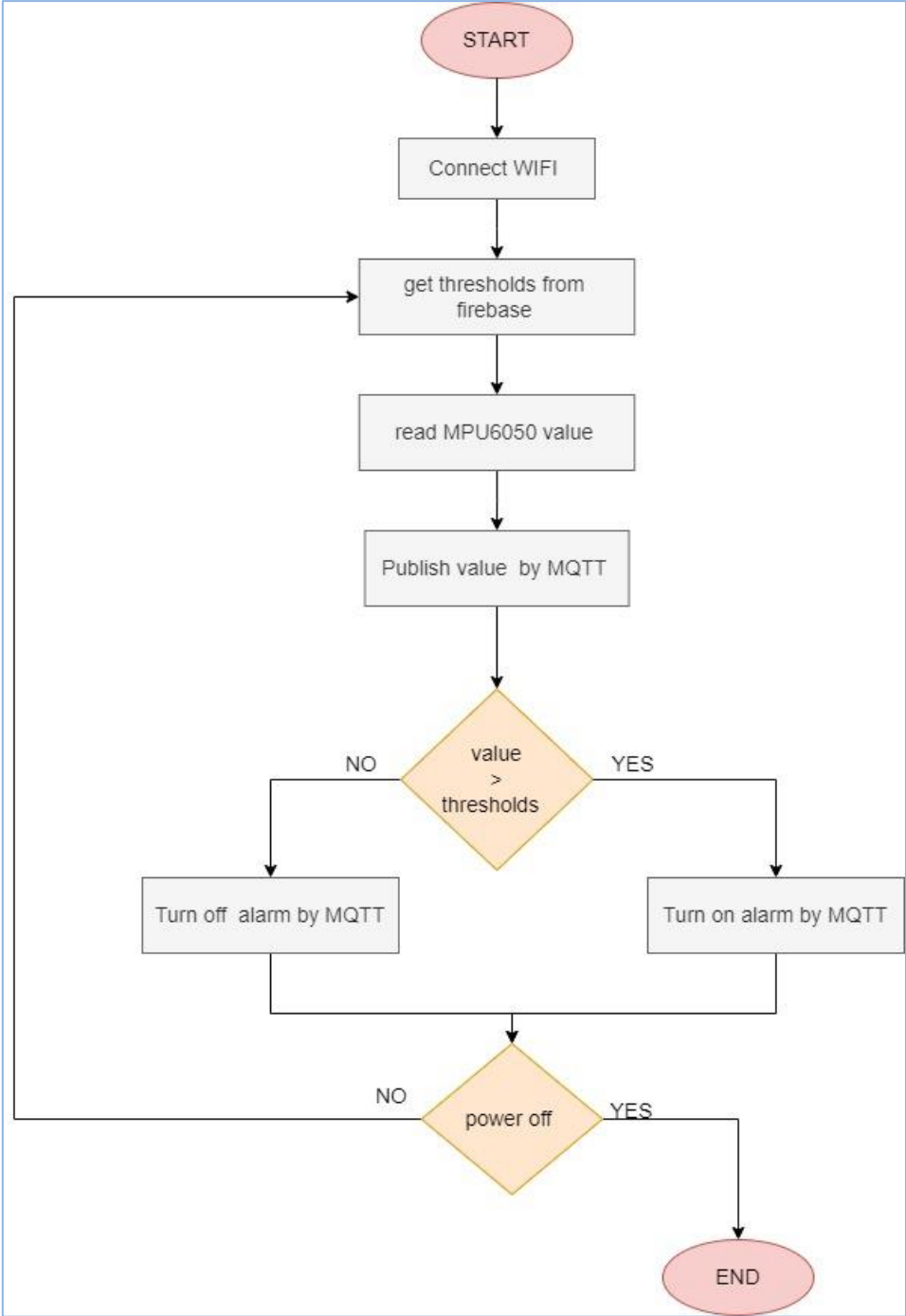


Figure 11:flowchart for ESP8266

### 3.4 System Wiring Diagrams

The system wiring diagrams offer a detailed view of the physical connections between components within the wearable device. This includes the intricate network of wires connecting sensors and microcontrollers and communication modules and emergency response elements. The wiring diagrams provide a practical guide for the assembly and maintenance of the device, ensuring a clear understanding of the hardware layout. In this section some components are shown with their connection to the ESP32. The pins of each equipment will be physically connected as shown in the following figures.

◆ ESP32 connect with DS18B20 sensor :

| ESP32 microcontroller | DS18B20 |
|-----------------------|---------|
| VCC                   | VCC     |
| GND                   | GND     |
| GPIO22                | DATA    |

Table 6:ESP32 connect with DS18B20

◆ Figure 12, shows connection wiring diagram between the ESP32 controller and DS18B20 sensor:

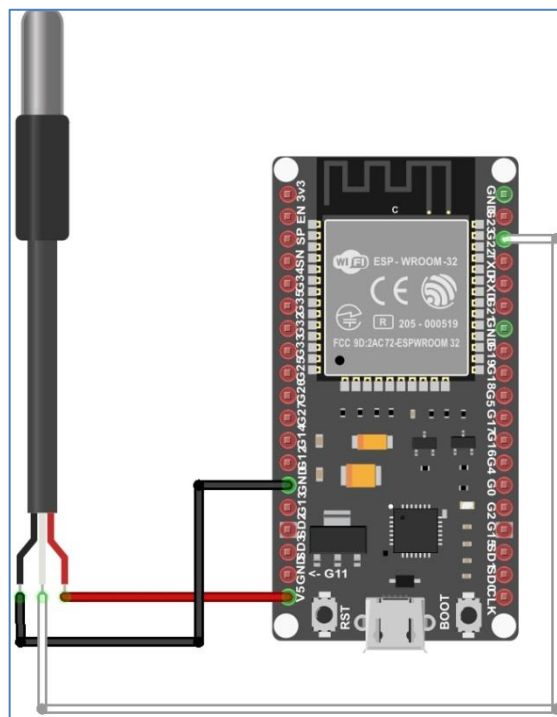


Figure 12:wiring diagram between ESP32&DS18B20

◆ ESP32 connect with MAX30100 :

| ESP32 microcontroller | MAX30100 |
|-----------------------|----------|
| VCC                   | VCC      |
| GND                   | GND      |
| GPIO23                | SCL      |
| GPIO21                | SDA      |

Table 7:ESP32 connect with max30100

◆ Figure 13, shows connection wiring diagram between the ESP32 controller and MAX30100 sensor:

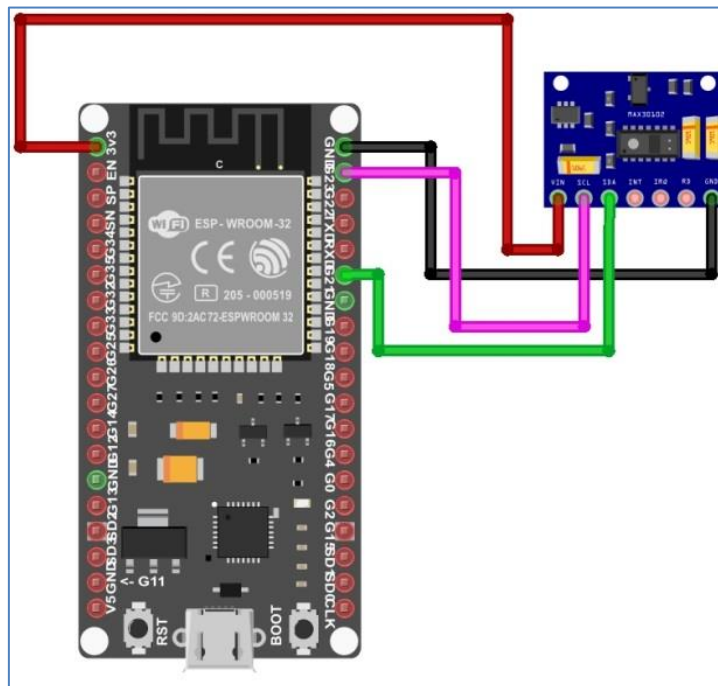


Figure 13:wiring diagram between ESP32&MAX30100

- ◆ ESP8266 connect with MPU6050 accelerometer and gyroscope:

| ESP8266 microcontroller | MPU6050 |
|-------------------------|---------|
| VCC                     | VCC     |
| GND                     | GND     |
| D1                      | SCL     |
| D2                      | SDA     |

Table 8:ESP8266 connect with MPU6050

- ◆ Figure 14, shows connection wiring diagram between the ESP8266 controller and MPU6050 sensor:

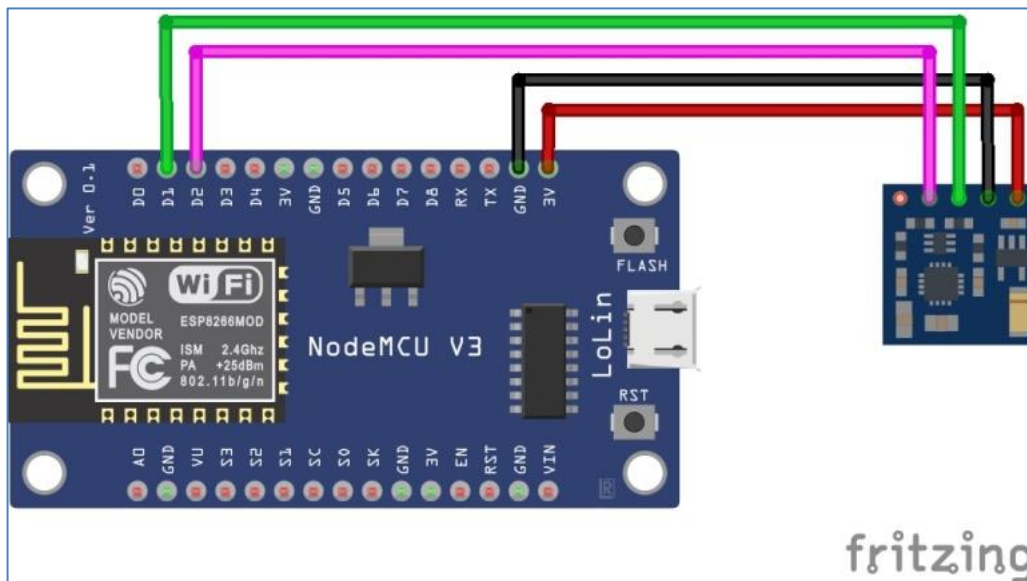


Figure 14:wiring diagram between ESP8266 &MPU6050

- ◆ ESP32 connect with Buzzer:

| ESP32 microcontroller | BUZZER |
|-----------------------|--------|
| GND                   | GND    |
| GPIO34                | DATA   |

Table 9:ESP32 connect with BUZZER

- ◆ Figure 15, shows connection wiring diagram between the ESP32 controller and Buzzer:

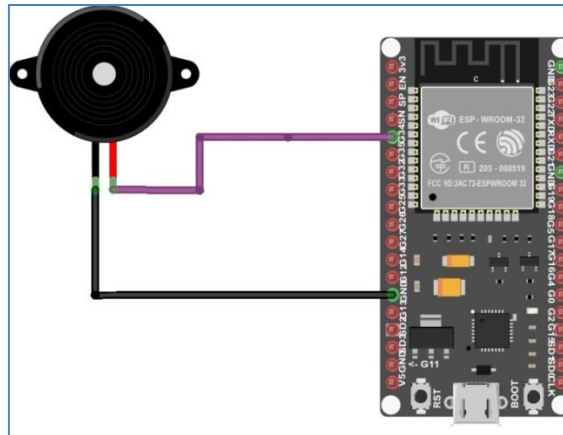


Figure 15:wiring diagram between ESP32&Buzzer

- ◆ ESP32 connect with Sos light :

| ESP32 microcontroller | Sos light |
|-----------------------|-----------|
| VCC                   | VCC       |
| GPIO 32               | DATA      |

Table 10:ESP32 connect with SOS light

- ◆ Figure 16, shows connection wiring diagram between the ESP32 controller and SOS light :

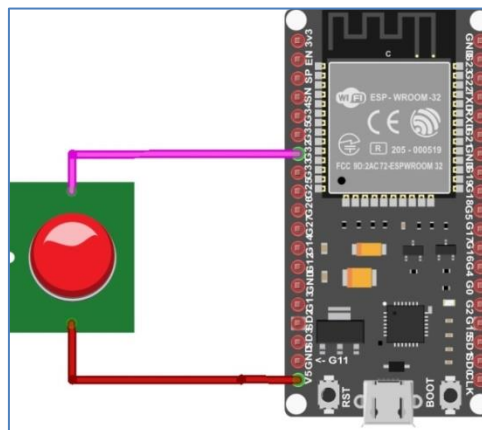


Figure 16:wiring diagram between ESP32&sos light

# Wiring diagram for all systems

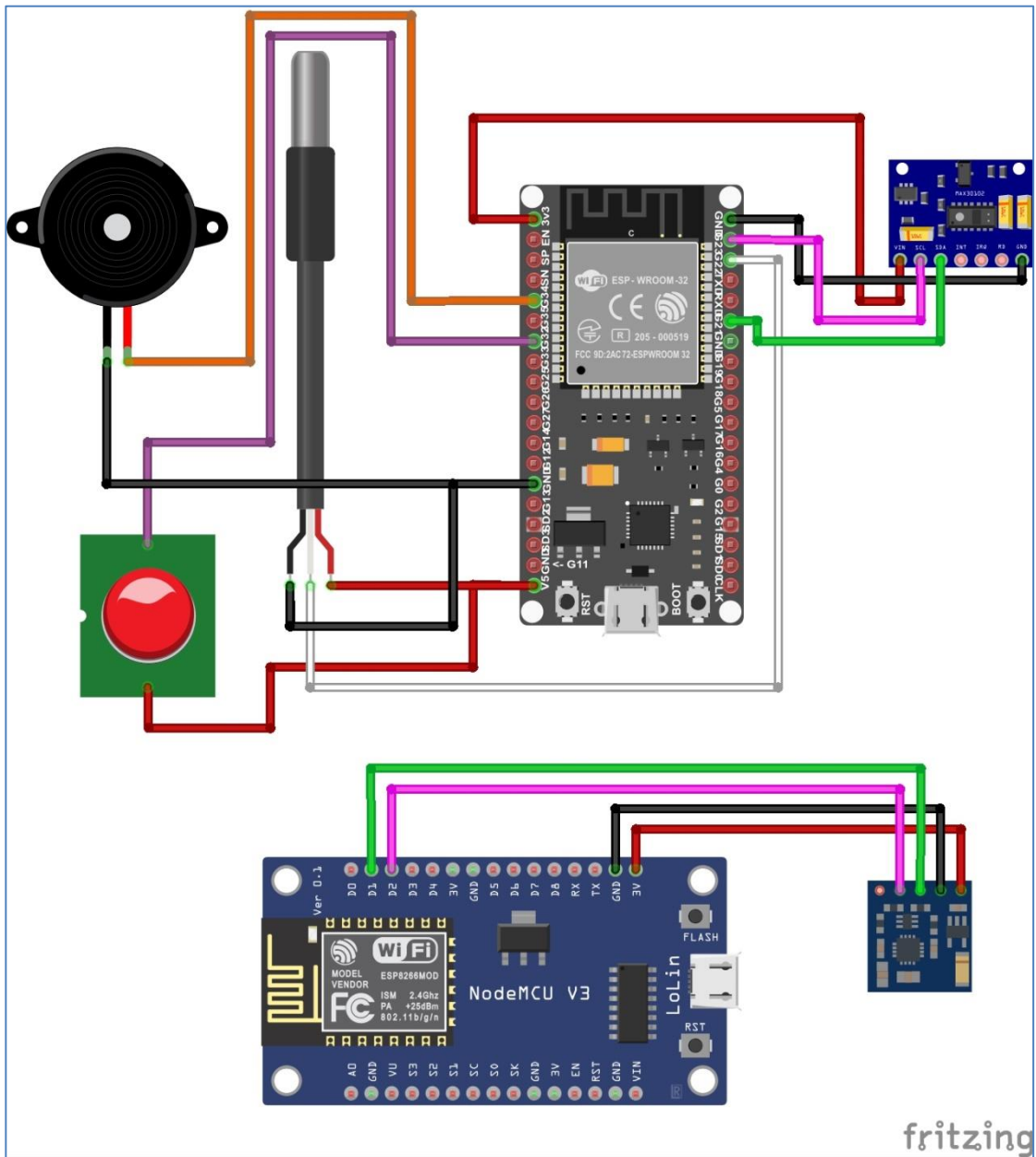


Figure 17: Wiring diagram for all systems



# **CHAPTER 4:**

## **Software & Hardware Implementation**

### **4.1 Overview**

In this chapter, we will discuss the implementation of both the software and hardware components of a wearable safety device for children project. We will begin implementing the program, by presenting the mobile application and explaining the functions it performs, and how to communicate with devices through MQTT broker technology and Firebase technology. Next, we will move on to the hardware implementation, which involves setting up the electronic components and connecting them to the mobile app . Finally, we will discuss the implementation results.

## 4.2 Software Implementation

Is the stage we will apply the design and plans to coding and hardware, this mean convert all specifications and requirements to usable and executable software app interact with microcontroller and find best methods and library to implement it.

In this figure19, the login interface to the application is shown by entering the correct username and password in order to enter the main interface.

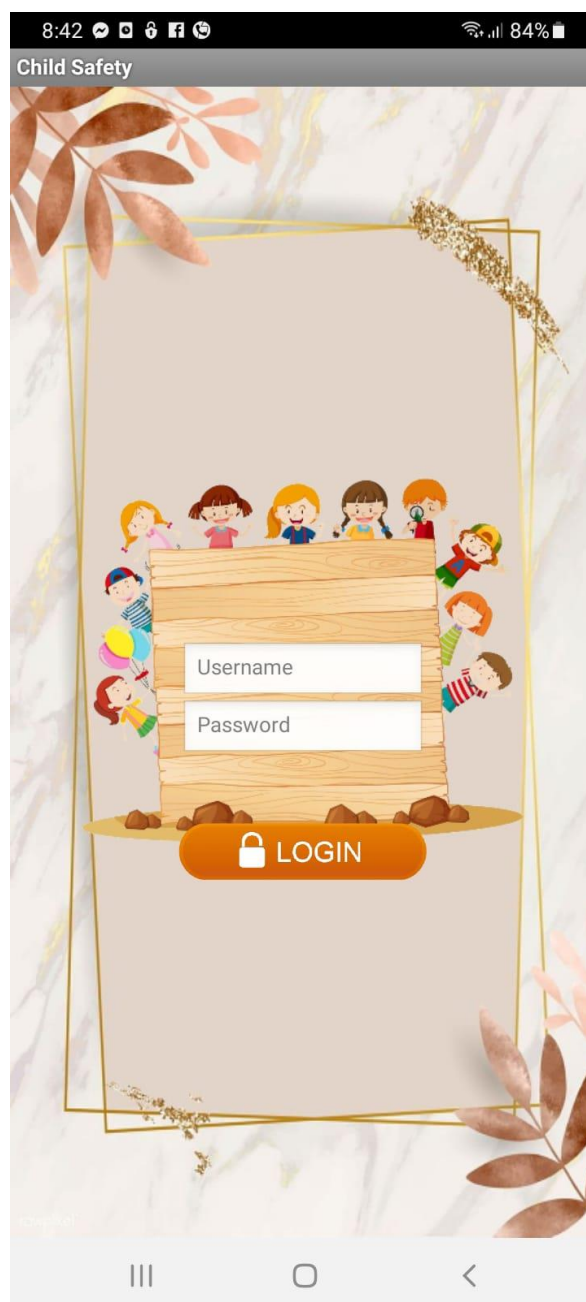


Figure 19:login page

Figure 20, shows the main interface of our application serves as the central hub for users to access and monitor their child's health and safety information. Key features and elements of the main interface include: Connect to the Internet , display sensor values and issue an audible alarm and determine the child's location .

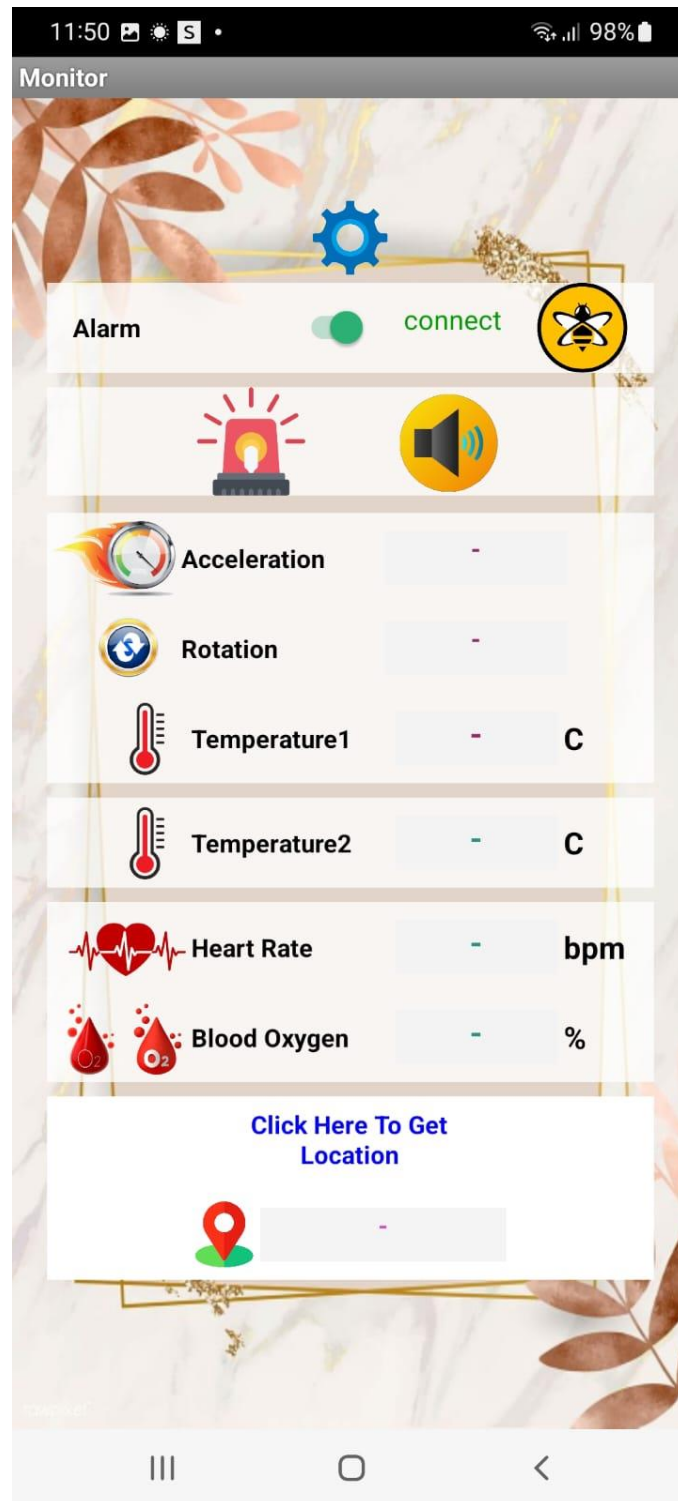


Figure 20:main page

Figure 21 shows the main interface of the mobile application that is with the child to determine his geographical location and send the coordinates to the parent application automatically.

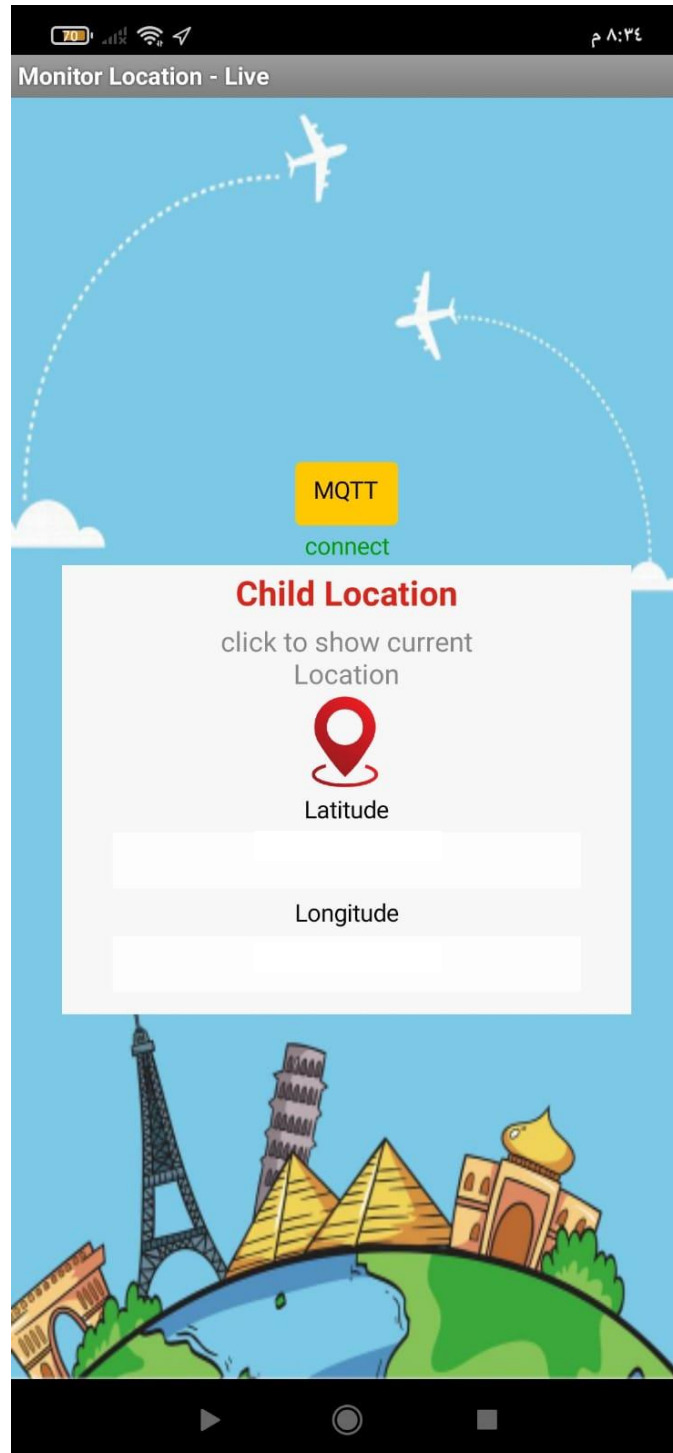


Figure 21:main page for location

### 4.3 Hardware Implementation

The hardware implementation of the proposed system involves several key component design to monitor and communicate vital information about the child health and safety to parents in real time. Below the hardware element integrated into the device:

- This figure 22, show temperature Sensor : used to measure the child body temperature ,This sensor provides accurate readings which are crucial for monitoring the child health and give notifications if the temperature drops.



Figure 22: hardware (esp32 connect DS18B20 )

- This figure 23 , show acceleration sensor (MPU6050) : is sensitive to changes in motion and can help in identifying unusual activity such as a child falling or experiencing a sudden jolt which might indicate an emergency situation.

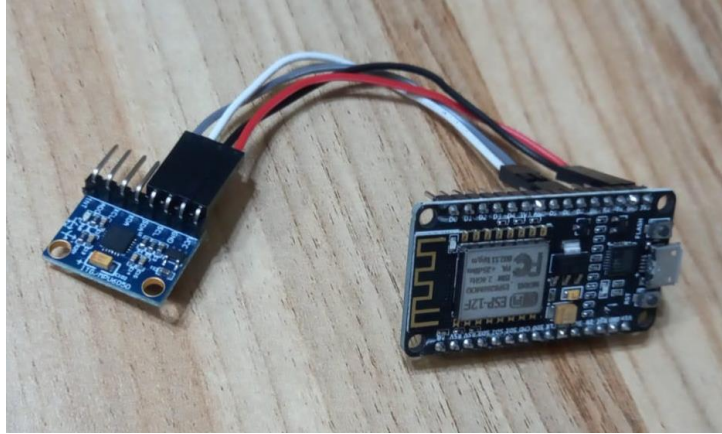


Figure 23: hardware (esp8266 connect MPU6050 )

- This figure 24 , show Blood oxygen and heart rate sensor (MAX30100) This component is essential for assessing the child's respiratory and cardiovascular health and monitoring of the child's vital signs.

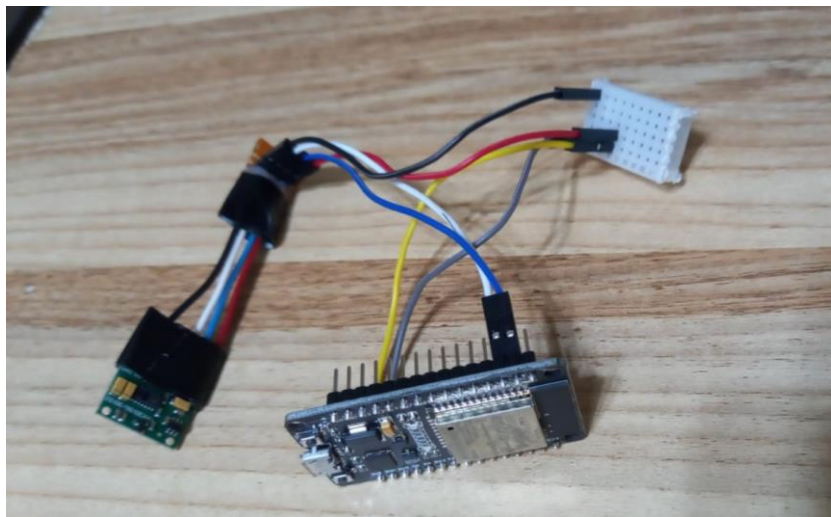


Figure 24: hardware (esp32 connect MAX30100 )

## **4.4 Implementation challenges**

Implementing a project across multiple programming environments is a personal challenge and requires advanced programming skills and expertise. We developed a mobile application using the App Inventor platform which played a crucial role in integrating with a middleware mobile application that uses the MQTT protocol. This integration presented a significant challenge in connecting the programming components of the mobile application to the MQTT protocol as well as integrating the Firebase database.

Another challenge involved ensuring accurate temperature readings, heart rate, blood oxygen levels, and getting the exact location of the child while managing power efficiently to prevent battery drain and maintain continuous operation. The device is fixed on the foot to give better and more accurate results, especially for the acceleration sensor.

# **Chapter 5: Validation & Testing**

## **5.1 Overview**

In this chapter, we show the validation and testing processes for the wearable safety device for children . Validation ensures that the system meets the requirements and expectations of users, while testing verifies its functionality, reliability, and performance. This chapter provides an overview of the validation and testing methods employed.

## **5.2 Validation**

Validation involved ensuring the system components functioned accurately and reliably and sensor calibration and accuracy tests were conducted to ensure precise readings and system integration was tested to confirm seamless operation of sensors communication modules MQTT protocol and the Firebase database. Real-time data transmission was verified for reliability and security while the mobile application user interface was assessed for usability, Power efficiency was optimized to prevent battery drain and Verify the location coordinates directly and automatically.

### 5.3 Software Testing(mobile app)

Software testing phase to verify the functionality, usability and performance of our mobile application. The following figure 25, shows the values of the sensors used in the project, including the values of acceleration, rotation and temperature of the child. It also shows the values of the heart rate sensors, oxygen percentage and alerts for danger situations that the child is exposed to. The application also shows whether the device is connected to the Internet or not and display location coordinates to the child.

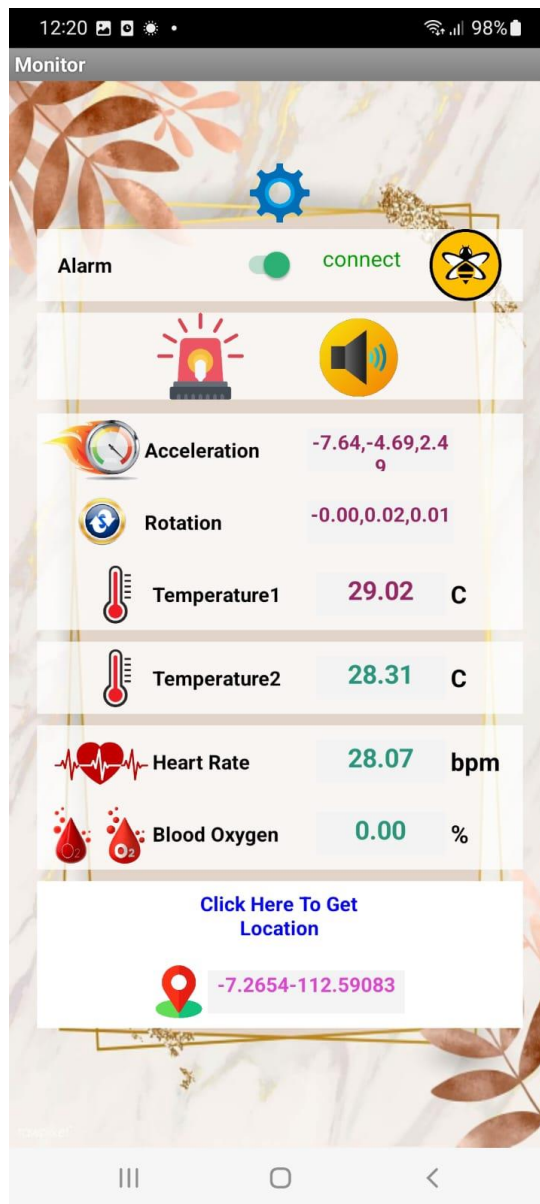


Figure 25: mobile application testing

The following figure 26, shows the mechanism for adjusting the threshold values for both acceleration and rotation.

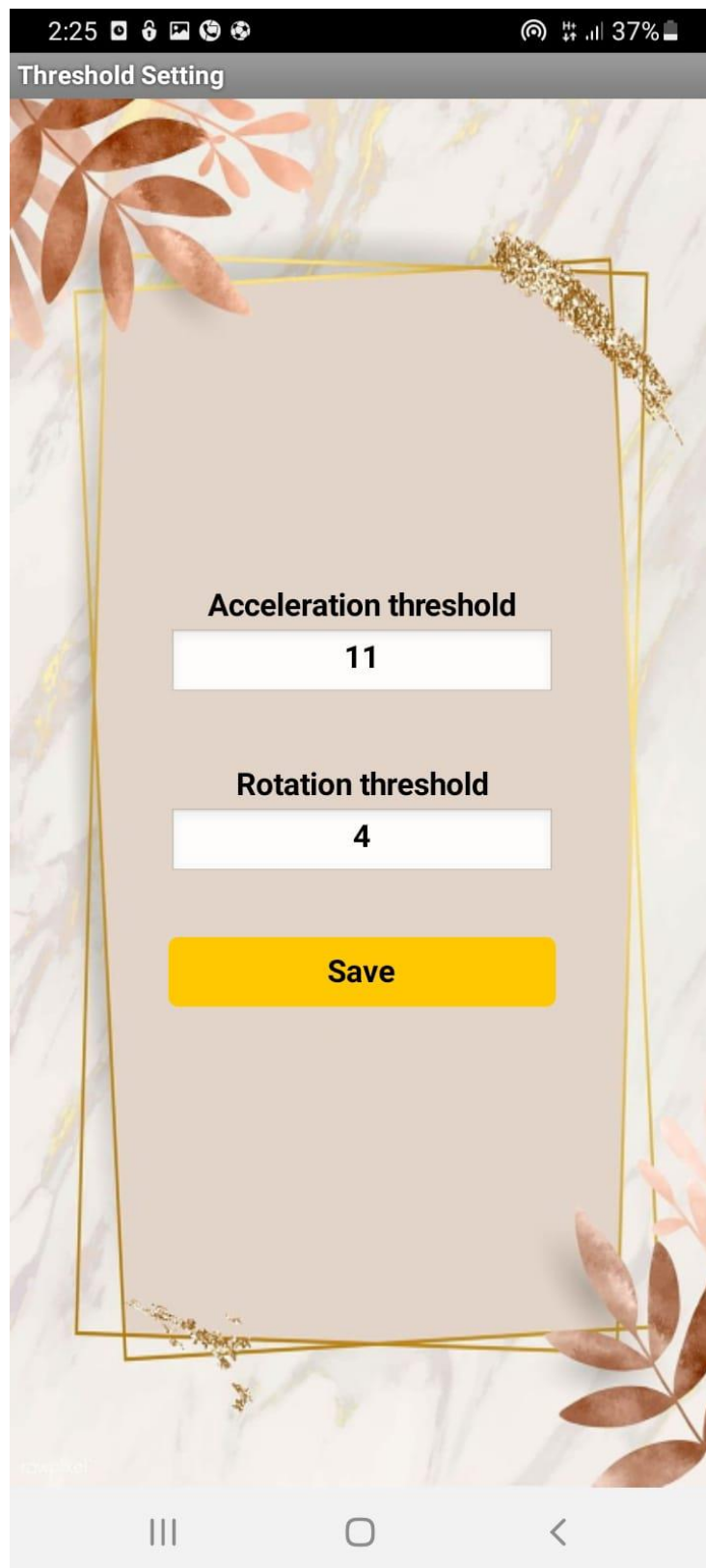


Figure 26: threshold values testing

The following figure 27 shows how to determine the location of the child by determining the lines of longitude and latitude.

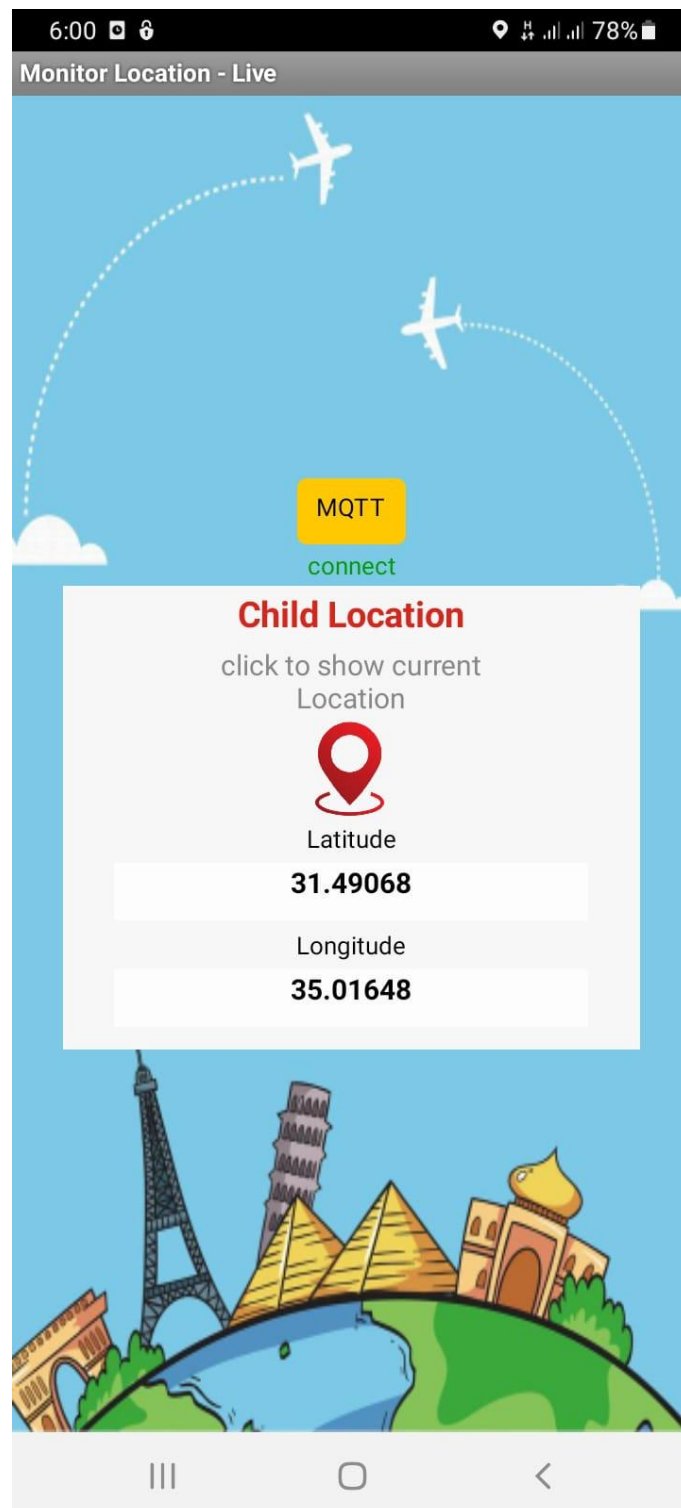


Figure 27: location test

## 5.4 Hardware Testing

The following figure 28, shows how to test the sensors connected to the controllers and verify the values that appear on the mobile phone application.

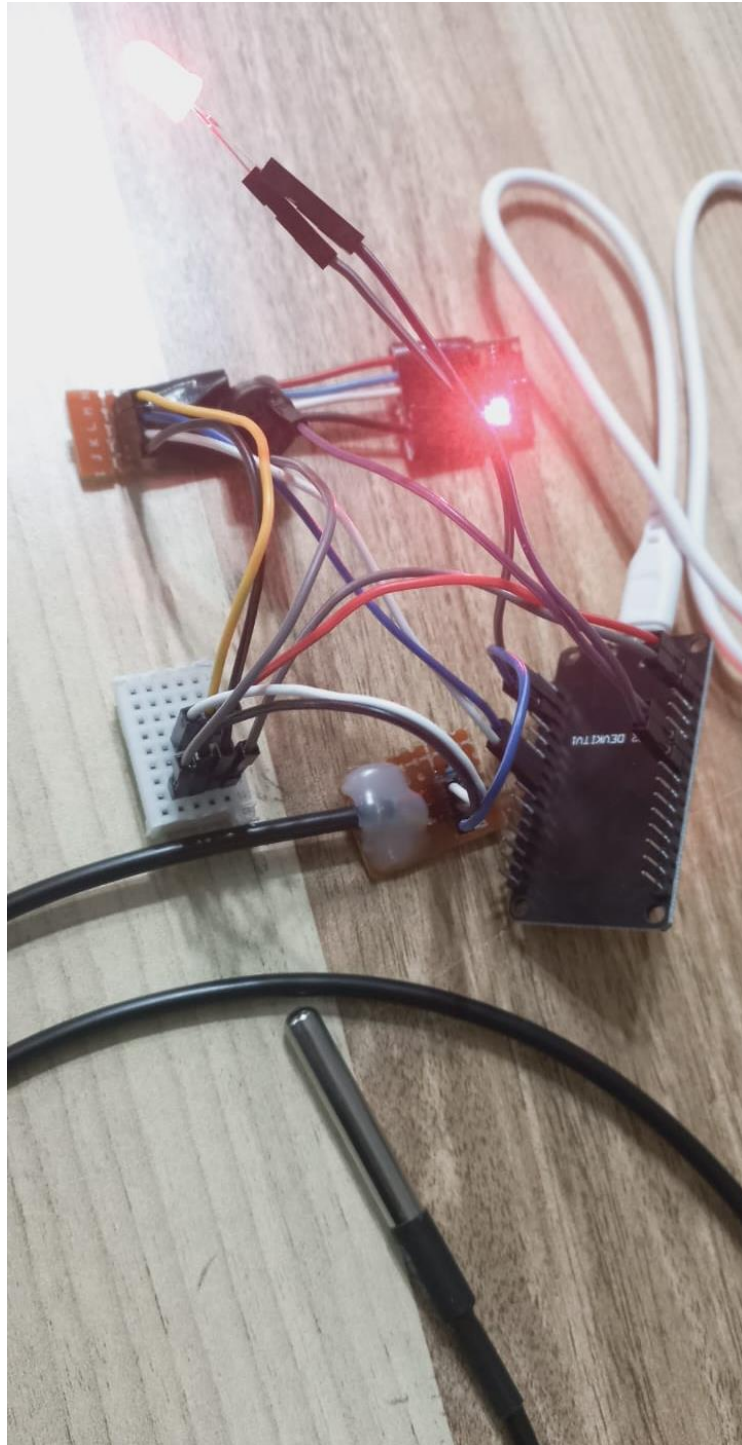


Figure 28: hardware testing

# **Chapter 6:**

## **Conclusion & Future work**

### **6.1 Overview**

In this final chapter, we will provide an overview of wearable safety device for children system's accomplishments and discuss potential future work. We will summarize the final result of the project, highlight areas for improvement or expansion, and conclude the overall project.

### **6.2 Final Result**

A wearable safety device project for children was developed to ensure the safety and security of the child by providing real-time monitoring. The system includes several sensors and features that monitor the child's vital signs including heart rate, oxygen level, and temperature, in addition to an acceleration sensor that classifies the child's movements based on specific threshold values. An alarm bell and SOS light are activated in emergency situations to alert those around them and help the child, which increases their visibility in crises and facilitates getting help quickly, and obtaining the child's location using a mobile phone. The device uses MQTT technology to transmit real-time data to parents' phones to ensure continuous communication and instant updates. Firebase technology is also used to adjust acceleration values, which enhances the accuracy and reliability of motion detection. Overall, this smart device enhances child safety by providing parents with comprehensive and immediate information about their children's health and activities, ensuring that they can respond quickly to any potential problems.

## 6.3 Future work

Future work of wearable safety device project for children focuses on several key areas to develop the project and increase efficiency and effectiveness including:

- Additional sensors that increase the efficiency of the project such as environmental sensors to detect air quality and humidity or allergens.
- Working on using machine learning algorithms to analyze data from different sensors.
- Adding a camera and microphone to communicate with the child through audio and video.
- Using long life batteries to ensure that it remains operational for longer periods.
- Protecting data stored and transferred between parts.

## Conclusion

This smart wearable device is an advanced step towards enhancing child safety by providing parents with comprehensive information about their child's health and activities. With advanced technologies such as precise sensors to track vital signs such as heart rate, oxygen level, and baby's temperature, an accelerometer to detect baby's movements and locate the baby, as well as emergency features such as an alarm bell and SOS light, parents can rest assured about their children and respond quickly in case of any problem. The use of MQTT and Firebase technologies also ensures real-time data transmission and precise movement control, making the device a reliable and effective tool for enhancing child safety and security.

## References

1) Child safety wearable device

<https://nevonprojects.com/child-monitoring-system-app/>

2) Child Monitoring System

<https://scholar.ppu.edu/handle/123456789/7528>

3) ESP32 NODMCU microcontroller ,25/10/2023.

<https://www.make-it.ca/nodemcu-details-specifications/>

4) DS18B20, 26/10/2023 .

[https://geeksville.com/product/ds18b20/#:~:text.](https://geeksville.com/product/ds18b20/#:~:text=)

5) MAX30100, 2/11/2023

<https://lastminuteengineers.com/max30100-pulse-oximeter-heart-rate-sensor-arduino-tutorial/>

6) MPU6050 accelerometer and gyroscope, 4/11/2023.

<https://lastminuteengineers.com/mpu6050-accel-gyro-arduino-tutorial/>

7) Piezo Buzzer,15/11/2023.

<https://sensorkit.arduino.cc/sensorkit/module/lessons/lesson/04-the-buzzer>

8) SOS light, 25/12/2023

<https://www.sirena.it/en/prodotto/sos-light/>

9) Arduino IDE 10/11/2023.

<https://www.arduino.cc/en/software>

10) App Inventor to build android APK for web view 12/11/2023.

<https://appinventor.mit.edu/>

11) MQTT protocol 17/11/2023.

<https://mqtt.org/>

12) Fritizing, " Fritizing, 2/1/2024

<https://fritzing.org>

13) Firebase technology May 5, 2022.

<https://firebase.google.com/docs>