Portable and Wearable Stress Monitoring Device

BM1190 - Engineering Design Project

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1 Problem Definition

We started doing a survey on 18th March regarding the problems associated with mental stress. The analytics of the survey is as follows.

Out of the over 100 participants who took part in our survey, about 90% of the sample are aware of mental health issues, as shown in Figure 1. These people belonged to several age categories, with the majority being 18 - 25 years old, as depicted in Figure 2.

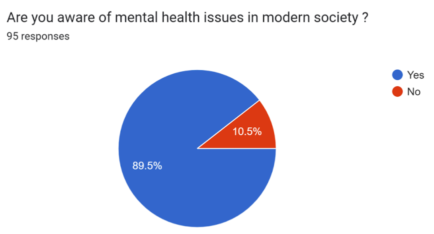


Figure 1: Awareness

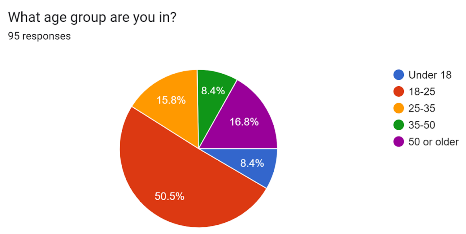


Figure 2: Age Group

Figure 3 shows how often they get stressed, with most people getting stressed daily or once every 2-3 days. Figure 4 shows whether they would like to measure stress levels often with a device. Almost 85% are interested in a device that can monitor their stress levels.

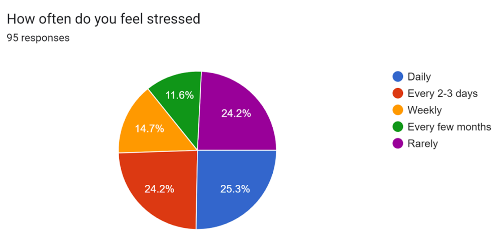


Figure 3: Stress Frequency

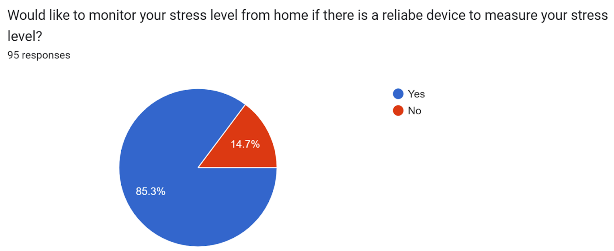


Figure 4: Interest in Stress Monitoring Device

The survey results indicate a significant need for a portable wearable stress monitoring device in the market. With 90% of participants aware of mental health issues and a large majority experiencing stress daily or every few days, the demand for effective stress management solutions is evident. Moreover, nearly 85% of respondents expressed interest in a device that can monitor their stress levels regularly. This data shows the growing necessity for accessible, real-time stress monitoring technology, especially among young adults, making it a crucial innovation for improving mental well-being.

2 Solution

2.1 Overview of the Solution

Our solution is a portable and wearable device designed to monitor stress levels with high accuracy. By integrating multiple advanced sensors, the device provides precise measurements of physiological indicators associated with stress. It is user-friendly, ensuring it can be comfortably worn throughout the day, making stress management both accessible and convenient. The primary goal of this device is to help mitigate the severe consequences of mental stress, such as diabetes, heart attack, depression, and even suicide. By offering real-time insights into stress levels, our product aims to enhance overall mental well-being and prevent stress-related health issues.

2.2 Sensor Technology

The effectiveness of our solution is grounded in its use of cutting-edge sensor technology. The device is equipped with the following sensors:

- **Heart Rate and SpO2 Sensor (MAX30100):** This sensor is crucial for monitoring heart rate and blood oxygen saturation (SpO2), both key indicators of stress. By tracking variations in these parameters, the device can accurately assess the user's stress levels in real time.
- **Temperature Sensor (MLX90614):** The MLX90614 is a non-contact infrared temperature sensor that measures skin temperature, another critical factor in stress detection. Changes in skin temperature can indicate physiological responses to stress, contributing to the device's overall accuracy.
- **Galvanic Skin Response Sensor:** This sensor measures the electrical conductivity of the skin, which varies with sweat gland activity. Since stress typically increases sweat production, this sensor provides additional data that enhances the accuracy of stress monitoring.

2.3 User-Focused Design

Our device is designed with the user in mind, ensuring both portability and wearability. The compact and lightweight form factor allows users to wear the device comfortably throughout the day without inconvenience. Its design is discreet, making it suitable for various settings, whether at work, home, or on the go. The user interface is intuitive, making it easy for users to understand their stress levels and take timely actions based on the feedback provided.

2.4 Impact on Mental Health

The primary purpose of our solution is to address the pressing issue of mental stress and its severe health consequences. Chronic stress is a major contributor to serious conditions such as diabetes, heart attacks, depression, and even suicide. By providing real-time monitoring, our device enables users to recognize early signs of stress and take proactive measures to manage it. This timely intervention can significantly reduce the risk of developing stress-related health issues, ultimately improving the user's mental health and quality of life.

3 Initial Sketches

3.1 Device Overview

The proposed device to measure stress levels and vital signs based on sensor fusion is able to measure a person's mental health (stress levels) and physical health (vital signs) simultaneously.. In this tool, the vital signs measured are oxygen saturation level (SpO2), body temperature, and heart rate. The stress level is measured by combining the galvanic skin response (GSR), body temperature, and heart rate sensor readings, which are then processed by a fuzzy logic algorithm in the microcontroller to determine the stress level. And then the determined stress level is displayed using the LCD. A system block diagram of the device is presented in the figure above.

3.2 Product Architecture

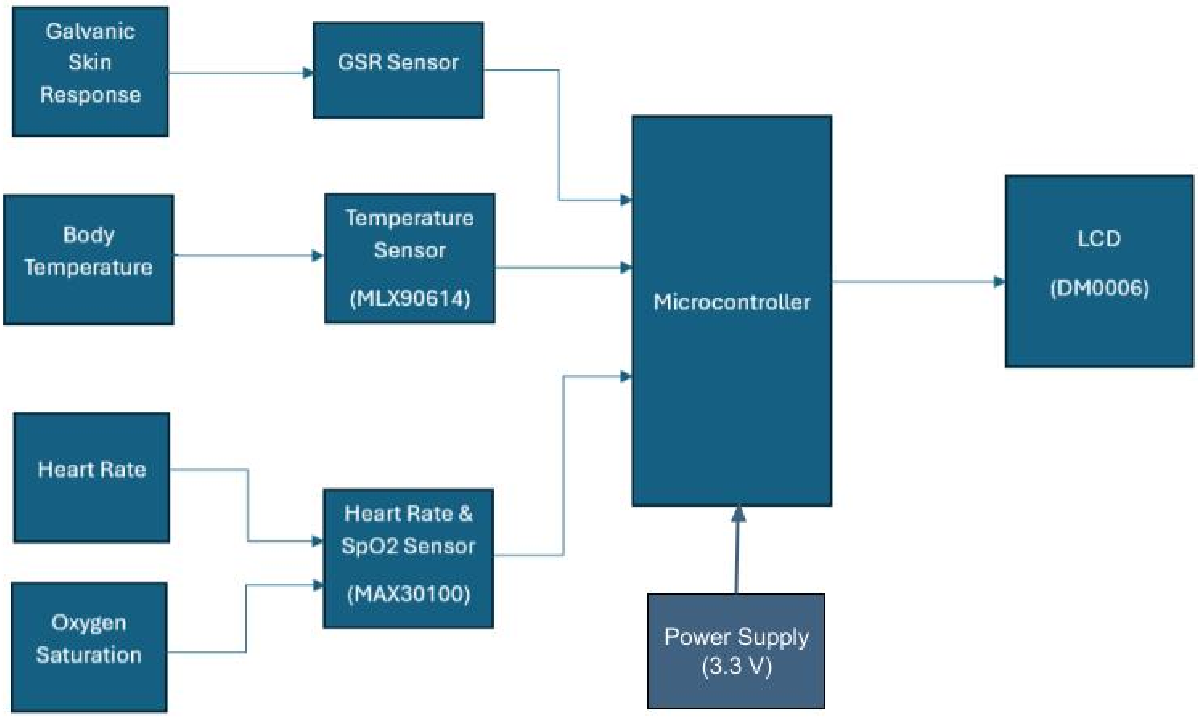


Figure 5: Product Architecture

3.3 Initial Enclosure Design

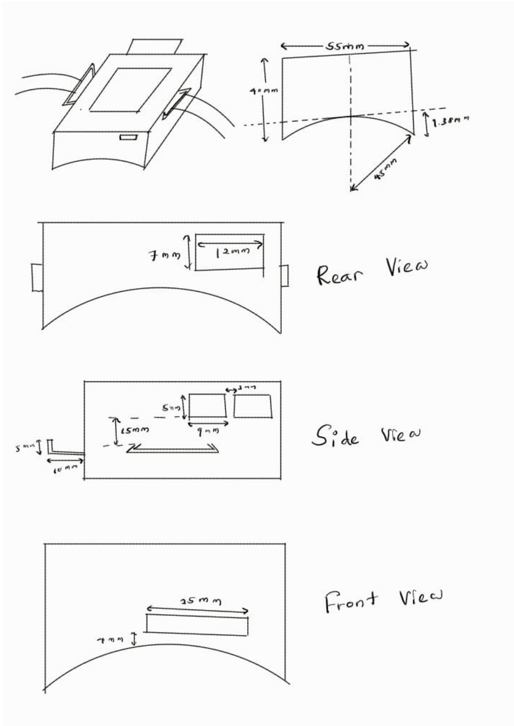


Figure 6: Initial Sketch of the enclosure

4 PCB Schematic Design

The PCB for this project integrates an ESP8266-12E microcontroller unit, responsible for processing sensor data and handling communication with external devices. Key sensors include the MAX30100 (for SpO2 and heart rate) and the MLX90614 (temperature sensor), interfaced through I2C lines, and a Galvanic Skin Response sensor. The board features proper power management using voltage regulators and capacitors to ensure stable operation.

The design ensures minimal noise and interference, with clear separation of analog and digital traces. The compact and efficient layout facilitates easy deployment in wearable applications, making it suitable for continuous real-time monitoring of vital parameters related to stress levels.

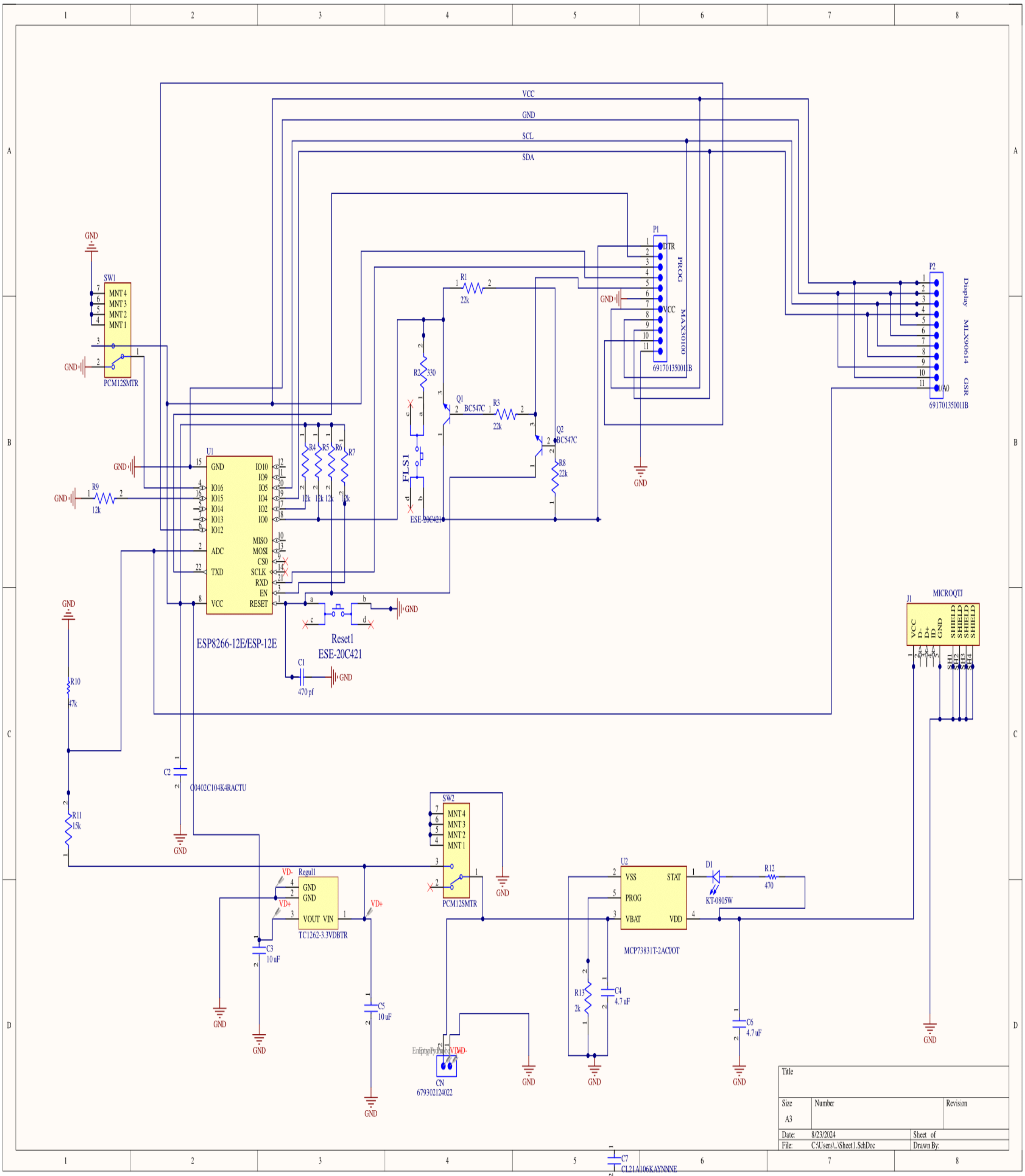


Figure 7: Schematic design

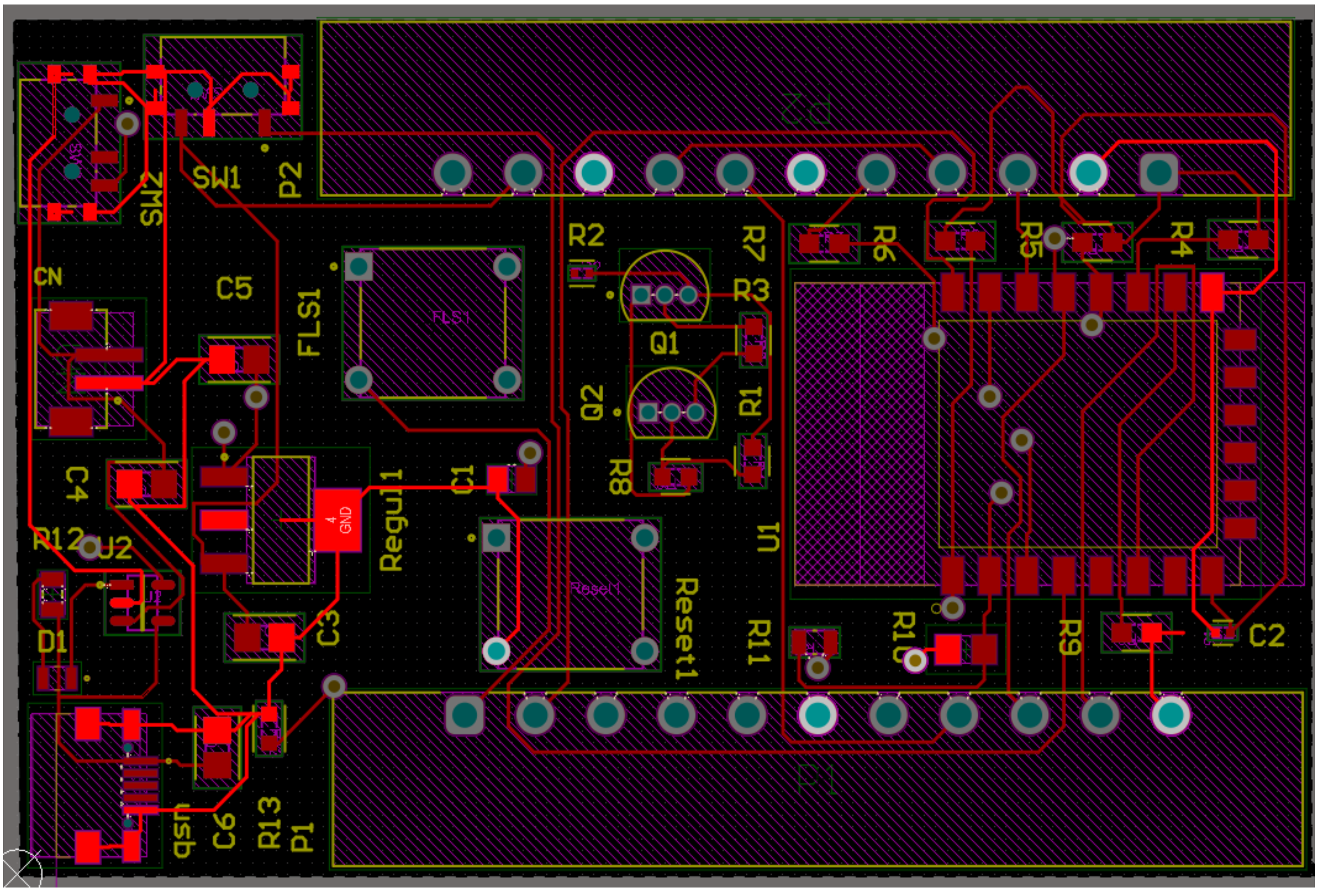


Figure 8: PCB Overview

Rule Violations	Count
Clearance Constraint (Gap=10mil) (All),(All)	0
Clearance Constraint (Gap=10mil) (All),(All)	0
Clearance Constraint (Gap=10mil) (All),(All)	0
Clearance Constraint (Gap=10mil) (All),(All)	0
Short-Circuit Constraint (Allowed=No) (All),(All)	0
Un-Routed Net Constraint ((All))	0
Modified Polygon (Allow modified: No), (Allow shelved: No)	0
Width Constraint (Min=10mil) (Max=10mil) (Preferred=10mil) (All)	0
Power Plane Connect Rule(Relief Connect)(Expansion=20mil) (Conductor Width=10mil) (Air Gap=10mil) (Entries=4) (All)	0
Hole Size Constraint (Min=1mil) (Max=100mil) (All)	0
Hole To Hole Clearance (Gap=10mil) (All),(All)	0
Minimum Solder Mask Sliver (Gap=10mil) (All),(All)	14
Silk To Solder Mask (Clearance=10mil) (IsPad),(All)	55
Silk to Silk (Clearance=10mil) (All),(All)	0
Net Antennae (Tolerance=0mil) (All)	0
Height Constraint (Min=0mil) (Max=1000mil) (Prefered=500mil) (All)	0
Total	**69**

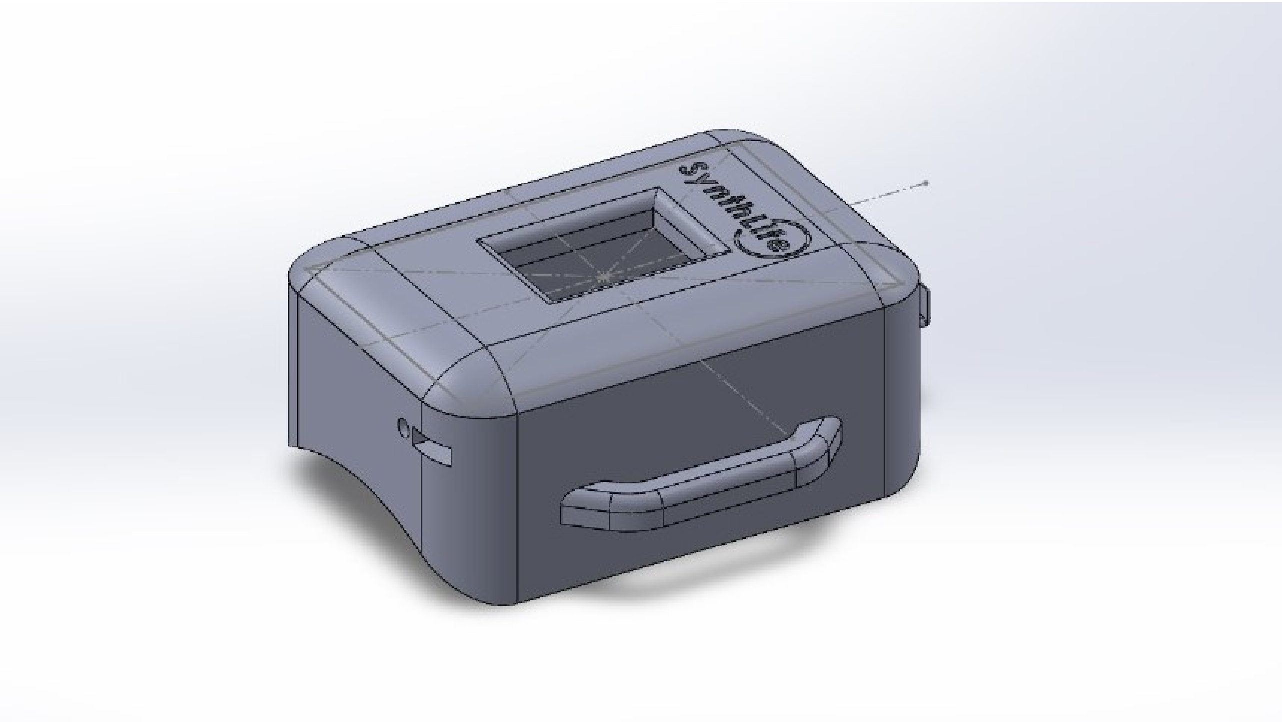
Figure 9: Rule Violations

5 Solidwork enclosure

5.1 Overview

The enclosure for our stress monitoring device was designed using SolidWorks to ensure precision and functionality. Leveraging SolidWorks' advanced modeling and simulation tools, we crafted a robust design that balances durability with user comfort. The model features a sleek, contoured shape that conforms to the wearer's body, minimizing discomfort during extended use. Through SolidWorks' simulation capabilities, we conducted thorough stress tests and thermal analyses to ensure the enclosure withstands environmental factors and internal heat generation. The design includes effective sensor placement and user interaction. Additionally, the detailed 3D models and assemblies created in SolidWorks streamline the manufacturing process, ensuring that all components fit together seamlessly and meet high-quality standards.

5.2 3D View



6 Software Implementation

6.1 Overview

The software implementation of our stress monitoring device is powered by C++, enabling efficient and responsive data processing. The C++ code interfaces directly with the device's sensors, capturing physiological data such as heart rate variability and skin conductance. Advanced algorithms, implemented in C++, analyze this data in real-time to determine the user's stress levels. The software is designed to be lightweight and fast, ensuring smooth operation while providing real-time feedback through a user-friendly interface. Additionally, it supports customizable alerts and long-term data logging, allowing users to monitor and manage their stress effectively

6.2 Algorithm

GSR Value	**Temperature**	**Heart Rate**			
		Low	**Medium**	**High**	**Very High**
Low	Low	Relax	Anxious	Anxious	Anxious
	Medium	Relax	Calm	Calm	Calm
	High	Calm	Calm	Calm	Anxious
	Very High	Relax	Calm	Calm	Relax
Medium	Low	Anxious	Anxious	Anxious	Stress
	Medium	Calm	Calm	Anxious	Anxious
	High	Calm	Calm	Calm	Anxious
	Very High	Relax	Calm	Calm	Relax
High	Low	Anxious	Calm	Anxious	Anxious
	Medium	Anxious	Anxious	Anxious	Anxious
	High	Calm	Calm	Anxious	Anxious
	Very High	Calm	Calm	Anxious	Stress
Very High	Low	Anxious	Anxious	Stress	Anxious
	Medium	Anxious	Anxious	Anxious	Stress
	High	Anxious	Calm	Anxious	Stress
	Very High	Calm	Calm	Anxious	Stress

Table 1: GSR, Temperature, and Heart Rate Table

Threshold Values	**GSR**	**Temperature (°C)**	**BPM**
Low	< 2	< 35	60 - 70
Medium	2 - 4	35 - 37	70 - 90
High	4 - 6	37 - 38.5	90 - 100
Very High	> 6	> 38.5	> 180

Table 2: Threshold Values for GSR, Temperature, and BPM

7 Hardware Specifications

7.1 Overview

Our stress monitoring device incorporates four essential sensors to accurately assess an individual's physiological state:heart rate,body temperature,SpO2 (oxygen saturation), and Galvanic Skin Response (GSR). By continuously collecting data from these sensors, the device computes a comprehensive stress indicator that determines the user's stress levels in real-time. This calculated value is then clearly displayed, enabling timely and effective monitoring of the patient's stress condition.

Now Let's dive into more detailed hardware analysis

7.2 Microcontroller

Figure 10: Microcontroller

For the microcontroller, we've used an ESP12E with the following features:

- Built-in Wi-Fi
- 2.2V to 3.6V operating voltage
- -40°C to +125°C operating temperature
- Working current: 240mA (MAX)

7.3 Power Supply

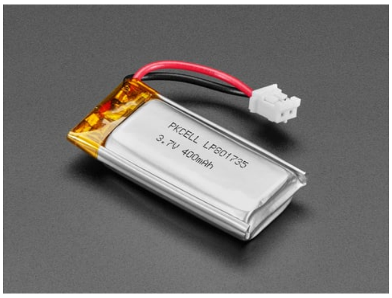


Figure 11: Power Supply

For the power supply we've used a rechargable LiPo Battery.

- BNominal Voltage: 3.7V
- Capacity: 1000mAh

7.4 Heart Rate and SpO2

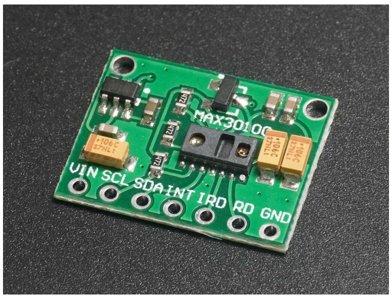


Figure 12: Heart Rate and SpO2 Sensor

To get the readings for the heart rate and SpO2 values we've used MAX30100 sensors with following specifications

- 1.8 to 3.3V Operating voltage rage
- Fast Data Output Capability
- Built-in temperature sensor on the module, used to compensate for environmental changes and calibrate the measurements.

7.5 Temperature

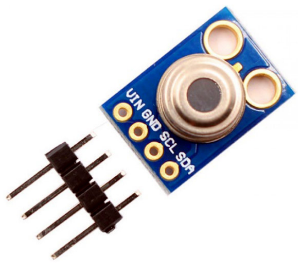


Figure 13: Temperature Sensor

To get the readings for the body temperature we've used MAX30100 sensors with following specifications.

- 3V-5V operating voltage
- Range -40°C to +125°C (ambient)—-70°C-380°C (object)
- Accuracy ±0.5°C

7.6 Galvanic Skin Response

Figure 14: GSR Sensor

The GSR sensor has following specifications

- 3.3V-5V operating voltage
- Measures electrical conductance of skin

7.7 Display

Figure 15: OLED Display

We've used an OLED Display (DM0037) as our display with following specifications.

- Low power consumption: 0.04 W during normal operation
- Support wide voltage: 3.3V–5V DC
- Working temperature: -30 to 80 degrees

8 Marketing and Sales

8.1 Marketing Strategies

- **Target Audience Identification:** Focus on health-conscious consumers, corporate partnerships, and healthcare providers to expand market reach.
- **Product Differentiation:** Highlight the unique selling points of the device, such as sensor fusion technology, portability, user-friendliness, and affordability. Offer customization options for personalized features.
- **Digital and Content Marketing:** Leverage social media campaigns, influencer partnerships, educational blogs, and videos to create engaging content. Host webinars and workshops to educate potential customers.
- **Strategic Partnerships:**Establish collaborations with health and fitness brands and telehealth services to enhance the device's visibility and integration into wellness routines.
- **Regulatory and Certification Marketing:** Emphasize health certifications, data privacy, and compliance with standards to build consumer trust and credibility.

8.2 Sales Strategies

- **Sales Channels:** Distribute the device through e-commerce platforms like Amazon and a dedicated website to ensure a user-friendly shopping experience.Distribute the device through e-commerce platforms like Amazon and a dedicated website to ensure a user-friendly shopping experience.
- **Retail Partnerships:** Collaborate with health and wellness stores, pharmacies, and tech retailers to expand the device's availability and reach.
- **Customer Feedback and Continuous Improvement:** Actively gather user feedback to make ongoing product enhancements, ensuring the device meets customer needs and expectations.

9 Budget and Product Pricing

Item	Cost (Rs/=)
Galvanic Skin Response Sensor	4,934
IR Temperature Sensor Module (MLX90614)	2,630
Pulse Oximeter SpO2 and Heart-Rate Sensor (MAX30102)	500
OLED Display	580
PCB	4,619
ESP-12E ESP8266	690
Enclosure print	1,521
Other small components	272
3.7V 1000mah 30C Lipo Battery 701855	1,090
Total estimated cost	**16,256**
Estimated Product Price	**20,000**

Table 3: Breakdown of the Estimated Project Costs

10 Task Allocation

Perea P.L.P. - Circuit Design, Altium, and PCB Design: Perea P.L.P. was responsible for the core electronics design of the project. This included developing the circuit schematic, selecting appropriate components, and ensuring the circuit met all functional and safety requirements. Utilizing Altium, Perea created the detailed PCB layout, optimizing it for size, power consumption, and signal integrity. Perea also managed the PCB fabrication process, ensuring that the final boards were produced according to the design specifications.

Fernando S.R.N. - SolidWorks and Enclosure Design: Fernando S.R.N. focused on the physical design aspects of the project. Using SolidWorks, Fernando designed the enclosure that houses the electronic components, ensuring it was ergonomic, aesthetically pleasing, and met all required specifications for durability and portability. The design process involved multiple iterations to ensure that the enclosure was compatible with the internal components while providing sufficient protection and ease of use for the end user.

Dulsara G.M.L. - Survey Analyzing, Microcontroller Programming and Testing, Market Analyzing, Presentation Designing Dulsara G.M.L. played a multifaceted role in the project. Dulsara led the analysis of survey data to gather insights into user needs and preferences, which informed the product development process. Additionally, Dulsara handled the microcontroller programming, focusing on implementing and testing the firmware required for sensor integration and data processing. Market analysis was also conducted to identify potential market segments and competitors. Finally, Dulsara was responsible for designing the presentation, ensuring that it effectively communicated the project's objectives, methodologies, and outcomes.

Yashodhara M.H.K. - Product Idea Surveying, Microcontroller Programming and Debugging, Product Marketing, Budget Coordinating, Final Report Making: Yashodhara M.H.K. took the lead in the initial product idea survey, gathering and analyzing data to shape the project's direction. Yashodhara also contributed to the microcontroller programming, focusing on debugging and optimizing the code. In addition to these technical tasks, Yashodhara managed the product marketing strategy, identifying key selling points and potential customer segments. Yashodhara also coordinated the budget, ensuring that the project stayed within financial constraints, and was responsible for compiling and editing the final report, ensuring it was comprehensive and well-structured.