POLITEKNIK SULTAN SALAHUDDIN
ABDUL AZIZ SHAH

ELECTROMYOGRAPH (EMG) BIO-SENSOR FOR ATHLETE BY USING ESP32 WITH IOT APPLICATION

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ELECTRICAL ENGINEERING DEPARTMENT

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ELECTROMYOGRAPH (EMG) BIO-SENSOR

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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 Medical Electronic Engineering

ELECTRICAL ENGINEERING DEPARTMENT

SESI I 2024/2025

DECLARATION OF PROJECT REPORT AND COPYRIGHT

EMG BIO-SENSOR FOR ATHLETE BY USING ESP32 WITH IOT APPLICATION

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(As a project supervisor at : 22.11.2024)

PUAN NOR KHARUL AINA BINTI MAT DIN

ACKNOWLEDGEMENT

First of all, I would like to take this opportunity to express my grateful to God because gave me a good health to finish my final year project. Secondly, I would like to express my thankful to my supervisor Puan Nor Kharul Aina Binti Mat Din who give me chance to work with them and for their guidance during my final year project.

My appreciation also goes to my family members who has been tolerant and supporting me all these times in accomplishing my final year project. Thanks for their encouragement, loves and emotional support that they had gave to me.

Besides that, I am highly indebted to my course mate for their guidance and constant supervision as well as for providing necessary information regarding the Project and also for their support in completing the project.

Lastly, I would like to thank all those who supported me in any aspect during the completion of the project, especially people in Polytechnic Sultan Salahuddin Abdul Aziz Shah (PSA). I owe sincere and earnest thankfulness for the unforgettable and unique experience of my life.

ABSTRAK

Projek ini dibina berdasarkan pembangunan sistem bio-sensor EMG yang boleh disambung dengan mikropengawal ESP32 dan aplikasi IoT untuk meningkatkan prestasi atlet. Sistem ini memanfaatkan kuasa elektromiografi (EMG) untuk menangkap dan menganalisis isyarat elektrik yang dihasilkan oleh pengecutan otot. Dengan pendekatan yang tidak invasif, projek ini akan mengukur aktiviti otot secara masa nyata, memaparkan maklumat mengenai prestasi atlet dan berpotensi untk mengesan kecederaan. Selain itu, komponen utama sistem ini ialah “electrode sensor” EMG yang akan diletakkan pada tubuh atlet untuk mengkaji kumpulan otot tertentu. Sensor-sensor ini mengesan aktiviti elektrik yang dihasilkan oleh serat otot semasa pengecutan dan menghantar isyarat ke mikropengawal ESP32. ESP32 memproses isyarat EMG dan menggunakan teknik pemprosesan isyarat lanjutan seperti penapisan, penguatan, serta akan ekstraksi ciri untuk mendapatkan maklumat yang relevan. Sebagai contohnya, projek ini akan memaparkan keadaan otot dan keadaan atlet melalui nilai dan graf. Tambahan pula, penggunaan aplikasi IoT akan membuatkan projek ini lebih mesra pengguna iaitu ianya membolehkan atlet dan jurulatih memvisualisasikan data EMG, mengtahui kemajuan latihan, dan mengenal pasti masalah otot-otot atlet. Ciri-ciri utama yang diekstrak daripada isyarat EMG termasuk tahap pengaktifan otot, indikator keletihan, dan corak pergerakan. Ciri-ciri ini memberikan pemahaman yang komprehensif mengenai prestasi otot atlet dan boleh digunakan untuk mengenal pasti kawasan yang perlu diperbaiki. Akhir sekali, data yang telah diproses kemudian dihantar tanpa menggunakan wayar ke aplikasi IoT, dan membolehkan pemantauan serta analisis secara masa nyata.

ABSTRACT

This research presents the development of a wearable EMG bio-sensor system that integrated with an ESP32 microcontroller and an IoT application to enhance athletic performance. The system leverages the power of electromyography (EMG) to capture and analyses electrical signals that generated by muscle contractions. As a result, by utilizing a non-invasive approach, this project will measure muscle activity in real-time, providing valuable insights into an athlete's performance and potential for injury. Other than that, is the core component of the system. This component is an array of EMG sensors that were strategically placed on the athlete's body to target specific muscle groups. These sensors detect the electrical activity produced by muscle fibres during contraction and transmit the signals to the ESP32 microcontroller. The ESP32 processes the raw EMG signals, applying advanced signal processing techniques such as filtering, amplification, and feature extraction to extract relevant information. Furthermore, the IoT application provides a user-friendly interface that allows athletes and coaches to visualize EMG data, track training progress, and identify potential performance bottlenecks. Last but not least, key features extracted from the EMG signals include muscle activation levels, fatigue indicators, and movement patterns. These features provide a comprehensive understanding of the athlete's muscle performance and can be used to identify potential areas for improvement. The processed data is then transmitted wirelessly to an IoT application, enabling real-time monitoring and analysis.

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LIST OF ABBREVIATIONS

IoT - Internet of Thinking
EMG - Electromyography
ADC - Analog to Digital Converter
AC - Alternating Current
mV - Millivolts
Wi-Fi - Wireless Fidelity
LCD - Liquid Crystal Display
ECG - Electrocardiogram
MM - Male to Male
FM - Female to Male
Arduino IDE - Arduino Integrated Development Environment

CHAPTER 1

INTRODUCTION

1.1 Introduction

EMG or known as Electromyography is a non-invasive technique that measures the electrical activity generated by muscles during contraction. These tiny electrical signals hold a wealth of information about muscle activation patterns, fatigue levels, and potential imbalances. By analyse EMG data, we can gain valuable insights that traditional methods simply cannot provide.

This project utilized by ESP32 as the primary component. The ESP32 is a powerful processing capabilities that will integrated Wi-Fi connectivity make it ideal for developing advanced wearable technology. This allows us to optimize training regimens by analyse muscle activation patterns to identify weaknesses or imbalances, enabling targeted training programs to improve performance and prevent injuries.

1.2 Project Background

In recent years, advancements in wearable technology and sensor systems have opened up new possibilities for optimizing athletic performance. Electromyography (EMG) is a non-invasive technique that measures the electrical activity of muscles. By analyzing EMG signals, valuable insights can be gained into muscle activation patterns, fatigue levels, and overall performance.

However, traditional EMG systems often require bulky equipment and specialized expertise to operate. This limits their accessibility to athletes and coaches. To address this limitation, this project aims to develop a portable and user-friendly EMG biosensor system integrated with an ESP32 microcontroller and an IoT application. By leveraging the capabilities of these technologies, the system will enable real-time monitoring of muscle activity, providing valuable insights into an athlete's performance and potential for injury.

The system will consist of a wearable device equipped with EMG sensors strategically placed to capture electrical signals from specific muscle groups. These signals will be processed by the ESP32 microcontroller, which will extract relevant features such as muscle activation levels, contraction intensity, and fatigue indicators. The processed data will then be transmitted wirelessly to an IoT application, where it can be visualized and analyzed in real-time.

1.3 Problem Statement

In the world of sports, understanding how an athlete's muscles are working in real-time is crucial for optimizing training and preventing injuries. Traditional methods, like reviewing their training video basically not provide accurate or timely information. This can lead to athletes making poor decisions about their training even getting hurt. To solve this problem, we will create a system that can give athletes real-time feedback on their muscle activity. This will help them make better decisions about their training, leading to better performance and fewer injuries.

First of all, how athletes detect and analyze their muscle activity in real-time and receive immediate feedback to improve their performance during workouts. Nowadays, athletes often struggle to accurately assess their muscle activation during training. Traditional methods, such as relying on visual cues will be unreliable and may not provide the necessary insights for optimal performance. A wearable EMG bio-sensor system can address this challenge by providing real-time data on muscle activity. By analyzing these signals, athletes can identify areas of weakness, optimize their training routines, and prevent injuries.

Then, how can athlete assess their muscle engagement fatigue, which leads to ineffective training and increased risk of injury. Based on my research, overtraining and inadequate recovery can significantly impact athletic performance and increase the risk of injuries. Objective measures of muscle fatigue, such as those derived from EMG signals, can provide valuable insights into an athlete's readiness to train and recover.

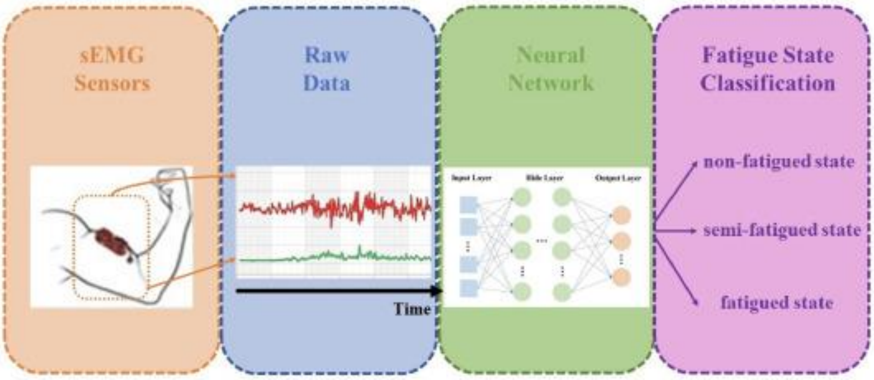


Figure 1.1 How can Athlete Assess Their Muscle Engagement Fatigue

Last but not least, what is the issue that will affects athletes who aim to enhance their training by optimizing muscle use and ensuring proper recovery after exercise. This problem is to achieve peak performance and athletes need to balance their training to load and recovery. However, training methods without knowing athletes condition can lead to suboptimal results and increased risk of injury. By utilizing wearable EMG technology, athletes can gain a deeper understanding of their muscle activity and adjust their training routines accordingly. This will help minimize fatigue and accelerate recovery.

Below is the comparison between EMG Machine and The EMG Bio-Sensor project.

EMG Machine	Comparison	EMG BioSensor by using ESP32 with IoT application
Tethered to a computer or data acquisition system	Data Acquisition	Wireless data transmission
Limited real-time feedback	Real-time Monitoring	Real-time monitoring and analysis
High cost of equipment and maintenance	Cost	Lower cost and more accessible
Complex and requires specialized training	User Interface	User-friendly and intuitive interface

Table 1.1. Comparison between EMG Machine and EMG Biosensor Project

Then, the impact of the problem above is including how it affects them and why it is important to address. This helps to highlight the importance and urgency of the problem. A problem statement should focus on describing the problem, not on proposing solutions. It is important to separate the problem from the potential solutions, as this helps to avoid biases and ensure that all potential solutions are considered. Finally, a problem statement should be concise and to the point, focusing on the most important aspects of the problem. Avoid including unnecessary details or background information.

1.4 Project Objective

The objectives of this project are:

(a) To detect and analyse muscle activity in real time for immediate insights into muscle performance.

(b) To aid in optimizing athletic performance by providing data driven feedback on muscle engagement and fatigue.

(c) To monitor muscle recovery effectively, ensuring athletes follow proper rest and rehabilitation protocols.

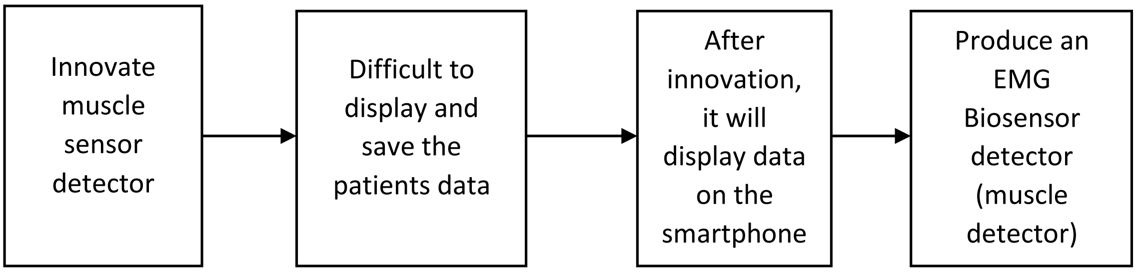
1.5 Project Scope

This project aims to develop a wearable EMG biosensor system that can accurately monitor and analyse muscle activity in real-time. The system will consist of wearable EMG sensors, an ESP32 microcontroller, and an IoT application. The primary goal is to provide athletes with real-time feedback on their muscle activation, fatigue levels, and movement patterns. However, while this project aims to provide a comprehensive solution, there are certain limitations to consider which is the sensor placement and signal noise. For sensor placement, we found that optimal sensor placement can vary depending on the specific muscle groups being monitored and individual anatomical differences. Then, due to my search, the signal noise will generate because of environmental factors, such as electrical interference and movement artefact. As a result, this can affect the quality of the EMG signals.

22.

1.6 Problem Significance

This project aims to develop a cost effective and user-friendly system for athletes to assess their muscle condition using electromyography (EMG) biosensor with an ESP32 microcontroller. By creating this project, it can improve the performance in the real-time EMG graph. This project will reveal the data muscle activation patterns and allowing athletes to identify imbalances, weaknesses, and areas for improvement. Other than that, this can lead to more targeted training programs and optimized performance. Then, by utilizing the ESP32 for this project, it can keep the system cost-effective and create an EMG sensor more accessible to a wider range of athletes. Overall, this project has the potential to revolutionize athlete training by providing a data-driven approach to muscle condition assessment, ultimately leading to improved performance and a reduced risk of injuries.



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1.7 Definition of Term or Operation

Electromyography (EMG) refers to the technique of recording the electrical activity produced by muscle contraction. The resulting electrical signals, known as EMG signals, are captured by electrodes placed on the skin surface. These signals provide valuable insights into muscle activation patterns, fatigue levels, and movement mechanics (showed in figure 1.2). Other than that, this project also generated the real-time monitoring which refers to the continuous collection and analysis of data as it occurs. In the context of EMG, real-time monitoring allows for immediate feedback on muscle activity, enabling athletes to make adjustments to their training routines in real-time. Last but not least, this EMG biosensor was created with Internet of Things (IoT) application.

This application was referring to the network of interconnected devices that can collect and exchange data. In the context of this project, IoT enables the wireless transmission of EMG data from the wearable device to a remote server for analysis and visualization.

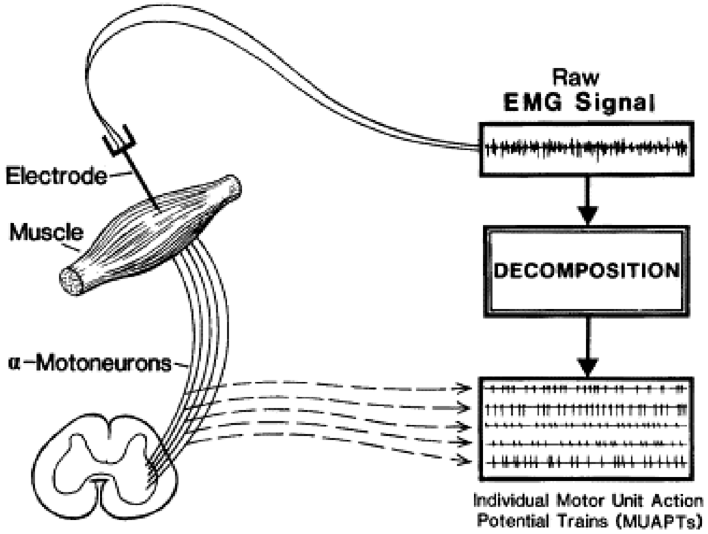


Figure 1.2. How the EMG signal can be generate

1.8 Summary

In conclusion, this project was combined with ESP32 and will created a project for athletes to gain valuable insights into their muscle health and performance. By providing real-time detector on muscle activation patterns, this technology empowers athletes to optimize training programs, identify weaknesses, and potentially reduce injury risks. The accessibility and customization potential of ESP32 further is to enhance the significance of this project. For example, we will make a EMG bio-sensor more feasible tool for a wider range of athletes. Furthermore, future advancements in sensor technology and data analysis techniques can further refine this system. This project will ultimately lead to a more comprehensive understanding of athlete performance and a personalized approach to training.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Electromyography (EMG) is a technique used to measure the electrical activity produced by muscles. By analysing these electrical signals, we can gain valuable insights into muscle function, fatigue, and movement patterns. In recent years, there has been a growing interest in developing wearable EMG sensors to monitor muscle activity in real-time. These devices have the potential to revolutionize various fields, including sports performance, rehabilitation, and human-computer interaction.

Previous research has explored the use of wearable EMG sensors in a variety of fields. In sports performance, for example, EMG sensors are used to analyses muscle activation patterns, which can help athletes optimize their training programs and prevent injuries by identifying inefficient movement patterns or overuse. Other than that, in rehabilitation, these sensors will monitor muscle activity during recovery exercises, it also can allow patients to assess progress and receive real-time feedback to improve outcomes. Additionally, in human-computer interaction, EMG sensors allow people to control prosthetic devices and other interactive devices using their own muscle signals.

Furthermore, wearable EMG technology has several challenges remain before it can reach its full potential. For instance, noise and artefact reduction. The environmental factors such as electrical interference and movement artefacts can distort EMG signals and making them less accurate. Additionally, accurate sensor placement and calibration are essential for reliable data collection. Finally, data processing and analysis remain complex. As advanced signal processing techniques are needed to extract meaningful information from the complex EMG signals produced during muscle activity.

2.2 User-Friendly EMG Sensor Interfaces for Athlete Performance Analysis

Electromyography (EMG) sensors are increasingly used in sports science to analyze muscle activity and improve athlete performance. However, effectively presenting the complex data generated by these sensors to athletes and coaches requires user-friendly interfaces. One of the key advantages of this interface is its ability to provide real-time feedback during training sessions. As athletes perform various exercises, the EMG sensors capture data on muscle activity, which is then processed and displayed instantaneously on the interface. This feedback loop empowers athletes to make informed decisions and adjusting their technique or intensity based on the classification results. Coaches also can remotely monitor their athletes progress and offering timely guidance.

Furthermore, the interface can offer personalized guidance based on the classification system output. If the system detects muscle imbalance or fatigue, the interface could suggest corrective exercises or recommend adjustments to training intensity. Ideally, the interface should be accessible on various devices such as a smart phone app, a tablet display, or even a wearable device which can allowing athletes to seamlessly integrate EMG biofeedback into their training routines.

Other than that, the impact of a user-friendly interface can extend beyond immediate feedback. By empowering athletes to visualize and understand their muscle function, it will interface fosters a deeper connection with their bodies. So, athletes become active participants in their training journey, able to make informed decisions based on objective data rather than relying solely on intuition. As a result, this data driven approach not only leads to improved performance but also plays a crucial role in injury prevention.

Lastly, by transforming complex muscle activation data into intuitive visualizations and personalized guidance, this interface empowers athletes to become active participants in their training journey. A real-time feedback on muscle activation patterns allows for targeted training and optimized performance. It also can provide real-time insights into muscle function, allowing athletes to optimize training based on objective data.

2.3 Optimizing Performance and Rehabilitation with Wearable EMG Technology

Athletes and coaches have traditionally relied on subjective methods like self-reported feelings or video analysis to assess muscle activity and training effectiveness. However, these approaches are often inaccurate and lack real-time insights. This article, "Electromyography Science for Performance and Rehabilitation" from SimpliFaster, was explores the potential of wearable EMG technology as a game-changer in optimizing athletic performance and aiding rehabilitation efforts.

The article highlights the limitations of traditional methods. Athletes may push themselves too hard or not hard enough based on inaccurate self-assessment, potentially hindering performance or increasing injury risk. Similarly, delayed video analysis offers limited feedback, preventing real-time adjustments in technique. EMG bio-sensor systems offer a promising solution. These devices capture muscle activity in real-time, providing valuable feedback on muscle activation, fatigue levels, and movement patterns. This data empowers athletes and coaches to make informed decisions about training programs, technique refinement, and injury prevention.

For athletes, wearable EMG technology translates to several benefits. First, it enhances self-awareness of muscle activation patterns, allowing them to understand how specific exercises engage different muscle groups. This knowledge can be used to optimize training programs to target specific muscles and minimize unnecessary strain. Additionally, real-time feedback allows athletes to adjust their technique during training, leading to improved performance and reduced risk of injury.

Coaches also benefit from the objective data provided by wearable EMG systems. This allows them to assess the effectiveness of training programs and identify areas where athletes may need more focus. With this data, coaches can personalize training plans based on individual muscle activation patterns, ensuring a more targeted and efficient approach. Moreover, early detection of muscle fatigue through EMG data allows coaches to prevent overtraining and potential injuries.

The article acknowledges some challenges associated with wearable EMG technology. Optimal sensor placement can vary depending on the targeted muscle group and individual body structure. Environmental factors like electrical interference can also affect the quality of the EMG signals. Additionally, analysing this data requires advanced signal processing techniques and expertise, which might not be readily available to everyone. Finally, some devices have limitations in battery life, potentially restricting the duration of monitoring.

Despite these challenges, future research directions aim to address them and further unlock the potential of EMG technology. Advancements in sensor design and placement could enhance data collection accuracy and consistency. Development of advanced signal processing algorithms could improve noise reduction and facilitate more detailed data analysis. Additionally, user-friendly data visualization and interpretation tools could be developed, making EMG data more accessible and actionable for both athletes and coaches.

In conclusion, wearable EMG technology offers a transformative approach to athletic training. By providing real-time feedback on muscle activity, it empowers athletes and coaches to optimize training programs, refine technique, and ensure a safer training environment. With continuous research and development addressing current challenges, EMG systems hold the potential to revolutionize the way athletes train, leading to improved performance and a more informed training experience.

2.3.1 EMG-Guided Neuromuscular Rehabilitation

One promising application of wearable EMG technology lies in the field of neuromuscular rehabilitation. By providing real-time feedback on muscle activity, EMG systems can help individuals recover from injuries and regain motor function.

In the context of rehabilitation, EMG can be used to assess muscle activation patterns, identify muscle weakness, and monitor progress over time. Therapists can use this information to tailor rehabilitation exercises and provide specific feedback to patients. For example, EMG can be used to ensure that patients are performing exercises correctly and with the appropriate level of intensity. Additionally, EMG can be used to detect early signs of fatigue, allowing therapists to adjust the intensity and duration of exercise sessions to prevent overexertion.

Furthermore, EMG can be used to develop and implement biofeedback-based training programs. By providing real-time visual or auditory feedback on muscle activity, these programs can help patients learn to activate specific muscles and improve their motor control (figure 2.1). This can be particularly beneficial for individuals with neurological disorders, such as stroke or spinal cord injury.

In conclusion, wearable EMG technology has the potential to revolutionize the field of neuromuscular rehabilitation. By providing objective and quantitative measures of muscle function, EMG can help therapists develop more effective and personalized treatment plans. As technology continues to advance, we can expect to see even greater integration of EMG into rehabilitation practices.

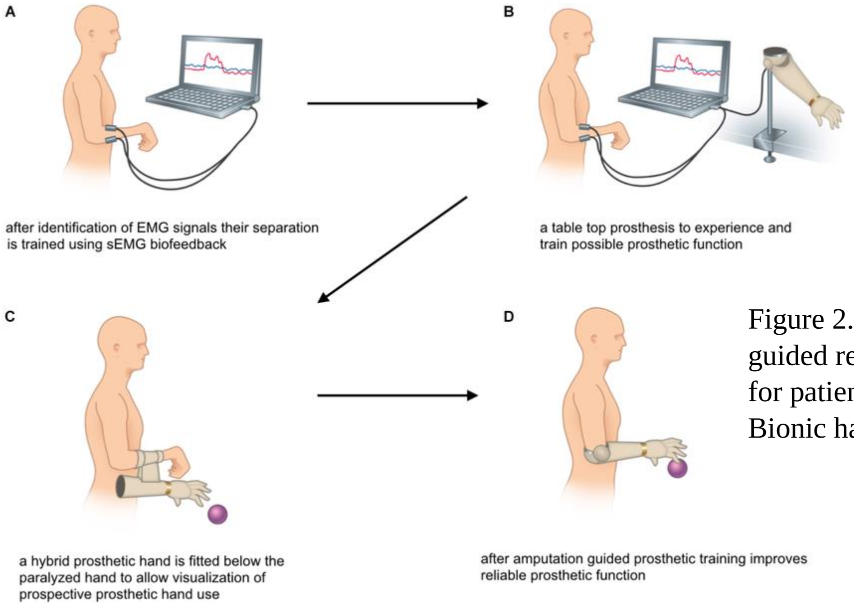


Figure 2.1 EMG guided rehabilitation for patients with Bionic hand

2.4 The Advantages of EMG for Athlete

First of all, EMG data allows coaches to design exercises that target specific muscle groups with greater precision. By analysing EMG signals during exercises, the coach can identify the underactive muscle and design drills to improve its recruitment. This targeted approach optimizes training by ensuring all muscle groups contribute efficiently, leading to improved performance and reduced compensation patterns that can cause injuries.

Then, EMG also can preventing injuries. It can early detection of muscle imbalances or weaknesses is key to injury prevention. EMG also can reveal subtle changes in muscle activation patterns that might otherwise go unnoticed. For example, a weightlifter experiencing fatigue may exhibit increased activation in secondary muscles during a lift, indicating potential risk of form breakdown and injury. By monitoring EMG data, coaches can adjust training intensity or technique to prevent such situations from escalating. In the table 2.1 will show the benefits of this system.

Last but not least, the benefits of EMG extend to athletes in various disciplines. Endurance athletes like cyclists can use EMG to monitor fatigue levels, ensuring they pace themselves optimally. Rehabilitation specialists can leverage EMG to track muscle recovery after injury, facilitating a more data-driven approach to rehabilitation.

ADVANTAGES	**DISADVANTAGES.**
EMG data reveals muscle activation patterns, allowing athletes to identify weaknesses and imbalances.	Setting up and interpreting EMG data can require technical expertise, potentially hindering user adoption.
Early detection of muscle fatigue or imbalances helps prevent overuse injuries.	EMG primarily focuses on muscle activation and may not capture other factors affecting performance, such as cardiovascular fitness or psychological aspects

EMG data can be used to personalize training programs based on individual muscle function and performance goals.	Surface EMG electrodes might cause discomfort during prolonged use, while intramuscular electrodes are invasive and require a medical professional for placement.
Real-time EMG bio-sensor allows athletes to visualize muscle activation and learn to activate specific muscle groups more efficiently, improving coordination and movement patterns.	High-quality EMG systems can be expensive, limiting accessibility for some athletes.

Table 2.1. The Advantages and Disadvantages EMG System for Athlete

2.5 Related Project

The previous research has explored the potential of EMG technology for athletic performance. We found that many studies have relied on expensive, complex systems that are not readily accessible to athletes. These systems often require specialized expertise to operate or maintain and also to limiting their widespread adoption. In contrast, this project aims to develop a low-cost, user-friendly wearable EMG system that can be easily integrated into training routines. By utilizing simple electronic circuits and affordable sensors, we aim to make EMG technology more accessible to a wider range of athletes.

Furthermore, these focused on laboratory-based studies, where participants are tethered to equipment and limited in their movement. This wearable EMG system is designed to be portable and wireless system, which can be allowing for unobtrusive monitoring of muscle activity during real-time training and competition. By capturing these data, we can provide useful details about the athletic performance and help spot areas where improvements can be made.

2.5.1 Project 1: Arduino-Based EMG System

Based on my research, the common method for building EMG system was uses the Arduino microcontrollers. Arduino is easy to use for prototyping and it often creates systems that use a lot of power and are not very portable. Additionally, this project has the complicated wiring and setup (Figure 2.2). It can be challenging for people without technical skills. These issues make it harder for EMG technology to become widely adopted, especially by athletes and coaches who need a more practical and easy-to-use solution. So, to overcome these limitations, this project aims to create a smaller, more efficient, and user-friendly EMG system. By using a more advanced microcontroller like the ESP32, this project can achieve a more compact design and reduce power consumption. In addition, I also plan to simplify the circuit design and use wireless communication to improve portability and make the system easier to use.

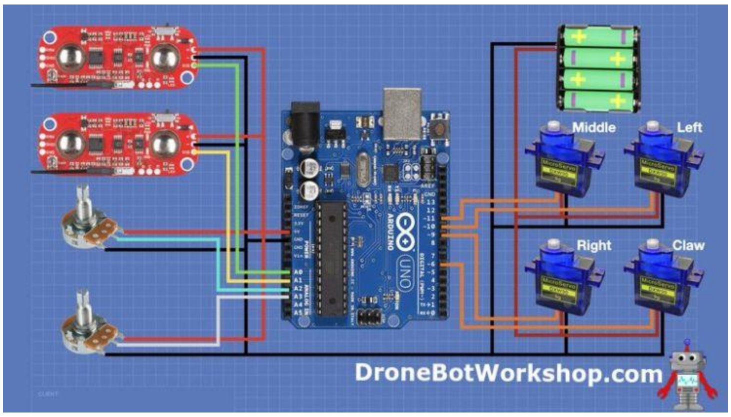


Figure 2.2 Arduino Based EMG System

2.5.2 Project 2: EMG Signal Controlled Game

The idea of this project is to design and implement two channels EMG signal controlled video game (show in Figure 2.3). The player controls the motion of the ball to the left or to the right to avoid the descending obstacles. Then, the electrode will be placed to the back of the player hands to measure the voltage difference of the muscles when squeezing the hands. The signal will be filtered by a band-pass filter and amplified before sending to the ADC channels of the PIC32 microcontroller. A valid hand motion will allow the player to move the ball to interact with the game.

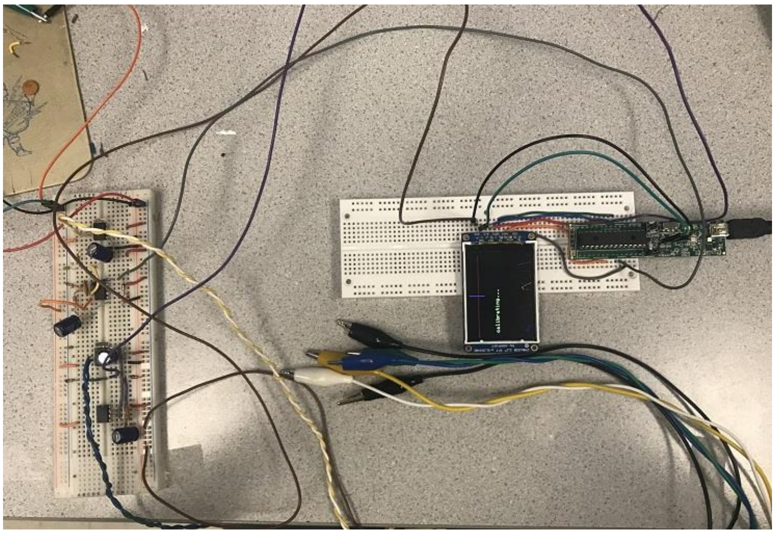


Figure 2.3. EMG Signal Controlled Game

2.6 Comparison of Project

Based on my research, Arduino-based systems offer a flexible platform for prototyping. They often suffer from limitations in terms of processing power, wireless connectivity, and power consumption. This will make the project larger, heavier and less energy-efficient devices. In contrast, ESP32-based systems provide a more powerful and versatile solution, enabling advanced features like real-time data processing and wireless communication.

However, EMG signal channels were implemented to measure low level signal. The signals were able to control the ball movement accurately. Then, the calibration stage adjusts the signal to a standard level prior to starting the game, which allows any person to play the game without manually adjusting the program. Furthermore, the player can place the electrode at any convenient place rather than just the back of the hand. So, the comparison for these project was show in Table 2.2

Table 2.2 Comparison between previous projects

Comparison	Project 1	Project 2	Proposed Project
Microcontroller	Arduino Nano	Band Pass Filters	ESP32
Cost	RM 800	RM 400	RM 200
Size	100cm x 60cm x 30cm	80cm x 40cm x 30 cm	30cm x 15cm x 15cm
Sustainability to the environment	Using Battery	Using Power Supply	Powered by direct power supply
Wireless Connectivity	Limited or requires additional modules	Used the USB cable	Built-in Wi-Fi and Bluetooth
Data Storage and Analysis	Limited data storage and analysis capabilities	Limited data storage and analysis capabilities only display ADC graph	Can store and analyze data locally
Data Processing Capabilities	Limited real-time processing capabilities, often relying on external processing units	Process data once time	Capable of real-time signal processing and feature extraction

2.7 Summary

In conclusion, this chapter explored the current state of wearable EMG technology and its potential applications in various fields. For example, it was including sports performance and rehabilitation. This chapter also discussed the limitations of traditional EMG systems, which often involve bulky equipment and complex setups. In contrast, wearable EMG systems offer a more convenient and accessible solution, enabling real-time monitoring of muscle activity.

However, challenges such as noise reduction, sensor placement, and power consumption remain. To address these limitations, the EMG Biosensor aims to develop a compact, user-friendly, and energy-efficient wearable EMG system. By incorporating advanced signal processing techniques and innovative design approaches, we aim to provide accurate and reliable muscle activity data.

The next chapter will delve into the technical details of the proposed system, including the hardware components, software algorithms, and data processing techniques.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will delve into the specific design considerations, hardware components, software algorithms, and testing procedures that underpin the project. The initial step involved a comprehensive analysis of existing EMG systems, identifying their strengths, weaknesses, and limitations. This analysis informed the design decisions for our proposed system, aiming to address the shortcomings of previous approaches. Other than that, the subsequent section will focus on the hardware design, which including the selection of suitable EMG sensors, microcontrollers, and wireless communication modules. In this chapter also will discuss the considering factors such as sensitivity, noise reduction, power consumption, and ease of use. Finally, the chapter will conclude with a description of the testing and evaluation procedures. This will involve real-time trials to assess the system's performance in various conditions. By rigorously testing the system, we aim to identify potential limitations and areas for improvement.

3.2 Project Design and Overview

The proposed wearable EMG bio-sensor system is designed to be a compact, user-friendly, and efficient device capable of monitoring muscle activity in real-time. So, the system consists of three main components:

a) Hardware

The hardware component includes a set of EMG sensors, a microcontroller, and a power source. The EMG sensors are strategically placed on the user's skin to capture electrical signals generated by muscle contractions. Figure 3.1 show that the EMG electrode place. These signals are then amplified and filtered by the microcontroller, which extracts relevant features such as muscle activation levels and fatigue indicators.

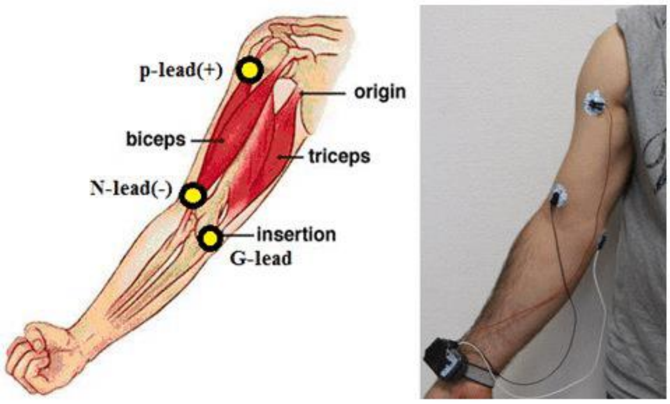


Figure 3.1. EMG Electrode Placement

b) Software

The software component is responsible for processing the raw EMG signals, extracting meaningful features, and displaying the results on a user-friendly interface. For example, as show in the figure 3.2 below. The software will employ advanced signal processing techniques, such as noise reduction, filtering, and feature extraction algorithms.

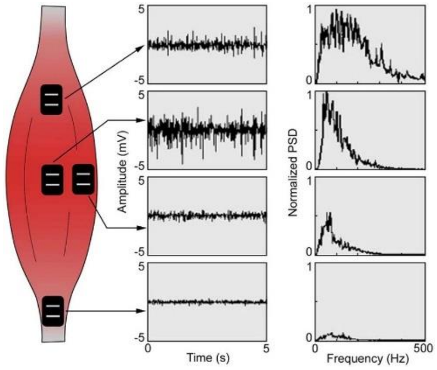


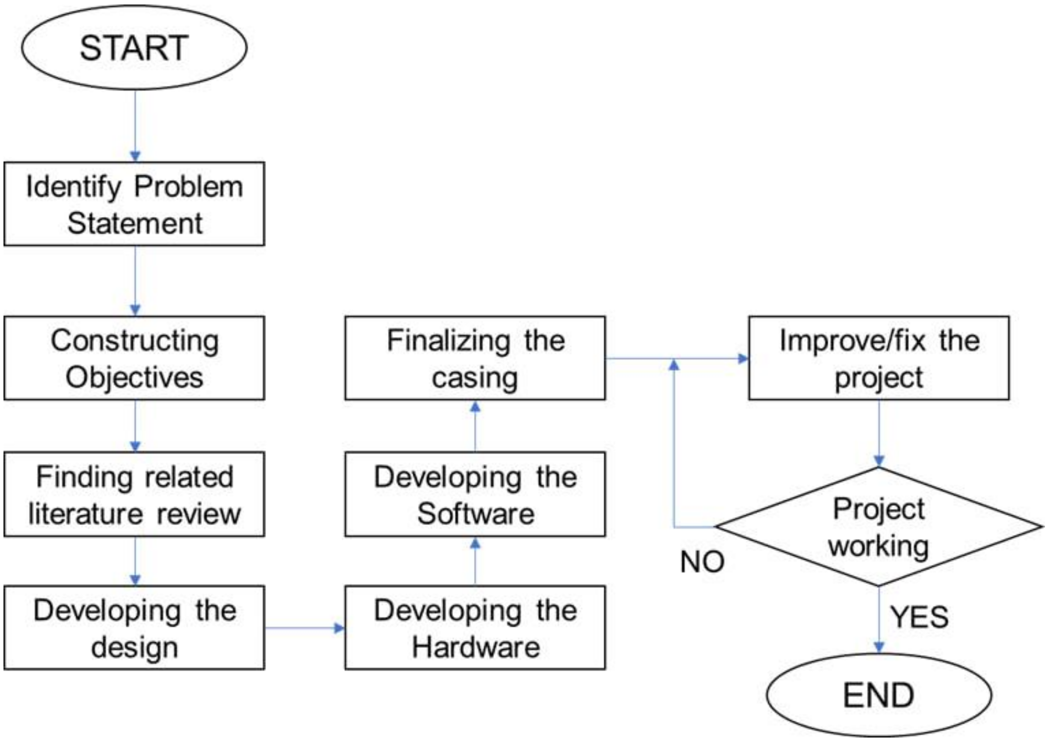
Figure 3.2 EMG Signal

c) **User Interface**

The user interface will provide a clear and intuitive way for users to interact with the system. It will display real-time data on muscle activity, allowing users to monitor their performance and make adjustments to their training regimen.

3.2.1. Project Planning Flow Chart

Based on thorough research and studies, I have identified specific steps required to create this project. These steps guide the development process to ensure that the EMG biosensor is effective and reliable. Flowchart below illustrates the structured process followed in developing the EMG biosensor and also providing a clear overview of each stage involved.



Process flow of the project

As we can see, the flowchart above is the overall workflow of the project. The process begins with the identification of the problem statement, which involves defining the specific goals and objectives of the project. Once the problem statement is established, the next step is to construct clear and measurable objectives to guide the development process.

Then, thorough literature review is carried out to find relevant research and the latest techniques in EMG technology. This information helps guide the design and development of the system. In the design phase, both hardware and software components are created. For example, it was including selecting the right sensors and microcontrollers. Next, the hardware and software are combined and tested to make sure they work as intended. If the system meets the requirements, it moves to the finalization phase, where the design is refined, any issues are resolved, and the system is prepared for user testing. If the system does not meet the, improvements, the testing process is repeated.

Once the system is finalized and tested, it ready for user evaluation. Feedback is gathered to assess its usability, accuracy, and overall performance. Based on this feedback, further adjustments may be made to enhance the system.

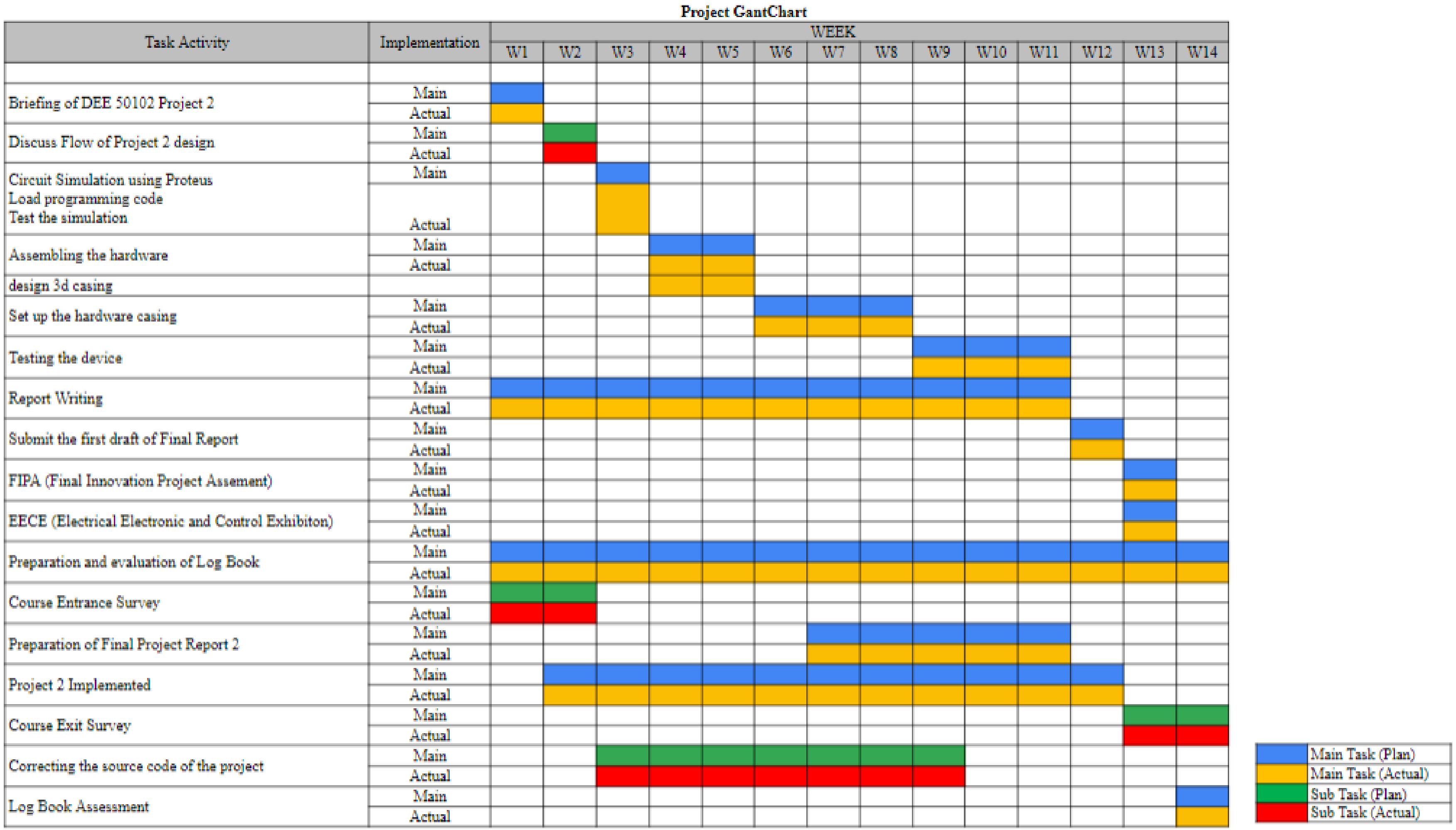
3.2.2 Project Gant Chart

The Gantt chart below provides a clear timeline of all the main tasks for Project 1 and Project 2 over a 14-week period. Below is the Table 3.1 and Table 3.2 that show about the Gant Chart for these project. It shows of each key activity by starting with the project briefing and design discussions. Then, its moving through stages such as building the hardware, testing the software, and creating reports. By showing both the planned and actual progress for each task, the chart allows for easy identification of any adjustments made to the original schedule. This organized timeline supports effective tracking of the project's progress and ensures that all tasks remain aligned with deadlines and goals.

Table 3.1 The Gant Chart for Project 1

TASK/ WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Select project to undertake and plan project	🟩	🟩												
Find and research the problem statement and objective for the project		🟩	🟩											
Presentation the project to confirmation of the topic			🟩	🟩										
Start writing the literature review				🟩	🟩	🟩								
Prepared infographic and survey costing of the project				🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Prepared and submit Investigation Report Draft						🟩	🟩							
Completing the investigation report							🟩	🟩	🟩					
Construct circuit for mini project								🟩	🟩	🟩				
Starting soldering the component									🟩	🟩	🟩	🟩		

Solve the problem that occur with this project									🟩	🟩	🟩	🟩	🟩	🟩
Final project presentation												🟩	🟩	🟩
Prepared and proposal												🟩	🟩	🟩
Submit proposal													🟩	🟩



Project GantChart

Task Activity	Implementation	WEEK													
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Briefing of DEE 50102 Project 2	Main	🟦													
	Actual	🟨													
Discuss Flow of Project 2 design	Main		🟩												
	Actual		🟥												
Circuit Simulation using Proteus Load programming code Test the simulation	Main			🟦											
	Actual			🟨											
Assembling the hardware	Main				🟦	🟦									
	Actual				🟨	🟨									
design 3d casing					🟨	🟨									
Set up the hardware casing	Main						🟦	🟦	🟦						
	Actual						🟨	🟨	🟨						
Testing the device	Main									🟦	🟦	🟦			
	Actual									🟨	🟨	🟨			
Report Writing	Main	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦			
	Actual	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨			
Submit the first draft of Final Report	Main												🟦		
	Actual												🟨		
FIPA (Final Innovation Project Assement)	Main													🟦	
	Actual													🟨	
EECE (Electrical Electronic and Control Exhibiton)	Main													🟦	
	Actual													🟨	
Preparation and evaluation of Log Book	Main	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
	Actual	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
Course Entrance Survey	Main	🟩	🟩												
	Actual	🟥	🟥												
Preparation of Final Project Report 2	Main							🟦	🟦	🟦	🟦	🟦			
	Actual							🟨	🟨	🟨	🟨	🟨			
Project 2 Implemented	Main		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
	Actual		🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨		
Course Exit Survey	Main													🟩	🟩
	Actual													🟥	🟥
Correcting the source code of the project	Main			🟩	🟩	🟩	🟩	🟩	🟩	🟩					
	Actual			🟥	🟥	🟥	🟥	🟥	🟥	🟥					
Log Book Assessment	Main														🟦
	Actual														🟨

🟦	Main Task (Plan)
🟨	Main Task (Actual)
🟩	Sub Task (Plan)
🟥	Sub Task (Actual)

Table 3.2 The Gant Chart for Project 2

First of all, this Gantt chart provides a detailed timeline and progress report for the tasks involved in Project 2, which the period is 14 weeks. Each task is shown in a row, with "Main" representing the planned schedule and "Actual" showing the real progress. The project starts in Weeks 1 and 2 with the initial briefing and discussion of the project design. Tasks like simulating the circuit in Proteus and loading the programming code follow in Weeks 2 to 4, with testing planned in Weeks 3 to 5. Any delays or early completions are shown by the difference between the "Main" and "Actual" bars.

In Weeks 3 to 7, it shows that we were assembling the hardware and designing the 3D casing. The actual progress is shown alongside the planned schedule, highlighting any adjustments in timing. Report writing is scheduled for Weeks 7 to 8, with the first draft of the final report due in Week 9. Other than that, for weeks 9 and 10 have events like the Final Innovation Project Assessment (FIPA) and the Electrical Electronic and Control Exhibition (EECE). Meanwhile, we were preparing the Log Book and completes entrance and exit surveys from Weeks 10 to 14.

The final stages, including preparation of the final project report and project implementation are planned for the last few weeks. By comparing the "Main" and "Actual" timelines, this chart makes it easy to see if each task was completed on time, delayed, or finished early. This structured timeline helps keep the project on track and ensures that all tasks are completed efficiently.

3.2.3 Block Diagram of the Project

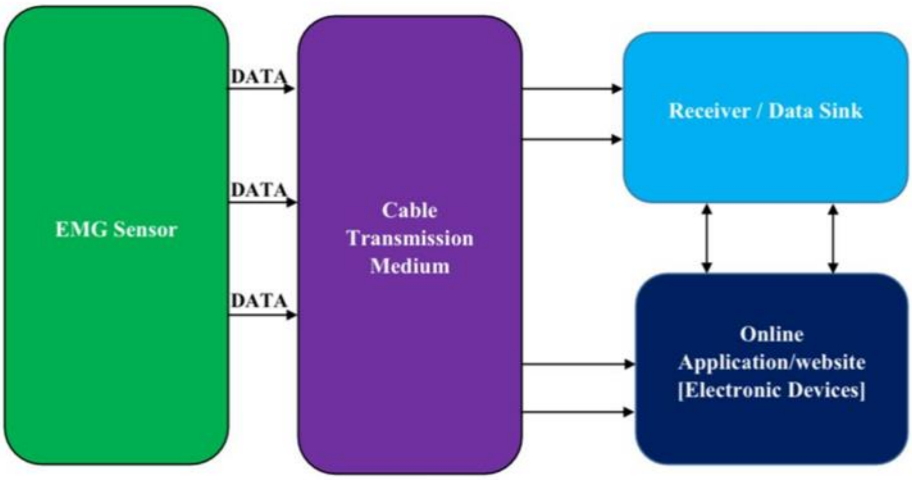
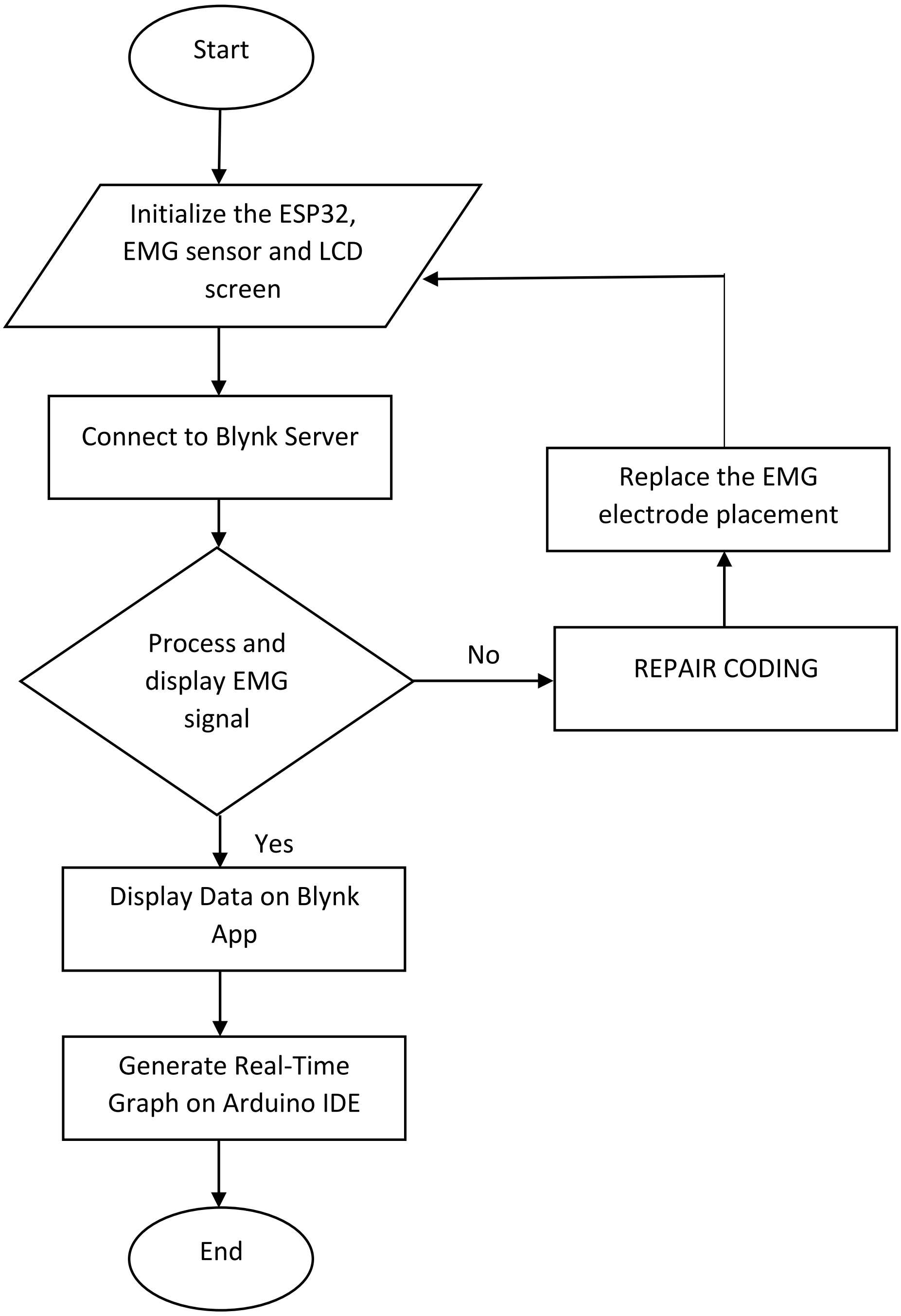


Figure 3.3 Block Diagram for EMG Biosensor

This diagram represents a system for capturing and transmitting data from an Electromyography (EMG) sensor. EMG sensors measure electrical activity in muscles. The system in the diagram takes this data, processes and sends it to a receiver or online application for further analysis or display. Based on the figure 3.3 above, I identify that the EMG sensor is the main components for these project. An EMG sensor captures electrical signals from muscles and sends them via a cable or wirelessly to a receiver. This receiver forwards the data to an online application (IoT Application). Other than that, when the data is processed and will be analysed to provide insights into muscle activity. These insights can be used for various purposes, such as optimizing athletic performance, tracking rehabilitation progress, or even controlling devices through muscle signals. Last but not least, the potential applications of this system include sports performance analysis, where athletes can monitor their muscle activity during training to optimize their performance

3.2.4 Project Flow Chart

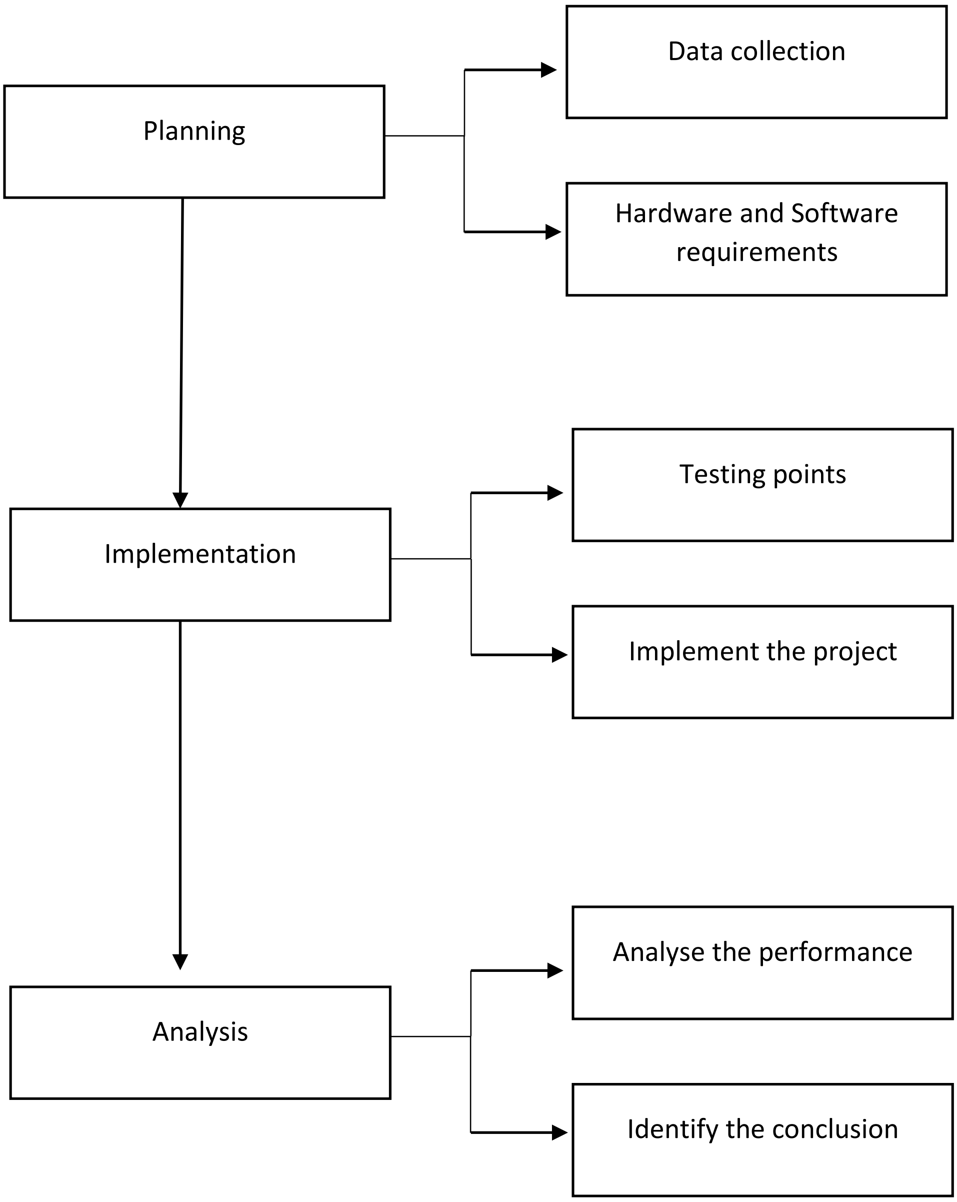


Based on the flowchart above, the process begins by initializing the ESP32 microcontroller, the EMG sensor, and the LCD screen. This ensures that all components are ready for operation. Next is the ESP32 will connects to the Blynk server, which is an IoT platform that enables remote monitoring and control of devices. The EMG signal is then read from the Myoware sensor and processed to extract relevant features. The processed signal is displayed on the LCD screen for local monitoring. Simultaneously, the processed data is transmitted to the Blynk server, where it can be visualized in real-time on the Blynk app. This allows for remote monitoring and analysis of muscle activity. Additionally, the Arduino IDE can be used to generate real-time graphs of the EMG data, providing a more detailed visual representation of muscle activity patterns. If the EMG electrode placement is incorrect or the signal quality is poor, the suggestion for this project is replacing the electrode placement and potentially repairing the coding.

3.2.5 Project Description

This project focuses on developing an EMG biosensor to monitor muscle activity in real-time. However, during the process of making these project, I identify that the EMG Biosensor aims to develop a user-friendly EMG biosensor system that can capture, process, and transmit muscle activity data to a smartphone app for remote monitoring and analysis. Other than that, it also can explore the design and implementation of an EMG biosensor that will integrated with IoT technology. Through this way, it can enable the real-time monitoring and analysis of muscle activity.

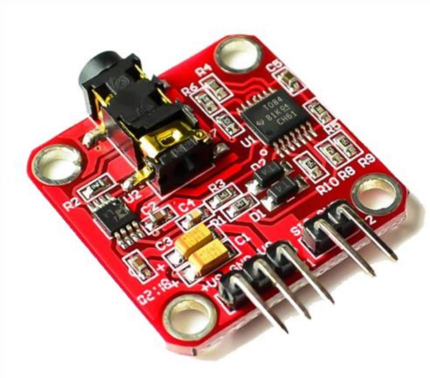
Below is the flowchart for EMG Project Process:



3.3 Project Hardware

This project hardware design to integrates a variety of components essential for capturing, processing, and displaying EMG (electromyography) data. First of all, I identify that the key components were include the ESP32 microcontroller, EMG Myoware sensor, and a 1602 LCD screen with I2C module. All the components were connected through stable wiring and electrode patches. Together, these parts work cohesively to monitor muscle activity in real time and provide valuable insights through a user-friendly interface. So, to describe each of the component, below is the Table 3.3 to explain the project hardware.

Table 3.3 Project Hardware for EMG Biosensor

No	Components	Description
1.	ESP32-WROOM 	The ESP32-WROOM module serves as the main microcontroller for this system. It will manage the data processing, communication, and control of other connected components. This microcontrollers also built with Wi-Fi and Bluetooth capabilities, and suit for wireless communication
2.	EMG Myoware Sensor 	The Myoware EMG sensor is a sensor designed to measure electrical activity that generated by muscle contractions. It captures analog EMG signals and converts them into a format compatible with the ESP32 microcontroller. This sensor also enabling efficient monitoring and analysis of muscle activity

3.	EMG Electrode Cable 	The electrode cable serves as the connection between the Myoware sensor and the ECG patches or electrodes placed on the skin. This cable is designed to transmit muscle signals with minimal noise and reliable signal from the muscle.
4.	ECG Patch or Electrode 	ECG patches or electrodes are adhesive components placed on the skin to capture electrical signals produced by muscle contractions.
5.	Jumper Wires (MM and FM) 	Jumper wires are used to establish flexible and stable connections between different components in the circuit
6.	LCD Screen 1602 with I2C Module Shield 	The 16x2 LCD screen with an I2C module shield provides a simple yet effective interface to display real-time EMG data

3.3.1 Schematic Circuit

The circuit was designed by using the **Proteus Design Suite** (Figure 3.4), where each component connection was carefully planned. After selecting the components, the next step was circuit design. By using the Proteus Design Suite, the circuit diagram was created. I carefully considering all interconnections between components, including power supply, ground, and signal connections. After the circuit diagram complete, the circuit was simulated within Proteus to validate its functionality. This simulation step was crucial as it allowed for troubleshooting and optimizing performance by identifying and correcting potential design errors.

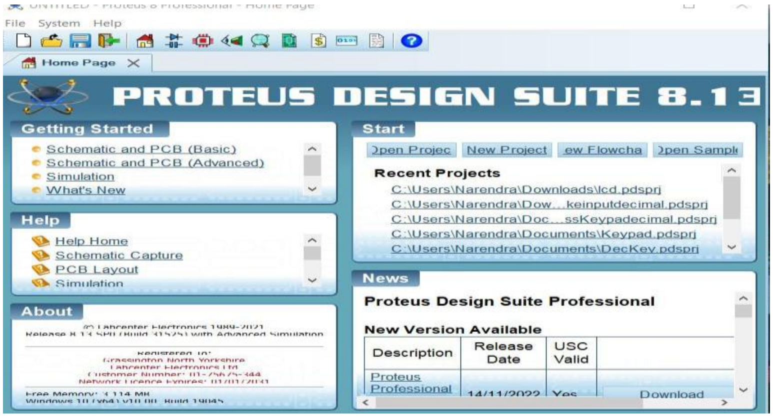


Figure 3.4 Proteus Design Suite

My circuit diagram for EMG Biosensor was created with the ESP32 that connected to the Myoware sensor to receive EMG signals. Then it was processed and sent to the LCD for display. Other than that, the jumper wires facilitated the connectivity between each component meanwhile the I2C module was made with the LCD integration efficient and straightforward. Furthermore, in this project I also used the ECG patches and electrode cables. These components were used to establish a reliable connection between the muscle and the EMG sensor. It also allowing accurate signal acquisition. As shown as in the Figure 3.5 and Figure 3.6

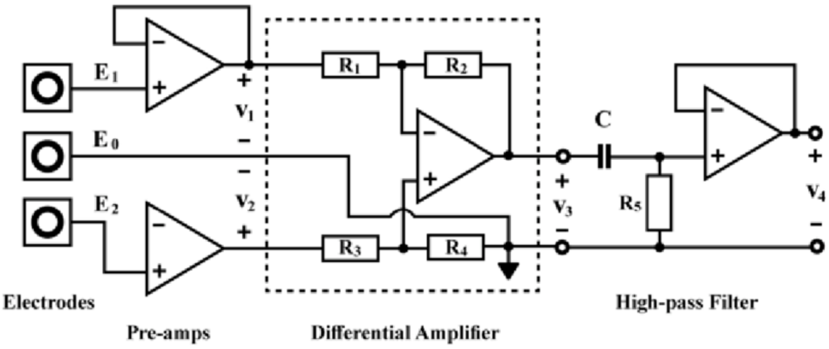


Figure 3.5 Circuit Diagram of EMG Sensor

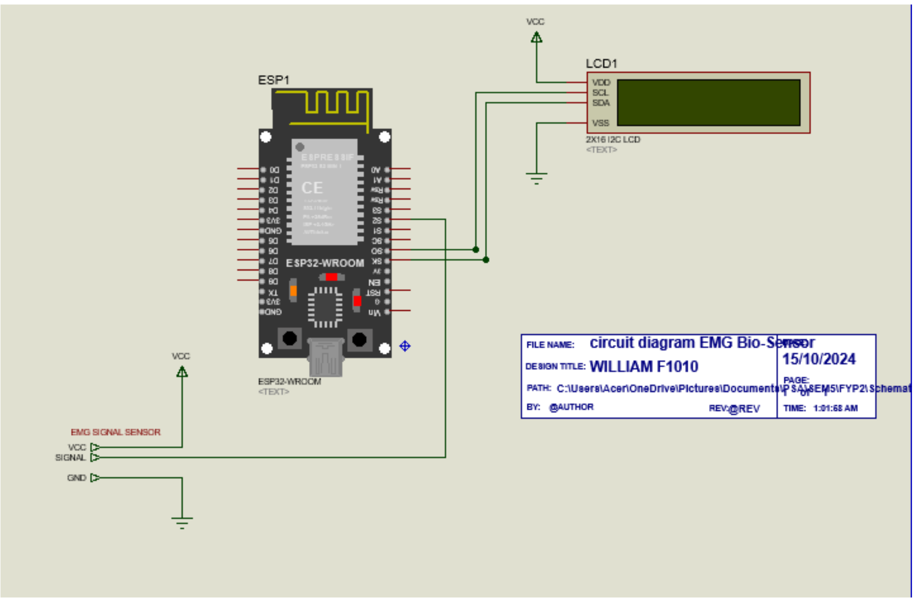


Figure 3.6 Schematic circuit for EMG Biosensor project

3.3.2 Description of Main Components

This project integrates four essential hardware component and each component are performing their vital role. All of these components is to measure, process, and display muscle activity data. So, the main components for these EMG Biosensor project is the EMG Myoware sensor, ESP32-WROOM microcontroller, 1602 LCD display with I2C module and EMG electrodes.

a) EMG Myoware Sensor

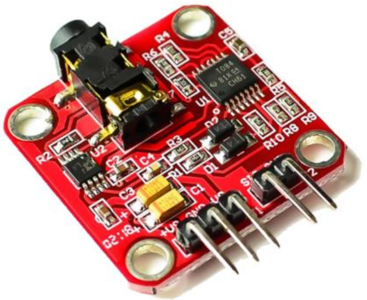


Figure 3.7 EMG Myoware Sensor

The EMG (Electromyography) Myoware sensor is the main component for muscle signal detection (figure 3.7). When muscles contract, they generate small electrical signals due to the activity of muscle fibres. The Myoware sensor is designed specifically to detect these signals from the skin surface and convert them into an analog voltage signal that reflects the level of muscle activity. Other than that, this sensor is small and lightweight, which allows it to be easily attached near muscles on the body. The Myoware sensor includes built with filters and amplifiers to clean up the muscle signals, reducing noise and enhancing signal clarity. This is critical for accurate monitoring, as muscle signals are typically weak and prone to interference.

b) ESP32-WROOM

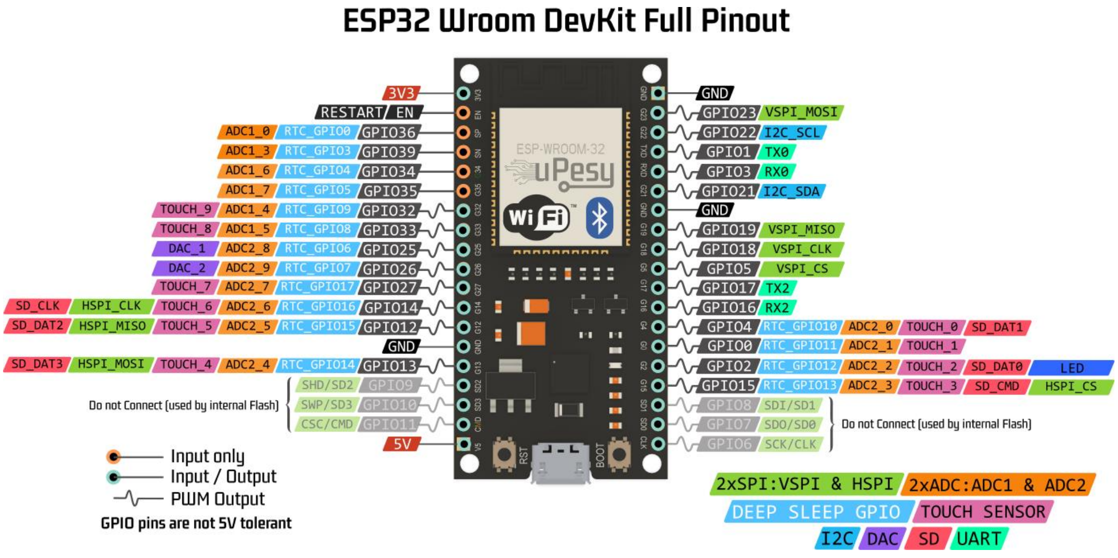


Figure 3.8. ESP32 WROOM

The ESP32 microcontroller is the brain of these project (Figure 3.8). It was responsible for processing the data and collected by the Myoware sensor. The ESP32 has a dual core processor which allows it to handle multiple tasks at once. For example, it will read the EMG data, running signal processing algorithms and controlling the display without lag or delay. Other than that, since the Myoware sensor provides an analog signal, the ESP32 was built with ADC. This ESP32 will converts analog voltage into digital data that it can process. This allows the ESP32 to accurately read and corresponding to the strength of the muscle contractions. The most important part is this microcontroller was built-in Wi-Fi and Bluetooth modules. The ESP32 enables wireless data transmission and allows the EMG data to be sent to external devices. For example, such as a smartphone by using applications like Blynk.

c) 1602 LCD display with I2C module

Figure 3.9 LCD Screen

In EMG Biosensor project, the LCD screen (Figure 3.9) will provides a real-time readout of muscle contraction levels and system status messages which allowing the user to see feedback immediately. For example, it might show the intensity of muscle contractions as numerical values graphs and giving an instant indication of muscle activity. Then, the LCD display is easy to read and provides a clear view of muscle activity. This makes it ideal for applications where simple and direct feedback is required. For example, such as in fitness monitoring.

d) EMG Electrode

Figure 3.10 EMG Electrode

EMG electrodes (Figure 3.10) are small adhesive patches that detect electrical signals from the muscles and relay these signals to the EMG sensor. For this project, EMG electrodes are placed on the skin over the target muscles. When the muscle contracts, these electrodes pick up the small electrical signals generated. They are designed to stick firmly to the skin and ensuring stable contact that is essential for consistent signal acquisition. Furthermore, the EMG electrodes serve as the first point of contact for muscle signals. It also enabling accurate and efficient data collection directly from the body.

3.3.3 Circuit Operation

The circuit works by being controlled by the ESP32 microcontroller. The ESP32 microcontroller will detect muscle activity, processing this data, and displaying it on an LCD screen. First of all, when we flex or move our muscle, the electrical signals will generate. The EMG Myoware sensor that were connected to ECG patches and will be on your skin will picks up these signals. The EMG electrode cable links the patches to the sensor and allowing it to collect the muscle signals effectively.

Then, once the EMG sensor picks up these signals, it sends them as analog data to the ESP32 microcontroller. The ESP32 takes this raw data and processes it. It also will analysing the muscle activity based on the signal strength and frequency. This processing step is important because it will filter and interprets the data.

Lastly, after processing the muscle data, the ESP32 sends the information to the 1602 LCD screen. This screen shows the real-time muscle activity data, which can include levels of muscle contraction or relaxation. The display is updated as the muscle activity changes and giving us the immediate feedback.

3.4 Project Software

During the process of making this project, I did some research and study about the suitable software for EMG Biosensor by using ESP32 with Iot application. So, I found that the software component of this project was involves two key tools which is the Arduino IDE and the Blynk IoT platform.

I. Arduino Integrated Development Environment (IDE)

First of all, is the Arduino IDE software (Figure 3.11). The Arduino IDE serves as the programming environment for the ESP32 microcontroller. This powerful microcontroller is the brains of the operation will responsible for tasks like acquiring raw EMG signals from the sensor. It also will process the signals to extract meaningful information and transmitting the data wirelessly to a smartphone or computer. Other than that, the Arduino IDE is a cross platform application written in Java. It is capable of compiling and uploading programs to the board. A language reference in Arduino programs can be divided in several parts which is the values for variables with constants and functions. It will run machine code compiled from either C, C++, Java4 or any other language that has a compiler for the Arduino instruction set.

Figure 3.11 Arduino IDE Software

II. Blynk Internet of Thinking (IoT) Platform

Blynk is an IoT platform that simplifies the process of creating and managing IoT applications (Figure 3.12). It enables users to connect various devices such as sensors and microcontrollers. This platform will directly to the cloud and control them remotely through a mobile or website. The platform also offers cloud connectivity and enabling real-time data monitoring and storage. Furthermore, the Blynk platform provides a user-friendly interface for monitoring and controlling the device. It enables real-time visualization of the EMG data and allowing users to see their muscle activity patterns. Additionally, Blynk can store historical data for later analysis and comparison. By using the platform, we can view real-time EMG data on our smartphones or computers.

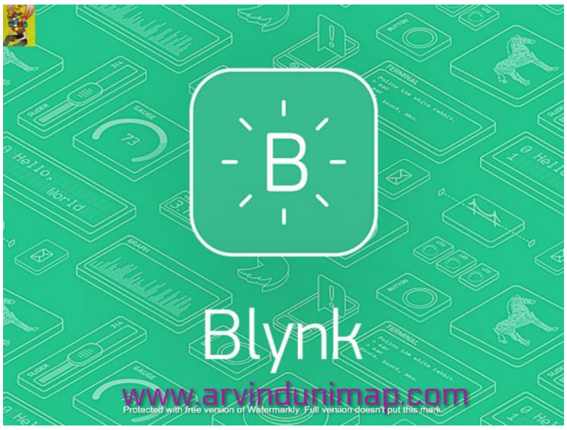


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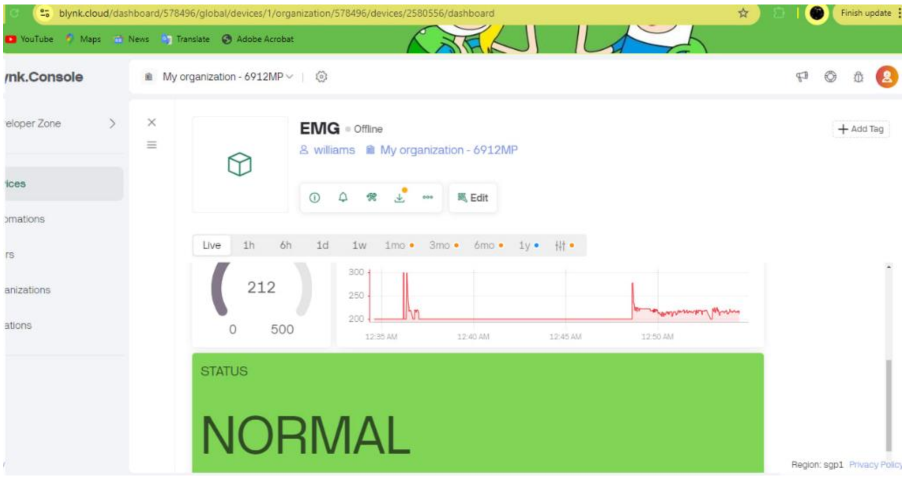
Figure 3.12 Blynk Application

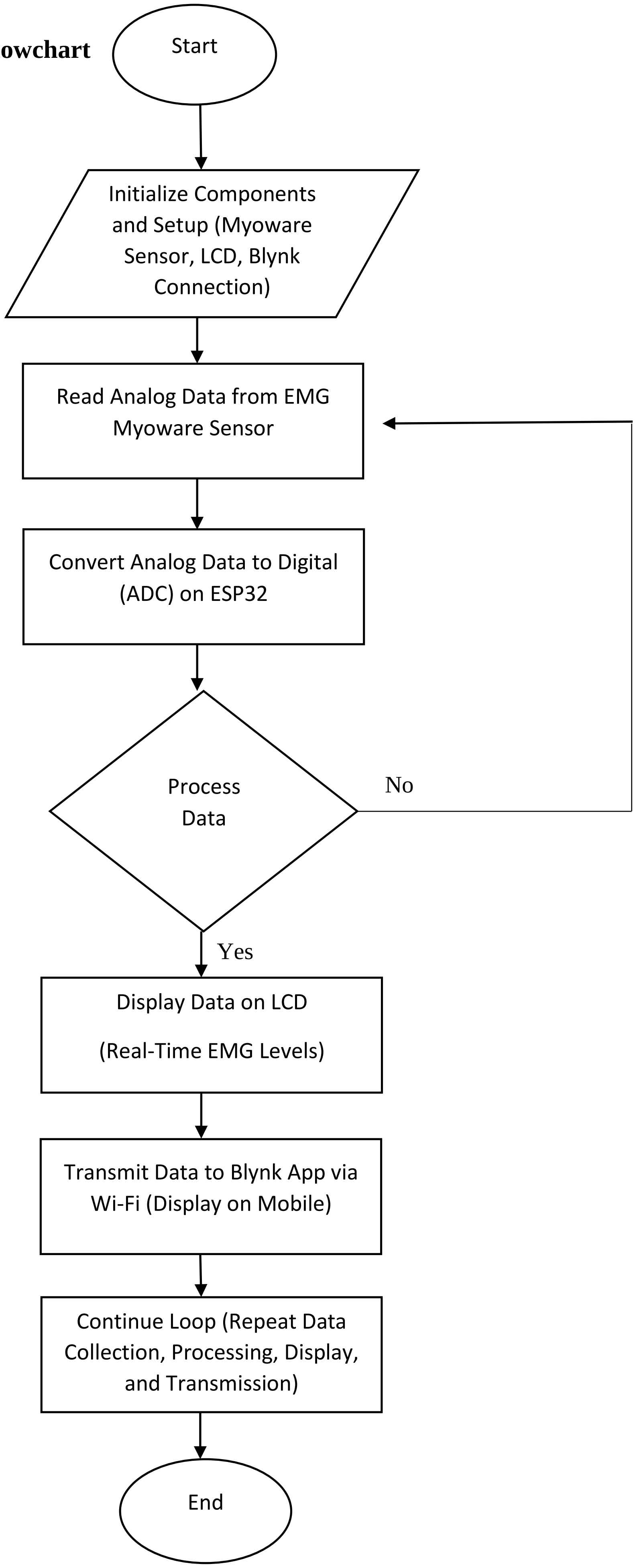

blynk.cloud/dashboard/578496/global/devices/1/organization/578496/devices/2580556/dashboard

EMG Offline
williams My organization - 6912MP

STATUS

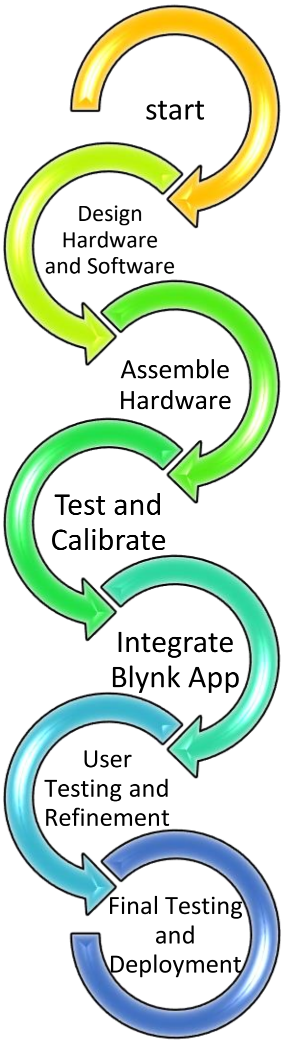
NORMAL

3.4.1 System Flowchart



3.5 Prototype Development

This section delves into the practical aspects of bringing the EMG biosensor project to real life. It covers the hardware assembly and software development that involved in creating a functional and reliable device. So, below is the block diagram for project development process



In the hardware assembly phase, each component was carefully choosing for its compatibility and performance. This was including the ESP32 microcontroller, Myoware muscle sensor, LCD display, and power supply. The circuit was designed to ensure efficient power distribution and signal flow between components. The components were then assembled on a breadboard with connections made using wires and soldering techniques.

The next phase was software development. This phase was included creating firmware for the ESP32 microcontroller by using the Arduino IDE. This firmware was designed to read raw EMG signals from the Myoware sensor and process these signals with filtering the data. It also extracts key features like muscle activation levels and fatigue. The processed data will display on the LCD screen and transmitted to the Blynk app with via Wi-Fi. Additionally, a user-friendly mobile app was created on the Blynk platform to display real-time EMG data, log historical data, and provide a simple interface for monitoring and control.

In the testing and calibration phase, each hardware component was tested individually to confirm functionality. The firmware was checked to ensure accurate signal acquisition, processing, and transmission. The Myoware sensor was calibrated to provide accurate readings. Finally, all the hardware and software components were integrated and tested as a complete system.

3.5.1 Mechanical and Product Design

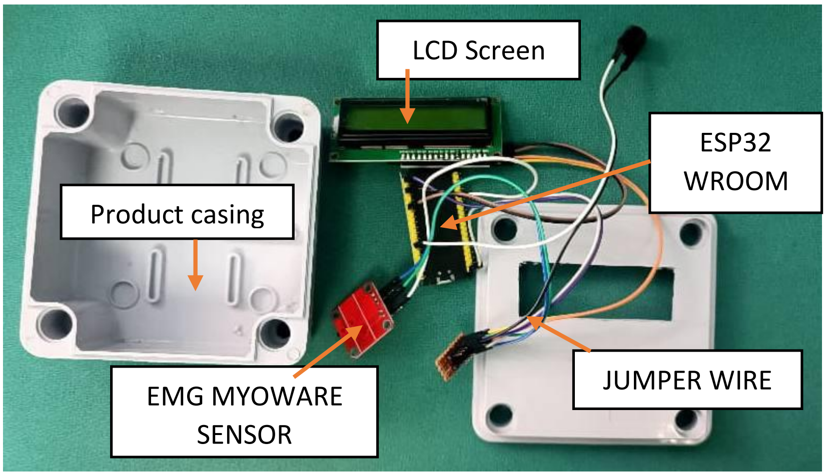
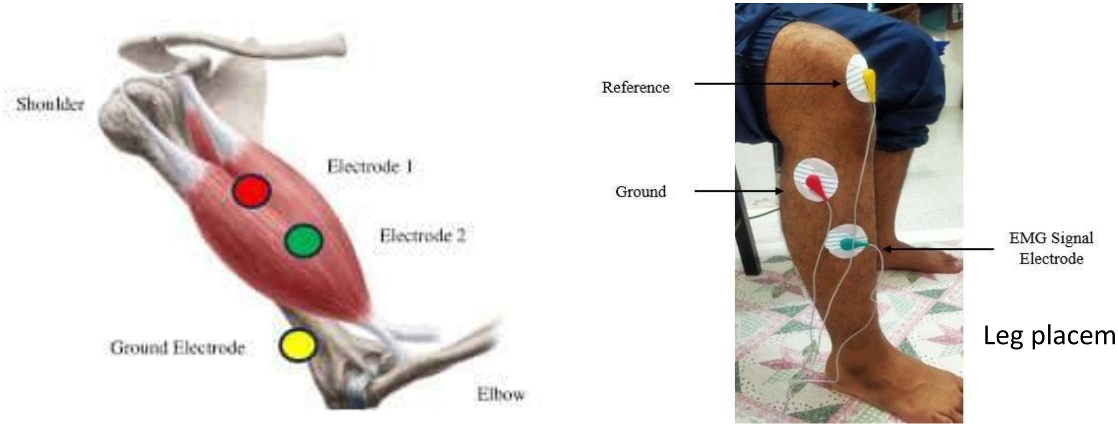


Figure 3.13 Mechanical Design for EMG Biosensor

The mechanical design of the EMG biosensor (Figure 3.13) was created due to durability, and functionality. This project was made by materials like ABS plastic which can essential to protect the internal components. Then, the enclosure was designed to fit comfortably on the athlete arm or leg. For example, I was created it with secure straps or clips to keep it in place. Proper cable management within the enclosure is crucial to prevent damage and interference with the sensor's performance.

Other than that, the placement of electrodes on the skin is important to get an accurate muscle activity measurement. Research and experimentation can help determine the optimal placement for different muscle groups. The electrodes should be attached securely using adhesive electrodes or reusable straps to minimize movement and noise in the signal. Figure 3.14 below show that the correct placement in arm and leg for EMG electrode.



Arm placement

Leg placement

Figure 3.14

Last but not least, the product design focuses on creating a user-friendly experience. This product design was show in Figure 3.15 below. The LCD screen should display clear and concise information, such as real-time muscle activity data and system status. The Blynk app should provide a visually appealing and intuitive interface for remote monitoring and control. The device should be comfortable to wear, lightweight and portable.

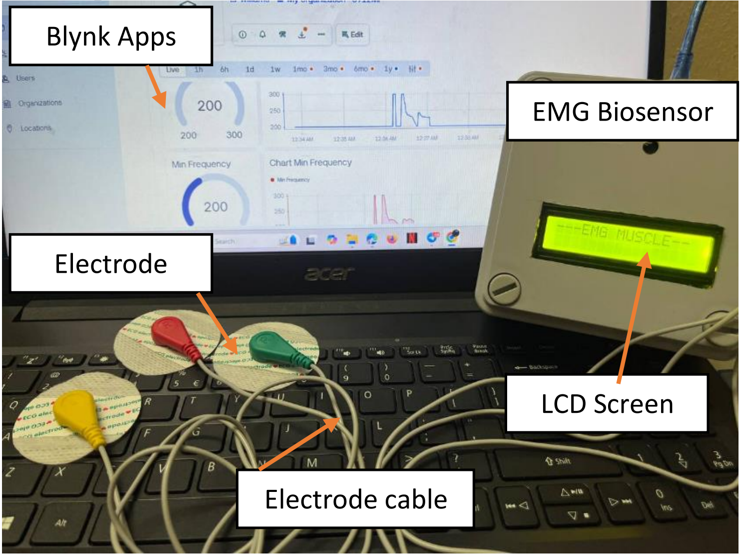


Figure 3.15 Product Design For EMG Biosensor

3.6 Summary

In conclusion, the EMG biosensor is designed with user comfort and durability. It has a lightweight, strong casing and a secure way to attach it. The placement and attachment of the electrodes are carefully chosen to accurately measure muscle activity, which is crucial for getting reliable results. The device also includes the simple features, user-friendly display on both the LCD screen and the Blynk app. This allows users to get muscle data, receive real-time feedback, and control settings remotely. By focusing on accurate measurements, this EMG biosensor becomes a practical tool for athletes.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This section presents the results gathered from the EMG biosensor system and analyses the significance of these findings. The evaluation includes a detailed look at the system performance in terms of accuracy, and user experience. The results will help to assess how effectively the system measures muscle activity and processes signals. It also will provide real-time monitoring and data analysis through the Blynk application. Furthermore, the analysis will highlight any limitations encountered in the current design and discuss potential areas for improvement.

4.2 Results and Analysis

The project effectively identified and categorized in various muscle conditions based on the EMG signal strength by using pre-defined thresholds. These thresholds provided a reliable means to differentiate between normal muscle activity, abnormal strain, muscle fatigue, and weakness. This categorization is valuable for applications such as fitness monitoring. It also enabling users to make informed decisions about their muscle health and activity levels. So, Figure 4.1 below show the final product for these project.

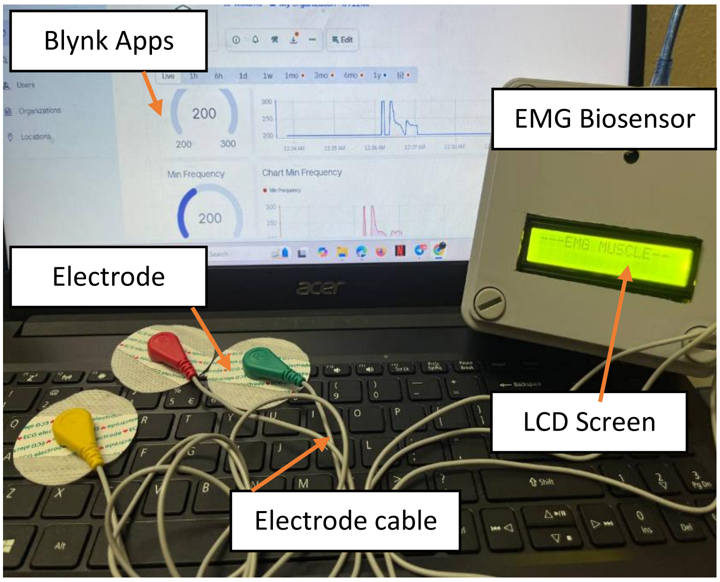


Figure 4.1 EMG Biosensor for Athlete by using ESP32 with IoT Application

STRESS now
THEY'RE STRESS

EMG now
Abnormal

NORMAL now
This patient muscle condition is normal

NORMAL 1m ago
This patient muscle condition is normal

NORMAL 1m ago
This patient muscle condition is normal

NORMAL 1m ago
This patient muscle condition is normal

NORMAL 3m ago
This patient muscle condition is normal

4.2.1 Data Analysis

After this project design is complete, this EMG Biosensor is tested on several people. Due to the data and analysis, we found that a **normal muscle condition** is indicated when the EMG signal strength falls within the range of 200mV to 240mV. This range suggests that the muscle is functioning within healthy parameters and showing normal activity without signs of fatigue. During light physical activity or resting, muscles generally produce EMG signals in this range. It also signalling that they are neither under stress nor overextended.

Then, the result identify mostly these people have **abnormal muscle condition.** This condition is flagged when the signal strength rises above 250mV. This elevated range may indicate that the muscle is under strain or is engaging in unusually intense activity. This could lead to discomfort or potential injury if sustained. Recognizing this range will help users to identify early signs of muscle strain and allowing them to adjust their activities and potentially prevent injury.

Furthermore, we found a **stressed or tired muscle condition.** This is identified when the signal strength exceeds 270mV. Based on analysis, these high reading typically occur when muscles have been heavily used or are experiencing fatigue. This can happen during prolonged exercise or repetitive tasks. By monitoring this muscle activity, it will help users to avoid overuse and the risk of strain or injury due to muscle exhaustion.

Lastly, a **weak muscle condition.** This condition is indicated by signal strengths below 200mV. This lower range may suggest underuse, possible atrophy. This is particularly beneficial in rehabilitation settings, as it helps users track gradual improvements in muscle strength over time or identify specific muscles that require strengthening exercises.

In summary, these threshold ranges enabled the project to deliver reliable and real-time muscle condition monitoring. Users can easily interpret their muscle health and activity levels. User also can adjust their routines accordingly and track progress in physical therapy or fitness training. This practical feature enhances the device to empowering users to maintain healthy muscle activity while minimizing the risk of strain or injury.

4.2.2 Testing Tools and Calibration Method

I. Testing Tools

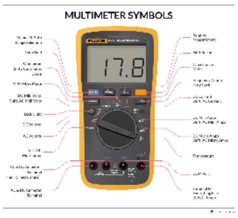
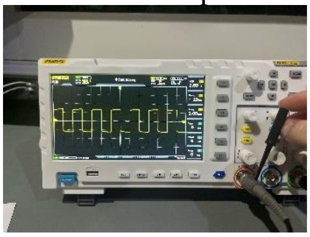
Components	**Description**
Multimeters 	Used to measure voltage levels across the circuit, ensuring consistent power supply to all components.
Oscilloscope 	Visualizes and monitors EMG signal waveforms, verifying the clarity and quality of muscle signals
Smartphone with Blynk App 	Provides a real-time interface to monitor data transmission from the ESP32 via Bluetooth and evaluate the system's wireless connectivity.

Table 4.1 Description about Testing Tools

II. Calibration Method

The calibration of the EMG sensor is a process to ensure accuracy and consistency in capturing muscle activity signals. First, the EMG sensor is positioned on various muscle groups to establish a baseline for signal strength and responsiveness. This step allows the sensor to adapt to different muscle types and ensures that it can detect subtle variations in muscle contractions across body regions. During calibration, the sensor responsiveness is measured to confirm that it reliably detects muscle.

Then, the LCD testing. This testing is to ensure it displays sample data clearly and in real time. Testing the LCD involves checking the readability, contrast and responsiveness to data changes. Furthermore, to validate Bluetooth connectivity, the ESP32 Wi-Fi module is paired with a smartphone that running the Blynk app. This test ensures the stable data transmission and allowing real-time monitoring. This connectivity is essential for applications that hands free data access and potential connectivity issues such as dropouts or delays data display.

Last but not least, this project also includes the signal processing testing. It will test the accuracy of the system filtering and amplification steps. It also known as muscle contraction levels that are used to generate data and analyse it to confirm that the signal processing is correctly reflecting muscle activity. This phase is essential to ensure that the EMG sensor produces accurate readings that align with expected values.

4.2.3 Testing Safety or Precautionary Measures

These project was created to ensure a safe and effective testing process for the EMG biosensor system. First of all, make sure the **testing environments were clear from unnecessary electronic devices**. This precaution is to reduce electromagnetic interference which can affect signal quality and compromise accurate readings. This was particularly important during EMG sensor testing to maintain clean, reliable data for analysis.

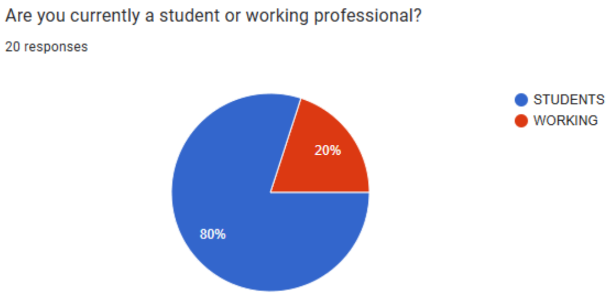
Then, to prevent electrical hazards, make sure **all connections and power supplies were double checked for proper grounding before each test**. The device battery and power components were also monitored to ensure they did not overheat during testing. This will be minimizing the risk of short circuits or accidental burns.

Other than that, make sure **the placement of electrodes on human skin for testing purposes was correct**. To get a smooth value, we need to ensuring that skin surfaces were clean and it can reduce the risk of irritation. Last but not least, make sure the subjects were fully briefed on testing procedures. We also need advised on what to expect during measurements. This preparation is to ensured subjects were comfortable.

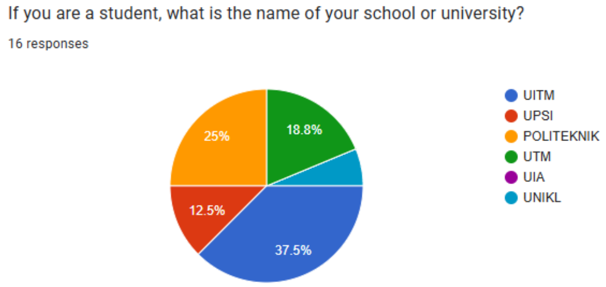
4.3 Survey about the EMG Biosensor

A survey is a research instrument that consisting a series questions and other prompts for the purpose of gathering information from respondents. Once the product was finalized, a study was conducted to assess the product functionality and gather user feedback. In addition, the distribution of survey forms was distributed level of user satisfaction to ensure the information is correct in order to improve this product.

This survey was conducted involving 20 people that live around Selangor. Based on this survey, mostly of them was the university students and only four is working. This was show in the pie chart below. The working people was including the physical education teacher, personal trainer and Technologist Professional. Furthermore, a few of these students are in final year that have undergoing their industrial training in hospitals and company. Other than that, I also collect some survey from the sport science students. During the survey, I demonstrated the product to the participants and provided them with a questionnaire to gather their feedback.


Are you currently a student or working professional?

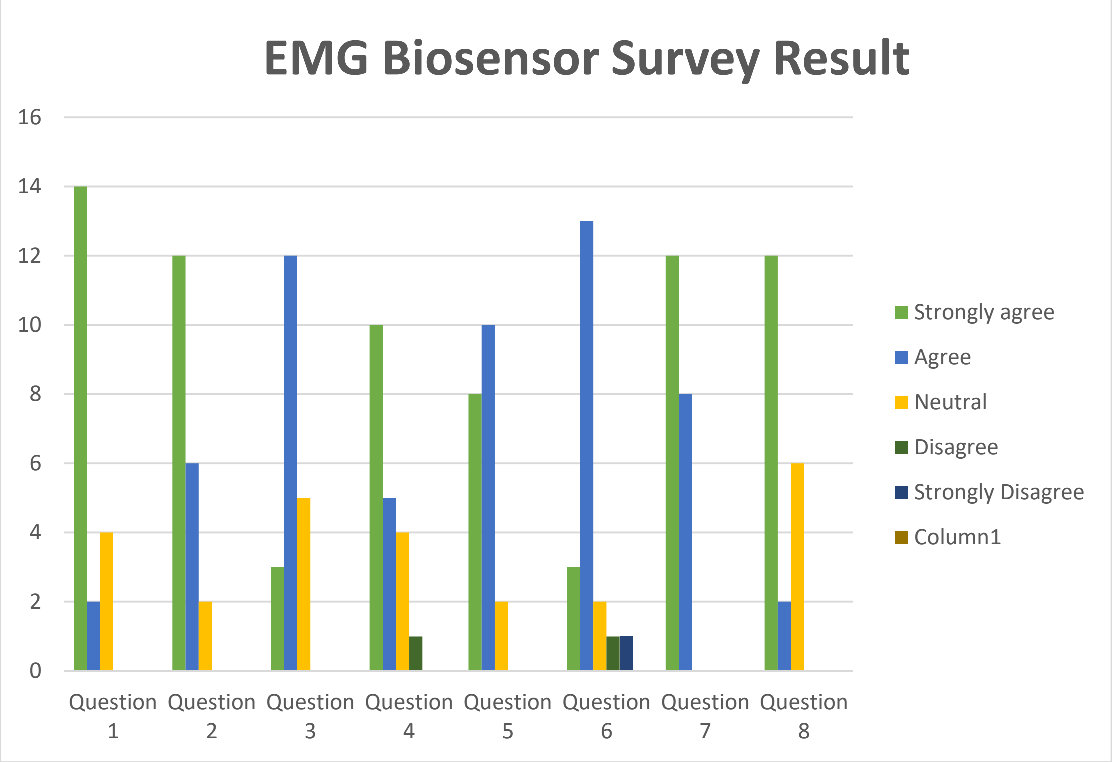
20 responses


If you are a student, what is the name of your school or university?

16 responses

Table 4.2 Table below present the data collection for this EMG Biosensor survey

No	**Survey Question**	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1.	Do you agree that EMG biosensor device is to provide accurate data on muscle performance?	14	2	4	0	0
2.	This project is helpful if the device alerted me when I'm at risk of muscle fatigue or overuse.	12	6	2	0	0
3.	Did you agree about the ability to connect the EMG biosensor with smartphone?	3	12	5	0	0
4.	Find the visual representations (graphs) of my muscle activity will be useful.	10	5	4	1	0
5.	Do you consider using an EMG biosensor to optimize your training and recovery.	8	10	2	0	0
6.	Did you think that having access to your muscle activity data could help you avoid injuries by adjusting your training intensity.	3	13	2	1	1
7.	The integration of EMG and IoT technology would enhance my understanding of how my body responds to different types of exercises.	12	8	0	0	0
8.	Do you believe that monitoring muscle activation can help you target specific muscle groups more effectively?	12	2	6	0	0



The graph above show about the "EMG Biosensor Survey Result" that presents participant responses to eight questions. Each question responses are organized into five levels of agreement wich is strongly agree, agree, neutral, disagree, and strongly disagree. The height of each colored bar in the chart indicates the number of respondents who selected that level of agreement for each question.

Due to the graph above, we can analyse that the high level of agreement is in responses for questions 1, 2, 5, 6, and 7. As the result, the majority of respondents choosing "Strongly Agree" or "Agree" for indicating a generally positive perception of the biosensor's performance. Meanwhile, Questions 3 and 4 saw more neutral responses. These show that some participants were unsure about specific aspects of the product.

Although the exact wording of each question is not provided, the trends in agreement suggest that respondents found the EMG biosensor to be effective and user-friendly. However, the presence of neutral responses, particularly for Questions 3 and 4, could indicate areas where the biosensor may have limitations. Overall, the survey results suggest that users had a positive experience with the EMG biosensor but might see room for further enhancements in certain areas.

4.4 Discussion

This project aimed to develop a functional and user-friendly EMG biosensor. At the end, EMG Biosensor could monitor muscle activity and provide real-time feedback. It also will display data on both a device and mobile app. The findings from this project align with previous research that supports the usefulness of EMG technology in monitoring muscle performance and condition. Due to the research on electromyography, it has consistently shown that EMG sensors can be valuable for understanding muscle health especially in fields like sports science, rehabilitation, and healthcare. This project adds to that body of research by demonstrating how an EMG biosensor can be adapted into a compact, accessible device for personal and professional use.

Other than that, the results from the user survey was function to support the feasibility of this project in real life applications. Most users, including students reported high satisfaction with the device performance, easy to used and accessibility. This feedback aligns with the theory that wearable health-monitoring devices are more effective and accepted when they are intuitive and easy to operate. Users were able to quickly understand the feedback provided by the device and indicating that in real-time monitoring. It also has the capabilities that offer meaningful insights into muscle conditions, such as normal activity, stress, or weakness.

However, during the process of making these project, one of the primary difficulties encountered was related to signal quality. We identify that the EMG signals was sensitive to external interference. During testing these project, we observed that environmental noise could sometimes affect the sensor readings. This required careful calibration and adjustments to ensure accuracy especially in less controlled environments. We make some research about this problem and found that by improving signal filtering, it will potential area for enhancement as it would make the device more reliable across different settings. Before this, we decided to use the Bluetooth module for these project. After testing and connect the circuit, we identify that the Bluetooth connection was sometimes inconsistent. This result was in occasional delays in data transmission to the Blynk app. To address this, we focus on optimizing the wireless communication by switching to Wi-Fi instead of Bluetooth. Wi-Fi would likely provide a more stable and faster connection especially making the device even more responsive and reliable for real-time monitoring.

In summary, the project succeeded in developing a functional EMG biosensor prototype and demonstrated its potential for muscle health monitoring. Although the device performed well, further improvements could increase its reliability and usability especially in areas such as signal stability, power efficiency, and personalized calibration. By addressing these challenges, the EMG biosensor could become a more comprehensive tool for monitoring muscle condition .

4.5 Summary

In this chapter, we discussed the results and focusing on its performance. We also describe about user feedback and areas for improvement. The device was designed to monitor muscle activity in real time, with data displayed on LCD and a mobile app. The user feedback from a survey was indicated with high satisfaction of the device's functionality and usability. Then, we also despite the positive feedback and several challenges were identified during testing. Signal interference impacted the quality of EMG readings and switching to Wi-Fi could address these connectivity issues and providing a more stable and responsive communication method. Lastly, the project successfully demonstrated the feasibility of a compact and user-friendly EMG biosensor. With these improvements, the EMG biosensor could become an even more valuable tool for monitoring muscle condition .

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section summarizes the key outcomes of the EMG biosensor project and provides recommendations for future work. The project aimed to develop a reliable and user-friendly biosensor to monitor muscle activity, display real-time data, and enhance accessibility. Through careful design, testing, and user feedback, the device demonstrated the potential to effectively measure and report muscle conditions such as fatigue, normal activity, and stress condition.

Other than that, the conclusion part consolidates the project achievements and reflecting on the biosensor’s strengths in terms of functionality. Additionally, it also identifies areas where the project encountered challenges such as signal stability, power limitations, and occasional connectivity issues. This will impact the device performance under certain conditions.

5.2 Conclusion

In conclusion, this project was successful finished. So, the objectives of this project is to utilizing an EMG biosensor to enhance understanding, performance, and recovery of muscle activity. This also will through the real-time monitoring, data-driven feedback, and effective recovery tracking. These goals aim to support athletes or trainers in making informed decisions about muscle condition and training strategies.

a) Objective 1

To detect and analyse muscle activity in real time for immediate insights into muscle performance.

The first objective of this project is to enable the real-time detection and analysis of muscle activity. This project also will allow the athletes to gain immediate insights into muscle performance. By using an EMG biosensor, the system can capture and process electrical signals generated by muscles as they contract and relax. This capability very valuable for situations that require on the spot data as it provides a clear and accurate picture of muscle engagement. Other than that, the real-time monitoring also will help athletes to make quick decisions such as adjusting an exercise intensity or identifying moments of fatigue. This objective underscores the biosensor role to understand their muscle function and performance in real time.

b) Objective 2

To aid in optimizing athletic performance by providing data driven feedback on muscle engagement and fatigue.

The second objective is to aid in optimizing athletic performance by providing data-driven feedback on muscle engagement and fatigue. With continuous monitoring, the biosensor offers valuable insights into how muscles are used during physical activities. This feedback can help athletes or coaches to identify when certain muscles are in abnormal and weak condition. As the result, it will enable them to make informed adjustments to training routines. For instance, if an athlete's muscle shows signs of fatigue too early, they may need to modify their technique or intensity. This objective highlights the biosensor potential as a training aid and enabling athletes to change their exercise routines based on objective data and reducing the risk of overtraining or injury.

c) Objective 3

To monitor muscle recovery effectively, ensuring athletes follow proper rest and rehabilitation protocols.

The last objective is to support the effective monitoring of muscle recovery. This objective was created because to ensure that athletes follow the proper rest and rehabilitation protocols. Recovery is a crucial part of athletic training, as muscles need time to repair and grow stronger after intense use. By continuously monitoring muscle activity during rest periods, the biosensor helps users verify that their muscles are adequately resting and abnormal. This data can also guide rehabilitation practices which will helping physical therapists and athletes alike to know the recovery progress and adjust rest strategies as necessary. With this objective, the EMG biosensor contributes to safe recovery practices, avoid the risk of injury and more effective rehabilitation for muscle health.

5.3 Future Recommendations

The following recommendations are designed to address the key findings and support the achievement of our objectives. It also providing actionable steps for future improvements and success.

First of all, we recommend that to add an LED indicator to the EMG biosensor system. This could significantly enhance user feedback by display about device status and muscle activity levels. This LED feature would serve multiple roles, including alerting users to specific conditions, improving usability, and ensuring they receive instant or straightforward signals during operation. For example, the LED could be programmed to change colour or brightness based on different muscle activity thresholds. This addition would make the biosensor more intuitive and responsive. It also allowing users to adjust their activities quickly based on real-time feedback.

Lastly, we also suggest to enhance energy sustainability and reduce the power sources. The integration was included the solar energy that could be a significant improvement. A small solar panel that was designed as an attachable module could supplement power for extended use or particularly during outdoor activities. Furthermore, solar power also would provide an eco-friendly alternative for charging.

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APPENDICES

EMG Bio-Sensor Coding

```
#define BLYNK_TEMPLATE_ID "TMPL6EZUWUkrw"
#define BLYNK_TEMPLATE_NAME "BEE"
#define BLYNK_AUTH_TOKEN "pzI0DGn9Yk_X1wnIdkIDILsWztbzlWwd"

// Comment this out to disable prints and save space
#define BLYNK_PRINT Serial
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

#define vCalibration 83.3
#define currCalibration 0.50
int mode=0;
int SECURITY=0;

// Potentiometer is connected to GPIO 34 (Analog ADC1_CH6)
const int potPin = 34;
const int potPin2 = 35;
const int potPin3 = 32;
const int potPin4 = 33;
const int potPin5 = 25;

float ADC1,ADC2,ADC3,ADC4;
float temperature = 25;
float h=0,t=0;
float hx=0,tx=0;
// variable for storing the potentiometer value
```

```
int potValue = 0;
int ALM1=0,ALM2=0,ALM3=0,ALM4=0;
int Ready=0;
int Ml=0;
String MinS="00";
String HourS="00";
String SecS="00";
int DataIn=0;
String DATA="";
String Temp1x="";
String PHx="";
String Temp2x="";
String Temp1y="";
String PHy="";
String Temp2y="";
String Temp3y="";
String Temp3x="";
String Temp4y="";
String Temp5y="";
String Temp4x="";
String Temp5x="";
String currentTime;
String currentDate;
String TimerGet="00:00:00";
int MODE=0;
int Hour=0;
int Min=0;

float SIG=0;
int Sec=0;
```

```
float LEVEL=0;
int ALM=0;
int Val=100;
int Index=0;
float CV=0;
int CKN=0;
//---------------------------------------------------------------
int Par=70;
int TDIS=0;
int Rly1=0;
int wait=0;
int Rly2=0;
int Rly3=0;
int Rly4=0;
int Rly5=0;
int TMR_BV=0;
float BV_AVG=0;
//---------------------------------------------------------
char auth[] = BLYNK_AUTH_TOKEN;

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "EMG";
char pass[] = "12345678";

BlynkTimer timer;
// This function is called every time the Virtual Pin 0 state changes
BLYNK_WRITE(V10)
{
  int pinValue = param.asInt(); // assigning incoming value from pin V1 to a variable
  Rly1=pinValue;
```

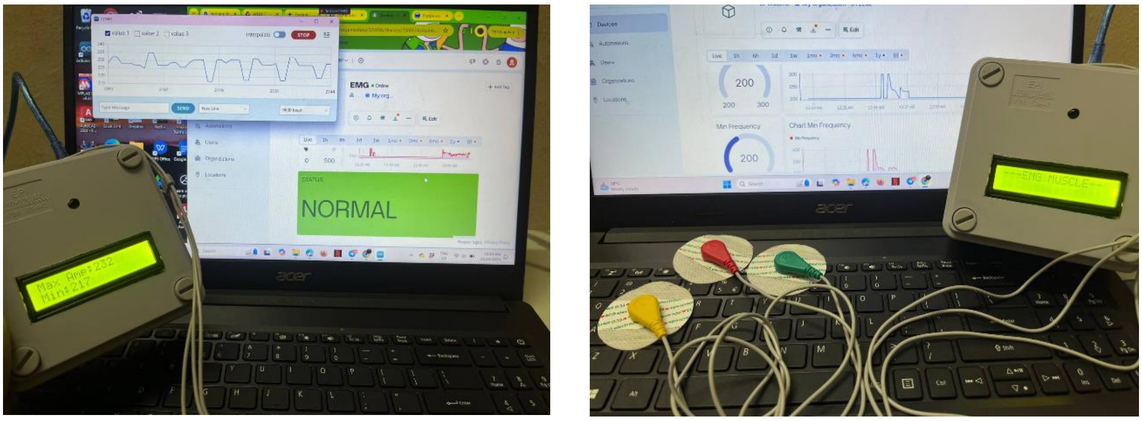
```
   if (pinValue==1){
   ALM=1;
  }
  if (pinValue==0){
   ALM=0;
  }
BLYNK_WRITE(V11)
{
  int pin2Value = param.asInt(); // assigning incoming value from pin V1 to a variable
  Rly2=pin2Value;
if (pin2Value==1){
  // process received value }
BLYNK_WRITE(V12) {
  int pin3Value = param.asInt(); // assigning incoming value from pin V1 to a variable
  Rly3=pin3Value;
  if (pin3Value==1){ }
}
BLYNK_WRITE(V13)
{
  int pin4Value = param.asInt(); // assigning incoming value from pin V1 to a variable
  Rly4=pin4Value;
    if (pin4Value==1){
}
BLYNK_WRITE(V14)
{
  int pin5Value = param.asInt(); // assigning incoming value from pin V1 to a variable
  Rly5=pin5Value;
  if (pin5Value==1){
  }
  // process received value
}
```

```
//------------------------------------------------------------------------
// This function is called every time the device is connected to the Blynk.Cloud
BLYNK_CONNECTED()
void CheckSIG()
   //----------------------------------------------------------------
static unsigned long timepoint = millis();
  if (millis() - timepoint > 1000U) //time interval: 1s
  {
  }
  //----------------------------------------------------------
void myTimerEvent()
   //----------------------------------------------------------------
static unsigned long timepoint = millis();
Blynk.virtualWrite(V0, SIG);
  //----------------------------------------------------------
}

void setup()
{
  Serial.begin(9600);
  Blynk.begin(auth, ssid, pass);
  // You can also specify server:
  //Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
  //Blynk.begin(auth, ssid, pass, IPAddress(192,168,1,100), 8080);
 timer.setInterval(1000L, myTimerEvent);

}

void loop()
{
   SIG=analogRead(potPin);
```

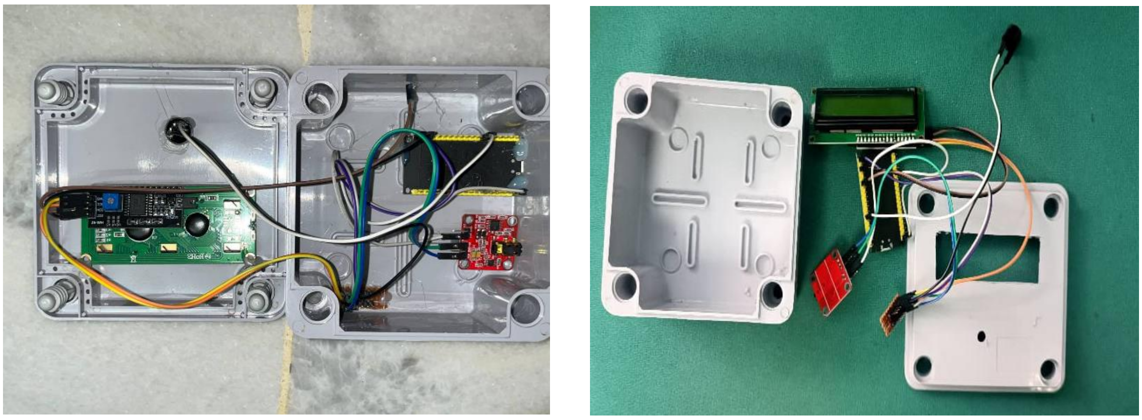
```
   SIG=1000-(SIG/4095.0*1000.0);
   Serial.println(SIG);
  Blynk.run();
  timer.run();
     while (Serial.available()) {
    // get the new byte:
    char inChar1 = (char)Serial.read();
  if (inChar1 == '*') {
      DataIn++;


    }


     if (inChar1 == '!')
if (inChar1 == 'X'){
}
    while (DataIn > 0){
        while (Serial.available()) {
    // get the new byte:
    char inChar = (char)Serial.read();
    if (inChar == '*') {
      DataIn++;


    }
    if (inChar != '*' && inChar != '#' && DataIn==1) {
      Temp1x+=inChar;


    }
    if (inChar != '*' && inChar != '#' && DataIn==2) {
      Temp2x+=inChar;


    }
```

```
   if (inChar != '*' && inChar != '#' && DataIn==3) {
     Temp3x+=inChar;


   }
    if (inChar != '*' && inChar != '#' && DataIn==4) {
     Temp4x+=inChar;
   }
     if (inChar != '*' && inChar != '#' && DataIn==5) {
     Temp5x+=inChar;
   if (inChar == '#') {
     DataIn=0;
    Temp1y=Temp1x;   PHy=PHx;      Temp2y=Temp2x;  Temp3y=Temp3x;
Temp4y=Temp4x;
    Temp5y=Temp5x;
    Temp1x="";
    PHx="";   Temp2x="";
    Temp3x="";
    Temp4x="";
    Temp5x="";
5
    //Blynk.virtualWrite(V0, Temp1y);
    //Blynk.virtualWrite(V1, Temp2y);
    //Blynk.virtualWrite(V2, Temp3y);
   }
       }


   }
//********************************************************************
**************************************************
//********************************************************************
*************************************************
}
```

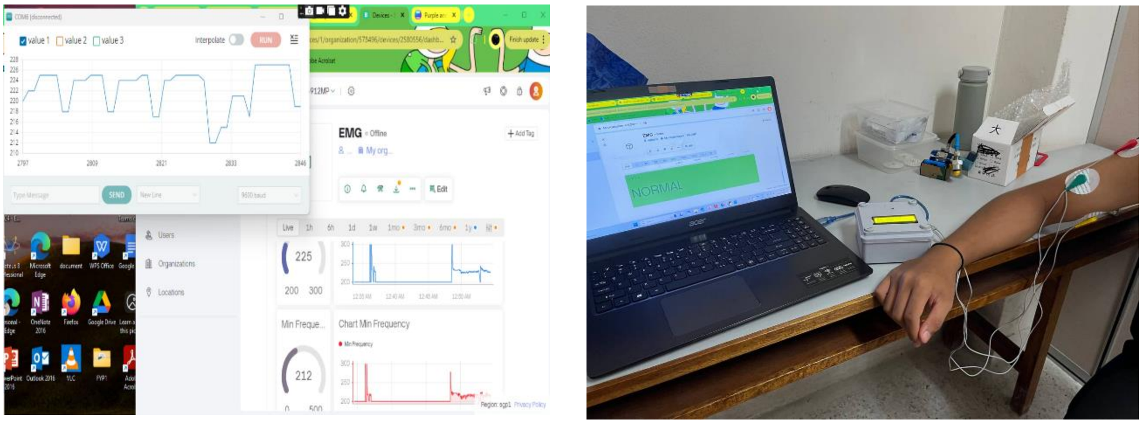
Picture of EMG Bio-Sensor Project for athletes by using ESP32 with Iot Application



Appendix 1; EMG Biosensor product design

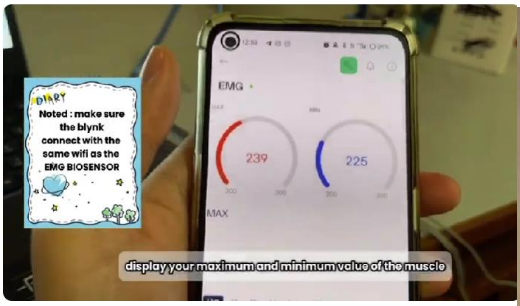


Appendix 2: EMG Bio-Sensor Circuit



Appendix 3: Product Result and Testing

Appendix 4: Project Presentation

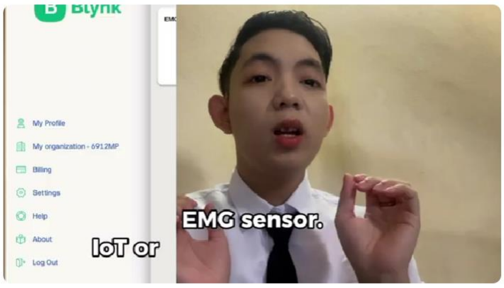


Noted : make sure the blynk connect with the same wifi as the EMG BIOSENSOR

display your maximum and minimum value of the muscle

EMG BIOSENSOR BY USING ESP32 WITH IOT APPLICATION FOR ATHLETES

it will show you the maximum



IoT or EMG sensor.

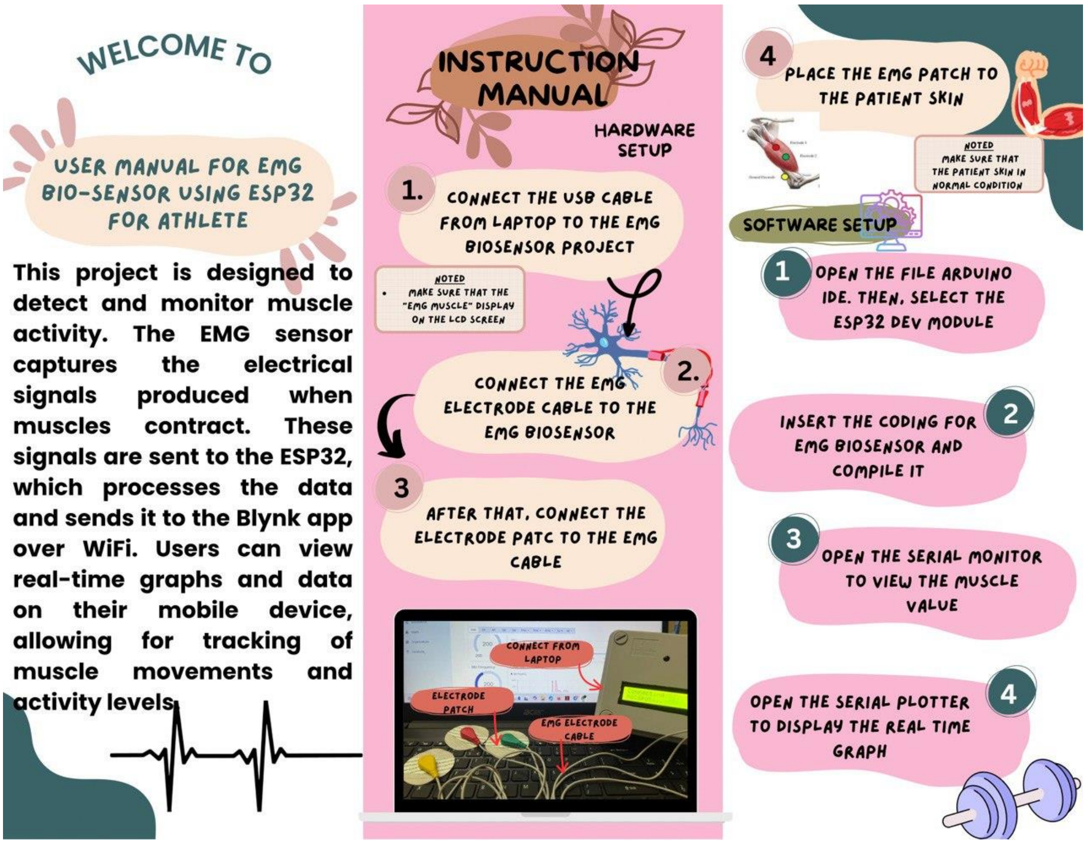
EMG BIOSENSOR BY USING ESP32 WITH IOT APPLICATION FOR ATHLETES

William S... Analytics Edit video 8 Share ...

and display the result of this project

EMG BIOSENSOR BY USING ESP32 WITH IOT APPLICATION FOR ATHLETES

Appendix 5: Project User Manual



WELCOME TO

USER MANUAL FOR EMG BIO-SENSOR USING ESP32 FOR ATHLETE

This project is designed to detect and monitor muscle activity. The EMG sensor captures the electrical signals produced when muscles contract. These signals are sent to the ESP32, which processes the data and sends it to the Blynk app over WiFi. Users can view real-time graphs and data on their mobile device, allowing for tracking of muscle movements and activity levels

INSTRUCTION MANUAL

HARDWARE SETUP

1. CONNECT THE USB CABLE FROM LAPTOP TO THE EMG BIOSENSOR PROJECT

NOTED
- MAKE SURE THAT THE "EMG MUSCLE" DISPLAY ON THE LCD SCREEN

2. CONNECT THE EMG ELECTRODE CABLE TO THE EMG BIOSENSOR

3 AFTER THAT, CONNECT THE ELECTRODE PATC TO THE EMG CABLE

4 PLACE THE EMG PATCH TO THE PATIENT SKIN

NOTED
MAKE SURE THAT THE PATIENT SKIN IN NORMAL CONDITION

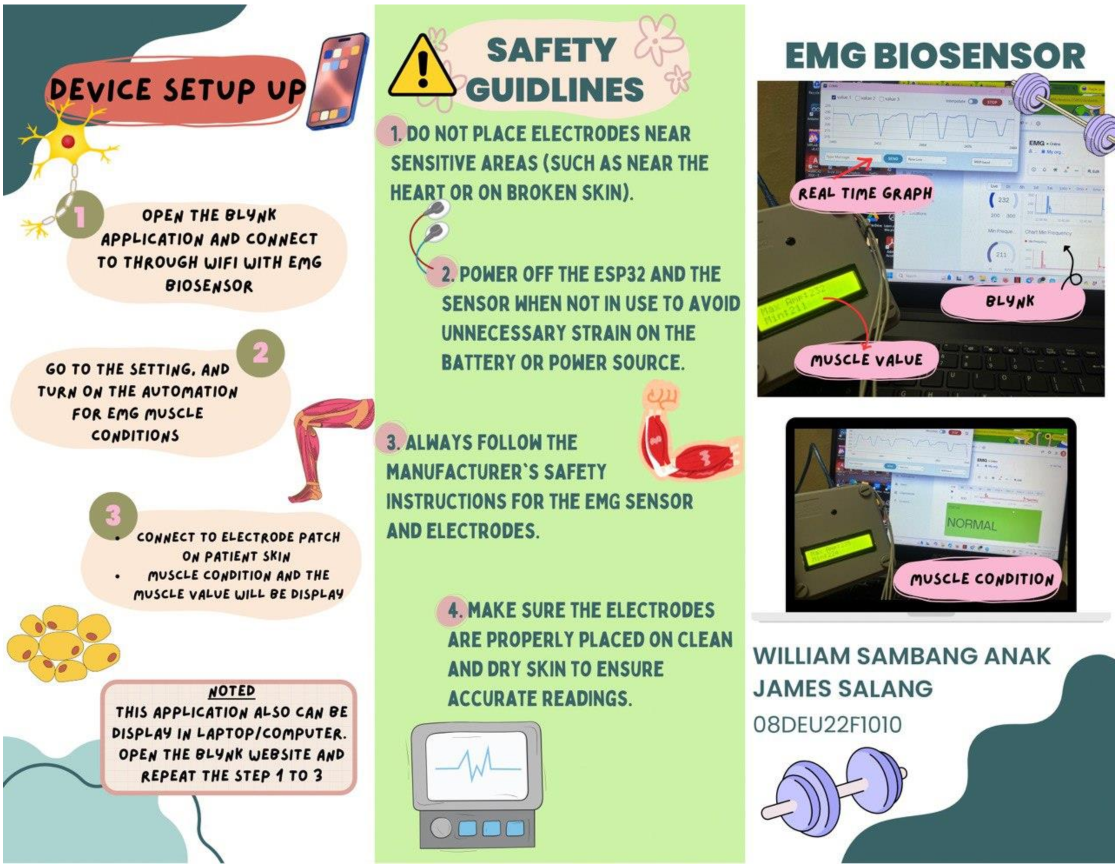
SOFTWARE SETUP

1 OPEN THE FILE ARDUINO IDE. THEN, SELECT THE ESP32 DEV MODULE

2 INSERT THE CODING FOR EMG BIOSENSOR AND COMPILE IT

3 OPEN THE SERIAL MONITOR TO VIEW THE MUSCLE VALUE

4 OPEN THE SERIAL PLOTTER TO DISPLAY THE REAL TIME GRAPH



DEVICE SETUP UP

1 OPEN THE BLYNK APPLICATION AND CONNECT TO THROUGH WIFI WITH EMG BIOSENSOR

2 GO TO THE SETTING, AND TURN ON THE AUTOMATION FOR EMG MUSCLE CONDITIONS

3
- CONNECT TO ELECTRODE PATCH ON PATIENT SKIN
- MUSCLE CONDITION AND THE MUSCLE VALUE WILL BE DISPLAY

NOTED
THIS APPLICATION ALSO CAN BE DISPLAY IN LAPTOP/COMPUTER. OPEN THE BLYNK WEBSITE AND REPEAT THE STEP 1 TO 3

SAFETY GUIDLINES

1. DO NOT PLACE ELECTRODES NEAR SENSITIVE AREAS (SUCH AS NEAR THE HEART OR ON BROKEN SKIN).

2. POWER OFF THE ESP32 AND THE SENSOR WHEN NOT IN USE TO AVOID UNNECESSARY STRAIN ON THE BATTERY OR POWER SOURCE.

3. ALWAYS FOLLOW THE MANUFACTURER`S SAFETY INSTRUCTIONS FOR THE EMG SENSOR AND ELECTRODES.

4. MAKE SURE THE ELECTRODES ARE PROPERLY PLACED ON CLEAN AND DRY SKIN TO ENSURE ACCURATE READINGS.

EMG BIOSENSOR

REAL TIME GRAPH

BLYNK

MUSCLE VALUE

NORMAL

MUSCLE CONDITION

WILLIAM SAMBANG ANAK JAMES SALANG
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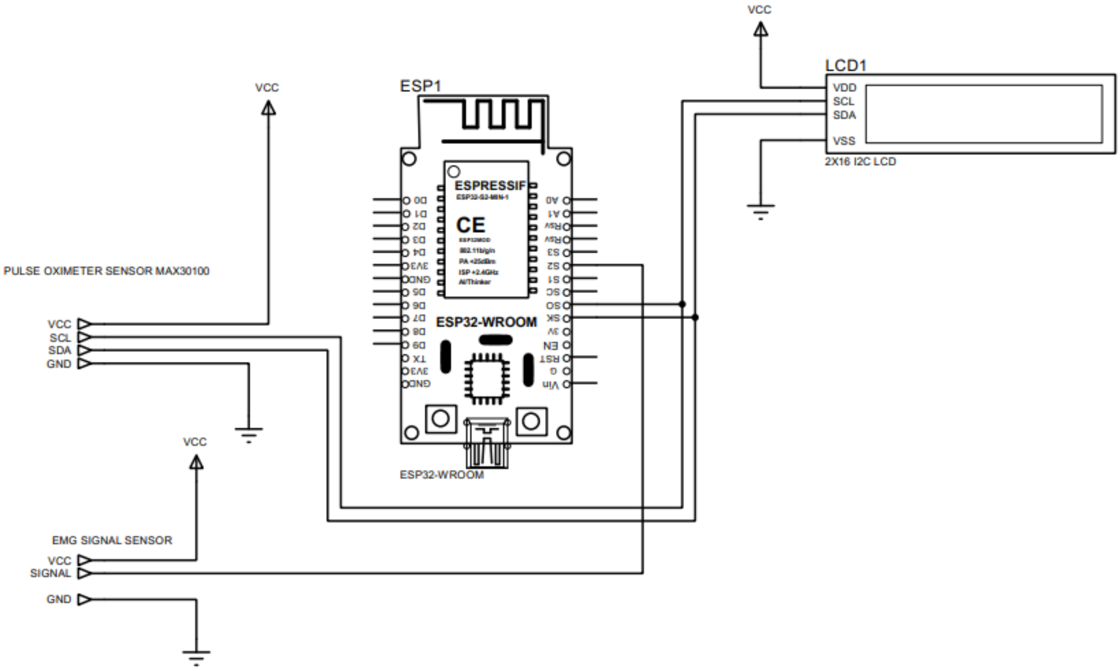
Appendix 6 : Schematic Diagram



Appendix 7 : Project Poster

ELECTROMYGRAPH(EMG) BIO-SENSOR FOR ATHLETE BY USING ESP32 WITH IOT

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PROJECT BACKGROUND

This EMG Bio-sensor project will integrated with the ESP32 microcontroller and allows athletes to monitor their muscle activity in real-time. It captures electrical signals that generated by muscle contractions and transmits this data to an IoT-enabled cloud platform. Through this platform, both athletes and coaches can visualize muscle fatigue levels, performance metrics, and potential injury risks.

PRODUCT DESCRIPTION

BACKGROUND OF INNOVATION/IDEA/METHODOLOGY

The EMG bio-sensor with ESP32 for athletes is designed to monitor muscle activity during physical training and athletic performance. The integration with IoT allows for real-time data collection and remote monitoring of muscle conditions. The EMG sensor is placed on the athlete's muscles to capture the electrical signals produced by muscle contractions. These signals are processed by the ESP32, a powerful microcontroller with built-in Wi-Fi capabilities. The data is then wirelessly transmitted to an IoT cloud platform, where it is stored and analyzed. A mobile or web application will displays the data in an easily understandable format. It also providing real time feedback and long term insights for athletes and trainers.

ADVANTAGES

1. This EMG Bio-sensor can identifying imbalances between muscle groups can help address potential weaknesses and reduce the risk of injuries
2. EMG Bio-sensor with IoT capabilities allow for remote data collection and analysis, enabling coaches and trainers to monitor athlete performance and provide personalized guidance.
3. By analyzing EMG signals, athletes can refine their technique and identify areas for improvement to enhance performance
4. The compact size and lightweight design of the ESP32 microcontroller, will make it easy to incorporate into a portable EMG biosensor for real time monitoring.

PROBLEM STATEMENT

1. How athletes detect and analyze their muscle activity in real time and receive immediate feedback to improve their performance during workouts.
2. How can athlete assess their muscle engagement fatigue, which leads to ineffective training and increased risk of injury.
3. What is the issue that will affects athletes who aim to enhance their training by optimizing muscle use and ensuring proper recovery after exercise.

OBJECTIVE

1. To detect and analyze muscle activity in real time for immediate insights into muscle performance.
2. To aid in optimizing athletic performance by providing data-driven feedback on muscle engagement and fatigue.
3. To monitor muscle recovery effectively, ensuring athletes follow proper rest and rehabilitation protocols.

PRODUCT AND RESULT

THE PRODUCT WAS TESTING ON PATIENTS