

Wireless EMG Monitoring System for Biceps Muscle Recovery

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Abstract

Muscle recovery is an essential process in the treatment of patient with muscle injuries, especially the biceps muscle. However, current monitoring methods are still not very accurate or reliable in tracking patient progress during rehab sessions, this make it hard to know if the treatment is working and can lower the patient's motivation. Additionally, patient who live far away often have trouble going to rehab session regularly. This can cause low attendance and slower recovery. This project aims to create a wireless EMG monitoring system to track biceps muscle activity in real time more effectively. The main system uses an ESP32, EMG sensor and OLED display and the Blynk IoT platform for monitoring. The result show that the system can accurately record biceps muscle activity with peak EMG readings reaching 4095 bit and 100% signal detection accuracy.

1. Introduction

As a medical technology continues to grow and improve, monitoring muscle activity in real time has become very important for physical therapy and recovery. Electromyography (sEMG) has merged as a highly effective non-invasive technique for assessing skeletal muscle function, particularly in detecting muscle fatigue and identifying muscle activation patterns during motion [1]. In biceps muscle rehabilitation, (sEMG) monitoring can detect early sign of fatigue and compensatory movement patterns that may occur due to primary muscle weakness. During biceps curl exercises, fatigue in the biceps can lead to increased activation of the shoulder muscle as a form of compensation, which compromises the effectiveness of the rehabilitation process and increases the risk of secondary injuries [2].

Other than that, despite its clinical utility, most traditional (sEMG) system still rely on wired connection, which limit the user's natural range of motion and are unsuitable for continuous monitoring outside clinical setting. To overcome these limitations, wireless (EMG) system have been develop, enabling flexible and mobile muscle monitoring. A designed wireless (EMG) system communication to detect muscle fatigue during exercise [3]. In additionally, a wireless solution that combine modern technologies with wearable sensor, such as EMG sensor can enable development of an all-in-one remote patient monitoring system. This system allows doctors to monitor muscle activity and recovery remotely, without the need for patient to visit clinic. By integrating telemedicine, wireless communication, and wearable monitoring devices, an EMG based wireless monitoring system can be designed to support real-time rehabilitation tracking. this project to aim as to apply these innovations to improves access and enhance the quality of rehabilitation monitoring, especially for patient receiving care at home. The goal is to make rehabilitation more efficient, accessible and consistent by support both patient and healthcare provider through real-time remote data monitoring.

2. Methodology

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2.1 Overview

Fig. 1 shows a block diagram of a Wireless EMG monitoring system designed to help with biceps muscle recovery. This system is built to monitor muscle activity in real time and give useful feedback through different output components. The main part of the system is the ESP32 NodeMCU microcontroller, which acts as the brain of the devices [4]. It processes the data and handle wireless communication. Surface electrodes are placed on the biceps muscle to detect the electrical signals that are naturally produced when the muscle contracts. These signals are then sent to the EMG sensor module (SEN-13027), which filter, stabilizes, and amplifies the signals so they are strong and clean enough to be processed [5]. After receiving the signal, the ESP32 processed the data to the Blynk mobile apps using Wi-fi. This allows users or physiotherapist to monitor the muscle performance remotely and manage the recovery sessions more easily. A push button is included to manually start the measurement process. For quick and clear feedback, the system also uses LED indicator that light up at different muscle activity levels such as 25%, 50%, 75% and 100%. So, users can instantly see how strong the muscle is working. The OLED display show real-time EMG values, system status, and even a live graph of the muscle signal. This helps both user and therapists understand how the muscle is reacting during each session. In short, this block diagram shows how the hardware and software work together in one compact system. It offers real-time monitoring, easy to understand feedback, and wireless access and making it a practical and helpful tool for muscle rehabilitation.

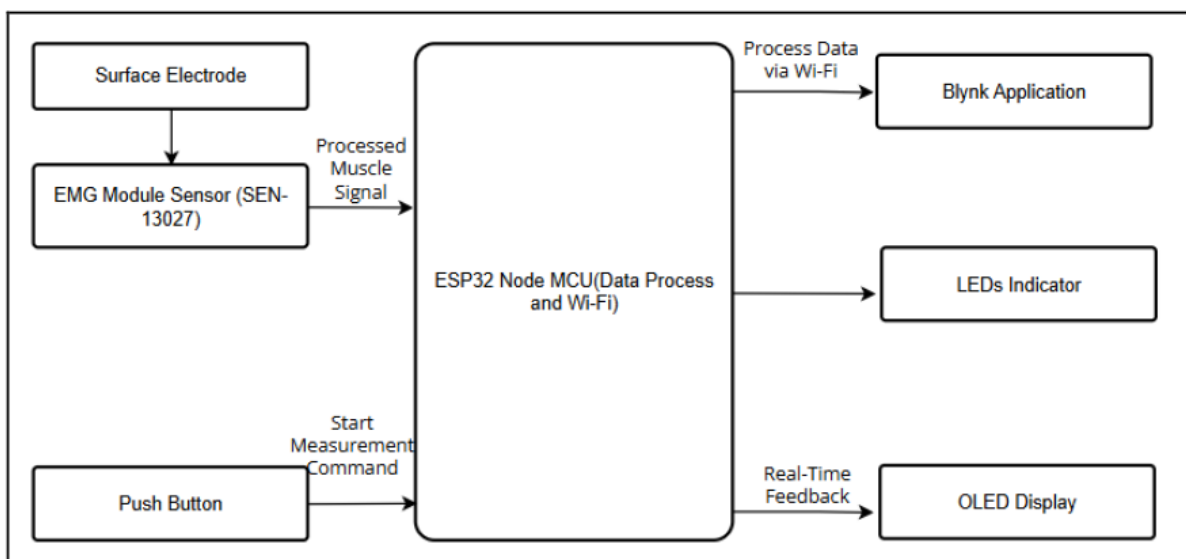


Fig. 1 Block diagram of the project

2.2 Flowchart of the Wireless EMG Monitoring System for Biceps Muscle Recovery

This flowchart in Fig. 2 shows the working process of the wireless EMG Monitoring System, which is designed specifically for muscle rehabilitation. The system begins by initializing all important hardware components, including the ESP32 microcontroller, OLED display, LED indicators, Wi-fi connection, and the Blynk application. This step ensures that the system is fully ready before it starts monitoring. After initialization, the system tries to connect to the Blynk platform through Wi-fi. If the connection fails, it will automatically retry until the connection is successful. Once connected, the system turns on an LED to let the user know that the device is active and ready to use. Next, the system continuously reads the EMG signals from the biceps muscle using surface electrodes. These signals are processed in real time by the ESP32 microcontroller. The OLED display is update with the live values of muscle activity, and the LED indicators light up based on the strength of the muscle performance. The OLED screen also shows a real-time graph of the EMG signal, making it easier to understand how the muscle behaves over time. To make the system more user-friendly, a reset button function is included. When a reset command is received (either from a push button or through the Blynk app), the system clears the OLED display, reset the highest EMG value, and clear the graph. This prepares the OLED display, reset the highest EMG value, and clears the graph. This prepares the device for a new session. Whether for the same patient or a different one. In conclusion, the flowchart outlines a smart and responsive system that not only supports accurate and real time EMG monitoring but also provides useful visual feedback. Its wireless and reset features make it efficient and practical for muscle rehabilitation therapy.

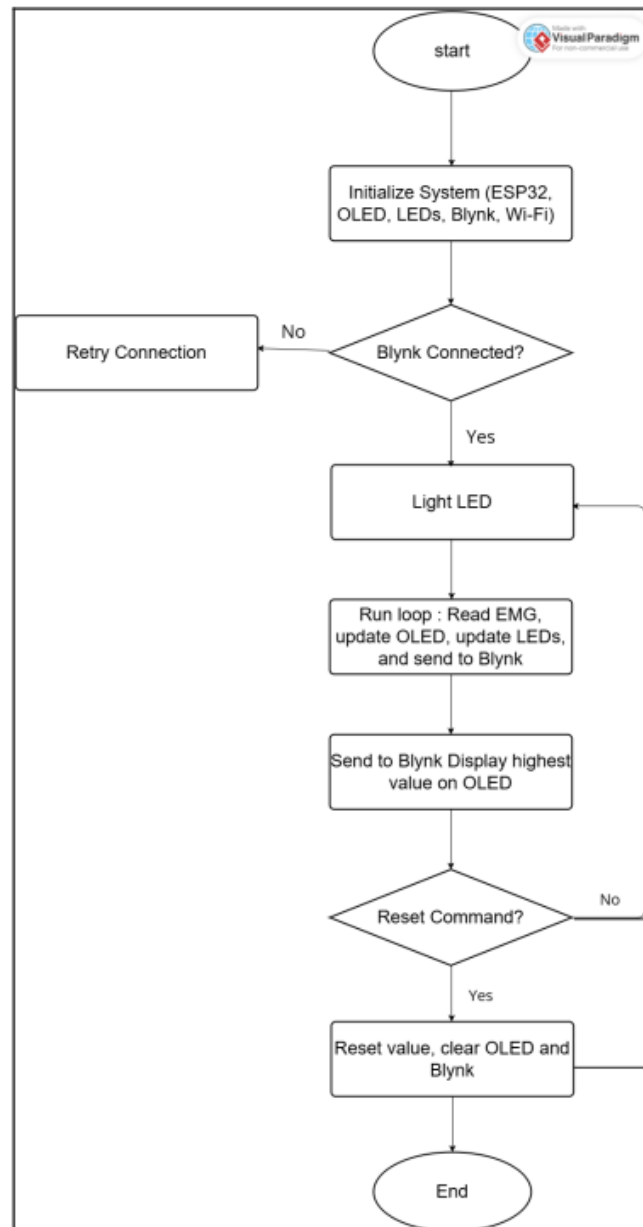


Fig. 2 Flowchart of the Wireless EMG Monitoring System for Biceps Muscle Recovery

2.3 Circuit Diagram Connection

The circuit diagram connection in Fig 3 shows the complete circuit for the Wireless EMG monitoring for biceps muscle recovery. The system uses important components such as the ESP32 microcontroller, EMG sensor, OLED display, LED indicator, push button, switch, and the three 9V batteries for power. The EMG sensor is connected to the ESP32 to detect muscle signals. These signals are processed by the ESP32 and then sent to the Blynk apps for real-time monitoring. The OLED display shows the muscle signal in real time. It is connected using 12C pins. LEDs light up at different level 25%, 50%, 75%, and 100% to show the strength of the muscle activity. A blue LED turns when the Wi-fi connection is successful. A push button is used to start the signal reading manually, and a switch controls the power. All components work together to give accurate reading and easy monitoring for muscle rehab.

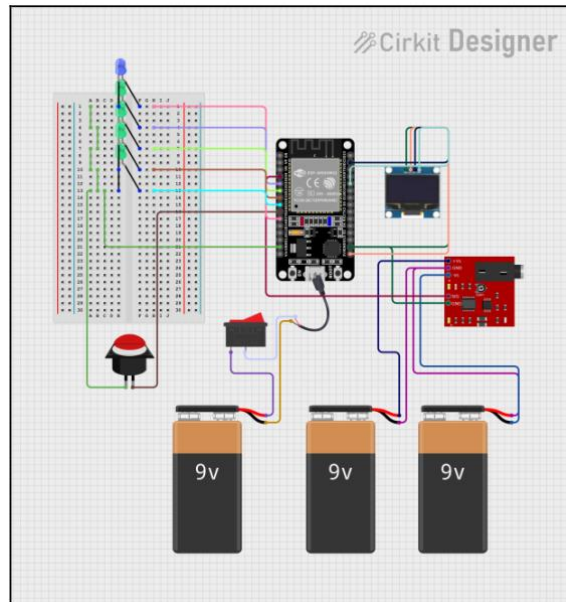


Fig. 3 Circuit diagram for the project prototype

3. Result and Discussion

This section explains about the project outcomes and discussion the prototype model's, testing result. All aspect of the electronic and mechanical component is considered.

3.1 Prototype Design

The prototype of Fig. 4 had been successfully produced. This prototype shows a complete design of a wireless EMG monitoring system intended for biceps muscle recovery. The design was created using SolidWorks software and includes key component arranged neatly in a portable enclosure. At the front, an OLED screen displays real-time EMG signal and percentage of muscle contraction. Below the screen, several LED indicators light up to show muscle strength level at 25%, 50%, 75% and 100%. The EMG used in EMG sensor V3 SEN-13027, which is connected to the biceps muscle using surface electrode (red, green, yellow) to detect bioelectrical activity. This setup allows the system to give clear and immediate feedback during muscle exercises. The prototype is lightweight and user-friendly, making it suitable for use at home or in physiotherapy clinic. Overall, this system offers an effective and practical solution for monitoring muscle recovery, especially for people who need remote or regular rehabilitation support.

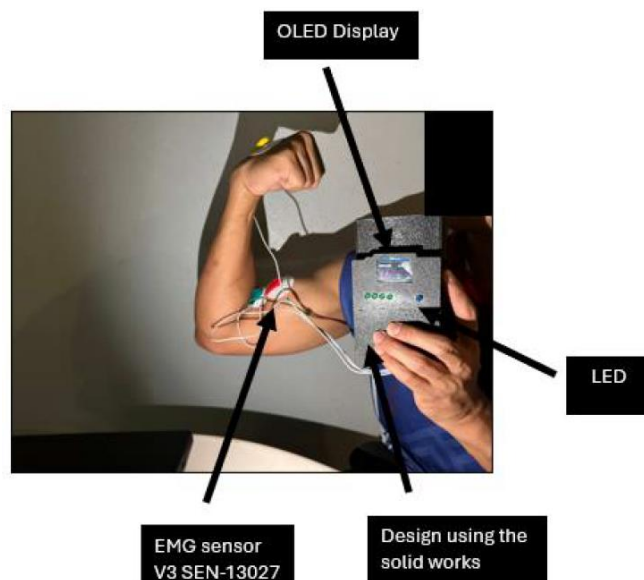


Fig. 4 Project prototype

3.2 Integration of Hardware and Software Design

Fig. 5 show the Blynk interfaces this system integrates both hardware and software component to enable real-time monitoring of muscle activity through the Blynk IoT platform. As shown in Fig. 5 the Blynk interfaces is designed to be easy used and provides live EMG signal data in both graphical and numerical formats. The live EMG value panel shows the current signal being detected from the biceps muscle, while the "highest EMG value" box records the peak signal during a session. A reset switch is also included to allow users to clear previous peak values before starting a new session. This interface makes easier for user and physiotherapist to track muscle performance during rehab. With automatic data logging and wireless accessibility through smartphone, the system supports remote monitoring, making rehab more flexible and accessible. This type of integration not only improves the efficiency of the system but also promotes continuous engagement in recovery activities from any location.



Fig. 5 Blynk interface

Fig. 6 shows the workflow and system functionality of the Wireless EMG Monitoring System for Biceps Muscle Recovery. In Fig. 6(a) the device is powered on and connected to the Blynk IoT platform, as shown on the OLED screen. Once connected, the LED indicators are activated in Fig. 6(b), is preparing the user for the EMG signal reading session. As shown in Fig. 6(c), surface electrodes are then properly placed on biceps such as the red electrode -V+ placed on the middle of the biceps muscle, aligned along the muscle fiber, the green electrode -V- placed on the red electrode, slightly only desired muscle signal and cancel out noise and lastly, yellow electrode -Ground placed on a bony or electrically neutral area, such as elbow bone or wrist area (not on the muscle) to detect muscle activity during contraction. The OLED display show the real-time EMG signal value and the percentage of muscle contraction, while LED lights respond according to the signal intensity, as in Fig. 6(d). lastly, Fig. 6(e) shows the Blynk interface. The reset button allows users to clear previous data before starting a new measurement.

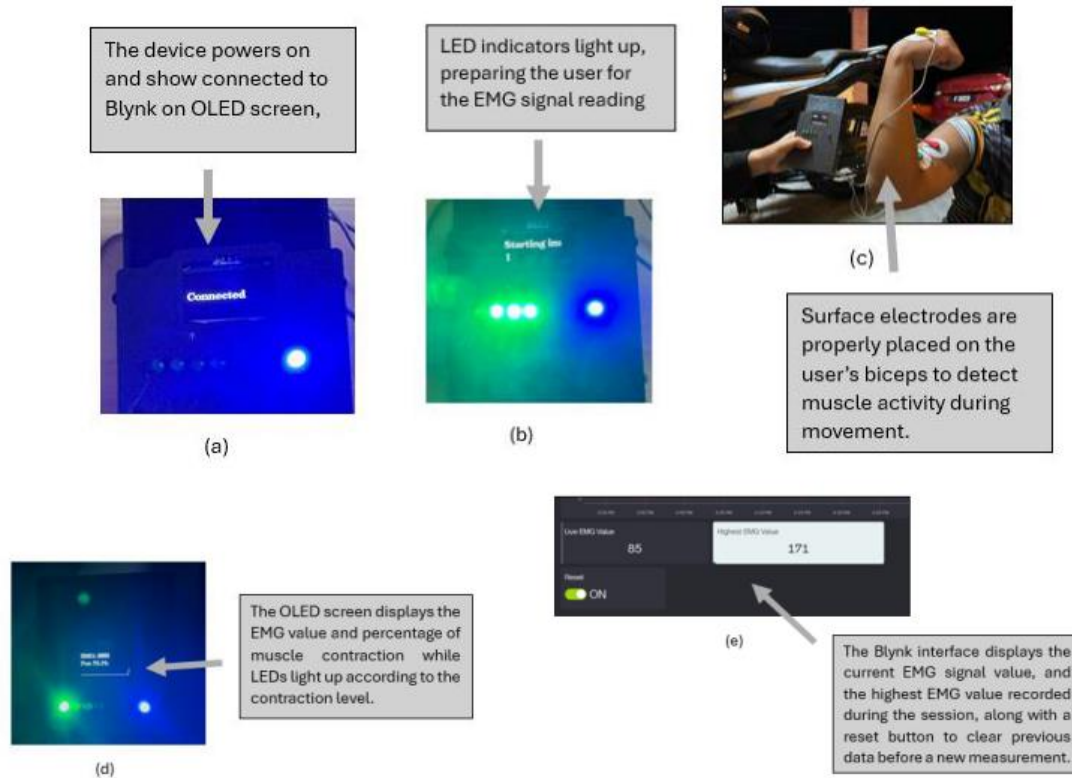


Fig. 6 (a) Device connection confirmation via OLED display, (b) LED indicator initializing EMG session, (c) Surface electrode placement on biceps muscle, (d) OLED display show EMG contraction percentage, (e) Blynk interface display live and peak EMG data

4. Conclusion

In conclusion, the wireless EMG monitoring system for Biceps Muscle Recovery has demonstrated promising performance and reliability in early testing across six individuals from different physical backgrounds. The EMG values recorded showed consistency and accuracy. The system's integration of surface electrode, allows for real-time muscle activity monitoring and visual feedback, enhancing its usability in rehabilitation. The ability to view live and peak EMG value through the Blynk interface, along with the reset functionality, ensure user, friendly operation session tracking. Lastly this project successfully combines practical functionality and real-time data accessibility, making it a valuable tool for remote and home-based muscle rehabilitation. With further development, this prototype has the potential to support physiotherapy and patient in monitoring progress and improving recovery outcomes. .

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Nurul Izwani Kamalruzaman, Muhammad Mahadi Abdul Jamil; **data collection:** Muhammad Mahadi Abdul Jamil; **analysis and interpretation of results:** Nurul Izwani Kamalruzaman, Muhammad Mahadi Abdul Jamil; **draft manuscript preparation:** Nurul Izwani Kamalruzaman, Muhammad Mahadi Abdul Jamil. All authors reviewed the results and approved the final version of the manuscript.

References

- [1] Y. Zhang, Y. Yu, Z. Feng, W. Zhang, and H. Yuan, "A Review of Surface Electromyography Monitoring Based on Flexible Sensors," *Electronics*, vol. 12, no. 7, p. 1520, 2023. <https://www.mdpi.com/2079-9292/12/7/1520>
- [2] M. X. Chua, et al., "Analysis of Fatigue-Induced Compensatory Movements in Bicep Curls: Gaining Insights for the Deployment of Wearable Sensors," arXiv preprint, arXiv:2402.11421, 2024. <https://arxiv.org/abs/2402.11421>
- [3] Y.-W. Chang, et al., "Development of a Portable Surface EMG Measurement System Based on MSP430 Microcontroller," *Sensors*, vol. 12, no. 1, pp. 1738–1755, 2012. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3279225>
- [4] The internet of things with ESP32. The Internet of Things with ESP32. (n.d.). <http://esp32.net/>
- [5] Advancer Technologies, "Advancer Technologies Muscle Sensor v3," <http://www.pololu.com/product/2726>. Accessed: Jun. 14, 2025.