

# EMG Driven Prosthetic ARM

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**Abstract**—In this paper, a prosthetic arm controlled by Electromyographic (EMG) signals, developed with Arduino Nano microcontroller technology, is introduced. The goal is to create an affordable, easy-to-use prosthetic solution to help individuals with upper limb amputations regain their autonomy and undertake daily activities. The system employs EMG sensors to pick up on electrical signals created by remaining muscle activity, which are then processed to drive servo motors and reproduce natural arm motions. The prosthetic is engineered for comfort as well as performance, allowing for intuitive and sensitive control through limited user training. The project keeps the requirement for sophisticated control systems to a minimum by using simple signal processing and calibration techniques. The whole arrangement is designed to close the gap between functionality and affordability, with subsequent advancements leading to customizable, 3D-printed products and integration into rehabilitation, industrial, and defense industries to improve the quality of life for the users.

**Keywords**— EMG Sensor, Arduino Nano, Prosthetic Arm, Servo Motor, Myoelectric Control, Muscle Signals.

## I. INTRODUCTION

A prosthetic hand is a sophisticated hardware product aimed at supporting those who have lost limb ability, with the intention of reinstating motor control and minimizing their reliance on other people. The harmony between hardware and software gives rise to smart assistive technologies such as EMG-controlled prosthetic hands.

This technology is a significant advancement in biomedical engineering as it enables patients to regain normal movement and enhance their quality of life. Since each human movement is specific and vital, EMG-based systems translate muscle signals to control the prosthetic hand, enabling users to overcome physical disabilities. Such devices provide precision and

responsiveness and are a groundbreaking development in rehabilitation technology. EMG-controlled prosthetics are especially valuable in settings where standard limb usage is limited or not allowed, like in precise motor usage during daily chores or in post-injury recovery situations. Android adds to this capability through the provision of smartphone-based control and calibration via specific apps, enabling real-time modification and observation.

The prosthetic hand is controlled by the muscle contractions picked up by EMG (Electromyography) sensors mounted on the residual limb. These are processed by a microcontroller, often Arduino, and actuation commands are sent to servo motors for hand movement. In this design, IoT (Internet of Things) provides cloud connectivity, allowing remote diagnostics, performance monitoring and individualized adjustments. The MyoWare EMG sensor picks up small muscle movements, with an ESP-8266 Wi-Fi module sending this information to a user or healthcare provider using platforms such as Cayenne. The combination of EMG, Arduino, and IoT has been a breakthrough in medical robotics with both precision and flexibility. This EMG-controlled prosthetic hand not only aids amputees in gaining functional independence but also finds application in healthcare facilities, rehabilitation clinics, and remote therapy installations.

## II. LITERATURE SURVEY

In [1], Usman Khan and Mainak Roy present a system for controlling a prosthetic hand using EMG (Electromyography) signals to improve the quality of life for amputees by replicating natural hand movements. The design uses an Arduino Uno microcontroller interfaced with MyoWare EMG sensors, servo motors, and an HC-05 Bluetooth module. EMG sensors placed on the user's residual limb detect muscle contractions, which are

processed to control hand gestures like open, close, and grip. An Android application developed via MIT App Inventor allows users to calibrate and customize gesture sensitivity, enhancing adaptability and user experience.

In [2], Narek N. Unanyan and Alexey A. Belov propose a low-cost prosthetic hand system driven by EMG signals to restore functionality for amputees with enhanced precision. Their system features Arduino for EMG signal processing and control, interfaced with an ESP8266 Wi-Fi module for wireless data transmission. Cloud integration using the Cayenne IoT platform enables real-time monitoring and adjustment of the prosthetic response. Servo motors provide accurate movement control of the fingers, and remote access functionality supports healthcare monitoring and adaptability for varied user needs.

In [3], Dr. Mercy Paul Selvan, Rish I. Raj, R. Gowtham Sai, Dr. S. Jancy, and Dr. Viji Amutha Mary detail the development of a 3D-printed prosthetic arm equipped with a feedback system for enhanced functionality. The system employs MyoWare EMG sensors, Arduino Uno, and servo motors to mimic natural muscle-driven motion. Notably, it integrates a DHT11 temperature and humidity sensor for environmental monitoring and features a solar-powered charging module to improve autonomy and mobility. Wireless communication is enabled through both Bluetooth and Wi-Fi modules, and mobile control allows real-time operation and monitoring, contributing to both user convenience and energy efficiency.

In [4], Sivapong Nilwong, Delowar Hossain, Eneo Petoku, and Genci Capi have developed a smart prosthetic system that supports secure wireless communication for real-time gesture control and feedback. The prosthetic hand is operated using an Android-based application named BLYNK, ensuring intuitive control and configuration. Arduino Uno R3 is used as the central processing board, interfaced with the NodeMCU ESP module and servo motor drivers. The ESP8266 Wi-Fi module connects to Android devices using stored credentials predefined by the developer, ensuring access security and user privacy. This secure wireless communication method makes the EMG-controlled prosthetic hand reliable and protected from unauthorized access, empowering users with independence and safety.

### III. SYSTEM HARDWARE

#### A. Arduino Nano Microcontroller

A compact single-board microcontroller that enables easy application development with various interactive objects and their environments is called Arduino Nano. It is also known as a microcontroller board that supports the ATmega328P, similar to the Arduino Uno. This board features 22 input/output digital pins, of which 6 are used for PWM output and 8 for analog input. It includes a mini USB port for connection, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), and a reset button [3,4]. The board can be powered through a USB connection, an external adapter, or a battery. The connection to a PC is made via a USB mini-B cable, enabling programming and serial communication. Fig. 1 shows the Arduino Nano Microcontroller.

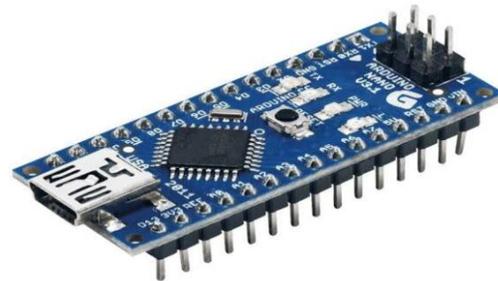


Fig. 1. Arduino Nano Microcontroller

#### B. MG995 Standard Metal Gear Servo Motor

The MG995 is a standard metal gear servo motor module designed to provide precise control over angular position, making it suitable for robotic and automation applications. This servo motor operates on a voltage range of 4.8V to 7.2V and delivers a stall torque of up to 11 kg-cm at 6V, ensuring powerful performance for medium to heavy-duty tasks [8]. It receives control signals through a PWM (Pulse Width Modulation) interface, allowing users to manipulate the motor shaft's position with high accuracy. The motor includes durable metal gears for improved longevity and reduced wear under mechanical stress. Signal, VCC, and GND pins are connected to the microcontroller or motor driver circuit, enabling stable input reception and actuation. The MG995 adjusts its position based on the duty cycle of the PWM signal applied, with typical control angles ranging from 0° to 180°. The MG995 servo motor is illustrated in Fig. 2.



Fig. 2. MG995 standard metal gear servo motor

*C. EMG Sensor Module*

The EMG sensor module is utilized for sensing muscle-generated electrical signals that occur during muscle contraction, converting them into analog voltages readable by a microcontroller. This analog signal can then be transmitted, processed, and analyzed for controlling various external devices such as prosthetic limbs, robotic elements, or gesture-based systems [9,10]. The sensor works by using surface electrodes placed over specific muscles to detect changes in electrical potential. The module comprises signal conditioning circuits such as amplifiers, filters, and rectifiers that ensure the output is clean and noise-free. It operates at a supply voltage of around 3.3V to 5V, making it compatible with standard microcontroller boards. The EMG sensor setup is shown in Figure 3 and is highly suitable for biomedical and robotic projects.

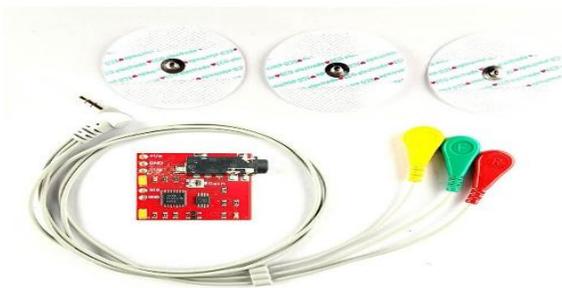


Fig. 3. EMG sensor module

*D. Buck Converter Module*

The LM2596 Buck Converter is a DC-DC step-down power module with the capability of converting input voltages of 4V to 40V into adjustable outputs of 1.3V to 37V with continuous current support up to 2A. The module comes equipped with an onboard LED voltmeter to read input or output voltage in real-time [9,10]. The module relies on the LM2596 switching regulator IC to

provide efficient conversion of voltages with negligible heat generation. A potentiometer enables accurate voltage regulation, and internal features such as thermal shutdown and overcurrent protection improve safety. The module is suited for use in embedded systems, battery-operated devices, and stable output voltage projects. The hardware configuration and voltmeter interface are depicted in Figure 4.

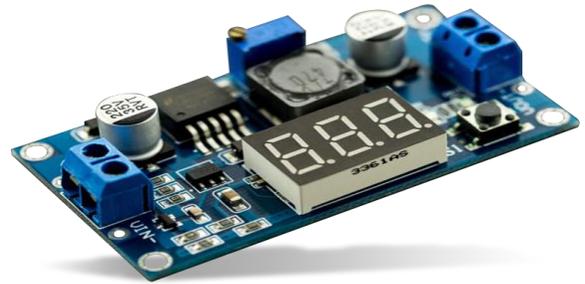


Fig. 4. LM2596 buck converter module

*E. Lithium Battery Module*

The 12V Lithium Battery is a battery power source with rechargeable properties that is common in embedded systems, robotics, and portable electronics. It generally comprises three cells of 3.7V lithium-ion arranged in series to provide a nominal voltage of 11.1V to 12.6V when fully charged [9,10].

The batteries are characterized by high energy density, low self-discharge, and long cycle life, which qualifies them for applications with long duration. A built-in Battery Management System (BMS) provides safeguards against over-charging, over-discharging, and short-circuits. Outputs of between 1A and 5A depending on the configuration are provided to allow for reliable supply to microcontrollers, motor drives, and wireless modules. Light in weight, with a very compact size, the 12V lithium battery is perfect for use in remote- and mobile-powered systems. Figure 5 indicates the configuration of the batteries.



Fig. 5. 12V Lithium battery module

IV. SOFTWARE SPECIFICATIONS

A. Arduino IDE

This Arduino IDE is an open source and cross platform software, it can be used to write programs, compile it and burn into Arduino boards. The Arduino Integrated Development Environment consists of two different sections, one is compiler and another is editor. The text editor is used for writing codes[13]. These codes are called as sketch and .hex file is saved. Arduino IDE is compatible with Windows, MAC and LINUX operating system. It is suitable and simple to make by the programming codes which helps the robot to make the movement and it may be very helpful for the sensors to be interfaced with microcontroller to do the appropriate action which is going to be performed further.

V. SYSTEM ARCHITECTURE

The proposed EMG-driven prosthetic arm system is centered around an Arduino Nano microcontroller, which plays a critical role in processing biosignals and generating motor control commands. The architecture of the system is designed to interpret muscle activity signals (EMG) from the user's residual limb and convert them into corresponding mechanical movements in the prosthetic arm. The system begins with EMG sensors placed on the skin above targeted muscles. Fig. 6 shows block diagram of the EMG Driven Prosthetic ARM.

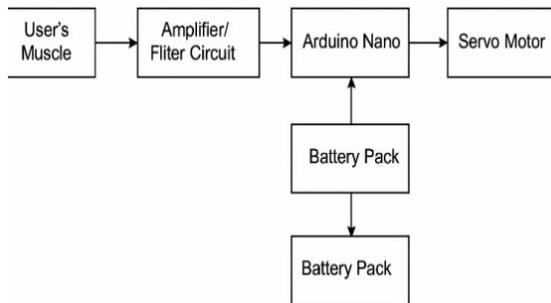


Fig. 6. Block diagram of the EMG-driven prosthetic ARM

These sensors detect the tiny electrical potentials generated during muscle contractions. Raw EMG signals are generally low and noisy, so they are subjected to an amplification and filtering process to make them stronger and eliminate unwanted frequencies. The filtered signals are then sent to the Arduino Nano, which is programmed

through Arduino IDE. Fig. 7 shows the complete Interfacing diagram of the EMG Driven Prosthetic ARM.

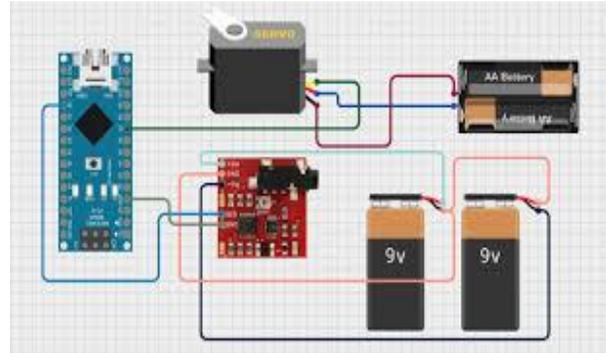


Fig. 7. Interfacing diagram of the EMG-driven prosthetic arm system.

The microcontroller reads the signal strength and duration and converts it into the user's intention—e.g., opening or closing the hand. According to this reading, it drives Pulse Width Modulation (PWM) signals to the servo motors integrated in the prosthetic limb, which permits smooth and proportionate finger or hand motion. Fig. 8 shows the structure of the prosthetic ARM.

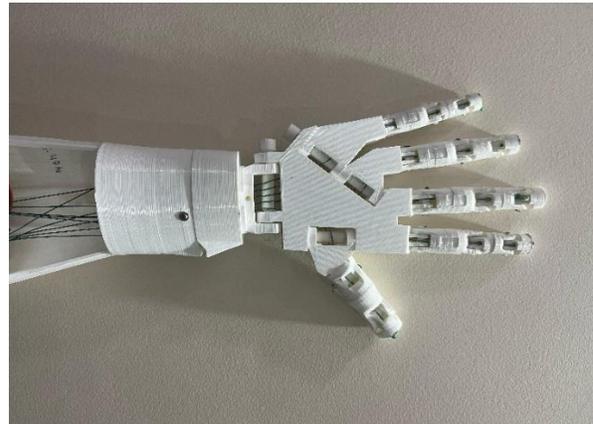


Fig. 8. Visualization of 3D-printed prosthetic ARM

The entire system is powered by a battery module, typically rated at between 5V and 9V, that provides portability and ease of use for everyday wear. The microcontroller is loaded with algorithms for decision-making to respond to different input thresholds and motor actions for distinct gestures or grip types. The system can also have a calibration routine, which corrects for the variations between individuals in EMG signal amplitude to provide more accurate and customized control. An optional feedback mechanism can also be added to offer real-time information to the user or system for enhanced motion precision and user flexibility. Generally, the architecture is lightweight, modular, and

inexpensive, which allows amputees to carry out routine everyday activities with more autonomy and enhanced quality of life. user adaptability. Overall, the architecture is designed to be lightweight, modular, and cost-effective, enabling amputees to perform basic daily tasks with greater independence and improved quality of life. Fig. 9 shows Interfacing EMG sensor with Arduino Nano.



Fig. 9. EMG sensor interfacing with Arduino Nano microcontroller.

## VI. CONCLUSION

The key feature of the EMG Driven Prosthetic Arm is that it possesses multiple abilities of identifying muscle signals and translating them into respective mechanical motions. Based on the EMG sensor data recorded from the subject's muscles, the arm will react by moving in the intended direction such as opening, closing, lifting, or rotating. It can perceive the strength and rhythm of muscle movement to carry out accurate actions. The system achieves smooth and natural movement, simulating actual limb functions. All sensor and motor elements cooperate to improve the responsiveness and precision of the prosthetic. The arm can be easily controlled by the user's muscle activity without any external buttons or remotes. This project is highly useful and convenient for physically disabled people, restoring independent movement and enhancing quality of life.

## REFERENCES

- [1] U. Khan and M. Roy, "Prosthetic Hand Control Using EMG Sensor," *International Research Journal of Engineering and Technology (IRJET)*, vol. 9, no. 7, pp. 2601–2605, Jul. 2022.
- [2] N. N. Unanyan and A. A. Belov, "Low-Price Prosthetic Hand Controlled by EMG Signals," in *Proc. Int. Carpathian Control Conf. (ICCC)*, pp. 299–304, 2021.
- [3] M. P. Selvan, R. I. Raj, R. G. Sai, S. Jancy, and V. A. Mary, "Development of 3D Printed Prosthetic Arm with Integrated Feedback System," in *Proc. Int. Conf. Mathematical Sciences (ICMS)*, pp. 1–8, 2020.
- [4] S. Nilwong, D. Hossain, E. Petoku, and G. Capi, "Development of Myoelectric Robotic Hand Using 3D Printer," in *1st Int. Conf. Advances in Science, Engineering and Robotics Technology (ICASERT)*, 2019.
- [5] V. Pawar, S. Bire, S. More, K. More, and R. Mule, "Review on Design and Development of Robotic Arm Generation-1," *Int. J. Innovative Science and Research Technology*, vol. 3, no. 3, pp. 529–533, Mar. 2018.
- [6] T. Vanhuy, D. T. Minh, K. N. Phan, and V. A. Tran, "Simple Robotic Hand in Motion Using Arduino Controlled Servos," *Int. J. Science and Research (IJSR)*, vol. 6, no. 3, pp. 972–974, Mar. 2017.
- [7] C. Shi, D. Yang, J. Zhao, and L. Jiang, "i-MYO: Gaze-Based Mode Switching for EMG-Controlled Prosthetics with Augmented Reality," *arXiv preprint arXiv:2205.08948*, 2022.
- [8] R. B. Azhiri, M. Esmacili, and M. Nourani, "Real-Time EMG Signal Classification for Prosthetic Control: Feature Extraction and Post-Processing," *arXiv preprint arXiv:2107.00733*, 2021.
- [9] M. Jafarzadeh, D. C. Hussey, and Y. Tadesse, "Deep Learning for Controlling Prosthetic Hands Using Electromyography Signals," *arXiv preprint arXiv:1909.09910*, 2019.
- [10] E. Hocaoglu and V. Patoglu, "Natural Control of Variable Stiffness Transradial Hand Prosthesis via Surface EMG Signals," *arXiv preprint arXiv:1910.11946*, 2019.
- [11] A. Krasoulis, M. S. Erden, and S. Vijayakumar, "Towards low-dimensional proportional myoelectric control," *J. NeuroEngineering and Rehabilitation*, vol. 14, no. 1, pp. 1–14, 2017.
- [12] G. Purushothaman and K. K. Ray, "Continuous myoelectric signal classification for prosthetic hand control – A review," *Int. J. System Assurance Engineering and Management*, vol. 6, no. 3, pp. 365–372, 2015.