SURFACE ELECTROMYOGRAPHY ACQUISITION SYSTEM

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ABSTRACT

This project focuses on the design and development of a Surface Electromyography (sEMG) Acquisition system aimed at accurately capturing and analyzing muscle activity. By using non-invasive electrodes, the device detects electrical signals generated by muscle fibers during contraction and relaxation. These signals are processed and digitized to provide biofeedback, enabling applications in clinical diagnosis, rehabilitation, and sports science. It incorporates advanced filtering and signal amplification techniques to improve signal quality and reduce noise, ensuring high fidelity in muscle signal acquisition. It gives a comprehensive understanding of the variations in sEMG signals under various conditions.

INTRODUCTION

The importance of accurately capturing and analyzing muscle activity is central to this work, focusing on the use of Surface Electromyography (sEMG) as a reliable and noninvasive method to study skeletal muscle function. Unlike invasive EMG, which requires needle electrodes, sEMG utilizes electrodes placed on the skin surface, providing a convenient way to record the electrical activity generated by muscle contractions. This technique offers valuable insights into muscular health, movement patterns, and recovery processes, making it an essential tool in fields such as biomedical engineering, sports science, rehabilitation, and ergonomics. By recording muscle activity non-invasively, sEMG can support a wide range of applications, from monitoring athletic performance to evaluating muscle recovery in clinical settings. The goal of this project is to develop a robust sEMG Acquisition system capable of recording high-quality EMG signals. Through careful consideration of signal acquisition techniques, this system is designed to improve precision by implementing advanced filtering and amplification methods to reduce interference and capture muscle signals with clarity. The extracted signals may be used for research and development in many fields such as bio-medical applications, prosthetics, etc

BLOCK DIAGRAM

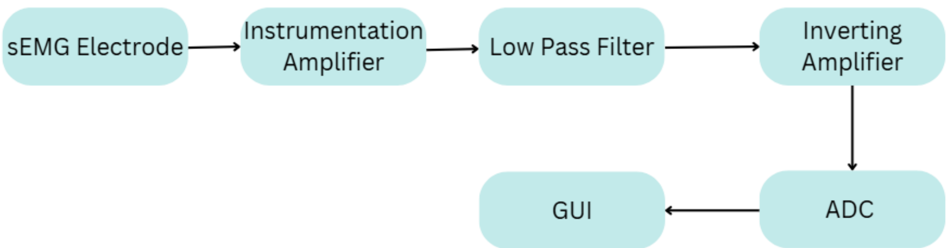

FIG 1 BLOCK DIAGRAM OF SEMG SYSTEM

DESIGN EQUATIONS

1.Instrumentation Amplifier:

Av = Vo / (V2 - V1) = (1 + ((2*R1)/Rgain))(R3/R2)

2.Low-Pass Filter:fc = 1 / (2*pi*R2*C2)

3.Inverting Amplifier:Vgain = - (R2 / R1)

4.Frequency response:20*log(Av*Vgain)

METHODOLOGY

1. The proposed sEMG acquisition system is designed and developed using a modular circuit-based approach for capturing and analyzing muscle electrical activity.
2. A surface EMG electrode is placed over the targeted muscle group to detect biopotentials generated during neuromuscular activity, such as isometric or dynamic contractions.
3. The weak EMG signal is first fed into an Instrumentation Amplifier (INA) to achieve high common-mode rejection and appropriate gain, ensuring clear and accurate amplification of the input signal.
4. The amplified signal is conditioned using a Low-Pass Filter to remove high-frequency noise components, preserving only the useful bandwidth of the muscle signals (typically between 20 Hz – 450 Hz).
5. An Inverting Amplifier stage is used to further adjust the amplitude and polarity of the signal, enabling optimal compatibility with the analog-to-digital conversion stage.
6. The filtered and amplified analog signal is then passed into an Arduino microcontroller, which includes an inbuilt ADC (Analog-to-Digital Converter) to digitize the sEMG signal for further analysis.
7. Analytical techniques such as RMS value calculation and frequency spectrum analysis were applied to interpret muscle activity levels and detect signs of fatigue or performance variations.

CIRCUIT SETUP

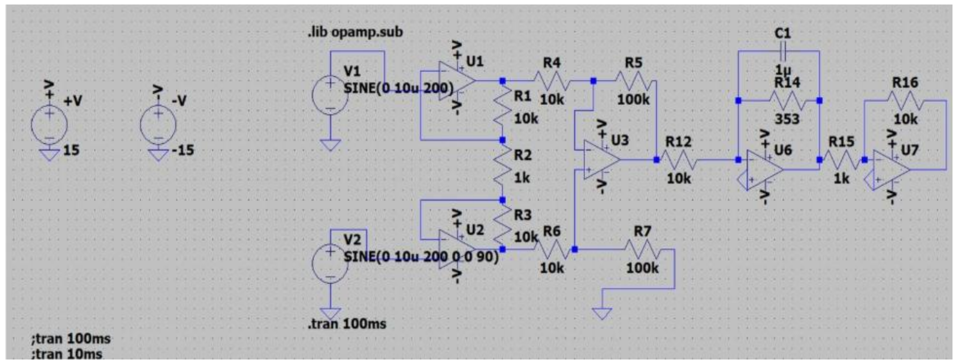

FIG 2 SIMULATION CIRCUIT

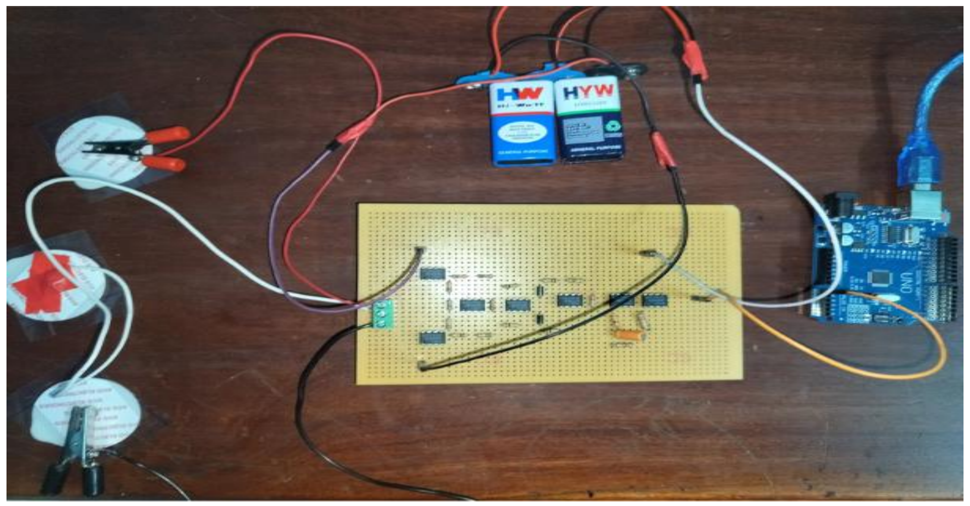

FIG 3 COMPLETE CIRCUIT SETUP

RESULTS

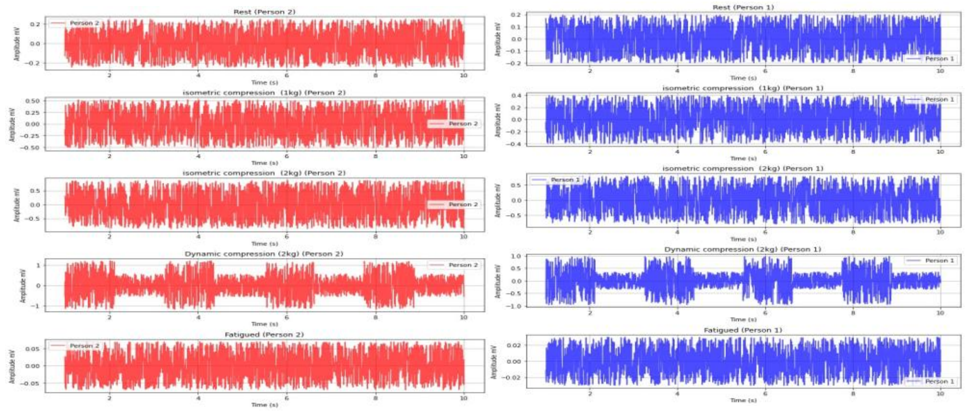

FIG 4, FIG 5 SIGNALS FROM TWO SUBJECTS

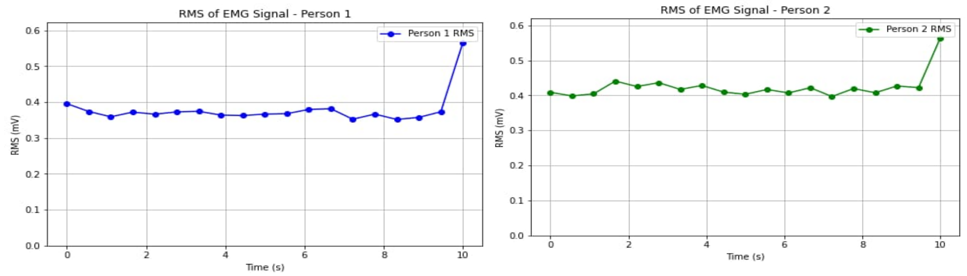

FIG 6, FIG 7 RMS ANALYSIS OF ISOMETRIC COMPRESSION

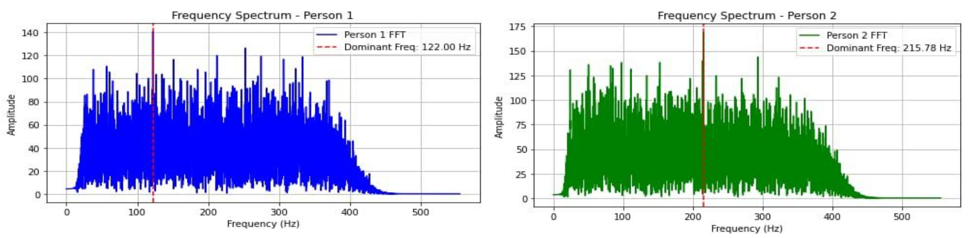

FIG 8, FIG 9 FREQUENCY ANALYSIS OF ISOMETRIC COMPRESSION

CONCLUSION

We designed and implemented an sEMG acquisition system that captures, processes, and analyzes muscle activity. A functional circuit was developed for signal acquisition, enabling effective extraction of raw sEMG signals. We applied time-domain and frequency-domain analyses to understand muscle behavior during tasks like isometric and dynamic contractions. Our system successfully differentiated muscle activity levels and revealed characteristic shifts in activation. This work lays the groundwork for improvements in signal quality, filtering techniques, and real-time analysis for biomedical and rehabilitation applications.

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