A Flexible EMG Sensor for Prosthetic Actuation and Communication

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Introduction

Upper limb prosthetic rejection rates among users are frequently associated with lack of comfort and limited function [1].

In this project, our research examined the advantages of incorporating a multi-channel array of flexible electrodes into the current surface electromyography (EMG) sensor design for the prosthetic arm.

The single-channel EMG sensors at Limbitless Solutions are:

- Accurate at signal acquisition
- Compact and durable
- Easy to manufacture
- Rigid and non-conformal
- Prone to shifting due to movement

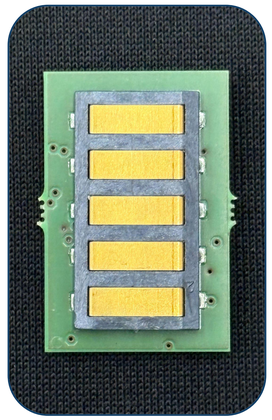


Figure 1: Current EMG sensor

How can flexible electronics be integrated into the Limbitless Solutions bionics to improve performance of the arm and enhance quality of life in users?

Introduction: Next Gen. Flexible EMG Sensors

Enhancing the traditional rigid EMG sensors requires innovative techniques for structural design and proper selection of materials for maximum stretchability, flexibility, and electrical performance [2]. Researchers have tested distinct approaches including:

Materials

- Dry electrodes on a polyimide flexible printed circuit board [3]
- Copper/polyimide metal film incorporated in a Ecoflex encapsulation layer [4]
- Copper/gold film encapsulated by polyimide substrate [5]

Design Strategies

- Connecting wires to the electrodes for universal EMG integration [5]
- Serpentine traces with circular structures allows for electrode flexibility with strong signal quality [4]
- Multi-channel EMG system detects activation of muscle groups for gesture control [3]

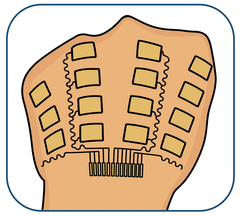


Figure 2: Multichannel EMG array with serpentine interconnects

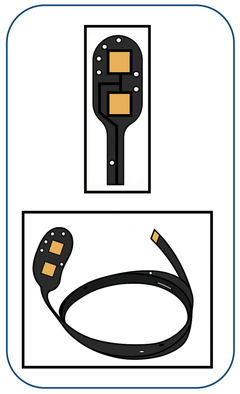


Figure 3: Two-electrode flexible EMG

Background: Design Process

AUTODESK Fusion

As an introduction to developing smart sensors, this research project challenge required designing a PCB using several bio-sensing sensors (inputs) and activators (outputs).

Inputs

- Temperature
- Motion
- RFID
- Galvanic Skin

Outputs

- Haptic Motor
- Mini-Display
- Speaker
- LED

Prosthetic RFID

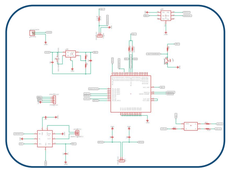


Figure 4: Schematic

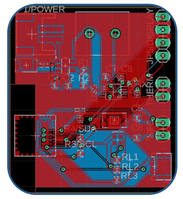


Figure 5: Board Layout

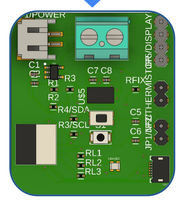


Figure 6: 3D Model

Stress Detection

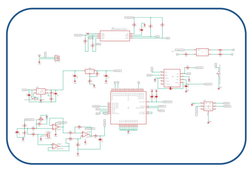


Figure 7: Schematic

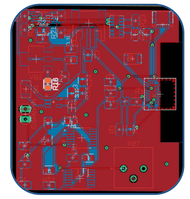


Figure 8: Board Layout

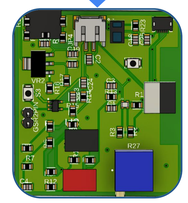


Figure 9: 3D Model

Case Study: A Flexible Multichannel Electromyography Array

Design and Manufacturing

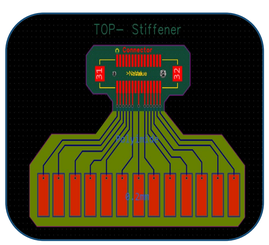


Figure 10: Flexible PCB (FPCB) Design for the Array

Flexible Array Design

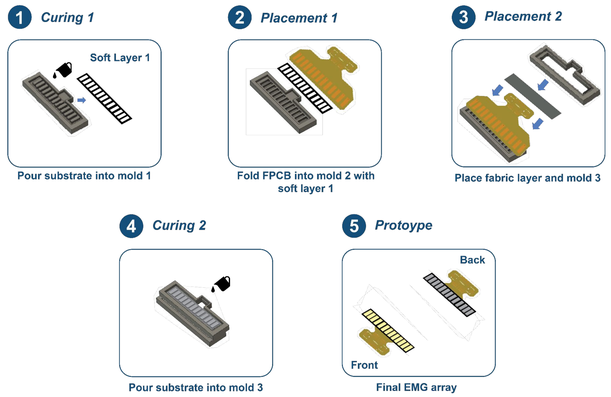
- 13 electrodes
- 6 Independent channels
- Polyimide substrate
- FR4 Reinforced connector

Material Roles

- Polyimide
  - Flexibility [3]
  - Dielectric properties [12]
- FR4
  - Mechanical stability
  - Electrical interfacing

Encapsulation

- 3 Molds
- Array FPCB
- Substrate
  - Low viscosity
  - Flexible
  - Biocompatible
- Fabric
  - Porous
  - Flexible
  - Durable



Advantages of a Multichannel System

- Increased user embodiment and satisfaction [7]
- Higher gesture classification success [8]
- Potential for more Degrees of Freedom (DOFs) [9]

Advantages of a Flexible System

- Improved skin-to-electrode interface [10]
- Decreased electrode location specificity [10]
- Increased user comfort [11]

Key Considerations for Multichannel System

- Increased cost
- Increased signal processing complexity
- Limited bluetooth connectivity

Key Considerations for Flexible System

- Material characteristics
- Non-traditional design and manufacturing process
- Durability and longevity

Continuing Work

Manufacturing a low-cost and high-functioning multi-channel EMG system requires many intricate steps and designs. Future work involves:

- Developing a system that meets the application requirements including cost-effectiveness
- Finalizing a design that is compatible with current bionic arms
- Prototyping and interfacing electrode array with the bionic arm
- Integrating multiplexers to manage multi-channel signal acquisition

References and Acknowledgments

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