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Feature Extraction and Comparative Classification of Myoelectric Signal for Prosthetic Arm Control

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Abstract*— Peoples who have lost their hand in accident or having born disability in their hand are unable to perform daily routine work. Prosthetic arm helps those people to accomplish this task. The forearm muscle helps to establish wrist movement. Thus surface electromyographic signal which are collected from the forearm muscles helps to establish control over movements of the prosthetic arm. Electromyographic signals are source for extracting features of position and movement. We have extracted the features of electromyographic signal with the help of temporal approach. These extracted features refereed as motor unit action potential which drives the prosthetic arm after classification. In this work we have intended open, close and hold movements. We have implemented Matlab based algorithm for mean absolute value feature extraction and comparative classification. This paper presents method of analyzing myoelectric signal using Matlab and Proteus software. With the help of Proteus software we have done virtual simulation for movement's classification and control using microcontroller. Result and Conclusion section describes the simulation and practical result obtained from conducted experiment.

***Keyword*—MES Myoelectric Signal, EMG Electromyography, MAUP Motor Activation Unit Potential, MAV Mean absolute value**

I. INTRODUCTION

Classifying different movements for prosthetic arm it is necessary to process collected MES signal. Signal processing includes signal acquisition, Feature extraction and movement recognition. Feature extraction is very important step for classification of different movements [1]. Driving prosthetic devices involved EMG signal feature extraction and classification.

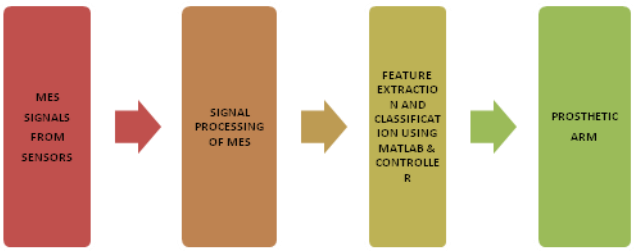

Fig. 1.1 Block Diagram for proposed work

Fig 1.1 shows the block diagram of proposed work. In this work we have acquired MES signal from the surface of the normal as well as abnormal persons with the help of disk surface electrodes. In signal processing we have denoised, amplified, filtered and rectified signal. We have stored acquired EMG signal in.txt file on personal computer and extracted MAV feature. Prosthetic arm has drive based on the comparison classification of MAV features for open, close and hold movements.

There are two nonparametric approaches for feature extraction temporal and spectral approach temporal method has offered much better time efficiency and lower dimension of the feature vector than the other expensive method with just a slightly smaller classification hit rate [6] .

II. PROPOSED METHOD

Proposed work has been categorized in two approaches Hardware Approach and Hardware Software Approach. Block diagram shows steps in respective approach.

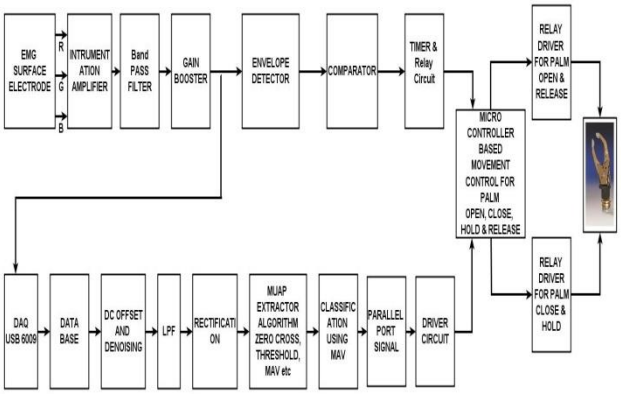

Fig. 2.0 Block Diagram for proposed method.

2.1 Hardware Approach

In hardware approach we are acquising EMG signals from the surface of amputee with the help of disk surface electrodes and then we are doing signal processing of these signals to extract features with temporal approach. In signal processing we are doing Filtering, gain boosting and extracting average pulses using comparator and averaging circuit. In feature extraction we are extracting Motor Unit Activation Potential (MUAP) from EMG signal which we are using for movement classification by comparison method. In temporal approach we are computing Mean Absolute Value (MAV) of collected signal and by comparing that pulse we are driving prosthetic ARM with the help of microcontroller. We are using different three switches for controlling movement namely open close and hold. In this work our intended movements are arm open, close and hold.

2.1.1 Virtual Simulation for Hardware Approach

Section 2.1.1.1 describes the methodology of processing EMG signal in PROTEUS software. Section 2.1.1.2 describes the methodology of classifying and controlling prosthetic arm movement using microcontroller.

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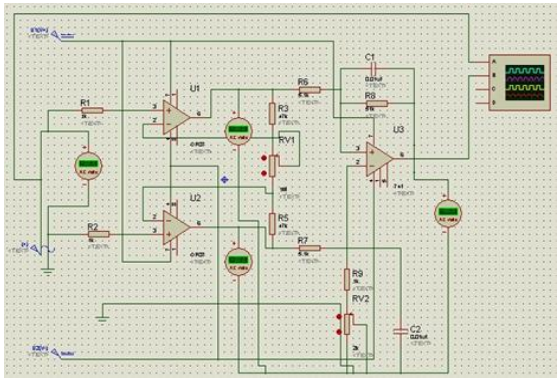
2.1.1.1 Virtual Simulation for EMG signal processing

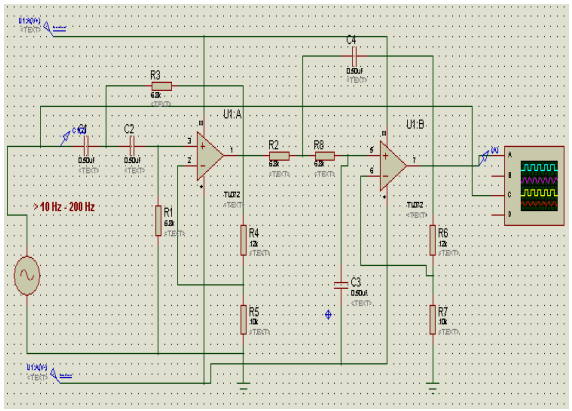
We have done virtual simulation of Instrumentation amplifier, 4th order Butterworth filter, peak detection, averaging, comparator and Timer circuit using PROTEUS software and observed simulated result discussed in result section

A) Instrumentation Amplifier Design



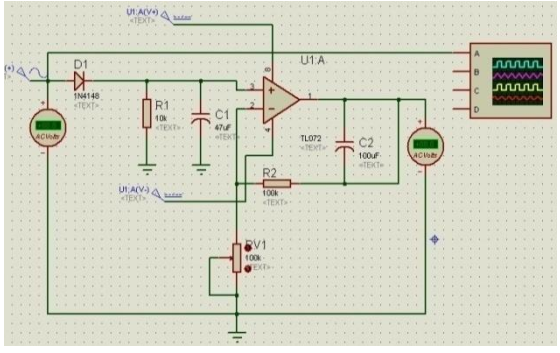
CMRR Adjustment

B) Filter Design



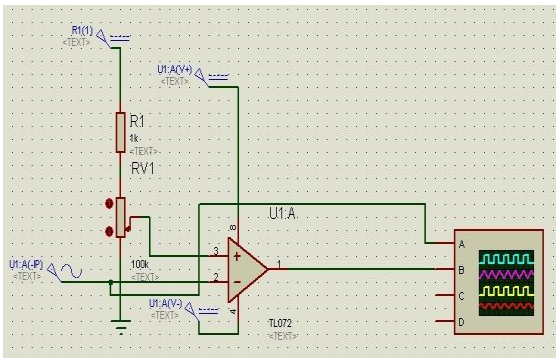
Butterworth Band Pass Filter

C) Envelop Detector

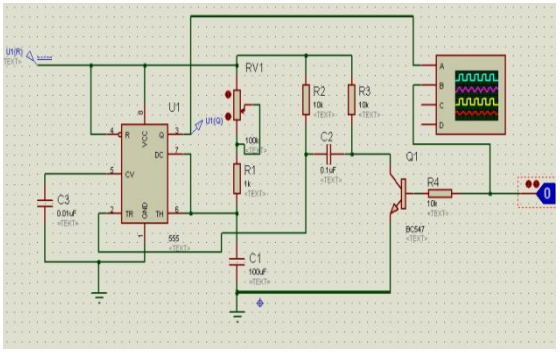


Positive Peak Detection & Averaging Threshold Value Adjustment

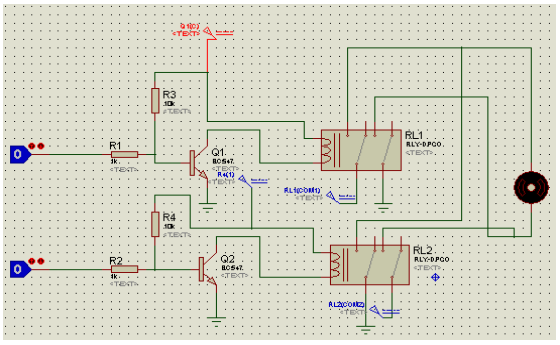
D) Comparator



E) Timer Design for Delay Circuit



F) Motor Driving Relay Circuit



Rotating Motor Clockwise & Anticlockwise

Fig. 2.1.1 Virtual Simulation for Hardware Approach

Fig 2.1.1 shows simulation for hardware setup in which we have extracted features using EMG average. As shown in figure 2.1.1 A) EMG signal are amplified and denoised by the Instrumentation amplifier. This amplified signal is then filtered by band pass filter shown in figure 2.1.1 B). Filtered EMG signal is then passed through peak detection and averaging circuit, this average signal referred as raw MUAP shown in fig 2.1.1 C). Averaged signal is then compared by comparator circuit in which averages signals are compared to threshold value which passes averaged signal below threshold value shown in fig 2.1.1 D). Output pulse of the comparator circuit is used to trigger timer circuit which creates pulse shown in fig 2.1.1 E). Output pulse from the timer circuit drives relay circuit shown in fig 2.1.1 F).

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2.1.1.2 Virtual Simulation for movement control and classification

This virtual simulation elaborates method of controlling and classifying open, close and hold wrist movement. Movements are controlled using mechanical switches by checking high status on microcontroller port pin as shown in fig 2.1.1.2 A)

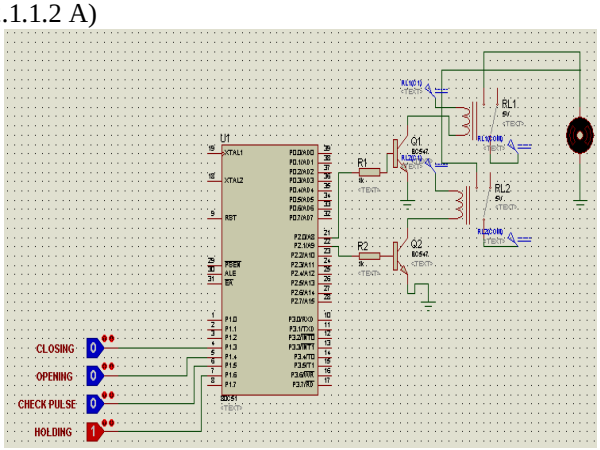

Fig 2.1.1.2 A) Virtual Simulation for Prosthetic arm movement control and classification

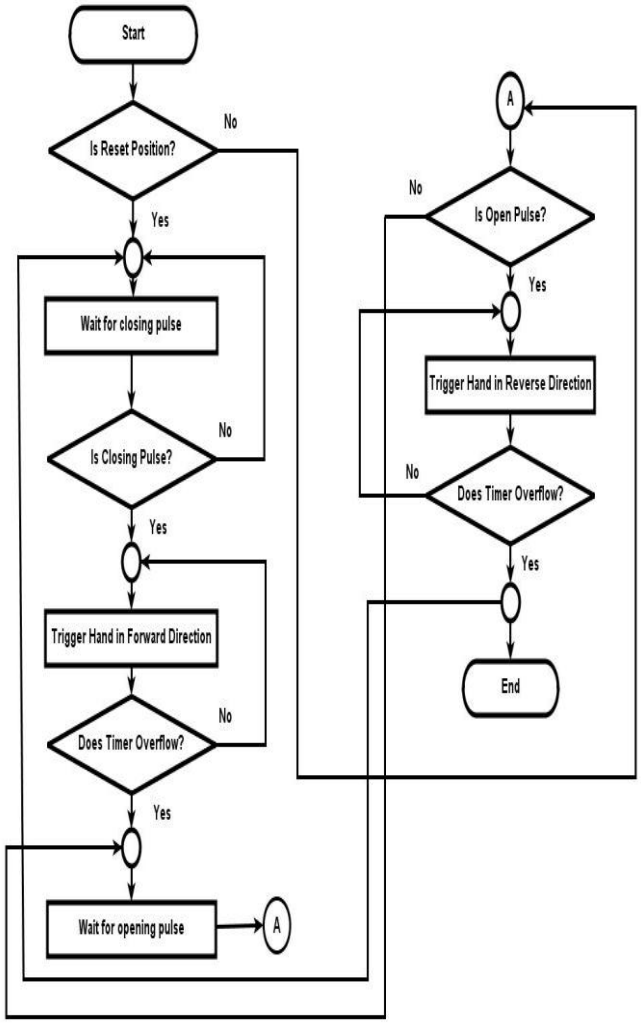

Fig 2.1.1.2 B) Algorithm for movement control and classification

2.1.2 Experimental Setup

Fig 2.1.2 Photographs of designed work

As shown in the Fig 2.1.2 I have designed EMG instrumentation amplifier and acquiring patient data for further analysis.

2.2 Hardware – Software approach

In hardware - software approach we are acquising EMG signals for intended movements with the help of NI DAQ card and storing these signals to .txt file. We are doing signal processing of these stored signals and display it by using Matlab Software. In Matlab we are extracting Motor Unit Activation Potential (MUAP) from EMG signal and computing Mean Absolute Value (MAV) for different movements. Using MAV comparison algorithm we are doing movement classification and sending pulse on parallel port which further being use by microcontroller for driving prosthetic Arm.

2.2.1 Matlab based Signal Processing for feature extraction and Classification

In Hardware – Software approach we have collected EMG signal for open, close and hold movement from EMG simulator hardware with the help of data acquisition card and stored signals in database. Feature extraction of these signal have been done through Matlab software as shown in fig 2.2.1 A).

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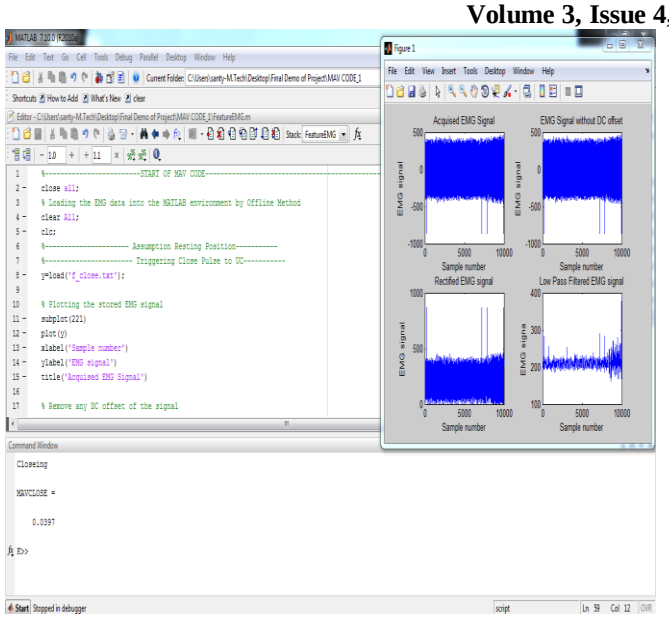


Fig 2.2.1 A) EMG signal processing through Matlab software

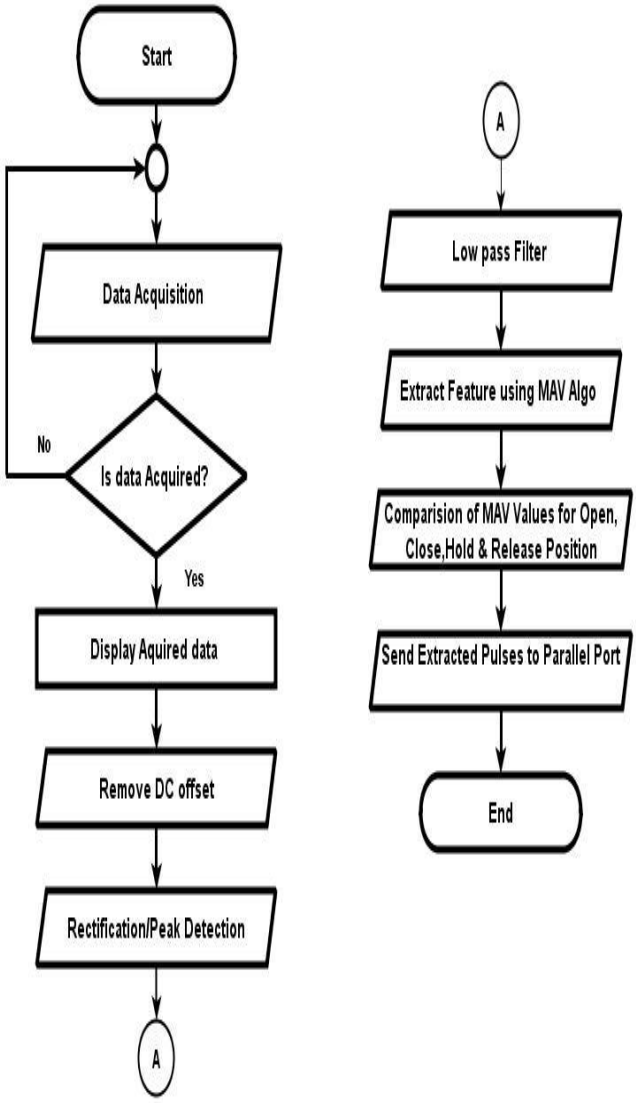


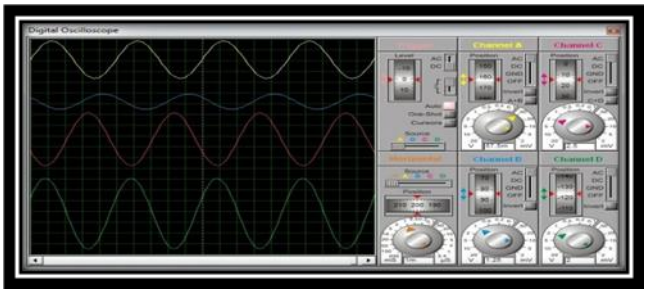
Fig 2.2.1 B) EMG signal processing through Matlab software

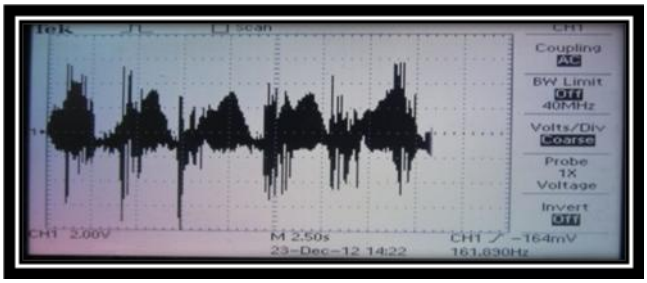
Fig 2.2.1 B) elaborates steps for EMG signal feature extraction and classification. In this algorithm we have used acquired EMG signal and extracted MAV features by denoised, rectification and filtering commands. After extraction of MAV feature for open, close and hold movements we are doing comparative classification of these features and sending pulse to parallel port.

III. RESULTS AND ANALYSIS

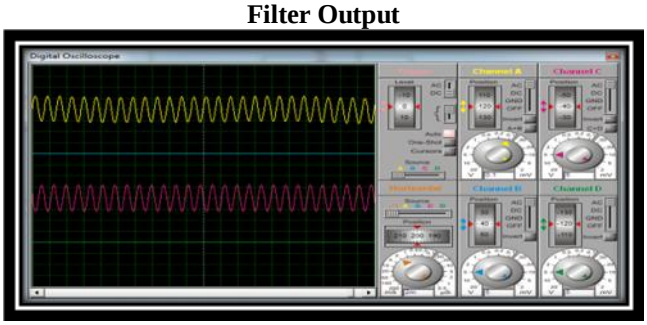
Based on the virtual simulation we have designed hardware and obtained experimental results. This section describes simulation and practical results for different signal processing stages.

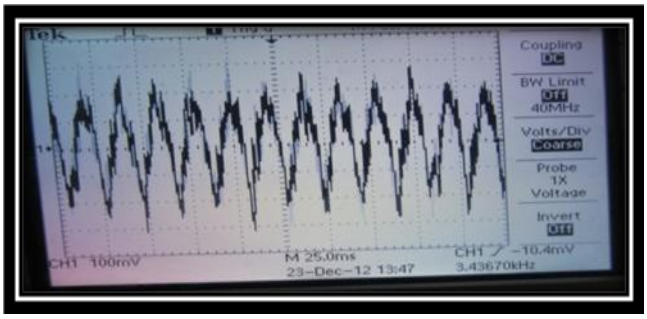
Instrumentation Amplifier Output





Filter Output





Peak Detection Circuit output

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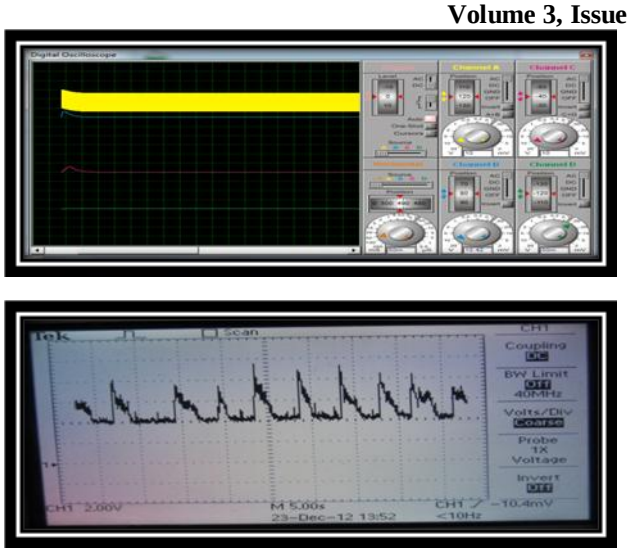
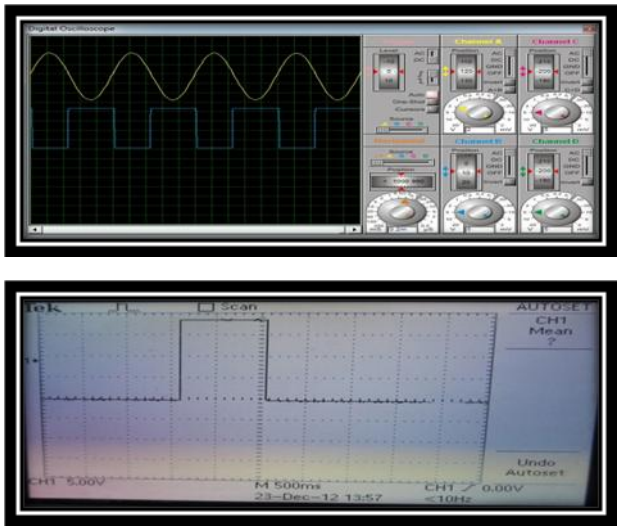


Comparator Circuit Output



Timer Circuit Output

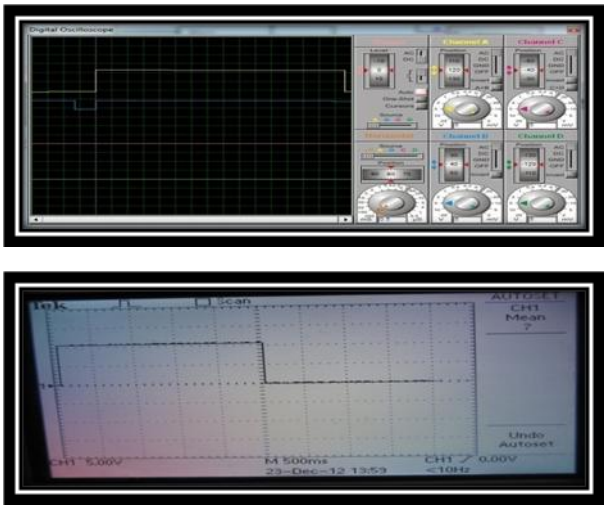


Fig 3.1 Simulation and Experimental result

Fig 3.1 elaborates simulated and experimental results for Instrumentation amplifier, Filter, Envelope detector, Comparator and Timer.

Mean Absolute Value			
	Open	**Close**	**Hold**
Person1	0.0037	0.0241	0.0147
Person2	0.0504	0.8222	0.6321
Person3	0.1926	0.291	0.1999

Table 3.1 Observation table for MAV Features for open and close movement.

MAV	True	False	Test Condition			Movement Acceptance %
Open	20	0				100
Close	11	9	Close	<	Open	55
Hold	9	11	Open	>	Hold	55

Table 3.2 Observations for Comparative classifier

Table 3.1 describes the calculated MAV for open and close movement for different three persons. We have calculated MAV features for 20 healthy persons and based on the comparative classifier we have got comparative equation MAV (Open) > MAV (Hold) > MAV (Close).As shown in table 3.2 Open is initial condition with 100% movement acceptance ratio. For close movement we have applied comparative expression Close < Open and observed 55 % movement acceptance. For Hold movement we have applied comparative expression Open > Hold and observed 55 % movement acceptance.

IV. CONCLUSION

Noise less EMG signal collection requires strong interface between amputee surface and sensor, low noise data acquisition and amplifying components. Noise less and appropriate data collection helps in extracting features of EMG signal which affects on accuracy of feature extraction. Time domain temporal approach is easy to implement and gives better accuracy in feature extraction.

Developed Matlab algorithm helps to extract MAV features and classifying open, close and hold movement based on the comparative classification. Proteus Virtual simulation helps to understand response of different system components before actual implementation. Developed protocol have been tested for two different case studies born amputee and amputee after accident, based on protocol testing we have concluded that proposed system is useful for amputees to perform basic movements to accomplish gripping and lifting light weighted objects.

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