A Cost Effective Approach for EMG Signal Recording System

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Abstract: Electromyography (EMG) signals have been widely used in clinical and biomedical applications.EMG is finding its use in human computer interaction as well [1]. EMG signals are matter of study because there is an association between EMG signals and the force exerted by muscles. Recording EMG signals requires high end sensors (high sensitivity with low Signal to noise ratio) and hardware circuitry along with data acquisition device, thereby making the complete system too costly. The purpose of this paper is to introduce a cost effective approach for EMG signal recording. This paper provides a basic understanding and method of recording of EMG signals.

Keywords: Electromyography (EMG), Motor unit action potential (MUAP), LabVIEW, VI (virtual Instrument), AtoD conversion, Signal Acquisition, DAQ devices.

I. INTRODUCTION

Electromyogram (EMG) is a combined electrical signal generated by muscle activity which consists of information about muscular activities like amplitude, phase and frequency. Muscular actions are directly controlled by brain through nervous system; the nervous system provides stimulus to respective motor neurons for different motions, this action potential which activates motor neurons is usually known as motor unit action potential (MuAP).

To pick up Electromyogram signals from subject, two types of interfaces are widely used:

a. Surface Electromyogram. (S-EMG).

b. Needle Electromyogram. (invasive)

Even though both techniques results in Electromyogram signals, S-EMG(surface Electromyogram) is more popular than needle Electromyogram as it is pain free and non-invasive method. When placed on the skin over a muscle, it provides information about the activation of the underneath fibers.

Conventional amplifiers and data acquisition devices used to record EMG signals are costly, hence a cost effective approach has been presented in this paper to record EMG signals.

To reach this goal, surface electrodes are used to pick up electrical signals from skin surface. Also an EMG amplifier has been designed to amplify, eliminate noise and filter the EMG signals. The signal is then sent to LabVIEW (graphical programming software) using Arduino UNO via serial data communication.

II. PROCESS FLOW

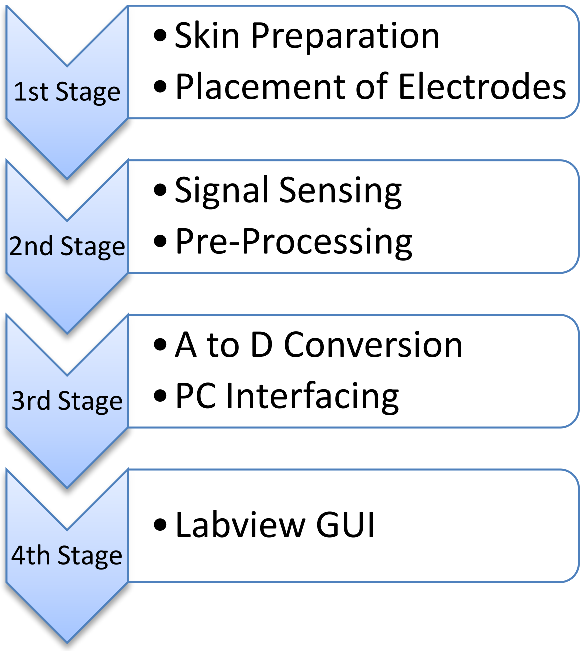


Fig. 2.1 Showing the proposed methodology

III. SENSING EMG SIGNALS

Surface EMG is the key input to the whole system. This signal is useful to study the skeletal muscle as the muscle

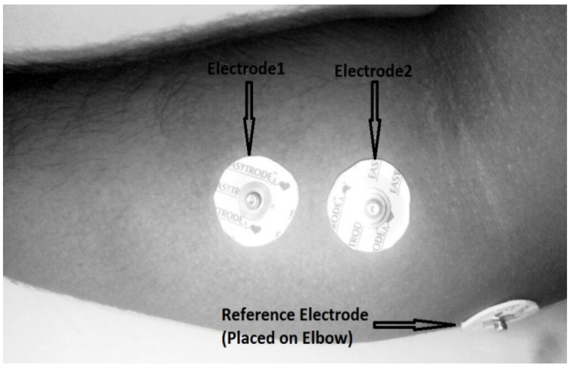


Fig 3.1 Layout of sensor placement.(Forearm Flexor muscles)

tissue is attached to the bone and its contraction is responsible for the motion and support of the skeleton [3]. EMG measures the motor unit action potentials (MUAPs) [4] of all involved muscle fibers as an electrical potential between two electrodes and a reference electrode is grounded to remove inherent noise signals generated on skin surface.

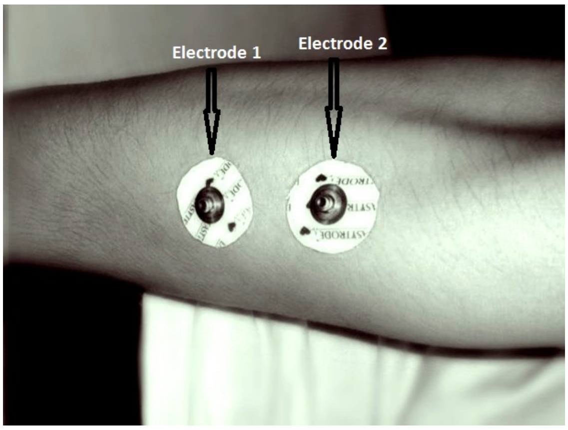


Fig 3.2 Layout of sensor Placement. (Forearm Extensor Muscle)

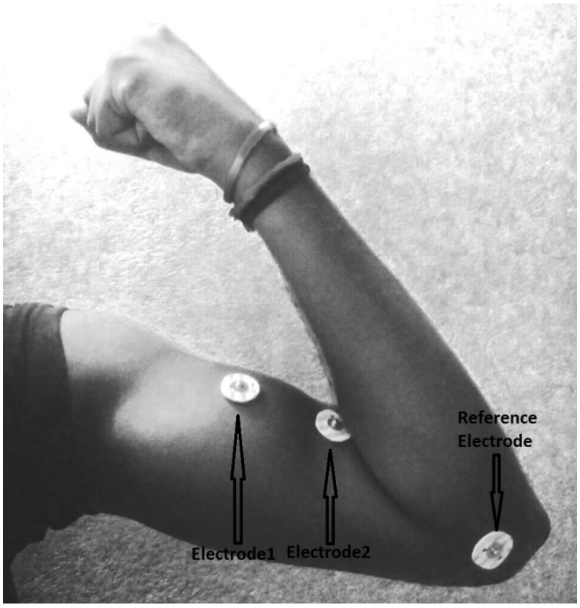
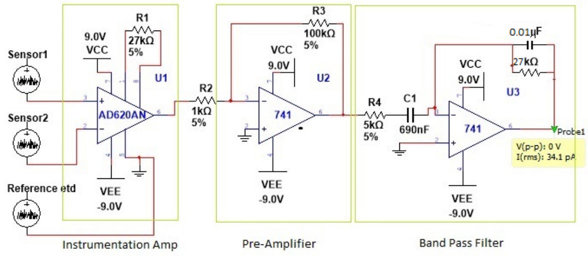


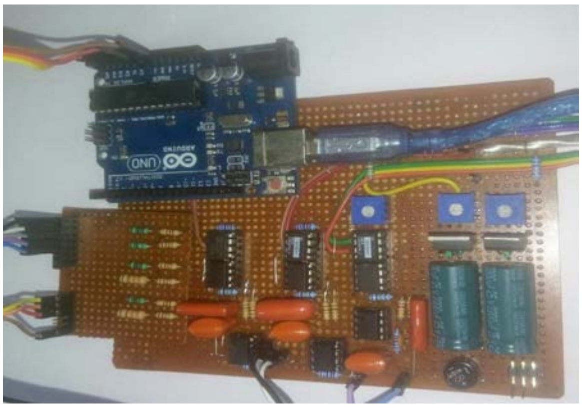
Fig 3.3 Layout of sensor placement. (Bicep muscle)

IV.PRE-PROCESSING SURFACE EMG SIGNALS.

Amplification and filtering of bio-signal is done in this stage. General purpose Op-amp is used to amplify the signal. Single stage amplification is performed on the signal (µV-mV) [5] so that it can be read by data acquisition device (mV-V). The amplified signal is fed to a second order band pass filter with bandwidth of 450Hz, (the dominant EMG signals are present between 50Hz and 500Hz) [6], Although features of EMG signals can be extracted from a wide band of frequencies i.e., 20Hz to 2000Hz, but in this project, we have considered lower cutoff frequency of 50Hz and higher cutoff frequency of 500Hz. As the bio-signals are bipolar in nature, the output of filter is then fed to a clamper circuit so as to make it compatible with our ADC unit which can read from 0V to + 5V range.



(a)



(b)

Fig 4.1 Showing Electronic Circuitry developed to collect and filter biosignals.

Table 1

Stage	**Gain Range**	**Amplitude (Volts)**
1^{st} stage(Instr-amp)[7]	2.83	~ 4.5mV
2^{nd} Stage(Op-amp)	-100	~450mV
3^{rd} Stage(Filter)	-5.4	2.43V
Cumulative gain(Input~1590µV)	1528	2.5V

Table Showing the gain provided at different electronic stages. Last row defines the compliance of all gains provided to the biosignals at each stage.

V. EMG SIGNALS ACQUISITION.

We used Arduino Uno® board in this project to acquire biosignals. The Arduino Uno board consists of a 6 channel 10-bit AtoD converter. It means that it will map input signal voltages between 0 and+ 5 volts into integer values in between 0 and 1023 (2^{10}=1024 points). This gives a resolution between readings of: 5 volts per 1024 units or, .0049 volts/unit (i.e. 4.9 mV/unit). It takes nearly 100µs (0.0001 s) to read one analog input [8, 9], it is set to read at the maximum baud rate of about 115200 which is adjusted in program.

A program to read and display biosignals using Graphical user interface has been developed in Lab VIEW™ (V 14.0). LIFA (Lab VIEW Interface for Arduino) Package is installed additionally on LabVIEW using VI (Virtual Instrument) Package manager, to communicate with Arduino Board. LIFA_Base program (available with LIFA package) is then uploaded on Controller chip of Arduino for the interfacing of Lab VIEW VI (Software) and Arduino controller board (hardware).

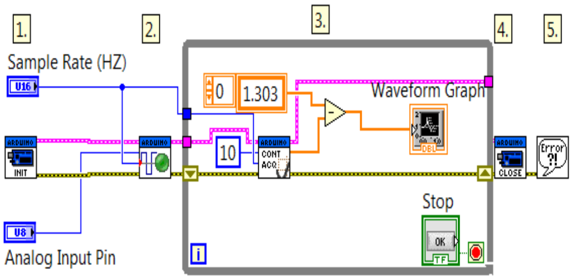


Fig 5.1 showing a VI developed on Lab VIEW to communicate with Arduino.

Once the Arduino board is connected to the LabVIEW, it starts sending and receiving data/commands via serial bus (USB) at a baud rate of 115200 which can be adjusted in LIFA_base.ino (program uploaded on Arduino's controller chip.)

Different Labels from 1 to 5 have been done in the program to explain various steps used in VI to communicate with Arduino controller, collecting serial data from it, as well display it in GUI for user interface which are explained in a form of table as follows:

Table 2

Label	Explanations
1	Setting up Arduino pins and sample rate.
2	Initializing continuous sampling
3	Plotting up data onto a visual graph
4	Closing connection with Arduino
5	Error message handler

VI.RESULTS

A variety of patterns collected from different muscle groups are shown in this section.

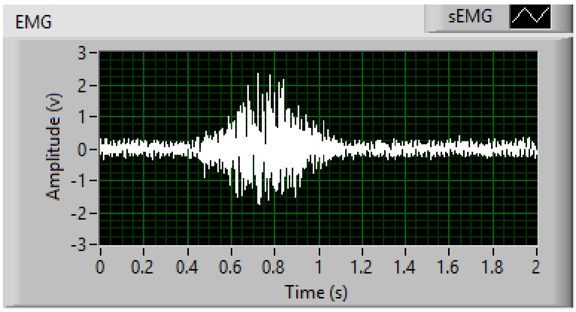


Fig 6.1. EMG activity showing contraction of flexor muscle (forearm) of a subject.

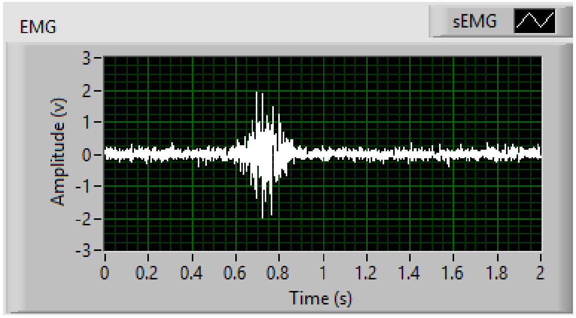


Fig 6.2 EMG activity showing contraction of extensor muscle (forearm) of a subject.

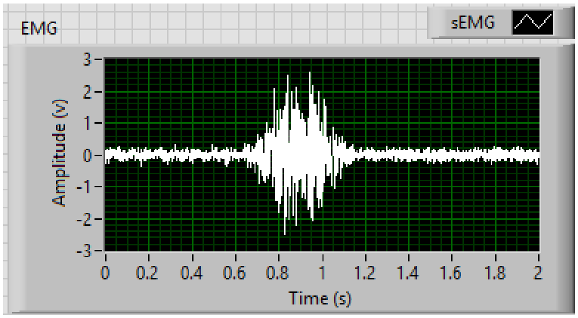


Fig 6.3 EMG activity showing contraction of Bicep brachhi muscle of a subject.

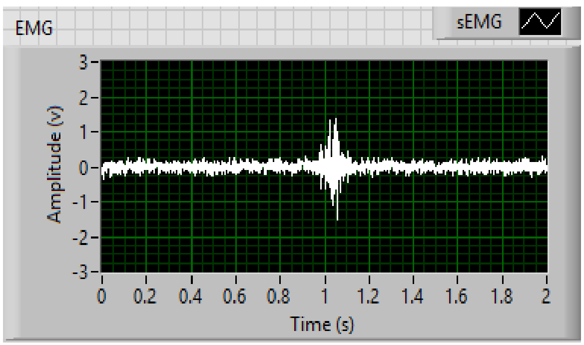


Fig 6.4 EMG activity showing contraction of triceps muscle of a subject.

VII. DISCUSSION

The VI (Virtual Instrument) developed in this project can be further developed so as to extract features of EMG signals; however the algorithm can be modified accordingly as per the application and this methodology can be used to acquire digital as well as analog data acquisition with very little modification. Analog data can be acquired up to frequency range of 5 kHz, beyond this frequency the data starts getting distorted. Multiple channels can be used to collect data from various sources; the only thing is that as the Arduino is having one AtoD convertor and is using serial communication, it can send data from one source at a time. To expand the range of simultaneous data acquisition, one has to use multiple Arduino boards via different serial ports, which in turns increase the cost of system by very little margin as compared to high end DAQ devices.

VIII. CONCLUSION

The system developed using this methodology for sensing and acquisition of EMG signals is capable of acquiring analog data with an amplitude range of ±2.5Vpk-pk and frequency range of 0-5000Hz without any significant distortion in signal. High frequency signals can also be acquired (up to 7.5 kHz) by using Finite signal acquisition mode. Cost reduction and reliable signal acquisitions of EMG was the main aim of this project which has been successfully achieved. The Cost of Commercially available DAQ cards/devices start from at least Rs.50000 (INR) and proposed methodology reduces this cost by more than 90% and is completed under Rs 5000 (INR) along with Sensing and amplification circuit. This methodology can be employed in acquisition of analog signals with frequency not more than 5 kHz and can be used with any voltages by isolating the board with the source using suitable step-down transformers.

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