Acquisition of EMG Signals for Controlling the Artificial Hand

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Abstract— This paper presents one of the concepts useful in the development of an artificial hand for prosthesis that is controlled based upon the EMG (Electromyography) signals of the user's remained active muscles in his hand. Surface EMG (sEMG) skin electrodes are used for obtaining and calculating the EMG signals and it is signal conditioned using instrumentation amplifier, high pass filter, low pass filter and precision rectifier. These pulses are given to the microcontroller (ATMEGA328p) which in turn controls the respective servomotors for movements of hand .So those pulses are referred to as EMG signals. An oscilloscope and a multimeter is used for observing as well as calculating the EMG waveform. In this hand the sEMG electrodes are placed on the biceps of the hand.

Key words: EMG Signals for Controlling the Artificial Hand, EMG

I. INTRODUCTION

In case of the physically disabled persons, there are some basic body muscular signals which are useful for activating artificial devices that could replace the missing body parts those are lost by accident, trauma, congenital or any other disease. EMG (Electromyography) signal is one of them.

EMG is basically about the study of muscular function through analysis of the electrical signals emanated during their contractions. It is often used for many purposes by doctors, clincians and researchers. EMG is used more often because it is safer and easier to use. EMG is used in both the fields of engineering and medical. Electromyography is usually the process of measuring the electrical signal associated with the activation of the muscle. These muscles have a small thin layer membrane called Myofibres. Myofiber is basically composed of water. It dissolves the ions which are separated from extra cellular space. It produces a potential variance along its cell membrane with different concentration of ions. These fibers are excitable cells and due to the contraction a rapid depolarization, also ion diffusion occurs. This may be voluntary or involuntary muscle contraction. During this process a EMG signal is generated and is measured. As the range of these signals are low an instrumentation amplifier INA114P is used for amplifying the signal which also acts as a differential amplifier. There is a need for high pass and low pass filters to remove the noise interference as the signal of interest is in the range 50-500Hz .After this filtering there is a requirement of the rectifier in order to obtain the positive pulses which could be given to microcontroller ATMEGA328P.

This research work basically tells how the EMG signals are detected and are being generated to the microcontroller for the movements in the motors for controlling the required motion in the artificial hand mechanism.

II. DETAILS OF THE EXPERIMENT

A. EMG Signal Acquisition

In myofibers, a motor unit is a complete contractile system in functional unit cell. Motor unit of muscle is the neuron motor. Axon and all the muscle fibers are attached to provide the signal for contraction and expansion. Muscle fibers related to single motor unit fluctuates from muscle to muscle. Each muscle has a number of unit motors. In the output of brain signal the shrinkage from muscle fibre increases, then more motors unit and higher value of firing frequency is needed.

All muscle cells inside the single motor unit are activated at the same time. By changing number of motor units in use, the human body controls the force of the contraction/expansion of muscle. With the separate motor contraction, it rapidly emits a rush of the electric activity which is known as MUAP (Motor Unit Action Potential).

This potential is detected by using the electrode from the surface. All fibers that are fitted to a single motor are stimulated at the same time. MUAP is an electrical reaction of the axon reaction. The physical topology of the muscle fibers, the effect of filtering of the tissue, characteristics of the capturing electrode and required instruments are primary factor that define the shape of MUAP. The EMG signal's amplitude is between 20-2000uV frequency range is between 0 to500 Hz. But the dominant value of signal is in between 50 to 150 Hz. The EMG signal is influenced by noise. Electrical noise is caused by electromagnetic radiation sources e.g. radio transmission devices, fluorescent lights and interference from electrical wires. Electrical noise maximum occurs at 50 – 60Hz frequency range. EMG signal is acquired through differential amplification. Differential amplifier should have very low output impedance and high input impedance. Ideally, a differential amplifier has infinite input and zero output impedance. Differential amplification is attained with the help of an instrumentation amplifier for high input impedance.

B. EMG Electrode Placement

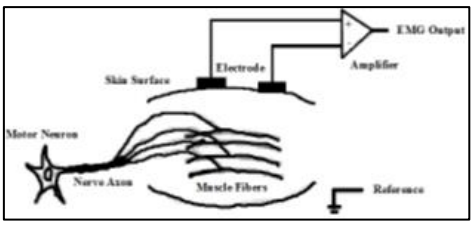

Fig. 1: Bipolar configuration

The EMG electrode placement can be done b different configurations: Monopolar, Bipolar and Multipolar. In this research work we are using the bipolar configuration. Bipolar Configuration needs two electrodes on skin with the reference electrode as shown in Fig1. The signal from two electrodes is connected to the differential amplifier. The differential

amplifier suppresses the common noise signals to both inputs and then amplifies the difference.

C. Instrumentation amplifier (INA114P)

The INA114 is lower in cost, general purpose instrumentation amplifier offering excellent accuracy. Its versatile 3-op amp design and small in size make it ideal for many kinds of applications such as bridge amplifier, thermocouple amplifier, RTD sensor amplifier and Medical instrumentation. Here in this experiment it senses the differentiation in the muscle fibers and amplifies for the measurement. It operates with power supplies as low as 2.25V, allowing use in battery operated and single 5V supply systems.

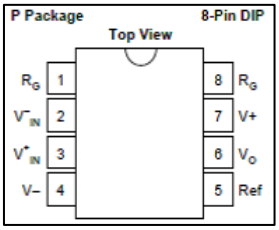

Fig. 2: INA114P

III. SIGNAL CONDITIONING

Once the electrode is placed and signal is extracted, then noise plays a major part in hampering the EMG signal. Noise frequency contains the raw EMG signal of high as well as low frequency. Low level frequency noise is due to DC offset and temperature variation. So for removal of this electrical noise high pass filter and low pass filter are used. But for getting the positive pulse there is a precision rectifier used.

A. High Pass Filter

A high pass filter is used for the removal of low frequency from electrical signal. The signals are transmitted is known as "pass band" region. A high pass filter can be constructed by using a resistor and a capacitor. But in this experiment we have used LF351N along with resistor and capacitors are used for this circuit will then be known as a CR circuit. The filter response is "1".

$$fc = 1 / 2 \pi R C.$$

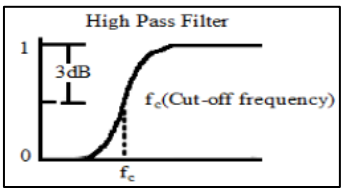

Fig. 3: High pass filter.

B. Low Pass Filter

Low pass filter is entirely opposite to that of high pass filter. In these filters, the frequencies less than the cut-off frequency are transferred. Here the Low pass filter is also constructed using LF351N.

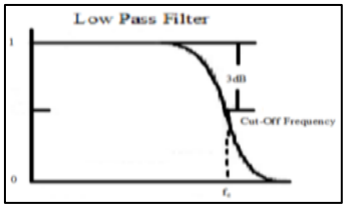

Fig. 4: Low pass filter.

C. Precision Rectifier

The precision rectifier which is also known as a super diode, was a configuration obtained with an operational amplifier in order to have a circuit behave like an ideal diode and rectifier. It is very useful for high-precision signal processing.

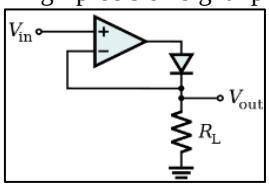

Fig. 5: Precision rectifier

The op-amp based precision rectifier should not be confused with the power MOSFET-based active rectification ideal diode.

D. LF351

The LF351 is a low cost high speed JFET input operational amplifier with an internally trimmed input offset voltage. In this paper all the filters and precision rectifier are constructed using LF351. The LF351 is pin compatible with the standard LM741 and uses the same offset voltage adjustment circuitry. This feature allows designers to immediately upgrade the overall performance of existing LM741 designs. This is used for constructing a Band pass filter (a combination of High Pass filter and Low pass filter). The LF351 can be used for several applications such as high speed integrators, fast D/A converters, sample-and-hold circuits and many other circuits.

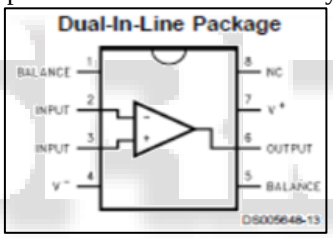

Fig. 6: LF351N

E. Interfacing with microcontroller ATMEGA328P

In order to successfully get output achieve an active control technique is very important. To control the motors according to detected signal, the analog form of EMG signal has to be converted into digital format. This is possible by Analog to Digital Conversion. These days, many microcontrollers are available with built-in support of analog input pins.

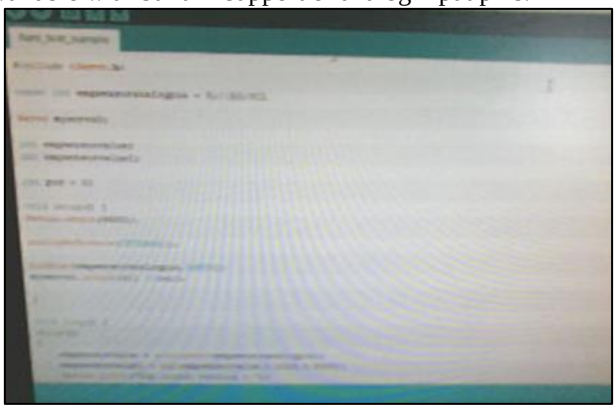

Fig. 7: Arduino code for controlling part 1

In this research work, ATMEGA328P is used as microcontroller. Purpose of that controller is to receive analog EMG signal of 0 to 5 volts range and to convert this analog signal to digital values. Then these digital values are

mapped for rotating servo motor between 0 to 180 degrees to control. Analog EMG values are converted to 0 to 1023 decimal value while servo motors can be rotated between 0 to 180 degrees. So, mapped command of Arduino is used to interchange these values to rotate motor according to detected EMG signals.

Fig. 8: Arduino code for controlling part 2

IV. RESULTS AND CONCLUSION

For every Scholar there is an experiment that gives a memorable experience for learning and application. This has given that new experiences for us. We have designed and made PCB (Printed Circuit Board) for acquiring the EMG signals and controlled the servomotors using the controller ATMEGA328P using the developed Arduino code and implemented .These servomotors are connected to the hand mechanism and then many things open and close operations are done by it. This is a very good and huge experience that can expertise scholars in designing, coding and construction an artificial hand basically.

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