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Emg Controlled Prosthetic Limb

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Abstract: *The EMG Controlled Prosthetic Limb is an electromechanical device which can be used by amputees to perform their daily physical activities with ease. The system consist of EMG Electrodes which are attached to the body of the user, a signal processing unit to convert the signal into usable form, a microcontroller to analyse the signal received from signal processing unit and then send a signal to servo motor unit present in the prosthetic limb to perform motion accordingly. The circuitry is powered by batteries. The signal processing unit consists of Instrumentation Amplifier and Band Pass Filter.*

Keywords: *EMG Electrodes, Instrumentation Amplifier, Band Pass Filter, Isolation Amplifier, Servo Motors And Prosthetic Limb.*

I. Introduction

Limbs are one of the most used body part in our day to day activity. Limbs are necessary to walk, wear clothes, pick up objects and perform much more actions. Loss of a limb results in not being able to perform these activities well. Throughout the human histories, there have been many instances where people were born without a limb or had to remove a limb due to an infection. Because of this, amputees have to face many difficulties in performing daily activities. To overcome this problem, amputees have used prosthetic limbs such as hooks instead of hands or a wooden leg. Ordinary prosthetic limbs, such as wooden leg or hooks assist the amputees to perform activities such as walking or picking up objects, but they do not provide the complete control to the amputee. A wooden leg instead of a real, healthy leg cannot be used for tasks such as running, jumping efficiently. Similarly, a hook instead of a hand cannot be used to eat food or wear clothes. A real or healthy limb cannot be replaced by ordinary prosthetic limb as they do not provide complete control to the amputee. If the amputee is able to control the movement of their ordinary prosthetic limb, then they might be able to perform their daily activities as control over the limb is very important while performing even basic activities. Human brain uses skeletal muscles and neurons connected to them to control the limb. Whenever we want to perform an action, our brain sends a signal to the muscles which are necessary to perform the action, via a series of interconnected neurons. The muscle then contracts or lengthens depending upon the signal it receives and the intended action is performed. Whenever the signal from the brain travels through the synapse of the connecting neurons, a chemical reaction takes place which in turn creates a changing electric field. This changing electric field can be measured by an electrode called EMG Electrode and the signal measured by the EMG Electrode is called EMG Signal. EMG Signal is generated during a muscle activity. Each EMG Signal is different for different muscle activities. Therefore, while performing an action, an EMG Signal is generated which is exclusive only to that particular action. Using this technology and combining it with a prosthetic limb, it is possible to control the prosthetic limb thereby allowing the amputee to control their prosthetic limb like a normal limb and perform their daily activities with ease. To achieve the control over the prosthetic limb, servo motors can be used to move the prosthetic limb. Since each action generates a different EMG Signal, each signal can be mapped to different motion of the prosthetic limb. This enables the amputee to perform the activities almost as naturally as a normal limb. If an amputee does not have a lower arm, a prosthetic limb can be used in its place. EMG Electrodes can be attached to the upper arm muscles. Since the upper arm contains various muscles, each can be contracted to generate a different EMG Signal which then is mapped to different motions of the prosthetic limb which is used as the lower limb. The EMG Controlled Prosthetic Limb can mimic the movements of an actual limb. Therefore, amputees can perform basic activities such as picking up objects, pushing, pulling easily. This technology can also be used for other purposes such as gaming consoles, part of rehabilitation systems for people with motor dysfunction and many more.

II. System Description

A. Working Principle :-

EMG Signals received from electrodes are very low in magnitude and therefore susceptible to noise. Also, the EMG Signals are strongest in 50Hz to 500Hz frequency range. Due to these reasons, EMG Signals needs to be processed before being of any use. EMG Signals are received from the user by attaching two electrodes to target muscle and one more electrode (also called reference electrode) to a muscle which won't be used. Since the signal received from the electrodes is very low in magnitude, it is amplified to adequate level by using an instrumentation amplifier with an adjustable gain. Electrodes connected to the target muscle are connected to the inputs of instrumentation amplifier and the reference electrode is grounded. The amplified EMG Signal is then filtered by using a band pass filter with lower and upper cut-off frequencies 50Hz and 500Hz respectively. The signal is then given to the ADC of microcontroller which converts the Analog EMG Signal into digital form. The microcontroller then takes this EMG Signal, analyses it and accordingly sends an appropriate signal to one of the servo motors present in the prosthetic limb.

If an external power supply (which is connected to the mains power supply, directly or indirectly) is used, then it is necessary to provide some form of electrical isolation between the device connected to power supply and the user. This is done by using an isolation amplifier.

B. BlockDiagram:-

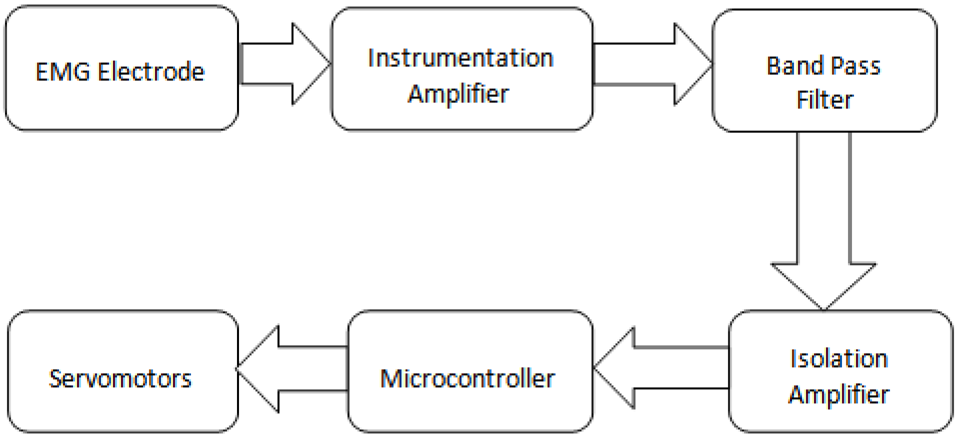

Fig. 1 Block diagram of the system

C. System Explaination :-

I. EMG Electrodes:

When user flexes their muscle, brain sends a signal to the muscle via a series of connected nerve fibers to contract that muscle. That signal is known as action potential. The action potential has a fixed magnitude and speed. When the action potential travels through the synapse of nerve fibers, a chemical reaction takes place which creates a changing electric field. This changing electric field can be measured by the EMG Electrode connected to the user's muscle. When the muscles are inactive, they still carry a resting potential. Therefore, two EMG Electrodes need to be attached to detect any muscle activity. The impulses generated by the EMG Electrode are 20-20000uV in magnitude and of ~15 ms duration.

II. Instrumentation Amplifier:

Instrumentation Amplifier receives input from the EMG Electrodes attached to the user. The instrumentation amplifier has very high input impedance.

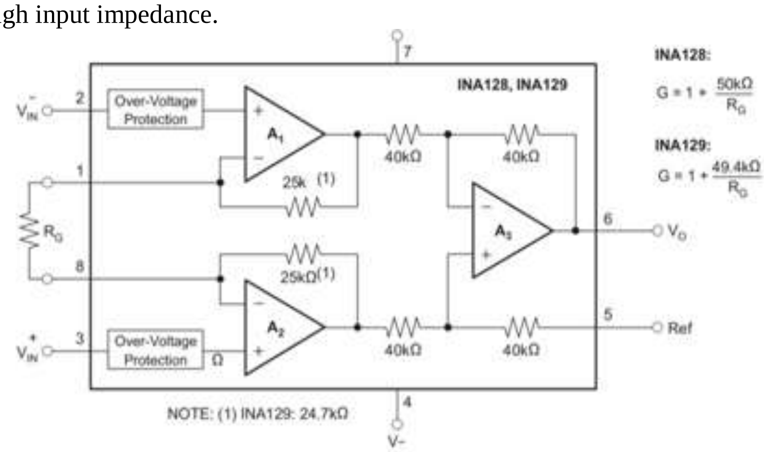

Fig. 2 INA 128 Block Diagram

It takes two different signals as the input and amplifies the difference between them. EMG Electrodes connected are far apart from each other, such that they produce different signals when a muscle is flexed thereby making it easier to detect muscle activity. The output of the Instrumentation amplifier contains desired EMG signal, which has a frequency of 50-500Hz and noise, which contains frequency of entire spectrum. Therefore, the signal needs to be filtered to obtain EMG Signal.

III. Band Pass Filter:

The band pass filter is configured to pass signals between two specific frequencies. The strength of EMG signals is strong in range of 50Hz to 500Hz. Therefore, the band pass filter used has pass band of 50Hz to 500Hz. This ensures that no noise signal except this band of frequency is passed further into the circuit, which may degrade the performance of the circuit .The band pass filter is implemented using Operational Amplifier IC and R-RC circuit.

IV. Isolation Amplifier:

Isolation Amplifier provides an electrical isolation between input and output stage.

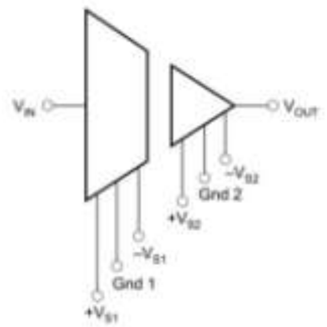

Fig 3 ISO124 amplifier

While developing any system which makes use of electrodes directly attached to human body, it is required that no other device in the system is connected to the power line. If any device is connected to the power line, it is necessary to provide an electrical isolation between the user and that device. That way, there is no electrical contact, i.e. no ohmic continuity between human body and power line. Since analog isolation amplifier is used, transformers and capacitive couplers are used to transmit signals through isolation barrier.

V. Microcontroller

Microcontroller is used to receive the EMG Signal from the signal processing circuit, analyze it and generate an appropriate signal to be given to the servo motors present in the prosthetic limb. Since the microcontroller is connected to a computer/laptop to display values and also receiving power supply, ADC of the microcontroller is connected to the output of the isolation amplifier. After receiving the EMG signal from the input of the ADC, microcontroller then analyzes the signal and then sends the signal to appropriate servo motor to move the prosthetic limb.

VI. Servo Motor

Servo motor is an electrical device used to rotate the prosthetic limb along various axis. Servo motor can move from 0 to 180. Servo motor is a programmable motor and it can be programmed using a microcontroller.

III. Future Scope

We are currently working on incorporating Machine Learning with EMG Controlled Prosthetic Limb. Each user may have different application for the product in their mind. Also, users may generate different number of distinct EMG Signals. Therefore, it is necessary to customize the product according to the user's desired application and his ability to produce a wide variety of EMG Signals.

The problem with this approach is that, a person's ability to efficiently use a muscle increases after repeated use. Muscles may also behave differently once they are fatigued. All of this may change the behaviour of the product. This problem can be overcome using Machine Learning.

IV. Conclusion

EMG Controlled prosthetic limb is a great tool developed to assist the amputees in performing their daily activities. Most of the current prosthetic limb does not provide the user control over the movement of the prosthetic limb. Integrating EMG with prosthetic limb provides a natural control over the movements of the limb. Use of compact circuitry also makes the prosthetic limb lightweight making it much more usable. Even though the system has a limitation of battery, there is scope to improve the battery life of the system. The system can be enhanced in such a way that more load can be lifted by using the prosthetic limb by changing the servo motors used.

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