Patient Healthcare System (PHS)

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Submitted to the faculty of Department of Electrical Engineering,
Military College of Signals, National University of Sciences and Technology, in
partial fulfillment for the requirements of B.E Degree in Electrical Engineering
July 2020

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By

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Certified that work contained in this thesis titled “Patient Healthcare System (PHS)*”,* carried out by NC Malik M. Shahzad Ghaffar, NC M. Anas Ibraheem, NC Usama Ali Lone and NC Hafeez Ahmed under the supervision of Asst. Prof. Dr. Shibli Nisar for partial fulfillment of Degree of Bachelor of Electrical (Telecomm.) Engineering in Military College of Signals, National University of Sciences and Technology, Islamabad during the academic year 2019-2020 is correct and approved. The material that has been used from other sources has been properly acknowledged / referred.

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Dedicated to our distinguished parents, honorable teachers, and adored siblings whose tremendous support, inspiration and cooperation led us to this accomplishment.

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ABSTRACT

EMG based “Patient Healthcare System (PHS)” is a healthcare system which helps the patients who are suffering from any serious illness and cannot move on their own, to communicate their basic needs to their caretakers. The functioning of human body is captivating and enchanting activity. Motion of the human body is a perfect assimilation of the brain , nervous system, and muscles. Our system acquires the EMG signal originated from brain from the healthy muscle of the patient’s body. After the acquisition of the EMG signal this healthcare system removes noises through various techniques of signal processing like rectification, amplification, and filtration. When the noise is removed the signal is segmented on the basis of time. The next step is feature extraction from the segments of the EMG signals. The values of the features are compared with the dataset already present for different gestures of muscle by the MATLAB code. The values of these features generate different messages regarding the patient’s needs for the caretaker through GSM.

In this fast pace of life, it is difficult for people to be constantly available for their near ones who might need them while they are suffering from any serious illness. EMG based “Patient Healthcare System” is very helpful for those patients who cannot communicate their needs to their caretakers who are far away. This project is a good step towards the Human Computer Interaction (HCI) because we are linking biomedical signals i.e. EMG signals to the computer for processing.

Key Words:

EMG: Electromyogram

MATLAB: Matrix Laboratory

GSM: Global System for Mobile Communication

HCI: Human Computer Interaction

EHW: Evolvable Hardware

PC: Personal Computer

EEG: Electroencephalogram

ECG: Electrocardiogram

DRL: Driven Right Leg

ARV: Average Rectified Value

RMS: Root Mean Square

DSP: Digital Signal Processing
ASP: Analog Signal Processing
ADC: Analog to DigitalConverter
ANN: Artificial Neural Network
SNR: Signal to Noise Ratio
PWM: Pulse Width Modulation
IDE: Integrated Development Environment
TDMA: Time Division Multiple Access
BTS: Base Transceiver Station
BSC: Base Station Controller
MSC: Mobile Switching Center
HLR: Home Location Register
VLR: Visitor Location Register
EIR: Equipment Identity Register
IMEI: International Mobile Equipment Identity
ISDN: Integrated Services DigitalNetwork
FDN: Fixed Dialing Number
OS: Operating System

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CHAPTER 1

INTRODUCTION

1 INTRODUCTION

Biomedical signal means an aggregate electrical signal gained from any organ that serves as a physical variable of interest. This signal is typically a function of time and is describable in terms of its amplitude, frequency , and phase. The EMG signal is a biomedical signal that estimates electrical currents generated by brain which are acquired from muscle contraction representing neuromuscular exercises. The nervous system consistently controls the muscle action (contraction/relaxation). Consequently, the EMG signal is an intricate signal, which is controlled by the nerve system and is reliant on the biological and physical properties of muscles. EMG signal gains noise while going through various tissues. Also, the EMG detector, especially if it is placed at the exterior of the skin, gathers signals from various motor units coinstantaneously which may cause interaction of diverse signals. Tracking down of EMG signals with groundbreaking and advance strategies is turning into a significant necessity in biomedical engineering. The primary reason behind the enthusiasm in EMG signalinvestigation is in clinical diagnosis and biomedical applications.

Raw biomedical signals are rich with useful information and used in industrial applications such as entertainment, medical, artificial robotic arms and controlling purposes. The electric signal delivered during muscle initiation known as the EMG signal, is created from small electrical currents produced by the exchange of ions over the muscle membranes. These signals can be detected with the help of surface electrodes.

Nowadays EMG signals are used for biomedical applications, robotics arms, ergonomic design, medical research, sports sciences, and EHW (Evolvable Hardware) chips evaluations. EMG signals could be utilized to control existing, commercially available multifunctional myo-electric prostheses. Moreover, it also provides control options to amputees, who are not able to use conventional control system. EMG signals-based control systems are extremely valuable for handicapped people as speech recognition-based control systems. Recently, different endeavors in HCI (Human Computer Interaction) has been created utilizing user friendly interfaces, for example, voice, gestures, and vision recognition. The most defying techniques in HCI are to interface PCs (Personal Computers) with biomedical signals, for example, EEG (Electroencephalogram), ECG (Electrocardiogram), and EMG (Electromyogram). EMG Signal generated by arm muscles is a raw biomedical signal that contains different noises such as instability of signals, motion artifacts, ambient, cross talk, transducer, equipment noise and the interaction of different tissues so preprocessing techniques are used to remove these noises. The amplitude of surface EMG signal exists in the scope of 1-10mV which is marginally higher than amplitude of EEG signal. The range of frequency contents lies between 0Hz to 500Hz, and signal’s dominant range is from 50Hz to 150Hz. The dominant region for ambient noise is 48Hz to 52Hz. Due to motion artifacts frequency range 0Hz to 20Hz is unstable, there are two main reasons of motion artifacts: first one is movements of connecting wires between surface electrodes and amplifier circuit and the second is instability of electrodes on the skin.

1.1 Overview

PHS involves various processes which are based upon signal processing. Our main objective is helping the patient by making a system which helps a patient informing his/her caretaker about the needs of the patient. The patient will be moving his healthy hand and his needs will be conveyed to the caretaker by various distinct gestures of his hand. Each gesture will be mapped to a particular message in our code. That message will be transferred to the caretaker via GSM. We acquired our signal from the muscles of the arm. The signal acquired by the muscles is very weak as there are many noises which will lessen its power and amplitude. Firstly, the noise will be produced by the pumping of the heart and will affect the amplitude of our electromyographic signal. Secondly the noise produced by the wrong positioning of the electrodes will greatly affect the signal’s amplitude. The amplitude of electromyographic signals is already very low i.e. in order of milli volts. The electromyographic signal is unstable in the range of 0-20 Hz and is not very dominant above 500 Hz.

1.2 Problem Statement:

In this fast pace of life , it is difficult for people to be constantly available for their near ones who might need them while they are suffering from any serious illness. There are lots of patients who are suffering from serious illness or amputees. These patients are unable to move. These patients need special care to have their basic needs like water, food and medicine conveyed to their caretakers who are at a distance.

1.3 Objective:

- Applying the theoretical knowledge into practicality pertaining to the core features of engineering and technology.
- Having a complete grasp on the concepts relating to the problem-solving aspects of outcome-based learning.
- To provide a control options to those individuals, who are not capable to use conventional control systems. EMG (Electromyogram) signal-based control systems are extremely valuable for handicapped people as gesture recognition-based control system.
- EMG signals could be utilized to control existing, commercially available multifunctional myo-electric prostheses.
- User friendly, it can be used for different applications depending on user's choice like video games, toys for special handicapped children etc.

We would achieve our objectives by designing a gesture recognition system for such patients using EMG (Electromyograph) signals.

1.4 Working Principle:

In this project EMG signal is acquired by using the surface electrodes which are placed on arm muscles. EMG Signal acquired through arm muscles is a raw biomedical signal that contains different noises such as instability of signals, motion artifacts, ambient, cross talk, transducer, equipment noise and the interaction of different tissues so preprocessing techniques are used to remove these noises. EMG Signal went through an instrumentation amplifier (INA 128) to expel common mode noise and to amplify the signal. A DRL circuit is utilized to expel the common mode interference. Bandpass filter of 20Hz to 500Hz is used because the signal is unstable from 0Hz to 20Hz and a notch filter of 48Hz to 52Hz is used to remove ambient noise which is dominant in this range. Then analog EMG signal is converted to a digital signal by using Arduino and then the signal is transferred to computer for digital signal processing. Then features extraction and classification is done. The block diagram of proposed PHS is demonstrated in Fig. 1

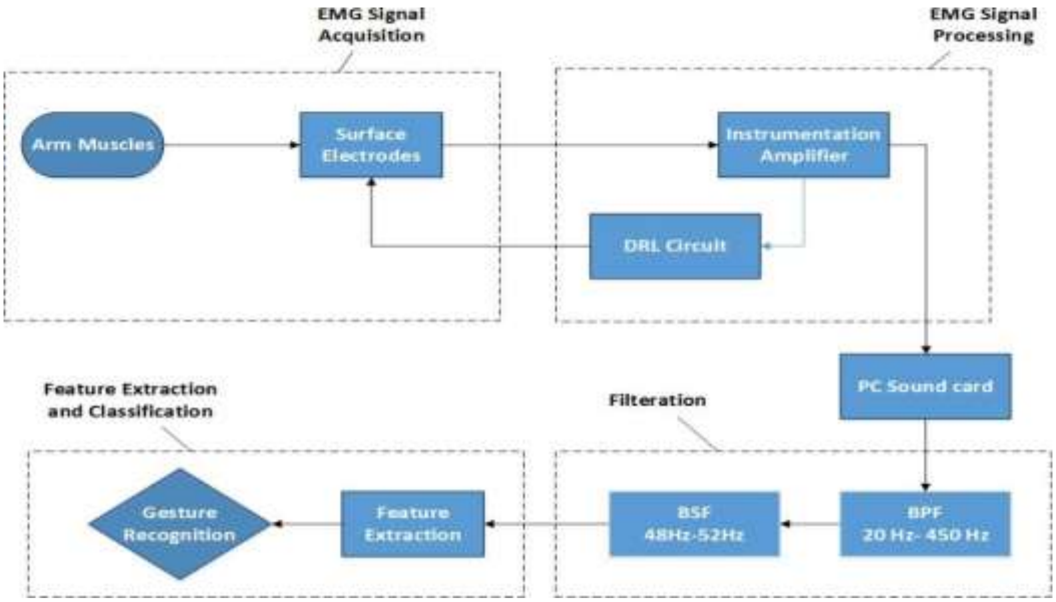


Fig. 1 Block Diagram of PHS

In this project first of all signal is acquired through arm muscles by surface electrodes. The acquired signal is filtered to remove all the noises. Two filters are used bandpass and band stop filters. The filtered signal is then segmented in time domain so that it is suitable for feature extraction. Different features such as ARV (Average Rectified Value), RMS (Root Mean Square), skewness, kurtosis and energy are extracted from segmented EMG signal. Based on these features system classified the signal for different gestures. After classification user will be able to convey the messages to caretaker through GSM using user's active muscle's EMG signal instead of using the remote-control unit. The Fig. 2 illustrates the detailed block diagram of proposed PHS.

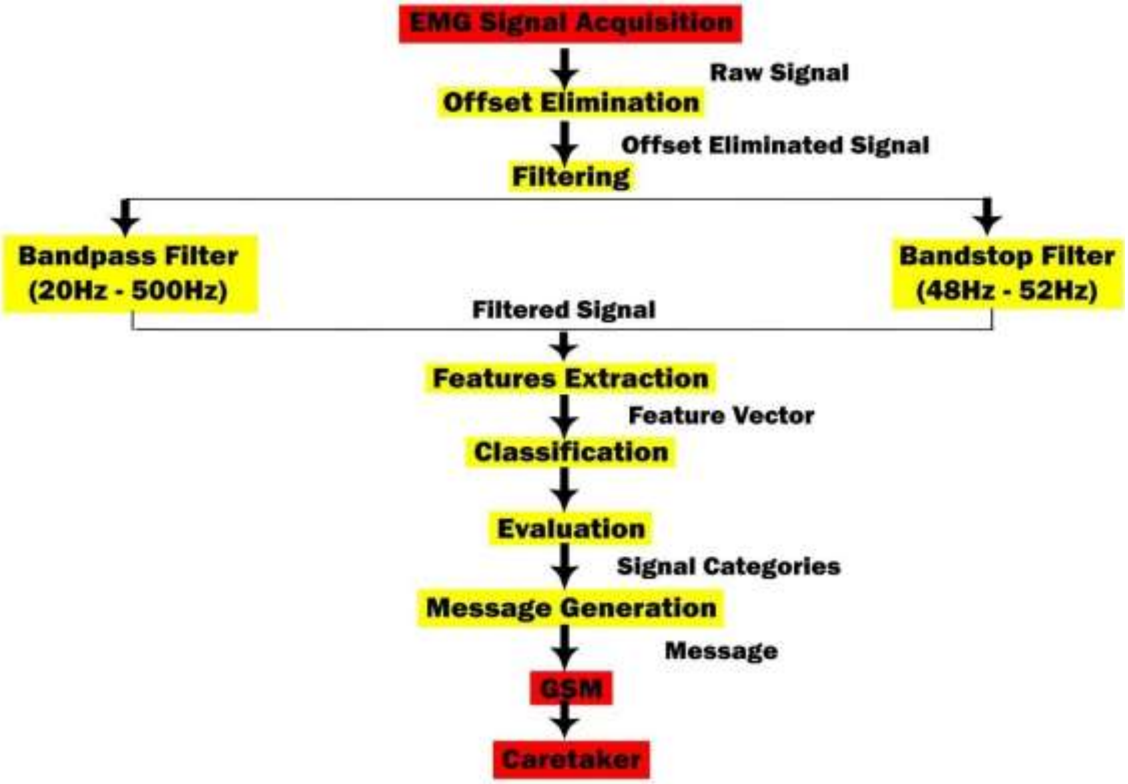


Fig. 2 Detailed Block Diagram of PHS

1.5 Scope

Our project finds its scope in the field of Biomedical Engineering. It helps the patients who are suffering from serious illness to communicate their needs better to their caretaker. The information gathered from the EMG signal which helps in the HCI (Human Computer Interaction) is being used in the industry to interface EMG signals with the robotic arms.

1.6 Deliverables

PHS will be implanted on the patient's muscle and whenever the patient will make distinct gesture the distinct message will be generated accordingly. We will be providing software solution of the PHS and we will be able to achieve our objectives by attaching this software solution to the hardware module.

CHAPTER 2

SIGNAL PROCESSING

2 SIGNAL PROCESSING

Our project is based upon Signal Processing. So, the question is that what is signal processing? Signal processing is a sub field of electrical engineering in which we study about signals and the tasks which we can perform on those signals. Signal Processing includes feature extraction, noise removal, filtration, and many other processes which we can apply on those signals.

2.1 Types of Signal Processing

There are two types of signal processing.

1. Digital Signal Processing
2. Analog Signal Processing

2.1.1 Digital Signal Processing

DSP (Digital Signal Processing) is the processing of those discrete time and discrete amplitude signals which are sampled at discrete points in time. DSP is a sub-field of signal processing in which computing machines are used for processing the signals. The digital signals processed in this approach are a series of numerals that serve as samples of a continuous variable in time, space, or frequency domain. In digital electronics, a digital signal is portrayed as a pulse train, which is usually produced by the switching of a transistor. DSP is frequently used due to its signal processing techniques such as data compression and error detection and correction in transmission which cannot be used in ASP (Analog Signal Processing). We use ADC (Analog to Digital Converter) to transsform analog signals to the digital signals. Some applications of DSP are given below;

- Signal Processing for Telecommunications
- Biomedical Engineering
- Control Systems
- Speech and Audio Processing
- Data Compression
- DIP (Digital Image Processing)
- Image Compression

2.1.2 Analog Signal Processing

ASP (Analog Signal Processing) is the processing of those signals which are continuous analog signals and not digitized by some analog means. “Analog” means data that is mathematically characterized as a group of continuous values. Analog values are generally characterized as a voltage, electric charge or electric current around peripherals in electronic apparatus. Any noise influencing such physical quantities will generate an analogous error in the signals characterized by such physical quantities. Popular analog processing components consist of capacitors, resistors and inductors (as the passive components) and transistors or op-amps (as the active components). Few ASP systems are classical radio, telephone, TV, radar etc.

2.2 EMG Signal acquisition

The EMG signal acquisition is a method of obtaining the signal through the muscle and then conversion of that signal from the physical form to a form which can be manipulated by a computer. There are four steps involved in EMG signal acquisition. First of all, signal acquired from muscle is transformed to electrical signal using EMG sensor. After that electrical signal is transformed into a form which can be transformed to the digital form using a circuit. Then that signal is transformed to a digital form utilizing ADC (Analog to Digital Converter) in ARDUINO. Lastly computer is utilized for the conditioning of the digital signal.

2.2.1 Serial Communication

In telecommunication serial communication is the process in which data bits are sequentially sent one by one over a communication channel. While in parallel communication several bits are sent at the same time over a link with several parallel channels.

2.2.2 Sampling

Sampling is used to transform a continuous-time signal to discrete-time signal. Sample is a chunk of data which is taken picked up from the entire data which is continuous in the time domain. For example, conversion of EMG signal (continuous-time) to a series of samples(discrete-time).

2.2.2.1 Nyquist's Principle of Sampling

The sampling of a signal must follow the condition stated in the Nyquist Principle. According to Nyquist Principle the sampling frequency must exceed the double of the maximum frequency component of asignal to reconstruct a signal out of its samples.

2.2.3 Analog to Digital Conversion

Conversion of an analog signal to digital signal involves two stages i.e. Discretization and Quantization. Discretization is a process in which we divide the signal in equal chunks of time so that each chunk of time is delineated by a specific amplitude level. After discretizing the signal along the time axis, we make levels along amplitude axis. We do this so that the continuous measures of amplitudes of the analog signal can be mapped to a specific quantization level. We either map those values to one or zero.

2.3 Fourier Transform

Fourier transform is a mathematical transform that disintegrates a function into its constituent frequencies. It transforms a function in time domain into a function in frequency domain.

2.3.1 Frequency Spectrum

Frequency spectrum is the extent of frequencies whereon the energy of the signal is distributed.

2.4 Offset Elimination

When an analog signal is transformed into digital signal by ADC (Analog to Digital Converter), DC offset is added to the primary signal at converter's output. This DC offset value may have come from the primary analog signal or from the imperfections within ADC. The removal of this DC offset is called offset elimination.

2.5 Filtration

The noise frequencies contaminating the raw EMG signal can be high in addition to low. Low frequency noise can be caused from amplifier DC offsets, sensor drift on skin and temperature fluctuations and can be removed utilizing a high pass filter. High frequency noise can be caused from nerve conduction and high frequency interference from radio broadcasts, computers, cellular phones etc. and can be deleted utilizing a low pass filter. In order to eliminate these high and low frequencies, different filters will be used.

2.5.1 High pass Filtering

A high pass filter is utilized to eliminate low frequency component from a certain electrical signal. A term ‘cut-off frequency’, denoted by ‘fc’, is the frequency below which all frequencies are eliminated. All frequencies above fc are carried forward. The frequency range where the filter response is ‘1’ and the signals are transmitted is called ‘pass band’ region. On the other hand, the frequency range where the filter response is ‘0’ and the signals are attenuated is called ‘stop band’. A high pass filter response is shown in Fig. 3.

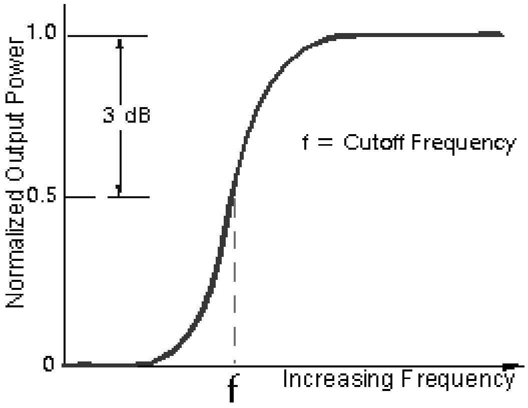


Fig. 3 High pass Filter

2.5.2 Low pass Filtering

The principle of low pass filters is entirely contrary to that of high pass filters. In these filters, the frequencies lower than the cut-off frequency are transmitted and above that are removed. A low pass filter response is shown in Fig. 4.

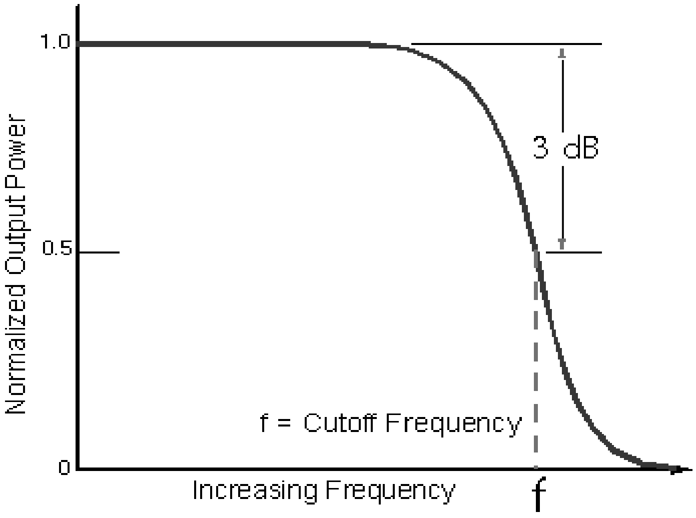


Fig. 4 Low pass Filter

2.5.3 Band pass Filtering

For the transmission of pure EMG signal, the high and low frequency noise must be eliminated. For this purpose, only a specific band of frequency must be carried forward. This can be made possible through the use of a band pass filter. A band pass filter response is shown in Fig. 5.

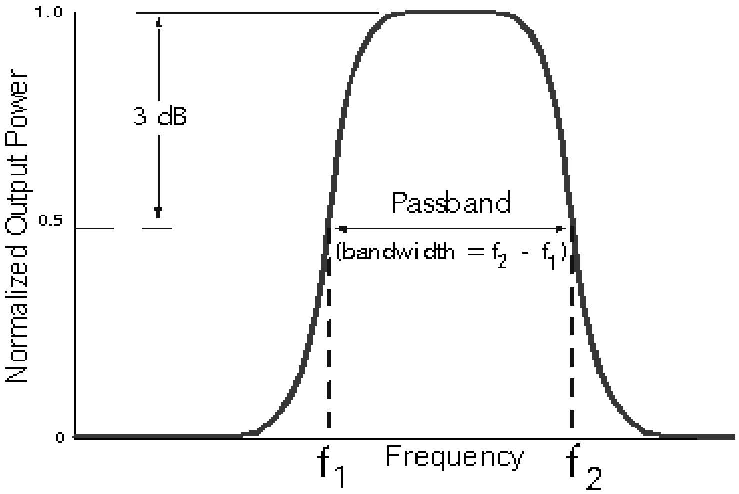


Fig. 5 Band pass Filter

2.5.4 Band stop (Notch) Filtering

For the transmission of pure EMG signal, a group of frequencies should be removed to eliminate ambient noise. For this purpose, a specific group of frequencies must be stopped. This can be made possible through the use of a band stop filter. A band stop (notch) filter response is shown in Fig. 6.

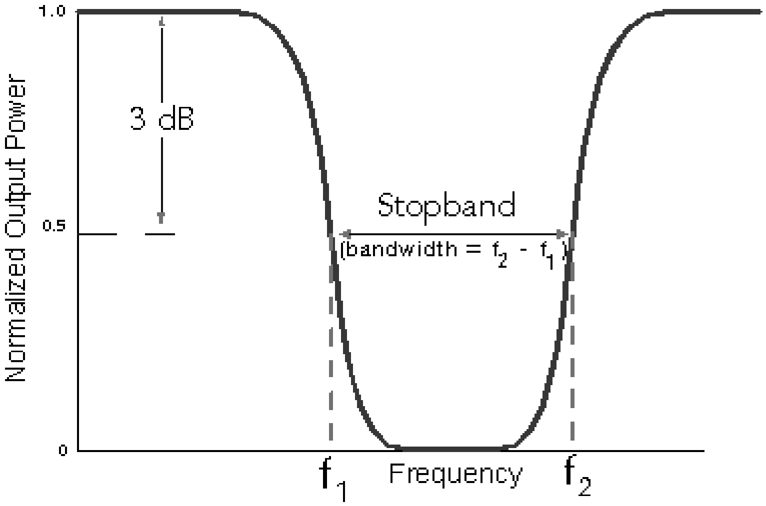


Fig. 6 Band stop (Notch) Filter

2.6 Segmentation

Signal segmentation is the procedure of splitting a signal into small-scale chunks which have same statistical interpretation such as the frequency and amplitude. Segmentation might be done in time domain.

2.7 Feature Extraction

Feature extraction is procedure of estimating preselected characteristics of EMG signals to be augmented to a processing scheme (such as classification) to improve the efficiency of the EMG based control system. One of the most significant part is selecting proper features and efficacy of techniques for selected feature capability to retrieve these features in real-time.

2.7.1 Amplitude of First Burst

Amplitude of first burst is the amplitude of first peak existing in a signal.

2.7.2 Mean Absolute Deviation

Mean absolute deviation is also referred to as ‘Average Absolute Deviation. It is the average or mean of the absolute deviations from a central point.

2.7.3 Standard Deviation

The standard deviation is a measure of the extent of divergence or dispersal of an array of values. A low standard deviation signifies that the values inclined to be close to the mean of the series, whereas a high standard deviation signifies that the values are dispersed over a broader range.

2.7.4 Mean of Integrated Rectified EMG

Mean of Integrated Rectified EMG is the average of the area beneath the curve of the rectified EMG. It is the average of the mathematical integral of the absolute amplitudes of the raw EMG signal.

2.7.5 Kurtosis

Kurtosis is the measure of dissemination of numbers around the peak number. A function having high kurtosis will have lesser numbers above and below the peak number. A function having low kurtosis will have more numbers above and below the peak number.

2.7.6 Skewness

Skewness of a function means how a data distribution leans. Skewness is of two types;

1. Positive Skewness
2. Negative Skewness

2.7.6.1 Positive Skewness

If the data piles upon left side and the posteior lies on the right side of graph, then it is known as positive skewness.

2.7.6.2 Negative Skewness

If the data piles upon right side and the posterior lies on the left side of the graph, then it is known as negative skewness.

2.7.7 Maximum Amplitude

Maximum amplitude is the greatest peak of the EMG signal.

2.7.8 Total Power

The total power of a signal is the aggregate of the absolute levels of its time-domain samples divided by the length of signal.

2.7.9 Root Mean Square

Root Mean square value of the EMG signal is measured by taking the square of the signal values then taking average of those values and then taking the root of those values. Root mean square values of active EMG signal are greater than the inactive EMG signal so we can easily identify the inactive and active portions by looking at the root mean square values of the EMG signal.

2.7.10 Variance

Variance is the anticipation of the squared deviation of a random variable from its mean. Generally, it calculates how far an array of numbers are dispersed from their average or mean value.

2.7.11 Zero Crossings

Zero crossing is the measure of the point where signal varies its sign or crosses the zero line.

2.8 Classification

After the extraction of features from the real time EMG signal various features' numbers are compared with the numbers of the already created dataset. On the basis of the comparison classification of the signal is done. The signals with same features are categorized in the same class and vice versa.

CHAPTER 3

LITERATURE REVIEW

3 LITERATURE REVIEW

Myoelectric signals have been widely utilized in the medical sphere for more than 200 years, with EMG (Electromyography), ECG (Electrocardiography) and EEG (Electroencephalography) being eminent examples. Over the last few decades, the application of engineering theorems to the domain has proven to be of paramount significance, resulting to miraculous scientific, methodological and technical accomplishments.

3.1 Biological Background

EMG (Electromyography) is the subject which pertains to the disclosure, assessment and utilization of myoelectric signals emanating from forearm muscles. The domain of electromyography is comprehended in Biomedical Engineering and prosthesis operating electromyography is executed under Bio-mechatronics The electrical signal delivered during muscle excitation which is known as the myoelectric signal, is generated from tiny electrical currents produced by the shifting of ions around the muscle membranes and tracked down by means of electrodes. Electromyography is used to analyze and detect the myoelectric activity induced by muscles activation of a human body. The apparatus by which we acquire the EMG signal is called electromyograph and the consequent signal acquired is called electromyogram.

In the last few years, EMG has also found its application in recuperation of patients who are amputated in the form of robotic prostheses. EMG turns out to be a precious tool as it provides a naturalistic approach of feeling and categorizing various motions of the body. A multi-degree of freedom robotic operation can efficiently emulate the movement of the human limb. Recent advances in electronics and microcontroller technology have allowed advanced control options for robotic operations. One of the most important advantages of microprocessor technology in robotic prostheses is the improved EMG filtration algorithms. Presently, control options are even accessible to those who at one time were not proficient for such prosthetic administration.

3.2 Survey

Healthcare systems are a very substantial part of the economy of a country and for the public health. In this fast pace of life, it is arduous for people to be permanently available for their loved ones who might need them while they are adversely affected by the serious disease. Patient health surveillance systems evaluate physiological peculiarities either continually or at periodic interludes of time. Latest survey of WHO (World Health Organization) states that it is estimated approximately 5.6 million people were paralyzed portraying 1.9 percent of the population imprecisely 1 amongst 50. Health supervision of the serious patients in the hospitals discloses that, there are several activities, medicines, and stimulations to ensure protection of the serious patients. But there is not a meticulous monitoring device to supervise the health conditions of the patient. To overcome these challenges a surveillance system is presented, which is used to care for the patients' health conditions. In this surveillance system myoelectric sensors are utilized to sense the different hand gestures of patients and then the message generated is transmitted to the caretaker by using GSM.

We come upon NGO’s (Non Governmental Organizations) and hospitals attending patients who are impaired. These patients in most situations are unable to communicate their needs as they are neither able to speak properly nor they are able to move easily due to loss in motor control by their brain. In such cases we suggest a system that helps impaired person in displaying a message over the LCD by just simple movement of any part of his body which has movement capabilities. This system also takes care of the cases wherein no one is present as an attendant to the patient and thus sending a message through GSM of what he wants to communicate his/her need by SMS. For this objective, we are utilizing EMG surface electrodes to obtain the myoelectric signal from muscles. Tracking down of EMG signals with advance and powerful techniques is becoming a very significant condition in biomedical engineering. The primary motive for the curiosity in EMG signal investigation is in biomedical applications and clinical diagnosis.

3.3 Research Papers

We have reviewed the literature of several research papers. The motion of the human body is viable through muscles in collaboration with the brain. The brain transmits energization signals using the Nervous System whenever the muscles of the body are to be engaged for a certain action. Muscles are triggered in clusters which are known as ‘Motor Units’. A motor unit is the intersection point where the motor neuron and the muscle fibers intersect. When the motor unit is triggered, it generates a MUAP (Motor Unit Action Potential). The stimulus from the Nervous System is reiterated continually for as long as the muscle is needed to provoke force. This continuous actuation generates motor unit activity potency strings. The strings from concomitantly activated motor units superpose to generate the consequent EMG signal [1].

Accurate detection of distinct cases in the sEMG (Surface EMG) is a substantial concern in the examination and determination of the motor system. Various techniques have been suggested for observing the off and on moment of the muscle. The most prevalent methodology for the settlement of motor-related cases from EMG signals comprises perceptible examination by skilled perceivers. The ‘Single-Threshold Method’, which correlates the EMG signal with a steady threshold, is the most visceral and prevalent method of time-tracking the inception of muscle contraction action based on computer [2].

Another research paper come up with the establishment of cost-effective physiotherapy EMG signal acquisition system having two channel input. In this acquisition system, both the input signals are amplified by a differential amplifier andgo through signal preconditioning to acquire the linear envelope of EMG signal. Acquired EMG signal is then digitized and transmitted to the computer for being plotted [3].

In another research paper, a system for acquiring, conditioning and disintegrating

EMG signals with the aim of extracting plentiful MUAPTs (Motor Unit Action Potential Trains) with tremendous level of precision is depicted [4]

In another research paper, the researcher related to the disintegration of the EMG signal as the process by which the EMG signal is distributed into its constituent elements MUAPTs (Motor Units Action Potential Trains) [5].

Another research paper demonstrates an effort to establish a four channel EMG signal acquisition system as part of a progressing research in the establishment of an active prosthetic device. The acquired EMG signals are utilized for recognition and classification of six distinct motions of hand and wrist i.e. hand close, hand open, wrist extension, wrist flection, ulnar divergence and radial divergence. The above mentioned data is utilized for excitation of prosthetic action. The features of signal in time domain are extracted, and their magnitude is downsized by the use of principal component analysis. The downsized features are classified using two different methods: KNN (K- Nearest Neighbour) and ANN (Artificial Neural Networks), and the aftermaths are analyzed [6].

Another paper concentrated on small-scale filtration and amplification circuit design for conditioning of surface EMG signals collected from muscles of human forearm and intended to fix the filters and amplifiers inside a robotic hand with bounded space to command and control the robot hand motion. The paper made a study on the generally used techniques for circuitry design EMG signal processing and presented a circuit design for EMG signal filtration and amplification [7].

Another research paper was written to review the different algorithms and techniques used for EMG signal classification aimed to interpret the EMG signal into computer command [8].

Another paper delineates the establishment of an ASIC (Application-Specific Integrated Circuit) for acquisition of biomedical signals through invasive electrodes in order to provide an input for the controller of a hand prosthetic [9].

Another research paper’s objective is to innovate a movable robotic hand for bodily disabled persons to carry out basic hand motions. Surface EMG (Electromyograph) signal is acquired from muscles of an upper limb to extract the human's ambitions of action, where six types of gestures are chosen for disquisition. An ANN (Artificial Neural Network) is conditioned and used to differentiate the intended motion according to the features extracted from the biomedical signal [10].

CHAPTER 4

PROJECT DESCRIPTION

4 PROJECT DESCRIPTION

4.1 Hardware

In our project following hardware is used.

- EMG Electrodes
- EMG Muscle Sensor Module
- Instrumentation Amplifier
- Band pass Filter
- DRL (Driven Right Leg) Circuit
- Arduino Mega 2560
- GSM Module

4.1.1 EMG Electrodes:

There are two types of electrodes.

1. Invasive Electrodes
2. Noninvasive Electrodes

4.1.1.1 Invasive Electrodes:

These electrodes are also called inserted electrodes because these are inserted directly into the muscle through skin. By using these electrodes, the signal quality is improved because the SNR (Signal to Noise Ratio) is high. Invasive electrodes have further two types: needle and fine wire electrodes. EMGinvasive electrode is shown in the Fig. 7.

Fig. 7 EMG Invasive Electrodes

4.1.1.2 Noninvasive Electrodes:

These electrodes are implanted on the skin surface and are used externally therefore these are called surface electrodes. These electrodes provide noninvasive technique for acquisition and detection of EMG signal. These electrodes are disposable surface electrodes. These electrodes structure a chemical equilibrium between the skin of the body and the detecting surface of electrode through electrolytic conduction so signal current can stream into the electrode. The implementation of these electrodes is simple and very easy. The quality of the acquired signal is contingent on the placement of electrodes. If placement of the electrodeis on the exact muscle, then the signal quality would be better and if its placement is not at right position then crosstalk noise will affect the signal. As these electrodes are less expensive therefore these are preferred over invasive electrodes. The major drawback of surface electrodes is that these are less immune to noise that is why different noises lower the signal quality. Surface electrodes are shown in Fig. 8 and the placement of electrodes is demonstrated in Fig. 9.

Fig. 8 EMG Noninvasive Electrodes

Fig. 9 EMG Electrodes Placement

4.1.2 EMG Muscle Sensor Module:

This muscle sensor module is used to measure, filter, rectify and amplify the electrical activity of the muscle and to produce an analogue output signal that can easily be read by a microcontroller or Arduino. This sensor is basically used to sense the muscle activity. The muscle sensor is shown in the following Fig. 10.

Fig. 10 EMG Muscle Sensor

4.1.3 Instrumentation Amplifier

An instrumentation amplifier is a differential amplifier which is utilized to amplify very low-level signal by rejecting noise and interference signals. It has high CMRR (Common Mode Rejection Ratio). Its open-loop gain is high. It has low drift as well as low DC offset. The instrumentation amplifier is utilized to improve the input impedance of the circuit. In our project INA-128 amplifier is used as an instrumentation amplifier. The functional schematic of INA-128 is shown in the Fig. 11 and pin configuration is given in Fig. 12.

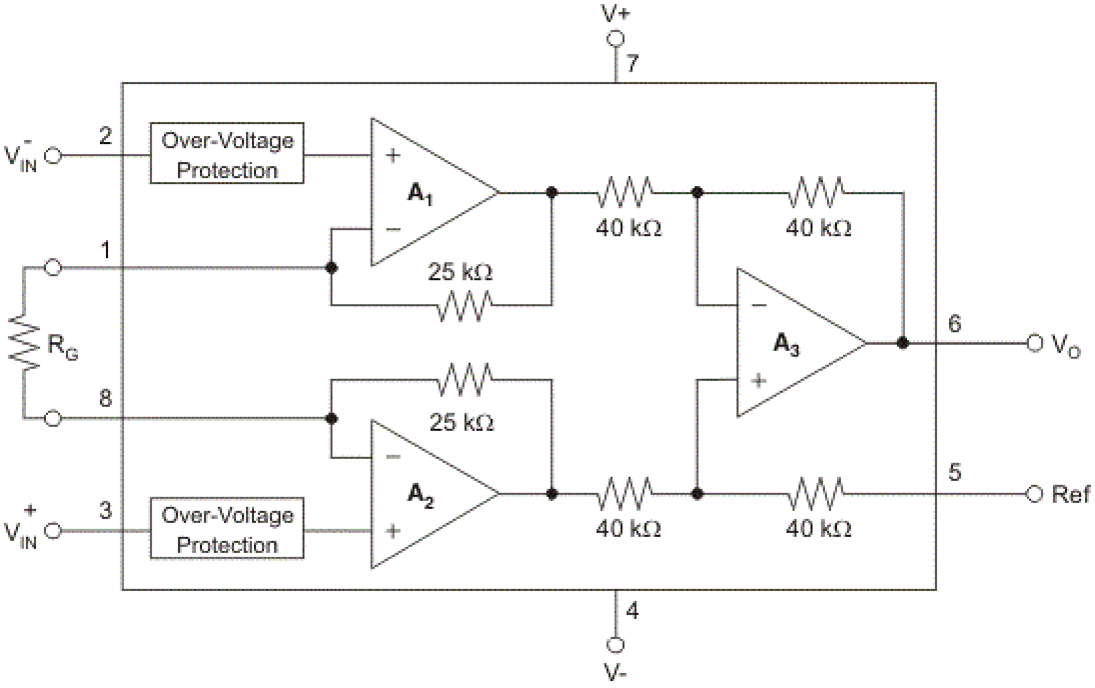


Fig. 11 Functional Schematic of INA-128

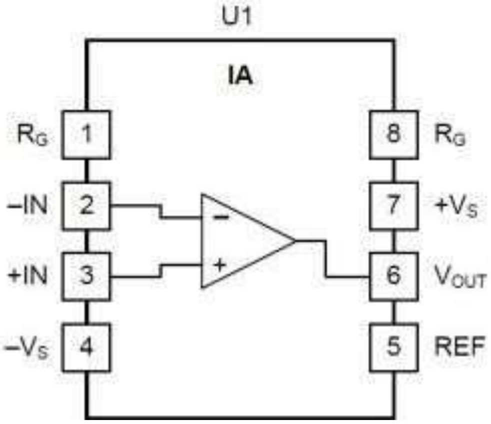


Fig. 12 Pin Configuration INA-128

4.1.4 Band pass Filter

In our project we have designed a bandpass filter of frequency range 20Hz – 500Hz because EMG signal is dominant in this frequency range. This filter is designed by cascading low pass filter having cutoff frequency 500Hz and high pass filter having cutoff frequency 20 Hz. Frequency response of bandpass filter is given in the Fig. 13.

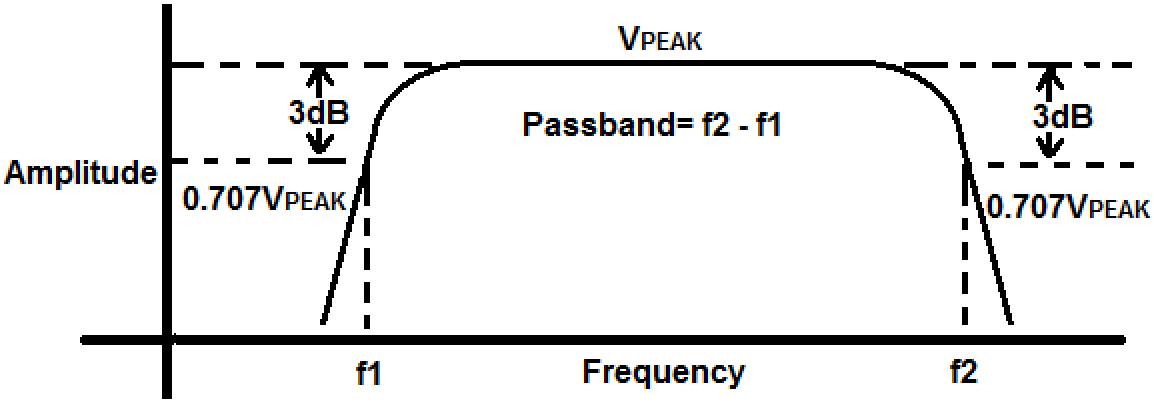


Fig. 13 Band pass Filter Frequency Response

4.1.4.1 Low pass Filter

In our project we have designed a 2nd order low pass filter around non-inverting op-amp with equal resistor and capacitor values and its cut-off frequency was 500 Hz because EMG signal is dominant in frequency below 500 Hz. This filter will remove all the frequencies above 500 Hz to remove noise. As in our project the resistors and capacitors values are same so its cutoff frequency can be determined by the following equation;

$$f_c = \frac{1}{2\pi\pi\pi\pi\pi\pi}$$

The circuit diagram of 2nd order low pass filter is given in the Fig. 14 and frequency response in the Fig. 15.

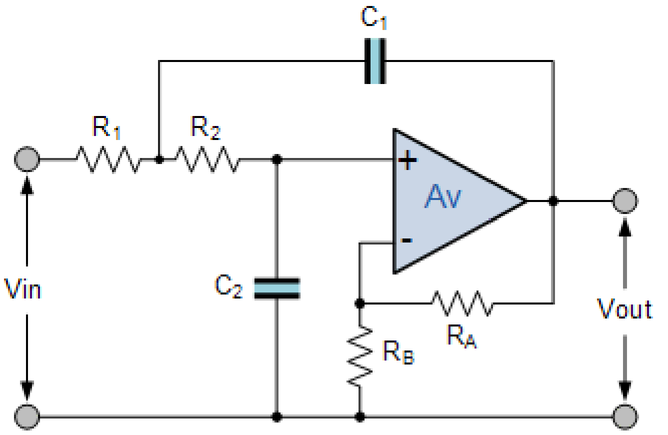


Fig. 14 Circuit Diagram of 2nd Order Low pass Filter

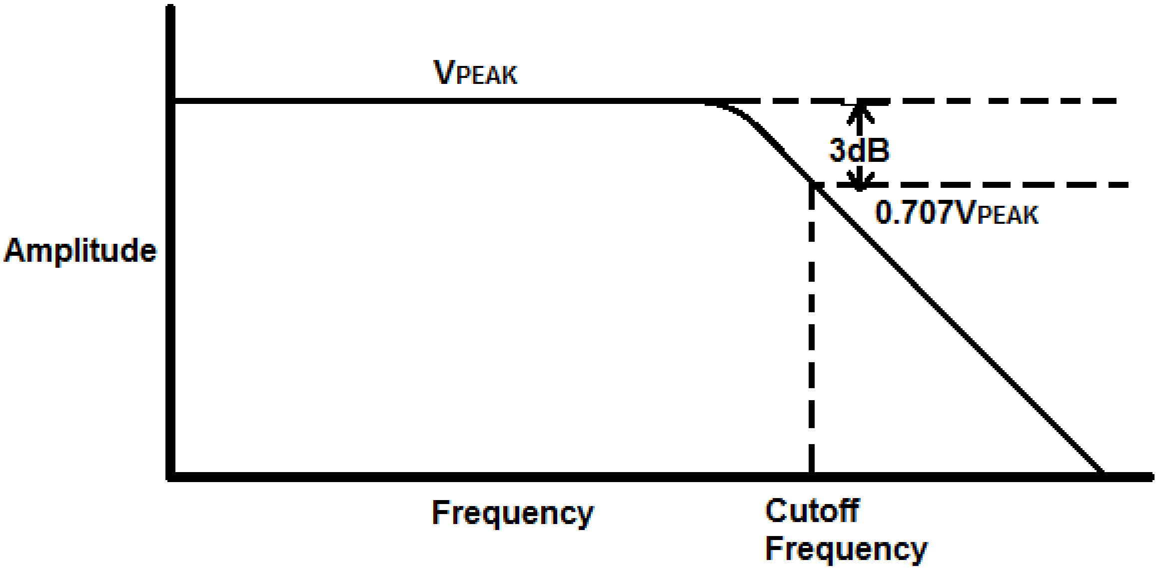


Fig. 15 Low pass Filter Frequency Response

4.1.4.2 High pass Filter

In our project we have designed a 2nd order high pass filter around non-inverting amplifier with equal resistor and capacitor values and its cutoff frequency was 20Hz because in EMG signal there is ambient noise below 20Hz and SNR (Signal to Noise Ratio) is very low. This filter will remove all the frequencies below 20Hz and hence ambient noise.

As in our project the resistors and capacitors values are same so its cutoff frequency can be determined by the following equation;

$$f_c = \frac{1}{2\pi\pi\pi\pi\pi\pi}$$

The circuit diagram of 2nd order high pass filter is given in the Fig. 16 and frequency response in the Fig. 17.

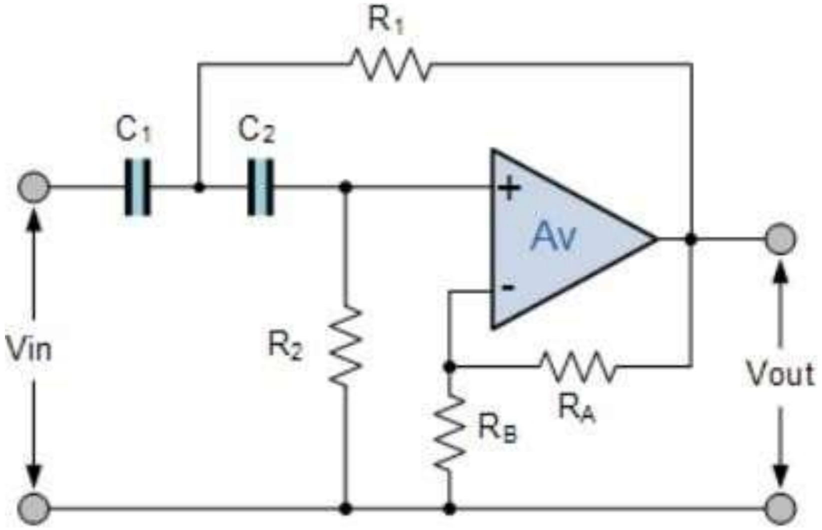


Fig. 16 Circuit Diagram of 2nd Order High pass Filter

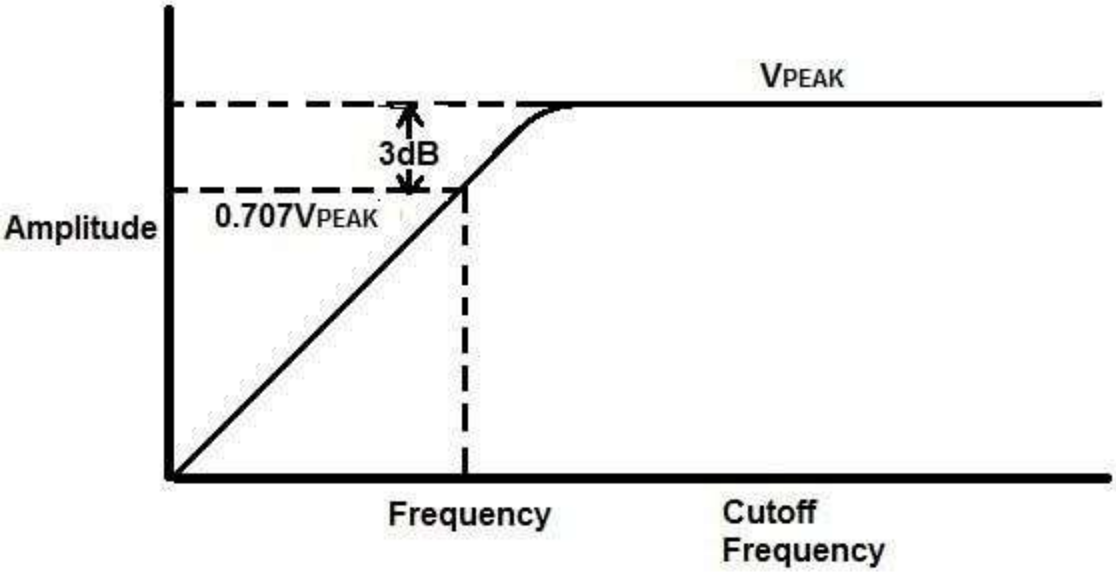


Fig. 17 High pass Filter Frequency Response

4.1.5 Arduino Mega 2560

- The Arduino Mega 2560 is a microcontroller board build by ATmega2560 microcontroller.
- It has 54 digital pins (Input/Output) out of which 15 pins are adopted for PWM (Pulse Width Modulation).
- It has 16 analog input pins.
- It has reset button and 4 hardware serial ports called USART which generate maximum speed for communication.
- It has a 16 MHz crystal oscillator .
- It has a USB connection that is utilized to interface and transfer code from PC to Arduino .
- It has a power jack that is utilized to power the Arduino.
- It has an ICSP header that is used for programming the Arduino and uploading code from computer.
- It has more memory space and I/O pins as compared to other Arduino boards.
- This board has two voltage regulators i.e.5V and 3.3V which provides flexibility to regulate voltage as per requirement.
- Arduino IDE is an Arduino software which is needed to program the board.
- Arduino Mega is specially designed for projects having complex circuitry and requiring more memory space.
- Each pin on this board has a specific function associated with it. All analog pins can be adopted as a digital I/O pins.

Fig. 18 shows Arduino Mega 2560, Fig. 19 shows schematic and Fig. 20 shows pin configuration of Arduino Mega 2560.

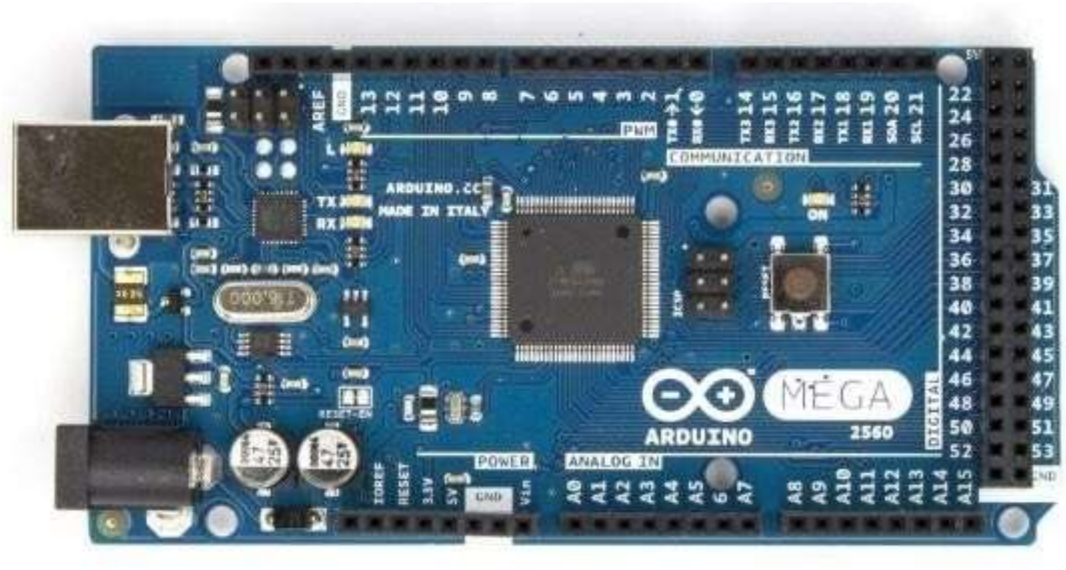


Fig. 18 Arduino Mega 2560

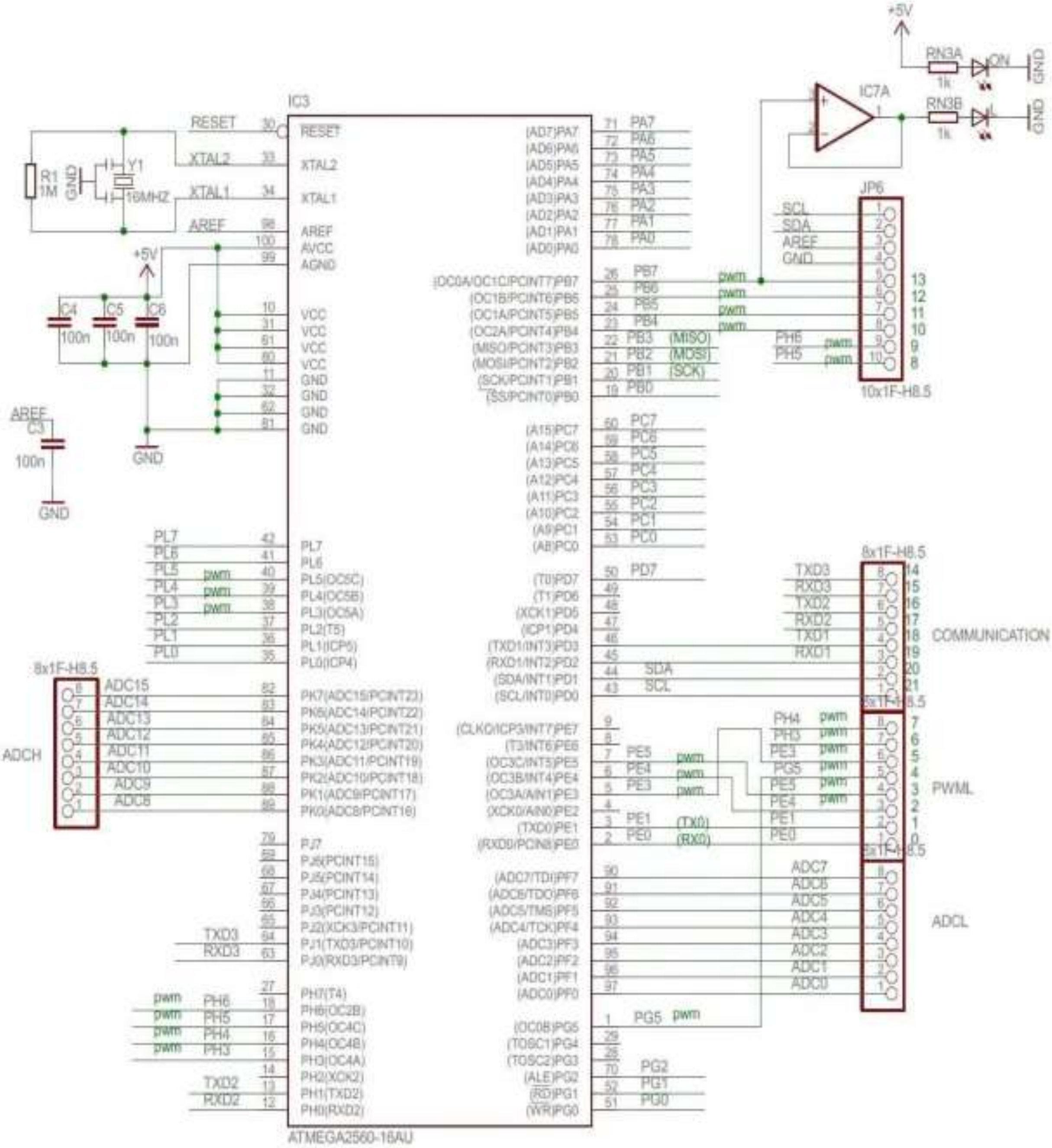


Fig. 19 Schematic Arduino Mega 2560

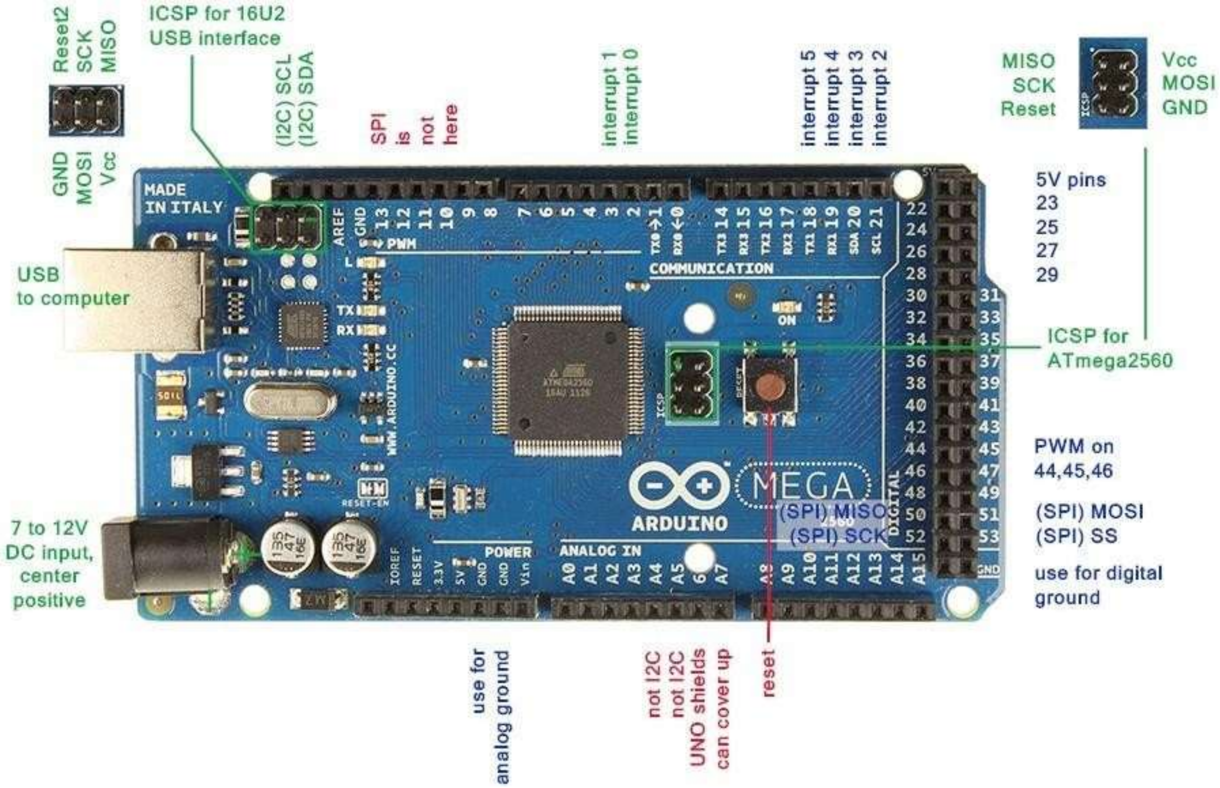


Fig. 20 Pin Configuration Arduino Mega 2560

4.1.6 GSM Module

A GSM (Global System for Mobile Communication) module is a chip or circuit that is used to set up communication between a mobile device or a computing machine and a GSM system. GSM is a digital system which uses TDMA (Time Division Multiple Access) technique for communication purpose. A GSM digitizes and shrinks the data, then transmits it through a channel with two unique streams of client information each in its own peculiar time slot. This framework has data rates 64 kbps to 120 Mbps. There are five diverse cell sizes in a GSM framework i.e. macro, micro, pico and umbrella cells. Every cell contrasts according to the implementation domain.

A GSM network comprises of the following components:

4.1.6.1 Mobile Station

Mobile station is a mobile phone which incorporates the transceiver, the display, and the processor. It is controlled by a SIM card operating over the network.

4.1.6.2 Base Station Subsystem

It is an interface between the mobile station and the network subsystem. It incorporates BTS (Base Transceiver Station) and BSC (Base Station Controller) which controls BTS.

4.1.6.3 Network Subsystem

It grants the primitive network connection to the mobile stations. It comprises of MSC (Mobile Switching Center). It also consists of HLR (Home Location Register) and VLR (Visitor Location Register) which provides call routing and roaming services of the GSM. It also comprises the EIR (Equipment Identity Register) which maintains an account of all the mobile equipment by their IMEI (International Mobile Equipment Identity) number.

Some features of GSM are given below;

- It has improved spectrum efficiency.
- It has international roaming service.
- It provides compatibility with ISDN (Integrated Services Digital Network)
- It has support for new utilities.
- It has SIM phonebook management.
- It has FDN (Fixed Dialing Number)
- It has real-time clock with alarm management.
- It has high quality speech.
- It uses encryption techniques to make phone calls more secure.

Fig. 21 shows GSM module and Fig. 22 shows GSM module pin configuration.

Fig. 21 GSM Module

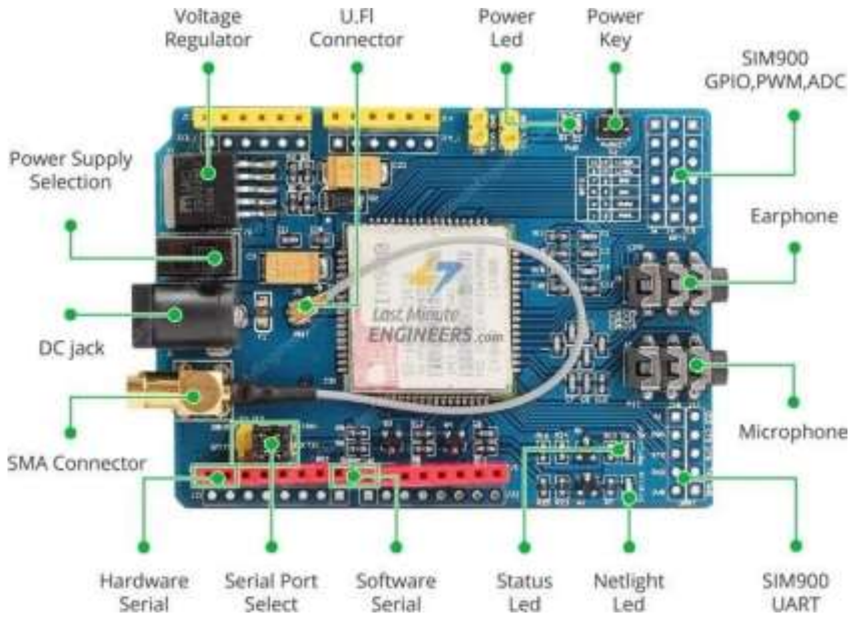


Fig. 22 GSM Pin Configuration

4.2 Software

In our project following software is used

- Arduino Software (IDE)
- MATLAB
- Proteus

4.2.1 Arduino Software (IDE)

4.2.1.1 Description

Arduino Software (IDE) is an open-source software that is primarily utilized for composing and compiling the code into the Arduino Module. It is an official Arduino Software (IDE), which makes code compilation too simple that even a layman with no prior technological proficiency can consider going all in with learning process. It is conveniently accessible for OSs (Operating Systems) like Windows, Linux, MAC and operates on the Java Platform that comes with built-in functions and commands that play a significant role for debugging, editing and compiling the code in the IDE. A variety of Arduino modules accessible this includes Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and several other. The main code, also referred to as a sketch, set up on the IDE platform will eventually produce a Hex file which is then transmitted and uploaded in the microcontroller on the board. The IDE primarily comprises of two rudimentary fragments i.e. Editor and Compiler where former is designed for composing the desired code and later is designed for compiling and uploading the code into the Arduino Module. This IDE supports both C and C++ languages.

4.2.1.2 Features

Following are some of the main features of Arduino Software (IDE)

- Serial Monitor
- Board Selection and Management
- Libraries
- Project Documentation
- Fix Encoding and Reload
- Programmer Functions
- User Preferences
- Sketch Editing Tools
- Port Menu
- Auto Format
- Burn Bootloader

4.2.1.3 Application

Arduino Software (IDE), in this project, is utilized for:

- Acquisition of the Electromyograph (EMG) signal.

4.2.1.4 Version

Arduino adaptation 1.8.13 is utilized in this project.

4.2.2 Proteus Design Suite

4.2.2.1 Description

Proteus Design Suite is a software toolset that is primarily designed for making schematics, simulating electronic circuits, and designing PCB (Printed Circuit Boards) outlines. Proteus ISIS is utilized by engineering students & proficient to make schematics & simulations of various electronic circuits. Proteus ARES is used for designing PCB outlines of electronic circuits. It is accessible in four languages which are English, Spanish, French and Chinese. Proteus is quite flexible in circuit sketching and it functions on ideal conditions. Proteus is also utilized for PCB designing, Proteus ARES is used for that.

4.2.2.2 Features

Following are some of the main features of Arduino Software (IDE)

- Schematic Drawing
- Microcontroller Simulation
- PCB Designing
- 3D Visualization
- Library Parts
- High Speed Design
- DRC (Design Rule Check)
- VSM (Virtual System Modelling)
- Debugging
- IoT (Internet of Things)

4.2.2.3 Application

In our project, it is used for PCB designing and simulation of signal acquisition and DRL circuit.

4.2.2.4 Version

Proteus 8.8 adaptation is utilized in this project.

4.2.3 MATLAB

4.2.3.1 Description

MATLAB stands for Matrix Laboratory. MATLAB is a highly efficient language for technical computation. It incorporates visual representations, calculations, and programming in user-friendly environment where problems and solutions are demonstrated in well-known mathematical notation. MATLAB platform is advanced for solving scientific and engineering problems. MATLAB language, which is matrix- based, is the world's most spontaneous way to demonstrate computational mathematics. Inbuilt graphics make it easier to envisage and comprehensive from data. MATLAB is used by engineering students and professionals in many fields such as signal processing, control systems for industry, communication, image and video processing, robotics, smart grid design along with computational finance.

4.2.3.2 Features

Following are some of the main features of MATLAB

- High-Level Language
- Interactive Environment
- Math and Computation
- Handling Graphics
- Mathematical Functions Library
- Algorithm Development
- API (Application Program Interface
- Toolboxes
- Data Analysis, Exploration & Visualization
- Interfacing with Other Languages
- Data Processing
- Machine Learning
- Text Analytics
- Multi-Platform Deployment

4.2.3.3 Application

In our project, it is used for the processing of the signal.

4.2.3.4 Version

In our project, MATLAB 2019 adaptation is used.

CHAPTER 5

PROJECT INTEGRATION

5 PROJECT INTEGRATION

Project integration management is the organization of all the components of a project. Fundamentally, project embodiment involves that how we connect different sections of the project.

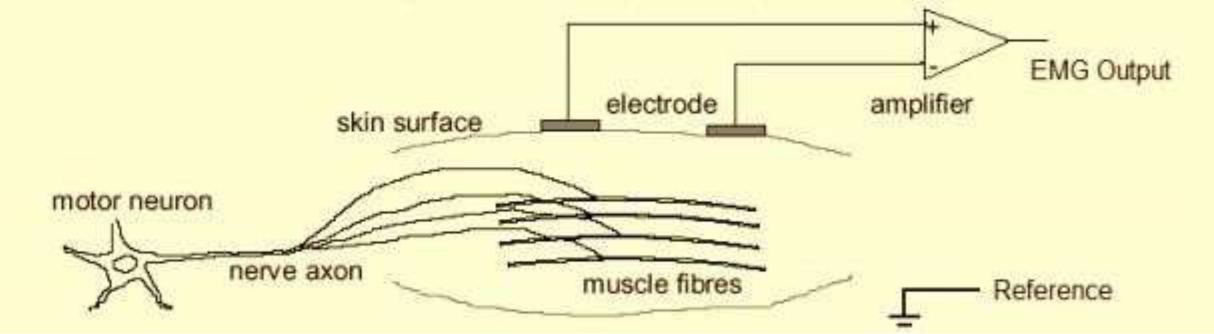


Fig. 23 EMG Signal

In our project we are using surface electrodes to acquire the signal from muscles. The signals obtained from the upper forearm by the two EMG surface electrodes are linked to a differential amplifier. The two sensing surface electrodes are positioned only 1 to 2 cm away from each other. The differential amplifier restrains the common mode noise signals from both inputs and then amplifies the difference.

Output of differential amplifier then undergoes filtration process. Filtration is done by hardware as well as software design.

5.1 EMG Signal Acquisition

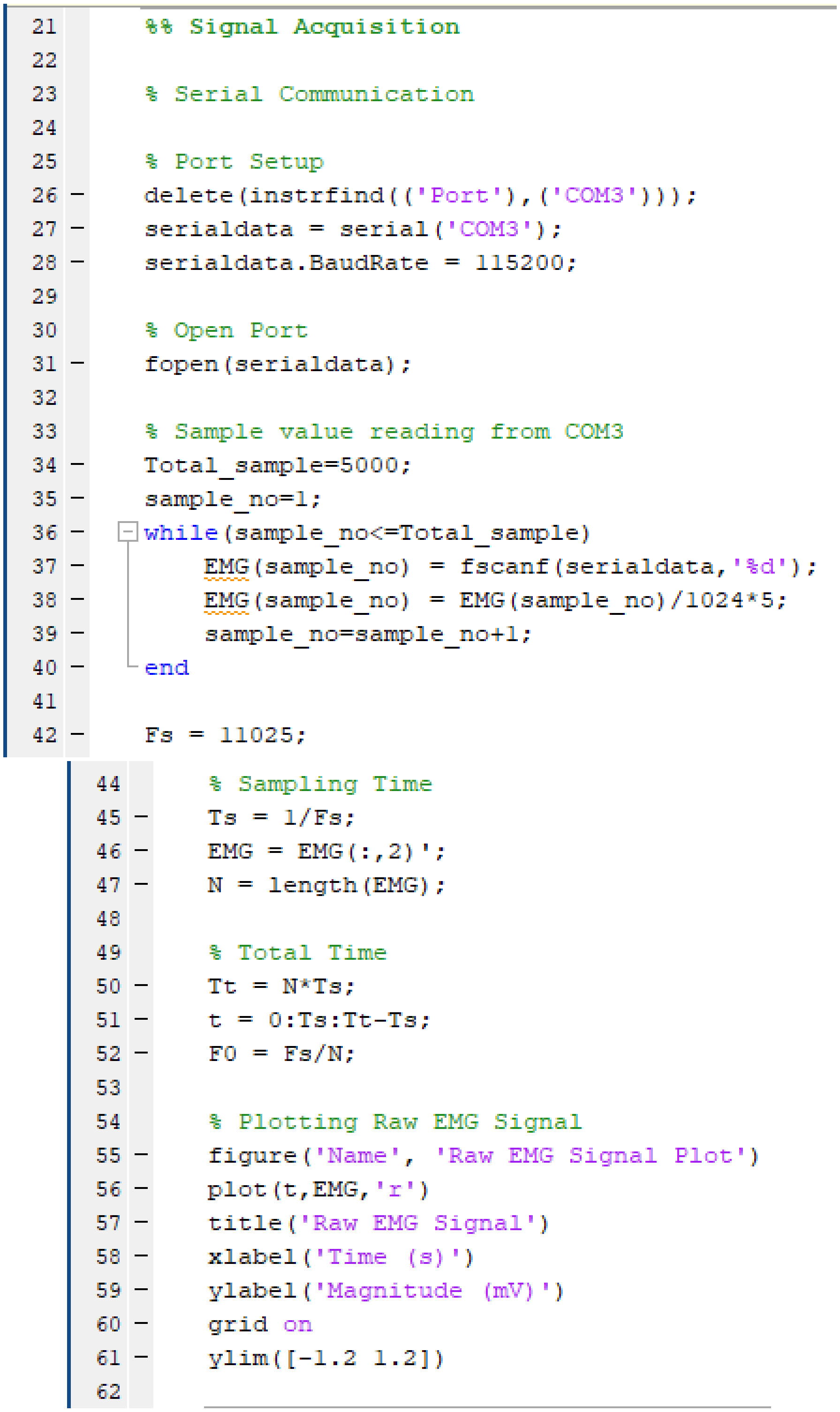
EMG Signal was acquired by surface electrodes from arm muscle. It was then transmitted to PC by Arduino for further signal processing. Serial communication was initiated to transfer EMG signal from Arduino towards MATLAB for processing.

5.1.1 Arduino Code

```
  /*     Final Year Project
        Patient Healthcare System
 Supervisor:
   Dr. Shibli Nisar

 Group Members:
   1. Malik M. Shahzad Ghaffar
   2. M. Anas Ibraheem
   3. Usama Ali Lone
   4. Hafeez Ahmed */

   // Defined Analog Pin
 const int analogPin = A0;

   // Defined various ADC Prescalers
 const unsigned char PS_2 = (1 << ADPS0);
 const unsigned char PS_4 = (1 << ADPS1);
 const unsigned char PS_8 = (1 << ADPS1) | (1 << ADPS0);
 const unsigned char PS_16 = (1 << ADPS2);
 const unsigned char PS_32 = (1 << ADPS2) | (1 << ADPS0);
 const unsigned char PS_64 = (1 << ADPS2) | (1 << ADPS1);
 const unsigned char PS_128 = (1 << ADPS2) | (1 << ADPS1) | (1 << ADPS0);

 void setup() {
 Serial.begin(115200);

  // Set up the ADC
ADCSRA &= ~PS_128; // Remove bits set by Arduino library

  // Set our own Prescaler to 128
ADCSRA |= PS_128;

  pinMode(analogPin,INPUT);
  noInterrupts(); // Disable All Interrupts

  //Pulse Width Modulation

  // Reset Timers
  TCCR1A = 0;
  TCCR1B = 0;
  TCNT1 = 0;

  // Prescale Value = 256 ; OCR = 16 MHz/(Prescale Value*Required Frequency)
  // For 500HZ OCR=125; 1000Hz OCR=62.5; 2000Hz OCR=31.25; 4000Hz OCR=15.625 but OCR must be integer

  OCR1A = 63; // Time period=1/62500=0.000016sec
  TCCR1B |= (1 << WGM12); // CTC Mode
  TCCR1B |= (1 << CS12); // 256 Prescaler = 16 MHz/256 = 62500Hz
  TIMSK1 |= (1 << OCIE1A); // Enable Timer Compare Interrupt
  interrupts(); // Enable All Interrupts
}
     ISR(TIMER1_COMPA_vect) // Timer Compare Interrupt Service Routine
     {
       Serial.println(analogRead(analogPin)); // Serially send Analog Information
     }
     void loop()
     {


     }
```

Fig. 24 EMG Signal Acquisition Arduino Code

5.1.2 MATLAB Code



```
%% Signal Acquisition

% Serial Communication

% Port Setup
delete(instrfind({'Port'},{'COM3'}));
serialdata = serial('COM3');
serialdata.BaudRate = 115200;

% Open Port
fopen(serialdata);

% Sample value reading from COM3
Total_sample=5000;
sample_no=1;
while(sample_no<=Total_sample)
    EMG(sample_no) = fscanf(serialdata,'%d');
    EMG(sample_no) = EMG(sample_no)/1024*5;
    sample_no=sample_no+1;
end

Fs = 11025;
```

```
% Sampling Time
Ts = 1/Fs;
EMG = EMG(:,2)';
N = length(EMG);

% Total Time
Tt = N*Ts;
t = 0:Ts:Tt-Ts;
F0 = Fs/N;

% Plotting Raw EMG Signal
figure('Name', 'Raw EMG Signal Plot')
plot(t,EMG,'r')
title('Raw EMG Signal')
xlabel('Time (s)')
ylabel('Magnitude (mV)')
grid on
ylim([-1.2 1.2])

```

Fig. 25 EMG Signal Acquisition MATLAB Code

5.1.3 Raw EMG Signal:

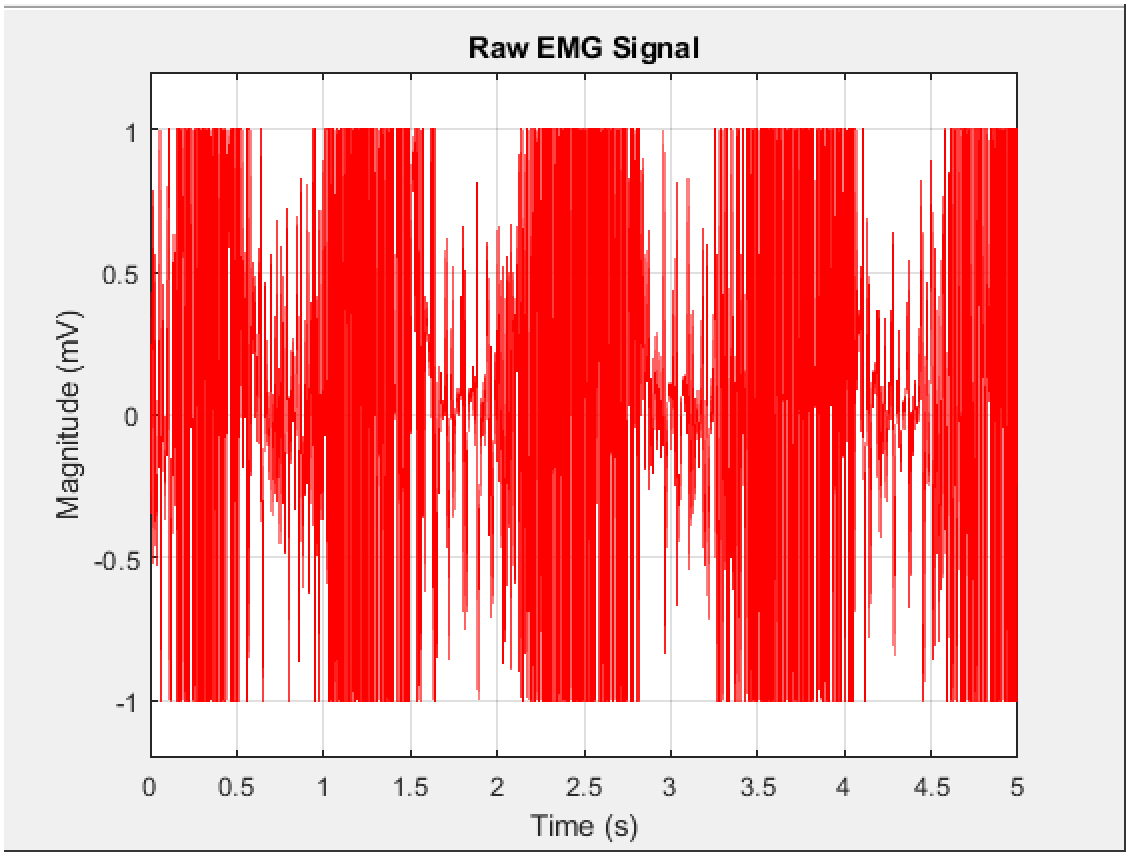
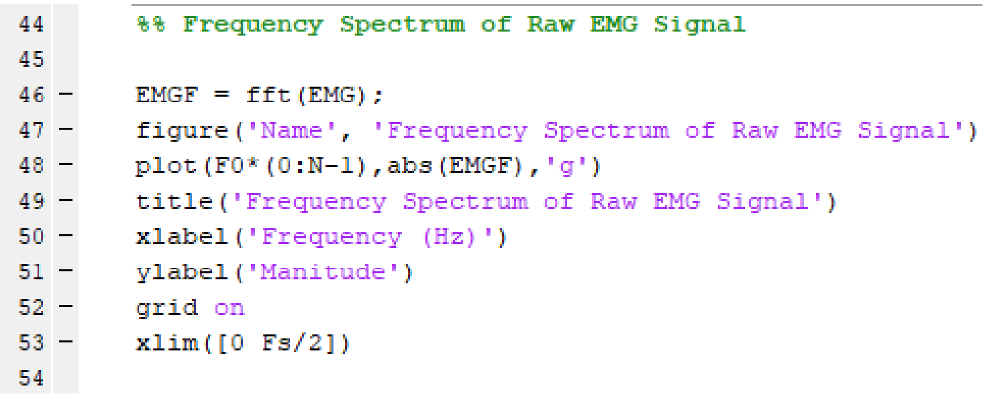


Fig. 26 Raw EMG Signal

5.2 Frequency Spectrum of Raw EMG Signal



```
%% Frequency Spectrum of Raw EMG Signal

EMGF = fft(EMG);
figure('Name', 'Frequency Spectrum of Raw EMG Signal')
plot(F0*(0:N-1),abs(EMGF),'g')
title('Frequency Spectrum of Raw EMG Signal')
xlabel('Frequency (Hz)')
ylabel('Manitude')
grid on
xlim([0 Fs/2])

```

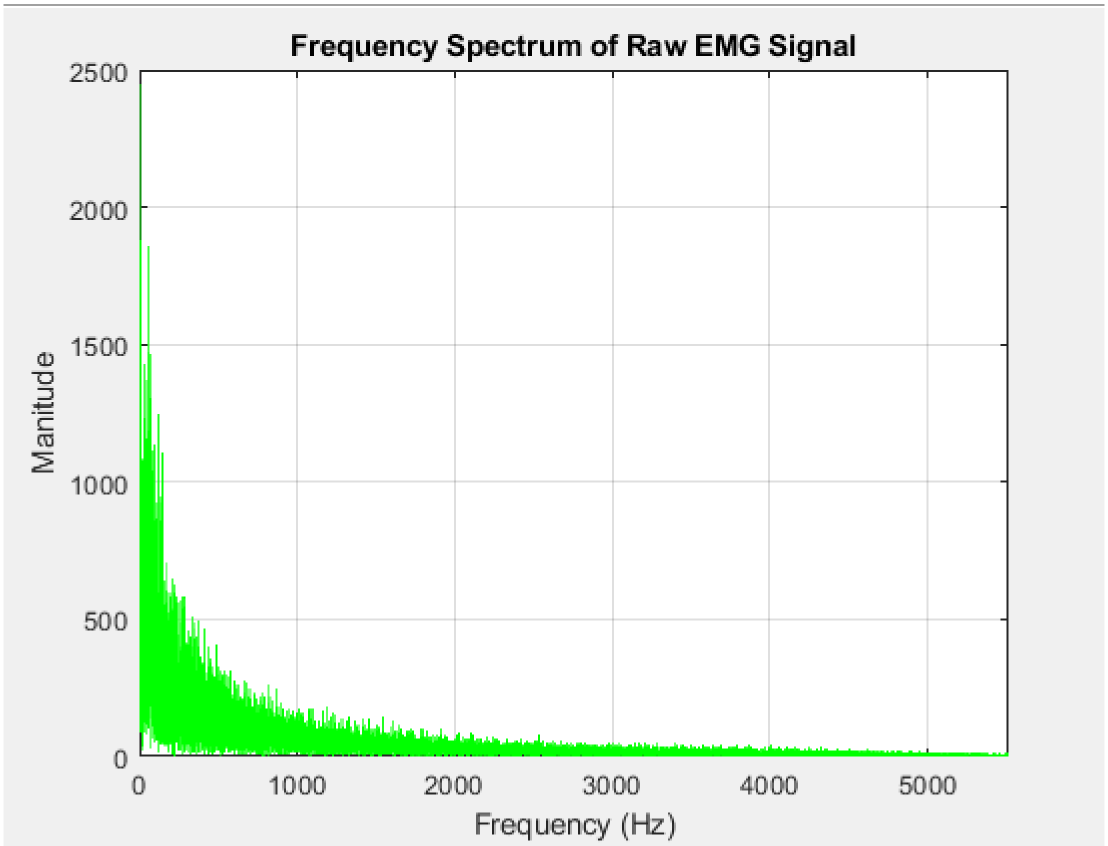
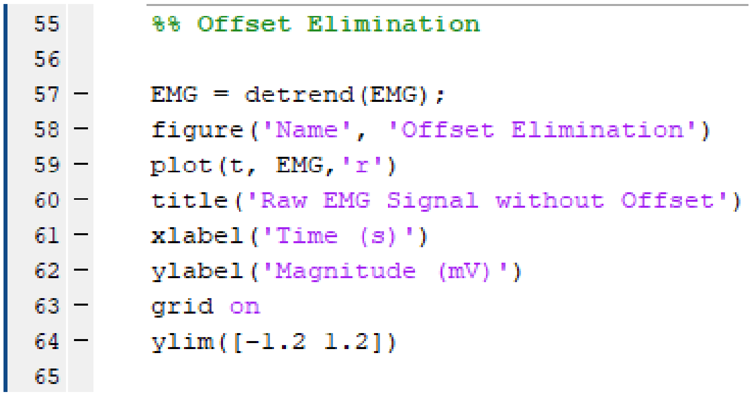


Fig. 27 Frequency Spectrum of Raw EMG Signal

5.3 Offset Elimination



```
%% Offset Elimination

EMG = detrend(EMG);
figure('Name', 'Offset Elimination')
plot(t, EMG,'r')
title('Raw EMG Signal without Offset')
xlabel('Time (s)')
ylabel('Magnitude (mV)')
grid on
ylim([-1.2 1.2])

```

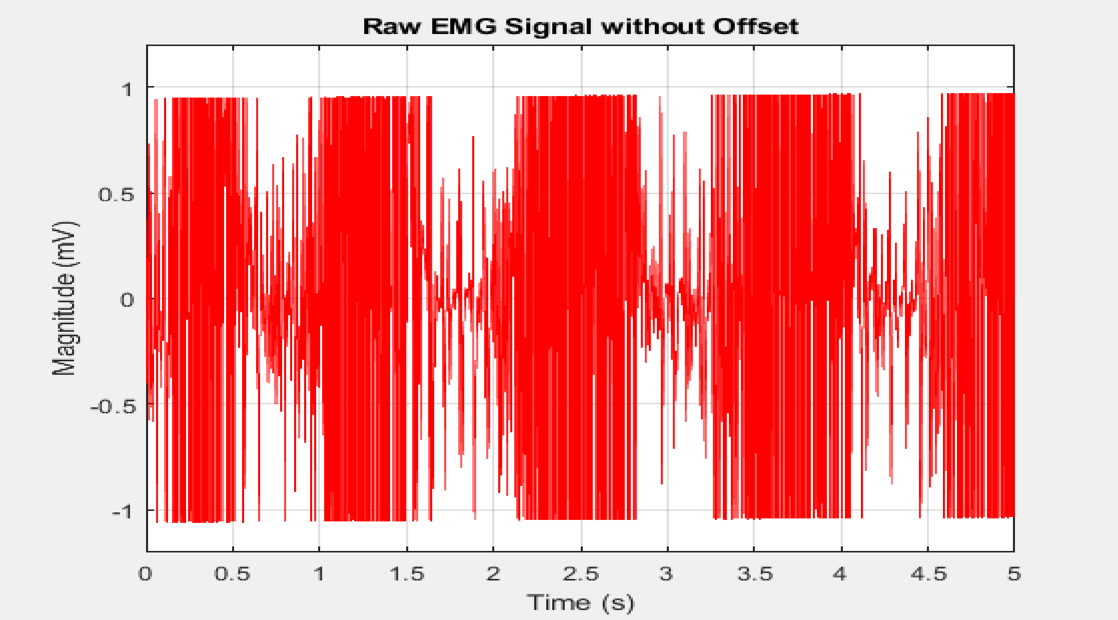
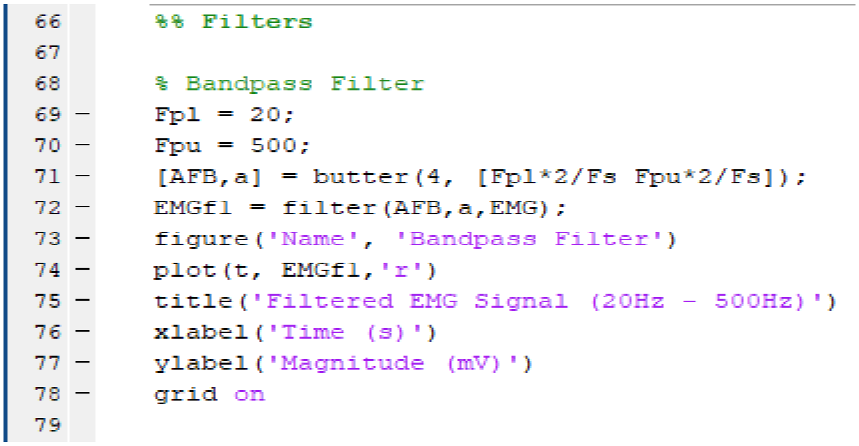


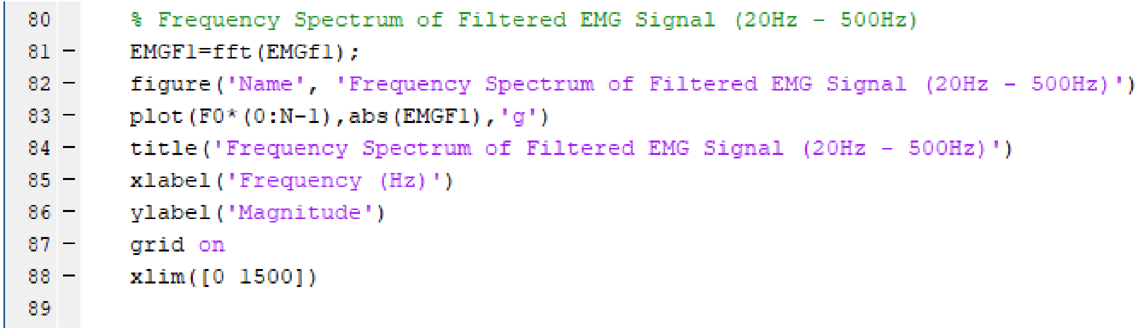
Fig. 28 Raw EMG Signal without Offset

5.4 Filters

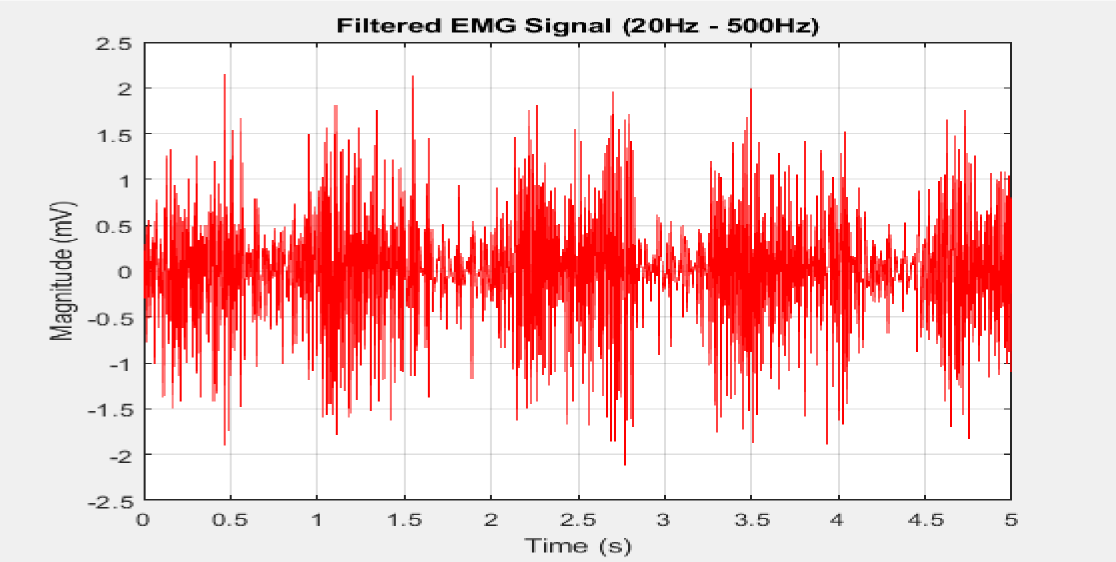
5.4.1 Band pass Filter

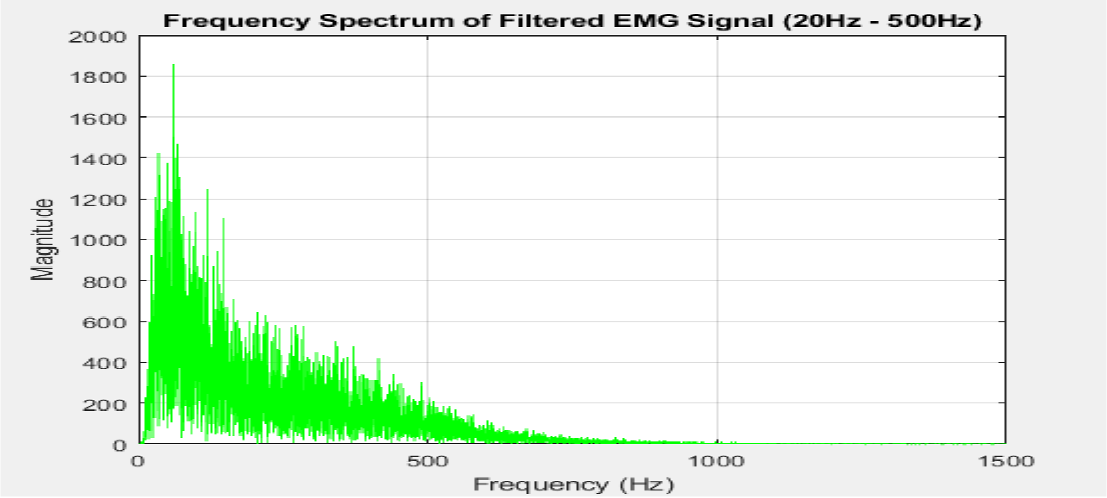


```
%% Filters

% Bandpass Filter
Fpl = 20;
Fpu = 500;
[AFB,a] = butter(4, [Fpl*2/Fs Fpu*2/Fs]);
EMGfl = filter(AFB,a,EMG);
figure('Name', 'Bandpass Filter')
plot(t, EMGfl,'r')
title('Filtered EMG Signal (20Hz - 500Hz)')
xlabel('Time (s)')
ylabel('Magnitude (mV)')
grid on

```

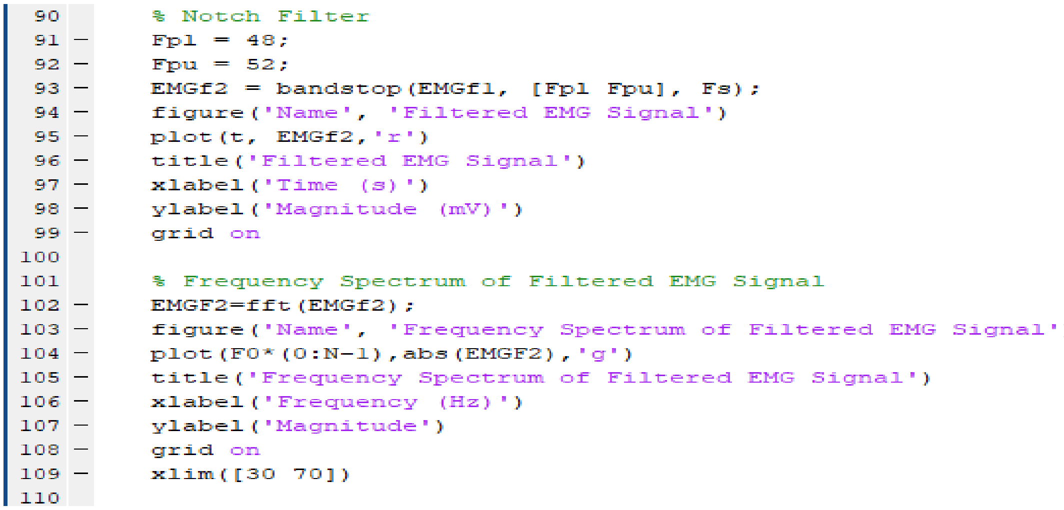


```
% Frequency Spectrum of Filtered EMG Signal (20Hz - 500Hz)
EMGF1=fft(EMGf1);
figure('Name', 'Frequency Spectrum of Filtered EMG Signal (20Hz - 500Hz)')
plot(F0*(0:N-1),abs(EMGF1),'g')
title('Frequency Spectrum of Filtered EMG Signal (20Hz - 500Hz)')
xlabel('Frequency (Hz)')
ylabel('Magnitude')
grid on
xlim([0 1500])

```





5.4.2 Band stop (Notch) Filter



```
% Notch Filter
Fpl = 48;
Fpu = 52;
EMGf2 = bandstop(EMGf1, [Fpl Fpu], Fs);
figure('Name', 'Filtered EMG Signal')
plot(t, EMGf2,'r')
title('Filtered EMG Signal')
xlabel('Time (s)')
ylabel('Magnitude (mV)')
grid on

% Frequency Spectrum of Filtered EMG Signal
EMGF2=fft(EMGf2);
figure('Name', 'Frequency Spectrum of Filtered EMG Signal')
plot(F0*(0:N-1),abs(EMGF2),'g')
title('Frequency Spectrum of Filtered EMG Signal')
xlabel('Frequency (Hz)')
ylabel('Magnitude')
grid on
xlim([30 70])

```

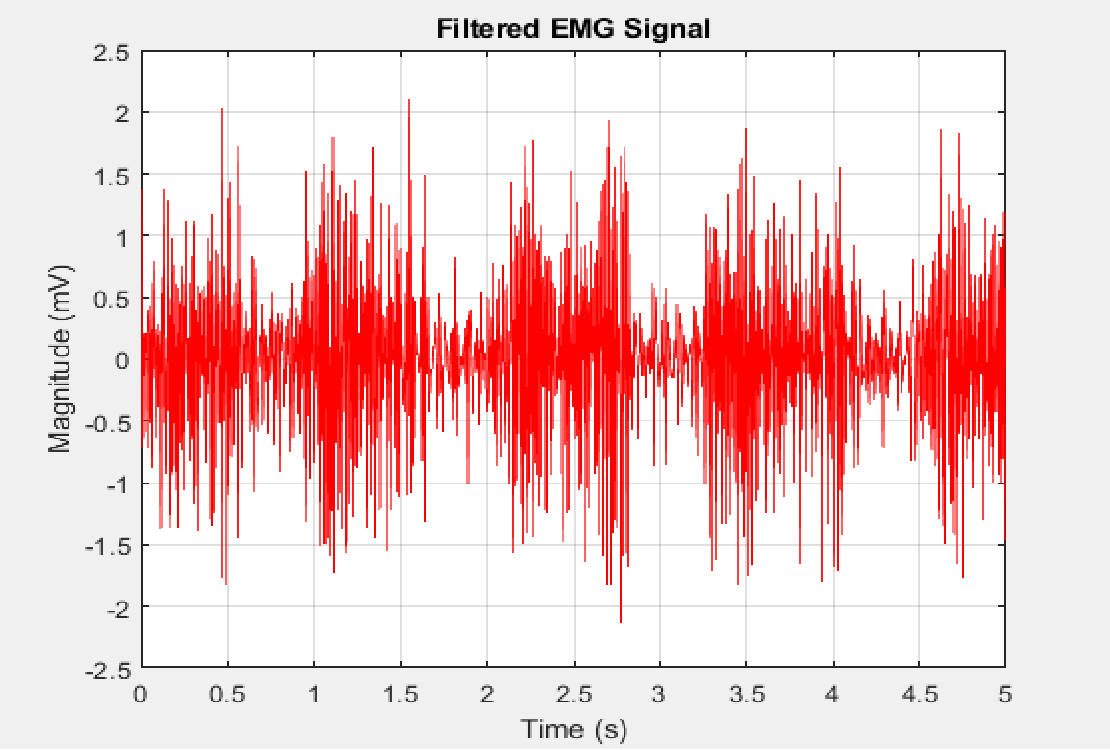


Fig. 29 Filtered EMG Signal

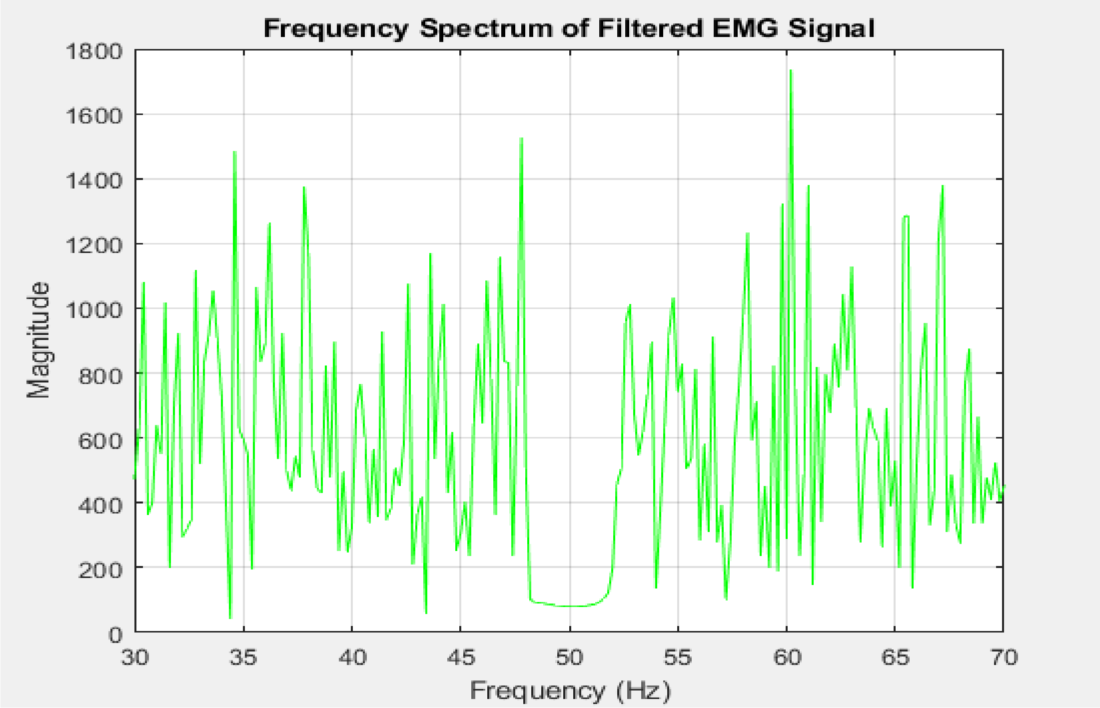
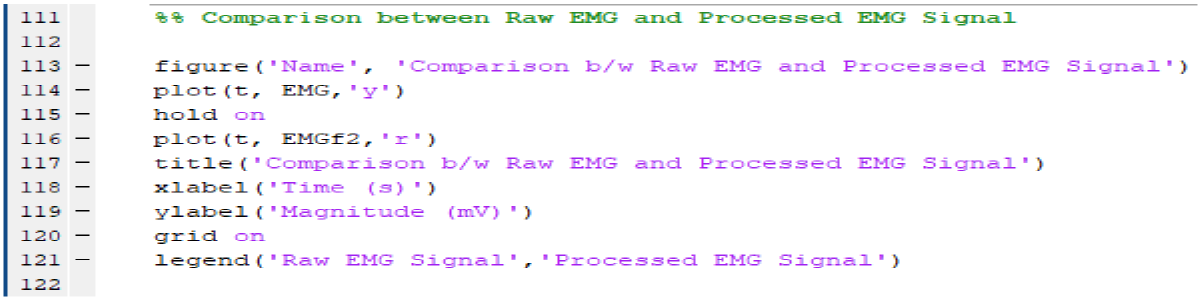
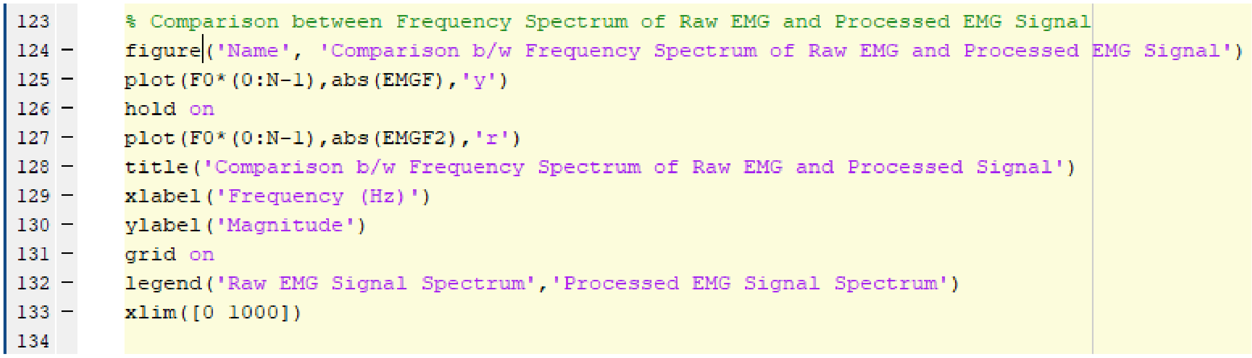


Fig. 30 Frequency Spectrum of Filtered EMG Signal

5.5 Comparison between Raw EMG and Processed EMG Signal



```
%% Comparison between Raw EMG and Processed EMG Signal

figure('Name', 'Comparison b/w Raw EMG and Processed EMG Signal')
plot(t, EMG,'y')
hold on
plot(t, EMGf2,'r')
title('Comparison b/w Raw EMG and Processed EMG Signal')
xlabel('Time (s)')
ylabel('Magnitude (mV)')
grid on
legend('Raw EMG Signal','Processed EMG Signal')

```



```
% Comparison between Frequency Spectrum of Raw EMG and Processed EMG Signal
figure('Name', 'Comparison b/w Frequency Spectrum of Raw EMG and Processed EMG Signal')
plot(F0*(0:N-1),abs(EMGF),'y')
hold on
plot(F0*(0:N-1),abs(EMGF2),'r')
title('Comparison b/w Frequency Spectrum of Raw EMG and Processed Signal')
xlabel('Frequency (Hz)')
ylabel('Magnitude')
grid on
legend('Raw EMG Signal Spectrum','Processed EMG Signal Spectrum')
xlim([0 1000])

```

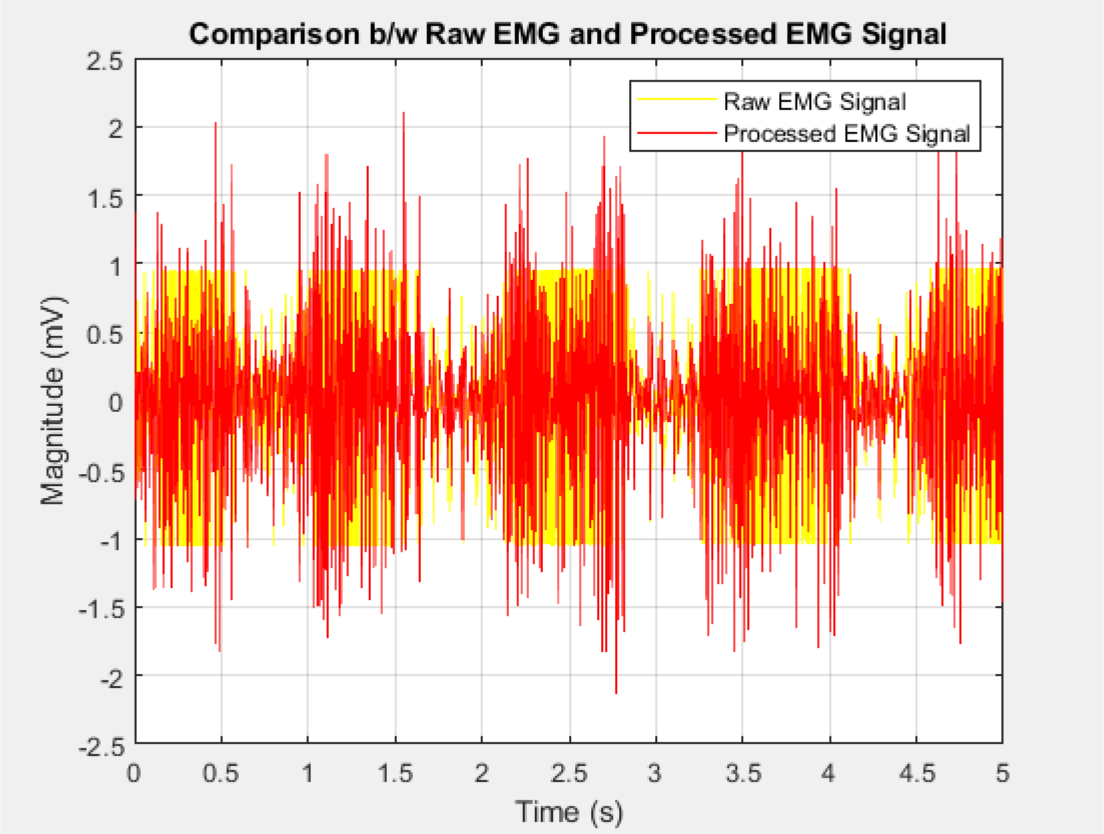


Fig. 31 Comparison b/w Raw EMG and Processed EMG Signal

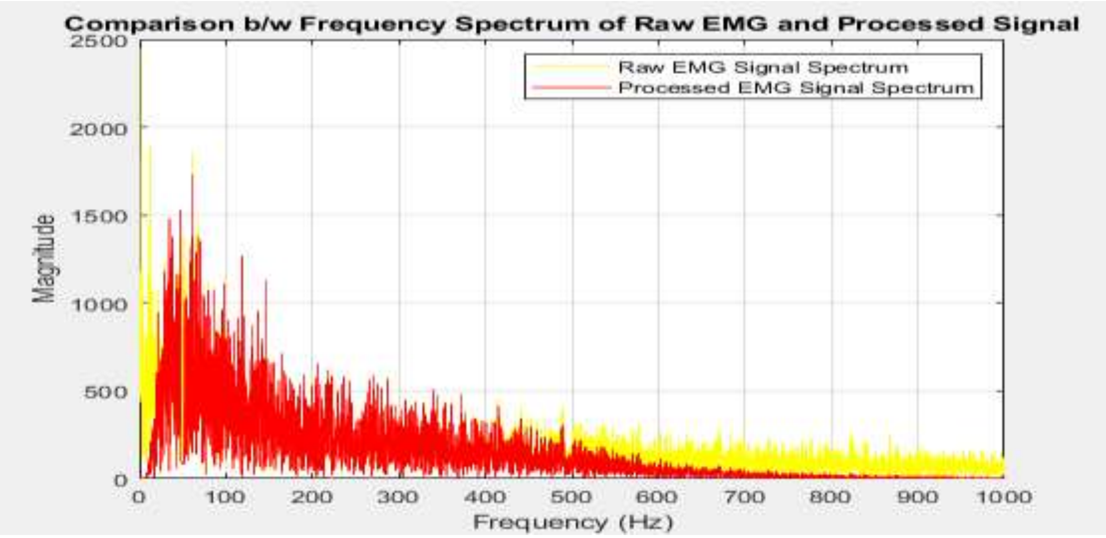
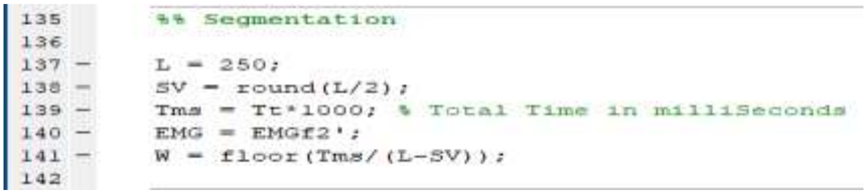


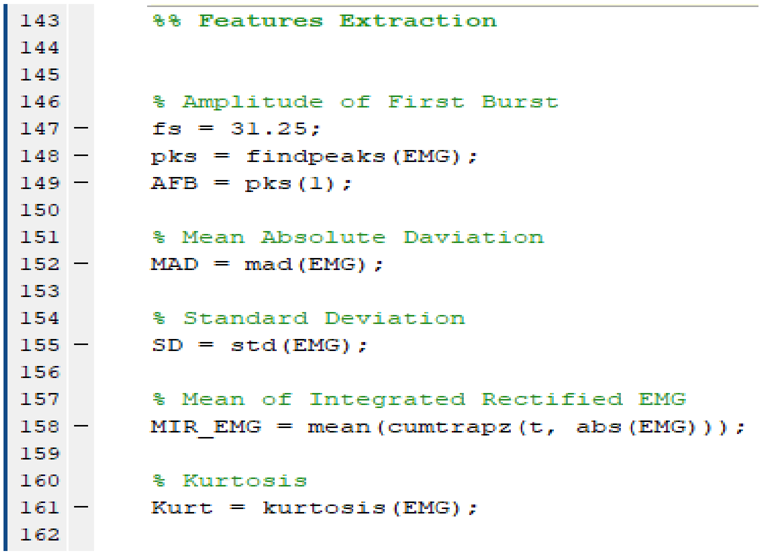
Fig. 32 Comparison b/w Frequency Spectrum of Raw EMG and Processed EMG Signal

5.6 Segmentation

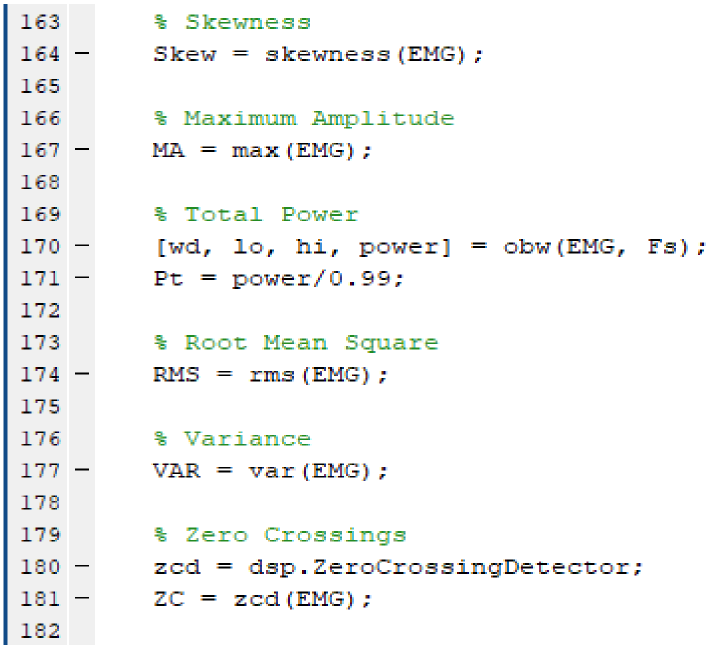


```
%% Segmentation

L = 250;
SV = round(L/2);
Tms = Tt*1000; % Total Time in milliSeconds
EMG = EMGf2';
W = floor(Tms/(L-SV));

```

5.7 Feature Extraction

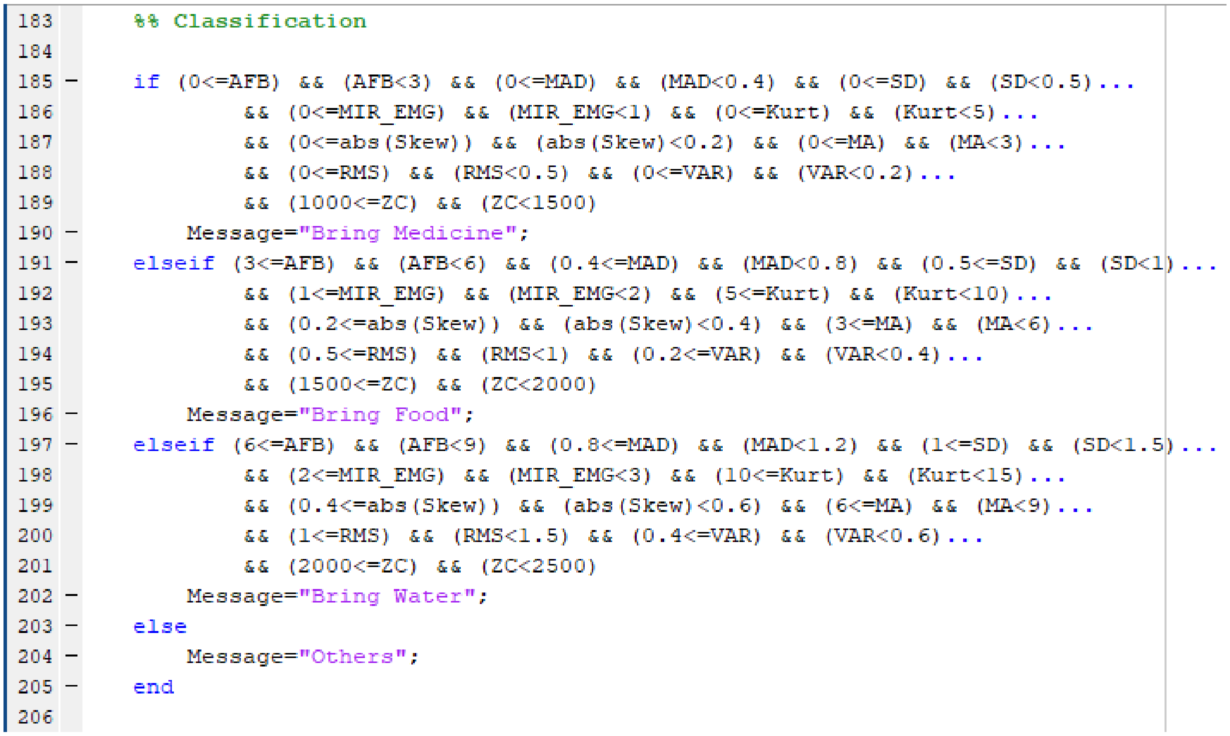


```
%% Features Extraction


% Amplitude of First Burst
fs = 31.25;
pks = findpeaks(EMG);
AFB = pks(1);

% Mean Absolute Daviation
MAD = mad(EMG);

% Standard Deviation
SD = std(EMG);

% Mean of Integrated Rectified EMG
MIR_EMG = mean(cumtrapz(t, abs(EMG)));

% Kurtosis
Kurt = kurtosis(EMG);

```



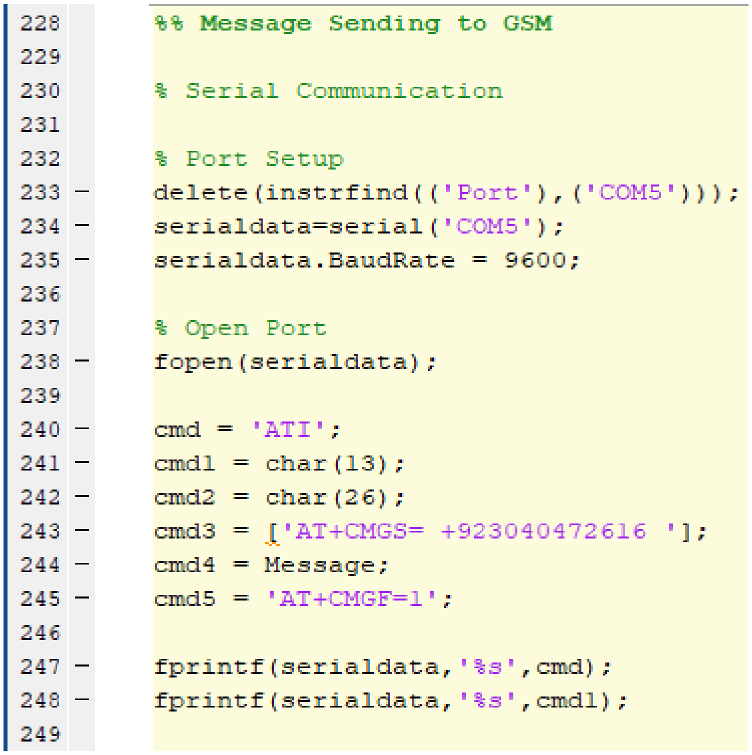
```
% Skewness
Skew = skewness(EMG);

% Maximum Amplitude
MA = max(EMG);

% Total Power
[wd, lo, hi, power] = obw(EMG, Fs);
Pt = power/0.99;

% Root Mean Square
RMS = rms(EMG);

% Variance
VAR = var(EMG);

% Zero Crossings
zcd = dsp.ZeroCrossingDetector;
ZC = zcd(EMG);

```

5.8 Classification

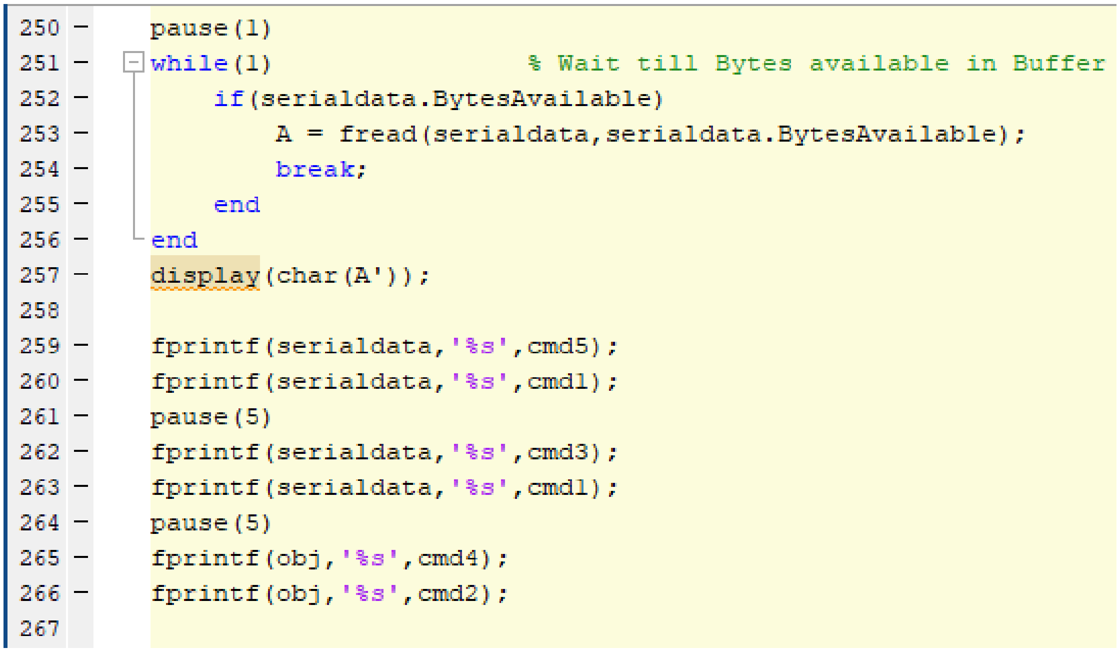


```
%% Classification

if (0<=AFB) && (AFB<3) && (0<=MAD) && (MAD<0.4) && (0<=SD) && (SD<0.5)...
        && (0<=MIR_EMG) && (MIR_EMG<1) && (0<=Kurt) && (Kurt<5)...
        && (0<=abs(Skew)) && (abs(Skew)<0.2) && (0<=MA) && (MA<3)...
        && (0<=RMS) && (RMS<0.5) && (0<=VAR) && (VAR<0.2)...
        && (1000<=ZC) && (ZC<1500)
    Message="Bring Medicine";
elseif (3<=AFB) && (AFB<6) && (0.4<=MAD) && (MAD<0.8) && (0.5<=SD) && (SD<1)...
        && (1<=MIR_EMG) && (MIR_EMG<2) && (5<=Kurt) && (Kurt<10)...
        && (0.2<=abs(Skew)) && (abs(Skew)<0.4) && (3<=MA) && (MA<6)...
        && (0.5<=RMS) && (RMS<1) && (0.2<=VAR) && (VAR<0.4)...
        && (1500<=ZC) && (ZC<2000)
    Message="Bring Food";
elseif (6<=AFB) && (AFB<9) && (0.8<=MAD) && (MAD<1.2) && (1<=SD) && (SD<1.5)...
        && (2<=MIR_EMG) && (MIR_EMG<3) && (10<=Kurt) && (Kurt<15)...
        && (0.4<=abs(Skew)) && (abs(Skew)<0.6) && (6<=MA) && (MA<9)...
        && (1<=RMS) && (RMS<1.5) && (0.4<=VAR) && (VAR<0.6)...
        && (2000<=ZC) && (ZC<2500)
    Message="Bring Water";
else
    Message="Others";
end

```

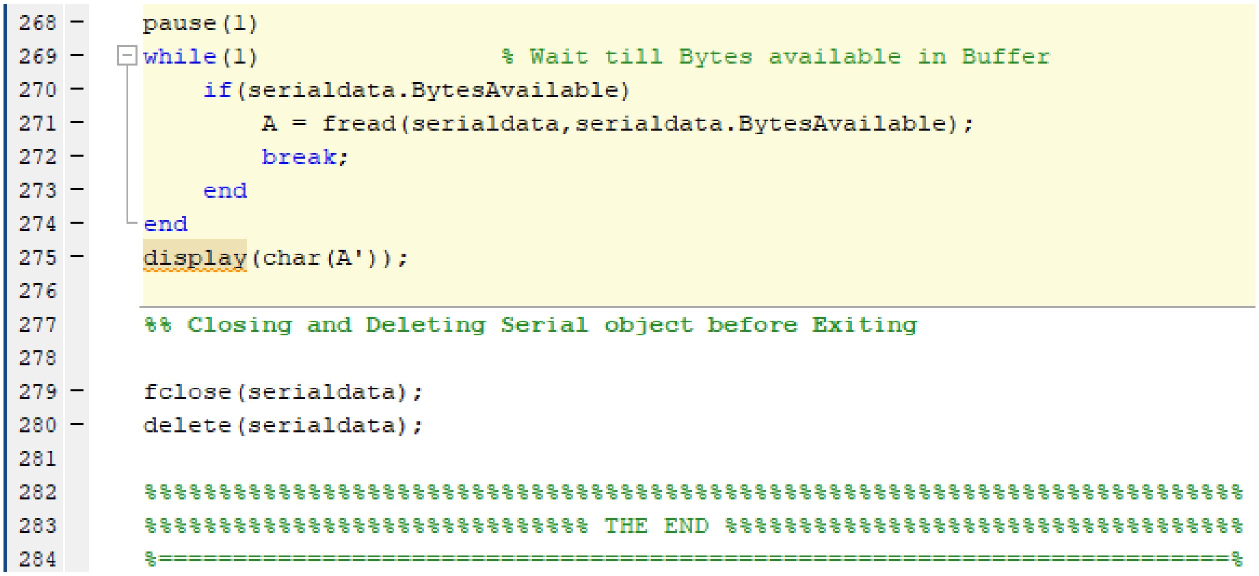
5.9 Message Sending to GSM



```matlab
%% Message Sending to GSM

% Serial Communication

% Port Setup
delete(instrfind(('Port'),('COM5')));
serialdata=serial('COM5');
serialdata.BaudRate = 9600;

% Open Port
fopen(serialdata);

cmd = 'ATI';
cmd1 = char(13);
cmd2 = char(26);
cmd3 = ['AT+CMGS= +923040472616 '];
cmd4 = Message;
cmd5 = 'AT+CMGF=1';

fprintf(serialdata,'%s',cmd);
fprintf(serialdata,'%s',cmd1);

```

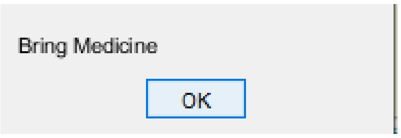


```matlab
pause(1)
while(1)                     % Wait till Bytes available in Buffer
    if(serialdata.BytesAvailable)
        A = fread(serialdata,serialdata.BytesAvailable);
        break;
    end
end
display(char(A'));

fprintf(serialdata,'%s',cmd5);
fprintf(serialdata,'%s',cmd1);
pause(5)
fprintf(serialdata,'%s',cmd3);
fprintf(serialdata,'%s',cmd1);
pause(5)
fprintf(obj,'%s',cmd4);
fprintf(obj,'%s',cmd2);

```



```
pause(1)
while(1)                % Wait till Bytes available in Buffer
    if(serialdata.BytesAvailable)
        A = fread(serialdata,serialdata.BytesAvailable);
        break;
    end
end
display(char(A'));

%% Closing and Deleting Serial object before Exiting

fclose(serialdata);
delete(serialdata);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% THE END %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%========================================================================%
```

5.10 Message



Bring Medicine

CHAPTER 6

CONCLUSION

6 CONCLUSION

Our project is very helpful for the people who are paralyzed and cannot move on their own. They can communicate their needs to their caretakers who are at a distance very easily through a mere gesture of their healthy body part. They do not need to call their care takers. This project also helps amputees to communicate their needs to the care takers .Our project is a step forward in the emerging field of HCI (Human Computer Interaction) because our project acquires the Electromyographic signal from the body of the patient and then processes the information gathered from that signal on a computer. The interfacing of computer with the human body is not easy as the biomedical signals such as EMG signals have very low amplitude and there are many noises which make it difficult to acquire them. The physiological noises which make the detection of EMG signals difficult are the ECG signals produced by heart and the fat of the skin. The tissues of the body and muscle membranes also make it difficult to detect EMG signals. We have applied various techniques for removing the noises from the EMG signals. The processing techniques used on EMG signals in our project can be used in other EMG applications as well for e.g. the processed EMG signals can be used to control the artificial limbs available commercially. EMG signals are very information rich signals. This information can be very helpful for controlling purposes.

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