SURFACE ELECTROMYOGRAPHY (EMG) SIGNAL ACQUISITION

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UNIVERSITI TEKNOLOGI PETRONAS
JUNE 2010

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by

Siti Hajar bt Mat Jam

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronic Engineering)

JUNE 2010

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CERTIFICATION OF APPROVAL

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Universiti Teknologi PETRONAS
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Approved:

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JUNE 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Siti Hajar Bt Mat Jam

ABSTRACT

The aim of this project is to develop technology to acquire signal from the surface electromyography based on the muscle activity. SEMG, the Surface Electromyography, is a non-invasive technique aimed at detecting and/or inferring EMG signal acquired from surface of the skin underlying the human muscle. In this research, the signal is analyzed using MATLAB was created to study on the EMG signal acquired. By designing a system that will acquire the sEMG (Surface Electromyography) signal from the human hand into software named MATLAB to perform an analysis on the muscle activity, to control the signal obtain and perform filtering to the signal acquire. From there, an experiment will be conducted to a group of people to look into the comparison of the muscle strength of an individual from the analysis data acquired from the surface EMG. The final form of the projects consists of a successful finding on how the signal acquisition from the surface EMG can be acquired from the system and the performance of the muscles can be determined.

ACKNOWLEDGEMENT

Praise to Allah for giving the opportunity to me to accomplish my Final Year Project on Surface Electromyography (EMG) Signal Acquisition. Firstly, I like to express my deepest appreciation to Universiti Teknologi PETRONAS (UTP) for providing a stimulating environment to do all the work.

I would also like to express my whole heart gratitude and profound thanks to my supervisor, Dr.Irraivan a/l Elamvazuthi for giving her such a wonderful opportunity to work on such an interesting research and for his guidance and perseverance throughout this project. It is through the help of him that made this research leads to a successful project to work into.

Thanks to the Electrical & Electronics lab technician, especially Puan Siti Hawa bt Haji Tahir for her contribution in term of preparation of the documentation and her knowledge that assist us toward the completion.

Lastly, thanks to my parents and colleagues for their endless love and support given.

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LIST OF ABBREVIATIONS

EMG	Electromyography
sEMG	Surface Electromyography
NEMG	Needle Electromyography
FEMG	Fine wire Electromyography
MATLAB	Matrix laboratory
MUAPT	Motor Unit Action Potential Training
IMF	Intrinsic Mode Functions
EMD	Empirical Mode Decomposition
AR	Autoregressive Model
AI	Artificial Intelligent
PC	Personal Computer

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Electromyography signals and its usage have been studied for several decades. Electromyography is defined as the electrical recording of muscle activity [1] where it provide easy access to physiological processes that cause the muscle to generate force, produce movement and performed countless function which enable us to interact with the environment. An instrument in medical field that were using this signals is known as electromyography [2]. Figure 1 shows the definition of the electromyography [3].

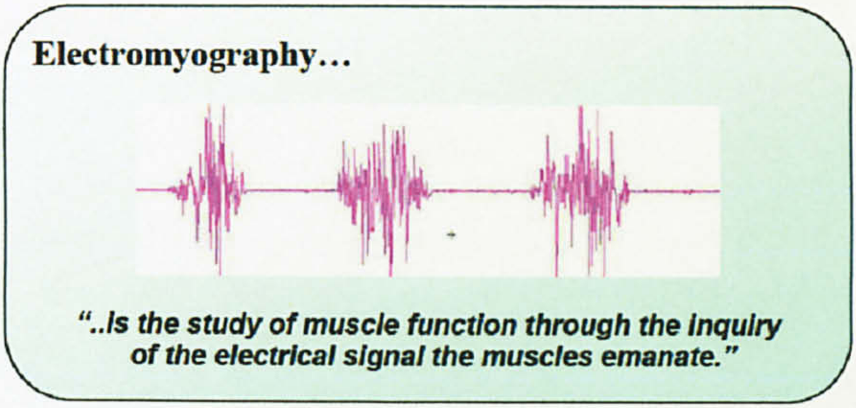

Figure 1: Definition on EMG

This technique has evolved from year 1658 with limitedly but nowadays, it has become the diagnostic tools for studies of muscle weakness, fatigue, pareses, paralysis and nerve conduction velocities, lesions of the motor unit or for neurogenic and myogenic problems [4]. This wide spread application of EMG are in the classical Neurological EMG and Kinesiological EMG studies where an artificial muscle response are due to an external electrical stimulation is analyzed in static conditions and the neuromuscular activation of muscles within postural tasks, functional movements, work conditions and treatment/training regimes respectively [5]. Figure 2 shows the application areas using the EMG technique [3].

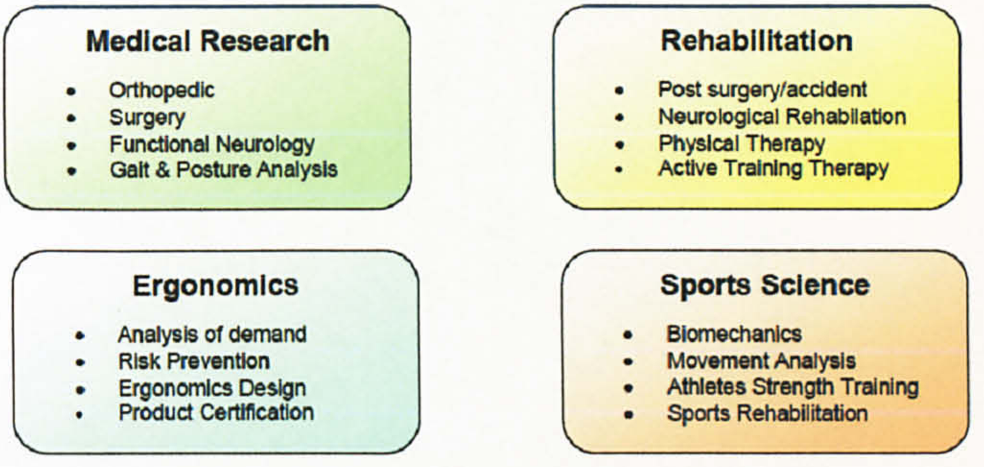

Figure 2: Application areas on the usage of EMG

It can be seen from figure above that one of the application areas on the usage of EMG signals has been applied for rehabilitation purposes. From the studied, the author found that among the reason to do rehabilitation is to know individual muscle strength. One of the diseases which are needed to be rehabilitated is stroke. Stroke or is defined as a condition where a blood clot or ruptured artery or blood vessels interrupt blood flow to an area of the brain. A research made by the hospital shows the number of death because of stroke is increased from years to years. It has shown that it is a very serious condition as it may lead to death and significant disability. Figure 1 shows the statistic of death which cause by stroke [6].

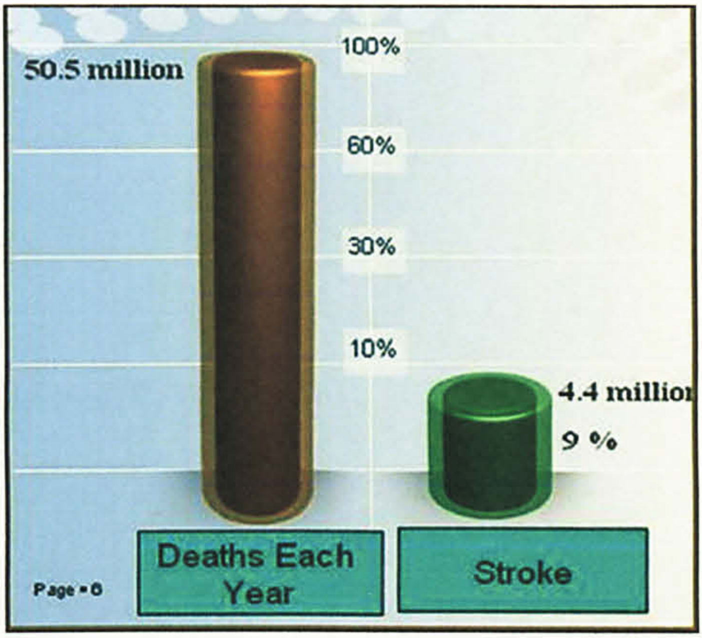

Figure 3: Worldwide statistics of stroke effects

1.2 Surface Electromyography

This technique has been developed for the purpose of measuring the muscle activity. It is a noninvasive technique because the tools used will be placed on the skin overlying the muscles not being inserted into the muscles as compared to NEMG or FEMG, that are invasive and painful thus limits their use when activity from several muscles that needs to be monitored simultaneously [4]. However, there are several advantages and disadvantages of using the surface electrodes. The advantages and disadvantages of using this technique were described as below [7].

- Advantages
    - Quick, easy to apply
    - No medical supervision, required certification
    - Minimal discomfort

- Disadvantages
    - Generally used only for superficial muscles
    - Cross-talk concerns
    - No standard electrode placement
    - May affect movement patterns of subject
    - Limitations with recording dynamic muscle activity

1.3 Problem Statement

From the background of study mentioned in earlier pages, it can be observed that the electromyography has been used for many usages mostly for clinical purposes. It is because the most common manifestations in patients with idiopathic inflammatory myopathies are on muscle weakness and muscle fatigue. One of it is stroke. Stroke has been the commonest cause of death or even the most frequent cause of severe adult disabilities. The impact of stroke on individual can lead to [4]:

- Pathology (disease or diagnosis): operating at level of the organ or organ system
- Impairment (symptoms and signs): operating at the level of the whole body
- Activity (disability): observed behavior or function
- Participation (handicap): social position and roles of the individual

In addition, these stroke patients shall need rehabilitation in order for them to move their limbs. Thus, to do rehabilitation, it needs some special devices which is operates using EMG signals. Next, the data can be analyzed based on the muscle signal acquired from the unhealthy patient in comparison to the healthy patient. Thus, it is important to build a system that can drive the signal into the MATLAB for further analysis.

1.4 Objectives

- To study on the basic concept of electromyography (EMG).
- To study on the EMG signals detected on skeletal muscles which control the limbs.
- To acquire the EMG signals from different range of hand movement by grouping the subject into gender, age and work.
- To analyze the EMG data acquired for the rehabilitation purposes.

1.5 Scope of Study

The scope of study for this project is to develop a hardware and simulation. The hardware design must be able to acquire the signal from the muscle activity while the simulation using simulink/MATLAB for analyzing the sEMG data acquisition. For this project, the sEMG signals acquisition will be limited on certain area such as measuring the muscle activity from the human hand. The surface EMG will be experimented on a group of people so the comparison can be made from the surface EMG signals recorded.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic concept of Electromyography

Our body has being gifted with a very unique system that allows us to communicate with our surrounding in its own ways. One of the systems is the muscular system where to gain the understanding of EMG signals implies the understanding of muscles and the way they generate bioelectrical signals [9].

2.1.1 Motor Units and Force

As human usually doing a lot of activities in their daily life, they shall require enough force to perform the tasks where the basic principles of motor control is the skeletomotor system which plays a major role in the control of force and movements in human [9].

There are 3 major components in the central nervous system which pre-motor cortex, spinal cord and skeletal muscle. Pre-motor cortex is where the motor programming takes place where the output later will influence the neurons of the spinal cord and the spinal cord will provide direct control to the muscle activity. Figure 4shows the simplified schematic diagram of the basic motor control mechanisms, motor unit and its components.

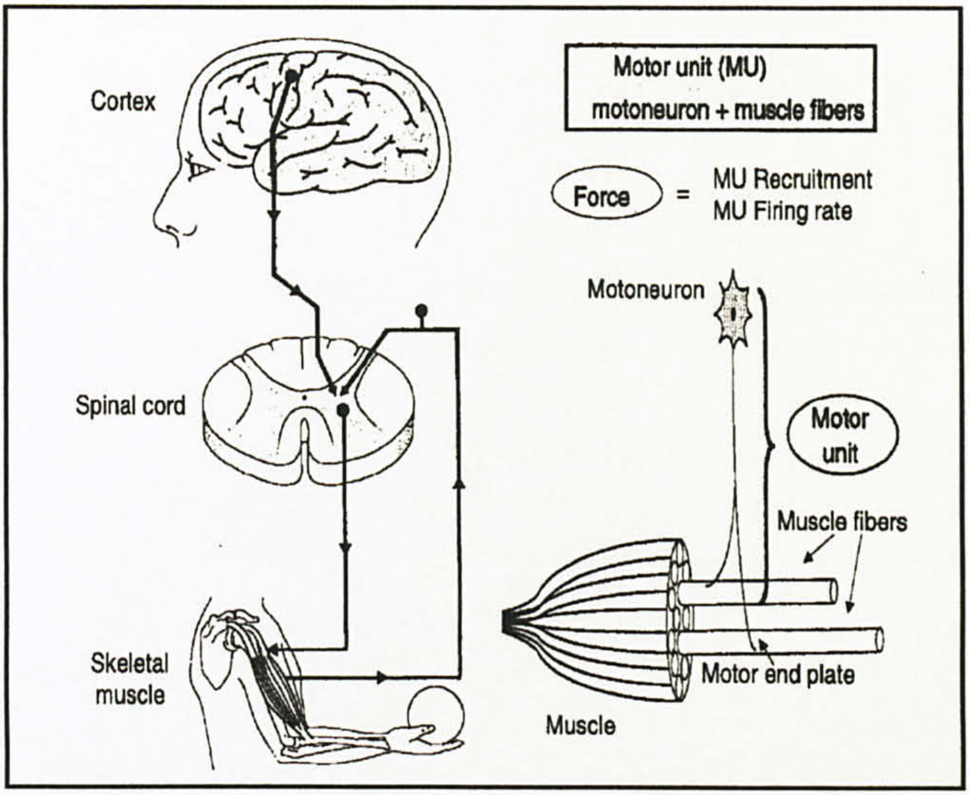

Figure 4: Schematic diagram of basic motor control mechanism

In our body, the muscles consists of muscle fibers which is being measured with motor units where the average value of the fibers per motor unit is determined by the areas of the muscles and varies according to the muscles function [10]. Motor unit is defined as the smallest functional subdivision of a muscle [9]. It is named by the activation of its branches from the single alpha (α)- motor neuron, and all the muscle fibers where it is term as 'innervates' by the neurophysiologist [9, 10, 11].

From the Figure 4, it can be shown that our skeletal muscles are composed of individual muscle fibers that contracts when it is stimulated by a motoneurons. Motoneurons or motor neuron originate in the ventral horn of the spinal cord and consists of a cell body, dendrites and an axon. By forming synapses with muscle fibers, the axon need to projects to a muscle where it was branches [12]. Whenever the motor unit is activated, it will generate a motor unit action potential.

As long as the muscle is required to generate force, the motor unit activation from the central nervous system will repeated continuously. This continued activation generates motor unit action potential trains. These trains from the concurrently active motor units superimpose to form the EMG signal. As the excitation from the central nervous system increases to generate greater force in the muscle, a greater number of motor units are activated (or recruited) and the firing rates of all the active motor units' increases to form the twitch [11].

Figure 5 shows the on how the force is produced from the motor unit activation [13].

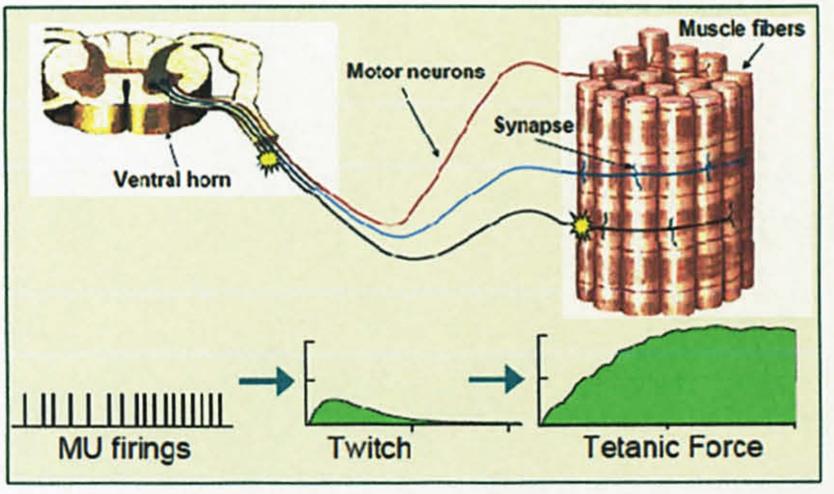

Figure 5: Motor units and force

2.1.2 Motor Unit Action Potential

Motor unit action potential or **MUAP** is the electrical signal that emanates from the activation of the muscle fibers of a motor unit that are detectable vicinity of an electrode [11]. It is also being defined as the spikes of electrical activity recorded during an EMG that reflect the number of motor units (motor neurons and the muscle fibers they transmit signals to) activated when the patient voluntarily contracts a muscle [14].

There are several factors that influence the shape of the MUAP [11].

- The relative geometrical relationship of the detection surfaces of the electrode and the muscle fibers of the motor units in its vicinity.
- The relative position of the detection surfaces to the innervations zone that is the region where the nerve branches contact the muscle fibers.
- The size of the muscle fibers because the amplitude of the individual action potential is proportional to the diameter of the fiber.
- The number of muscle fibers of an individual motor unit in the detectable vicinity of the electrode.

Figure 6 shows schematic representation of the genesis of a MUAP [11].

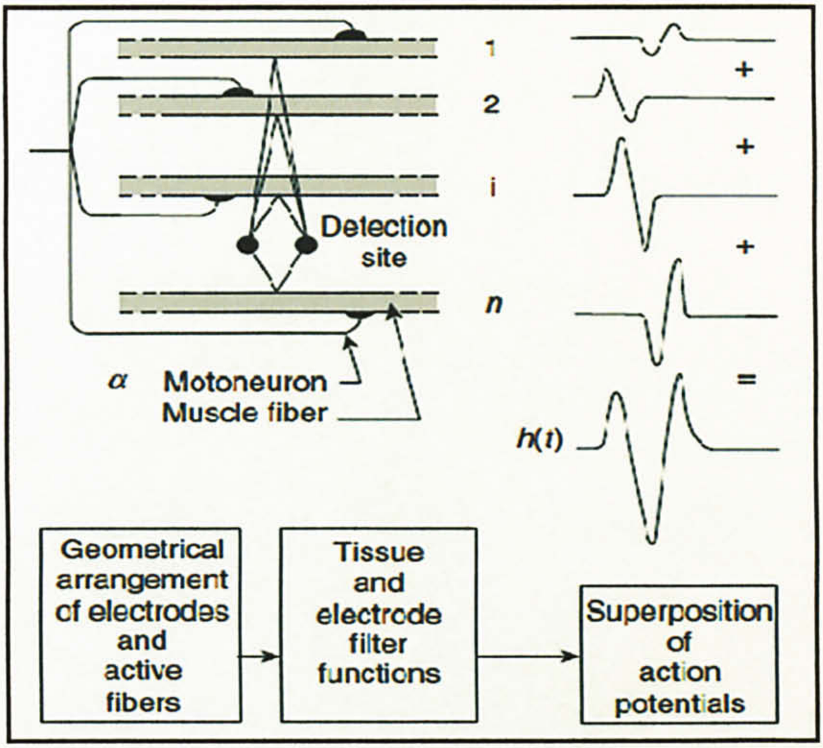

Figure 6: Schematic representation of the generation of the motor unit action potential

The force produced is come from the recruitment of motor units and the regulation of the firing rates which has modulating it. It can be seen from Figure 6 that the muscle force is varying at certain level based on the motor unit firing.

2.1.3 Motor Unit Action Potential Trains

MUAPT or motor unit action potential train is a sequence of motor unit action potential when the electrode placed recorded the pulse (MUAP) whenever a motor unit is stimulated [11, 15]. Figure 7 shows the motor unit control and the EMG produced from the summation of the MUAPT [13].

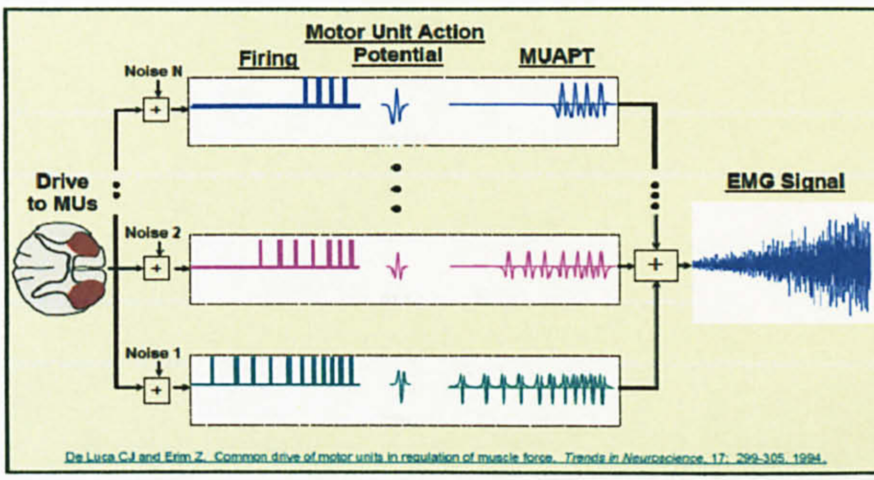

Figure 7: Motor Unit Control and EMG

It is called as train because of the repetitive firings by the motoneurons that later creates a train of impulses [12]. Every time the motor units were recruited or de-recruited, the EMG signals will be produced from the variance that happened to it.

The geometric relationship between the electrode and the active muscle fibers need to be constant to ensure the waveform of the MUAPs within a MUAPT will remain constant. Another factor that also needs to be considered is the properties of the recording electrode did not change and if there are no significant biochemical changes in the muscle tissue [11].

To describe a MUAPT can be done via the time between the adjacent MUAPs which is its inter-pulse intervals and the waveform of the MUAP. The shape of the MUAP can be represented mathematically by expressing the inter-pulse intervals as a sequence of Dirac delta impulses $\delta i(t)$ that is convoluted with a filter $h(t)$. Figure 8 shows a graphic representation of a model for the MUAPT [11].

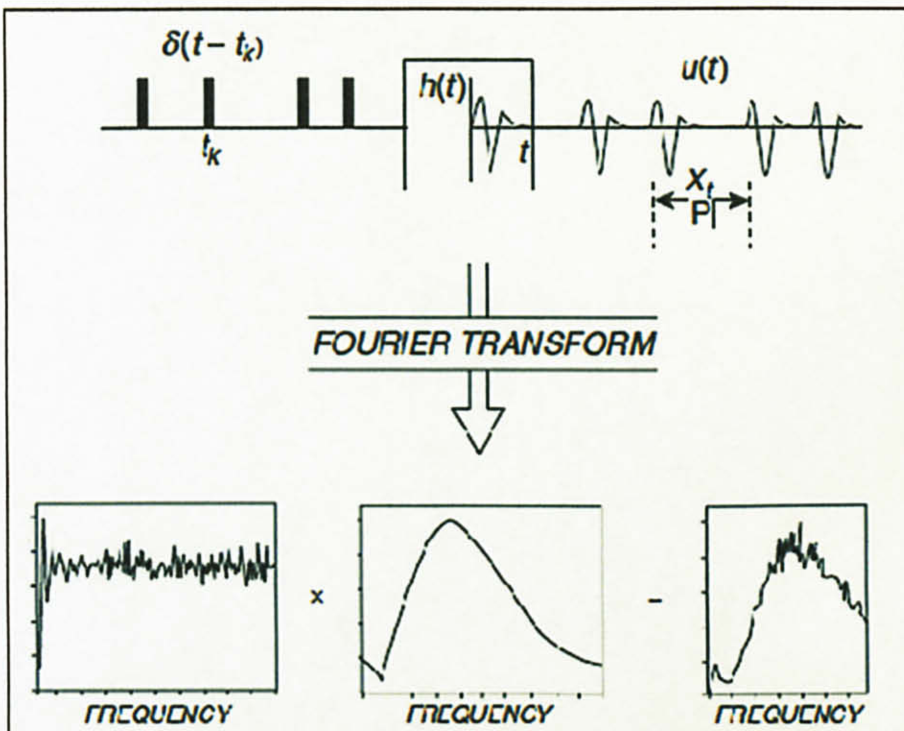

Figure 8: Model for a MUAPT in Fourier Transform modeling

From the model above, the MUAPT, $u_i(t)$ can be expressed as,

$$u_i(t) = \sum_{k=1}^{n} h_i\ (t - t_k) \tag{1}$$

where,

$$t_k = \sum_{l=1}^{k} x_l \, for k, l = 1, 2, 3, \dots, n$$

(2)

In the above expression it represents as:

t_k= time locations of the MUAPs

x = the inter-pulse intervals

n = total number of inter-pulse intervals in a MUAPT

i, k, l = integers that denote specific events

2.1.4 The EMG Signal

By linearly summing the MUAPTs, the EMG signal may be synthesized by expressed it in the equation below where,

$$\mathrm{m}(t, F) = \sum_{i=1}^{p} u_i \,(t, F)$$

(3)

F = force generated by the muscle and is the firing rate of the motor unit

p = the total number of MUAPTs that constitute the signal

This approach is used as in Figure 9 which consists of 25 Motor Unit Action Potential Trains (MUAPT). These are synthesized signals with shapes that closely represent the characteristics of real action potential [13]. Mathematically, these 25 generated MUAPTs were added to yield the signal the signal at the bottom.

Figure 9 shows the EMG signal formed from the constituents MUAPTs [11].

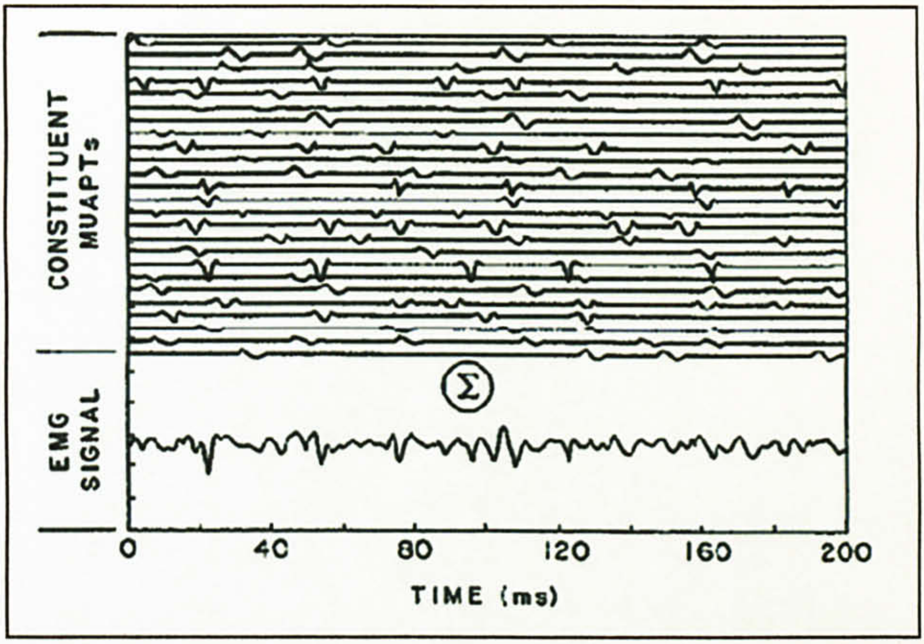

Figure 9: An EMG signal formed by adding or superimposing 25 mathematically generated MUAPTs.

The combination of the muscle fibers action potentials from all muscle fibers of a single motor is the motor unit action potential (MUAP) which also can be expressed by the simple model of the EMG signal as follows [16]:

$$x(n) = \sum_{r=0}^{N-1} h(r)\, e(n-r) + w(n)$$

(4)

Where,

$x(n)$ = modeled EMG signal

$e(n)$ = point processed that represents the firing impulse

$h(r)$ = represents the MUAP

$w(n)$= zero mean addictive white Gaussian noise

N = The number of motor unit firings

2.2 Concept of Frequency Spectrum

Normally, the EMG signal need to be expressed in term of frequency spectrum where the sEMG signal constructs have to be in the approximate range with the peak place in the middle of the spectrum [13].

2.3 Basic Concept of Filtering

Filter is use to avoid noise from the signal acquired from the muscle. Since the signals need to be free from noise contamination, filter is applied which one can determine type of filter that can be used for example Chebysev or Butterworth and etc. Figure 10 shows the EMG signal with baseline noise and artifact reduced which is being filtered from range 20-450Hz [13].

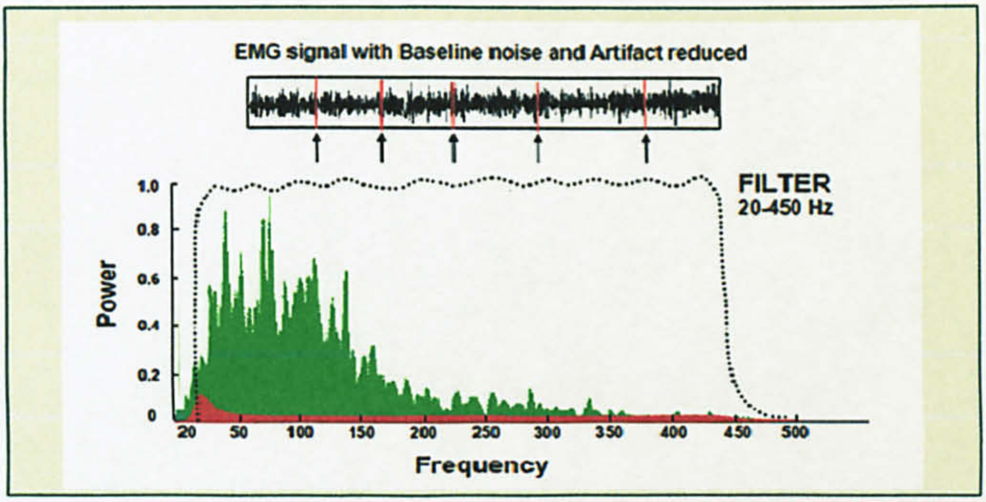

Figure 10: EMG signal with baseline noise and Artifact reduced

2.4 Basic EMG circuit

The basic circuit of EMG acquisition system was constructed from 3 major sections which are electrode-muscle interface, amplifier and the signal processor. Figure 11shows the basic EMG circuit of the system. [10]

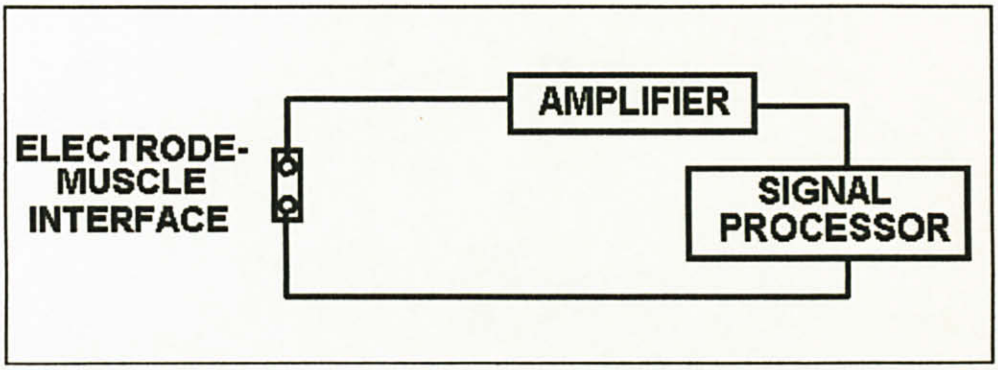

Figure 11: General circuit of the EMG acquisition system

The signals obtained from the electrode-muscle interface will be amplified as it is very small and the signals detected by the surface electrodes are in range of 5mV. The signal processor will processed the signals acquired to obtain the desired signals based on the design specification. The outcome measured of this system is analyzed for voltage reading.

Figure 12shows the outcome desired from the process above [17].

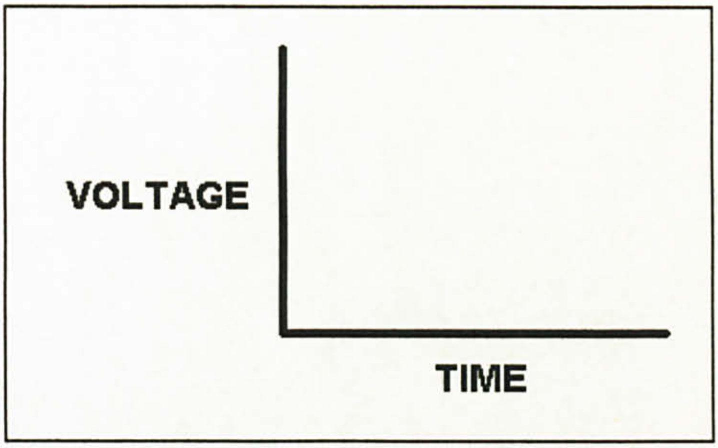

Figure 12: The outcome measured

The signals that being sampled can be analyzed by applying the Ellaway's cumulative sum histogram technique [17]:

$$S_i = \sum x_i - \overline{x} \qquad (5)$$

where S_i = cumulative sum up to sample i

X = mean voltage over trial

x_i = voltage at sample i

2.5 Recent Research and Development of EMG

Since the sEMG technique offered many advantages as diagnostic tools, many research and development have been done in order to obtain a good quality of EMG signal.

2.5.1 Analysis on the surface EMG Signal

Many researchers have studied on the sEMG signal characteristics and analyzed it into various form of mathematical model such as time domain analysis, Fourier Transform, relative wavelet packet energy and many more. Based on the RWPE, this technique has introduced an analysis done for the spectral energy distribution from two stages: preparation stages and action stages which is involved the calculation of the frequency band and rate of change of it during both stages above. It is because the researcher found that by analyzing on the spectral energy distribution, some of the muscle contraction in a different stages of limb actions can be measured compared to time-frequency domain that can only focused on a surface EMG signal at one stage of limb action [18].

As to the Method of Hilbert-Huang Transform, the analysis of the data has been narrowed down by looking into the finite and small number of Intrinsic Mode Functions (IMF) from the Empirical Mode Decomposition (EMD) that can analyzed on the instantaneous frequency based on the local properties of the signal. However, IMF can only be used if it can satisfy two conditions: (1) the number of extremal and the number of zero crossing must either equal or differ at most by one from the whole data set; (2) and at any point, the mean value of the envelope defined by the local maxima where the local minima is zero from the enveloped definition [12].

Compared to two methods above, the Autoregressive Model (AR) is being used to represent the sEMG signal with the delay of intramuscular EMG as the input where it had been chosen by many researchers because of its computational speed. Other methods that widely used is the Neural Network, one of the Artificial Intelligent (AI) technique which output is representing the degree of desired muscle stimulation over a synergic but an enervated muscle [12].

2.5.2 Existing Product using sEMG

This EMG technique is been used widely in many areas and because of that some researcher have implemented it uses for many purpose. Basically, there are products using EMG that exist today but they were focused on the signal acquired from the muscles and location of measuring the muscle activity that suite with their research like acquiring signal from handwriting and movement[19], measuring the consumer reaction while participating in a consumer activity [20], and etc.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

Figure 13 shows the flow of project during the whole semester for FYP 1 and FYP 2.

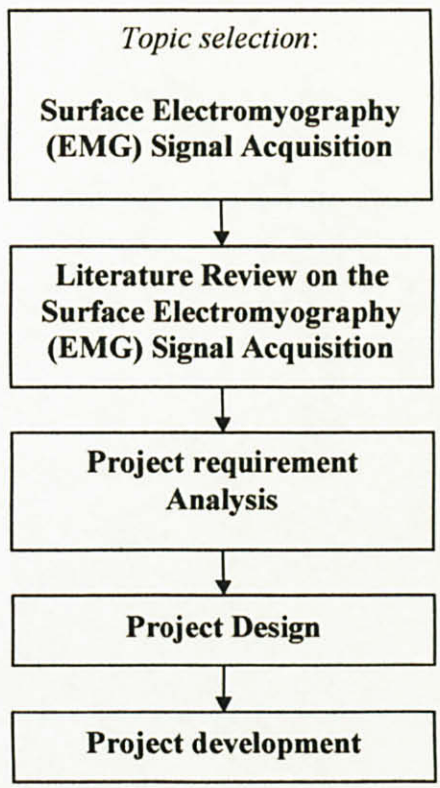

Figure 13: Project Flow Chart

3.2 Topic Selection

At the beginning of the new semester, Final Year Semester 1 students are required to propose their own project or by selecting the topic that have been listed by the FYP coordinator. Thus, the topic on Surface Electromyography (EMG) Signal Acquisition has been selected by the author for the project.

3.3 Literature Review on sEMG Signal Acquisition

Generally, at this phase it is important to gather data or information as much as possible on the topic selected like the theory behind the EMG, analyzing on the signal acquired because there were several techniques from the previous research to analyze the EMG signal. This literature review has been discussed in Chapter 2.

3.4 Analysis on the Project Requirement

Throughout the review on the topic selected, an analysis has been carried out to find out the on the requirement needs for the project. One of outcome of this analysis is the tools or equipment that will be used. The tools and equipment that will use for the project is discussed below.

3.4.1 Tools and equipment required

3.4.1.1 MATLAB/Simulink

For the data acquisition, MATLAB will be used to analyze the data collected from the measuring sensor. MATLAB is known as the high level language used for technical computing.

Moreover, it is said as an easy-to-use language because it can be used in a wide range of applications such as in signal and image processing, control design, communications, and many more. By using MATLAB, the computation, visualization of image and programming can be integrated using the interactive tools provided. Thus, the solution and problem solved can be expressed in familiar mathematical notation. Simulink's software enables its user to model, simulate and analyze on the dynamic system where it indicates the change of output over time [21].

3.4.1.2 PC (Personal Computer)/ Laptop

For the data acquisition purpose, PC or laptop needs to be used because the data collected through the MATLAB will be sent to the PC/laptop to be stored for further analyzed. The data stored can be retrieved for future reference.

3.4.1.3 Sensor

To measure the physical signal from the surface EMG, a device named EMG sensor is used where it will detect any physical quantity before being converted into signal that can be read or observed by an instrument [15] and, for this project is by MATLAB/Simulink.

3.4.1.4 Electronic Components

In order to perform the filtering of noise, sEMG sampling and interference of the signal acquire, a circuit will be constructed using electronic components such as operational amplifier or op-amp to amplify signals, resistors, capacitors for filtering noise and other components as well.

3.5 Project Design

Figures 14and 15shows the overview on sEMG acquisition for the project which is comprised into 3 sections:

1. Surface EMG signal Measurement
2. Processing Unit
3. Software for analysis

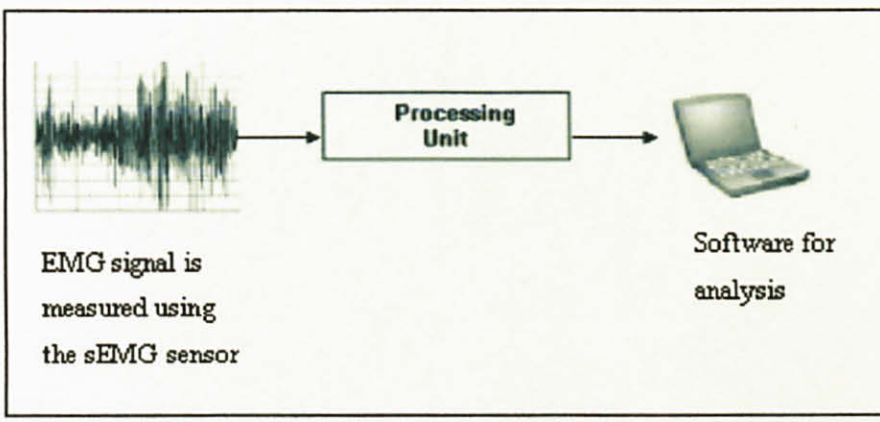

Figure 14: Overview on sEMG acquisition

3.5.1 Surface EMG Signal Measurement

The surface EMG signal is measured using the surface EMG electrodes. To pick up the EMG signals from the skin surface three electrodes will be needed - two go over the muscle which were recorded to the preamplifier - while the third electrode is a ground and just needs to be connected somewhere close to the muscle that will be recorded from. This electrode will be pasted at a particular area on the hand. A clip is used to connect the EMG electrodes with the processing unit.

The electrode will be placed as in the positions shown by the black circles in this illustration. However, it is very important that the two electrodes lie ALONG the line of the muscle as shown in Figure 15 and not across the muscle. With the hand relaxed positions, a very little activity can be seen depending on how well one can relax their thumb. By touching the little finger the thumb - this will cause the muscles shown to contract and generate an EMG signal. The EMG signal will be about 100-300mV. Figure 15 shows the illustration of a hand with black circles indicates on the electrodes placement onto the subject palm.

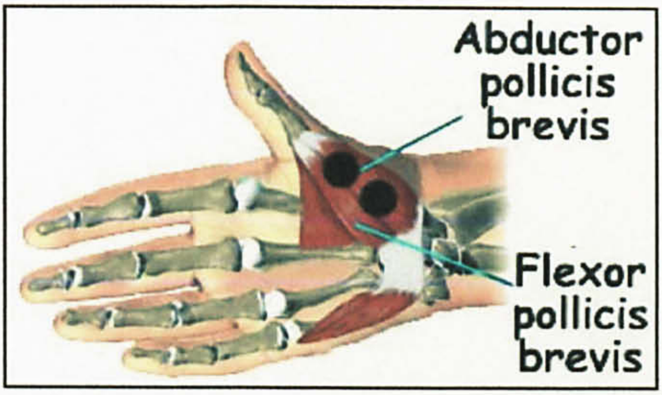

Figure 15: Black circles indicate the position of the electrodes

Basically, when the hardware is setup, the earlier signal detected is sine wave signal which is the AC line pickup. This is either because one or both of the round electrodes are not pressed firmly against the skin or because of the electrodes is not having a good ground. Thus, adding a ground electrode by just holding a wire that connects to the black lead and central battery connection with the other hand.

3.5.2 Processing Unit

In this processing unit, there will be transmitter and receiver unit. The connection between these two units can be done via wireless transmission as previous research [18] but for this project the transmission is not going to be use. All these types of transmission have its own pros and cons.

3.5.3 Software for Analysis

The signal acquired from the processing unit will be sent into MATLAB for analyzed.

3.6 Project Development

The author has to design an amplifier circuit which is very tedious as the signal is very small in range. Moreover, the circuit for the communication part between the rs232 and the microprocessor is using the typical circuit. Choosing the right surface electrodes is also an important factor as well. It is because there are several surface electrodes available such as simple platinum, silver disc, pre-gelled Ag-AgCl electrodes and wet gel electrodes.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result and Discussion

4.1.1 Cost Estimation

Table 1 shows the cost estimated for the project. However, the cost can be reduced as certain component and software are applicable at the university laboratory.

Table 1: Cost estimates for the project purpose

No	Equipment	Quantity	Cost/unit
1	sEMG sensor	1	RM220
2	Circuit & Component	-	RM50
3	MATLAB software	1	-
4	Microcontroller	2	RM60
		TOTAL	RM310

4.1.2 Development of the System Configuration

This configuration is done with the equipment development for the prototype system. Figure 16 shows the configuration of the system step by step which covered three parts: surface sensor, interfacing circuit and analysis into MATLAB.

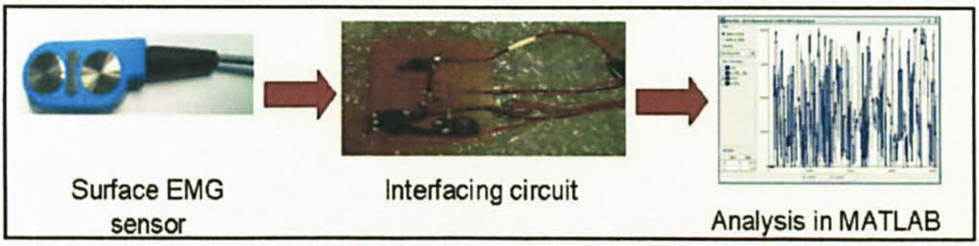

Figure 16: The configuration of the prototype

A. Amplifier Circuit

Figure 17 shows the amplifier circuit constructed on a bread board. The INA121 amplifier is used as it can provide very high gain. In addition, this circuit will be tested using a 5V AC voltage before replacing with the surface electrodes later. However, in a real situation the signals detected will vary faster as is being measured from an active muscle. This design is preferably to have very high impedance on the cable used as it can reduce a number of noises in the signals obtained.

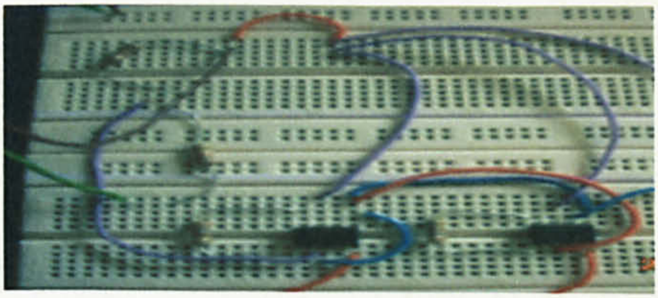

Figure 17: Circuit on amplifier design

B. Z03 EMG Preamplifier

Instead of built a circuit of preamplifier, it can be replaced from a preamplifier from Motionlab which is located mainly in USA. Figure 18 shows the preamplifier from the Motion Lab (See APPENDIX A for details).

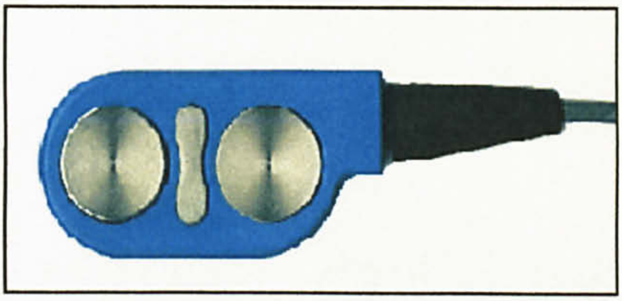

Figure 18: EMG Preamplifier

The preamplifiers from the Motionlab need a positive and negative power supply which is - a couple of 9V batteries would make it work well. The preamplifier boards have a gain of x300 where it could amplify a 1mV EMG signal on the skin surface to 300mV so the ADC should be able to digitize signals in the range of 1 to 2 Volts. Basically, the preamplifier has four wires that need to be connected:

1. RED - Connect to positive 9 volts via a 200 ohm resistor to limit current.
2. GREEN - Connect to negative 9 volts via a 200 ohm resistor to limit current.
3. BLACK - This is the signal and power common connection - connected to the ADC ground and the battery grounds.
4. WHITE - this is the amplified EMG signal - connect to the ADC input via a capacitor (1uF) - the EMG signal on the WHITE lead can be as large as the battery voltages (9 volts) if the preamplifier input are open and picking up AC noise. But on the skin surface very little AC line noise can be seen and just an EMG signal of about 100-500mV.

However to detect an EMG signal the preamplifier must be pressed directly over the muscle that user want to record from and aligned with the muscle - the two round pick up disks must be along the body of the muscle - not across the muscle.

C. PCB Design on PIC

Figure 19 and 20 shows the schematic circuit and the printed circuit board design for the processor part. The connection made is typical one for the microcontroller connected to the serial communication RS232 with MAX 232.

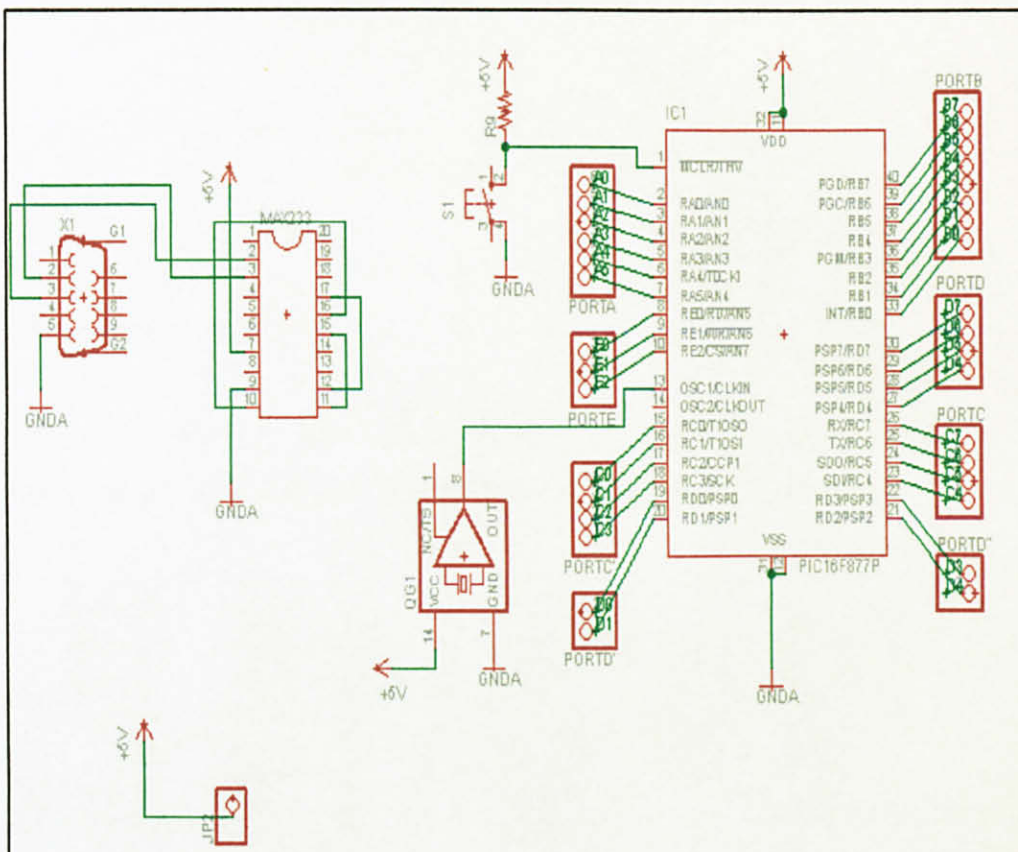

Figure 19: Schematic circuit for the interfacing

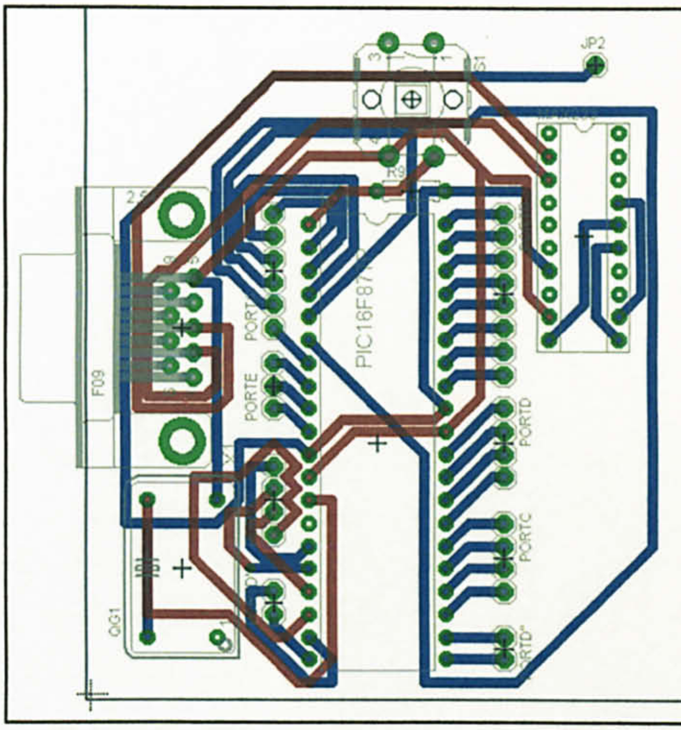

Figure 20: PCB design

4.1.3 EMG Signal Acquisition

After all the hardware has been setup, the EMG signal is acquired from the surface of the subject hand. Figure 21 shows the signal acquired on the subject.

Figure 21: Signals acquired with a different movement of hand.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective of this project is to emulate a working mechanism of a surface EMG signals acquisition. The development undertaking involves both on the amplifier design and the microcontroller together with a serial communication. The differential amplifier is a block that performs signals amplification on the EMG signals detected from the surface electrodes. Thus, there will be 2 channels used to acquire the signals from the muscle. The other part is responsible to process the signals obtained and send the data to a PC by communicating using a serial communication RS232 and MAX232 level conversion. MATLAB will be used to model the EMG signals and EAGLE 5.1.0 will be used to design the microcontroller printed circuit board. The verification of this model as a whole will be done in the near future. The prototype has shown that it is able to acquire the EMG signal from the subject hand.

5.2 Recommendation

During the experimental, some problem has occurred which is the sEMG electrodes have malfunctioned where it didn't detect or infer the signal from the hand muscle. Although the EMG signal obtained from the surface in very small and it is hard to get the contraction of the muscle itself, thus, to enhance the signal acquired it can be measured at the other part of the body such as at bicep and triceps at arm.

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APPENDICES

A: SURFACE EMG SENSOR

MOTION LAB SYSTEMS

Surface EMG Preamplifiers

High Gain Z03

Z03 EMG Preamplifier

Z03 - A surface preamplifier with a x300 gain, designed for EMG signals

The Z03 EMG preamplifier has been designed for ease of use and reliability and provides superb performance in day to day clinical use, as well as in the hands of the researcher or first time user. Unlike other EMG preamplifiers, Motion Lab Systems preamplifiers incorporate both radio frequency interference (RFI) filters and electrostatic discharge (ESD) protection circuitry resulting in an extraordinarily reliable EMG preamplifier that can be used in almost any environment.

Featuring a differential input design, the unique design of the Motion Lab Systems EMG preamplifiers enables researchers to produce high-quality, low-noise EMG data from subjects under the most adverse conditions (e.g. on treadmills, using mobile phones etc.) with minimal skin preparation or subsequent signal processing.

This preamplifier, with x300 gain, is plug compatible with the BIOPAC TSD150 Series Active Electrode for surface EMG recording when ordered with the 005 connector option (RJ11 jack).

Features

- Direct EMG pre-amplification at the skin surface provides the highest myoelectric signal quality for accurate, reliable EMG signal detection and eliminates cable motion artifact.
- Internal RFI and ESD protection prevents radio frequency interference and static damage.

- The low-impedance output of the preamplifier eliminates cable noise and cable motion artifacts without requiring any additional signal processing within the preamplifier.
- An integral ground reference plane provides immunity to electromagnetic environmental noise.
- All signal and power conductors in the preamplifier cable are enclosed inside an independent, isolated shield to eliminate interference from AC power-lines and other sources of interference.
- All subject contacts are corrosion-free, medical grade stainless steel for maximal signal flow.
- Constructed using bio compatible housing and sensor materials to prevent allergic reactions.
- Each unit is professionally built in FDA inspected facilities using high precision surface-mount instrumentation components for optimal EMG performance.

Mechanical Specifications

- Sensor Contacts - two 12mm disks
- Reference Contact - 12 x 3mm bar separating the sensors
- Inter-electrode distance - 18mm
- Contact Material - Medical Grade Stainless Steel
- Body Size - 38mm x 19mm x 8mm.
- Weight - 10 grams (excluding lead and connector).
- Cable Length - 1.4 meters.
- TemperatureRange - 0 to 40 degrees C.

Electrical Specifications

- Gain at 1 kHz x300 ±1%
- Input Impedance > 100,000,000 ohms.
- Noise < 1.2uV RMS
- CMRR > 100 dB at 65Hz.
- Input Protection - RFI and ESD protected.
- Signal Bandwidth - 15Hz to 2,000Hz (-3dB).
- Power supply range ±5 Volts to ±15 Volts
- Power consumption 2.4mA per supply throughout voltage range.

Connector Options

- Z03-000 - no connector.
- Z03-002 - 4-pin BINDER connector.
- Z03-004 - 5-pin LEMO connector.
- Z03-005 - 6-pin RJ12 (BIOPAC TSD150 pinout)

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Gantt Chart for the First Semester of 2 Semester Final Year Project

No	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Selection of Project Topic															
	> Propose Topic															
	> Topic assigned to students															
2	Preliminary Research Work															
	> Introduction															
	> Objective															
	> List of references/literature															
	> Project Planning															
3	Submission of preliminary Report															
4	Project Work															
	> Reference/Literature															
	> Component Research															
5	Submission of progress report															
6	Project work continue															
	> Enhance skills using software															
7	Seminar I FYP															
8	Submission of Draft Report															
9	Submission of Interim Report															
10	Oral Presentation															

Due Date

Process

Gantt Chart for the Second Semester of 2 Semester Final Year Project