بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering and Technology

Electrical and Computer Engineering Department

Graduation Project

Design and Implementation of a Myoelectric Control Medical System

Project Team

Hamdah M.Elyan **Motaz M.Awawdeh**

Project Supervisor
ENG. ABDALLAH ARMAN

Hebron – Palestine
June, 2008

Design and Implementation of a Myoelectric Control Medical System

Project Team:

Hamdah M.Elyan **Motaz M.Awawdeh**

Supervisor:

ENG. Abdallah Arman

Graduation Project Report

Submitted to the Department of Electrical and Computer Engineering in the College of Engineering and Technology

Palestine Polytechnic University

Approved by ______________________________

Chairperson of Supervisory Committee

____

____

____

Date ______________________________

جامعة بوليتكنك فلسطين

الخليل-فلسطين

كلية الهندسة و التكنولوجيا

دائرة الهندسة الكهربائية والحاسوب

اسم المشروع

Design and Implementation of a Myoelectric Control Medical System

أسماء الطلبة

حمدة محمد عليان .... معتز محمود عواودة

بناءً على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية والحاسوب، وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص هندسة الأجهزة الطبية.

توقيع المشرف

....

توقيع اللجنة الممتحنة

....

توقيع رئيس الدائرة

....

ABSTRACT

The project team proposes to construct, build and test an EMG (Electromyography) device that detects the electrical activity of a muscle by means of electrodes placed over the surface of the skin.

After detecting the signal generated by the contraction of the skeletal muscle, we will use the signal to start a moving system, such as a system of artificial parts.

Nowadays, this idea seems to be the central core in the most cases of designing artificial parts; taking into consideration that many other designs use other principles such as neural activity or tendons mechanical activity; but in this project just the myoelectric activity is used to simulate the operation of an artificial part.

This report contains the design for the project and the steps done by the project team so as to accomplish the objectives of this

project, by implementing and testing each individual subsystem in the project; and finally testing the whole project as one unit and getting the results.

ملخص المشروع

في هذا المشروع تم بحمد ا بناء وتركيب وفحص جهاز تخطيط العضلات والذي يستخدم لتسجيل النشاط الكهربائي للعضلات باستخدام الكترودات خاصة تثبت على سطح جسم المريض.

وبعد عملية تحديد وضبط الإشارة الناتجة عن عملية انقباض العضلة، استخدمت هذه الاشارة المسجله في عملية بدء حركة نظام كهربائي مثل الأنظمة المكونة للأطراف الإصطناعية لمساعدة ذوي الاحتياجات الخاصة.

حيث تمثل هذه الفكرة العنصر الرئيس والحيوي في تصميم معظم الأطراف الصناعية في وقتنا الحالي ، مع الأخذ بعين الأعتبار أن هناك أيضا العديد من التصميمات تستخدم ركائز أخرى كالنشاط العصبي أو النشاط الميكانيكي للأربطة ، ولكننا هنا قد قمنا فقط باستخدام الإشارة الكهربائية للعضلة بهدف تصميم محاكاة بسيطة لعمل هذه الاطراف.

يحتوي هذا التقرير على التصميم التفصيلي للمشروع والمراحل التي تم اتباعها من أجل الوصول إلى الأهداف المرجوة من هذا المشروع والتي تتمثل في

تركيب وفحص كل مرحلة جزئية من مراحل المشروع على حدة والتأكد من ناتجها، ثم تجميع هذه المراحل كوحدة واحدة ثم فحصها وعرض النتائج.

DEDICATION الإهداء

إلى روح الحبيب المصطفى ....

محمد صلى الله عليه وسلم

إلى نبع الحب والأمان ....أمي الحبيبة

إلى رمز العطاء و الحنان...أبي العزيز

إلى من هم أغلى من الماس ....أخوتي الأحبة

إلى عناوين الطموح والتفاني..أساتذتي الكرام

إلى من هم أكرم منا جميعا.............. عناوين التضحية والفداء................... شهداؤنا الأبرار

إلى كل من ساهم في إنجاز هذا المشروع

نهدي إليكم هذا العمل المتواضع

فريق العمل

ACKNOWLEDGMENT

Firstly, we thank our god for helping us in completing our project, and specially for helping us in constructing and testing our different project circuits, and also getting our needed results.

Here, we don't forget to thank Eng. Abdallah Arman for his supervision, taking care of our project, and his very useful advices in each step of our work; also we want to thank Eng. Gamal Al-heleqawi for helping us.

TABLE OF CONTENTS

FIRST PAGE	I
TITLE PAGE	II
SIGNATURE PAGE	III
ABSTRACT	IV
DEDICATION	VIII
ACKNOWLEDGMENT	IX
TABLE OF CONTENTS	X
LIST OF TABLES	XIII
LIST OF FIGURES	XIV
CHAPTER ONE: INTRODUCTION	1
1.1 Overview	2
1.2 Literature Review	3
1.3 Scheduling Table	5
1.4 Estimated Cost	8
1.5 Project Risk Management	9
1.5.1 Hardware Risks	9
1.5.2 Group Risks	10
1.5.3 Project Risks	10
1.6 Human Development Resources	11
1.7 Report Road Map	11
CHAPTER TWO: THEORETICAL BACKGROUND	14
2.1 Muscle Physiological Structure	15
2.1.1 Muscle Structure	15
2.1.2 Muscle Categories	16
2.1.3 Structure of Skeletal Muscle	18
2.1.4 Mechanism of Contraction of Muscle	19
2.2 Project Theory	22
2.2.1 Main Idea	22
2.3 Project Components	25
2.3.1 The Power Supply	26

2.3.2 Biopotential Electrodes	26
2.3.3 Instrumentation Amplifier	28
2.3.4 Active Band – Pass Filter	29
2.3.5 Notch Filter	30
2.3.6 Rectification Circuit	31
2.3.7 Comparator Circuit	31
2.3.8 PIC 16F84 Microcontroller	31
2.3.9 DC Motor Circuit	32
CHAPTER THREE: PROJECT CONCEPTUAL DESIGN	33
3.1 Project Objectives	34
3.2 General Block Diagram	35
3.2.1 DC Power Supply Block Diagram	36
3.2.2 Signal Detection Block Diagram	37
3.2.3 Signal Processing Block Diagram	39
3.2.4 Control – Movement Block Diagram	42
3.3 How System Works?	43
CHAPTER FOUR: DETAILED TECHNICAL PROJECT DESIGN	45
4.1 Detailed Description Of The Project Phases	46
4.2 Overall System Design	47
4.2.1 Power Supply Subsystem	47
4.2.2 Instrumentation Amplifier Circuit	49
4.2.3 Active Band – Pass Filter Circuit	50
4.2.4 Active Notch Filter Circuit	52
4.2.5 Active Rectifier Circuit	54
4.2.6 Comparator Circuit	55
4.2.7 PIC 16F84 Microcontroller Circuit	56
4.2.8 DC Motor Circuit	56
CHAPTER FIVE: SOFTWARE	58
5.1 Project Flowchart	59
5.2 Programming Code	60
5.3 Programming and Downloading Software	64

CHAPTER SIX: SYSTEM IMPLEMENTATION AND TESTING 66

6.1 Actual Project Implementation 67

6.1.1 DC Power supply implementation 67

6.1.2 Instrumentation Amplifier Implementation 69

6.1.3 Active Band Pass Filter Connection 69

6.1.4 Active Rectifier Implementation 70

6.2 Testing and Results 71

CHAPTER SEVEN: CONCLUSION AND FUTURE WORK 75

7.1 Conclusion 76

7.2 Future Work 77

APPENDECIES 78

Appendix A (Definitions) 79

Appendix B (Used Programs) 80

Appendix C (Data Sheets) 81

LIST OF TABLES

Table 1.1: The Task Duration 7

Table 1.2: Hardware Cost 9

Table 2.1: Comparison Between Different Types Of Muscles 17

LIST OF FIGURES

Fig 1.1: Timing plane for first semester.	8
Fig 1.2: Timing plane for second semester.	8
Fig 2.1: Skeletal muscle detailed construction	19
Fig 2.2: Cell Membrane At Rest Condition	20
Fig 2.3: Neuromuscular Junction	21
Fig 2.4: Muscle Sarcomere	22
Fig 2.5: The Action Potential That Is Generated In Excitable Cells	23
Fig 2.6: EMG Recording For A Stimulus Muscle	24
Fig 2.7: Electrode-Electrolyte Interface	27
Fig 2.8: Bode Plot Of Active Band-Pass Filter	30
Fig 3.1: General Block Diagram	35
Fig 3.2: DC Power Supply Block Diagram	36
Fig 3.3: Signal Detection Block Diagram	37
Fig 3.4: Silver-Silver Chloride Electrode Construction	37
Fig 3.5: Electrode-Skin Coupling Using A Gel Electrolyte	38
Fig 3.6: Connection Diagram For AD620 Chip	39
Fig 3.7: Signal Processing Block Diagram	40
Fig 3.8: Pin configuration of LM358 OP-AMP.	41
Fig 3.9: Control – movement block diagram.	42
Fig 3.10: Pin Diagram of PIC 16F84.	43
Fig 4.1: DC Power Supply Circuit	47
Fig 4.2: Output waves from DC supply	48
Fig 4.3: AD620 Instrumentation Amplifier Schematic	49
Fig 4.4: Active Band – Pass Filter Schematic	50
Fig 4.5: 50Hz notch filter schematic	53
Fig 4.6: Active Rectification Schematic Diagram	54
Fig 4.7: Comparator Schematic Diagram	55
Fig 4.8: PIC 16F84 connections.	56

Fig 4.9: DC motor circuit schematic. 57

Fig 5.1: Project Flowchart. 60

Fig 5.2: MPASM user interface. 64

Fig 5.3: LP16 user interface. 65

Fig 6.1.A: DC power supply implementation for positive output. 68

Fig 6.1.B: DC power supply implementation for negative output. 68

Fig 6.2: AD620 practical connection. 69

Fig 6.3: Active band pass filter connection. 70

Fig 6.4: Active rectifier implementation. 70

Fig 6.5: Instrumentation amplifier, band bass filter, and rectifier circuits 71

Fig 6.6: Testing bicep muscle & getting results by oscilloscope. 72

Fig 6.7: AD620 Instrumentation amplifier output at muscle rest. 72

Fig 6.8: AD620 Instrumentation amplifier output at muscle stress. 73

Fig 6.9: Active band pass filter output. 73

Fig 6.10: Notch filter output. 74

Chapter

1 ONE 1

Introduction

1.1 Overview.

1.2 Literature Review.

1.3 Project Scheduling.

1.4 Estimated Cost.

1.5 Project risk Management.

1.6 Human Development Resources.

1.7 Report Road Map.

Chapter One
Introduction

1.1 Overview

Nowadays, our world becomes a huge field for the development and evolution through out various areas, such as scientific and cultural fields. This evolution is used in most cases for solving our problems, or making our life easier.

Our aim from this design is to provide a simple and basic idea for helping people with special needs; mainly people who has a cutoff or missing biological parts. Prosthetic science uses many techniques to compensate those special needs people even partially, by providing them with artificial parts.

In our project of "Design and Implementation of a Myoelectric control Medical System", we aim to provide a simple, basic implementation for an EMG (electromyography) – artificial controlled device; which depends mainly on the technique of sensing, detecting, and recording of electrical activity of the muscle, namely "EMG" (electromyography) technique.

The EMG technique is widely used in the medical field, for diagnosis and also treatment of many muscle disorders using different methods of analysis. But in our project, we will use it only to control a medical movement system, and this will be viewed through the project.

1.2 Literature Review

When we decide to work at this project, the first thing to do was providing a full, explaining view about the ideas contained inside our project. So we perform a literature review about our project and its idea.

After our research, we get the following projects sharing some ideas with our project, list as follow:

1. **EMG With Weight Adjustment.**

Brandon Ceaser, Andy Eddleman, Robert Lewton 9/12/2007

This project creates a system that will detect and analyze bicep muscle strain during a lift and automatically adjust the weight lifted to keep the strain on the users muscle in the optimal range for strength training. The strain on the muscle will be measured using an EMG. This signal will be amplified and then sent through signal processing. The evaluation of the EMG signal will determine if the load that the user is lifting needs to be automatically adjusted and send out a signal to do so, removing all responsibility from the user.

2. **Surface Electromyography and Muscle Fatigue.**

Eric Beltt May 9, 2002

The objective of this experiment was to confirm that the frequency spectrum of an EMG signal shifts to lower frequencies as a muscle, under voluntary contraction, fatigues. The primary motivation for the experiment, however, was to gain engineering experience through the design and construction of the actual apparatus used to measure the EMG signal.

3. **Wireless Electromyograph.**

Arthur Gariety and Benjamin Madoff

This project implements a wireless surface electromyograph that displays the signal using a television as an oscilloscope.

Electromyography detects the electrical signals that the human body generates to contract muscles. Detecting very low voltages in the milliVolt range on the skin surface is not a trivial task. EMG signals are inherently low frequency signals. The human body is a great antenna and filtering out RF and 60Hz power system noise is essential to observing the EMG signal. Converting the analog EMG signal to digital and transmitting using a wireless transmission protocol was an effective way to electrically isolate the human. The transmitted EMG data was displayed on a television we setup to be a virtual oscilloscope.

1.3 Scheduling Table

The time planning includes two time estimation schedules; the first one show what has been done in the first semester, and the second shows the scheduling time of the second semester. This time management clarifies each step of the project and guarantees the full completion of the overall system.

The timing management will divide the system hierarchy according to the actions::

T_1: Project Preparation: the aim of this stage is to specify the main objectives of the project, on the other hand the initial information will be collected and discussed; finally to determine the tasks should be executed through out the project .

T_2: Analyzing Project Levels: a comprehensive study to the different levels of the project, the Literature Review, and the design alternatives will be done at this stage.

T_3: Analyzing Project Demands: to execute the determined tasks, to provide the project requirements, and finally handling the collected information are the aims of this stage.

T_4: Conceptual Design: in this stage of project the main objectives, the design of the general block diagram and how our system operates will be discussed and explained.

T_5: Detailed Project Design and Schematic Analysis: this stage contains the detailed design of each subsystem included in the project in conjunction with designing the schematic of each subsystem.

T_6: **Writing the Documentation**: the writing began from the first phase to the last one in parallel.

T_7: **Implementing Circuits in Subsystems**: starting by the power supply subsystem, the subsystems are constructed and the connections between them are implemented practically.

T_8: **Testing Subsystems**: in this part; the testing of each individual subsystem is done so as to be sure that it works as planed in our design.

T_9: Design and Implementation of Software: this stage expresses the programming and then implements it through the PIC component.

T_{10}: Overall System Testing: the whole components of the project will be tested in this stage so as to see the validity and the efficiency of the design.

T_{11}: Final Documentation Writing: the final documentation will be written in a parallel way with the practical implementation (last stages) of the project.

Table (1.1): The Task Duration

	Task Name	*Duration (week)*	*Start*	*Finish*	*Dependencies*
T_1	Project Preparation	2	Sat 9/22/07	Thu 10/4/07	---------
T_2	Analyzing Project Levels	5	Sat 9/22/07	Wed 10/24/07	---------
T_3	Analyzing Project Demands	3	Thu 10/25/07	Wed 11/14/07	T_1, T_2
T_4	Conceptual Design	3	Thu 11/15/07	Wed 12/5/07	T_3
T_5	Detailed Project Design and Schematic Analysis	3	Thu 12/6/07	Wed 12/26/07	T_4
T_6	Writing the Documentation	14	Sat 9/22/07	Wed 12/26/07	---------
T_7	Implementing Circuits in Subsystems	7	Sun 24/02/08	Thu 10/04/08	---------
T_8	Testing Subsystems	3	Sun 13/04/08	Thu 01/05/08	T_7
T_9	Design and Implementation of Software	2	Sun 04/05/08	Thu 15/05/08	T_7, T_8
T_{10}	Overall System Testing	2	Sun 18/05/08	Thu 29/05/08	T_7, T_8 , T_9
T_{11}	Final Documentation writing	14	Wed 27/02/08	Thu 29/05/08	---------

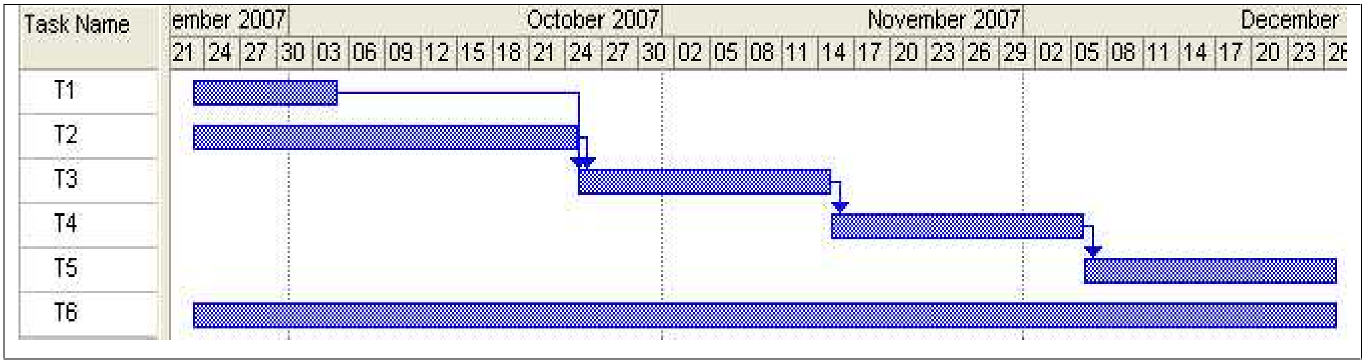


Fig (1.1): Timing plane for first semester.

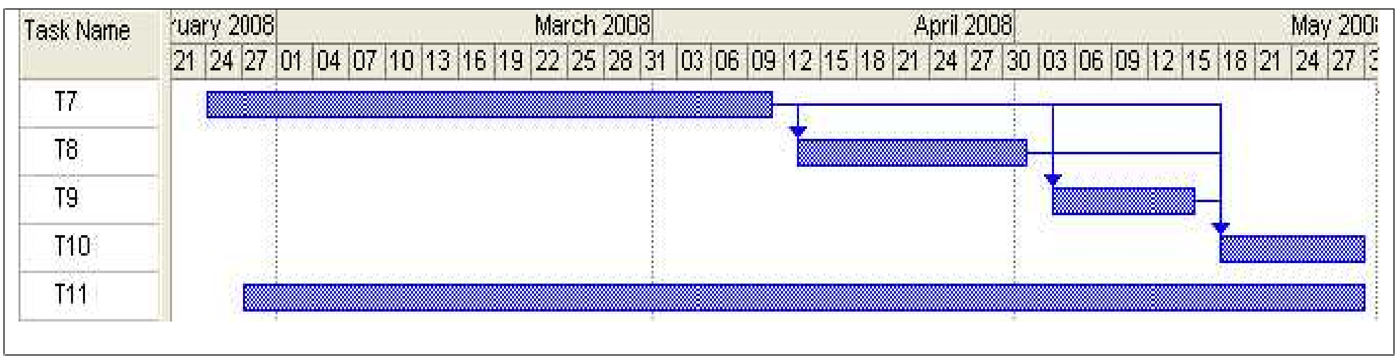


Fig (1.2): Timing plane for second semester.

1.4 Estimated Cost

In this section we provide the overall expected cost of the requests and equipments that will be used in our project.

The following table implements the hardware costs; detailing the major parts that will be used for our project.

Table (1.2): Hardware Cost

Component	Cost
PIC 16F84 IC	$20.00
Surface Electrodes	$10.00
Lead Wires	$40.00
Electronics	$40.00

1.5 Project Risk Management

In the design, implementation, and test of this project we expect many problems in different field to appear; and so we will try to avoid and resolve each of those problems.

1.5.1 Hardware Risks

The most important hardware parts in our project are the PIC 16F84 IC and the Surface electrodes. The predicted risks are:

- The surface electrodes don't respond, so no output signal.

- PIC 16F84 doesn't work properly.
- Damaging the ICs used through exceptional and unexpected high voltage.

1.5.2 Group Risks

- Illness of one or more of group members.
- Group meeting difficulties.

1.5.3 Project Risks

- Inaccurate schedule.
- Latency in getting equipments.

Recovery

- Implementing the project earlier.
- Request equipments needed earlier.
- Use alternate devices with the same functionality and less cost.

1.6 Human Development Resources

The team is composed entirely of Two Biomedical Engineering undergraduate students who are interested in medical control field.

The project Team: Hamdah M. Elyan and Motaz M. Awawdeh

Supervisor: Eng. Abdallah Arman

1.7 Report Road Map

Our documentation is divided into many parts. The following titles explain shortly the contents of each chapter:

Chapter 1: Introduction

An overview, literature review, and project scheduling will be shown in this chapter in conjunction with the estimated cost, Project risks, and Human Development Resources.

Chapter 2: Theoretical Background

The muscle physiological structure, the project main idea (theory), and the project components will be explained in this section.

Chapter 3: Project Conceptual Design

At this chapter we will view the project objectives, the design of the general block diagram, and finally how our system works.

Chapter 4: Detailed Technical Project Design

This chapter explains the project different phases, and also contains the subsystem detailed design.

Chapter 5: Software

This chapter includes flowchart of the project (block), and programming code of the project which has been done in the second semester.

Chapter 6: System Implementation and Testing

This chapter includes testing of our design which has been done in the second semester.

Chapter 7: Conclusion and Future Work

Conclusions taken from our project, and future works will be provided in this chapter.

Chapter

TWO

Theoretical Background

2.1 Muscle Physiological Structure.

2.2 Project Theory.

2.3 Project Components.

Chapter Two
Theoretical Background

2.1 Muscle Physiological Structure

In this section, the physiological structure of the muscle will be discussed, mentioning the categories of muscles, also the contraction process of muscle will be explained.

2.1.1 Muscle Structure

Muscles are a sort of soft tissues that possess specific contractile properties and function as flexible shortening actuators on the different components of the organism. They also convert chemical energy into force. The muscular system is composed of specialized cells called muscle fibers. Their predominant function is contractibility. Muscles, where attached to bones or internal organs and blood vessels, are responsible for movement. Nearly all movement in the body is the result of muscle contraction.

Each muscle fiber ("muscle cell") is covered by a plasma membrane which is called the sarcolemma. Tunnel-like extensions from the sarcolemma pass through the muscle fiber from one side to the other one in transverse sections through the diameter of the fiber, these tunnel-like extensions are known as transverse tubules. The nuclei of muscle fiber are located at the edges of the diameter of the fiber, adjacent to the sarcolemma, noting that muscle fiber may have many nuclei. Cytoplasm is present in all living cells, and the one present in muscle fibers is called sarcoplasm. The sarcoplasm present in muscle fibers contains very many mitochondria, which are the energy-producing units within the cell. These mitochondria produce large amounts of a chemical called "Adenosine Triphosphate", which as usually referred to in abbreviated form as "ATP", this chemical substance is necessary for contracting muscles, transporting substances across the cell membranes, and moving structures within the cell. These Components are the major components inside the muscle fiber needed to be mentioned.

2.1.2 Muscle Categories

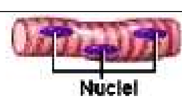
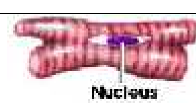
There are three types of muscle in the body:

1. Skeletal muscle: By definition is muscle which is involved in movement of the skeleton. Skeletal muscle is composed of cells that have specialized functions. They are called muscle fibers, due to their appearance as a long cylindrical shape plus numerous nuclei. Their lengths range from 0.1 cm to 30 cm with a diameter from 0.001 cm to 0.01 cm [1]. It is also called striated muscle as the fibers, which are made up of many cells, are composed of alternating light and dark stripes, or striations. Skeletal muscle can be contracted without conscious control, for example in sudden involuntary movement.

2. Smooth muscle: This tissue is so called because it does not have striations and therefore appears smooth under a microscope, noting that the smooth cell is spindle-shape and has one nucleus. It is also called involuntary because it is controlled by the autonomic nervous system. Unlike skeletal muscle, it is not attached to bone. It is found within various systems within the human body, for example the circulatory, the digestive and respiratory. Its main difference from skeletal muscle is that its contraction and relaxation are slower. Also, it has a rhythmic action which makes it ideal for the gastro-intestinal system. The rhythmic action pushes food along the stomach and intestines.

3. Cardiac muscle: is a specialized kind of muscle found only within the heart. Cardiac muscle can't be controlled consciously so it is an involuntary muscle. The cardiac muscle has one central nucleus, like smooth muscle, but it also striated like skeletal muscle. The cardiac muscle cell is rectangular in shape, while its contraction is strong, and rhythmical.

Table (2.1): Comparison between different types of muscles.

	Skeletal Muscle Cell	**Cardiac Muscle Cell**	**Smooth Muscle Cell**
Shape	Elongated Cells	Branching Cells	Spindle-Shaped Cell
Nuclei Type	Multiple Peripheral Nuclei	Single Central Nucleus	Single Central Nucleus
Striations Existence	Visible Striations	Visible Striations	Lack Visible Striations
Movement Type	Voluntary	Involuntary	Involuntary
Normal picture	 [8]	 [8]	 [8]

2.1.3 Structure of Skeletal Muscle

Because our project is related to the skeletal muscle, we will explain widely the construction of this type. At the high level, skeletal muscles consist of muscle cells and fibrous connective tissues. The cells, which are elongated and shaped like cylinders, are called muscle fibers. A group of muscle fibers forms a bundle (also called fasciculi), and many fascicles (bundles) together form a muscle head. Finally, one or more heads constitute a complete muscle belly.

By looking at fig. (2.1), at the low level, we can define a muscle as a combination of many strands of tissue called fascicles. Each fascicle is composed of fasciculi which are bundles of fibers, themselves composed of parallel bundles of myofibrils. The myofibril is the basic fiber of muscle and can contract, relax, and elongate (lengthen). It consists of series of contractile units, named sarcomeres, composed of arrays of actin protein ("which is thinner and therefore more transparent") and myosin protein ("which is thicker and responsible for the darker bands") myofilaments, arranged so as to form the contractile mechanism of muscle.

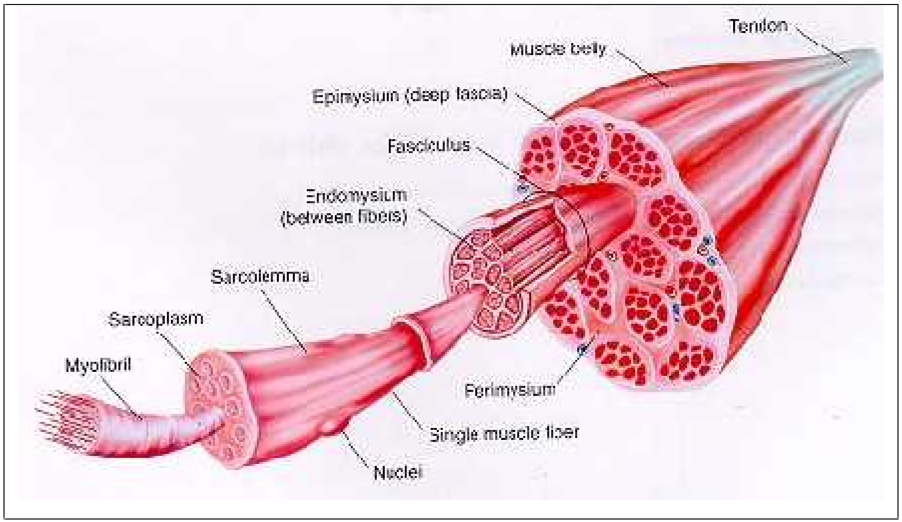


Fig (2.1): Skeletal muscle detailed construction. [11]

The connective tissue in muscle can be divided into three structural entities, the epimysium, which surrounds the center part of the muscle (also called "belly"), the perimysium, which binds bundles of muscle fibers into individual fasciculi, and the endomysium, which surrounds each muscle fiber individually. The whole of these tissue sheaths is called the fascia. It encloses the muscles, groups or separates them into layers, and ultimately connects them at their ends by the tendons.

2.1.4 Mechanism of Contraction of Muscle

Cell membrane situation at rest conditions is shown in fig. (2.2). Muscles are connected to the spine by nerves. The connection between these two structures is called neuromuscular junction.

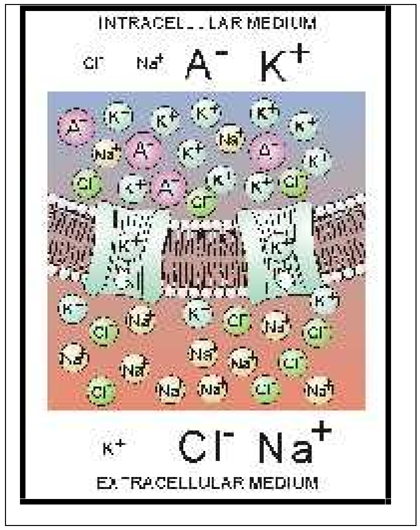


Fig (2.2): Cell membrane at rest condition. [7]

Muscle has an all or none phenomenon. In order for it to contract it has to receive a stimulus of a certain threshold. Below this threshold muscle will not contract; above this threshold muscle will contract but the intensity of contraction will not be greater than that produced by the threshold stimulus.

The mechanism of contraction can be explained with reference to Fig. (2.3). A nerve impulse travels down the nerve to the motor end plate. Calcium diffuses into the end of the nerve. This releases a neuro transmitter called acetylcholine, a neural transmitter. Acetylcholine travels across the small gap between the end of the nerve and the muscle membrane. Once the acetylcholine reaches the membrane, the permeability of the muscle to sodium (Na^+) and potassium (K^+) ions increases. Both ions are positively charged. However, there is a difference between permeabilities for the two ions. (Na^+) enters the fiber at a faster rate than the (K^+) ions leave the fiber. This results in a positive charge inside the fiber. This change in charge initiates the contraction of the muscle fiber.

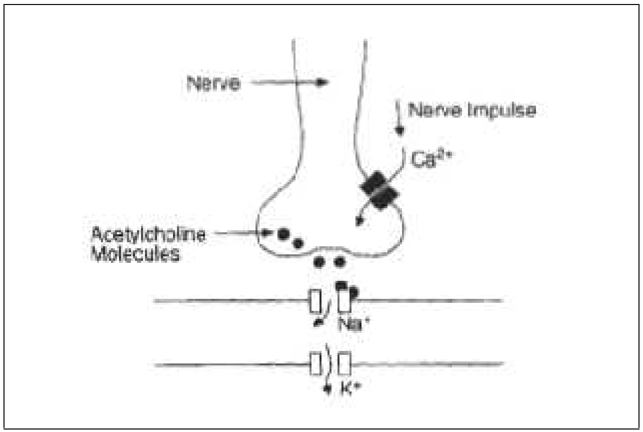


Fig (2.3): Neuromuscular junction. [1]

The mechanism of contraction involves the actin and myosin filaments which, in a relaxed muscle, are held together by small cross bridges, see fig. (2.4). The introduction of calcium breaks these cross bridges and allows the actin to move using ATP as a fuel. Relaxation of muscle occurs via the opposite mechanism. The calcium breaks free from the actin and myosin and enables the cross bridges to reform.

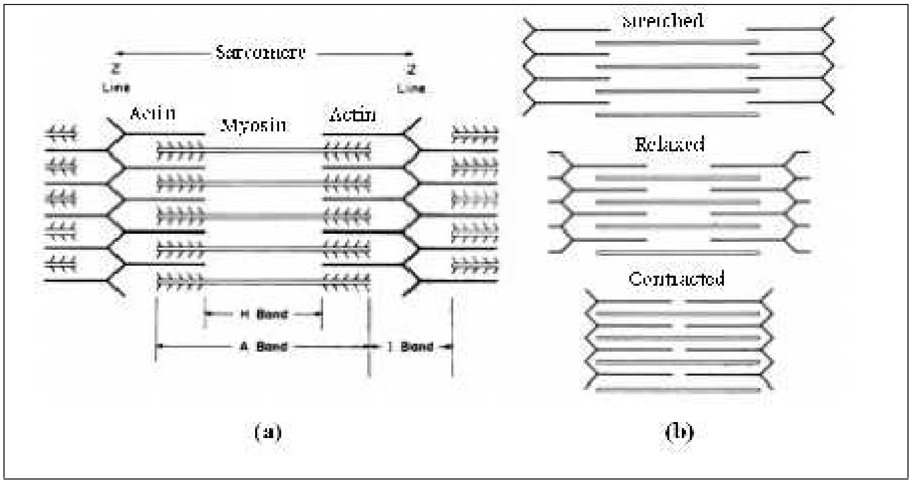


Fig (2.4): Muscle Sarcomere: (a) Striating bands of the sarcomere crossing the filaments; (b) appearance of a sarcomere within stretched, relaxed and contracted muscle. [2]

2.2 Project Theory

In our design, we depend mainly on the depolarization process of the muscle which respectively causes muscle contraction as we will explain later.

2.2.1 Main Idea

Our project depends mainly on the phenomenon of muscle depolarization, which describes muscle contraction. In muscle contraction, the passage of information is associated with the movement of chemicals across a semi-permeable membrane. This ionic movement causes the generation of an action potential. The generation of these action potentials is controlled by what is called Nernst relationship, shown in equation (1):

$$V = -\frac{RT}{nF}\left[\frac{C_{in}}{C_{out}}\right] \text{..........................} (1)$$ [1]

Where R is the universal gas constant, T is the absolute temperature, n is the valence of the ion, and C_{in} and C_{out} are the respective ionic concentrations inside and outside the cell membrane. Fig. (2.5) shows the action potentials generated by the muscle membrane in its three different situations (at rest, depolarization, and repolarization different situations).

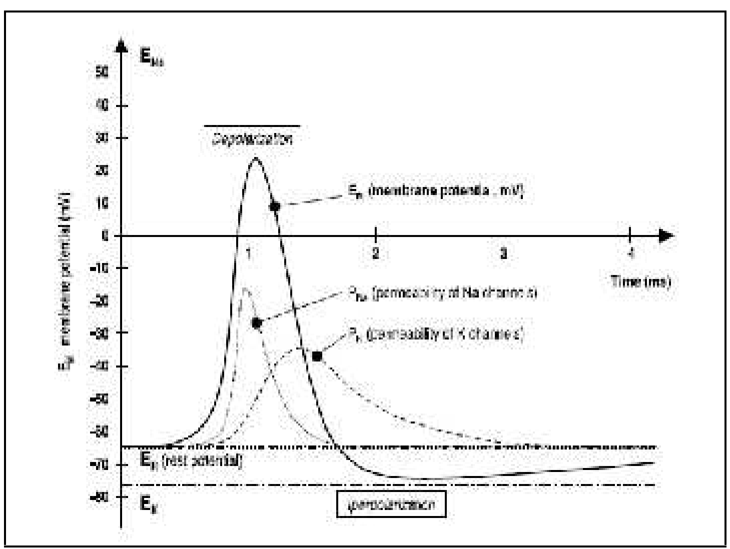


Fig (2.5): The action potential that is generated in excitable cells. [2]

Skin-surface electrodes placed over contracting skeletal muscles will record a complex time-varying biopotential waveform known as an electromyogram (EMG). This electric signal arises from the summed action potential events of individual muscle motor units. Because a large number of cells are undergoing action events during muscle contraction, bioelectric current flows are relatively large and can produce skin potentials as high as 10 mV, although more usually it is in the range of a few millivolts. Fig. (2.6) shows an EMG example.

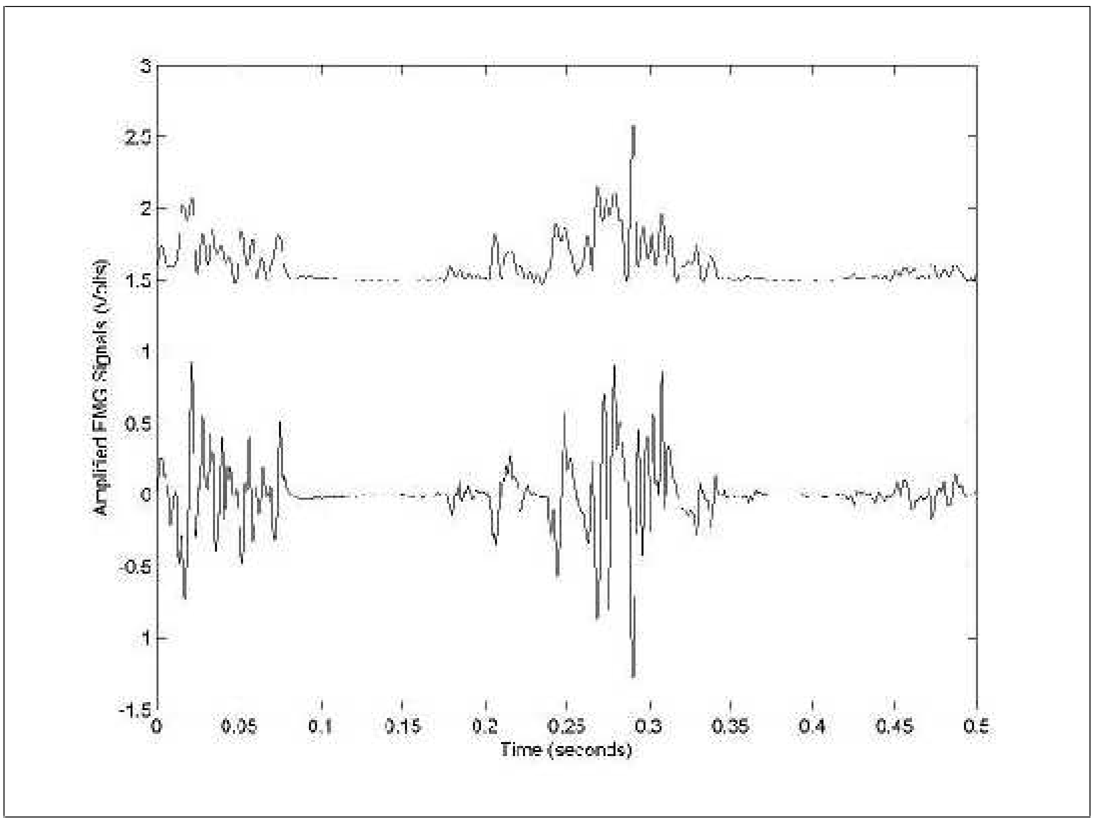


Fig (2.6): EMG recording for a stimulus muscle. [12]

The EMG normal characteristics of a skeletal muscle will be in the following ranges:

- Amplitude of (200-400) μV.[4]
- Frequency of (20-550) Hz.[4]

In our project, we aim to pick up an electromyographic signal, and use this signal to start a movement system, like the ideas used in prosthetics (science of the artificial parts).

2.3 Project Components

We are going to provide the theoretical background of each component in our project in this section.

The design consists of the following components:

1) DC Power Supply.
2) Biopotential Electrodes.
3) Instrumentation Amplifier.
4) Active Band-Pass Filter.
5) Notch Filter.
6) Rectification Circuit.

7) Comparator Circuit.
8) PIC 16F84 Microcontroller.
9) DC Motor Circuit

2.3.1 The Power Supply

In our design, many integrated ICs are contained; on the other hand our DC motor will also need a DC power supply to be driven with; for these reasons the necessity of the DC power supply takes a place. See Fig. (3.2) for block diagram, and Fig. (4.1) for schematic.

We can list the main components of the DC power supply as follow:

- ❖ Center tab Step-down transformer.
- ❖ Bridge rectifier.
- ❖ Capacitors.
- ❖ Regulators.

2.3.2 Biopotential Electrodes

Biopotential electrode is a transducer that converts the ionic current in the body into the traditional electronic current flowing in the electrode.

Electrode-Electrolyte Interface: When metals are placed in electrolytes, such as in the saline environment of tissue or skin, atoms of the metal slightly dissolve into solution. This slight dissolution of metal is accompanied by a loss of electrons to the atoms that remain with the parent metal. It leaves the parent metal with a net negative charge and the dissolved metal ions with a positive charge. The created electric field tends to draw the ions back to the vicinity of the metal surface; however, energy is required for their recombination, so the ions are just held close to the metal surface. An interfacial double layer of charged ions is formed as seen in Fig. (2.7).

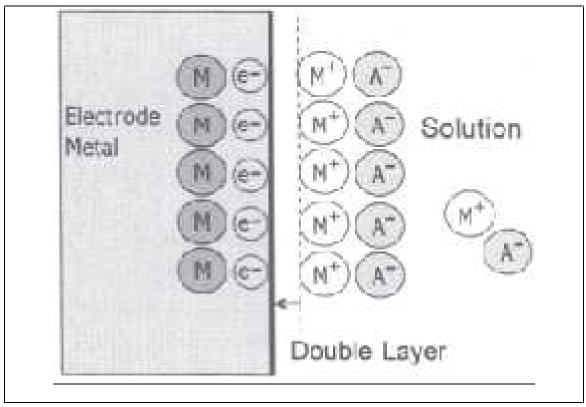


Fig (2.7): Electrode-Electrolyte Interface. [4]

One of the problems faced Biopotential electrodes is polarization. So we can divide the electrodes into two categories:

- Perfectly polarizable electrodes: no actual current crosses the electrode-electrolyte interface.

- Non-polarized electrodes: allow the current to pass freely in electrode-electrolyte interface.

Silver – silver chloride electrode (Ag/AgCl) possesses characteristics which are similar to a perfect non-polarizable electrode. It is also a surface electrode.

- Advantages of (Ag/AgCl) electrodes:
  - Quick, easy to apply.
  - No medical supervision, required certification.
  - Minimal discomfort.
  - Cheap.
  - Excellent efficiency.

For the previous reasons, we will use the Ag/AgCl surface electrodes as the biopotential electrodes.

2.3.3 Instrumentation Amplifier

Human body acts as a huge antenna. It receives and catches a wide range of electromagnetic signals. The most dominant being 50Hz signal, acts as an artifact for the desired biomedical signals. For the two differentially placed electrodes, these artifacts act as common mode signals, which get rejected by the instrumentation amplifier. Due to the above mentioned important factor, a very high input impedance and a high Common Mode Rejection Ratio (CMRR) is desirable.

Instrumentation amplifiers are differential voltage amplifiers that combine several operational-type stages within a single package. Their use can simplify the circuitry needed for biopotential amplification because they combine low-noise, high-impedance buffer input stages and high-quality differential amplification stages. Some of the desirable characteristics of bioelectric amplifiers are:

- Gains of 10^3 to 10^4
- Input impedance greater than $10^8\ \Omega$
- Common-mode rejection ratio greater than 100 dB.

2.3.4 Active Band-Pass filter

Active band-pass filters refer to those filters of RC circuits built on an amplifier basing. In this type, an amplification factor will be provided to the output signal in addition to the main process of filtering.

The filtering process is done by passing only a determined range of frequency according to the application used for. Fig. (2.8) shows the bode plot of active band-pass filter.

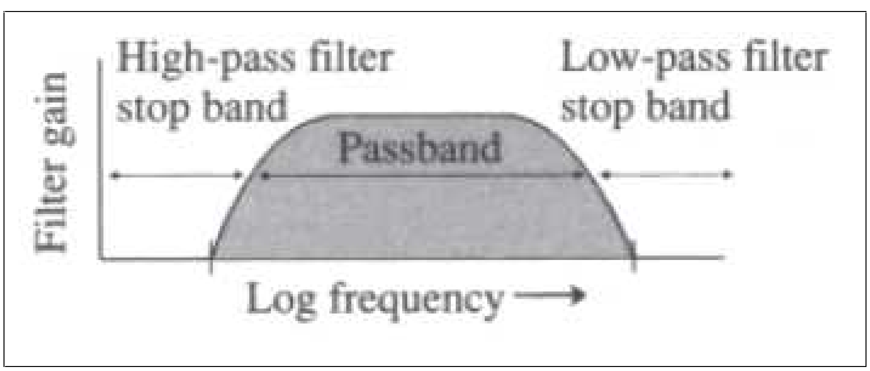


Fig (2.8): Bode plot of active band-pass filter. [4]

2.3.5 Notch Filter

Even using a band pass filter, but also we need to ensure that the 50Hz noise interference is removed to get high performance and efficiency.

In order to get that, a notch filter circuit is added so as to get red of the power lines noise interference that may cause many troubles and this type of filter is also built on an operational amplifier so as to get high noise removing and not to lose the main signal wanted to be filtered. See fig (4.5) for schematic design.

2.3.6 Rectification Circuit

This circuit is used to change the AC signals into DC. In our design we use an active rectifier. See fig. (4.6) for schematic

2.3.7 Comparator Circuit

This circuit will provide a pure DC line output voltage by comparing to values of input signals. In our design, we will use a (0.1) DC voltage as a reference one, depends mainly on previous researches. The input signals can be analog or digital ones. See fig. (4.7) for schematic.

2.3.8 PIC 16F84 Microcontroller

PIC 16F84 is a Programmable Integrated Circuit that used in many and wide applications. There are many characteristics that encourage us to use PIC 16F84 in various applications such as:

.

- High-speed technology.
- Low power consumption
- Only 35 single word instructions to learn.

This programmable device accepts only DC voltage, and also provides an output of DC voltage. See fig. (3.10) for diagram and fig (4.8) for schematic connection.

2.3.9 DC motor circuit

This circuit contains a DC motor controlled by the DC output of the PIC 16F84 microcontroller. See fig. (4.9) for schematic circuit.

Chapter

3 THREE 3

Project Conceptual Design

3.1 Project Objectives.

3.2 General Block Diagram.

3.3 How System Works?

Chapter Three
Project Conceptual Design

In this chapter we will explain the main objectives from our project; also the general block diagram will be discussed. Finally we will show how the overall system works.

3.1 Project Objectives

Our project contains and implements many ideas and objectives that can be summarized in the following points:

1) To design and implement a Myoelectric Control Medical System.

2) To simulate the same idea of an EMG-controlled prosthetic device.

3) To understand the change of electrical potential on different muscular activities, including the conscious controls and triggering event of muscle.

4) Can learn the change of muscle force when skeletal muscle works on different types of contraction.

3.2 General Block Diagram

The following Fig. (3.1) shows the block diagram of our project.

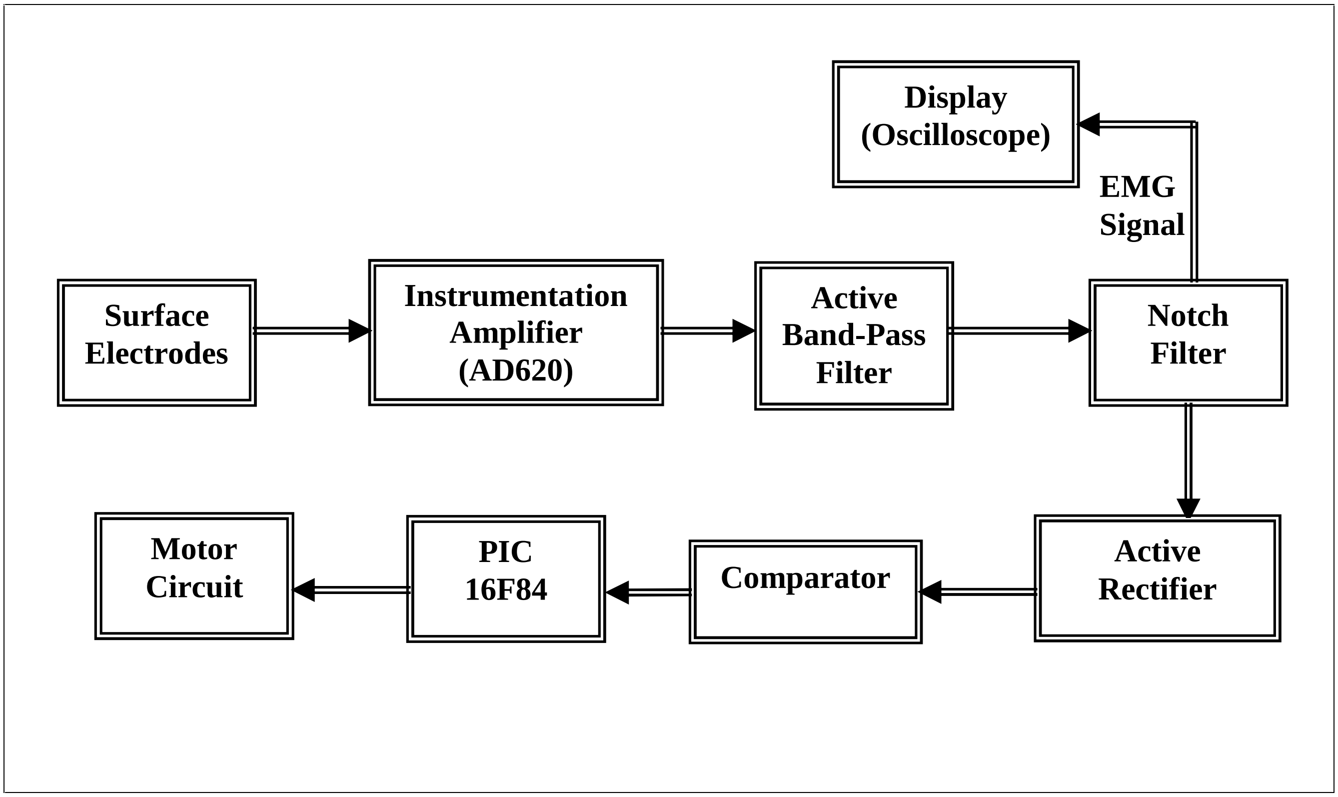


Fig (3.1): General block diagram.

We can see clearly that each individual block has its own function, and by summing those functions, and integrating with each other; our myoelectrical control movement system will be accomplished.

Here is the explanation of our individual units:

3.2.1 DC Power Supply Block Diagram

In our design, we need the DC power supply to provide the necessary (+ve) and (–ve) voltage supply for the ICs used in our project, the following figure (fig. (3.2)) shows the block diagram for the DC power supply:

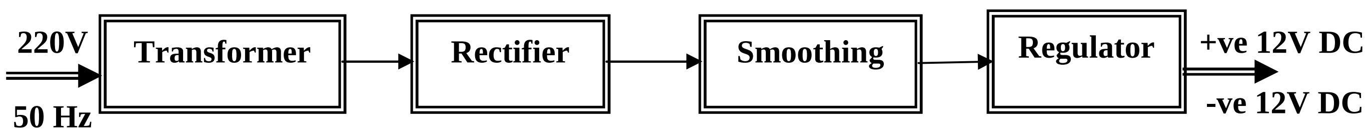


Fig (3.2): DC power supply block diagram.

1. **Transformer**: it is used for reduce voltage and to perform the isolation process too.

2. **Rectifier:** this stage will be used for converting form AC to DC voltage using a bridge full wave rectifier.

3. **Smoothing:** here, the ripple voltage will be reduced.

4. **Regulator:** the output of this stage is a pure DC line voltage as we want.

3.2.2 Signal Detection Block Diagram

This block diagram implements the stages used to detect and get the myoelectric signal form the living body, fig. (3.3) view this block diagram:

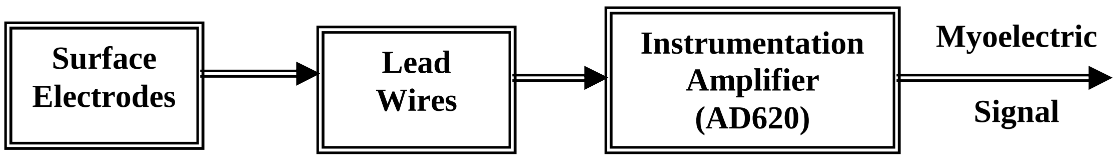


Fig (3.3): Signal detection block diagram.

1. **Surface Electrodes**: The devices that convert ionic potentials to measurable electrical signals, according to Nernst’s equation. Passive electrodes of silver/silver chloride have been used for basic signal extraction. These circular disks, of 5mm diameter, have to be secured to the skin of the subject using conductive gel and adhesive patches, to avoid undue artifacts (see Fig. (3.4)).

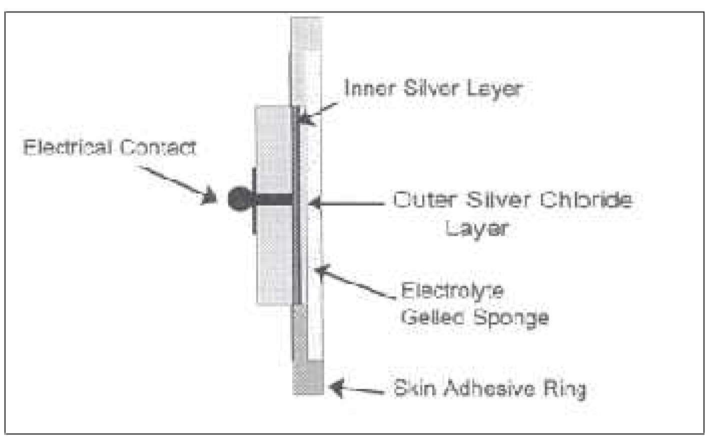


Fig (3.4): Silver-silver chloride electrode construction. [4]

In the study, for observation of EMG, for every muscle three electrodes, two being placed on the muscle for differential input and one placed at some electrically isolated tissue, acts as a reference electrode. Fig. (3.5) shows Electrode-skin interface.

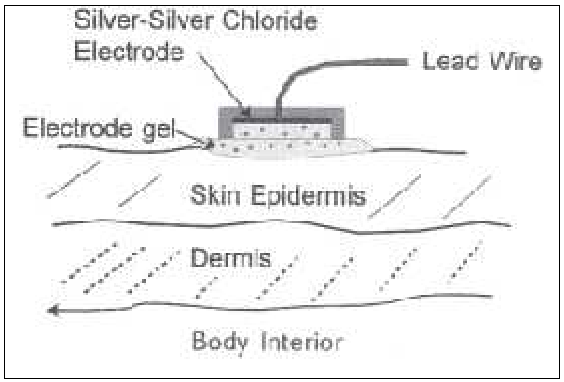


Fig (3.5): Electrode-skin coupling using a gel electrolyte. [4]

2. **Lead Wires:** Some care must be taken with lead wires to biopotential recording electrodes. Commercial bioelectrodes are often sold with 100cm lengths of an insulated but unshielded signal-carrying wire. Keeping the electrode wires close to grounded objects or near the body can be helpful in reducing line-frequency noise pickup. In more demanding applications, the electrode lead wires should be shielded.

3. **Instrumentation Amplifier**: In our project we will use AD620 instrumentation amplifier chip. This chip has high-impedance ($>10^9\ \Omega$) input buffers that work well with even high-impedance bioelectrodes. The amplifier gain is easily selected from several standard gains by interconnection of pins on the package or, alternatively, by adjusting the value of a single external resistor. Taking into consideration that the

common mode rejection ratio (CMRR) for this instrumentation amplifier is equal to 100 dB. Fig. (3.6) contains AD620 connection Diagram.

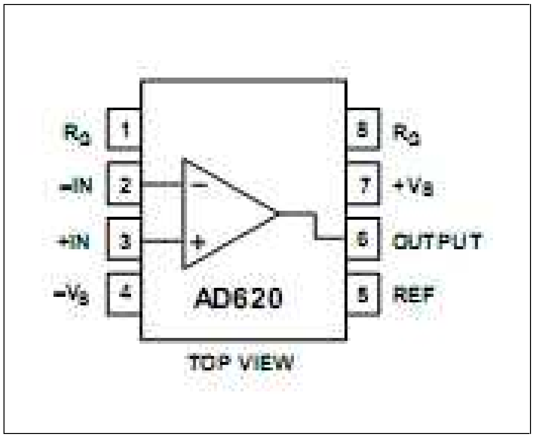


Fig (3.6): Connection Diagram for AD620 Chip. [14]

3.2.3 Signal Processing Block Diagram

The detected signal will get through some processing stages before complete its way to the control circuit of the movement system, fig. (3.7) shows this block diagram.

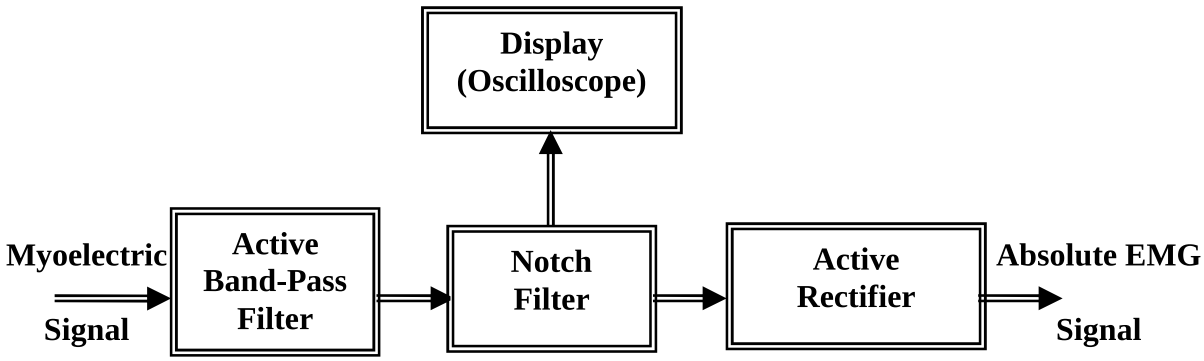


Fig (3.7): Signal processing block diagram.

1. **Active Band – Pass Filter:** An understanding of the frequency content of bioelectric signals can be helpful in maximizing the biopotential recording quality. The basic EMG acquired signal had been a mixture of low frequency artifacts (0-20Hz), due to electrode movements; power line noise (50Hz); desired EMG signal (20-550Hz); and some high frequency noise. The most significant component of the EMG had been in the range of 70Hz to 250Hz. A second order band-pass filter had been used to extract the above EMG from the mixture of signals.

2. **Notch Filter:** this stage will offer the elimination of 50Hz noise caused by the interference of the power lines that exist mostly every where around us; To make our control depends only on the pure EMG signal with any noise specially 50Hz noise. For building the two previous filtering stages an IC called LM358 Dual Operational Amplifier is used because the two stages are an Active filtering stages (constructed on an operational amplifier); and the next figure (Fig(3.8)) shows the internal construction of the LM 358.

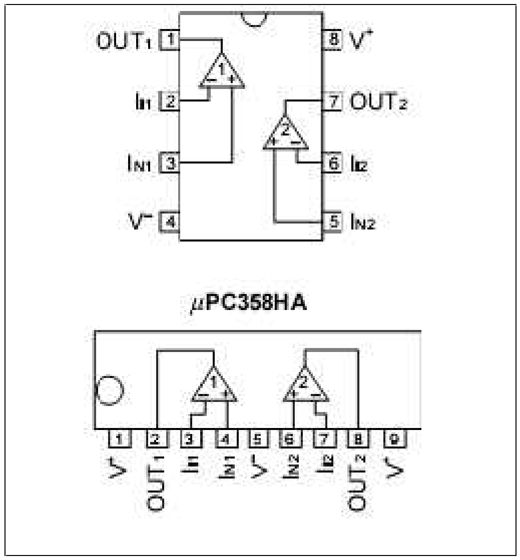


Fig (3.8): Pin configuration of LM358 OP-AMP.

3. **Display (using oscilloscope)**: after filtering the myoelectric signal (EMG) from other noise signal, we will display it using an oscilloscope device; that give us many display options of changing display frequency and amplitude to make the signal clearer for displaying.

4. **Full Wave Active Rectifier:** in this stage, the output AC signal from the band pass active filter will be changed to DC on to ensure getting benefit from all the parts of the output AC signal from the band pass filter.

3.2.4 Control – Movement Block Diagram

After rectifying the EMG signal, it will be moved through the system to the control – movement system, which can be shown as a block diagram in fig. (3.9).

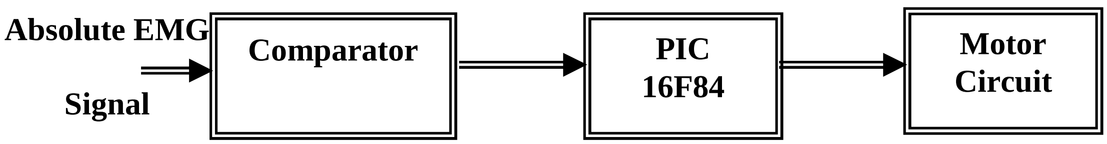


Fig (3.9): Control – movement block diagram.

1. **Comparator Circuit:** the output of the previous stage (active rectifier) could be used to trigger a threshold circuit to actuate an EMG-controlled movement system, and this stage will perform as a threshold circuit.

2. **PIC 16F84:** in this step, a programmable PIC 16F84 microcontroller IC will be used for ensuring the continuity of the EMG flowing signal, by checking this flowing each determined period of time. And so according to this flowing, the movement circuit (DC motor) will be controlled. Fig. (3.10) implements the 16F84 programmable microcontroller.

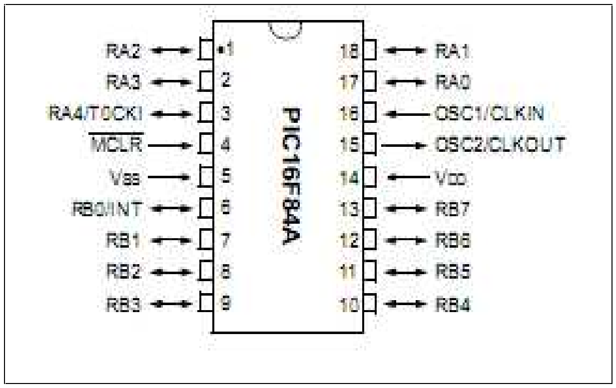


Fig (3.10): Pin Diagram of PIC 16F84. [14]

3. **Motor Circuit:** according to the output of the previous stage (the PIC 16F84), the movement of a DC motor in this stage will be controlled and its aim is to simulate the design of an EMG-controlled prosthetic device.

3.3 How System Works?

The following steps explain how the project works, and what steps should be taken, to give an accurate control movement system.

- The operator should place the Ag-AgCl electrodes on the surface of the skin after providing a good amount of conductive gel to ensure high conductivity and low effects of artifacts.

- The surface electrodes then will be connected with instrumentation amplifier using lead wires.
- The instrumentation amplifier takes the biopotential EMG signal, and with its high common mode rejection ratio (CMRR) it will reject the small mode voltages that could affect the desired EMG signal.
- The active band pass filter will give us the frequencies that contain our concerned information by removing the unwanted frequencies from passing, and passes only a determined range of frequencies.
- The notch filter is added to the design so as to ensure removing the 50Hz noise those results from the interference with the power lines.
- The active rectifier will change the output AC signal from the filter stage to DC signal to get benefit from all the parts of the signal; also it will send this DC signal to the comparator.
- In the comparator stage, the DC signal flowing from the active rectifier will be used as a threshold voltage to trigger the movement of the motor.
- The PIC 16F84 will check periodically the flowing of the EMG signal by its direct connection to the comparator, and using this checking to control the movement of the motor.

Chapter

4 FOUR 4

Detailed Technical Project Design

4.1 Detailed Description of the Project Phases.

4.2 Overall System Design.

Chapter Four
Detailed Technical Project design

The necessity of this chapter takes a place in order to explain the detailed design for each unit in this project. Also to clarify the main characteristics that will make this project to operate as planted, after viewing the theoretical background, and the general block diagram that explain how the system works in the previous chapters.

4.1 Detailed Description of the Project Phases

Our project is divided mainly into the following phases:

- Detection phase: by placing the Ag/AgCl surface electrodes on the surface of the skin, an EMG signal will be detected and then transferred through leading wires to the next phase; amplification and filtration phase.

- Amplification and filtration phase: in this stage an instrumentation amplifier will be used to get a clear EMG signal by providing amplification factor; also an active band pass filter will be used to perform the filtering process, additionally providing an amplification factor containing the notch filter stage.

- Processing phase: at this phase, an active rectifier will be used in order to get the benefit from all the parts of the signal; after that the signal will go as an input for a controlled movement system.

4.2 Overall System Design

Here we are to particularize the characteristics, and specifications for each circuit. Also to view the schematics, and features of those subsystems.

4.2.1 Power Supply Subsystem

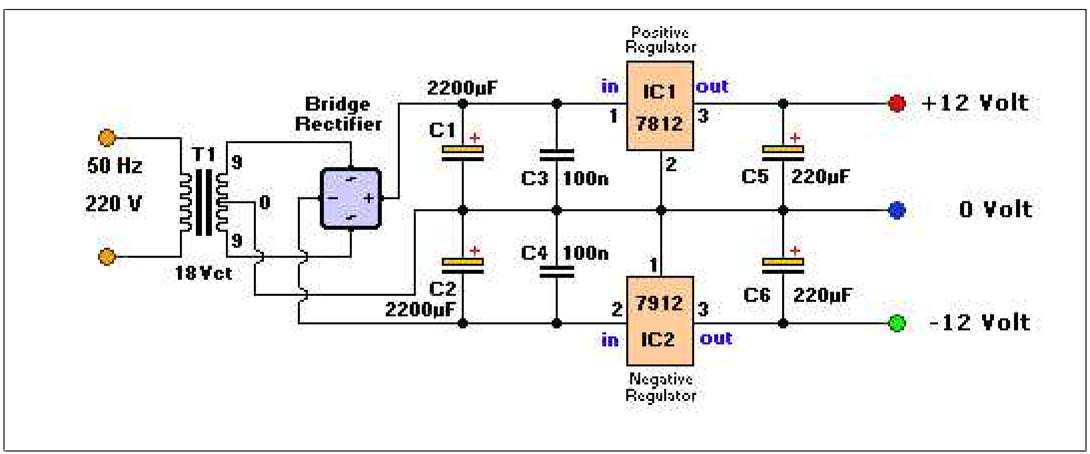


Fig (4.1): DC power supply circuit.

The above DC power supply circuit will convert the 220V/50Hz AC voltage to 12V DC voltage, the circuit is composed of:

1- Centre-tab Step-down transformer: The transformer available is a Hammond Type C, Model 166G25, the secondary is center-tapped (this provides the ground output) and provides a 5:1 voltage reduction ratio.

2- Regulator: 7812 and 7912 are available to have (+ve) 12 v and (-ve) 12 v output.

3- Bridge Rectifier: this IC is a available and easy to use, for those reason we take this IC in our design as shown on fig (4.1) .

The following figure (Fig (4.2)) shows the output waveform from each component of the DC power supply:

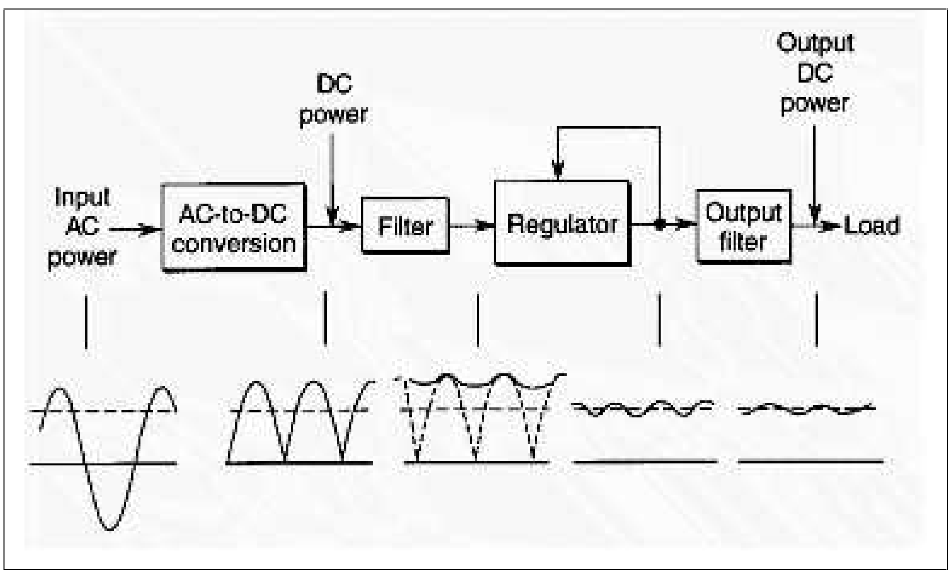


Fig (4.2): Output waves from DC supply.

4.2.2 Instrumentation Amplifier Circuit

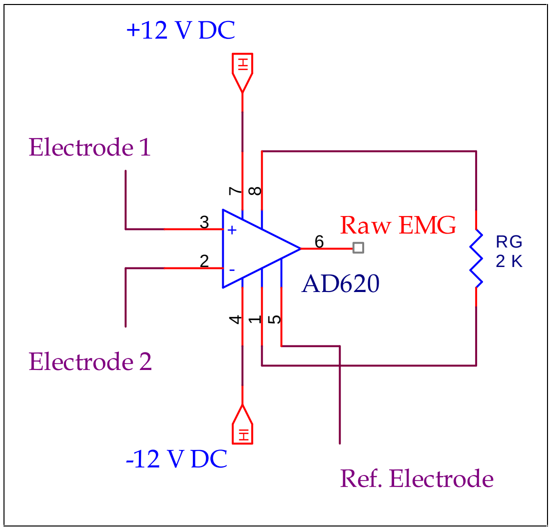


Fig (4.3): AD620 instrumentation amplifier schematic.

The circuit above expresses an AD620 instrumentation amplifier (fig. (4.3)). From the data sheet of this IC, the gain can be controlled by the law:

$$A = (49.4k / R_G) + 1 \quad \text{.......................... (4.1)}$$ [14]

Where:

A = Amplifier voltage gain.

R_G = External resistance added to achieve a determined voltage gain.

So, if we want the gain (A) of this stage to be (25), then the added R_G = 2K Ω

Now, the reason why to choose AD620:

- ✓ Very high common mode rejection ratio (CMRR = 100 dB).
- ✓ Very high input Impedance ($>10^9$ Ω).

✓ Easy to use.

✓ Good price.

4.2.3 Active Band – Pass Filter Circuit

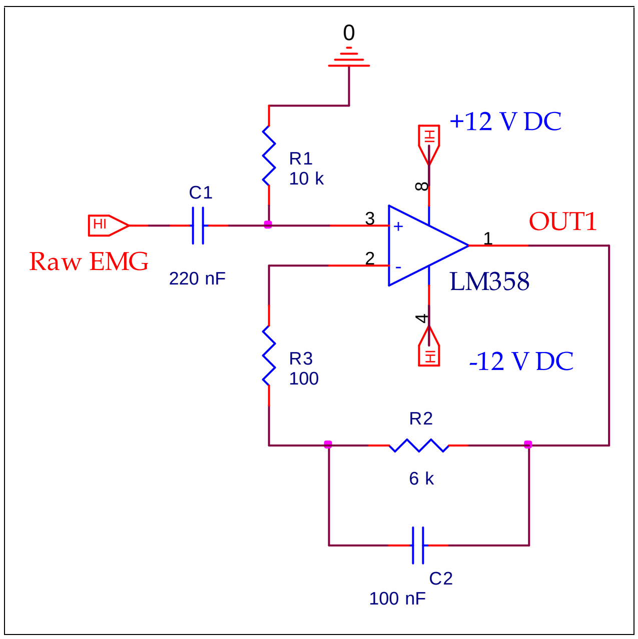


Fig (4.4): Active band – pass filter schematic.

The previous figure (fig. (4.4)) implements an Active Band – Pass Filter circuit. A band-pass filter consists from a high-pass component and low-pass component; so to design a band-pass filter, we must determine the high-pass and low-pass cutoff frequencies.

As we say in chapter 3, the high-pass cutoff frequency = 70 Hz, on the other hand the low-pass cutoff frequency = 250 Hz. By usage of the below equation (4.2) we can get:

$$F_{cutoff} = \frac{1}{2 \times ® \times R \times C} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.2)}$$ [6]

- Let C_1 = 220 nF ➔ $R_1 = \frac{1}{2 \times ® \times 220n \times 70} = 10.33k\Omega$ ➔ $R_1 \approx$ 10 KΩ

- Let C_2 = 100 nF ➔ $R_2 = \frac{1}{2 \times ® \times 100n \times 250} = 6.36k\Omega$ ➔ $R_2 \approx$ 6 KΩ

So the final cutoff frequencies are:

F_{cutoff} (high-pass) = 72 Hz.

F_{cutoff} (low-pass) = 241 Hz.

→ The gain of this stage follows the equation:

$$A = (R_2 / R_3) + 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.3)}$$ [6]

So if we want the gain (A) to be (61), R3 = 100 Ω.

- The overall gain of these two stages will be:

$$A_{(total)} = A_1 \times A_2 = 25 \times 61 = 1525$$

The operational amplifier that used to design the active filter is LM358 IC.

The reason behind choosing LM358:

- ✓ Easy to use.
- ✓ Low power consumption.
- ✓ Excellent price.
- ✓ Contains a package of two OP-AMP.
- ✓ Good stability.

4.2.4 Active Notch Filter Circuit

This operational amplifier notch filter circuit is simple yet effective, providing a notch on a specific fixed frequency. It can be used to notch out or remove a particular frequency that may need to be removed.

The circuit is quite straightforward to build. It employs both negative and positive feedback around the operational amplifier chip and in this way it is able to provide a high degree of performance. The following figure (fig (4.5)) presents the 50Hz notch filter circuit.

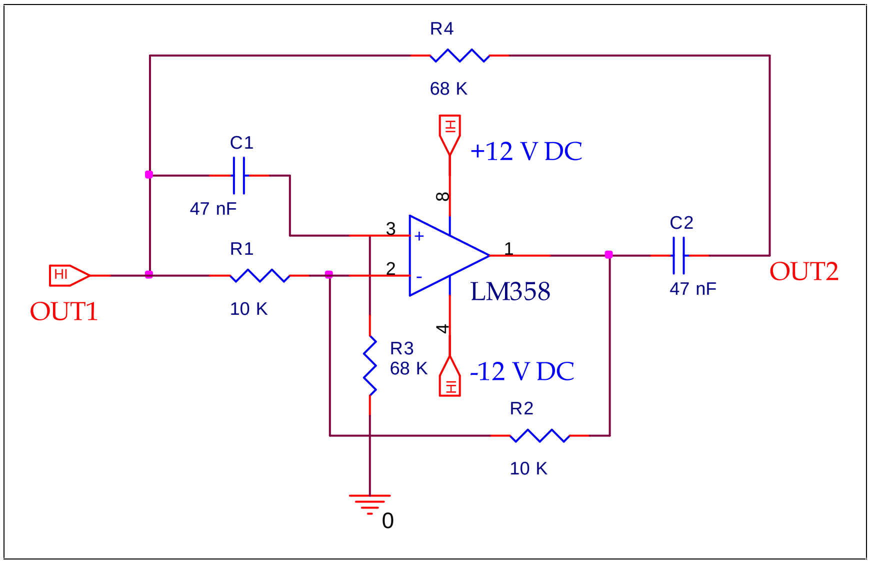


Fig (4.5): 50Hz notch filter schematic.

The circuit is quite straightforward to build. It employs both negative and positive feedback around the operational amplifier chip and in this way it is able to provide a high degree of performance. Calculation of the value for the circuit is very straightforward. The formula to calculate the resistor and capacitor values for the notch filter circuit is:

$$F_{notch} = \frac{1}{2 \times \Pi \times R \times C}$$

$$R = R_3 = R_4$$

$$C = C_1 = C_2$$

Where:

$F_{\mathbf{notch}}$ = centre frequency of the notch in Hertz (50Hz).

pi (∏) = 3.142.

R and C are the values of the resistors and capacitors in Ohms and Farads.

4.2.5 Active Rectifier Circuit

This circuit will convert the output of the previous stages from AC voltage into DC voltage. It depends mainly in its structure of containing an operational amplifier in addition to the diodes. Fig (4.6) views the schematic diagram of this stage noting that R = 1K Ω.

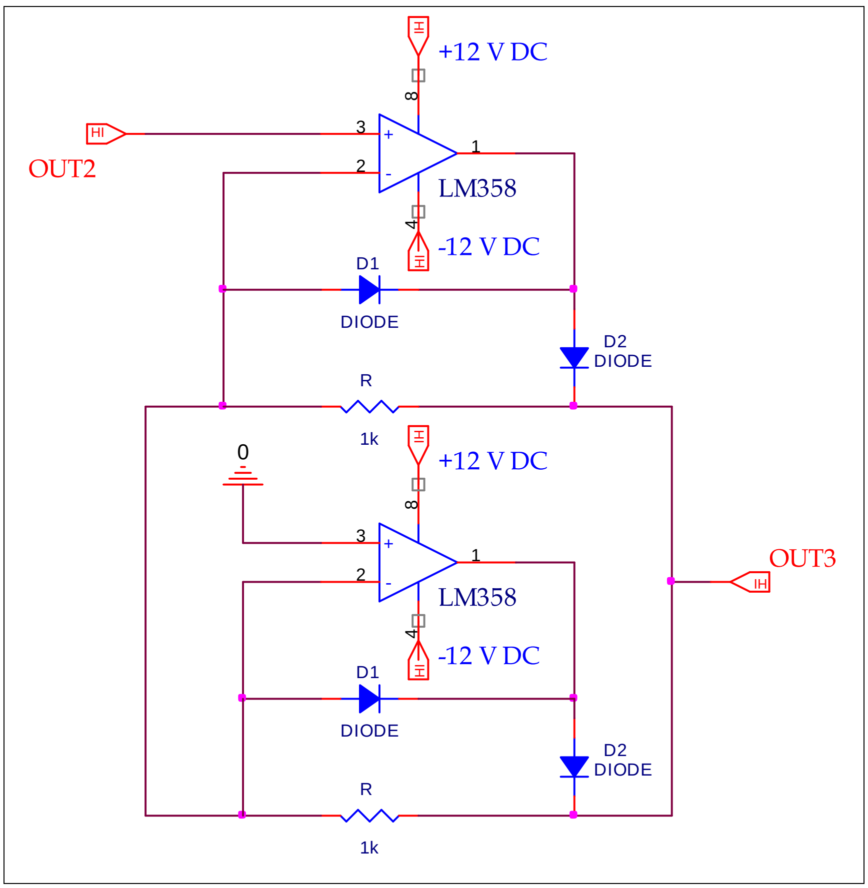


Fig (4.6): Active Rectification schematic diagram.

4.2.6 Comparator Circuit

The principle of operation for this circuit is so simple depends mainly on comparing two input signals, the first one or the reference on the inverting input, while the second one will be placed on the non-inverting part. The output will be either (+ve) V(saturation) or (–ve) V(saturation). Look at fig (4.7) for the schematic diagram.

Noting that the PIC 16F84 can receive a maximum voltage of 6V so we need to divide the output voltage so as to prevent the PIC 16F84 from being damaged; and in order to do that a voltage divider role will be applied by constructing to equal resistors in series and taking the output voltage between them as shown in below figure (Fig (4.7)) so as to get a maximum output of 6V to protect PIC16F84 From being damaged.

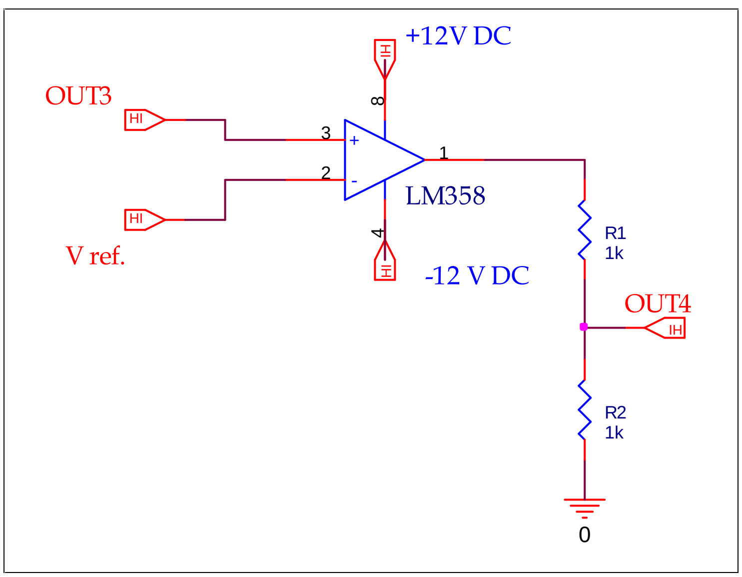


Fig (4.7): Comparator schematic diagram.

4.2.7 PIC 16F84 Microcontroller Circuit

In this circuit, the output of the comparator (OUT4) will be used to control the output from this IC (OUT5) to start or stop the movement of the motor in the next stage. This IC can only receive a maximum voltage of 6V and can be programmed to control its operation. See fig (4.8) for the PIC16F84 schematic connection.

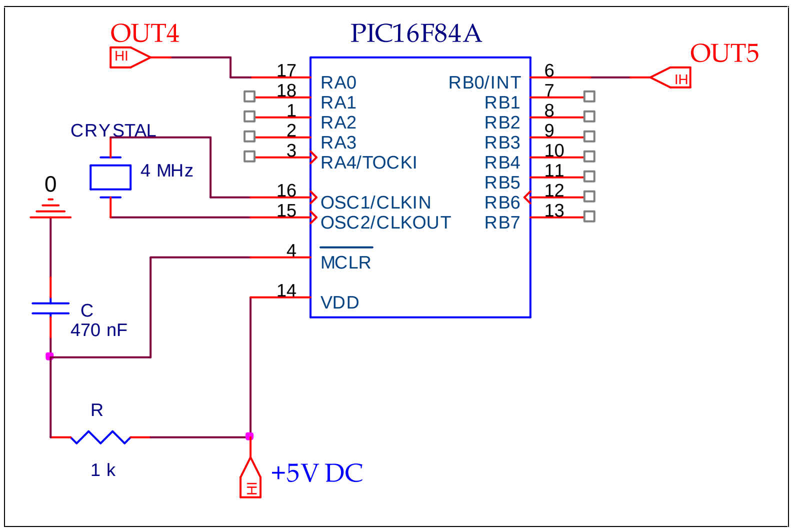


Fig (4.8): PIC 16F84 connections.

4.2.8 DC Motor Circuit

As we see above, the DC motor is connected to a DC power supply, also driven by an NPN transistor. The function of resistance R is to provide protection for the PIC 16F84 from high current values that can be result from the transistor.

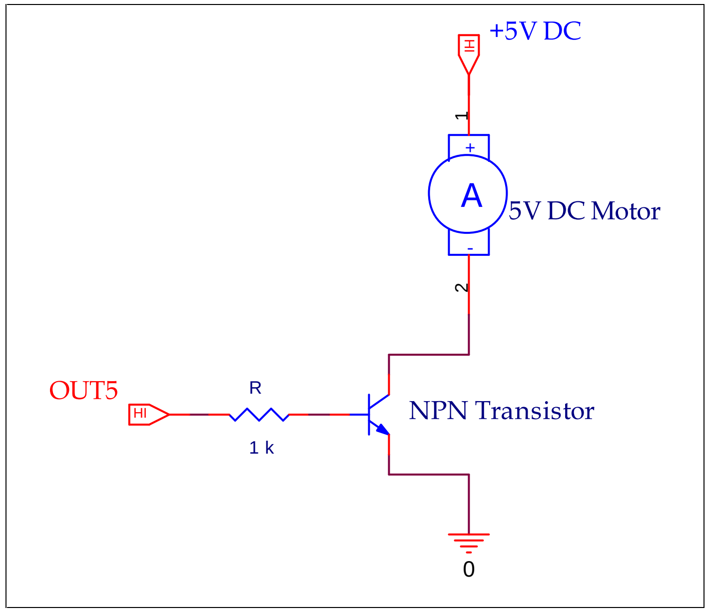


Fig (4.9): DC motor circuit schematic.

Chapter

5 FIVE 5

Software

5.1 Project Flowchart.

5.2 Programming Code.

5.3 Programming and Downloading Software.

Chapter Five
Software

5.1 Project Flowchart

In this section, we will view the flowchart that implements the operation of the programmable PIC 16F84 IC.

We will use this flowchart to provide the programming code next section by the god help. Fig. (5.1) views our concerned flowchart.

We can see clearly from the flowchart that the PIC 16F84 will check the flowing continuity of the EMG signal periodically and every determined period, that depends mainly on the frequency of the EMG signal.

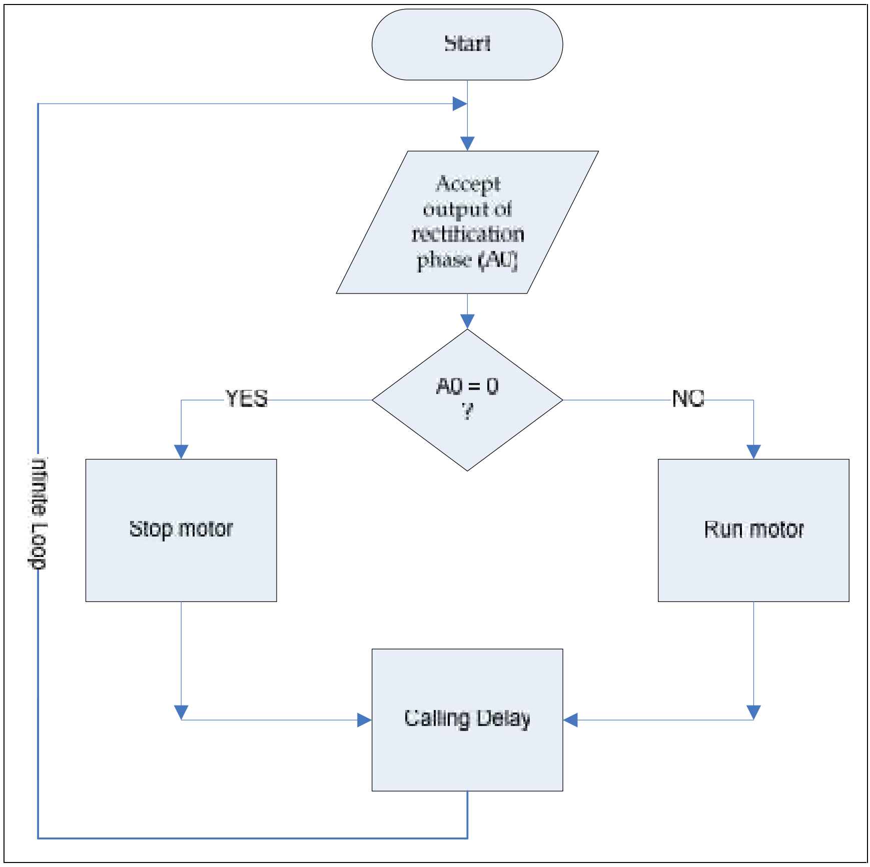


Fig (5.1): Project Flowchart.

5.2 Programming Code

To control the operation of the PIC 16F84 we must write a program using assembly language and download this program on the microcontroller.

The following code implements the program downloaded on the PIC which used to control its operation:

```
;*************************************************************
;        **   PIC16Fxx MPASM Initialized Data Startup File, Version 0.01   **
;             **   (c) Copyright 1997 Microchip Technology                  **
;*************************************************************

                    LIST C=80,N=60,P=16C84,R=DEC
                        TITLE "OUR11.ASM"

;*************************************************************
; **   Declarations for input and output ports, PORTA and PORTB consequently  **
;*************************************************************
STATUS          EQU    3              ;STATUS is file register 03h
PORTA           EQU    5              ;PORTA is file register 05h
PORTB           EQU    6              ;PORTB is file register 06h
TRISA           EQU    5              ;TRISB is file register 85h
TRISB           EQU    6              ;TRISB is file register 86h
RP0             EQU    5              ;Bit 5 of STATUS
COUNTER         EQU    133            ;VALUE FOR OUTER DELAY
COUNTER1        EQU    100            ;VALUE FOR INNER DELAY

;*************************************************************
;                        **   MAIN PROGRAM  **
;************************************************************
        ORG 0
```

```
;*************************************************
;           **   Initializing PORTA as input port  **
;*************************************************
        BSF STATUS, RP0 ;
        MOVLW       0XFF   ; Set RA<4:0> as inputs
        MOVWF       TRISA

;*************************************************
;           **   Initializing PORTB as outport  **
;*************************************************
        MOVLW       0X00   ; Set RB<7:0> as outputs
        MOVWF       TRISB

;*************************************************
;           **   Check the flow of EMG signal  **
;*************************************************
        BCF STATUS, RP0 ;
LOOP    BTFSC       PORTA,0
        GOTO        ON
        GOTO        OFF

ON      MOVLW       0X01
        MOVWF       PORTB
        GOTO        LOOP

OFF     MOVLW       0X00
        MOVWF       PORTB
```

```
          GOTO           LOOP

;*******************************************************
;    **    Delay subroutine determining the checking frequency  **
;*******************************************************
DELAY         MOVLW  0X01
              MOVWF  0X0C

DELAY1        MOVLW  COUNTER
              MOVWF  0X0D

DELAY2        MOVLW  COUNTER1
              MOVWF  0X0E

DELAY3        DECFSZ 0X0E
              GOTO   DELAY3
              DECFSZ 0X0D
              GOTO   DELAY2
              DECFSZ 0X0C
      GOTO   DELAY1
      RETURN
      END
```

5.3 Programming and Downloading Software

After writing the code, it needs to be checked from errors and for this job a program called MPASM is used to find if there are any errors in the code and the following figure (fig (5.2)) view the user interface for this software.

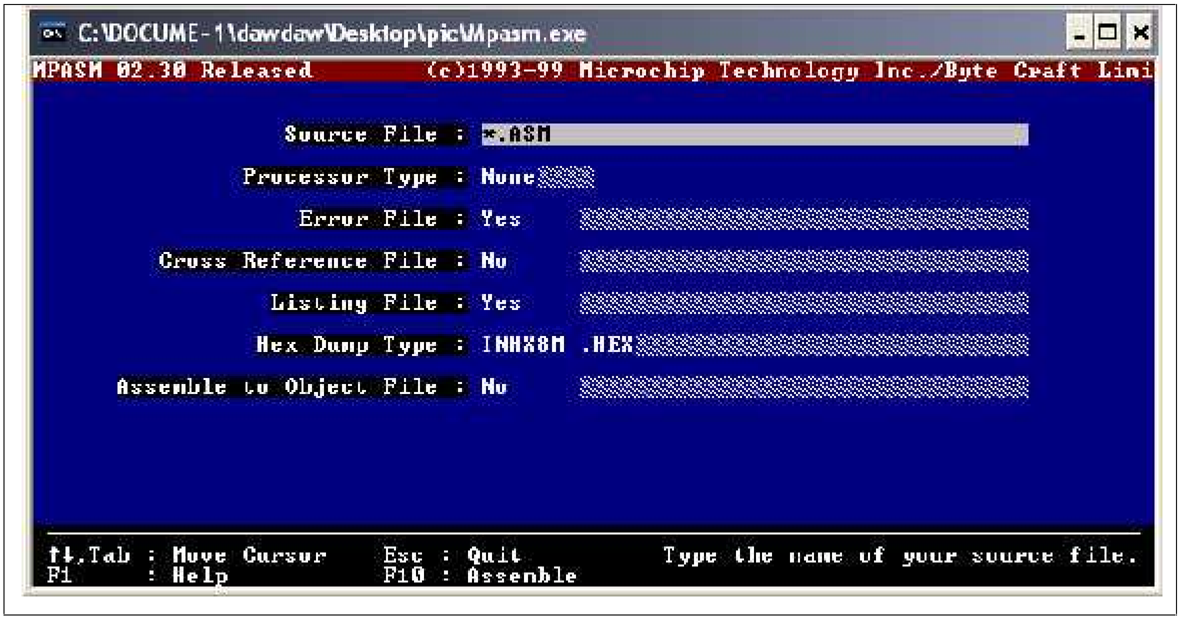


Fig (5.2): MPASM user interface.

After checking the validity of the code, we need to download it on the PIC16F84 and this also been done by the usage of a software called LP16 software; the following figure (fig (5.3)) view the user interface for LP16 software and its choices to program the PIC16F84.

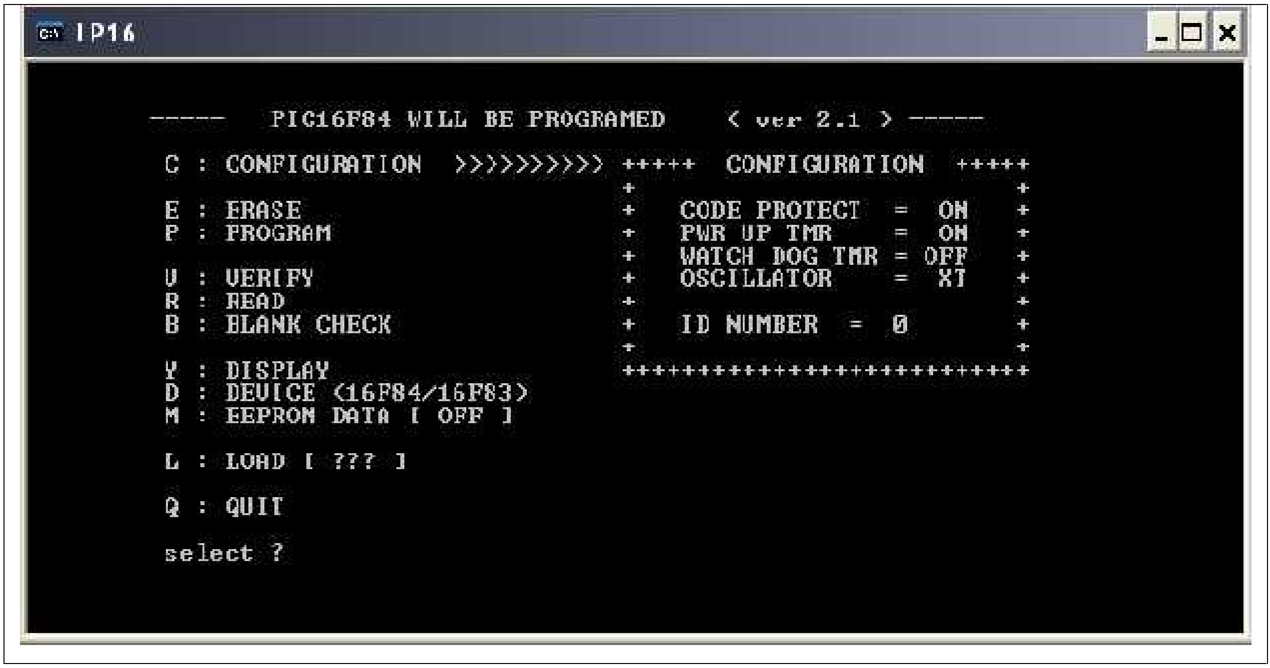


Fig (5.3): LP16 user interface.

Chapter

6 SIX 6

System Implementation and Testing

6.1 Actual Project Implementation.

6.2 Testing & Results.

Chapter Six
System Implementation and Testing

6.1 Actual Project Implementation

Practical implementation of the project have been done in the second semester, and this implementation started by implementing each individual subsystem and after completing this implementation, the individual subsystems are connected together to accomplish the project as one unit.

6.1.1 DC Power supply implementation

The implementation of the project started by implementing the DC power supply circuit, and the following figures shows the implementation process.

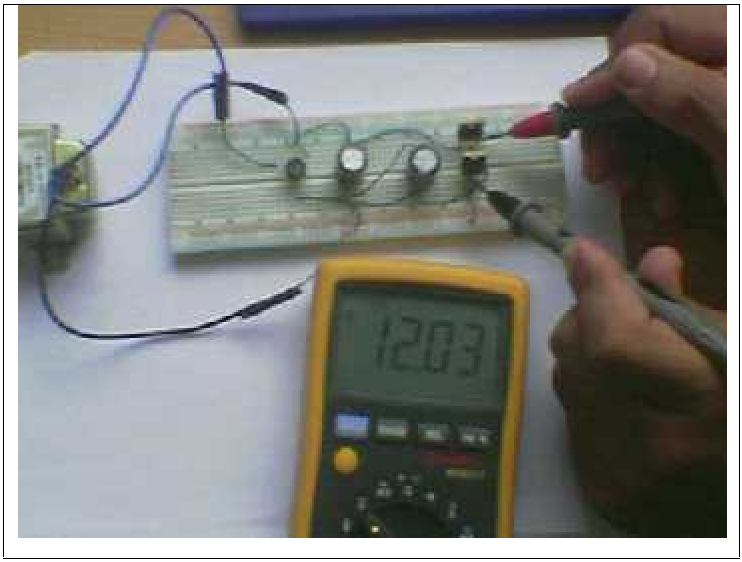


Fig (6.1.A): DC power supply implementation for positive output.

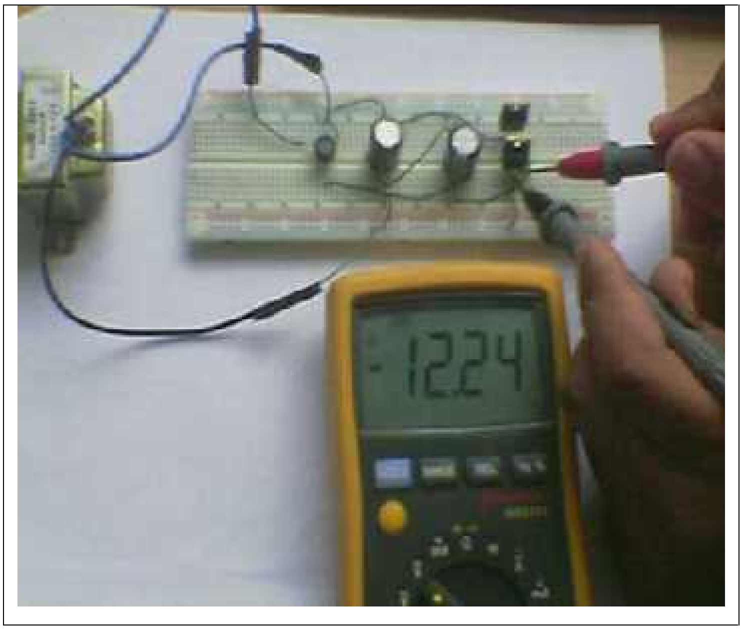


Fig (6.1.B): DC power supply implementation for negative output.

6.1.2 Instrumentation Amplifier Implementation

After completing the implementation of the power supply, the instrumentation amplifier circuit had been connected as the first component in the project; the following figure (fig (6.2)) views the connection of the AD620 Instrumentation amplifier.

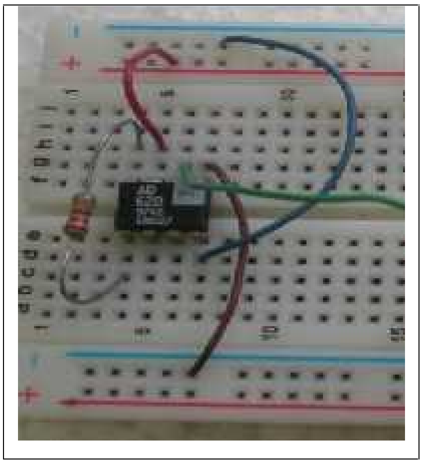


Fig (6.2): AD620 practical connection.

6.1.3 Active Band Pass Filter Connection

This stage had been the in the third position to be connected by the usage of an LM358 operational amplifier IC and the figure below shows the connection.

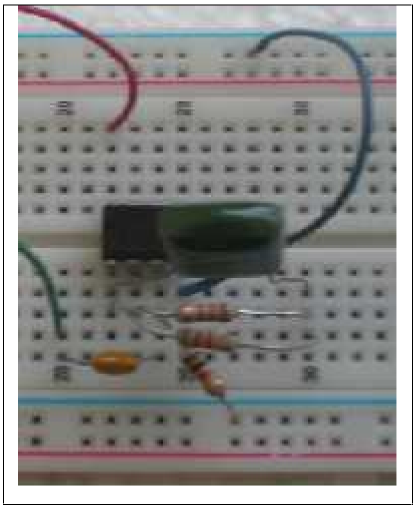


Fig (6.3): Active band pass filter connection.

6.1.4 Active Rectifier Implementation

Connecting active rectifier in order to get absolute EMG would be the next step to do, figure (6.4) presents the implementation of the Active rectifier circuit.

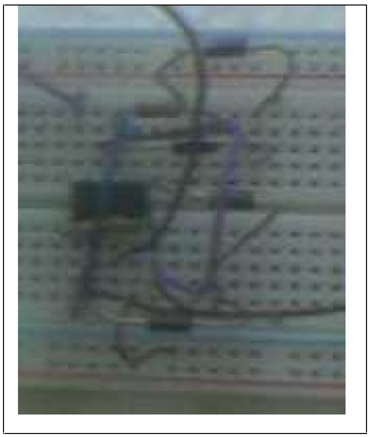


Fig (6.4): Active rectifier implementation.

And by connecting the previous steps together we get the following figure:

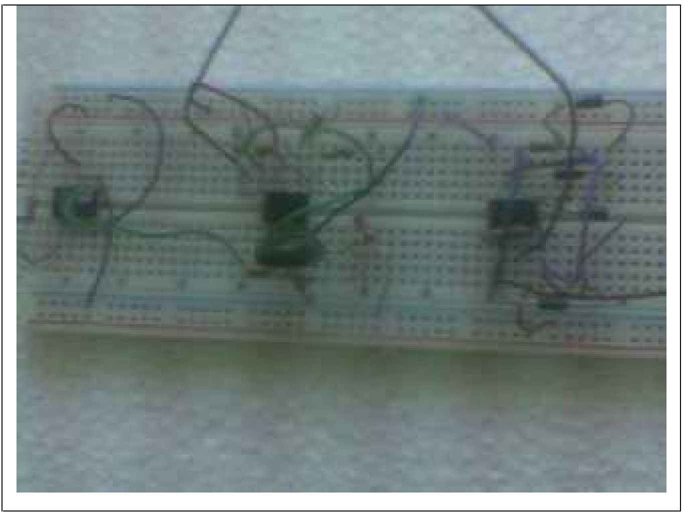


Fig (6.5): Instrumentation amplifier, band bass filter, and rectifier circuits

6.2 Testing and Results

After implementing all individual subsystems and connecting them together, testing operation is done to get the results of each subsystem and the following results appear as follows:

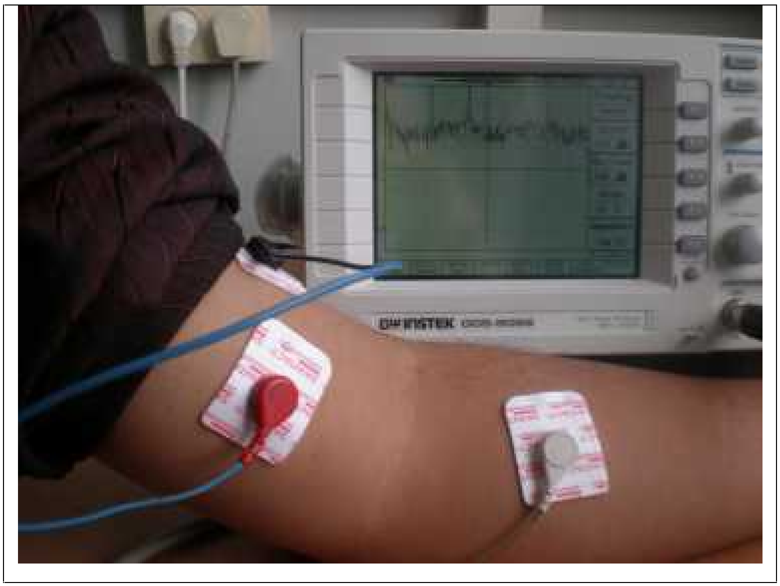


Fig (6.6): Testing bicep muscle & getting results by oscilloscope.

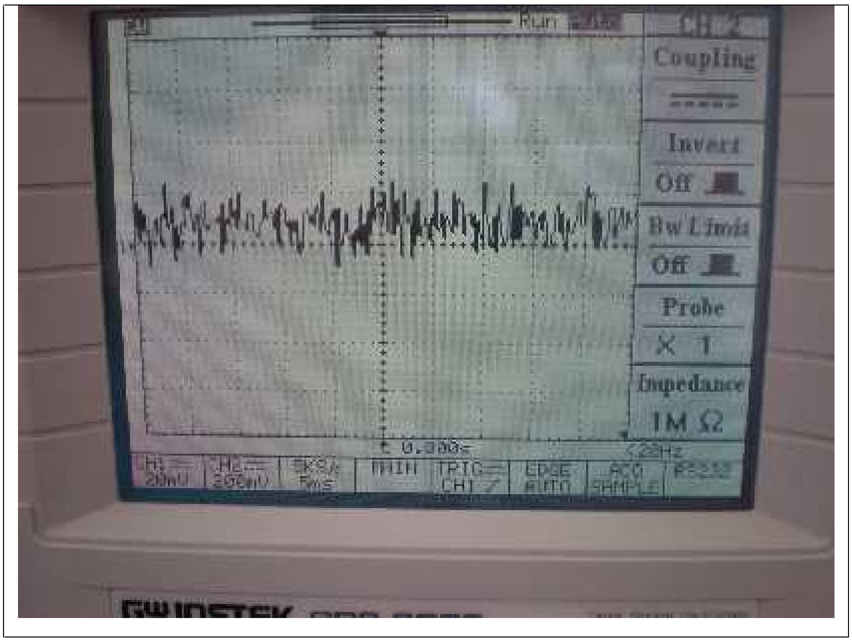


Fig (6.7): AD620 Instrumentation amplifier output at muscle rest.

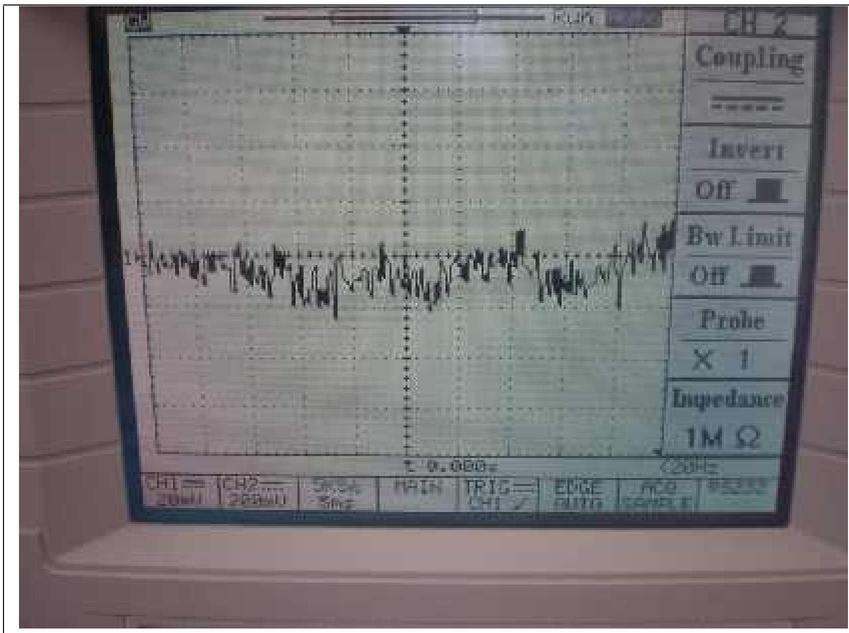


Fig (6.8): AD620 Instrumentation amplifier output at muscle stress.

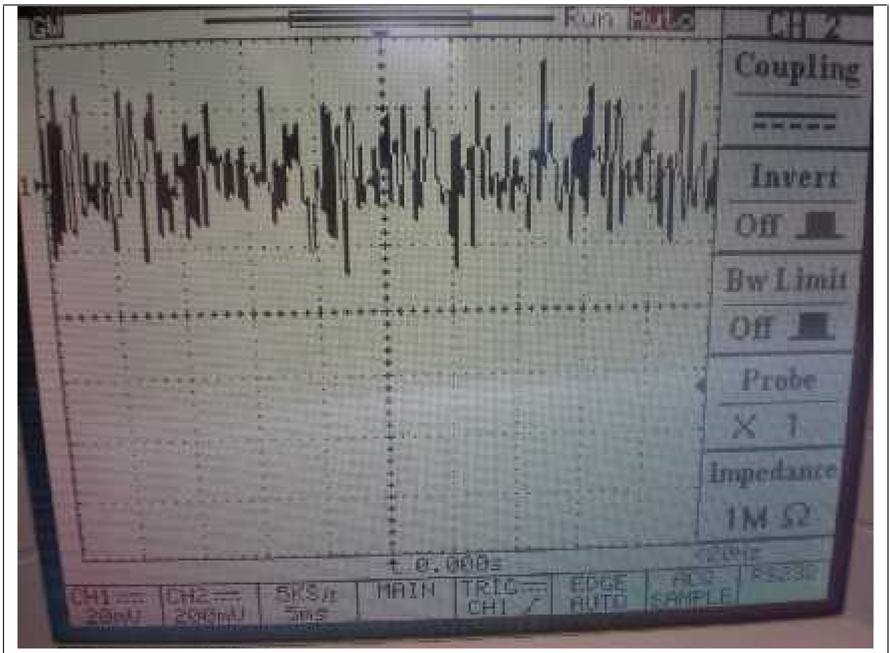


Fig (6.9): Active band pass filter output.

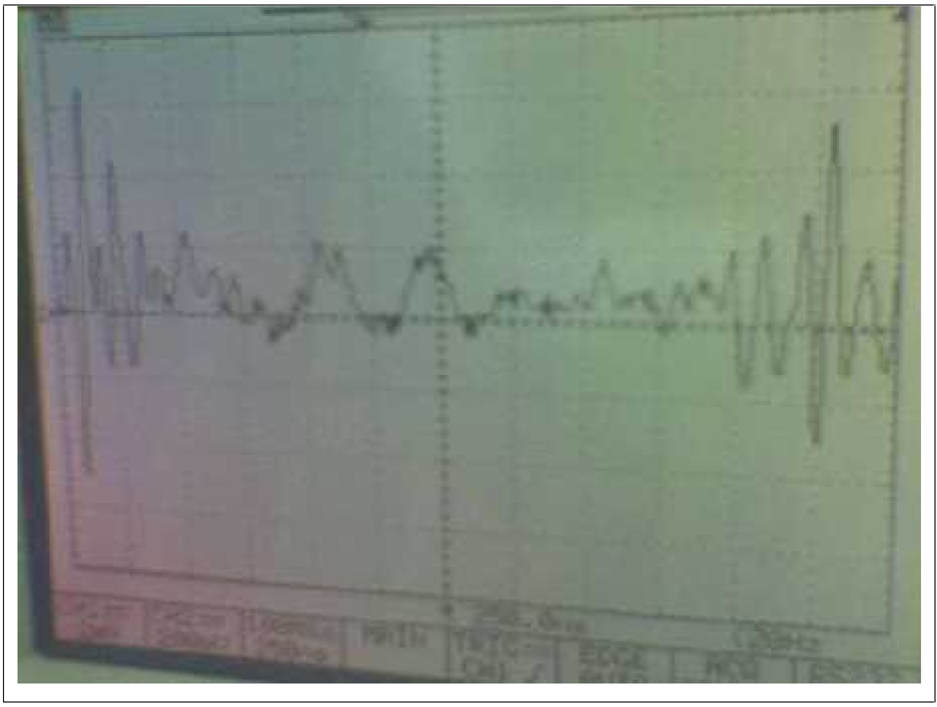


Fig (6.10): Notch filter output.

Chapter

7 SEVEN 7

Conclusion and Future Work

7.1 Conclusion.

7.2 Future Work.

Chapter Seven
Conclusion and Future Work

7.1 Conclusion

The project contains several results, namely:

1. Our project shows that EMG detected signal can be used to control the movement of an artificial part, and this idea is very useful in the prosthetic science.

2. PIC 16F84 is a very useful programmable, easy used device. So we recommend using it in graduated projects, and also focusing on it in some under graduated courses.

3. EMG signal can be taken and analyzed to diagnose many muscle disorders, according to the electrical activity of those muscles.

4. EMG signal characteristics changed according to the type and the place of the muscle, and it also depends on the situation of the muscle (rest, stress, … etc).

5. Controlling artificial parts has many basic ideas and is not an easy operation to be performed, but need great effort and focus in the design process.

6. AD620 operational amplifier is an excellent IC to be used and its price is also good, easy to use; all these reason encourage us to use this IC in our design.

7. Notch filter circuit must be added so as to ensure get red from the 50Hz power lines noise resulting from interference.

8. EMG signal is a very small signal in amplitude and frequency, so we must be very accurate when dealing with this signal, because it needs many processing operation to get it lonely and to separate it from the noise signals.

7.2 Future Work

Our main idea is a very interesting one, and also open many doors in the medical field to help special needs people even it is not a new idea, but it has a central core in the field of designing artificial parts.

The researches about this idea must be developed, to get more opportunities about the ways of controlling and many other things depending on this idea.

APPENDECIES

1. Appendix A (Definitions).

2. Appendix B (Used Programs).

3. Appendix C (Data Sheets).

Appendix A (Definitions)

Term	*Meaning or Definition*
EMG (*E*lectro*M*yo*G*raphy)	**technique of sensing, detecting, and recording of electrical activity of the muscle.**
PIC 16F84	**It is a *P*rogrammable *I*ntegrated *C*ircuit Microcontroller that can be easily programmed to change its function.**
Muscles	**A sort of soft tissues that possess specific contractile properties and function as flexible shortening actuators on the organism.**
Sarcolemma	**A plasma membrane covering the muscle cell.**
Transverse Tubules	**Tunnel-like extensions pass through the muscle fiber from one side to the other one in transverse sections through the diameter of the fiber.**
Sarcoplasm	**Cytoplasm is present inside the muscle cell.**
Mitochondria	**The part of the muscle cell that is responsible for generating or producing energy inside cell.**
ATP "*A*denosine *T*ri*P*hosphate"	**chemical substance used for contracting muscles, transporting substances across the cell membranes, and moving structures within the cell**

Appendix B (Used Programs)

1. Microsoft Word: this program was used for writing the documentation of our project. It is a very easy program to deal with; also gives many opportunities for controlling the options of writing.

2. Microsoft Project: this program was used for generating the scheduling table, and also producing the timing plan. It is an important program and every body must have even little information about this program.

3. Microsoft Visio: this program was used for generating the block diagrams implemented inside this project. This program gives also excellent choices to draw and generate block diagrams.

4. Orcad 9.2: this program was use for drawing the schematic diagrams of the subsystems in our design

Appendix C (Data Sheets)

REFERENCES

Books:

[1] D. Jennings, A. Flint, B.C.H. firton and L.D.M. Nokes, **Introduction to Medical Electronics Applications,** Edward Arnold,1995.

[2] J. Moore, G. Zouridakis, Editors. **Biomedical Technology And Devices Hand book**, CRC PRESS, 2004.

[3] Ed. John G. Webster, **Encyclopedia of Medical Devices and Instrumentations**, Second Edition, Volume 1, A John Wiley & Sons, 1988.

[4] Myer Kutz, **Standard Handbook of Biomedical Engineering and Design**, First Edition, McGraw-Hill, 2004.

[5] Ed. Joseph D. Bronzino, **The Biomedical Engineering Handbook**, Second Edition, CRC Press LLC, 2000.

[6] Malvino, **Electronic Principles**, Sixth Edition, McGraw Hill, 1999

Web sites:

[7]http://www.casaengineering.com/instr.htm

[8]http://www.bmed.mcgill.ca/REKLAB/manual/Common/EMG/Main/specifications.shtm

[9]http://www.bmed.mcgill.ca/REKLAB/manual/Common/EMG/Analysis/

[10]http://courses.ece.uiuc.edu/ece445/projects/spring2006/project37_appendix.doc

[11]http://academic.wsc.edu/faculty/jatodd1/351/ch6outline.html

[12]http://www.isr.umd.edu/Labs/CSSL/horiuchilab/projects/EMGtail/emg_tail.html

[13]http://www.datasheetarchive.com

[14]http://www.datasheet.in

[15] http://courses.ece.uiuc.edu/ece445/projects/fall2007/project2_proposal.doc

[16] http://mxp.physics.umn.edu/s02/Projects/Muscle/Project_Report.htm

[17]http://instruct1.cit.cornell.edu/Courses/ee476/FinalProjects/s2005/bsm24_ajg47/web site/website/index.html