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Title:

Fabric Glove for Measuring the Strength of Fingers And Hand Muscle

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الايه

اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ ﴿١﴾ خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ ﴿٢﴾ اقْرَأْ وَرَبُّكَ
الْأَكْرَمُ ﴿٣﴾ الَّذِي عَلَّمَ بِالْقَلَمِ ﴿٤﴾ عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ ﴿٥﴾



This project is dedicated to

Our fathers , who taught us that the best kind of knowledge to have is that which is learned for its own sake . It's also dedicated to

Our mothers who taught us that even the largest task can be accomplished if it's done one step at a time and all members of

Our families who supported us all the time,

Our friends who gave us the strength to complete our journey and

Our teachers who gave us the light through the way of learning.

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Abstract

This project aims to design a wearable, flexible physiotherapy hand glove. Because the hardness facing the physiotherapist to diagnosis the problems in hand muscle, evaluating the treatment process. So the needed to make the device that wearable, portable to measure the force of fingers increase. This device consist of five force sensors (FSR 402) that is resistive sensor the resistor decrease with the force to measure the press force of finger, microcontroller (atmrga8) to process signal from sensor and calculate the force for every finger, LCD display to display the result from microcontroller and power supply unit to supply all components in circuit, all components sewed and connected in glove using conductive thread to fabricated the circuit to make the circuit flexible and wearable. Determine the normal ranges and abnormal ranges to any individual finger by measuring the force of fingers to thirty normal people, to measure the grip force (pinch grip, support grip, crush grip) calculate the average of force for five fingers, after complete the design experiment in physiotherapy clink for ten abnormal people during four sections the result obtain from device approximately the result obtain from physiotherapist . The design is comfortable for long term wear, portable, low power consumption, easy to use, low cost

المستخلص

الهدف من هذا البحث هو تصميم قفاز مرن لليد يستخدم فى العلاج الطبيعى حيث يقوم بقياس قوة عضلات الاصابع وذلك لمواجهة المشاكل والصعوبات التى تواجهه اخصائى العلاج الطبيعى فى تشخيص الامراض والاصابات والمشاكل المتعلقة باليد والتى تصيب الاصابع خاصة وايضا فى تقييم مراحل العلاج المختلفه, لذلك ازادت الحاجة لتصميم جهاز يمكن ارتدائه وحمله ويسهل التنقل به لقياس قوة الاصابع. هذا الجهاز يحتوى على حساس للقوه من نوع (FSR402) يقوم على مبدأ تغير المقاومه مع تغير القوه المسلطه عليه حيث تقل المقاومه بزياده قوة الضغط ويقوم بتحسس مقدار قوة ضغط الاصبع عليه حيث استعمل خمس حساسات ويحولها الى اشاره كهريبيه تنقل الى المعالج الدقيق من نوع (atmega8) الذى يقوم بحساب مقدار القوه لكل اصبع ثم تنقل الاشاره الى وحدة العرض لعرض مقدار القوه وتغذى كل مكونات الدائره من بطاريه ومعها منظم , وصلت كل مكونات الدائره بواسطة خيط موصل بدلا عن استخدام الاسلاك (conductive thread) لجعل الدائره مرنه ويسهل ارتدائها حدد مدى القوه كل اصبع على حده عندما يكون فى الحاله الطبيعىه وعندما يكون فى حاله مرضيه عن طريق اخذ ثلاثين عينه من اشخاص اصحاء وقياس قوة الاصابع لهم بواسطة الجهاز كل اصبع على حده , لتحديد القوه لجميع الاصابع مجتمعه اخذ متوسط القوه للخمس اصابع , كما جرب الجهاز بعد الانتهاء من تصميمه فى احدى مراكز العلاج الطبيعى على تسعه اشخاص لديهم مشاكل مرضيه واصابات فى الاصابع على مدى اربعة جلسات, . وكانت النتائج المتحصل عليها من الجهاز مقاربه مع نتائج تقييم دكتور العلاج الطبيعى هذا التصميم يعتبر مريح حتى عند ارتدائه لفتره طويله, كما يمكن التنقل به, ولا يستهلك طاقه كبيره, وسهل الاستعمال, ورخيص

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LIST OF ABBREVIATION

AREF	Supply voltage pin for A/D converter
AVCC	Analog reference pin for A/D converter
VOUT	voltage output of voltage divider of FSR sensor
F	force that applied to sensor
R	Resistor of FSR sensor
ACSM	American College of Sport Medicine
MMT	Manual Muscle Test
LCD	Liquid Crystal Display
ROM	Range Of Motion
ICC	Interclass Correlation Coefficient
DGAS	Dynamic Grasping Assessment System
FSR	Force Sensing Resistor
LED	Light Emitting Diode
ADC	Analog to Digital Conversion
PC	Personal Computer
MCU	Micro Controller Unit
EEPROM	Electrically Erasable Programmable Read only Memory
SRAM	Static Random Access Memory
RISC	Reduced Instruction Set Computing

GUI	graphical user interface
DJD	Degenerative Joint Disease
PROM	Passive Range of Motion
AAROM	Active Assistive Range of Motion
AROM	Active Range of Motion
DMT	Diametric Muscle Testing
AMLCD	Active Matrix Liquid Crystal Display
VLSI	Very Large Scale of Integration
AC	Alternative current
DC	Direct current
IDE	Integrated Development Environment
POT	Potentiometer
PTF	Polymer Thick Film
STN	Super Twisted Neumatic

CHAPTER ONE
INTRODUCTION

1.1 Introduction

For many centuries measuring muscle strength has been an area of interest for those who have been studying and are responsible for diagnosing many diseases that are accompanied by loss of strength. Numerous neurological diseases are accompanied by atrophy of the intrinsic muscles of the hand. Therefore, muscle function strength testing is frequently used for clinical decision, Making in rehabilitation medicine, neurology, hand surgery and physical therapy.

The purpose of this muscle strength testing is, besides diagnosis, to evaluate and compare treatments, document progression or regression of e.g. muscle strength during rehabilitation, to provide feedback during the rehabilitation process, and to evaluate handicaps/restrictions of participation after injury, after Hemiplegia (is its most severe form, complete paralysis of half of the body), Hemi paresis (Slight paralysis or weakness affecting one side of the body. Also called hemiamyosthenia) Hemiparesis and hemiplegia can be caused by different medical conditions, including congenital causes, trauma, tumors, or stroke and after Trigger finger, (is a condition in which one of your fingers gets stuck in a bent position)[1].

1.2 Problem statement

Muscle test in physical therapy assessment and evaluations doing by physical therapist in finger disorders as:

- a) After Hemiplegics
- b) After Hemi paresis
- c) Weakness of muscle after fracture
- d) Weakness of muscle due to disuse
- e) Trigger fingers

Previously the measurement of muscle strength depend on the physical therapists them self how much are resistance that giving to patients therefore it change according to mode (nervous, worry ,sadness) and the fitness(sex ,age ,illness) of the therapist that is lead to:

- a) Not Accurate to obtain the level of progress in treatment,
- b) Measurements are done by observation so it takes time,
- c) Not appropriated for research,
- d) Suffer from human error,
- e) Quality of measurements,
- f) Need hard effort to appropriate do test,

1.3 Main Objectives

The general objective of the current project is to design, prototype and test the physiotherapy gloves

1.4 Specific Objective

The specific objective is to design a wearable monitoring glove that is:

- i. Convenient for user,
- ii. Easy to wear,
- iii. Use with flexible and soft material,
- iv. Low cost,
- v. Portable.

1.5 contribution of project

The mean contribution of this project is based on using soft and fabric materials as hand glove device. The device has been proposed to measure the strength of fingers and hand muscle. Moreover the components used in device have been connected together using conductive thread unlike

previous devices that focused on the usage of wires as connected between components

1.6 Methodology

In this research, an effort has been made to study and investigate the possibilities designing and fabricating a wearable physiotherapy and monitoring gloves. The major scopes of this research are detailed as follows:

- i. Study and understand the techniques to monitor the patient in order to enhance the physiotherapy treatment
- ii. Conduct simulation and experiments techniques to investigate, examine and categorize each component required and necessary for designing the wearable gloves
- iii. Build the preliminary circuit to investigate the possibility of sewing component
- iv. Build the circuit (stage1) using rigid component
- v. Build the circuit (stage2) using fabric material
- vi. Evaluate and compare measured results and consequences of the wearable gloves with simulated results
- vii. Finalize the designs, compile reports, and produce regional/international conferences and journal papers ,as described in figure 1.1

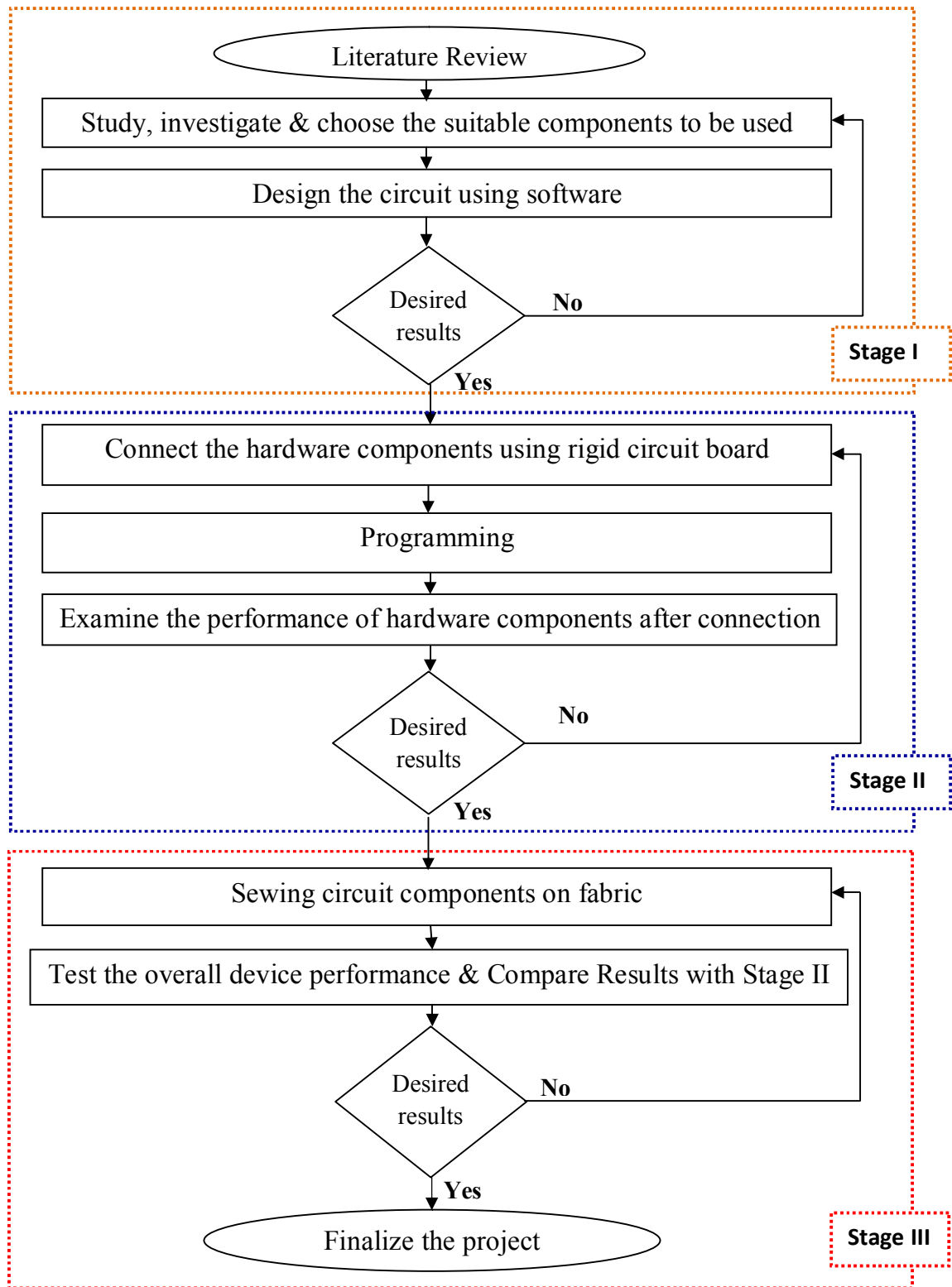


Figure 1.1: Methodology of the Research

1.7 Project organization

The thesis consists of six chapters. The current chapter discusses the problem definition, justification for carrying out the research, and objectives. The chapter is introduced with the vision of the importance of measuring the muscle strength and some traditional ways to do that.

Chapter 2 reviews some of the previous researches on some attempts to invented new ways to measure the muscle strength of hand and fingers , also some research using FSR sensor, and researches using conductive thread, The anatomy of hand and fingers (muscles and bones) are introduced in Chapter 3. The traditional ways to measure the manual muscle tests are also discussed, Chapter 4, discuss the options of components using in this design, the software procedures where the microcontroller is programmed along with the options available for the purpose were discussed as well as the stages of fabrication the device, Chapter 5 discusses and presents results obtained by the design and some troubles that have been in the research path. Also discusses the device final designs that have been tested to indicate the final results achieved as well as the efficiency of the device, The conclusions are stated in Chapter 6 together with the findings summary of the research and suggestions for other areas of additional research.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The first public research report on wearable devices dates back to 2001, in which a fabric electronic device was designed for wearable and ubiquitous equipment. Since then the research on wearable devices has received growing interest among universities and industry researchers. Recently, textile electronic devices have been presented in international conferences as well as journal papers. These studies have demonstrated that fabrics are suitable for wearable electronic and medical devices.

This chapter will discuss the previous work and research related to the force of the finger, usage of FSR sensor, tactile materials.

2.2 Measures of the Force of the Finger

Laura Dipietro, PhD et al [2] , they designed Humanglove using for quantitative assessment of digit range of motion (ROM) is often needed for monitoring effectiveness of rehabilitative treatments and assessing patients' functional impairment.

A 20-position sensors glove had been used to measure fingers' ROM, with particular regard to measurement repeatability. With this aim they had been performed a series of tests on six normal subjects. Data analysis had been based on statistical parameters and on the intraclass correlation coefficient (ICC). Sources of errors that had been affected measurement repeatability were also analyzed. The results demonstrated that, in principle the glove could be used as goniometric device.

The main advantage yielded by its use is reduction in the time needed to perform the whole measurement process, while maintaining process repeatability comparable to that achieved by traditional means of assessment. It also allows for dynamic and simultaneous recording of

hand-joint movements. This device is not very precise, so Future work will investigate accuracy of measurements.

A Dynamic Grasping Assessment System (DGAS) was designed and investigated by T. Keller et al [3], that provides quantitative assessment of the grasping function and allows the grasping function improvements to be monitored over time can potentially be very useful for hand surgeons, physiotherapists and occupational therapists.

DGAS that is capable of measuring finger forces during wrist extension, flexion, adduction and abduction was developed. The DGAS can measure forces for each individual finger in the range from 0 to 125 N with accuracy of ± 0.5 N, and can measure the wrist extension/flexion angle and the wrist ulnar/radial abduction angle with an accuracy of ± 0.25 deg. Furthermore the DGAS is capable of generating resistive torque during the wrist motion and allows to assess finger forces during wrist motion against resistive load.

B.D. Lowe *et al* [4] in their research they developed the athletic grip gloves for the measurement of hand contact force. The system incorporates 16 to 20 thin profile conductive polymer pressure sensitive resistors attached to a thin athletic grip glove to cover the pulpar regions of the phalangeal segments and palm that contact the grasped object.

The electrical responses of these sensors had been found to be linear when calibrated against applied force distributed over the sensor surface area. It had been constructed a custom power supply and amplifier module to provide excitation and an adjustable gain to scale all sensor outputs for compatibility with a +5V analog to digital data acquisition board. Attaching thin profile pressure/force sensors to a glove had the advantage of its low cost, replaceable sensors, facilitating measurements of hand force on any grasped object, such as a hand tool,

without the need to instrument the tool itself. The disadvantage of this measurement approach is that the material properties of the glove and sensor may alter the frictional conditions between the hand and the tool and may degrade tactile representation of the coupling between the hand and the tool. If these limitations are acceptable the glove-based system is a useful measurement device for characterizing hand grip contact forces in the evaluation of many hand tools.

2.3 Sensors

Sivaramakrishnan Rajaraman *et al* [5], They had been made project that aims to train health professionals in a basic newborn care it had been used a prototype with an ultimate objective to have one person at every delivery trained in neonatal resuscitation. This prototype will be a user-friendly device with which one can get trained in performing neonatal resuscitation in resource-limited settings.

They had been used in this project the Force Sensing Resistor (FSR) that measures the pressure applied and is interfaced with Arduino® which controls the Liquid Crystal Display (LCD) and Light Emitting Diode (LED) indication for pressure and compression counts.

FSR sensor had been observed that , it was a smaller size and low power consumption can be easily embedded into the system. The controller, to which the FSR is interfaced with, is Arduino®, an open source platform available for electronics prototyping for creating interactive environments. However, the FSR sensor was difficult to calibrate.

Prof. Dr. Kerstin Dautenhahn *et al* [6], They had been made project aimed to explore the possibility of using FSR Sensors with the humanoid robot KASPAR in order to gain tactile feedback. The FSR

sensor had been used and the Arduino board used to receive the sensor data and send it to the computer is discussed.

FSR sensor had been observed that , it had advantage and disadvantage as below:The main advantages of FSR sensors is that they are cheap, self-adhesive and very robust enduring up to 10M actuations. FSR sensors are simple variable resistors, thus the circuit used for reading the resistor value is summarily very simple.

However the FSR sensors have a very long tail and careful consideration needs to be taken at the design stage to ensure there will be enough space for the tail connector. Theses sensors also have the disadvantage that if you blend them they change their resistor values. In addition, it was very hard to and a suitable connector for the sensor, and applying the sensor to curved surfaces can cause pre-loading.

Stacy J. Morris Bamberg et al [7], they described a wireless wearable system that had been developed to provide quantitative gait analysis outside the confines of the traditional motion laboratory. The sensor had been suited includes three orthogonal accelerometers, three orthogonal gyroscopes, four force sensors, two bidirectional bend sensors, two dynamic pressure sensors, as well as electric field height sensors. The “GaitShoe” was built to be worn in any shoe, without interfering with gait and was designed to collect data unobtrusively, in any environment, and over long periods.

FSR sensor had been observed that , it was easy to use, low power consumption, and cost effective , however it was The output of the FSRs is nonlinear, somewhat due the choice of conditioning electronics. Also, over time and with use, the adhesive layer in the FSRs may break down and contribute to an increased nonlinearity.

E.MuthuSundhara Pandiyan et al [8], this project had been designed to measure the heart rate of an elderly people and to alert the

care taker when the heart rate is abnormal. The innovation done in this project is measuring the force of the heartbeat at the wrist and thereby measuring the heart rate. This device can be implemented by means of wrist watch or wrist band. It also monitors the heart rate of the people for 24 hours.

The FSR sensor had been used in this project to measure the heart rate (change its resistive value depending on the force of the heartbeat.), it had been observed that it was low cost, easy to use and less sensitive to temperature. However, it was rarely accurate.

2.4 Tactile Materials

Scott Gilliland et al[9], this paper had been studied The Textile Interface Swatchbook demonstrates how conductive embroidery can render graphical user interface-like(GUI) widgets on fabric. Such widgets might be used to control mobile electronics such as a music player, mobile phone, or projected display. At present, six swatches have been created for the swatchbook: pleat, menu, rocker, multitouch gesture, zipper, and proximity. The three most diverse and original are discussed here. In addition, we develop a hybrid resistive-capacitive touch sensing technique designed to be more tolerant to the flexing typical of fabric.

In this paper had been used a thread that is coated with silver. There are many variants on these types of threads; thicker conductive threads are wound from thinner ones, and the thicker ones less resistance per unit length. In this research had been used thicker thread was constructed from 4 thinner threads. The thicker thread is less flexible and may have difficulty feeding through an domestic embroidery machine, possibly causing the machine damage.

A research done by Shiyu Zhang *et al* [10] was focused on using conductive threads to design flexible antennas with textile features which means antennas can be embroidered directly into normal clothes. The fabric microstrip antennas had been made from commercial conductive threads. They found that better conduction and lower loss can be achieved by stitching threads in a direction parallel to the current flow.

Inese Parkova *et al* [11], this research had been presented the comfort properties of nocturnal enuresis alarm system, a modular humidity sensor should be replaced with a textile sensor. In this research, two-electrode textile moisture sensor had been developed to study its electrical properties. Cotton fabric substrate and polyamide silver-coated conductive yarns had been used for moisture sensor designing.

CHAPTER THREE

BASIC PRINCIPLE

3.1 Introduction

Together with the brain, the hand is the most important organ for accomplishing tasks of adaptation, exploration, prehension, perception and manipulation, unique to humans. To study the anatomy and kinetic chains of the hand and the complex interplay of more than 40 muscles that control its movements requires an appreciation of the biomechanics of the hand and its dexterity.

The muscles of the lower arm and hand can be conveniently arranged according to innervation and localization. Usually the muscles are divided into extrinsic ones, where muscles have their origin proximal to the hand and intrinsic muscles which have their origin and insertion within the hand.[12]

3.2 Hands and Fingers Bones

There are 28 bones in hand, where bones of phalanges are 14 bones, meta carpals are 5 bones, carpals had 9 bones all these configurations of bones are shown in figure 3.1.

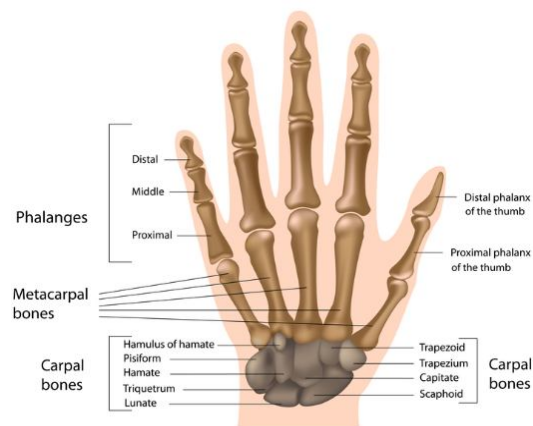


Figure 3.1: Hand and fingers bones

3.3 Diseases of Hands and Fingers muscles

There are several types of hand and fingers muscle diseases such as Impaired Muscle Performance, Endurance Impairment, Nerve Injuries, etc..., These types of diseases can be treated in several ways. However, the treatment of these diseases are not of this project concerns.

3.4 Types of muscles strength

3.4.1 Normal muscle strength

Muscle strength was introduced as a medical subject heading by the National Library of Medicine and the National Institute of Health (PubMed database) 'Muscle strength' is there defined as the amount of force generated by muscle contraction. Muscle strength can be measured during isometric, isotonic, or isokinetic contraction.

3.4.2 Muscle endurance

Muscle endurance was defined by the American College of Sport Medicine (ACSM) as the ability of a muscle group to execute repeated contractions over a period of time sufficient to cause muscular fatigue, or to maintain a specific percentage of the maximum voluntary contraction for a prolonged period of time . In general, skeletal muscle endurance is more impaired than skeletal muscle force in many chronic diseases.[1]

3.5 Methods to measure muscle strength

Physical therapists require an accurate, reliable method for measuring muscle strength. They often use manual muscle testing (MMT) or hand-held dynamometric muscle testing (DMT).

3.5.1 Manual muscle test (MMT)

The Manual muscle testing is a procedure for the evaluation of the function and strength of individual muscles and muscle groups based on the effective performance of a movement in relation to the forces of gravity and manual resistance. Although the MMT is widely used within clinical contexts, it is a descriptive, subjective and less sensitive method.

Classically, muscle force is often assessed using manual muscle testing. Manual muscle testing was first described by Wright in 1912. The five point Medical Research Council scale is undoubtedly the most commonly used scale. This scale assesses muscle force with five grades where zero means that no contraction is visible or can be felt, three means that a limb can be moved against gravity with no additional resistance. Five means that the subject can move the limb against a normal resistance over the full range of motion. This scale is easy to use and allows assessment without the use of tools. Assessment without the use of tools it has been shown that the scale lacks accuracy and responsiveness in ambulant patients with muscle weakness.

The Manual muscle testing has several limitations such as that the muscle group is tested rather than just one muscle. Some have suggested labeling the movement rather than the muscle. Moreover, MMST is not appropriate for higher-level muscle function due to lack of sensitivity and precision, and should be used in conjunction with other evaluation tools. The MMST is dependent on the examiner's ability to assess the pressure as a parameter for strength. Experience of the examiner is important for reliable measurements [13].

3.5.2 Dynamometry

Dynamometry is a method of strength testing using sophisticated strength measuring devices (e.g., hand-grip, hand-held, fixed, and isokinetic dynamometry). When performing strength testing a particular muscle or muscle group is first isolated, then an external force is applied.

The portable dynamometer is capable of providing accurate, valid, reliable, and sensitive measurements of strength; however, its relatively high cost has hindered its use in most clinical contexts, including those in which there are insufficient financial resources, Depends on proper positioning, less dependent on technique; limited normative data; possible calibration errors [14].

An alternative to MMT is a quantitative, instrumented system for assessing muscle strength. The Graham-Desagu-liers force dynamometer, developed in London in 1763 to measure human muscle strength while eliminating syn-ergistic activity, was the earliest reported instrumented system.

In 1798, Regnier in Paris invented an all-purpose portable dynamometer, which he used for the first recorded attempt to study muscle strength in individuals with diseases. Numerous devices have been designed since to provide objective, quantitative strength measurements. They register the peak force generated by a muscle through loading in tension or compression [1].

Such a dynamometer should be easy to handle, e.g. portable and with an ergonomical design. It should also have the possibility to measure the opposition force of the thumb. Reliability should be good with acceptable measurement error making it possible to detect reasonably small changes in muscle strength.

The dynamometry method has several limitations such as that the measurement on a dynamometer is not always feasible. In order to assess

skeletal muscle strength bed-side, or when a large apparatus is unavailable also care must be taken that the age range and positioning is correct [12]

3.5 Types of tests used to evaluate hand muscles strength

1. Finkelstein Test

Finkelstein Test Indicates stenosing tenosynovitis (de Quervain's disease). shown in figure 3.2.

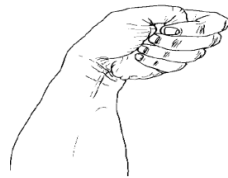


Figure 3.2: Finkelstein Test

2. Grind Test

In the grind test, the assessment of osteoarthritis in the carpometacarpal joint of the thumb. shown in figure 3.3.



Figure 3.3: Grind test

3. Stability Test

Stability Test for a Torn Ulnar Collateral Ligament in the Metacarpophalangeal Joint of the Thumb. shown in figure 3.4

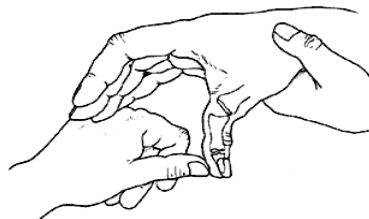


Figure 3.4: Stability Test for a Torn Ulnar Collateral Ligament in the Metacarpophalangeal Joint of the Thumb

4. Tests of Motor Function in the Hand

The Tests of Motor Function in the Hand Demonstrate motor and sensory deficits in the presence of nerve lesions. This type of test is divided into the followings:

- a) Testing the Pinch Grip: shown in figure 3.5 (a).
- b) Testing the Key Grip: shown in figure 3.5 (b).
- c) Testing the Power Grip: shown in figure 3.5 (c).
- d) Testing the Chuck Grip: shown in figure 3.5 (d).
- e) Testing Grip Strength: shown Figure 3.5 (e).

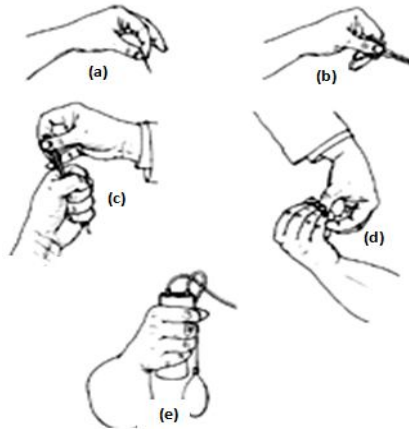


Figure 3.5: Tests of motor function in the hand, (a) Pinch grip, (b) Key grip, (c) Power grip, (d) Chuck grip, and (e) Testing grip strength

5. Thumb Extension Test

Assesses a radial nerve lesion, as shown in figure 3.6.

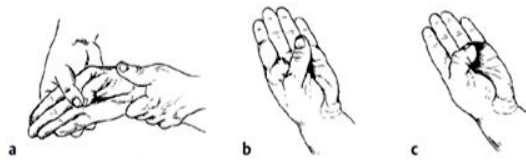


Figure 3.6: thumb extension test:(a) Starting position, (b) Normal function, and (c)Abnormal weakness in thumb extension

6. Supination Test

This test is used to assess supinator pathology shown in figure 3.7.

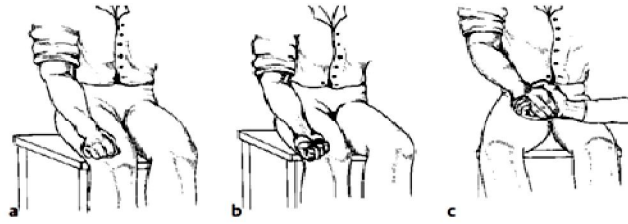


Figure 3.7: Supination test, (a) Starting position, (b) Normal supination, (c) Supination against resistance

7. **Bottle Test**

Indicates median nerve palsy. as shown in figure 3.8.

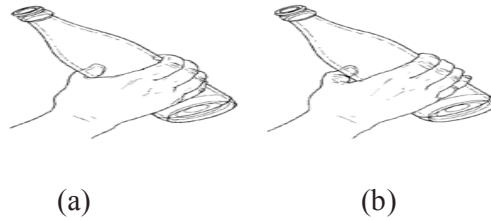


Figure 3.8: Bottle test, (a) Normal, (b) abnormal

8. **Froment Sign**

Indicates a cubital tunnel syndrome. as shown in figure 3.9.[15].



Figure 3.9: Froment sign test, (a) normal, (b) abnormal

CHAPTER FOUR
SOFTWARE AND HARDWARE
IMPLEMENTATION

4.1 Introduction

In order to design a system, one of the major concerns is the choices made to decide the type of hardware to be used in the required circuit design. In fact, the size and weight of the device are the most important considerations of any wearable device. Therefore, a wearable physiotherapy hand glove generally should have a signal-processing unit, sensor to measure the muscle strength, power supply (battery), On/Off switch, voltage regulator, LCD to display results and soft fabric suitable for wearable applications.

4.2 Microcontrollers

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals, Microcontrollers come in many varieties, Depending on The power and features that are needed, table 4.1 shows an example for the difference between several types of microcontrollers.[16]

Table 4.1: Comparisons between Common Types of Microcontrollers

No.	Type	Advantages	Disadvantages
1	ARM	High speed operation	Not available, high cost
2	8051	Low cost	High power consumption
3	AVR	Low cost , available, low power consumption , effective	Low speed ,small memory
4	PIC	Low cost , available, low power consumption	Low speed ,small memory
5	Motorola	High speed operation	More expensive
6	Texas (MSP)	Ultra low power consumption	Not available, high cost

Atmel Atmega8 microcontroller has been selected for this project hence a large flash memory is required by the project circuit design. Therefore, that makes the Atmel Atmega8 microcontroller cheap in price, small in size, easy in programming and available in the markets, figure (4.1). The Atmel Atmega8 has the following features:

- a) High-performance
- b) Low-power.
- c) Advanced RISC Architecture.
- d) High Endurance Non-volatile Memory segments.
- e) I/O and Packages, 23 Programmable I/O Lines, 28 lead PDIP.
- f) Operating Voltages 5 V - 7V.
- g) Speed Grades 0 - 16MHz, Other performances, features and data sheet of the Atmel Atmega8 microcontroller is provided in Appendix A



Figure 4.1: Atmel Atmega8 microcontroller

4.3 Sensors

There are several pressure sensors available on the market. Such sensor technologies utilize capacitive sensors, resistive sensors, piezoelectric sensors and piezoresistive sensors, these sensors provide electrical signal output (either voltage or current) that is proportional to the measured pressure. The required key specifications for a pressure sensor in terms of sensor performance include linearity, hysteresis, and temperature sensitivity, sensing size and pressure range. The most common pressure sensors shown in table 4.2.[17]

In this project Force Sensing Resistors, (FSRs) has been used , that are robust polymer thick film (PTF) devices that exhibit a decrease in resistance with increase in force applied to the surface of the sensor. FSR sensors are simple variable resistors, thus the circuit used for reading the resistor value is summarily very simple it has been connected as voltage divider [18].

The value of the resistor determines the range of weight that can be read by the microcontroller . In this project has been used a 10K resistor because it will enable us to read forces of 20g or less. Choosing a higher value resistor will give the ability to read smaller forces, but would decrease the ability to distinguish between greater forces [7].

Force accuracy ranges from approximately 5% to 25% depending on the consistency of the measurement and actuation system The force resolution of FSR devices is better than 0.5% of full use force[18].

In this project has been used the standard FSR 402 sensor is a round sensor 18.28 mm in diameter. (this model has been chosen due to it has suitable shape for finger and more available in the market), Figure 4.2 demonstrates the FSR 402 sensor, The main advantages of FSR 402 sensors are that they are cheap, and very robust enduring up to 10M actuations, However the FSR sensors have a very long tail and careful consideration needs to be taken at the design stage to ensure there will be enough space for the tail connector. Theses sensors also have the disadvantage that if you blend them they change their resistor values.

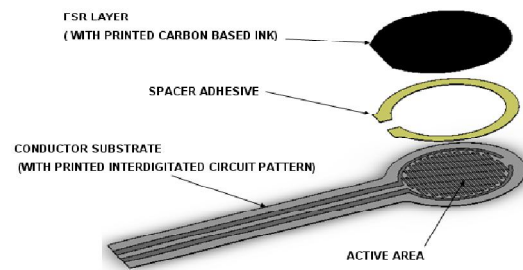


Figure 4.2: FSR 402 sensor

Table 4.2: Types of sensor, principle, advantage and disadvantage

Name	Capacitive sensor	Resistive sensor	Piezoelectric sensor	Matrix kit sensor
Principle	The sensor is a capacitor the distance between the two plates resulting in a voltage change proportional to the applied pressure	the sensor measures the resistance of conductive foam between two electrodes. The current increases as the conductive layer changes under pressure	The sensor produces an electric field (voltage) in response to pressure	Using neoprene, Velostat (a piezoresistive plastic film that reacts to pressure with a decrease in resistance), conductive thread and stretch conductive fabric to construct a fabric bend sensor.
Adv.	low cost ,low power ,good stability and reliability, resolution, speed, easy to integrate into ICs ,Good frequency response ,Low hysteresis ,Good linearity	Low cost , dynamic cell response ,thin and light weight , reliable technology , added value	Low cost , High sensitivity ,Broad frequency range ,Exceptional linearity ,Excellent repeatability ,Small size	Low cost , low power
Disadv.	High sensitivity to temperature- Acceleration- Orientation- Mechanical noise	Not too sensitive –does not support multi-touch	React to temperature as well as pressure, The response drifts with temperature work on very high frequencies, up to 100 KHz-high impedance	Difficult to make – low accuracy

4.4 LCD LM016L (16x2) Display

One of the most commonly and cheapest LCD is the LM016L that has the following specifications:

- a) LCD Display Mode : STN, Negative, Transmissive
- b) Display Color: Display Data = “1” : Light Gray (*1)
Display Data = “0” : Deep Blue (*2)
- c) Viewing Angle : 6H
- d) Driving Method : 1/16 duty, 1/5 bias
- e) Back Light : White LED backlight (the advantage of the led backlight mention in previous chapter)
- f) Size: 16*2 this size has been chosen because of the limitation of the space provided in the fabric glove, Figure 4.3 demonstrates the LCD, used in the project circuit design. Moreover, other performances, features and data sheet of the 16 x 2 LCD Display is provided in Appendix E.[19]

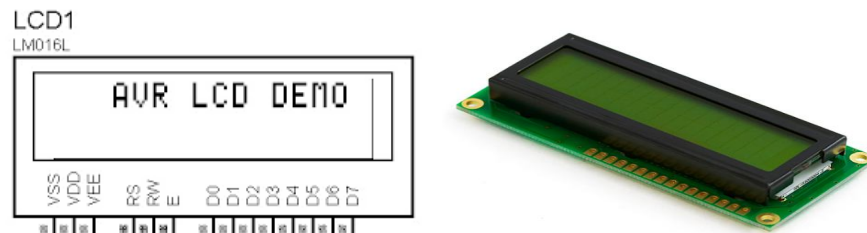


Figure 4.3: LCD LM016L Configuration

4.4 Voltage Regulator LM7805

In this project LM7805 regulator has been chosen because it is widely available in the market, its small in size and gives the desired output voltage. The LM78XX series of three terminal positive regulators

are available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents. Figure 4.4 shows the type of regulator used in the circuit design. On the other hand, other performances, features and data sheet of the LM7805 regulator is provided in Appendix B.[20]

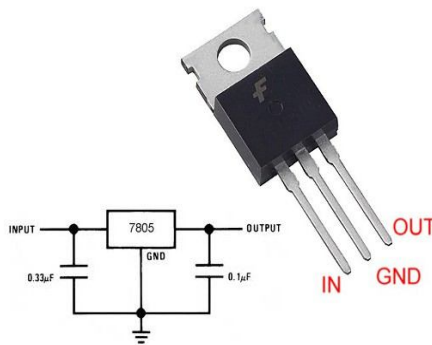


Figure 4.4: The LM7805 type of regulator used in the circuit design.

4.6 Conductive thread

Until not too long ago the mixed properties of electronics and textiles was unheard of. With technology moving as fast as it has in recent years, the possibilities of clothing and accessories with visual and audio effects by the use of flashing lights sensors and piezo-electronics has now been made much easier in a domestic situation with the availability of conductive thread.

Conductive thread is similar in properties to ordinary sewing thread but it also has the ability to conduct a small amount of voltage through it. It can do this as it has metal incorporated into it (usually silver, nickel, tin

or copper) with a core of normally cotton or polyester. The thread is not insulated and therefore attaching it to a metal component within a circuit in place of the usual wires means the circuit is much more flexible allowing you to maintain many of the original properties of the material such as drape and feel. As it is a thread it also allows you to sew by hand or machine and even embroider designs into textiles. Its resistance properties are 4Ω per 100mm[21] as shown in figure 4.5.



Figure 4.5: Conductive Thread

4.7 Extracting the Equation of FSR 402 sensor

The value of the resistor determines the range of weight that can be read by the microcontroller. In this project has been used a 10K resistor because it will enable us to read forces of 20g or less. Choosing a higher value resistor will give the ability to read smaller forces, but would decrease the ability to distinguish between greater forces to determine the equation, the values (force vs volt) have been obtained from stander graph from datasheet provided in Appendix D, the EXCEL programming has been used to re-draw the graph in order to obtain the reliable equation as shown in figure 4.6.

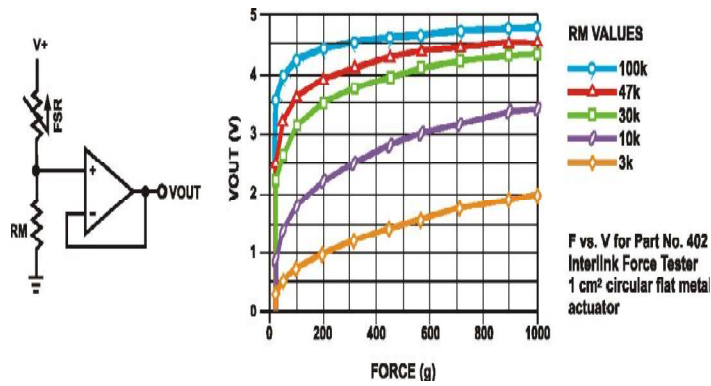


Figure 4.6: Curve of sensor (volt vs force)

From the graph, we found that:

$$V_{OUT} = 0.6799 \ln(F) - 1.3325$$

$$F(g) = e^{((V_{OUT} + 1.3325) / 0.6799)}$$

$$F(n) = F(g) * 9.8$$

$$F(KN) = F(n) / 1000$$

Where:

V_{OUT} = Voltage Output (of voltage divider) of FSR sensor F = Force that applied to sensor

According to that, at the first stage of simulation we assumed that the force of each finger can be divided into four levels indicating strength or weakness of the figure muscles. Hence, 100 indicates full strength and zero indicate totally weakness.

These levels are:

- a) Level 0: from 0.7 up to 25
- b) Level 1: from 25 up to 50
- c) Level 2: from 50 up to 75
- d) Level 3 : from 75 up to 100

Each finger has been given a code to represent the name of the finger when it is displayed on the LCD. The sign of each finger is described in table 4.3

Table 4.3: the code that represents each finger in the LCD display

No.	Finger	Sign/code
1	Little finger	A
2	Ring finger	B
3	Mid Finger	C
4	For Finger	D
5	Thumb	E

4.8 Software Design and Simulation

The purpose of this stage is to have a virtual representation of the circuit to make sure that if the circuit is to be implemented in real life it would actually work, the simulation shown below shows the connections made. Proteus application software is used to test the design in an easy and simple way. The simulation presents the sensing unit, processing unit and indicating stage of the design

4.8.1 Atmel Atmega8 Microcontroller in circuit Simulation

The microcontroller had been programmed by easy used application known as BASCOM-AVR. Although, there are several types of programming language available to program microcontrollers such as assembly, BASCOM and C/C++. The microcontroller was programmed with BASCOM-AVR due to the compiler that uses a version of Basic that is very similar to QBASIC to produce programs.

The AVR. BASCOM-AVR uses an Integrated Development Environment (IDE) which allows you to write and edit programs, compile them, test them with a simulator and finally write the program to the microcontroller for use in a circuit.

Therefore, the microcontroller atmega8 has been used, port b was configured as output, connected to LCD display, port C was configured as input, and connected to the sensor, AREF and AVCC were connected to the ground as shown in figure 4.7.

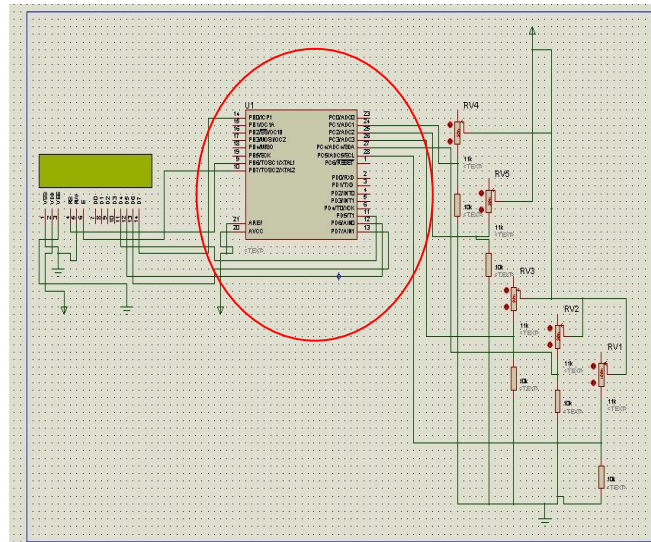


Figure 4.7: Implementing the Atmel Atmega8 microcontroller in simulation

4.8.2 The Potentiometer as FSR Sensor in circuit Simulation

Potentiometer (POT_HG) has been used instead of FSR 402 sensor because it is not available in proteus program ,one terminal is connected to VCC ,second terminal is connected to resister(10K) and from it to the ground ,between the potentiometer and the resister is connected to the microcontroller ,the third terminal is not used as shown in figure4.8.

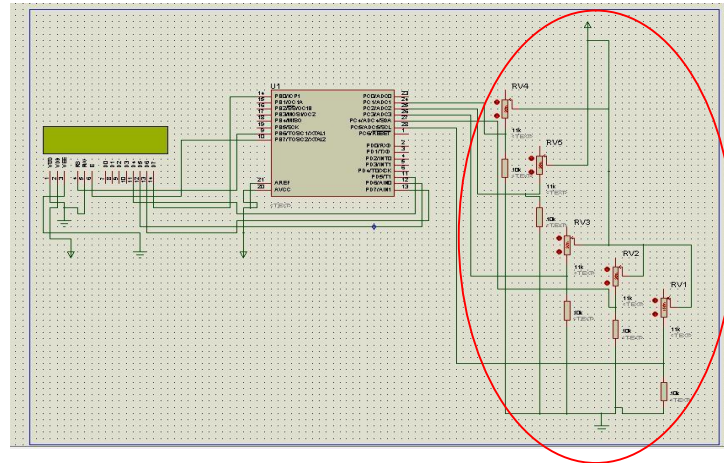


Figure 4.8: Implementing Potentiometer as FSR sensor in simulation

4.8.3 The LCD LM016L in Circuit Simulation

LCD display (LM016L) has been used to display the result , it connected to microcontroller as mentioned above, VEE (pin 3), VSS (pin1) and R/W (pin5) connected to the ground , and VDD (pin2) connected to VCC as depicted in figure 4.9.

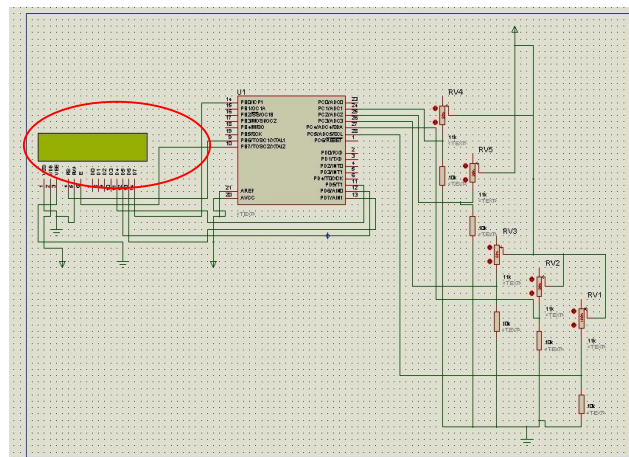


Figure 4.9: LCD configuration in simulation

To organize the LCD display because it was very small, first the result of three fingers has been displayed as depicted in figure 4.10, and then the result of others fingers and average has been displayed as depicted in figure 4.11. Moreover, figure 4.12 represent the whole circuit in simulation.

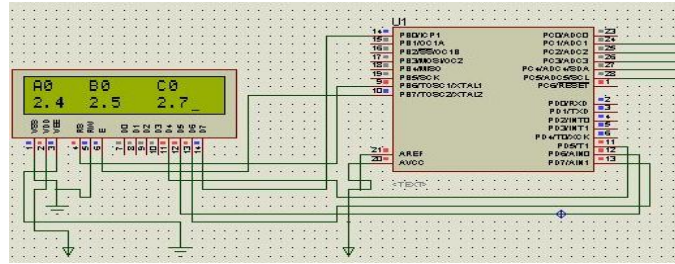


Figure 4.10: Result of three fingers as Little finger, Ring finger and Mid Finger have been displayed in the LCD

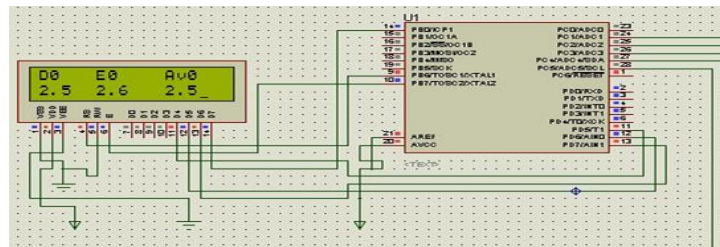


Figure 4.11: Result of For finger, Thumb and average have been displayed in the LCD

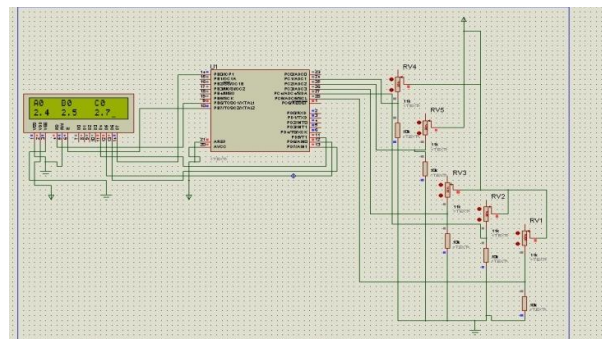


Figure 4.12: The whole circuit in simulation.

4.9 Hardware Implementation

The process of hardware implementation has been divided into three stages. Figure 4.13 represents the three stages of hardware implementation.

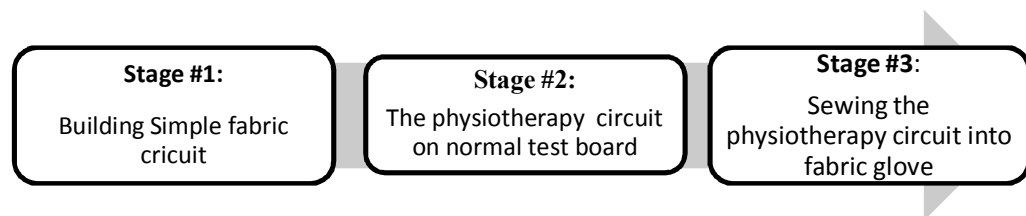


Figure 4.13: Stages of hardware Implementation

4.9.1 First Stage (Building Simple Fabric Circuit)

In this stage of project, studies has been made to investigate the possibilities of using soft materials instead of PCB, by using switch, LED, and battery connected together by conductive thread on a fabric as shown in figure 5.18. Therefore, figure 4.14 (a) shows the circuit when the battery is Off while figure 4.14 (b) shows the circuit when the battery is ON.

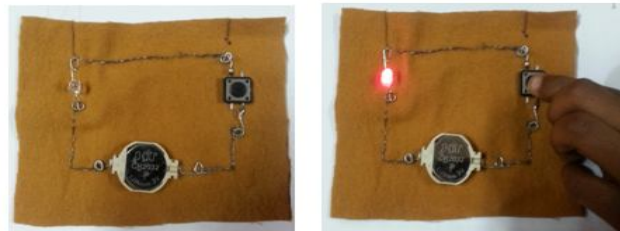


Figure 4.14: Building simple fabric circuit (a)The circuit when the battery is off, (b) The circuit when the battery is on

4.9.2 Second Stage by Building The Circuit on Test Board

To make the final design in textile material firstly the component combined in a test board . according to the simulation to make sure the output is as supposed to be.

First: the battery (9v) connected to the push button switch then connected to voltage regulator to drop the voltage to 5v

Second: from the voltage regulator the power derived to LCD ,microcontroller ,sensors

Third : in LCD pin (1,3)connected to ground , pin(2) connected to VCC ,and the other pin connected to microcontroller in port B as output signal and port C as follow : Db4 = Portd.5 (pin 11) , Db5 = Portd.6 (pin 12) ,

Db6 = Portd.7 (pin 12) , Db7 = Portb.0 (pin 14) , Rs = Portb.6 (pin 9) , E = Portb.7 (pin 10)

Fourth: One terminal of sensor connect to ground directly and another terminal connect to microcontroller and to resistor to limitation the current this is connection is voltage divider as shown in figure 4.15. The sensors connected to port C as input to microcontroller. The circuit finally seen in figure 4.16

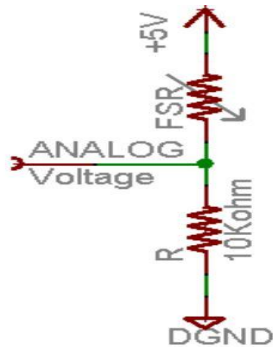


Figure 4.15: Voltage Divider Connection

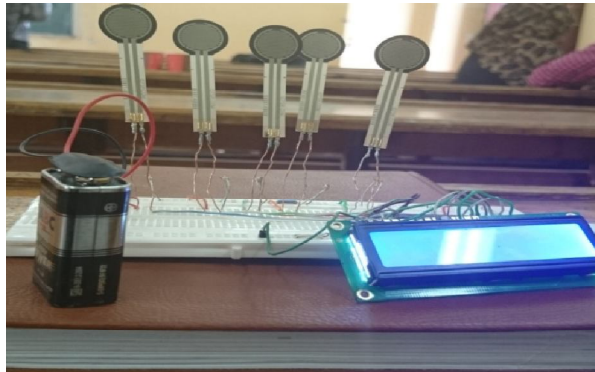


Figure 4.16: The overall components of the circuit connected together in a test board

4.9.3 Calibrating the sensor

In order to make sure that sensor is working properly, several values of weights have been used to investigate the output of the sensor when specific load is applied to it. Therefore, the readouts has been took by

applying the known weight on sensor as shown in figure 4.17 and measured the voltage of voltage divider and resistor of FSR resistor and registered in table 4.4



Figure 4.17: Calibrating the Sensor

Table 4.4: Readouts of Voltage and Resistors

Weight(g)	Volt(v)	Resistor(k)
1000	3.7	0.5k
900	3.5	0.7k
950	3.2	0.9k
800	3.3	1k
850	3.1	1.3k
700	3.15	1.6k
750	3.00	2.19k
600	2.9	2.5k
650	2.91	3k
500	2.8	4.15k
550	2.65	5k
400	2.5	5.50k
450	2.35	6.5k
300	2.3	7.00k
350	2.25	7.5k
200	2.1	8.05k
250	2.00	9.00k
100	1.7	10.98k
150	1.6	11.00k
90	1.5	11.25k
80	1.4	11.80k
70	1.3	12.46k
60	1.1	12.70k
50	0.9	12.97k
40	0.8	13.35k
30	0.3	13.64k
20	0.2	14.33k
10	0.1	14.59k

After that, EXCEL program has been used to draw the graph in order to compare between the standard curve provided in the data sheet of the sensor and the readouts taken by applying weights on the sensor. Therefore, figure 4.18 shows the voltage versus force in a matter of comparison between the standard curve and the readouts taken by applying weights.

Moreover, figure 4.19 shows the resistor versus force in a matter of comparison between the standard curve and the readouts taken by applying weights. From figure 4.19 Series1: standard curve, Series2: readouts curve. the figure indicated that there are small difference in response between practical and stander curve due to environmental parameters and electrical parameters. Therefore, one can conclude that the FSR sensor has produced acceptable results in order to be used in the circuit design.

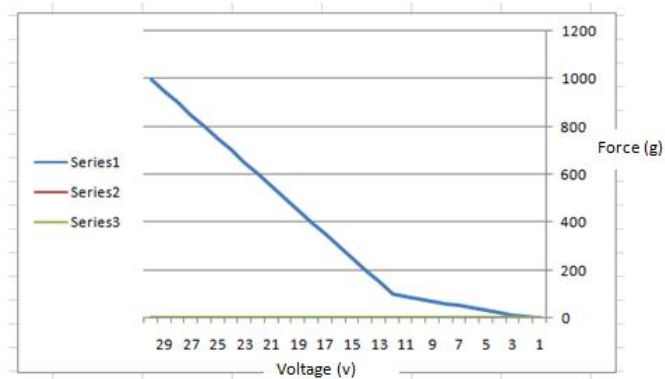


Figure 4.18: Voltage versus force in a matter of comparison between the standard curve and the readouts taken by applying weights.

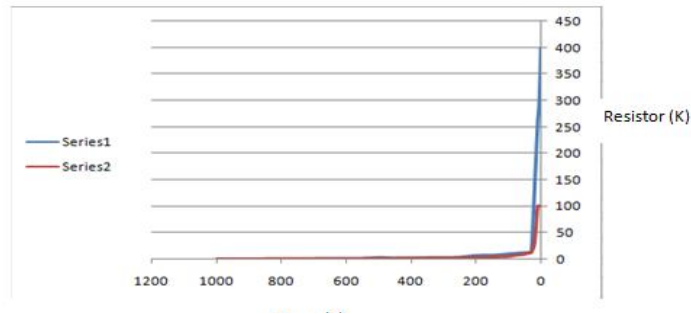


Figure 4.19: Resister (k) versus force (g) in a matter of comparison between the standard curve and the readouts taken by applying weights.

4.9.4 Third Stage (Sewing the Components)

The circuit had been mapped in the paper, firstly the dimension of components and glove had been determined table 4.5 , then drew the circuit in the paper, the position of the component on the glove had been determined by putting rags in the place of component depending on the map.

Table4.5: Dimension of the components

Component	Length [cm]	Width [cm]
Battery	5	2.5
Sensor	6.7	1.8
Microcontroller	3.5	0.8
LCD display	8.2	3.7
Voltage regulator	1.7	1.2
Switch	0.9	0.8

The circuit had been stitched by normal thread to ensure the position of the component that is suitable with the hand .Then connect all the components with VCC and ground figure 4.20.

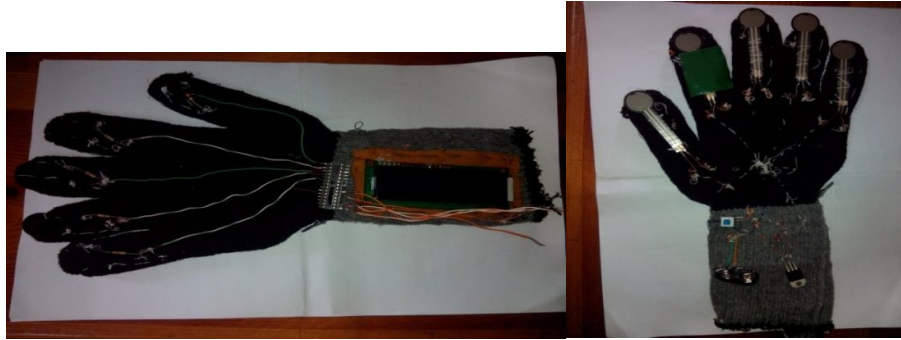


Figure 4.20: primary sewing of the circuit using normal thread

Last stage the conductive thread had been used instead of the normal thread. Firstly sewed the LCD in the forearm, figure 4.21(a) Then the microcontroller fixed in the hand with voltage divider resistance 10k ,figure 4.21(b), then conducted another terminal of all resistors in one point (ground), connected this point with ground of microcontroller and LCD display and then with the ground of power supply, figure 4.21(c), and FSR sensor sewed in fingers in the fingers , the adhesive had been used to fix the sensor properly figure 4.21(d), The VCC of microcontroller and LCD display in same point and then connected to VCC point of all sensors then connected this point with output of power supply (VCC), Power supply using battery 9V, push- button switch and regulator are fixed in the forearm as shown in figure 4.20(e) and figure 4.20(f)

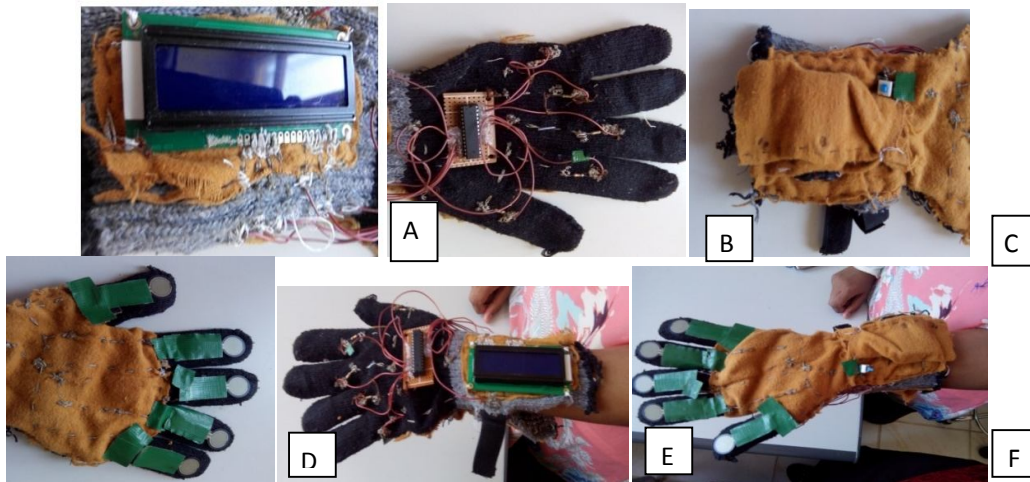


Figure (4.21): Sewed the components

A: Sewed LCD B: Fix the microcontroller and resistors (10K) C: Sewed power supply
D: The sensors after sewing E: Overall device after sewing back side F: Overall device after sewing front side (fore arm)

CHAPTER FIVE
RESULTS AND DISCUSSION

5.1 Introduction

This chapter include the result that were achieved in this project and some difficulties that were existed in this project ,some were solved and some were not. The final design of the device is tested to see what are the result range and the efficiency of the device.

5.2 Testing the circuit before sewing

As mentioned in chapter 5 the circuit had been constructed in tested board .the five FSR sensors (with resistors [10K] noticed that it is the most suitable with this project) connected with microcontroller as voltage divider, LCD display connected with microcontroller to display the result of measured force from sensors ,the power supply unit consist of battery 9V,voltage regulator 5V which supplied whole circuit with power(5V) ,finally the switch was connected to control ON/OFF for the circuit. The calibration was made by applied thirty known weights on the sensors and measured the output voltage and resistance of sensor, then compared with standards values from data sheet by EXCLE programming from this result the overall performance of the circuit was confirmed as presented in figure 5.1

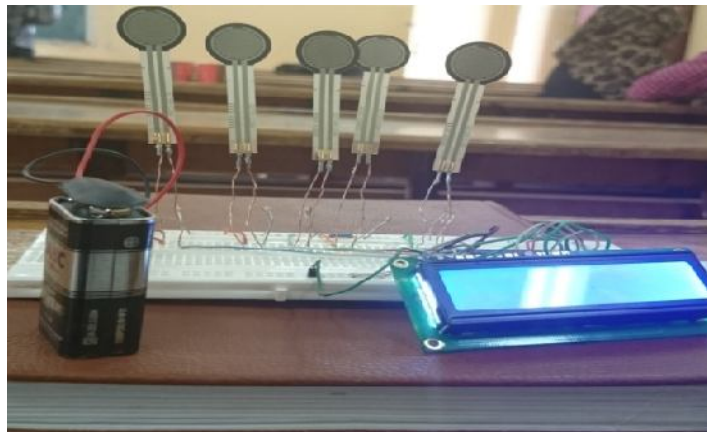


Figure 5.1: Circuit design using test board

5.3 Testing the device on normal people

After replacing the test board with fabric material, all the components were sewed and connected by conductive thread in the glove as depicted in figures 5.2



Figure 5.2 : Final design after sewing the component

The maximum force of the five fingers for thirty normal persons were measured, from this results the ranges of every finger were obtained.

5.3.1 Observing the readouts of little finger (finger A)

After taking thirty readouts from thirty different users, results were plotted in excel to make better comparison between the read outs of the little finger as shown in figure 5.3

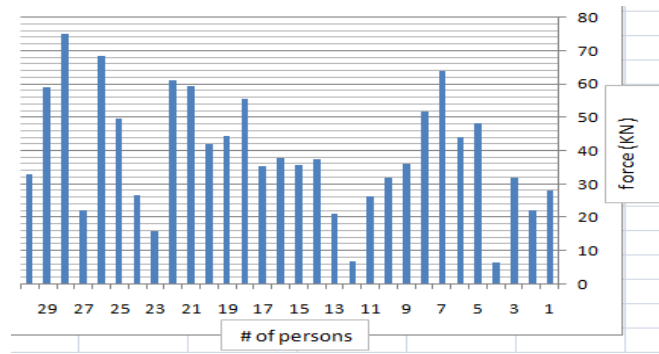


Figure 5.3: little finger (finger A) readouts

From figure 5.3 the range of force readouts between 30 and 40 have more repetition than other ranges. Then the ranges of the little finger were determined and accordingly has been settled in the program of the microcontroller. The appearance of the readout of the little finger will be as shown in table 5.1

Table 5.1: Readouts of the little finger (finger A)

Little finger (finger A)	
Force (KN)	Readouts
0-10	A1
11-20	A2
21-30	A3
31-75	Normal (N)
76-100	Perfect (P)

5.3.2 Observing the readouts of ring finger (finger B)

After taking thirty readouts from thirty different users, results were plotted in excel to make better comparison between the read outs of the ring finger as shown in figure 5.4

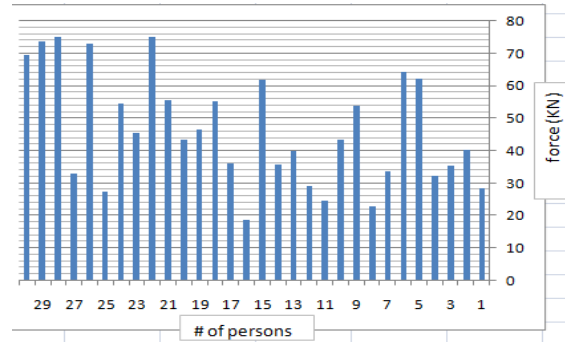


Figure 5.4: Ring finger (finger B) readouts

From figure 5.4 the range of force readouts between 35 and 50 have more repetition than other ranges. Then the ranges of the ring finger were determined and accordingly has been settled in the program of the microcontroller. The appearance of the readout of the ring finger will be as shown in table 5.2

Table 5.2: Readouts of the ring finger (finger B)

Ring finger (finger B)	
Force (KN)	Readouts
0-10	A1
11-23	A2
24-35	A3
36-75	Normal (N)
76-100	Perfect (P)

5.3.3 Observing the readouts of Mid finger (finger C)

After taking thirty readouts from thirty different users, results were plotted in excel to make better comparison between the read outs of the mid finger as shown in figure 5.5

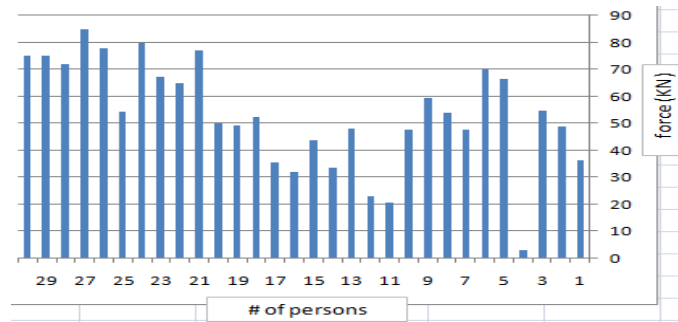


Figure 5.5: Mid finger (finger C) readouts

From figure 5.5 the range of force readouts between 40 and 70 have more repetition than other ranges. Then the ranges of the mid finger were determined and accordingly has been settled in the program of the microcontroller. The appearance of the readout of the mid finger will be as shown in table 5.3

Table 5.3: Readouts of the mid finger (finger C)

Mid finger (finger C)	
Force (KN)	Readouts
0-12	A1
13-25	A2
26-40	A3
41-75	Normal (N)
76-100	Perfect (P)

5.3.4 Observing the readouts of fore finger (finger D)

After taking thirty readouts from thirty different users, results were plotted in excel to make better comparison between the read outs of the fore finger as shown in figure 5.6

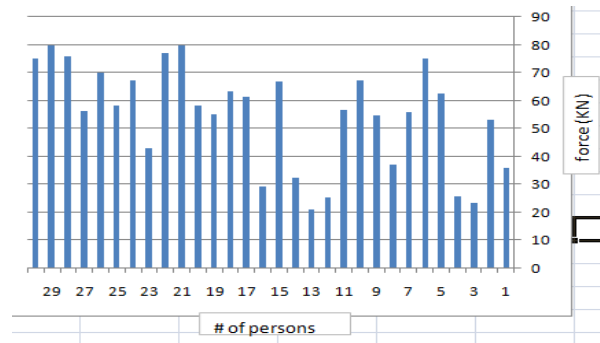


Figure 5.6: Forefinger (finger D) readouts

From figure 5.6 the range of force readouts between 50 and 70 have more repetition than other ranges. Then the ranges of the forefinger were determined and accordingly has been settled in the program of the microcontroller. The appearance of the readout of the forefinger will be as shown in table 5.4

Table 5.4: Readouts of the fore finger (finger D)

Forefinger (finger D)	
Force (KN)	Readouts
0-16	A1
17-32	A2
33-49	A3
50-75	Normal (N)
76-100	Perfect (P)

5.3.5 Observing the readouts of the thumb (finger E)

After taking thirty readouts from thirty different users, results were plotted in excel to make better comparison between the read outs of the thumb as shown in figure 5.7

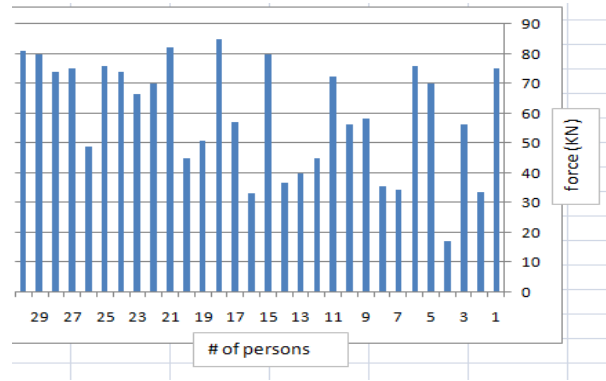


Figure 5.7: Thumb finger (finger E) readouts

From figure 5.7 the range of force readouts between 45 and 70 have more repetition than other ranges. Then the ranges of the thumb were determined and accordingly has been settled in the program of the microcontroller. The appearance of the readout of the thumb will be as shown in table 5.5.

Table 5.5: Readouts of the thumb (finger E)

Thumb (finger E)	
Force (KN)	Readouts
0-16	A1
17-32	A2
33-49	A3
50-75	Normal (N)
76-100	Perfect (P)

5.3.6 Calculation of average

According to results of all five fingers, there will be an average results presented to indicate a summary about the patient health situation. The average results decision will be made according to table 5.6.

Table 5.6: Average results of all five fingers

Average (avg)	
Force (KN)	Readouts
0-17	A1
18-27	A2
28-46	A3
47-75	Normal (N)
76-100	Perfect (P)

5.3.7 Re-Programming the microcontroller

The microcontroller has again re-programmed to implements the observation data made on previous sections. Therefore, the device after this process of r-programming will be ready to be used on patient in order to justify he suitability of the device as well as investigating the accuracy of the results obtained from the device.

5.4 Testing the device

In order to test the device, a comparison is required to be made with diagnosing data taken by physiotherapist. Therefore, nine patients have examined by the physiotherapy clinic after taking a verbal permission from them, over four scions to evaluate the improvement and compare between the results from the device and the diagnose of the physiotherapist.

5.5 Physiotherapist diagnosing data

Follow to compare between the device test and PT evaluation it is nearly too equally to them, give more accurate information to diagnose and evaluate the treatment of patient case. The Muscle Test Grade according to physiotherapist is depicted in table 5.7

Table 5.7: Muscle Test Grade according to physiotherapist

Grade	Meanings
0	no contraction
1	freckle contraction
2-	less than middle of range of motion without gravity
2	complete range of motion without gravity
2+	less than middle of range of motion with gravity
3-	more than middle of range of motion with gravity
3	complete range of motion with gravity
3+	less than middle of range of motion with minimal or moderate resistance
4-	more than middle range of motion with moderate resistance
4	complete range of motion with minimal or moderate resistance
4+	less than middle of range of motion with maximum resistance
5-	more than middle of range of motion with maximum resistance
5	complete range of motion with maximum resistance

According to that, nine patients have been examined and monitored by the physiotherapist as well as using the proposed wearable fabric glove device of our project. Each patient passed through four sessions,

where time gap between sessions are one week. Table 5.8 below presents the evaluation and the diagnosis of the physiotherapist about each patient.

Table 5.8: Evaluation of physiotherapist for nine patient, each patient monitored for four sessions

Patient NO	Session#1	Session#2	Session#3	Session#4
1	4	-4	+3	+3
2	+3	-4	+3	-4
3	3	+3	-4	-4
4	+3	+3	+3	+3
5	4	-4	+3	+3
6	-4	-4	-4	-4
7	+3	+4	+4	+3
8	+4	+4	+4	+4
9	+3	-4	-4	-4

5.6 Measured result using the fabric glove

1. Patient #1

From the physiotherapist observation table 5.8 the patient slightly improve during section 1 to section 2, where his case in range (-4) improved to (+4)), but in session 3 and session 4 there are decrease in performance because his case return to (+3)

From figure 5.8 and table 5.9 which emphasis the curves for measurements to all fingers and average by this device observation there is increase and improvement during session 1 and 2 but still in level of zero, decrease during session 3 and measurement in level of zero except C (Middle finger), increase during session 4 from session 3 but still less than session 1 and session 2 and still all fingers in level zero.

Table 5.9: Result obtained from patient #1 using the wearable fabric glove

No. of sessions	A	B	C	D	E	AVG
1	A0 1	B0 1.2	C0 7.6	D0 5.3	E0 2	AVG0 3.42
2	A0 1.1	B0 10.4	C0 13.1	D0 8.4	E0 5	AVG0 7.6
3	A0 0.7	B0 3.1	C1 16.6	D0 3.4	E0 0.8	AVG0 4.9
4	A0 0.7	B0 1.5	C0 7.2	D0 4.2	E0 5	AVG) 3.72

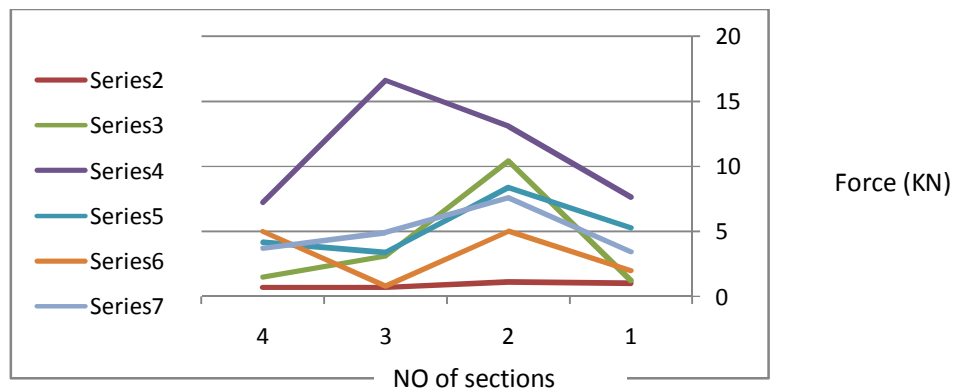


Figure 5.8: result of patient #1, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

2. Patient #2

From the physiotherapist observation table 5.8 the patient improve during section 1 to section 2 (where his cause in range (+3) improve to (-4)), but in section 3 there is decrease in performance because his cause return to (+3) , in section4 there is improvement because his cause return again to (-4)

From table 5.10 and figure 5.9 which emphasis the curves for measurements to all fingers and average by this device , observation there is increase in improvement during section 1 and 2; the force of finger C, D and AVG increase from level (zero) to level (one) and measurements for finger A and B increase but still in level (zero),the improvement decrease during section 3; the force for all fingers decrease to level (zero) the measurement for AVG decrease but still in level (one), the improvement again increase during section4; force of finger (A) increase but still in level (zero),force of finger (B) and (D) increase to level two, force of finger (C) has more increase and arrived to normal level and AVG still in level one but also increase.

Table 5.10: Result of patient #2

No of section	A	B	C	D	E	AVG
1	A0 1.5	B0 2	C0 2.6	D0 4.4	EN 53	AVG0 10.7
2	A0 4	B0 8.4	C1 22.7	D1 31	EN 52.1	AVG1 23.6
3	A0 2.4	B0 0.2	C0 5.8	D0 4.5	EN 57.6	AVG1 14.1
4	A0 1.3	B2 25.7	CN 44.4	D2 33.6	E1 16.6	AVG1 24.3

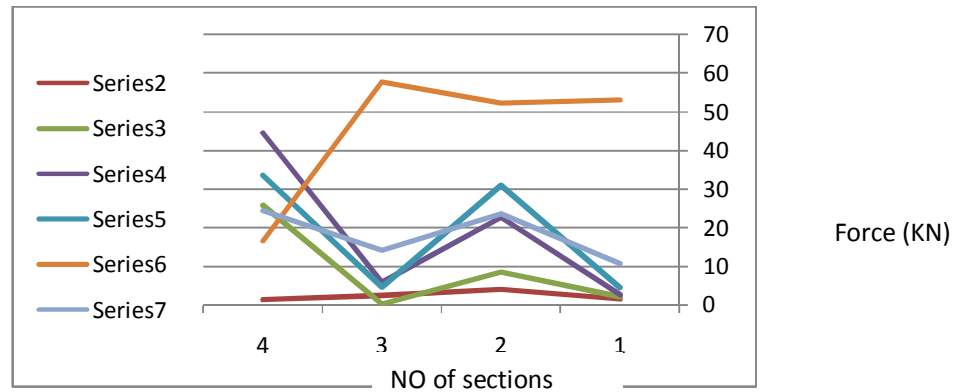


Figure 5.10: result of patient #2, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

3. Patient #3

From the physiotherapist observation table 5.8 the patient improve during section 1 to section 2, where his cause in range (3) improve to (+3)), also there is increase during section 3 because his cause improvement to (-4), in section4 there is slightly improvement so his cause remain in (-4)

From table 5.11 and figure 5.10 which emphasis the curves for measurements to all fingers and average by this device, observation there is increase in improvement during section 1 and 2; the force for fingers (A) and (E) increase from level zero to level two, the force for finger (D) increase but still in level zero , the force of fingers (B) ,(C) and AVG increase from level zero to level one , continue improvement during section 3; the force of fingers (B),(D),(E) and AVG in level two and force of finger (A) has more increase and arrived to normal level (except in ring finger (C) there is slightly decrease; retain to level zero and slightly improvement during section 4 all finger remain its level except finger (D) arrived to normal level

Table 5.11: Result of patient #3

No of section	A	B	C	D	E	AVG
1	A0 1.2	B0 0.3	C0 0.18	D0 0.1	E0 1.5	AVG0 3.8
2	A2 26.3	B1 18.9	C1 13.5	D0 4.9	E2 33	AVG1 19.32
3	AN 34	B2 31.9	C0 10.7	D2 44.8	E2 33.8	AVG2 31.4
4	AN 40	B2 33	C0 12	DN 50	E2 36	AVG2 36.8

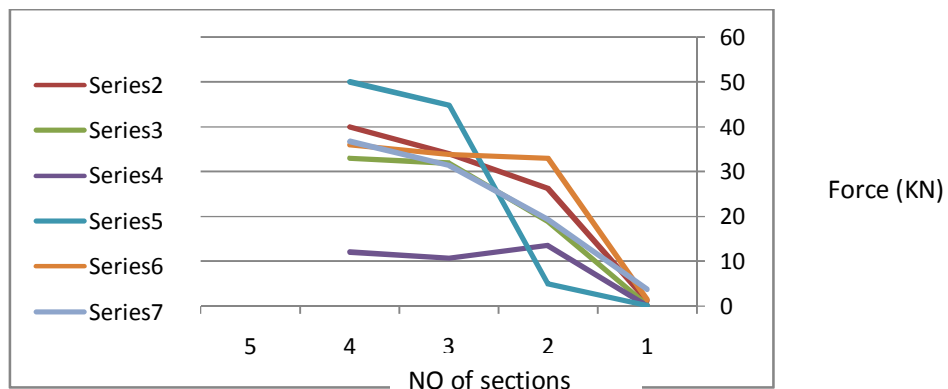


Figure 5.10: result of patient #3, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

4. Patient #4

From the physiotherapist observation table 5.8 the patient improved during section 1 to section2 because his cause improve from (3 to +3) during section 3 and section4 there is slightly improvement so his cause remain in (+3)

Table 5.12 and figure 5.11 emphasis the curves for measurements to all fingers and average by this device. From the observation, there is increase in improvement during section 1,section2; the force for fingers

(A), (C) and (E) increase from level zero to level one, the force for finger (D),(B) and AVG increase but still in level zero , continue improvement during section 3; the force of fingers (B),(C),(E) in level two and force of finger (A),(D) and AVG in level one , and slightly improvement during section 4 all finger arrived to level two

Table 5.12: Result of patient #4

No of section	A	B	C	D	E	AVG
1	A0 0.2	B0 0.4	C0 0.16	D0 0.1	E0 3	AVG0 0.7
2	A1 16.8	B0 3.1	C1 14.4	D0 9	E1 18.2	AVG0 12.3
3	A1 19.1	B2 23.2	C2 26.8	D1 31	E2 32.6	AVG1 26.5
4	A2 20	B2 25	C2 30	D2 40	E2 35	AVG2 30

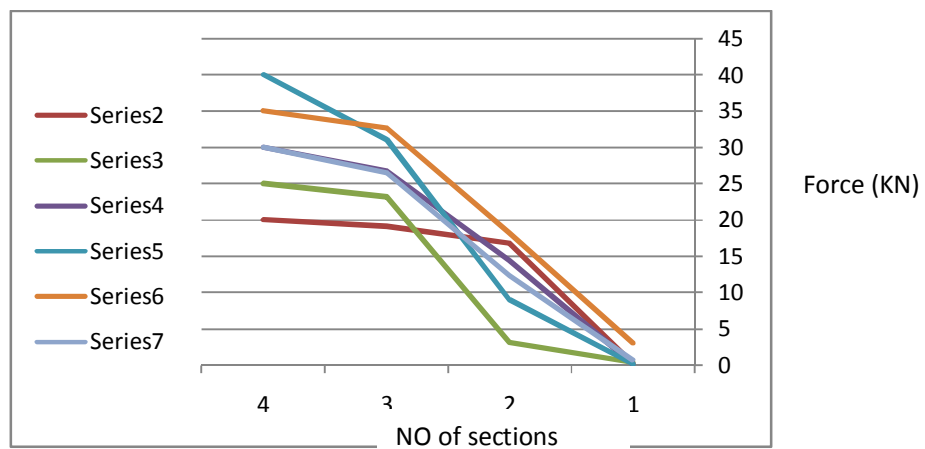


Figure 5.11: result of patient #4, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

5. Patient #5

From the physiotherapist observation table 5.8 the patient degradation during section 1 to section2 because his cause decrease from (4 to -3) continue in degradation during section 3 his cause decrease to +3, in section4 there is slightly improvement so his cause remain in (+3)

From table 5.13 and figure 5.12 which emphasis the curves for measurements to all fingers and average by this device , observation there is decrease in improvement during section 1,section2; the force for fingers (B), (D)and AVG decrease from level one to level zero, the force for finger(A)decrease from level two to level zero, the force for finger(E)decrease but still in level one, and the force for finger (C) decrease from normal level to level zero in section3 all measurements in level zero, but there is slightly improvement during section 4 however all measurements still in level zero

Table 5.13: Result of Patient #5

No of section	A	B	C	D	E	AVG
1	A0 2.8	B1 18.2	CN 54.5	D1 25	E1 33	AVG1 25
2	A0 2.6	B0 2.2	C0 11.8	D0 11.6	E1 26.9	AVG0 11.1
3	A0 4.1	B0 2.8	C0 3.9	D0 0.5	E0 0.8	AVG0 4.1
4	A0 1.4	B0 8.4	C0 12.5	D0 2	E0 7.5	AVG0 6.36

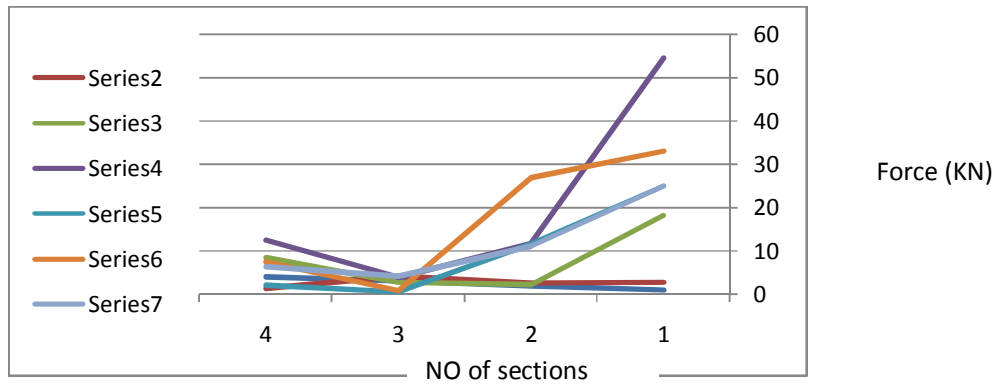


Figure 5.12: result of patient #5, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

6. Patient #6

From the physiotherapist observation table 5.8 the patient has slight degradation during section 1 to section2; his cause remain in (-4) continue in degradation during section 3 his cause decrease to -3, in section4 there is slightly improvement so his cause increase to (-4)

From table 5.14 and figure 5.13 which emphasis the curves for measurements to all fingers and average by this device , observation there is decrease in improvement during section 1,section2; the force for fingers (B) and (A) decrease from level one to level zero, the force for finger(E)decrease from level two to level zero, the force for finger(D) and AVG decrease but still in level one, and the force for finger (C) decrease from level two to level zero, in section3 all measurements in level zero except finger (D) which also decrease but still in level one , but there is slightly improvement during section 4 in finger (a), (B) and AVG which still in level zero, finger (C) and finger (B) has increment to level two and finger (E) and AVG increment to level one.

Table 5.14: Result of Patient #6

No of section	A	B	C	D	E	AVG
1	A1 13	B1 16	C2 39	D1 31	E2 37	AVG1 21
2	A0 6.1	B0 1.9	C1 18.5	D1 20	E0 10	AVG1 19.9
3	A0 0.3	B0 0.4	C0 10.3	D1 19.5	E0 4.3	AVG0 6.7
4	A0 1.5	B0 2.6	C2 30	D2 33	E1 23	AVG1 18.02

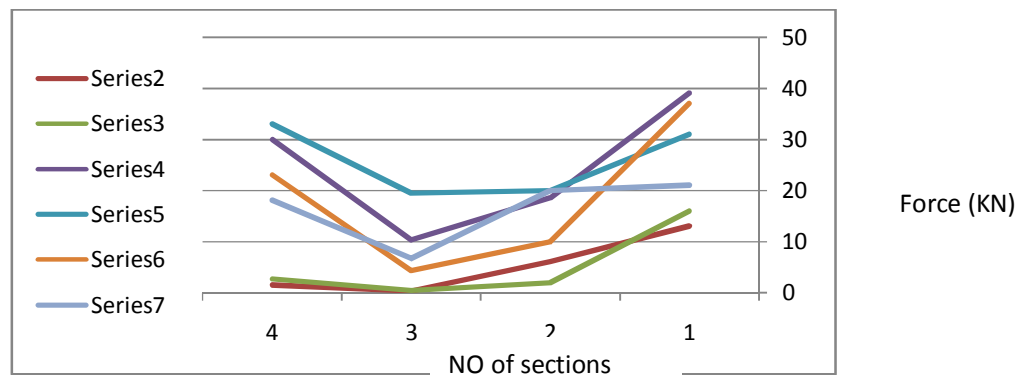


Figure 5.13: result of patient #6, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

7. Patient #7

From the physiotherapist observation table 5.8 the patient has improvement during section 1 to section2; his cause increase from (+3 to +4) but has slightly improvement during section 3; his cause still in(+4), in section4 there is degradation so his cause decrease to(+3)

From table 5.15 and figure 5.14 which emphasis the curves for measurements to all fingers and average by this device, observation there is increase in improvement during section 1,section2; the force for fingers (B), (A),(C) and AVG slightly increase so it is still in level zero,

the force for finger(E) and (D) has more increase and arrive to level one , in section3 all measurements have slightly increase and remain it's levels except the AVG increase to level one but there is decreasing during section 4 so all measurements in level zero except the finger (D) has slightly increase but still in level zero.

Table 5.15: Result of Patient #7

No of section	A	B	C	D	E	AVG
1	A0 3.9	B0 2.9	C0 0.6	D0 13	E0 11	AVG0 4.5
2	A0 3.9	B0 3.8	C0 7.8	D1 21.3	E1 21.8	AVG0 11.72
3	A0 4	B0 4.1	C0 9.7	D1 26	E1 27	AVG1 14.16
4	A0 3.4	B0 5.9	C0 4.2	D0 5.9	E0 10.7	AVG0 6.02

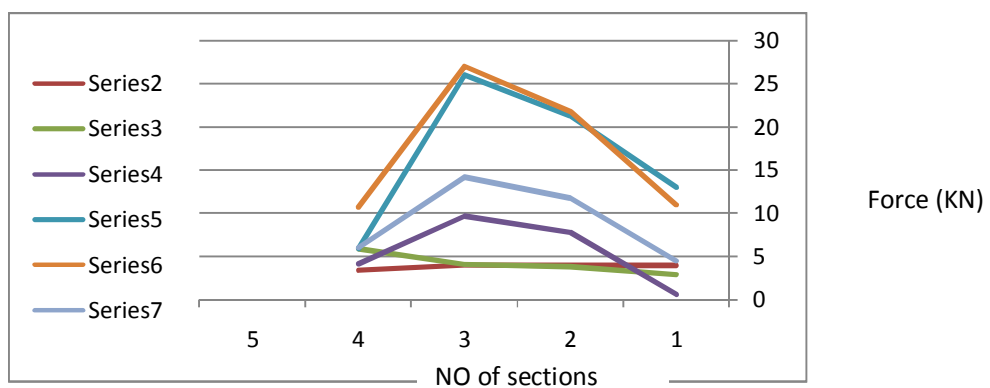


Figure 6.15: result of patient #7, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

8. Patient #8

From the physiotherapist observation table 5.8 the patient has slightly change in performance during all sections; his case was (+4)

during four sections, From table 5.16 and figure 5.15 which emphasis the curves for measurements to all fingers and average by this device , observation there is increase in improvement during section 1,section2; the force for fingers (D), (A),(E) and AVG has increment from level zero to level one, the force for finger(B) has slightly increment and still in level zero, except finger (c) which has decrease from level one to level zero , in section3 all measurements have increment; the force for fingers (A), and AVG has increment from level one to level two, the force for finger(B) has increment level one , finger (c) has slightly increment so it sill in level zero also finger (E) has slightly increment so it sill in level one however finger (d) has more increment ; arrived to normal level, during section 4 there is slightly increment so all measurements in previous level except increment in finger (E) which increase to level two .

Table 5.16: Result of Patient #8

No of section	A	B	C	D	E	AVG
1	A0 4.1	B0 4.9	C1 16.3	D0 11.9	E0 1.2	AVG0 4.6
2	A1 20	B0 10	C0 8	D1 30	E1 29	AVG1 19.2
3	A2 34	B1 20	C0 8.2	DN 52	E1 29	AVG2 28.6
4	A2 35	B1 30	C0 10	DN 55	E2 40	AVG2 34

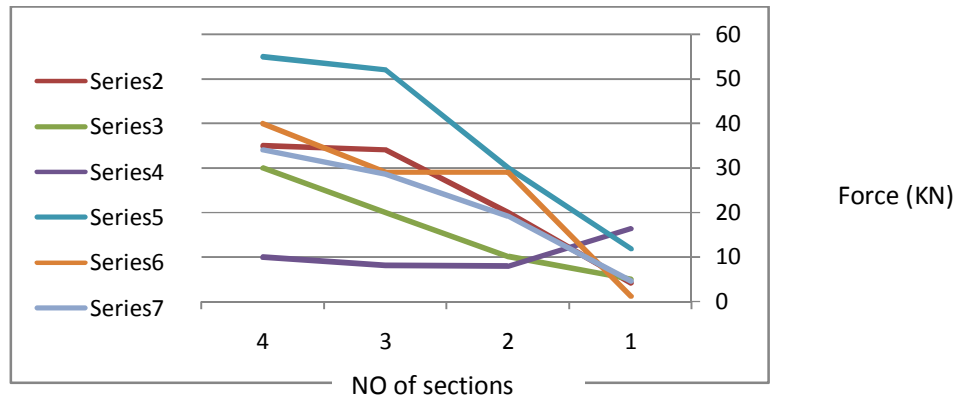


Figure 6.16: result of patient #8, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

9. Patient #9

From the physiotherapist observation table 5.8 the patient has improvement during section 1 to section2; his cause increase from (+3 to -4) but has slightly improvement during section 3; his cause still in(-4), in section4 his cause remain in (-4) ,From table 5.17 and figure 5.16 which emphasis the curves for measurements to all fingers and average by this device , observation there is slightly change in readings; all fingers during all sections have the same level (zero level) except the finger(C) from section one to section zero decrease from one to zero level

Table 5.17:Result of Patient #9

AVG	E	D	C	B	A	NO ofsection
AVG0	E0	D0	C1	B0	A0	1
5.78	0.7	5.1	17.9	3.5	1.7	
AVG0	E0	D0	C0	B0	A0	2
6.34	0.5	3.2	12	6	10	
AVG0	E0	D0	C0	B0	A0	3
5.14	7.4	6.4	9.7	2.1	0.1	
AVG0	E0	D0	C0	B0	A0	4
6.02	10.7	5.9	4.2	5.9	3.4	

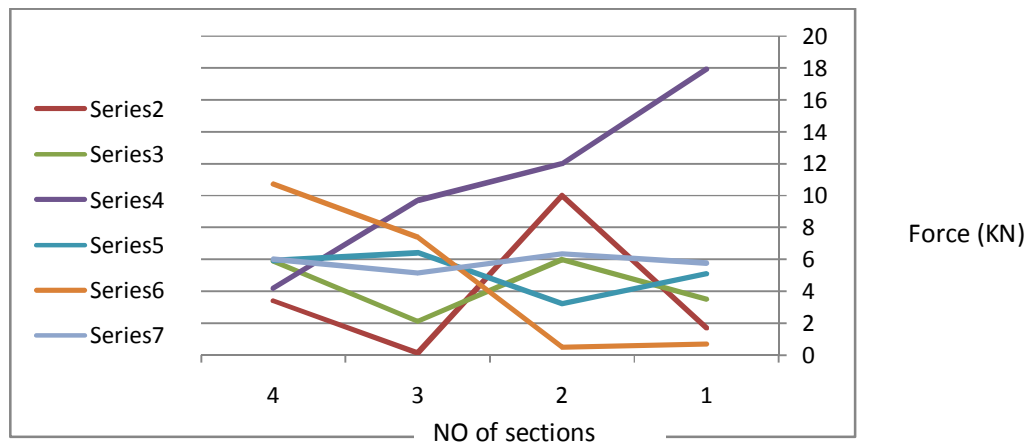


Figure 6.17: result of patient #9, where Series2: A, Series3: B, Series4: C, Series5: D, Series6: E, Series7: AVG

CHAPTER SIX
CONCLUSIONS AND FUTURE
VIEW

6.1 Conclusion

The project presents a study of wearable, flexible physiotherapy hand glove. This research is highly motivated by the increasing need for light weight, low cost device using to accurate evaluate, monitoring, of muscle strength performance of hand.

- i. The Circuit operate successfully in rigid board
- ii. Possibility of replacing hard/metallic glove by flexible glove is very high according to results of stage 1
- iii. The circuit fabricated and sewing successfully and operated as in rigid board
- iv. The device's objectives have been achieved successfully , low cost , portable, wearable, and flexible
- v. According to the result got from scions of patients the device performed effectively
- vi. Some problems were not solved, the glove cannot fitted by different persons because the size of hands change with ages and sex, but we tried to solve this problem by using the elastic strip

There are some problems faced the progress of this project considering some of the components used as illustrated in table 7.1

Table (6.1): Problems in using some components

Component	problem	How the problem solved
Sensor	Long tail, metal terminal	Using conductive thread instead of metal terminal figure(7.1)
Battery	Low ampere and voltage	not solved
LCD display	Small screen	Organize the display



Figure (6.1): Replacing metal terminal with conductive thread

6.2 Future view

- i. The device can be wireless
- ii. Using more accurate sensor
- iii. Makes the device fitted by every person
- iv. Modification in range to give more accurate result

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APPENDIX A

Datasheet of the Atmel Atmega8 Microcontroller

Features

- High-performance, Low-power Atmel®AVR® 8-bit Microcontroller
- Advanced RISC Architecture
 - 130 Powerful Instructions – Most Single-clock Cycle Execution
 - 32 × 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 16MIPS Throughput at 16MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
 - 8Kbytes of In-System Self-programmable Flash program memory
 - 512Bytes EEPROM
 - 1Kbyte Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
 - Data retention: 20 years at 85°C/100 years at 25°C
 - Optional Boot Code Section with Independent Lock Bits In-System Programming by On-chip Boot Program True Read-While-Write Operation
 - Programming Lock for Software Security
- Peripheral Features
 - Two 8-bit Timer/Counters with Separate Prescaler, one Compare Mode

- One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
- Real Time Counter with Separate Oscillator
- Three PWM Channels
- 8-channel ADC in TQFP and QFN/MLF package Eight Channels 10-bit Accuracy
- 6-channel ADC in PDIP package Six Channels 10-bit Accuracy
- Byte-oriented Two-wire Serial Interface
- Programmable Serial USART
- Master/Slave SPI Serial Interface
- Programmable Watchdog Timer with Separate On-chip Oscillator
- On-chip Analog Comparator
- Special Microcontroller Features
 - Power-on Reset and Programmable Brown-out Detection
 - Internal Calibrated RC Oscillator
 - External and Internal Interrupt Sources
 - Five Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, and Standby
- I/O and Packages
 - 23 Programmable I/O Lines
 - 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF
- Operating Voltages
 - 2.7V - 5.5V (ATmega8L)

– 4.5V - 5.5V (ATmega8)

• Speed Grades

– 0 - 8MHz (ATmega8L)

– 0 - 16MHz (ATmega8)

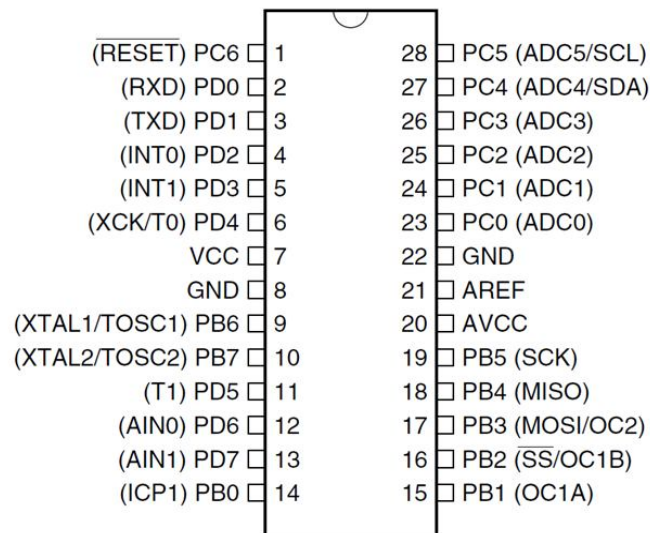
• Power Consumption at 4 MHz, 3V, 25°C

– Active: 3.6mA

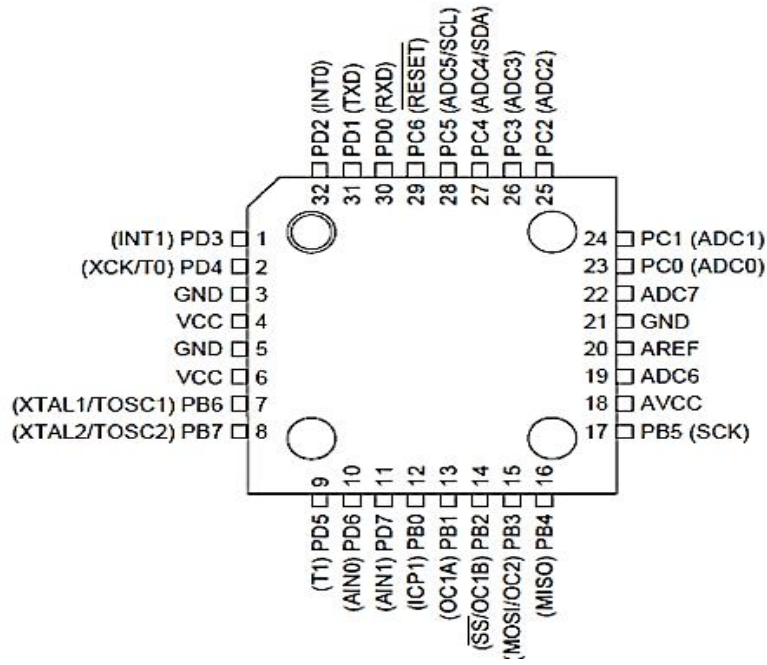
– Idle Mode: 1.0mA

– Power-down Mode: 0.5µA

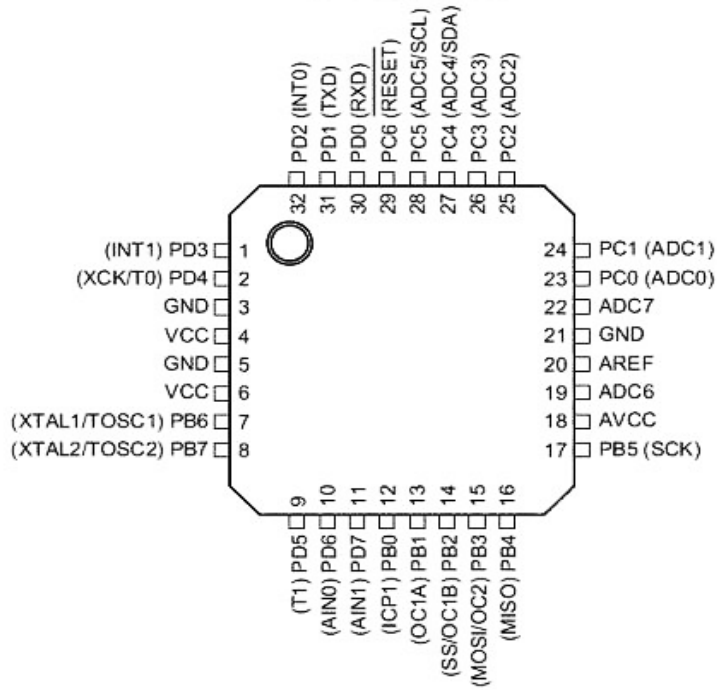
PDIP



TQFP Top View



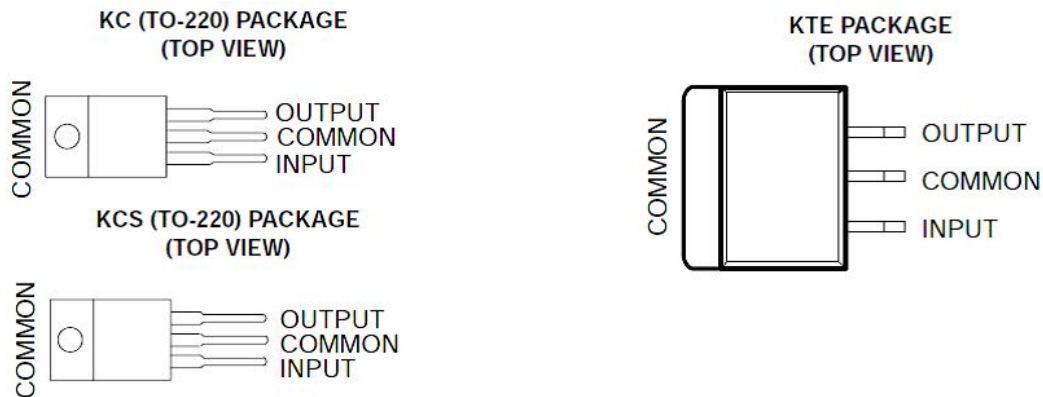
MLF Top View



APPENDIX B

Datasheet of the LM7805 Voltage Regulator

- 3-Terminal Regulators
- Output Current up to 1.5 A
- Internal Thermal-Overload Protection
- High Power-Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation



Description/ordering information

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current. The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

APPENDIX C

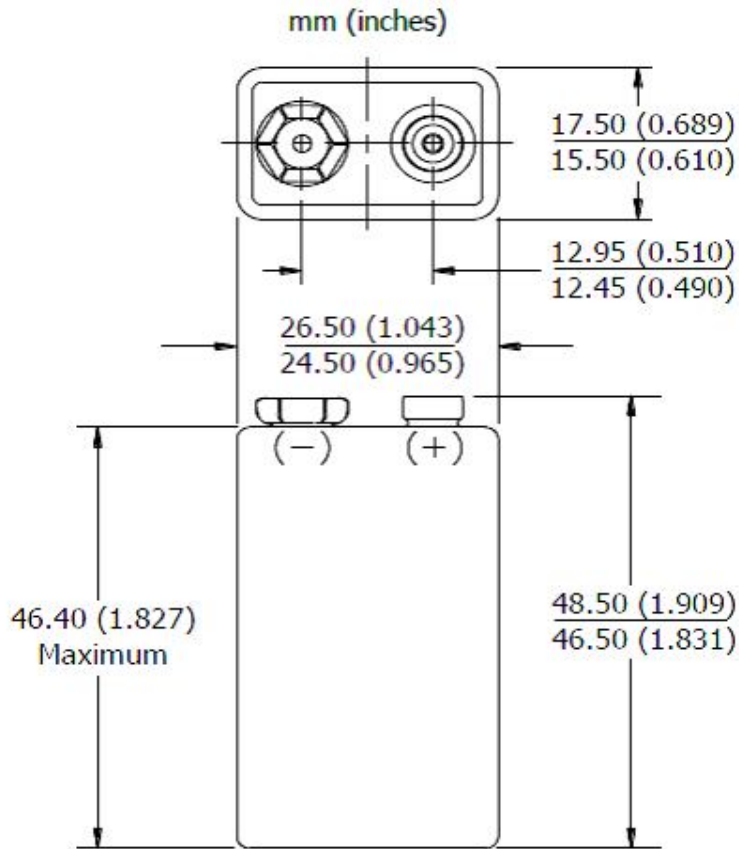
Datasheet of the 9V Energizer Battery

Classification:	Alkaline
Chemical System:	Zinc-Manganese Dioxide (Zn/MnO ₂) No added mercury or cadmium
Designation:	ANSI-1604A, IEC-6LR61
Nominal Voltage:	9.0 volts
Operating Temp:	-18°C to 55°C (0°F to 130°F)
Typical Weight:	45.6 grams (1.6 oz.)
Typical Volume:	21.1 cubic centimeters (1.3 cubic inch)
Jacket:	Metal
Shelf Life:	5 years at 21°C
Terminal:	Miniature Snap

ENERGIZER 522

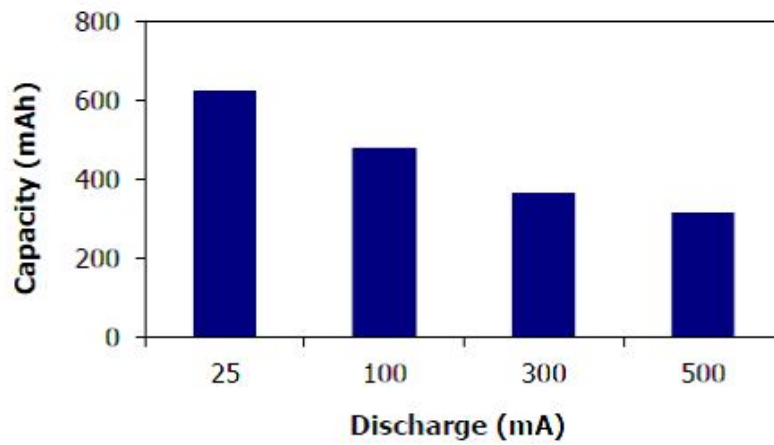


Industry Standard Dimensions



Milliamp-Hours Capacity

Continuous discharge to 4.8 volts at 21°C



APPENDIX D

DATA SHEET OF THE LMB16AFC LCD DISPLAY

1. Basic Specifications

1.1 Display Specifications

- 1) LCD Display Mode : STN, Negative, Transmissive
- 2) Display Color : Display Data = "1" : Light Gray (*1)
: Display Data = "0" : Deep Blue (*2)
- 3) Viewing Angle : 6H
- 4) Driving Method : 1/16 duty, 1/5 bias
- 5) Back Light : White LED backlight

Note:

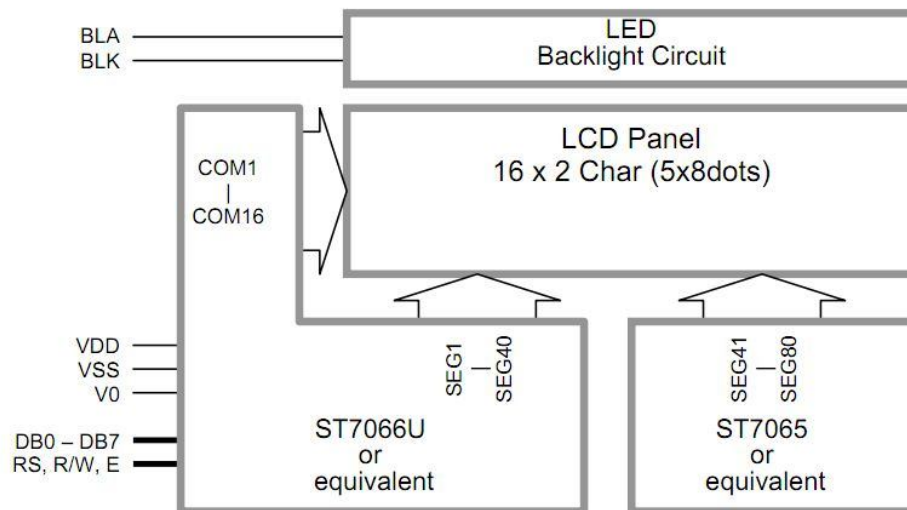
*1. Color tone may slightly change by Temperature and Driving Condition.

*2. The Color is defined as the inactive / background color

1.2 Mechanical Specifications

- 1) Outline Dimension : 80.8 x 36.0 x 12.5MAX
(See attached Outline Drawing for details)

1.3 Block Diagram



CODE OF THE PROGRAMM BY BASCOM PROGRAMM:

```
$regfile "m8def.dat"

$crystal = 1000000

Config Portd = Output

Config Adc = Single , Prescaler = Auto , Reference = Avcc

Start Adc

Config Lcd = 20 * 2

Config Lcdpin = Pin , Db4 = Portd.5 , Db5 = Portd.6 , Db6 = Portd.7 ,
Db7 = Portb.0 , Rs = Portb.6 , E = Portb.7

Dim Z As Single , Av As Single , X1 As Word , Y As Single , T As
Single , R1 As Single

Dim X2 As Word , X3 As Word , X4 As Word , X5 As Word

Dim F1 As Single , F2 As Single , F3 As Single , F4 As Single , F5 As
Single

Dim Hstr As String * 3

Cls

Do

X1 = Getadc(5)

Waitms 30

X2 = Getadc(4)

Waitms 30

X3 = Getadc(3)

Waitms 30

X4 = Getadc(2)

Waitms 30

X5 = Getadc(1)
```

Waitms 30

Cls

Waitms 30

$Y = X1 * 5$

$Y = Y / 1024$

$Y = Y + 1.3325$

$Y = Y / 0.6779$

$Z = \text{Exp}(y)$

$Z = Z * 9.8$

$F1 = Z / 1000$

Hstr = Fusing(f1 , "#.#")

If F1 > 0.07 And F1 < 10 Then

Locate 1 , 1

Lcd "A0"

Locate 2 , 1

Lcd Hstr

End If

If F1 > 10 And F1 < 20 Then

Locate 1 , 1

Lcd "A2"

Locate 2 , 1

Lcd Hstr

End If

If F1 > 30 And F1 < 75 Then

Locate 1 , 1

Lcd "AN"

Locate 2 , 1

Lcd Hstr

```
End If
If F1 > 75 And F1 < 100 Then
Locate 1 , 1
Lcd "AP"
Locate 2 , 1
Lcd Hstr
End If
Y = X2 * 5
Y = Y / 1024
Y = Y + 1.3325
Y = Y / 0.6779
Z = Exp(y)
Z = Z * 9.8
F2 = Z / 1000
Hstr = Fusing(f2 , "#.#")
If F2 > 0.07 And F2 < 11 Then
Locate 1 , 6
Lcd "B0"
Locate 2 , 6
Lcd Hstr
End If
If F2 > 11 And F2 < 23 Then
Locate 1 , 6
Lcd "B1"
Locate 2 , 6
Lcd Hstr
```

End If

If F2 > 23 And F2 < 35 Then

Locate 1 , 6

Lcd "B2"

Locate 2 , 6

Lcd Hstr

End If

If F2 > 35 And F2 < 75 Then

Locate 1 , 6

Lcd "BN"

Locate 2 , 6

Lcd Hstr

End If

If F2 > 75 And F2 < 100 Then

Locate 1 , 6

Lcd "BP"

Locate 2 , 6

Lcd Hstr

End If

Y = X3 * 5

Y = Y / 1024

Y = Y + 1.3325

Y = Y / 0.6779

Z = Exp(y)

Z = Z * 9.8

F3 = Z / 1000

Hstr = Fusing(f3 , "#.#")

If $F3 > 0.07$ And $F3 < 13$ Then

Locate 1 , 12

Lcd "C0"

Locate 2 , 12

Lcd Hstr

End If

If $F3 > 13$ And $F3 < 26$ Then

Locate 1 , 12

Lcd "C1"

Locate 2 , 12

Lcd Hstr

End If

If $F3 > 26$ And $F3 < 40$ Then

Locate 1 , 12

Lcd "C2"

Locate 2 , 12

Lcd Hstr

End If

If $F3 > 40$ And $F3 < 75$ Then

Locate 1 , 12

Lcd "CN"

Locate 2 , 12

Lcd Hstr

End If

If $F3 > 75$ And $F3 < 100$ Then

Locate 1 , 12

```
Lcd "CP"  
Locate 2 , 12  
Lcd Hstr  
End If  
Wait 3  
Cls  
Y = X4 * 5  
Y = Y / 1024  
Y = Y + 1.3325  
Y = Y / 0.6779  
Z = Exp(y)  
Z = Z * 9.8  
F4 = Z / 1000  
Hstr = Fusing(f4 , "#.#")  
If F4 > 0.07 And F4 < 17 Then  
Locate 1 , 1  
Lcd "D0"  
Locate 2 , 1  
Lcd Hstr  
End If  
If F4 > 17 And F4 < 33 Then  
Locate 1 , 1  
Lcd "D1"  
Locate 2 , 1  
Lcd Hstr  
End If
```

If F4 > 33 And F4 < 50 Then

Locate 1 , 1

Lcd "D2"

Locate 2 , 1

Lcd Hstr

End If

If F4 > 50 And F4 < 75 Then

Locate 1 , 1

Lcd "DN"

Locate 2 , 1

Lcd Hstr

End If

If F4 > 75 And F4 < 100 Then

Locate 1 , 1

Lcd "DP"

Locate 2 , 1

Lcd Hstr

End If

Y = X5 * 5

Y = Y / 1024

Y = Y + 1.3325

Y = Y / 0.6779

Z = Exp(y)

Z = Z * 9.8

F5 = Z / 1000

Hstr = Fusing(f5 , "#.#")

If F5 > 0.07 And F5 < 17 Then

Locate 1 , 6

Lcd "E0"

Locate 2 , 6

Lcd Hstr

End If

If F5 > 17 And F5 < 33 Then

Locate 1 , 6

Lcd "E1"

Locate 2 , 6

Lcd Hstr

End If

If F5 > 33 And F5 < 50 Then

Locate 1 , 6

Lcd "E2"

Locate 2 , 6

Lcd Hstr

End If

If F5 > 50 And F5 < 75 Then

Locate 1 , 6

Lcd "EN"

Locate 2 , 6

Lcd Hstr

End If

If F5 > 75 And F5 < 100 Then

Locate 1 , 6

Lcd "EP"

```
Locate 2 , 6
Lcd Hstr
End If
Waitms 20
If F1 > 0 And F2 > 0 And F3 > 0 And F4 > 0 And F5 > 0 Then
Locate 1 , 1
Av = F1 + F2
Av = Av + F3
Av = Av + F4
Av = Av + F5
Av = Av / 5
Hstr = Fusing(av , "#.#")
If Av > 0.07 And Av < 14 Then
Locate 1 , 12
Lcd "Av0"
Locate 2 , 12
Lcd Hstr
End If
If Av > 14 And Av < 27 Then
Locate 1 , 12
Lcd "Av1"
Locate 2 , 12
Lcd Hstr
End If
If Av > 27 And Av < 46 Then
Locate 1 , 12
```

```
Lcd "Av2"  
Locate 2 , 12  
Lcd Hstr  
End If  
If Av > 46 And Av < 75 Then  
Locate 1 , 12  
Lcd "AvN"  
Locate 2 , 12  
Lcd Hstr  
End If  
If Av > 75 And Av < 100 Then  
Locate 1 , 12  
Lcd "AvP"  
Locate 2 , 12  
Lcd Hstr  
End If  
Waitms 20  
End If  
Wait 3  
Cls  
Loop
```

