Mechanical Engineering Department

Mechatronics Engineering

Bachelor Thesis

Graduation Project

Smart Bed for Paralyzed People

Project Team

Husam Alrjoub Rashad Alarab

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Project Supervisor

Eng. Zuheir Wazwaz

Hebron – Palestine

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إهداء

- إلى فلسطين: الأرضْ والإنسان...

- إلى التُربةِ المَقدسية التي أنبَتتْ القطوف الهندسية الدانية من رحمِ الأمِّ الغالية وروح الأبِ العالية، إلى ذوينا ذوي القلوب الراقية.

- إلى الأبوةُ والأخوةُ .. إلى الذينَ لولاهُمْ لما كُنا، إلى دائرة الهندسة الميكانيكية وكلية الهندسة والتكنولوجيا في جامعة بوليتكنيك فلسطين.

- لكل يدٍ زرعتْ بذرةً في هذا المشروع فأنبتتْ فكرةً خدمتْ الوطن نُهدي هذا العمل الفلسطيني الخالص لأرواحكم العطرة بذكر الله.

شكر وتقدير

الشُكرُ للهْ أولاً وأخيراً، وبعد الله نتقدم بجزيل الشكر إلى مؤسستنا الرائدة جامعة بوليتكنيك فلسطين وعلى رأسها كلية الهندسة والتكنولوجيا، وكذلك نشكر مدرسي دائرة الهندسة الميكانيكية على وجه الخصوص، ونتقدم بالشكر إلى زملائنا الطلبة في دائرة الهندسة الميكانيكية والى كل من ساهم في إتمام هذا العمل المتواضع بالشكل الذي هو عليه.

Abstract

Smart Bed is a medical bed with controls in its back rest, to help paralyzed people who suffer from amputated hands. It's one of human obligations to serve the disabled. The smart bed is intended to recognize the intentions of the patients laying on it. By analyzing the patterns of the sensors attached to the bed, and taking actions through the actuators to help the patient fulfill these intentions.

These people will not suffer from practicing their daily activities again, and minimal assistance will be needed to help them.

الملخص

السرير عبارة عن سرير مزود بمجسات ووصف معالجة للإشارات التي تأتي من المجسات المركبة في السرير، وتقوم وحدة المعالجة بتحليل أنماط معينة من المجسات وفهم ما يريد المريض أن يفعل، وذلك من خلال حركة المريض على السرير. وتقوم وحدة المعالجة بإصدار الأوامر للمفعلات لمساعدة المريض على تحقيق الغاية التي ينوي عملها (مثل : الاستناد، الجلوس،الدوران) .

يتحكم السرير في منطقة الظهر لأولئك الناس الذي يعانون من شلل نصفي وبتر في الأيدي، لبناء نظام ذكي يخدم هؤلاء الناس كأحد أهم الالتزامات الإنسانية علينا، لذلك هؤلاء الناس لن يعانوا من ممارسة أنشطتهم اليومية، وكذلك يحتاجون أقل مساعدة ممكنة لهم .

Abbreviations

CPR.	Conservatives for Patients' Rights
DC.	Direct Current
PIC.	Peripheral Interface Controller
USB.	Universal Serial Bus
PPU.	Palestine Polytechnic University
PRCS.	Palestine Red Crescent Society
NIS.	New Israeli Shaklee
DIP.	Dual In-line Package
QFP.	Quad Flat Package
LLC.	Leadless Chip Carrier
ADC.	Analog to Digital Converter
I/O.	Input / Output
RR	Rehabilitation Robots
KB	Kilo Byte
MIPS	Million Instructions Per Second
RAM	Random Access Memory
EEPROM	Electrically Erasable Programmable Read-Only Memory
MSSP	Master Synchronous Serial Port
SPI	Serial Peripheral Interface
USART	Universal Synchronous/Asynchronous Receiver/Transmitter
PWM	Pulse-Width Modulation
CCP	Capture/Compare/PWM
ECCP	Enhanced Capture/Compare/PWM
CPU	Central Process Unit
LCD	Liquid Crystal Display
COP	Center Of Pressure
TA	Contacting Area

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References

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[2] Muhamad Almazadi, Rolin D.Mckinlay and Danny Causy, PIC microcontroller and embedded system, New Jersey, United State of America, 2008.

[3] Prof.Ludwik Finkelstien, Measurement science for engineers, London, United Kingdom, 2004.

[4] Prof. Z. Zenn Bien and PhD Dimitar Stefanov, Advances in Rehabilitation Robotics, Berlin, Germany, 2004.

[5] http://en.wikipedia.org/wiki/Wheatstone_bridge.

[6] http://en.wikipedia.org/wiki/Differential_amplifier.

[7] https://en.wikipedia.org/wiki/Problem_statement.

[8] http://www.humanillnesses.com/original/Pan-Pre/Paralysis.html.

Appendix

Chapter One

Introduction

1.1 Concept of the Project

The bed controls in the back area for paralyzed people who suffer from amputated hands, by touching the ends of the bed using feet, to build an intelligent system that serves these people as one of the most important humanitarian obligations on us, so these people will not suffer from the exercise of their daily activities, and they need the minimal assistance.

1.2 Problem Statement

The project focuses on physically paralyzed people who suffer from amputation of hands as an intelligent bed serves this category, and the principle of work is based on taking the signal from the sensor to CPU that analyzing certain types of sensors and understanding of what he wants to do through the movement of the patient on the bed. The processing unit issuing commands actuators to help the patient achieve the purpose for which intends to work (such as: reference, sit, spin).

What is the problem? They are special category of disabled people that need permanently assistance, so the project teams choose this project to serve these people to need the minimal assistance.

Who has the problem? This project serves the paralyzed people, who suffer from amputated hands to help them to do their daily activities, by touching the ends of the bed using feet to build an intelligent system, which serves these people as one of the most important humanitarian obligations on us.

1.3 Recognition of Need

Paralysis is the complete loss of muscle function for one or more muscle groups. Paralysis can cause loss of feeling or loss of mobility in the affected area.

Paralysis could be localized, or generalized, or it may follow a certain pattern. Most paralyses caused by nervous system damage (i.e. spinal cord injuries) are constant in nature; however, there are forms of periodic paralysis, including sleep paralysis, which are caused by other factors.

Muscle is a special kind of tissue that enables our bodies to move. It is under the control of the nervous system, which processes messages to and from all parts of the body. Sometimes the nerve cells, or neurons, that control the muscles become diseased or injured. When that happens, a person loses the ability to move the muscles voluntarily, and we say that the person is paralyzed.

In Fig. 1.1, shows the types of the paralysis in the muscles of the face, arm, and leg on one side of the body is called hemiplegia ("hemi" means "half"), and usually results from damage to the opposite side of the brain. Damage to the nerves of the spinal cord affects different parts of the body, depending on the amount of damage and where it occurred. Paralysis of both lower limbs is called paraplegia, and paralysis of both arms and both legs is called quadriplegia. Paralysis may be temporary or permanent, depending on the disease or injury. Because paralysis can affect any muscle in the body, a person may lose not only the ability to move but also the ability to talk or to breathe unaided.

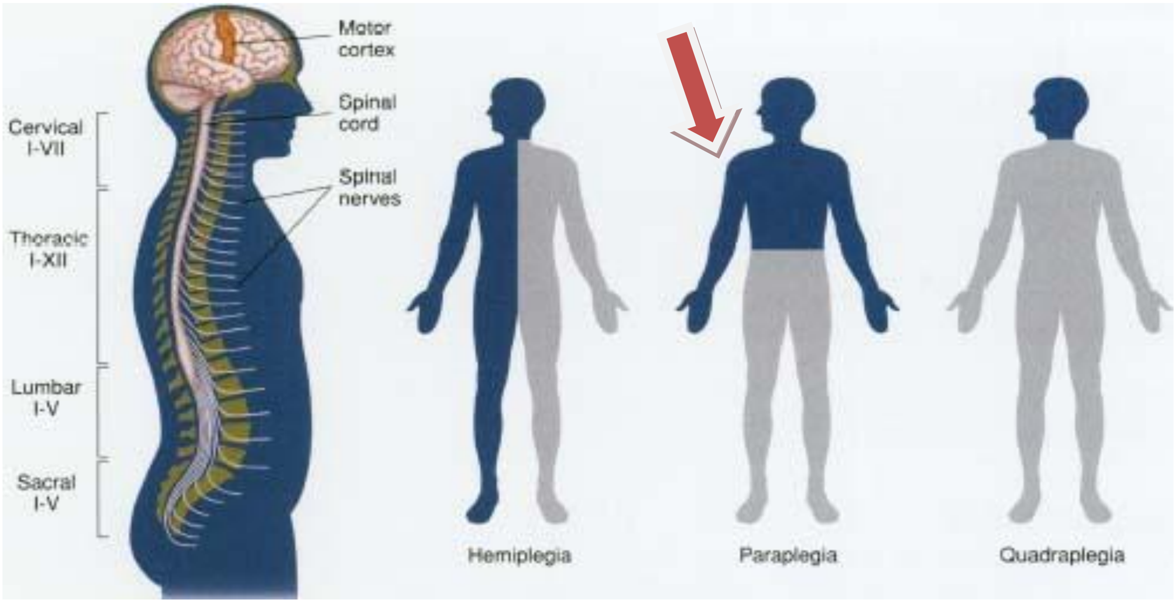


Figure 1.1: Paralysis Types.

This smart bed targets medical, service to help paralyzed people who suffer from amputated hands. It offers adapt movement in addition to personal comfort. This bed can be used in hospital, house. This bed can also be used for paralyzed people who suffer from amputated feet, and any normal person can be used it.

1.4 Project Importance

Smart bed systems has many important issues: the most important one is designed to help the paralyzed people as one of the human obligations, so these people will not suffer from practicing their daily activities, and will need minimal assistance.

1.5 Project Objectives

The project has the following objectives:

1- Encourage the paralyzed people to feel the value of technology.

2- Simplify human daily activities (drinking, eating, reading ...).

3- Create reliable and sensitive system in order to get the right action at the right moment.

4- Establish portable system. (Using Microcontroller makes the system portable).

1.6 Literatures Review

There are some researches and projects that worked on this topic, some of these are:

Advances in Rehabilitation Robotics: This study about Rehabilitation Robots (RR) which are expected to play an important role toward the independent life of older persons and persons with disabilities.

Intelligent Bed Robot System

Based on the survey that we conducted, we have developed an intelligent bed robot system composed of a pressure sensor-laid bed, and a manipulator as shown in Fig.1.2. Most previous researches have focused on the system which can monitors the patient's posture and motion on bed. We, however, propose a robotic system which can actively help the patient using a robotic manipulator. While the patients on the bed, the pressure sensors monitor his posture and motions. When he moves on the bed, the robotic manipulator can support his body.

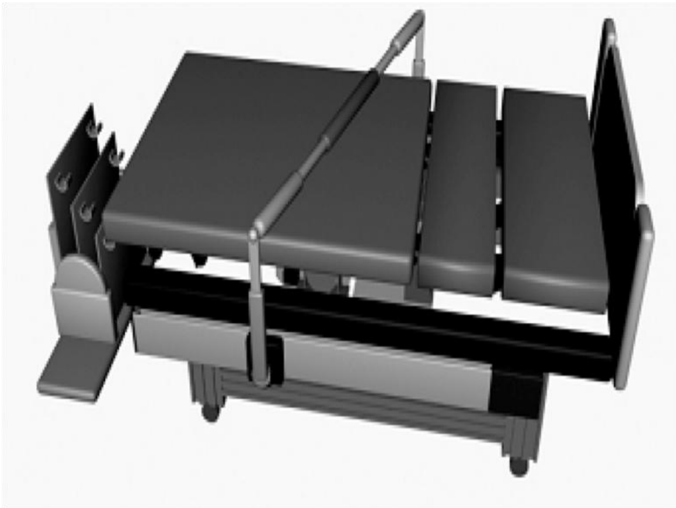


Fig. 1.2: Intelligent bed robot system

In developing the pressure sensor-laid mattress, a set of Force Sensing Resistors (FSR) is used as a pressure sensor. The resistance value of the FSR decreases in proportion to applied force on the active surface.

Intention Reading in Bed

Until now, there have been many intelligent bed systems, but most of them were focused on the monitoring of user's behavior on bed based on temperature, pressure, or vision sensor. So, it can tell what he is doing but cannot tell what he wants to do.

Compared with other systems, our research is also focused on finding what he likes to do, i.e. user's intention as an input of the system as shown in Fig. 1.3. This function becomes very important for the elderly and the handicapped since they are not good at mobility and at manipulation of devices.

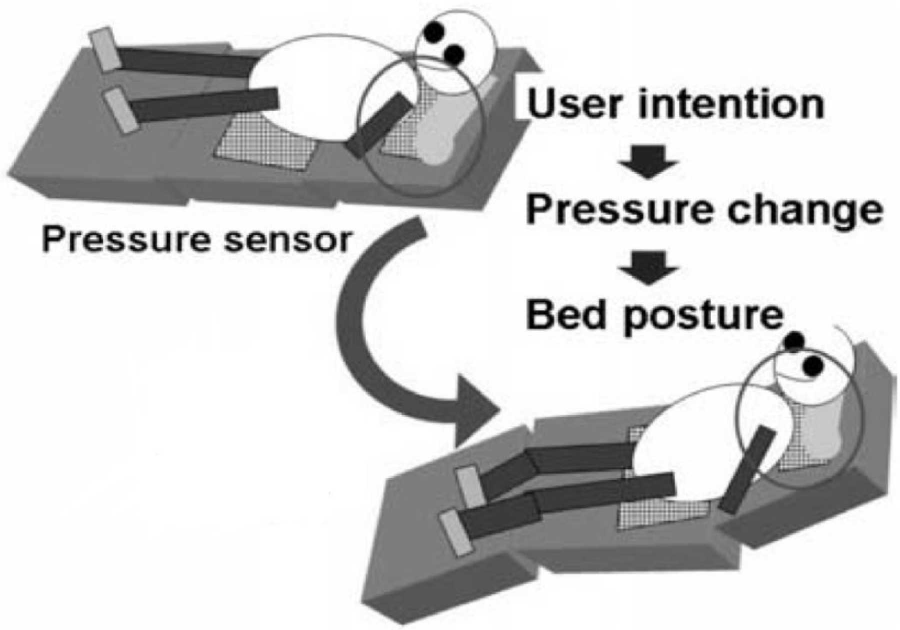


Fig. 1.3: Interaction between user and intelligent bed.

When the user intends to lift his/her body up, center of pressure (COP) moves toward his/her hip and total contacting area (TA) becomes bigger. When the user intends to lower his/her body down, COP moves toward his/her head and TA becomes smaller.

1.7 Time Plan

The time plan covers the stages of designing and building the system components. The Table1.1 includes the first semester, while the Table 1.2 shows the tasks scheduling for the second semester. Table1.1 shows the first semester and Table 1.2 shows the second semester:

Table 1.1: Time Planning (First Semester).

Tasks \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project Determination																
Data Collection																
Literature Review																
Design and Analysis																
Documentation																

Table 1.2: Time Planning (Second Semester).

Tasks \ Week	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Software Design																
Hardware Implementation																
Software Testing																
Hardware Testing																
Integrated System																
Documentation																

1.8 Cost Estimation and Budget Breakdown

This section lists the overall cost of the project. The cost includes the hardware, the software, and the human resources costs.

- **Hardware Cost**:

  Include the cost of the components that will be used to implement the project.

Table 1.3: Hardware Cost.

Component	Quantity	Price
PIC	1	60NIS
Load Cell Sensors	4	100 NIS
Medical Bed	1	(PRCS)
LCD	1	50 NIS
IC's	-	100 NIS
Power Supplies	1	100 NIS
Total		**410NIS**

- PRCS offered a motorized bed for this project.

- **Software Cost:**

  Includes the cost of software used to implement the project. Table1.4 shows the cost of each component:

Table 1.4: Software Cost.

Component	Price
MPLAB program	Free
PROTEUS program	Free

1.9 Risk Management

The implementation of any project may face many risks during each stage of the project: defining and analyzing the system requirements, designing, implementing and testing the whole system. This section illustrates the problems which may occur during the implementation.

1.9.1 Technology Risk

Technology risks can be classified as hardware and software risks:

- **Hardware risks include:**
  - Multi functions of electronic chips such as PIC microcontroller and encoding chip, which is used in the interfacing circuit.

- **Software include:**
  - The program may face problem (build failed).

1.9.2 Risks Avoidance

✓ Taking care when using hardware components and using them according to their specifications.

✓ Taking care of the team members health during the project development.

- ✓ Including an extra amount of the hardware components, so when any problem occurs the alternative components could be found and replaced easily.

1.10 The Structure of Report

The documentation for this project is presented into three chapters, the report structure views the outline for discussed subjects in each chapter. The outline of all chapters is summarized briefly as follows:

Chapter One: Introduction.

Demonstrates concept of the project, problem statement, recognition of need project importance and objectives, a literature review, estimated cost and time planning, risk management and risk avoidance, finally this chapter shows the structure of project report.

Chapter Two: Theoretical Background.

Focus on theories and materials that related to the project. It mentions the laws behind the used hardware or software project components.

Chapter Three: Design Concepts.

Describe the details of system objectives, design options, a general block diagram and the control block diagram.

Chapter Four: Hardware System Design.

Describe the hardware system (motor, driver, circuits, PIC).

Chapter Five: Software System and System Testing.

Describe the details of system code, flowchart.

Chapter Six: Conclusion and Future Work.

Describe the experimental results, conclusion of the whole system and the future works.

1.11 Summary

This chapter included concept of the project, problem statement, recognition of need, project importance and objectives, a literature review, estimated cost and time planning, risk management and risk avoidance, finally this chapter shows the structure of project report.

Chapter Two

Theoretical Background

2.1 Introduction

This chapter focuses on theories and materials that are related to our system operation and behavior.

2.2 Project Components

The components of this project include several parts; each of them is related to the other to form the whole system. These components are:

1- One Microcontroller.
2- Stryker secure II Medical bed.
3- Four load cell sensors.
4- Software.
5- LCD (Liquid Crystal Display).

2.3 Hardware Theoretical Background.

Smart bed is system that collects between mechanical, electrical, control, electronic engineering, in order to build mechatronic system that serves paralyzed people, the essential point here is to recognize the intention of the man sitting in the bed by load sensor (strain gauge).

2.3.1 Sensor

A sensor is transducer (or detector) that provides what is necessary to generate a correct representation of a sensed or controlled quantity (e.g. temperature, pressure, strain, flow, ph., etc.).

A sensor is device that converts physical, biological, or chemical input into an electrical or optical signal. To be useful, the signal must be measured and transformed into digital format which can be processed and analyzed efficiently by computers.

Sensors are used in everyday life. Applications include automobiles, machines, aerospace, medicine, industry and robotics.

- Strain gauge sensor

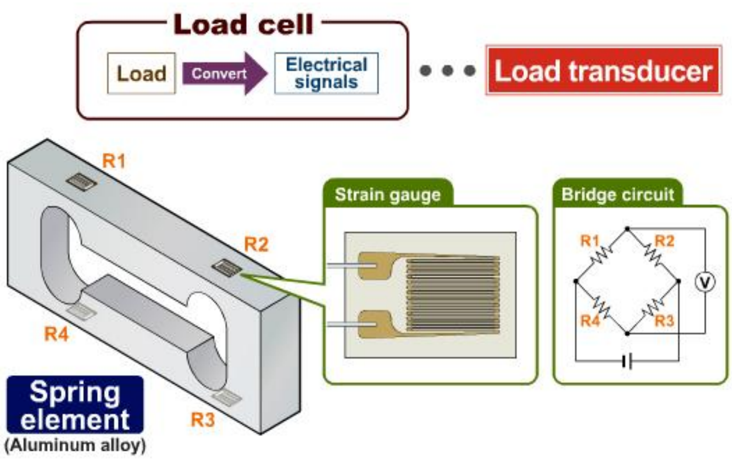


Figure 2.1: Strain Gauge Sensor.

A strain gauge takes advantage of the physical property of electrical conductance and its dependence on the conductor's geometry. When an electrical conductor is stretched within the limits of its elasticity such that it does not break or permanently deform, it will become narrower and longer, changes that increase its electrical resistance end-to-end.

Conversely, when a conductor is compressed such that it does not buckle, it will broaden and shorten this, at decrease its electrical resistance end-to-end. From the measured electrical resistance of the strain gauge, the amount of the applied stress may be inferred.

A typical strain gauge is a long, thin conductive strip in arranged a zigzag pattern of parallel lines such that a small amount of stress, in the direction of the orientation of the parallel lines results in a multiplicatively larger strain over the effective length of the conductor, and hence a multiplicatively larger change in resistance - than would be observed with a single straight – line conductive wire.

Strain gauges measure only local deformations, and can be manufactured small enough to allow a "finite element" like analysis of the stresses to which the specimen is subject.

An excitation voltage is applied to input leads of the gauge network, and a voltage reading is taken from the output leads. Typical input voltages are 5 V or 12 V and typical output readings are in millivolts. Foil strain gauges are used in many situations. Different applications place different requirements on the gauge. In most cases the orientation of the strain gauge is significant.

Gauges attached to a load cell would normally be expected to remain stable over years, if not decades; while those used to measure response in a dynamic experiment may only need to remain attached to the object for a few days, be energized for less than an hour, and operate for less than a second.

Strain gauge based technology is utilized commonly in the manufacture of pressure sensors. The gauges used in pressure sensors themselves are commonly made from silicon, poly silicon, metal film, thick film, and bonded foil.

2.3.2 The Bed

The PRCS offered to install our project on one of the electrically powered beds available at the PRCS clinic.

In our project we want to use ready hardware which is: Stryker secure II with all components, with these specifications:

✓ **Standard Features**

- 6" (15 cm) casters.

- Dual pedestal design.

- CPR release.

- In-rail fowler/knee gatch control.
- Electronic function lock-out control.

- Four-wheel, steel-ring brake system with centrally-located activation pedals.

- Backrest angle indicator.
- Locking-caster steering.
- Four traction sockets.
- Removable headboard with CPR capability.
- Retractable litter top.
- Four Foley bag hooks.
- Four IV receptacles.
- Patient restraint locations.
- Trend. /reverse Trend Controls.

✓ **Specifications of Bed**

- International 3221 (230 VAC).
- Overall Length93" (236 cm).
- Overall Width
  - Side rails up 42.5" (108 cm).
  - Side rails down 40" (102 cm).
- Weight Capacity500 lbs (228 kg).
- Height Range (to litter top)
  - High 30" (76 cm).
  - Low (standard with 6" casters) 16" (41 cm).
  - Low (ZX option) 19.75" (50 cm).

- Litter Positioning

  - Backrest 0° - 60°.
  - Knee Gatch 0° - 40°.
  - Trend./reverse Trend. ±12° (± 10° with ZX option).
  - Retraction 14" (36 cm).

- Patient Surface 35" x 84" (89 x 213 cm).

- Caster Diameter

  - Standard 6" (15 cm).

✓ **Electronics:**

- 230 VAC (International).
- 4A (International), 10A (rating for 115 volt outlet option).
- Current Leakage <100 microamperes.
- 50-60 Hz (International).
- Hospital Grade Plug.

2.3.3 Central Control Unit

- **Bed**

Here we needed one microcontroller to control in the bed, by using PIC and sensors for the bed. In this stage bed must be smart than automatic, by using load cell sensors to recognize the need and control the motion of back rest of bed.

2.4 Software Theoretical Background

Our system depends on the software of strain gauge on the bed, and the PIC. We used the MPLAP which uses C language. In order to program the microcontroller to give us an analog output in order to know the movement of the bed .

We did a hardware simulation by using Proteus in order to detect the errors before we connected the system.

2.4.1 Programming Language

We used microcontroller in order to use C program, by using MPLAP and Proteus to program and Simulink it before we work in real system.

2.5 Summary

This project is intended to design and build a smart system, that controls the back rest of bed, according to the movement of patient. The motion is detected by load cell sensor and the signal filtered and amplified and analyzed in the control unit, that is based on the PIC microcontroller.

Chapter Three

Design concepts

3.1 Introduction

This chapter consists of the project objectives, requirement general objectives of the project, the project requirements, and the general block diagram of the project, design options, load cell sensor.

3.2 Project Objectives

This project is proposed to fulfill the "Graduation Project" course at Mechanical Engineering of PPU.

The graduation project is (Smart Bed For Paralyzed People).

Project objectives:

1- Build smart bed that recognizes the intentions of the paralyzed people.
2- Build flexible system that can be adapted to different persons with different weights and disabilities.

3.3 Project Requirement

- One microcontrollers (PIC18F4550).
- Medical bed (Stryker II).

- Sensors (strain gauge).
- Control circuit.

Figure 3.1: Medical Bed.

3.4 Schematic Diagram of the Project

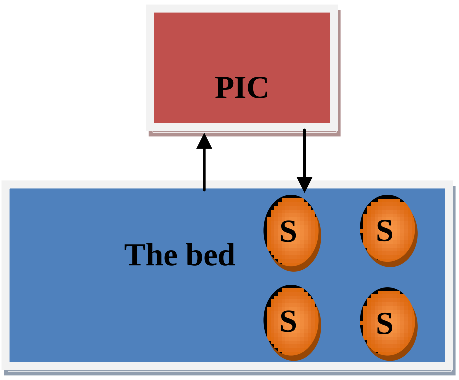


Figure 3.2: Schematic Diagram.

3.5 Design options

We had ready medical bed from Palestine Red Crescent Society Hospital in Hebron, the PRCS accepted to use their medical equipment, and offered a motorized bed to build the project and install the control system and sensors on it, this bed is an electrical bed with AC motor, so we don’t need any mechanical or electrical design.

Smart bed is system that controls its backrest using load cell sensors, composed of strain gauges. The motion of the patient lying on the bed will load the strain gauges in different ways according to the changes of the center of gravity of the head, shoulders, and arms. Strain gauge sensors convert the difference in resistances to electrical signal "voltage" that goes to microcontroller. The microcontroller analysis the signals coming from the four sensors and accordingly sends signals to the actuators to adjust the position of the backrest of the bed.

When the user intends to lift his/her body up, center of pressure (COP) moves towards his/her hip and total contacting area (TA) becomes bigger. When the user intends to lower his/her body down, COP moves toward his/her head and TA becomes smaller.

We wanted to design and build the control system and install it on the bed here to make control design using PIC, and sensor in order to control in the whole system.

3.5.1 Microcontroller

Here we used PIC18F4550 with 40 pins, High-Performance, enhanced flash, USB, with 5 voltage as maximum voltage. We wanted to use one microcontroller that controls in the bed.

The PIC18F4550 family come in different packages, such as DIP (dual in line package), QFP (quad flat package), and LLC (leadless chip carrier).They all have many pains that are dedicated to various functions such as I/O, ADC, timer, and interrupts.

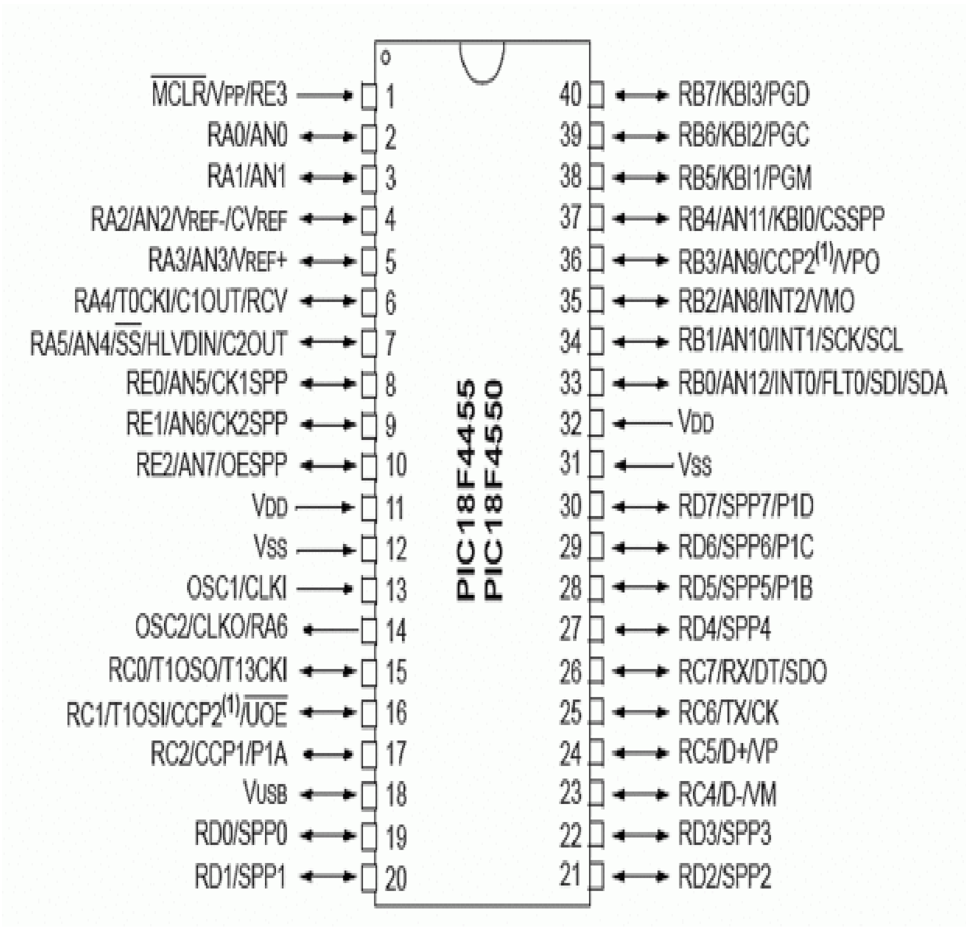


Figure 3.3: Microcontroller PIC18F4550.

3.5.2 Stability (Control)

At the beginning; it was problem in the stability of the bed, with noisy movement in up and down, because the value is in between up and down. For example; if the value is greater than 3 bits, the bed goes up, and if less the bed goes down, so the system was unstable.

The solution was in programming by using multi cases, and choose case between up and down that saves the value, which means the bed starts going down is the value is more than 10 bits, and goes up if the value less than 10 bits, and still up until the value reaches 1 bit. In the case of value less than 3 bits, the bed goes up until the value more than 3 bits, and still to reaches 20 bits to go down. The value of 3 and 10 bits is the starting value before up and down.

3.5.3 Simulink

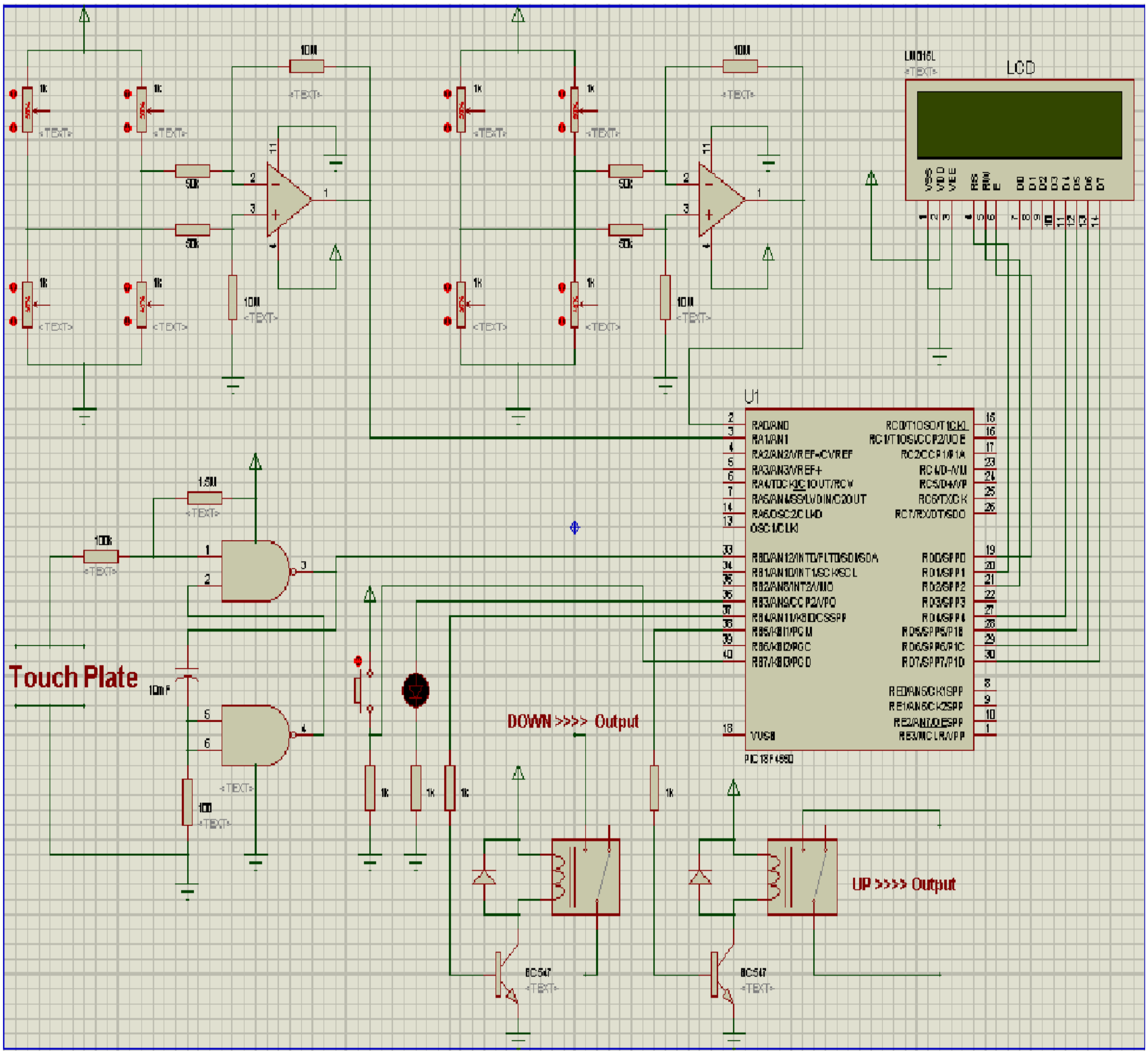


Figure 3.4: Simulink in Proteus Program.

3.6 Strain Gauge Test

This figure is the output from strain gauge sensor, that gave us the relation between force and distance in order to know the movement of each part of the bed, this figure3.6; is taken by oscilloscope with strain gauge (Full Bridge) up to 1.5Kg, in order to apply that by sensor that loads up to 100 kg.

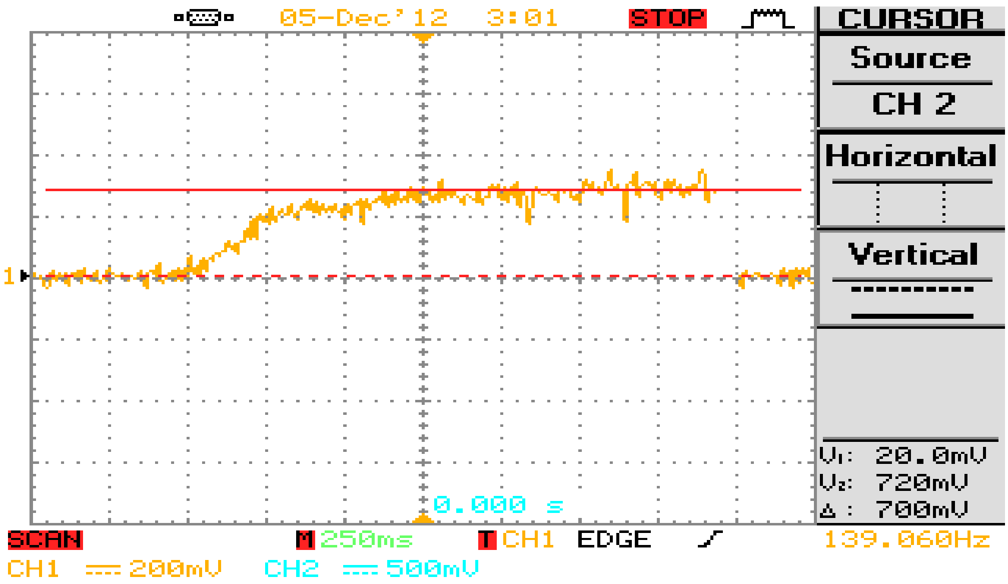


Figure 3.5: Strain Gauge Test.

3.6.1 Data Flow Model

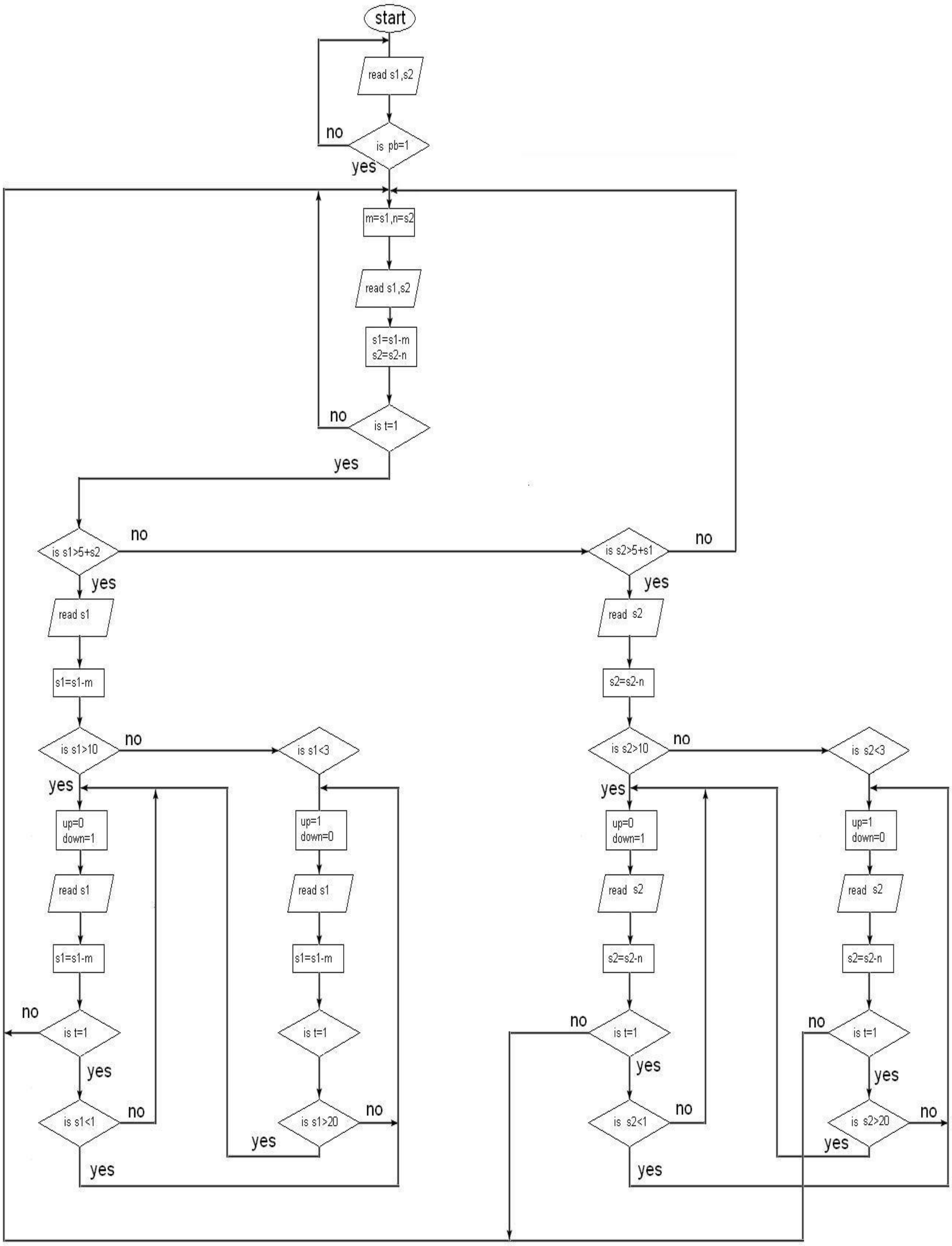


Figure 3.6: Data Flow Model.

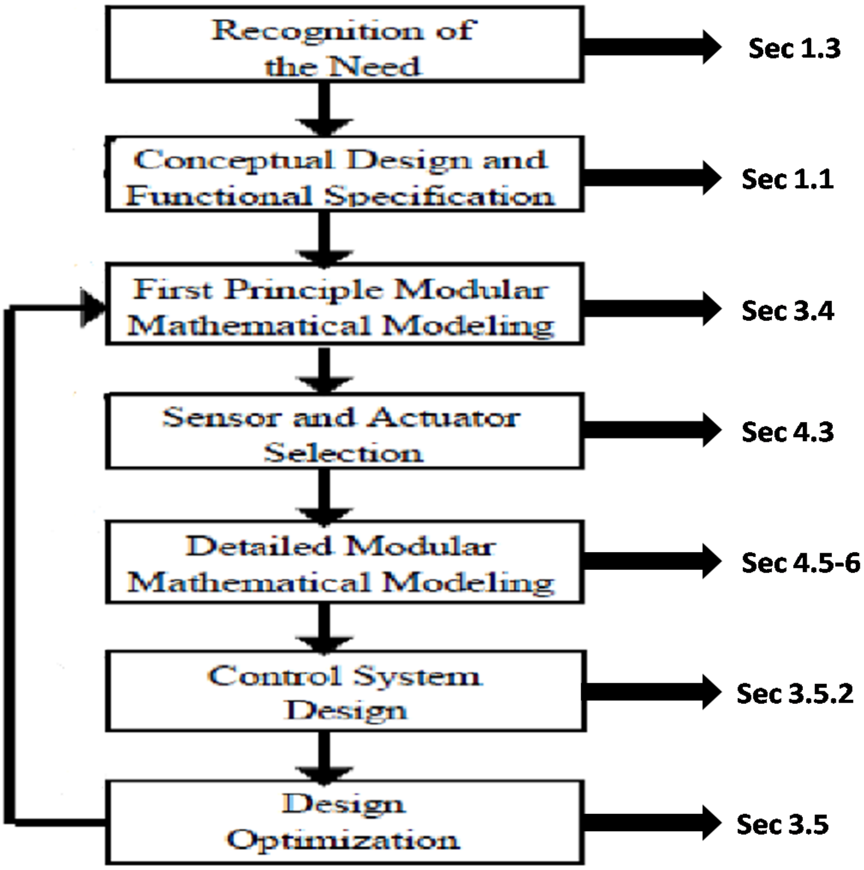


Figure 3.7: Mechatronics Design Approach

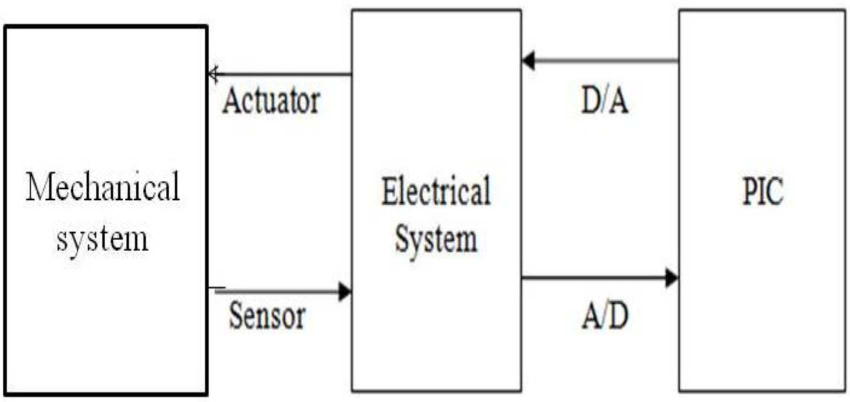


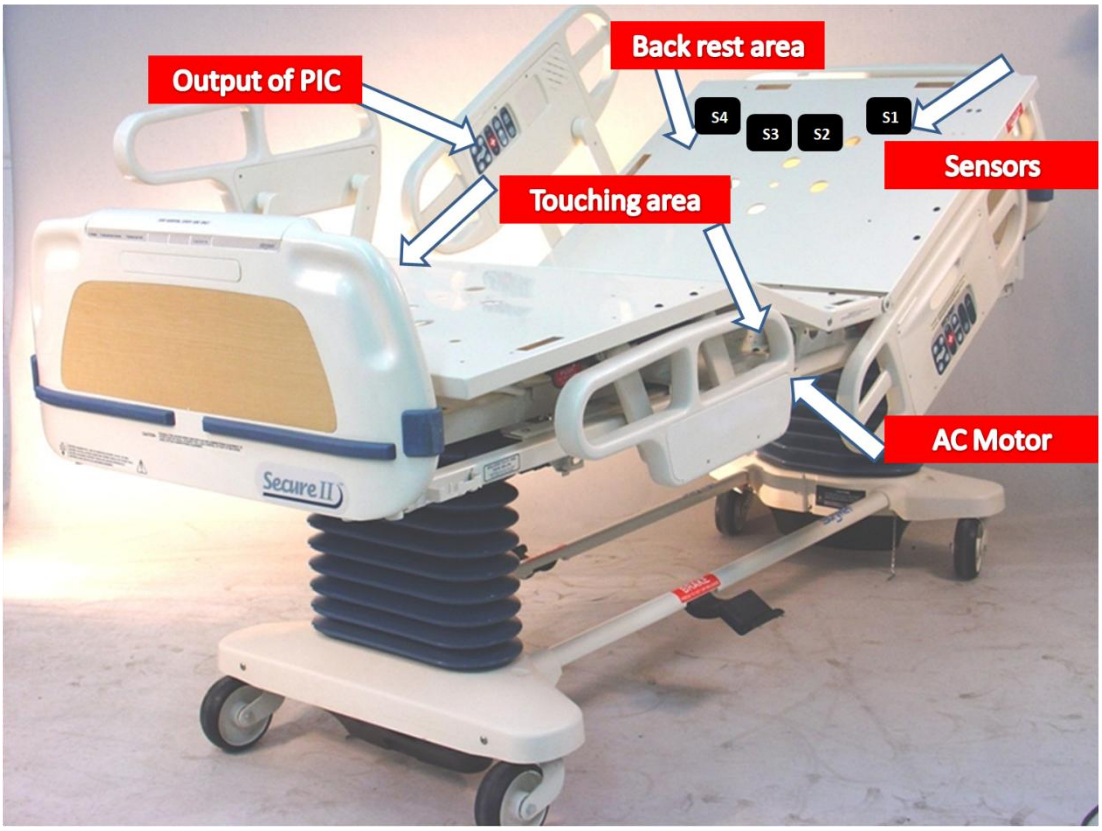
Figure 3.8: Mechatronic System

3.7 Summary

This chapter described design options, general block diagram, and schematic diagram, flow chart for the system, the system requirements, control block diagram, and mechatronic system.

Chapter Four

Hardware system design


Output of PIC
Back rest area
S4
S3
S2
S1
Sensors
Touching area
AC Motor
Secure II

4.1 Introduction

This chapter describes the hardware system including microcontrollers, load cell sensors, motors, and the bed as whole system with the circuits and drivers.

4.2 Microcontroller

The 40 pins PIC18F4550 is shown in Figure 4.1; was selected for this project. This Microcontroller is a high-performance, enhanced flash, and USB. Because of these characteristics and others it was our choice to control the bed system.

The PIC18F4550 family come in different packages, such as DIP (dual in line package), QFP (quad flat package), and LLC (leadless chip carrier).They all have many pins that are dedicated to various functions such as I/O, ADC, timer, and interrupts, Microcontroller characteristics is shown in Table (4.1).

Figure 4.1: PIC18F4550 microcontroller.

Table 4.1: Microcontroller characteristics.

Parameter Name	Value
Program Memory Type	Flash
Program Memory (KB)	32
CPU Speed (MIPS)	12
RAM Bytes	2,048
Data EEPROM (bytes)	256
Digital Communication Peripherals	1-A/E/USART, 1-MSSP(SPI/I2C)
Capture/Compare/PWM Peripherals	1 CCP, 1 ECCP
Timers	1 x 8-bit, 3 x 16-bit
ADC	13 CH, 10-bit
Comparators	2
USB (CH, speed, compliance)	1, Full Speed, USB 2.0
Temperature Range (C)	-40 to 85
Operating Voltage Range (V)	2 to 5.5
Pin Count	40

This figure 4.2; shows every bit in microcontroller how much equal in millivolts, this value used in the project, the value used to decrease the noise and response to the wanted values

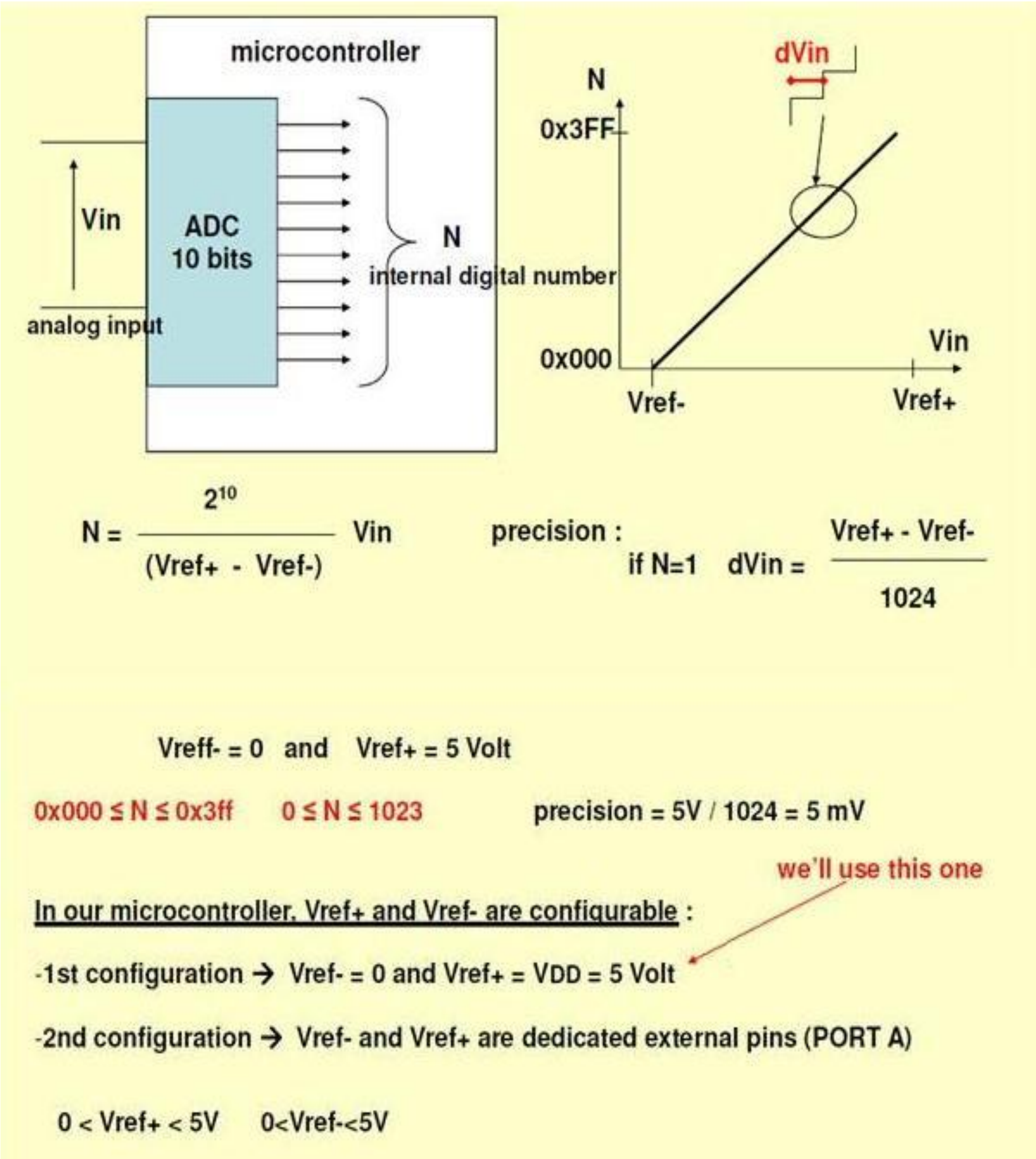


Fig.4.2: ADC "Bits-Volts equations"

4.3 Sensors

A load cell is a transducer which converts force into a measurable electrical output, **Strain-gage load cells** convert the load acting on them into electrical signals. The gauges themselves are bonded onto a beam or structural member that deforms when weight is applied.

In most cases, four strain gages are used to obtain maximum sensitivity and temperature compensation. Two of the gauges are usually in tension, and two are in compression, and are wired with compensation adjustments. When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load.

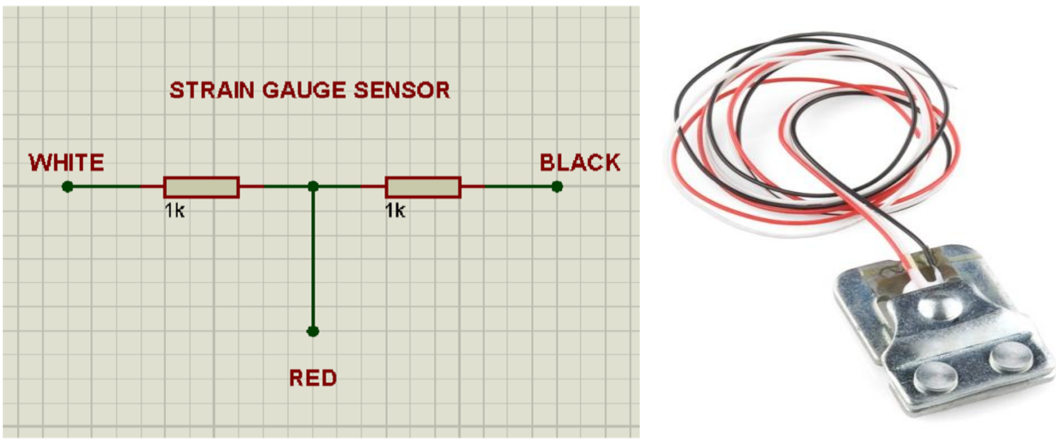


Figure4.3: Connection Of Load Cell Sensor.

The load cell sensor is 34*34 mm, it has three wires one for positive and other for negative and the third one is for signal, it loads from 100g to 150 Kg .

We mad many experiments on several persons in different lengths between (1.6-1.85) meter, and reached to the proper dimensions of the four load cell sensors, as shown in the figure below.

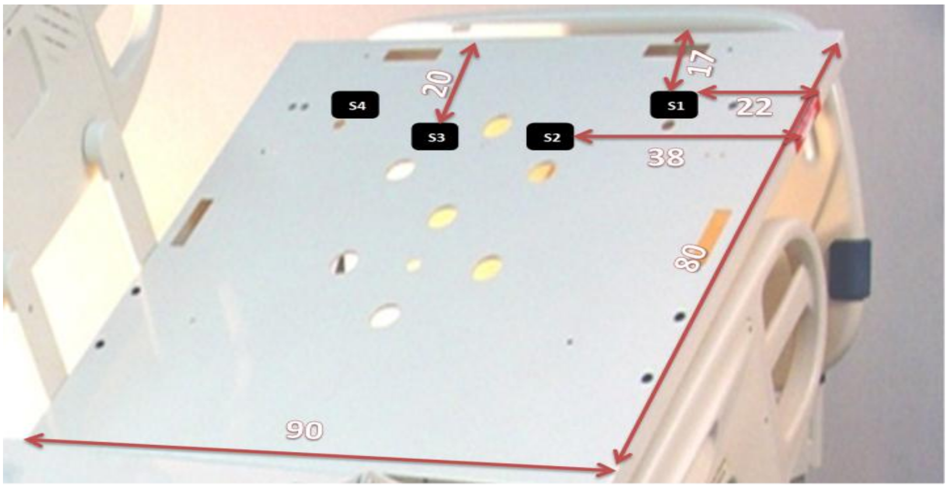


Figure 4.4: Four Load Cell Sensors on the Medical Bed & Dimensions .

The output relationship between voltage and masses is linear with the range of 0.5 kg gives 0.1 millvolt with voltage input 12 V as shown in Figure 4.5.

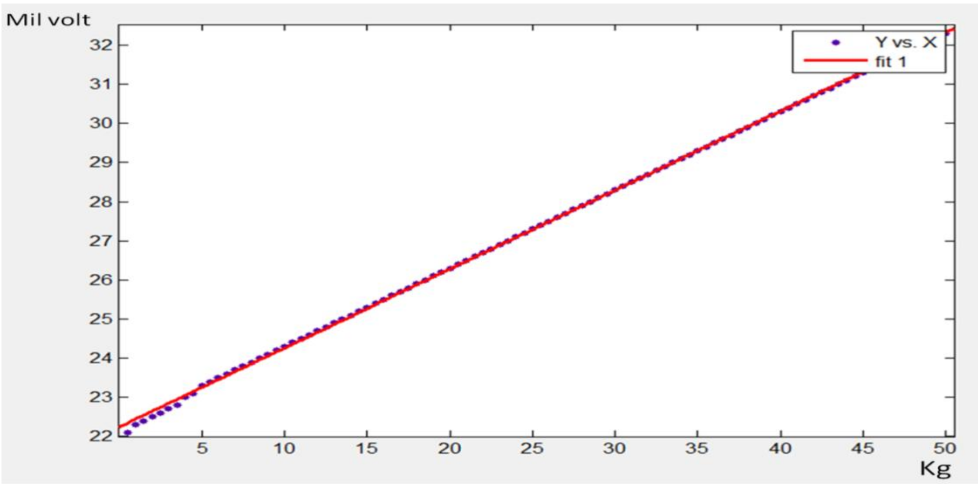


Figure 4.5: Relationship Between Mass &Voltage.

4.4 Motor

An **AC Motor** is an electric motor driven by an Alternating Current (AC).

It commonly consists of two basic parts, an outside stationary stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft that is given a torque by the rotating field.

There are two main types of AC motors, depending on the type of rotor used. The first type is the induction motor, which runs slightly slower than the supply frequency. The magnetic field on the rotor of this motor is created by an induced current. The second type is the synchronous motor, which does not rely on induction and as a result, can rotate exactly at the supply frequency or a sub-multiple of the supply frequency. The magnetic field on the rotor is either generated by current delivered through slip rings or by a permanent magnet. Other types of motors include eddy current motors, and also AC/DC mechanically commutated machines in which speed is dependent on voltage and winding connection.

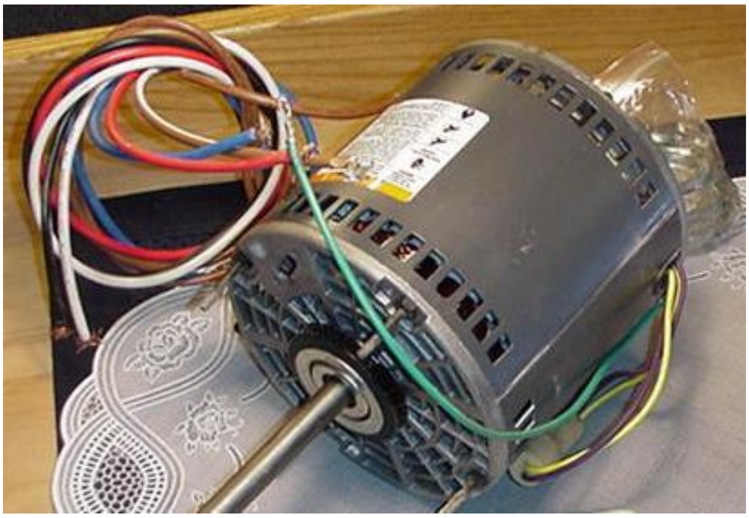


Figure 4.6: AC Motor.

We have two AC motors in the bed , but we did in the backrest AC motor with 230 Volt, 1 Phase, 50-60 Hz,1Ampere, 100 RPM (Revolution Per Minute), the other one with speed of 12 inch\min, 0.8 Ampere, one phase, 50-60 Hz. Our control will be in the backrest AC motor .

4.5 Liquid Crystal Display

A Liquid crystal display (LCD) is a flat panel display, electronic visual display or video display that uses the light modulating proprieties of liquid crystals.

Figure 4.7: LCD-display.

4.6 Circuits

We benefited from balance of resistances in doubling actual signal and canceling the noise of sensors. Differential amplifier works to minus values and double the value of 200 times magnification, because the value of the sensor voltages is very little, and to read voltages by the microcontroller.

The output is connected to microcontroller, and the input is from sensors.

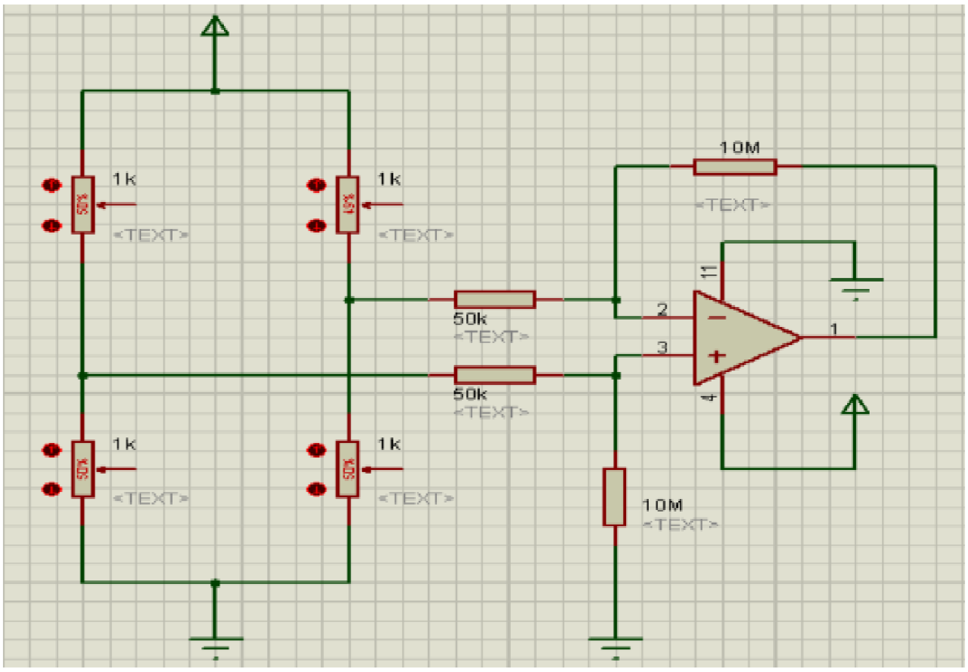


Figure 4.8: Sensor-Gain Circuit.

The converter consists of a Wheatstone bridge with two amplifiers (differential and proportional).

The Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component. Its operation is similar to the original potentiometer.

4.6.1 Operation (Wheatstone Bridge)

The project has four resistances (1Kiloohm), the output of full bridge -Wheatstone bridge- will be zero because all resistances have equal values.

When the resistances values change the voltage change.

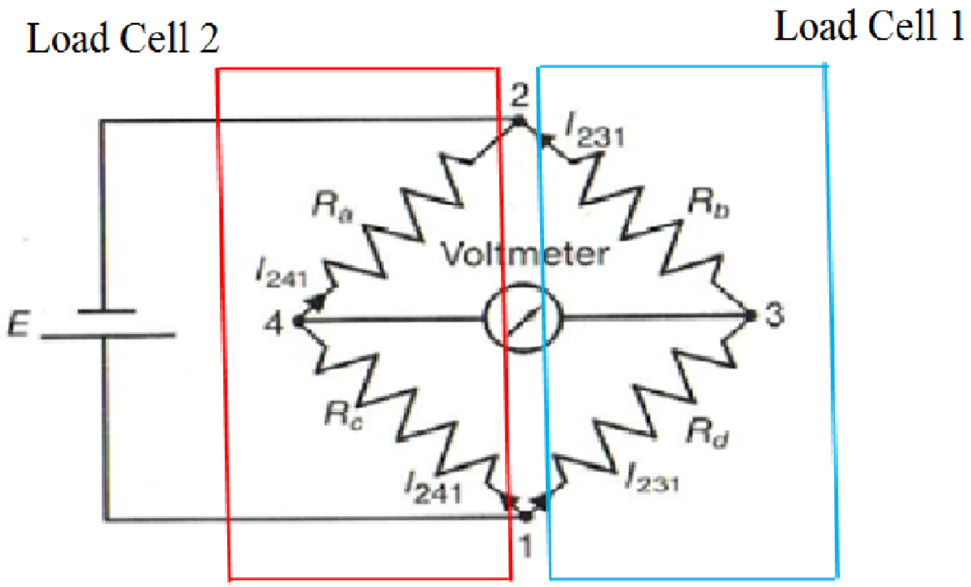


Figure 4.9: Wheatstone bridge.

$$V_{24}=I_{241}R_a=V_{23}=I_{231}R_b \quad \text{and} \quad V_{14}=I_{241}R_c=V_{13}=I_{231}R_d,$$

so

$$I_{241}R_a=I_{231}R_b, \tag{1}$$

and

$$I_{241}R_c=I_{231}R_d. \tag{2}$$

Dividing (1) by (2) gives:

$$\frac{R_a}{R_c}=\frac{R_b}{R_d}. \tag{3}$$

Refer to equation (3) of Wheatstone bridge $V_{out} = 0$.

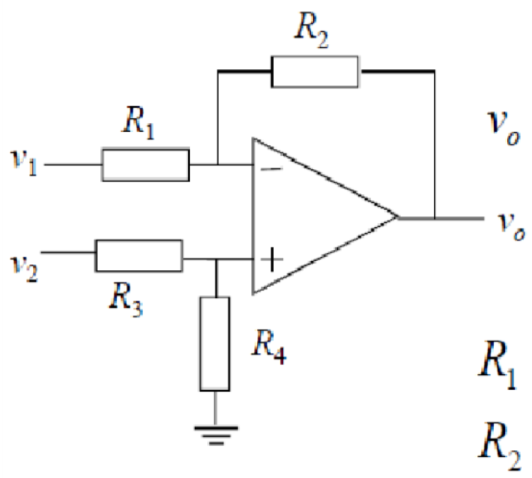
Figure 4.7: shows a strain gauged cantilever undergoing bending. When the gauges are connected as shown the following resistance changes occur under the load:

R_a increases to $R+\delta R$
R_b decreases to $R-\delta R$
R_c decreases to $R-\delta R$
R_d increases to $R+\delta R$.

Calculating the out-of-balance voltage as before it is simple to show that the out-of-balance voltage V is:

$$V=\pm\frac{E\delta R}{R}.$$

4.6.2 Differential Amplifier



$$v_o = -\frac{R_2}{R_1}v_1 + \frac{R_4}{R_3+R_4}\left(1+\frac{R_2}{R_1}\right)v_2$$

$$R_1 \neq R_3$$

$$R_2 \neq R_4$$

$$v_o \neq \frac{R_2}{R_1}(v_2 - v_1)$$

Figure 4.10: Differential Amplifier

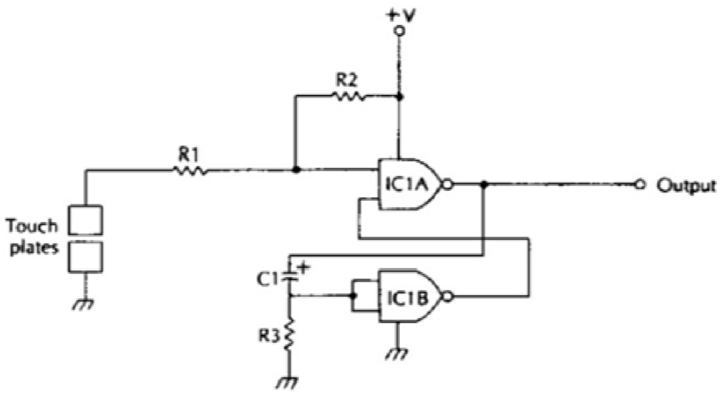
We used it in the project to make difference between two readings, in the equilibrium gives zero output, in non-equilibrium gives changeable reading.

A differential amplifier is a type of electronic amplifier that amplifies the difference between two voltages but does not amplify the particular voltages.

The proportional amplifier requires a smoothed DC power supply in the range 12 - 30 V. The operational status of the proportional amplifier is influenced by the external control signal on the one hand, and on the other by a second demand signal potentiometer. The control voltage at the input to the amplifier is thus dependent on the amplitude of the external control signal and on the setting of the second demand signal potentiometer.

4.6.3 Touch Circuit

We used this circuit to turn on\off the system using two ends, one is connected to the ground, and the other is connected to the input.



This circuit produces an output for a time approximately equal to time constant R_3C_1.

IC1, IC2	CD4011 quad NAND gate
IC3	CD4066 quad bilateral switch
C1	47-µF, 25-V electrolytic capacitor
C2	100-µF, 25-V electrolytic capacitor
C3	220-µF, 25-V electrolytic capacitor
C4	470-µF, 25-V electrolytic capacitor
C5, C6, C7	0.1-µF capacitor
R1, R3, R4, R6	100-kΩ, ¼-W 5% resistor
R7, R9, R10, R12	
R2, R5, R8, R11	10-MΩ, ¼-W 5% resistor

The touching circuit is working if and only if the patient himself touches the two ends of the bed by his feet, if the patient touches one side and other person touches the other side the system will not response. The figure 4.11; shows the connection of touching circuit in proteus program.

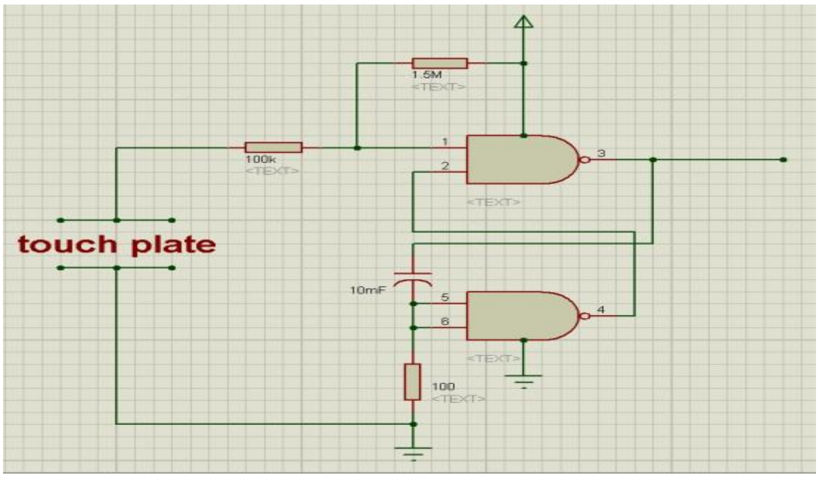


Figure 4.11: Touching Circuit.

4.7 Sensor-Microcontroller-Motor Interfaces

The figure 4.12; shows the integrated system circuit, which consists of several circuits and electronic pieces, including the touching circuit when the patient touches the ends of bed gives 5 volts. The pushbutton is used to make the value of sensors zero. The led used to know if the microcontroller is on or off. LCD is used to know the readings of sensors.

We used relay as alternative about the button on the bed, as normally open, to connect and cut the current. We used transistor because the relay needs high current and the PIC has low current as protector to isolate two circuits.

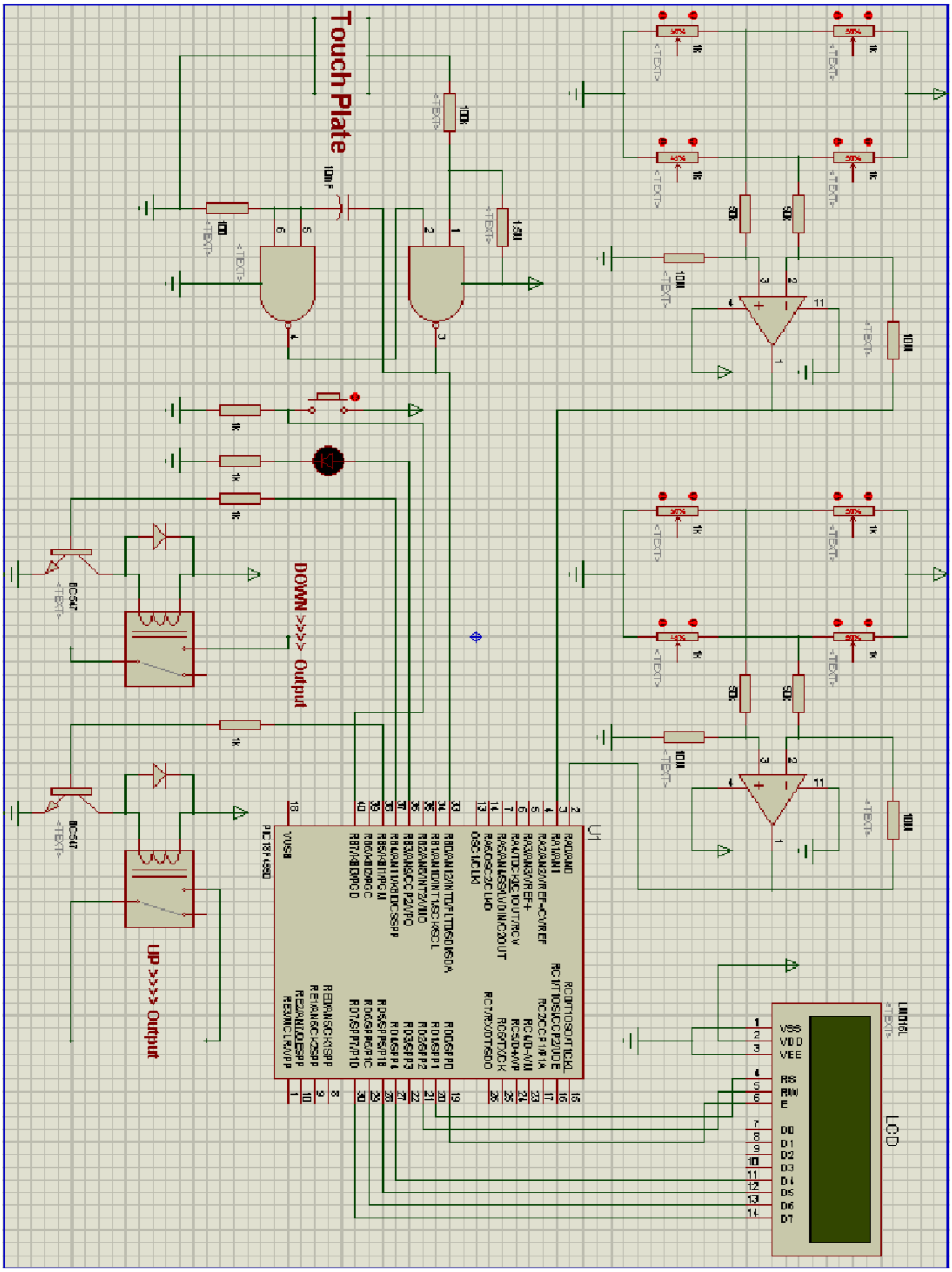


Figure 4.12: System Circuit.

The circuit in figure 4.12; contains three circuits which are (Touching – Sensors - Microcontroller), when patient compresses by his head on the sensor the value of voltage will change, then the system will enter the voltage to RA0,RA1 analogue signal in microcontroller .

In figure 4.13 below; it was hard to connect between the output of PIC and bed motors, because the up and down need driving circuits, so we preferred use the bed driving circuits.

The relays used to benefit from normally open platens, to convert the pushbuttons of up and down from mechanical to automatic. The platens connected in parallel with up and down pushbuttons, the relays receive commands from microcontroller by pressure and raise the patient's head on the bed.

When the microcontroller sends command to up relay, normally open converts into normally close, then the bed works in up case, and that represents compression on up push button because the two buttons connected parallel, and the same thing for down.

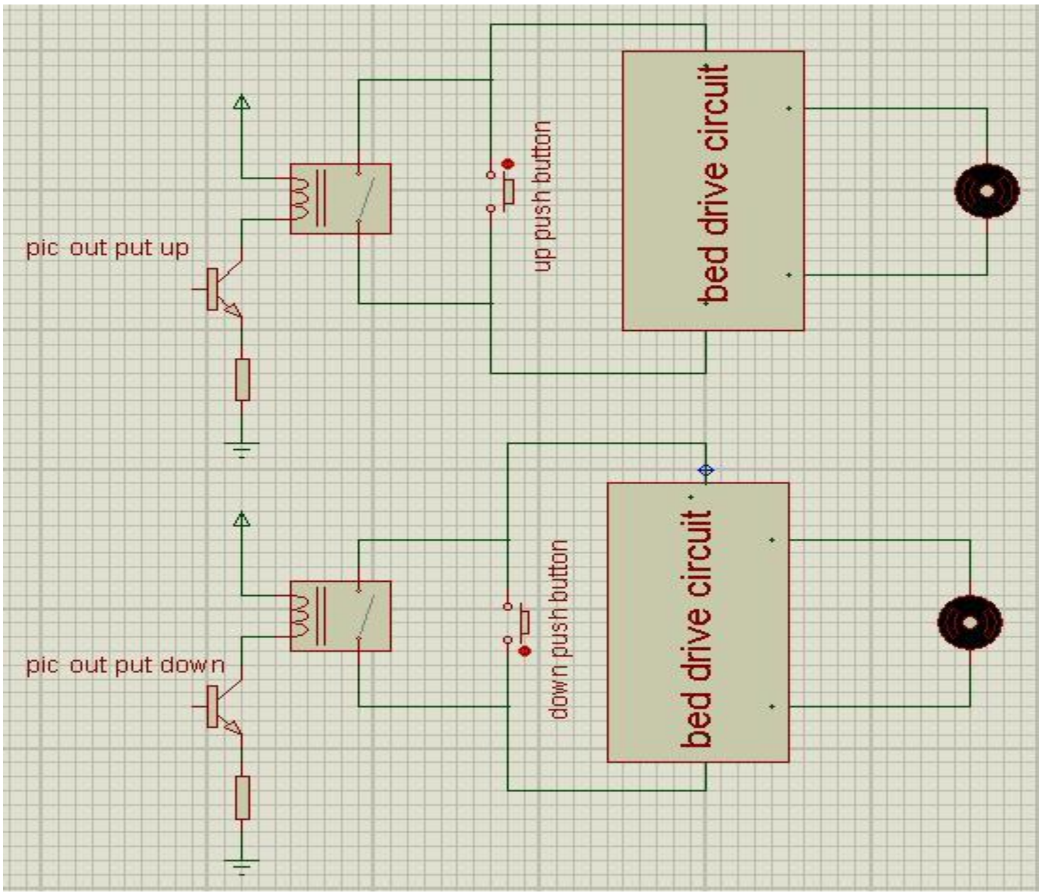


Figure 4.13: Driving Circuit.

4.8 Summery

We explained in this chapter the type of PIC which we used in our project, the load cell sensors (its operation and characteristics), the motors which are in the project, the circuits which turn on and control the whole system.

Chapter Five

Software Design &System Testing

5.1 Introduction

This chapter contains the C++ program, the flow chart, the testing for the whole system after installation.

5.2 Intention Recognition

5.2.1 Algorithm

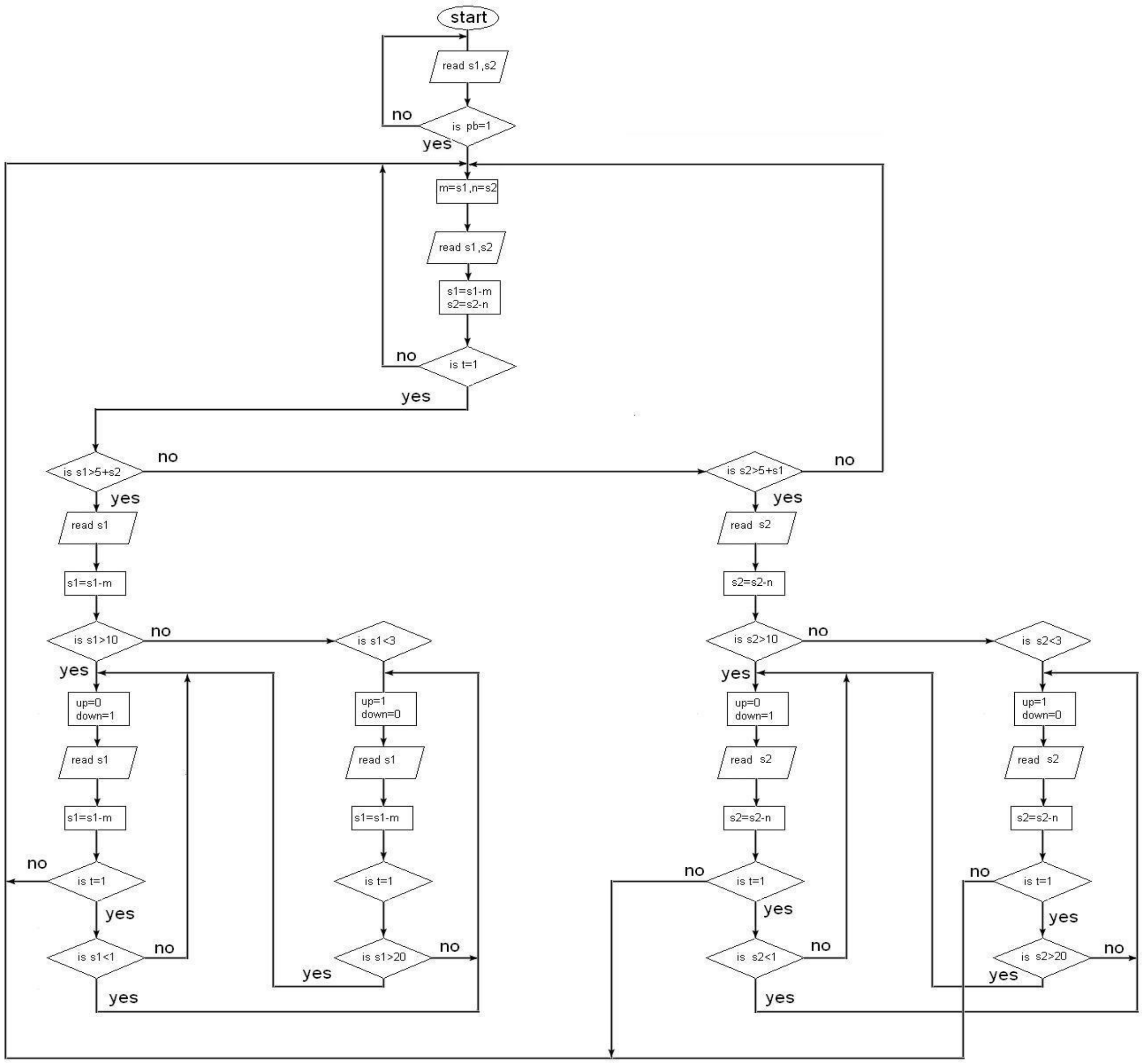


Figure 5.1: Flow Chart Algorithm.

5.2.2 Program

Project programmed by C++ using switch cases. They are 8 cases shown if figure 5.2:

- When the project turning on the code waits the compression of the pushbutton to take the first reading.
- In case8-2; the code subtracts the new reading from the last.
- In case 2; the code waits the touch of the bed by patient, then it makes comparison between (S1&S2) and if (S1>S2) the code adds 5 bits to S1 and takes reading from S1 if (S2>S1) adds 5 bits to S2 and takes reading from S2.
- If the code takes reading from S1 transfers to case 3.
- In case 3; the code checks if (S1> 10) bits goes to case 5 then the bed goes down, and if (S1<3) bits goes to case 6 and goes up.
- In case 5; if the (S1<1) bits goes to case 6 and goes up.
- In case 6; if (S1>20) bits goes to case 5 and goes down.
- If the code takes readings from S2 the code goes from case 2 to 4.
- In case 4; if the (S2>10) bits goes to case 7 and the bed goes down, and if (S2<3) bits goes to case 8 and goes up.
- In case 7; is (S2<1) bits goes to case 8 and goes up.
- In case 8; if (S2>20) bits goes to case 7 and goes down.

Case 3-8; if the patient does not touch the bed, and the touch switch=0.0, the code goes to case 2, and the values of up and down=0.0, and the code waits the touch of the bed.

The bed doesn’t work without touching it.

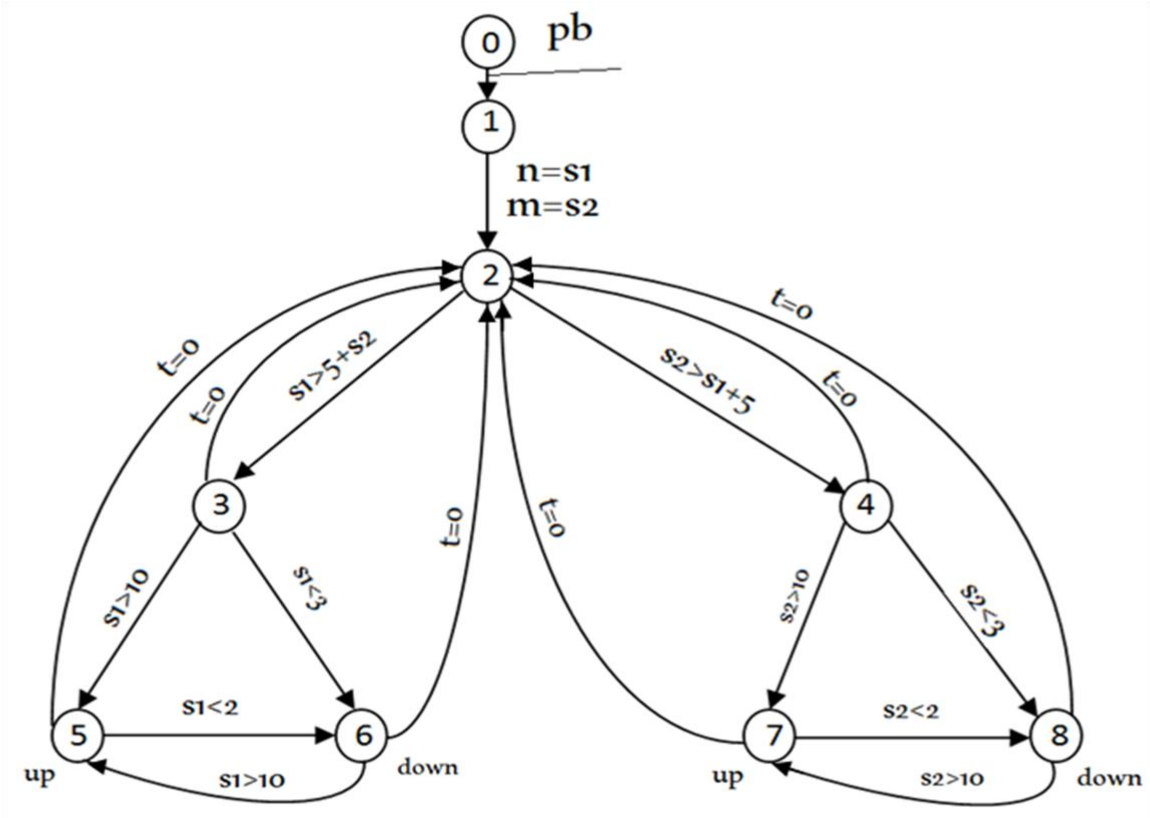


Figure 5.2: Data Flow Model.

We used C++ language to achieve the duty by using MPLAB program with its programmable, our code is:

```
#include<p18f4550.h>                    // PIC18f4550 library
#include<adc.h>                         // AD Converter library
#include"gamelcd_v3.h"                  // LCD library
#include"gamelinit.h"                   // Initial value for PIC

#define pb PORTBbits.RB7                // Rest(take rest value)
#define t PORTBbits.RB0                 // Touch switch
#define u PORTBbits.RB5                 // Out put up
#define d PORTBbits.RB4                 // Out put down
```

```
#define l PORTBbits.RB3               // Test PIC



void main()
{
      int s2,x,n,v,s1,m,v2,f,j,k;

      ADCON1=0b1010;
      // To make only pin1-pin4 analog and all pins digital

      TRISB=0b10000001;
      // To define input and output for port B

      OpenADC(ADC_FOSC_64& ADC_RIGHT_JUST& ADC_20_TAD,
            ADC_INT_OFF& ADC_VREFPLUS_EXT&
ADC_VREFMINUS_EXT,10);                // Configure ADC

      x=0;
      l=1;
      u=0;
      d=0;
      while(1)
      {
            switch(x)
            {

                  case 0: //..............................

                        SetChanADC(ADC_CH0);  // Set channel
input
                        ConvertADC();         //Start conversion
```

```
                    while(BusyADC()==1);  // Wait finish
convert
                    s1=ReadADC();         // Read AD convert


                    SetChanADC(ADC_CH1);  // Set chanel0
input
                    ConvertADC();
                    while(BusyADC()==1);
                    s2=ReadADC();


                    lcd_init();           // Call LCD
                    lcd_gotoyx(1,1);// Cursor go to position
                    lcd_putrs("s1=");     // Write text
                    lcd_gotoyx(1,4);
                    lcd_puti((int)s1);    // Write integer
                    lcd_gotoyx(1,8);
                    lcd_putrs("0c");
                    lcd_gotoyx(2,1);
                    lcd_putrs("s2=");
                    lcd_gotoyx(2,4);
                    lcd_puti((int)s2);

                    if(pb==1)
                         {
                              n=s1;       // Store value
                              m=s2;
                              x=1;        // Go to case 1
                         }
               break;

               case 1: //..............................
```

```
        f=m-n;

        x=2;                  // Go to case 2
break;

case 2: // ..............................

        SetChanADC(ADC_CH0);
        ConvertADC();
        while(BusyADC()==1);
        s1=ReadADC();

        SetChanADC(ADC_CH1);
        ConvertADC();
        while(BusyADC()==1);
        s2=ReadADC();


        v=s1-n;
        v2=s2-m;

        lcd_init();
        lcd_gotoyx(1,1);
        lcd_putrs("s1=");
        lcd_gotoyx(1,4);
        lcd_puti((int)v);
        lcd_gotoyx(1,8);
        lcd_putrs("2c");
        lcd_gotoyx(2,1);
        lcd_putrs("s2=");
        lcd_gotoyx(2,4);
        lcd_puti((int)v2);
```

```
        if(v>(v2+5) && t==1)
              x=3;            // Go to case 3
        if(v2>(v+5) && t==1)
              x=4;            // Go to case 4


  break;

  case 3: //..................................

        SetChanADC(ADC_CH0);       // Set chane1
input
        ConvertADC();
        while(BusyADC()==1);
        s1=ReadADC();

        s1=f+s1;
        v=s1-m;               //S1 value start
from zero


        lcd_init();
        lcd_gotoyx(1,1);
        lcd_putrs("s1=");
        lcd_gotoyx(1,4);
        lcd_puti((int)v);
        lcd_gotoyx(1,8);
        lcd_putrs("3c");



        if(v>10 && t==1)
              {
```

```
                x=5;

            }
        if(v<3&&t==1)
            x=6;

        if(t==0)
            {
                u=0;            // Stop up
                d=0;            // Stop down
                x=2;            // Go to case
            }
        if(pb==1)
            x=0;

    break;

    case 4: //..................................

        SetChanADC(ADC_CH1);
        ConvertADC();
        while(BusyADC()==1);
        s2=ReadADC();

        v2=s2-m;        // Value start from zero


        lcd_init();
        lcd_gotoyx(1,8);
        lcd_putrs("4c");
        lcd_gotoyx(2,1);
        lcd_putrs("s2=");
        lcd_gotoyx(2,4);
```

```
            lcd_puti((int)v2);

        if(v2>100 && t==1)
                {
                        x=7;

                }
            if(v2<3&&t==1)
                x=8;



            if(t==0)
                {
                        u=0;
                        d=0;
                        x=2;        // Go to case 2
                }

            if(pb==1)
                x=0;
        break;

        case 5:
                u=0;
                d=1;

            SetChanADC(ADC_CH0);  // Set chane1
input
            ConvertADC();
            while(BusyADC()==1);
            s1=ReadADC();

            s1=f+s1;
```

```
            v=s1-m;               //S1 value start
from zero

            lcd_init();
            lcd_gotoyx(1,1);
            lcd_putrs("s1=");
            lcd_gotoyx(1,4);
            lcd_puti((int)v);
            lcd_gotoyx(1,8);
            lcd_putrs("5c");

            if(v<-1&&t==1)
            x=6;
            if(t==0)
                  {
                        u=0;              // Stop up
                        d=0;              // Stop down
                        x=2;              // Go to case
                  }
      break;

      case 6:
            u=1;
            d=0;

            SetChanADC(ADC_CH0);  //Set chanel1 input
            ConvertADC();
            while(BusyADC()==1);
            s1=ReadADC();

            s1=f+s1;
```

```
            v=s1-m;              //S1 value start
from zero


            lcd_init();
            lcd_gotoyx(1,1);
            lcd_putrs("s1=");
            lcd_gotoyx(1,4);
            lcd_puti((int)v);
            lcd_gotoyx(1,8);
            lcd_putrs("6c");

            if(v>10&&t==1)
                  x=5;
            if(t==0)
                  {
                        u=0;              // Stop up
                        d=0;              // Stop down
                        x=2;              // Go to case
                  }
      break;

      case 7:
            u=0;
            d=1;

            SetChanADC(ADC_CH1);
            ConvertADC();
            while(BusyADC()==1);
            s2=ReadADC();

            v2=s2-m;             // S2 value start
from zero
```

```
        lcd_init();
        lcd_gotoyx(1,8);
        lcd_putrs("7c");
        lcd_gotoyx(2,1);
        lcd_putrs("s2=");
        lcd_gotoyx(2,4);
        lcd_puti((int)v2);

        if(v2<-1&&t==1)
            x=8;
        if(t==0)
            {
                u=0;                // Stop up
                d=0;                // Stop down
                x=2;                // Go to case
            }
    break;

    case 8:
        u=1;
        d=0;

        SetChanADC(ADC_CH1);
        ConvertADC();
        while(BusyADC()==1);
        s2=ReadADC();

        v2=s2-m;                // S2 value start
from zero
        lcd_init();
        lcd_gotoyx(1,8);
        lcd_putrs("8c");
```

```
                    lcd_gotoyx(2,1);
                    lcd_putrs("s2=");
                    lcd_gotoyx(2,4);
                    lcd_puti((int)v2);

                    if(v2>10&&t==1)
                         x=7;

                    if(t==0)
                         {
                              u=0;                // Stop up
                              d=0;                // Stop down
                              x=2;                // Go to case
                         }
               break;
          }
     }
}
```

5.4 Subsystems Testing

When the first circuit was initially built, many problems were faced in the amplifier, DC-AC converter, direction, resistances, wires.

Amplifier: we faced variable noise, so we used low pass filter to cancel this error but unfortunately we could not fix it, so we changed the type of amplifier and the same error is still in the reading.

DC-AC: we faced problems in convert the 12V DC to 220V AC, so we tried to buy an inverter but the inverters in the local market are three phase output, so we used relays to convert the voltage from 5 volts to 7 volts for the button of up-down switch.

Direction: we faced problem how to reverse the direction of back rest area, the motor is fitted with a four pins connector and can be controlled using the code.

Then we assembled the circuit with power supply and sensors in order to take readings to our bodies by using four sensors, two under the head and the others under the back, and we saw they are not changed in the values of the back sensors so we put the four sensors under the head area every two above the two shoulders in order to take any value if the paralyzed patient moved left or right.

5.5 Real Circuits

In the figure 5.3; the green area is touching circuit consists of capacitor and NAND gate which turns on\off the system, the red wire in the left of figure is connected to the end of bed, the red area is sensors circuits consists of resistances and amplifier, the wires in the right of the figure are sensors wire entered to differential amplifier.

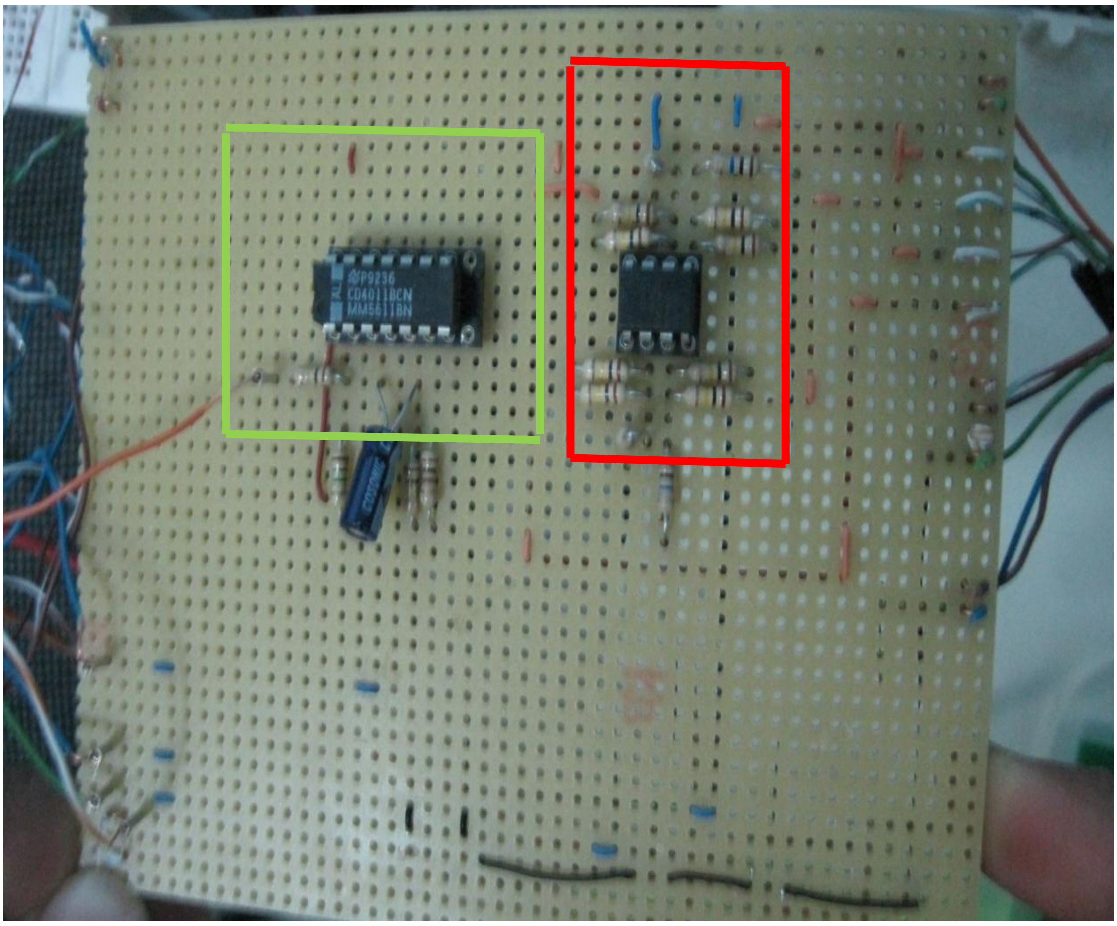


Figure 5.3: Touching – Amplifier Circuit.

When patient compresses by his head on the sensor the value of voltage will be changed, then the system enters the voltage to RA0, RA1 analogue signal in microcontroller.

Touching circuit when the patient touches the ends of bed gives 5 volts in microcontroller to start the system. The pushbutton used to make the value of sensors zero. The led used to know if the microcontroller is on or off. LCD used to know the readings of sensors and the stages of the programming sequence.

We used relay as alternative about the button on the bed, as normally open, for connect and cut the current, and we used transistor because the relay needs high current and the PIC has low current as protector to isolate two circuits.

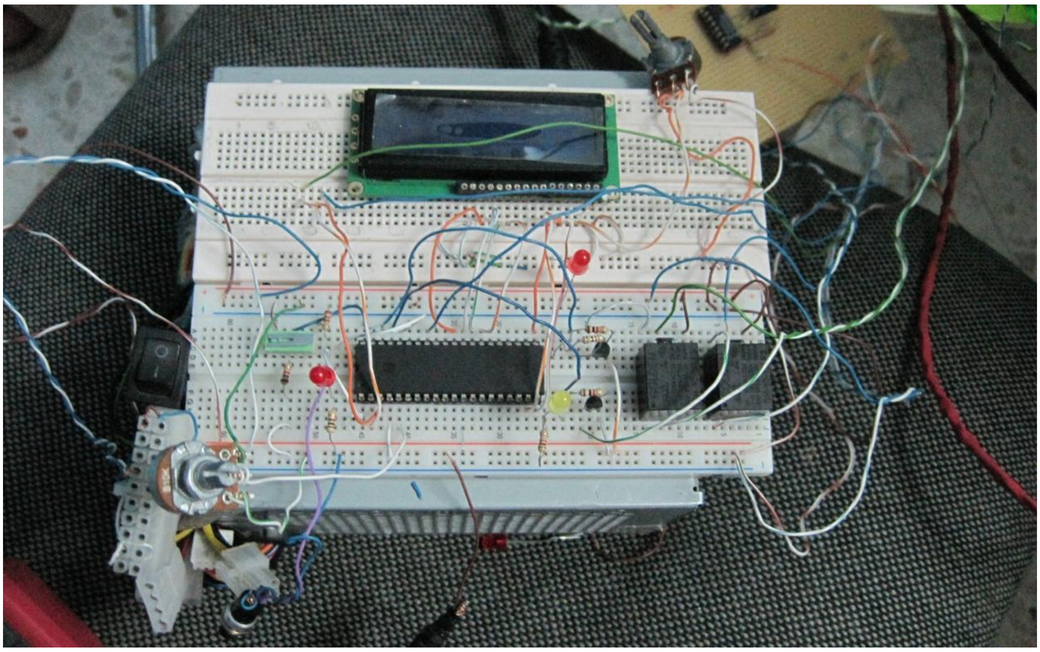


Figure 5.4: Microcontroller –LCD.

5.6 Summary

This chapter displayed program on the PIC to give instructions for the actuators to move the motor in order to help the paralyzed people, the flow chart to build the code easy, the testing experiments.

Chapter Six

Conclusion & Future Works

6.1 Introduction

This chapter contains the experimental results, conclusion, and the future works.

6.2 Experimental Results

These figures 6.1(A&B); shows the tension and compression of the patient in two cases (up & down) for head.

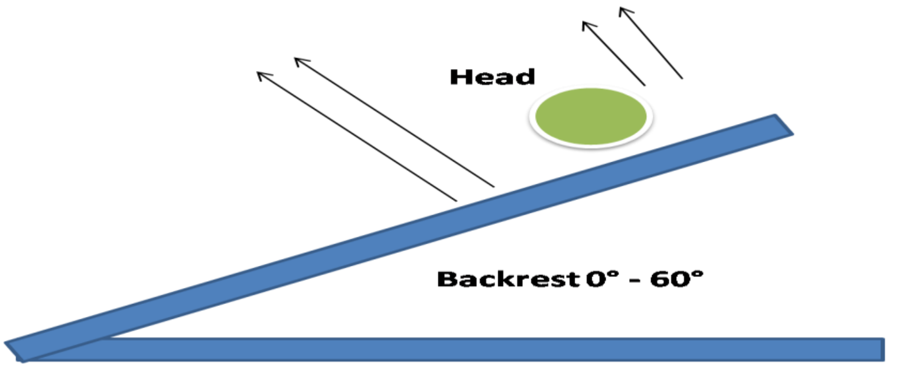


Figure6.1A

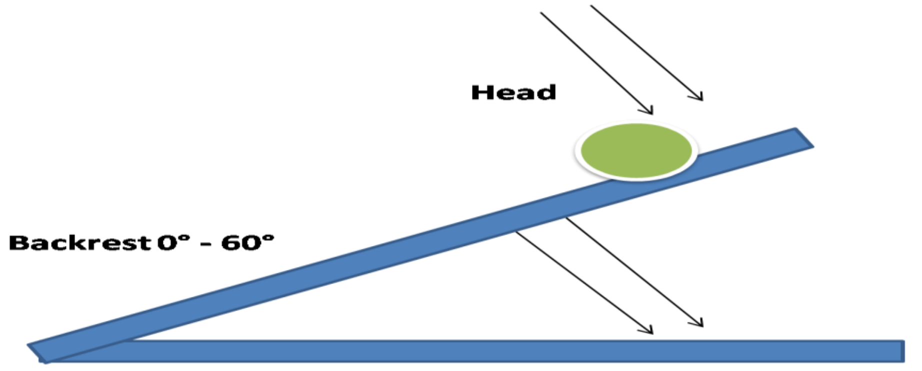


Figure6.1B

This figure 6.2; shows the output of sensor readings with noise, using differential amplifier and quarter bridge to give us the output for sensor as actual signal using oscilloscope device, the noise was from heat. We noticed the signal with noise reaches to 20 millivolts, this value before the signal doubling and this noise is large because the double in value makes the sensor reading value.

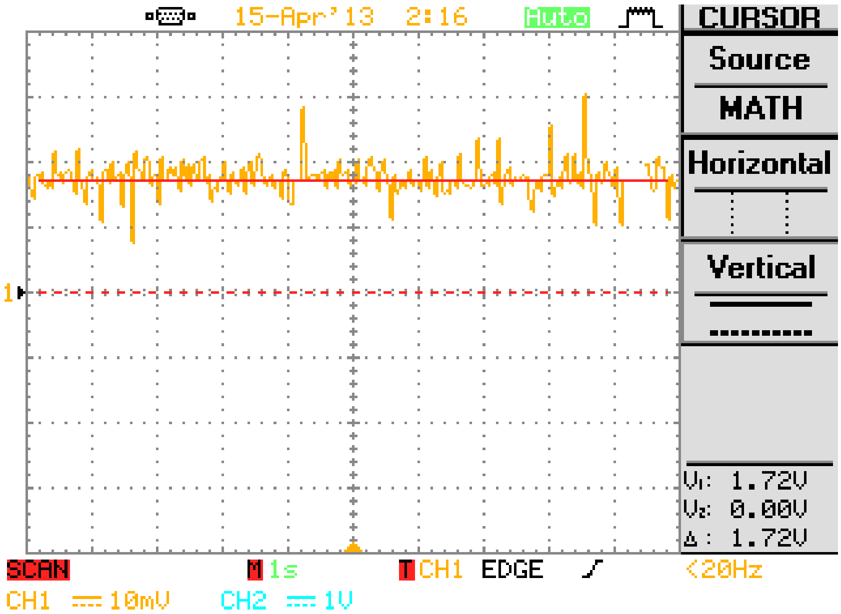


Figure 6.2: Output of sensor readings with noise

These figures 6.3(A,B,C&D); show the output of sensor readings without noise, using differential and proportional amplifier, and full bridge to give us the output for sensor as actual signals, using oscilloscope device, the noise after 200 gain becomes 50mv.

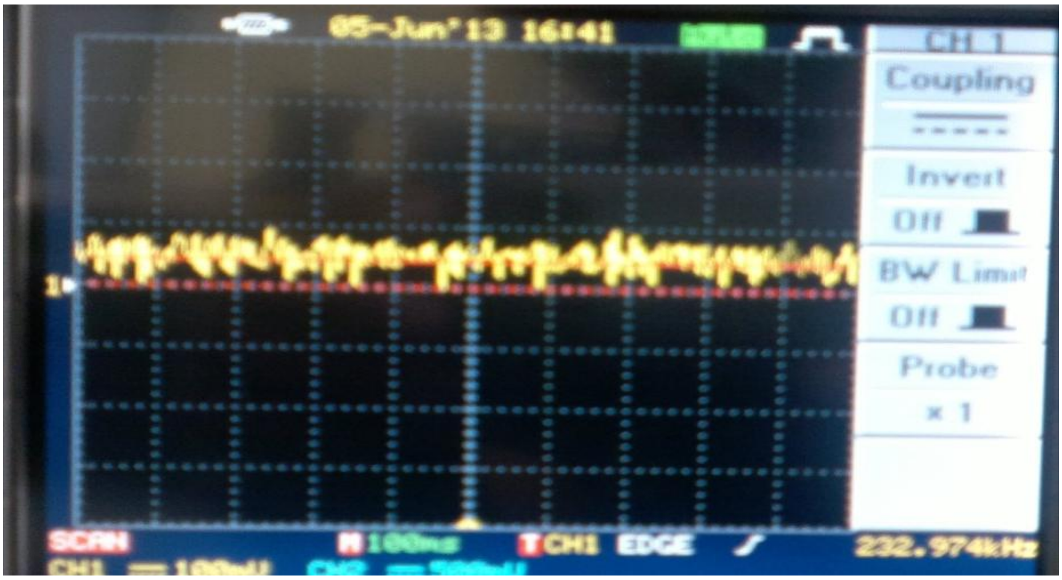


Figure 6.3A: S1 Normal

This figure 6.3A; shown sensor reading, we noticed the noise in quart and in full is hidden. This figure is the output of S1 and this value is double 200 times, it was displacement in normal value because the resistances in strain gauge are not equal, the first value for S1 was 45 mv and the noise was little, the problem solved by coding using microcontroller.

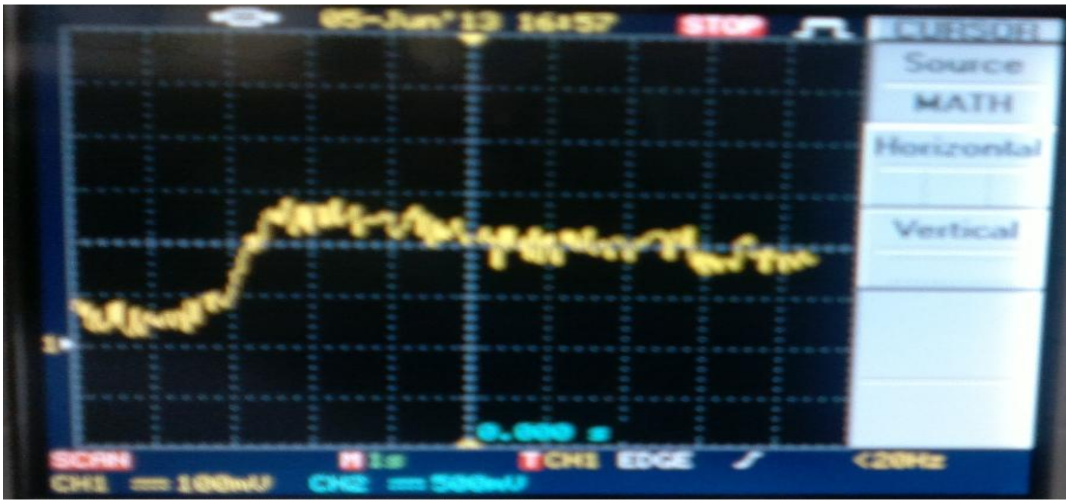


Figure 6.3B: S1 Compression

The figure 6.3B; shown the reading of S1 when the patient compress on it by his head, the value reaches to 200 mv, the compression strength refer to the bed angle, the value reaches to 100 mv with 7 minutes continuously.

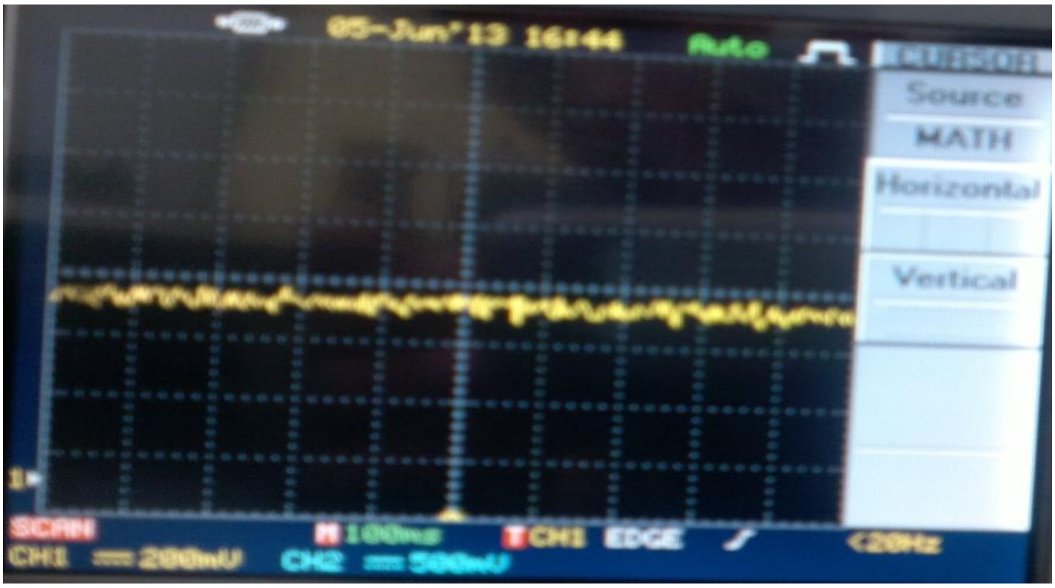


Figure 6.3C: S2 Normal

The figure 6.3C; shows us the S2 reading in the case of normal, the displacement was 400 mv, this figure for full bridge as solution to quart circuit, the value was doubled 200 times and the noise was little, the noise solved by coding using microcontroller.

Figure 6.3D: S2 Compression

This figure 6.3D; shown the S2 reading when the patient in compression case, the value reaches to 250mv, the compression strength refer to the bed angle, the value reaches to 100 mv with 8 minutes continuously .

This tables 6.1(A&B); contains the experimental results for sensors on the bed, in the first we used two sensors under back and others under head, then we reached to use the four sensors under head area. There is a different resistance of strain gauge in S2 which one of them equals 999 ohm value; it is less than 1killo ohm.

S1 means sensor 1 &sensor 2, S2 means sensor 3 &sensor 4

Table 6.1A: Experimental Results.

State (Rashad)	**Readings S1**	**Reading S2**
Middle		
Normal	20-24mv	54mv
Tension(head)	35mv	55mv
Uplift	9-12mv	48-53mv
Left		
Normal	-	65-75mv
Tension(head)	-	90mv
Uplift	-	55-60mv
Right		
Normal	25-30mv	-
Tension(head)	35mv	-
Uplift	16-18mv	-

Table 6.1B: Experimental Results

State (Husam)	**Readings S1**	**Reading S2**
Middle		
Normal	15-20mv	52-58mv
Tension(head)	20-35mv	59-70mv
Uplift	8mv	49mv
Left		
Normal	-	70mv
Tension(head)	-	80-90mv
Uplift	-	59mv

Right		
Normal	23mv	-
Tension(head)	35mv	-
Uplift	17mv	-

The microcontroller does not understand the voltage language, so it understands bits language so we uses the following equations:

X=1000mv

Y=value

M=X\Y

Z=1024\M

For the Bed, Rashad & Husam results from the bed.

Table 6.2: Experimental Results.

State	**X**	**Y**		**M**		**Z**	
	(mv)	***S1 (mv)***	***S2 (mv)***			***bits***	***Bits***
Bed	1000	40	410	25	2.439	40	419
Bedplate	1000	8	45	125	22.22	8	46
Bedplate+Bolster	1000	14	50	71.428	20	14	51

Rashad							
Middle		*S1 (mv)*	*S2 (mv)*	*S1 (mv)*	*S2 (mv)*	*bits*	*Bits*
Normal	1000	20-24	54	50-41.67	18.51	20-24	55
Tension (head)	1000	35	55	28.57	18.18	35	56
Uplift	1000	9-12	48-53	111.1-83.3	20.83-18.87	9-12	49-54
Left							
Normal	1000	-	65-75		15.38-13.3		66-76
Tension (head)	1000	-	90		11.11		92
Uplift	1000	-	55-60		18.18-16.67		56-61
Right							
Normal	1000	25-30	-	40-33.33		25-30	
Tension (head)	1000	35	-	28.57		35	
Uplift	1000	16-18	-	62.5-55.55		16-18	
Husam							
Middle		*S1 (mv)*	*S2 (mv)*	*S1 (mv)*	*S2 (mv)*		
Normal	1000	15-20	52-58	66.67-50	19.2-17.24	15-20	53-59
Tension (head)	1000	20-35	59-70	50-28.57	16.95-14.28	20-35	60-71
Uplift	1000	8	49	125	20.41	8	50

Left							
Normal	1000	-	70	-	14.28	-	71
Tension (head)	1000	-	80-90	-	12.5-11.11	-	81-92
Uplift	1000	-	59	-	16.95	-	60
Right							
Normal	1000	23	-	43.48	-	23	-
Tension (head)	1000	35	-	28.57	-	35	-
Uplift	1000	17	-	58.82	-	17	-

We noticed that our system is slow, because the internal clock of microcontroller has a small size with 8 Megahertz, so the microcontroller needs external clock with high speed.

6.3 Conclusion

In this project we used the load cell sensors with microcontroller in order to actuate the AC motor in the backrest of paralyzed people bed to control in its movement by sense without any help.

6.4 Future Works

They are many future works on the project which are the smart room which is room has full control system by medical bed (close windows, door, conditions, lights), the electric chair which uses radio waves in order to help the paralyzed people, then we will do the system for the whole system (knees and back rest).