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Automotives Engineering

Graduation project

Handicapped Driving Assistance Unit

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جامعة بوليتكنك فلسطين

الخليل –فلسطين

كلية الهندسة والتكنولوجيا

دائرة الهندسة الميكانيكية

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Handicapped Driving Assistance Unit

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بناء على نظام كلية الهندسة والتكنولوجيا واشراف ومتابعة المشرف المباشرة على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع الى دائرة الهندسة الميكانيكية وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص هندسة السيارات

توقيع المشرف

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توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

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اهــداء

إلى من جرع الكأس فارغاً ليسقيني قطرة حب
إلى من كلّت أنامله ليقدم لنا لحظة سعادة
إلى من حصد الأشواك عن دربي ليمهد لي طريق العلم
والدي العزيز إلى القلب الكبير

إلى من أرضعتني الحب والحنان
إلى رمز الحب وبلسم الشفاء
إلى القلب الناصع بالبياض والدتي الحبيبة

إلى القلوب الطاهرة الرقيقة والنفوس البريئة إلى رياحين حياتي إخوتي

إلى الأرواح التي سكنت تحت تراب الوطن الحبيب الشهداء العظام

الآن تفتح الأشرعة وترفع المرساة لتنطلق السفينة في عرض بحر واسع مظلم هو بحر الحياة وفي هذه الظلمة لا يضيء إلا قنديل الذكريات ذكريات الأخوة البعيدة إلى الذين أحببتهم وأحبوني أصدقائي

إلى الذين بذلوا كل جهدٍ وعطاء لكي أصل إلى هذه اللحظة أساتذتي الكرام ولا سيما الدكتور زهدي سلهب

إليكم جميعاً أهدي هذا العمل

Dedication

We thank God who gave us the wisdom

and courage throughout the roughest and happiest moments during this project.

To the best father and mother on the world

who have always wanted the best for me and worked so hard to

bring me up as a responsible and respectable person.

To my brothers and sisters, all my friends and relatives who have

always encouraged me to work hard no matter what I encounter.

We also dedicate this project to those who have contributed to its success in one

way or the other and

We dedicate it to all the friends we made during our five years at

Palestine Polytechnic University.

work Group

ABSTRACT

As a result of increasing the numbers of “person with disabilities” who suffers from weakness in their upper limbs and paralysis in their feet, and due to absence of assistance to facilitate their movement, so it’s become more important to build a system that can solve their problems.

This project aims to build a system with special specifications for “person with disabilities”. By this system, the driver can control all vehicle systems, like acceleration, directing, and breaking. Henceforward, “person with disabilities” can perform their work without any external effort.

The working of this system is by moving a joystick, and this joystick has the ability to move in four directions. The left and right directions to control steering system, and the forward and backward to control acceleration and breaking systems.

ملخص

نتيجة لزيادة عدد ذوي الإحتياجات الخاصة الذين يعانون من شلل في أطرافهم السفليه, وضعف عام في أطرافهم العلويه, ونتيجة لعدم الاهتمام الملموس من جانب القطاعات العامه لتوفير الدعم اللازم لهم من خلال العمل على المساعده في تسهيل تنقلهم لإنجاز حوائجهم بسهوله , لذلك أصبح من الضروري تطوير نظام يوفر لهم حرية التنقل بسهوله ويحل الكثير من المشاكل التي تواجهها هذه الفئه من المجتمع.

هذا المشروع يهدف الى تصميم نظام يتمتع بمزايا خاصة, تتيح لذوي الاحتياجات الخاصة قيادة المركبة والتحكم بأنظمة السرعه والتوجيه والفرمله الكترونياً عن طريق تحريك عصا التحكم في الأربع إتجاهات. من الآن فصاعداً أصبح بإمكان ذوي الاحتياجات الخاصة إنجاز اعمالهم من دون أي مساعدة خارجية.

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CHAPTER FORE

Chapter One

Introduction

1.1 Overview

As a result of increasing the numbers of “person with disabilities” who suffers from weakness in their lower limbs, and due to absence of assistance to facilitate their movement, so it’s become more important to build a system that can solve their problem which is mainly the difficulty in movement.

This project aims to build a system with special specifications for “person with disabilities”. By this system, the driver can control all vehicle systems, as acceleration, directing, and Brakeing. Henceforward, “person with disabilities” can perform the works without any external effort. The people who are considered for this type of vehicles, often suffer from muscular diseases which leave them with severely impaired strength and range of motion.

In exceptional cases, joystick control is also considered suitable for individuals with high spinal injuries (with very weak function in their arms and hands and an impaired sense of touch) or individuals who lack both legs. These individuals are users of electrical wheelchairs in every case.

1.2 Project objectives

- To facilitate the translation of “person with disabilities”.
- To make an improvement in automobiles world especially in Palestine.
- To reactive the busyness and effectiveness of “person with disabilities” in society.
- To help “person with disabilities” to do their daily activates, and to find a suitable work for them.

1.3 Project motivations

By increasing the importance of vehicles, this creates the neediness for an assistance system to facilitate the life of “person with disabilities” within translation, working, excursion etc.

At the same time, the huge improvement in automobiles world, created a motivation to improve a new assistance vehicle for “person with disabilities”, to give them a chance to live like other normal people.

Now, it's important for disabled persons to take care of a large proportion of their own transport requirements. This contributes to increased freedom and a higher quality of life. From being entirely dependent on personal assistants and the transportation service for disabled persons, these people are now able to provide a large proportion of their mobility themselves with their own car

.

1.4 Approach

This project requires deep knowledge in electrical steering, braking, and acceleration, so by improve a way to make these systems more flexible, and by connect these systems with each others, so the driver will not face any difficulty in driving the vehicle.

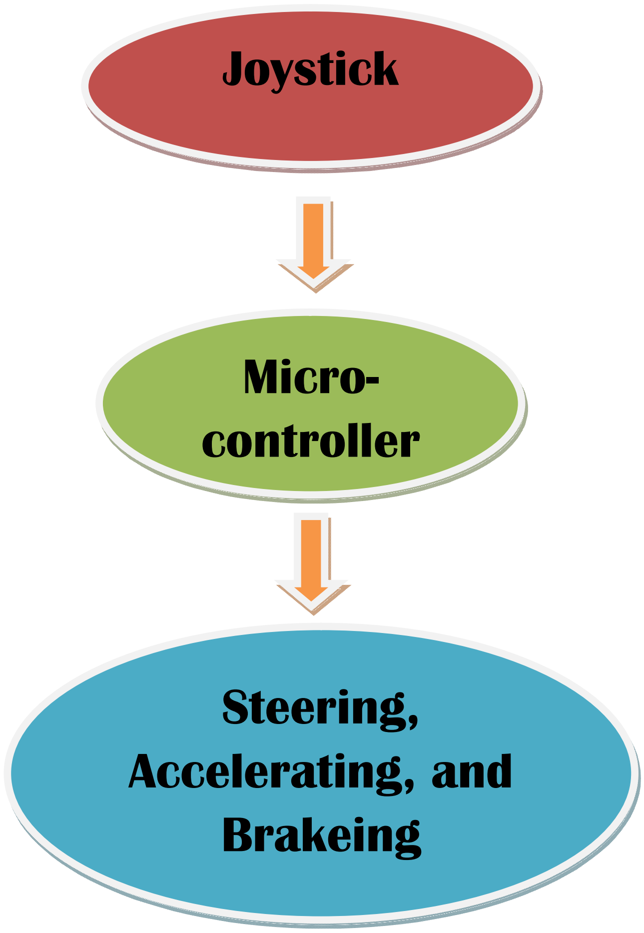
There is a electrical ramp at central door of the car, it have to lift the driver and his/her seat, and this ramp controlled by a remote control. The driver will move his/her seat to a certain place, where will couples with the vehicle body, to prevent any motion of the seat through driving. A microcontroller will take the input from joystick movement, and according to this input, it will send orders to steering and braking and accelerating actuators.

By moving this joystick to front, the vehicle will accelerate gradually, and by moving it to rear, the vehicle will decelerate gradually, and by moving the joystick to right and lift the wheels can be moved at the same direction. The other keys are for starting the engine, lights, etc.

1.5 Project assumptions requirements

- Any person can drive this vehicle, not just handicapped.
- The type of transmission in the vehicle must be automatic.
- The wheelchair must couple with inside car body, to prevent any movement for wheelchair, so protect the driver from dangerousness.
- The vehicle must contain an electric ramp to lift the handicapped driver inside the car, and this ramp should controlled by a remote control.

1.6 Block diagram



1.7 Literature Review

The idea can be seen in different systems. However, the proposed system is expected to provide better accuracy at lower cost. The following section will summarize the previous related works, and describe their principle of operation.

1.7.1 A joystick car drive system with seating in a wheelchair

This system presents a joystick car drive system for a handicapped person. The joystick drive system enables handicapped person to drive a car by a single hand with seating in an electric wheelchair. The joystick operation in backward and forward directions controls acceleration or deceleration of a car, while in left and right direction turns the steering wheel. Therefore a person, who has disabilities such as no enough force nor limited movable area of their arms together with disabilities in legs, can drive a car by oneself. Additionally, a wheelchair driver does not have to change seat from a wheelchair to a car seat.

Since a developed van equips with a lift on the back, a wheelchair user can access to the driver's position with propelling a wheelchair inside of a van. For maintaining driving safety of a van in case of system fault, gas and brake pedals are physically moved by a mechanical linkage which is connected to a joystick lever. Therefore a van can be stopped by manual operation in any case. A steering wheel is turned by an electric motor which is controlled by a micro-computer system. [1]

1.7.2 Toyota Experimenting With Joystick Control for Cars (i-real)

In this system the car's steering, braking and acceleration can be controlled by hand so foot pedals aren't needed, freeing up space to provide more legroom for the driver. The i-Real, also utilizes two joysticks. It's a single-person transporter that looks like a futuristic chair on wheels. The joysticks are at the end of each armrest.

Left and right movements of the stick steered the vehicle, in this case a digital car on a driving simulator screen, while acceleration and braking was accomplished by pushing it forwards and pulling in back.

1.7.3 Distinction of the System

This system is different because it depend on one joystick, and unable to control the direction, Brakeing and acceleration systems smoothly, fast and accurately, due to it contains tools with advanced technology.

There are another systems are similar to this system, and these systems allows to control of the vehicle by buttons installed on steering wheel. But the project design is more useable and easy to control.

There are also other systems related to this project, but these systems work mechanically rather than electronically, so this reduces the efficiency, accuracy and responding time of the system.

1.8 System schedule

The following table, describe the overall stages of the system

Table (1.1): Overall System Timing Table

Task/Week	Second semester														
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Selecting The idea of the project															
Search and collecting information															
Preparing for the project															
Studying the Principles															
System and requirement analysis															
Studying and searching for a suitable microcontroller															
Searching for joysticks															
Searching for motors types and their specifications, and the general relations between all parts of system															
System parts collection															
Documentation writing															

Chapter Two

THEORITICAL BACKGROUND

2.1 Joysticks

2.2 Arduino Microcontroller

2.3 Steering System

2.4 Braking System

2.5 Acceleration System

2.6 Stepper Motors

2.7 Wheelchair Ramps

2.8 Electrical Sliding Door And Ramp

2.1 Joysticks

A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling, and there are two types of joysticks, digital and analog, where the analog one will be in this project used.

2.1.1 Why Analog Joysticks

Generally the purpose is to control the back and forth motion of any object along with the ability to make it turn left and right. For this it's should use a common joystick with two axis. The y axis is used to move the object forward and backward, while the x axis is used to turn the object left or right. The type of joystick which are using in this system is an Analog Joystick that means it can give the magnitude of motion along with the direction. For example a person can push the joystick little forward to make start moving forward slowly, also can push the joystick further up to increase the speed of forward motion faster. Similarly there is ability to control the speed of vehicle while making a reverse motion. Turning magnitude can also be controlled in the same way by moving the joystick left or right.

Figure (2.1): Analog Joystick

2.1.2 Working of Analog Joystick

Analog joystick has two variable resistors for two axes. Each variable resistor has three pins, two extreme pins are connected to Vcc (5v in this case) and ground. The center pin is the output pin. The output voltage is between Vcc and GND depending on the position of stick. By measuring the voltage output of two variable resisters from which the joystick is built, so it's can determine the position of stick in x and y axis. [3]

2.1.3 Joystick Wiring

The joystick is wired as described in the figure below. The two extreme points or both the variable resistor are connected to Vcc and Ground respectively. While the central pin provide output, which is connected to ADC input channel.

Figure (2.2): Analog Joystick Wiring

Both the Vcc should to connect together and connect them to 5v out point of the development board. Similarly should to connect both the grounds and connect them to ground point of the board, also it's should to Connect out-x to ADC Channel 0, and out-y to ADC Channel 1. [3]

2.2 Arduino Microcontroller

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can be communicate with software running on your computer (e.g. Flash, Processing, MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free.

The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment. [5]

2.2.1 Joystick with Arduino Microcontroller

As told above the position of stick can be determined by measuring the voltage from the output of the two variable resistors of the joystick. This can be easily done by using the ADC of arduino Microcontroller. The output of the two variable resistors of the joystick is connected with the two channels of ADC. The return value is between 0-1023 [1], the midpoint is 512, so it's subtracting 512 from the ADC reading. This finally gives a value between -512 to +511.

2.2.2 Why the Arduino:

There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

- Inexpensive, Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50
- Cross-platform, The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment, The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with the look and feel of Arduino
- Open source and extensible software, The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. SImilarly, you can add AVR-C code directly into your Arduino programs if you want to.

- Open source and extensible hardware, The Arduino is based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

2.3 Steering System

The steering system converts the rotation of the steering wheel into a swiveling movement of the road wheels in such a way that the steering-wheel rim turns a long way to move the road wheels a short way.

Electric power steering system with a motor-driven pump is now considered as viable alternatives to conventional hydraulic power steering systems because of their energy efficiency and size.

Electrical Powered Hydraulic Steering, or EPHS, replaces the customary drive belts and pulleys with a brushless motor that drives a high efficiency hydraulic power steering pump in a conventional rack and pinion steering system. Pump speed is regulated by an electric controller to vary pump pressure and flow. This provides steering efforts tailored for different driving situations. The pump can be run at low speed or shut off to provide energy savings during straight ahead driving. An EPHS system is able to deliver an 80 percent[6], improvement in fuel economy when compared to standard hydraulic steering systems.

2.3.1 Electronic power steering system EPS

An EPS Direct electric steering system uses an electric motor attached to the steering rack via a gear mechanism and torque sensor. A microprocessor or electronic control unit, and diagnostic software control steering dynamics and driver effort. Inputs include vehicle speed and steering, wheel torque, angular position and turning rate.

In these systems “Active control” as it is known provides constant feedback from sensors in the vehicle to the control unit, which calculates sophisticated computer algorithms. This allows the steering system to react to the road, the weather and even the type of driver, and provide assistance to the front or rear road wheels independent of direct driver input. Active steering produces enhanced steering response, stability & handing improvements to the vehicle without impacting the base steering feel.

2.3.2 A number of steering systems using an electric motor have been developed [6]

- Electro hydraulic power steering, where the hydraulic pump is powered by an electric motor instead of being driven by an accessory belt from the engine.
- Column assists, where the electric motor is mounted on the steering column.
- Pinion assist, where the electric motor is mounted where the pinion gear of the rack and pinion steering system connects to the rack.
- Double pinion, where an additional pinion is added to the rack and is driven by an electric motor.
- Rack assist, where the electric motor is mounted on the rack.

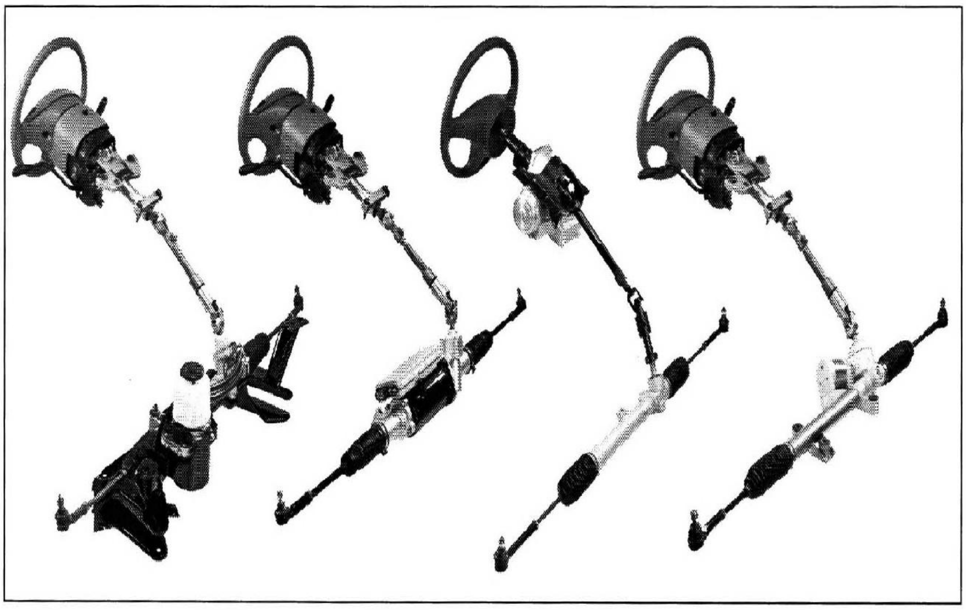


Figure (2.3): Steering Systems Using an Electrical Motor

2.4 Braking System

Modern cars have brakes on all four wheels, operated by a hydraulic system. The brakes may be disc type or drum type. The front brakes play a greater part in stopping the car than the rear ones, because braking throws the car weight forward on to the front wheels.

Many cars therefore have disc brakes, which are generally more efficient, at the front and drum brakes at the rear. All-disc braking systems are used on some expensive or high-performance cars, and all-drum systems on some older or smaller cars.

2.4.1 Brake hydraulics

A hydraulic brake circuit has fluid-filled master and slave cylinders connected by pipes. By pushing on the brake pedal it depresses a piston in the master cylinder, forcing fluid along the pipe. The fluid travels to slave cylinders at each wheel and fills them, forcing pistons out to apply the brakes.

2.4.2 Brake system components

- **Brake pedal:** The brake pedal acts as a lever to increase the force applied to the brake pedal pad, by the driver.
- **Brake lines:** Brake lines carry brake fluid from the master cylinder to the brakes. For most of their length they are steel, and attached to the body with clips or brackets to prevent damage from vibration. They are much the same on all brake systems.
- **Brake fluid:** Brake fluid is a special purpose high-boiling point fluid. It transmits the hydraulic pressure generated by the master cylinder to the brake units.
- **Master cylinder:** The single-piston master cylinder transforms the applied pedal force into a hydraulic pressure which is transmitted simultaneously to all four wheels.
- **Power booster or brake unit:** The power booster assists the driver by reducing the amount of effort that has to be applied to the brake pedal during braking.
- **Applying brakes:** As the brakes are applied, the pedal pushrod transmits movement through the power unit to the master cylinder piston to apply the brakes.

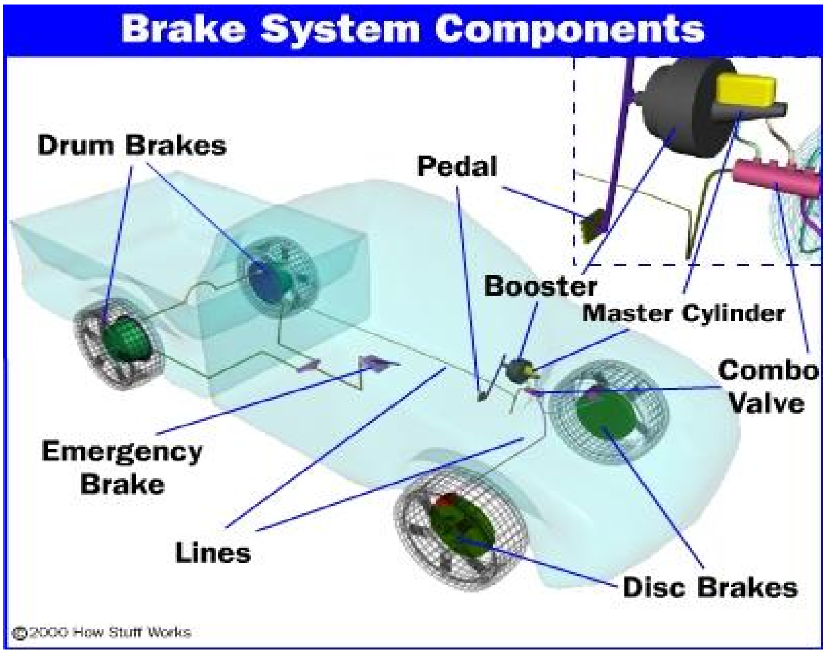


Figure (2.4): Braking System Components

2.5 Acceleration System

The accelerator pedal is connected to a throttle body which opens up depending on how much the pedal is pushed. The throttle allows air to enter the combustion chamber where a series of controlled explosions drive the pistons transferring power to the transmission and then to axles. Some cars have a throttle position sensor that will control fuel input based on the position of the throttle. Some have a mass air sensor that measures the amount of air entering and adjusts fuel to a preset ratio. Some newer cars do not connect the accelerator to the throttle directly, The ECU determines the throttle position based on the pedal position which called EPC.

2.6 Stepper Motors

The stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied.

2.6.1 Stepper Motor Advantages

- The rotation angle of the motor is proportional to the input pulse.
- The motor has full torque at standstill (if the windings are energized)
- Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3 – 5% of a step and this error is non cumulative from one step to the next.
- Excellent response to starting stopping/reversing.
- Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependant on the life of the bearing.
- The motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.
- It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.
- A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

2.6.2 Stepper Motor Disadvantages

- Resonances can occur if not properly controlled.
- Not easy to operate at extremely high speeds.

2.6.3 Open Loop Operation

One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. The position is known simply by keeping track of the input step pulses.

2.6.4 Stepper Motor Types

There are three basic stepper motor types:

- Variable-reluctance
- Permanent-magnet
- Hybrid

2.6.5 When to Use a Stepper Motor

A stepper motor can be a good choice whenever controlled movement is required. They can be used to advantage in applications where there is neediness to control rotation angle, speed, position and synchronism. Because of the inherent advantages listed previously, stepper motors have found their place in many different applications. Some of these include printers, plotters, high-end office equipment, hard disk drives, medical equipment, fax machines, automotive and many more. [11]

2.7 Wheelchair Ramps

A wheelchair ramp is an inclined plane installed in addition to or instead of stairs. Ramps permit wheelchair users, as well as people pushing strollers, carts, or other wheeled objects, to more easily access a building.

Ramps must be carefully designed in order to be useful. A less steep rise can be easier for a wheelchair user to navigate, as well as safer in icy climates. Wheelchair accessible vehicles may also include a ramp to facilitate entry and exit. These may be built-in or portable designs. Most Major Automotive companies offer rebates for portable ramps and mobility access equipment for new vehicles. These rebates are intended to help cover some of the cost of making a new vehicle accessible.

2.7.1 Types of Ramps [7]

There are many types of ramps can uses:

- Permanent ramps are designed to be bolted or cemented in place.
- Semi-permanent ramps rest on top of the ground or cement pad and are commonly used for the short term.
- Portable ramps are usually aluminum and typically fold for ease of transport. Portable ramps are primarily intended for home and building use but can also be used with vans to load an unoccupied mobility device or to load an occupied mobility device when both the device and the passenger are easy to handle.

2.8 Electrical sliding door and Ramp

The electrical sliding door should controlled by a remote control, to be easier for the wheelchair to enter the vehicle, and the main components are:

- **Dc motor**

A DC Motor is a very simple electric motor which is operated on direct current (DC). The DC Motor moves due to the torque generated by the electro-magnetic field. A simple DC Motor uses electric coil and magnets of opposite polarity. As the magnets with opposite poles attracts and repels one another, a DC Motor turns. The electric coil used in a DC Motor acts as an electromagnet. The function of the electromagnet is to switch the polarity of the magnets as the current flow. Hence it keeps the motor running. In a typical DC Motor, the electromagnet is placed in core and it moves along with the permanent magnets. This arrangement can vary in different models. DC Motors are commonly used for electric car windows, electric razors, and remote control cars.

- **Remote control transmitter and receiver**

Infrared remote controls work by sending pulses of infrared light to a device. IR remote controls require a clear line of sight to the receiving device and their range maxes out at about 30 feet (9.14 meters). [8]

By pushing on a button on a remote control, it transmits a corresponding code to the receiving device by way of LED infrared pulses. The idea is, the flashing LED light is transmitting a series of 1s and 0s. The "1" might be represented by a long flash, while "0" a short flash. A receiver, built into the component, receives the pulses of light and a processor decodes the flashes into the digital bits required to activate the function.

Along with the desired function, remote controls must also piggyback other data. Firstly, they transmit the code for the device they are controlling. This lets the IR receiver in the component know that the IR signals it is picking up are intended for it. It essentially tells the component to start listening. The function data follows, capped by a stop command to tell the IR device go back into passive mode.

Chapter Three

Conceptual Design

3.1 Introduction

3.2 System main components

3.3 wheelchair lift

3.4 The System in figure

3.5 System Flowchart

3.1 Introduction

This chapter describes the block of the system. Also discusses the system entities and the software and the flow chart needed it to explain the system operation.

3.2 General system block diagram

The general block diagram contains three main components which are: an analog joystick, microcontroller, and stepper motors. The analog joystick connected to the steering, acceleration, and braking system, these systems will be controlled by the joystick. The joystick is also connected to a microcontroller which will receive the inputs, and process it, to active the stepper motor of required system.

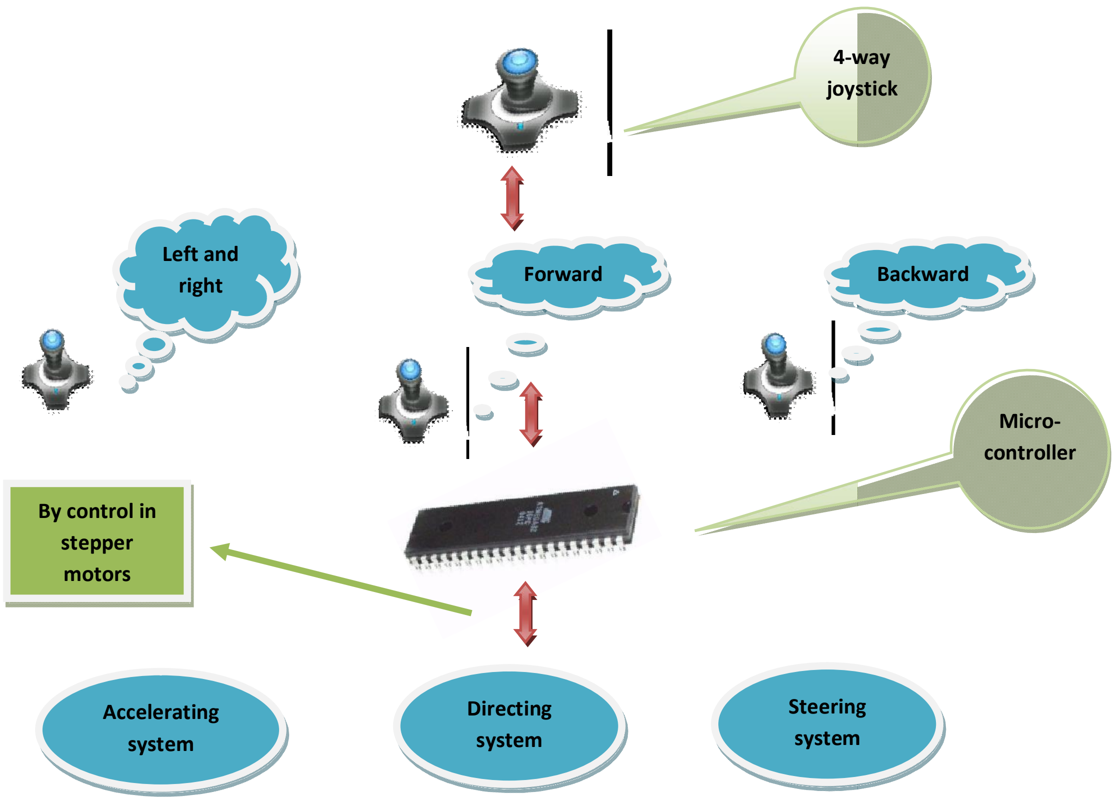


Figure (3.1): General Block Diagram

3.3 System main components

The main components of this project are the joystick, microcontroller, and actuators (stepper motors). This section will explain these components in more details.

3.3.1 Analog joystick

The joystick has two potentiometers that allow us to measure the movement of the stick in 2-D. Potentiometers are variable resistors and, they work as sensors variable voltage, depending on the rotation of the device around its shaft.

3.3.2 Arduino microcontroller

The Arduino microcontroller is an easy to use yet powerful single board computer that has gained considerable traction in the hobby and professional market. The Arduino is open-source, which means hardware is reasonably priced and development software is free. This guide is for students in ME 2011, or students anywhere who are confronting the Arduino for the first time. For advanced Arduino users, prowl the web; there are lots of resources.

The Arduino project was started in Italy to develop low cost hardware for interaction design. An overview is on the Wikipedia entry for Arduino.

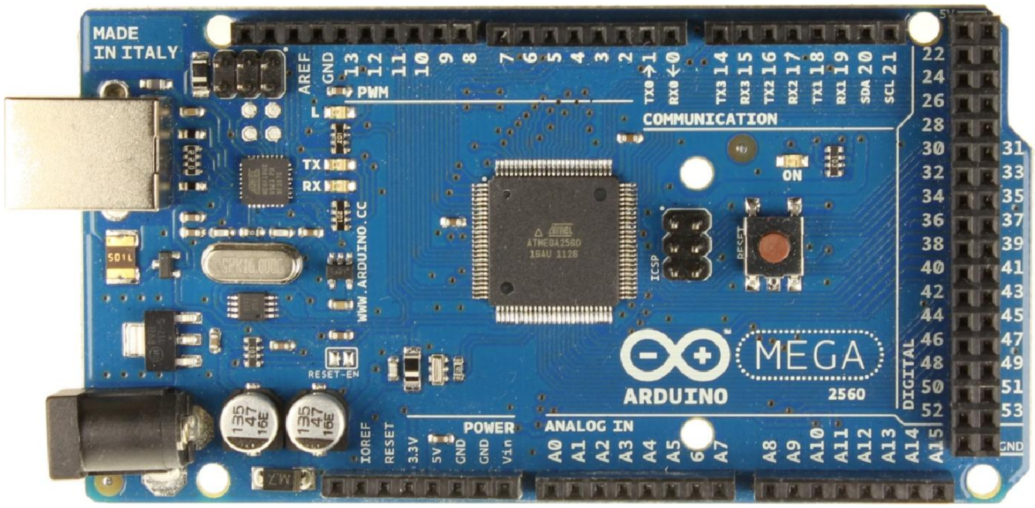
With the Arduino board, you can write programs and create interface circuits to read switches and other sensors, and to control motors and lights with very little effort. [5]

3.3.2.1 Arduino types [5]

There are a lot of types of arduino, but the following types are the most important which are:

- **Arduino Uno:** This is the latest revision of the basic Arduino USB board. It connects to the computer with a standard USB cable and contains everything else you need to program and use the board. It can be extended with a variety of shields: custom daughter-boards with specific features. It is similar to the Duemilanove, but has a different USB-to-serial chip the ATMega8U2, and newly designed labeling to make inputs and outputs easier to identify.
- **Arduino Mega:** A larger, more powerful Arduino board. Has extra digital pins, PWM pins, analog inputs, serial ports, etc.
- **Arduino Diecimila**
- **Arduino Fio**
- **Arduino Duemilanove**
- **Arduino BT**
- **Arduino Nano**
- **Arduino Serial**
- **Arduino Mini**
- **Arduino shields**

While the arduino Mega 2560 will be used, due to it's more accurate and has a lot of inputs and outputs.



Figure(3.2): Arduino Mega 2560

3.3.2.1.1 Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560, It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila. [5]

3.3.2.1.2 Software

The Arduino integrated development environment (IDE) is a cross-platform application written in Java, and is derived from the IDE for theProcessing programming language and the Wiring projects. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. A program or code written for Arduino is called a "sketch".

Arduino programs are written in C or C++. The Arduino IDE comes with a software library called "Wiring" from the original Wiring project, which makes many common input/output operations much easier.

3.3.2.1.3 Microcontroller Programming

The Arduino Mega can be programmed with the Arduino software, The ATmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer.

3.3.2.1.4 Arduino Mega Features

The arduino mega has the following features:

Table (3.1): Arduino Mega Features

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

3.3.2.1.5 Power

The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.
- IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

3.3.2.1.6 Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM

3.3.2.1.7 Inputs and Outputs

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), anddigitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial:** 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega16U2 USB-to-TTL Serial chip.
- **External Interrupts:** 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM:** 2 to 13 and 44 to 46. Provide 8-bit PWM output with the analogWrite() function.
- **SPI:** 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication using the SPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Uno, Duemilanove and Diecimila.
- **LED:** 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- **TWI:** 20 (SDA) and 21 (SCL). Support TWI communication using the Wire library. Note that these pins are not in the same location as the TWI pins on the Duemilanove or Diecimila.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference()
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

3.3.2.1.8 Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication.

An ATmega16U2(ATmega 8U2 on the revision 1 and revision 2 boards) on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2/ATmega16U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Mega2560's digital pins.

The ATmega2560 also supports TWI and SPI communication. The Arduino software includes a Wire library to simplify use of the TWI bus; see the documentation for details. For SPI communication, use the SPI library.

3.3.2.1.9 Pin Diagram

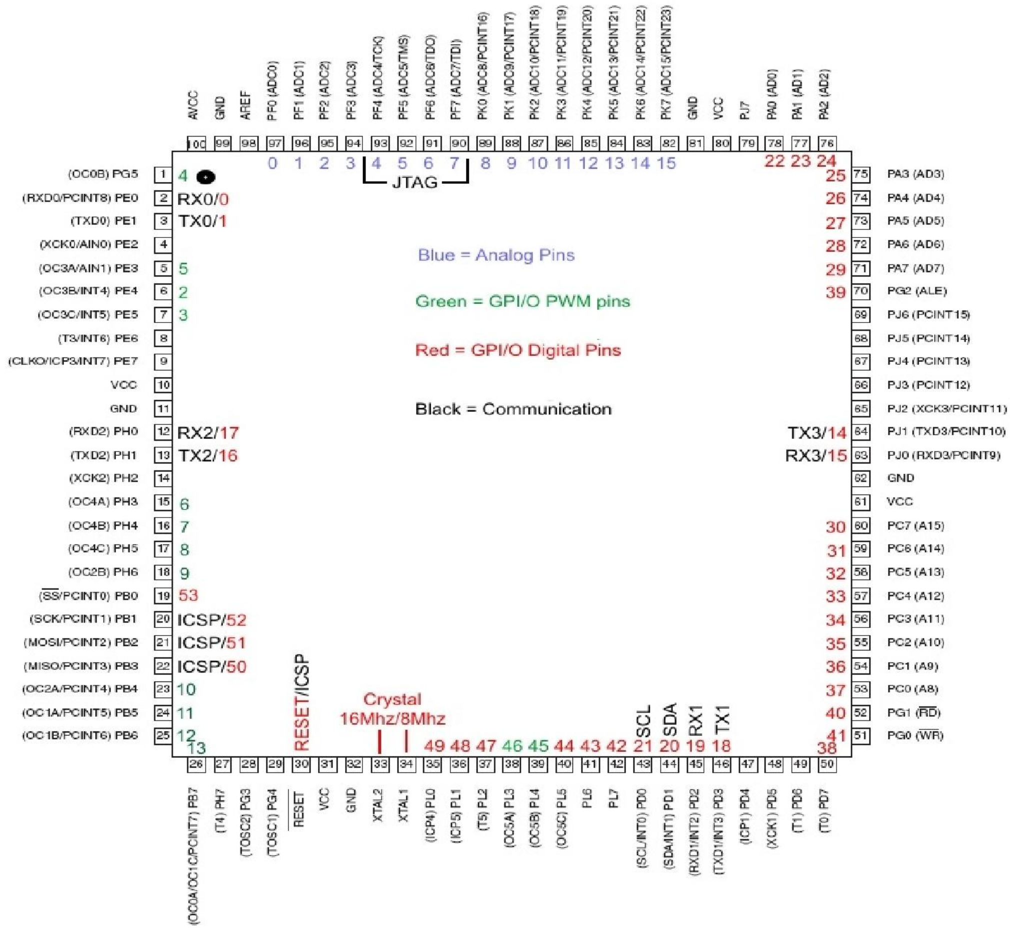


Figure (3.3): Arduino Mega 2560 Microcontroller PIN Diagram

3.3.3 Stepper Motors

3.3.3.1 Acceleration System Stepper Motor

Since that the Bowden cable which transfers the force from acceleration pedal to the throttle arm will be removed, a stepper motor with proper specifications will be used instead of it to change the throttle position. The desired torque of stepper motor expected to be about 1N.m [9], because the throttle doesn't need high torque to move due to it is light almost.

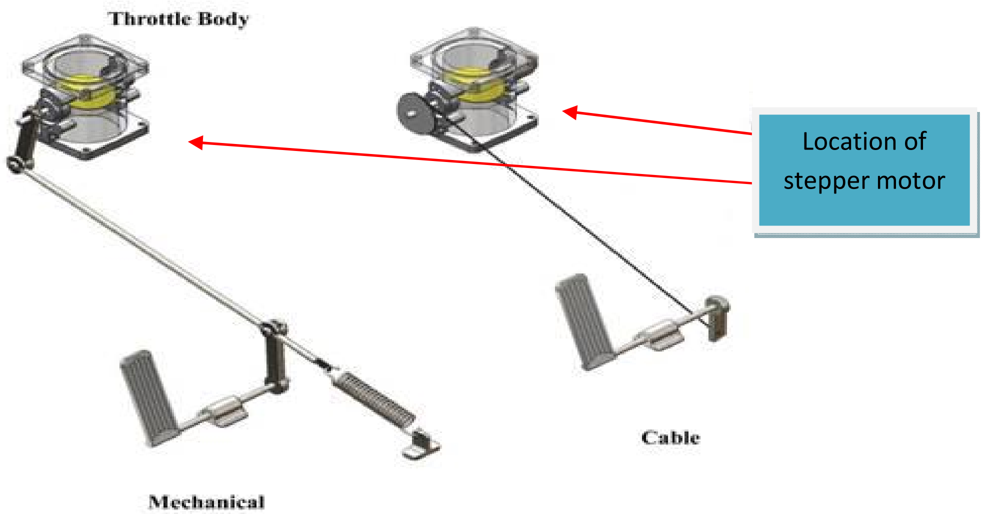


Figure (3.4): Acceleration System Stepper Motor

3.3.3.2 Steering System Stepper Motor

Since that the electrical power steering has a Dc motor which must assist the driver to control in pinion's motion, where the movement will reach this motor by steering arm which controlled by the driver, there is another stepper motor should locates behind this Dc motor, and this stepper motor will be instead of the arm.

As another solution, the DC motor, and the steeper motor can be replaced by just one steeper motor but with high specifications and quality, so the system can be more briefed. The desired torque of stepper motor expected to be about 15N.m, in the first case, but it's should be more in the other.

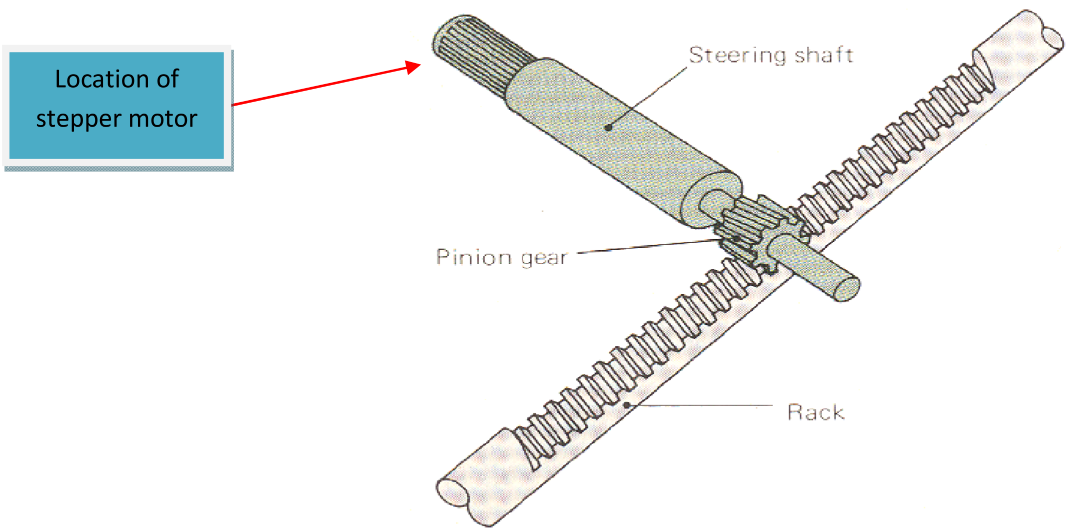


Figure (3.5): Steering System Components

3.3.3.3 Braking System Stepper Motor

Since that the braking system has a Booster which assists the driver to push the braking pedal, a steeper motor can replaced by the arm of pedal, and this motor will connect to the Booster to transmit the force to the master cylinder. Another way to control in braking system can be used, by removing the Booster, and connect the stepper motor directly with the master cylinder. The desired torque of stepper motor expected to be about 10N.m in the first case, but it's should be more in the other.

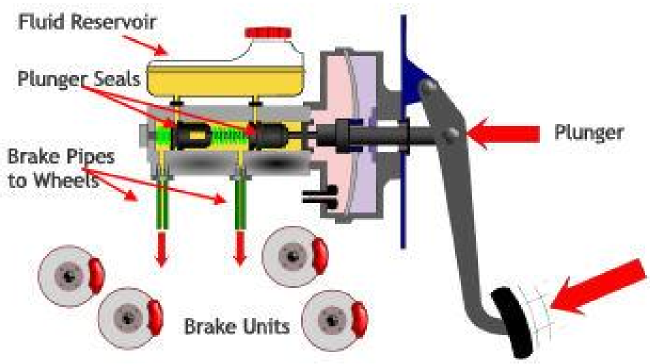


Figure (3.6): Braking System Master Cylinder and Booster

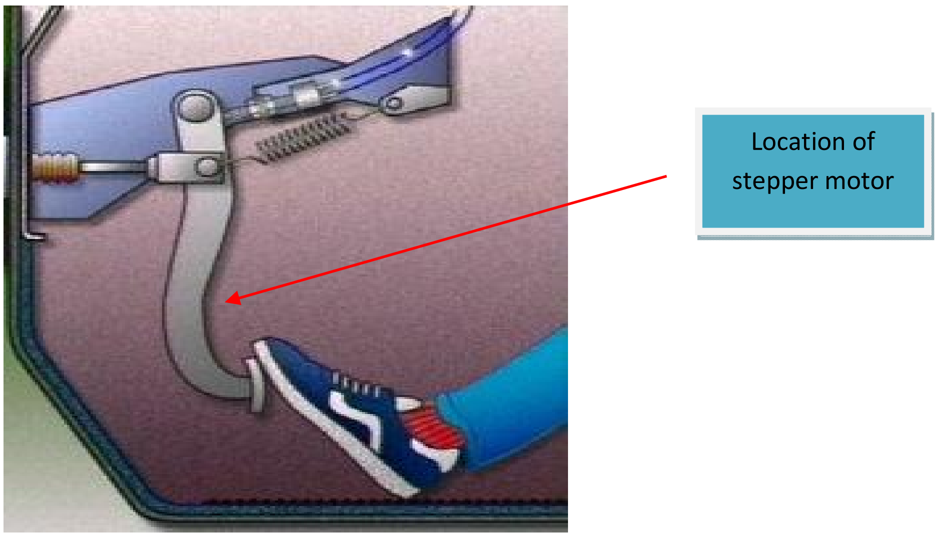


Figure (3.7): Stepper Motor Location

3.3.3.4 Stepper Motors Selection [11]

Steeper motors are available in three types, permanent magnet, variable reluctance, and hybrid motors, and in this system the hybrid motors will be used because its provide torques higher than other types, and it's most widely used in industrial applications.

There are several factors affect the choice of stepper motors for particular applications, such as the type of motor, the torque requirement of system, complexity of the controller, and physical characteristics of the motor. Choosing the right stepper motor depends upon the application.

3.3.3.4.1 Stepper motor specifications

- The number of full steps per revolution.
- Whether to operate in full step, half step or micro step mode.
- The rotational inertia of the motor and shaft.
- Holding torque.
- Detent torque.
- Pull-out torque.
- Expected ambient temperature.

3.3.3.5 High Torque Stepper Motor

High torque stepper motor is ideal for high torque and high resolution application and generates 1.4 times the torque of a conventional hybrid stepping motor of the same size.

NEMA Size 10, 11, 17, 23, 34 and 42 available, Step angles include and 1.8° and 0.9° degree. Custom housing, encoder, gearbox & gearbox sub-assemblies are also available.

3.3.3.5.1 Features

- The Hi-torque stepping motor generates 1.4 times the torque of a conventional hybrid stepping motor of the same size.
- Available in most popular NEMA Size (10, 11, 17, 23, 34 and 42) in a variety of lengths
- Available in 1.8° / 0.9° step angle
- Ideal for High Torque, High Resolution applications
- Upper level assembly available
- Available modifications include: Custom windings, shaft modifications (flat, pinion, keyway, knurl, cross-pin, hollow shaft), special bearings and mounting configurations.
- Custom housings, encoders, gearbox & gearbox sub-assemblies are also available.

And the following table is for the High torque stepper motors specifications:[11]

Table (3.2): High Torque Stepper Motors Specifications

NEMA Size	Frame Size (mm)	No. of Phases	Step Angle	Max. Holding Torque (N.m)
8	20	2	1.8	0.0294
11	28	2	1.8	0.127
17	42	2	0.9/1.8	0.637
23	56	2	0.9/1.8	2.471
	60	2	1.8	3.04
34	86	2	1.8	11.964
42	110	2	1.8	30

3.3.4 Stepper Motor Driver

The stepper motor needs a driver to control its motion, and this driver must give the required torque and accuracy. This system used the M860 stepper motor driver.

3.3.4.1 M860 Driver Overview

The M860 is a high performance microstepping Drive based on pure-sinusoidal current control technology. Owing to the above technology and the self-adjustment technology (self-adjust current control parameters) according to different motors, the driven motors can run with smaller noise, lower heating, smoother movement and have better performances at higher speed than most of the Drives in the markets. It is suitable for driving 2-phase and 4-phase hybrid stepping motors. It is compatible with all our Stepper Motor products.[12]

Figure (3.8): Stepper Motor Driver

3.3.4.2 Driver Specifications

- Output current : up to 7.2A
- Input voltage: 24-72V
- Microstepps : up to 1/512

3.3.4.3 Driver Features

- High performance, cost-effective
- Supply voltage up to +72VDC
- Output current up to 7.2A
- Self-adjustment technology
- Pure-sinusoidal current control technology
- Pulse input frequency up to 300 KHz
- TTL compatible and optically isolated input
- Automatic idle-current reduction
- 16 selectable resolutions in decimal and binary, up to 51,200 steps/rev
- Suitable for 2-phase and 4-phase motors
- Support PUL/DIR and CW/CCW modes
- Short-voltage, over-voltage, over-current and short-circuit protection

3.3.5 Electric Wheelchair Ramp

3.3.5.1 Wheelchair Ramp Overview

Electric wheelchair ramp is suitable for the lower-floor vehicles. It is installed under the step of driver door. The bus ramp platform reach working position, the rear-end of ramp will raise automatically to eliminate height of threshold of driver door so as to ensure rear-end of platform level up to vehicle floor, convenient for wheelchair to access vehicle.

3.2.5.2 The Components and working of Wheelchair Ramp

The wheelchair is an incredibly simple device, considering its usefulness. It connected with electrical motor which have a gear, and in the other side there is another gear, and a track between this tow gears.

When the electric motor turn on the gears will rotate and the ramp will move toward the ground inclined with the vehicle body, and when the motor turns in the other direction, the ramp will go back to its position inside the vehicle.

3.3 The System in figure

The electric ramp was lowered, and the driver is ready to be carried.

The driver has carried on the lifter and is ready to be lifted.

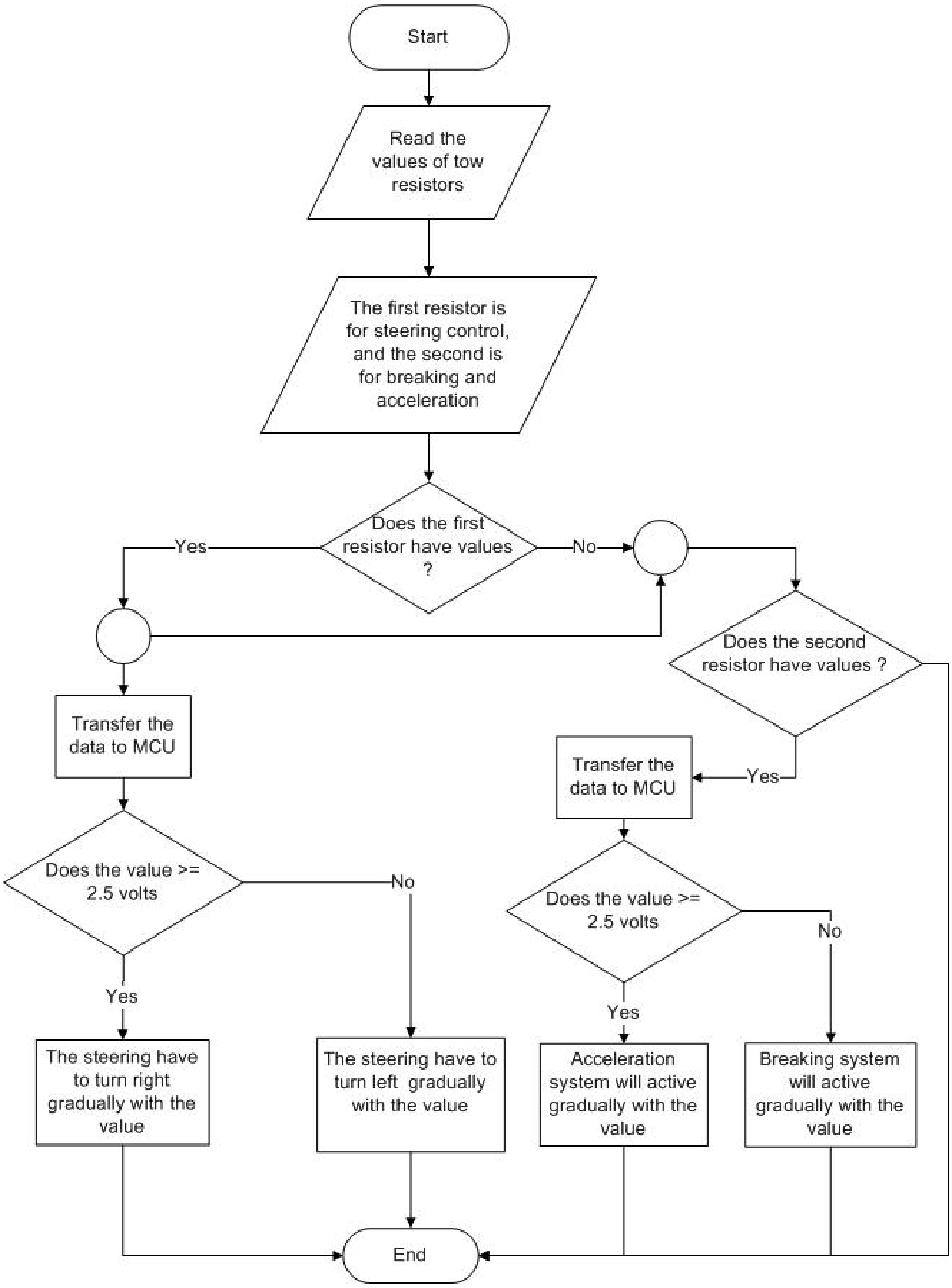
The driver now inside the vehicle and going to a place of leadership.

The driver installs chair to the floor through the locking device.

Background image for the status of the driver in the vehicle.

The driver now is ready to drive the vehicle by the joystick.

3.4 System Flowchart



CHAPTER FOUR

Implementation System Design

4.1 Introduction.

4.2 Hardware Design Implementation.

4.3 Software Design Implementation

4.1 Introduction

After explaining the block diagram and the sub blocks of the system in the previous chapter, this chapter explains the specific details of the hardware and software system implementation.

4.2 Hardware Design Implementation

4.2.1 Introduction

This section presents the hardware details of the connections and components interfaces.

4.2.2 Steering System

To connect the stepper motor to steering shaft, the new design of steering system should have two gears with gear ratio of 1-3. The large gear is installed into steering shaft where the steering wheel has been removed.

The small gear is installed at the stepper motor, and located beside the large gear, where a track is connected between two gears to control their motion together. The design of this system is very simple, and gives high torque to steering shaft, due to the small gear will drive the large gear. The figure below shows the steering system design:

Figure (4.1): The design of steering system

4.2.2.1 Chain Selection Calculation

- Horsepower motor HP = 2
- Service factor SF = 1.75
- Design horsepower DHP = HP * SF = 3.5
- Speed motor = 90 RPM
- Speed shaft = 30 RPM
- Choice RX238 Chain
- Diameter = 3.86 * 3.5 = 13.52 in
- Ratio = 90/30 = 3 to 1
- Min. center distance Min.CDp = 2 pitches
- Min. center distance Min.CD = 0.5 feet
- LP = 8.8 pitches ➔ 9
- Length =(9 *4.5)/12 = 3.5 feet

4.2.3 Braking System

The braking system is designed to be simple and don't need very high torque to operate. And this system installed at the shaft of brake pedal.

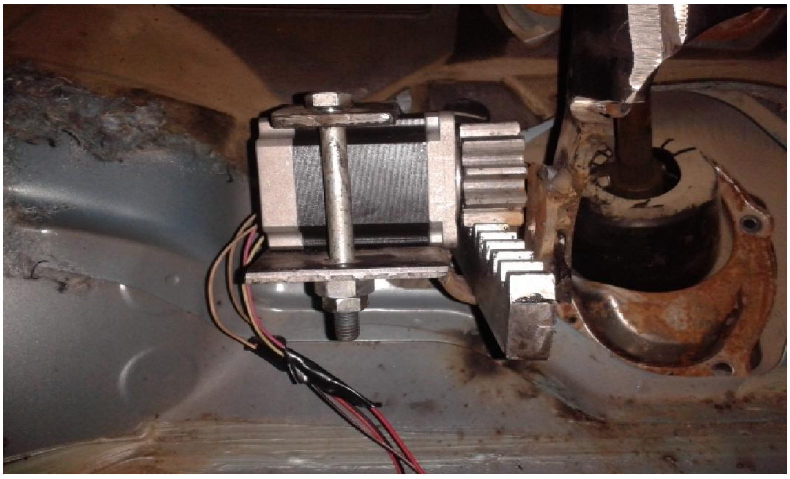
4.2.3.1 Rack and Pinion

A rack is a toothed bar or rod that can be thought of as a sector gear with an infinitely large radius of curvature. Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. Such a mechanism is used in automobiles to convert the rotation of the steering wheel into the left-to-right motion of the tie rod(s). Racks also feature in the theory of gear geometry, where, for instance, the tooth shape of an interchangeable set of gears may be specified for the rack (infinite radius), and the tooth shapes for gears of particular actual radii then derived from that. The rack and pinion gear type is employed in a rack railway.

Figure (4.2): Rack and Pinion

4.2.3.2 braking system design

The stepper motor located on the brake pedal, where a spur gear installed at the motor. In the other side there is a rack installed in the vehicle body with availability of vertical angular motion, and interleaves to the gear. The figure below shows the design of braking system:



Figure(4.3): The Braking Design

4.2.4 Acceleration System

The design of acceleration system is very simple, where the shaft stepper motor installed itself inside the throttle shaft.

The figure shows the stepper motor interfacing with throttle

Figure (4.4): The acceleration system design

4.2.5 Electric Door Control

Another using for Rack and Pinion is for controls of vehicle door, a DC motor installed inside the door, where the pinion is installed at the motor. The rack is also installed in the vehicle bode with availability of horizontal angular motion, and interleaves to the pinion.

Figure (4.5): The Electrical doors design

The receiver remote control is located at the motor wires to control of its motion, as shown in the figure below.

4.2.6 Wheelchair Ramp

The ramp is hand-made, where it's depends on electrical motor installed in the vehicle body under the ramp, and another gear installed at the ramp itself, where there is a track between them. When the motor turn on, the ramp will slide horizontally with vehicle body, then will slide with inclined motion to reach the ground. The driver can enter the vehicle through walking on the ramp by his wheelchair.

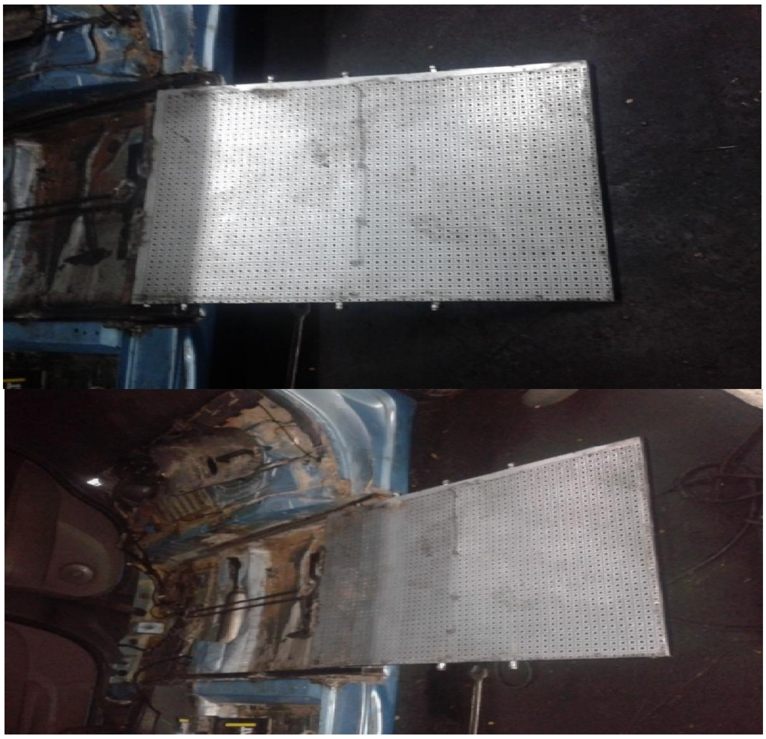
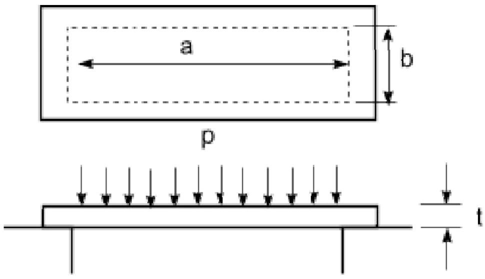


Figure (4.6): The Ramp design

4.2.6.1 Ramp deflection calculation



$$\sigma_m = \frac{0{,}75\, pb^2}{t^2\,[1{,}61(b/a)^3 + 1\,]}$$ At centre

$$y_m = \frac{0{,}142\, pb^4}{Et^3[2{,}21(b/a)^3 + 1]}$$ At centre

- $p = ma$ = 140 * 9.81 = 1373.4 N
- a = 80cm , b = 60cm , t = 1.5cm
- E steel = 200 GPs
- ❖ Stress = 2426 * 10^3 N/m2
- ❖ Deflection = 19.37 mm

4.3 Software Design Implementation

4.3.1 Introduction

Operating and controlling any component requires software handling. This section presents the software with detailed flowcharts and arduino codes.

4.3.2 Arduino Microcontroller Connections

The Arduino Mega 2560 which used connected with each stepper motor driver by three lines, which are (Step, Direction, Ground), so these pins of arduino named as outputs. Another four pins of arduino uses to connect with joystick which are (VDC, GND, Signal_X, Signal-Y).

So for completely connection design of Arduino, there are 9 pins works as outputs, connected with three different stepper motor drivers, and another 4 pins as inputs, connected with joystick.

4.3.3 Stepper Motor Driver Connections

The driver is M860, where have Three Pins works as inputs from arduino, and another four pins works as outputs to the stepper motor, which are (A+, A-, B+, B-).

4.3.4 Arduino-Stepper motor Programming interface

In the acceleration system, the driver pins input which are (Step, Direction) are connected to pins (3,4) of adruino, where in the brake system are connected to pins (5,6), and in the steering connected to pins(7,8) of arduino microcontroller.

CHAPTER FIVE

Testing and System performance

5.1 Introduction

The final stage to complete the project is to test the system to get results and measure the performance of our system. This chapter shows all measurements needed to evaluate the performance of the system.

5.2 Sub-System Testing

There are two sub-systems of this project, which are doors working system, and wheelchair ramp system.

5.2.1 Stepper Motor Testing

The working of stepper motor and its driver, is the most important part in the project, and there are problems appeared through testing the operation of stepper motor, where the stepper have low torque, there is shaking during operation of stepper motor, and the motor turns uncontrolled one cycle at the beginning of its operation. But all of these problems solved through the software and programming.

5.2.2 Wheelchair Ramp and Doors System Testing

There are problems appeared during and after installing the wheelchair ramp, such as ramp itself was very heavy, the design of the system allows don't allow to ramp to slides smoothly, the bearings which installed around the ramp have not good quality. But these problems solved by replacing the ramp and bearings, and redesign the ramp system, and installing more amount of bigger bearings around the ramp to decrease the friction. The other system which is door opening and closing system, was more simple, and there isn't any problems appeared.

5.3 Main Systems Testing

This section shows the testing of acceleration, braking, and steering designs.

5.3.1 Braking system testing

As the braking system is very important and sensitive, and needs high torque, so the stepper motor which will be used, have to give high torque, to ensure the system works properly and safely.

The first test has a problem that the stepper motor doesn't supply the required torque, but after increasing the value of current supply to stepper motor, its torque become more properly and high.

5.3.2 Steering system testing

The same problem appeared here, where the torque was so low, but this problem solved as previous.

The first design of this system was to install the stepper motor directly with steering shaft, but this design needs a lot of torque and higher stepper motor. So the final design which is install two gears with different sizes, where the bigger gear installed on steering shaft, and the other installed on motor shaft, this design has not need a lot of torque. In this design it's have to calculate the ratio between steering angel, and joystick angel.

5.3.3 Acceleration system testing

The design of this system very simple, and there isn't any problem occurred.

5.4 Testing Scenarios

This section will show two testing scenarios as well as explaining the results, errors, and the challenges for each one. The second scenario will solve the problems that we faced in the first scenario to get high performance.

Test:

The first test is driving the vehicle at 20km/h.

Results:

- Acceleration response: the response was good, and the rotation ratio between joystick angel and throttle is about (1:2).
- Steering response: it's very good response, where the ratio between joystick angel and wheels is about (1:1).
- Braking response: The brake motor has a good response.

Errors

While testing the system the following errors happened:

- The rotation ratio between joystick angel and throttle is about (1:2), but this is not accurate, because the joystick turns about 3٠ degrees for each side, and the throttle turns 90 degrees, so the ratio must be (1:3).
- The response in steering system is not good due to the ratio is not correct, so it should be (1:2) to turns the wheels from lock to lock.

CHAPTER SIX

RECOMMENDATIONS

6.1 Introduction

This chapter describes the real learning outcomes have been acquired during the work on the project, we will mention what we achieved in this project, and the conclusion for all things that we have done, also we will talk about the challenges that we faced and ending with recommendations needed for the future work.

6.2 Problems

Many problems, challenges, and issues have been faced during the work on the project. Many experiments, suggestions, ideas and researches have been carried out to deal with the different situations. Some of these problems are:

1) The accuracy of joystick is not good, due to it's operate on small rang of voltage, which is between (1.4V-3.7V).
2) The Israeli Restrictions on the imported equipment and the delay that occurs accordingly.
3) The prices of system components
4) The Vehicle which the system applied on, where it's very small and narrow.

6.3 Acquired Learning Outcomes

After accomplishing, the project tasks many talents and abilities have been achieved as:

1) Learning C++ programming language.
2) Entering the world of microcontrollers, and learning about arduino and its programming.
3) Gains the ability of achieve many mechanical tasks.
4) Taking experience in the world of microcontrollers.

6.4 Recommendation for future work

At the end, some ideas can be given to develop the system or extend its duties and functions, and some recommendations can be given for moving forward to avoid the problems that may happen in the future as:

1) Using the suitable joystick to have best control.
2) Select the suitable vehicle to achieve the project easier.
3) Improve the system to be appropriate at high speeds.

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APPENDIX A

Aorduino Pin Description

Pin Number	Pin Name	Mapped Pin Name
1	PG5 (OC0B)	Digital pin 4 (PWM)
2	PE0 (RXD0/PCINT8)	Digital pin 0 (RX0)
3	PE1 (TXD0)	Digital pin 1 (TX0)
4	PE2 (XCK0/AIN0)	
5	PE3 (OC3A/AIN1)	Digital pin 5 (PWM)
6	PE4 (OC3B/INT4)	Digital pin 2 (PWM)
7	PE5 (OC3C/INT5)	Digital pin 3 (PWM)
8	PE6 (T3/INT6)	
9	PE7 (CLKO/ICP3/INT7)	
10	VCC	VCC
11	GND	GND
12	PH0 (RXD2)	Digital pin 17 (RX2)
13	PH1 (TXD2)	Digital pin 16 (TX2)
14	PH2 (XCK2)	
15	PH3 (OC4A)	Digital pin 6 (PWM)
16	PH4 (OC4B)	Digital pin 7 (PWM)
17	PH5 (OC4C)	Digital pin 8 (PWM)
18	PH6 (OC2B)	Digital pin 9 (PWM)
19	PB0 (SS/PCINT0)	Digital pin 53 (SS)
20	PB1 (SCK/PCINT1)	Digital pin 52 (SCK)
21	PB2 (MOSI/PCINT2)	Digital pin 51 (MOSI)
22	PB3 (MISO/PCINT3)	Digital pin 50 (MISO)
23	PB4 (OC2A/PCINT4)	Digital pin 10 (PWM)
24	PB5 (OC1A/PCINT5)	Digital pin 11 (PWM)
25	PB6 (OC1B/PCINT6)	Digital pin 12 (PWM)
26	PB7 (OC0A/OC1C/PCINT7)	Digital pin 13 (PWM)
27	PH7 (T4)	
28	PG3 (TOSC2)	
29	PG4 (TOSC1)	
30	RESET	RESET
31	VCC	VCC
Pin Number	**Pin Name**	**Mapped Pin Name**
32	GND	GND
33	XTAL2	XTAL2
34	XTAL1	XTAL1
35	PL0 (ICP4)	Digital pin 49

36	PL1 (ICP5)	Digital pin 48
37	PL2 (T5)	Digital pin 47
38	PL3 (OC5A)	Digital pin 46 (PWM)
39	PL4 (OC5B)	Digital pin 45 (PWM)
40	PL5 (OC5C)	Digital pin 44 (PWM)
41	PL6	Digital pin 43
42	PL7	Digital pin 42
43	PD0 (SCL/INT0)	Digital pin 21 (SCL)
44	PD1 (SDA/INT1)	Digital pin 20 (SDA)
45	PD2 (RXDI/INT2)	Digital pin 19 (RX1)
46	PD3 (TXD1/INT3)	Digital pin 18 (TX1)
47	PD4 (ICP1)	
48	PD5 (XCK1)	
49	PD6 (T1)	
50	PD7 (T0)	Digital pin 38
51	PG0 (WR)	Digital pin 41
52	PG1 (RD)	Digital pin 40
53	PC0 (A8)	Digital pin 37
54	PC1 (A9)	Digital pin 36
55	PC2 (A10)	Digital pin 35
56	PC3 (A11)	Digital pin 34
57	PC4 (A12)	Digital pin 33
58	PC5 (A13)	Digital pin 32
59	PC6 (A14)	Digital pin 31
60	PC7 (A15)	Digital pin 30
61	VCC	VCC
62	GND	GND
63	PJ0 (RXD3/PCINT9)	Digital pin 15 (RX3)
64	PJ1 (TXD3/PCINT10)	Digital pin 14 (TX3)
65	PJ2 (XCK3/PCINT11)	
66	PJ3 (PCINT12)	
67	PJ4 (PCINT13)	
Pin Number	**Pin Name**	**Mapped Pin Name**
68	PJ5 (PCINT14)	
69	PJ6 (PCINT 15)	
70	PG2 (ALE)	Digital pin 39
71	PA7 (AD7)	Digital pin 29

72	PA6 (AD6)	Digital pin 28
73	PA5 (AD5)	Digital pin 27
74	PA4 (AD4)	Digital pin 26
75	PA3 (AD3)	Digital pin 25
76	PA2 (AD2)	Digital pin 24
77	PA1 (AD1)	Digital pin 23
78	PA0 (AD0)	Digital pin 22
79	PJ7	
80	VCC	VCC
81	GND	GND
82	PK7 (ADC15/PCINT23)	Analog pin 15
83	PK6 (ADC14/PCINT22)	Analog pin 14
84	PK5 (ADC13/PCINT21)	Analog pin 13
85	PK4 (ADC12/PCINT20)	Analog pin 12
86	PK3 (ADC11/PCINT19)	Analog pin 11
87	PK2 (ADC10/PCINT18)	Analog pin 10
88	PK1 (ADC9/PCINT17)	Analog pin 9
89	PK0 (ADC8/PCINT16)	Analog pin 8
90	PF7 (ADC7)	Analog pin 7
91	PF6 (ADC6)	Analog pin 6
92	PF5 (ADC5/TMS)	Analog pin 5
93	PF4 (ADC4/TMK)	Analog pin 4
94	PF3 (ADC3)	Analog pin 3
95	PF2 (ADC2)	Analog pin 2
96	PF1 (ADC1)	Analog pin 1
97	PF0 (ADC0)	Analog pin 0
98	AREF	Analog Reference
99	GND	GND
100	AVCC	VCC

APPENDIX B

Software Code

```
final
const int steps1 = 5;
const int steps2 = 6;
const int st = 12;
const int dir1 = 8;
const int dir2 = 9;
const int dirst = 10;

const int sig1 = 0;
const int sig2 = 1;
const int sigst1 = 2;
const int sigst2 = 3;


int val1;
int val2;
int val3;
int valst1;//CP- GND, CP+ STEP
int valst2;
int c1=250;// the driver of fuel must be active the switch 5&8.
int c2;
int c3=6125;//the driver of fuel must be active the switch 5.
int c4;
int c5=625;// the driver of brake must be active the switch 5.
void setup()
{
  pinMode(steps1,OUTPUT);
  pinMode(steps2,OUTPUT);

  pinMode(st,OUTPUT);
  pinMode(dir1,OUTPUT);
  pinMode(dir2,OUTPUT);
  pinMode(dirst,OUTPUT);
  pinMode(sig1,INPUT);
  pinMode(sig2,INPUT);
  pinMode(sigst1,INPUT);
  pinMode(sigst2,INPUT);

  }

void loop ()
  {
  val1 = analogRead(sig1)/20*10; //fuel value
  val2 = analogRead(sig2);
  valst1 = analogRead(sigst1)/28*343;//steering value
  valst2=analogRead(sigst2);
  val3=analogRead(sig1)/20*25; // brake value
  if(val2>650)
   {
    c2=1;
   }

  if(val2<500)
   {
    c2=2;
   }
```

final

```
if(c2==1)                                          //1
 {
if (val1>c1)
 {
digitalWrite(dir1,HIGH);
digitalWrite(steps1,HIGH);
delayMicroseconds(1000);
digitalWrite(steps1,LOW);
delayMicroseconds(1000);

 c1++;
 }
 if (val1<c1)
 {
digitalWrite(dir1,LOW);
digitalWrite(steps1,HIGH);
delayMicroseconds(10);
digitalWrite(steps1,LOW);
delayMicroseconds(10);
c1--;
 }}
if(c2==2)                                          //2
 {
if (val3>c5)
 {
digitalWrite(dir2,LOW);
digitalWrite(steps2,HIGH);
```

```
delayMicroseconds(500);
digitalWrite(steps2,LOW);
delayMicroseconds(500);

 c5++;
 }
if (val3<c5)
 {
digitalWrite(dir2,HIGH);
digitalWrite(steps2,HIGH);
delayMicroseconds(10);
digitalWrite(steps2,LOW);
delayMicroseconds(10);
c5--;
 }}
 if(valst2>650)
 {
  c4=1;
 }
if(valst2<500)
 {
  c4=2;
 }
if(c4==1)                                               //1
 {
if (valst1>c3)
 {
```

```
final
digitalWrite(dirst,HIGH);
digitalWrite(st,HIGH);
delayMicroseconds(300);
digitalWrite(st,LOW);
delayMicroseconds(300);

 c3++;
 }
 if (valstl<c3)
 {
digitalWrite(dirst,LOW);
digitalWrite(st,HIGH);
delayMicroseconds(300);
digitalWrite(st,LOW);
delayMicroseconds(300);
c3--;
 }

 }
if(c4==2)                                      //2
 {

if (valstl>c3)
 {
digitalWrite(dirst,HIGH);
digitalWrite(st,HIGH);
delayMicroseconds(300);

digitalWrite(st,LOW);
delayMicroseconds(300);

 c3++;
 }
if (valstl<c3)
 {
digitalWrite(dirst,LOW);
digitalWrite(st,HIGH);
delayMicroseconds(300);
digitalWrite(st,LOW);
delayMicroseconds(300);
c3--;
 }}}
```

APPENDIX C

Control System Circuit Sketch

APPENDIX D

User's Manual

For

M860

High Performance

Microstepping Drive

http://www.leadshine.com/UploadFile/Down/M860m.pdf

APPENDIX F

Joystick JC2000

Multi Axis Contactless

Joystick