PPU College of Engineering and Technology

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Electrical and Computer Engineering Department

Industrial Automation Engineering Program

Graduation Project

Smart Wheelchair

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الخليل – فلسطين

كلية الهندسة والتكنولوجيا

دائرة الهندسة الكهربائية والحاسوب

Smart Wheelchair

نادر أحمد عدوي علاء محمود الرجوب

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

توقيع المشرف

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توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

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Dedication

This project is dedicated to our parents who help and give us their love and to oppressed people throughout the world and their struggle for social justice and egalitarianism.

ACKNOWLEDGEMENT

We would like to acknowledge all who collaborated to carry out this project, and we would like to make special thanks to our supervisor Eng. Abed Al-Qadir Al-Zaro.

Industrial Automation supervisor Dr. Sammer Khader

And Dr. Yousef Al-Swati

ABSTRACT

The smart wheel chair is an electrical chair design, designed for transporting of handicap in untraditional way; which make this person able to climb stairs in addition of moving along straight ways with the same mechanism. This smart chair use solar power as main source in addition to traditional electrical charger.

The whole design is controlled by microcontroller unit which used to drive the motors according to user control signals, this is done by special program.

الملخص

الكرسي الكهربائي الذكي هو تصميم لكرسي كهربائي صمم بهدف الحصول على مدى أكبر من الحركة لذوي الإعاقة بحيث يسمح للمعاق بالحركة في نطاق أوسع يشمل المرور على حواجز وصعود الدرج. يعتمد هذا النظام في الأساس على استخدام الطاقة الشمسية كمصدر أساسي للتغذية، بالإضافة إلى استخدامه للطاقة الكهربائية من الشبكة.

يتم التحكم في النظام من خلال وحدة معالجة مركزية تتلقى الإشارات من المستخدم فتقوم بتحليلها بناءً على البرنامج ، ثم تتحول هذه الإشارات إلى أوامر تتلقاها المحركات وبالتالي يتحرك الكرسي.

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CHAPTER ONE

INTRODUCTION

Nowadays , electric powered wheelchairs are very common and efficient for transportation of the old and the disabled, it is certain that electric powered wheelchairs can improve the mobility of physically handicapped people. Although an electric powered wheelchair is more and more important to play the assistant roles, and may bring a happiness and convenience to those who need it, however, architectural barriers like stairs still exist in our living environments to prevent from usefulness. Whilst numerous modifications have been taken in recent years to improve the accessibility of public buildings and transportation services, the problem of negotiating stairs in a wheelchair has not yet been satisfactorily resolved.

1.1 General Description Of The Project

In Palestine and Arab countries more than 90% of the buildings don't have way for handicap, so there is difficult on invalid to move without any help. There for we need to design a wheelchair that can solve this problem.

In this project we will make wheelchair climb the stairs, control from two way local control or remote control, and provide by the power from solar cell or electricity plug.

Figure 1.1 shows a sketch of the smart wheelchair

Figure 1.1: Smart wheelchair.

1.2 Project Motivation

This project help the handicap to be more flex upstairs or passing barrier such as few steps , therefore our design is directed to help important sector of our community. And the solar power that we will use to energize the chair to keep up with direction of using renewable energy.

1.3 Literature Review

We find many studies that talk about the climbing stairs wheelchair .

1- Lawn and Ishimatsu focuses on presenting the development of a stair-climbing wheelchair mechanism with high single step capability. The mechanism was based on front and rear wheel clusters connected to the base (chair) via powered linkages so as to permit both autonomous stair ascent and descent in the forward direction, and high single step functionality for such as direct entry to and from a van.

A stair-climbing wheelchair mechanism with high single step capability has been numerically modeled, simulated and a functional scale model built. The scale model mechanism has been equipped with a minimal control system and successfully operated in the negotiation of stairs both up and down in the forward direction. The mechanism has also been successfully operated in boarding and disembarking from a scale model van .[1]

Figure 1.2 shows Lawn and Ishimatsu model of the stair-climbing wheelchair , (left) ascent. (right) descent

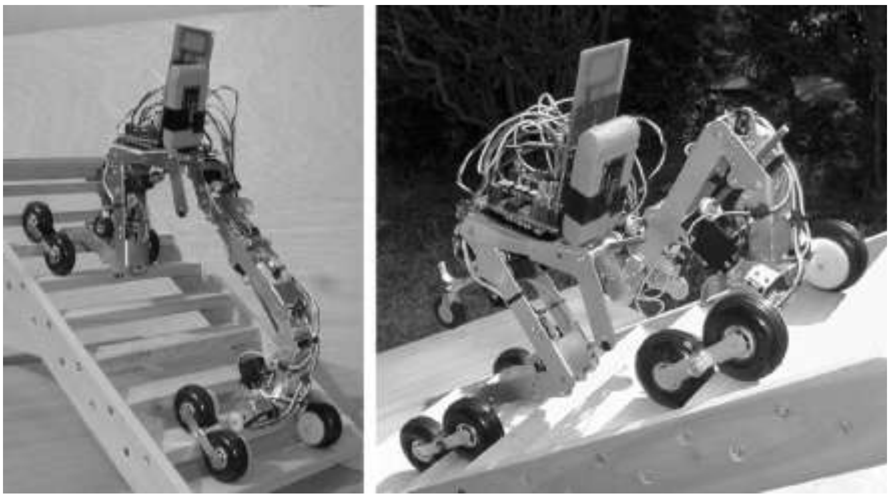


Figure 1.2: Lawn and Ishimatsu model of the stair-climbing wheelchair. [1]

2- Morales , Feliu , González and Pintado they work on the movements and the trajectory generation of a novel wheelchair prototype capable of climbing staircases. The key feature of the mechanical design is the use of two decoupled mechanisms for each axle, one used to negotiate steps, and the other to position the axle with respect to the chair to accommodate the overall slope. This decoupling makes many different climbing strategies possible, the overall mechanism becoming extraordinarily versatile from a control point of view.

The control system is necessary to synchronize the movements of all the actuators of the wheelchair so that its centre of mass can follow arbitrary spatial trajectories. Different trajectories have been designed in order to keep the seat as erect as possible to guarantee passenger comfort .[2]

Figure 1.3 shows Morales , Feliu , González and Pintado stair-climbing wheelchair .

Figure 1.3: Morales wheelchair Prototype. [2]

3- Chun-Ta Chen , Te-Tan Liao and Hoang they made analysis on a winding stair-climbing is investigated using their proposed rotational arm type of robotic wheelchair. The robotic wheelchair is operated in an open mode to climb winding stairs by a dynamic turning, therefore, the dynamics model is required to ensure a passenger’s safety. Equations of motion based on the skid-steering analysis are developed for the trajectory planning and motion analysis on climbing winding stairs.

In most hybrid legged-wheeled staircase-climbing systems, the wheels serve as contact soles when climbing the stairs. However, if the wheels are too large, they only make contact at the edges of each step. Conversely, a small wheel radius improves the contact area on the stair, but reduces the efficiency of the system when navigating planar terrains. [3]

Figure 1.4 shows Chun-Ta Chen , Te-Tan Liao and Hoang schematic of the rotational arm of robotic wheelchair.

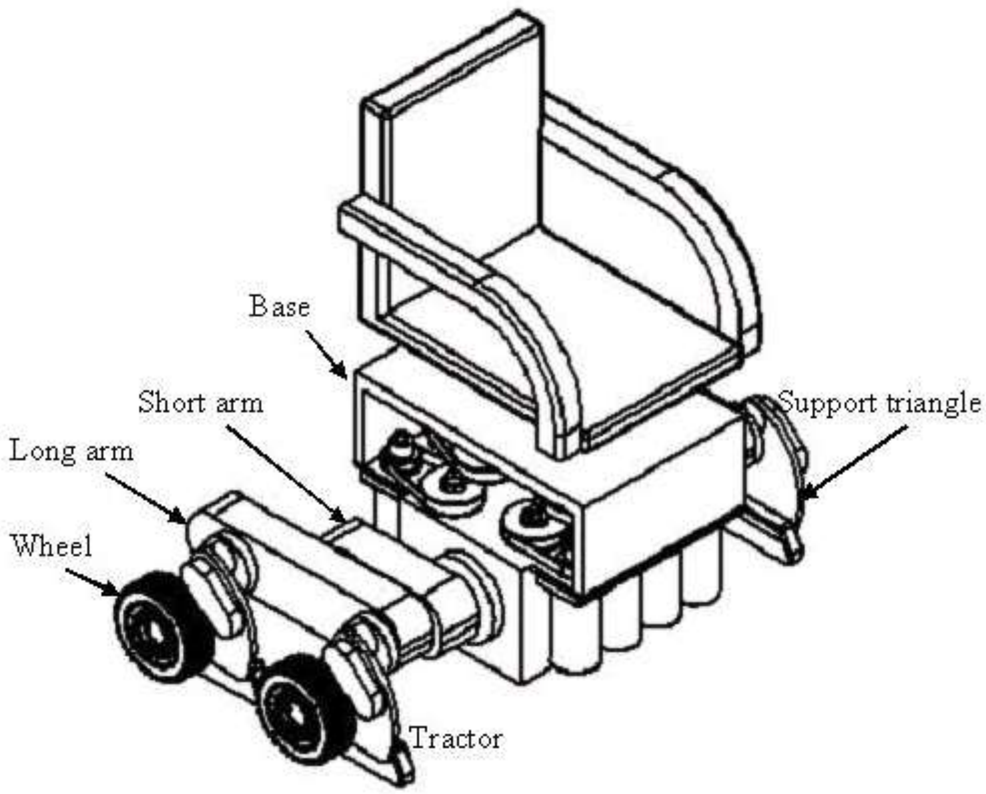


Figure 1.4: Schematic of the rotational arm of robotic wheelchair. [3]

Here comparison between different stair-climbing wheelchair

Table 1.1 : Comparison Between Different Stair Chairs. [1]

Device	Advantages	Disadvantages
Stair chair lift	Compact, suits narrow stairways	Requires transfer to and from such as wheelchair, mechanism dedicated to single stairway, expensive.
Platform stair lift	Compact (when not in use), carries wheelchair directly	Requires wide stairway, mechanism dedicated to single stairway, expensive.
Tracked stair-climbing wheelchair	Autonomous operation on stairs, slopes and irregular terrain.	Usually not well suited to general purpose use, must ascend stairs in reverse, special provision required for entry to van.
Lightweight manual wheelchair with stair-climbing attachment	Same as for manual wheelchair plus stair-climbing ability (with assistance).	Requires assistance with stairs and sloped areas (one person). Special training for assistant usually required.
Powered single cluster stair-climber	Excellent overall mobility in most environments including stairs (with assistance).	Special provision required for entry to van. Requires assistance with stairs (one person).
Powered single cluster (balancing) stair-climber	Autonomous operation on stairs, slopes and irregular terrain.	Special provision required for entry to van. Requires assistance with stairs (one person) if appropriate hand rail/s not provided, must ascend stairs in reverse.
Powered dual cluster stair-climber	Autonomous operation on stairs.	Special provision required for entry to van. Wider than standard wheelchairs, must ascend stairs in reverse.

After we view many literature review , We decide to built new design for climbing stair wheelchair that solve some of the problem we will talk about it more detailed later .

1.4 Time Plan

1st week to 8th week we studied the project and collected data from the internet and books about the wheelchair and its component , from 9th week to 15th week we wrote the documentation , design and make calculation .And in 16th week collect the component and build the wheelchair .

Table 1.2 : Time Line of Project.

Activity	**Week number**																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	28	30
Literature Review	■	■	■	■																								
Theoretical Design				■	■	■	■	■																				
Write the documentation									■	■	■	■																
Report												■	■	■	■													
Collect the Component																■	■	■	■									
Assembly &Electrical Wiring																				■	■	■	■					
Test & Calibration																								■	■	■		
Final Test																											■	■

1.5 Finance Study

The following table shows a cost of the project .

Table 1.3 : Cost of Project

Item	*No.*	*Price per Component*	*Price*
Gears	*28*	*10*	*280*
Motors	*5*	*10*	*50*
Raw Material	*-*	*100*	*100*
Batteries	*2*	*10*	*20*
Solar module PV	*1*	*50*	*50*
Electronics	*-*	*250*	*250*
Wheels	*12*	*5*	*60*
Wiring , Chain …	*-*	*50*	*50*
Total			*830$*

CHAPTER

2 THEORETICAL BACKGROUND

CHAPTER TWO

THEORETICAL BACKGROUND

In this chapter we will talk electrical wheelchair in general, the climb stairs mechanism and about the electrical and mechanical components that will use in our project .

2.1 Electrical Wheelchair

Electric wheelchairs, which are often also called power chairs, offer the advantage of a manual wheelchair, in that they are very maneuverable. However, unlike manual wheelchairs, power chairs are powered electronically, so they can typically be operated very easily, requiring very little physical activity from the handicaps .

A simple joystick control is most popular for controlling electric wheelchairs, which allows the handicaps to simply push the joystick. The joystick, which is attached to the arm of the power chair, then moves the wheelchair in the direction they wish to travel. Of course, there are a number of alternate wheelchair control systems available as well, including breath controlled systems and remote controlled systems.

An electric motor was attached to the manual wheelchair, which was controlled using a simple joystick control, although even during the 1950′s, researchers were already coming up with alternate control schemes. One popular method was to mount something similar to a joystick near the individuals head. They could then use their face to control the electric wheelchair.

Today, while some portable electric wheelchairs do use a traditional steel tube folding wheelchair design, most look much different from a traditional manual wheelchair. Instead, an electric motor and battery is contained in the base of the wheelchair, usually covered by molded plastic.

A captain's chair, which, depending on the cost of the power chair, often rivals that of most office chairs, both in comfort and durability is mounted on the base of the wheelchair. The captain's chair often reclines and swivels, to facilitate comfort and make transferring into and out of the wheelchair easier. Some even include an electric lifting system to raise and lower the chair.

While many power chairs share a similar design, one way they are often classified is by their wheels. A mid-wheel power chair features one set of large wheels in the middle of the base and one set of smaller wheels on the front and back of the base. The larger wheels are what does all of the work and are powered by the electric motor. The smaller set of wheels on either side of the drive wheels, provide extra support and stability.

The mid-wheel electric wheelchair offers the advantage of excellent maneuverability. It can turn in much smaller spaces. However, in some cases it might not offer the same stability as a rear-wheel drive wheelchair. This is because the center of balance for a mid-wheel wheelchair is in the middle of the power chairs base.

The other common type of electric power chair is the rear wheel drive wheelchair. These feature a set of rear wheels, which depending on the model might be slightly larger, and a set of front wheels, giving it four wheels in total. The rear wheels are powered and what actually moves the power chair.

The rear wheel drive wheelchair does not offer the same maneuverability that a mid-wheel power chair does, but does offer increased stability. This is because the weight of the occupant is more evenly distributed across the base, making a wider center of balance.

As is the case with manual wheelchairs, power chairs, both mid-wheel and rear wheel drive models, include anti-tip casters to prevent the wheelchair from tipping over backwards.

2.1.1 Advantages of Electrical Wheelchairs

1) One of the major advantages that an electric wheelchair offers is that it does not require much effort to use. Simply push the joystick and the power chair will move, with many offer very small turning radius and sensitive controls.

2) The range of a power chair varies, but most can travel at least 5 miles without requiring a recharge.

3) Along the same lines, if the rider weighed 300 pounds, the battery would wear down quicker than if they weighed 150 pounds. Often, an extra battery pack is purchased for those who use the power chair continuously, as this way when one battery pack wears down, it can be removed and charged and the fresh battery pack used.

2.2 Climb Stairs Mechanism [6]

2.2.1 Tread Drive

The tread design features two parallel treads with a ramped front and back to allow for more surface contact while climbing stairs. The treads are powered by electric motors. Each tread will be powered by its own motor to allow for skid steering. The tread design is a proven method for navigating tough terrain. When climbing, the contact with the stair becomes a line contact which does not provide optimal traction. Some positive aspects are that the treads are good for various terrains and that there is no additional design necessary to drive from floor to stairs. As well, the treads could be store-bought, not machined. On the downside, the treads may slip and more power is required to move horizontally compared to using wheels.

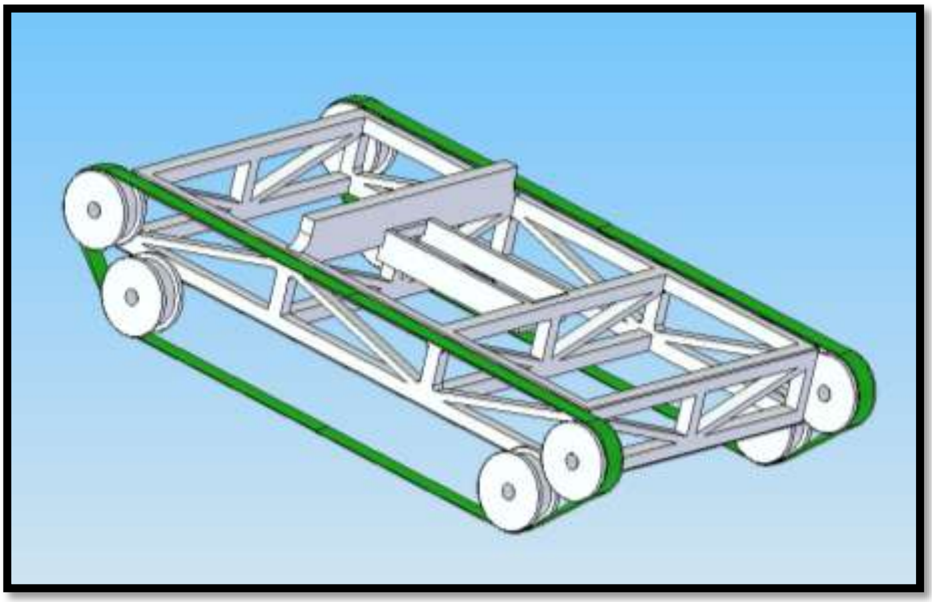


Figure 2.1 : Trade drive mechanism. [6]

2.2.2 Corkscrew Drive

In this design, small wheels are mounted about two axles parallel to the direction of climbing, such that they form two helices mirrored about the centre. The two “corkscrews” effectively act as worm gears as they rotate, using the staircase as a mating gear, which in turn propels up the stairs. Using the corkscrew drive it will be difficult to fall back down the stairs once engaged. This design is unfavorable because it will be difficult to fabricate, may tilt from left to right as it climbs, cannot travel across flat ground, and will be less compatible with other modules due to the strange geometry of the drive system.

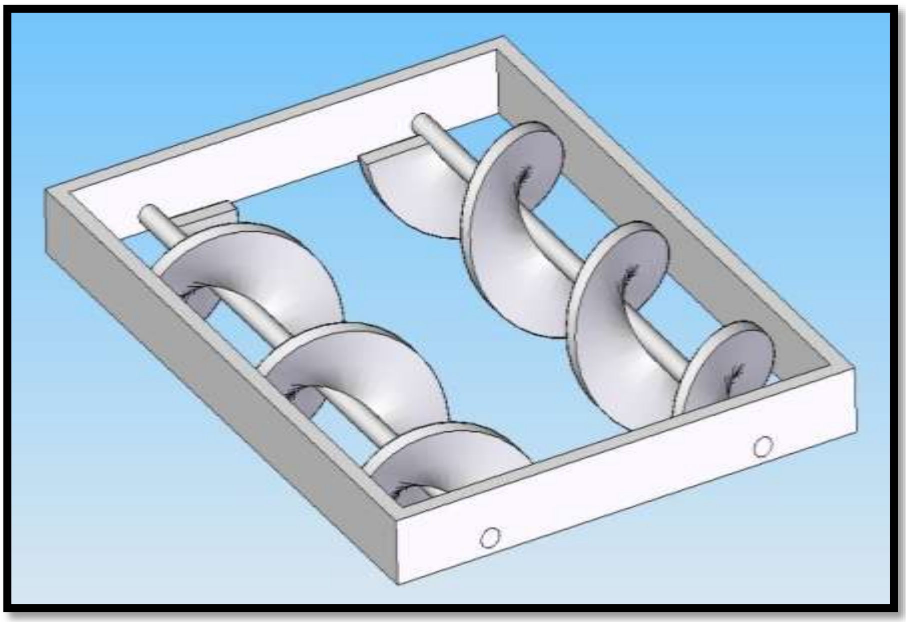


Figure 2.2 : Corkscrew drive mechanism. [6]

2.2.3 Tri-wheel Drive

The tri-wheel stair climbing system has four sets of three driven wheels. Power is transmitted to each of the three wheels in a set by a gearing system, with a central gear connected to the motor, intermediate gears, and one gear directly connected to each wheel, forming a semi planetary gear set. The whole mechanism rotates the wheel set to climb the stairs.

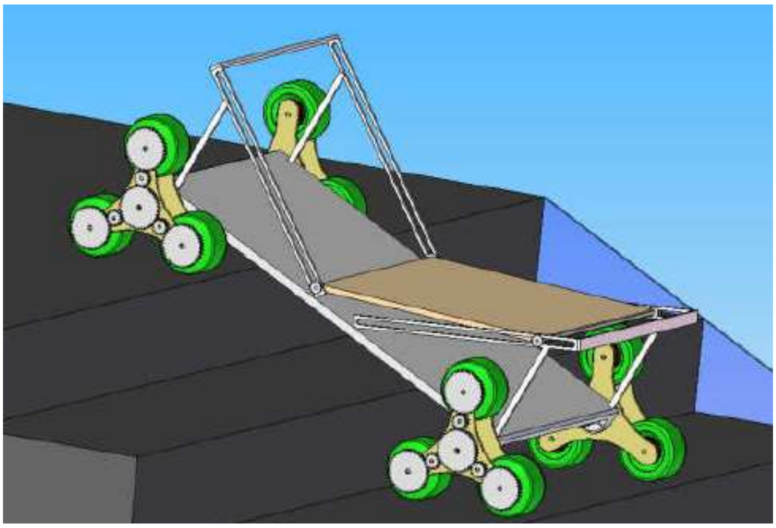


Figure 2.3 : Tri-wheel drive mechanism. [6]

2.3 Chain and Sprocket

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles.

Most often, the power is conveyed by a roller chain, known as the drive chain or transmission chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force into the system.

Sometimes the power is output by simply rotating the chain, which can be used to lift or drag objects. In other situations, a second gear is placed and the power is recovered by attaching shafts or hubs to this gear. Though drive chains are often simple oval loops, they can also go around corners by placing more than two gears along the chain; gears that do not put power into the system or transmit it out are generally known as idler-wheels. By varying the diameter of the input and output gears with respect to each other, the gear ratio can be altered, so that, for example, the pedals of a bicycle can spin all the way around more than once for every rotation of the gear that drives the wheels.[13]

A sprocket is a profiled wheel with teeth that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which are radial projections that engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth.

Sprockets are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc. Perhaps the commonest form of sprocket is found in the bicycle, in which the pedal shaft carries a large sprocket-wheel which drives a chain which in turn drives a small sprocket on the axle of the rear wheel. Early automobiles were also largely driven by sprocket and chain mechanism, a practice largely copied from bicycles.

Sprockets are of various designs, a maximum of efficiency being claimed for each by its originator. Sprockets typically do not have a flange. Some sprockets used with timing belts have flanges to keep the timing belt centered. Sprockets and chains are also used for power transmission from one shaft to another where slippage is not admissible, sprocket chains being used instead of belts or ropes and sprocket-wheels instead of pulleys. They can be run at high speed and some forms of chain are so constructed as to be noiseless even at high speed.[14]

2.4 Microcontrollers

Microcontroller is a functional computer system on single chip, which contains a microprocessor core, some memory (RAM/ROM) to store data, parallel and serial input/output ports to transmit and receive data, timer, and analog to digital converter. Microcontroller is used to control product and device automatically, such as remote control and automobile engine control system. Because of the low cost and easy of integration within an application they are used whenever possible to reduce the chip count of piece [15].

2.4.1 ATMEL AVR microcontroller

The ATMEL AVR is a single chip and modified Harvard architecture. The Harvard architecture is means that the data and program are stored in separate memory space. The AVR was the one of the microcontroller family which is used on chip flash memory for program storage as EEPROM, and low power and high performance device. AVR microcontroller can handle demanding 8 and 16 bit applications The AVR architecture ensures easy application development and fast code execution combine with the lowest possible power consumption, and I/O structure in the AVR is limit the need for external component and reduces developmental cost, variety of timers, UARTS, analog comparators, and watch dog timer .AVR microcontroller may be programmed using assembly or a higher level languages such as c and Java language .[16]

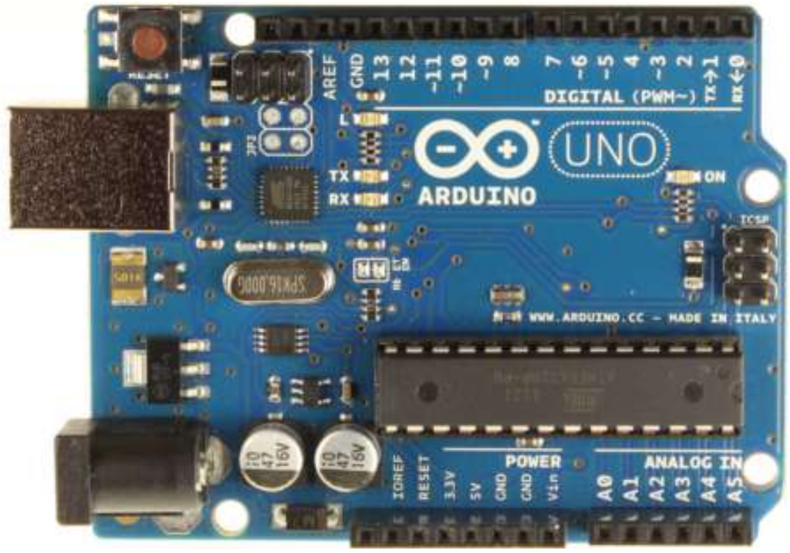


Figure 2.4 : ATmega 328 microcontroller on arduino board.

Appendix B

2.5 DC Motors

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. As you are well aware of from playing with magnets as a kid, opposite (North and South) polarities attract, while like polarities (North and North, South and South) repel. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

2.5.1 Permanent-magnet motors

A permanent-magnet motor does not have a field winding on the stator frame, instead relying on permanent magnets to provide the magnetic field against which the rotor field interacts to produce torque. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. Permanent-magnet fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding. Larger DC motors are of the "dynamo" type, which have stator windings. Historically, permanent magnets could not be made to retain high flux if they were disassembled; field windings were more practical to obtain the needed amount of flux. However, large permanent magnets are costly, as well as dangerous and difficult to assemble; this favors wound fields for large machines.

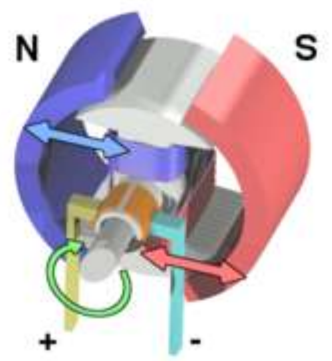


Figure 2.5 : PM DC motor.

2.6 Solar Electricity [5]

In general terms, solar energy means all the energy that reaches the earth from the sun. It provides daylight, makes the earth hot, and is the source of energy for plants to grow. Solar energy is also put to two types of use to help our lives directly: solar heating and solar electricity.

Another major use of solar energy is solar electricity. This is electricity generated directly from sunlight using solar or photovoltaic cells. The word " photovoltaic " refers to an electric voltage caused by light.

Solar cells were first developed to power satellites for the space programmers in the 1950s. Most solar cells are made of a form of silicon. This is a hard material that is either dark blue or red in appearance. The blue cells are made as thin discs or squares which are quite fragile. The red type of silicon is coated on to glass as a thin film. As sunlight shines on the surface of the silicon, electricity is generated by a process known as the photoelectric effect, as in physics.

Each silicon solar cell produces about 0.4 V, solar cells are connected together (in series) to produce a higher voltage that is more useful. Connected in this way, they are often called solar panels but the names used by the suppliers are solar cell modules, photovoltaic modules, or just PV modules.

2.6.1 Parts of a solar electric system

A small solar electric system can be divided into three basic parts :

1) Solar modules generate electricity from available sunlight.
2) Rechargeable batteries are needed to store electricity for later use at night and during cloudy periods.
3) control unit is necessary for all solar electric systems. Functions of the control unit include switching the loads either manually or automatically, protecting the batteries and wiring,

monitoring the performance of the system, and giving warnings when something is not working properly.

2.6.2 advantages of solar electricity

The solar electric system has many advantages:

1) No running costs of buying or transporting fuel.
2) No dependence on regular supplies of fuel. For many countries that are in or close to the tropics, the amount of sunshine available each day is high for most months of the year.
3) Solar cells have no moving parts so the system is less likely to break down than the engine or dynamo in a generator. Also a medium-size solar electric -system can usually continue to work when one part fails, such as one module in the array or one battery in the storage system.
4) Installation and maintenance are straightforward, requiring no special expertise or tools.
5) A solar electric system can be gradually enlarged in small steps. When a generator is found to be too small, it must be completely replaced by a larger one.
6) The low voltage produced by solar modules is safer than mains voltage
7) By storing solar electricity in rechargeable batteries, power is available all the time. A generator has to be started up fully even when only one lamp is needed and this is very wasteful of fuel.
8) Solar cells work silently and have no exhaust pollution.

2.6.3 Disadvantages of solar electricity

There are some disadvantages of solar electricity:

1) Solar modules are not economical for high-power (high-wattage) appliances such as heaters and large motors.
2) The low-voltage D.C. produced by solar modules is less versatile appliances can run only from A.C. mains voltage.
3) Since the source of energy is sunlight, there is less electricity generate during cloudy weather.

2.7 Batteries [4]

An electrical battery is one or more electrochemical cells that convert stored chemical energy into electrical energy .

Five major types of rechargeable batteries are lead-acid, nickel-cadmium, silver-zinc, silver-cadmium and nickel-zinc, and these are discussed in more detail below.

2.7.1 Lead-acid batteries

The lead-acid battery is the most widely used , its main application being in the automotive field. Its advantages are low cost, high voltage per cell and good capacity life. Its disadvantages are that it is relatively heavy, it has poor low-temperature characteristics and it cannot be left in the discharged state for too long without being damaged.

2.7.2 Nickel-cadmium batteries

The nickel-cadmium battery is mechanically rugged and long lived. In addition it has excellent low-temperature characteristics and can be hermetically sealed. Cost, however, is higher than for either the lead-acid or the nickel-zinc battery and, by comparison, its capacity on light drain in terms of watt hours per kilogram is also poorer than for nickel-zinc.

2.7.3 Silver-zinc batteries

Rechargeable silver-zinc batteries can provide higher currents, more level voltage and up to six time's greater watt hour capacity per unit weight and volume than the lead-acid, nickel-zinc and nickel-cadmium storage batteries. Because it is capable of delivering high watt hour capacities at discharge rates less than 30 min, the silver-zinc battery is used extensively for missile and torpedo applications. Its high energy density makes it attractive in electronics indications, satellites and portable equipment where low weight and high performance are prime considerations. It is highly efficient and mechanically rugged, operates over a wide temperature range and offers good shelf life; quick readiness for use and the ability to operate at -40°C without heating are two of the features of this battery. It is available in both high-rate and low-rate cells. Until now the fact that it is more expensive, sensitive to overcharge and has a shorter cycle life than ordinary storage batteries has limited the silver-zinc battery -applications where space and weight are prime . Consecrations. However, long-life silver-zinc batteries have been developed in which some 400 cycles over a period of 30 months' application have been achieved .

2.7.4 Silver-cadmium batteries

The silver-cadmium battery combines the high energy and excellent space and weight characteristic the silver-zinc battery with the long-life , low-rate characteristics and some resistance to overcharge of the nickel-cadmium battery. The battery also provides high efficiency on extended shelf life in charged or uncharged conditions, level voltage and mechanical ruggedness. Watt hour capacity per unit of weight and volume are two to three times greater than those of a comparable nickel-cadmium battery and it has superior charge retention. The silver-cadmium battery promises great weight and space savings and superior life characteristics to those of the nickel-cadmium battery currently used as storage batteries in most satellite programmers'.

Today a silver-zinc system offers the greatest available energy density in terms of watt hours per kilogram. There are newer so-called high energy density couples which have been under development for many years; the effective energy density of many of these systems tends to decline as they are developed close to the point of practical utilization. In addition, chronic safety problems have already caused serious difficulties with the lithium systems and are potentially dangerous in others, most of which are high-temperature systems based on volatile materials. The use of silver as a couple obviously increases initial costs (although silver costs are recoverable) when compared to other existing systems such as lead-acid, nickel-cadmium, etc. When space and weight are limiting factors, the silver-zinc system is a very attractive proposition.

Other metal couples that are considered at present to be of great potential are the nickel-hydrogen and nickel-zinc systems. These may be batteries of the future in applications such as utilities load leveling and electric vehicles; the latter type is, in fact, now in commercial production.

2.7.5 Nickel-zinc batteries

With the development of new separators and improved zinc electrodes, the nickel-zinc battery has now become competitive with the more familiar battery systems. It has a good cycle life and has load-voltage characteristics higher than those of the silver-zinc system. The energy per unit of weight and volume are slightly lower than those of the silver-cadmium system. Good capacity retention (up to 6 months) has made the nickel-zinc battery a more direct competitor of the silver-zinc and silver-cadmium systems. Nickel-zinc batteries are not yet available in a sealed form.

2.8 Fuses

A fuse is a type of low resistance resistor that acts as a sacrificial device to provide over-current protection, of either the load or source circuit. It's essential component is a metal wire or strip that melts when too much current flows, which interrupts the circuit in which it is connected. Short circuit, overloading, mismatched loads or device failure are the prime reasons For excessive current.[20]

Figure 2.6 : Fuse.

2.9 Liquid Crystal Display

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly.

LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or Monochrome. The most flexible ones use an array of small pixels.[21]

2.10 Sensors

2.10.1 Tachogenerator[22]

An electromechanical generator is a device capable of producing electrical power from mechanical energy, usually the turning of a shaft. When not connected to a load resistance, generators will generate voltage roughly proportional to shaft speed. With precise construction and design, generators can be built to produce very precise voltages for certain ranges of shaft speeds, thus making them well-suited as measurement devices for shaft speed in mechanical equipment. A generator specially designed and constructed for this use.

By measuring the voltage produced by a tachogenerator, you can easily determine the rotational speed of whatever its mechanically attached to. One of the more common voltage signal ranges used with tachogenerators is 0 to 10 volts. Obviously, since a tachogenerator cannot produce voltage when it's not turning, the zero cannot be "live" in this signal standard. Tachogenerators can be purchased with different "full-scale" (10 volt) speeds for different applications. Although a voltage divider could theoretically be used with a tachogenerator to extend the measurable speed range in the 0-10 volt scale, it is not advisable to significantly over speed a precision instrument like this, or its life will be shortened.

Tachogenerators can also indicate the direction of rotation by the polarity of the output voltage. When a permanent-magnet style DC generator's rotational direction is reversed, the polarity of its output voltage will switch. In measurement and control systems where directional indication is needed, tachogenerators provide an easy way to determine that.

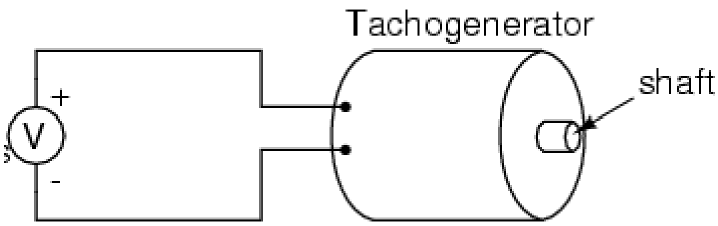


Figure 2.7 Tachogenerator.

2.10.2 IR proximity sensor

An IR proximity sensor works by applying a voltage to a pair of IR light emitting diodes (LED's) which in turn, emit infrared light. This light propagates through the air and once it hits an object it is reflected back towards the sensor. If the object is close, the reflected light will be stronger than if the object is further away.[23]

Figure 2.8 : IR proximity sensor.

2.10.3 Position Sensor

A position sensor is any device that permits position measurement. It can either be an absolute position sensor or a relative one (displacement sensor). Position sensors can be either linear or angular.[24]

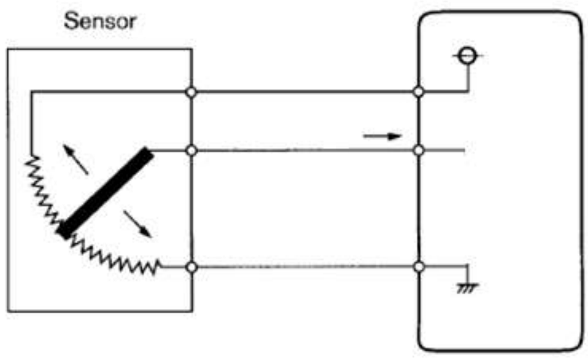


Figure 2.9 : Position sensor.

CHAPTER

3 MECHANECAL DESIGN

3.1 Wheel Design

3.2 Torque Calculation

3.3 Chair Balancing

3.4 Base Dimension

3.5 Base Balancing

CHAPTER THREE

MECHANICAL DESIGN

This chapter talks about mechanical design start first with wheels design after defined the standard stairs dimension, second torque calculations, third chair balancing and finally base balancing and the dimension.

*For real scale design look appendix A

3.1 Wheel Design

The dimension of stairs the horizontal dimension of stairs " X " = 85 mm and the vertical dimension = 20 mm . As shown in figure 3.1.

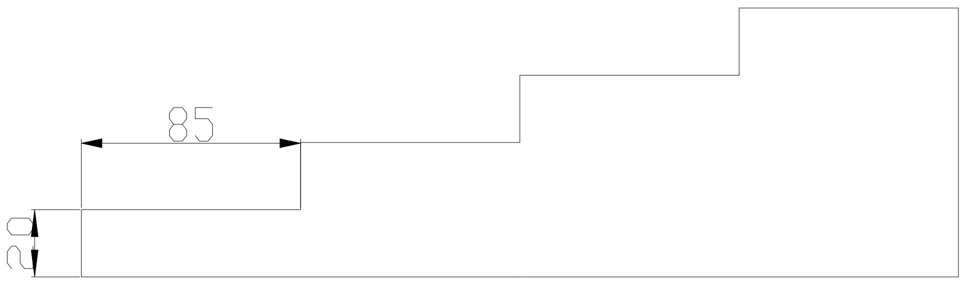


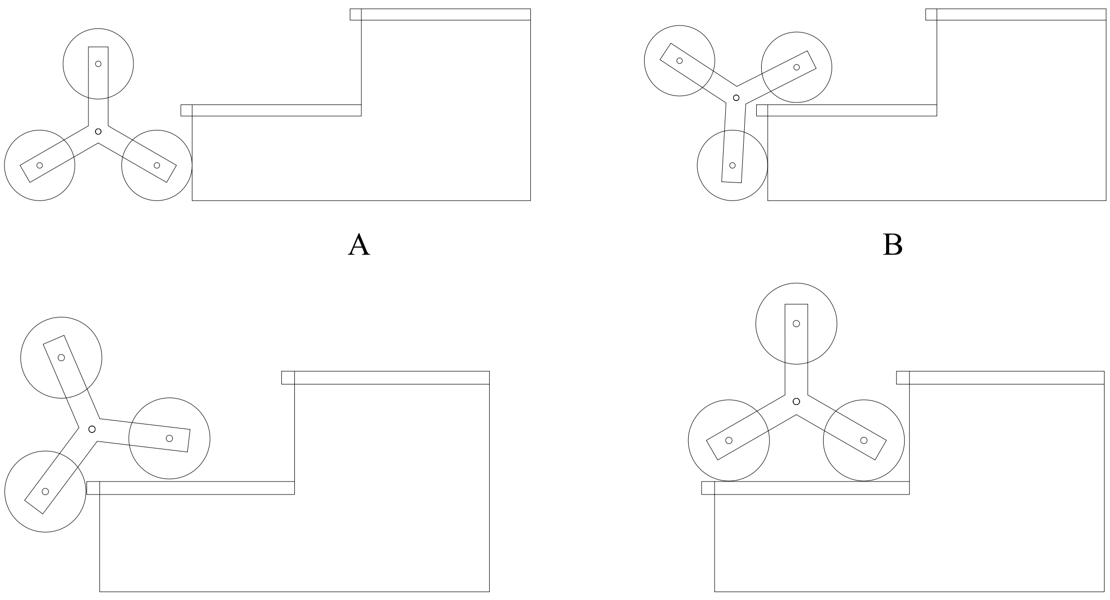
Figure 3.1 : Stairs dimensions.

We choose the tri- wheel mechanism dependent on the table 3.1; because we found the tri – wheel the best mechanism.

Table 3.1 : Selection of wheel system. [6]

Design Selection of wheel systems								
System	Ease of Fabrication	Ease of Maintenance	Cost	Modularity	Lifetime	Smoothness	Traction/ Hold	Total
Weighting	3	1	3	2	1	2	3	
Cork-Screw	2	2	1	1	2	1	3	
(Weighted Score)	6	2	3	2	2	2	9	26
Treads	5	4	3	2	3	3	2	
(Weighted Score)	15	4	9	4	3	6	6	47
Tri-Wheel	3	3	3	4	5	5	5	
(Weighted Score)	9	3	9	8	5	10	15	59

The tri – wheel plate must be climbing the stairs with dimension (20 mm , 85 mm) . So the arms of the plate must flip on the stairs without any troubles .by using wheel with 32 mm diameter as shown in Figure 3.2.



A B C D

Figure 3.2 : Tri – wheel operation sequence.

The plate dimension shown in figure 3.3.

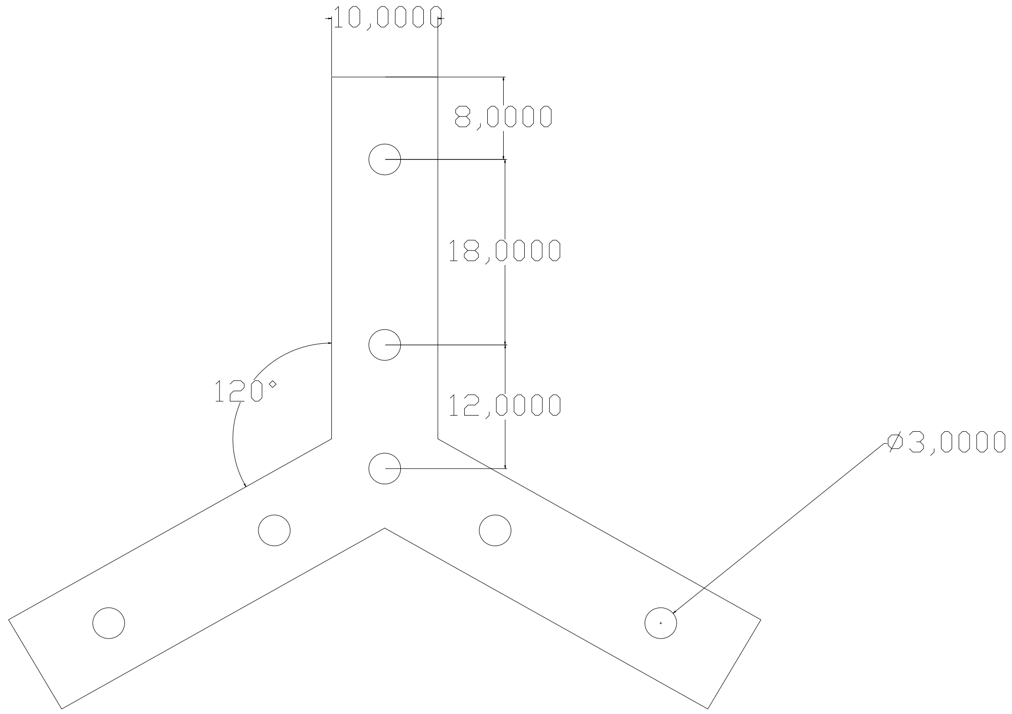


Figure 3.3 : Tri – wheel plate dimension.

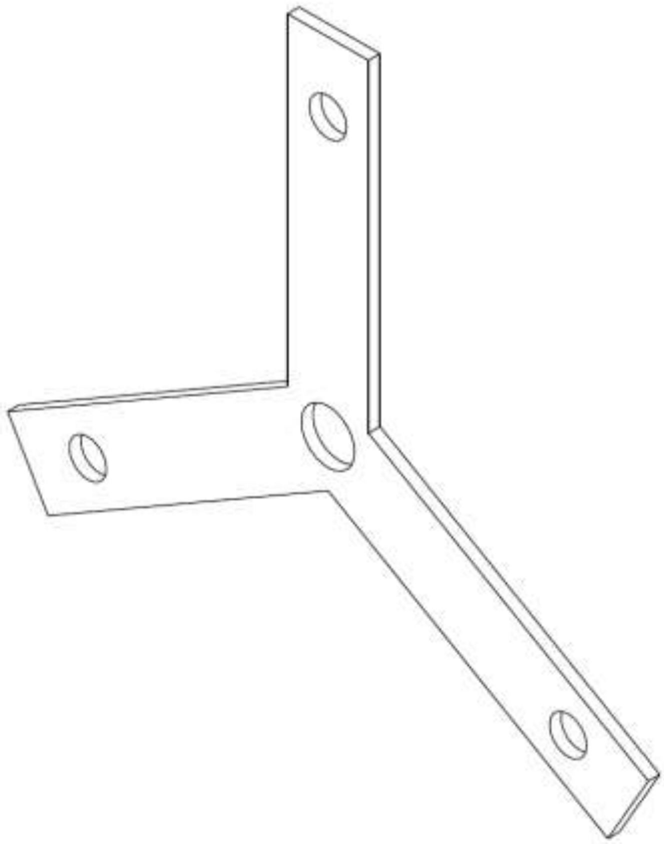


Figure 3.4 : 3D plate diagram .

To make the tri – wheel move we need power transmission system from the main shaft " center shaft " to the wheels shafts , there is two way to solve this problem : -
First : Using Gears (spur gear)

Figure 3.5 : Spur gear.

Second : Using Chain and Sprocket

Figure 3.6 : Chain and sprocket.

We choose the spur gear because is more suitable than the chain and sprocket.

After we choose the spur gear we design the spur gear that fit our design using CAD help . Figure 3.7 shows spur gear design.

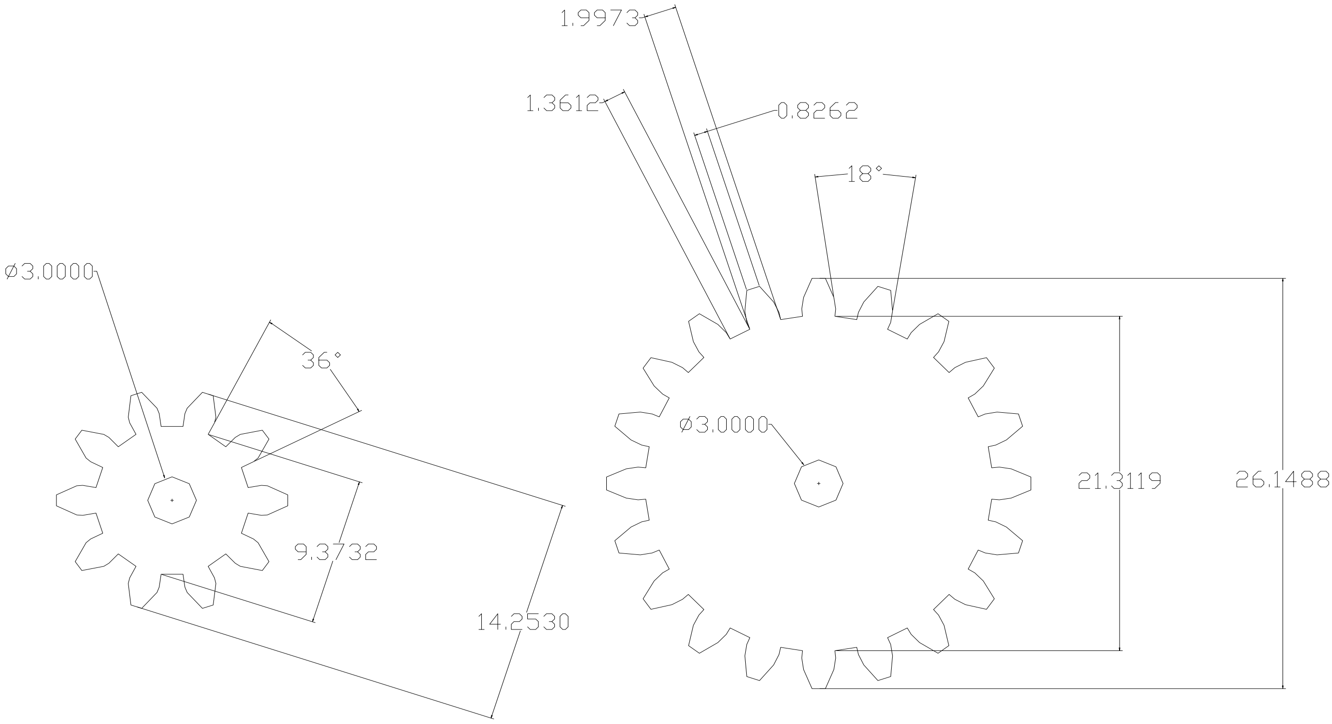


Figure 3.7 : Spur gear design.

The last part in the tri – wheel is the rods we choose it by using CAD help " Catia Analysis " to sure that the rods will carry the chair without any problem . So the rods 3mm diameter.

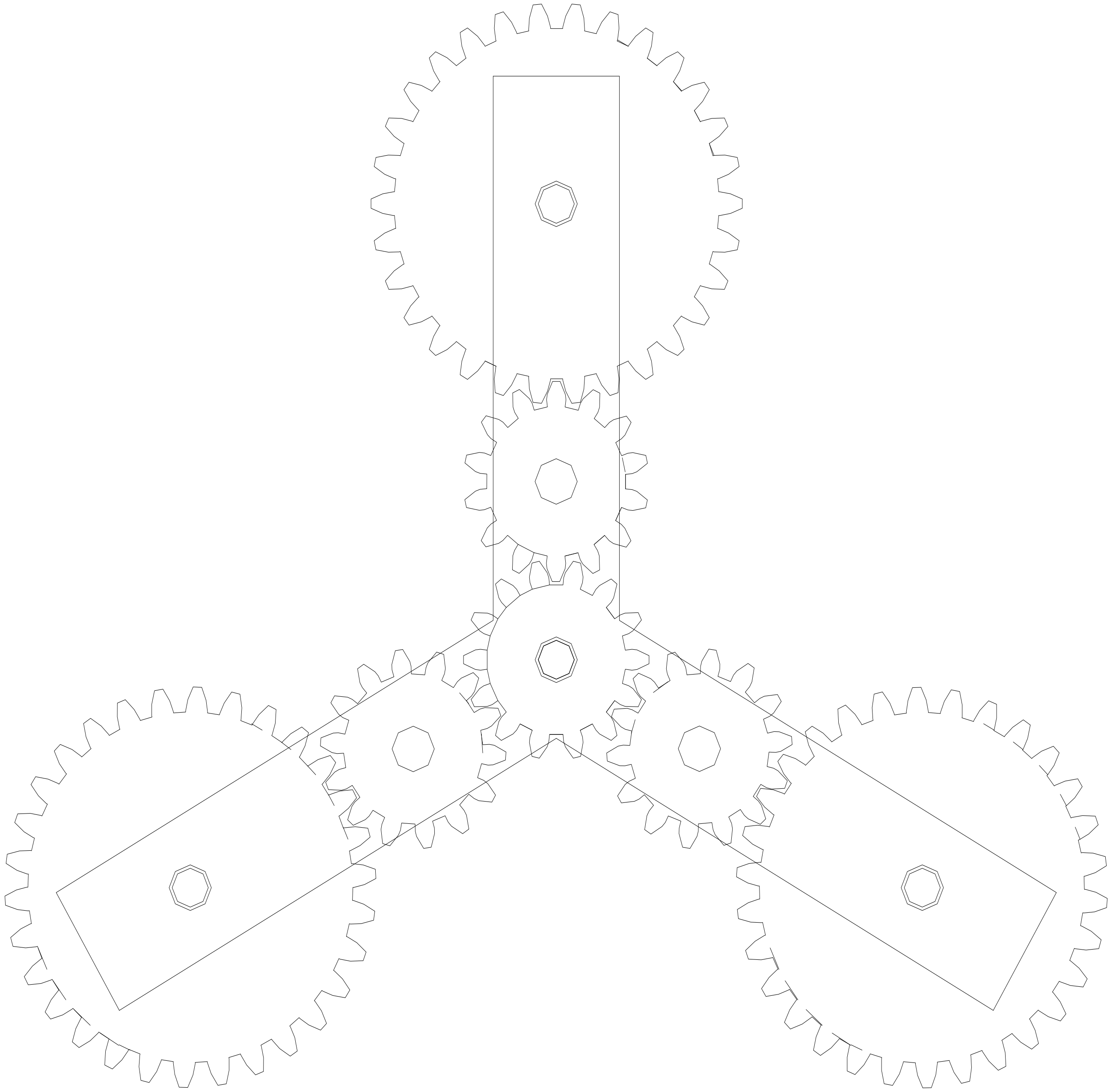


Figure 3.8 : Spur gear design for tri-wheel.

3.2 Torque Calculation

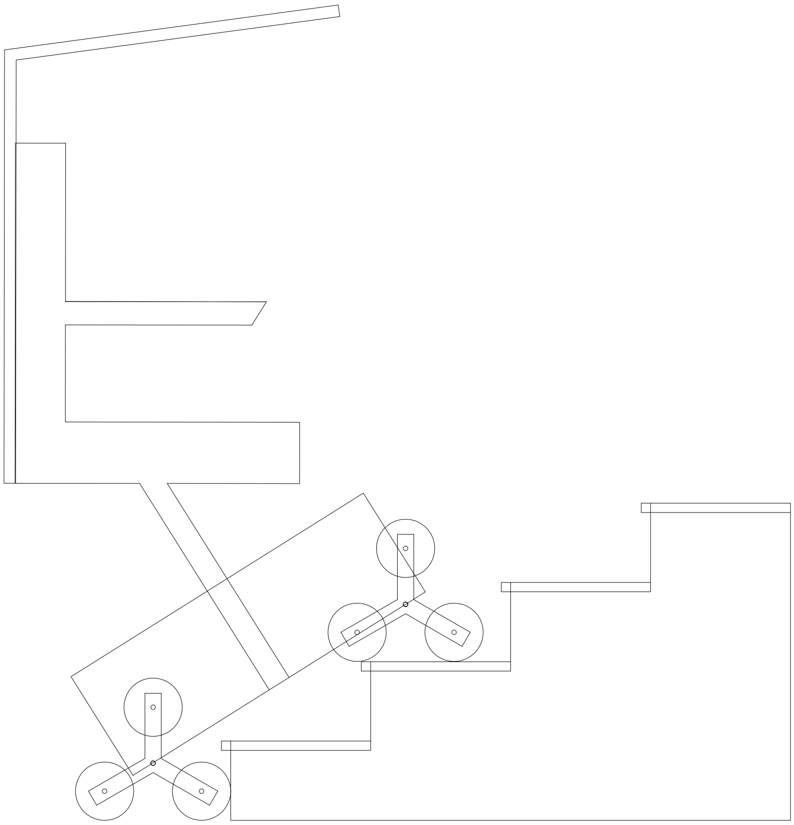


Figure 3.9 : Sketch for the wheelchair on the stairs.

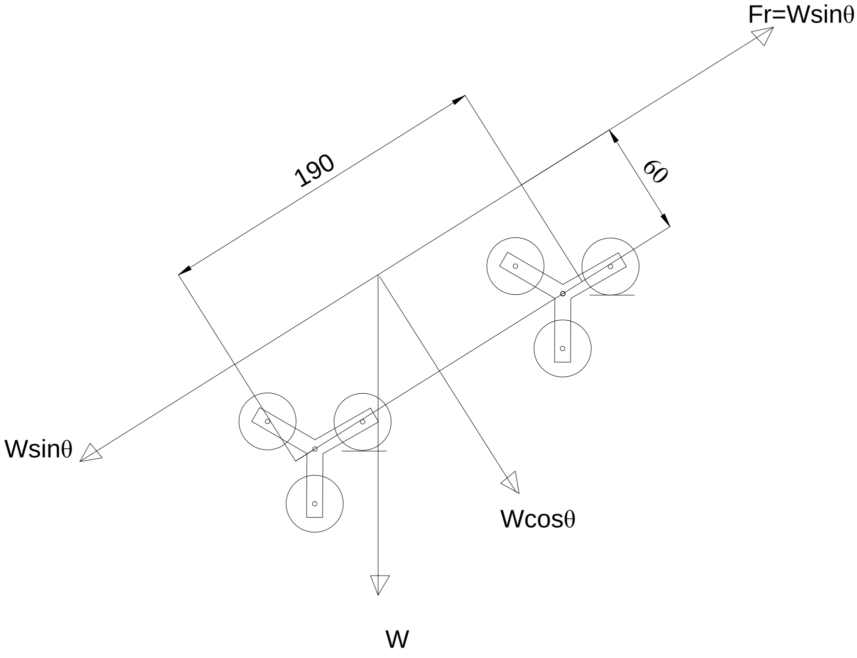


Figure 3.10 : Free body diagram for the wheelchair.

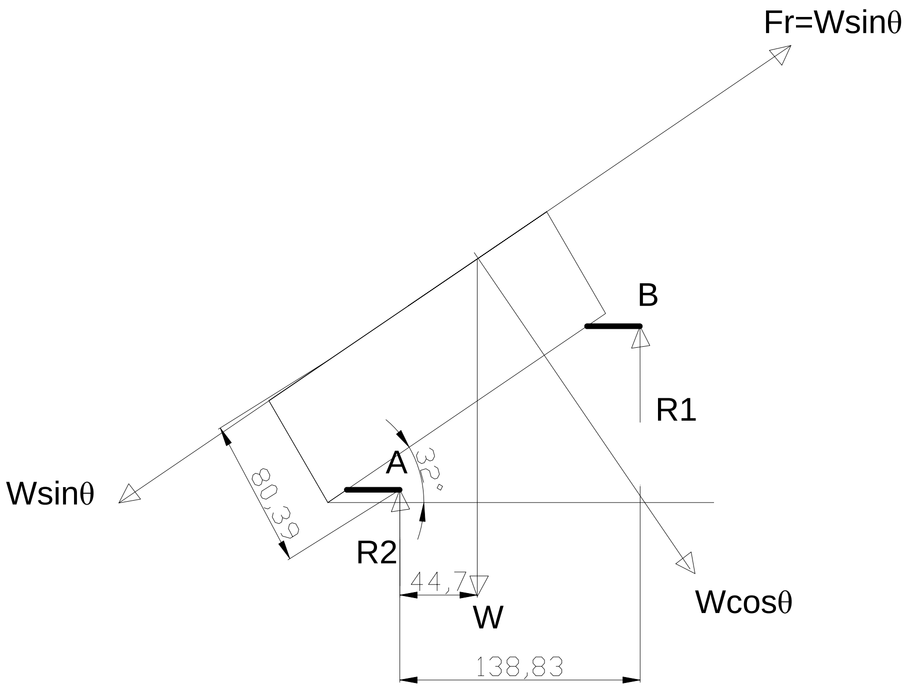


Figure 3.11 : Equivalent model for torque calculation.

Where : W : Weight (N) F_r : Fraction Force (N) R: Reaction (N)

Total mass = 2kg

W = Mass * Acceleration of gravity (g) (3.1)

Where : g = 9.8 (m/s^2)

W : Weight (N)

Total weight (W) = 2 * 9.8 = 19.6 N

$\sum M_A = 0$ (3.2)

$R_1 a_0 - W \cos\theta\, a_1 + W \sin\theta\, a_2 - W \sin\theta\, a_2 = 0$

Where : M_A : The moment (N.m)

R : Reaction force (N)

a_0 , a_1 , a_2 : lengths (m)

$a_0 \approx 0.139$ m

$a_1 \approx 0.045$ m

$a_2 \approx 0.08$ m

$$R_1 = \frac{W cos\theta a_1}{a_0}$$

$$R_1 = \frac{19.6 cos 32\ 0.045}{0.139}$$

R_1 =5.4 N

$\sum F_y = 0$ (3.3)

Where : F : The force (N)

$R_1 + R_2 - W\cos\theta = 0$

$R_2 = 19.6\cos32 - 5.4$

$R_2 = 11.22$ N

$T_1 = R_1\, a$ (3.4)

Where : T : Torque (N.m)

R : Reaction force (N)

a : Plate arm length (m)

$T_1 = R_1\, a = 5.4 * 0.03 = 0.162$ N.m

$T_2 = R_2\, a = 11.22 * 0.03 = 0.3366$ N.m

We take maximum torque $T_2 = 0.3366$ N.m

The safety factor of the torque will be 1.5 times more than the calculated :

$T_m = 0.3366 * 1.5 = 0.505$ N.m

Torque per motor = 0.505/2 = 0.2525 N.m

We will use four motor .

3.3 Chair Balancing

In the chair design the handicapped must be not afraid when he became up or down on the stairs so the chair must be horizontal regardless of the angel of chair base .

The chair connect with the base by system allow the chair to move around the center to keep the chair horizontal . This mechanism drive by using motor with gear.

To calculate the needed force to move the chair we analysis the weights on the chair and make the bearing at the center of mass to make any small force to move the chair .

Figure 3.12 shows how connect the motor to the chair

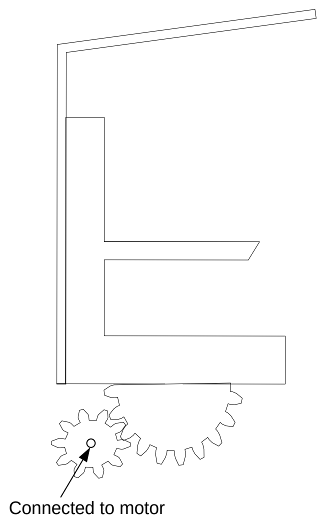


Figure 3.12 : Chair balancing.

3.4 Base Dimension

The base of the chair must cover the all component into it like batteries , motors and electronics circuits …ets . There is another reason to defined the length of the base it make sure the two wheels " the fronts and the rear " will not both at same time up the stairs .

By using CAD help " Auto Cad " we choose the length of the base. Figure 3.13 shows the dimension of the base .

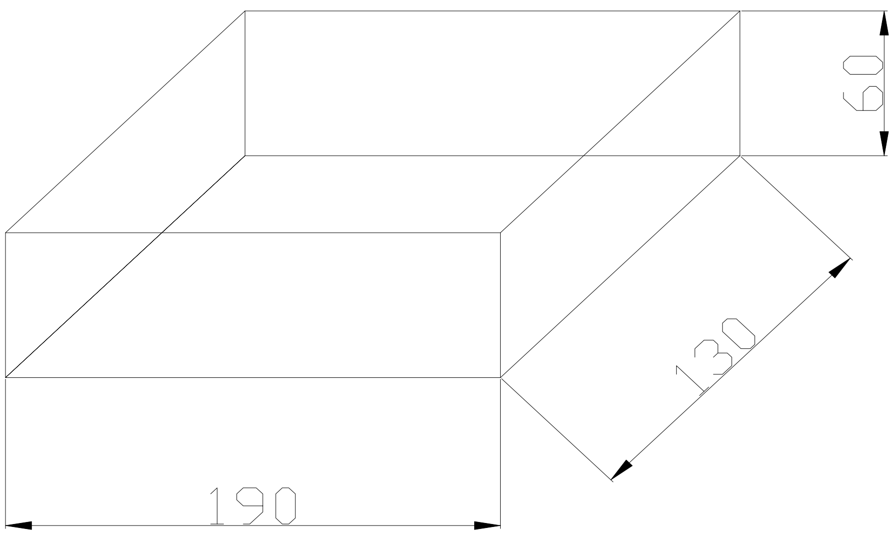


Figure 3.13 : Base dimension .

3.5 Base Balancing

To sure that the chair will be safe when climbing the stairs the base must be balancing by using the conditions for static equilibrium :

1- The sum of the (vector) forces must equal zero .
2- The sum of the torques must equal zero.

- ⇨ $\sum F = 0$
  - ⇨ $\sum F_x = 0$
  - ⇨ $\sum F_y = 0$
- ⇨ $\sum M = 0$

Where F : Force (N)

M : Moment (N.m)

The component's put in the base of the chair in way to make it equilibrium .

CHAPTER 4 ELECTRICAL DESIGN

CHAPTER FOUR

ELECTRICAL DESIGN

This chapter talks about electrical design start first with block diagram of the system, second batteries selection, PV calculation , third the drive circuit, charger circuit, protection, and finally the flow chart for the main program.

4.1 Block Diagram and Microcontroller

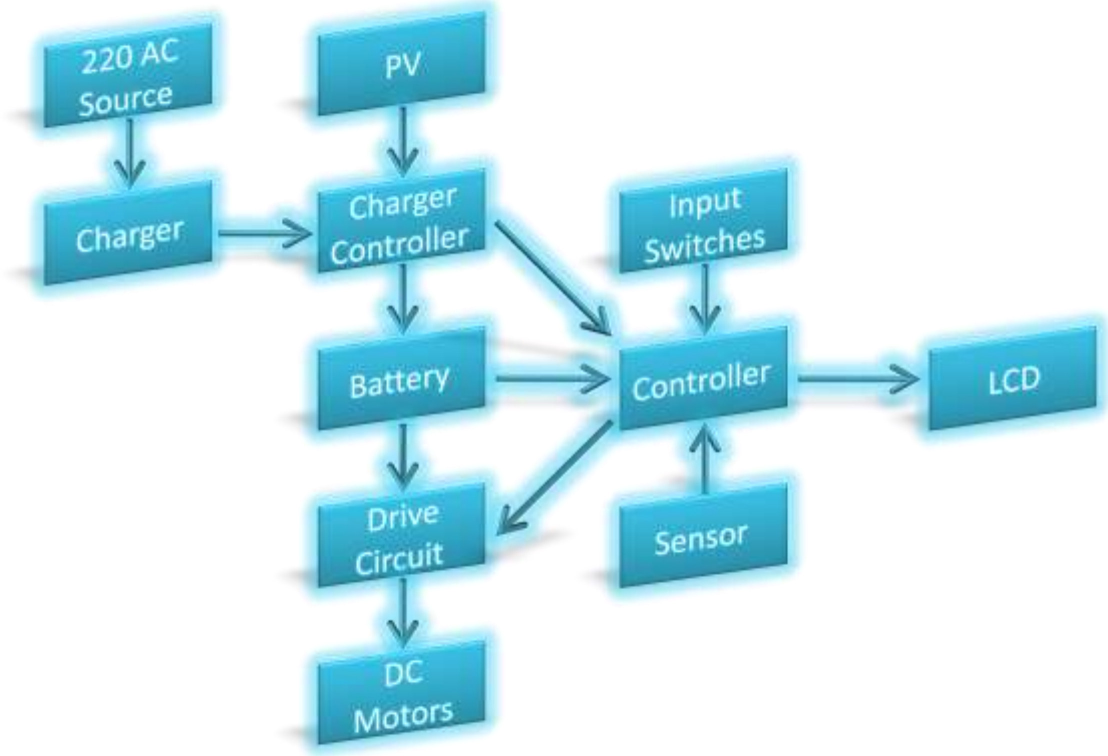


Figure 4.1 : Smart wheelchair block.

4.2 Batteries Selection

When selecting batteries we were concerned primarily with cost, durability, energy density and the number of recharge cycles. The most common batteries used are sealed li-ion batteries due to their low costs and reasonably good energy density.
These batteries are well suited to electric applications because they can be mounted in any orientation without the possibility of leakage or safety being compromised. So we select a battery with a good capacity life.

We determined that li-ion battery would meet our needs. These batteries can be stay for long life and can recharge many numbers of times . This battery will be sufficient.

Loads:-

ATmega 328 #1	20mW
ATmega 328 #2	20mW
LCD	70mW
Motors	5W

Total Power = 5.11W

$$I = \frac{P}{V} \qquad (4.1)$$

Where :- I : current (A)
V : voltage (V)
P : power (W)

$$I = \frac{5.11}{5} = 1.02\ A$$

The battery will remain 1 hour without recharge
Battery capacity = I * t (4.2)
Where :- I : current (A)
t : time (h)
Battery capacity = 1.02 x 1 ≈ 1 Ah

So we use two batteries 500mAh

Figure 4.2 : Li-ion 9V ,500mAh battery.

4.3 PV System

Solar photovoltaic system is one of renewable energy system which uses PV modules to convert sunlight into electricity. Solar PV system is very reliable and clean source of electricity that can suit a wide range of applications such as home use, industry, etc.

The major components for solar PV system are solar charge controller, inverter, and battery bank.

- PV module – converts sunlight into DC electricity.
- Solar charge controller – regulates the voltage and current coming from the PV current for AC appliances or fed back into grid line. In our system not use .
- Battery – stores energy for supplying to electrical appliances when there is a demand.

Solar PV system sizing

First : we determine power we need .

Total Power = 5.11W

Second : Size the PV modules

The system will be powered by 9 Vdc, 2.5 Wp PV module.

Because the size of the PV module is suitable for the chair .

Third : Solar charge controller sizing

The solar charge controller is typically rated against Amperage and Voltage capacities. The sizing of controller depends on the total PV input current which is delivered to the controller. the sizing of solar charge controller is to take the short circuit current (Isc) of the PV array, and multiply it by 1.3.

Solar charge controller rating = Total short circuit current of PV array x 1.3 (4.3)

Isc =300mA from data sheet

Solar charge controller rating = 300mA x 1.3

= 0.39 A ➔ select MOSFET with I_D more than 0.4A

Appendix B

4.4 Electrical Charger

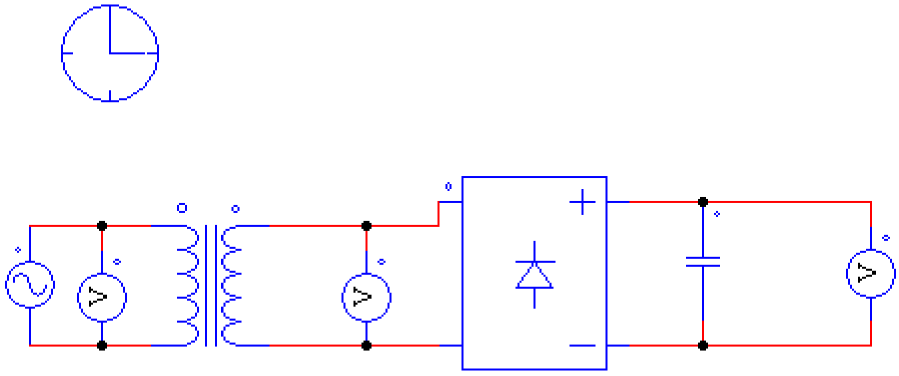


Figure 4.3 : Charger circuit.

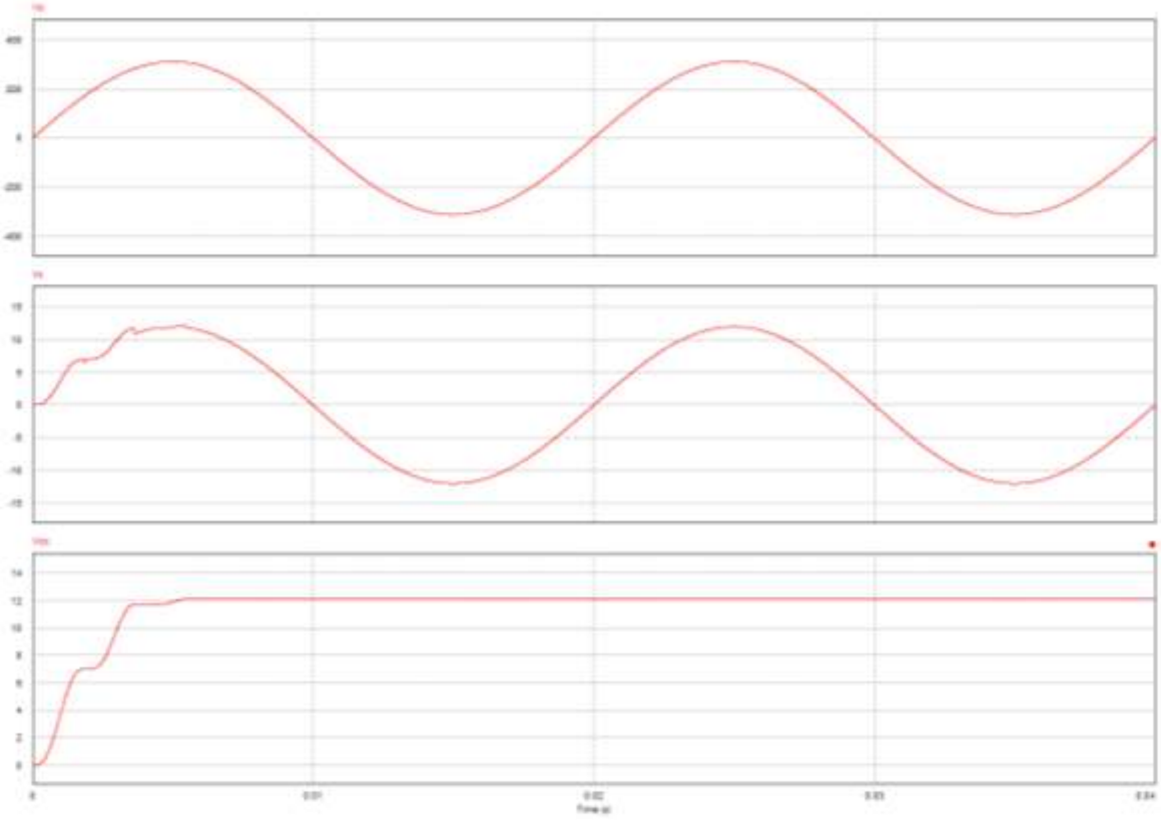


Figure 4.4 : PSIM charger simulation.

4.5 Motor Control

DC motor equations:

$$V_a = E + I_a R_a \quad (4.4)$$

$$E = c\varphi\omega \quad (4.5)$$

$$\omega = \frac{V_a}{c\varphi} - \frac{R_a I_a}{c\varphi} \quad (4.6)$$

Where : V_a : *terminal voltage* (V)

R_a : *motor resistance* (Ω)

I_a : *motor current* (A)

E : *Induced voltage* (V)

φ : *Flux*

c : *Constant represinting the construction of the machine*

ω : *The speed radians per second* $(^{rad}/_{s})$

The drive circuit must achieve :

1- Motor work in two direction .
2- Control the speed of the motor .
3- Braking for the motor .

First : motor speed control and direction we can control the speed of the DC motor by changing the voltage value this can achieve by chopper circuit and the direction achieve by H-bridge circuit as shown in figure 4.5

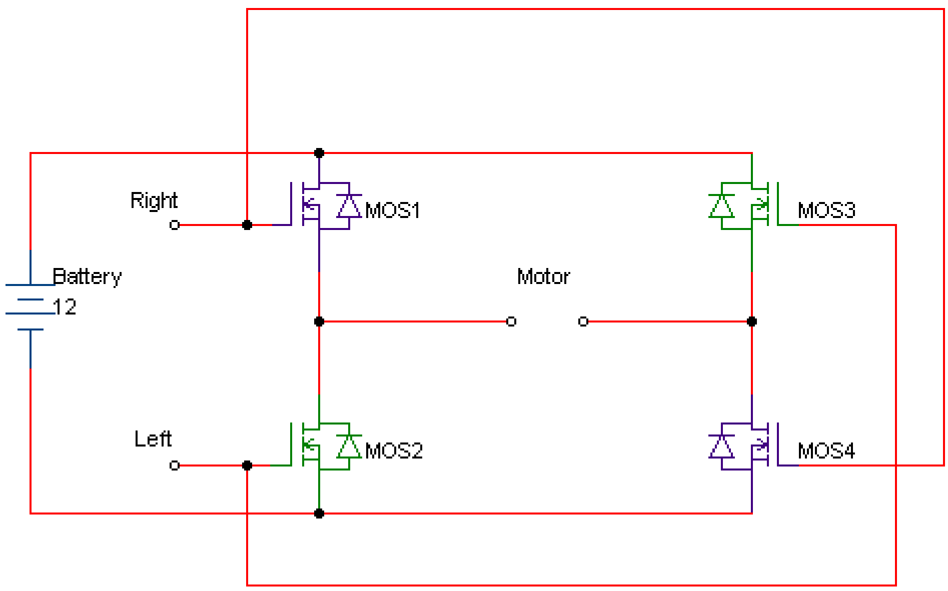


Figure 4.5 : MOSFET H- bridge.

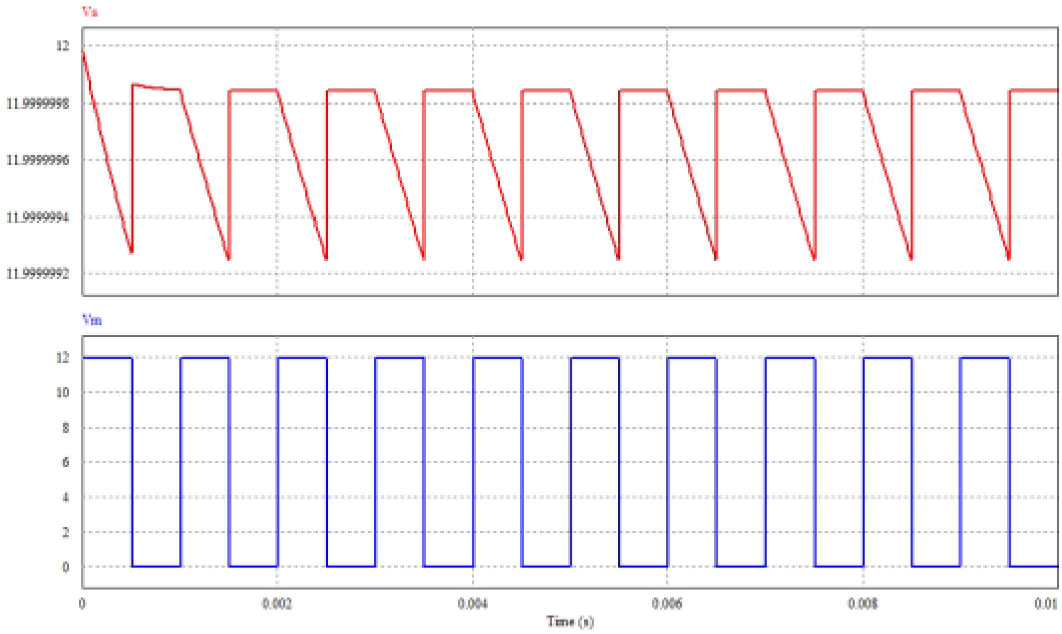


Figure 4.6 : PISM simulation for positive voltage on the motor.

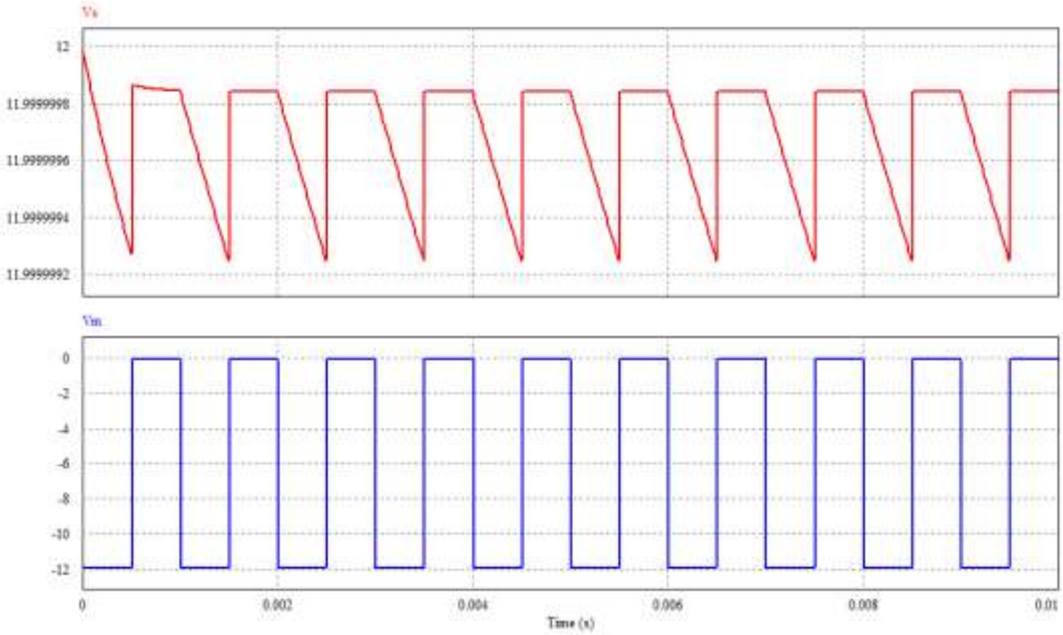


Figure 4.7 : PISM simulation for negative voltage on the motor.

We use H-bridge on IC because is cheaper than built an H-bridge from four MOSFET's.

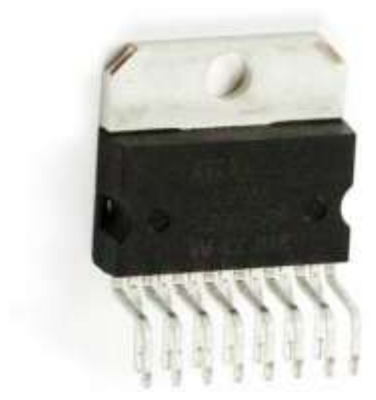


Figure 4.8 : L298 H-bridge.

4.6 Heat Sink Calculation

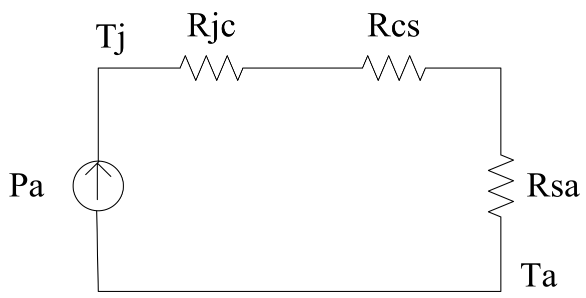


Figure 4.9 : Electrical analog of heat transfer.

$$T_J = P_A(R_{JC} + R_{CS} + R_{SA}) \quad (4.8)$$

Where : R_{JC} : Thermal resistance from junction to case (ºC/W)
R_{JC} : Thermal resistance from junction to case (ºC/W)
R_{JC} : Thermal resistance from junction to case (ºC/W)
T_J : Junction temperature (ºC)
T_A : Junction temperature (ºC)

4.7 Electrical Protection

The electrical protection is very important for the person and for the equipment .So when we choose the voltage source of the chair 9V; because 9V in the range of the extra low safety voltage .

For the battery , motors , charger and microcontroller supply circuit we use fuses by using selectivity way . as shown in figure 4.11 .

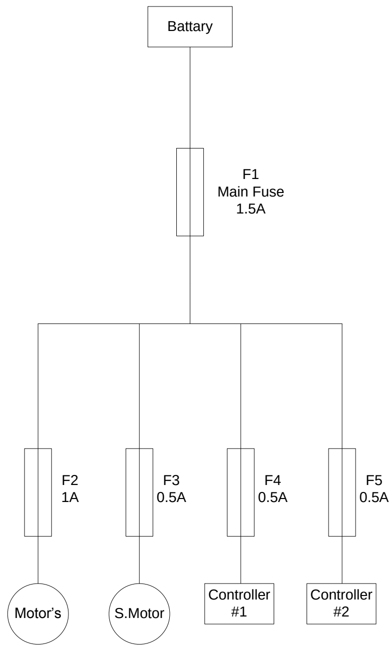


Figure 4.10 : System protection.

4.8 Main Program Flow Chart

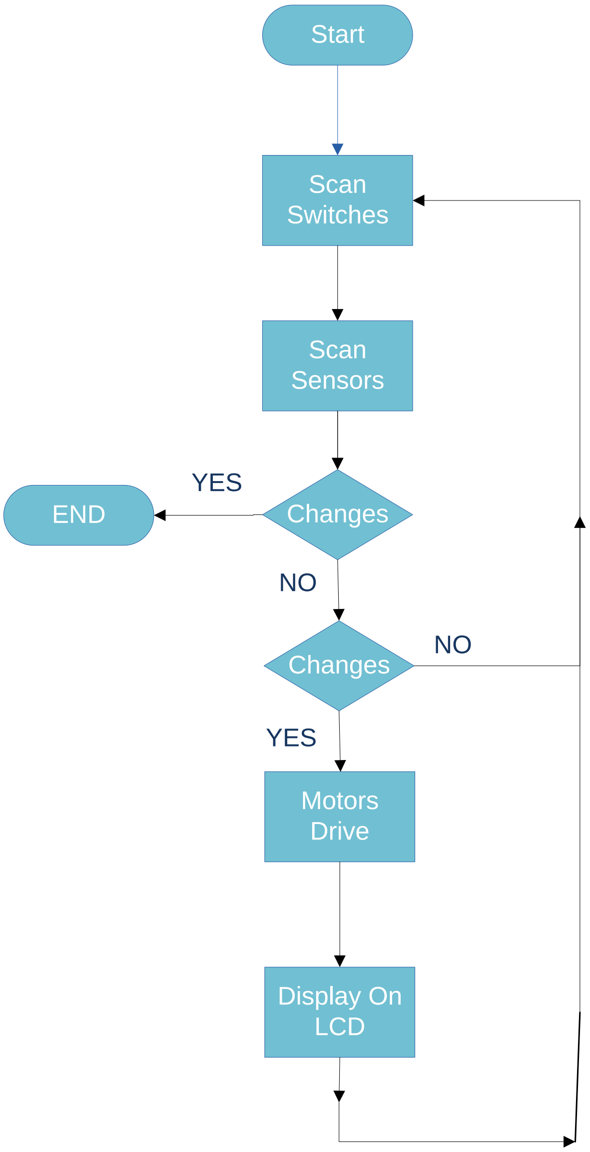


Figure 4.11 : Main program flow chart.

The previous flowchart describes how the microcontroller follows a specific sequence in order to match the desired results. This sequence indicates that the program initializes the microcontroller ports using the build in libraries in the software.

4.9 Schematics

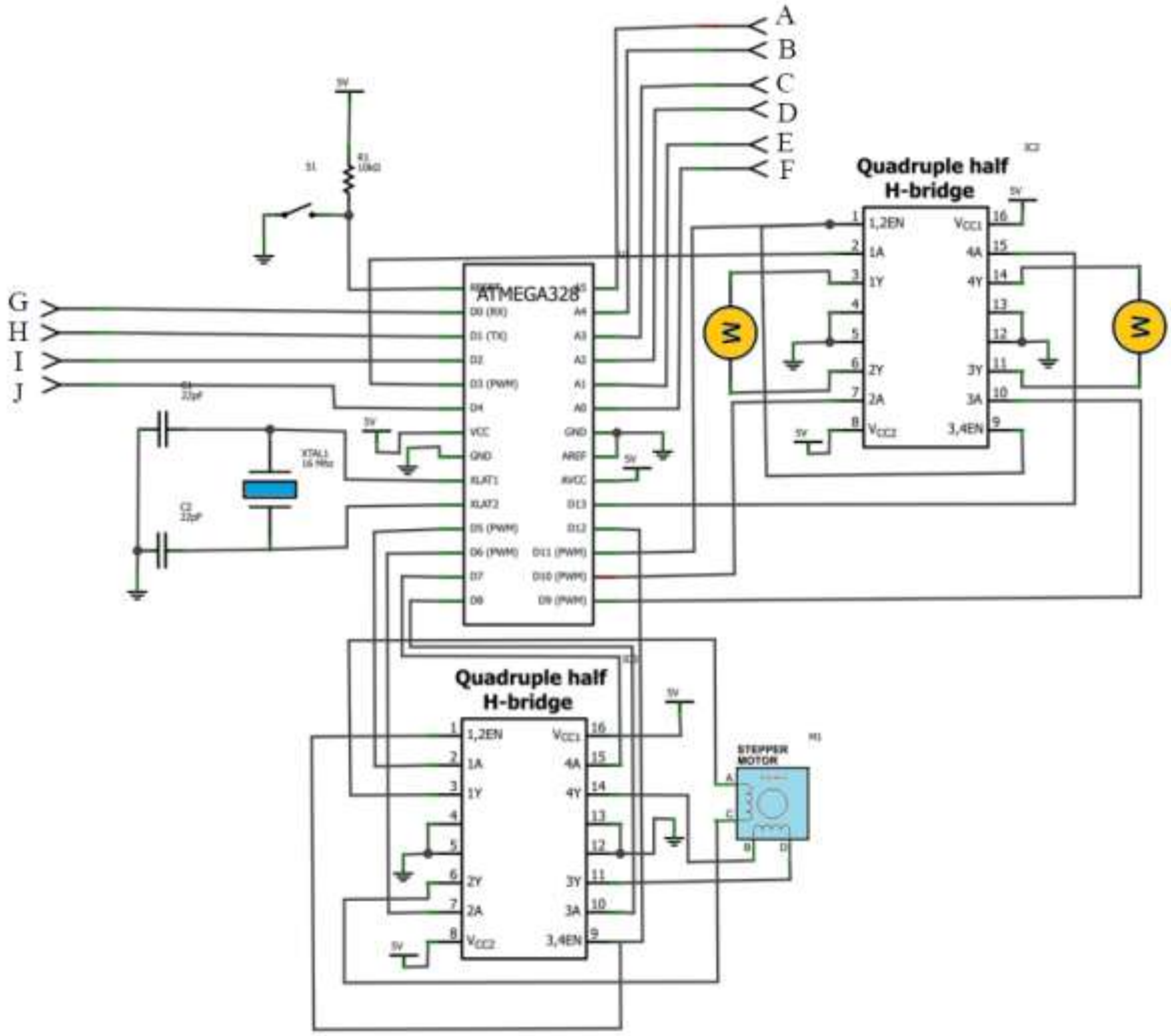


Figure 4.12 : ATmega 328 microcontroller #1 (Motors Controller).

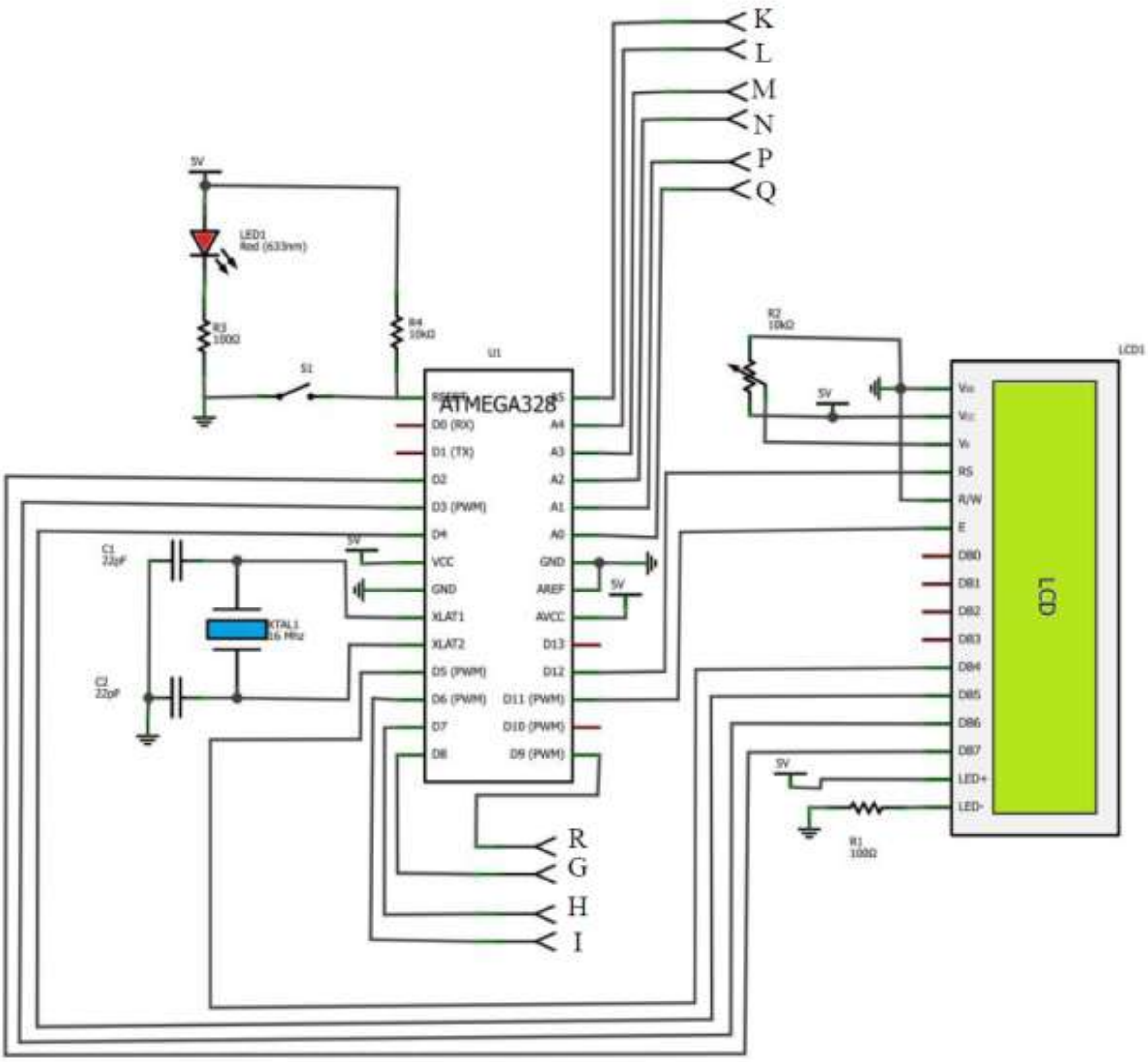


Figure 4.13 : ATmega 328 microcontroller #2 (LCD & Sensor microcontroller).

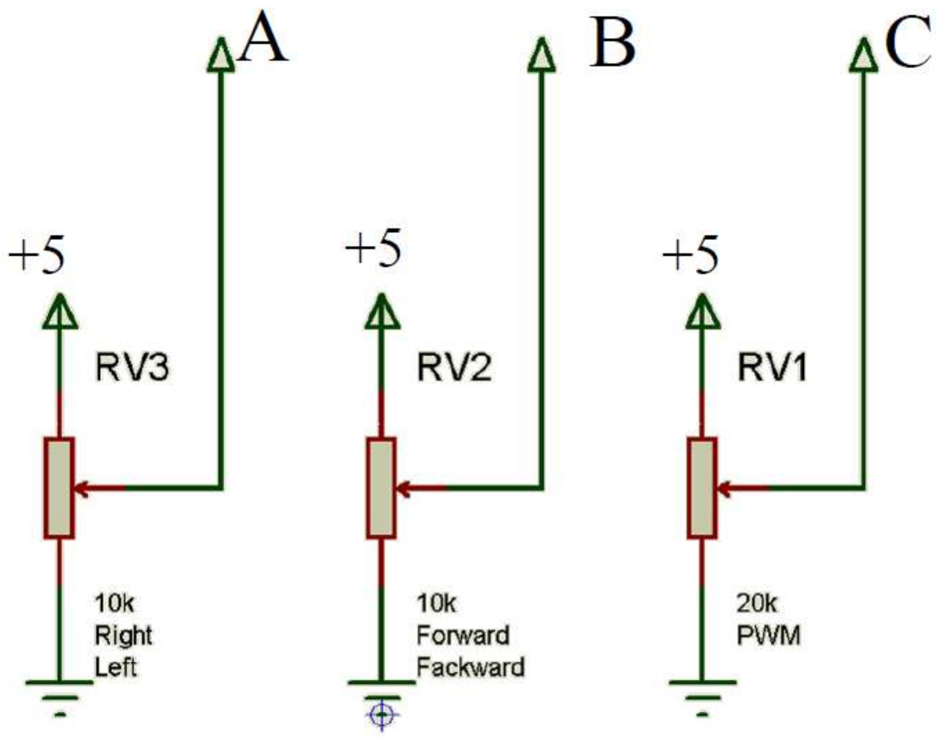


Figure 4.14 : Direction & PWM potentiometers.

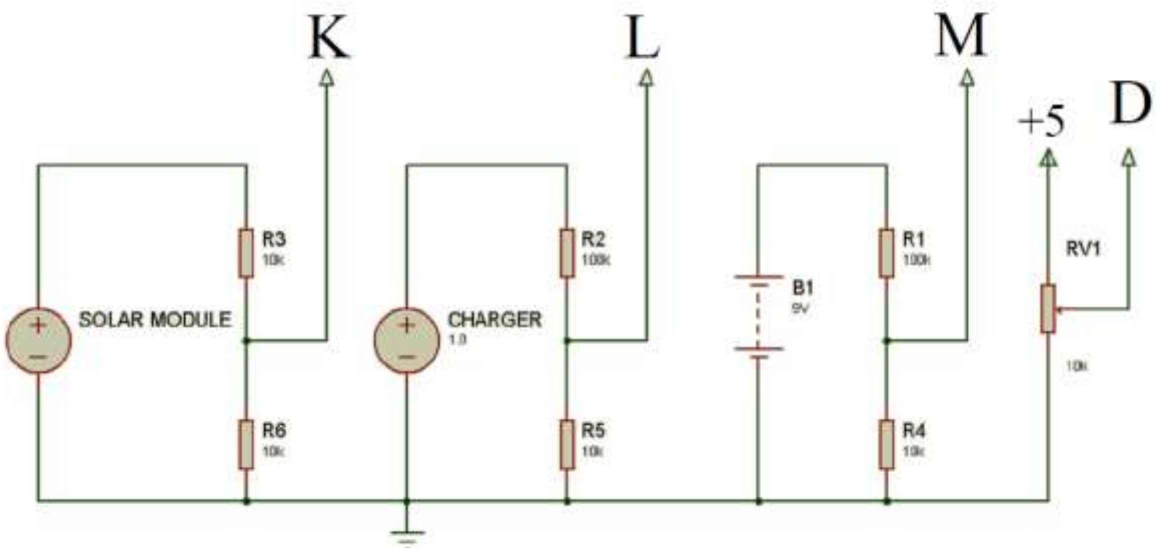


Figure 4.15 : Position sensor & Voltage source value.

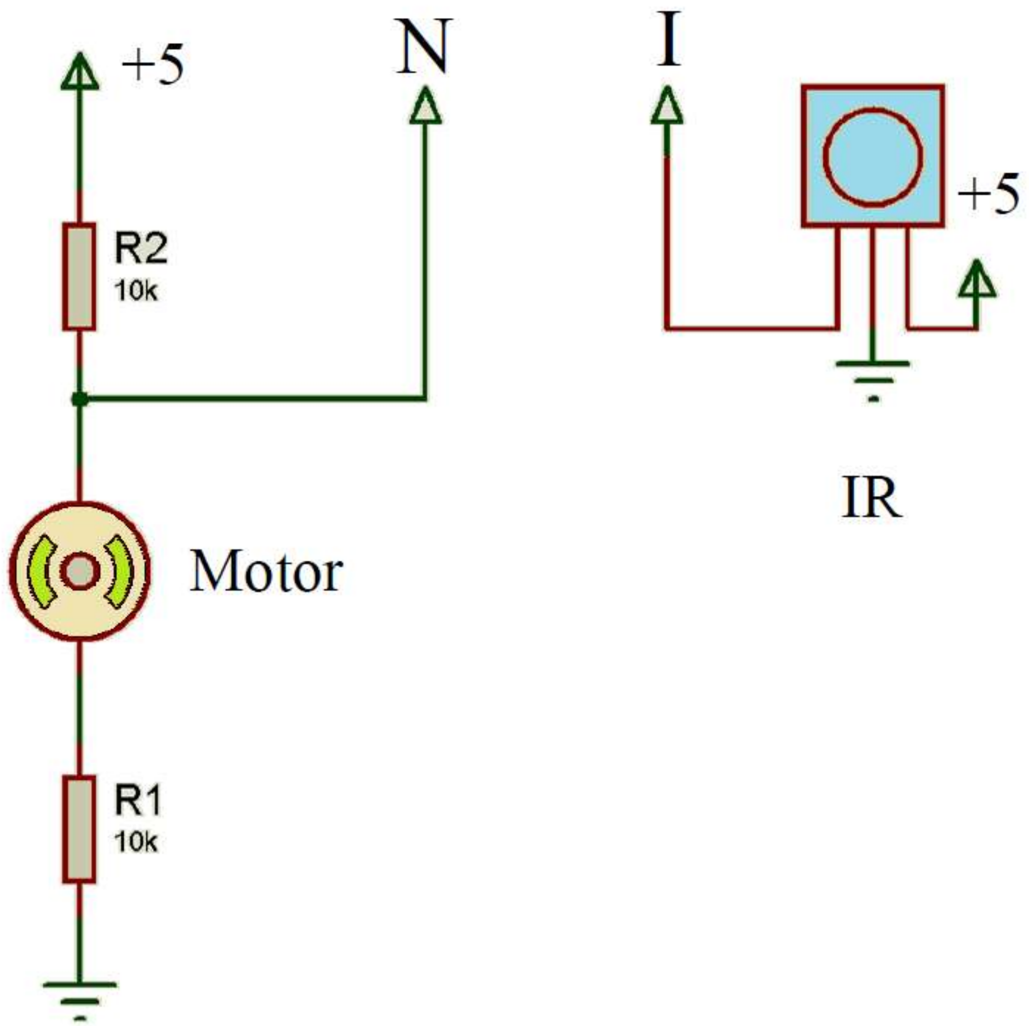


Figure 4.16 : Speed sensor & IR receiver.

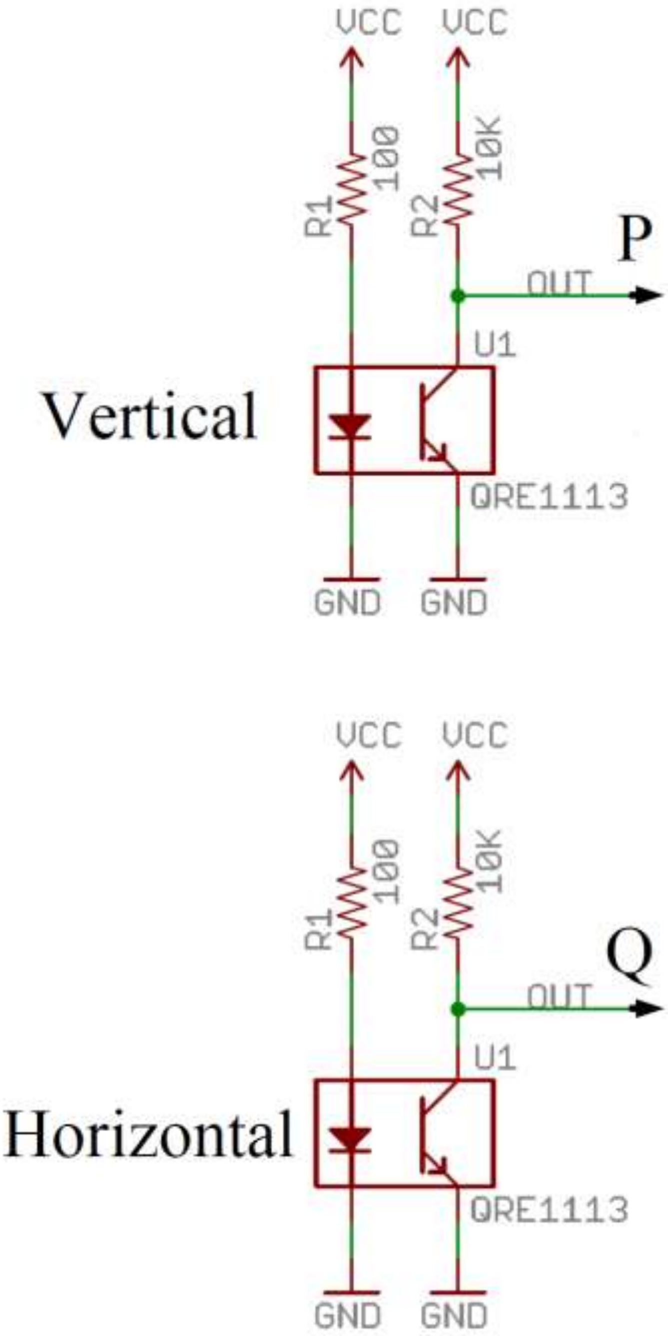
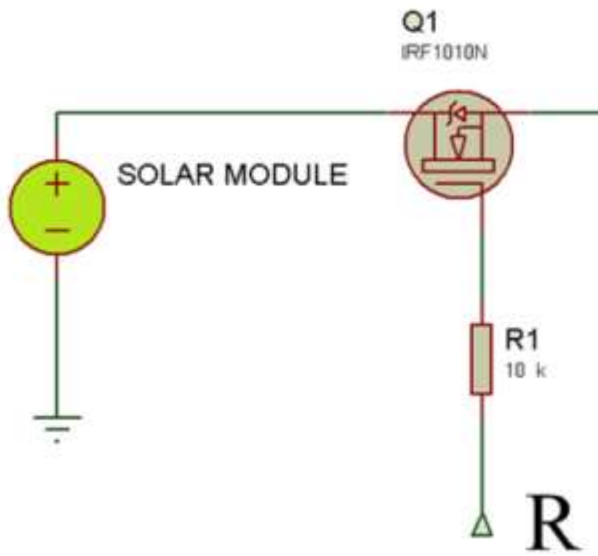


Figure 4.17 : Reflect Object Sensor.



(a)

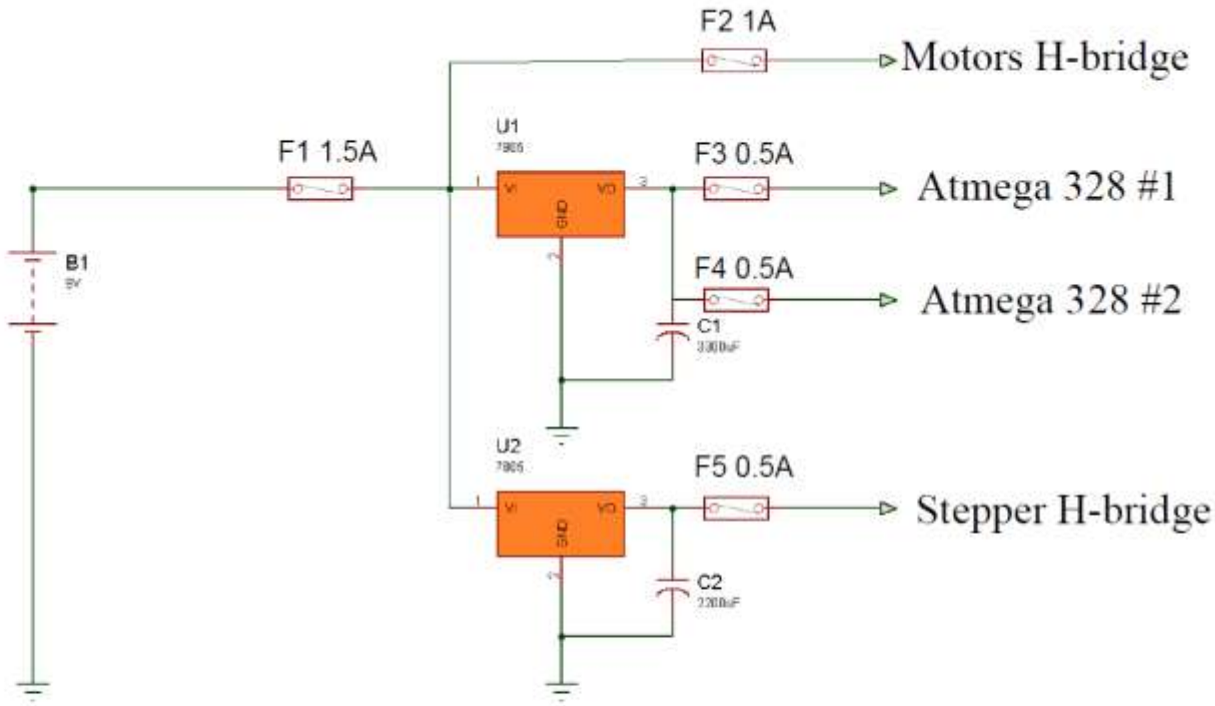


Figure 4.18 : (a) Charger controller –(b) Power supply & Fuses.

CHAPTER 5 SYSTEM TESTING

CHAPTER FIVE

SYSTEM TESTING

This chapter demonstrates how the system was tested. Each subsystem is tested independently. Software and hardware of the subsystem is included in the same subsection. Finally complete system testing is presented.

5.1 Subsystems Testing

At this stage each subsystem was tested independently, to ensure that the subsystem realizes its specified function .This way of testing simplify trouble shooting detection.

5.1.1 ATmega 328 (#1) Microcontroller Testing " motors controller "

ATmega 328 Microcontroller with the oscillating circuit and the external reset circuit was built as shown in Figure 5.1, this testing needs the use of the programmer in order to download the test program in order to ensure that the ATmega 328 Microcontroller response to its desired function.

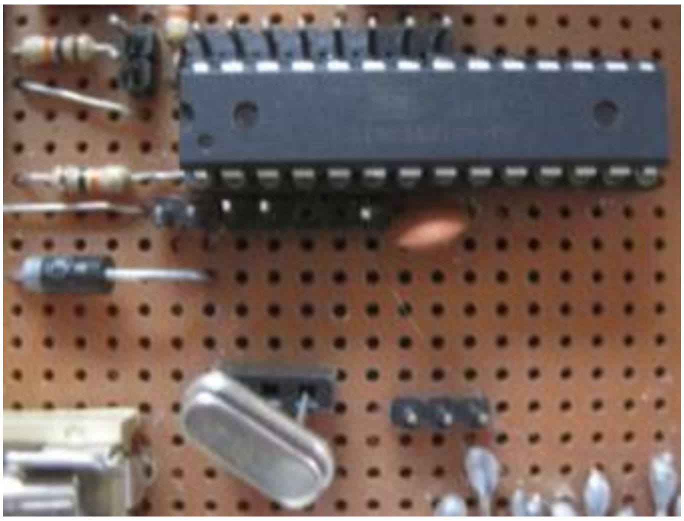


Figure 5.1 : ATmega 328 (#1) microcontroller test circuit.

The following program initializes the ATmega328 to make blink at pin 13 , which used as testing program.

```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.
 */

void setup()
 {
  // initialize the digital pin as an output.
  pinMode(13, OUTPUT);
}

void loop()
{
  digitalWrite(13, HIGH);    // set the LED on
  delay(1000);                      // wait for a second
  digitalWrite(13, LOW);    // set the LED off
  delay(1000);              // wait for a second
}
```

5.1.2 ATmega 328 (#2) Microcontroller Testing " LCD & Sensor controller "

ATmega 328 Microcontroller with the oscillating circuit and the external reset circuit was built and LCD connected as shown in Figure 5.2, In order to ensure that the ATmega 328 Microcontroller response to its desired function.

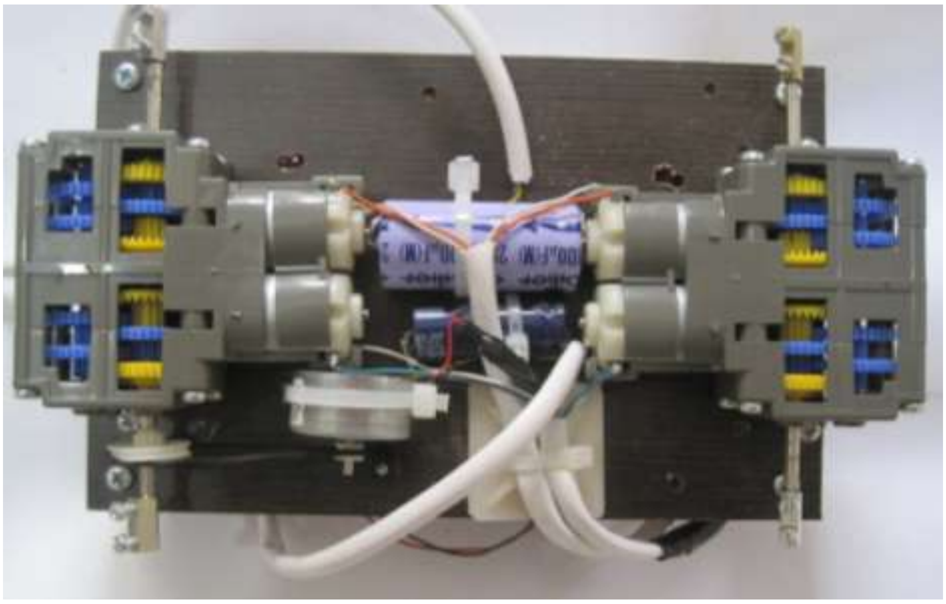
Figure 5.2 : ATmega 328 (#2) microcontroller test circuit.

The following program initializes the ATmega328 to " Hello World! " display on the LCD and show time , which used as testing program .

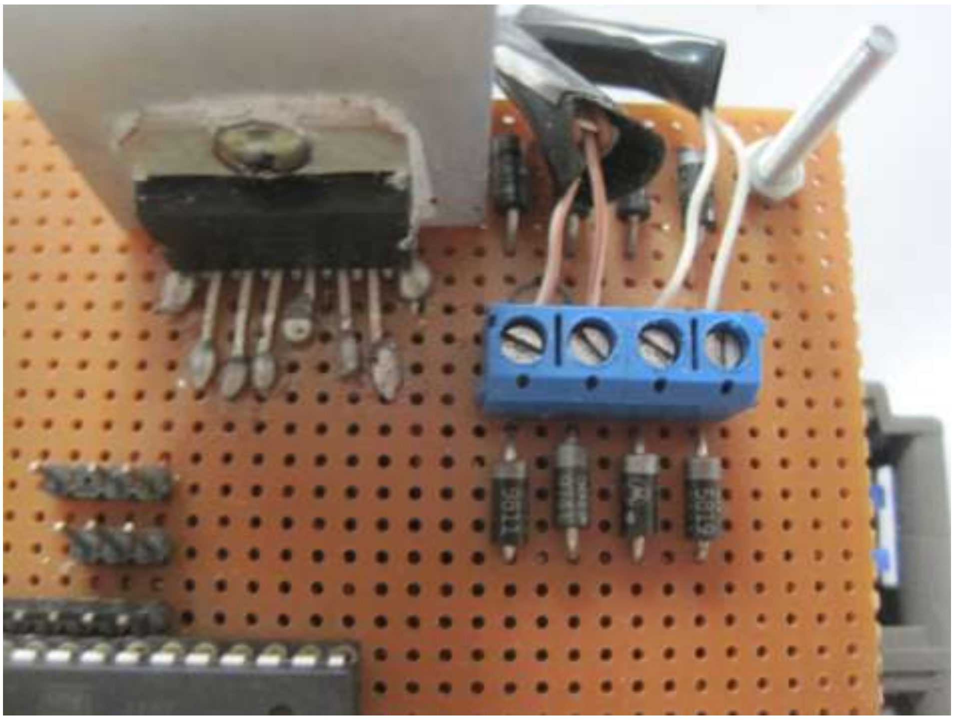
```
/*
 This sketch prints "Hello World!" to the LCD
 and shows the time.

  The circuit:
 * LCD RS pin to digital pin 12
 * LCD Enable pin to digital pin 11
 * LCD D4 pin to digital pin 5
 * LCD D5 pin to digital pin 4
 * LCD D6 pin to digital pin 3
 * LCD D7 pin to digital pin 2
 * LCD R/W pin to ground
 * 10K resistor:
 * ends to +5V and ground
 * wiper to LCD VO pin (pin 3)
*/

// include the library code:
#include <LiquidCrystal.h>

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup()
 {
  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("hello, world!");
}

void loop()
{
  // set the cursor to column 0, line 1
  // (note: line 1 is the second row, since counting begins with 0):
  lcd.setCursor(0, 1);
  // print the number of seconds since reset:
  lcd.print(millis()/1000);
}
```

5.1.3 Motors Testing

The circuit shown in figure 5.3 is circuit tested the control of direction and the speed of the motors .



(a)



(b)

Figure 5.3 : (a)The motors - (b)Speed and direction control circuit.

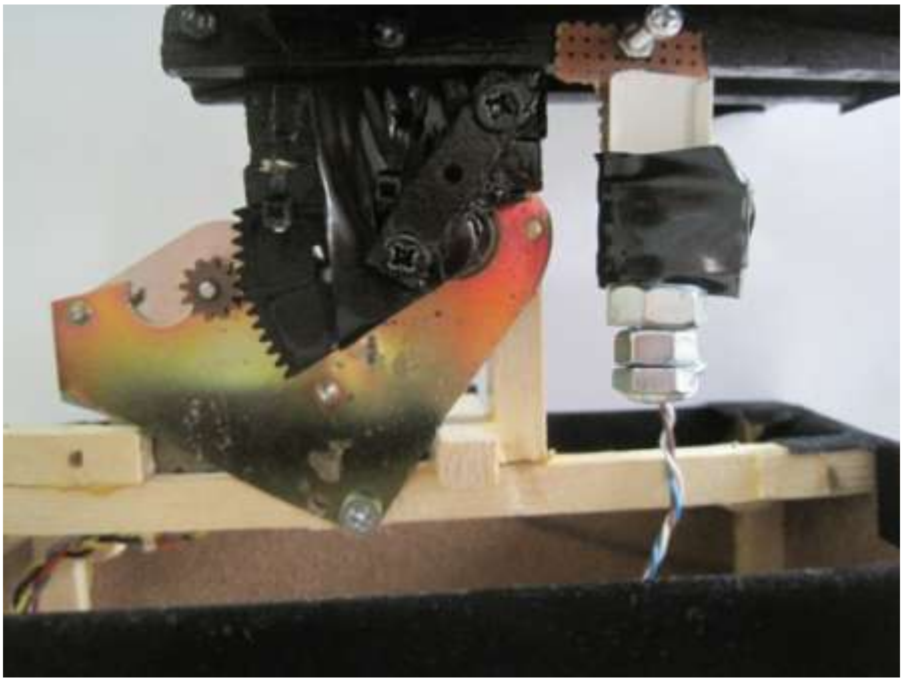
The following program is testing program :

```
void setup()
{
TCCR2B = (TCCR2B & 0xF8) |  2;

pinMode(3, OUTPUT);
pinMode(9, OUTPUT);
pinMode(10, OUTPUT);
pinMode(13, OUTPUT);
digitalWrite(3, LOW);
digitalWrite(9, LOW);
digitalWrite(10, LOW);
digitalWrite(13, LOW);
}
void f()
{
  digitalWrite(3, LOW);
  digitalWrite(9, HIGH);
  digitalWrite(10, LOW);
  digitalWrite(13, HIGH);
}
void b()
{
  digitalWrite(3, HIGH);
  digitalWrite(9, LOW);
  digitalWrite(10, HIGH);
  digitalWrite(13, LOW);
}
void r()
{
  digitalWrite(3, HIGH);
  digitalWrite(9, LOW);
  digitalWrite(10, LOW);
  digitalWrite(13, HIGH);
}
void l()
{
  digitalWrite(3, LOW);
  digitalWrite(9, HIGH);
  digitalWrite(10, HIGH);
```

```
  digitalWrite(13, LOW);
}
void n()
{
  digitalWrite(11,LOW);
  digitalWrite(3, LOW);
  digitalWrite(9, LOW);
  digitalWrite(10, LOW);
  digitalWrite(13, LOW);
}
void loop()
{
  int run = analogRead(A5);
  int dir = analogRead(A4);
  int spd = analogRead(A3);
  int pwm = ((spd/1023.0)*255.0);
   if (dir < 400)
   {
  analogWrite(11, pwm);
  r();
   }
  else if (dir > 600)
   {
  analogWrite(11, pwm);
  l();
   }
  else if (run<400)
   {
  analogWrite(11, pwm);
  b();
   }
  else if (run>600)
   {
  analogWrite(11, pwm);
  f();
   }
  else
   {
  n();
   }
```

5.1.4 Stepper Motor & Position Sensor Testing

The circuit that controls the stepper motor was build and tested as shown in figure 5.4



(a)

(b)

Figure 5.4 : (a)Stepper motor and position sensor - (b)Stepper motor control circuit.

The following program is testing program :

```
// Nader stepper
#include <Stepper.h>
Stepper stepper(200, 5,6,7,8);
void setup()
{
  stepper.setSpeed(100);
  pinMode(12, OUTPUT);
  digitalWrite(12, LOW);
}
void loop()
{
   int val = analogRead(A0);
  if (val < 400)
  {
    digitalWrite(12, HIGH);
     stepper.step(50);
    }
  else if (val > 600)
  {
    digitalWrite(12, HIGH);
     stepper.step(-50);
  }
  else
  {
       digitalWrite(12, LOW);
  }
 }
```

5.1.5 Infrared Proximity Sensor Testing

The picture shown in figure 5.5 is infrared proximity sensor the output value of the sensor from 0-5 volt and the table 5.1 shows the value of the outputs and the distance.

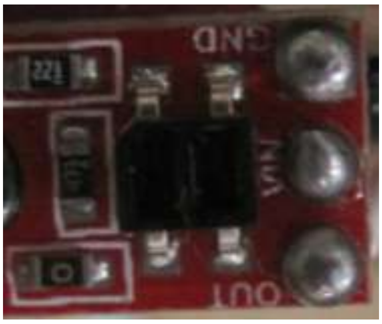


Figure 5.5 : Infrared proximity sensor.

Table 5.1 : Reading value from infrared proximity sensor.

Distance (cm)	Analog value (Volt)	Digital value (Dec)
0.0	0.15	30
0.5	3.60	740
1.0	4.15	850
1.5	4.65	952
2.0	4.81	984
2.5	4.88	999
3.0	4.95	1014
3.5	4.98	1020
4.0	5.00	1023

5.1.6 Speed Sensor Testing

The circuit that shows the speed of wheelchair was build and tested as shown in figure 5.6.

Figure 5.6 : Speed sensor.

5.1.7 IR remote control Testing

The picture shown in figure 5.7 is IR transmitter and receiver that remote controls the wheelchair.

Figure 5.7 : IR transmitter and receiver.

The following program is testing program :

```
#include <IRremote.h>
int RECV_PIN = 2;
int led = 13;
IRrecv irrecv(RECV_PIN);
decode_results results;
void setup()
{
irrecv.enableIRIn(); // Start the ir receiver
 pinMode(led, OUTPUT);
}
void loop() {
if (irrecv.decode(&results))
 {
    if(results.value == 16718055)
    digitalWrite(led, HIGH);   // set the LED on
```

```
        if(results.value == 16716015)
    digitalWrite(led, LOW);   // set the LED off


    irrecv.resume(); // Receive the next value
 }
}
```

5.2 Overall System Testing

All circuits of modules that designed and explained at chapter four and appendix A were build and implemented and tested. The complete system as all gets the desired function successfully.

5.3 Summary

At this chapter every part of the system was tested, this chapter presented the results that obtained from implementing the system. At first the chapter showed the testing of the microcontroller then the control circuits of motors, after that sensing circuits. Finally the complete system testing was presented.

CHAPTER

6 CONCLUSION AND FUTURE WORK

CHAPTER SIX

CONCLUSION AND FUTURE WORK

This chapter presents some conclusions that resulted from implementing and testing the project, also it explains in details the goals that were achieved from the project. Finally, it proposes some suggestions and recommendations for developing the system in the future.

6.1 Conclusions

Although there were many difficulties during the implementation, we have succeeded to solve them, on the other hand these difficulties enhanced the work team experience; through implementation of new technologies that was covered briefly in the text books, through some hardware components that were mostly new, and through improving the team ability to deal with the used software. The following are the obtained outputs from the whole project work:

1- The team work of the project put the aims of the project and studied the theoretical part of the project (theories and laws). The team proved that theoretical methods can be executed in real world and they are can be applicable.

2- After using IR-technology and comparing it with other methods the result was using IR-technique is more reliable, accurate, cheap, and easy to configure.

3- Dealing with the AVR microcontroller made the controlling easy and attractive.

4- The choice of using the indicated sensors in the project was very successful; it provided the controller with an optimal measurements from the surrounding environment.

6.2 Remarks

This project has many discriminating signs that must be found in any successful project. Firstly, smart wheelchair use solar energy and accurate. Beside that this system is flexible because it is programmable system.

Also this project is robust system; any malfunction of any component of the project can be easily replaced . In addition this system have interface for user.

6.3 Problems

Every project may face several problems while working in. These problems can be divided into two parts Hardware problems and Software problems.

6.3.1 Hardware Problems:

- ❖ Late arrival of some of the essential components such as microcontroller.
- ❖ The work was paused for three weeks at least, because shortage of funding .
- ❖ Problem to get the gear of the wheel because the gear is too small .
- ❖ The gearbox of the motors is big.

6.3.2 Software Problems:

- ❖ Conflict between the PWM code and the IR code .

6.4 Future Work

We can add some ideas that the students can work on in the future such that:

- ❖ Develop system to be easier to the users by adding touch screen to control and display the system parameters.
- ❖ Using RF-technology instead of IR-technology for remote control.
- ❖ Develop the solar energy to make it the main and only source for the wheelchair or using PV module with higher efficiency.
- ❖ Building the stairs should be standardized measurements as defined in the project.
- ❖ Using battery with high capacity to make the wheelchair more reliable.
- ❖ Sensing system to check the angle of the stairs before starting climbing.
- ❖ Current sensors for the motors to check status of motors.
- ❖ Auto diagnostics for the wheelchair.
- ❖ System check the power storage in the batteries enough to climbing stairs before starting climbing.

6.5 Summary

This chapter summarized the conclusions that came from implementing the project; it describes the problems that occurred during the project implementation. Finally it suggests some future ideas for the interested researchers.

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Appendix A

Real Scale for Smart wheelchair

A.1. Mechanical Design

A.2. Electrical Design

1.MECHANICAL DESIGN

1.1 Wheel Design

After we take a sample of stairs we found the stairs angle from 30º to 35º ,the horizontal dimension of stairs " X " = 320 mm and the vertical dimension = 170 mm. as shown in figure1.1.

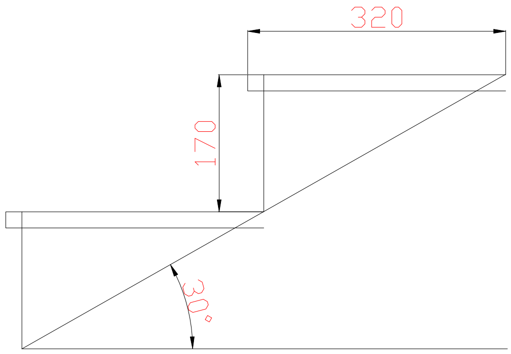


Figure 1.1 : Stairs dimensions .

The tri – wheel plate must be climb the stairs with dimension (320 mm , 170 mm) . so the arms of the plate must flip on the stairs without any troubles .by using wheel with 12.5 cm diameter .

So the plate dimension will be as shown in figure 1.2.

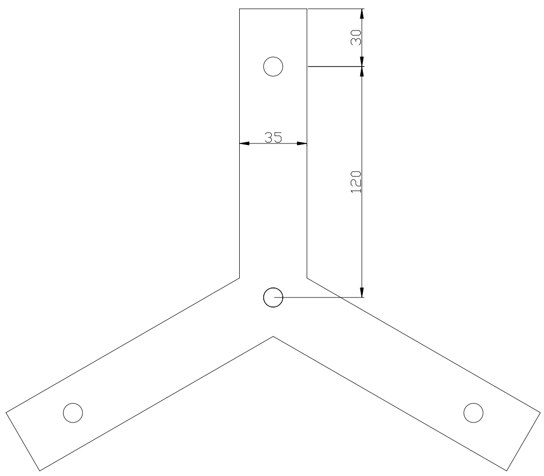


Figure 1.2 : Tri – wheel plate dimension.

To make the tri – wheel move we need power transmission system from the main shaft " center shaft " to the wheels shafts using chain and sprocket.

Figure 1.3 : Chain and sprocket.

After we choose the sprocket we choose 10 teeth sprocket because it light and the diameter of the sprocket less than 35 mm " arm width " to can cover it . Figure 1.5 shows the 10 teeth sprocket.

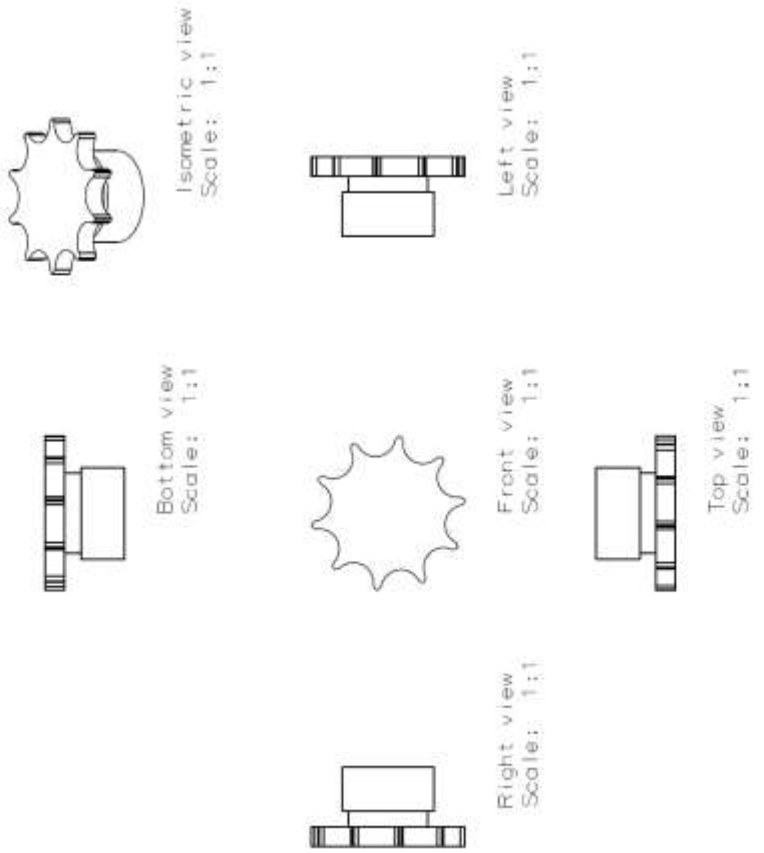


Figure 1.4 : 10 teeth sprocket.

The last parts in the tri – wheel is the bearings and the rods, the main rod 17mm diameter and the wheel rod 12mm .

Figure 1.5 shows the Bearing.

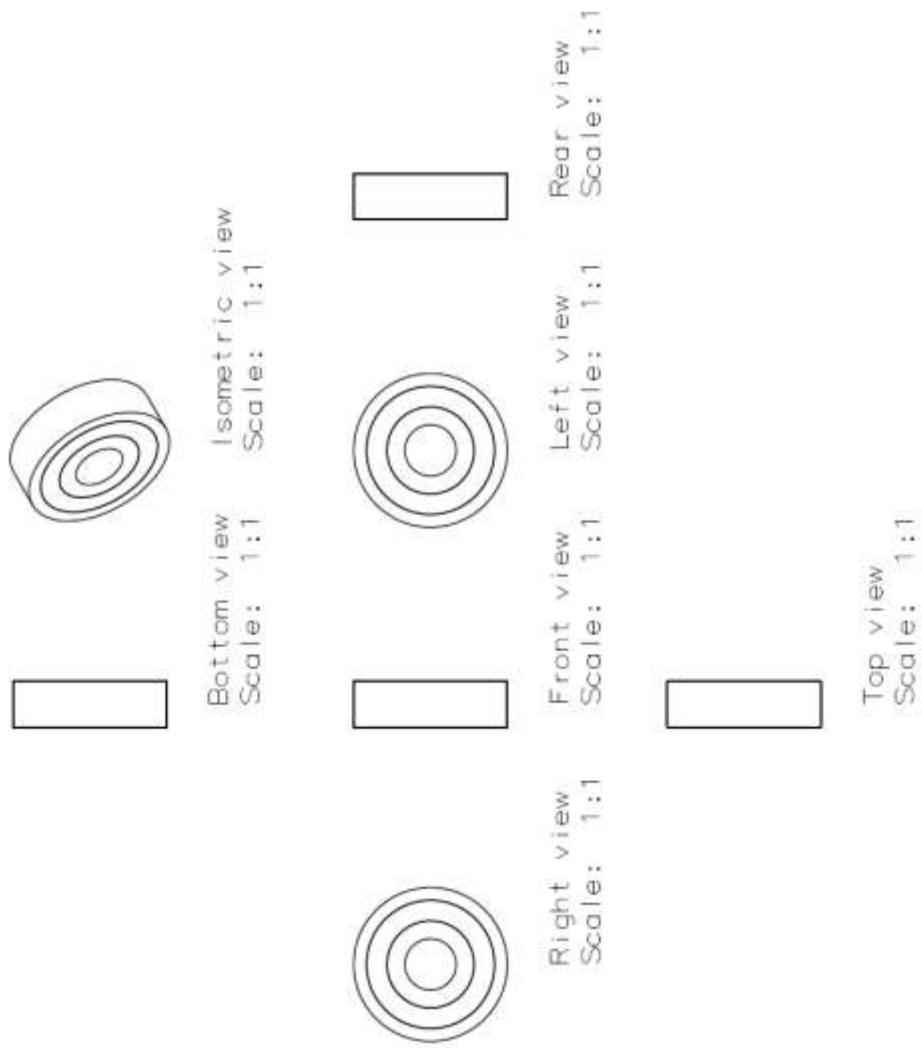


Figure 1.5 : Bearing diagram.

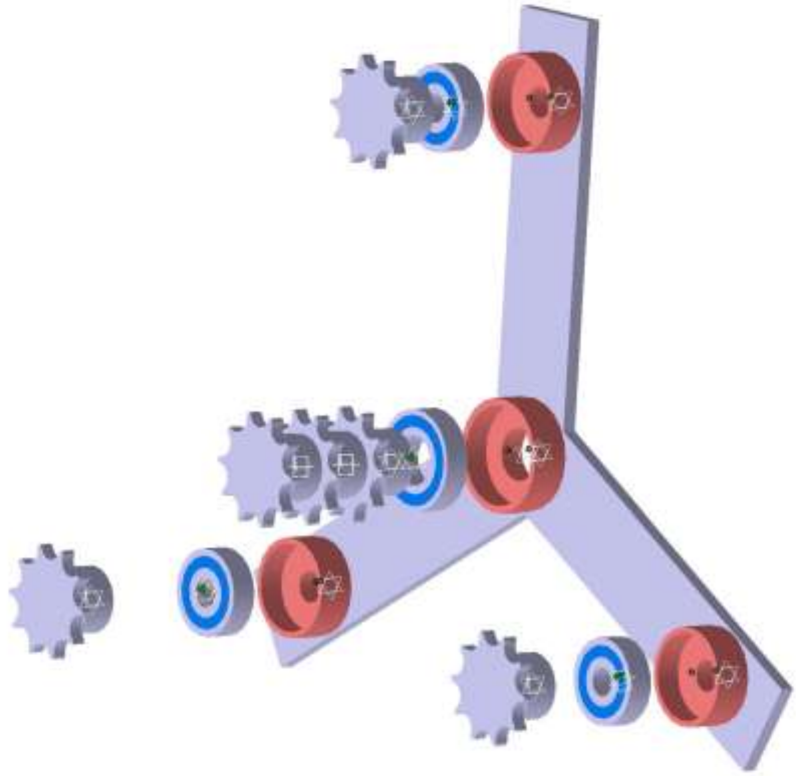


Figure 1.6 : Full wheel assembled diagram.

1.2 Torque Calculation

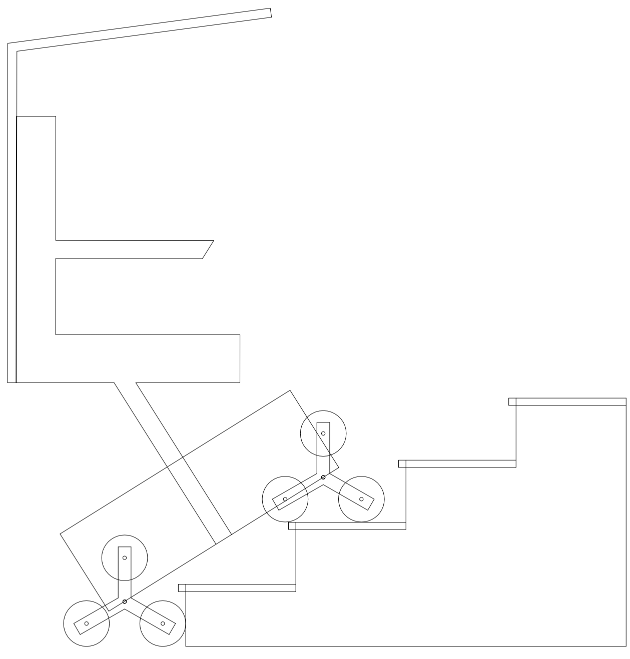


Figure 1.7 : Sketch for the wheelchair on the stairs.

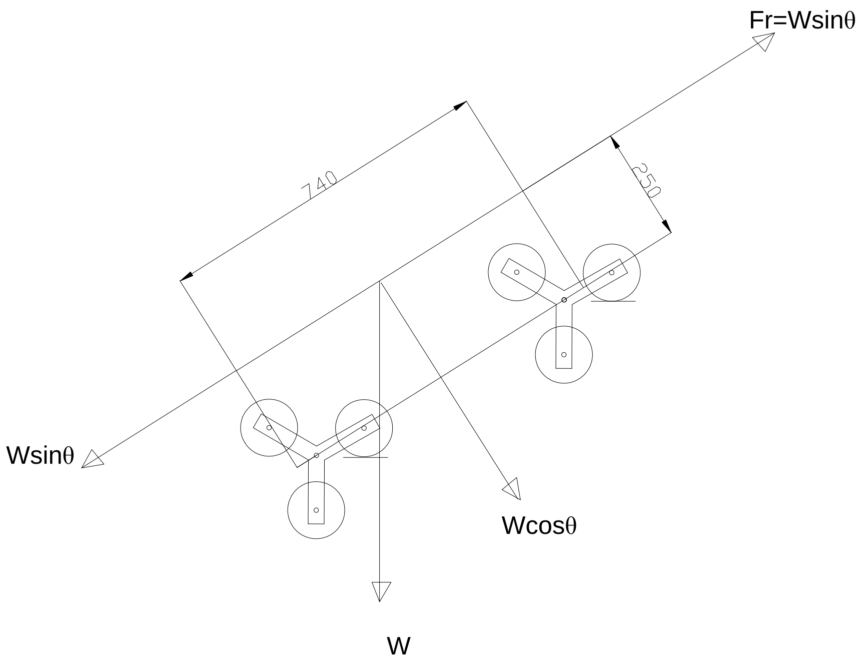


Figure 1.8 : Free body diagram for the wheelchair.

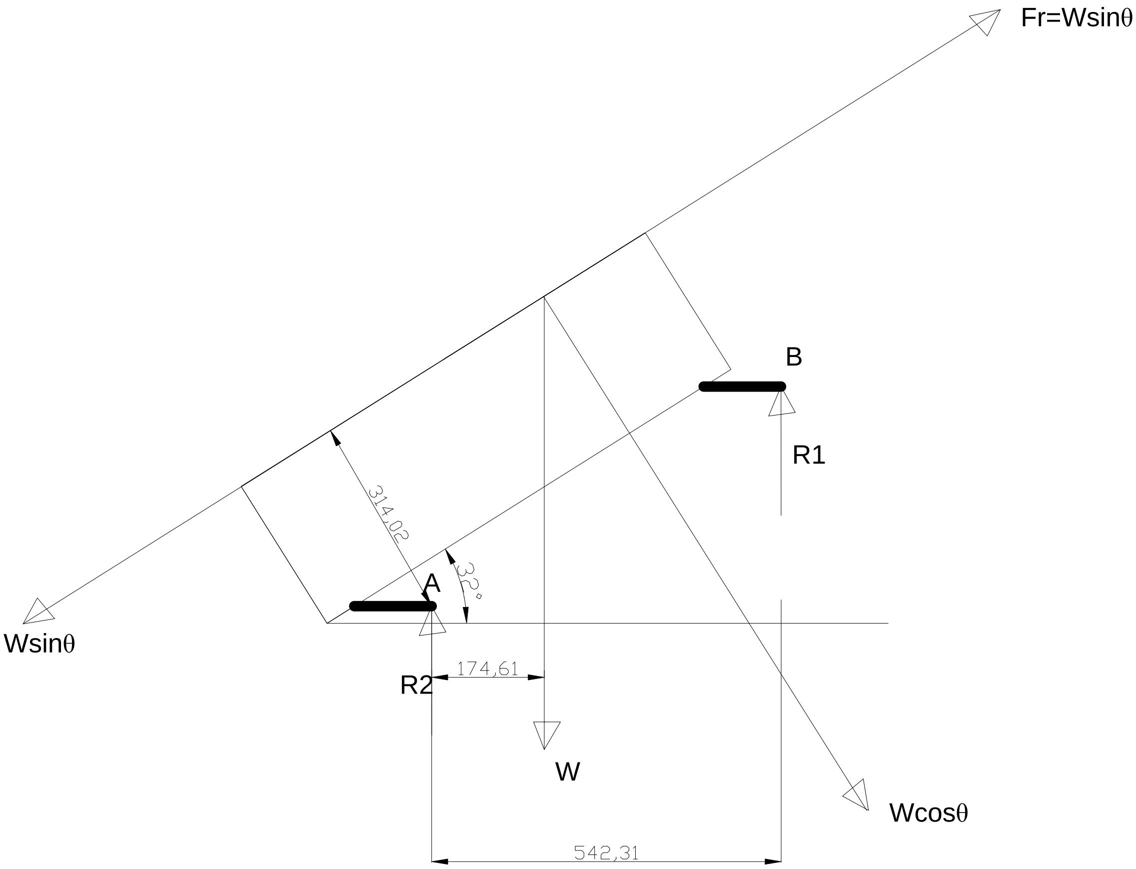


Figure 1.9 : Equivalent model for torque calculation.

Where : W : Weight (N) F_r : Fraction Force (N)   R: Reaction (N)

Total maximum mass for the person 80kg and the approximate mass for the chair 70kg .
Total mass = 80 +70 = 150kg
W = Mass * Acceleration of gravity (g)   (1.1)
Where : g = 9.8 (m/s^2)
W : Weight (N)

Total weight (W) = 150 * 9.8 = 1470 N

$\sum M_A = 0$ (1.2)
$R_1 a_0 - W \cos\theta a_1 + W \sin\theta a_2 - W \sin\theta a_2 = 0$
Where : M_A : The moment (N.m)
R : Reaction force (N)
a_0 , a_1 , a_2 : lengths (m)

$a_0 \approx 0.54$ m
$a_1 \approx 0.18$ m
$a_2 \approx 0.31$ m

$$R_1 = \frac{W cos\theta a_1}{a_0}$$

$$R_1 = \frac{1470 cos32\ 0.18}{0.54}$$

R_1 =415.5 N

$\sum F_y = 0$ (1.3)
Where : F : The force (N)

$R_1 + R_2 - W \cos\theta = 0$
R_2= 1470 cos32 - 415.5
R_2 = 831 N

$T_1 = R_1 a$ (1.4)
Where : T : Torque (N.m)
R : Reaction force (N)
a : Plate arm length (m)

$T_1 = R_1 a$ = 415.5* 0.12 = 49.86 N.m
$T_2 = R_2 a$ = 831* 0.12 = 99.72 N.m
We take maximum torque T_2 = 99.72
The safety factor of the torque will be 1.5 times more than the calculated :
T_m = 99.72 * 1.5 = 149.58 N.m

Torque per motor = 149.58/2 = 74.79 N.m
We will use four motor each motor produce 30 N.m so we need a gear with ratio
74.79/ 30 = 2.5

1.3 Chair Balancing

In the chair design the handicapped must be not afraid when he became up or down on the stairs so the chair must be horizontal regardless of the angel of chair base.

The chair connect with the base by bearing to allow the chair to move around the center to keep the chair horizontal . this mechanism drive by using liner actuator (motor with gear).

To calculate the needed force to move the chair we analysis the weights on the chair and make the bearing at the center of mass to make any small force to move the chair .
In figure 1.10 shown how connect the motor to the chair

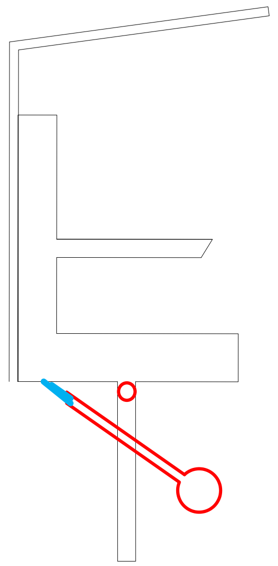


Figure 1.10 : Chair balancing.

1.4 Base Dimension

The base of the chair must cover the all component into it like batteries , motors , charger and electronics circuits …ets . there is another reason to defined the length of the base it make sure the two wheels " the fronts and the rear " will not both at same time up the stairs .

By using CAD help " Auto Cad " and choose the length of the base. figure 1.11 show the dimension of the base.

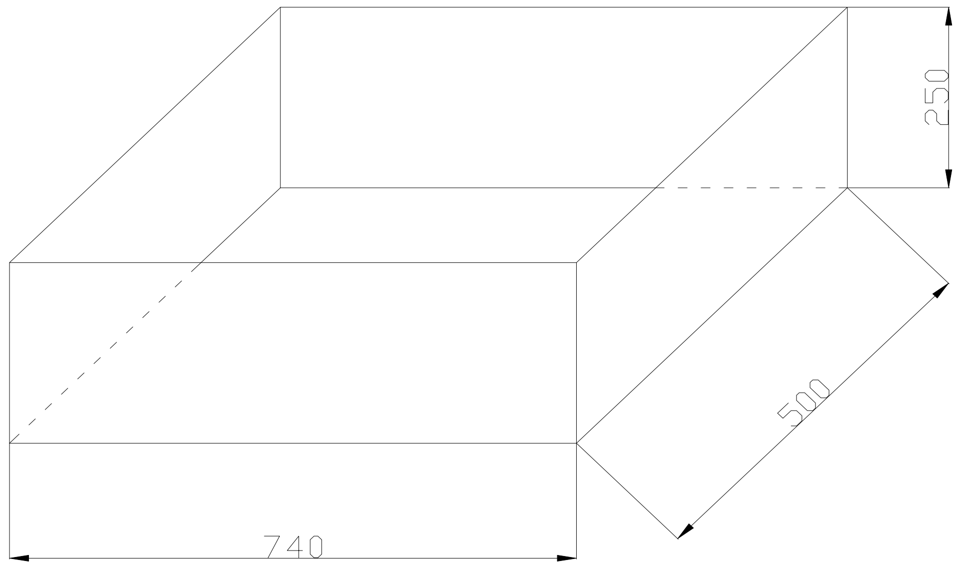


Figure 1.11 : Base dimension .

2.ELECTRICAL DESIGN

2.1 Batteries Selection

We want to extend the range of the wheelchair, such that it is a viable mode of transport over medium distances, 10Km or less. In order to meet this objective we needed a battery with a sufficient Amp-Hr Capacity.

The motor speed = 18 rpm , torque = 30 N.m (wiper motor)

$$\omega = \frac{2\pi n}{60} \quad (2.1)$$

where :- ω : the speed (rad/s)
n : the speed (rpm)

$$\omega = \frac{2\pi 18}{60} = 1.8\, rad/s$$

$$P_{out} = T * \omega \quad (2.2)$$

where :- P_{out} : the output power (watt)
T : Torque (N.m)

$$P_{out} = 30 * 1.8 = 54\, watt$$

$$P_{in} = \frac{P_{out}}{\mu} \quad (2.3)$$

where :- P_{in} : the input power (watt)

μ : the efficiency of the motor

$$P_{in} = \frac{54}{0.9} = 60\ watt$$

Total power = number of motor x the power per motor

$P_T = 4 * 60 = 240\ watt$

Battery capacity = current x time

$$I = \frac{P}{V} \quad (2.4)$$

$$I = \frac{240}{12} = 20\ A$$

The battery will remain 3 hours without recharge

Battery capacity = I * t (2.5)

where :- I : current (A)

t : time (h)

Battery capacity = 20 * 3 = 60 Ah

2.2 PV System

Solar PV system sizing

First : we determine power we need .

Total Power = Motors Power + Controller Power

= 240 + 0

= 240 watt

Second : Size the PV modules

The system will be powered by 12 Vdc, 110 Wp PV module.

Because the size of the PV module is suitable for the chair .

Third : Solar charge controller sizing

The solar charge controller is typically rated against Amperage and Voltage capacities.

The sizing of controller depends on the total PV input current which is delivered to the controller . the sizing of solar charge controller is to take the short circuit current (Isc) of the PV array, and multiply it by 1.3

Solar charge controller rating = Total short circuit current of PV array x 1.3

Isc =7.16 from data sheet (2.6)

Solar charge controller rating = 7.16 x 1.3

= 9.308 A ➔ select 10A charger controller

2.3Motor Control

From mechanical design the needed torque 30 N.m . So we select DC motor with 30N.m torque and 18 rpm speed .

DC motor equations:

$$V_a = E + I_a R_a \quad (2.7)$$

$$E = c\varphi\omega \quad (2.8)$$

$$\omega = \frac{V_a}{c\varphi} - \frac{R_a I_a}{c\varphi} \quad (2.9)$$

Where : $V_a : terminal\ voltage\ (V)$

$R_a : motor\ resistance\ (\Omega)$

$I_a : motor\ current\ (A)$

E : *Induced voltage* (V)

$\varphi :\ Flux$

$c : Constant\ represinting\ the\ construction\ of\ the\ machine$

$\omega : The\ speed\ radians\ per\ second\ (^{rad}/_{s})$

The drive circuit must achieve :

1- Motor work in two direction .
2- Control the speed of the motor .
3- Braking for the motor .

First : motor speed control and direction we can control the speed of the DC motor by changing the voltage value this can achieve by chopper circuit and the direction achieve by H-bridge circuit we combine the two circuit as shown in figure 2.1

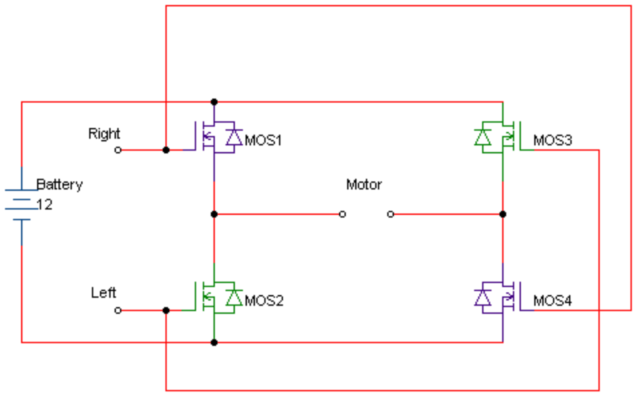


Figure 2.1 : MOSFET H- bridge.

Second : the braking we use the dynamic braking to stop the motor immediately .

$$R_D = \frac{E}{\lambda\, I_n} - R_a \qquad (2.10)$$

Where : $R_a : motor\ resistance\ \ (\Omega)$

$I_n : motor\ rated\ current\ (A)$

E : Induced voltage (V)

$\lambda :\ Maximum\ current\ factor$

$R_D\ : Dynamic\ resistance\ \ (\Omega)$

2.4 Electrical Protection

The electrical protection is very important for the person and for the equipment .So when we choose the voltage source of the chair 12V; because 12V in the range of the extra low safety voltage .

For the battery , motors , charger and microcontroller supply circuit we use fuses by using selectivity way . as shown in figure 2.3 .

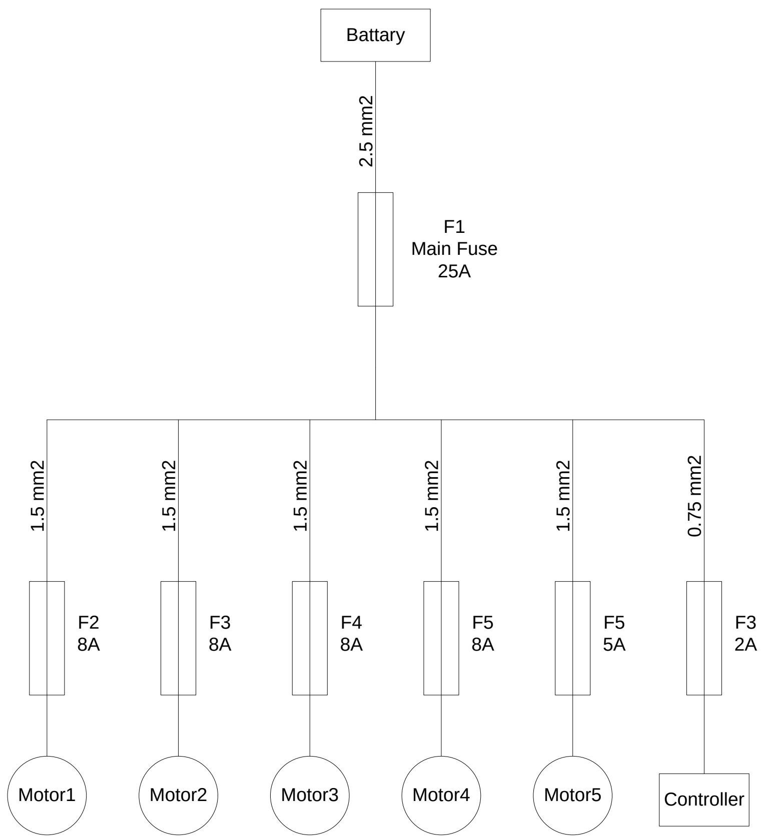


Figure 2.3 : System protection.

Appendix B

Datasheet

B.1 Atmel Microcontroller

B.2 L298 DUAL FULL-BRIDGE DRIVER

B.3 QRD1113/1114 REFLECTIVE OBJECT SENSOR

B.4 Infrared Receiver Module

B.5 LM78XX Voltage Regulators

B.6 IRFD024 Power MOSFET

B.7 1N5817, 1N5818, 1N5819 SCHOTTKY BARRIER

B.8 FA 130RA Motor

Features

- High Performance, Low Power Atmel®AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 4/8/16/32KBytes of In-System Self-Programmable Flash program memory
  - 256/512/512/1KBytes EEPROM
  - 512/1K/1K/2KBytes Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C[(1)]
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - Programming Lock for Software Security
- Atmel® QTouch® library support
  - Capacitive touch buttons, sliders and wheels
  - QTouch and QMatrix® acquisition
  - Up to 64 sense channels
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    Temperature Measurement
  - 6-channel 10-bit ADC in PDIP Package
    Temperature Measurement
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Byte-oriented 2-wire Serial Interface (Philips I^2C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V
- Temperature Range:
  - -40°C to 85°C
- Speed Grade:
  - 0 - 4MHz@1.8 - 5.5V, 0 - 10MHz@2.7 - 5.5.V, 0 - 20MHz @ 4.5 - 5.5V
- Power Consumption at 1MHz, 1.8V, 25°C
  - Active Mode: 0.2mA
  - Power-down Mode: 0.1μA
  - Power-save Mode: 0.75μA (Including 32kHz RTC)

8-bit Atmel Microcontroller with 4/8/16/32K Bytes In-System Programmable Flash

ATmega48A
ATmega48PA
ATmega88A
ATmega88PA
ATmega168A
ATmega168PA
ATmega328
ATmega328P

Rev. 8271D–AVR–05/11

1. Pin Configurations

Figure 1-1. Pinout ATmega48A/PA/88A/PA/168A/PA/328/P

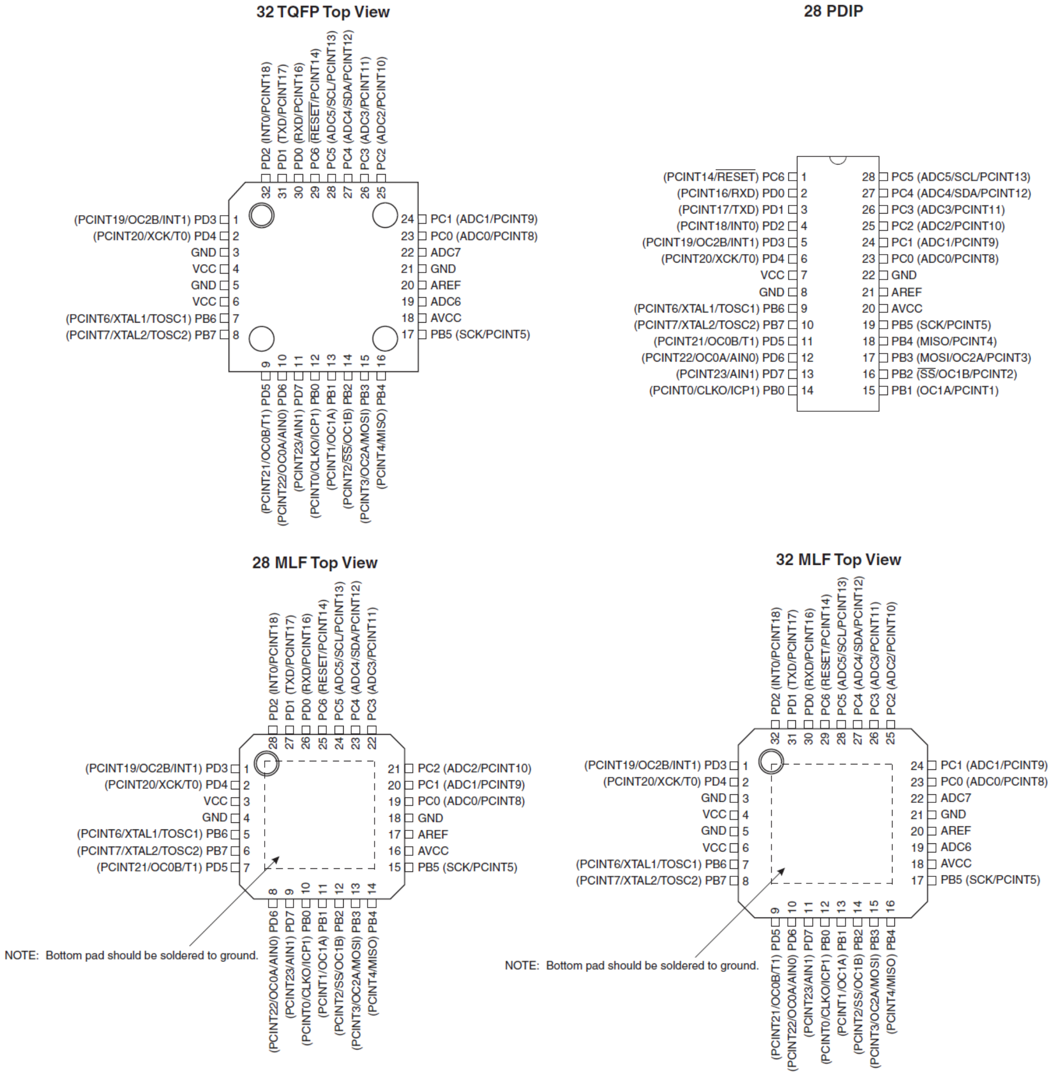


Table 1-1. 32UFBGA - Pinout ATmega48A/48PA/88A/88PA/168A/168PA

	1	2	3	4	5	6
A	PD2	PD1	PC6	PC4	PC2	PC1
B	PD3	PD4	PD0	PC5	PC3	PC0
C	GND	GND			ADC7	GND
D	VDD	VDD			AREF	ADC6
E	PB6	PD6	PB0	PB2	AVDD	PB5
F	PB7	PD5	PD7	PB1	PB3	PB4

1.1 Pin Descriptions

1.1.1 VCC

Digital supply voltage.

1.1.2 GND

Ground.

1.1.3 Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

If the Internal Calibrated RC Oscillator is used as chip clock source, PB7...6 is used as TOSC2...1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

The various special features of Port B are elaborated in "Alternate Functions of Port B" on page 84 and "System Clock and Clock Options" on page 27.

1.1.4 Port C (PC5:0)

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5...0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

1.1.5 PC6/$\overline{\text{RESET}}$

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. The minimum pulse length is given in Table 29-12 on page 324. Shorter pulses are not guaranteed to generate a Reset.

The various special features of Port C are elaborated in "Alternate Functions of Port C" on page 87.

1.1.6 Port D (PD7:0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

The various special features of Port D are elaborated in "Alternate Functions of Port D" on page 90.

1.1.7 AV_{CC}

AV_{CC} is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter. Note that PC6...4 use digital supply voltage, V_{CC}.

1.1.8 AREF

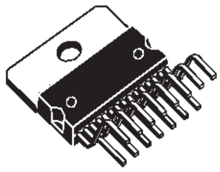
AREF is the analog reference pin for the A/D Converter.

1.1.9 ADC7:6 (TQFP and QFN/MLF Package Only)

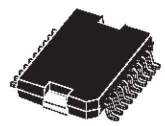
In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

DUAL FULL-BRIDGE DRIVER

- OPERATING SUPPLY VOLTAGE UP TO 46 V
- TOTAL DC CURRENT UP TO 4 A
- LOW SATURATION VOLTAGE
- OVERTEMPERATURE PROTECTION
- LOGICAL ”0” INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)



Multiwatt15



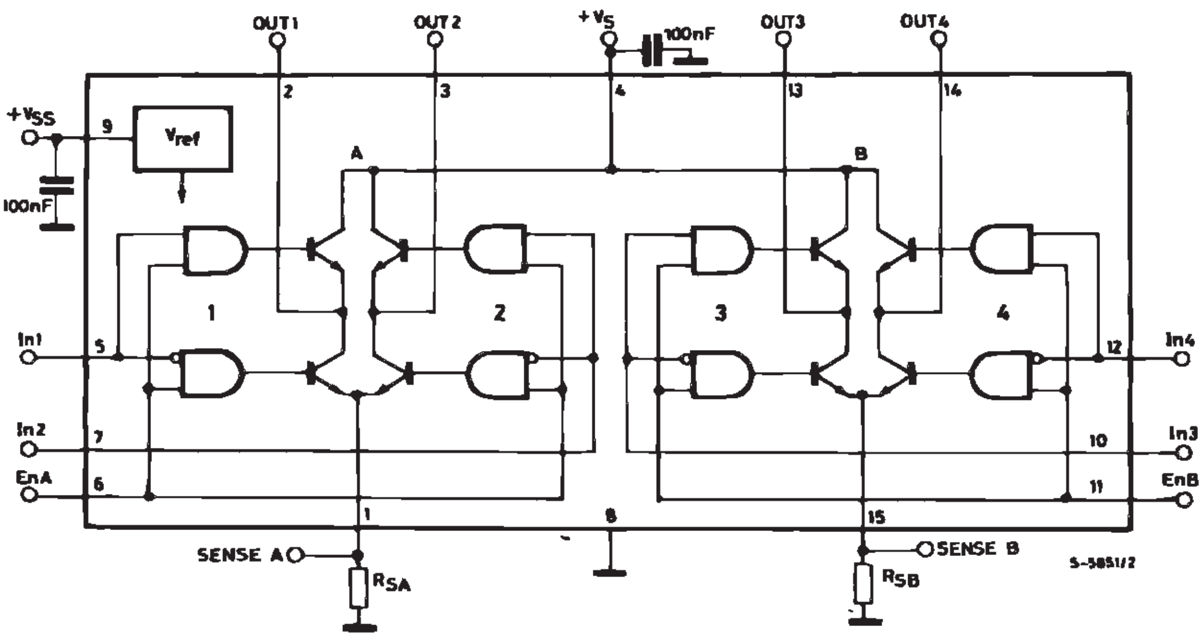
PowerSO20

ORDERING NUMBERS : L298N (Multiwatt Vert.)
L298HN (Multiwatt Horiz.)
L298P (PowerSO20)

DESCRIPTION

The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

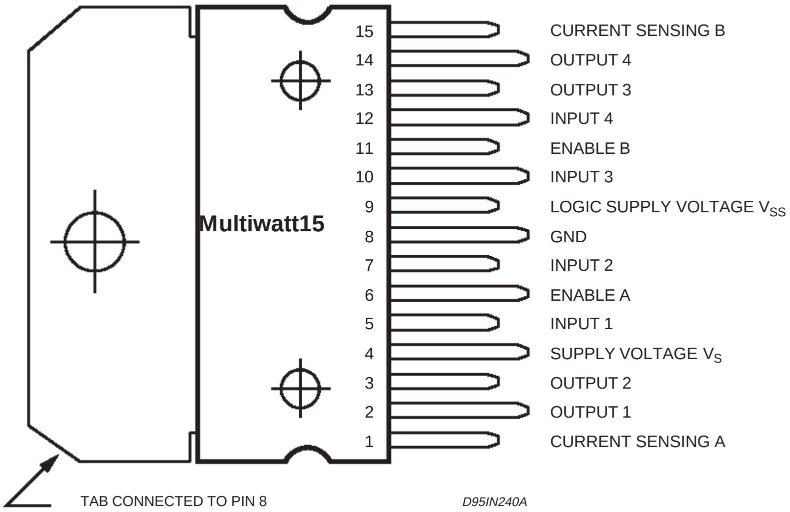
BLOCK DIAGRAM

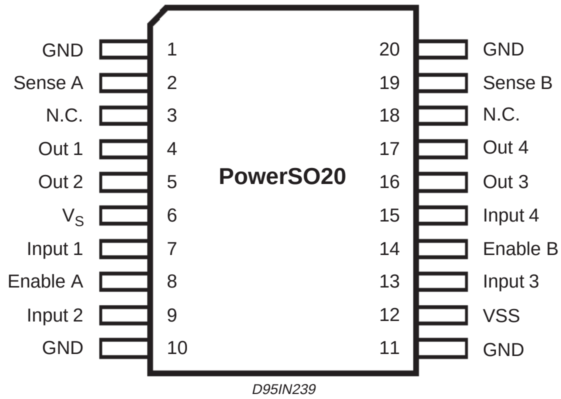


ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Power Supply	50	V
V_{SS}	Logic Supply Voltage	7	V
V_I, V_{en}	Input and Enable Voltage	–0.3 to 7	V
I_O	Peak Output Current (each Channel) – Non Repetitive (t = 100μs) –Repetitive (80% on –20% off; t_{on} = 10ms) –DC Operation	 3 2.5 2	 A A A
V_{sens}	Sensing Voltage	–1 to 2.3	V
P_{tot}	Total Power Dissipation (T_{case} = 75°C)	25	W
T_{op}	Junction Operating Temperature	–25 to 130	°C
T_{stg}, T_j	Storage and Junction Temperature	–40 to 150	°C

PIN CONNECTIONS (top view)





THERMAL DATA

Symbol	Parameter		PowerSO20	Multiwatt15	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max.	–	3	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	13 (*)	35	°C/W

(*) Mounted on aluminum substrate

PIN FUNCTIONS (refer to the block diagram)

MW.15	PowerSO	Name	Function
1;15	2;19	Sense A; Sense B	Between this pin and ground is connected the sense resistor to control the current of the load.
2;3	4;5	Out 1; Out 2	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
4	6	V_S	Supply Voltage for the Power Output Stages. A non-inductive 100nF capacitor must be connected between this pin and ground.
5;7	7;9	Input 1; Input 2	TTL Compatible Inputs of the Bridge A.
6;11	8;14	Enable A; Enable B	TTL Compatible Enable Input: the L state disables the bridge A (enable A) and/or the bridge B (enable B).
8	1,10,11,20	GND	Ground.
9	12	VSS	Supply Voltage for the Logic Blocks. A100nF capacitor must be connected between this pin and ground.
10; 12	13;15	Input 3; Input 4	TTL Compatible Inputs of the Bridge B.
13; 14	16;17	Out 3; Out 4	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at pin 15.
–	3;18	N.C.	Not Connected

ELECTRICAL CHARACTERISTICS (V_S = 42V; V_{SS} = 5V, T_j = 25°C; unless otherwise specified)

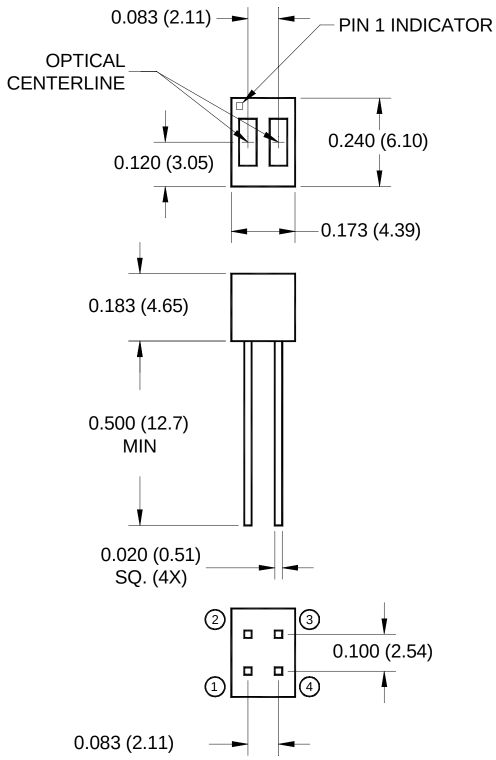
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 4)	Operative Condition	V_{IH} +2.5		46	V
V_{SS}	Logic Supply Voltage (pin 9)		4.5	5	7	V
I_S	Quiescent Supply Current (pin 4)	V_{en} = H; I_L = 0 V_i = L V_i = H		13 50	22 70	mA mA
		V_{en} = L V_i = X			4	mA
I_{SS}	Quiescent Current from V_{SS} (pin 9)	V_{en} = H; I_L = 0 V_i = L V_i = H		24 7	36 12	mA mA
		V_{en} = L V_i = X			6	mA
V_{iL}	Input Low Voltage (pins 5, 7, 10, 12)		–0.3		1.5	V
V_{iH}	Input High Voltage (pins 5, 7, 10, 12)		2.3		VSS	V
I_{iL}	Low Voltage Input Current (pins 5, 7, 10, 12)	V_i = L			–10	μA
I_{iH}	High Voltage Input Current (pins 5, 7, 10, 12)	Vi = H ≤ V_{SS} –0.6V		30	100	μA
V_{en} = L	Enable Low Voltage (pins 6, 11)		–0.3		1.5	V
V_{en} = H	Enable High Voltage (pins 6, 11)		2.3		V_{SS}	V
I_{en} = L	Low Voltage Enable Current (pins 6, 11)	V_{en} = L			–10	μA
I_{en} = H	High Voltage Enable Current (pins 6, 11)	V_{en} = H ≤ V_{SS} –0.6V		30	100	μA
$V_{CEsat(H)}$	Source Saturation Voltage	I_L = 1A I_L = 2A	0.95	1.35 2	1.7 2.7	V V
$V_{CEsat(L)}$	Sink Saturation Voltage	I_L = 1A (5) I_L = 2A (5)	0.85	1.2 1.7	1.6 2.3	V V
V_{CEsat}	Total Drop	I_L = 1A (5) I_L = 2A (5)	1.80		3.2 4.9	V V
V_{sens}	Sensing Voltage (pins 1, 15)		–1 (1)		2	V

QRD1113/1114

REFLECTIVE OBJECT SENSOR

FAIRCHILD SEMICONDUCTOR™

PACKAGE DIMENSIONS

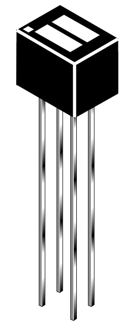


PIN 1 COLLECTOR
PIN 2 EMITTER
PIN 3 ANODE
PIN 4 CATHODE

NOTES:

1. Dimensions for all drawings are in inches (millimeters).
2. Tolerance of ± .010 (.25) on all non-nominal dimensions unless otherwise specified.
3. Pins 2 and 4 typically .050” shorter than pins 1 and 3.
4. Dimensions controlled at housing surface.

FEATURES

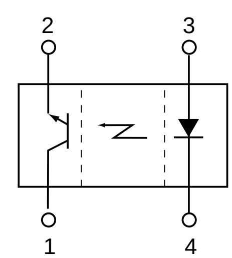


- Phototransistor Output
- No contact surface sensing
- Unfocused for sensing diffused surfaces
- Compact Package
- Daylight filter on sensor

NOTES (Applies to Max Ratings and Characteristics Tables.)

1. Derate power dissipation linearly 1.33 mW/°C above 25°C.
2. RMA flux is recommended.
3. Methanol or isopropyl alcohols are recommended as cleaning agents.
4. Soldering iron 1/16" (1.6mm) from housing.
5. As long as leads are not under any spring tension.
6. D is the distance from the sensor face to the reflective surface.
7. Cross talk (I_{CX}) is the collector current measured with the indicator current on the input diode and with no reflective surface.
8. Measured using an Eastman Kodak neutral white test card with 90% diffused reflecting as a reflective surface.

SCHEMATIC



ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise specified)

Parameter	Symbol	Rating	Units
Operating Temperature	T_{OPR}	-40 to +85	°C
Storage Temperature	T_{STG}	-40 to +85	°C
Lead Temperature (Solder Iron)(2,3)	T_{SOL-I}	240 for 5 sec	°C
Lead Temperature (Solder Flow)(2,3)	T_{SOL-F}	260 for 10 sec	°C
EMITTER			
Continuous Forward Current	I_F	50	mA
Reverse Voltage	V_R	5	V
Power Dissipation(1)	P_D	100	mW
SENSOR			
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}		V
Power Dissipation(1)	P_D	100	mW

QRD1113/1114

REFLECTIVE OBJECT SENSOR

ELECTRICAL / OPTICAL CHARACTERISTICS (T_A = 25°C)						
PARAMETER	**TEST CONDITIONS**	**SYMBOL**	**MIN**	**TYP**	**MAX**	**UNITS**
EMITTER Forward Voltage	I_F = 20 mA	V_F	—	—	1.7	V
Reverse Current	V_R = 5 V	I_R	—	—	100	µA
Peak Emission Wavelength	I_F = 20 mA	λ_{PE}	—	940	—	nm
SENSOR Collector-Emitter Breakdown	I_C = 1 mA	BV_{CEO}	30	—	—	V
Emitter-Collector Breakdown	I_E = 0.1 mA	BV_{ECO}	5	—	—	V
Dark Current	V_{CE} = 10 V, I_F = 0 mA	I_D	—	—	100	nA
COUPLED QRD1113 Collector Current	I_F = 20 mA, V_{CE} = 5 V D = .050” (6,8)	$I_{C(ON)}$	0.300	—	—	mA
QRD1114 Collector Current	I_F = 20 mA, V_{CE} = 5 V D = .050” (6,8)	$I_{C(ON)}$	1	—	—	mA
Collector Emitter Saturation Voltage	I_F = 40 mA, I_C = 100 µA D = .050” (6,8)	$V_{CE\ (SAT)}$	—	—	0.4	V
Cross Talk	I_F = 20 mA, V_{CE} = 5 V, E_E = 0 (7)	I_{CX}	—	.200	10	µA
Rise Time	V_{CE} = 5 V, R_L = 100 Ω	t_r	—	10	—	µs
Fall Time	$I_{C(ON)}$ = 5 mA	t_f	—	50	—	µs

TYPICAL PERFORMANCE CURVES

Fig. 1 Forward Voltage vs. Forward Current

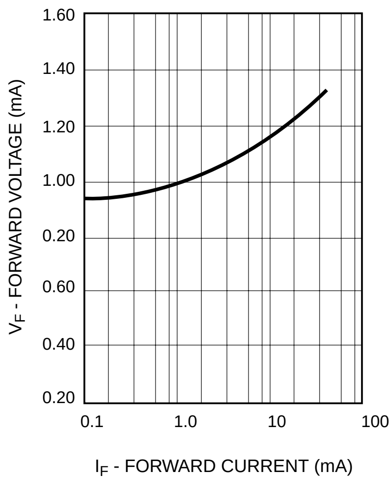


Fig. 2 Normalized Collector Current vs. Forward Current

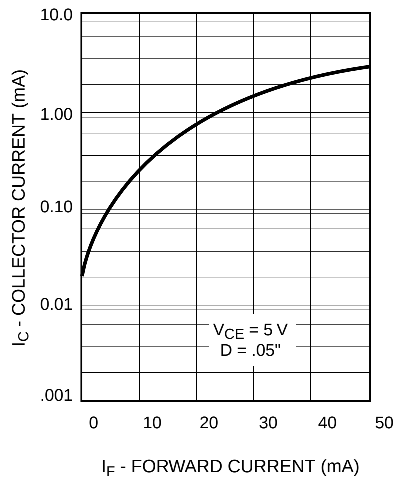


Fig. 3 Normalized Collector Current vs. Temperature

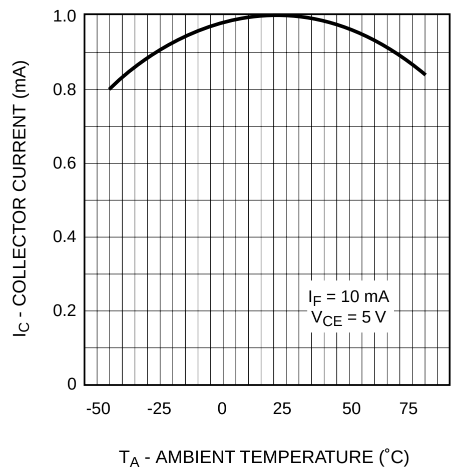


Fig. 4 Normalized Collector Dark Current vs. Temperature

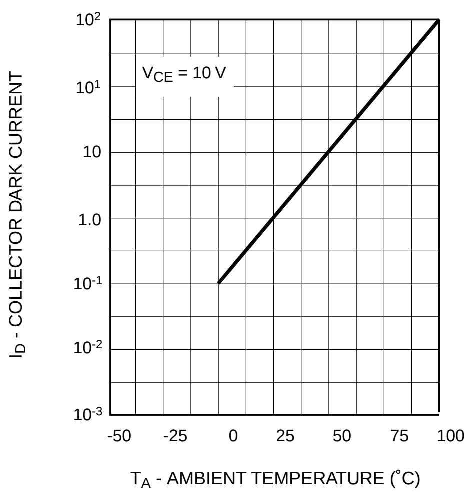
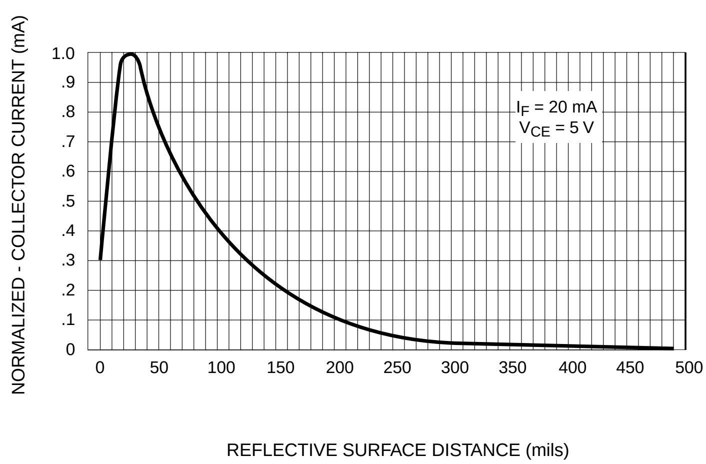


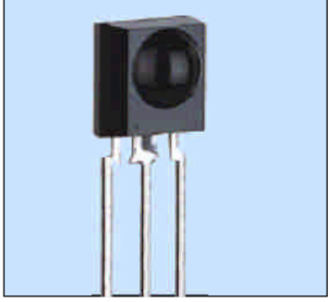
Fig. 5 Normalized Collector Current vs. Distance



Infrared Receiver Module

NationStar

FPS-60 Series



Electrical/Optical Characteristics Ta=25℃

Part No.	Pin order	B.P.F	Supply Voltage	Supply Current	Angle	Distance
FPS-6038	Out-Gnd-Vcc	37.9KHz	2.7-5.5V	Min=0.6mA Typ.=1.1mA Max=3.0 mA	±45°	≥8m
			4.5-5.5V			
FPS-6033		33KHz	2.7-5.5V			
			4.5-5.5V			
FPS-6036		36KHz	2.7-5.5V			
			4.5-5.5V			
FPS-6037		36.7KHz	2.7-5.5V			
			4.5-5.5V			
FPS-6056		56KHz	2.7-5.5V			
			4.5-5.5V			

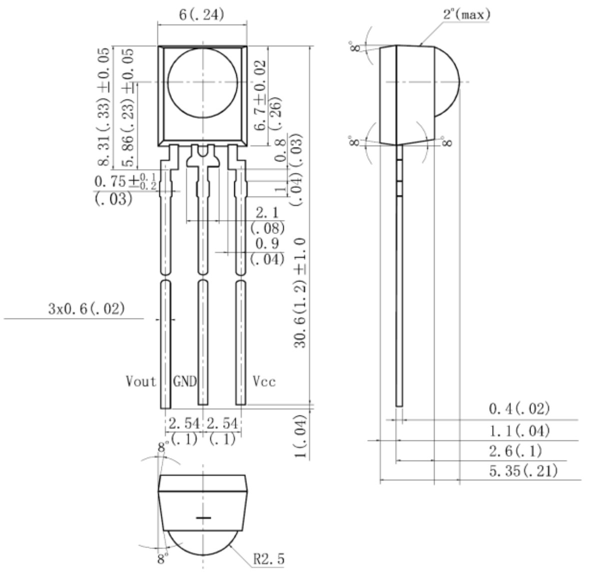
FPS-62 Series

Electrical/Optical Characteristics Ta=25℃

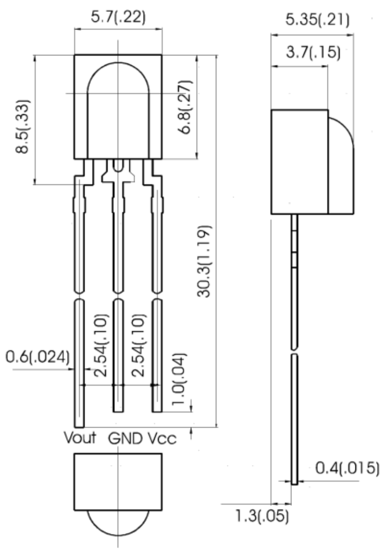
Part No.	Pin order	B.P.F	Supply Voltage	Supply Current	Angle	Distance
FPS-6238	Out-Gnd-Vcc	37.9KHz	2.7-5.5V	Min=0.6mA Typ.=1.1mA Max=3.0 mA	±45°	≥8m
			4.5-5.5V			
FPS-6233		33KHz	2.7-5.5V			
			4.5-5.5V			
FPS-6236		36KHz	2.7-5.5V			
			4.5-5.5V			
FPS-6237		36.7KHz	2.7-5.5V			
			4.5-5.5V			
FPS-6256		56KHz	2.7-5.5V			
			4.5-5.5V			

Dimensions

FPS-60 Series



FPS-62 Series



Notes

All dimensions are millimeters(inches);

Tolerance is 0.25mm(0.01″) unless otherwise noted;

National Semiconductor

May 2000

LM78XX
Series Voltage Regulators

General Description

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Considerable effort was expanded to make the LM78XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

For output voltage other than 5V, 12V and 15V the LM117 series provides an output voltage range from 1.2V to 57V.

Features

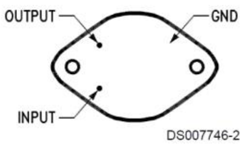
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

Voltage Range

LM7805C	5V
LM7812C	12V
LM7815C	15V

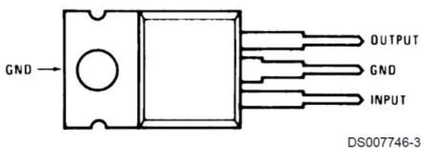
Connection Diagrams

Metal Can Package
TO-3 (K)
Aluminum



Bottom View
Order Number LM7805CK,
LM7812CK or LM7815CK
See NS Package Number KC02A

Plastic Package
TO-220 (T)



Top View
Order Number LM7805CT,
LM7812CT or LM7815CT
See NS Package Number T03B

Absolute Maximum Ratings (Note 3)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Input Voltage	
(V_O = 5V, 12V and 15V)	35V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range (T_A)	0°C to +70°C
Maximum Junction Temperature	
(K Package)	150°C
(T Package)	150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-3 Package K	300°C
TO-220 Package T	230°C

Electrical Characteristics LM78XXC (Note 2)

0°C ≤ T_J ≤ 125°C unless otherwise noted.

Output Voltage				5V			12V			15V			Units
Input Voltage (unless otherwise noted)				10V			19V			23V			
Symbol	Parameter	Conditions		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage	Tj = 25°C, 5 mA ≤ I_O ≤ 1A		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A		4.75		5.25	11.4		12.6	14.25		15.75	V
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7.5 ≤ V_{IN} ≤ 20)			(14.5 ≤ V_{IN} ≤ 27)			(17.5 ≤ V_{IN} ≤ 30)			V
ΔV_O	Line Regulation	I_O = 500 mA	Tj = 25°C		3	50		4	120		4	150	mV
			ΔV_{IN}	(7 ≤ V_{IN} ≤ 25)			14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)			V
			0°C ≤ Tj ≤ +125°C			50			120			150	mV
			ΔV_{IN}	(8 ≤ V_{IN} ≤ 20)			(15 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)			V
		I_O ≤ 1A	Tj = 25°C			50			120			150	mV
			ΔV_{IN}	(7.5 ≤ V_{IN} ≤ 20)			(14.6 ≤ V_{IN} ≤ 27)			(17.7 ≤ V_{IN} ≤ 30)			V
			0°C ≤ Tj ≤ +125°C			25			60			75	mV
			ΔV_{IN}	(8 ≤ V_{IN} ≤ 12)			(16 ≤ V_{IN} ≤ 22)			(20 ≤ V_{IN} ≤ 26)			V
ΔV_O	Load Regulation	Tj = 25°C	5 mA ≤ I_O ≤ 1.5A		10	50		12	120		12	150	mV
			250 mA ≤ I_O ≤ 750 mA			25			60			75	mV
		5 mA ≤ I_O ≤ 1A, 0°C ≤ Tj ≤ +125°C				50			120			150	mV
I_Q	Quiescent Current	I_O ≤ 1A	Tj = 25°C			8			8			8	mA
			0°C ≤ Tj ≤ +125°C			8.5			8.5			8.5	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A				0.5			0.5			0.5	mA
		Tj = 25°C, I_O ≤ 1A				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN}≤ 27)			(17.9 ≤ V_{IN} ≤ 30)			V
		I_O ≤ 500 mA, 0°C ≤ Tj ≤ +125°C				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN}≤ 30)			(17.5 ≤ V_{IN} ≤ 30)			V
V_N	Output Noise Voltage	T_A =25°C, 10 Hz ≤ f ≤ 100 kHz			40			75			90		µV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz	I_O ≤ 1A, Tj = 25°C or	62	80		55	72		54	70		dB
			I_O ≤ 500 mA 0°C ≤ Tj ≤ +125°C	62			55			54			dB
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(8 ≤ V_{IN} ≤ 18)			(15 ≤ V_{IN} ≤ 25)			(18.5 ≤ V_{IN} ≤ 28.5)			V
R_O	Dropout Voltage	Tj = 25°C, I_{OUT} = 1A			2.0			2.0			2.0		V
	Output Resistance	f = 1 kHz			8			18			19		mΩ

Electrical Characteristics LM78XXC (Note 2) (Continued)

$0^{\circ}C \leq T_J \leq 125^{\circ}C$ unless otherwise noted.

Output Voltage			5V			12V			15V			Units
Input Voltage (unless otherwise noted)			10V			19V			23V			
Symbol	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	Short-Circuit Current	Tj = 25°C		2.1			1.5			1.2		A
	Peak Output Current	Tj = 25°C		2.4			2.4			2.4		A
	Average TC of V_{OUT}	0°C ≤ Tj ≤ +125°C, I_O = 5 mA		0.6			1.5			1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	Tj = 25°C, I_O ≤ 1A		7.5		14.6			17.7			V

Note 1: Thermal resistance of the TO-3 package (K, KC) is typically 4°C/W junction to case and 35°C/W case to ambient. Thermal resistance of the TO-220 package (T) is typically 4°C/W junction to case and 50°C/W case to ambient.

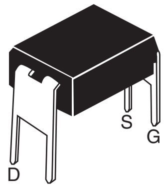
Note 2: All characteristics are measured with capacitor across the input of 0.22 µF, and a capacitor across the output of 0.1µF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

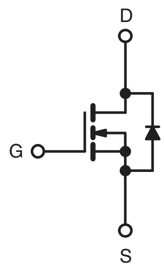
Note 3: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. For guaranteed specifications and the test conditions, see Electrical Characteristics.

Power MOSFET

PRODUCT SUMMARY		
V_{DS} (V)	60	
$R_{DS(on)}$ (Ω)	V_{GS} = 10 V	0.10
Q_g (Max.) (nC)	25	
Q_{gs} (nC)	5.8	
Q_{gd} (nC)	11	
Configuration	Single	

HVMDIP





N-Channel MOSFET

FEATURES

- Dynamic dV/dt Rating
- For Automatic Insertion
- End Stackable
- 175 °C Operating Temperature
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements
- Compliant to RoHS Directive 2002/95/EC

Pb Available
RoHS* COMPLIANT

DESCRIPTION

Third generation Power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.
The 4 pin DIP package is a low cost machine-insertable case style which can be stacked in multiple combinations on standard 0.1" pin centers. The dual drain serves as a thermal link to the mounting surface for power dissipation levels up to 1 W.

ORDERING INFORMATION	
Package	HVMDIP
Lead (Pb)-free	IRFD024PbF
	SiHFD024-E3
SnPb	IRFD024
	SiHFD024

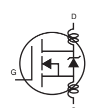
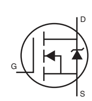
ABSOLUTE MAXIMUM RATINGS (T_A = 25 °C, unless otherwise noted)

PARAMETER			SYMBOL	LIMIT	UNIT
Drain-Source Voltage			V_{DS}	60	V
Gate-Source Voltage			V_{GS}	± 20	
Continuous Drain Current	V_{GS} at 10 V	T_A = 25 °C	I_D	2.5	A
		T_A = 100 °C		1.8	
Pulsed Drain Current[a]			I_{DM}	20	
Linear Derating Factor				0.0083	W/°C
Single Pulse Avalanche Energy[b]			E_{AS}	91	mJ
Maximum Power Dissipation	T_A = 25 °C		P_D	1.3	W
Peak Diode Recovery dV/dt[c]			dV/dt	4.5	V/ns
Operating Junction and Storage Temperature Range			T_J, T_{stg}	- 55 to + 175	°C
Soldering Recommendations (Peak Temperature)	for 10 s			300[d]	

Notes
a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
b. V_{DD} = 25 V, starting T_J = 25 °C, L = 16 mH, R_g = 25 Ω, I_{AS} = 2.5 A (see fig. 12).
c. $I_{SD} \le 17$ A, dI/dt ≤ 140 A/μs, $V_{DD} \le V_{DS}$, $T_J \le 175$ °C.
d. 1.6 mm from case.

* Pb containing terminations are not RoHS compliant, exemptions may apply

THERMAL RESISTANCE RATINGS				
PARAMETER	**SYMBOL**	**TYP.**	**MAX.**	**UNIT**
Maximum Junction-to-Ambient	R_{thJA}	-	120	°C/W

SPECIFICATIONS (T_J = 25 °C, unless otherwise noted)							
PARAMETER	**SYMBOL**	**TEST CONDITIONS**		**MIN.**	**TYP.**	**MAX.**	**UNIT**
Static							
Drain-Source Breakdown Voltage	V_{DS}	V_{GS} = 0 V, I_D = 250 μA		60	-	-	V
V_{DS} Temperature Coefficient	$\Delta V_{DS}/T_J$	Reference to 25 °C, I_D = 1 mA		-	0.061	-	V/°C
Gate-Source Threshold Voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = 250 μA		2.0	-	4.0	V
Gate-Source Leakage	I_{GSS}	V_{GS} = ± 20 V		-	-	± 100	nA
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 60 V, V_{GS} = 0 V		-	-	25	μA
		V_{DS} = 48 V, V_{GS} = 0 V, T_J = 150 °C		-	-	250	
Drain-Source On-State Resistance	$R_{DS(on)}$	V_{GS} = 10 V	I_D = 1.5 A[b]	-	-	0.10	Ω
Forward Transconductance	g_{fs}	V_{DS} = 25 V, I_D = 1.5 A[b]		0.90	-	-	S
Dynamic							
Input Capacitance	C_{iss}	V_{GS} = 0 V, V_{DS} = 25 V, f = 1.0 MHz, see fig. 5		-	640	-	pF
Output Capacitance	C_{oss}			-	360	-	
Reverse Transfer Capacitance	C_{rss}			-	79	-	
Total Gate Charge	Q_g	V_{GS} = 10 V	I_D = 17 A, V_{DS} = 48 V, see fig. 6 and 13[b]	-	-	25	nC
Gate-Source Charge	Q_{gs}			-	-	5.8	
Gate-Drain Charge	Q_{gd}			-	-	11	
Turn-On Delay Time	$t_{d(on)}$	V_{DD} = 30 V, I_D = 17 A, R_g = 18 Ω, R_D = 1.7Ω, see fig. 10[b]		-	13	-	ns
Rise Time	t_r			-	58	-	
Turn-Off Delay Time	$t_{d(off)}$			-	25	-	
Fall Time	t_f			-	42	-	
Internal Drain Inductance	L_D	Between lead, 6 mm (0.25") from package and center of die contact		-	4.0	-	nH
Internal Source Inductance	L_S			-	6.0	-	
Drain-Source Body Diode Characteristics							
Continuous Source-Drain Diode Current	I_S	MOSFET symbol showing the integral reverse p - n junction diode		-	-	2.5	A
Pulsed Diode Forward Current[a]	I_{SM}			-	-	20	
Body Diode Voltage	V_{SD}	T_J = 25 °C, I_S = 2.5 A, V_{GS} = 0 V[b]		-	-	1.5	V
Body Diode Reverse Recovery Time	t_{rr}	T_J = 25 °C, I_F = 17 A, dI/dt = 100 A/μs[b]		-	80	180	ns
Body Diode Reverse Recovery Charge	Q_{rr}			-	0.29	0.64	μC
Forward Turn-On Time	t_{on}	Intrinsic turn-on time is negligible (turn-on is dominated by L_S and L_D)					

Notes

a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).

b. Pulse width ≤ 300 μs; duty cycle ≤ 2 %.

1N5817, 1N5818, 1N5819

1N5817 and 1N5819 are Preferred Devices

Axial Lead Rectifiers

This series employs the Schottky Barrier principle in a large area metal−to−silicon power diode. State−of−the−art geometry features chrome barrier metal, epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low−voltage, high−frequency inverters, free wheeling diodes, and polarity protection diodes.

Features

- Extremely Low V_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- Lead and Mounting Surface Temperature for Soldering Purposes: 220°C Max. for 10 Seconds, 1/16 in from case
- Shipped in plastic bags, 1000 per bag.
- Available Tape and Reeled, 5000 per reel, by adding a “RL” suffix to the part number
- These devices are manufactured with a Pb−Free external lead finish only*

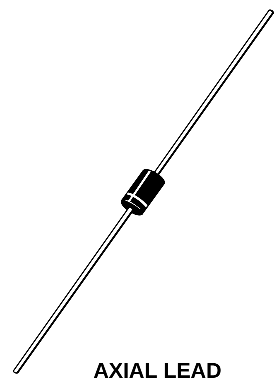
Mechanical Characteristics

- Case: Epoxy, Molded
- Weight: 0.4 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Polarity: Cathode Indicated by Polarity Band

ON Semiconductor®

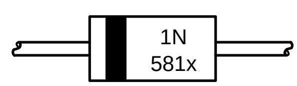
http://onsemi.com

SCHOTTKY BARRIER RECTIFIERS
1.0 AMPERE
20, 30 and 40 VOLTS



AXIAL LEAD
CASE 59−10
DO−41
PLASTIC

MARKING DIAGRAM



1N581x = Device Code
x = 7, 8 or 9

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

Preferred devices are recommended choices for future use and best overall value.

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

MAXIMUM RATINGS

Rating	Symbol	1N5817	1N5818	1N5819	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	V
Non−Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	V
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	V
Average Rectified Forward Current (Note 1), ($V_{R(equiv)} \leq 0.2\ V_R$(dc), T_L = 90°C, $R_{\theta JA}$ = 80°C/W, P.C. Board Mounting, see Note 2, T_A = 55°C)	I_O	1.0			A
Ambient Temperature (Rated V_R(dc), $P_{F(AV)}$ = 0, $R_{\theta JA}$ = 80°C/W)	T_A	85	80	75	°C
Non−Repetitive Peak Surge Current, (Surge applied at rated load conditions, half−wave, single phase 60 Hz, T_L = 70°C)	I_{FSM}	25 (for one cycle)			A
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}	−65 to +125			°C
Peak Operating Junction Temperature (Forward Current applied)	$T_{J(pk)}$	150			°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

THERMAL CHARACTERISTICS (Note 1)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	80	°C/W

ELECTRICAL CHARACTERISTICS (T_L = 25°C unless otherwise noted) (Note 1)

Characteristic	Symbol	1N5817	1N5818	1N5819	Unit
Maximum Instantaneous Forward Voltage (Note 2) (i_F = 0.1 A) (i_F = 1.0 A) (i_F = 3.0 A)	v_F	0.32 0.45 0.75	0.33 0.55 0.875	0.34 0.6 0.9	V
Maximum Instantaneous Reverse Current @ Rated dc Voltage (Note 2) (T_L = 25°C) (T_L = 100°C)	I_R	 1.0 10	 1.0 10	 1.0 10	mA

1. Lead Temperature reference is cathode lead 1/32 in from case.
2. Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

ORDERING INFORMATION

Device	Package	Shipping†
1N5817	Axial Lead	1000 Units/Bag
1N5817RL	Axial Lead	5000/Tape & Reel
1N5818	Axial Lead	1000 Units/Bag
1N5818RL	Axial Lead	5000/Tape & Reel
1N5819	Axial Lead	1000 Units/Bag
1N5819RL	Axial Lead	5000/Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

FA-130RA

MABUCHI MOTOR

Metal-brush motors

OUTPUT : 0.2W~ 1W (APPROX)

WEIGHT : 17g (APPROX)

Typical Applications
Home Appliances : Hair Dressing / Beauty Appliance
Toys and Models : Motorized Toy / Motorized Plastic Model

DIRECTION OF ROTATION