Abstract

بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering and Technology
Electrical & Mechanical Engineering Department

Solar Elevator

Project Team

ABED EL RUHMAN K. SHAKHTOUR

ATIA M. JAFRAH **YOUSEF A. SAYAR`A**

Project Supervisor

Dr. Sameer H. Khader

&

Dr. Abdul-Karim Daoud

Hebron – Palestine

Jan. 2010

Abstract

This project aims to design electrical elevator done by solar energy, this is a new idea for using subsistent energy in electromechanically system, by conversion the solar energy into electrical energy and then to motion to provide mechanical objective.

Space elevator consider as one model for movement car consist from solar boards and motor found in above of elevator, used to motion the car above and below through mechanical transport (rollers) ,the motor is feed to the engine power from the solar cells installed on a vehicle lift.

The project consists of following:

- *Transmission system.*
- *System converts solar energy to electricity.*
- *Control system help to ensure the quality of movement.*

Table of contains

Table of figure:

Chapter 1

Introduction.

Industrial Automation Engineering & Mechatronics is the most improved sector in the field of electrical & mechanical engineering due to wide spread application of the most systems in the world industry.

There are three fields covered in this project:

- Electrical.
- Mechanical.
- control.

1.1 Project aim:

This project aim to:

1- Use the solar energy in our industrial application.

2- Employment solar energy to give power to elevator without use electric.

3- Use the new control technology (PIC) to control the elevator.

4- To learn to use modern technology and to develop it.

1.2 Literature view:

It is only a question of time when steam and hydraulic elevators will be a thing of the past, for the reason that it is desirable to have but one kind of power in a building, and that electricity .All that is necessary for the passing of the other types of elevators, it is to produce an electric elevator as safe, as speedy, as reliable, as efficient, and as economical as the best type of hydraulic elevator .

A space elevator is a proposed structure designed to transport material from a celestial body's surface into space .Many variants have been proposed, all of which involve traveling along a fixed structure instead of using rocket powered space launch . The concept most often refers to a structure that reaches from the surface of the Earth on or near the Equator to geostationary orbit (GSO) and a counter-mass beyond.

The concept of a space elevator dates back to 1895 when Konstantin Tsiolkovsky proposed a free-standing "Tsiolkovsky "tower reaching from the surface of Earth to geostationary orbit .Most recent discussions focus on tensile structures (specifically, tethers) reaching from geostationary orbit to the ground .This structure would be held in tension between Earth and the counterweight in space like a guitar string held taut . Space elevators have also sometimes been referred to as beanstalks, space bridges, space lifts, space ladders, skyhooks, orbital towers, or orbital elevators.

Current technology is not capable of manufacturing practical engineering materials that are sufficiently strong and light to build an Earth-based space elevator . The primary issue is that the total mass of conventional materials needed to construct such a structure would be far too great to be economic .

1.3 Block Diagram:

The fig (1.1) is the block diagram of the elevator which consists of:

- PV panel : this unit use to convert solar power to electrical power
- Charger: This unit is used to convert the variable voltage to constant voltage and control the battery charge.
- Battery: Used to store energy and be a secondary source of power.
- DC motor: Used to run the elevator.
- Controller: Used to control the mechanism of the elevator.
- Elevator : this unit use to lift up or down the Stuff

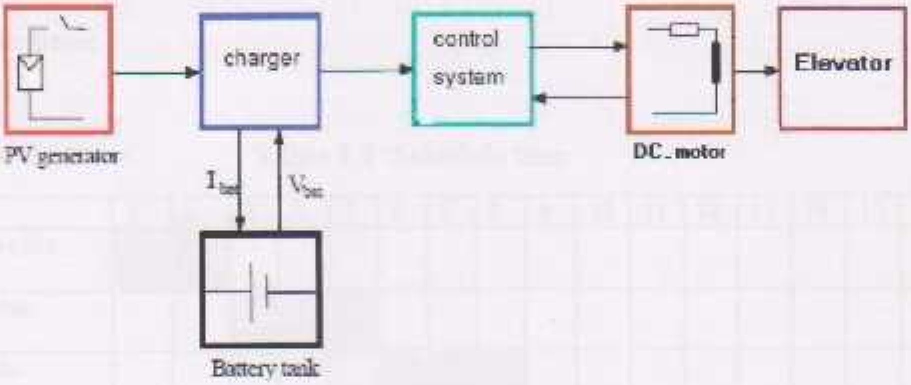


Fig1.1: block diagram of project

1.4 Project Cost / (Visible Study):

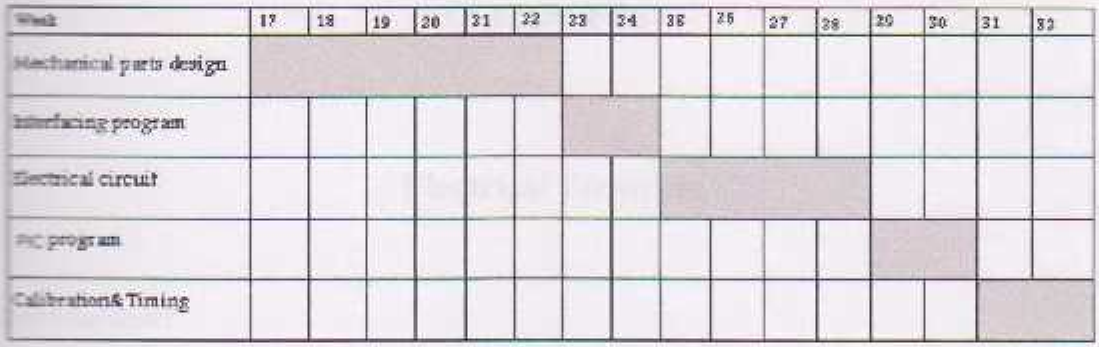
Table 1.1: Project cost

Equipment's	Cost ($)
Motors	100
PV Panels	600
Charger Battery	100
Microcontroller	150
Sensors	150
Elevator body	400
Drivers	200
Total cost	1700

1.5 Schedule time:

Table 1.2 :Schedule time

week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Choosing project																
Collection data																
Data analysis																
Electrical design																
mechanical design																
Writing project text																



1.6 Suggestions:

The suggestions are:

- ➢ Make the regenerative when the elevator goes down.
- ➢ Using the project in practical application.
- ➢ Build a control system to control the direction of PV panels to take maximum solar energy.

Chapter Two

Electrical Elements

Introduction:

In this chapter we illustrate and explain the main electrical parts that should be used in the project.

The content parts are:

- **Photovoltaic Panels.**
- **battery**
- **Charger battery.**
- **Electrical motor.**

2.1 Photovoltaic Panels.

2.1.1 History of Photovoltaic:

The first conventional photovoltaic cells were produced in the late of 1950s, and throughout the 1960s were principally used to provide electrical power for earth-orbiting satellites. In the 1970s, improvements in manufacturing, performance and quality of PV modules helped on reduce costs and opened up a number of opportunities for powering remote terrestrial applications, including battery charging for navigational aids, signals, telecommunications equipment and other critical, low power needs.

In the 1980s, photovoltaic become a popular source for consumer electronic devices, including calculators, watches, radios, lanterns and other small battery charging applications. Following the energy crises of the 1970s, significant efforts also began to develop PV power systems for residential and commercial uses both for stand-alone, remote power as well as for utility-connected applications. During the same period, international applications for PV systems to power rural health clinics, refrigeration, water pumping, telecommunications, and off-grid households increased dramatically, and remain a major portion of the present world market for PV products. Today, the industry's production of PV modules is growing at approximately 25 percent annually, and major programs in the U.S. Japan and Europe are rapidly accelerating the implementation of PV systems on buildings and interconnection to utility networks.

2.1.2 PV Cells, Modules, and Arrays, Description

2.1.2.1 PV Description

Photovoltaic (PV) means solar electricity from sunlight. Photovoltaic systems use sunlight to power ordinary electrical equipment, for example, household appliances, computers and lighting. The photovoltaic (PV) process converts free solar energy-the most abundant energy source on the planet-directly into electricity. Note that this is not the familiar "passive" or solar thermal technology used for space heating and hot water production.

A PV cells consists of two or more thin layers of semi-conducting material, most commonly silicon. When the silicon is exposed to light, electrical charges are generated and this can be conducted away by metal contacts as direct current (DC). The electrical output from a signal cell is small, so multiple cells are connected together and encapsulated (usually behind glass) to form a module (sometimes refers to as a "panel"). The PV module is the principle building block of a PV system and any number of modules can be connected together to give the desired electrical output.

PV equipment has no moving parts and as a result requires minimal maintenance. It generates electricity without producing emissions of greenhouse or any other gases, and its operation is virtually silent.

2.1.2.2 PV Cells, Modules, and Arrays

Photovoltaic cells are connected electrically in series and\or parallel circuits to produce higher voltages, currents and power levels. Photovoltaic modules consist of PV cell circuits sealed in an environmentally protective laminate, and are the fundamental building block of PV systems. Photovoltaic panels include one or more PV modules assembled as a pre-wired, field installable unit. A photovoltaic array is the complete power-generating unit, consisting of any number of PV modules and panels.

The performance of PV modules and arrays are generally rated according to their maximum DC power output (watts) under Standard Test Conditions (STC). Standard Test Conditions are defined by a module (cell) operating temperature of 25 degrees C (77 degrees F), and incident solar irradiance level of 1000 W\m2 and under Air Mass 1.5 spectral distribution. Since these conditions are not always typical of how PV modules and arrays operate in the field, actual performance is usually 85 to 90 percent of the STC rating.

Today's photovoltaic modules are extremely safe and reliable products, with minimal failure rates and projected service lifetimes of 20 to 30 years. Most major manufactures offer warranties of twenty or more years for maintaining a high percentage of initial rated power output. When selecting PV modules, look for the product listing (UL), qualification testing and warranty information in the module manufacture's specifications.

2.1.3 Equivalent Circuit of a solar cell.

During darkness, the solar cell is not an active device; it works as a diode, i.e. a p-n junction. It produces neither a current nor a voltage. However, if it is connected to an external supply (large voltage) it generates a current ID, called diode current or dark current.

A solar cell is usually represented by an electrical equivalent one-diode model (Lorenzo, 1994), as shown in Figure 2.1.

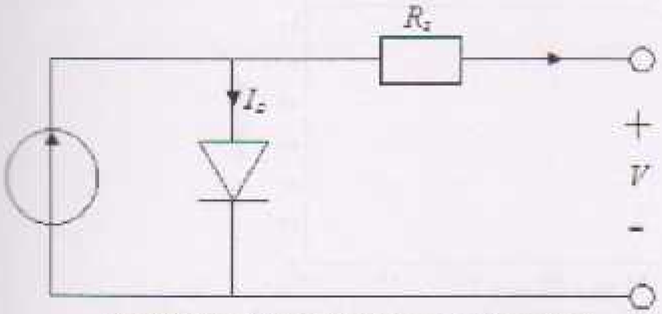


Fig 2.1: The Equivalent Circuit of a solar cell

2.1.4 The Electrical Characteristics of Solar Cells

2.1.4.1 Introduction

As we know that the network supply voltage for one phase that feeding the home is approximately 220V the frequency equal to 50Hz on other hand the solar cells generator depends on many factors can be summarized as follow:

1. The size and the number of the used solar cells, so the increase in solar cells number will cause an increase in the generated energy.
2. The light intensity where the current intensity that generated from the solar cells will increase proportionally with the sun light intensity.
3. The temperature of the solar cells when the temperature of the solar cell increases the operating point will be decrease and so the generated power will decrease too.
4. The electrical loads that are used where the electrical loads that used must be in relation with the magnitude of the generated electrical power.

2.1.4.2 Voltage \ Current Characteristics

The Fig 2.2will explain the voltage-current relationship curve for the solar cells.

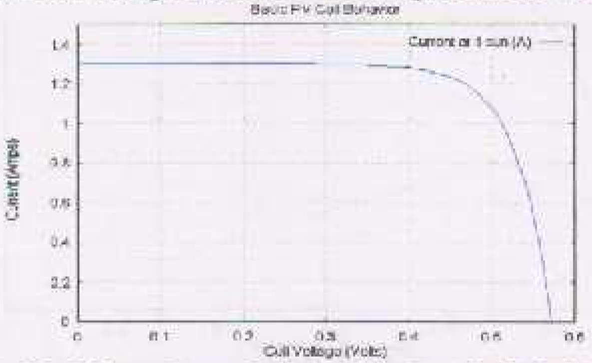


Fig. 2.2: Voltage-Current Relation Ship Curve for Solar Cell.

This graph shows the characteristics of a PV cell. It is called an I-V curve. This I-V curve is for the type of a PV cell used in the solar modules. So that comparisons can be made of the electrical characteristics of different PV cells these measurements are made at standard test conditions (STC) defined as alight intensity of 1000 W/m_2 and a temperature of 25 °C. The graph also shows the maximum power point of the PV cell.

2.1.4.3 Voltage - Power and Current Characteristics:

The Fig 2.3 will explain the voltage-power and relationship curve for the solar cell we can note from the Fig 2.1 that the electrical power the be resulted from the solar cell increase when the output voltage of the cell increase where the electrical power can be reach to its maximum value at specific output voltage then the electrical power resulted from the solar cell will be decrease strongly until reaching zero.

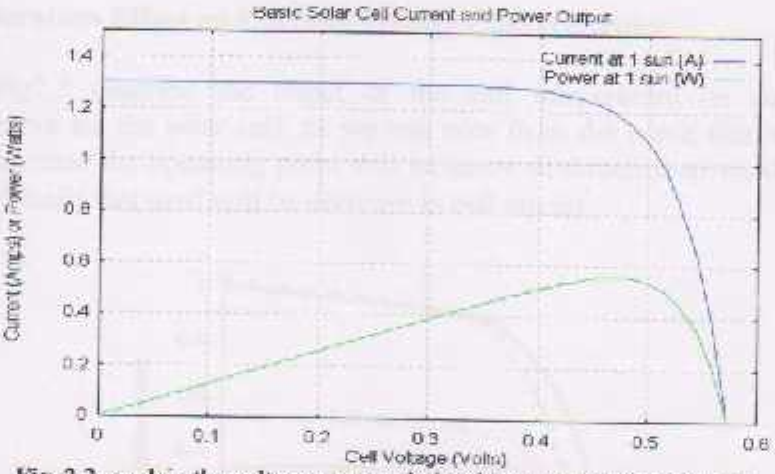


Fig. 2.3: explain the voltage-power relationship curve for the solar cell.

2.1.4.4 Effect of Sunlight intensity:

The Fig 2.4 describes the effect of the sunlight intensity on the solar cell voltage-current cell relationship curve. We can note from the increasing of the resulted current intensity from the cell when the sunlight increase for every 1 Sq meter and we can note also the change of operating point for the cell following the change in magnitude of the sunlight power.

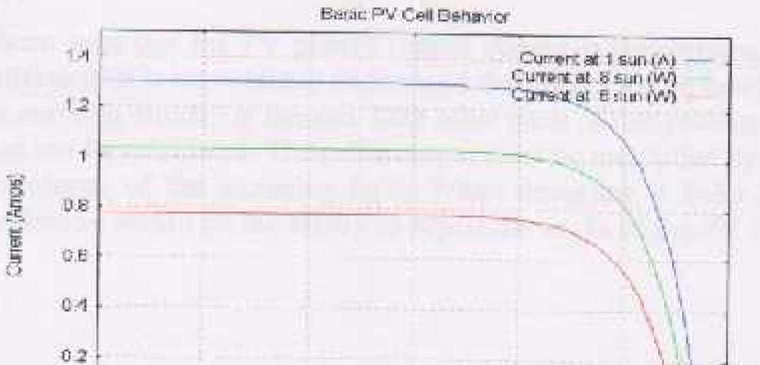


Fig. 2.4: describes the effect of the sunlight intensity on the solar cell voltage-current cell relationship curve.

2.1.4.5 Temperature Effect on Current-Voltage Characteristic:

The Fig2.5 describe the effect of the cell temperature on current-voltage relationship curve for the solar cell, as we can note from the curve that when the cell temperature increase the operating point will be move in direction to ward low voltage so the value of loads that used will be decrease in cell circuit.

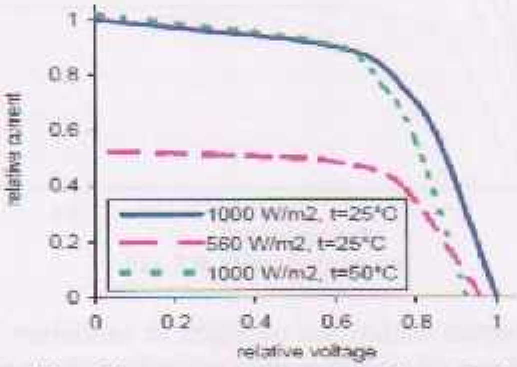


Fig. 2.5: describe the effect of the cell temperature on current-voltage relationship Curve for solar cell.

2.1.4.6 Sun Angle:

It has been seen that the PV panel's output current is proportional to the solar radiation that strikes it. It is important to understand that this radiation level is reduced if the panel is not pointing directly at the sun. Like other parts of this problem, the amount that it is reduced can be calculated. The cell's output must be multiplied by the cosine of the angle of incidence of the incoming light. When designing a Solar Sprint car, a possible design feature would be the ability to adjust the angle of the PV cell, show the fig2.6.

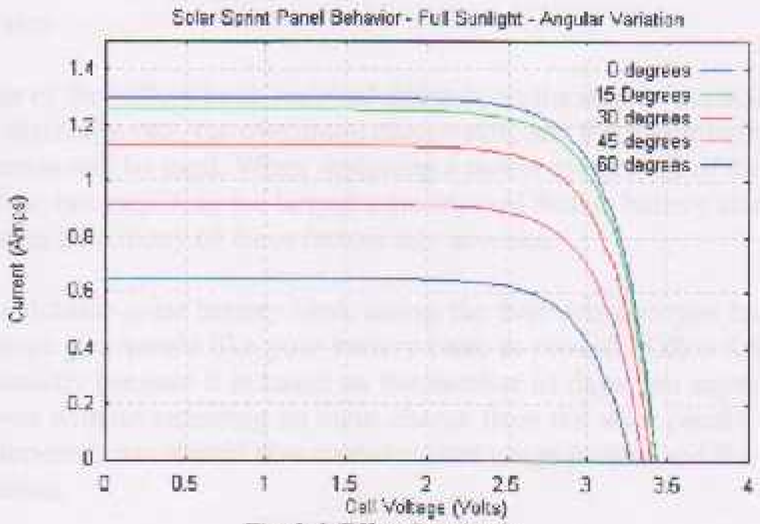


Fig. 2.6: Effect Sun Angle.

Note that small variations in angle do not reduce output very much. Even a 60 degree angle of incidence only makes the output decline by one half.

2.2 Battery

2.2.1 Introduction:

A **battery charger** is a device used to put energy into a cell or (rechargeable) battery by forcing an electric current through it. Lead-acid battery chargers typically have two tasks to accomplish. The first is to restore capacity, often as quickly as practical. The second is to maintain capacity by compensating for self discharge. In both instances optimum operation requires accurate sensing of battery voltage.

When a typical lead-acid cell is charged, lead sulphate is converted to lead on the battery's negative plate and lead dioxide on the positive plate. Over-charge reactions begin when the majority of lead sulphate has been converted, typically resulting in the generation of hydrogen and oxygen gas. At moderate charge rates, most of the hydrogen and oxygen will recombine in sealed batteries. In unsealed batteries however, dehydration will occur.

2.2.2 Battery size

The size of the battery bank required depends on the storage capacity required, the maximum discharge rate, the maximum charge rate, and the minimum temperature at which the batteries will be used. When designing a power system, all of these factors are looked at, and the one requiring the largest capacity will dictate battery size. Our system sizing work forms take many of these factors into account.

When calculate solar battery bank sizing the first decision you have to make is how much storage you would like your battery bank to provide. Often this is expressed as days of autonomy because it is based on the number of days you expect your system to provide power without receiving an input charge from the solar panels. In addition to the days of autonomy, you should also consider your usage pattern and the critical nature of your application.

Alternatively, if you are adding a solar panel array as a supplement to a generator based system, your battery bank can be slightly undersized since the generator can be operated in needed for recharging. Once you have determined your storage capacity

2.2.3 Charging process of batteries

Charging a lead acid battery is a matter of replenishing the depleted supply of energy that the battery had lost during use. This replenishing process can be accomplished with several different charger implementations: constant voltage charger, constant current charger or a multistage constant voltage/current charger. Each of these approaches has its advantages and disadvantages that need to be compared and weighed to see which one would be the most practical and realistic to fit with our requirements.

Solar cells are one of our main portable power sources. Inherently, they provide a constant current which is dependent on light intensity and other uncontrollable variability in the environment. This characteristic fits well with a constant voltage charge design, which does not depend on the current provided by the input source, which in turn eliminates the dependence of the charger on external variations like the time of day, weather conditions or temperature. The effects of the changing voltage are also minimized since the voltage is being regulated.

2.2.3.1Charging Circuit:

The full charger feedback control circuit can be seen in Fig2.18. This circuit implements a three stage charger algorithm: constant current state, constant voltage full charge state, and constant voltage float charges state.

The comparator is used to provide feedback of the current that the battery is drawing from the circuit: as the battery charges, the current drawn decreases. The current sensing resistor is used to convert that current into voltage, which can be used to compare to a reference within the circuit.

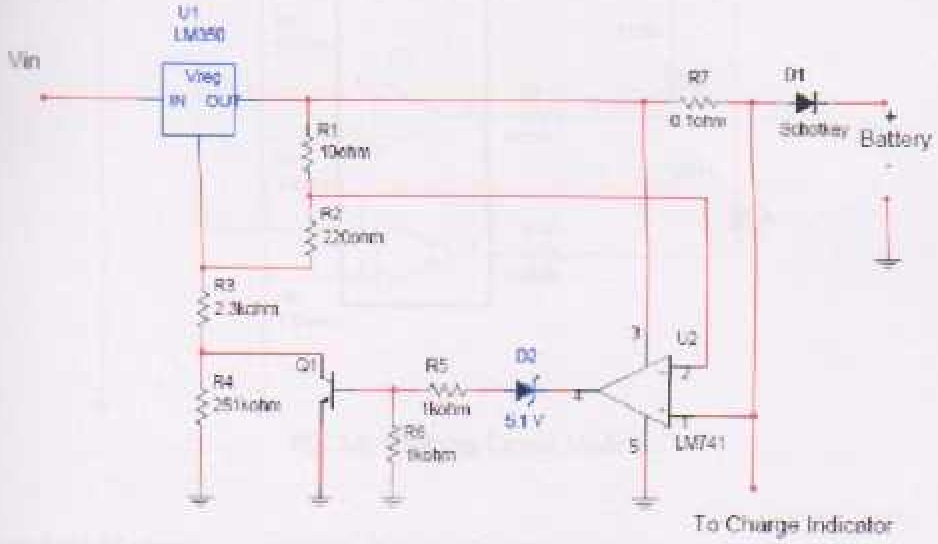


Fig. 2.7: Charging Circuit Equivalent.

2.2.3.2 Battery Indicator

We came up with a very simple design for a voltage monitor. Fig2.19 depicts a quad-voltage comparator (LM324) that used to control a simple bar graph meter to indicate the charge condition of the 12-volt lead acid battery. A 5.4-volt reference voltage (D1) is connected to each of the non-inverting inputs of the four comparators and the inverting inputs are connected to successive points along a voltage divider.

The LED illuminate as the voltage at the inverting terminals exceeds the reference voltage. LED 1turns on at 11 volts, LED 2 turns on at 13 volts, LED 3 turns on at 14 volts, and LED 4 turns on at 14.3 volts.

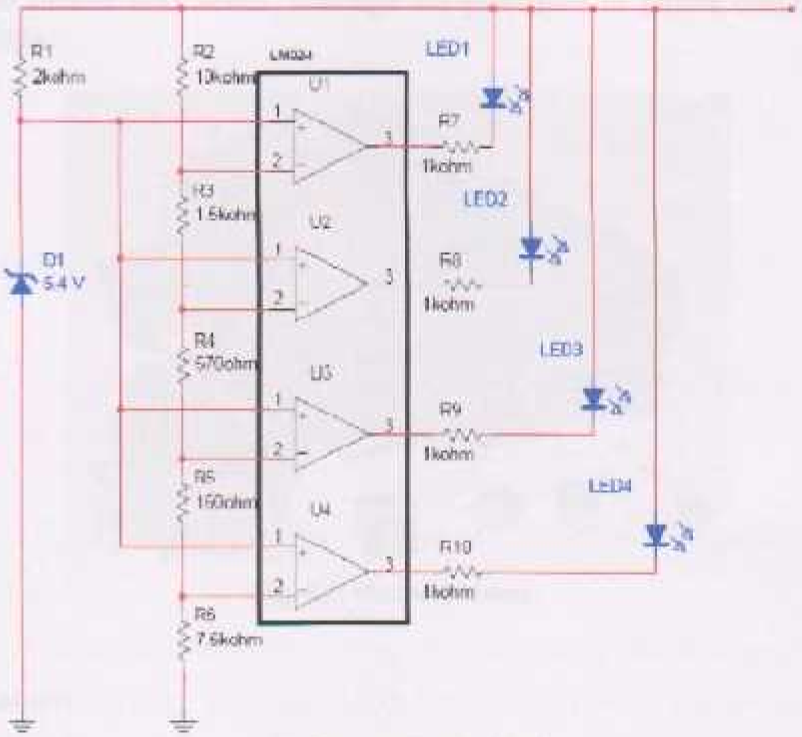


Fig. 2.8: Charging Circuit Module.

2.3 Electrical Motors:

2.3.1 Introduction:

Electrical Motors are used to efficiently convert electrical energy into mechanical energy. Magnetism is the basis of their principles of operation. They use permanent magnets, electromagnets, and exploit the magnetic properties of materials in order to create these amazing machines.

There are several types of electric motors available today. The following outline gives an overview of several popular ones. There are two main classes of motors: AC and DC. AC motors require an alternating current or voltage source to make them work. DC motors require a direct current or voltage source to make them work. Universal motors can work on either type of power. Not only is the construction of the motors different, but the means used to control the speed and torque created by each of these motors also varies, although the principles of power conversion are common to both.

Fig. 2.9: Electrical Motors.

2.3.2 DC Motors:

DC Motors are fairly simple to understand. They are also simple to make and only require a battery or dc supply to make them run.

2.3.2.1 DC Motors Construction:

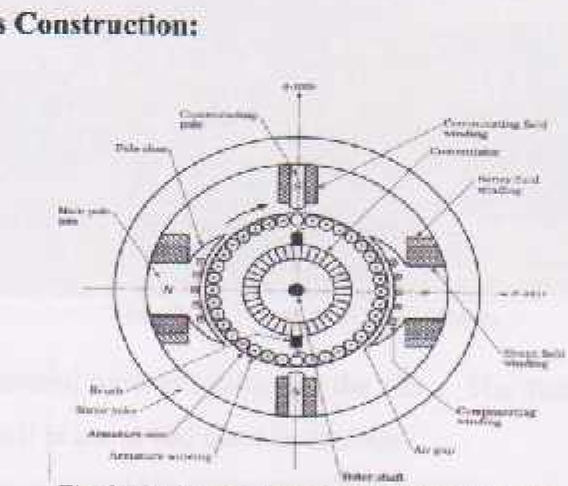


Fig. 2.10: General Arrangement of a DC Motors.

- The stator of the dc motor has poles, which are excited by dc current to produce magnetic fields.

Fig. 2.11: The stator of a DC Motors.

- In the neutral zone, in the middle between the poles, commutating poles are placed to reduce sparking of the commentator.
- The commutating poles are supplied by dc current.
- Compensating windings are mounted on the main poles. These short-circuited windings damp rotor oscillations.
- The poles are mounted on an iron core that provides a closed magnetic circuit.
- The motor housing supports the iron core, the brushes and the bearings.
- The rotor has a ring-shaped laminated iron core with slots.

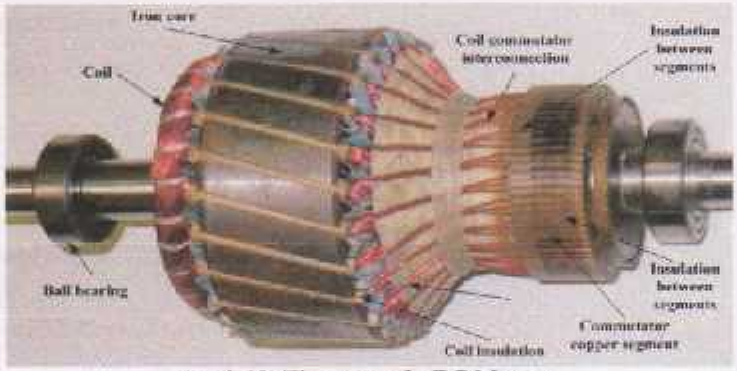


Fig. 2.12: The rotor of a DC Motors.

- Coils with several turns are placed in the slots. The distance between the two legs of the coil is about 180 electric degrees.
- The coils are connected in series through the commentator segments.

- The ends of each coil are connected to a commentator segment.
- The commentator consists of insulated copper segments mounted on an insulated tube.
- Two brushes are pressed to the commentator to permit current flow.
- The brushes are placed in the neutral zone, where the magnetic field is close to zero, to reduce arcing.
- The commentator switches the current from one rotor coil to the adjacent coil.
- The switching requires the interruption of the coil current.
- The sudden interruption of an inductive current generates high voltages.
- The high voltage produces flashover and arcing between the commentator segment and the brush.

2.3.2.2 Dc Motor Operation:

There are five different methods for supplying the dc current to the motor:

1- Separate excitation.
2- Shunt connection.
3- Series connection.
4- Compound.
5- Permanent magnet (Wiper Motor).

2.3.2.3 Advantages and Disadvantages of DC Motors:

Advantages of dc motors:

- Easy to understand design.
- Easy to control speed.
- Simple, cheap drive design.

Disadvantages of dc motors:

- Expensive to produce.

- Physically larger.
- High maintenance.

Chapter Three

Design and Analysis

Introduction:

This chapter contains the mechanical component of the system and equation needed to build the system..

The content part is:

- **General structure.**
- **Elevator cart.**
- **Pulley.**
- **Wheels.**
- **Wheels path.**
- **Gearboxes.**
- **System calculation.**
  - **Motor calculation.**
  - **Sizing PV System.**
  - **Battery sizing .**
  - **Mat lap Simulink**

3.1 General structure:

When talking about mechanical design an important thing must be mentioned first is the stress and strain calculations, but in this project these calculations not assumed since the project is simply doesn't have high loads and no high stress or high strain at this one.

Another important thing should be talked about is movements correspond to each part, friction, and normal forces on that part. In the following section all parts going to be described.

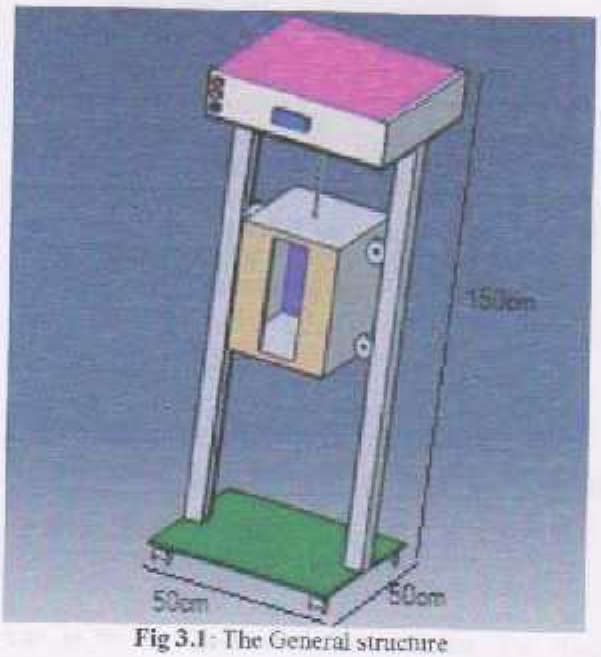


Fig 3.1: The General structure

The third important thing is shaping of the project, that means the construction of the project must by good looking, but in the contrary, the shaping and the construction of the project must keep the parts to move, rotate, and translate freely without any obstacles, so the best shape design has chosen and it appear in the three dimensions (3D) views of all the parts in fig 3.1.

3.2 Elevator cart

The elevator car is the cage that is left up and down on the secondary of the motor, and goes in and out the persons. The fig (3.3) has shown the elevator car.

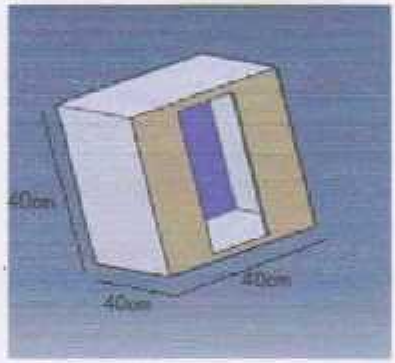


Fig. 3.2: Elevator car

This car has a length 40cm , width 40cm , height 40cm ,and the structure consists of aluminum to be lighter weight..

The elevator car is to be controlled its position, the displacement, and the velocity. It is have an air gap that difference of the permanent magnet and a coil that makes the magnetic field. In this project will install solar cells with a car elevator to move with the car.

3.3 pulleys

Pulleys are used to change direction of movement or to link parts of a mechanism together.The amount of increase in the force depends on how many times the rope wraps round the pulleys .By wrapping the rope several times around the pulleys it is easily possible to lift your own weight off the ground.

Fig. 3.3: The pulley form

In this project uses simple pulley .As the rope is pulled down the weight moves up by the same distance.

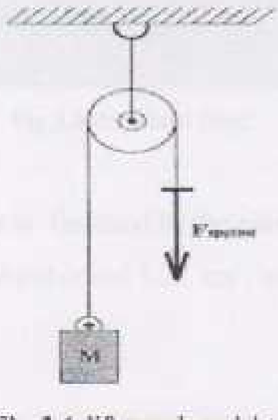


Fig. 3.4: lift sample weight

3.4 Wheels

A wheel is a circular device that is capable of rotating on an axle through its centre, facilitating movement or transportation while supporting a load (mass), or performing labour in machines. Common examples are found in transport applications. A wheel, together with an axle overcomes friction by facilitating motion by rolling. In order for wheels to rotate, a movement needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force.

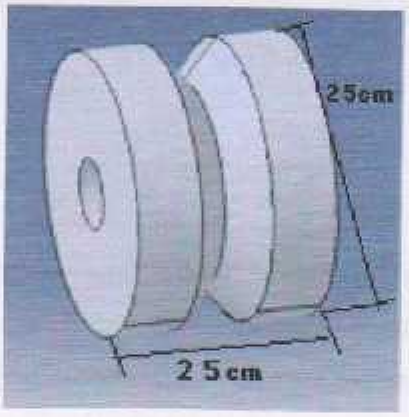


Fig 3.5:the wheel form.

In this project use four wheels fastened to the elevator car as . Fig 3.5 represents a form of wheel. the radius of the wheel equal 1.25 cm , and the width equal 2

3.5 Wheels path

Wheels path is the path that the wheels are moving it vertically up and down, fig 3.6 represents a form of wheel path.

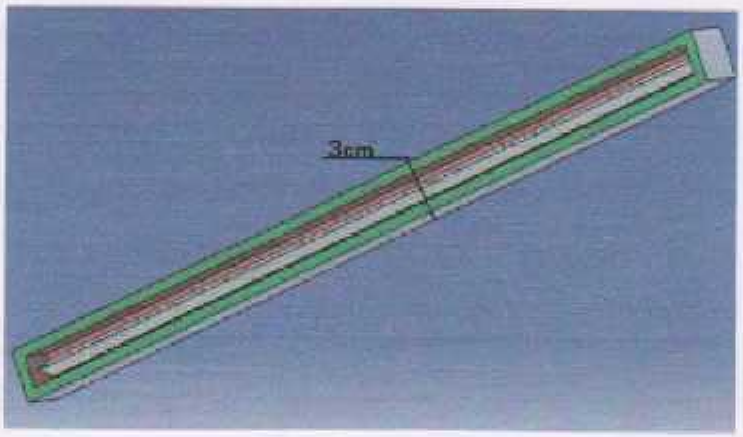


Fig3.6:wheel path.

3.6 Gearboxes [2]

Gear head motors begins simply with a standard DC motor. The next major component is the spur gearbox. This consists of a series of small gears that mesh with larger gears, and placed in a rigid frame. The gears are greased to minimize friction and then secured in a gearbox cover to avoid debris from entering and disrupting the gears. Finally, a pair of screws fastens the gearbox on top of the DC Motor.

Fig. 3.7: gear box.

In this project gear use to convert the speed by limit ratio, that is

$$a = \frac{N_1}{N_2} \quad \text{...(3.1)}$$

Where: N_1: the number tooth of first pulley.

N_2: the number tooth of second pulley.

The mass of first pulley is X gm.

The mass of second pulley is Y kg.

The moment of inertia of the first pulley is:

$$JP_1 = 0.2X \times 10^{-3}\, kg.m^2 \quad \text{.. (3.2)}$$

The moment of inertia of the second pulley:

$$JP_2 = 0.2Y \times kg.m^2 \quad \text{.. (3.3)}$$

The gear ratio is 1:75

$$a = \frac{N_1}{N_2} = \frac{1}{75} = 0.013$$

3.7 calculations and analysis .[2]

By mechanical equation we calculate the speed, torque and power of the motor, to choose the appropriate motor to move the elevator.

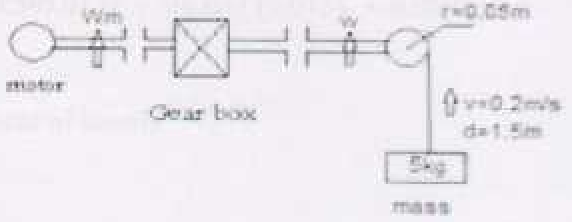


Fig. 3.8: Equivalent circuit of electric drive.

Speed of elevator equal 0.2m/s and the radius of the pulley is 0.05m.

- $a = 0.013$
- $v = \omega \times r$ .... (3.4)
- $\omega = \frac{v}{r} = \frac{0.251}{0.05} = 5.024r^{-1}$ .... (3.5)
- $n = \frac{60\omega}{2\pi} = \frac{60(5.02)}{2(3.14)} = 48rpm$ ....(3.6)
- $\omega_m = \frac{\omega}{a} = \frac{5.02}{0.013} = 376.87s^{-1}$ .... (3.7)
- $n_m = \frac{n}{a} = \frac{48}{0.013} = 3600rpm$ .... (3.8)

Where:

a: gear ratio.

v : Speed of elevator.

r : Radius pulley.

ω: angular velocity.

n_m : Motor speed.

To calculate equivalent moment of inertia of the drive referred to motor shaft:

$J_{oe} = J_m + J_g + J_w a^2 + mr^2 a^2$ .... (3.9)

$$J_{eq} = 0.001 + 0.001 + 0.5(0.013)^2 + 5(0.05)^2(0.013)^2 = 0.002 kg.m^2$$

Where:

J_{eq} : Equivalent moment of inertia.

J_m :Motor inertia.

J_g :Gear inertia.

m :Weight to be lifted.

To calculate the equivalent motor torque:

$$T_m = T_{fm} + T_{fp}\frac{a}{\eta_g} + \left(F\frac{r}{\eta_g}\right)\frac{a}{\eta_g} \quad (3.10)$$

$$T_m = 1Nm + 5Nm\frac{0.013}{0.8} + (5)(9.81)\left(\frac{0.05}{0.8}\right)\left(\frac{0.013}{0.8}\right) = 1.2Nm$$

Where:

T_m: Motor torque.

T_{fm}: Friction torque at motor shaft.

T_{fp}: Friction torque at pulley shaft.

η_g: Gear efficiency.

F : Force resulting from the weight.

Output power of the motor:

$$P_{out} = \omega_m T_m \quad (3.11)$$

$$P_{out} = (5.025)(3.08) = 15.47 watt$$

Input power of the motor:

$$P_{in} = \frac{P_{out}}{\eta} \quad \text{...(3.12)}$$

$$P_{in} = \frac{15.477}{0.8 * 0.8} = 24.18 watt$$

Where: η Efficiency of motor.

3.7.1 Motor calculation [3]

Basic equations applicable to all dc motor are:

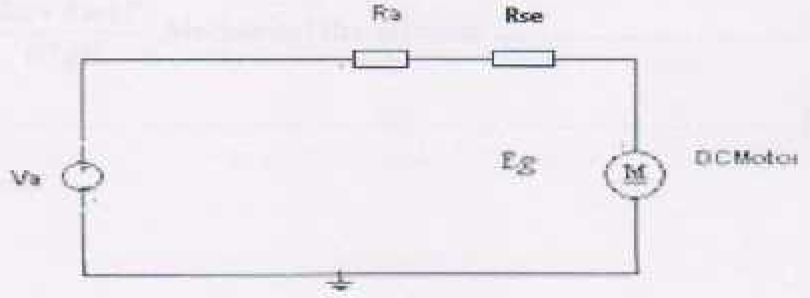


Fig. 3.9: Steady State Equivalent Circuit of Armature

Series equations [4].

$$E = C.\phi \times \omega \quad \text{..(3.13)}$$

$$Va = E + (Ra + Rse) \times Ia \quad \text{..(3.14)}$$

$$T = C.\phi \times Ia \quad \text{..(3.15)}$$

Where: ϕ : Flux per pole.

I_a : Armature Current, Ampere.

V_a : Armature Voltage, volt.

R_a : Resistance of the armature circuit, Ω.

Rse : Resistance of the field circuit, Ω

ω_m : Speed of armature, Rad/sec.

T : torque developed by motor, N.m.

$C\phi$: Motor constant.

From Equation (4.13 – 4.15) the mechanical angular frequency could be represented as:

$$\omega = \frac{Va}{C.\phi} - \frac{(Ra + Rse).Ia}{C.\phi}$$; Electro mechanical characteristic .... (3.16).

$$\omega = \frac{Va}{C.\phi} - \frac{(Ra + Rse).T}{(C.\phi)^2}$$; Mechanical characteristic .... (3.17).

$$P_m = V_a I_a \quad \text{..................} \quad (3.18).$$

$P_m = 24.18 watt$

$V_a = 24 volt$

$I_a = \frac{24.18}{24} = 1.007A$

By equation 3.15 we can calculate $C\Phi$

$C\Phi = T/I_a = \frac{1.2}{1.007} = 1.19$

By equation 3.13 we can calculate E_g

$E_g = C\phi\omega_m = (1.19)(5.025) = 5.98 volt$

The speed-torque and torque- current characteristics of a PM dc motor for rated terminal voltage are shown in Figure (4.11). The speed-torque curve is a straight line.

Speed decreases as torque increases and speed regulation depends on the armature circuit resistance.

The used drop in speed from no load to full load, in case a medium size motor is of the order of 5%. Depending on the Motor calculation we select the motor has a standard specification following:

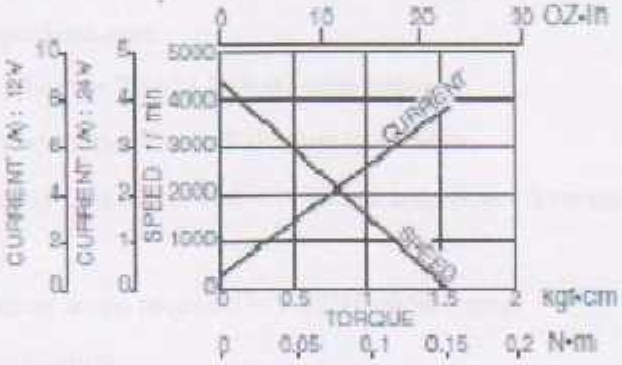


Fig. 4.10: Performances of dc motors.

3.7.2 Sizing PV System:

To calculate the number of solar cells needed to operate the load follow the following steps

- $E = P_{in} \times T \longrightarrow$ (1) Where: E: Energy (Watt)

  P_{in}: input Power of Motor (Watt)

  T: Time (Hour)

  P_{in} = 24.18 Watt, and T = 6 Hours/days.

  $E = 24.18*6 = 145.08$ wh/days.

- Divide the energy by the efficiency of chopper and battery:

  $\eta_c = 0.8$, where ηc : efficiency of chopper and battery.

E_1=145.08/0.8=181.35wh/days

- DC input voltage, usually 12, 24, or48 voltage .

  select v = 24 volt
- Average amp hour = E_1/v

  Average amp hour = 181.35/24= 7.56amp.h/day.
- Multiply Total average amp hours per day by 1.2 to compensate for loss from battery charge/discharge.

  Average amp hour = 7.56*1.2=9.07 amp.h/day
- Average sun hours per day in Palestine is 10 hour.
- Total solar array amps required = (average amp hour/ Average sun hours per day in Palestine).

  Total solar array amps required = 9.07/10=0.907 amp.
- Module specification:

  Maximum power = 40 w.

  Maximum power voltage = 17.4 v.

  Maximum power current = 2.29 amp.

  Open circuit voltage = 21.7 v.

  Short circuit current = 3.31 amp.
- Total number of solar modules in parallel required:

  # module = (Total solar array amps required/ Maximum power current)

  # module = (0.907/2.29) = 0.4 ≅ 1module.

3.7.3 Battery sizing

To calculate the number battery needed to operate the load when cut the source follow the following steps:

- Average amp hour = 9.07 amp.h/day.
- Maximum number of continuous cloudy days expected in Palestine is (3)
- Amount of Amp hour storage needed = (Average amp hour * cloudy days)
  Amount of Amp hour storage needed = 9.07 * 3 = 27.21 amp.h.
- Discharge limit for the batteries is (0.8)
- Divide Amount of Amp hour storage needed by Discharge limit for the batteries
  Amount of Amp hour storage needed = 27.21/.8 =34.01 amp.h

- The Amp hour rating for your batteries is 24 amp.h
- Number of batteries wired in parallel needed = (Amount of Amp hour storage needed/ Amp hour rating for your batteries)
  # batteries = (34.01/24) = 1.42 ≅ 2

So we needed tow batteries each one has the following specification:
24 V DC, 24 Amp. Hour, 0.8 deep cycle, sun rise model.

Chapter Four

Control system of elevator

- Introduction.
- Mechatronics part.
- Block diagram.
- Microcontroller.
- Introduction to Microcontroller.
- Choosing a chip.
- Programming microcontroller.
- Pulse Width Modulation (PWM).
- The Regulator.
- LCD (Liquid Crystal Display).
- Push Button Switches.
- Photo coupler.
- Control System Implementation.

4.1 Introduction

In this project, we need to build a prototype so that we need to use modern technology to control the elevator and to make something different form the general control whew published in this day in industrial manufacture called programmable logic control (PLC) so we need to use microcontroller (PIC) as a major controller to control the elevator.

4.2 Mechatronics part

The controlling of a elevator speed, vibration, voltage, position, acceleration using a elevator system represents the integration of four basic subsystems, which are, the mechanical, electrical, control and computer, which are the four basic disciplines that make up mechatronics, as shown in figure (4.1).

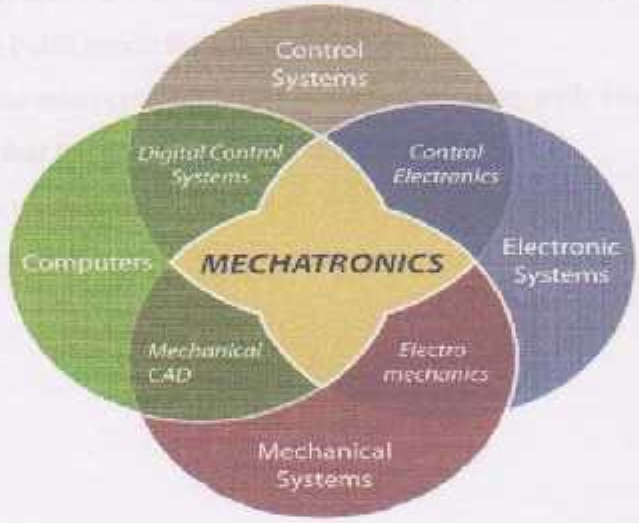


Fig 4.1 Mechatronics basic disciplines

4.3 Block diagram

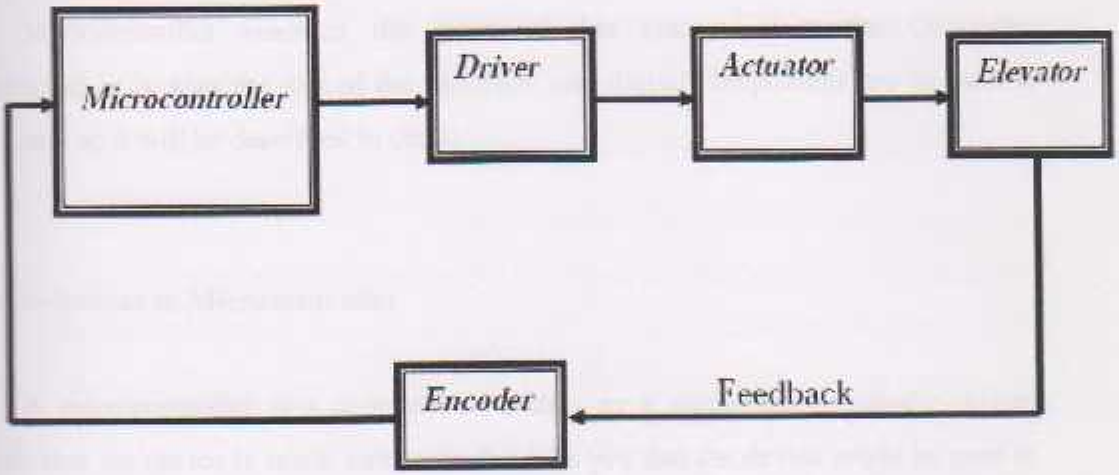


Fig 4.2 block diagram of control system

- **Microcontroller:** it's the brain in the control system and all the loops control, commands build inside the microcontroller.
- **Driver:** the microcontroller can't supply the motor with required voltage and current so that the driver amplifies the required values.
- **Actuator :** dc motor
- **Sensor:** encoder

4.4 Microcontroller

Microcontroller assumed the brain of this system, since the Controller programmed in it, also the rest of the electrical and digital components are connected with it, and so it will be described in detail.

4.5 Introduction to Microcontroller

A microcontroller is a computer-on-a-chip, or a single-chip computer. Micro suggests that the device is small, and controller tells you that the device might be used to control objects, processes, or events. Microcontrollers can be found in all kinds of things these days. Any device that measures, stores, controls, calculates, or displays information is a candidate for putting a microcontroller inside. The largest single use for microcontrollers is in automobiles; just about every car manufactured today includes at least one microcontroller for engine control, and often more to control additional systems in the car. In desktop computers, you can find microcontrollers inside keyboards, modems, printers, and other peripherals. In test equipment, microcontrollers make it easy to add features such as the ability to store measurements, to create and store user routines, and to display messages and waveforms. Consumer products that use microcontrollers include cameras, video recorders, compact-disk players, and ovens [1].

Microcontrollers have long been a convenient interface for the embedded systems; they represent the core of the control system for the electronic devices in dedicated applications. Thus, in contrast the microprocessors that are used in general purpose applications like personal computers that need high-performance. Microcontrollers contain data and program memory, serial and parallel I/O, timers, and external and internal interrupts [2], and many more peripherals, made them a strong choice when implementing control systems.

4.6 Choosing a chip

All microcontrollers contain a CPU, within each device family, usually a selection of family members are found, each with different combinations of options. For example, the 8052-BASIC is a member of the 8051 family of microcontrollers, which includes chips with program memory in ROM or EPROM, and with varying amounts of RAM and other features. The version that best suits the system's requirements must be selected. Microcontrollers are also characterized by how many bits of data they process at once, with a higher number of bits generally indicating a faster or more powerful chip. Eight-bit chips are popular for simpler designs, but 4-bit, 16-bit, and 32-bit architectures are also available. The PIC 18F4550 is an 8-bit chip. [1]

Power consumption is another consideration, especially for battery-powered systems. Chips manufactured with CMOS processes usually have lower power consumption than those manufactured with NMOS processes. Many CMOS devices have special standby or "sleep" modes that limit current consumption to as low as a few microamperes when the circuits are inactive. Using these modes, a data logger can reduce its power consumption between samples, and power up only when it's time to take data.

The PIC microcontroller (PIC 18F4550) from Microchip has chosen in this project since its found easily, has a lot of ports (port A, B, C, D and E), can be programmed simply and it give all characteristics that the project needs. A PIC18F4550 port is shown in figure (4.3).

Fig 4.3 PIC18F4550

4.7 Programming microcontrollers

Programming PIC microcontrollers is a simple three steps process, write the code, compile the code, and upload the code into a microcontroller. [3] Writing the code can be developed in many Integrated Development Environments (IDE's) for example, MPLAP IDE, which is software, developed for the Microchip appliances like the PIC microcontrollers. Compiling the code can be done by the compiler of the MPLAP IDE. There are different compilers associated to work with PIC chips, C compiler, or assembler for assembly language codes, and many more, the decision of which compiler to use, is a developer choice, depending on the application which the PIC is a part of. The final step of programming the PIC chip is uploading the code into the microcontroller. This can be done also in MPLAP IDE or in different programs that are connected to the PIC kit (figure 4.4). The uploading process can be done through a USB cable or other connecting technique depending on the kit that contains the PIC chip.

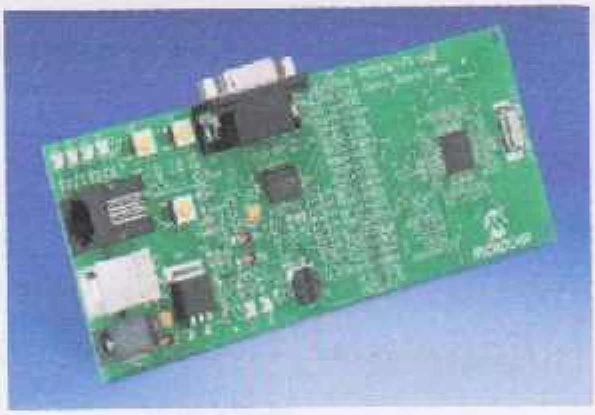


Fig 4.4 PICDEM™ FS-USB Evaluation Kit for PIC18F4550

The PIC microcontroller architecture makes interfacing most peripherals with the PIC a far from hard task, the I/O's are organized as ports, PORTA, PORTB, etc. each port can be treated as a unit or as single I/O pins, 8-bit, 5-bit or other organization. Each port was initially configured to do a specific operation, serial data operations, Analog-to-Digital conversion, and many more, but it's not always necessary to stick with the initial configuration, each port or single I/O pin can be configured to do different operation from what initially configured.

4.8 Pulse Width Modulation (PWM)

Is a very efficient way of providing intermediate amounts of electrical power between fully on and fully off. A simple power switch with a typical power source provides full power only, when switched on. PWM is a comparatively-recent technique, made practical by modern electronic power switches.

PWM is an important property in the microcontroller which used her to control the voltage that drives the motor; the PWM mode produces a PWM output at 8 bit resolution. A PWM output is basically a square waveform with a specified period and duty cycle as shown in figure (4.5).

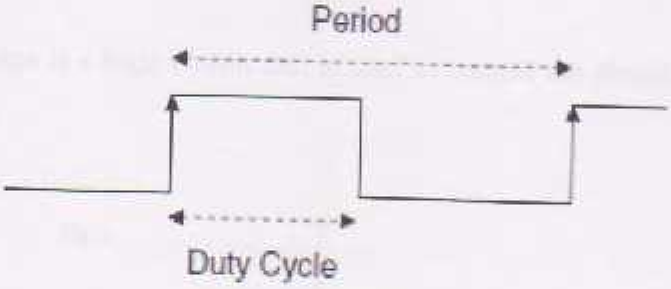


Fig 4.5 PWM Shape.

PIC has the feature of generating pulse with different duty cycles using the PWM (Pulse Width Modulation) pins built in one of its I/O ports, as shown in fig (4.6) the duty cycle of a pulse can be modulated to be within (0 to 100 %), if for example it is 20 % then the pulse is on or logic one for a time forms 20 percent of the total period or pulse time, the idea then is that the average output is the same as duty cycle, more about PWM in PIC is shown in appendix (E).

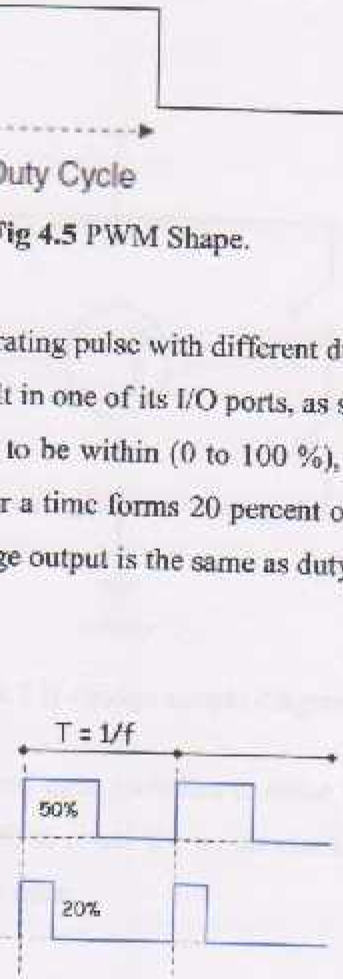


Fig 4.6 PWM and duty cycle

Talking about the PWM without taking about H-bridge circuit is useless, the H-bridge is the circuit needed to translate this modulated pulse into analog signal the actuators understand.

The H Bridge is a logic circuit that is used to control the direction of a motor as shown in fig (4.7).

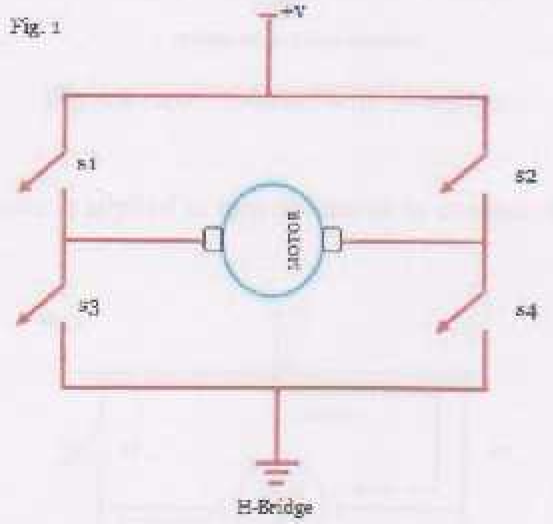


Fig 4.7 H-Bridge simple diagram

The motion needs to close and open switches in order for the motor to rotate in either direction, as shown in fig (4.8) to rotate the motor clockwise, S1 and S4 must be closed while S2 and S3 must be kept open.

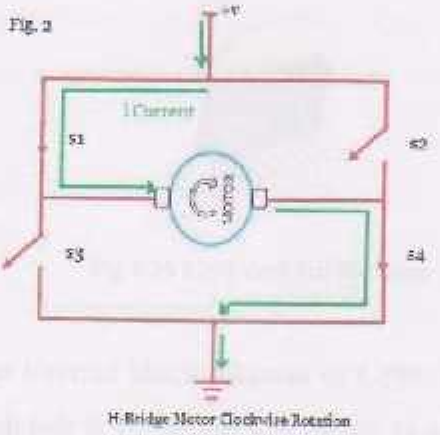


Fig 4.8 motor rotation with H-bridge

While the opposite is applied to turn the motor to counter clock wise as shown in fig (4.9).

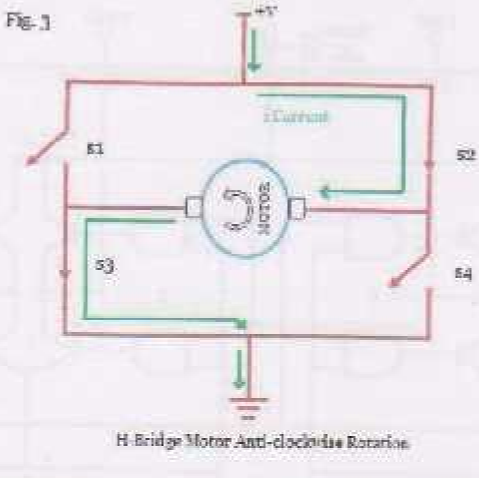


Fig 4.9 motor opposite rotation with H-bridge

L298 shown in fig (4.10) is a high current up to 4 Ampere, high voltage up to 46 VDC dual full-bridge driver designed to accept TTL (square wave of logic 1 (5VDC)) logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors, more details are described in appendix (F).

Fig 4.10 L298 dual full H-bridge

Fig (4.11) shows the internal block diagram of L298, as shown it has 4 outputs (pins 1,2) and (pins 3,4) each pair is connected to a motor, in addition each output pair is controlled by three logic pins In 1, In 2 and En A for the first motor (the first pair of outputs) and pins In 3,In 4 and En B for the second motor, so for any motor if the En port is enabled and one of the (In)s is on and the other is off the motor will rotate in a direction while if the (In)s logic is inverted it will rotate in the opposite direction.

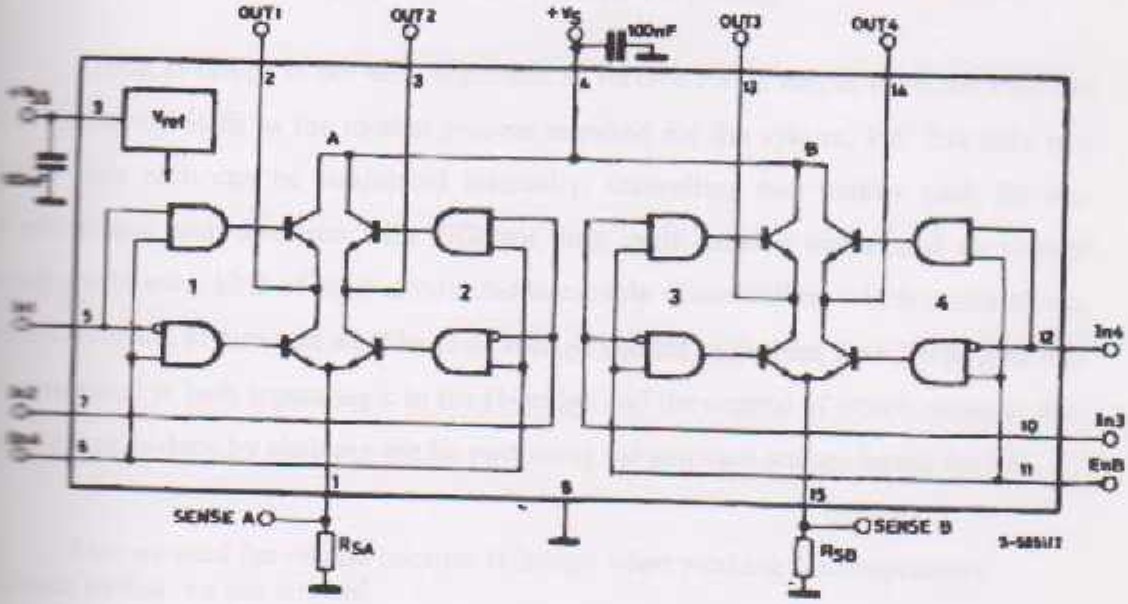
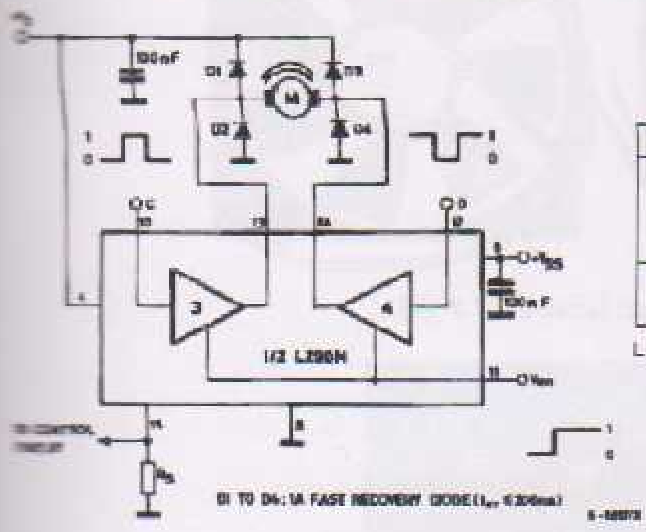


Fig 4.11 internal circuit diagram of H-bridge

The complete truth table for any motor pins is shown in fig (4.12), where the diodes are used to protect the motor from any short circuit could occur.



Inputs		Function
V_{en} = H	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
V_{en} = L	C = X ; D = X	Free Running Motor Stop

L = Low H = High X = Don't care

Fig 4.12 truth table of input ports of H-bridge

Using H-bridge is not only important to receive PWM output from the PIC, but also because it is fit to the motion process required for the system, PIC has only two PWM pins each can be modulated internally, controlling two motors each for two direction and each direction with different duty cycle (analog output and so voltage level) needs some kind of logic circuit that is capable of controlling which motor to use, which direction to turn and what level of voltage needed each time, here PWM pins will be connected to both inputs logic in the H-bridge and the control of which motor to turn on at a time is done by enabling the En port using the software written inside the PIC.

Else we used fan or sink because H-bridge when working the temperature increase so that we use coolers.

Fig 4.13 General fan shape

Fig4.14 General sink shape

4.9 The Regulator

Sometimes a regulator is important when converting the voltage level or when a specified voltage must be entered to a device or an IC in exact level, here the regulator used to convert the voltage level from 12V to 9V to be used for the motor, another regulator used to enter an exact voltage of 5V to the microcontroller input voltage, the regulator input could be any voltage but the output is specified as fig (4.15) shows.

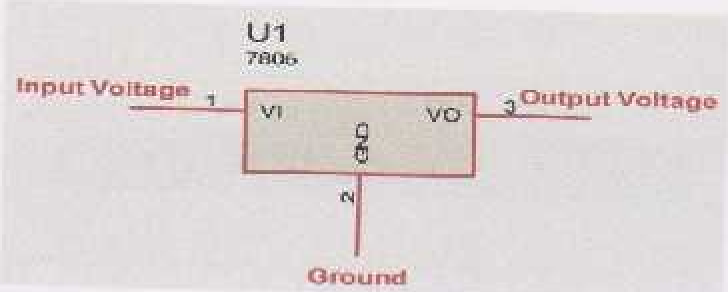


Fig 4.15 Regulator

And we used the regulator because we need to supply all the system from the battery so that we need to regulate the output voltage from the battery because the Microcontroller working at low voltage and all enable pins working at low voltage.

4.20 LCD (Liquid Crystal Display)

LCD is used here to monitor the system's parameters; LCD technology is based on the properties of polarized light. Two thin, polarized panels sandwich a thin liquid-crystal gel that is divided into individual pixels. An X/Y grid of wires allows each pixel in the array to be activated individually. The pixel darkens in proportion to the voltage applied to it for a bright detail, a low voltage is applied to the pixel; for a dark shadow area, a higher voltage is applied [5]. Pins of the LCD which used here are shown in fig (4.16) & (4.17).

Fig 4.16 LCD pins

Fig4.17 LCD display

4.11 Push Button Switches

We show in the fig 4.18 the push button switches are used:

Fig 4.18 push button switches

When we push the switch to specify any level the Microcontroller talk the signal and hold it until the elevator reach to required level else all switches with lamp work at 6V dc the lamp work when the signal hold by the Microcontroller and turn off after the elevator reach to required level.

Note: we used Photo-coupler between the microcontroller and switches because the lamps light need current higher then microcontroller so that we used Photocoupler to protection the microcontroller from over load.

4.12 Photo-coupler

Fig 4.19 Photo-coupler

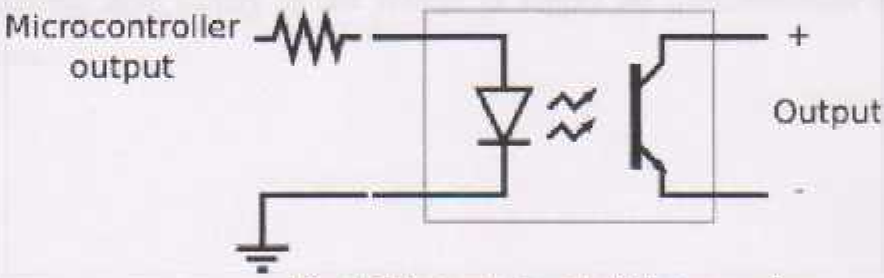


Fig 4.20 Internal circuit of Photo-coupler

4.13 Control System Implementation

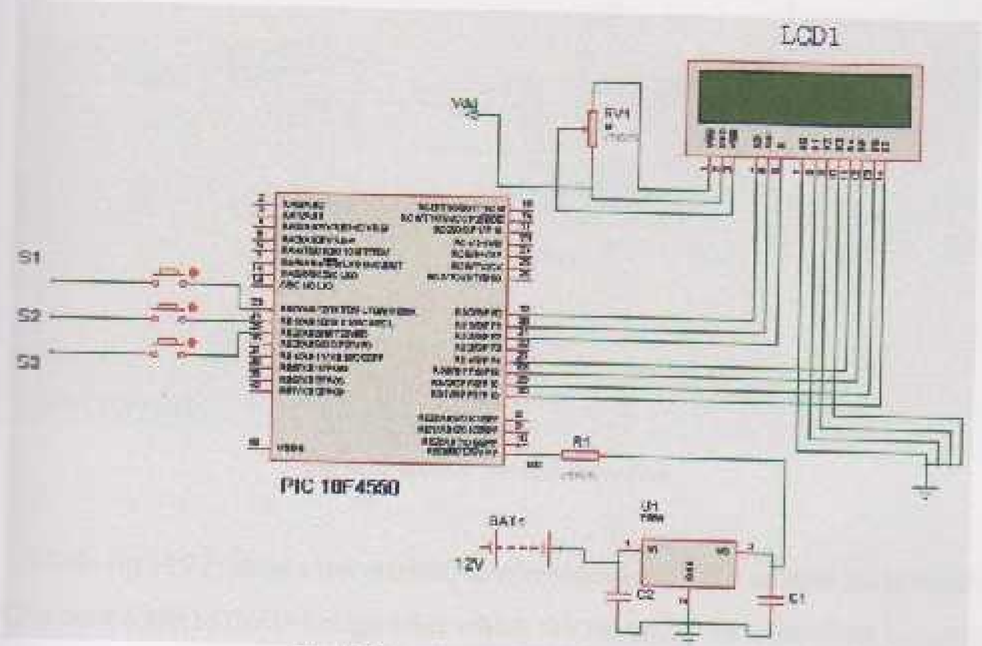


Fig 4.21 control system connection

We show the fig(4.21) display the connection of LCD with microcontroller to display number of level where the elevator reach and we see three push button switch's from this switch's we can demand the elevator else we see the regulator to convert the voltage coming from battery to law voltage to supply the microcontroller and other components.

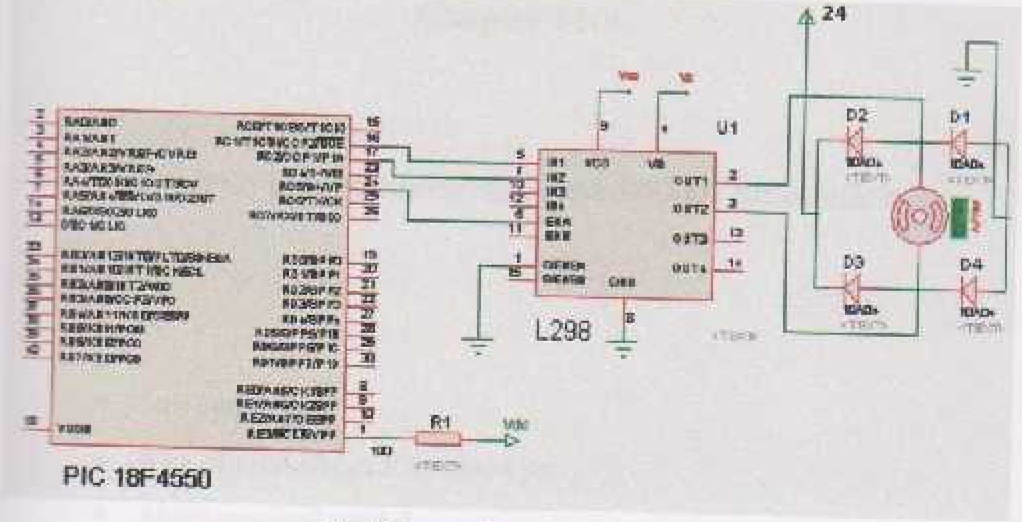


Fig 4.22 control system connection

While fig (4.22) shows the internal implementation of the control system, where the PIC is connected to the H-bridge after which the motors to be controlled is connected and connect the motor in the output of H-bridge.

Chapter Five

Analysis and Mathematical model and Simulation

- ***Introduction***
- **The Movement of Elevator Car**
- **Mathematical model**
- **Trapezoidal velocity profile**
- **Wire Rope & Sheave Design**
- **Transfer Function**
- **Mechanical Analysis and Modelling**
- **Simulation**

5.1 Introduction

Theory and equations are an important section of the project, since the project is based on principles and assumptions that generalized to mathematical model; this mathematical model has the core of the project which the practical work depends on. The mathematical model of the project contains inputs, outputs, block diagram which relate inputs to output as a transfer function.

5.2 The Movement of Elevator Car

The elevator car is moving up and down in vertical line, thus there is a motion result from it, a speed and acceleration are result from it. The equation of motion is given by the following equation

$$ma = F - mg + F_r$$

Where m: mass of the cage *[kg]*, g: acceleration of gravity *[m/s²]*, *Fr*: resistance force due to the wheels *[N]* and that upper direction of the guide way is positive of axis x.

The sign indicates that a plus sign is for falling and a minus sign is for rising. The defection of moving is determined by the magnitude of thrust;

Upward	$F > mg + Fr;$
Downward	$F < mg - Fr$
Stop	$mg - Fr < F < mg + Fr;$

The motion of the elevator is divided into three stages:

1. Constant acceleration: at the beginning of the motion from one floor to another.

2. Constant velocity: after specific period the inertia force overcame and the elevator begins to move with constant velocity.

3. Constant deceleration: when the elevator approach its destination.

Where:

$$a = \begin{bmatrix} a & 0 < t < t_1 \\ 0 & t_1 \le t \le t_f - t_c \\ -a & t_f - t_c \le t \le t_f \end{bmatrix}$$

Which means that the acceleration response must be make fine acceleration - then will be constant and finally make fine deceleration. This can be obviously note the next but in real life the jerk can be ignored because of the constant acceleration so the system description can be as in figure 5.1.

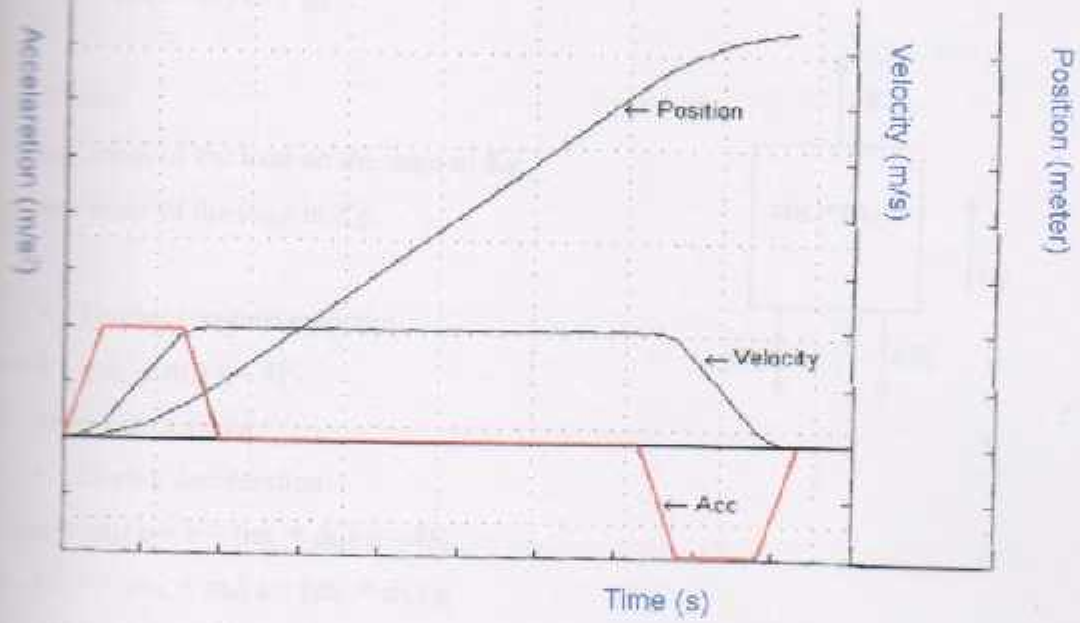


Fig 5. 1 Elevator position, velocity, and acceleration

5.3 Mathematical model

The loading of the elevator is rated between four extreme cases:

1. Raising a full car.
2. Lowering a full car.
3. Raising an empty car.
4. Lowering an empty car.

1. Raising a full Load:

- During acceleration:

$(m_L + m_c)\, a = F - (m_L + m_c)\, g - 4F_r$

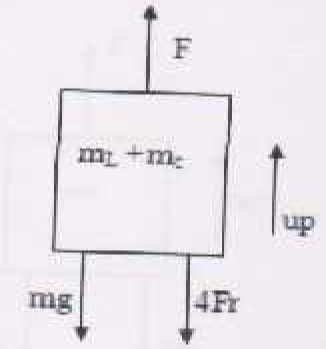
$F - 4F_r = (m_L + m_c)\, a + (m_L + m_c)\, g$

$F - 4F_r = (m_L + m_c)\,(a + g)$

Where:

m_L: mass of the load on the cage in Kg.

m_c: mass of the cage in *Kg*.



- During constant velocity:

$0 = F - (m_L + m_c)\, g - 4F_r$

$F - 4Fr = (m_L + m_c)\, g$

- During deceleration:

$-(m_L + m_c)\, a = F - (m_L + m_c)\, g - 4F_r$

$F - 4F_r = -(m_L + m_c)\, a + (m_L + m_c)\, g$

$F - 4F_r = (m_L + m_c)\,(g - a)$

2. Lowering empty car:

- During acceleration:

$m_e\,a = F - m_e\,g + 4F_r$

$F + 4F_r = m_e\,a + m_e\,g$

$F + 4F_r = m_e\,(a + g)$

- During constant velocity:

$0 = F - m_e\,g + 4F_r$

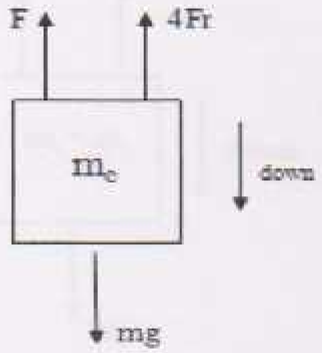
$F + 4F_r = m_e\,g$

- During deceleration:

$-m_e\,a = F - m_e\,g + 4F_r$

$F + 4F_r = -m_e\,a + m_e\,g$

$F + 4F_r = m_e\,(g - a)$



3. Raising an empty car:

- During acceleration:

$m_e\,a = F - m_e\,g - 4F_r$

$F - 4F_r = m_e\,a + m_e\,g$

$F - 4F_r = m_e\,(a + g)$

- During constant velocity:

$0 = F - m_e\,g - 4F_r$

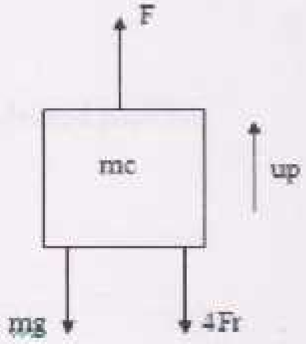
$F - 4Fr = m_e\,g$

- During deceleration:

$-m_e\,a = F - m_e\,g - 4F_r$

$F - 4F_r = -m_e\,a + m_e\,g$

$F - 4F_r = m_e\,(g - a)$



4. Lowering a full car:

- During acceleration:

$(m_L+m_c)\,a = F - (m_L+m_c)\,g + 4F_r$

$F + 4F_r = (m_L+m_c)\,a + (m_L+m_c)\,g$

$F + 4F_r = (m_L+m_c)\,(a + g)$

- During constant velocity:

$0 = F - (m_L+m_c)\,g + 4F_r$

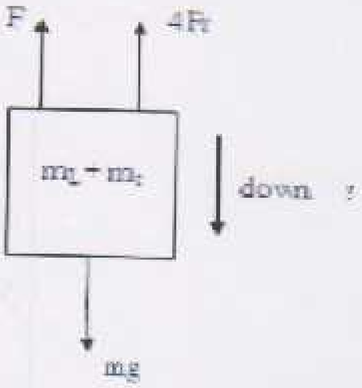
$F + 4F_r = (m_L+m_c)\,g$

- During deceleration:

$(m_L+m_c)\,a = F - (m_L+m_c)\,g + 4F_r$

$F + 4F_r = (m_L+m_c)\,a + (m_L+m_c)\,g$

$F + 4F_r = (m_L+m_c)\,(a + g)$



5.4 Trapezoidal velocity profile:

By specifying the q_i, q_f, t_f, and the admissible velocity q_c for elevator car. Where:

q_i: The initial car position.

q_f: The final car position.

t_f: The final time for elevator car to reach the desired position.

$q_c = (q_i + q_f) / 2 - q_c / (t_f - t_c)$

Also:

$q_c = q_i + q_i t_c + 0.5\, q''_c\, t^2_c$

$q_c = q'_i + q_i'' t_c$

$q_c = q_i'' t_c$

$q_i'' = q_c / t_c$

$q_c = q_i + 0.5\, q\, t_c$

$t_c = (q_i - q_f + q_i' t_c) / q'_c$

Constant speed in selecting the maximum speed q we know that $0 \le t_c \le t_f / 2$

$q_c \le 2(q_i - q_f) / t_f$

$(q_i - q_f) / t_f \le q_c \le 2(q_i - q_f) / t_f$

$$q(t) = \begin{cases} q_i + \frac{1}{2}\frac{q_c}{t_c} t^2 & , \ 0 \le t \le t_c \\ q_i + q_c\left(t - \frac{t_c}{2}\right) & , \ t_c \le t \le t_f - t_c \\ q_f + \frac{1}{2}\frac{q_c}{t_c}(t_f - t)^2 & , \ t_f - t_c \le t \le t_f \end{cases}$$

The elevator is designed to travel at $q_i = 0$, $q_f = 1.5$m in 15 second at each floor with a consisting of velocity q =0.1m/s, the number of floors is 3, then to calculate the car position and acceleration.

5.5 Wire Rope & Sheave Design

Main specification for elevator:

- Car weight = 4kg
- Passenger weight = 2kg
- Length of wire rope (L) = 1.5m
- No. of ropes= 1
- Speed of elevator = 0.2m/s

Design equation:

w rope + w car + w passenger + Equivalent being load + Inertia load =

$\frac{\Pi}{4}$ d²rope * $\frac{Su}{f.o.s}$ =

A*sigma=f=w

Sigma= Su/f.o.s

1) w rope = 0.036 d²rope * (length of wire rope)

= 1.19 d²rope N

2) w car + w passenger = (4+2)*9.8 = 58.8 N

W /#ropes = $\frac{58.8}{1}$ = 58.8 N

3) Equivalent bending load = E.B.L

$= \frac{3}{8} Er \frac{0.063\,drope}{D_{sheave}} * A$

Er= Modulus of elasticity = 80 GPA

A = Area of wire rope

$E.B.L = \frac{3}{8} * 80 * 10^3 * \frac{0.063\,drope}{45\,drope} * \pi/_4\, d^2 rope$

$= 33\, d^2$ rope N

4) I.L = mass * acceleration

$I.L = \frac{w\,rope + w\,car + w\,passenger}{9.8} * A$

$a = v\frac{dv}{dy}$

$\int v\,dv = a \int_0^1 dy$

$\frac{v2}{2} = a[y]_0^1$

$(0.2)^2 = 2a*1$

A= 0.02 m/s^2

$\therefore$ I.L = $\frac{1.19\, d^2\, rope + 58.8}{9.8} * 0.02$

= 0.00243 d^2 rope + 0

Assume material steel

$\therefore$ su= 730 Mpa

Assume f.o.s =8

$\therefore$ F_t = 1.19 d^2 rope + 58.8 +33 d^2 rope + 0.00243 d^2 rope + 0.12

$= \frac{730}{8} * \frac{\pi}{4} d^2 rope$

$\therefore$ 34.2 d^2 rope + 58.92 = 71.66 d^2 rope

D rope = 1.57 mm

$\therefore$ D_{Sheave} = 71 mm

Take D_{Sheave} = 85 mm

5.6 Transfer function (G(s))

The analysis of the internal dc motor where its model in s-domain is shown in fig (5.2)

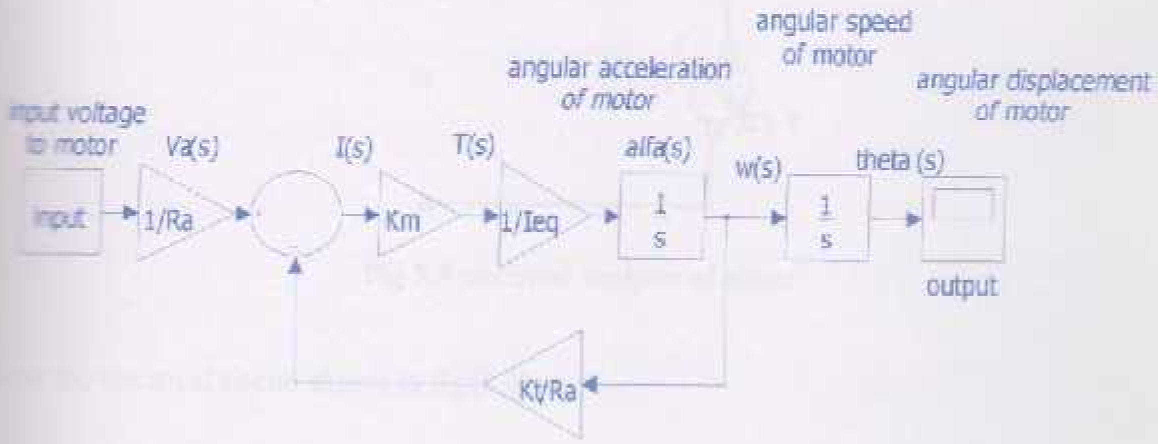


Fig 5.2 motor block diagram

$$T = K_m I_a \quad 5.1$$

Where T is the torque at motor shaft, K_m is the motor torque constant and I_a is the armature current.

The Laplace transform of this equation is:

$$T(s) = K_m I_a(s) \qquad 5.2$$

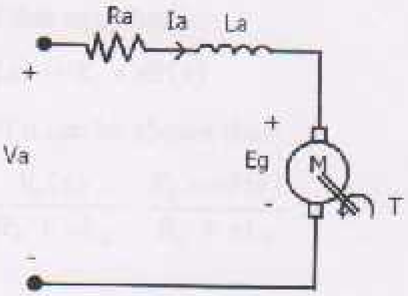


Fig 5.3 electrical analysis of motor

From the electrical circuit shown in fig (5.3)

$$V_a = I_a * R_a + I_a' * L_a + E_g \qquad 5.3$$

Where V_a is the armature voltage, R_a is the armature resistance, L_a is the armature inductance and E_g is the induced voltage.

The Laplace transform of this equation is:

$$V_a(s) = I_a(s)(R_a + sL_a) + E_g(s) \qquad 5.4$$

The induced voltage in motor is related to its angular velocity as follows

$$E_g = K_t * w \qquad 5.5$$

Where w is the angular velocity of the motor and K_t is the back electromotive force constant.

The Laplace transform of this equation is:

$$E_g(s) = K_t * s\theta(s) \quad 5.6$$

From eq (5.4) and eq (5.6) it can be shown that:

$$I_a(s) = \frac{V_a(s)}{R_a + sL_a} - \frac{K_t * s\theta(s)}{R_a + sL_a} \quad 5.7$$

If it is assumed that the armature inductance L_a is small compared to R_a, then eq 5.7 becomes

$$I_a(s) = \frac{V_a(s)}{R_a} - \frac{K_t * s\theta(s)}{R_a}$$

To find K_t the induced voltage must be found, for the previous motor speed the armature voltage $V_a = 24\ V$, the motor internal resistance $R_a = 6.1\ \Omega$ and the armature current $I_a = 0.3\ A$, for these values

$$E_g = V_a - I_a R_a \quad 5.8$$

$$E_g = 24 - 0.3 * 6.1$$

$$E_g = 22.17\ V$$

Then the electromagnetic constant of the actuator K_t is calculated according to eq5.5

$$E_g = K_t * \omega$$

$$K_t = \frac{E_g}{\omega}$$

$$K_t = \frac{22.17}{5.026} = 4.41\ V.s/rad$$

In order to find torque/current constant the torque produced for the previous armature voltage was found where the efficiency of the actuator is η =0.85 then

$$P_{in} = \frac{P_{out}}{\eta} \quad 5.9$$

Substituting for P_{in} and P_{out} yields

$$V_a I_a = \frac{T\omega}{\eta}$$

$$12 * 0.15 = \frac{T * 5.026}{0.85}$$

$$T = 1.21767\ N.m$$

Back to eq 5.1 the electromechanical constant K_m is calculated through the following equation

$$K_m = \frac{T}{I_a}$$

$$K_m = \frac{1.217672}{0.3} = 4.06\ N.m/A$$

5.7 Mechanical Analysis and Modelling

The mechanical analysis of the basic structure

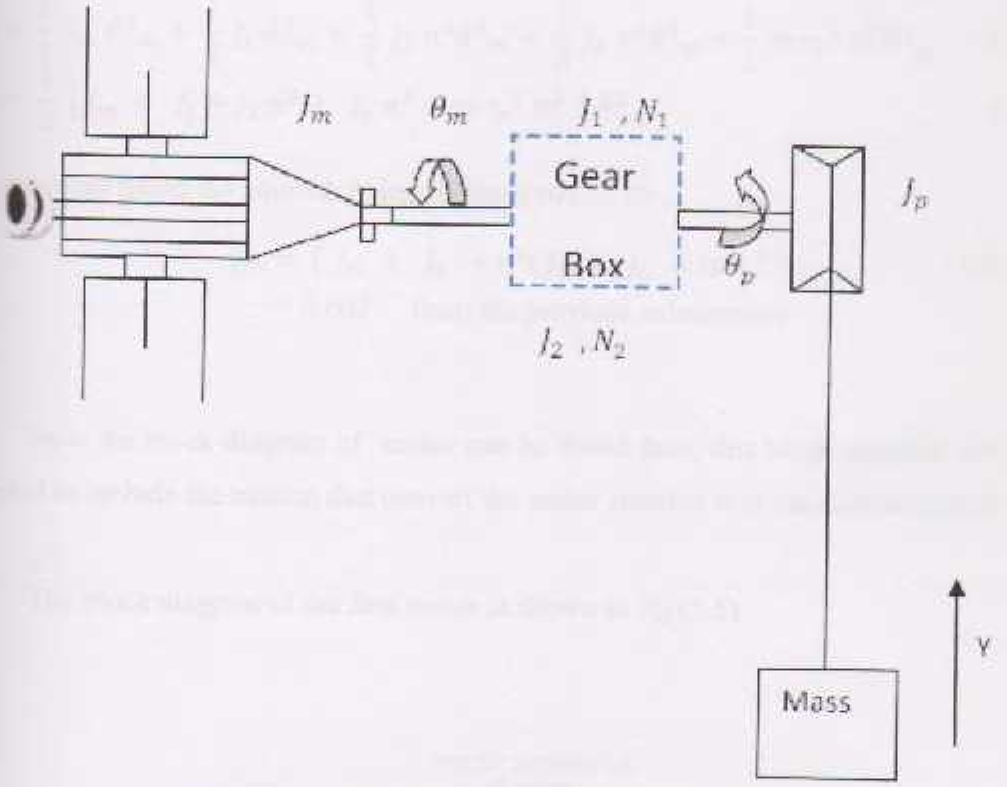


Fig 5.4 block diagram of mechanical structure

Where we need to find J_{eq} is the equivalent mass moment of inertia at motor shaft to find the transfer function.

We can found Kinematic energy reflected at motor shaft from the **fig 5.4**:

$$KE = \frac{1}{2} J_m \dot{\theta}^2{}_m + \frac{1}{2} J_1 \dot{\theta}^2{}_m + \frac{1}{2} J_2 \dot{\theta}^2{}_p + \frac{1}{2} J_p \dot{\theta}^2{}_p + \frac{1}{2} m \dot{y}^2 \qquad 5.10$$

$$\theta_p = \frac{N_1}{N_2} \theta_m \quad , \quad n = \frac{N_1}{N_2} \qquad 5.11$$

$$\dot{\theta}_p = n\,\dot{\theta}_m \qquad 5.12$$
$$\dot{y} = r_p\,\dot{\theta}_p = r_p n \dot{\theta}_m \qquad 5.13$$

By sub. All equations in 5.10 we found KE

$$KE = \frac{1}{2} J_m \dot{\theta}^2{}_m + \frac{1}{2} J_1 \dot{\theta}^2{}_m + \frac{1}{2} J_2\, n^2 \dot{\theta}^2{}_m + \frac{1}{2} J_p\, n^2 \dot{\theta}^2{}_m + \frac{1}{2}\, m\, r_p{}^2\, n^2 \dot{\theta}^2{}_m \qquad 5.14$$

$$KE = \frac{1}{2}\left[J_m + J_1 + J_2\, n^2 + J_p\, n^2 + m\, r_p{}^2\, n^2\right] \dot{\theta}^2{}_m \qquad 5.16$$

Know we can found the equivalent inertia from equ. 5.16:

$$J_{eq} = [\, J_m + J_1 + n^2 (J_2 + J_p + m\, r_p{}^2\,)] \qquad 5.17$$

$= 0.002$ from the previous calculations

Now the block diagram of motor can be found then, this block diagram will be extended to include the motion that convert the motor rotation into translation motion.

The block diagram of the first motor is shown in fig (5.5)

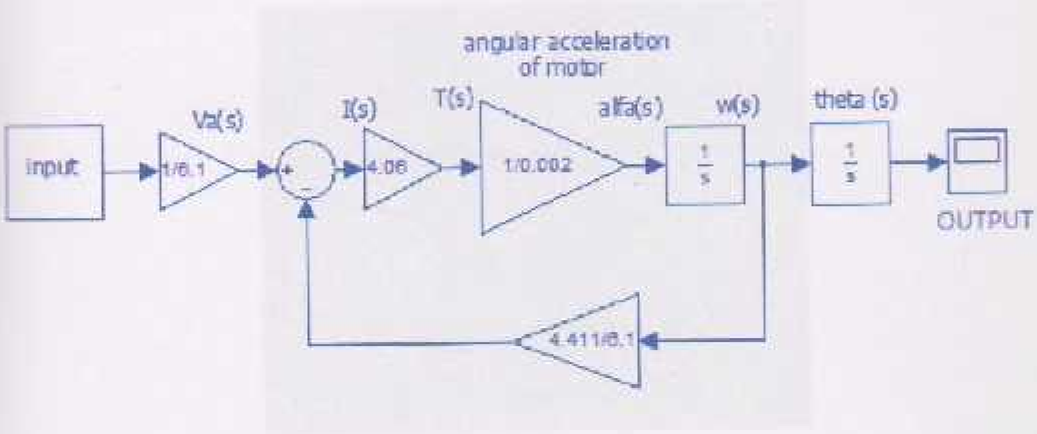


Fig 5.5 motor block diagram

After reduction and simplification this diagram can be as shown in fig (5.6)

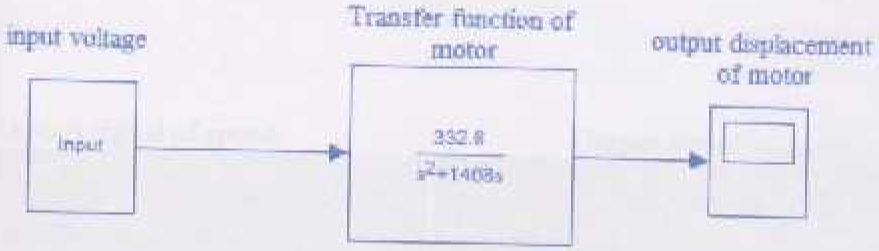
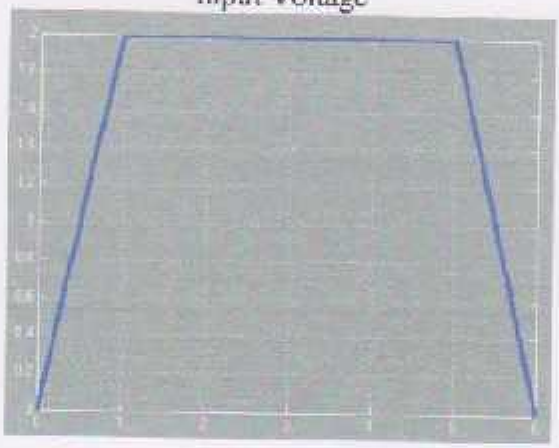


Fig 5.6 motor reduced block diagram

5.8 Simulation

From the previous analysis we can show the simulate response to achieve the required response & we use Matlab program to show the input signal and output signal.

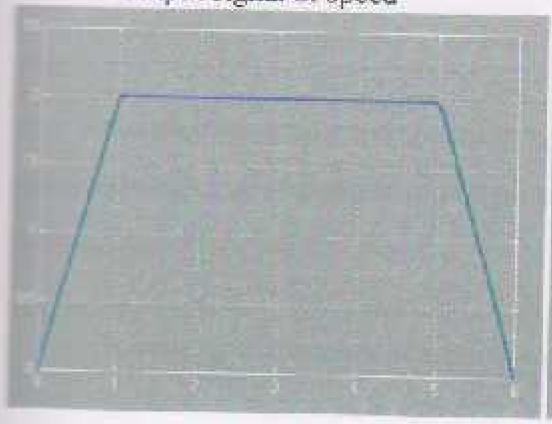
Input Voltage



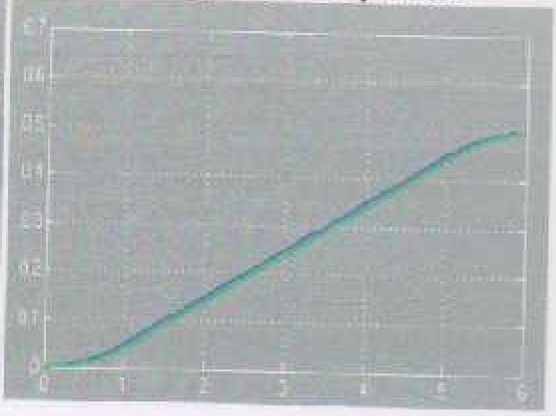
[illegible]

[illegible]

Output signal of speed



Output signal of position



[illegible]

[illegible]

[illegible]

[illegible]

Chapter6

Conclusions & Recommendations

6.1 Conclusions

The implementation of the project has finished successfully, the elevator has the ability to work as an embedded system such that, the microcontroller controls the elevator cart motion, up and down.

However the operation of the system is not perfect, it has encountered some problems, due to some errors in applying mechanical model on real ground.

While the performance of the system does need more work, the performance of the solar system is much better. The solar panel is able to charge the battery controlled by the overcharge controller, the battery can handle the motion of the system with approximately no losses of its capacity.

6.2 Obstacles

As any first time project many problem and obstacles were encounter, technical, economical and un controlled barriers made it very hard, but not impossible mission to finish the project goal.

A major problem that opposed the project progress is the delay of the financial support which in return retards the working on the project because of lack of the tools and parts required.

Because the speed the elevator few, we have faced difficulty in finding the motor with gearbox Appropriate.

The most difficult problems we have encountered is in the mechanical design of the elevator model in terms of design and accuracy in work.

6.3 Recommendations

- Renewable energy researches must be supported and financed for its importance next years. Palestine has very promising future in the area of solar energy systems and it does have a huge amount of unused source of power.
- Build generative system to store the energy in the battery when the elevator moves downward.
- Add observer system to get full control system.
- Solar energy suppliers and companies have to take place in the economical field of Palestine, they will gain benefits by time, and by time installing solar systems would be cheaper, faster, easier and more popular.
- More researches must be applied in the economical feasibility of using solar energy and building solar stations in Palestine.

- Some courses that deal with energy types and its calculations must be taught at the university to help students in their energy related researches, especially in the field of the renewable energy studies as it gains a larger global attention by time.

- Also courses that are related to microcontroller specially the PIC microcontroller should be worked with and taught, they are very important for embedded systems and industrial applications.
- The most important recommendation is that the university must prepare a large lab for graduation projects to help students to work in, since the graduation lab that is running now is not sufficient to all students, and other labs are not always opened to students to work in, as a result you might lose your day if the lab teacher is out of his work or in vacation.
- More financial support and administration's attention and care must be paid for the graduation projects; they are the completions of its student and the apparent part of its academic skills and efforts.
- Renewable energy and scientific research department in the university must increase its support for the graduation project in this field; it must embrace such concepts and turn them into beneficial and economical plans in future.
- The university must Strengthen it's relation with scientific institutions and colleges outside Hebron, it should market the students' graduation projects, be proud of them and let others know about, an annual journal includes such thoughts and information would be great idea that could help improve the university picture and reputation and might give it's student more opportunities to compete with other universities and improve their experience.

References

- [1] Power Electronics and Drives (Version 2): Dr. Zainal Salam.
- [2] Gopal K. Dubey, Fundamentals of Electrical drives, 2nd edition, 1995, narosa publishing house.
- [3]Stephen J. Chapmen, Electric machinery fundamental, 3rd edition.
- Norman S.Nise,Control system engendering , Forth Edition
- [4] Jan Axelson, the Microcontroller Idea Book, Circuits, Programs, & Applications Featuring the 8052-BASIC Microcontroller, 1994, by Jan Axelson,
- [5] Dogan Ibrahim, Advanced PIC Microcontroller Projects in C, Elsevier Publishing, March 2008.
- [6] John Iovine, A Beginner's Guide to Robotics Projects Using the PICmicro, McGraw-Hill Publishing, 2004.
- http://www.netrino.com/Embedded-Systems/How-To/PWM-Pulse-Width-Modulation
- http://www.dtvcity.com/lcdtv/lcdtvresources.htm
- http://www.scolar.org.uk/html/pdf/stu-pdf/ks4-sis-2c.PDF
- http://www.faqs.org/patents/app/20090003021#ixzz0Zyl07vTG
- http://www.medenec.com/en/TOPIC/Strategies%20and%20Laws/Khader_sustainable%20energy%20in%20Palestine.pdf
- http://inventors.about.com/library/inventors/blelevator.htm
- http://www.brighthub.com/engineering/electrical/articles/66777.

Appendix

Appendix (A): Solar panel KC40T

Appendix (B): Sol sum 6.6 Charging Controller

Appendix (C): Battery CP12240 24Ah

Appendix (D): DME44 Motor

Appendix (E): General Purpose Type Photo coupler

Appendix (F): DUAL FULL-BRIDGE DRIVER L298

Appendix (G): Semiconductor technical data

Appendix (H): LCD GDM1602K

Appendix (I): PIC18F4550 Microcontroller

Appendix (J): Control PIC Code Developed In C Programming Language

Appendix (A)

Solar panel KC40T

THE NEW VALUE FRONTIER

KYOCERA

KC40T-1

MODULI FOTOVOLTAICI POLICRISTALLINI AD ALTE PRESTAZIONI

TECNOLOGIA AVANZATA

Grazie a un intenso lavoro di ricerca, una continua evoluzione del processo produttivo e ad una produzione altamente automatizzata, i moduli solari policristallini Kyocera raggiungono uno standard qualitativo straordinario e un rendimento notevolmente elevato. Le cellule solari ad alto rendimento Kyocera incassate, con le dimensioni base 15 x 15,5 cm raggiungono un rendimento del 16% e garantiscono una resa energetica annua estremamente elevata dell'impianto fotovoltaico.

Per la protezione contro le condizioni climatiche più estreme, le celle sono incorporate tra una copertura in vetro temprato e una pellicola EVA e sigillate posteriormente con una pellicola PET. Il laminato è racchiuso in un solido telaio di alluminio facile da fissare.

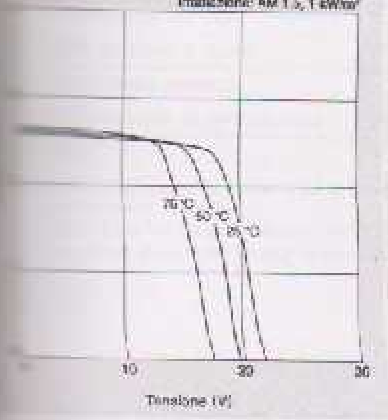
Kyocera produce tutti i componenti in sedi di produzione proprie - senza acquisti supplementari di semilavorati - per una qualità costantemente elevata dei prodotti.

ESEMPI APPLICATIVI

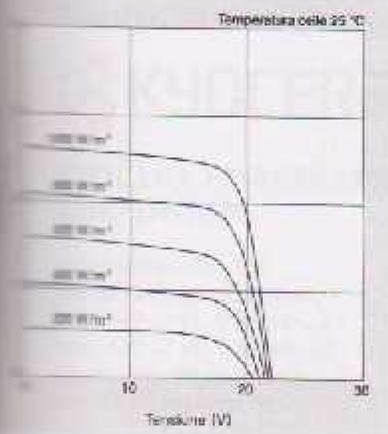
- Impianti collegati alla rete
- Soluzioni isolate (p. es. elettrificazione di case isolate, case per vacanze, orti, ecc.)
- Alimentazione elettrica di paesi e ambulatori isolati in regioni rurali e aeree in via di sviluppo
- Alimentazione d'emergenza di energia elettrica, protezione civile
- Sistemi di pompaggio (p. es. approvvigionamento di acqua potabile e irrigazione)
- Telecomunicazione (p. es. reti di telefonia mobile, stazioni ripetitrici, ecc)
- Olio e gas (per esempio protezione contro la corrosione, comando e controllo, ecc.)
- Centrali a energia solare

Tipo di modulo KC40T-1

DATI ELETTRICI



Curva della tensione elettrica del modulo KC40T-1 nelle diverse temperature delle celle.



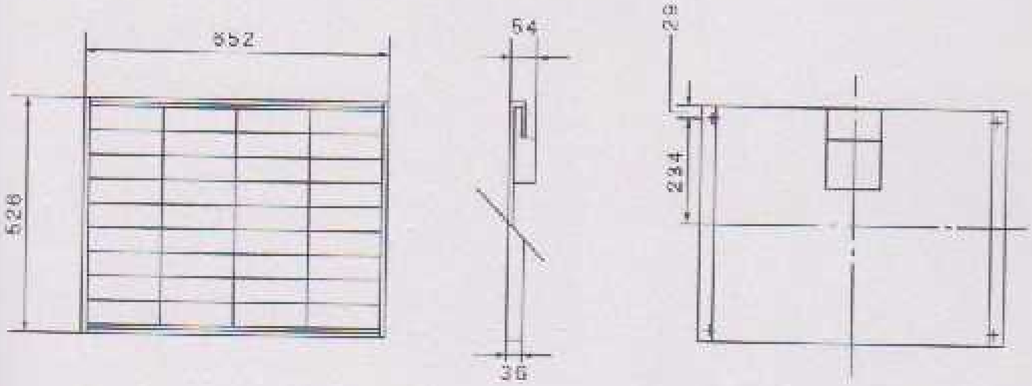
Curva della tensione elettrica del modulo KC40T-1 nelle diverse irradiazioni.

TÜV

CE

Kyocera è un'impresa certificata e registrata secondo le ISO9001 e ISO14001.
TÜVdotCOM Service: piattaforma Internet per qualità e sicurezza collaudate.
TÜVdotCOM-ID: 0000007146.

SPECIFICAZIONI



DATI ELETTRICI

…po di modulo fotovoltaico		KC40T-1
…enza nominale P sotto STC	[W]	43
…fferenza max. da P	[%]	+15 / -5
…nsione max. del sistema	[V]	750
…nsione in caso di potenza nom.	[V]	17,4
…rrente in caso di potenza nom.	[A]	2,48
…nsione a vuoto	[V]	21,7
…rrente di cortocircuito	[A]	2,65
…efficiente termico della tensione a vuoto	[V/°C]	-8,21 x 10[illegible]
…efficiente termico della corrente di cortocircuito	[A/°C]	1,06 x 10[illegible]
…OCT	[°C]	47

… elettrici valgono in condizioni di prova standard (STC):
…diazione di 1000 W/m²,
… d'aria AM 1,5 e temperatura celle di 25 °C.
… di modifiche senza preavviso delle specificazioni.

DIMENSIONI

Lunghezza	[mm]	526
Larghezza	[mm]	652
Altezza/ scatola di giunzione incl.	[mm]	36 / 54
Peso	[kg]	4,5
Tipo di collegamento		morsetti a vite

DATI GENERALI

Garanzia prestazionale	12 anni* / 25 anni**
Garanzia	2 anni

CELLE

Quantità per modulo		36
Tecnologia celle		policristallino
Forma celle		rettangolare
Dimensioni celle	[mm]	150 x 155
Contatto celle		3 bus bar

*12 anni sul 90 % del rendimento minimo P specificato in condizioni di prova standard (STC).

**25 anni sull'85 % del rendimento minimo P specificato in condizioni di prova standard (STC).

…mo lieti di inviarvi altre informazioni.

…E NEW VALUE FRONTIER

KYOCERA

…OCERA FINECERAMICS GMBH
…lar Division

…-Mueller-Str. 107
…30 Esslingen/Germany
… +49-7 11-9 39 34-17
… +49-7 11-9 39 34-50
…: solar@kyocera.de
…kyocerasolar.de

Vostro rivenditore locale Kyocera:

Appendix (B)

Sol sum 6.6 Charging Controller

Steca Solsum 6.6C

Solar Charge Controller

...Steca's bestsellers are the photovoltaic controllers ...Solsum C series which are used in small solar home ...with a 5 to 10 Amp solar charging and load current ...(up to 240 Wp). The Solsum C series was launched ...as a redesign of the Solsum X series. The C series ...ages are large connection terminals, fully covered ...and a easy to understand display. The electronic board ...automized through hole technology for easy local ...enance.

...tures

- ...tage regulation
- ...shunt battery charging
- ...charging
- ...charging
- ...matic load reconnection
- ...matic selection of voltage (12 V / 24 V)
- ...perature compensation
- ...tive grounding
- ...negative grounding on one ...minal

Displays

two LEDs
(1) battery charging LED
- by solar module = green LED in "sun" symbol
(2) battery voltage LED
- end of charge voltage = green LED
- battery voltage level = red & yellow & green LED
- load disconnect prewarning = fast flashing red LED
- deep discharge protection = slowly flashing red LED

...tronic Protections

- ...voltage disconnect (HVD)
- ...voltage disconnect (LVD), ...cept 5.0c & 8.0c
- ...se polarity of solar modules
- ...se polarity of load & battery
- ...t circuit of solar modules
- ...t circuit of load
- ...temperature
- ...voltage
- ...ing protection by varistor
- ...electronic interference (EMC)
- ...circuit battery
- ...se current at night

Specifications

Solar Charge Controller Model	Solsum 6.6c
System Voltage	12 V / (24 V)
Max. Module Input Short Circuit Cur.	6 A
Max. Load Output Current	6 A
LVD	yes
Max. Consumption	4 mA
End of Charge Voltage (Float)	13.7 V / (27.4 V)
Boost Charge Voltage	14.4 V / (28.8 V)
Equalisation Charge	-
Reconnection Setpoint (LVR)	12.6 V / (25.2 V)
Deep Discharge Protection (LVD)	11,1 V / (22,2 V)
Ambient Temperature Allowed	-25 °C...+50 °C
Terminal Size (Fine / Single Wire)	2.5 mm² / 4 mm²
Enclosure Protection Class	IP 22
Weight	165 g
Dimensions L x W x H	130 x 88 x 39 mm

...Sistemas de Energias Alternativas de Portugal, Lda.
...que Industrial da Feiteirinha –
...nº 1 – Feiteirinha – Rogil
...– 440 Aljezur, Portugal

Tel. 282 998745
Fax 282 998746
mail@ffsolar.com
www.ffsolar.com

Appendix (C)

Battery CP12240 24Ah

CP12240 *12V 24Ah(20hr)*

The rechargeable batteries are lead-lead dioxide systems. The dilute sulfuric acid electrolyte is absorbed by separators and plates and thus immobilized. Should the battery be accidentally overcharged producing hydrogen and oxygen, special one-way valves allow the gases to escape thus avoiding excessive pressure build-up. Otherwise, the battery is completely sealed and is, therefore, maintenance-free, leak proof and usable in any position.

Battery Construction

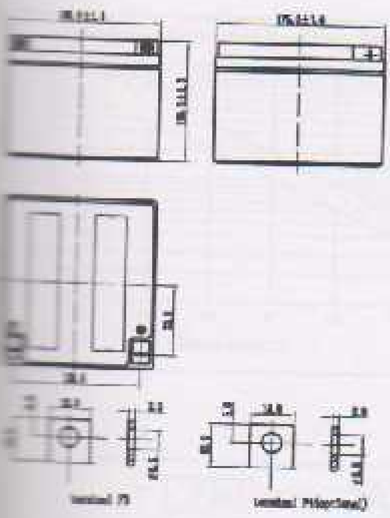
Component	Positive plate	Negative plate	Container	Cover	Safety valve	Terminal	Separator	Electrolyte
Raw material	Lead dioxide	Lead	ABS	ABS	Rubber	Copper	Fiberglass	Sulfuric acid

General Features

- Absorbent Glass Mat (AGM) technology for efficient gas recombination of up to 99% and freedom from electrolyte maintenance or water adding.
- Not restricted for air transport-complies with IATA/ICAO Special Provision A67.
- UL-recognized component.
- Can be mounted in any orientation.
- Computer designed lead, calcium tin alloy grid for high power density.
- Long service life, float or cyclic applications.
- Maintenance-free operation.
- Low self discharge.

Dimensions and Weight

Length(mm / inch)..............166 / 6.54
Width(mm / inch)...............175 / 6.89
Height(mm / inch)..............125 / 4.92
Total Height(mm / inch)........125 / 4.92
Approx. Weight(Kg / lbs).......8.6 / 18.96



Performance Characteristics

Nominal Voltage..............................12V
Number of cell...............................6
Design Life..................................10 years
Nominal Capacity 77ºF(25ºC)
  20 hour rate (1.2A, 10.5V)...................24Ah
  10 hour rate (2.37A, 10.5V)..................23.7Ah
  5 hour rate (4.1A, 10.5V)....................20.5Ah
  1 hour rate (16A, 9.6V)......................16Ah
Internal Resistance
  Fully Charged battery 77ºF(25ºC).............12mOhms
Self-Discharge
  3% of capacity declined per month at 20ºC(average)
Operating Temperature Range
  Discharge....................................-20~60ºC
  Charge.......................................-10~60ºC
  Storage......................................-20~60ºC
Max. Discharge Current 77ºF(25ºC)............300A(5s)
Short Circuit Current........................1200A
Charge Methods: Constant Voltage Charge 77ºF(25ºC)
  Cycle use....................................14.5-14.9V
    Maximum charging current...................9.6A
    Temperature compensation...................-30mV/ºC
  Standby use..................................13.6-13.8V
    Temperature compensation...................-20mV/ºC

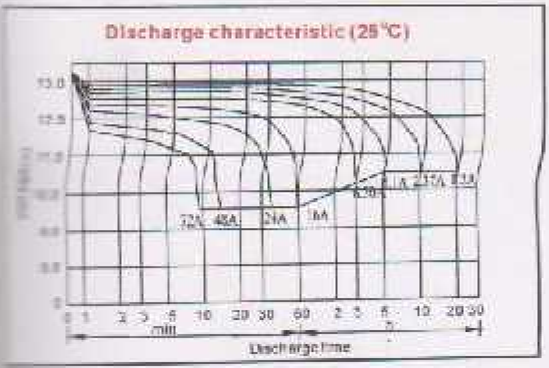
Discharge Constant Current (Amperes at 77ºF25ºC)

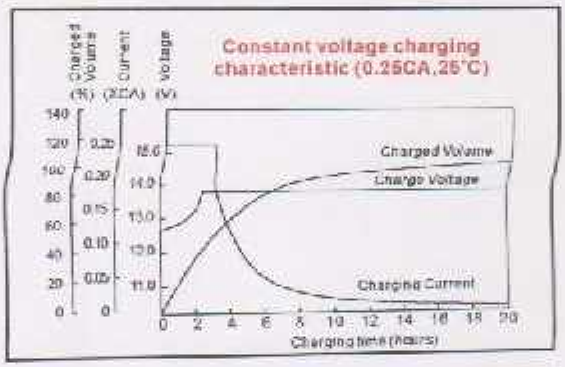
End Point Volts/Cell	5min	10min	15min	30min	1h	3h	5h	10h	20h
1.60V	95.0	64.0	48.0	28.5	16.0	6.74	4.47	2.52	1.24
1.65V	90.1	60.9	45.9	27.4	15.4	6.53	4.36	2.47	1.23
1.70V	84.9	57.8	43.7	26.2	14.8	6.30	4.24	2.42	1.22
1.75V	79.7	54.5	41.1	24.9	14.2	6.05	4.10	2.37	1.20
1.80V	74.3	51.3	39.1	23.6	13.5	5.78	3.95	2.31	1.18

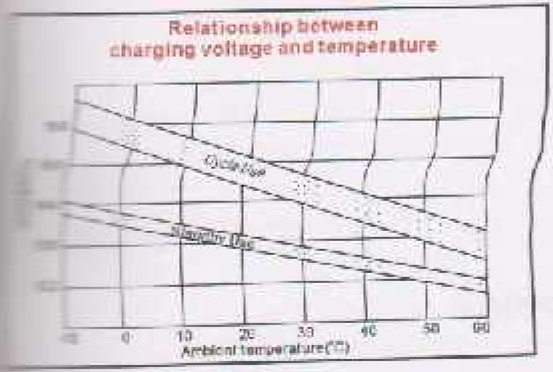
Discharge Constant Power (Watts at 77ºF25ºC)

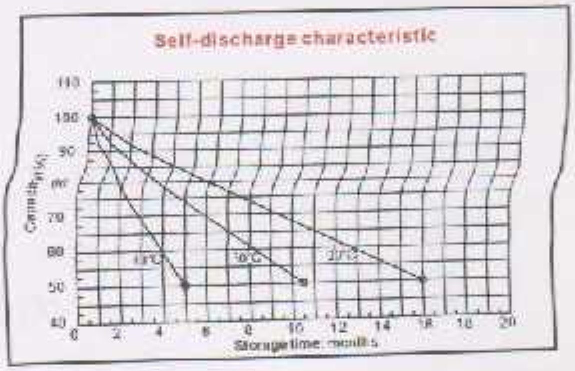
End Point Volts/Cell	5min	10min	15min	30min	45min	1h	2h	3h	5h
1.60V	185	121	90.0	55.0	40.0	31.7	19.6	13.4	8.54
1.65V	173	114	85.1	52.3	38.2	30.3	19.0	13.1	8.39
1.70V	161	107	80.2	49.4	36.3	28.9	18.3	12.5	8.22
1.75V	151	99.7	75.2	46.6	34.3	27.5	17.6	12.0	8.03
1.80V	139	92.7	70.3	43.7	32.3	26.0	16.9	11.4	7.83

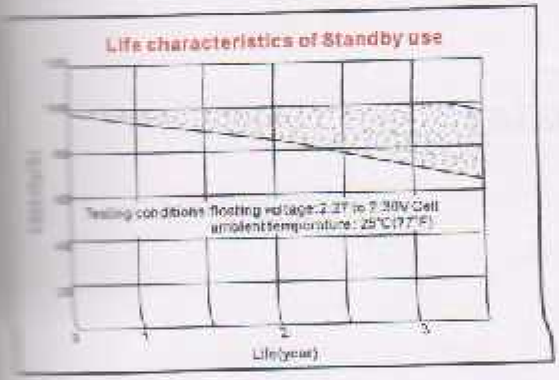
(Note)The above characteristics data are average values obtained within three charge/discharge cycles not the minimum values.

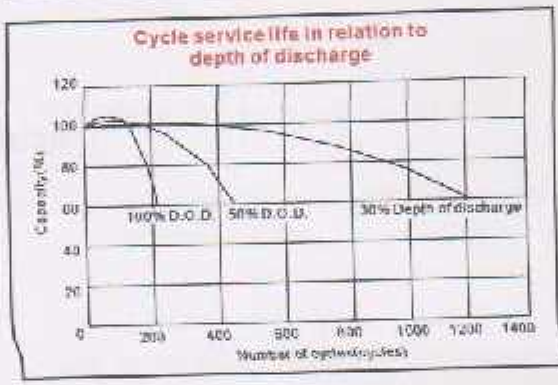


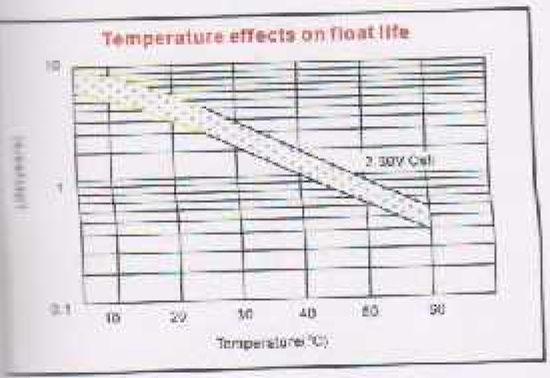


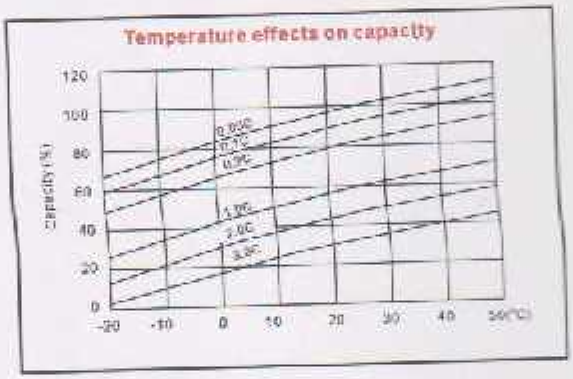












IQNet ISO9001:2000
CE

www.vision-batt.com

Shenzhen Center PowerTech. Co., Ltd.
Center Power Industrial Park, Tongfu Industrial District Dapeng Town, 518120 Shenzhen, China
Tel: (+86-755) 8431 8088 Fax: (+86-755) 8431 8038 E-mail: sales@vision-batt.com

Appendix(D)

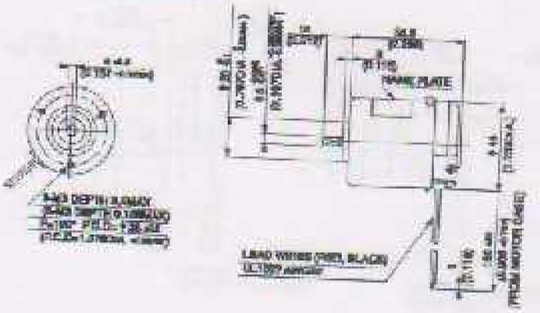
DME44 Motor

DME44

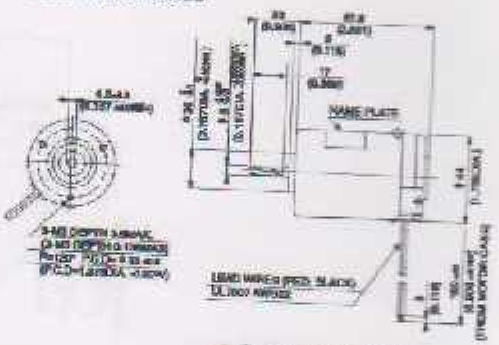
MODEL CODE	VOLTAGE	OUTPUT	CURRENT
SA	12V	9.2W	1.31A
SB	24V	9.2W	0.65A
BB	24V	14.8W	0.94A

● DIMENSIONS Unit mm(inch)

DME44SA, DME44SB

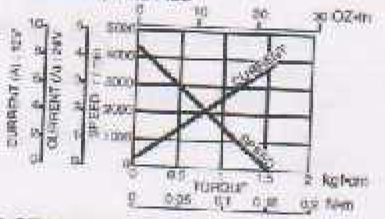


DME44BA, DME44BB

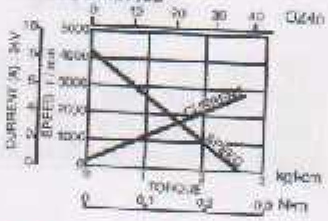


● CURRENT, SPEED-TORQUE CURVE

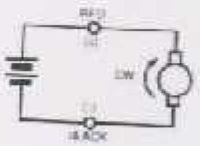
DME44SA, DME44SB



DME44BA, DME44BB



● CONNECTION

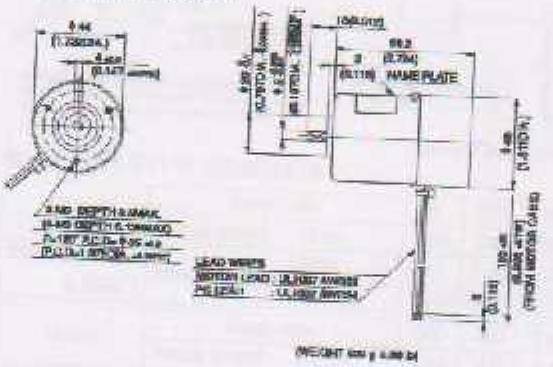


● STANDARD SPECIFICATIONS

Model	Rated						No load		Stall torque		Weight	
	Output W	Voltage V	Torque mN·m	Torque oz·in	Current A	Speed r/min	Current A	Speed r/min	mN·m	oz·in	g	lb
DME44SA	9.2	12	24	3.47	1.31	3600	0.31	4300	150	22.22	300	0.66
DME44SB	9.2	24	24	3.47	0.65	3600	0.15	4300	150	22.22	300	0.66
DME44BB	14.8	24	39	5.55	0.94	3600	0.16	4300	250	36.11	400	0.88

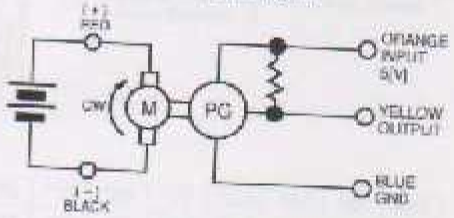
● REVOLUTION SENSOR MAGNET TYPE

DME44SMA, DME44SMB

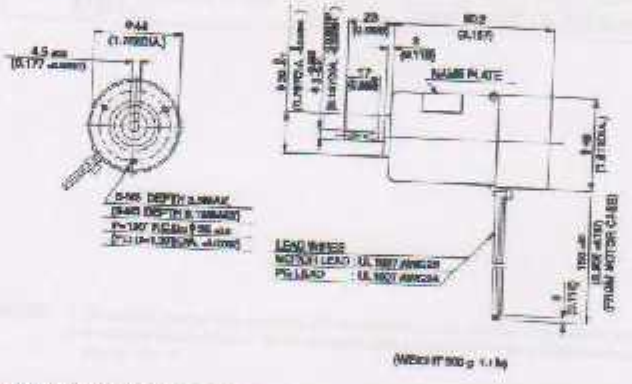


● CONNECTION OF REVOLUTION SENSOR

DME44SMA, DME44SMB, DME44BMB



DME44BMB



● SPECIFICATION OF REVOLUTION SENSOR ARE SHOWN ON PAGE 4.

DME44

MODEL CODE	VOLTAGE	OUTPUT	CURRENT
SA	12V	9.2W	1.31A
SB	24V	9.2W	0.65A
BB	24V	14.8W	0.94A

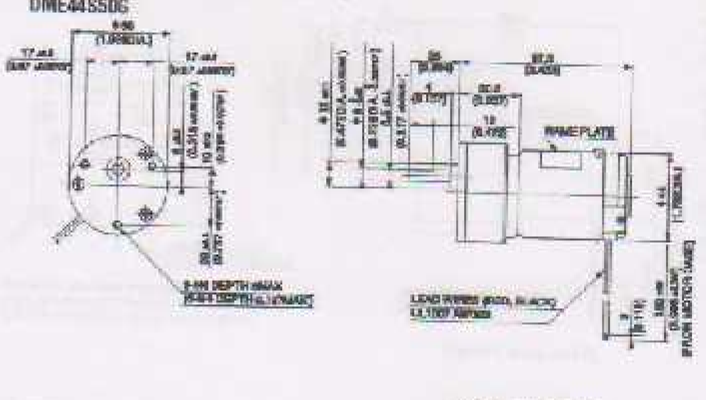
GEARBOX

50G

50G

●DIMENSIONS Unit mm(inch)

DME44S50G



(WEIGHT 460 g 0.98lb)

●with 50G TYPE GEARBOX

Model	Gear ratio		9	18	*27	*36	*54	*72
	Rated speed	r/min	400	200	133	100	66.6	52.3
DME44S50G□☆	Rated torque	N·m	0.18	0.35	0.48	0.64	0.96	0.98
		oz-in	25.00	48.99	68.05	90.27	136.09	138.87

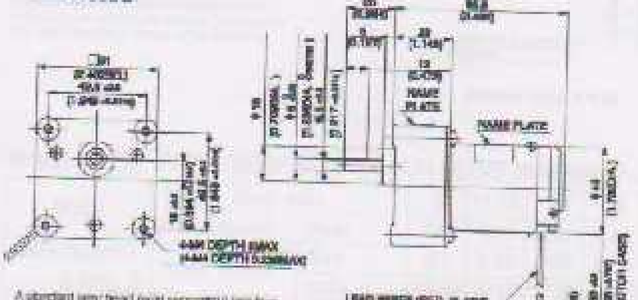
GEARBOX

6DG

6DG

●DIMENSIONS Unit mm(inch)

DME44S6DG



A standard gear head (sold separately) has four holes of 4.5mm (0.177inch) diameter and attached with four bolts of M4 x 40mm. (M4 x 1.77inch)

(WEIGHT 600 g 1.32 lb)

NOTE:
6DG gearboxes are available for either 4.5mm diameter mounting holes or M4 x 8mm tapped holes.
4.5mm diameter mounting holes type gearboxes are available as stock components. When ordering, please write the motor model and gearbox model numbers separately, as in the following example.
Pinion Shaft Motor + Gearbox
DME44S6HPB + 6DG□
M4 x 6mm tapped mounting hole type gearboxes are available only on demand, and are supplied only as combined unit with motors. When ordering, please write model number as a single unit, as in the following example : DME44S6H□B

●with 36G TYPE GEARBOX

Model	Gear ratio		5	12.5	15	*25	*30	*50	*75	*100	150	180	250
	Rated speed	r/min	720	288	240	144	120	72	50.5	39.1	26.7	22.5	16.5
DME44S6HP☆ & 6DG□	Rated torque	N·m	0.1	0.25	0.29	0.44	0.53	0.89	0.98	0.98	0.98	0.98	0.98
		oz-in	13.89	34.72	41.66	62.49	74.99	126.37	138.87	138.87	138.87	138.87	138.87

Model	Gear ratio		300	450	*500	*750	*900	*1800
	Rated speed	r/min	13.8	9.3	8.4	5.6	4.7	2.3
DME44S6HP☆ & 6DG□	Rated torque	N·m	0.98	0.98	0.98	0.98	0.98	0.98
		oz-in	138.87	138.87	138.87	138.87	138.87	138.87

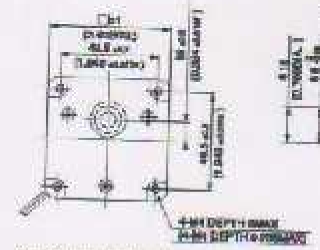
NOTES 1: On models marked with asterisks (*), the direction of the gearbox shaft rotation is in reverse of the motor rotation direction.
2: In notation model number: fill the reduction ratio denominator in the position marked with the box sign □; fill the voltage in the position marked with the star sign ☆.

GEARBOX 6DGF

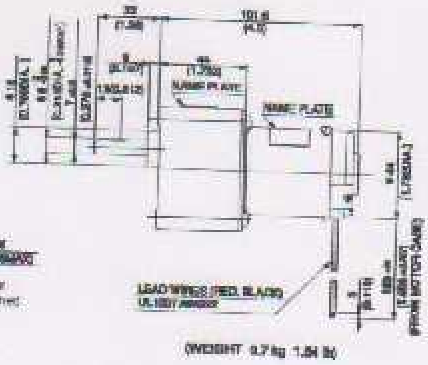
6DGF

●DIMENSIONS Unit mm(inch)

DME44S6DGF



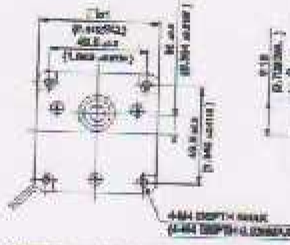
A standard gear head (sold separately) has four holes of 4.5mm (0.177inch) diameter and attached with four bolts of M4 x 60mm. (M4 x 2.36inch)



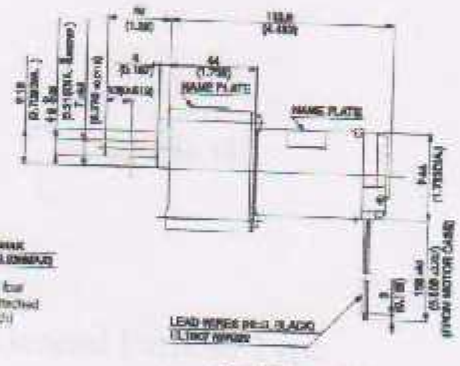
(WEIGHT 0.7 kg 1.54 lb)

NOTE:
6DGF gearboxes are available for either 4.5mm diameter mounting holes or M4 x 9mm tapped holes.
4.5mm diameter mounting holes type gearboxes are available as stock components. When ordering, please write the motor model and gearbox model numbers separately, as in the following example:
Pinion Shaft Motor + Gearbox
DME44B6HFPB + 6DG[ ]F
M4 x 9mm tapped mounting hole type gearboxes are available only on demand, and are supplied only as combined unit with motor. When ordering, please write model number as a single unit, as in the following example : DME44B6H[illegible]FB

DME44B6DGF



A standard gear head (sold separately) has four holes of 4.5mm (0.177inch) diameter and attached with four bolts of M4 x 60mm. (M4 x 2.36inch)



(WEIGHT 0.8 kg 1.76 lb)

●with 6DGF TYPE GEARBOX MOTOR MODEL DME44S6HFP☆, DME44B6HFPB & GEARBOX MODEL 6DG[ ]F

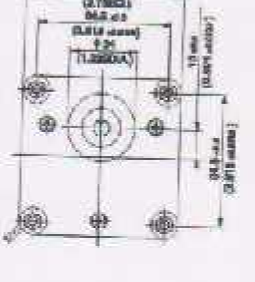
Model		Gear ratio	5	*12.5	*15	*25	*30	50	75	100	150	180
DME44S6HFP☆ & 6DG[ ]F	Rated speed	r/min	720	288	240	144	120	72	48	36	24	20.6
	Rated torque	N·m	0.1	0.22	0.27	0.44	0.53	0.80	1.2	1.6	2.4	2.4
		oz-in	13.89	30.55	37.50	62.49	74.99	113.87	166.65	222.19	333.28	347.18
DME44B6HFPB & 6DG[ ]F	Rated speed	r/min	720	288	240	144	120	72	48	36.3	25.7	21.8
	Rated torque	N·m	0.16	0.35	0.43	0.72	0.85	1.3	1.9	2.4	2.4	2.4
		oz-in	22.22	49.99	59.71	101.38	120.82	180.53	263.86	347.18	347.18	347.18

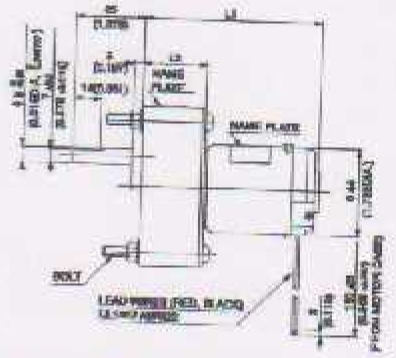
GEARBOX 8DG

8DG

●DIMENSIONS Unit mm(inch)

DME44S8DG





NOTE:
When ordering motors with 8DG gearboxes, please write the motor model and gearbox model numbers as in the following example:
Motor + Gearbox
DME44B6HFPB + 8DG[ ]

GEAR RATIO	L1		L2		BOLT		WEIGHT	
	(mm)	(inch)	(mm)	(inch)	(mm)	(inch)	kg	lb
30~150	90.1	3.547	32	1.26	M5X50	M5X1.969	0.8	1.76
250~1800	100.1	3.941	42	1.654	M5X60	M5X2.362	0.9	1.96

NOTES 1: On models marked with asterisks (*), the direction of the gearbox shaft rotation is in reverse of the motor rotation direction.
2: In rotation model number : fill the reduction ratio denominator in the position marked with the box sign [ ] fill the voltage in the position marked with the star sign ☆.

Appendix (E):

General Purpose Type

Photo coupler

LITEON

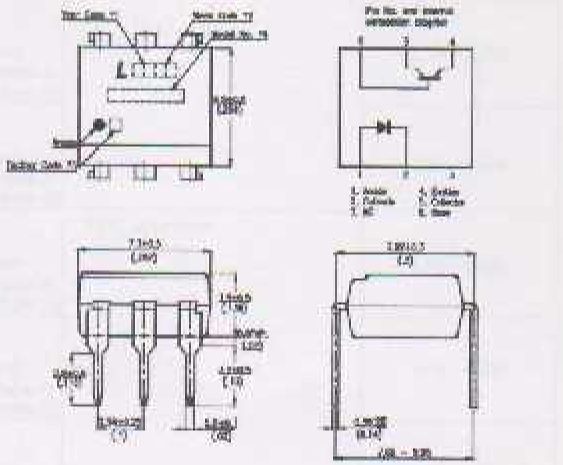
General Purpose Type Photocoupler

LTV-4N25 Series/LTV-4N26 Series
LTV-4N27 Series/LTV-4N28 Series
4N25 Series/4N26 Series/4N27 Series/4N28 Series

Features

- Response Time
  (tr : TYP.3 μs at V_{CE}=10V, I_C=2mA, R_L=100 Ω)
- UL approved (No. E113898)
- TUV approved (No.R9653630)
- CSA approved (No. CA91533-1)
- FIMKO approved (No. 193422)
- NEMKO approved (No. P96103013)
- DEMKO approved (No. 303985)
- SEMKO approved (No. 9646047/01-30)
- VDE approved (No. 094722)
- Options available :
  - Leads with 0.4"(10.16mm)spacing (M Type)
  - Leads bends for surface mounting(S Type)
  - Tape and Reel of Type I for SMD(Add"-TA"Suffix)
  - Tape and Reel of Type II for SMD(Add"-TA1"Suffix)
  - VDE 0884 approvals (Add"-V"Suffix)

Package Dimensions



Applications

1. I/O interfaces for computers.
2. System appliances, measuring instruments.
3. Signal transmission between circuits of different potentials and impedances.

Note:

1. Year date code.
2. 2 digit work week.
3. Factory code shall be marked (Z : Taiwan, Y : Thailand).
4. Model No. : LTV4N25 ; LTV4N26 ; LTV4N27 ; LTV4N28 ; 4N25 ; 4N26 ; 4N27 ; 4N28.
5. All dimensions are in millimeters (inches).
6. Tolerance is ± 0.25mm (.010") unless otherwise noted.
7. Specifications are subject to change without notice.

Ordering Information

Part Number	Package	Safety Standard Approval	Application part number
LTV-4N25 / 4N25 LTV-4N25M / 4N25M LTV-4N25S / 4N25S LTV-4N25S-TA / 4N25S-TA LTV-4N25S-TA1 / 4N25S-TA1	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)	· UL approved · TUV approved · CSA approved · FIMKO approved · NEMKO approved · SEMKO approved · DEMKO approved	LTV - 4N25
LTV-4N26 / 4N26 LTV-4N26M / 4N26M LTV-4N26S / 4N26S LTV-4N26S-TA / 4N26S-TA LTV-4N26S-TA1 / 4N26S-TA1	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)		LTV - 4N26
LTV-4N27 / 4N27 LTV-4N27M / 4N27M LTV-4N27S / 4N27S LTV-4N27S-TA / 4N27S-TA LTV-4N27S-TA1 / 4N27S-TA1	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)		LTV - 4N27
LTV-4N28 / 4N28 LTV-4N28M / 4N28M LTV-4N28S / 4N28S LTV-4N28S-TA / 4N28S-TA LTV-4N28S-TA1 / 4N28S-TA1	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)		LTV - 4N28
LTV4N25-V / 4N25-V LTV4N25M-V / 4N25M-V LTV4N25S-V / 4N25S-V LTV4N25STA-V / 4N25STA-V LTV4N25STA1-V / 4N25STA1-V	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)	· VDE approved	LTV - 4N25
LTV4N26-V / 4N26-V LTV4N26M-V / 4N26M-V LTV4N26S-V / 4N26S-V LTV4N26STA-V / 4N26STA-V LTV4N26STA1-V / 4N26STA1-V	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)		LTV - 4N26
LTV4N27-V / 4N27-V LTV4N27M-V / 4N27M-V LTV4N27S-V / 4N27S-V LTV4N27STA-V / 4N27STA-V LTV4N27STA1-V / 4N27STA1-V	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)		LTV - 4N27
LTV4N28-V / 4N28-V LTV4N28M-V / 4N28M-V LTV4N28S-V / 4N28S-V LTV4N28STA-V / 4N28STA-V LTV4N28STA1-V / 4N28STA1-V	6-pin DIP 6-pin (leads with 0.4" spacing) 6-pin (lead bends for surface mount) 6-pin (tape and reel packaging of type I) 6-pin (tape and reel packaging of type II)		LTV - 4N28

Absolute Maximum Ratings

(Ta=25℃)

Parameter			Symbol	Rating	Unit
Input	Forward Current		I_F	80	mA
	Reverse Voltage		V_R	6	V
	Power Dissipation		P	150	mW
Output	Collector-Emitter Voltage		V_{CEO}	30	V
	Collector-Base Voltage		V_{CBO}	70	V
	Emitter-Collector Voltage		V_{ECO}	7	V
	Collector Current		I_C	100	mA
	Collector Power Dissipation		P_C	150	mW
Total Power Dissipation			P_{tot}	250	mW
*1 Isolation Voltage		4N25	V_{iso}	2,500	V_{rms}
		4N26		1,500	
		4N27		1,500	
		4N28		500	
Operating Temperature			T_{opr}	-55~+100	℃
Storage Temperature			T_{stg}	-55~+150	℃
*2 Soldering Temperature			T_{sol}	260	℃

*1. AC for 1 minute, R.H. = 40 ~ 60%
- Isolation voltage shall be measured using the following method.
  (1)Short between anode and cathode on the primary side and between collector, emitter and base on the secondary side.
  (2)The isolation voltage tester with zero cross circuit shall be used.
  (3)The waveform of applied voltage shall be a sine wave.

*2. For 10 seconds.

Electrical/Optical Characteristics

(Ta=25℃)

Parameter			Symbol	Min.	Typ.	Max.	Unit	Conditions
Input	Forward Voltage		V_F	–	1.2	1.5	V	I_F=10mA
	Reverse Current		I_R	–	–	10	μA	V_R=4V
	Terminal Capacitance		C_t	–	50	–	pF	V=0, f=1kHz
Output	Collector Dark Current	4N25/26/27	I_{CEO}	–	–	50	nA	V_{CE}=10V
		4N28		–	–	100		
	Collector-Emitter Breakdown Voltage		BV_{CEO}	30	–	–	V	I_C=0.1mA
	Emitter-Collector Breakdown Voltage		BV_{ECO}	7	–	–	V	I_E=10μA
	Collector-Base Breakdown Voltage		BV_{CBO}	70	–	–	V	I_C=0.1mA
Transfer Characteristics	Collector Current	4N25/26	I_C	2	–	–	mA	I_F=10mA, V_{CE}=10V
		4N27/28		1	–	–		
	*1 Current Transfer Ratio	4N25/26	CTR	20	–	–	%	I_F=10mA, V_{CE}=10V
		4N27/28		10	–	–		
	Collector-emitter Saturation Voltage		$V_{CE(sat)}$	–	0.1	0.5	V	I_F=50mA, I_C=2mA
	Isolation Resistance		R_{ISO}	5×10^{10}	1×10^{11}	–	Ω	DC500V, 40~60% R.H.
	Floating Capacitance		C_f	–	1.0	–	pF	V=0, f=1MHz
	Response Time (Rise)		t_r	–	3	–	μs	V_{CE}=10V, R_{BE}=∞, R_L=100Ω, I_C=2mA
	Response Time (Fall)		t_f	–	3	–	μs	

*1. $CTR=\frac{I_C}{I_F}\times100\%$

Typical Electrical/Optical Characteristic Curves
(25℃ Ambient Temperature Unless Otherwise Noted)

Fig.1 Forward Current vs. Ambient Temperature

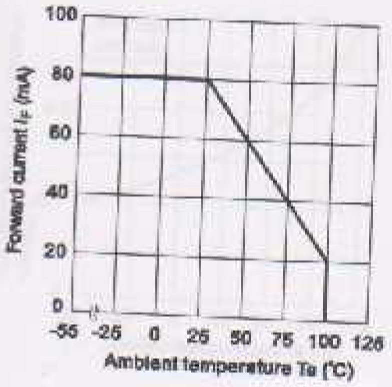


Fig.2 Collector Power Dissipation vs. Ambient Temperature

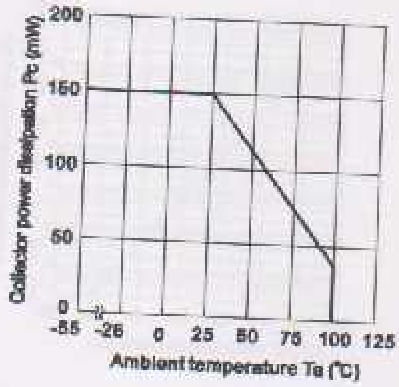


Fig.3 Forward Current vs. Forward Voltage

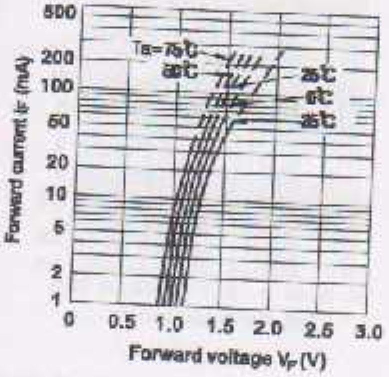


Fig.4 Current Transfer Ratio vs. Forward Current

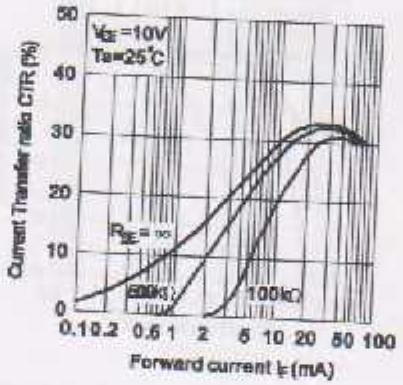


Fig.5 Collector Current vs. Collector-emitter Voltage

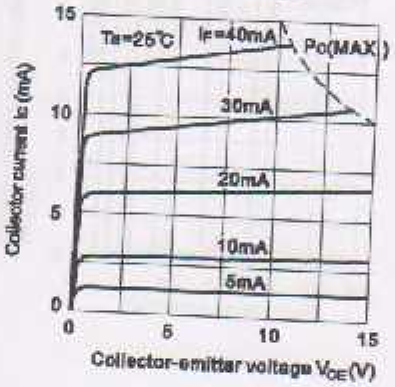
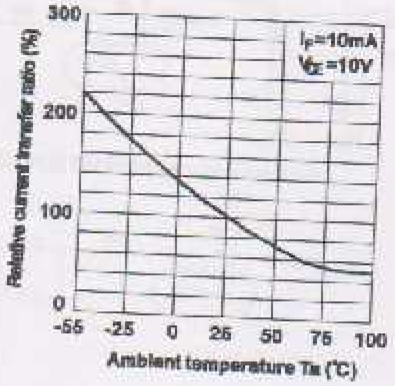


Fig.6 Relative Current Transfer Ratio vs. Ambient Temperature



PHOTOCOUPLER

Fig.7 Collector-emitter Saturation Voltage vs. Ambient Temperature

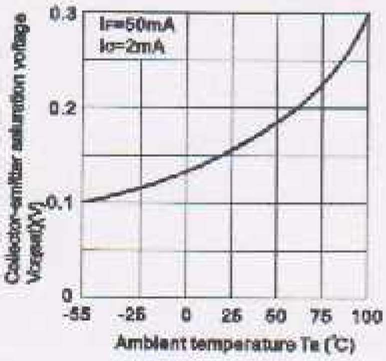


Fig.8 Collector Dark Current vs. Ambient Temperature

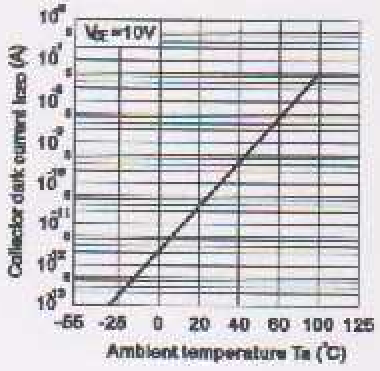


Fig.9 Response Time vs. Load Resistance

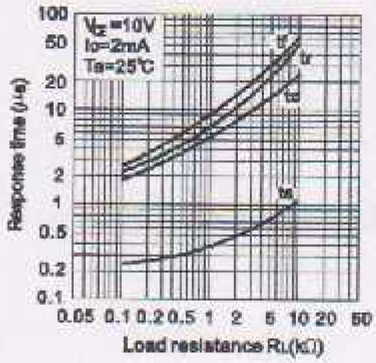


Fig.10 Frequency Response

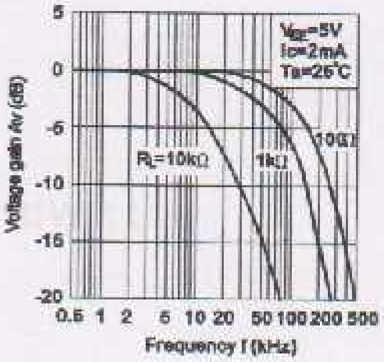
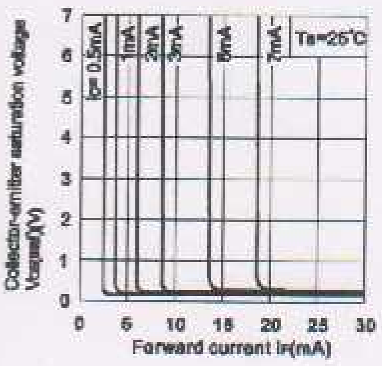
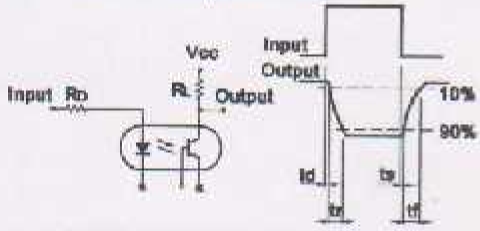


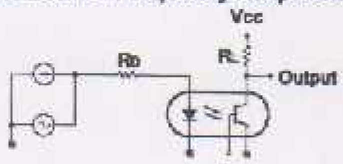
Fig.11 Collector-emitter Saturation Voltage vs. Forward Current



Test Circuit for Response Time



Test Circuit for Frequency Response



Appendix (F):

DUAL FULL-BRIDGE DRIVER L298

L298

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

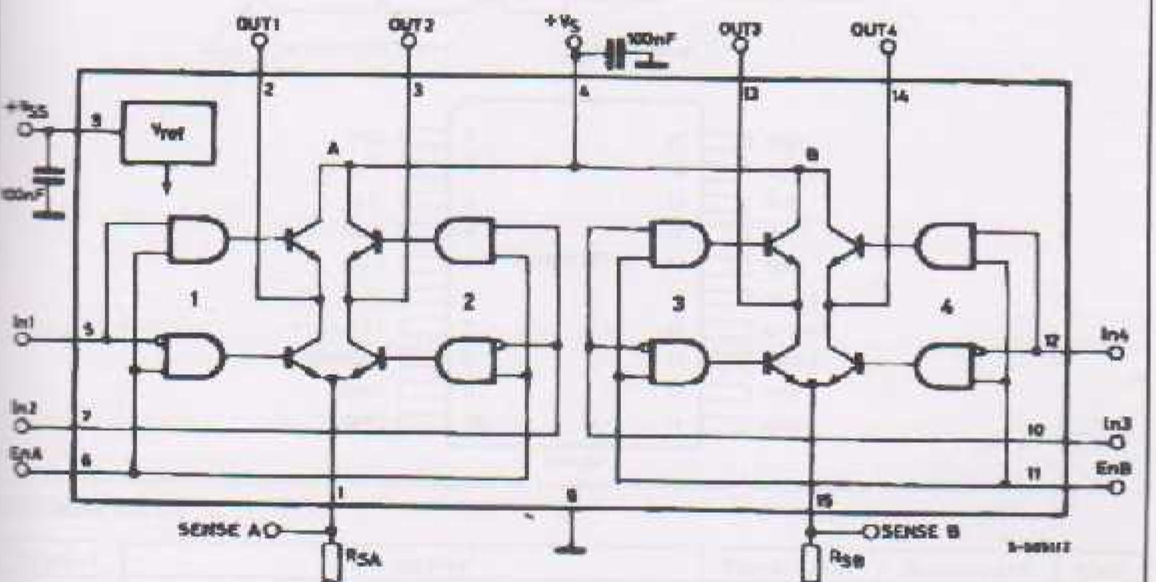

PowerSO20

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.

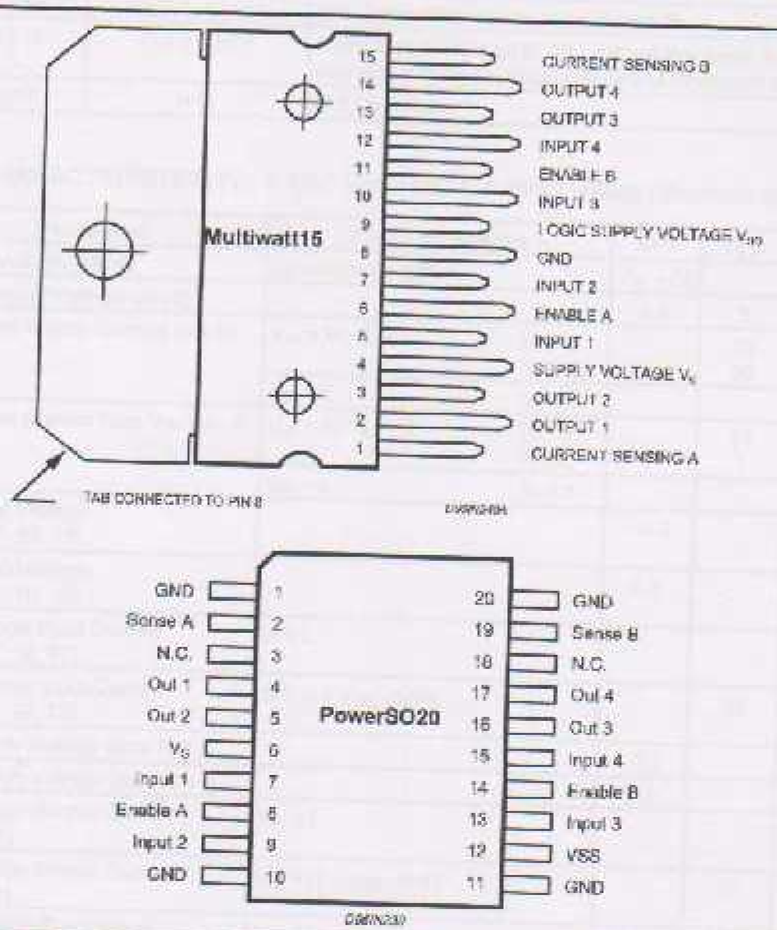
BLOCK DIAGRAM



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 those 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

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T_1 (V_i)	Source Current Turn-off Delay	0.5 V_i to 0.9 I_L (2); (4)		1.5		µs
T_2 (V_i)	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		0.2		µs
T_3 (V_i)	Source Current Turn-on Delay	0.5 V_i to 0.1 I_L (2); (4)		2		µs
T_4 (V_i)	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.7		µs
T_5 (V_i)	Sink Current Turn-off Delay	0.5 V_i to 0.9 I_L (3); (4)		0.7		µs
T_6 (V_i)	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.25		µs
T_7 (V_i)	Sink Current Turn-on Delay	0.5 V_i to 0.9 I_L (3); (4)		1.6		µs
T_8 (V_i)	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.2		µs
fc (V_i)	Commutation Frequency	I_L = 2A		25	40	KHz
T_1 (V_{en})	Source Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (2); (4)		3		µs
T_2 (V_{en})	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		1		µs
T_3 (V_{en})	Source Current Turn-on Delay	0.5 V_{en} to 0.1 I_L (2); (4)		0.3		µs
T_4 (V_{en})	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.4		µs
T_5 (V_{en})	Sink Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (3); (4)		2.2		µs
T_6 (V_{en})	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.35		µs
T_7 (V_{en})	Sink Current Turn-on Delay	0.5 V_{en} to 0.9 I_L (3); (4)		0.25		µs
T_8 (V_{en})	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.1		µs

1) 1)Sensing voltage can be –1 V for t ≤ 50 µsec; in steady state V_{sens} min ≥ – 0.5 V.
2) See fig. 2.
3) See fig. 4.
4) The load must be a pure resistor.

Figure 1 : Typical Saturation Voltage vs. Output Current.

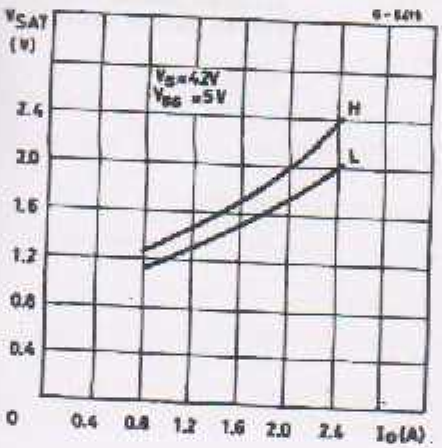
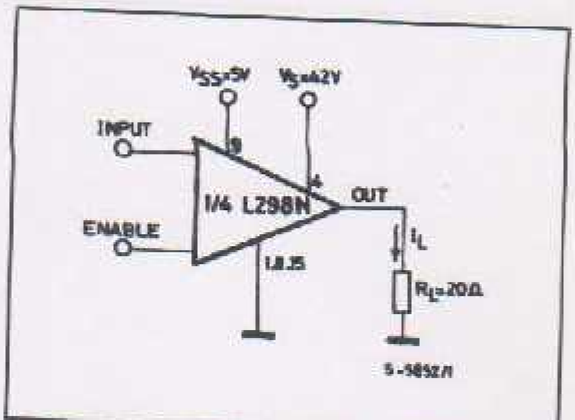


Figure 2 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = H

Figure 3 : Source Current Delay Times vs. Input or Enable Switching.

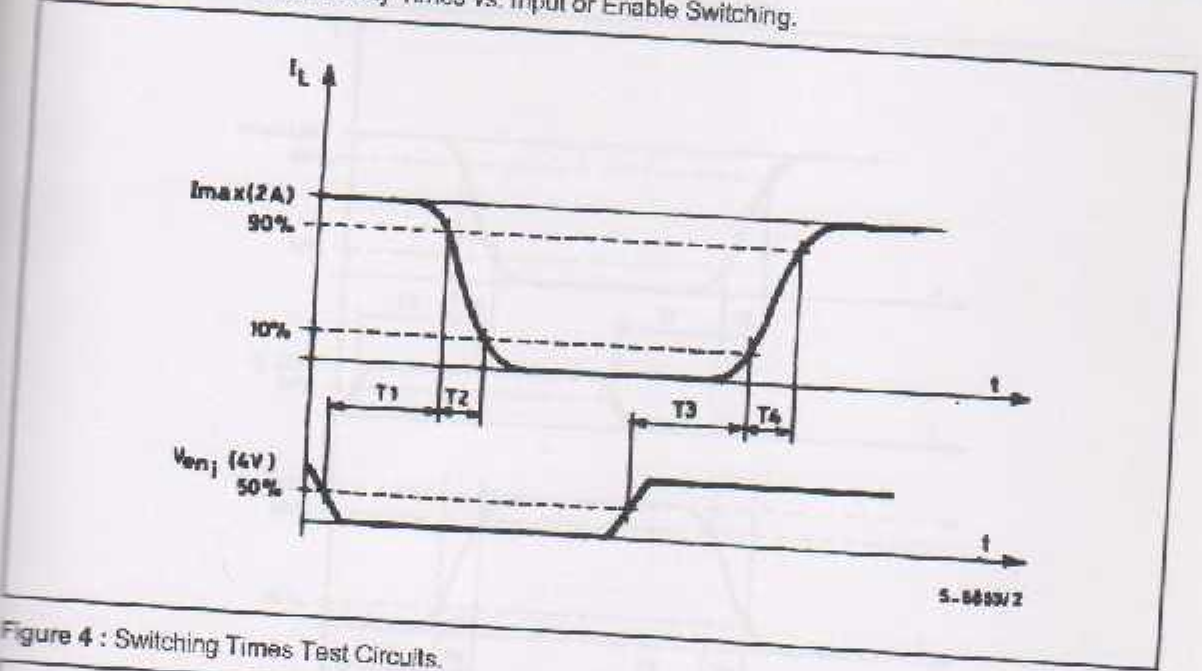
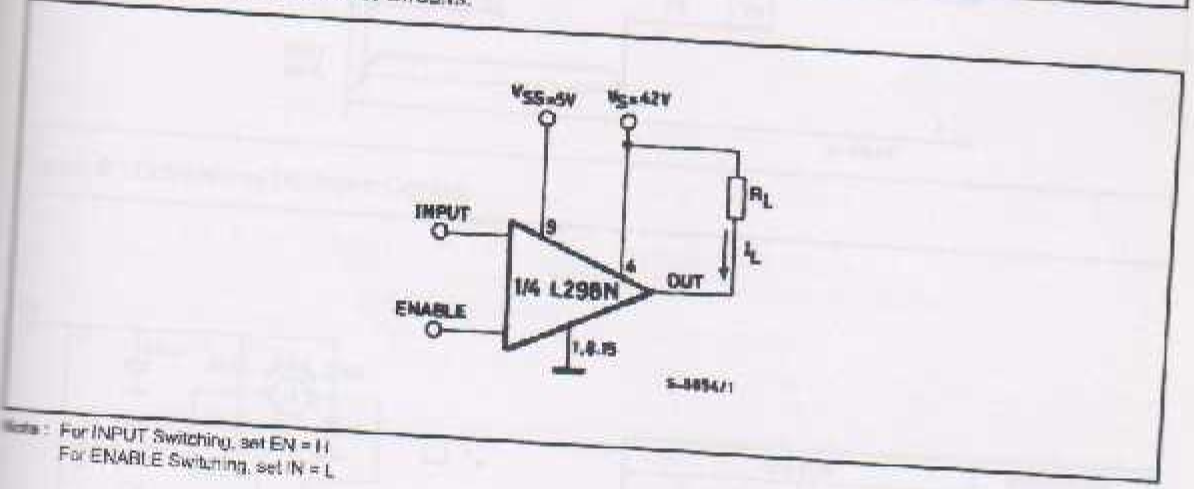


Figure 4 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = L

Figure 5 : Sink Current Delay Times vs. Input 0 V Enable Switching.

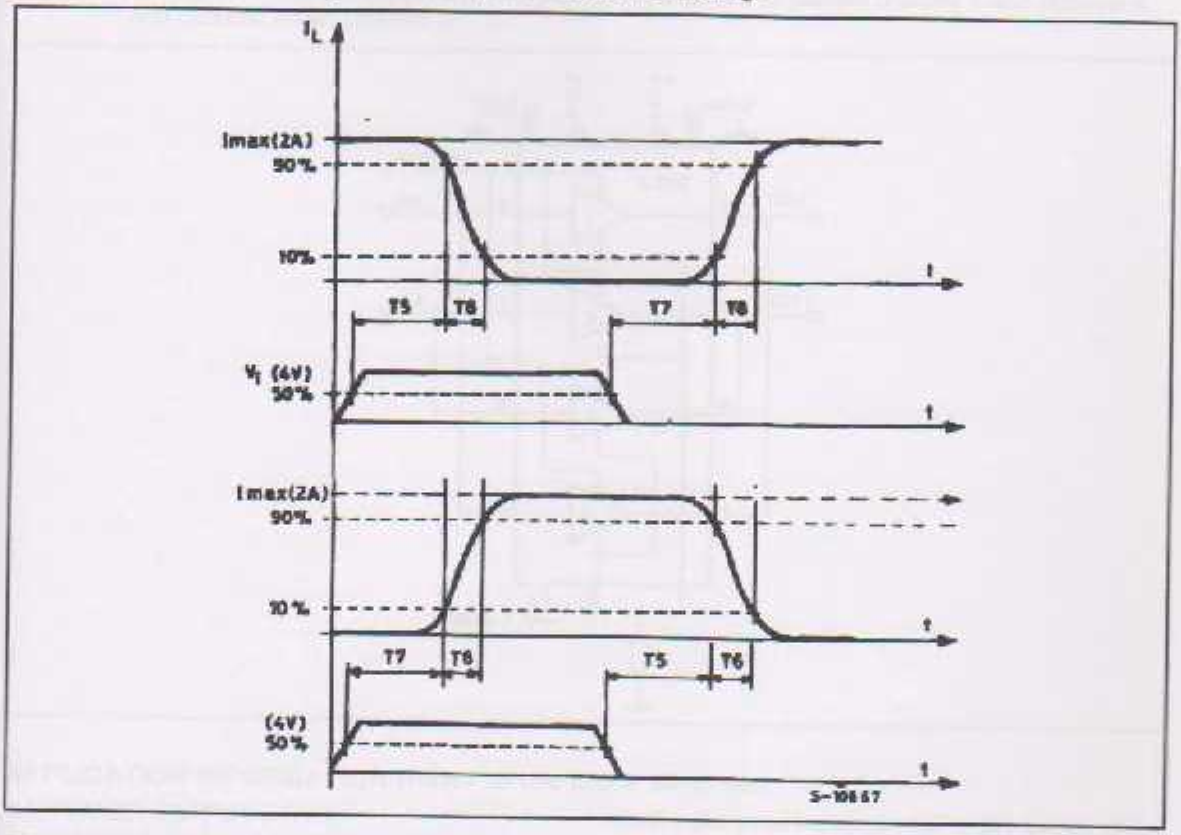
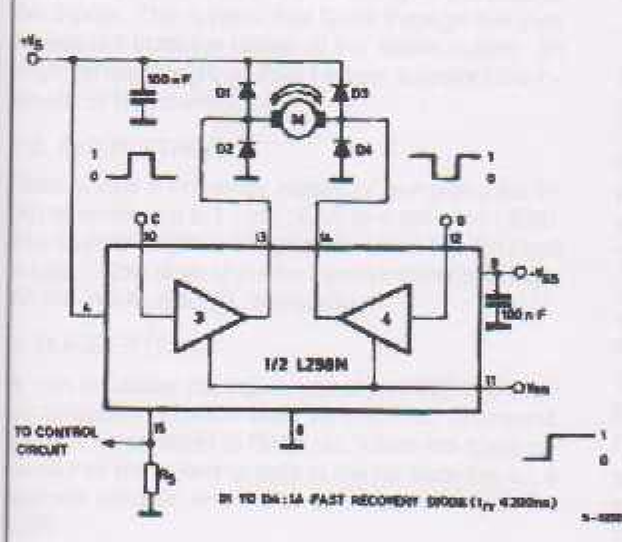


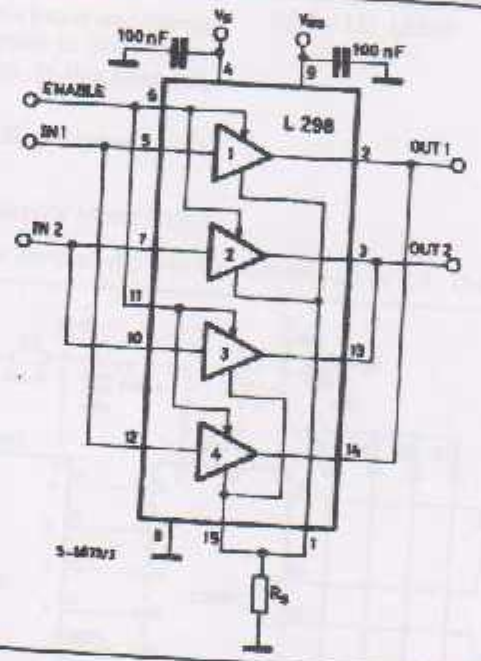
Figure 6 : Bidirectional DC Motor Control.



Inputs		Function
V_{en} = H	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
V_{en} = L	C = X ; D = X	Free Running Motor Stop

L = Low H = High X = Don't care

Figure 7 : For higher currents, outputs can be paralleled. Take care to parallel channel 1 with channel 4 and channel 2 with channel 3.



APPLICATION INFORMATION (Refer to the block diagram)

1.1. POWER OUTPUT STAGE

The L298 integrates two power output stages (A ; B). The power output stage is a bridge configuration and its outputs can drive an inductive load in common or differenzial mode, depending on the state of the inputs. The current that flows through the load comes out from the bridge at the sense output : an external resistor (R_{SA} ; R_{SB}.) allows to detect the intensity of this current.

1.2. INPUT STAGE

Each bridge is driven by means of four gates the input of which are In1 ; In2 ; EnA and In3 ; In4 ; EnB. The In inputs set the bridge state when The En input is high ; a low state of the En input inhibits the bridge. All the inputs are TTL compatible.

2. SUGGESTIONS

A non inductive capacitor, usually of 100 nF, must be foreseen between both Vs and Vss, to ground, as near as possible to GND pin. When the large capacitor of the power supply is too far from the IC, a second smaller one must be foreseen near the L298.

The sense resistor, not of a wire wound type, must be grounded near the negative pole of Vs that must be near the GND pin of the I.C.

Each input must be connected to the source of the driving signals by means of a very short path.

Turn-On and Turn-Off : Before to Turn-ON the Supply Voltage and before to Turn it OFF, the Enable input must be driven to the Low state.

3. APPLICATIONS

Fig 6 shows a bidirectional DC motor control Schematic Diagram for which only one bridge is needed. The external bridge of diodes D1 to D4 is made by four fast recovery elements ($t_{rr} \leq 200$ nsec) that must be chosen of a VF as low as possible at the worst case of the load current.

The sense output voltage can be used to control the current amplitude by chopping the inputs, or to provide overcurrent protection by switching low the enable input.

The brake function (Fast motor stop) requires that the Absolute Maximum Rating of 2 Amps must never be overcome.

When the repetitive peak current needed from the load is higher than 2 Amps, a paralleled configuration can be chosen (See Fig.7).

An external bridge of diodes are required when inductive loads are driven and when the inputs of the IC are chopped ; Shottky diodes would be preferred.

This solution can drive until 3 Amps In DC operation and until 3.5 Amps of a repetitive peak current.

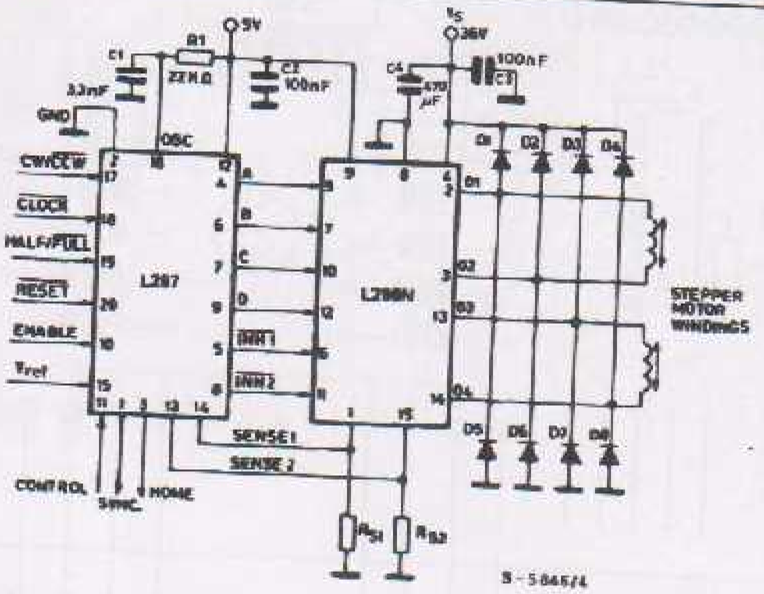
On Fig 8 it is shown the driving of a two phase bipolar stepper motor ; the needed signals to drive the inputs of the L298 are generated, in this example, from the IC L297.

Fig 9 shows an example of P.C.B. designed for the application of Fig 8.

Fig 10 shows a second two phase bipolar stepper motor control circuit where the current is controlled by the I.C. L6506.

Figure 8 : Two Phase Bipolar Stepper Motor Circuit.

This circuit drives bipolar stepper motors with winding currents up to 2 A. The diodes are fast 2 A types.



$R_{S1} = R_{S2} = 0.5\ \Omega$

D1 to D8 = 2 A Fast diodes { $V_F \leq 1.2\ V$ @ $I = 2\ A$, $t_{rr} \leq 200$ ns }

Figure 9 : Suggested Printed Circuit Board Layout for the Circuit of fig. 8 (1:1 scale).

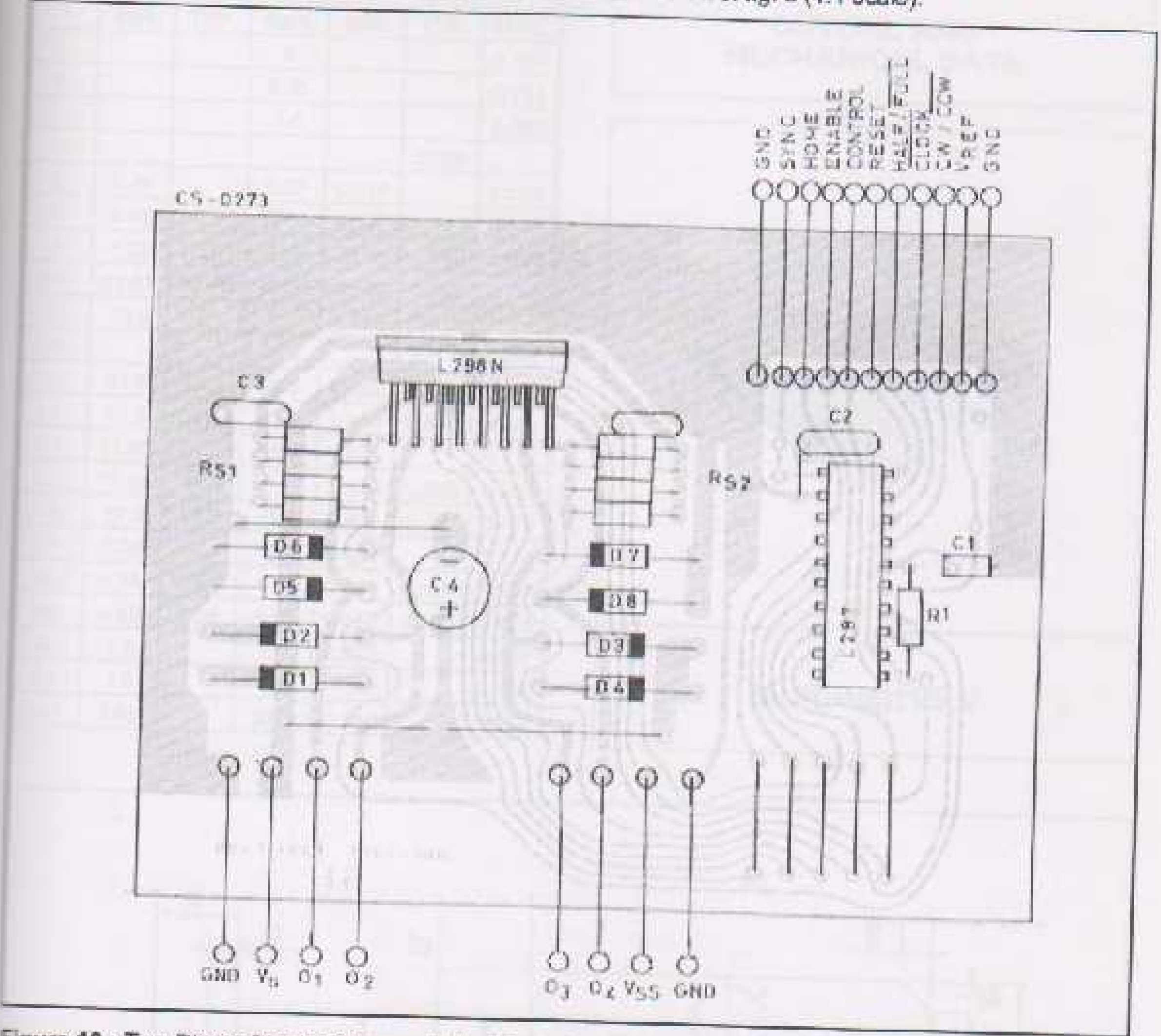
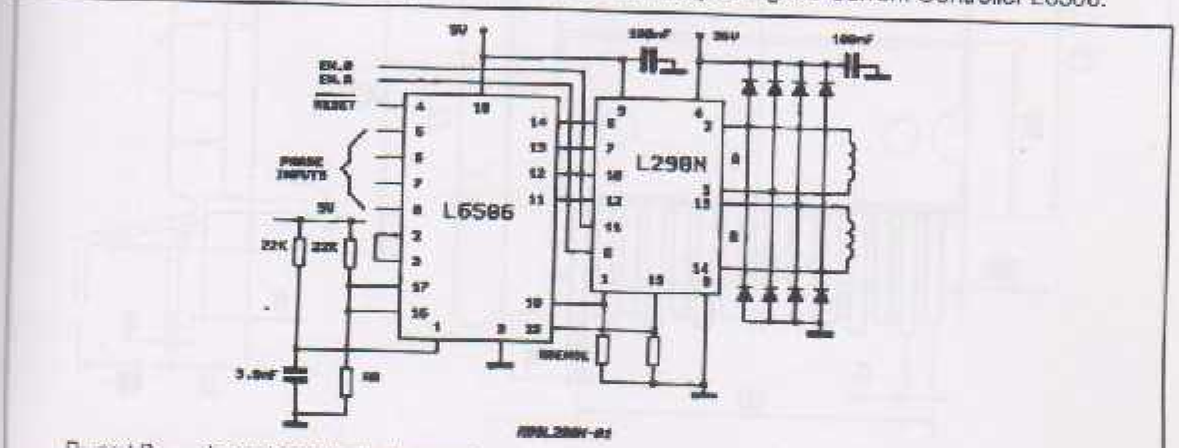


Figure 10 : Two Phase Bipolar Stepper Motor Control Circuit by Using the Current Controller L6506.

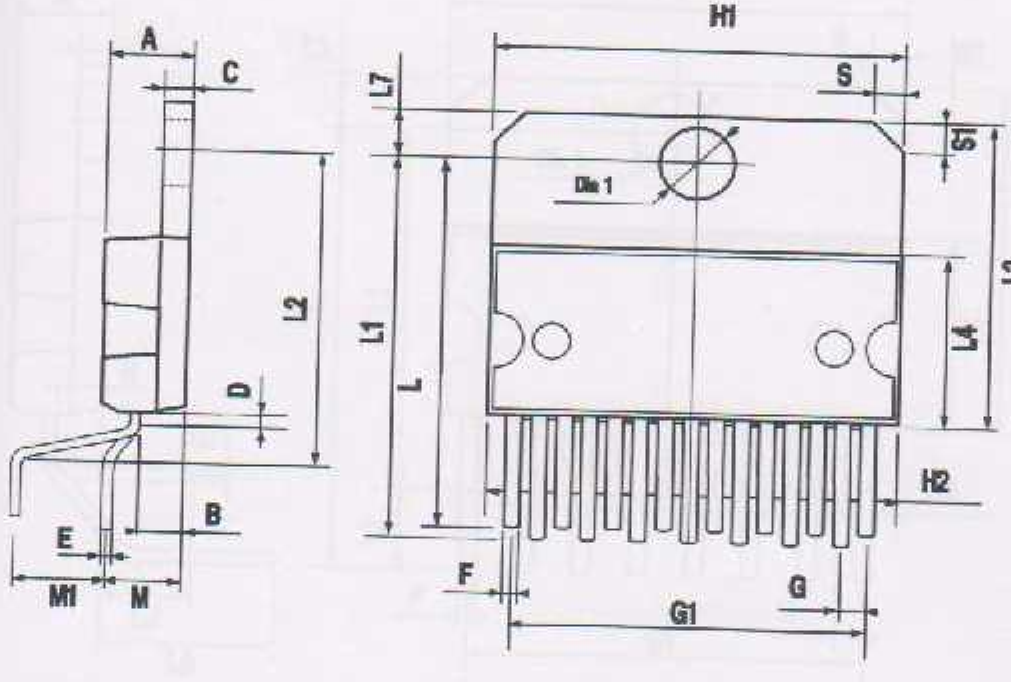


R_R and R_{sense} depend from the load current

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
D		1			0.039	
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.02	1.27	1.52	0.040	0.050	0.060
G1	17.53	17.78	18.03	0.690	0.700	0.710
H1	19.6			0.772		
H2			20.2			0.795
L	21.9	22.2	22.5	0.862	0.874	0.886
L1	21.7	22.1	22.5	0.854	0.870	0.886
L2	17.65		18.1	0.695		0.713
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L7	2.65		2.9	0.104		0.114
M	4.25	4.55	4.85	0.167	0.179	0.191
M1	4.63	5.08	5.53	0.182	0.200	0.218
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.85		3.85	0.144		0.152

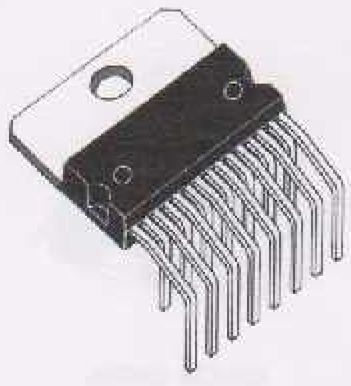
OUTLINE AND MECHANICAL DATA

Multiwatt15 V

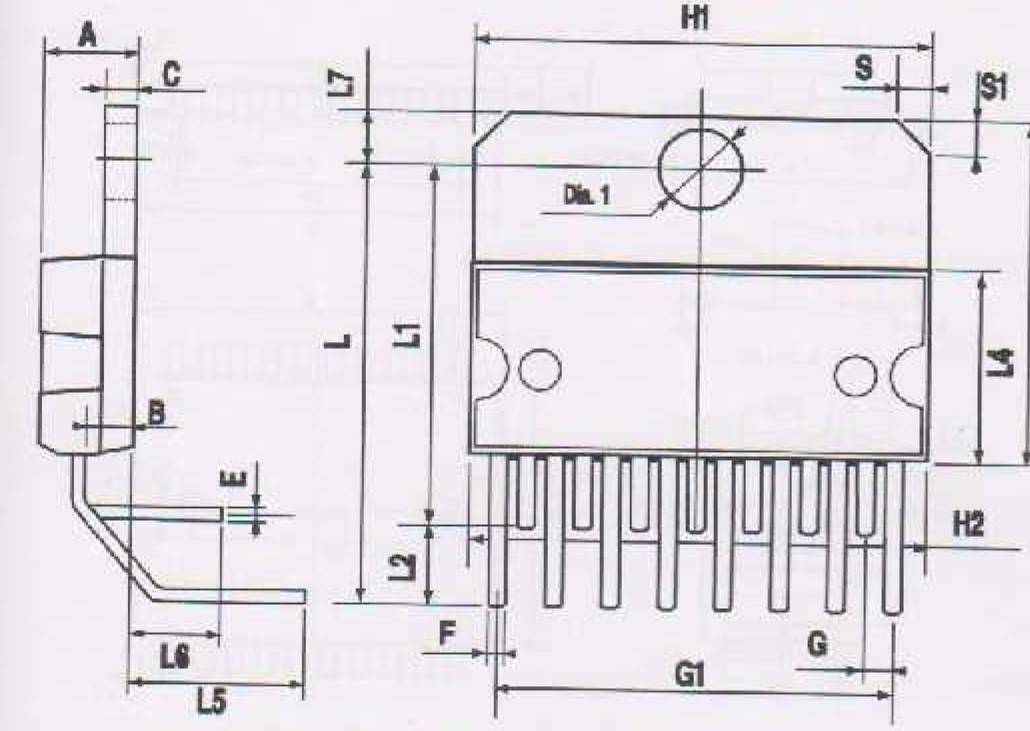


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.14	1.27	1.4	0.045	0.050	0.055
G1	17.57	17.78	17.91	0.692	0.700	0.705
H1	19.6			0.772		
H2			20.2			0.795
L		20.57			0.810	
L1		18.03			0.710	
L2		2.54			0.100	
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L5		5.28			0.208	
L6		2.38			0.094	
L7	2.65		2.9	0.104		0.114
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA



Multiwatt15 H



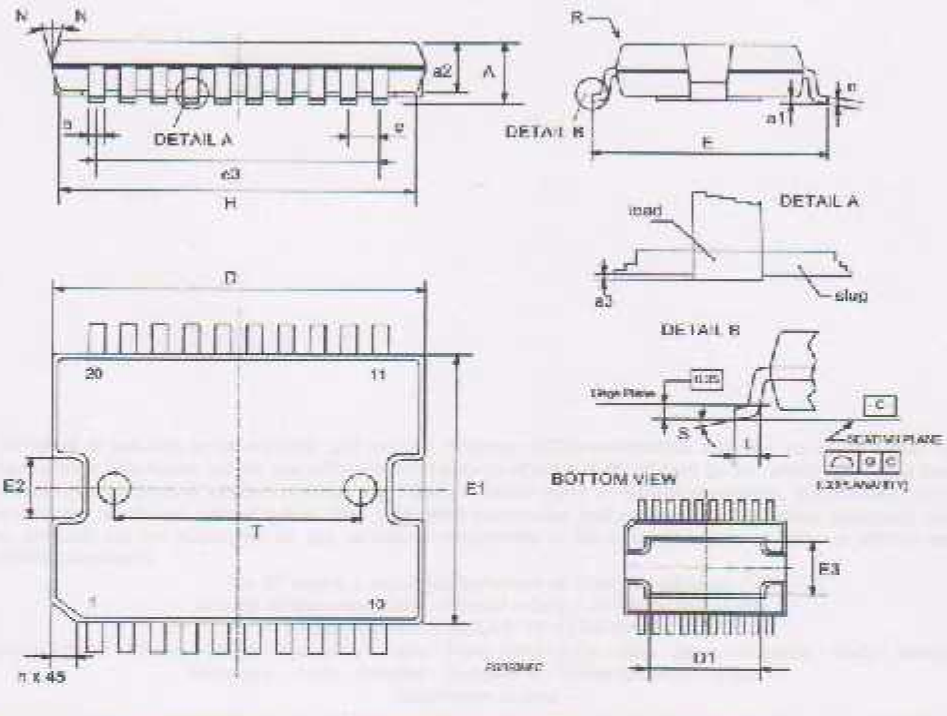
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.6			0.142
a1	0.1		0.3	0.004		0.012
a2			3.3			0.130
a3	0		0.1	0.000		0.004
b	0.4		0.53	0.016		0.021
c	0.23		0.32	0.009		0.013
D (1)	15.8		16	0.622		0.630
D1	9.4		9.8	0.370		0.386
E	13.9		14.5	0.547		0.570
e		1.27			0.050	
e3		11.43			0.450	
E1 (1)	10.9		11.1	0.429		0.437
E2			2.9			0.114
E3	5.8		6.2	0.228		0.244
G	0		0.1	0.000		0.004
H	15.5		15.9	0.610		0.626
h			1.1			0.043
L	0.8		1.1	0.031		0.043
N	10° (max.)					
S	8° (max.)					
T		10			0.394	

(1) "D and F" do not include mold flash or protrusions.
- Mold flash or protrusions shall not exceed 0.15 mm (0.006").
- Critical dimensions: "E", "G" and "a3"

OUTLINE AND MECHANICAL DATA

JEDEC MO-166

PowerSO20



Appendix (G):

Semiconductor technical data

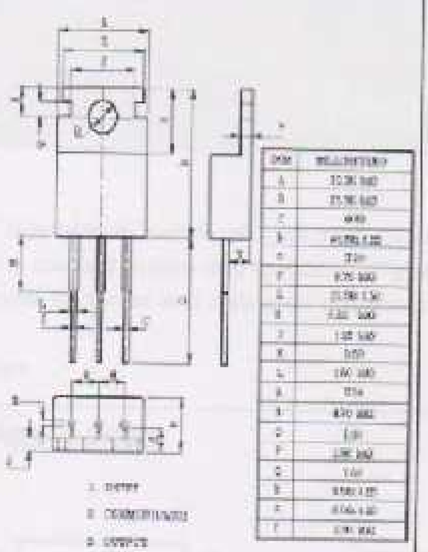
KEC
KOREA ELECTRONICS CO.,LTD

SEMICONDUCTOR
TECHNICAL DATA

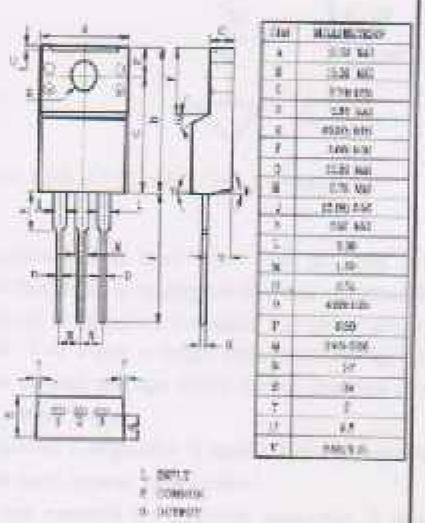
KIA7805AP/API~ KIA7824AP/API
BIPOLAR LINEAR INTEGRATED CIRCUIT

THREE TERMINAL POSITIVE VOLTAGE REGULATORS
5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, 20V, 24V.

FEATURES
- Suitable for C-MOS, TTL, the Other Digital IC's Power Supply.
- Internal Thermal Overload Protection.
- Internal Short Circuit Current Limiting.
- Output Current in Excess of 1A.
- Satisfies IEC-65 Specification. (International Electronical Commission).



TO-220AB



TO-220IS

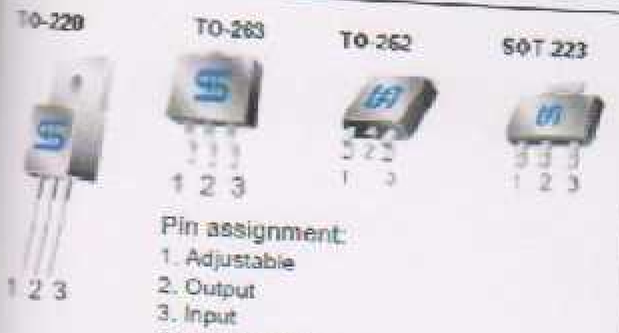
MAXIMUM RATINGS (Ta=25℃)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Input Voltage	KIA7805AP/API~ KIA7815AP/API	V_{IN}	35	V
	KIA7818AP/API~ KIA7824AP/API		40	
Power Dissipation (Tc=25℃)		P_D	20.8	W
Power Dissipation (Without Heatsink)	KIA7805API~ KIA7824API	P_D	2.0	W
Operating Junction Temperature		T_j	-30~150	℃
Storage Temperature		T_{stg}	-55~150	℃

TSC

TS317

3-Terminal Adjustable Output Positive Voltage Regulator



Pin assignment:
1. Adjustable
2. Output
3. Input

(Heatsink surface connected to pin 2)

Output Voltage Range From 1.25V to 37V
Output Current up to 1.5A

General Description

The TS317 is adjustable 3-terminal positive voltage regulator capable of supplying in excess of 1.5A over an output voltage range of 1.25 V to 37 V. This voltage regulator is exceptionally easy to use and require only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow-out proof.

The TS317 is offered in 3-pin TO-220, TO-263, TO-252 and SOT-223 package.

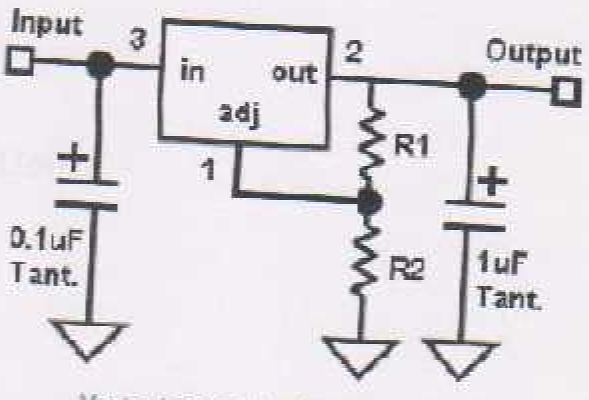
Features

- Output current up to 1.5A
  - * TO-220/TO-263 for 1.5A
  - * TO-252/SOT-223 for 500mA
- Output Adjustable between 1.25 V and 37 V
- Internal Thermal Overload Protection
- Internal Short-Circuit Current Limiting Constant with Temperature
- Output Transistor Safe-Area Compensation
- Floating Operation for High Voltage Applications
- Eliminates Stocking Many Fixed Voltages
- Output voltage offered in 4% tolerance

Ordering Information

Part No.	Operating Temp.	Package
TS317CZ	-20 ~ +150°C	TO-220
TS317CM		TO-263
TS317CP		TO-252
TS317CW		SOT-223

Standard Application



$V_{out} = 1.25\ V * (1 + R2 / R1) + I_{adj} * R2$

Since I_{Adj} is controlled to less than 100 μA, the error associated with this term is negligible in most applications. A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.

* = Cin is required if regulator is located an appreciable distance from power supply filter.

** = Co is not needed for stability; however, it does improve transient response.

Appendix (H):

LCD GDM1602K

XIAMEN OCULAR

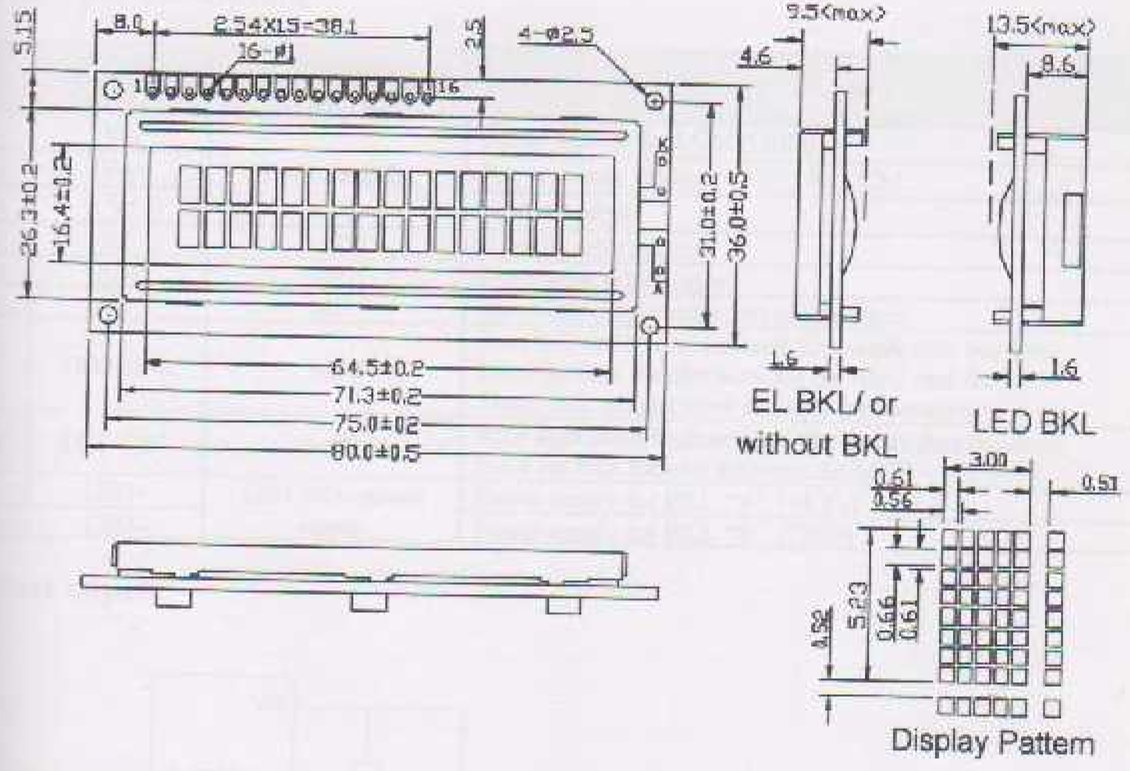
GDM1602K

SPECIFICATIONS OF LCD MODULE

eatures

- 5x8 dots with cursor
- Built-in controller (KS0066U or equivalent)
- Easy interface with 4-bit or 8-bit MPU
- +5V power supply (also available for =3.0V)
- 1/16 duty cycle
- N.V. optional
- BKL to be driven by pin1, pin2, or pin15, pin16 or A, K

utline dimension



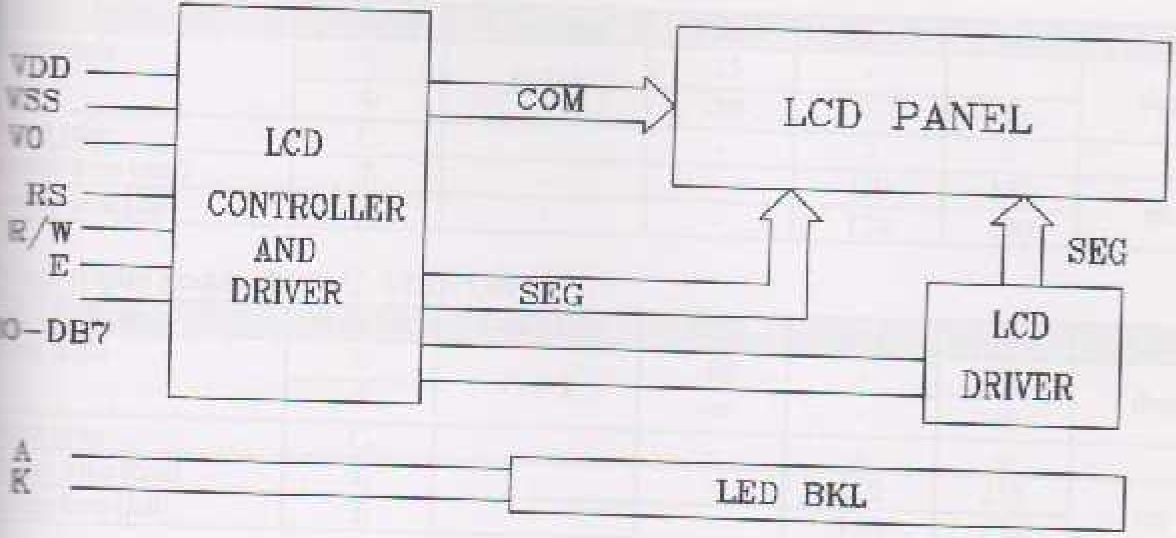
solute maximum ratings

Item	Symbol	Standard			Unit
er voltage	VDD-VSS	0	-	7.0	V
voltage	VIN	VSS	-	VDD	
g temperature range	VOP	0	-	+50	℃
temperature range	VST	-20	-	+60	

perature range is available

/storage temperature as -20~+70/-30~+80℃

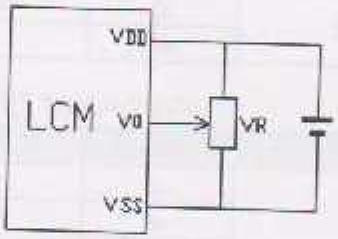
ck diagram



erface pin description

Pin no.	Symbol	External connection	Function
1	V_{SS}	Power supply	Signal ground for LCM (GND)
2	V_{DD}		Power supply for logic (+5V) for LCM
3	V_0		Contrast adjust
4	RS	MPU	Register select signal
5	R/W	MPU	Read/write select signal
6	E	MPU	Operation (data read/write) enable signal
7-10	DB0-DB3	MPU	Four low order bi-directional three-state data bus lines. Used for data transfer between the MPU and the LCM. These four are not used during 4-bit operation.
11-14	DB4-DB7	MPU	Four high order bi-directional three-state data bus lines. Used for data transfer between the MPU
15	LED+	LED BKL power supply	Power supply for BKL "A" (+4.2V)
16	LED-		Power supply for BKL "K" (GND)

trast adjust



V_{DD}-V_0: LCD Driving voltage
VR: 10k~20k

ptical characteristics

N type display module (Ta=25℃, VDD=5.0V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
wing angle	θ	$C_r \geq 4$	-25	-	-	deg
	Φ		-30	-	30	
ntrast ratio	C_r		-	2	-	-
sponse time (rise)	T_r	-	-	120	150	ms
sponse time (fall)	T_f	-	-	120	150	

N type display module (Ta=25℃, VDD=5.0V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
wing angle	θ	$C_r \geq 2$	-60	-	35	deg
	Φ		-40	-	40	
ntrast ratio	C_r		-	6	-	-
sponse time (rise)	T_r	-	-	150	250	ms
sponse time (fall)	T_f	-	-	150	250	

ectrical characteristics

C characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
ply voltage for LCD	$V_{DD}-V_0$	Ta=25℃	-	4.6	-	V
t voltage	V_{DD}		4.7	-	5.5	
ply current	I_{DD}	Ta=25℃, V_{DD}=5.0V	-	1.5	2.5	mA
t leakage current	I_{LKG}		-	-	1.0	uA
level input voltage	V_{IH}		2.2	-	V_{DD}	V
level input voltage	V_{IL}	Twice initial value or less	0	-	0.6	
level output voltage	V_{OH}	LOH=-0.25mA	2.4	-	-	
level output voltage	V_{OL}	LOH=1.6mA	-	-	0.4	
light supply voltage	V_F		-	4.2	4.6	

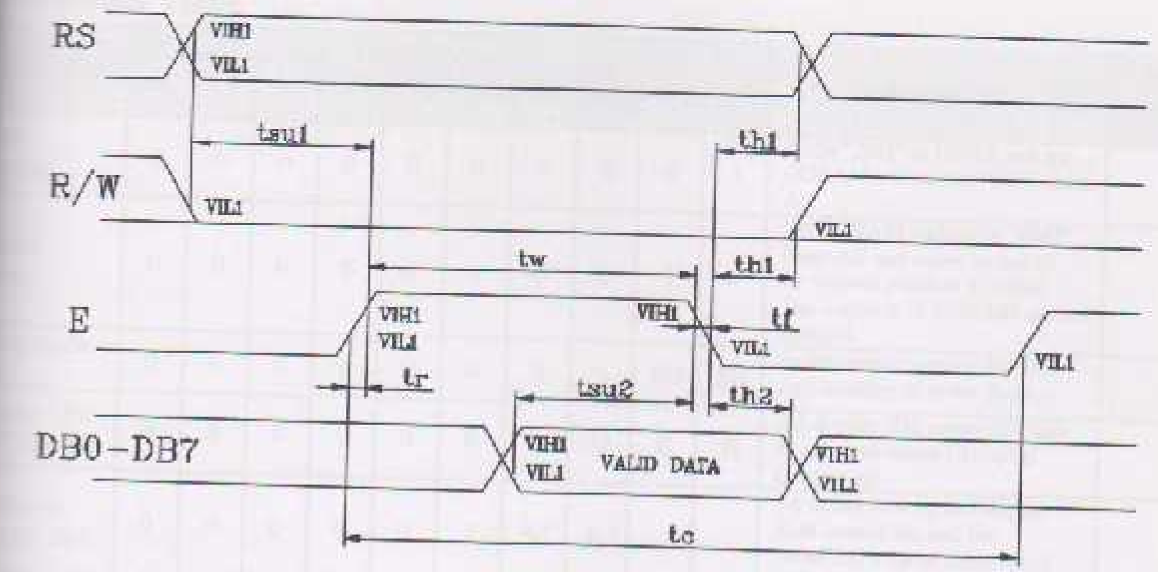
d cycle (Ta=25℃, VDD=5.0V)

Parameter	Symbol	Test pin	Min.	Typ.	Max.	Unit
le cycle time	t_c	E	500	-	-	ns
le pulse width	t_w		300	-	-	
le rise/fall time	t_r, t_f		-	-	25	
R/W setup time	t_{su}	RS; R/W	100	-	-	
R/W address hold time	t_h	RS; R/W	10	-	-	
d data output delay	t_d	DB0-DB7	60	-	90	
d data hold time	t_{dh}		20	-	-	

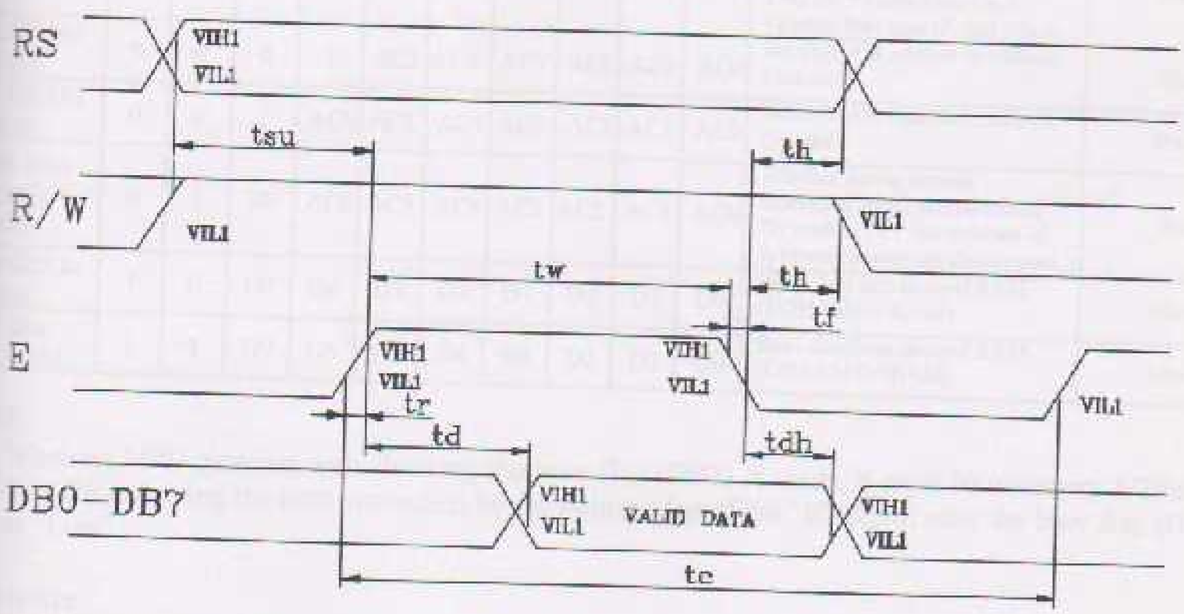
ite cycle (Ta=25℃, VDD=5.0V)

Parameter	Symbol	Test pin	Min.	Typ.	Max.	Unit
ble cycle time	t_c	E	500	-	-	ns
ble pulse width	t_w		300	-	-	
ble rise/fall time	t_r, t_f		-	-	25	
R/W setup time	t_{su1}	RS; R/W	100	-	-	
R/W address hold time	t_{h1}	RS; R/W	10	-	-	
d data output delay	t_{su2}	DB0-DB7	60	-	-	
d data hold time	t_{h2}		10	-	-	

rite mode timing diagram



ead mode timing diagram



struction description

utline

o overcome the speed difference between the internal clock of KS0066U and the MPU clock, KS0066U performs ernal operations by storing control in formations to IR or DR. The internal operation is determined according to the gnal from MPU, composed of read/write and data bus (Refer to Table7).
structions can be divided largely into four groups:

1) KS0066U function set instructions (set display methods, set data length, etc.)
2) Address set instructions to internal RAM
3) Data transfer instructions with internal RAM
4) Others

e address of the internal RAM is automatically increased or decreased by 1.

e: during internal operation, busy flag (DB7) is read "High".

Busy flag check must be preceded by the next instruction.

struction Table

truction	Instruction code										Description	Execution time (fosc=270 KHZ
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
ar play	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRA and set DDRAM address to "00H" from AC	1.53ms
urn me	0	0	0	0	0	0	0	0	1	-	Set DDRAM address to "00H" From AC and return cursor to Its original position if shifted. The contents of DDRAM are not changed.	1.53ms
ry mode	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction And blinking of entire display	39us
play ON/ control	0	0	0	0	0	0	1	D	C	B	Set display (D), cursor (C), and Blinking of cursor (B) on/off Control bit.	
sor or play shift	0	0	0	0	0	1	S/C	R/L	-	-	Set cursor moving and display Shift control bit, and the Direction, without changing of DDRAM data.	39us
ction set	0	0	0	0	1	DL	N	F	-	-	Set interface data length (DL: 8-Bit/4-bit), numbers of display Line (N: =2-line/1-line) and, Display font type (F: 5x11/5x8)	39us
CGRAM dress	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address Counter.	39us
DDRAM dress	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address Counter.	39us
ad busy g and dress	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Whether during internal Operation or not can be known By reading BF. The contents of Address counter can also be read.	0us
e data to dress	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43us
ad data m RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM).	43us

TE:

When an MPU program with checking the busy flag (DB7) is made, it must be necessary 1/2fosc is cessary for executing the next instruction by the falling edge of the "E" signal after the busy flag (DB7) es to "Low".

ntents

1) Clear display

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	0	1

Clear all the display data by writing "20H" (space code) to all DDRAM address, and set DDRAM dress to "00H" into AC (address counter).

Return cursor to the original status, namely, bring the cursor to the left edge on the fist line of the play.

Make the entry mode increment (I/D="High").

2) **Return home**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	1	-

Return home is cursor return home instruction.
Set DDRAM address to "00H" into the address counter.
Return cursor to its original site and return display to its original status, if shifted.
Contents of DDRAM does not change.

3) **Entry mode set**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	I/D	SH

the moving direction of cursor and display.

I/D: increment / decrement of DDRAM address (cursor or blink)
hen I/D="high", cursor/blink moves to right and DDRAM address is increased by 1.
hen I/D="Low", cursor/blink moves to left and DDRAM address is increased by 1.
GRAM operates the same way as DDRAM, when reading from or writing to CGRAM.

SH: shift of entire display
hen DDRAM read (CGRAM read/write) operation or SH="Low", shifting of entire display is not rformed. If SH ="High" and DDRAM write operation, shift of entire display is performed according to D value. (I/D="high". shift left, I/D="Low". Shift right).

4) **Display ON/OFF control**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	1	D	C	B

ntrol display/cursor/blink ON/OFF 1 bit register.

D: Display ON/OFF control bit
hen D="High", entire display is turned on.
hen D="Low", display is turned off, but display data remains in DDRAM.

C: cursor ON/OFF control bit
hen D="High", cursor is turned on.
hen D="Low", cursor is disappeared in current display, but I/D register preserves its data.

B: Cursor blink ON/OFF control bit
hen B="High", cursor blink is on, which performs alternately between all the "High" data and display racters at the cursor position.
hen B="Low", blink is off.

5) **Cursor or display shift**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	1	S/C	R/L	-	-

ifting of right/left cursor position or display without writing or reading of display data.
is instruction is used to correct or search display data.
ring 2-line mode display, cursor moves to the 2nd line after the 40th digit of the 1st line.
te that display shift is performed simultaneously in all the lines.
en display data is shifted repeatedly, each line is shifted individually.
en display shift is performed, the contents of the address counter are not changed.

ift patterns according to S/C and R/L bits

S/C	R/L	Operation
0	0	Shift cursor to the left, AC is decreased by 1
0	1	Shift cursor to the right, AC is increased by 1
1	0	Shift all the display to the left, cursor moves according to the display
1	1	Shift all the display to the right, cursor moves according to the display

6) Function set

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	DL	N	F	-	-

DL: Interface data length control bit

en DL="High", it means 8-bit bus mode with MPU.
en DL="Low", it means 4-bit bus mode with MPU. Hence, DL is a signal to select 8-bit or 4-bit bus ode.
en 4-but bus mode, it needs to transfer 4-bit data twice.

N: Display line number control bit

en N="Low", 1-line display mode is set.
en N="High", 2-line display mode is set.

F: Display line number control bit

en F="Low", 5x8 dots format display mode is set.
en F="High", 5x11 dots format display mode.

7) Set CGRAM address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0

t CGRAM address to AC.
e instruction makes CGRAM data available from MPU.

8) Set DDRAM address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0

t DDRAM address to AC.
s instruction makes DDRAM data available form MPU.
en 1-line display mode (N=LOW), DDRAM address is form "00H" to "4FH".In 2-line display mode =High), DDRAM address in the 1st line form "00H" to "27H", and DDRAM address in the 2nd line is

m "40H" to "67H".

9) **Read busy flag & address**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0

s instruction shows whether KS0066U is in internal operation or not.
he resultant BF is "High", internal operation is in progress and should wait BF is to be LOW, which by n the nest instruction can be performed. In this instruction you can also read the value of the address nter.

10) **Write data to RAM**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	D7	D6	D5	D4	D3	D2	D1	D0

te binary 8-bit data to DDRAM/CGRAM.
e selection of RAM from DDRAM, and CGRAM, is set by the previous address set instruction DRAM address set, CGRAM address set).
M set instruction can also determine the AC direction to RAM.
er write operation. The address is automatically increased/decreased by 1, according to the entry de.

11) **Read data from RAM**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	D7	D6	D5	D4	D3	D2	D1	D0

d binary 8-bit data from DDRAM/CGRAM.
The selection of RAM is set by the previous address set instruction. If the address set instruction of M is not performed before this instruction, the data that has been read first is invalid, as the direction AC is not yet determined. If RAM data is read several times without RAM address instructions set ore, read operation, the correct RAM data can be obtained from the second. But the first data would be rect, as there is no time margin to transfer RAM data.
In case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address instruction, it also transfers RAM data to output data register.
After read operation, address counter is automatically increased/decreased by 1 according to the ry mode.
After CGRAM read operation, display shift may not be executed correctly.

TE: In case of RAM write operation, AC is increased/decreased by 1 as in read operation.
At this time, AC indicates next address position, but only the previous data can be read by the read truction.

splay character address code:

Display position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DDRAM address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
DDRAM address	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F

Standard character pattern

Lower 4 bits \ Upper 4 bits	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)			0	@	P	`	p				ー	タ	ミ	α	p
xxxx0001	(2)		!	1	A	Q	a	q			。	ア	チ	ム	ä	q
xxxx0010	(3)		"	2	B	R	b	r			「	イ	ツ	メ	β	θ
xxxx0011	(4)		#	3	C	S	c	s			」	ウ	テ	モ	ε	∞
xxxx0100	(5)		$	4	D	T	d	t			、	エ	ト	ヤ	μ	Ω
xxxx0101	(6)		%	5	E	U	e	u			・	オ	ナ	ユ	σ	ü
xxxx0110	(7)		&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
xxxx0111	(8)		'	7	G	W	g	w			ァ	キ	ヌ	ラ	g	π
xxxx1000	(1)		(	8	H	X	h	x			ィ	ク	ネ	リ	√	x̄
xxxx1001	(2)		)	9	I	Y	i	y			ゥ	ケ	ノ	ル	⁻¹	y
xxxx1010	(3)		*	:	J	Z	j	z			ェ	コ	ハ	レ	j	千
xxxx1011	(4)		+	;	K	[	k	{			ォ	サ	ヒ	ロ	ˣ	万
xxxx1100	(5)		,	<	L	¥	l	|			ャ	シ	フ	ワ	¢	円
xxxx1101	(6)		-	=	M	]	m	}			ュ	ス	ヘ	ン	£	÷
xxxx1110	(7)		.	>	N	^	n	→			ョ	セ	ホ	゛	ñ	
xxxx1111	(8)		/	?	O	_	o	←			ッ	ソ	マ	゜	ö	█

Appendix (I):

PIC18F4550 Microcontroller

MICROCHIP PIC18F2455/2550/4455/4550

28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology

Universal Serial Bus Features:

- USB V2.0 Compliant
- Low Speed (1.5 Mb/s) and Full Speed (12 Mb/s)
- Supports Control, Interrupt, Isochronous and Bulk Transfers
- Supports up to 32 Endpoints (16 bidirectional)
- 1-Kbyte Dual Access RAM for USB
- On-Chip USB Transceiver with On-Chip Voltage Regulator
- Interface for Off-Chip USB Transceiver
- Streaming Parallel Port (SPP) for USB streaming transfers (40/44-pin devices only)

Power-Managed Modes:

- Run: CPU on, peripherals on
- Idle: CPU off, peripherals on
- Sleep: CPU off, peripherals off
- Idle mode currents down to 5.8 μA typical
- Sleep mode currents down to 0.1 μA typical
- Timer1 Oscillator: 1.1 μA typical, 32 kHz, 2V
- Watchdog Timer: 2.1 μA typical
- Two-Speed Oscillator Start-up

Flexible Oscillator Structure:

- Four Crystal modes, including High Precision PLL for USB
- Two External Clock modes, up to 48 MHz
- Internal Oscillator Block:
  - 8 user-selectable frequencies, from 31 kHz to 8 MHz
  - User-tunable to compensate for frequency drift
- Secondary Oscillator using Timer1 @ 32 kHz
- Dual Oscillator options allow microcontroller and USB module to run at different clock speeds
- Fail-Safe Clock Monitor:
  - Allows for safe shutdown if any clock stops

Peripheral Highlights:

- High-Current Sink/Source: 25 mA/25 mA
- Three External Interrupts
- Four Timer modules (Timer0 to Timer3)
- Up to 2 Capture/Compare/PWM (CCP) modules:
  - Capture is 16-bit, max. resolution 5.2 ns ($T_{CY}/16$)
  - Compare is 16-bit, max. resolution 83.3 ns (T_{CY})
  - PWM output: PWM resolution is 1 to 10-bit
- Enhanced Capture/Compare/PWM (ECCP) module:
  - Multiple output modes
  - Selectable polarity
  - Programmable dead time
  - Auto-shutdown and auto-restart
- Enhanced USART module:
  - LIN bus support
- Master Synchronous Serial Port (MSSP) module supporting 3-wire SPI (all 4 modes) and I²C™ Master and Slave modes
- 10-bit, up to 13-channel Analog-to-Digital Converter module (A/D) with Programmable Acquisition Time
- Dual Analog Comparators with Input Multiplexing

Special Microcontroller Features:

- C Compiler Optimized Architecture with optional Extended Instruction Set
- 100,000 Erase/Write Cycle Enhanced Flash Program Memory typical
- 1,000,000 Erase/Write Cycle Data EEPROM Memory typical
- Flash/Data EEPROM Retention: > 40 years
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
  - Programmable period from 41 ms to 131s
- Programmable Code Protection
- Single-Supply 5V In-Circuit Serial Programming™ (ICSP™) via two pins
- In-Circuit Debug (ICD) via two pins
- Optional dedicated ICD/ICSP port (44-pin devices only)
- Wide Operating Voltage Range (2.0V to 5.5V)

Device	Program Memory		Data Memory		I/O	10-Bit A/D (ch)	CCP/ECCP (PWM)	SPP	MSSP		EAUSART	Comparators	Timers 8/16-Bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)					SPI	Master I²C™			
PIC18F2455	24K	12288	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F2550	32K	16384	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F4455	24K	12288	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3
PIC18F4550	32K	16384	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3

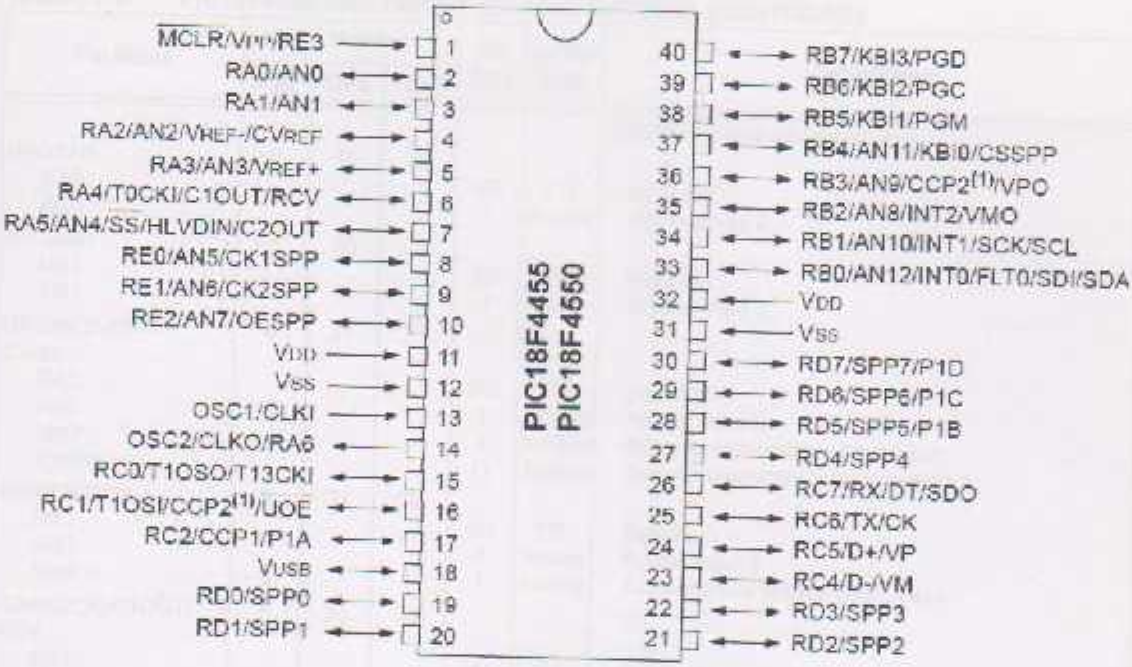


TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
MCLR/VPP/RE3	1	18	18			Master Clear (input) or programming voltage (input)
MCLR				I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP				P		Programming voltage input
RE3				I	ST	Digital input
OSC1/CLKI	13	32	30			Oscillator crystal or external clock input
OSC1				I	Analog	Oscillator crystal input or external clock source input
CLKI				I	Analog	External clock source input. Always associated with pin function OSC1. (See OSC2/CLKO pin.)
OSC2/CLKO/RA6	14	33	31			Oscillator crystal or clock output
OSC2				O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO				O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6				I/O	TTL	General purpose I/O pin

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the DEBUG Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number PDIP	Pin Number QFN	Pin Number TQFP	Pin Type	Buffer Type	Description
						PORTA is a bidirectional I/O port
RA0/AN0	2	19	19			
RA0				I/O	TTL	Digital I/O.
AN0				I	Analog	Analog input 0.
RA1/AN1	3	20	20			
RA1				I/O	TTL	Digital I/O.
AN1				I	Analog	Analog input 1.
RA2/AN2/VREF-/CVREF	4	21	21			
RA2				I/O	TTL	Digital I/O.
AN2				I	Analog	Analog input 2.
VREF-				I	Analog	A/D reference voltage (low) input.
CVREF				O	Analog	Analog comparator reference output.
RA3/AN3/VREF+	5	22	22			
RA3				I/O	TTL	Digital I/O.
AN3				I	Analog	Analog input 3.
VREF+				I	Analog	A/D reference voltage (high) input.
RA4/T0CKI/C1OUT/RCV	6	23	23			
RA4				I/O	ST	Digital I/O.
T0CKI				I	ST	Timer0 external clock input.
C1OUT				O	—	Comparator 1 output.
RCV				I	TTL	External USB transceiver RCV input.
RA5/AN4/$\overline{SS}$/HLVDIN/C2OUT	7	24	24			
RA5				I/O	TTL	Digital I/O.
AN4				I	Analog	Analog input 4.
$\overline{SS}$				I	TTL	SPI slave select input.
HLVDIN				I	Analog	High/Low-Voltage Detect input.
C2OUT				O	—	Comparator 2 output.
RA6	—	—	—	—	—	See the OSC2/CLKO/RA6 pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output
ST = Schmitt Trigger input with CMOS levels; I = Input
O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.
2: Default assignment for CCP2 when CCP2MX Configuration bit is set.
3: These pins are No Connect unless the $\overline{ICPRT}$ Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the $\overline{DEBUG}$ Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number PDIP	Pin Number QFN	Pin Number TQFP	Pin Type	Buffer Type	Description
						PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/AN12/INT0/FLT0/SDI/SDA	33	9	8			
RB0				I/O	TTL	Digital I/O.
AN12				I	Analog	Analog input 12.
INT0				I	ST	External interrupt 0.
FLT0				I	ST	Enhanced PWM Fault input (ECCP1 module).
SDI				I	ST	SPI data in.
SDA				I/O	ST	I²C™ data I/O.
RB1/AN10/INT1/SCK/SCL	34	10	9			
RB1				I/O	TTL	Digital I/O.
AN10				I	Analog	Analog input 10.
INT1				I	ST	External interrupt 1.
SCK				I/O	ST	Synchronous serial clock input/output for SPI mode.
SCL				I/O	ST	Synchronous serial clock input/output for I²C mode.
RB2/AN8/INT2/VMO	35	11	10			
RB2				I/O	TTL	Digital I/O.
AN8				I	Analog	Analog input 8.
INT2				I	ST	External interrupt 2.
VMO				O	—	External USB transceiver VMO output.
RB3/AN9/CCP2/VPO	36	12	11			
RB3				I/O	TTL	Digital I/O.
AN9				I	Analog	Analog input 9.
CCP2(1)				I/O	ST	Capture 2 input/Compare 2 output/PWM 2 output.
VPO				O	—	External USB transceiver VPO output.
RB4/AN11/KBI0/CSSPP	37	14	14			
RB4				I/O	TTL	Digital I/O.
AN11				I	Analog	Analog input 11.
KBI0				I	TTL	Interrupt-on-change pin.
CSSPP				O	—	SPP chip select control output.
RB5/KBI1/PGM	38	15	15			
RB5				I/O	TTL	Digital I/O.
KBI1				I	TTL	Interrupt-on-change pin.
PGM				I/O	ST	Low-Voltage ICSP™ Programming enable pin.
RB6/KBI2/PGC	39	16	16			
RB6				I/O	TTL	Digital I/O.
KBI2				I	TTL	Interrupt-on-change pin.
PGC				I/O	ST	In-Circuit Debugger and ICSP programming clock pin.
RB7/KBI3/PGD	40	17	17			
RB7				I/O	TTL	Digital I/O.
KBI3				I	TTL	Interrupt-on-change pin.
PGD				I/O	ST	In-Circuit Debugger and ICSP programming data pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the $\overline{DEBUG}$ Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTC is a bidirectional I/O port.
RC0/T1OSO/T13CKI	15	34	32			
RC0				I/O	ST	Digital I/O.
T1OSO				O	—	Timer1 oscillator output.
T13CKI				I	ST	Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2/$\overline{UOE}$	16	35	35			
RC1				I/O	ST	Digital I/O.
T1OSI				I	CMOS	Timer1 oscillator input.
CCP2[2]				I/O	ST	Capture 2 input/Compare 2 output/PWM 2 output.
$\overline{UOE}$				O	—	External USB transceiver $\overline{OE}$ output.
RC2/CCP1/P1A	17	36	36			
RC2				I/O	ST	Digital I/O.
CCP1				I/O	ST	Capture 1 input/Compare 1 output/PWM 1 output.
P1A				O	TTL	Enhanced CCP1 PWM output, channel A.
RC4/D-/VM	23	42	42			
RC4				I	TTL	Digital input.
D-				I/O	—	USB differential minus line (input/output).
VM				I	TTL	External USB transceiver VM input.
RC5/D+/VP	24	43	43			
RC5				I	TTL	Digital input.
D+				I/O	—	USB differential plus line (input/output).
VP				I	TTL	External USB transceiver VP input.
RC6/TX/CK	25	44	44			
RC6				I/O	ST	Digital I/O.
TX				O	—	EUSART asynchronous transmit.
CK				I/O	ST	EUSART synchronous clock (see RX/DT).
RC7/RX/DT/SDO	26	1	1			
RC7				I/O	ST	Digital I/O.
RX				I	ST	EUSART asynchronous receive.
DT				I/O	ST	EUSART synchronous data (see TX/CK).
SDO				O	—	SPI data out.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the $\overline{DEBUG}$ Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTD is a bidirectional I/O port or a Streaming Parallel Port (SPP). These pins have TTL input buffers when the SPP module is enabled.
RD0/SPP0	19	38	38			
RD0				I/O	ST	Digital I/O.
SPP0				I/O	TTL	Streaming Parallel Port data.
RD1/SPP1	20	39	39			
RD1				I/O	ST	Digital I/O.
SPP1				I/O	TTL	Streaming Parallel Port data.
RD2/SPP2	21	40	40			
RD2				I/O	ST	Digital I/O.
SPP2				I/O	TTL	Streaming Parallel Port data.
RD3/SPP3	22	41	41			
RD3				I/O	ST	Digital I/O.
SPP3				I/O	TTL	Streaming Parallel Port data.
RD4/SPP4	27	2	2			
RD4				I/O	ST	Digital I/O.
SPP4				I/O	TTL	Streaming Parallel Port data.
RD5/SPP5/P1B	28	3	3			
RD5				I/O	ST	Digital I/O.
SPP5				I/O	TTL	Streaming Parallel Port data.
P1B				O	—	Enhanced CCP1 PWM output, channel B.
RD6/SPP6/P1C	29	4	4			
RD6				I/O	ST	Digital I/O.
SPP6				I/O	TTL	Streaming Parallel Port data.
P1C				O	—	Enhanced CCP1 PWM output, channel C.
RD7/SPP7/P1D	30	5	5			
RD7				I/O	ST	Digital I/O.
SPP7				I/O	TTL	Streaming Parallel Port data.
P1D				O	—	Enhanced CCP1 PWM output, channel D.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the $\overline{\text{DEBUG}}$ Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTE is a bidirectional I/O port.
RE0/AN5/CK1SPP	8	25	25			
RE0				I/O	ST	Digital I/O.
AN5				I	Analog	Analog input 5.
CK1SPP				O	—	SPP clock 1 output.
RE1/AN6/CK2SPP	9	26	26			
RE1				I/O	ST	Digital I/O.
AN6				I	Analog	Analog input 6.
CK2SPP				O	—	SPP clock 2 output.
RE2/AN7/OESPP	10	27	27			
RE2				I/O	ST	Digital I/O.
AN7				I	Analog	Analog input 7.
OESPP				O	—	SPP output enable output.
RE3	—	—	—	—	—	See MCLR/VPP/RE3 pin.
VSS	12, 31	6, 30, 31	6, 29	P	—	Ground reference for logic and I/O pins.
VDD	11, 32	7, 8, 28, 29	7, 28	P	—	Positive supply for logic and I/O pins.
VUSB	18	37	37	O	—	Internal USB 3.3V voltage regulator output.
NC/ICCK/ICPGC[3]	—	—	12			No Connect or dedicated ICD/ICSP™ port clock.
ICCK				I/O	ST	In-Circuit Debugger clock.
ICPGC				I/O	ST	ICSP programming clock.
NC/ICDT/ICPGD[3]	—	—	13			No Connect or dedicated ICD/ICSP port clock.
ICDT				I/O	ST	In-Circuit Debugger data.
ICPGD				I/O	ST	ICSP programming data.
NC/ICRST/ICVPP[3]	—	—	33			No Connect or dedicated ICD/ICSP port Reset.
ICRST				I	—	Master Clear (Reset) input.
ICVPP				P	—	Programming voltage input.
NC/ICPORTS[3]	—	—	34	P	—	No Connect or 28-pin device emulation.
ICPORTS						Enable 28-pin device emulation when connected to VSS.
NC	—	13	—	—	—	No Connect.

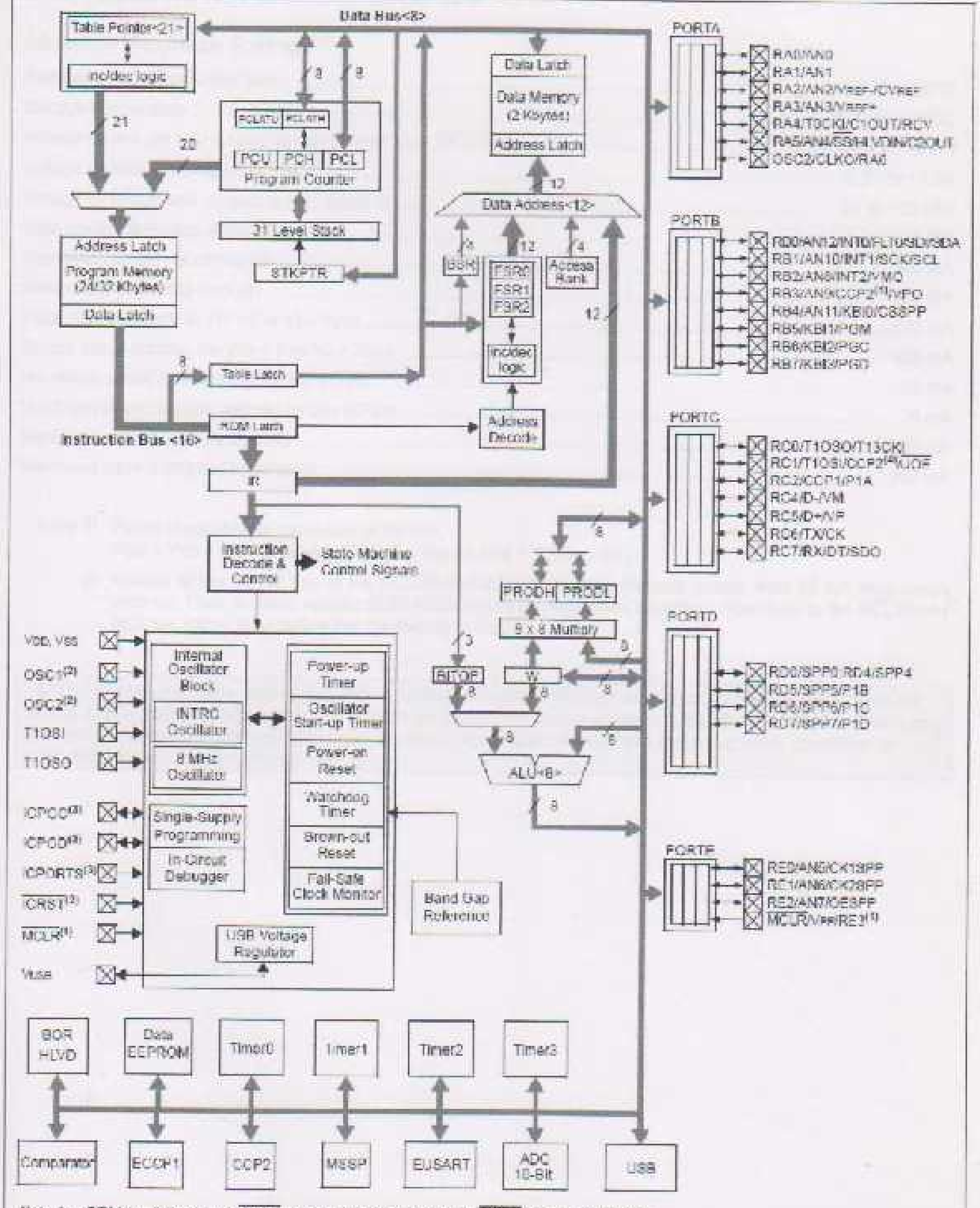
Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the DEBUG Configuration bit is cleared.

FIGURE 1-2: PIC18F4455/4550 (40/44-PIN) BLOCK DIAGRAM



Note 1: RE3 is multiplexed with $\overline{MCLR}$ and is only available when the $\overline{MCLR}$ Resets are disabled.

2: OSC1/CLKI and OSC2/CLKO are only available in select oscillator modes and when these pins are not being used as digital I/O. Refer to **Section 2.0 "Oscillator Configurations"** for additional information.

3: These pins are only available on 44-pin TQFP packages under certain conditions. Refer to **Section 25.9 "Special ICPORT Features (Designated Packages Only)"** for additional information.

4: RB3 is the alternate pin for CCP2 multiplexing.

28.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings(†)

Ambient temperature under bias	-40°C to +85°C
Storage temperature	-65°C to +150°C
Voltage on any pin with respect to V_{SS} (except V_{DD}, $\overline{MCLR}$ and RA4)	-0.3V to (V_{DD} + 0.3V)
Voltage on V_{DD} with respect to V_{SS}	-0.3V to +7.5V
Voltage on $\overline{MCLR}$ with respect to V_{SS} **(Note 2)**	0V to +13.25V
Total power dissipation **(Note 1)**	1.0W
Maximum current out of V_{SS} pin	300 mA
Maximum current into V_{DD} pin	250 mA
Input clamp current, I_{IK} (V_I < 0 or V_I > V_{DD})	±20 mA
Output clamp current, I_{OK} (V_O < 0 or V_O > V_{DD})	±20 mA
Maximum output current sunk by any I/O pin	25 mA
Maximum output current sourced by any I/O pin	25 mA
Maximum current sunk by all ports	200 mA
Maximum current sourced by all ports	200 mA

Note 1: Power dissipation is calculated as follows:
$P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum(V_{OL} \times I_{OL})$

2: Voltage spikes below V_{SS} at the $\overline{MCLR}$/V_{PP}/RE3 pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the $\overline{MCLR}$/V_{PP}/RE3 pin, rather than pulling this pin directly to V_{SS}.

† **NOTICE:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

FIGURE 28-1: PIC18F2455/2550/4455/4550 VOLTAGE-FREQUENCY GRAPH (INDUSTRIAL)

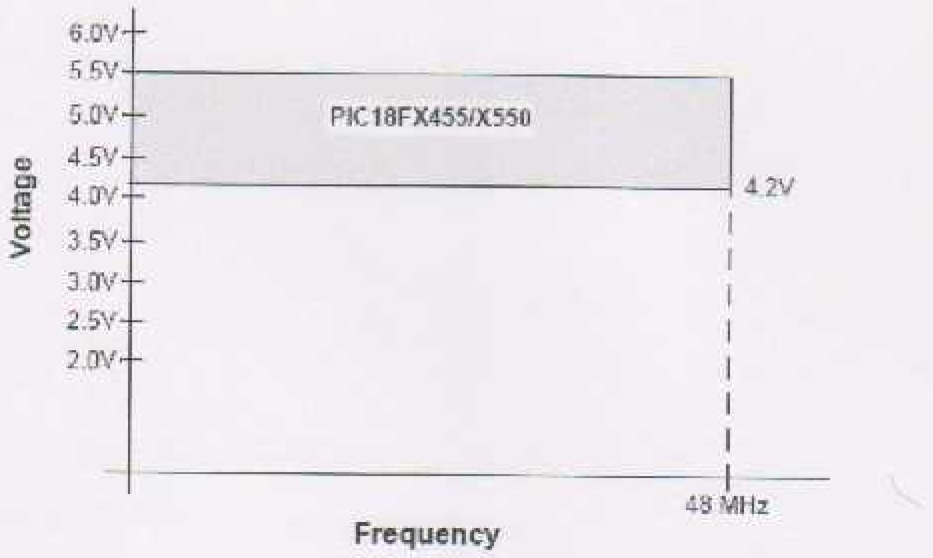
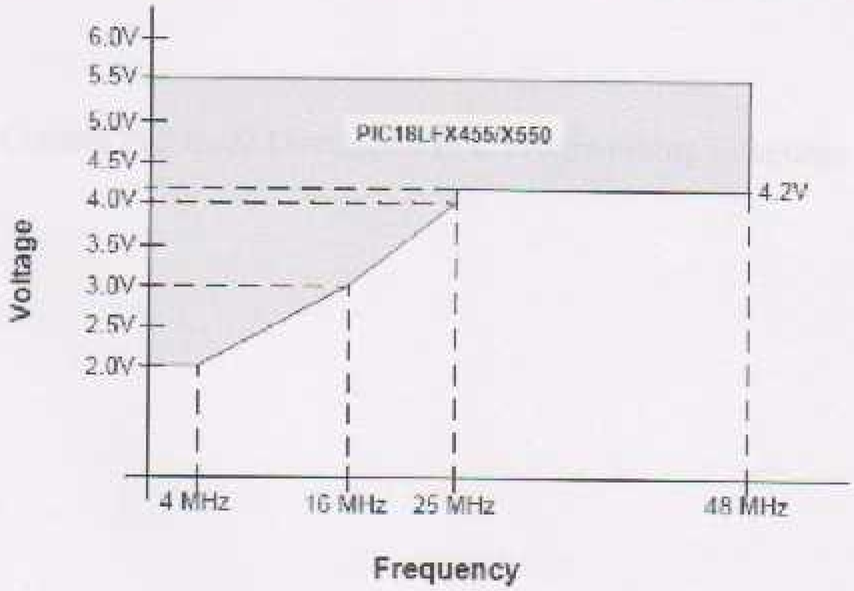


FIGURE 28-2: PIC18LF2455/2550/4455/4550 VOLTAGE-FREQUENCY GRAPH (INDUSTRIAL)



Note: VDDAPPMIN is the minimum voltage of the PIC® device in the application.

Appendix (J):

Control PIC Code Developed In C Programming Language

```
#include<p18f4550.h>
#include<delays.h>
#include<adc.h>
#include<PWM.h>
#include<timers.h>
#include "gamelcd_v3.h"
#pragma config FOSC = INTOSC_HS
#pragma config WDT = OFF
#pragma config PBADEN = OFF
void main (void)
{
unsigned char state=0 ;
unsigned int x=0,a,y;
        TRISA=0B00010000;
        TRISC=0;
        PORTC=0;
        TRISB=0b00001111;

lcd_init();
OpenTimer0( TIMER_INT_OFF &
T0_16BIT &
T0_SOURCE_EXT &
T0_PS_1_1 );
lcd_gotoyx(1,0);
lcd_putrs("Elevator ON");
```

```
OpenTimer2(TIMER_INT_OFF & T2_PS_1_4 & T2_POST_1_1 &
                                T3_SOURCE_CCP);

OpenPWM1(99);                              // Use of CCP1 as PWM module
OpenPWM2(99);                              // Use of CCP2 as PWM module
SetDCPWM1(0);
SetDCPWM2(0);
WriteTimer0(0);

while(1)
{
switch(state)
{
case 0:
lcd_gotoyx(2,0);
lcd_putrs("   floor one   ");
a=1;
y=ReadTimer0();
WriteTimer0(0);

while(a)
{
x=ReadTimer0 ();
x=y-x;// counding downward
```

```
SetDCPWM1(0);
SetDCPWM2(200); //revers
if(x==0)
{
SetDCPWM1(0);
SetDCPWM2(0); //brake
}
a=0;
}
WriteTimer0(0);
a=1;
while(a)
{
if(PORTBbits.RB2==0)
{
state=1;
a=0;
}
if(PORTBbits.RB3==0)
{
state=2;
a=0;
}
}
break;
```

```
case 1 :
lcd_gotoyx(2,0);
lcd_putrs("   floor two   ");
y=ReadTimer0();
if(y>=750)
{
WriteTimer0(0);
a=1;
while(a)
{
x=ReadTimer0 ();
x=y-x;// counding downward
SetDCPWM1(0);
SetDCPWM2(200); //revers
if(x==750)
{
SetDCPWM1(0);
SetDCPWM2(0); //brake
}
a=0;
}
}
if(y<750)
{
a=1;
```

```
while(a)
{
x=ReadTimer0 ();//upward counting
SetDCPWM1(200);
SetDCPWM2(0); //forward
if(x==750)
{
SetDCPWM1(0);
SetDCPWM2(0); //brake
}
a=0;
}
}
a=1;
while(a)
{
if(PORTBbits.RB1==0)
{
state=0;
a=0;
}
if(PORTBbits.RB3==0)
{
state=2;
a=0;
```

```
}
}
break;
case 2:
lcd_gotoyx(2,0);
lcd_putrs("    floor three ");
y=ReadTimer0();
if(y<1500)
{
a=1;
while(a)
{
x=ReadTimer0 ();//upward counting
SetDCPWM1(200);
SetDCPWM2(0); //forward
if(x==1500)
{
SetDCPWM1(0);
SetDCPWM2(0); //brake
}
a=0;
}
}
a=1;
while(a)
```

```
{
if(PORTBbits.RB1==0)
{
state=0;
a=0;
}
if(PORTBbits.RB2==0)
{
state=1;
a=0;
}
}
break;
}
}
}
```