SOLAR TRACKER SYSTEM

A PROJECT REPORT SUBMITTED TO

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PUNE

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MASTER OF SCIENCE IN
PHYSICS

UNDER THE FACULTY OF SCIENCE

BY

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JUNE-2021

Mula Education Society, Sonai

"ARTS, COMMERCE AND SCIENCE COLLEGE

SONAI"

DEPARTMENT OF PHYSICS

CERTIFICATE

This is certify that Mr.Kangare Rushikesh Raghunath has successfully completed his project on topic "Solar Tracker System" as the partial fulfillment of the Master of Science (physics) course of Savitribai Phule Pune University, with exam seat no._____ During academic year 2020-2021.

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I have made this report file on the topic "Solar Tracker System" . A dissertation work of such grate significance is not possible without the help of several people directly and indirectly. First and foremost I have immense happiness in expressing my sincere thanks to my guide, **"Prof. Bhakare.C.H"** for his valuable suggestion, co-operation and continuous guidance.

I feel a deep sense of gratitude to **" Dr. Sadekar.h.k"** Head of Physics Department for his continuous encouragement .

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Place: Sonai

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Date

Chapter 1

INTRODUCTION

1.1 Introduction of the project

The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications thereby effectively producing renewable energy. Solar energy is one of the abundant source of energy provide by nature and one of the most efficient form of renewable energy. Generally, solar panel is stationary and do not follow the movement of the sun and hence cannot obtain maximum sunlight throughout the day. **Solar Tracker System** that tracks the sun's movement across the sky and tries to maintain the solar panel perpendicular to the sun's rays, ensuring that the maximum amount of sunlight is incident on the panel throughout the day till evening, and starts all over again from the dawn next day.

1.2 Objectives.

- To design and construct a simple solar tracking system which can absorb maximum amount of sunlight
- To minimise the cost of installation and operation providing higher realibility.

CHAPTER 2

SYSTEM DESIGN & DEVELOPMENT

Solar Tracking System

Generally, solar panels are stationary and do not follow the movement of the sun. Here is a solar tracer system that tracks the sun's movement across the sky and tries to maintain the solar panel perpendicular to the sun's rays, ensuring that the maximum amount of sunlight is incident on the panel throughout the day. The solar tracker starts following the sun right from down, throughout the day till evening, and starts all over again from the dawn next day.

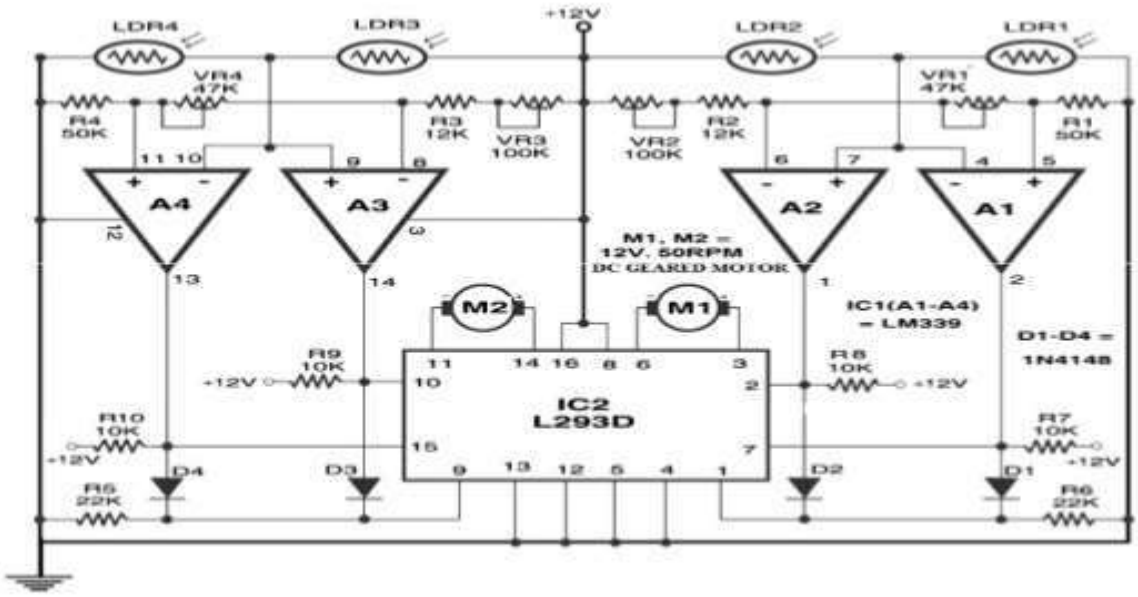


Fig. 1 Circuit Diagram

Fig. 1 shows the circuit of the solar tracking system.

The solar tracker comprises comparator IC LM339, H-bridge motor driver IC L293D (IC2) and a few discrete components. Light dependants resistors LDR1 through LDR4 are used as sensor to detect the panel's position relative to the sun. These provide the

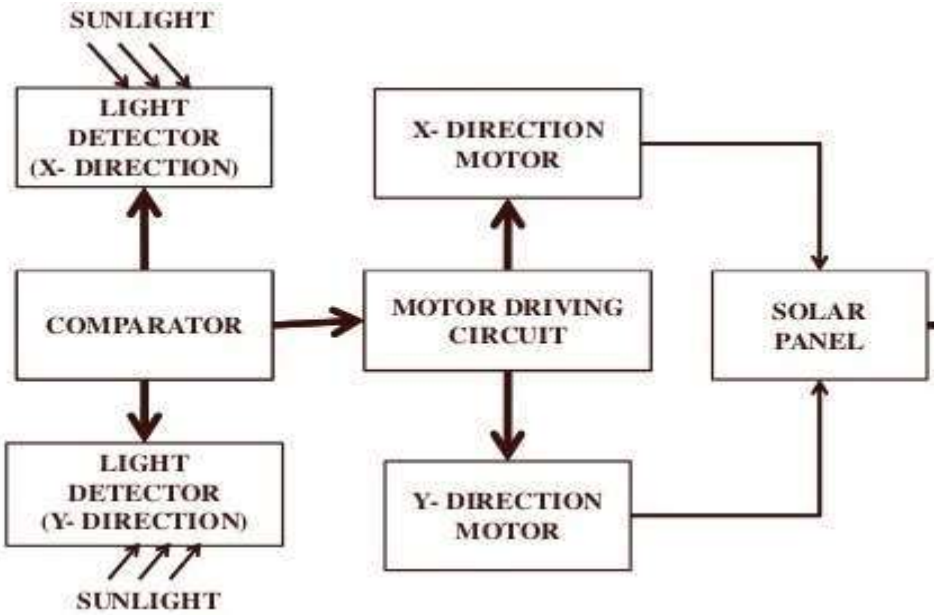
signal to motor driver IC2 to move the solar panel in the sun's direction. LDR1 and LDR2 are fixed at the edges of the solar panel along the X axis, and connect the comparators A1 and A2, resp. Presets VR1 and VR2 are set to get low comparator output at pins 2 and 1 of comparators A1 and A2 resp. so as to stop motor M1 when the sun's rays are perpendicular to the solar panel.

When LDR2 receives more light than LDR1, it offers lower resistance than LDR1, providing a high input to comparators A1 and A2 at pins 4 and 7, resp. As s result, output pin 1 of comparator A2 goes high to rotate motor M1 in one direction (say, anti-clockwise) and turn the solar panel.

When LDR1 receives more light than LDR2, it offers lower resistance than LDR2, giving a low input to comparators A1 and A2 at pins 4 and 7, resp. As the voltage at pin 5 of comparator A1 is now higher than the voltage at its pin 4, its output pin 2 goes high. As a result, motor M1 rotates in the opposite direction (Say Clock-wise) and the solar panel turns.

Similarly, LDR3 and LDR4 track the sun along Y-axis.

- **Functional Block Diagram**



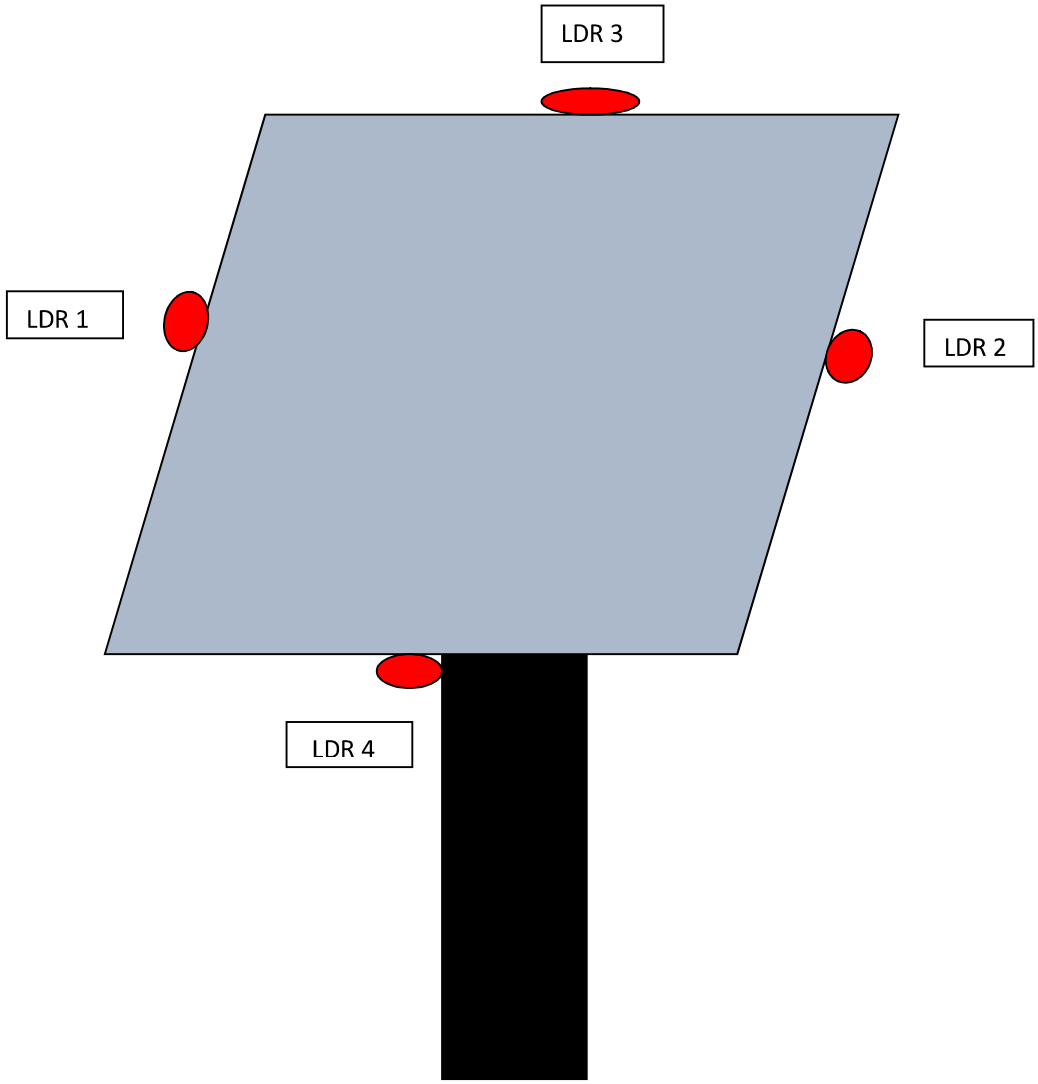
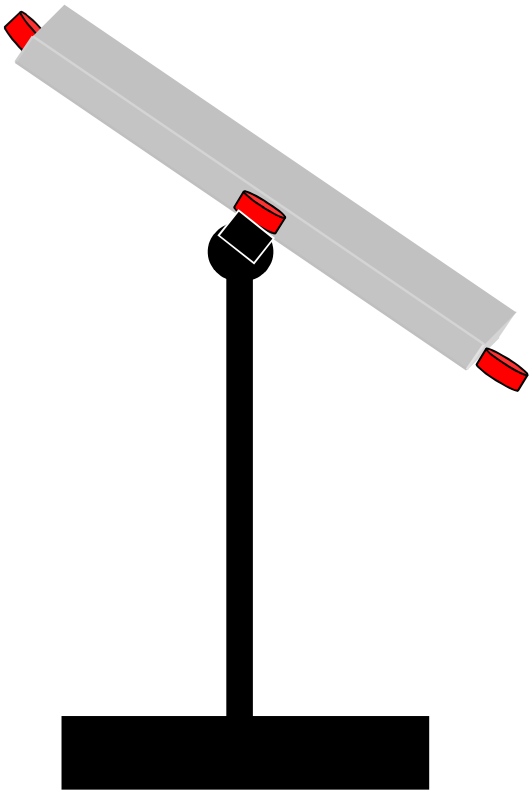


Fig :- Front View



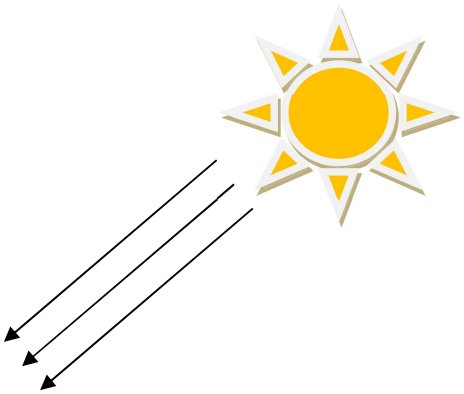


Fig -: At morning

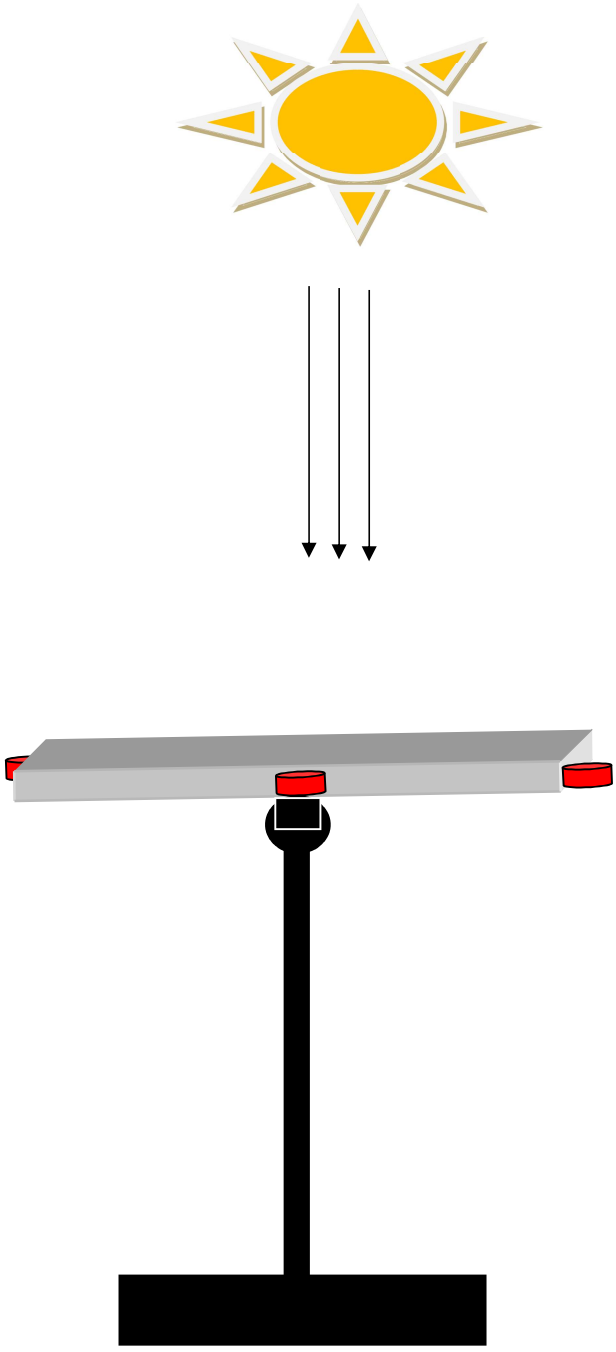


Fig -: At afternoon

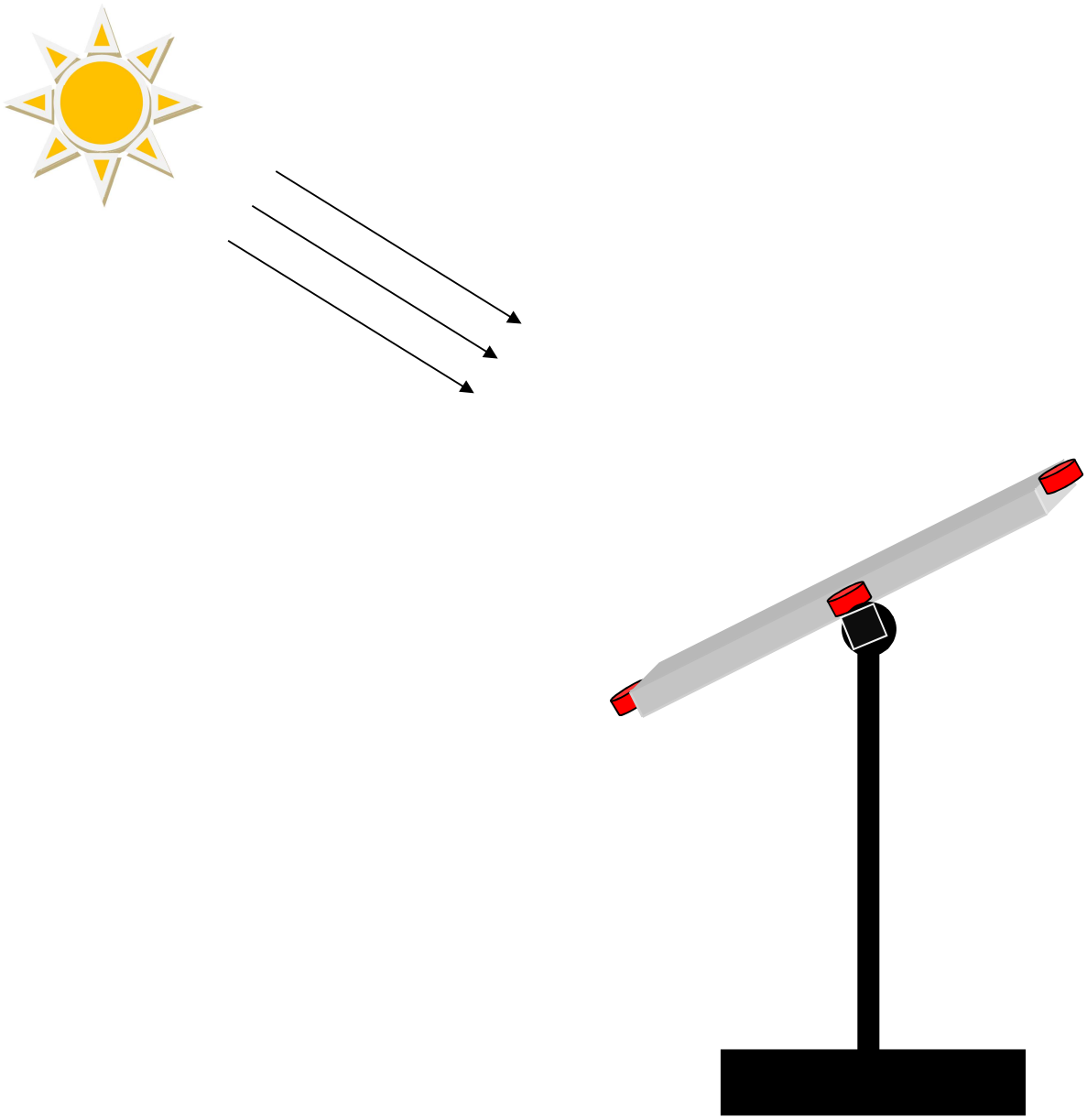


Fig -: At evening

Chapter 3

INTEGRATED CIRCUIT

3.1 L293D Motor Driver IC

Motor Driver IC

What Is Motor Driver IC?

A motor driver IC is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver ICs act as an interface between microprocessors in robots and the motors in the robot. The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. For this Project we will be referring the motor driver IC as L293D.

L293D Description

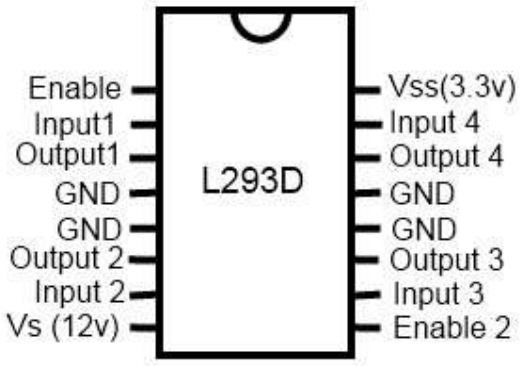
L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC.

Concept

It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. As we know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor. In a single L293D chip there are two H-Bridge circuit inside the IC which can rotate two dc motor independently. Given below is the pin diagram of a L293D motor controller.

There are two Enable pins on L293D. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It's like a switch.

L293D IC Pin Configuration



Pin-1 (Enable 1-2): When the enable pin is high, then the left part of the IC will work otherwise it won't work. This pin is also called as a master control pin.

Pin-2 (Input-1): When the input pin is high, then the flow of current will be through output 1

Pin-3 (Output-1): This output-1 pin must be connected to one of the terminals of the motor

Pin4 &5: These pins are ground pins

Pin-6 (Output-2): This pin must be connected to one of the terminals of the motor.

Pin-7 (Input-2): When this pin is HIGH then the flow of current will be though output 2

Pin-8 (Vcc2): This is the voltage pin which is used to supply the voltage to the motor.

Pin-9 (Enable3-4): When this pin is high, then the right part of the IC will work & when it is low the right part of the IC won't work. This pin is also called as a master control pin for the right part of the IC.

Pin-10 (Input-3): When this pin is high, then the flow of current will through output-3

Pin-11 (Output-3): This pin must be connected to one of the terminals of the motor.

Pin-12 & 13: These pins are ground pins

Pin-14 (Output-4): This pin must be connected to one of the terminals of the motor

Pin-15 (Input-4): When this pin is high, then the flow of current will be through output-4

Pin-16 (Vss): This pin is the power source to the integrated circuit.

Working of L293D

There are 4 input pins for L293D, pin 2, 7 on the left and pin 15, 10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.

In simple you need to provide Logic 0 or 1 across the input pins for rotating the motor.

L293D Logic Table.

Lets consider a Motor connected on left side output pins (pin 3, 6). For rotating the motor in clockwise direction the input pins has to be provided with Logic 1 and Logic 0.

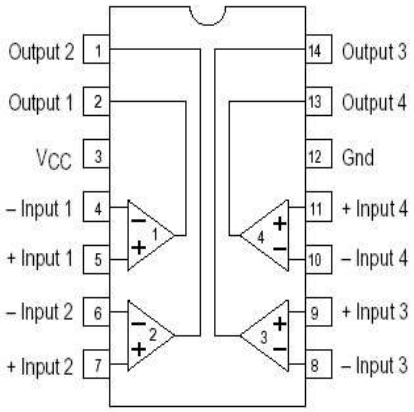
- Pin 2 = Logic 1 and Pin 7 = Logic 0 | Clockwise Direction
- Pin 2 = Logic 0 and Pin 7 = Logic 1 | Anticlockwise Direction
- Pin 2 = Logic 0 and Pin 7 = Logic 0 | No rotation
- Pin 2 = Logic 1 and Pin 7 = Logic 1 | No rotation

3.2 IC LM339

The voltage comparator is one kind of integrated circuit, especially used for contrast two voltages or currents at the comparator two inputs. The main function of this IC is the comparator has two inputs where it compares the two inputs with each other then generates a differential output like high-level signals or low-level signal.

IC LM339 Pin Configuration

LM339 IC has four inbuilt comparators. It is a 14-pin chip as shown in below pin configuration. This IC comprises four voltage comparators that are intended to work with only power supply. And also there will be a possibility of operation using a dual power supply, as long as the variation among the two voltages is 2 volts to 36 volts.



- **Pin1 (OUT):** It is an output pin of the first comparator.
- **Pin2 (OUT):** It is an output pin of the second comparator.
- **Pin3 (VCC):** It is a Power supply of the comparator.
- **Pin4 (IN-):** It is a negative input pin of the second comparator.
- **Pin5 (IN+):** It is a positive input pin of the second comparator.
- **Pin6: (IN-):** It is a negative input of the first comparator.
- **Pin7: (IN+):** It is a positive pin of the first comparator.
- **Pin8: (IN-):** It is a negative pin of the third comparator.
- **Pin9: (IN+):** It is a positive e pin of the third comparator.
- **Pin810: (IN-):** It is a negative pin of the fourth comparator.
- **Pin11: (IN+):** It is a positive input pin of the fourth comparator.
- **Pin12: (GND):** It is a ground pin
- **Pin13: (OUT):** It is an output pin of the fourth comparator.
- **Pin8: (OUT):** It is an output pin of the third comparator.

Chapter 4

Components

4.1 Diode

1N4148 it is basically a diode used for fast switching purposes. Switching diodes are usually single P-N diodes and their functionality is similar to that of normal switch. Below a specific voltage, switching diodes i.e. 1N4148 has high resistance. It is a most commonly used diode due to its smaller size, easy availability and low cost. It is mostly used in switches having extremely fast operation.

Introduction of 1N4148

1N4148 is a standard diode made up of silicon and is used for extremely fast switching operations. It has two modes of operation named as:

1. Forward Biased
2. Reverse Baised

In Forward Biased operational mode, it allows the current to pass though it and it acts as a closed switch, while in Reverse Biased operational mode it acts as an open switch and doesn't allow the current to pass through it.

4.2 Resistor

What is Resistance?

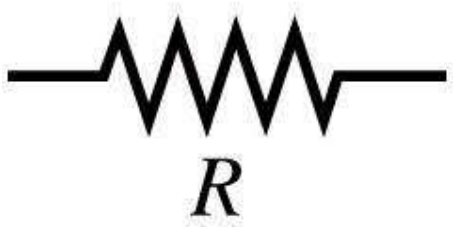
The definition of resistance is based upon the Ohm's law given by the German physicist Georg Simon Ohm.

The Ohm's Law states that the voltage [V] across a resistor is directly proportional to the current [I] flowing through it. Here, its resistance [R] is the constant of proportionality.

Therefore, V = I * R

Symbol of Resistor

Resistor is a 2 terminal passive device. The symbol is given below.



Types of resistors

The most commonly used resistors all look the same. They look like a small worm with coloured stripes on the side. There are many types of resistors available. The most common one ceramic rod wound by copper wires on the inside. The number of copper turns and the thickness of the copper determine the resistance of the component. The more the turns and lesser the thickness, the more the resistance. There are also resistors with spiral patterns of carbon, instead of the copper winding. Such resistors are used for making smaller value resistors. Let us take a closer look at all the resistors.

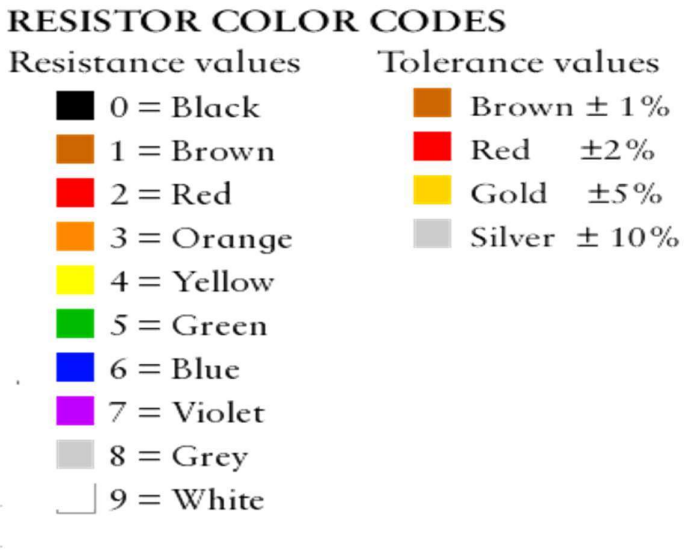
Colour Coding

The value of the resistance is found out by colour coding. The resistors have a band of colours shown in their outer covering. Here are the steps to determine the value of the resistor.

- All resistors have three bands of colours, followed by a space and then a fourth band of colour. The fourth band of colour will be brown, red, gold or silver.
- To read the colours turn it to the position such as the three consecutive colours come on the left and then the space and the rest of the colours.

- The first two colours from the left indicate the first two digits of the value. The third colour represents the digital multiplier. That is, it indicates how much you have to multiply the first two numbers with. Thus if you have a resistance with the first three colours being brown, black and red, the value of resistance is 10*100 = 1000 ohms or 1K.
- The last band, after the space indicates the tolerance of the resistor. This indicates the range of accuracy of the resistor. Thus, along with the three colours above, if the fourth colour is gold, it means you have a tolerance between +/-5%. Thus the actual value of the resistance can be between 950 Ohms and 1K.
- There can also be resistors with five colours. If so, the first three represents the digits, the fourth will be the multiplier and the fifth will be the percentage of tolerance. This indicates that a more precise value of the resistor used can be obtained from a 5-colour resistor.

Take a look at the colours and their associated numbers given below.



4.3 Variable Resistor (Preset)

What is a Variable Resistor?

A variable resistor is a device that is used to change the resistance according to our needs in an electronic circuit. It can be used as a three-terminal as well as a two terminal device. Mostly they are used as a three terminal device. Variable resistors are mostly used for device calibration.

Working of Variable Resistor

A variable resistor consists of a track which provides the resistance path. Two terminals of the device are connected to both the ends of the track. The third terminal is connected to a wiper that decides the movement of the track. The motion of the wiper through the track helps in increasing and decreasing the resistance.

The track is usually made of a mixture of ceramic and metal or can be made of carbon as well.. The track can be in both the rotary as well as straight versions. In a rotary track, some of them may include a switch. The switch will have an operating shaft which can be easily moved in the axial direction with one of its ends moving from the body of variable resistor switch.

The rotary track resistor with has two applications. One is to change the resistance. The switch mechanism is used for the electric contact and non-contact by on/off operation of the switch. There are switch mechanism variable resistors with an annular cross-section which are used for the control of equipments. Even more, components are added to this type of a variable resistor so as to make them compatible with complicated electronic circuits.

Preset

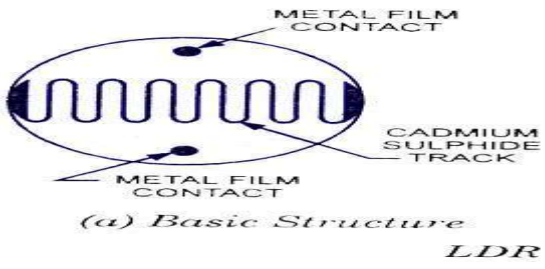
A preset is a three legged electronic component which can be made to offer varying resistance in a circuit. The resistance is varied by adjusting the rotary control over it. The adjustment can be done by using a small screw driver or a similar tool. The resistance does not vary linearly but rather varies in exponential or logarithmic manner. Such variable resistors are commonly used for adjusting sensitivity along with a sensor.

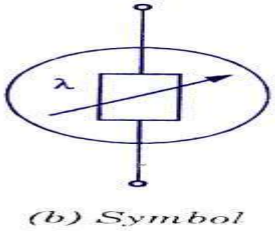
The variable resistance is obtained across the single terminal at front and one of the two other terminals. The two legs at back offer fixed resistance which is divided by the front leg. So whenever only the back terminals are used, a preset acts as a fixed resistor. Presets are specified by their fixed value resistance.

4.4 Light Dependant Resistor (LDR)

A Light Dependent Resistor (LDR) is also called a photoresistor or a cadmium sulfide (CdS) cell. It is also called a photoconductor. It is basically a photocell that works on the principle of photoconductivity. This optoelectronic device is mostly used in light varying sensor circuit, and light and dark activated switching circuits

Construction of a LDR





The construction of a LDR includes a light sensitive material which is placed on an insulating substrate like as ceramic. The material is placed in a zigzag shape in order to get the required power rating and resistance. The area of zigzag separates the metal placed areas into two regions. Where the Ohmic contacts are made either on the sides of the area. The resistances of the contacts must be as less as possible to make sure that the resistance, mainly varies due to the light effect only. The use of lead & cadmium materials are avoided as they are injurious to the environment.

Working Principle

The working principle of an LDR is photo conductivity, that is nothing but an optical phenomenon.When the light is absorbed by the material then the conductivity of the material reduces. When the light falls on the LDR, then the electrons in the valence band of the material are eager to the conduction band. But, the photons in the incident light must have energy superior than the band gap of the material to make the electrons jump from one band to another band (valance to conduction). Hence, when light having ample energy, more electrons are excited to the conduction band which grades in a large number of charge carriers. When the effect of this process and the flow of current start flowing more, the resistance of the device decreases.

- **Advantages**

LDR's are cheap and are readily available in many sizes and shapes. Practical LDRs are available in a variety of sizes and package styles, the most popular size having a face diameter of roughly 10 mm. They need very small power and voltage for its operation.

- **Disadvantages**

Highly inaccurate with a response time of about tens or hundreds of milliseconds.

4.5 Gear Motor

A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This Insight will explore all the minor and major details that make the gear head and hence the working of geared DC motor.

External Structure

At the first sight, the external structure of a DC geared motor looks as a straight expansion over the simple DC ones.

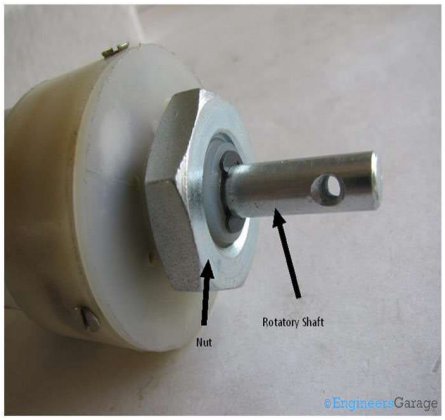


Fig. 1: External Structure of DC Geared Motor *Fig. 2: Lateral View of Parts of Motor*

The lateral view of the motor shows the outer protrudes of the gear head. A nut is placed near the shaft which helps in mounting the motor to the other parts of the assembly .Also, an internally threaded hole is there on the shaft to allow attachments or extensions such as wheel to be attached to the motor.

Outer Body of Gear Head & Rear View

The outer body of the gear head is made of high density plastic but it is quite easy to open as only screws are used to attach the outer and the inner structure. The major reason behind this could be to lubricate gear head from time to time.

The plastic body has a threading through which nut can be easily mounted and vice versa from the gear head.

Fig. 3: Outer Structure of Gear Head

Fig. 4: Rear View of Parts of DC Motor

Internal Structure

On opening the outer plastic casing of the gear head, gear assemblies on the top as well as on bottom part of the gear head are visible. These gear assemblies are highly lubricated with grease so as to avoid any sort of wear and tear due to frictional forces. Shown below is the top part of the gear head. It is connected to rotating shaft and has one gear that allows the rotation. A strong circular imprint shows the presence of the gear that rotates the gear at the upper portion.

Fig. 5: Gear Assembly

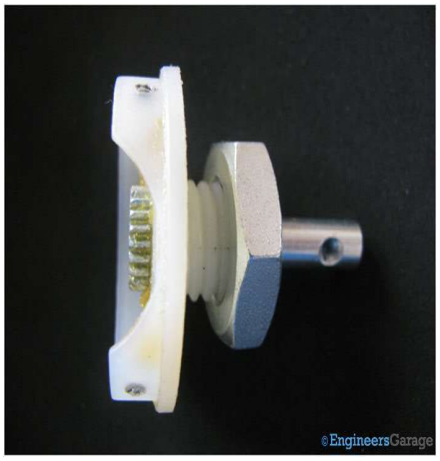


Fig. 6: Image showing Connection of Shaft with Gear

Connection of the shaft with the gear is shown in the image under.

The cap that accommodates the gear has an arc cut from its side to avoid frictional resistance forces with the bottom gear assembly.

Fig. 7: Shape of Cap that Accomodates Gear

The bottom houses the gear mechanism which is connected to the DC motor through screws. This mechanism rotates the gear at the top which is connected to the rotating shaft.

Bottom Gear Assembly

A closer look at the bottom gear assembly shows the structure and connection with other gears.

Fig. 8: Shape of Bottom Gear Assembly

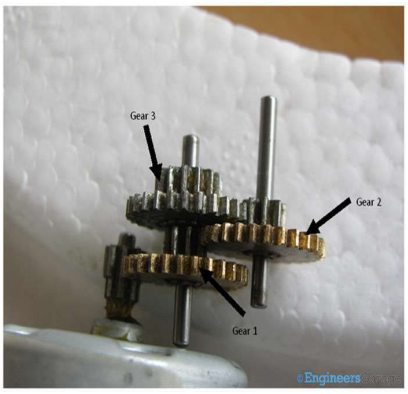


Fig. 9: Parts of Bottom Gear Assembly

Gear assembly's association with the motor (bottom gear assembly) can be understood with the help of the fig 9.

The gear assembly is set up on two metallic cylinders whose working can be called as similar to that of an axle. A total of three gears combine on these two cylinders to form the bottom gear assembly out of which two gears share the same axle while one gear comes in between them and takes a separate axle.

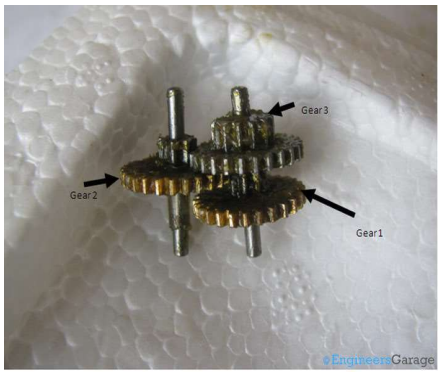


Fig. 10: Figure Indicating the Types of Gears

The gears are basically in form of a small sprocket but since they are not connected by a chain, they can be termed as duplex gears in terms of a second cog arrangement coaxially over the base. Among the three gears, two are exactly same while the third one is bigger in terms of the number of teeth at the upper layer of the duplex gear. The third gear is connected to the gear at the upper portion of the gear head. The manner in which they are located near the upper part of the gear head can be seen through the image shown below.

The combination of bottom gear assembly with the upper one can be seen down under.

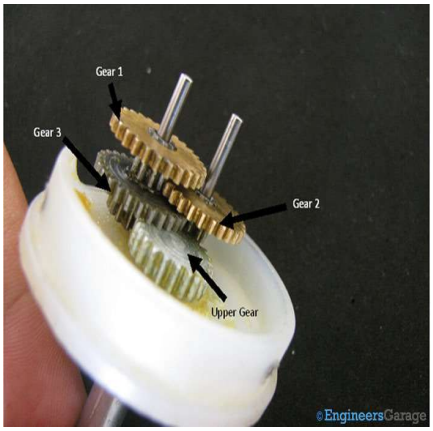


Fig. 11: Combination of Bottom Gear Assembly

Fig. 12: Gears Shown Separately

Combination of Gear Assemblies

After the gear assembly is removed, gear head's connection to the DC motor and its gear can be easily seen. The machine has a smaller gear in comparison to the gear head's gear assembly.

Working

Working of the DC Geared Motor

The DC motor works over a fair range of voltage. The higher the input voltage more is the RPM (rotations per minute) of the motor. For example, if the motor works in the range of 6-12V, it will have the least RPM at 6V and maximum at 12 V.

In terms of voltage, we can put the equation as:

RPM= K1 * V, where,

K1= induced voltage constant

V=voltage applied

The working of the gears is very interesting to know. It can be explained by the principle of conservation of angular momentum. The gear having smaller radius will

cover more RPM than the one with larger radius. However, the larger gear will give more torque to the smaller gear than vice versa. The comparison of angular velocity between input gear (the one that transfers energy) to output gear gives the gear ratio. When multiple gears are connected together, conservation of energy is also followed. The direction in which the other gear rotates is always the opposite of the gear adjacent to it.

In any DC motor, RPM and torque are inversely proportional. Hence the gear having more torque will provide a lesser RPM and converse. In a geared DC motor, the concept of pulse width modulation is applied. The equations detailing the working and torque transfer of gears are shown below:

$T_{in}\ \boldsymbol{\omega_{in}} = T_{out}\ \boldsymbol{\omega_{out}}$

Where,

T_{in}= input torque by the driver gear

$\boldsymbol{\omega_{in}}$ = angular speed of driver gear

T_{out} =output torque by the driven gear

$\boldsymbol{\omega_{out}}$ = angular speed of driven gear

In a geared DC motor, the gear connecting the motor and the gear head is quite small, hence it transfers more speed to the larger teeth part of the gear head and makes it rotate. The larger part of the gear further turns the smaller duplex part. The small duplex part receives the torque but not the speed from its predecessor which it transfers to larger part of other gear and so on. The third gear's duplex part has more teeth than others and hence it transfers more torque to the gear that is connected to the shaft.

Chapter 5

PCB DESIGNING AND FABRICATION

There are in all three basic methods to make a PCB:

1)Iron on Glossy paper method.

2)Circuit by hand on PCB.

3)Laser cutting edge etching.

In this project the PCB is made by circuit design by hand

-Paper and Pencil

-Ruler

-Tape

-Scissors

-Tiny #65 twist bit (0.035" which is good for most electronic components)

-Dremal or pin wise to drill holes, the Dremal is the obvious winner here

-Copper clad PC board

Materials to etch the board:

-Ferric Chloride(FC), which is used to etch the board.

Step 1: Designing the Circuit

Using paper and pencil design the layout of the circuit, it is easiest to do this as a top view of the board, it helps to also have all the different components on hand to help with spacing and placement. As a side note also make sure to design the layout so that it well fit on the board. When we get the idea about the layout then draw it on copper plate by using oil paint.

Step 2: Etching

-Start off by finding a clean dry place where you can safely etch the circuit board, preferably outside.

-Put gloves and safety glasses on.

-Make sure you put your gloves and safety glasses on, Ferric Chloride is nasty stuff.

-Take your small container and pour about 1/4" to 1/2" of Ferric Chloride into it.

-Fill the larger container with warm water about 1" deep.

-Drop PCB into the Ferric Chloride, copper side up and place the small container into the water in the larger container.

-Gently rock the small container in the water so as to keep the FC moving which helps with the etching process.

-In about 5-7 minutes you should start to see the copper start to dissolve away, notice the areas where the traces a drawn are unaffected.

-After about 10-12 minutes the board should be completely etched, at which time you should immediately remove the PCB and drop it into the water in the larger container to rinse it and then dry it off on the paper towel.

-When you are done put the cover on the small container, you can use the Ferric Chloride over again a few times, and pour out the water in the larger container and rinse it out. You can use the larger container to store the small container and your extra Ferric Chloride that is still in the original bottle.

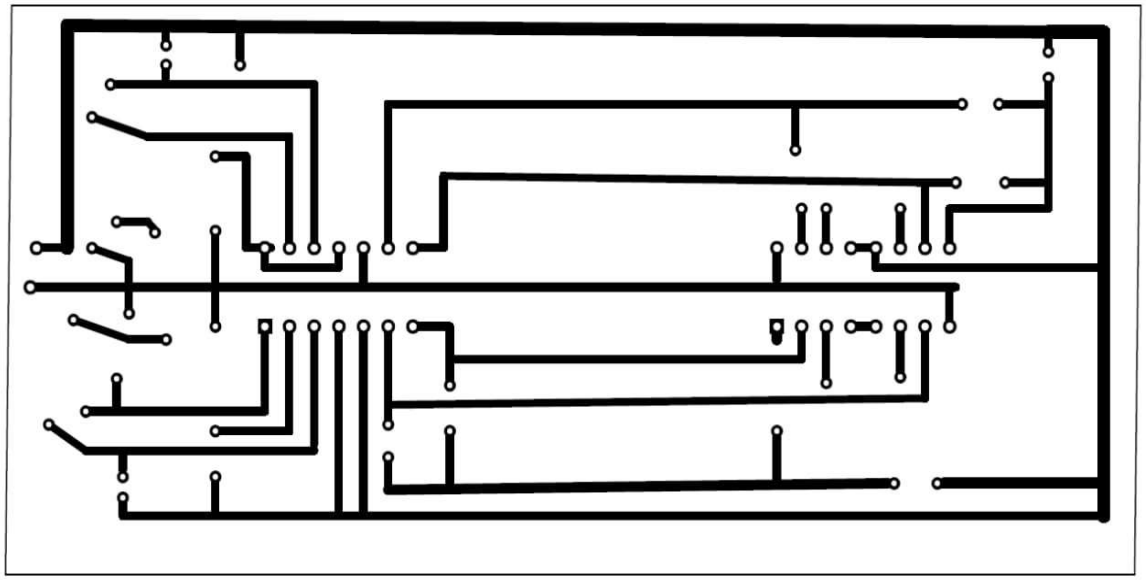
Step 3: Cleaning the PCB

Wash a PCB by using Acetone due to this paint on the PCB remove.

Step4: Drill the PCB

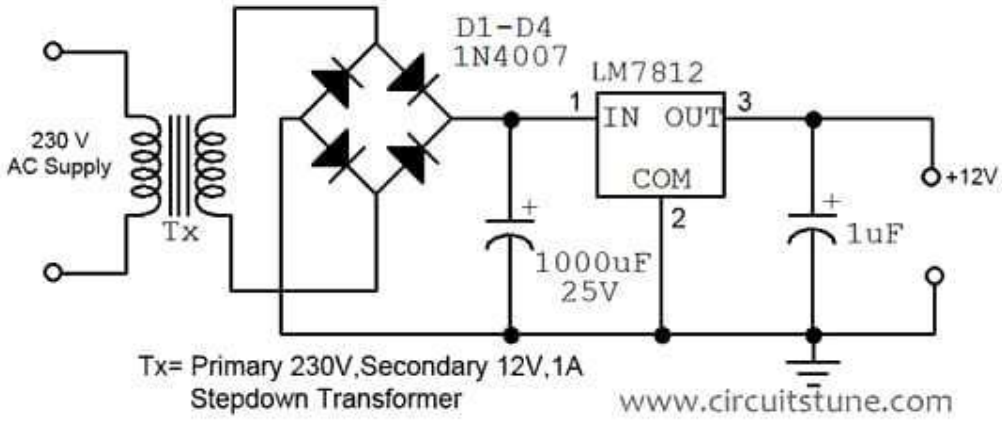
-With the #65 drill bit use the layout to drill a hole in the centre of all the solder pads for the individual components.

❖ **LAYOUT**



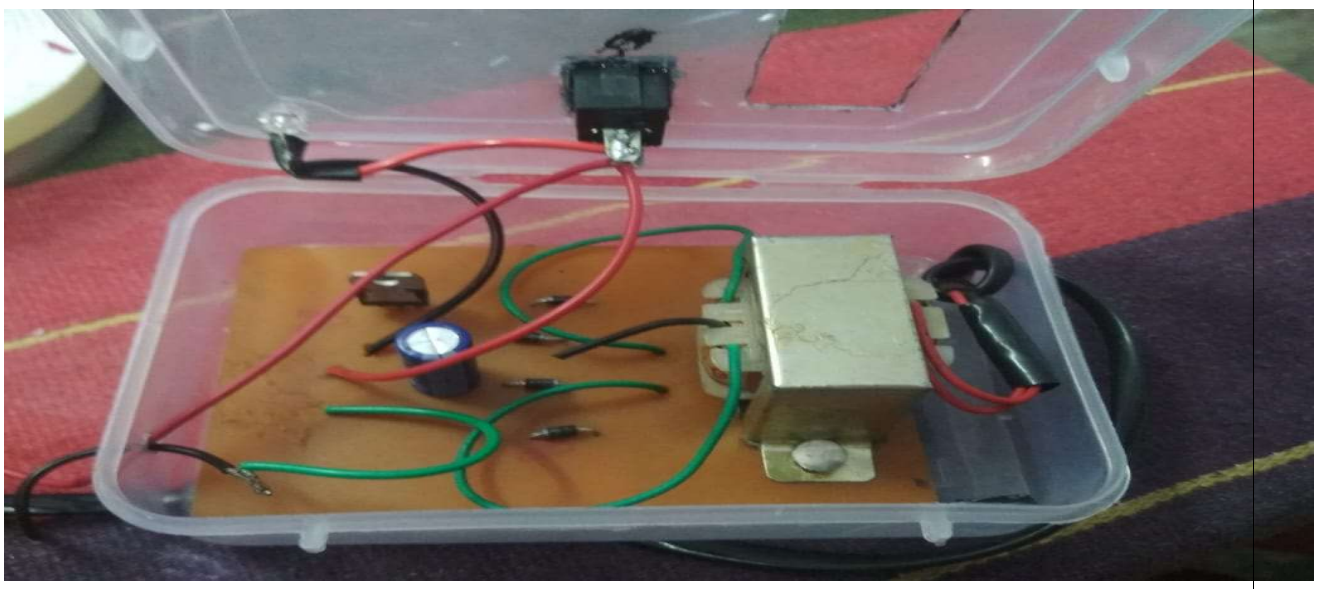
Chapter 6

12 Volt Power Supply



Description :-

The circuit given here is of a regulated dual power supply that provides +12V and -12V from the AC mains. A power supply like this is a very essential tool on the work bench of an electronic hobbyist.
The transformer T1 steps down the AC mains voltage and diodes D1, D2, D3 and D4 does the job of rectification. Capacitors C1 and C2 does the job of filtering.C3, C4, C7and C8 are decoupling capacitors. IC 7812 and 7912 are used for the purpose of voltage regulation in which the former is a positive 12V regulator and later is a negative 12V regulator. The output of 7812 will be +12V and that of 7912 will be -12V.



(12V Power Supply)

Application of regulator power supply:-

- D.C. variable bench supply (a **bench power supply** usually refers to a power supply capable of supplying a variety of output voltages useful for BE (bench testing) electronic circuits, possibly with continuous variation of the output voltage, or just some preset voltages; a laboratory (lab) power supply normally implies an accurate bench power supply, while a balanced or tracking power supply refers to twin supplies for use when a circuit requires both positive and negative supply rails).
- Mobile Phone power adaptors
- Regulated power supplies in appliances
- Various amplifiers and oscillators.

CONCLUSION

A predetermined Solar Tracking System has been designed economically. This project presented simple control implementation of sun tracker. This System not require programming and a computer interface. It achieve the following Features:

1) A simple and cost effective control implementation

2) Ability to move the two axes simultaneously within respective ranges.

3) Ability to adjust the tracking accuracy.

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