

Dual Axis Solar Tracker



Mounik D – 1BM11EE030

Nikhil R – 1BM11EE034

Raghav S – 1BM11EE045

Sirigauri N – 1BM11EE061

Why Solar Energy?



- Easily accessible.
- Energy harnessed is free of cost.
- Pollution FREE.
- Available in infinite quantity.

Facts:

- ▶ India has emerged as the world number one, along with United States of America, in annual solar power generation by virtue of the fifty solar power plants across the sub-continent. In total we are generating over 1000 Megawatt of power.
- ▶ As well-known, Gujarat is the leader in Solar Power generation in India and accounts for nearly 67% of total generation. Gujarat has commissioned Charanka solar power plant which when completed will be the Asia's biggest solar power plant.
- ▶ Rajasthan comes next generating 20% of total solar power in India. Much of the solar power is concentrated on the Thar Desert region which forms a good land base. A large project has been proposed, and a 35,000 square kilometre area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW.
- ▶ Karnataka houses three solar power plants, Shivanasamudra (5MW), Kolar (3MW) and Itanl (3MW).
- ▶ Bangalore has the highest number of rooftops solar power panels installed in India. It is primarily used for heating water and works out to be convenient to use.

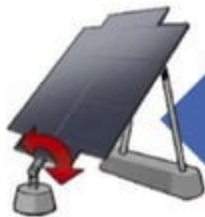
Solar power technology

- ▶ Solar power is the conversion of sunlight into electricity, either directly using Photovoltaics (PV), or indirectly using concentrated solar power (CSP). In order to do this, it is necessary to have solar cells. These cells are typically in the form of panels that perpendicularly placed, facing the sun, to capture the maximum light possible.
 - Photovoltaics (PV):
 - Photovoltaics convert light into electric current using the photovoltaic effect. Photovoltaics were initially, and still are, used to power small and medium-sized applications
 - They are an important and relatively inexpensive source of electrical energy where grid power is inconvenient, unreasonably expensive to connect, or simply unavailable.
 - CSP:
 - Concentrating Solar Power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam.
 - Various techniques are used to track the Sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage.

Solar Tracker

One way to make the Solar panel more effective is by adding the ability to track the sun as it moves across the sky.

- ▶ A Solar tracker is a device used for orienting a Solar PV panel or lens towards the sun by using the light sensors interfaced to motors, used for rotation, through a microcontroller, to have maximum solar radiation incident on the solar panel. The motors can be used to move the panels either along ONE or TWO axes.



Single Axis Trackers:

- A single axis tracker can pivot in only one plane – horizontal or vertical. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes (such as in UK) where the sun does not get very high, but summer days can be very long.
- Although the construction is less complicated it is also less effective in harnessing the total solar energy.



Dual Axis Trackers:

- Dual axis solar tracker has two degrees of freedom that act as axes of rotation. These axes are typically normal to one another.
- It can rotate simultaneously in horizontal and vertical directions and are able to point at the sun at all times. Dual axis trackers track the sun both East to West and North to South for added power output (approx. 40% gain) and convenience.

Solar Tracker

Classification based on on the Driver type

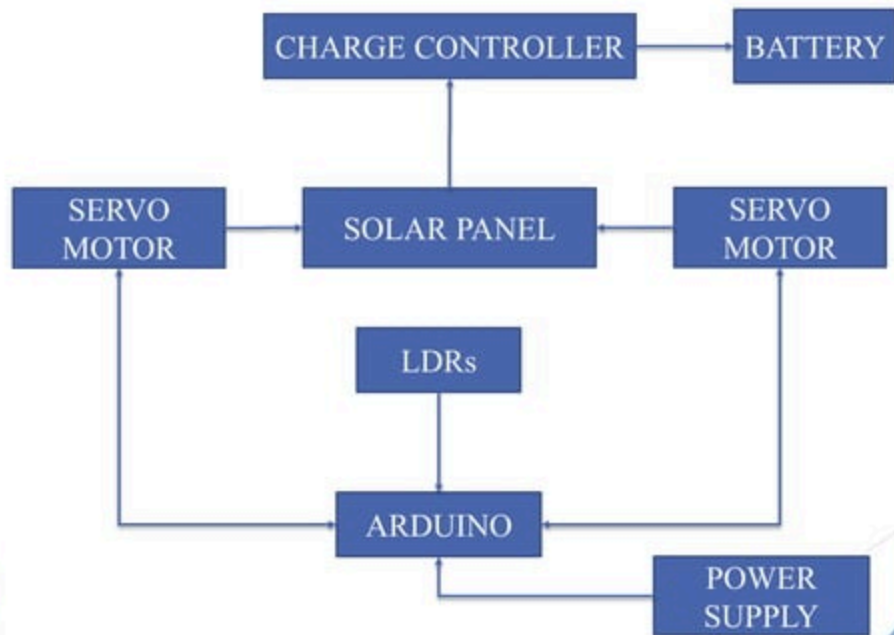
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graph TD; A[Classification based on on the Driver type] --> B[Active trackers]; A --> C[Passive trackers]; A --> D[Open-loop trackers];
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Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction.

Passive trackers use a low boiling point compressed gas fluid that is driven to one side or the other to cause the tracker to move in response to an imbalance.

Open-loop trackers use no sensing but instead determine the position of the sun through pre-recorded data for a particular site. They rotate at regular time intervals.

Block Diagram of Solar Tracker



Servomotors

- ▶ Servo motors run using a control loop and require feedback of some kind.
- ▶ They are generally an assembly of four things: a DC motor, a gear set, a control circuit and a position sensor(usually a potentiometer).
- ▶ Since servo motors have a control loop to check what state they are in, they are generally more reliable than stepper motors.
- ▶ Servo motors require a control PWM signal that represents an output position and applies power to the DC motor until the shaft turns to the correct position, determined by the position sensor.
- ▶ There are many advantages of using a servomotor, such as :
 1. High intermittent torque.
 2. High torque to inertia ratio.
 3. High speeds.
 4. Work well for velocity control.
 5. Available in all sizes.
 6. Quiet.

Arduino Uno

- ▶ The Arduino uno is a microcontroller board based on ATmega328. It has 14 digital inputs/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 16 MHz Ceramic Resonator, a USB connection, a power jack and a reset button.
- ▶ It has a number of libraries, including one for servo motor control.
- ▶ The input supply needed is ideally 7-12V DC.



LDR

- ▶ Light dependent resistors work on the principle that, if intensity of light on it increases, its resistance decreases and thus more current flows through it.
- ▶ Bigger LDRs have higher sensitivity.

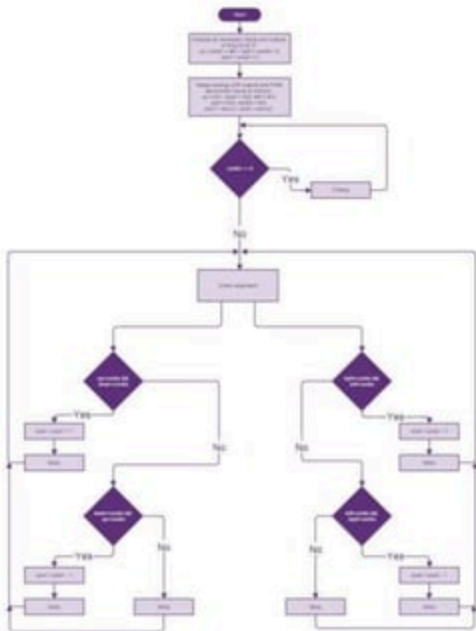
Solar Panel

- ▶ The rating of each Photo-Voltaic solar panel is, $P_{\max} = 1.3\text{W}$, $V_{\max} = 7.5\text{V}$.
- ▶ Two such panels are connected in series to get a stable output voltage of 12V.

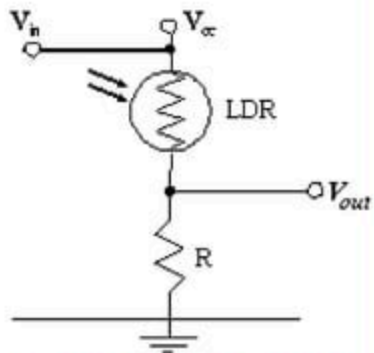
Charge Controller

- ▶ This is basically a voltage regulating circuit which is placed between a solar panel and battery to be charged or any load connected to the panel.
- ▶ It regulates the voltage that is received from solar panel.

Program Flow

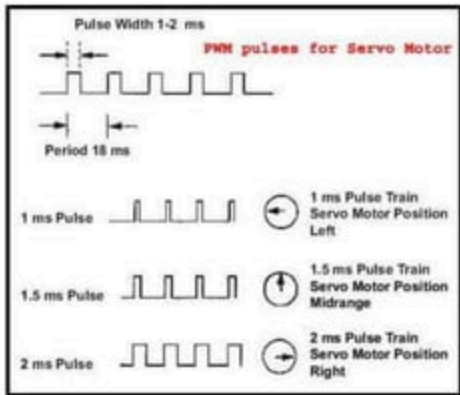


Input



Darkness \Rightarrow LDR high \Rightarrow V_{out} is low
Bright \Rightarrow LDR low \Rightarrow V_{out} is high

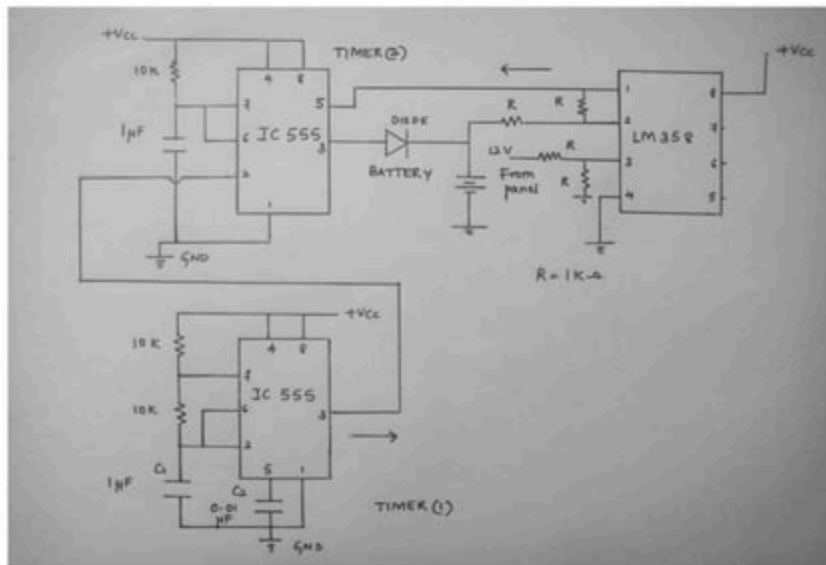
Output



Why is Charge Controller needed?

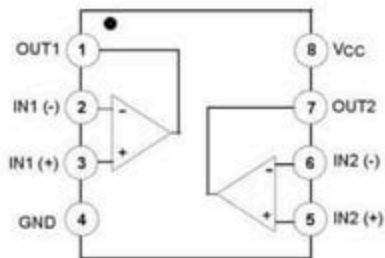
- ▶ A charge controller is placed between the solar panel and the battery.
- ▶ Charge controller limits the rate at which electric charge is added to the battery.
- ▶ Brighter the sunlight, more voltage the solar cells produce. The excessive voltage could damage the batteries.
- ▶ As the input voltage from the solar panel rises, the charge controller regulates the charge to the batteries preventing any over charging.

Circuit diagram of Charge Controller

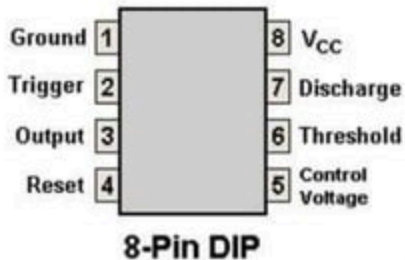


Pin Diagrams:

► LM358

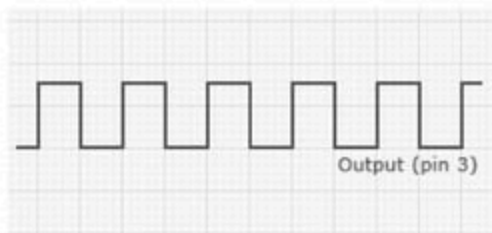
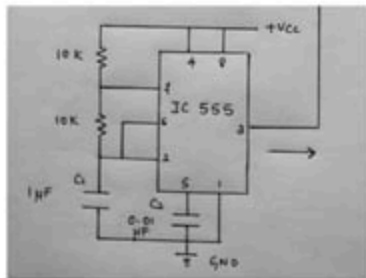


► 555 Timer IC



Timer 1 (Astable Mode):

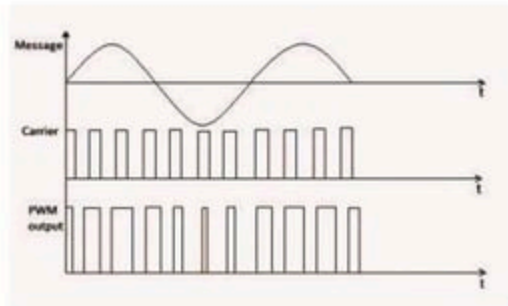
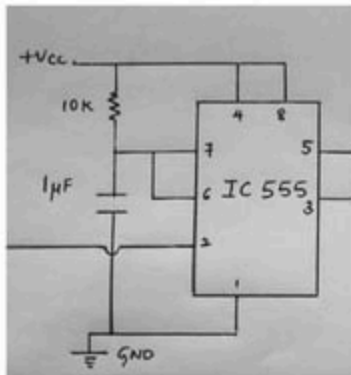
- ▶ An Astable Circuit has no stable state - hence the name "astable". The output continually switches state between high and low without without any intervention from the user, called a 'square' wave. This type of circuit is useful to generate a 'clock' pulse for other digital ICs and circuits.



- ▶ Here it is used as a Pulse generator.

Timer 2 (Monostable Mode):

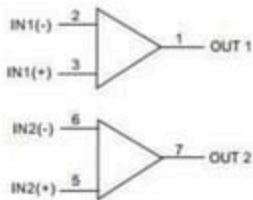
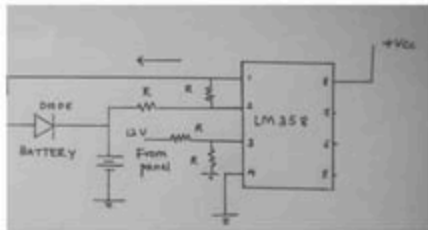
- ▶ A Monostable Circuit produces one pulse of a set length in response to a trigger input such as a push button. The output of the circuit stays in the low state until there is a trigger input, hence the name "monostable" meaning "one stable state".



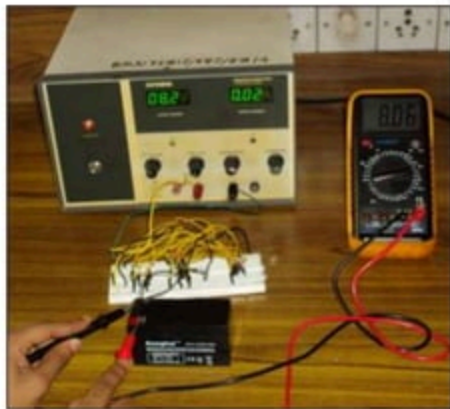
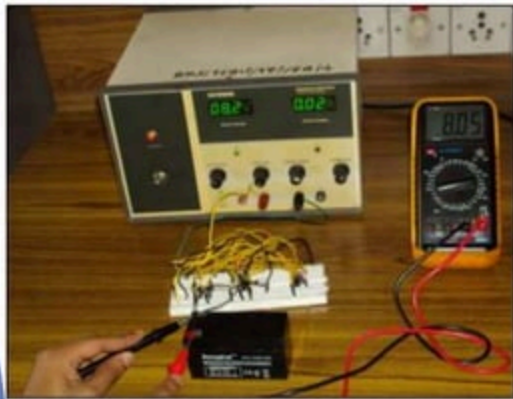
- ▶ Here it serves the purpose of a Pulse Width Modulator.

LM358 IC:

- ▶ The LM358 contains two independent high gain operational amplifiers with internal frequency compensation. The two Op-Amps operate over a wide voltage range from a single power supply. We can also use a split power supply.






- ▶ The Op-Amp here works as a Differential amplifier, where the output voltage is simply the difference between the two input voltages.



Advantages of using a Solar Tracker:

- Solar Tracking systems continually orient PV panels towards the sun and can help maximize the investment on PV system.
- One time investment, which provides higher efficiency and flexibility on dependency.
- Energy production is at an optimum and energy output is increased year round.
- It enhances the clean and emission free power production

Installation	Fixed	Single-Axis	Double-Axis
Demo			
Electricity Production	100%	increases 20%-30% relative to fixed installation	increases 30%-40% relative to fixed installation
Cost	100%	only 10%-15% higher than fixed installation	only 15%-20% higher than fixed installation

Financial Impact of Dual-axis Tracking

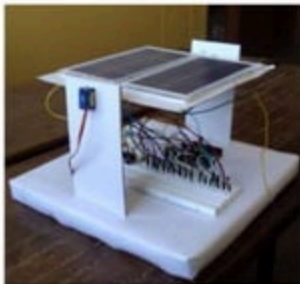
- Because dual-axis tracking generates 40% more power from each panel, you can achieve the same power output with fewer panels, frames and so on, which reduces a project's upfront costs and offsets to a great extent the additional cost for tracking hardware.
- On the other hand, you can use the same number of panels as originally planned and generate 40% more power and higher revenues.
- This reduces the project's payback time and also increases the overall return on investment (ROI), depending on the financial specifics of the project.

Disadvantages of Solar Tracker

- Initial investment is high.
- Moving parts such as gears needs periodic maintenance.
- Maintenance and repairing of mechanical and electronic parts of the tracking system requires extra man-power and of extra investment.
- Has to be built extreme environmental conditions such as storms, heavy rainfall etc.

Hardware Implementation:

► Prototype 1



► Prototype 2



Future Scope of the Project:

- ▶ Fabrication of Microcontroller using ASIC concepts: The number of wires can be greatly reduced by directly if a customized PCB is made upon which all the resistors can be directly soldered. This also eliminates the use of a Breadboard which was used to make all the external connections.
- ▶ Design Improvements: With the current design, it can be seen that the controller circuit rotates along with the panel. This was done to avoid tangling of wires. A better design may be realized in which only the panel rotates and all other parts are stationery.
- ▶ Mounting of the Panels: In our design, the panels are mounted on a horizontal shaft supported strongly at both ends. We can mount the panels directly onto a motor placed at the center of the Panel-Base in order to provide East-West movement. This reduces the weight and effective cost of the project.

Conclusion

- With Global Warming constantly affecting the world in numerous ways, it is essential we begin taking care of nature in whatever way possible.
- Present day technologies stress on being clean and green.
- Being environmentally friendly, solar power generators and panels are reasonably easy, safe and convenient to install.
- Hence enhancing the solar powered systems with intelligent trackers proves to be the optimal solution for utilizing the available solar energy.

Thank You!