ISSN 2250-3153

Solar Tracking System

Reshmi Banerjee

Electrical Engineering Department, Guru Nanak Institute of Technology

Abstract- " Solar Tracking System" is a power generating method from sunlight. This method of power generation is simple and is taken from natural resource. This needs only maximum sunlight to generate power. This paper helps for power generation by setting the equipment to get maximum sunlight automatically. This system is tracking for maximum intensity of light. When there is decrease in intensity of light, this system automatically changes its direction to get maximum intensity of light.

Index Terms- Decade Counter, 555 Timer, LDR, Solar Tracking System, Stepper Motor.

I. Introduction

Solar Panels are a form of active solar power, a term that describes how solar panels make use of the sun's energy; solar panels harvest sunlight and actively convert it to electricity. Solar Cells, or photovoltaic cells, are arranged in a grid-like pattern on the surface of the solar panel. Solar panels are typically constructed with crystalline silicon, which is used in other industries (such as the microprocessor industry), and the more expensive gallium arsenide, which is produced exclusively for use in photovoltaic (solar) cells.

Solar panels collect solar radiation from the sun and actively convert that energy to electricity. Solar panels are comprised of several individual solar cells. These solar cells function similarly to large semiconductors and utilize a large area p-n junction diode. When the solar cells are exposed to sunlight, the p-n junction diodes convert the energy from sunlight into usable electrical energy. The energy generated from photons striking the surface of the solar panel allows electrons to be knocked out of their orbits and released, and electric fields in the solar cells pull these free electrons in a directional current, from which metal contacts in the solar cell can generate electricity. The more solar cells in a solar panel and the higher the quality of the solar cells, the more total electrical output the solar panel can produce. The conversion of sunlight to usable electrical energy has been dubbed the Photovoltaic Effect.

A solar tracker is a device that orients a payload toward the sun. The use of solar trackers can increase electricity production by around a third, and some claim by as much as 40% in some regions, compared with modules at a fixed angle. In any solar application, the conversion efficiency is improved when the modules are continually adjusted to the optimum angle as the sun traverses the sky. As improved efficiency means improved yield, use of trackers can make quite a difference to the income from a large plant.

Commercial purpose of solar tracking system:

- Increase Solar Panel Output.
- Maximum efficiency of the panel.
- Maximize Power per unit area.
- Able to grab the energy throughout the day.

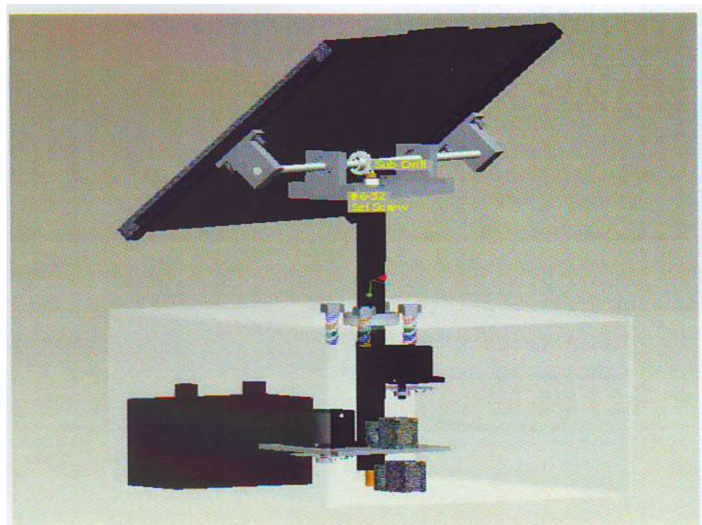

Fig. 1: Solar tracking system

The sun's position in the sky varies both with the seasons (elevation) and time of day as the sun moves across the sky. Hence there are also two types of solar tracker:

- Single Axis Solar Tracker
- Dual Axis Solar Tracker

Single Axis Solar Tracker: Single axis solar trackers can either have a horizontal or a vertical axle. 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.

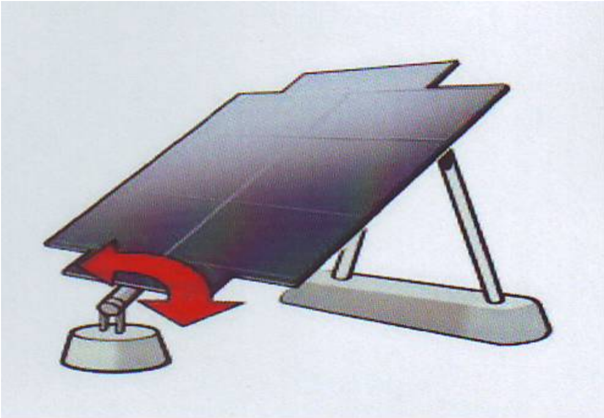

Fig. 2: Single axis solar tracker

Dual Axis Solar Tracker: Double axis solar trackers have both a horizontal and a vertical axle and so can track the sun's apparent motion exactly anywhere in the world. This type of system is used to control astronomical telescopes, and so there is plenty of software available to automatically predict and track the motion of the sun across the sky. Dual axis trackers track the sun both east to west and north to south for added power output (approx 40% gain) and convenience.

Fig. 3: Dual axis solar tracker

Solar tracker drives, can be divided into three main types depending on the type of drive and sensing or positioning system that they incorporate.

- Passive Trackers: Use the sun's radiation to heat gases that move the tracker across the sky.
- Active Trackers: Use electric or hydraulic drives and some type of gearing or actuator to move the tracker.
- Open Loop Trackers: Use no sensing but instead determine the position of the sun through pre recorded data for a particular site.

Passive Trackers: Passive trackers use a compressed gas fluid in two canisters each place in west and east of the tracker. The mechanism is in such a way that if one side cylinder is heated other side piston rises causing the panel to tilt over the sunny side. This affects the balance of the tracker and caused it to tilt. This system is very reliable and needs little maintenance.

Fig. 4: Passive tracker

Active Trackers: Active trackers measure the light intensity from the sun by using light sensors to determine where the solar modules should be pointing. Light sensors are positioned on the tracker at various locations in specially shaped holders. If the sun is not facing the tracker directly there will be a difference in light intensity on one light sensor compared to another and this causes to determine in which direction the tracker has to tilt with the help of the stepper or dc motor in order to be facing the sun.

Fig. 5: Active tracker

Light dependent resistor is made of a high resistance semiconductor. It can also be referred to as a photoconductor. If light falling on the device is of the high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance. Hence, light dependent resistors is very useful in light sensor circuits. LDR is very high resistance, sometimes a sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

The 555 timer is a very cheap, popular and useful precision timing device that can act as either a simple timer to generate single pulses or long time delays, or as a relaxation oscillator producing stabilized waveforms of varying duty cycles from 50 to 100%. The 555 timer chip is extremely robust and stable 8-pin device that can be operated either as a very accurate monostable multivibrator to produce a variety of applications such as one shot or delay timers, pulse generation. The single 555 timer chip in its basic form is a Bipolar 8-pin mini dual-in-time package (DIP) device consisting of some 25 transistors, 2 diodes and about 16 resistors arranged to form two comparators, a flip-flop and a high current output stage.

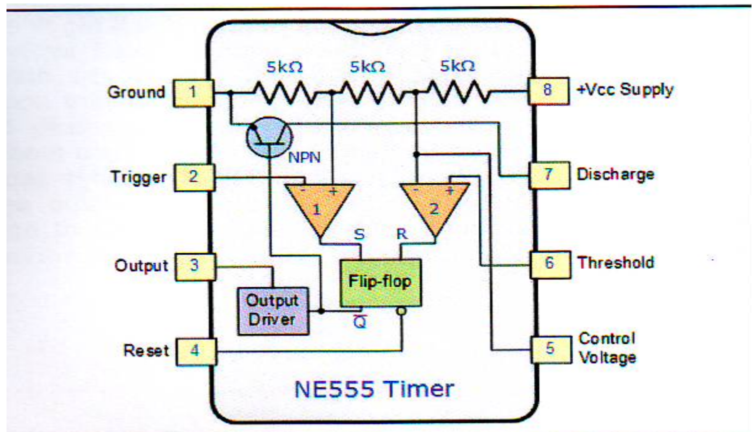

Fig. 6: 555 timer block diagram

- Pin 1: Ground. The ground pin connects the 555 timer to the negative (0V) supply.
- Pin 2: Trigger. The negative input to comparator no.1. A negative pulse on this pin sets the internal flip-flop when the voltage drops below 1/3 VCC causing the output to switch from a LOW to a HIGH state.
- Pin 3: Output. The output pin can drive any TTL circuit and is capable of sourcing or sinking up to 200mA of current at an output voltage equal to approximately VCC-1.5V so small speakers, LEDs or motors can be connected directly to the output.
- Pin 4: Reset. This pin is used to reset the internal flip-flop controlling the state of the output, pin 3. This is an active-low input and is generally connected to a logic 1 level when not used to prevent any unwanted resetting of the output.
- Pin 5: Control voltage.
- Pin 6: Threshold. The positive input to comparator no.2. This pin is used to reset the flip-flop when the voltage applied to it exceeds 2/3VCC causing the output to switch from HIGH to LOW state. This pin connects directly to the RC timing circuit.
- Pin7: Discharge. This pin is connected directly to the collector of an internal NPN transistor which is used to discharge the timing capacitor to ground when the output at pin 3 switches LOW.
- Pin 8: Supply +VCC. This is the power supply pin and for general purpose TTL 555 timers is between 4.5V and 15V.

The 555 timer name comes from the fact that there are three 5 kilo ohm resistors connected together internally producing a voltage divider network between the supply voltage at pin 8 and ground at pin 1. The voltage across this resistive network holds the positive input of comparator two at 2/3VCC and the positive input to comparator one at 1/3VCC. The two comparators produce an output voltage dependent upon the voltage difference at their inputs which is determined by the charging and discharging action of the externally connected RC network. The outputs from both comparators are connected to the two inputs of the flip-flop which in turn produces either a HIGH or LOW level output at Q based on the states of its inputs. The output from the flip-flop is used to control a high current output switching stage to drive the connected load producing either a HIGH or LOW voltage level at the output pin.

The CD4017B is a 5-stage divide-by-10 Johnson counter with 10 decoded outputs and a carry out bit. These counters are cleared to their zero count by a logical 1 on their reset line. These counters are advanced on the positive edge of the clock signal when the clock enable signal is in the logical 0 state. The configuration of the CD4017B permits medium speed operation and assures a hazard free counting sequence. The 10/8 decoded outputs are normally in the logical 0 state and go to the logical 1 state only at their respective time slot. Each decoded output remains high for 1 full clock cycle. The carry out signal completes a full cycle for every 10/8 clock input cycles and is used as a ripple carry signal to any succeeding stages.

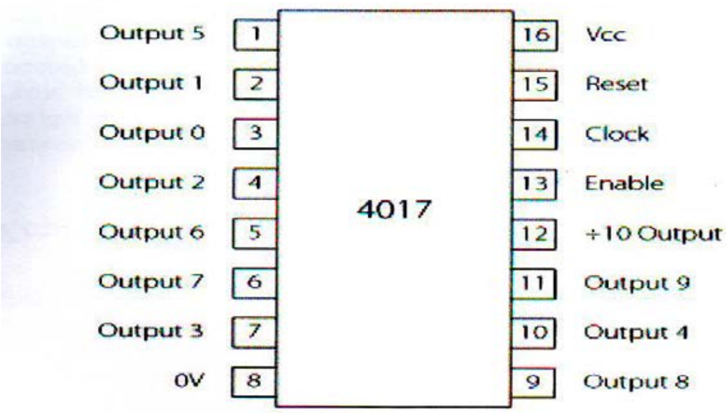

Fig.7: Pin configuration

- Pin 1: Output 5 (the 6^{th} sequential output).
- Pin 2: Output 1 (the 2^{nd} sequential output).
- Pin 3: Output 0 (the 1^{st} sequential output).
- Pin 4: Output 2 (the 3^{rd} sequential output).
- Pin 5: Output 6 (the 7^{th} sequential output).
- Pin 6: Output 7 (the 8^{th} sequential output).
- Pin 7: Output 3 (the 4^{th} sequential output).
- Pin 8: Ground (0V).
- Pin 9: Output 8 (the 9^{th} sequential output).
- Pin 10: Output 4 (the 5^{th} sequential output).
- Pin 11: Output 9 (the 10^{th} sequential output).
- Pin 12: /10 output (CO).
- Pin 13: Latch enable (LE).
- Pin 14: Clock in (CLK).
- Pin 15: Reset (RST).
- Pin 16: VCC (voltage between +3V and +15V).

When a clock signal (square wave pulse train) is provided at pin 14 (clock input), each of the other 10 output pins goes to logic 1 in turn. At any time only one output pin can be at logic 1; all the others remain at logic 0. If LEDs were connected to each output, each to light up in turn. If these were placed in a straight row in the correct sequence the effect would be for a ripple of light to run through the row, we use 555 timer in monostable mode.

The Darlington pair is basically a combination of two bipolar transistors. This circuit is used for amplifying currents, i.e. the amplified current from the first transistor is further amplified by the second transistor.

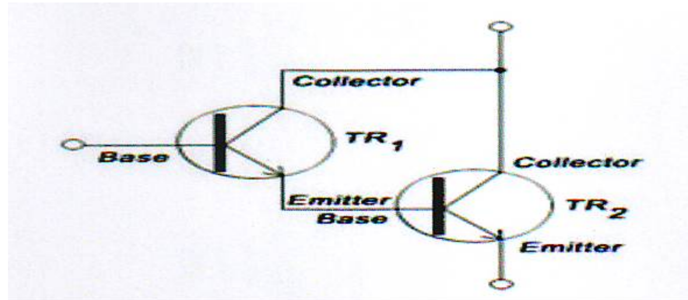

Fig. 8: Darlington Pair

ULN2003 is a high voltage and high current Darlington array IC. It contains seven open collector Darlington pairs with common emitters. A Darlington pair is an arrangement of two bipolar transistors. ULN2003 is commonly used while driving stepper motor.

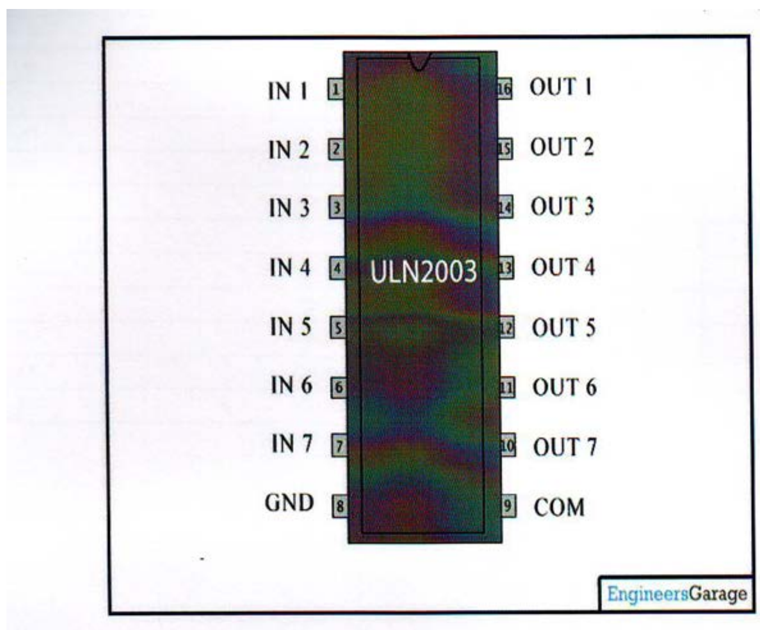

Fig. 9: Motor driver IC

- Pin 1: Input 1: Input for 1^{st} channel.
- Pin 2: Input 2: Input for 2^{nd} channel.
- Pin 3: Input 3: Input for 3^{rd} channel.
- Pin 4: Input 4: Input for 4^{th} channel.
- Pin 5: Input 5: Input for 5^{th} channel.
- Pin 6: Input 6: Input for 6^{th} channel.
- Pin 7: Input 7: Input for 7^{th} channel.
- Pin 8: Ground: Ground (0V).
- Pin 9: Common: Common freewheeling diodes.
- Pin 10: Output 7: Output for 7^{th} channel.
- Pin 11: Output 6: Output for 6^{th} channel.
- Pin 12: Output 5: Output for 5^{th} channel.

- Pin 13: Output 4: Output for 4th channel.
- Pin 14: Output 3: Output for 3rd channel.
- Pin 15: Output 2: Output for 2nd channel.
- Pin 16: Output 1: Output for 1st channel.

Stepper motors effectively have multiple toothed electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as using 555 timer. To make the motor shaft turn, first, one electromagnetic is given power, which makes the gear's teeth magnetically attracted to the electromagnet' teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. So, when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a step, with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle. Stepper motors are constant power devices. As motor speed increases, torque decreases. Most motors exhibit maximum torque when stationary, however the torque of a motor when stationary (holding torque) defines the ability of the motor to maintain a desired position while under external load.

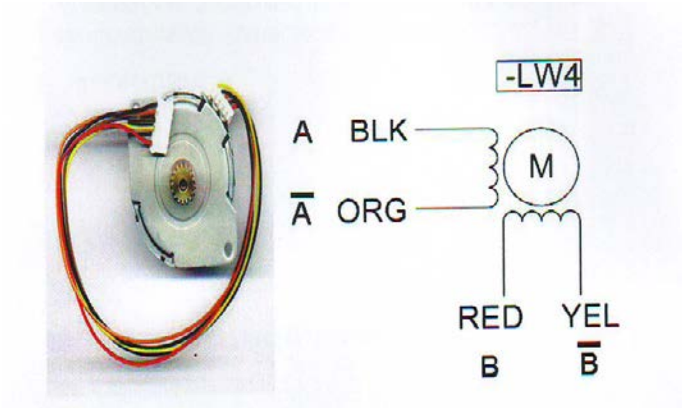

Fig. 10: Stepper motor & its internal diagram

II. METHODOLOGY & RESULTS

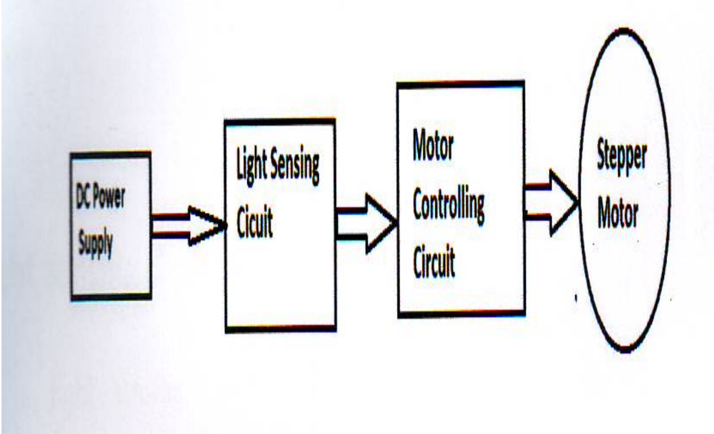

Fig. 11: Block diagram of solar tracking system

Components used: i) Light sensing circuit:-
a) LDR
b) 555 Timer

ii) Motor controlling circuit:-
a) Decade counter
b) Darlington pair (TIP 120, TIP 120)
c) ULN2003 Driver IC
d) Stepper motor (5W, 12V)

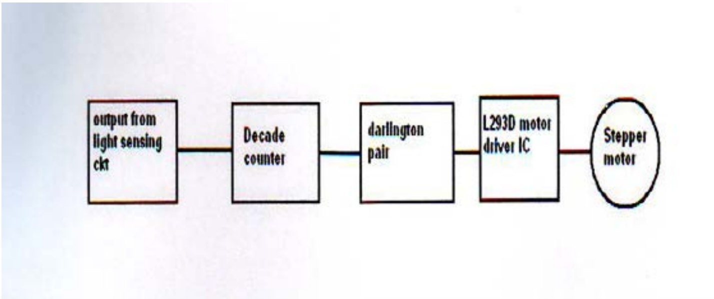

Fig. 12: Block diagram for motor control

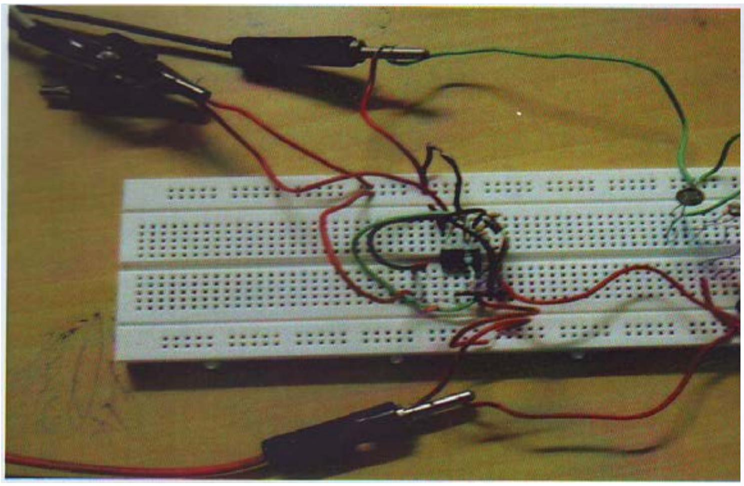

Fig. 13: Light sensing circuit

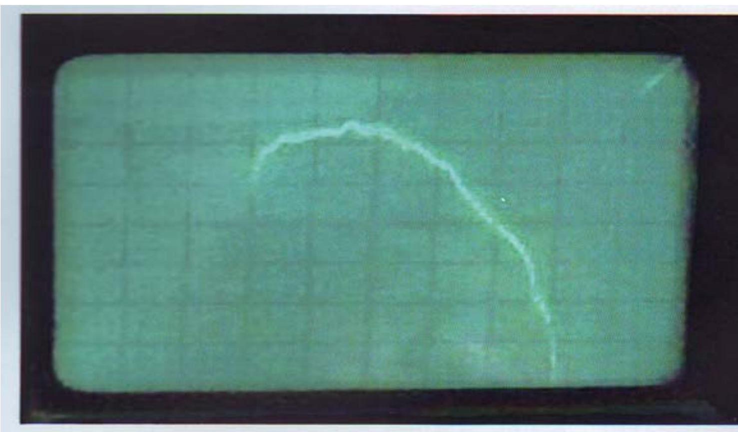

Fig. 14: Output pulse from light sensing circuit

Working of light sensing circuit: In this circuit constant current is given across LDR and constant voltage is given across 555 timer. 555 timer is used for monostable circuit. In monostable circuit a triggering pulse is needed; this pulse is given by LDR arrangement. LDR is negative temperature coefficient device, so when the circuit is kept under light, resistance across the LDR decreases. As current across the LDR is constant and resistance decrease with light intensity, voltage starts to change its state, this voltage is working as triggering pulse in monostable circuit. From monostable multivibrator circuit we get voltage waveform, which remains in high state at first, then changes its state with varying light intensity.

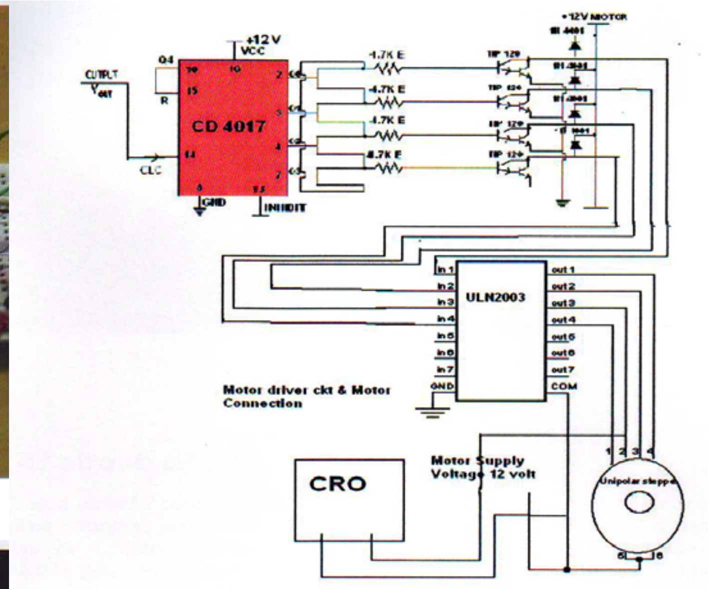

Fig. 15: Motor controlling circuit

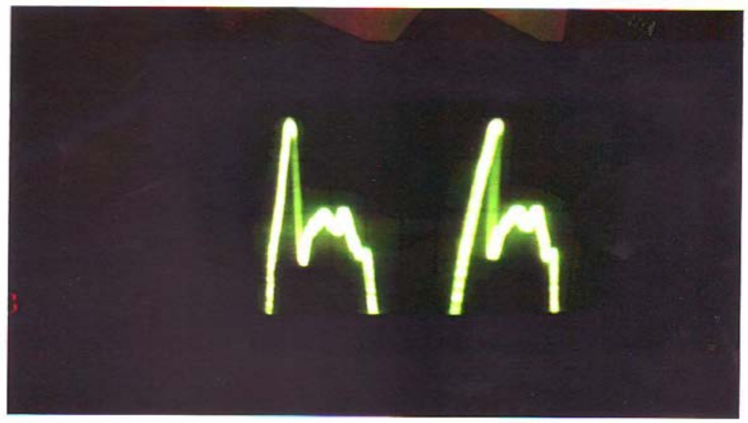

Fig. 16: Output pulse from CRO

Working of above circuit: Here Cd4017 is a decade counter, this counter gives medium speed operation and hazards-free counting sequence, output pulse from light sensing circuit act as clock pulse in decade counter (i.e. at pin no. 14). Here output is taken from (00, 01, 02, 03) pins which are connected through resistance to Darlington pair. Darlington pair is used to obtain high current gain because current obtained from decade counter is amplified by Darlington pair (which is a arrangement of bipolar transistor). This high current gain is needed for driving more load. Diode is connected across the Darlington pair to remove spike in case of inductive load. Resistance is connected in the base of Darlington pair to control the leakage current across CE. Output pulse of Darlington pair is connected across (1,2,3,4) pins of ULN2003 (which acts as motor driver IC). This gives more current gain as it is a Darlington pair IC to drive the load. Stepper motor is connected with it, which moves in a step. As output of decade counter changes sequentially, speed increases motor torque decreases which gives movement to load (i.e. solar panel).

III. CONCLUSION

In this paper of solar tracking system I reached up to the movement of stepper motor. Due to higher cost we couldn't afford a solar cell. Nonetheless, the working will be same if we connect a solar cell, as all parameters have been achieved. The aim of my paper was movement of motor by signal from light sensing circuit when the intensity of light is maximum, which has been successfully achieved.

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AUTHORS

First Author – Reshmi Banerjee, M.Tech., Guru Nanak Institute of Technology, E-mail: banerjee.reshmi@gmail.com.

Correspondence Author – Reshmi Banerjee, E-mail: banerjee.reshmi@gmail.com, Alternate E-mail: reshmi26@rediffmail.com, Contact No.: 09830319497.