Efficiency Enhancement by Live Sun Tracking for Solar PV System

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Abstract---The solar Photovoltaic system is now being adopted on a large scale as well as small house hold systems for general utilities. The conversion of solar energy into electrical energy is largely affected by the angle and direction of the solar panels. As the direct incident light is only light which is useful and produces electrical energy. The placing of solar panels at exact angle & direction according to motion of sun can maximize the overall efficiency of the system. This research work implements the solar tracking system according to sun's motion from east to west. The implementation of such a tracking system with small microcontroller controlled motors and sensors can be beneficial.

Keywords-*Solar Tracking system & design, Inveter operation, motro control.*

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I. INTRODUCTION

Nowadays available energy sources are being depleted rapidly. So it is beneficial to use those sources which are naturally available in abundance. One such source is Sun whose enormous amount of non-exhaustible energy can be cleverly put to use because it is available free of cost and it does not harm environment.

The electricity we have is being generated mainly using thermal power which is falling short of requirement as the demand for it is exceeding the supply. Thus Coal which is the main energy source here is practically not available in surplus amount and also its quality is not of desired value. Thus less power generation leads to Load-shedding which causes inconvenience to the common man. Hence the use of solar energy with its beneficial properties is justified. This project focuses on the optimization of the electric energy production by photovoltaic cells through the development of an intelligent sun-tracking system. The developed tracking system is innovative in relation to the usual sun tracking systems available in the market. In fact, the developed solution has many advantages in relation to similar existing devices, as this system is of the photovoltaic autonomous regarding the information needed to process the optimal orientation and is intelligent in a way that it performs on-line monitoring energy production.

II. SOLAR ENERGY

Solar energy refers to the utilization of the radiant energy from the Sun. Solar power is used Inter changeably with solar energy, but refers more specifically to the conversion of sunlight into electricity. If we could get a solar cell to turn and look at the sun all day, then it would be receiving the maximum amount of sunlight possible and converting it into a more useful form of energy-electricity.

In this event, you will explore how to maximize the performance of a solar cell for the part of the world where you live. There comes the importance of a solar tracker. If we could configure a solar cell so that it faces the sun continually as it moves across the sky from east to west, we could get the most electrical energy possible. What we need is a tracking system that would automatically keep the solar cell facing the sun throughout the day.

III. SOLAR TRACKER

A Solar Tracker is basically a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. After finding the sunlight, the tracker will try to navigate through the path ensuring the best sunlight is detected.

The design of the Solar Tracker requires many components. The design and construction of it could be divided into five main parts, each with their main function. They are:

1. Methods of Tracker Mount
2. Methods of Drives
3. Sensor and Sensor Controller
4. Motor and Motor Controller
5. Tracker Solving Algorithm

A. Methods of Tracker Mount

Single axis solar trackers:

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 where the sun does not get very high, but summer days can be very long. Figure 3 shows a Solar Tracker using horizontal axle. The single axis tracking system is the simplest solution and the most common one used.

Fig1. Single axis solar tracker

B. Double axis solar trackers

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. Figure shows a Solar Tracker using horizontal and vertical axle. 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. By tracking the sun, the efficiency of the solar panels can be increased by 30-40%.The dual axis tracking system is also used for concentrating a solar reflector toward the concentrator on heliostat systems. 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.

C. Light Dependent Resistor:

Light Dependent Resistor (LDR) 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 whole partner) conducts electricity, thereby lowering resistance. Hence, Light Dependent Resistors (LDR) is very useful in light sensor circuits. LDR is very high-resistance, sometimes as high as 1000 000Ω, when they are illuminated with light resistance drops dramatically. These sensors are made of Cadmium Sulphide. More the area of the sensor, more its sensitivity.

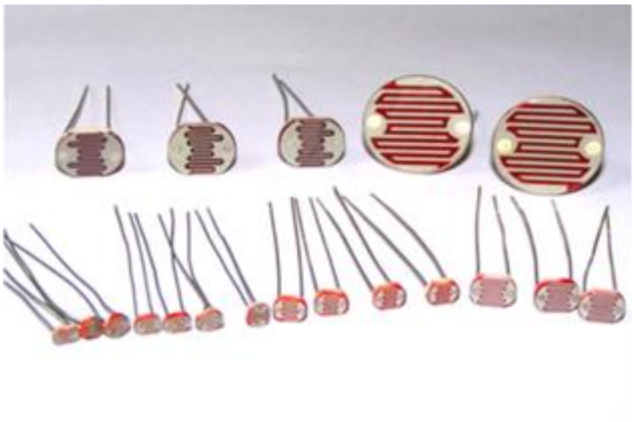

Fig 2. Light Dependent Resistors (LDR)

D. Photodiode:

Photodiode (BPW34) is a light sensor which has a high speed and high sensitive silicon PIN photodiode in a miniature flat plastic package. A photodiode is designed to be responsive to optical input. Due to its water clear epoxy the device is sensitive to visible and infrared radiation. The large active area combined with a flat case gives a high sensitivity at a wide viewing angle.

Photodiodes can be used in either zero bias or reverse bias. In zero bias, light falling on the diode causes a voltage to develop across the device, leading to a current in the forward bias direction. This is called the photovoltaic effect, and is the basis for solar cells - in fact a solar cell is just a large number of big, cheap photodiodes. Diodes usually have extremely high resistance when reverse biased. This resistance is reduced when light of an appropriate frequency shines on the junction.

Hence, a reverse biased diode can be used as a detector by monitoring the current running through it. Circuits based on this effect are more sensitive to light than ones based on the photovoltaic effect.

E. Selection of motors

Any type of DC motors can be used for the sun tracker. But we suggest using high torque geared DC motors or Servo type motors. Since the solar panel arrangement is heavy and so the motor requires a high holding torque for keeping the panel at a particular position. Step per motors can also be used, but since most common stepper motors available does not give enough dynamic torque, these motors if used have to be selected properly.

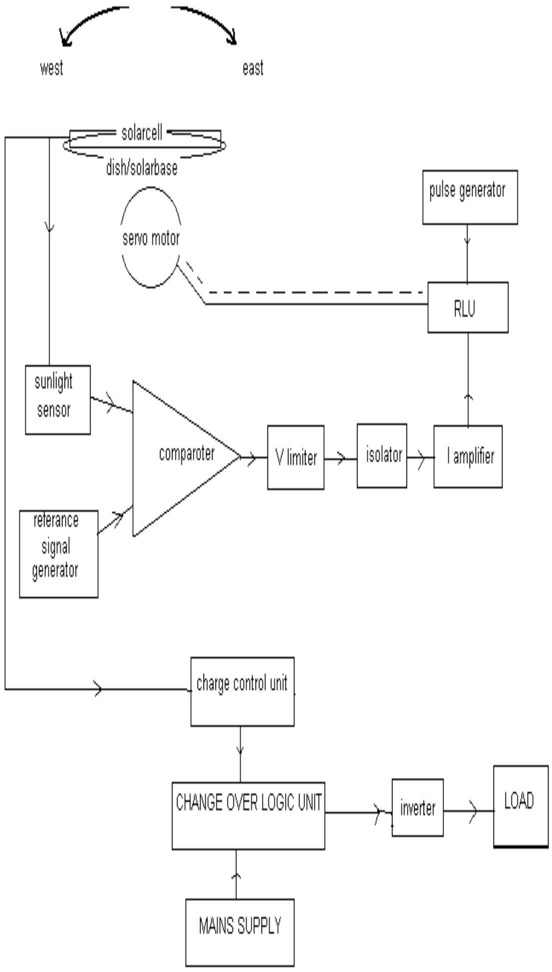

Fig 3. Comparator circuit

F. *Solar tracker circuit using H-bridge:*

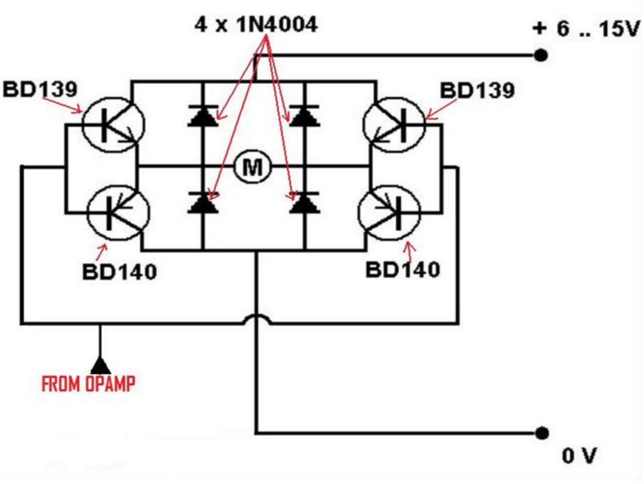

Fig. 4. Solar tracker circuit using H-bridge

G. *East to west sensor*

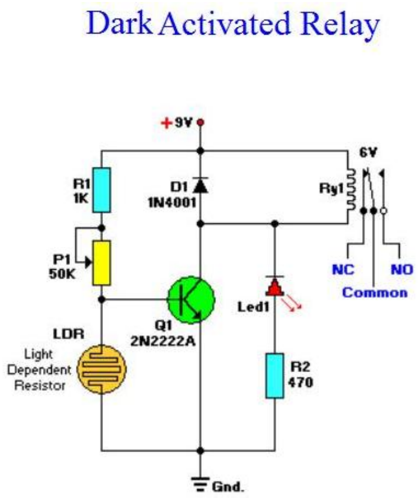

Fig. 5 East to west sensor circuit

IV. SOLAR CHARGE CONTROLLER

Circuit consists of 5 building blocks: The circuit does not turn on until a battery is connected across the terminals as shown in the diagram. (A push switch has been provided to start the circuit when a totally flat battery is fitted.) This action turns on the PNP transistor in the "Turn ON" block. The resistance between the collector-emitter terminals decreases and the indicator LED comes on. The path to the bottom rail of the circuit goes through a signal diode, the gate-cathode junction of the SCR and through two 1R8 resistors in parallel. This is why the LED illuminates. ac plug pack must be used.

Before we go any further, the circuit works on an AC plug pack. It must be an AC supply as we do not want any electrolytic to be present on the power rail as this will allow a very high charge-current to flow and possibly damage the SCR. A DC supply will not allow the SCR to turn off, as it turns off when the current through it falls to zero.

A. *THE CIRCUIT IS A HALF-WAVE RECTIFIER:*

The circuit is actually a half-wave rectifier. It only charges the battery on every half cycle. The plug pack doesn't like this as it leaves residual flux in the core of the transformer and causes it to overheat. This is only drawback with the circuit. The SCR turns on during each half cycle and current flows into the battery. A voltage is developed across the two 1R8 resistors (in parallel) and this voltage is fed into the 47u electrolytic. It charges and turns on the BC557 transistor. The transistor robs the SCR of gate voltage and the SCR turns off. The energy in the 47u feeds into the transistor but after a short time it cannot keep the transistor turned on. The transistor turns off and the SCR switches on and delivers another pulse of current to the battery.

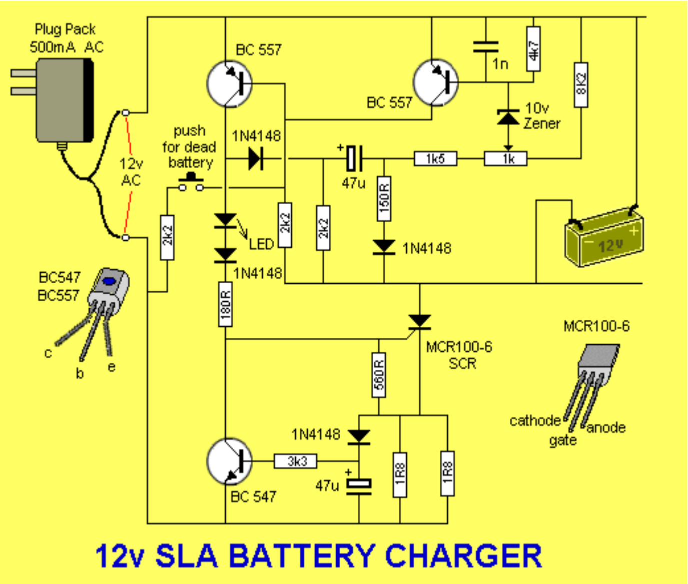

Fig .6 Basic battery charger circuit

As the battery charges, its voltage increases and this is monitored by the "Voltage Monitor" block. The circuit is very complex and one way to look at the operation is to consider the top rail as a fixed rail and as the battery voltage increases, the rail connected to the negative terminal of the battery is pushed down. The "Turn On" transistor is activated and the "Voltage Monitor" components create voltage drops across each of them. The "Voltage Monitor" components consist of a transistor and zenor diode as well as an 8k2 resistor, the 1k pot, a 1k5 resistor, a 150R resistor and a signal diode. The signal diode is actually part of the flasher circuit and we discuss its operation later.

As the voltage across the battery increases to 13.75 volts, each resistor in the "voltage detecting network" will have a voltage drop across it that corresponds to the resistance of the resistor. The diode will have a constant 0.7v a cross it. The voltage on the wiper of the pot will be about 3.25v and the voltage across the zenor will be 10v. This leaves 0.6v between the base and emitter of the Voltage Monitor transistor. This voltage is sufficient to turn the Transistor ON. When the Voltage Monitor transistor turns ON, it robs the "Turn On" transistor of base-emitter voltage and the circuit turns off. The

SCR has only two states: ON and OFF. During the half-cycle when it is turned on, the battery gets a high pulse of current and the current is only limited by the capability of the plug pack. There are no electrolytic to allow very high pulses of current to be delivered and this is fortunate as the SCR is only a 0.8 amp device, but will endure surges of 10amp for half a cycle.

Whenever the SCR is triggered into conduction during the half cycle of its operation, it remains in conduction until the voltage delivered by the plug pack falls to zero. This is when the SCR turns off. When the plug pack delivers a negative voltage to the top rail and a positive voltage to the lowest rail, the SCR is not triggered into conduction and none of the components in the circuit deliver current to the battery. The SCR delivers current for a few half-cycles and then it is turned off for a few cycles. This is how the average current delivered to the battery is controlled.

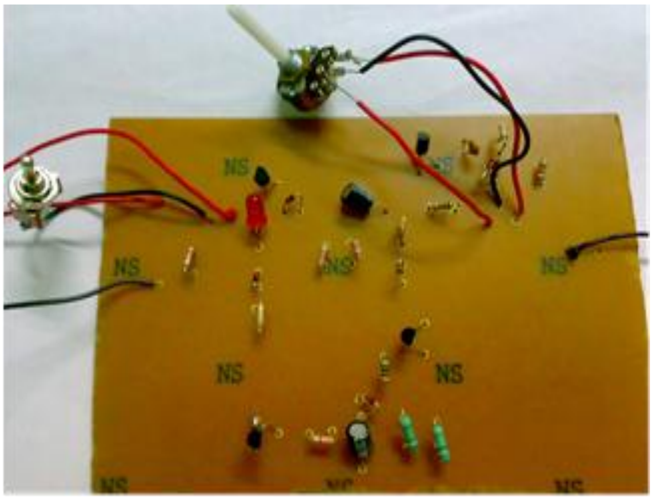

Fig 7. PCB design of Battery charger circuit

V. INVERTER

A. INTRODUCTION

An inverter is used to produce an un-interrupted 220V AC or 110V AC (depending on the line voltage of the particular country) supply to the device connected as the load at the output socket. The inverter gives constant AC voltage at its output socket when the AC mains power supply is not available.

To grasp the functioning of an inverter, the following situations are taken into consideration:

- When the AC mains power supply is available.
- When the AC mains power supply is not available.

When the AC mains supply is available, the AC mains sensor senses it and the supply goes to the Relay and battery charging section of the inverter. AC main sensor activates a relay and this relay will directly pass the AC mains supply to the output socket. The load will by driven by the line voltage in this situation. Also the line voltage is given to the battery charging section where the line voltage is converted to a DC voltage (12V DC or 24V DC usually), then regulated and battery is charged using it. There are special circuits for sensing the battery voltage and when the battery is fully charged the charging is stopped. In some inverters there will be a trickle charging circuit which keeps the battery constantly at full charge.

B. *When the AC mains power supply is not available:*

When the AC mains power supply is not available, an oscillator circuit inside the inverter produces a 50Hz MOS drive signal. This MOS drive signal will be amplified by the driver section and sent to the output section. MOSFETs or Transistors are used for the switching operation. These MOSFETs or Transistors are connected to the primary winding of the inverter transformer. When these switching devices receive the MOS drive signal from the driver circuit, they start switching between ON & OFF states at a rate of 50 Hz. This switching action of the MOSFETs or Transistors cause a 50Hz current to the primary of the inverter transformer. This results in a 220V AC or 110V AC (depending on the winding ratio of the inverter transformer) at the secondary or the inverter transformer. This secondary voltage is made available at the output socket of the inverter by a changeover relay.

C. *Automation in an Inverter:*

Inverter contains various circuits to automatically sense and tackle various situations that may occur when the inverter is running or in standby. This automaton section looks after conditions such as overload, over heat, low battery, over charge etc. Respective of the situation, the automation section may switch the battery to charging mode or switch OFF. The various conditions will be indicated to the operator by means of glowing LEDs or sounding alarms. In advanced inverters LCD screens are used to visually indicate the conditions.

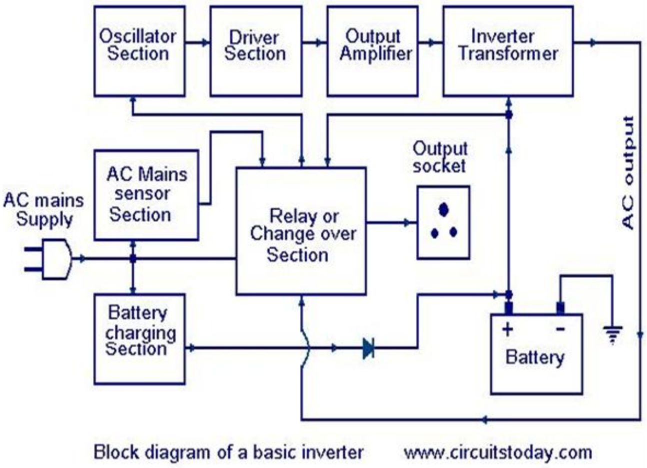

Fig. 8 Block diagram of inverter circuit

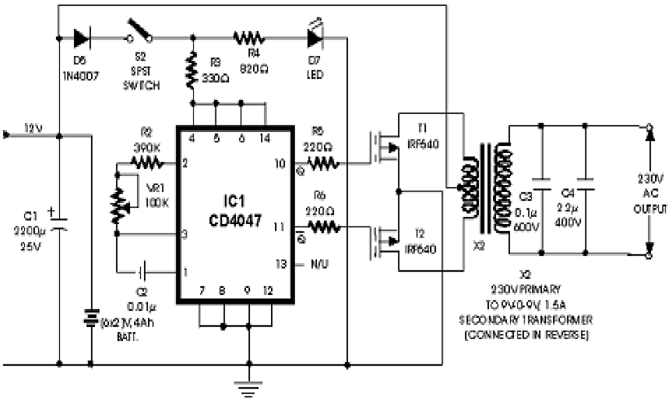

Fig.9 Inverter Circuit using CD4047

VI. RESULT & CONCLUSION

Prototype of an inverter has been designed and implemented. The prototype is successfully working with the logic from the operation of individual system components the solar panel tracks sunlight from morning to evening by moving in accordance with the movement of motor. Ultimately the bulb glows continuously taking energy from inverter battery. A solar tracker is designed employing the new principle of using small sensors to function as self-adjusting light sensors, providing a variable indication of their relative angle to the sun by detecting their voltage output. By using this method, the solar tracker was successful in maintaining a solar array at a sufficiently perpendicular angle to the sun. The power increase gained over a fixed horizontal array was in excess of 60%.

This efficiency can be further be increased with use of good quality inverters with high efficiency and better designs. The current design may lag in some aspects with inverter operation and waveforms.

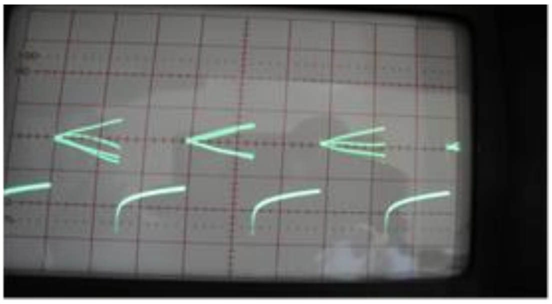

Fig.14. Output Waveform of Inverter

VII. CALCULATION

DC Motor Ratings: 30 rpm, 12V, 0.9A
Power consumption by the tracking system in one hour
= Power consumed by (DC motor + sensing circuit)
= (12V * 0.9A * 1H) + (4.2 WH from datasheet of BD 139 & BD 140) = 15 WH ………… (1)

ELECTRICITY CONSUMPTION:

1 KWH power is consumed @ Rs. 5 per unit i.e. equal to 1000 WH (Watt hour). Therefore power consumed in one hour = 10.8 * 1 hour = 0.0108 KWH @ Rs. 0.5 (50 paisa)
5W solar panel is used.

Hence Power generated by our PV system in 12hours = 5 * 12 = 60 WH ………… (2)

From equations (1) and (2), it can be concluded that
Power generated is greater than power consumed by the tracking system.

Therefore, Energy generated during day time = (60 – 15) WH = 45 WH ………… (3)

Suppose we have to light a CFL of 3W during night time then Energy consumed during night time for 12Hours
= 3W * 12 H
= 36WH ………… (4)

Hence subtracting equation (4) from equation (3) , we get,
Power saved = (45 – 36) WH = 9 WH.
Hence EFFICIENCY OF PV SYSTEM
= (9/15) * 100%
= 60 %
Efficiency of PV system is 60%.

VIII. REFERENCE

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