PLC Based Solar Tracking System

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Abstract- *The capability of photovoltaic (PV) panel to generate energy approximately follows the intensity of the sunlight on the panel. A dual-axis solar programmable logical controller (PLC) based automatic solar tracking system and its supervisory and control system was designed and implemented in this paper. The proposed automatic tracking system control elevation and orientation angles of solar panels such that the panels always maintain perpendicular to the sunlight. The major variables of our automatic solar tracking system were compared with those of a fixed-angle PV system. The results indicated that the automatic solar tracking system is low-cost, reliable and efficient. As a result of the experiment, the electricity generated by the proposed tracking system has an overall increase of about 8% ~ 25% more than the fix-angle PV system.*

Keywords- solar panel , plc , dual axis tracker , dc motor, LDR

I. INTRODUCTION

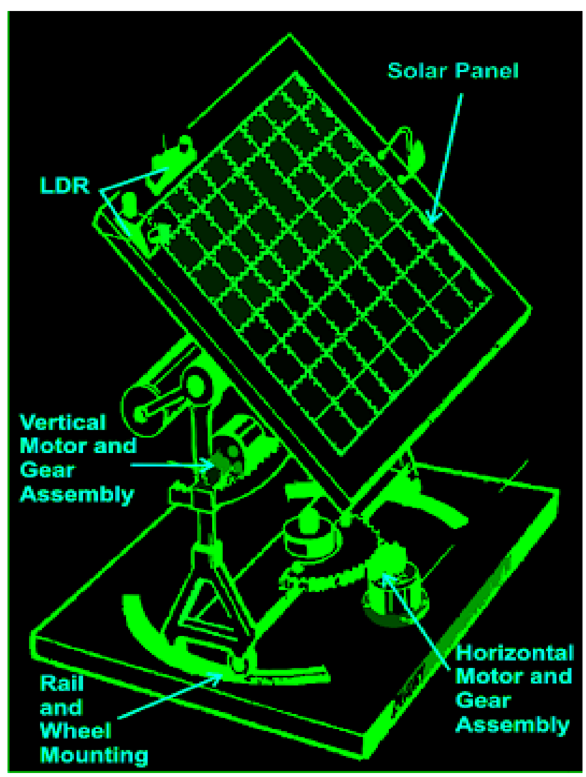
Light gathering is dependent on the angle of incidence of light from Sun to the solar cell's surface, and the closer to perpendicular, the greater the power. If a flat solar panel is mounted on level ground, it is obvious that over the course of the day the sunlight will have an angle of incidence close to 90 degree in the morning and the evening. At such an angle, the light gathering ability of the cell is essentially zero, resulting in no output. As the day progresses to mid-day, the angle of incidence approaches zero degree, causing a steady increase in power until at the point where the light incident on the panel is completely perpendicular, and maximum power is achieved. As the day continues towards dusk, the reverse happens, and the increasing angle causes the power to decrease again towards minimum again. From this background, we see the need to maintain maximum power output from the panel by maintaining an angle of incidence as close to zero degree as possible. By tilting the solar panel to continuously face the Sun, this can be achieved. This process of sensing and following the position of Sun is known as solar tracking. A solar tracker is a device onto which solar panels are fitted which tracks the motion of the Sun across the sky ensuring that maximum amount of sunlight strikes the panels throughout the day. The solar tracker will attempt to navigate to the best angle of exposure of light from the sun. There are two types of trackers single axis trackers and dual axis trackers.

Single axis trackers have one degree of freedom that acts as an axis of rotation. Dual axis trackers have two degrees of freedom that act as axes of rotation. Dual axis trackers allow for optimum solar energy levels due to their ability to follow the sun vertically and horizontally. No matter where the sun is in the sky, dual axis trackers are able to angle themselves to be in direct contact with the sun.

A. Solar Tracking Circuit-

The circuit and the mechanism explained in this article may be considered as the easiest and perfect dual axis solar tracker system.The device is able to track the daytime motion of the sun precisely and shift in the vertical axis accordingly.

The device also effectively tracks the seasonal displacement of the sun and moves the entire mechanism in the horizontal plane or in a lateral motion such that the orientation of the solar panel is always kept in a straight axis to the sun so that it complements the vertical actions.



As shown in the figure, a relatively easy mechanism can be witnessed here. The solar tracker is basically mounted over a couple of stand with a central movable axis.

The pivotal arrangement allows the panel mounts to move on a circular axis over almost 360 degrees.
A motor gear mechanism as shown in the diagram is fitted just at the corner of the pivotal axis in such a way that when the motor rotates the entire solar panel shifts proportionately about its central pivot, either anticlockwise or clockwise, depending upon the motion of the motor which in turn depends on the position of the sun.

The position of the LDRs are critical here and the set of LDR which corresponds to this vertical plane movement is so positioned that it senses the sun light accurately and tries to keep the panel perpendicular to the sun rays by moving the motor in the appropriate direction through a definite number of stepped rotations.

The LDR sensing is actually accurately received and interpreted by an electronic circuit which commands the motor for the above explained actions.

Another mechanism which is quite similar to the above vertical setting, but moves the panel through a lateral motion or rather it moves the whole solar panel mount in circular motion over the horizontal plane.

This motion takes place in response to the position of the sun during the seasonal changes, therefore in contrast to the vertical movements; this operation is very gradual and cannot be experienced on a daily basis.

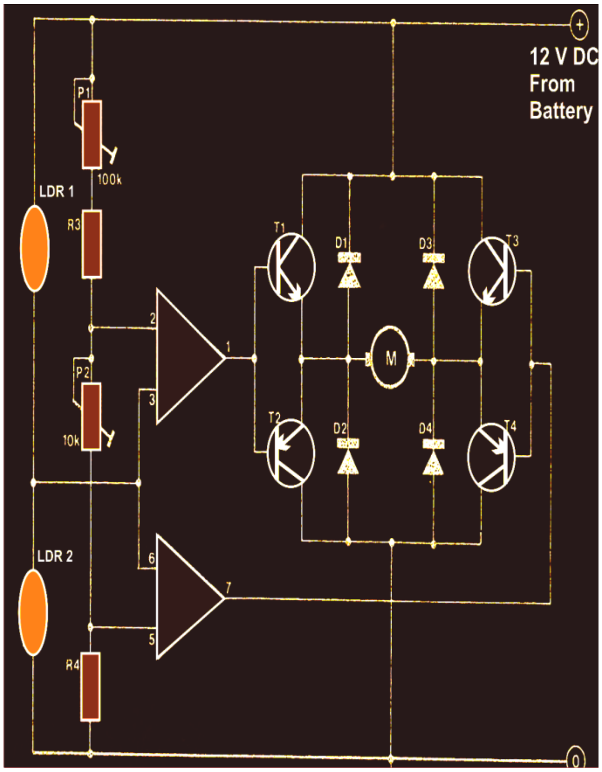
Again the above motion is in response to the command given to the motor by the electronic circuit which operates in response to the sensing done by the LDRs.

For the above procedure a different set of LDRs are used and are mounted horizontally over the panel, at a specific position as shown in the diagram.

B. How the Solar Tracker Control Circuit Functions

A careful investigation of the circuit shown in the diagram reveals that the whole configuration is actually very simple and straightforward. Here a single IC 324 is utilized and only two of its op amps are employed for the require operations.

The op amps are primarily wired to form a kind of window comparator, responsible for activating their outputs whenever their inputs waver or drift out of the predetermined window, set by the relevant pots.Two LDRs are connected to the inputs of the opamps for sensing the light levels.



As long as as the lights over the two LDRs are uniform, the outputs of the opamp remain deactivated.

However the moment one of the LDRs senses a different magnitude of light over it (which may happen due to the changing position of the sun) the balance over the input of the opamp shift toward one direction, immediately making the relevant opamps output go high.

This high output instantly activates the full bridge transistor network, which in turn rotates the connected motor in a set direction, such that the panel rotates and adjusts its alignment with the sun rays until uniform amount of light is restored over the relevant set of LDRs.

Once the light level over the relevant LDR sets is restored, the opamps again become dormant and switch off their outputs and also the motor.

The above sequence keeps on happening for the whole day, in steps, as the sun alters its position and the above mechanism keeps shifting in accordance to the suns position.

It should be noted that two sets of the above explained circuit assemblies will be required for controlling the dual actions or simply to make the above discussed dual tracker.

Parts

R3=15K,
R4=39K,
P1=100K,
P2=22K,
LDR = Normal type with a resistance of around 10 K to 40K in daylight under shade and infinite resistance
Op-amps are from IC 324 or separately two 741 ICs
T1,T3=TIP31C,
T2,T4=TIP32C,
Motor = As per the load and size of the solar panel

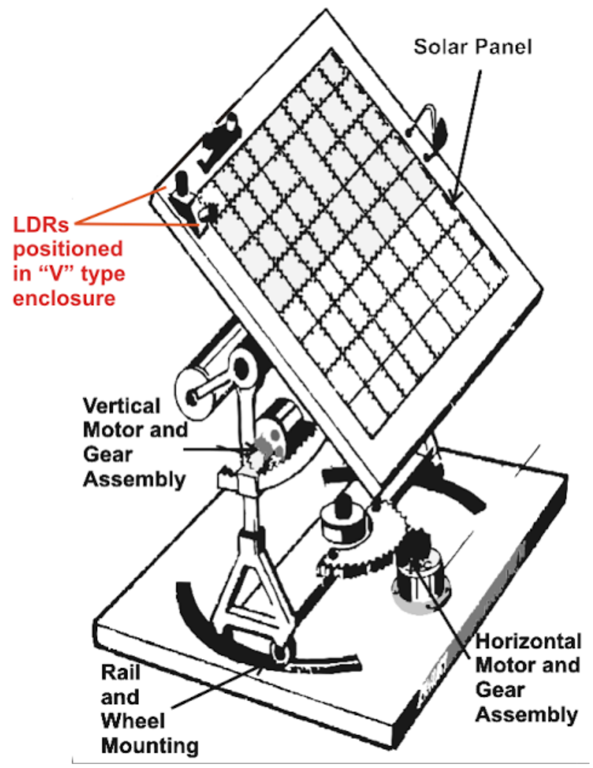
C. How to Add A Set/Reset Facility In The Above Circuit

At the first glance it might appear that the above circuit does not incorporate an automatic resetting feature. However a closer investigation will show that actually this circuit will reset automatically when dawn sets in or inthe morning daylight.

This might be true due to the fact that the LDRs are positioned inside enclosures which are specfiially designed in a "V" shape for facilitating this action.

From the reflection of of the rising sun light, during morning hours the sky gets more illuminated than the ground. Since the LDRs are positioned in "V" manner, the LDR which faces more toward the sky receives more light than the LDR which faces toward the ground. This situation activates the motor in the opposite direction, such that it forces the panel to revert in the early morning hours.

As the panel reverts towards the east, the relevant LDR begins getting exposed to even more ambient light from the rising sunlight, this pushes the panel even harder toward the east until both LDR are almost proportionately exposed toward the east rising sunlight, this completely resets the panel so that the process begins all over again.



D. Set Reset Function

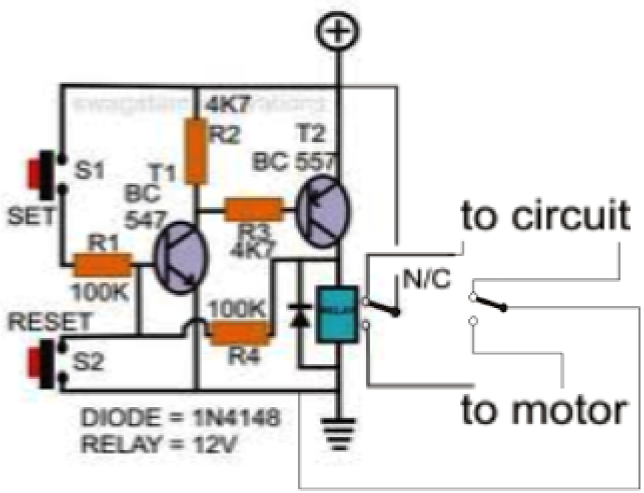
In case a set reset feature becomes imperative, the following design may be incorporated.

The set switch is placed at the "sun-set" end of the tracker, such that it gets depressed when the panel finishes it's days tracking.

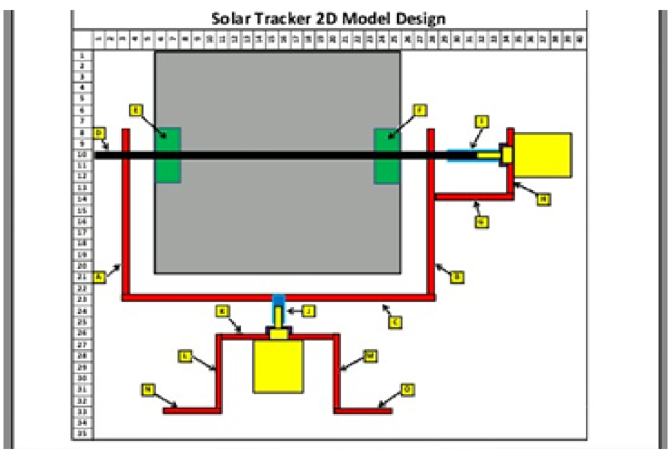
As can be seen in the below given figure, the supply to the tracker circuit is been given from the N/C points of the DPDT relay, it means when the 'SET" switch is pushed, the relay activates and disconnects the supply to the circuit so that the entire circuit shown in the above article now gets disconnected and does not interfere.

At the same time, the motor receives the reversing voltage via the N/O contacts so that it can initiate the reversing process of the panel to its original position.

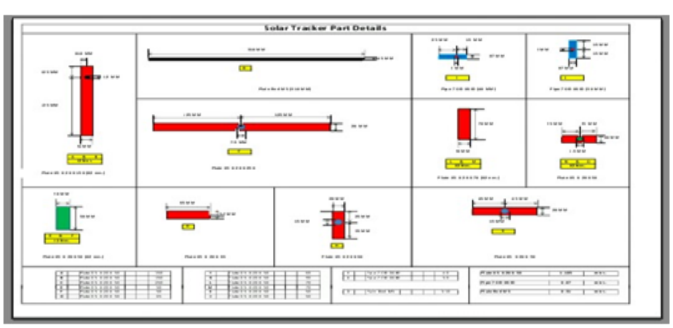
Once the panel finishes its reversing process toward the "sun-rise" end, it pushes the reset switch placed suitably somewhere at that end, this action deactivates the relay again resetting the entire system for the next cycle.



Solar tracker 2D model design



Solar tracker design model



E. Programmable Logic Controller

It is a control system using electronic operations .Its easy storing procedures ,functions of position control,timed counting and input /output control are widely applied to the field of industrial automation control.

Specification –
MPU point :14 (8DI+6DO)
Max.I/O points:494(14+480)
Program capacity :8K steps

II. CONCLUSION

The objective of the proposed work was to design a PLC based automated tracking of solar panel for maximum throughput using photo sensors. Solar panel will track Sun based on the output from the sensor successfully. The sensor output keeps varying based on the amount of sunlight falling on it. The output from the sensor is converted to digital (logic zero or one) and given to the PLC as input. The PLC output drives the motor to the position. The stepper motor is used for precise control of the solar panel here. The solar panel along with the sensor is interfaced and the tracking of solar panel is efficient

REFERENCES

JOURNAL / CONFERENCE PAPERS

[1] Bajpai P, Kumar S, “Design, development and performance test of an automatic two-axis solar tracker system”, Annual IEEE Conference Publication, India Conference (INDCON) 2011, Electr. Eng. Dept., IIT Kharagpur, Kharagpur, 16-18 Dec. 2011, 1–6.

[2] Esram T, Kimball JW, Krein PT, Chapman PL, Midya P, ”Dynamic maximum power point tracking of photovoltaic arrays using ripple correlation control”, IEEE Transactions. 2006 ;21(5), Illinois Univ., Urbana, IL , Sept. 2006, 1282–1291.

[3] Feng-run Liu, Le Xiao, Wen-jia Li,” The design of automatic solar tracking system for solar cell”, IEEE 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC) 2011; North China University of Technology, China, 8-10 Aug. 2011, 4451–4454

[4] Huifeng Jiao, Jianzhong Fu, Yuchun Li, Jintao Lai, “Design of automatic two-axis sun-tracking system”, IEEE International Conference on Mechanic Automation and Control Engineering (MACE) 2010, Dept. of Mech. Eng., Zhejiang Univ., China, 26-28 June 2010, 2323–2326.

[5] Khan MTA, Tanzil SMS, Rahman R, Alam SMS.” Design and construction of an automatic solar tracking system”, IEEE 6th International Conference on Electrical and Computer Engineering (ICECE), 2010, Dept. of Electr. & Electron. Eng.,