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A Noble Idea On PIC Based Automatic Solar Radiation Tracker

Rohan Chadha [1] , Siddhant Mathur [2+] , Vibhor Mittal [3] , Nater Bali [4] and Varun Dhusar [5]
[1234]Galgotias College of Engineering and Technology, Gr. Noida, India
[1]rohanchadha41@gmail.com
[1]+91-9582810784

Abstract. To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach to maximize the efficiency of solar array systems is sun tracking. Proposed in this paper is a system that controls the movement of a solar array so that it is constantly aligned towards the direction of the sun. This project offers a reliable and affordable method of aligning a solar module with the sun in order to maximize its energy output[3]. Polycrystalline photovoltaic module is used in this system and it is designed to track the maximum sunlight by stepping motor that is commanded by PIC16f877A to get the maximum energy out of it. The concise definition of this system is to design and develop a prototype of microcontroller[5] controlled solar array that actively tracks the sun so that maximum power is received by the array at all time of the day.

Keywords: Photovoltaic Module (PV), Master Clear (reset) Input (MCLR), Oscillator (OSC)

1. Introduction

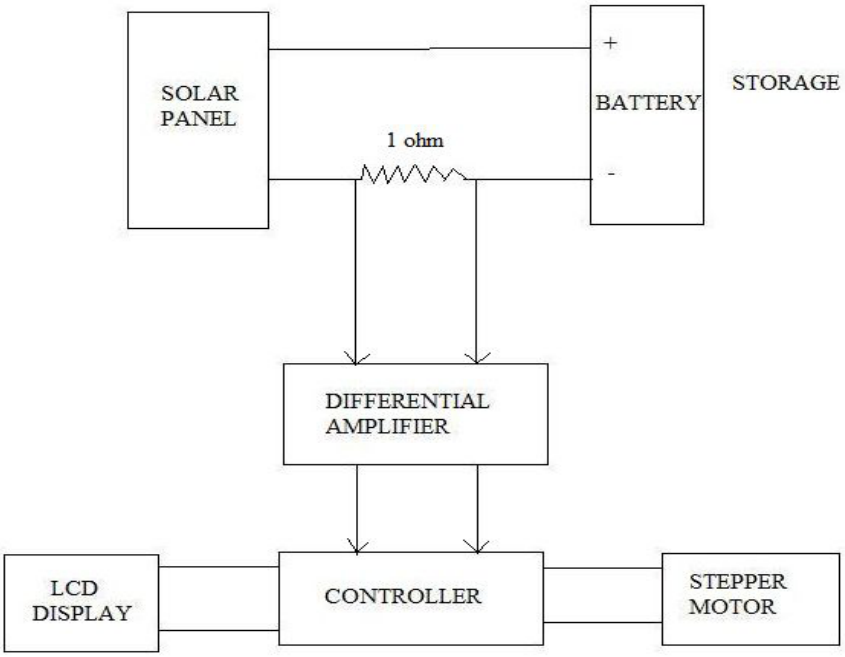
In remote areas the sun is a cheap source of electricity because instead of hydraulic generators it uses solar cells to produce electricity. While the output of solar cells depends on the intensity of sunlight and the angle of incidence, it means to get maximum efficiency; the solar panels must remain in front of sun during the whole day. But due to rotation of earth those panels can't maintain their position always in front of sun. This problem results in decrease of their efficiency. Thus to get a constant output, an automated system is required which should be capable to constantly rotate the solar panel to receive maximum solar energy. this tracker utilizes the solar module itself as a sensor to determine which part of the sky will deliver the most power to the load. Sun position is determined by measuring the in circuit current of the solar module during the "sky scanning" phase of the trackers movement[1]. The point of travel, which gives the highest in circuit current, is logged in the trackers microcontroller and this point is then targeted. Using the Photovoltaic module itself as the sensors means that there are no other external sensors required and therefore the cost and complexity of the device are lowered. After careful consideration of the forms of tracking available and the methods of implementing each, it has been decided that the preferred tracking system is built around a microcontroller based dynamic tracking system using stepper motors for alignment.

2. Operating Principles

Polycrystalline photovoltaic module is used in this system and it is designed to track the maximum sunlight by stepping motor that is commanded by PIC microcontroller to get the maximum energy out of it. The energy received by the solar panel depends on the atmospheric conditions too. For example, when outside is cloudy, the solar energy received goes down to 10% from its initial value; in this situation it is not advisable to move the solar panel[4]. The algorithm presented by us can foresee such a situation in which the program hibernate control action till the sun reappears.

[+] Siddhant Mathur. Tel:+91-9582535227
E-mail address: sidd2308@gmail.com

2.1 Block Diagram of hardware design:



LCD (Liquid Crystal Display) is used in our proposed scheme to display the values of in-circuit current. For simulation purpose, we can use LCD in a 4-bit Mode. For that, we require only four data lines to be connected to the four port pins of PIC and three control signals to control the data flow and display.

2.2 Circuit Diagram

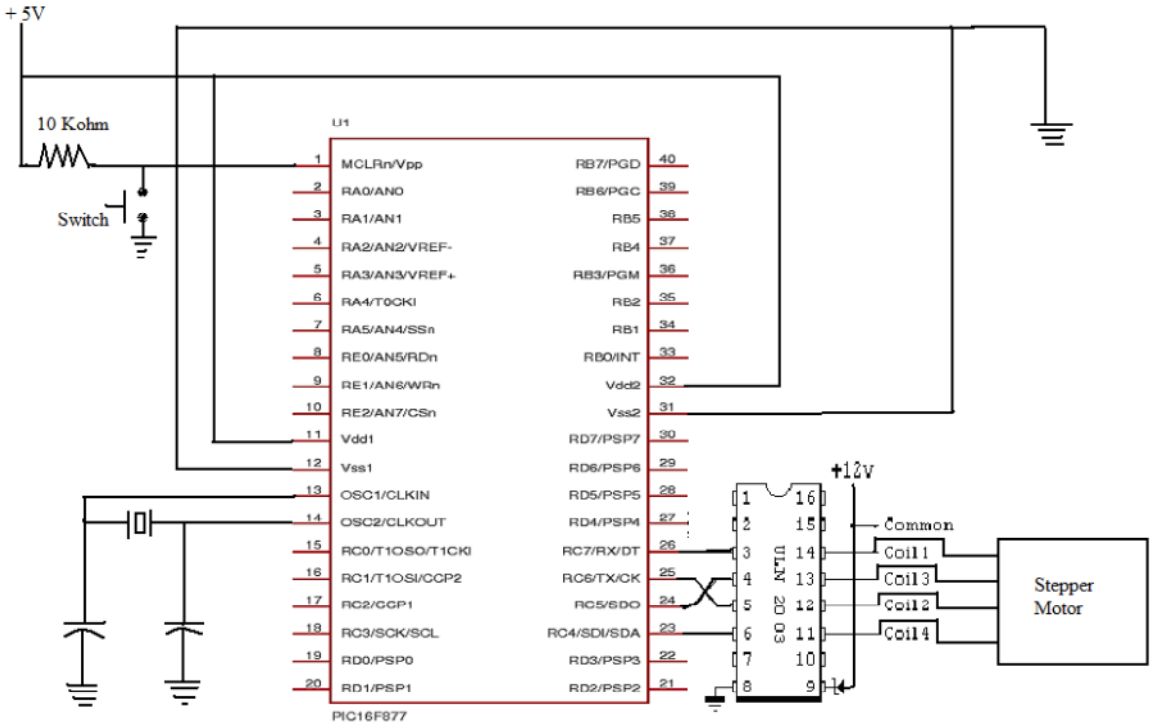


Table 1 Description of Pins used in Circuit.

Pin Name	Pin No.	Description	Application
Vss	12,31	Ground Reference	Ground Reference

OSC	13,14	For Oscillator or resonator	Connected to Resonator 8MHz with 22pF
V_{DD}	11,32	Positive Supply (+5V)	Positive Supply to chip
MCLR	1	Reset Input	Always connected to +5V

2.3 PIC Circuit

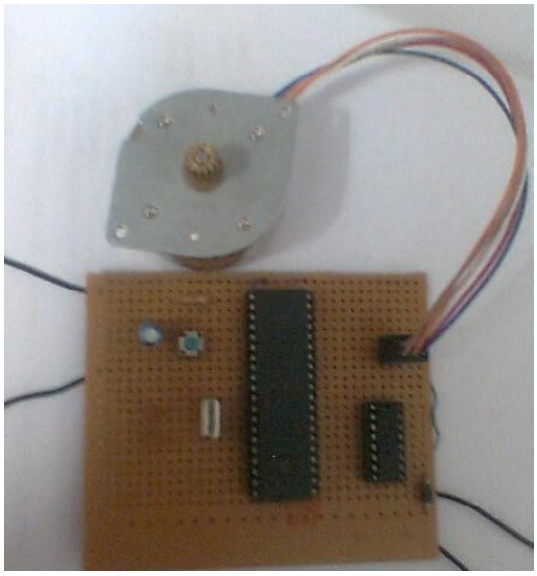


Fig.1 PCB made for the proposed scheme.

3. Control algorithm:

1. Measure in-circuit current.

2. If current is < dark value (It indicates onset of night) the tracker resets itself to reset position (extreme east) and sleeps for 10 hours, then it goes to step1.

3. If current < threshold value (minimal daylight current), wait for 15 minutes and go to step 1.

4. Turn panel forward by 15◦and measure current again after a pause of 1 minute. If current increases, continue with rotation. If it decreases, then revert back by 15◦. If it remains constant, stop rotating, wait for 15 minutes and go to step 1.

Using PIC 16F877A, in circuit current is being monitored as and when indicated in above algorithm and depend on the control strategy command is given to stepper motor to turn forward to backward .The monitored current is displayed on LCD panel . Here we use small stepper motor just for making the working model. We can use big motor of higher rating with proper gear arrangement to give automatic rotation to tracker.

4. Results

The tracking capability of the proposed technique had been verified experimentally with a 10-W solar panel at different rotations of Tracker. Solar panel of 10 W was connected with rheostat varying from 0-200 ohms which was in series with an ammeter. Tracker was connected in parallel to the voltmeter (0-50V). Here we have simulated 15V battery by keeping closed circuit voltage constant. Current was being monitored at various angles of tracker as the sun moved from east to west. The Tracker was moved manually but with the help of proper gearing and motor, we can actually rotate the panel and made it automatic[5]. Voltage level had to be maintained at 15V. We kept the standard alignment of tracker at 45 degree. Then we moved the tracker with 15 degree steps in rotation with sun from east to west so that it could extract maximum amount

of solar energy. At first, we measured open circuit voltage. For closed circuit, corresponding to constant voltage, we measured in-circuit current, resistance as well as angles at which tracker got to rotate. Variations of current with constant voltage of 15V were calculated from 8 a.m. to 6 p.m. Consequently we came up with the following results.

Table 2 Comparison of Maximum Current between fixed and variable angle.

Time of day	Open circuit voltage(V)	Closed circuit voltage(V)	Current at fixed angle 0 degree(Amperes)	Variable Angle (degrees) for Maximum current	Maximum current at variable angle (Amperes)
8.00 A.M	19.07	15	0.49	-30	0.72
9.00 A.M	19.08	15	0.71	-15	0.72
10.00A.M	18.74	15	0.65	-15	0.68
11.00 A.M	18.66	15	0.64	0	0.64
12.00 noon	18.80	15	0.59	0	0.59
1:00 P.M	18.78	15	0.60	0	0.60
2:00 P.M	18.74	15	0.64	0	0.64
3:00 P.M	18.54	15	0.63	0	0.63
4:00 P.M	19.12	15	0.59	+15	0.60
5:00 P.M	18.97	15	0.40	+30	0.52
6.00 P.M	18.70	15	0.24	+30	0.33
Total			6.18		6.67

$$\text{Efficiency}=\frac{(6.67-6.18)\times 100}{6.18}=7.9\%$$

Thus efficiency is increased around 8% on a clear sunny day[2]. Range for analog to digital conversion is 2^{10} = 1024 bit. Maximum current is taken as 1Ampere. So current value is 1/1024 is approximately 1milli ampere. Thus minimum current value is 240 mA and maximum current value is 640 mA as shown above in table. Threshold Value is 0.2Ampere i.e. 200 mA. When current value will be less than 200mA it will be overcast in sky. Tracker will stop working .It will be fixed in the same position. Dark value which is less than threshold value is 0.05 Ampere i.e. 50mA. If current value will be less than 50mA, it means it is dark now. Tracker will turn itself off, turn to east and remain in that fixed position. Tracker will be off for 10 hours, remaining fixed in the same position so that when the sun will rise next day, it will catch the sun.

5. Scope for Future Work

To improve the sun tracking, a standalone sun tracker can be designed using 18 series PIC microcontroller. In 18 series PIC microcontroller, data can be stored periodically in MMC card .We need not to do it manually (no need of rotation). In this proposed area, we took 45 degree as standard alignment during results which had been taken in April, 2008. Alignment can be varied changing with season. Moreover, concentrating type collectors are more efficient than flat plate collectors. We can make use of that to increase efficiency.

6. References

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