Tracking of Sun for Solar Panels and Real Time Monitoring Using LabVIEW

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***Abstract*—Sun is a very abundant source of power. Even so, only a fraction of the entire energy is harnessed and that too not efficiently. The main cause of this is the high cost of installation of solar cells. Also solar cells are mostly kept fixed, so they do not obtain the optimum amount of sunlight throughout the day. This paper aims at the development of a simple process to track the sun and attain maximum efficiency using Microcontroller and LabVIEW for real time monitoring.**

***Index Terms*—solar panel, ATMEGA microcontroller, tracking, LabVIEW.**

I. Introduction

Due to economic rise, the demand for energy has grown at an average of 3.6% per annum over the past 30 years. In June 2010, the installed power generation capacity of India stood at 162,366 MW while the per capita energy consumption stood at 612 kWH. The country's annual energy production increased from about 190 billion kWH in 1986 to more than 680 billion kWH in 2006 [1]. Electricity losses in India during transmission and distribution are extremely high and vary between 30 to 45%. In 2004-05, electricity demand outstripped supply by 7-11%. Due to shortage of electricity, power cuts are common throughout India and this has adversely effected the country's economic growth. With about 300 clear sunny days in a year, India's theoretical solar power reception, just on its land area, is about 5 PWh/year (i.e. = 5 trillion kWh/yr ~ 600 TW). The daily average solar energy incident over India varies from 4 to 7 kWh/m^2 with about 1500–2000 sunshine hours per year, depending upon location [1]. Even 10% of this power would be enough to meet the power requirements for our country.

Solar panel is mainly made from semiconductor materials. Si used as the major component of solar panels, which is maximum 24.5% efficient [2]. Solar trackers are the most appropriate and proven technology to increase the efficiency of solar panels through keeping the panels aligned with the sun's position. Solar trackers get popularized around the world in recent days to harness solar energy in most efficient way. This is far more cost effective solution than purchasing additional solar panels [2].

Today, solar energy accounts for about 0.4% to total energy generation compared to energy from thermal and nuclear plants. Solar energy if used efficiently will not only meet the power shortage but also reduce the burden on our natural oil reserves. Introduction of solar panels at homes is a solution. But the efficiency of fixed solar panels is quite low as the position of sun changes continuously and hence it moves out of the area of maximum efficiency [3].

This paper is an attempt to come up with an inexpensive tracking system so that is can be used extensively. Also it needs to be robust so that the entire device can be left alone in remote areas, without requiring further repairing. The problem that exists with such devices is the tracking system. Using of an IR sensor for tracking is actually very expensive [3]. This adds to the start-up price. Also if in any case the sensor may be damaged or does not get the proper input then the entire system will stop functioning. Normal solar panels have a full day efficiency of about 45-50% [4]. Introduction of single axis and dual axis trackers would increase the overall efficiency to about 30% more than what we already have. Using the power generated by solar power in conjunction with the existing power system of household the per capita power consumption from natural resources can be reduced [5]. The cost recovery of the entire unit is possible within 3-4 years without any appreciable maintenance charges. Unless high efficient solar panels are invented, the only way to enhance the performance of a solar panel is to increase the intensity of light falling on it [6].

In the proposed method we have not used any sensor or input from the environment at any point for tracking. Inputs are taken only for monitoring purpose which is a secondary goal. Monitoring can be done only if required and at organizations like a factory or an industry. Our primary goal is to set up a standalone device for continuous power generation.

II. Methodology

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In the block diagram that has been shown Fig. 1, shows the proposed method in which the microcontroller is the most important component. Initial steps of the setup are done by setting up the hardware of the solar panel. The solar panel will be fixed on a frame which will be free to move. The frame is basically rotated by the servomotor. The sensors around the frame will decide the position of the panel. The signals from the sensors will be fed through the DAQ device to the PC. The microcontroller unit will also be interfaced with the PC. The position of the panel will be passed to the microcontroller unit and based on the position the controller unit will send the signal to motor to set the position of the panel according to the day time (sun position).

The components being used here are the ATMEGA16 microcontroller which is a 8 bit controller. The servo motor that is used is a high precision Futaba S3003 motor. Finally the solar panel is a 2.5Watt panel which is being used as a prototype.

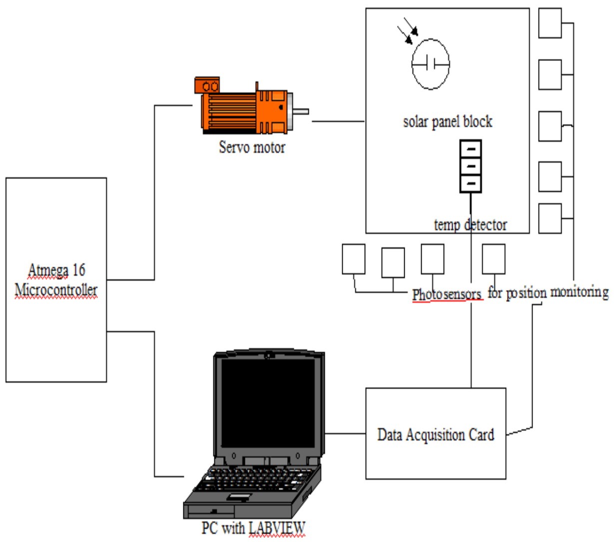

Figure 1. System block diagram

Pre-programmed microcontroller is used which is programmed to be synchronized with the solar movement during the day.

In this paper we have proposed a single axis tracker for our discussions. This avoids the complexity of construction and usage. To reduce the effect of the lateral shift of the sun from north to south the solution reached was that to tilt the panels in the direction of the sun by an angle that is equal to the latitude of that place. This simplifies the problem largely, also an error of **±5 °**reduce the output efficiency by just 2%, which is allowable [7].

Direct sensing and any other device that we may use involve the building up of circuitry and other problems. Webcam based solar tracker [8] was also developed but the clarity of the picture was a concern for such systems. Maintenance of such units is quite a problem because the common man necessarily need not be from a technical background. Programmed chips are an easy solution to this problem. These microcontrollers are used to synchronize a stepper motor to track the sun perfectly.

A. *Calculation of Solar Position*

In order to understand how to collect energy from the sun, one must first be able to predict the location of the sun relative to the collection device. In this part describes the necessary equations by use unique vector approach. This approach will be used in this work to develop the equations for the sun's position relative to a tracking solar collector.

Assuming that in the tropical zone, where solar panels are most effective, there is about 10 hours sunshine every day.

Total angle to be covered=180-150 º

Time taken for the sun to travel from sunshine to sunset= 10 hours= 10 X 60= 600mins

$$\therefore \text{Degree travelled per minute} = \frac{180^{\circ}}{600\,mins}$$

$$= 0.3^{\circ}/\text{min}$$

This is too small an angle to account for, so we take a minimum angle of at least 5 degrees for each pulse that is to be given to the steeper motor to rotate.

$$\therefore \text{Time after which each pulse is to be given} = 5 \div 0.3$$

$$= 16.777 \text{ min}$$

Thus a pulse is to be given every 17 minutes for the solar panels to properly track the sun.

To make the tracker more accurate we have to modify the programming so that the hours of sunshine as given in the program is changed every 14 days by adding or subtracting 20 minutes to the total hours of sunshine, depending on the time of setting up of the device. After the sun sets the panels have to be reset their initial position to allow further tracking the next day.

B. *Real Time Monitoring*

As we can see in the Fig. 2, 6 LDRs are connected to the DAQ card. The LDR used is 10KΩ. The LDRs are connected to analog input channels of the DAQ card and other side grounded. The resulting value is acquired by the DAQ assistant of LabVIEW. The principle of operation is that when maximum amount of sunlight falls on an LDR its resistance will drop. This value is compared with the values of all the other LDRs. The LDR with minimum resistance is the one that is most in line with the sun, hence the corresponding LED glows in the front panel.

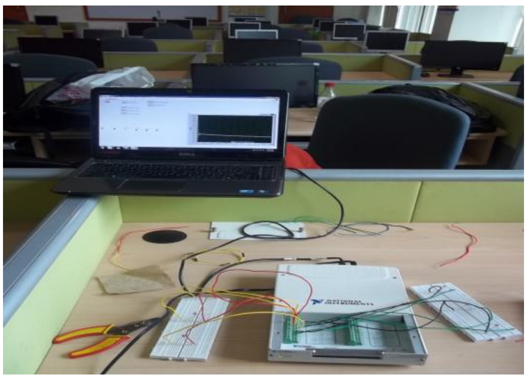

Figure 2. Monitoring device using LDR.

Fig. 3 shows the block diagram of the LabVIEW code generated for monitoring purpose. The signal from DAQ assistant is given to an array which is indexed in the next step. The DAQ used is NI USB 6221. It has 16 analog input channels. We have used 6 of them. They have to be configured for a maximum of +/- 10KΩ range. The array is next passed to the maximum and minimum function. As explained above, the LDR with minimum resistance is to be considered. The index option gives us the required position. This value is an integer and is passed to a switch case structure which in turn switches ON the correct LED depending on the position of the sun. Real time monitoring of the power could also be done, provided that the value is less than that of the safe operating of the DAQ card.

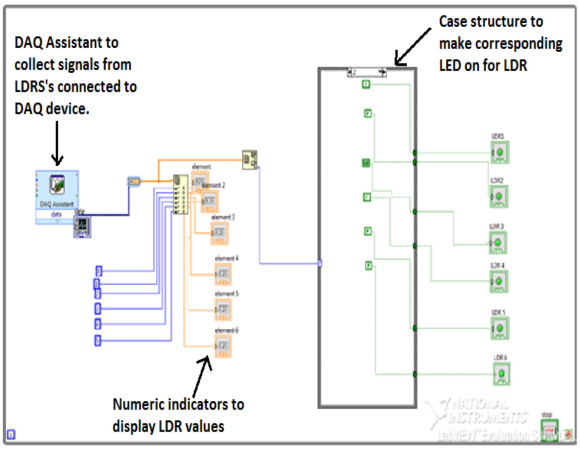

Figure 3. Block diagram for the monitoring logic.

III. Result Analysis

The tracking system was successful as theoretically suggested. The net power generation is increased drastically specially during the morning and afternoon hour.

Figure 4. Tracking system installed in a solar panle.

This Fig. shows the tracking system is implemented on a single panel. The solar panel is fixed on a frame which is free to rotate and the shaft of the frame is connected to the motor. The motor will be controlled by the microcontroller unit based on the signal coming from the LDR sensors. The Fig. 4 was captured at 3:00 PM. It can be seen that the solar panel is facing the sun in the most optimum position possible.

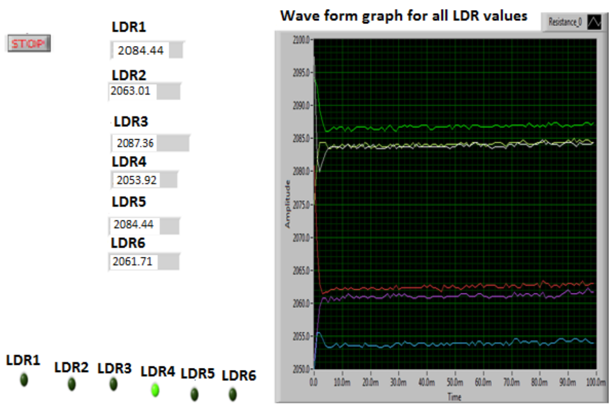

Figure 5. Front panel of monitoring system.

From Fig. 5 it can be seen this is the real time monitoring part for the position of the sun. LDR 4 has been exposed to directs sunlight so it has the minimum resistance, correspondingly the LED for LDR 4 is glowing. This system can be used to monitor the solar position.

TABLE I. Power Variations in the Day Time

Time	Power Without Tracking(In Watts)	Power With Tracking (In Watts)
9.00AM	15	29
9.30AM	23	35
10.00AM	37	46
10.30AM	37	48
11.00AM	40	48
11.30AM	40	47
12.00PM	48	48
12.30PM	47	47
1.00PM	40	45
1.30PM	37	45
2.00PM	37	48
2.30PM	35	47
3.00PM	33	44
3.30PM	29	40
4.00PM	25	34
4.30PM	20	31
5.00PM	13	28

Table I showing the power variations for the panel with and without tracking mechanism averaged over 2 days.

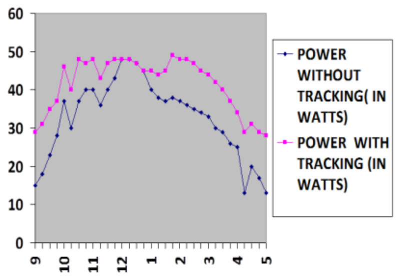

Figure 6. graph showing variation of power output vs Time

The graph in Fig. 6, which is formed after plotting the data showed in Table I shows the trend of solar tracking.

There is a significant increase in the power produced, especially during the morning and afternoon periods. The maximum variation being about 200%. Hence the intended result was achieved.

IV. CONCLUSION

From the work that has been done it is to be noted that there has been a significant increase in the total power generated throughout the day. About 29% increment was observed. The entire cost of the system being installed comes to about Rs1600 for every panel. The amount of extra power that it will generate is predicted to be about 72KWH per year (for a 75 watt panel). The operation life of the solar panels is about 20 years. So all in, it will be generating a profit while generating clean energy. The efficiency of the system can be further increased by considering dual axis tracking to cover north to south movement of the sun.

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