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Design and Development of Real Time Clock based efficient Solar Tracking System

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ABSTRACT

The growth or energy demand in response to industrialization, urbanization, and societal affluence has led to an extremely uneven global distribution of primary energy consumption. The sun, wind, waves and geothermal heat are renewable energy sources that will never run out. They are perpetual, or self-renewing. The rate of consumption does not exceed the rate of renewability. The cost of generating electricity from wind and solar power has decreased by 90% over the past 20 years. Maximizing power output from a solar system is desirable to increase the efficiency of a solar tracing system. To maximize the power output from solar panels, we need to keep the panels aligned with the sun. In this paper, the design of an efficient solar tracking system based on Real Time Clock (RTC) using ARM processor is described. The proposed tracking system is a low cost, high accurate, more efficient with low power consumption.

Keywords – ARM processor, Real Time Clock, Renewable energy, Solar tracking system

1. INTRODUCTION

The regeneration energy also called the green energy, has gained much importance nowadays. Green energy can be recycled, much like solar energy, water power, wind power, biomass energy, terrestrial heat, temperature difference of sea, sea waves, morning and evening tides, etc. [1, 2]. Among the non-conventional, renewable energy sources, solar energy affords great potential for conversion into electric power, able to ensure an important part of the electrical energy needs of the planet. The conversion principle of solar light into Electricity, called Photo-Voltaic (PV) conversion, is not very new, but the efficiency improvement of the PV conversion equipment is still one of top priorities for many academic and/or industrial research groups all over the world. Among the proposed solutions for improving the efficiency of PV conversion, we can mention solar tracking [3]-[4], the optimization of solar cell configuration and geometry [5]-[6], new materials and technologies [7]-[8], etc.

The topic proposed in this paper refers to the design of a single axis solar tracker system that automatically adjusts the optimum PV panel position with respect to the sun by means of a DC motor controlled by an intelligent controller unit that equipped with a positioning algorithm to mathematically solve the optimum tracker position for any time of the day using RTC. A practical measurement of the sun position with respect to the natural time relational table is implemented as an algorithm to track the sun position to achieve maximum energy. Finally, a comparison between the tracking system and the fixed system is made. From the experimental results, the proposed tracking system is verified more efficiently in generating energy than the fixed system.

2. The Sensing and Tracking Principle

Various methods have been implemented and used to track the position of the sun. The principle of operation of a PV cell is shown in Fig.1.

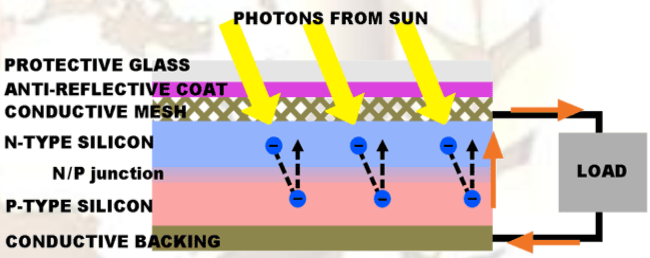

Fig. 1: Principle of operation of a PV Cell

The simplest of all uses an LDR – a Light Dependent Resistor to detect light intensity changes on the surface of the resistor. Other methods, such as that published by Jeff Dam in ‘Home Power’ [10], use two phototransistors covered with a small plate to act as a shield to sunlight, as shown in Fig. 2.

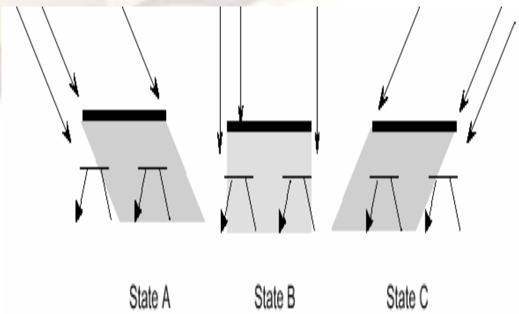

Fig. 2: Principle of operation of an LDR

When morning arrives, the tracker is in state A from the previous day. The left phototransistor is turned on, causing a signal to turn the motor continuously until the shadow from the plate returns the tracker to state B. As the day slowly progresses, state C is reached shortly, turning on the right phototransistor. The motor turns until state B is reached again, and the cycle continues until the end of the day or until the minimum detectable light level is reached. The problem with a design like this is that phototransistors have a narrow range of sensitivity, once they have been set up in a circuit under set bias conditions [9]. It was because of this fact that solar cells themselves were chosen to be the sensing devices. They provide an excellent mechanism in light intensity detection – because they are sensitive to varying light and provide a near-linear voltage range that can be used to an advantage in determining the present declination or angle to the sun. As a result, a simple RTC based control system is proposed, with the natural positioning of the sun with respect to time has been implemented as an algorithm to control the solar PV by controlling the DC motor.

3. ARCHITECTURE OF THE SYSTEM HARDWARE

The system architecture of the proposed solar tracking control system using LPC2148 is shown in Fig.3.

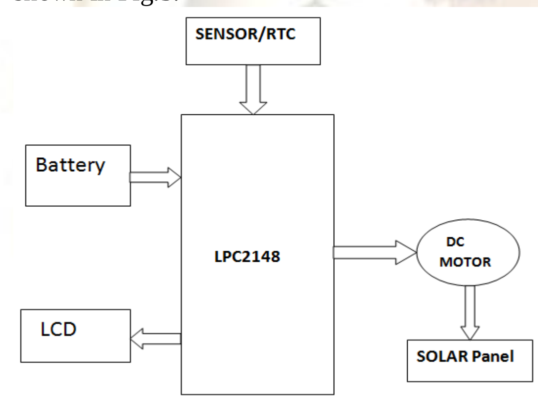

Fig.3: Block diagram of the RTC based solar tracking system.

The positional direction of the sun with respect to time has been measured and implemented as an algorithm in the controller. Then, the controller in the chip delivers an output, the corresponding PWM signals, to drive the stepping motors. Thus, the directions of the single dimensional solar platform can be tuned to achieve optimal energy, respectively. There are two modes in the controller as follows:

3.1 Balancing mode

It is used to set the initial position of the solar platform, we use switches for balancing position. The goal is to set boundary problems around for preventing too large elevating angles, which may make the solar panels crash the mechanism platform, and thus damage the motors and the platform.

3.2 Automatic mode

In this mode the controller will continuously reads the Real Time Clock (RTC) and compares with the tabular values stored, if it matches with those values the corresponding positional values will be send to the PWM generator which will make the motor to operate to rotate solar panel to words sun shine, By tuning the two-dimensional solar platform, the optimal efficiency of generating power will be achieved.

4. PRINCIPLE OF PROPOSED SOLAR TRACKER

The final stage involved coupling the circuitry to the motor and mounting it as single unit. The final product model is seen complete in Fig. 4.

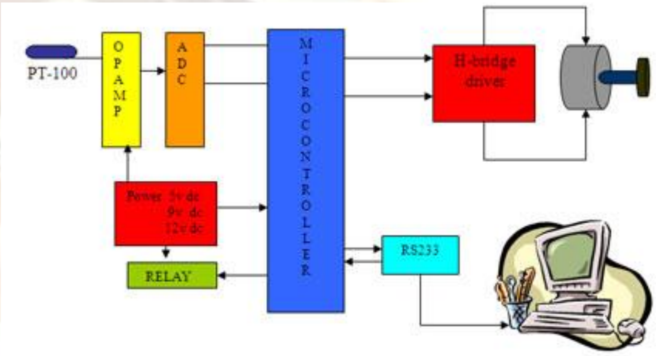

Fig.4: Final Product model of the proposed system

It has LPC2148 development board with built in ADC and RS232 features. A 6V, 300mA solar panel is fixed to the rotor of the DC motor. Communication between controller and Personal Computer (PC) is established through serial communication using RS232 to record the output voltage. The recorded output voltage from the panel is stored in the data base for analyses. The DC motor control input signals are connected to the controller and the output of the panel was connected to a load that would dissipate 9W that would match the panel's rating. 9W at 12V corresponds to a current of 0.75A, so by Ohm's law; a load resistance was calculated as being 16Ω. A 15Ω, 50W resistor was the closest value found and was connected to the panel. The tracking device still requires power, but a 12V battery that is connected in a charging arrangement with the solar panel supplies it. The voltage across and current through the load was monitored using ADC channels of the controller, and was recorded every half hour on a clear day into a data base. The readings were taken on a span of days that possessed similar conditions including no cloud cover.

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5. FLOW CHART

The flowchart is so drawn that it is self-explanatory and gives the complete idea of how computer sequentially does the different operations to measurement and control. The flow chart of motor position control system for solar tracking application is shown in Fig.5.

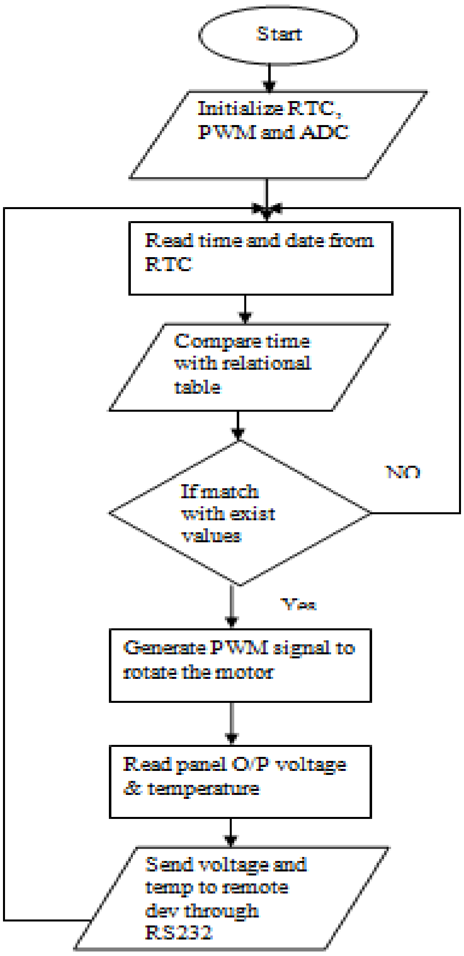

Fig.5: Flow chart of the RTC based solar tracking system

The controller will continuously reads the Real Time Clock (RTC) and compares with the tabular values stored, if it matches with those values the corresponding positional values will be send to the PWM generator which will make the motor to operate to rotate solar panel to words sun shine, By tuning the two-dimensional solar platform, the optimal efficiency of generating power will be achieved.

6. EXPERIMENTAL RESULTS

The hardware implementation of ARM based solar tracking system kit board is shown in below Fig. 6 and the test setup of the designed solar tracking system are shown in Fig. 7.

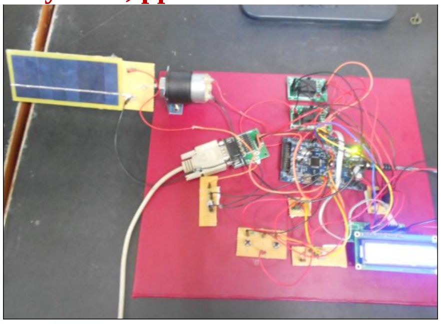

Fig.6: Prototype of proposed solar tracking system

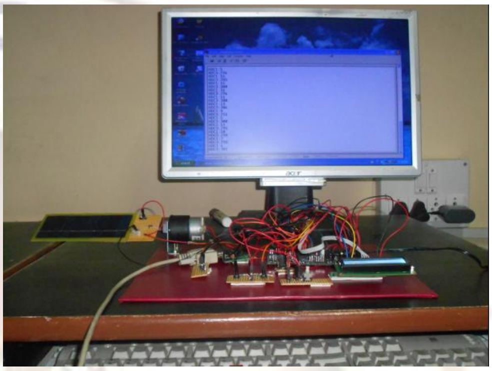

Fig. 7: Experimental setup of the proposed solar tracking system

The panel is connected to the DC motor and is controlled through the microcontroller. The output voltage of the panel will be read through the ADC channel of the controller and the converted digital voltage values are sent to the remote device through the RS232 communication channel, at the receiver side the personal computer will receives the signals sent by the controller and stores the readings in the Data Base. Initially the panel output voltage readings have been measured for a day by fixing the panel in a fixed direction, again tested by making panel rotatable according to the sun tracking using RTC. These values are recorded for six days.

The tracking results are compared with fixed solar system results. From the results, it is observed that the performance of the tracking system is 40% more efficient than a fixed solar system. The solar energy is captured from the sun with fixed system means without tracking can be taken for six days is shown in Table 1 and the energy captured with the tracking system can be taken for six days is shown in Table 2. The performance analyses of the proposed solar tracking system over fixed solar panel for six days are shown from Fig. 8 to Fig. 13.

Table 1: Captured solar energy with a fixed solar panel system.

Time	Captured voltage in Volts					
	On 12/12/2012	On 13/12/2012	On 14/12/2012	On 21/12/2012	On 22/12/2012	On 23/12/2012
6.00 AM	0	0	0	0	0	0
7.00 AM	1	0	1	0	0	0
8.00 AM	1	1	1	1	1	1
9.00 AM	2	2	2	1	2	1
10.00AM	2	2	2	2	2	2
11.00AM	3	3	3	2	2	2
12.00AM	4	3	3	3	3	3
1.00 PM	4	4	4	4	4	3
2.00 PM	3	4	4	3	4	4
3.00 PM	2	3	3	2	3	3
4.00 PM	1	2	2	1	2	2
5.00 PM	0	0	1	0	1	1
6.00 PM	0	0	0	0	0	0

Table 2: Captured solar energy with the proposed solar tracking system.

Time	Captured voltage in Volts					
	On 12/12/2012	On 13/12/2012	On 14/12/2012	On 21/12/2012	On 22/12/2012	On 23/12/2012
6.00 AM	1	0	0	0	0	0
7.00 AM	1	1	1	1	1	1
8.00 AM	2	2	2	1	2	2
9.00 AM	3	2	2	2	2	2
10.00AM	3	3	3	2	3	3
11.00AM	4	3	4	3	3	4
12.00AM	5	4	4	4	4	4
1.00 PM	5	5	5	5	5	5
2.00 PM	4	5	5	4	5	5
3.00 PM	4	3	4	3	4	4
4.00 PM	3	3	3	2	3	3
5.00 PM	2	2	1	1	1	2
6.00 PM	1	0	0	1	0	1

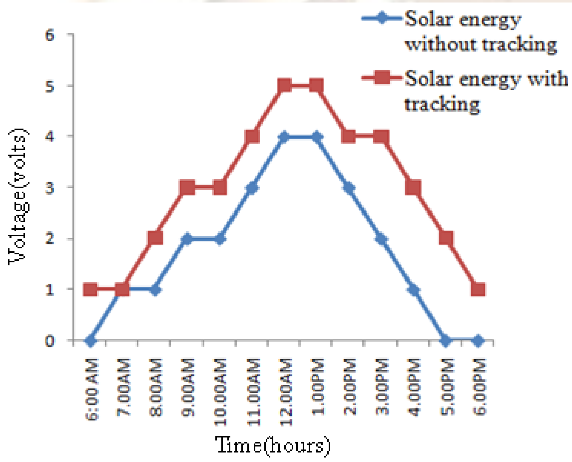

Fig.8: Comparison between fixed and proposed System on 12/12/2012

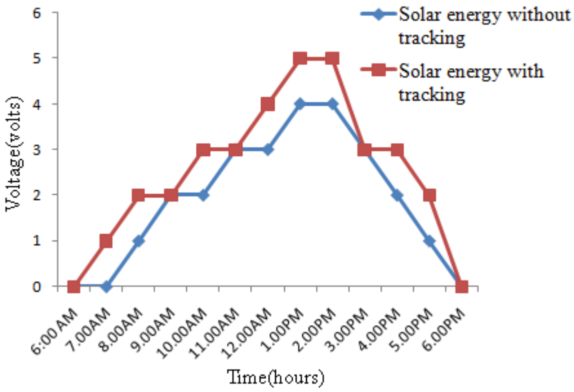

Fig.9: Comparison between fixed and proposed System on 13/12/2012

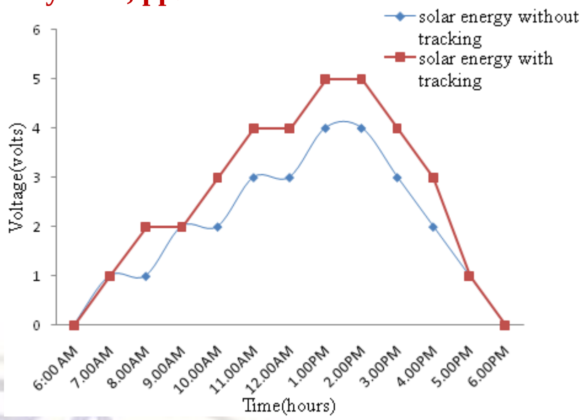

Fig.10: Comparison between fixed and proposed System on 14/12/2012

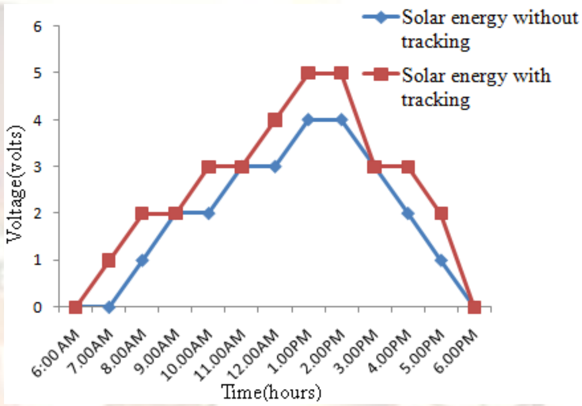

Fig.11: Comparison between fixed and proposed System on 21/12/2012

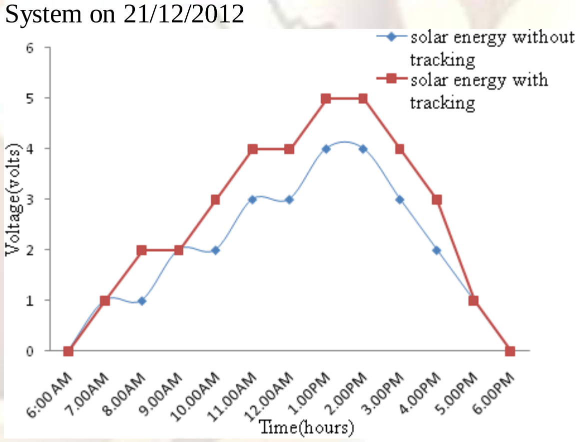

Fig.12: Comparison between fixed and proposed System on 22/12/2012

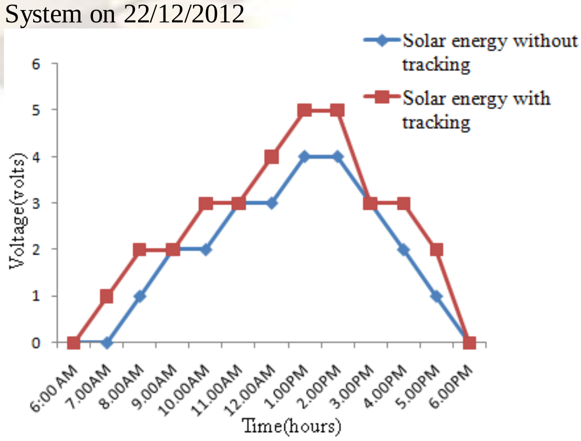

Fig.13: Comparison between fixed and proposed System on 23/12/2012

From the above graphs, it is concluded that the energy received from the Sun can be increased using the proposed solar tracking system during the time interval from 9.00AM to 4.00PM when compared with fixed solar cell system.

7. Conclusion

The design of ARM processor based an efficient solar tracking system with real time clock is developed and described. The proposed system provides a variable indication of their relative angle to the sun by comparing with pre defined measured readings. By using this method, the solar tracker was successfully maintained a solar array at a sufficiently perpendicular angle to the Sun. The power increase gained over a fixed horizontal array was in excess of 40%. The proposed design is achieved with low power consumption, high accuracy and low cost.

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