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GANG OPERATED PV PANELS-TRACKING WITH REFLECTORS

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Abstract— ***As the fossil resources are getting depleted very fast, the need to focus on the non-renewable sources has assumed greater urgency. Photo voltaic solar panel is a convenient method of generating electricity from sunlight. However the main constraint in the fast growth of these installations is the high cost of solar photo voltaic panel along with their low efficiency. Therefore any attempt to improve the effectiveness of the panel will be of great assistance to expand renewable energy applications. The output of the Photo-voltaic panel can be enhanced by providing reflectors to reflect more light on the panel. This also implies continuous tracking of the sun to capture the sunlight effectively.***

This paper gives the details of a practical device that has been developed based on a FPGA controlled clockwork mechanism with feedback to ensure correct positioning in each part of the day. The experimental results show that the plane reflector on either side enhances the output to the extent of 68.5%. An analysis of the costs involved indicates the arrangement to be economical and capable of wider deployment.

Key words: Reflector, Solar energy, collection efficiency

INTRODUCTION

In the recent years, photo voltaic power generation has been receiving considerable attention as one of the promising energy alternatives. The reason for this rising interest lies in the direct conversion of sunlight into electricity. Photo voltaic solar energy conversion is most attractive non-conventional energy sources of proven reliability from the micro to mega watt level. Its advantages are(i)Absence of moving parts (ii) Ability to function unattended for long periods(iii)Modular nature in which desired current, voltage and power level can be obtained by mere integration and (iv)Long effective life and high reliability.

A tropical country like India is particularly blessed with abundance of solar radiation. The wide spread use of PV generation is however mainly hampered by economic factors. Efforts are being made worldwide to reduce the cost per watt through various technological innovations. In the past 30 years, solar photovoltaic cells have increased in efficiency and the price levels have improved dramatically. Today the theoretical efficiency of a solar PV cell can be 25% to 30% and a practical efficiency around the 17% [1]. Any improvement in efficiency of solar energy system will make a big difference in the use of solar panels. Developments are also taking place in finding new photo voltaic cells which can withstand high concentration of light and heat and produce more output per unit area. Small concentrating reflectors of a few centimeters across provide considerable concentration on cells made of special material and a number of such small concentrating units can be assembled to form a bigger panel. The panel as a whole is mounted suitably and tracking

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arrangements are made. Other tracking arrangements have also been developed in the past[2],[4].In this work a simpler system of only one reflector on either side positioned at optimum angle is used which is found to enhance the light collection of conventional panels considerably and can be readily adopted in a wide scale. The elevation angle of sun remains almost invariant in a month and varies very little in a year. Therefore single axis position control scheme may be sufficient in most of the application where economy and ease of maintenance are important.

OUTLINE OF THE PROPOSED SYSTEM

In this work we have used a solar panel of 70watts/12 volt mono crystalline module. Sun tracking is carried out based on a real time clock generated by FPGA. For every one hour from 6 am to 6 pm the panel rotates and aligns in the direction of the sun driven by a 12V permanent magnet DC motor through a worm gear. After 6 pm the panel returns back to its initial position (morning 6 am position). The position of the panel is monitored by a position sensor. The solar panel output is stored in a battery which is also used to run the motor. The panel is provided with two Aluminum sheet reflectors fitted at optimum angle to increase the collection efficiency.

Details of the solar module, the FPGA, system logic by flow chart, control mechanism and the driver circuits are given here. A comparison has been made between stationary panel without reflectors and tracking type with reflectors.

DESIGN OF REFLECTORS

Each reflector is inclined at 60° to the plane of the panel. The width of the reflector is equal to the width of the solar panel and the length matches that of solar panel. The tracking ensures that the plane of the panel is always perpendicular to the sun's rays. This arrangement (Fig.2) enables the light falling at the tip of the reflector to reach the edge of the panel and the all other reflected rays falling within the width of the panel. Thus there is no wastage and the collection efficiency is maximized. Theoretically this should double the light collection .It enables realization of the full potential of the panel.

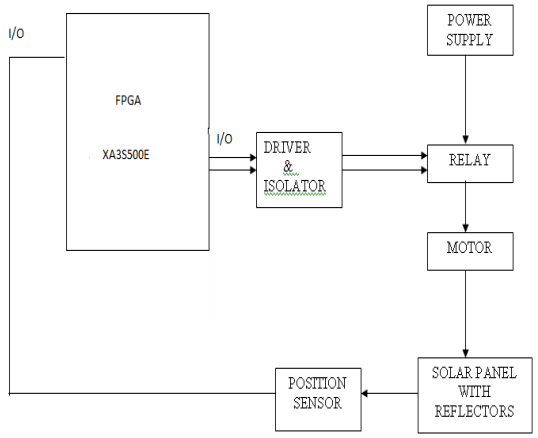

Fig. 1 Block diagram of proposed system

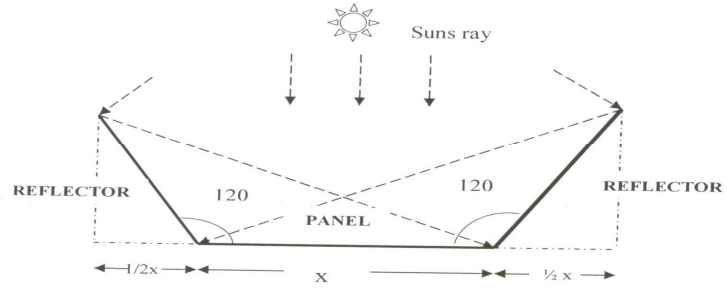

Fig. 2 Panel with reflectors

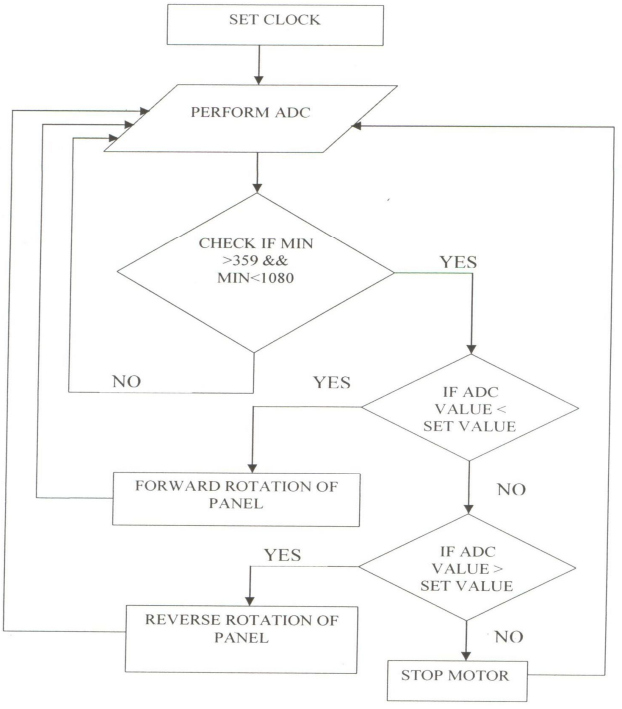

Fig. 3 Flow chart

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Using FPGA, pulses of 1 sec are generated. A portion of the program is used for 7 segment display of time in seconds, minutes and hrs. For operation control, switch case values are assigned for different positions. If time is less than 6 AM or more than 6 PM then case value is zero. If for example time is 12 noon, then case Value is 12-6=6 and case 6 is executed. The position of the panel comes in as analog voltage from the potentiometer and this is converted by A/D conversion in the FPGA[3]. The average of 50 samples of measurement in machine cycles is taken for better accuracy.

If the time is between 6 AM and 7 AM, case value is zero and program enters case zero. Within each case statement a particular range of digital values is set for the position of the sensor, to cater for sensor variations and avoid hunting .In case 1, the range is between 11 and 22. If the ADC[5] value is less than 11, corresponding I/O pin is made high so that motor rotates in the forward direction, otherwise the next I/O pin is made high to rotate in reverse direction to position the panel correctly. In case the position is in correct range then supply does not go to any of the pins as the present position is correct.

As the time advances, the case value changes every hour and corresponding case is executed. Case 11 corresponds to 6 PM. When the time exceeds 6 PM the program enters case zero and the panel is brought back to the 6AM position ready for next day. It remains there till the actual time passes through night and reaches 7 AM in the morning i.e. case 1. The Sun tracking is therefore automatic without human intervention. No separate photo detector is required since the movement of the sun depends always on the time of the day. Any uncertainty in light detection is thus avoided.

MANUAL OPERATION AND INITIAL SETTINGS

The clock time can be manually set by pressing the minute switch or hour switch alone at a time. When both hour and minute switches are pressed simultaneously, the time clock starts running, time is added to the set time and the panel position moves to match the indicated time. The panel can therefore be tested to move to any desired position by setting the time suitably and activating the clock.

The system operates from the same 12V battery which is used to collect power from the panel .The worm and worm gear arrangement ensures that the panel is held and does not move away from the set position when the control execution is complete and power is taken off the motor. Thus no power is consumed in the idle condition of the panel and power is taken from battery only during actual movement. Even this energy consumption is negligible compared to the daily collection.

Time	Power in Watts	
	Fixed Panel	With Reflector and Tracking
8 AM	16.61	51
9 AM	33.22	63
10 AM	41.14	63.42
11 AM	36.3	61.5
12 NOON	37.4	60.4
1 PM	37.4	65.6
2 PM(Cloudy)	33	45
3 PM	33.6	56
4 PM	19.6	30.8

Table. 1 Measurement of power

OUTPUT OF SOLAR PANEL

Open Circuit Voltage = 19.75 V

The measurements were made regarding the output of two solar panels, each under the different conditions viz., one fixed panel without reflector and another with reflector as well as tracking.

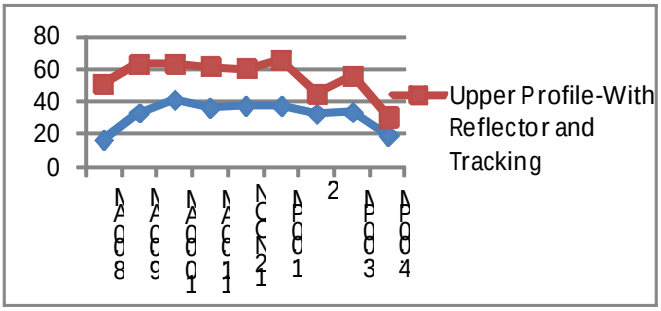

Fig. 4 Profile of power output in Watts of fixed panel Vs panel
with the reflector and tracking.

The area of the graph indicates the energy output during the span of 8 hrs. The energy output with reflector is 456Wh, whereas the energy output of the fixed panel is only 270.5 Wh. This shows the increase in energy collection by 68.57%.In other words, 3 panels with reflector will give the equivalent output of 5 fixed panels. The tracking arrangement requires negligible additional maintenance as the worm gear is compact and totally enclosed except the pair of spur gears. The electronics can be housed in a location box located nearby.

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FPGA

The Xilinx® Automotive (XA) Spartan®-3E family of FPGAs
is specifically designed to meet the needs of high-volume, Cost-sensitive automotive electronics applications.
The XA Spartan-3E family builds on the success of the earlier XA Spartan-3 family by increasing the amount of logic per I/O, significantly reducing the cost per logic cell. New features improve system performance and reduce the cost of configuration. These XA Spartan-3E FPGA enhancements, combined with advanced 90 nm process technology, deliver more functionality and bandwidth per dollar than was previously possible, setting new standards in the programmable logic industry.

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- DDR SDRAM support up to 266 Mb/s
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ECONOMICS OF THE SYSTEM

By using reflectors combined with tracking, the collection efficiency of the solar panel increases substantially. Even if we include the cost of tracking arrangement, there is still

considerable overall saving as brought out in the calculations below. The cost of electrical energy per unit will come down and the subsidy also can be reduced leading to wider deployment for the same funds.

COST OF PANEL WITH REFLECTORS AND TRACKING

Cost of 3 Solar panels Rs14000 each) = Rs. 42000

Cost of PM DC Motor with worm gear = Rs. 3500

(With inbuilt worm gear to reduce Speed from 2000rpm to 35

rpm)

Cost for Stand, Shaft and spur Gear (10:1) = Rs. 4500

Cost of Circuit and Driver Arrangement = Rs. 2000

TOTAL = Rs 52000

The above calculation is for installing 3 panels and this arrangement gives the power of 5 panels Installed without reflectors and tracking arrangement (based on 68.57% increase in output)

COST OF FIXED PANELS

Cost of 5 panels =Rs.70000

Cost of stand =Rs. 3500

TOTAL =Rs.73500

Saving in Investment =Rs(73500-52000)=Rs.21500

An investment of Rs 52000 gives the benefit of additional equivalent Investment of Rs.21500.

If more panels are connected together then the saving in capital will be higher because much of the drive arrangement can be made common for a group of panels.

CONCLUSION

In this work the collection of the solar panel was enhanced by 68.5% from that of the single panel with the help of reflectors and tracking. The working model of the solar tracking system with reflectors was successfully implemented and demonstrated. It is shown to be highly attractive economically.

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There is a strong case for providing new solar panel installations with reflectors and tracking arrangement in view of the above advantage.

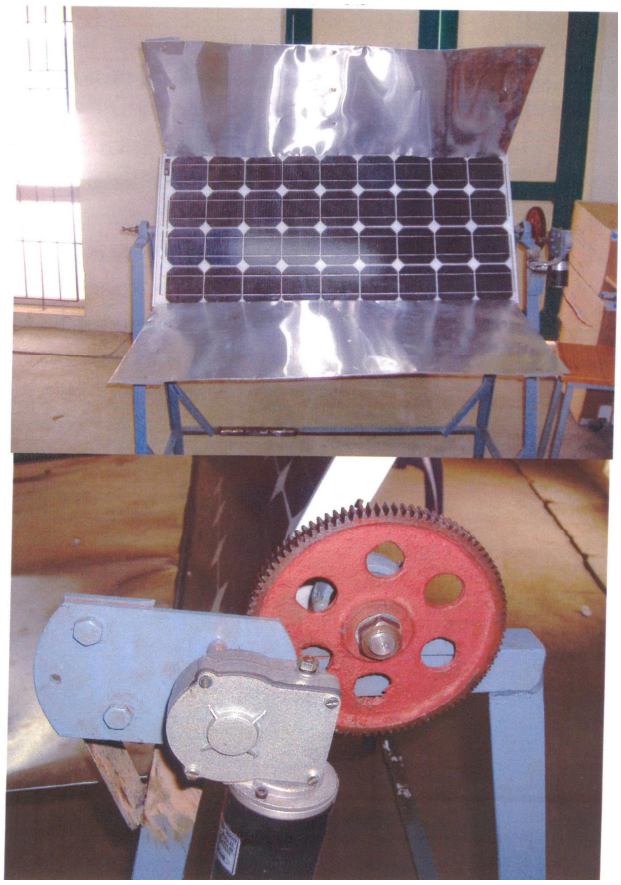

Fig. 5 Hardware

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