FRESNEL LENS AND TRACKING TO IMPROVE THE SOLAR PANEL EFFICIENCY

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ABSTRACT

Solar panel efficiency depends upon the intensity of sunlight and the angle of incidence of the solar rays on cells. As the earth rotate it become impossible to maintain the panel exactly facing the sun. It is the basic reason of reduced efficiency of solar panel. So to get maximum efficiency of solar panel it is require that the panel should always face the sun here microcontroller based solar tracking and control system is presented. This system not only keeps the peak power positioning of photovoltaic array by tracking but also uses a mechanical concentrator to increase efficiency. The mechanical concentrator presented in this system is Fresnel Lens. To keep track of increased efficiency here conventional stationary solar panel is also presented so that the difference in outputs can be clearly judged. For the Data analysis here an attempt is made to show graphical as well as tabular form display on Computer.

1. INTRODUCTION

The definition of this experiment is the design of a Sun-Tracking Solar Cell Array System with ability to increase efficiency with Fresnel Lens. The concise definition of the system is a microcontroller-controlled array that actively tracks the sun’s movement, such that maximum power is received at the array at all times. This is achieved by using light sensitive sensors to determine the position of the sun, and then using motors, controlled by a microcontroller, to align the array such that all incident rays strike normal to the array’s surface.

Solar concentrating collectors are being used in increasing numbers for various thermal and photovoltaic (PV) applications. These collectors usually require two-axis tracking of the sun to maintain the concentrated light focused on the receiver. The experiment described here examines a method of sun-tracking that uses the complete PV collector array as a sun sensor. This tracking and control system differs from the sun-tracking methods commonly used. One method of precision tracking requires lengthy calculations of the sun’s elevation and azimuth angles. [2]
Error information is obtained by comparing calculated values with high resolution measurements of the angular position of the array structure. Subsequent drive motor control minimizes tracking error (the difference between the calculated position and the measured position of the array).

A more common method of sun tracking employs a shadow-band device with sensors in four quadrants. [3] The sensors are used in up-down (elevation) and east-west (azimuth) pairs. Sun tracking error is minimal when the pairs are equally illuminated by the sun. Differential output voltages of the elevation or azimuth sensor pairs are used as feedback to the motor drive circuitry. The tracking and control system is capable of controlling the drive motors for tracking the sun and adjusting the load on the PV array to maintain peak power output. It also has other feature i.e. use of Fresnel Lens that increase the efficiency of the system in addition to the utility of the design.

2. SYSTEM DEVELOPMENT

The system is mainly divided into various parts as given below:

- Transmitter and Control Unit
- Receiver Unit
- Efficiency Improvement Unit (SUN TRACKING ASSEMBLY)
- Data Logging Unit

2.1 Transmitter and Control Unit
2.1.1 Ambient Light Reference LDR Sensor

Our sun tracking logic works by taking real-time feedback of sun position and then moving the mechanical assembly in such a way that the solar panel is facing sun and delivering maximum power. For getting the position of sun we are using five sensor assembly. Out of these five sensors, four are actual tracking sensors whereas one is reference sensor. We compare the output of all four sensors with reference sensor and the output of comparators is fed to microcontroller. As sun moves from east to west the overall intensity of light coming from sun is not constant because there may be cloudy weather. So the reference for comparators can’t be fixed and it must change real-time according to the ambient atmospheric conditions. Due to this we need a reference sensor whose output varies according to real-time light conditions and we use this for comparison.

2.1.2 East Tracking LDR Sensor:

It gives feedback of whether the panel is moving too much to the east side.

2.1.3 West Tracking LDR Sensor:

It gives feedback of whether the panel is moving too much to the west side.

2.1.4 North Tracking LDR Sensor:

It gives feedback of whether the panel is moving too much to the north side.

2.1.5 South Tracking LDR Sensor:

It gives feedback of whether the panel is moving too much to the south side.

2.1.6 Stationary Solar Panel

To demonstrate the increase in efficiency of solar panel due to tracking and concentrator we are using one solar panel without any sun tracking. It will be placed standstill at 30 degree facing north direction. We choose this position because majority of solar panels in INDIA which are used in a stationary position are kept in this position only.

2.1.7 Solar Panel with Tracking

One panel will be placed on a mechanical assembly having sun-tracker.

2.1.8 Charger

Batteries need to be charged properly taking care of maximum charging current and voltage so that we get maximum battery life. This block contains a constant voltage charging method with overcharge protection. When battery is completely discharged then it will draw heavy current so the charger must also take care of the heavy inrush current at the beginning of charging process. All these functions are done by this block.
2.1.9 Battery

We are using SMF (sealed maintenance free) battery. Typical life of these batteries is around 3 years if used and charged properly. Deep discharging the battery means if the terminal voltage of battery goes below 10V, then the life of battery is shortened. To avoid deep discharge a low battery cut-off circuit is very essential part of any battery operated system.

2.1.10 12V to 180V Converter

We need to develop 230V AC to operate household appliances for this firstly we make 180V DC from 12V battery. This block consists of a dc to dc converter. 12V DC is fed to a PWM controller whose output goes to control gates of high power MOSFETs IRF840. The MOSFETs IRF840 drives a ferrite core transformer. The output of this ferrite core transformer is fed to a high frequency rectifier to get a high voltage DC output.

2.1.11 Inverter

The high voltage dc is fed to a h-bridge inverter in which four MOSFETs IRF840 switch alternately in pair of two in order to convert the DC power into AC. The h-bridge switching is critical and two MOSFETs IRF840 of same branch must not be ON simultaneously otherwise it damage the bridge. The h-bridge needs a dedicated controller for flawless reliable operation.

2.1.12 Multi-Channel ADC

This is a 12-bit, 8-channel ADC which is used for converting the analog outputs of signal conditioning circuit into digital format so that microcontroller can read them and send it to PC.

2.1.13 Microcontroller

This is the heart for complete system. The total logic of the system resides in this. All inputs are processed in real-time and data is transmitted to the PC.

2.1.14 LCD

It shows the status of the system. The different data displayed on it are solar panel voltages with tracking and without tracking, battery voltage.

2.1.15 East West Motor Driver

The microcontroller after analyzing the sensor outputs of east–west direction decides the direction in which the solar panel must be moved so that panel face is exactly perpendicular to the sun rays. For doing this it needs to move the motors in clockwise or anti-clockwise direction. The function of this block is to accept I/O signal from microcontroller and accordingly drive the motors so that panel moves in east-west direction.
2.1.16 North-South Motor Driver

The microcontroller after analyzing the sensor outputs of north-south direction decides the direction in which the solar panel must be moved so that panel face is exactly perpendicular to the sun rays. For doing this it needs to move the motors in clockwise or anti-clockwise direction. The function of this block is to accept I/O signal from microcontroller and accordingly drive the motors so that panel moves in north-south direction.

2.1.17 East and West Limit Switches

The motors are moved by microcontroller, until the panel face is exactly perpendicular to the sun rays, but this is possible only during day-time. When sun is gone (sunset) then at that time microcontroller will try to move panel even further but there must be some limit of physical movement. This limit of physical movement in east-west direction is given by these limit switches.

2.1.18 North and South Limit Switches

The limit of physical movement in North-South direction is given by these limit switches.

2.1.19 East and West Motors

Two stepper motors are used to control the two axis tracking.

2.1.20 Power Supply for other Circuits

The microcontroller and its peripheral chips such as ADC, signal conditioning etc. requires 5V. So the function of this block is to generate appropriate voltages for proper operation of all components in the system from 12V source of battery.

2.2 Receiver Section:

The receivers function is to receive the data from distant RF transmitter, filter out unwanted spurious data and send to PC only valid data. This function of filtering spurious data is implemented using a microcontroller which runs a smart algorithm to extract valid data strings. The extracted valid data is sent to PC over the serial port.

Figure 2 Block Diagram of Receiver Section
2.3 Efficiency Improvement of Solar System

The efficiency improvement unit of this solar system is nothing but use of Fresnel Lens. It gives better output from the solar system than the conventional Solar Panel.

2.4 Data Logging Unit

PC is used as a data logging unit. VB based GUI and Data Collection system is incorporated in the system.

DISCUSSION AND RESULTS

The design and development of Solar Tracking and Efficiency improvement of Solar Panel System has been presented. The system combines into one unit two specific functions ordinarily found in separate equipment making possible a good comparison method of sun-tracking with concentration and stationary solar panel.

The economics of tracking systems for solar concentrators depend directly on the precision demanded in following the solar panel. The required precision is determined by the concentrator's performance sensitivity to tracking errors and by the concentration requirements of a particular application.

The Presented Solar Tracking and Efficiency improvement of Solar Panel System will be really affluent and the overall power collection efficiency which is about 30% in the solar systems without tracker will definitely increased due to two axis tracking. Also as we are going to implement the system with suitable and or available concentrator it will also enhance the efficiency of the solar panel and the system will result net increase in power output.

It has been proved from the previous experiments by using such a concentrator like fresnel lens or simply a convex lens the efficiency of the solar panel gets on increasing. Also the solar system with parabolic concentrator brings a great improvement in the efficiency of the system.

The Presented system also includes the DC to AC conversion with the help of low cost inverter. Hence one can use such a system for his/her domestic purpose.

The system also consists of the data communication from transmitter to receiver and at the receiving end the data will be observed on various tabular as well as graphical form and this data can be stored in log form This thing brings the researcher of interest a tool to research on the data obtained also it will inspire the researchers for the further developments on the sun tracking system.

The results of this experiment show that sun tracking by this method gives potentially high-performance results. It is a method which virtually assures peak efficiency from the array with little regard for structural deformations, dust, dirt, etc. and misalignment problems: When coupled with an adjustable load on the array, a peak power positioning sun tracker constitutes a major component in a photovoltaic concentrator array power system.

Here I have presented the results of comparison of Solar Panel with tracking and concentrator and Stationary solar panel. These readings are taken on 13th February 2012.
References


