Solar Power Generation along with the Efficiency Improvement of Solar Panels, Automatic Solar Tracking and Remote Monitoring

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Abstract

This paper proposes the combination of different efficiency improvement techniques which enhance the output in multi directions. Experiments were performed to work out for such possible approaches that is MPPT(maximum power point tracking) , solar tracking (dual axis) and use of convex lens on solar panel. The effectiveness of the proposed method is that it increased the output of up to 17.4% . Along with that remote monitoring system also have been inducted that is GSM based to monitor and control the different features of the system remotely. As experiment is performed on the following two features to control them remotely. First is Battery status check (low, medium and high) and second is switching on/off the working load. Therefore this proposed scheme of combining different techniques on a single system will overall maximize the system output and make it more suitable to work in different environments efficiently.

I. Introduction

Sun is a major source of energy. The earth obtains 174 pentawatt (PW) of the incoming solar energy at the upper atmosphere. Approximately one third (Approx. 30%) of it is reflected back to the space while the rest is absorbed by the clouds, oceans and land masses [7]. A portion of it is utilized for the photosynthesis process which is critical for the provisions of life on Earth. Man has tried to utilize this infinite source of energy in the best possible way and has been able to harness only a negligible or a minute fraction of this energy till today[8].

The broad categories of the large scale applications of the solar energy include the heating and cooling of residential / commercial buildings, in agriculture & horticulture and solar power generation etc.

A solar cell is a photovoltaic device which converts the light energy into the electrical energy. When the sunlight falls on the material surface, the electrons present in the valence bands of the metallic atom absorb energy and hence become excited. These excited electrons jump to the conduction band and become free. When these free electrons are attracted towards the positive electrode, the current flows and hence the light energy gets converted to the electrical energy[6].

Experiments were performed in five separate parts. In first part without applying any technique of power increasing simple operation is performed . In the second part solar tracking scheme was implemented to maximize the solar panel output by tracking the sun movement. In the third part the effect on the power conversion efficiency of solar panel by experimenting it with convex lens was studied. In the fourth part MPPT solar charge controller was designed whereas in the fifth part GSM based Monitoring system was designed to control certain features of this solar system remotely.

II. Simple Measurement without Applying any Power Output Increasing Technique

The Electrical Characteristics of the panel that is used as follows:

- Maximum Power = 100W
- V_o (Nominal) = 12V
- Voltage at P_{max} = 17.5V
- Current at P_{max} = 5.71A
- Current Short Circuit (I_{sc}) = 6.17A
- Voltage Open Circuit (V_{oc}) = 21.6V
- Power Tolerance = ± 3%
- STC Irradiance = 1000V/m^2
- Maximum System Voltage = 1000V

III .Solar Tracking System

A solar tracker is used for orienting day light on photovoltaic array. The position and movement of sun varies seasons and the time of day a s the sun movies across the sky [3]. Solar powered equipment works at their best when pointed towards the sun. So, a tracker can increase the effectiveness of such equipment over any position. Tracker can be implemented in various ways depending upon the feasibility and sensitivity of the components used.

The tracking scheme implemented was a simple one using the LDR sensors, voltage comparators and H-Bridge to run the dc motor. LDRs were oriented on the panel as shown in figure 1.

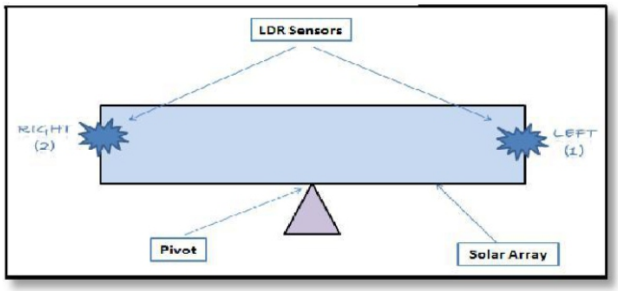


Figure 1

The sun tracking algorithm show n in figure 2

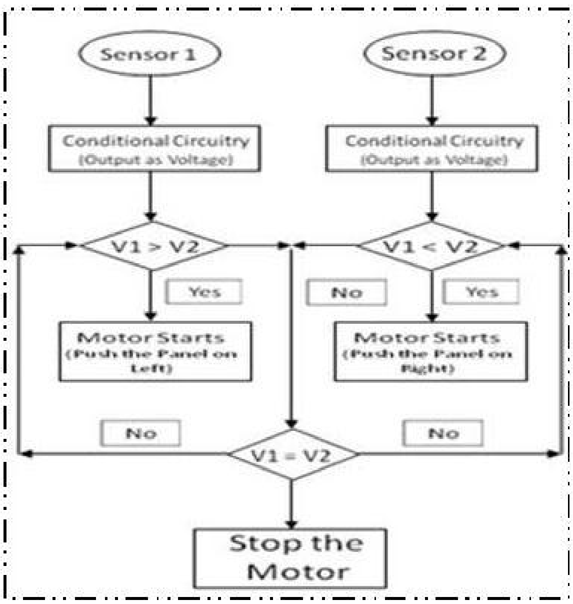


Figure 2

After tracking the movement of sun during the whole day, the panel will be facing the westward direction. i.e. the sunset direction. On the next day sun will have to rise from the eastward direction. So there must be some sort of logic system which will play its role in reverting the position of the panel back to the eastward direction in order to initiate the tracking cycle on the next day. A simple relay logic circuit was implemented to perform this resetting task automatically when the sun is about to set in the evening [3,4].

This designed tracking system was tested thoroughly and carefully and the behavior of system is summarized in table 2.

Status of LDRs	Status of Motor
LDR 1 is Illuminated more Than LDR 2	Motor is Running Anticlockwise
LDR 2 is Illuminated more than LDR 1	Motor is Running Clockwise
Both LDRs illuminated to Same Light	Motor is Stopped
Both LDRs are exposed to Darkness	Motor is Stopped

Table 1

The Reset system worked in a way that in the evening when the sun sets, the tracker will be in a position that it will activate the limit switch which will perform the reverting process.

The behavior of reset system is summarized in table 2.

Status of Limit Switches	Status of Motor
If Motor is Running Clockwise	
Limit Switch RESET is Pressed and Released	Motor is Continuously Running in the Clockwise Direction (In this situation Motor will not follow the outputs of LDRs)
Limit Switch SET is Pressed and Released	The Motor will start following the outputs of LDRs
If Motor is Running Anticlockwise	
Limit Switch RESET is Pressed and Released	Motor Changes its Direction and Runs in the Clockwise Direction (In this Situation Motor will not follow the outputs of LDRs)
Limit Switch SET is Pressed and Released	The Motor will start following the output of LDRs

Table 2

Result by using the solar tracking system

Month	Average power per day
January	333.47 wh
February	374.60 wh
March	366.20 wh
April	353.60 wh
May	315.20wh
June	281 wh
July	264 wh
August	269.8 wh
September	314.8 wh
October	313.4 wh
November	338 wh
December	341.12 wh

Table 3

MPPT or Maximum Power Point Tracking is an algorithm that is included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called 'maximum power point' . which varies with solar radiation, ambient temperature and solar cell temperature [3].

The major principle of MPPT is to harness maximum power from PV module by operating them at the most efficient voltage (maximum power point). MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery [2].

The Perturb & Observe (P&O) is the most common approach adopted today because of its ease in implementation. It works sporadically by incrementing and decrementing the voltage of Photovoltaic Array [2,3]. The change in the Power drawn can then be observed. If the voltage shifts of PV array results in increase in the output Power then it continues to shift in the same direction. On the other hand, if the power decreases, the voltage shifting is in the opposite direction. This algorithm is shown in figure 3.

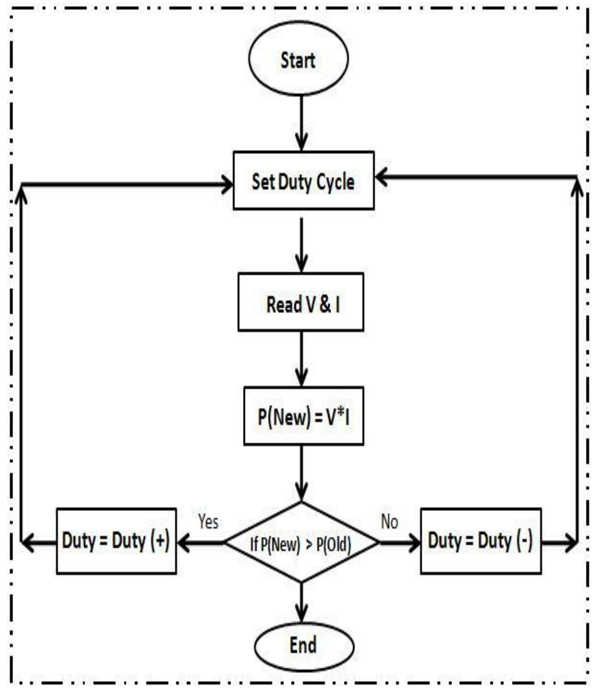
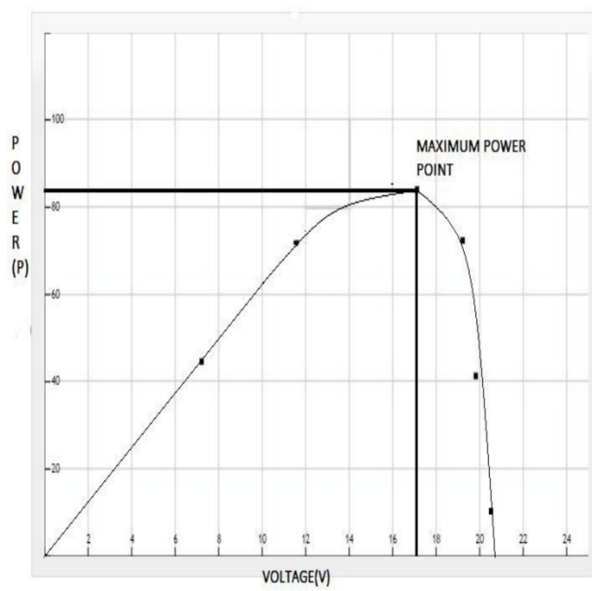


Figure 3

The solar panel used in this experimentation has the following specifications.



P-V CHARACTERSTICS OF SOLAR PANEL

Figure 4

Results by using the MPPT(maximum power point tracking).

Month	Average power per day
January	346.25 wh
February	390.76 wh
March	381.19 wh
April	368.23 wh
May	330.13 wh
June	294.2 wh
July	279.2 wh
August	284.7 wh
September	330.3 wh
October	327.4 wh
November	350.2 wh
December	355.30 wh

Table 4

It is clear from the above curve that there exists a point where there is maximum power. This point needs to be tracked in order to harness the maximum power from solar panels operating in any system.

V. Using Convex Lens with Solar Arry

The Convex Lens works on the principle of physics by converging the light rays falling on it at a point "F" which is a distance (Focal Length) from a point "O" on the radius of curvature of the lens. From the scientific inference, it is concluded that when a convex lens with more surface area than that of proposed photovoltaic array is placed at some distance over this array, it converges the falling light rays on the solar panel [5] thus by increasing the working power conversion efficiency of these solar arrays

- Jan = 4.81 kWh/m^2/Day
- Feb = 5.19 kWh/m^2/Day
- Mar = 5.05 kWh/m^2/Day
- Apr = 4.84 kWh/m^2/Day
- May = 4.34 kWh/m^2/Day
- Jun = 3.98 kWh/m^2/Day
- Jul = 3.54 kWh/m^2/Day
- Aug = 3.63 kWh/m^2/Day
- Sep = 4.46 kWh/m^2/Day
- Oct = 4.49 kWh/m^2/Day
- Nov = 4.72 kWh/m^2/Day
- Dec = 4.68 kWh/m^2/Day

So, the experiments were performed and the Power is calculated while using and without using the convex lens with our panel and the collected results are as follows:

A. *Power calculated without convex lens.*

The average power per day was calculated as mentioned below

Month	Average power per day
January	320.65 wh
February	360.25 wh
March	352.12 wh
April	340 wh
May	303.2 wh
June	270.2 wh
July	253.2 wh
August	259.40 wh
September	302.7 wh
October	301.7 wh
November	325 wh
December	328 wh

Table 5

B. *Power calculated with convex lens.*

The average power per day calculated with convex lens is as follows:

Month	Average power per day
January	336.68 wh
February	378.66 wh
March	369.72 wh
April	357 wh
May	318.35 wh
June	283.75 wh
July	265.85 wh
August	272.85 wh
September	317.8 wh
October	316.125 wh
November	341.25 wh
December	344.63 wh

Table 6

VI. Comparison Between Applied Techniques and their Effect on Output.

The comparison graph between simple, automatic solar tracking, MPPT(maximum power point tracking) ,convex lens and the combination of all these are presented below in a graph.

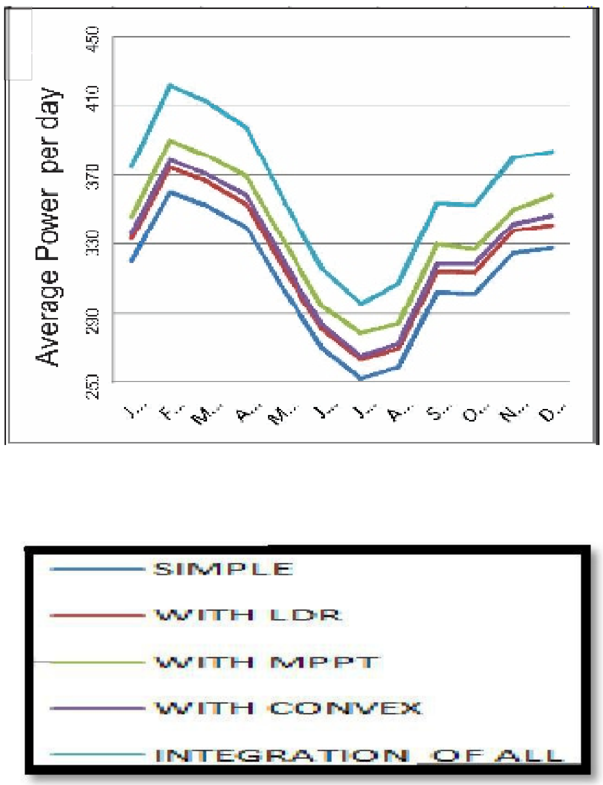


Figure 5

TECNIQUE	AST (B)	MPPT (C)	CONVEX (D)
AVERAGE POWER PER MONTH	291.5 Wh	302.7 Wh	294.3 Wh
OVERALL INCREASE IN OUTPUT	4.05+8.06 +5.03=17.4%		SIMPLE (A) 280.1 Wh
COMPARISON	MPPT > CONVEX > AST		

From the data we acquired that through different techniques we can increase the output of the pannel overall increase is about 17.4%.

VII . GSM Based Remote Monitoring System

The GSM based remote monitoring system was aimed to control certain features of the solar system remotely. These features can be more complex but as initial work, we selected the two features . The first is to check the status of the battery working in the system whether low, medium or high and second is to switch on or switch off the load workin on this system [4] Following tables summarize the implemented system and the collected results while testing

S.No.	Text Message Sent to GSM	Reply Received on Mobile
When Battery is Full		
1.	BATSTATUS?	System Battery Normal
When Battery is Medium		
2.	BATSTATUS?	System Battery is Medium
When Battery is Low		
3.	BATSTATUS	System Battery is Low
Switching On / Off Relays		
4.	S1ON	Switch 1 is Turned On
5.	S1OFF	Switch 1 is Turned Off
6.	S2ON	Switch 2 is Turned On
7.	S2OFF	Switch 2 is Turned Off
8.	S3ON	Switch 3 is Turned On
9.	S3OFF	Switch 3 is Turned Off

Table 8

In case of switching, the switching of relay was also observed through its switching sound practically.

VIII. Conclusion

This paper presented the basic concept of integrating different output enhancement techniques along with a new technique namely (distributed convex lens) method .Previously a single convex lens is used but in this experiment a piece wise distribution lenses are used smaller in size fixed on plastic transparent sheet which is mounted on the panel. Experiments has been carried out which shows that amalgamation of these techniques will increase the output in all weather conditions

Along with that GSM technique is applied to check the status of the system through cell phone (battery level and switching) which help the user to operate the system remotely. Therefore this proposed integrating and monitoring technique is very favorable to increase the output of panel rather than the use of individual techniques.

References

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QUOTATIONS

- The secret of getting ahead is getting started.

  Mark Twain

- What you do today can improve all your tomorrow.

  Ralph Marston

- It's always too early to quit.

  Norman Vincent Peale

- Things do not happen. Things are made to happen.

  John F. Kennedy

- Act as if what you do makes a difference. It does.

  William James

- The most effective way to do it, is to do it.

  Amelia Earhart

- Well done is better than well said.

  Benjamin Franklin

- The people who influence you are the people who believe in you.

  Henry Drummond

- To be a good loser is to learn how to win.

  Carl Sandburg

- Don't fight the problem, decide it.

  George C. Marshall

- If you want to conquer fear, don't sit home and think about it. Go out and get busy.

  Dale Carnegie

- Pursue one great decisive aim with force and determination.

  Carl von Clausewitz