

An Efficient Maximum Power Point Tracker for Solar System Using ARM

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ABSTRACT: It is very important in solar power systems to use the technic of Maximum Power Point Tracking (MPPT) because it does not need the large no. of solar panels to obtain the required output solar energy that means it reduces the cost by using less no. of solar panels. Several different MPPT methods have been proposed, but there has been no comprehensive comparison in between the results obtained by that methods of MPPT algorithms, depending on efficiency and intensity under environmental conditions. This task is performed with the help of Maximum Power Point Tracker (MPPT): it has a function to maximize the power output of a PV system for environmental conditions of radiation and temperature, thus enhancing the efficiency.

Results are obtained using a "ARM"11 microcontroller on Raspberry pi. The main aim will be to track the maximum power point of the photovoltaic module so that the maximum possible power can be extracted from the photovoltaic. The algorithms utilized for MPPT are generalized algorithms and are easy to model or use as a code. To achieve the Voltage characteristics with respect to time of solar panel and battery as well as when battery will be start charging then after every 2 min. send message on mobile. Also showing the battery charging status still to the charging of Battery is in process. In the present system, starting from the set of whole system of a PV module, an innovative procedure to identify and reach the MPP is presented and experimentally verified.

KEYWORDS: Photovoltaic (PV) cells, Circuit modelling, solar energy, Analysis.

I. INTRODUCTION

The energy obtained from Solar power is a renewable source of energy, which has become progressively more popular in recent times. It has clear advantages over non-renewable energy sources, such as coal, oil and nuclear energy. It is non-polluting, consistent and can produce energy anywhere that the area where the sun rays are following down, so its resources are not going to come to an end anytime soon. It even has benefits over other renewable energy sources, such that wind and water power. Solar power is generated using solar panels, which do not require any major mechanical parts, such as wind turbines required for wind energy. These mechanical parts can break and cause repairs issues and can also be quite noisy. Both of these issues are almost non-existent with solar panels. Also, the solar cells, that connected together to make up the solar panel system, can last up to several periods without replacement.

However, there is a weakness to solar power – energy can only be produce when the sun is shining and sunrays are following down on the solar plate. To overcome this, usually solar panels are attached with back up rechargeable batteries, which can store additional power generated during the day and use it to provide energy to systems when there is no sun rays. This technique of solar power can be used to power houses and other large ruler systems. In these systems DC-AC renovation is needed. This is because the solar panel creates an output that is DC (Direct Current) and the power supply in homes typically runs off AC (Alternating Current), so conversion is essential. For this project, however, the load to be attached only requires DC input, so DC-AC conversion is not needed. Instead, DC-DC

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

conversion would be used to provide the accurate power to the system from the power generated by the solar panel. Using this information, a number of design solutions were resolute and considered.

The behaviour of a PV module is defined by a family of voltage characteristic with respect to time. MPP is the point on the curve where the PV module runs with maximum efficiency and produces the maximum power output: every curve has a single MPP. One significant problem in PV systems is the probable mismatch between the operating characteristics of the load and the PV array. Plot the typical curve for a PV panel and Charged Battery, with the X-axis representing time and the Y-axis representing voltage. It can be calculated using a model of the PV array and measurements of irradiance and array temperature, but creation of such measurements is regularly too expensive for this application, and often the essential parameters for the PV array model are not known sufficiently. Thus, the MPPT must constantly search for the MPP. Several MPPT search algorithms have been proposed that make use of different characteristics of solar panels and the location of the MPP. Unfortunately, it is difficult to compare the efficiency of these methods because no inclusive experimental comparison has been performed. Several papers have been written equating different algorithms to the perturb and observe algorithm "P&O" but they have either been experimental judgments between one algorithm and P&O, or they have been simulations using an un optimized form of P&O. This problem is solved by using Incremental Conductance (IC) algorithm, but in the present paper, the present most popular algorithm Voltage Based Peak Power Tracking is used. Which has the main advantages that it Covers wide range of angle, having a Reliable algorithm, Simplicity and Less time consuming.

II. RELATED WORK(LITERATURE REVIEW)

In literature there are several MPPT techniques, algorithms and modules are used on solar panel. Quan Li and Peter Wolfs has stated that Among three different MIC arrangements, the MIC with a line frequency dc-ac converter currently appears to be the best topology and the frequency-changer-based MIC topologies will form a clear guideline and a useful establishment for future MIC development considerations [2]. LoredanaCristaldi has find out the solution that the task is performed by the tracker of the Maximum Power Point (MPPT): it increases the power output of a PV system for assigned conditions of radiation and temperature, thus improving the efficiency. The core of the MPPT is represented by the implemented algorithm dedicated to find and maintain the operation near to the Maximum Power Point (MPP). The proposed model can be employed to predict the maximum power generated by PV panel for a given value of temperature and radiation [3]. LoredanaCristaldi has stated that the efficiency of the photovoltaic technology is quite low, and this reduces its competitiveness with respect to the traditional energy sources thus highlighting the problem of the efficiency of the whole system. A flexible model of PV module suitable for off-line and on-line simulation will be obtainable and discussed [4]. Patrick L. Chapmanhas stated in his paper that in partial shading conditions, in some cases it is possible to have several local maxima, but overall there is still only one true MPP. Most techniques respond to changes in both irradiance and temperature, but some are exactly more useful if temperature is approximately constant. In con-text, the array based technique will typically be connected to a power converter that can vary the current coming from the PV array [5]. Nicola Femia have present in his paper that there is a key idea underlying the proposed optimization ap-proach present in the customization of the P&O MPPT parameters to the dynamic behavior of the whole system composed by the exact converter and PV array adopted. Results obtained by means of such approach clearly show that, in the design of effective MPPT regulators, the easiness and flexibility of P&O MPPT control technique can be exploited by optimizing it according to the specific system [7]. Marco Faifer has presented a simple model, suitable for verifying the effects of a PV plant on the power network. The model permits to perform plant simulations during the design phase being easily includable into the model of the whole plant. The electrical parameters of the model can be completely defined by means of a procedure that has been described [14]. BehzadAsaei has presented an effective new approach for estimat-ing the operating temperature of a photovoltaic (PV) module by using the simple diode model. In the model, effects of the temperature coefficients are considered.However, a new system to find all parameters of a PV module model is described. Comparing the model response with the experimental V-I curves at different irradiances and temperatures, the effectiveness accuracy of the proposed parameters' construct procedure is demonstrated for a CS6P-230P solar module [19]. Scrofani has presents two mathematical models: electrical and thermal. They have been coupled to determine the module temperature based on

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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the field examined real data: ambient temperature, wind speed, wind direction, relative humidity and electrical operating point (voltage and current values) [27].

III. OVERVIEW OF MPPT

MPPT Logic:

Maximum power point tracking (MPPT) is a method that charge controllers use for wind turbines and photovoltaic (PV) solar systems to exploit power output. PV solar systems exist in several different configurations. The most basic type sends power from collector panels directly to the DC-AC inverter and from there directly to the electrical grid. A second form, called a hybrid inverter might split the power at the inverter, where a percentage of the power drives to the grid and the remainder drives to a battery bank. The third version is not connected at all to the grid but employs a devoted PV inverter that features the MPPT. In this configuration, power flows directly to a battery bank. A variation on these arrangements is that instead of only one single inverter, micro inverters are deployed, one for each PV panel. This purportedly increases PV solar efficiency by up to 20%.

This article about the application of MPPT apprehensions itself only with PV solar. Solar cells have a complex relationship between temperature and total resistance that creates a non-linear output efficiency which can be analyzed based on the I-V curve. It is the determination of the MPPT system to taste the output of the PV cells and apply the proper resistance (load) to get maximum power for any given ecological conditions. MPPT devices are typically integrated into an electric power convertersystem that delivers voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

1. Solar inverters exchange the DC power to AC power and may incorporate MPPT: such inverters taste the output power (I-V curve) from the solar modules and given to the proper resistance (load) so as to obtain maximum power.
2. MPP(Maximum power point) is the creation of the MPP voltage(V_{mpp}) and MPP current(I_{mpp}).

Algorithms to track the Maximum Power Point

Different algorithms help to track the peak power point of the solar PV module mechanically.

In the perturb and observe algorithm a slight perturbation is present system. Due to this perturbation the power of the module changes. If the power rises due to the perturbation then the perturbation is continued in that direction. After the peak power is touched the power at the next instant decreases and hence after that the perturbation reverses.

When the steady state is grasped the algorithm oscillates round the peak point. In order to keep the power variation small the perturbation size is reserved very small. The algorithm is developed in such a manner that it sets a reference voltage of the module equivalent to the peak voltage of the module. A PI controller then acts moving the operating point of the module to that specific voltage level. It is observed that there some power loss due to this perturbation also the fails to track the power under fast variable atmospheric conditions. But still this algorithm is very popular and simple. The drawback of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by Incremental conductance method.

Instead of the above described methods the most popular method of MPPT algorithm is used.

Proposed Method (Voltage Based Peak Power Tracking)

The proposed method solves the problem caused in by perturb and observe & Incremented conductance process from those caused by irradiance changing by decoupling the PV power fluctuations.

The proposed method of MPPT Voltage Based Peak Power Tracking is used. Voltage Based Peak Power Tracking Algorithm (VPPT) algorithm is a tough method to track the position of maximum Solar voltage. In this algorithm we first bring the solar panel to Morning position (1stPosition) and then gradually read the solar panel voltage in few steps. At the end the solar panel is at the Evening position (last position). Once the μC has all the values of Solar panel voltage it will apply the voltage based peak power algorithm to find which position gives the highest voltage.

The μC will then move the panel to the position where the voltage is maximum. In this way we are implementing the MPPT algorithm to get the maximum amount of power at any given time of day.

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IV. SYSTEM BLOCK DIAGRAM

Following figure 1 and 2 shows the system block diagram.

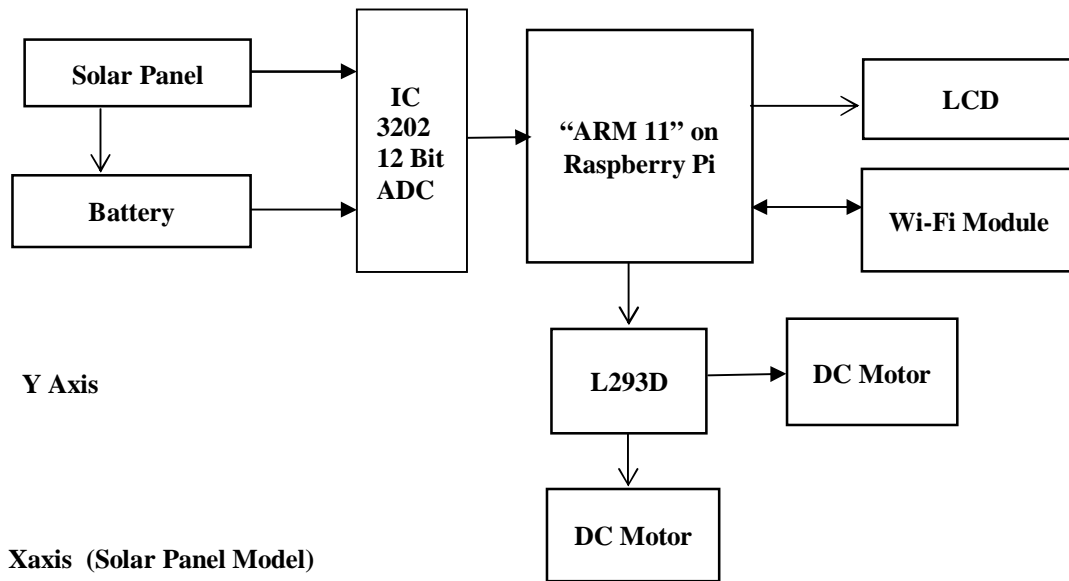


Figure 1. Block diagram of Solar Panel Model

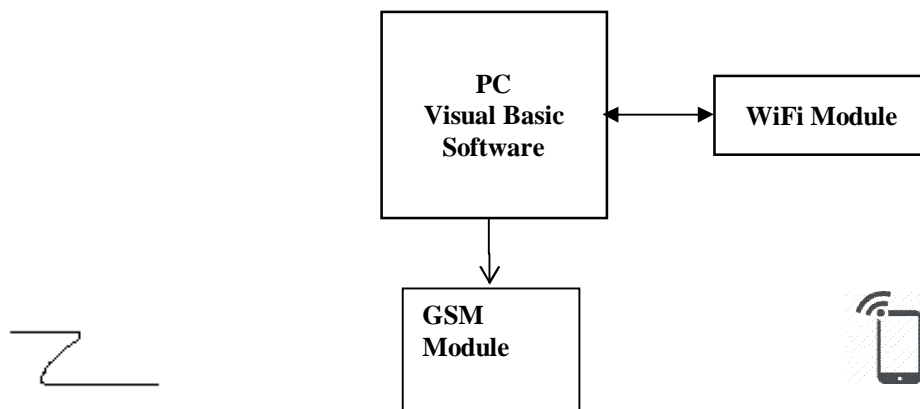


Figure 2. Block diagram of Monitoring System

Block Diagram Description: As shown in the block diagram the Raspberry Pi which is working as a controller is connected to the Solar panel and battery via 12 bit ADC. The IC 3202, 12 bit ADC is used to convert the analog voltage of solar panel and battery into digital voltage. The Pi will continuously read the panel and battery voltage via 12 bit

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Vol. 5, Issue 5, May 2016

ADC. Using the MPPT algorithm the Pi will read the battery voltage every after 30 seconds and send it to the Receiver section PC via WiFi module. The Pi will also read the panel voltage from time to time in 10 consecutive steps to get all the points in the MPPT algorithm. Once all the points are covered the Pi will send the readings of voltage of each position wirelessly to PC using WiFi. On PC we have Visual Basic software in which we have designed a Graphical user interface (GUI) on which we are showing all the positions in table as well as graphical format. The results have been attached in the report.

V. MAXIMUM POWER POINT TRACKING ALGORITHM

The voltage at which PV module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature. Maximum power point tracking (MPPT) is a technique used with wind turbines and photovoltaic (PV) solar systems to maximize power output.

The system's aim is the power generated by solar cell, showing battery charging status on PC via wi-fi network and sending message on mobile. This is done by using Maximum Power Point Tracking (MPPT) algorithm. There are different MPPT algorithms used like perturb and observe, Incremental conductance methods are used. These methods required constant voltage supply. Instead of these two methods the most popular MPPT algorithm **Voltage Based Peak Power Tracking** is used. Voltage Based Peak Power Tracking Algorithm (VPPT) is a forceful method to track the position of maximum Solar voltage. In this algorithm we first bring the solar panel to Morning position (1st Position) and then gradually read the solar panel voltage in few steps. At the end the solar panel is at the Evening position (last position). Once the μC has all the values of Solar panel voltage it will apply the voltage based peak power algorithm to find which position gives the highest voltage.

The μC will then move the panel to the position where the voltage is maximum. In this way we are implementing the MPPT algorithm to get the maximum amount of power at any given time of day.

Following Fig. 1 shows the Algorithms and flow diagram to track the Maximum Power Point i.e. Voltage Based Peak Power Tracking. The algorithm steps and flow chart are summarized as follows.

Voltage Based Peak Power Tracking Algorithm Steps and Flow Chart:-

Algorithm Steps:

1. "A"
2. Initialize Solar panel to 1st position
3. "B"
4. Take Voltage reading
5. Move Panel to next position
6. Is position = 10? N \rightarrow "B"
7. Y \rightarrow Calculate the Max voltage of all the readings
8. Position the Solar panel on the maximum Position
9. "C"
10. Is time = 2 minutes? Y \rightarrow "B"
11. N \rightarrow "C"

VI. EXPERIMENTAL RESULTS

Visual Basic results for solar panel are obtained by using MPPT algorithm. It will show the Voltage characteristics for solar panel and battery with respect to time. The parameters were obtained for a generalized solar cell. The plot is similar to the theoretically known plot of the solar cell voltage and battery voltage w.r.t. time.

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Following figure 4.shows results for the Voltage characteristics w.r.t. time of a solar cell in first graph which varies according to the variation in voltage and Voltage characteristics w.r.t. time of a Battery in second graph.

Also, this figure is showing Solar voltage levels at 10 different angles taken at 10 second interval in first, and Voltage characteristics w.r.t. time of a Battery taken at every 30 seconds in second graph.

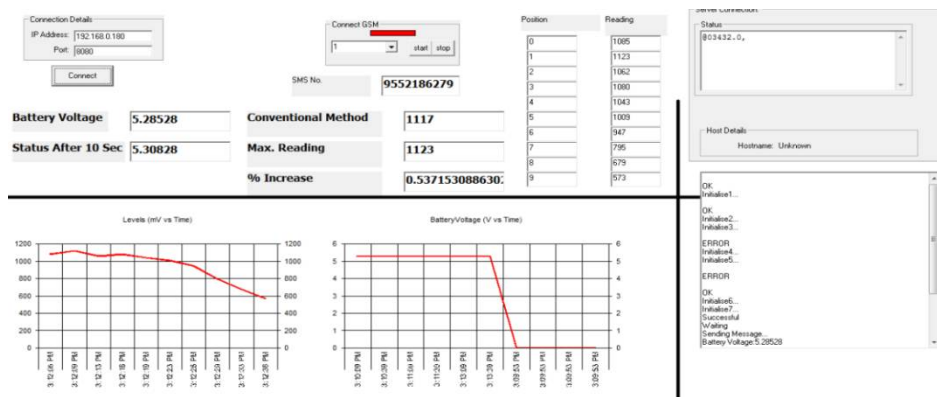


Figure4.The Plot of the solar cell voltage and battery voltage w.r.t. time.

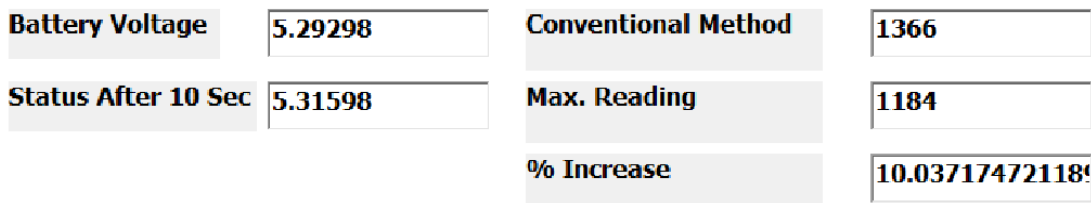


Figure 5.Battery Voltage Status.

Figure 4.shows the initial battery voltage and the battery voltage taken after 10 seconds. Clearly we can observe that there is a rise in battery voltage which is also shown in the Battery voltage Vs time graph. Also, aboveshow the reading of conventional method vs the Max reading obtained after applying the MPPT algorithm. Here we can observe that there is an increase of 10% after using the MPPT algorithm.

Position	Reading
0	1358
1	1320
2	1269
3	1215
4	1139
5	903
6	910
7	719
8	592
9	523

Figure 6.shows 10 position readings of solar panel taken at different level.

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Above figure 6. shows all the Solar readings from 1st position to last position. In which at 0 position, its showing large Intensity of solar panel and at 9th position its showing less intensity of solar panel.



Figure 7. Message send and displayed on mobile

Above figure shows the initial battery voltage and the battery voltage taken after 10 seconds. Whatever status of the battery after every 10 second, the message is send on mobile with the help of GSM module.

VII. CONCLUSION

In this system, tracking of solar energy is facilitated also the voltage across panel is observed on web using Raspberry Pi (ARM11). It gives real time update of the voltage across the panel. It gives the real time Voltage characteristics of solar panel and battery with respect to time.

In this system, MPPT algorithm is implemented for tracking the solar panel to get maximum energy for the Sun. The system measures the voltage across the solar panel and plots relationship between voltage across panel with respect to time. When battery will be fully charged then system sends SMS on mobile. The system also shows status of battery charging on monitoring system. Thus purpose of Maximum Power Point Tracking algorithm is achieved successfully.

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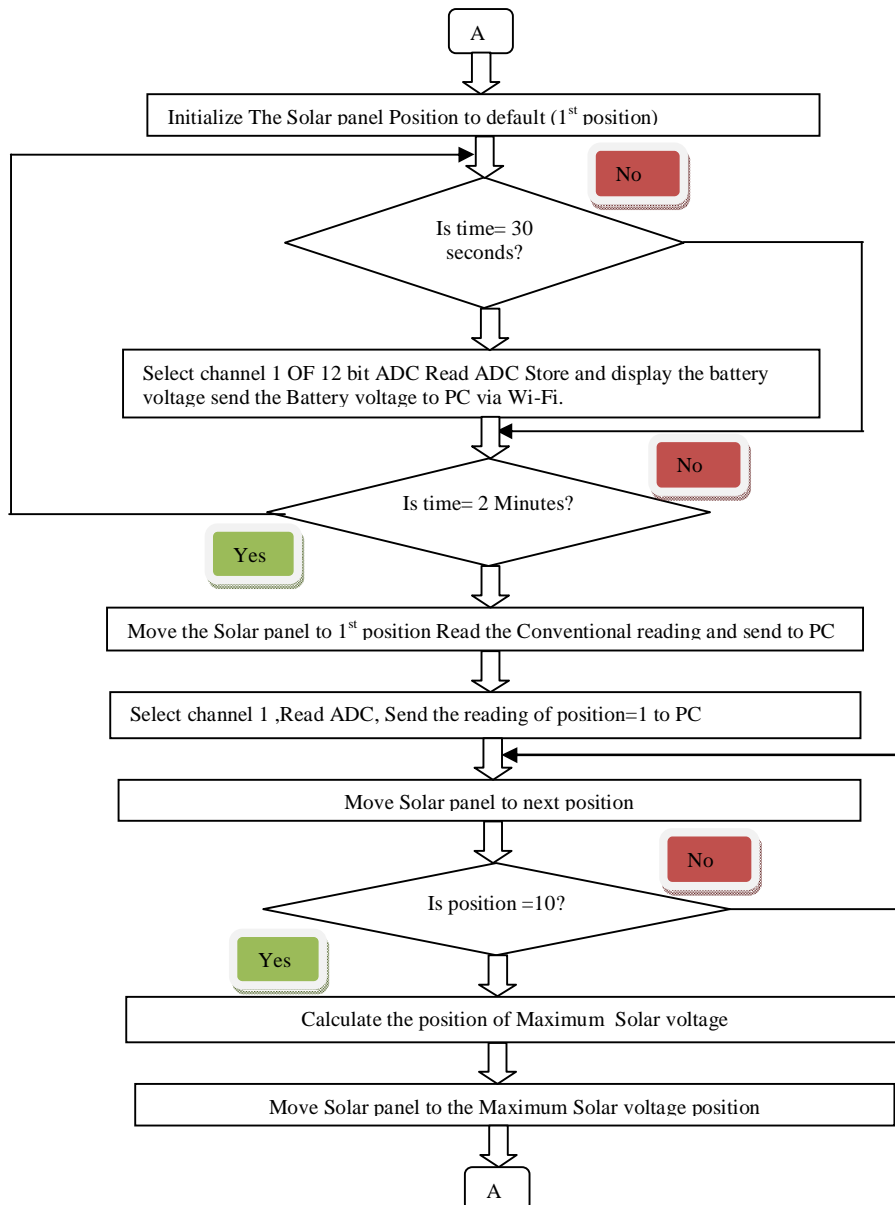
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Flow Chart of Voltage Based Peak Power Tracking.



Above figure shows flow diagram for the MPPT algorithm of Voltage Based Peak Power Tracking is used. Which shows the total working procedure of MPPT algorithm.