ISSN: 2583-5637 (Online)
International Journal of Inventive Research in Science andTechnology Volume 3, Issue 4, April 2024

STANDALONE PV SYSTEM WITH MPPT CONTROL- A REVIEW

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ABSTRACT:

This article focuses on the use of MPPT control in a self-sufficient PV system with a battery to power the load. This means that the battery is an energy storage element and can be used as a power source if the PV is not enough for this. The system consists of a battery, a PV panel and a boost converter circuit.. By controlling the duty cycle, the boost converter tracks the maximum power point (MPP) of the PV panel, which is given to the boost converter as a gate pulse. The function of the battery is to maintain a constant intermediate circuit voltage. The method of disturbance and observation is used as the MPPT (Maximum Power Point Tracking) control algorithm. A simulation model of a stand-alone PV system is created using MATLAB SIMULINK and the output is validated

KEYWORDS: ***BATTERY, DUTY CYCLE, STANDALONE PV SYSTEM, MPPT, BOOST CONVERTER, MATLAB***

1. INTRODUCTION

Standalone systems are typically used for stand-alone loads or home use [1]. The main problem is the increase in power demand on the supply side with less harmonics and fluctuations. While traditional energy sources can last for a limited amount of time, renewable energy sources such as solar energy are endless and environmentally friendly. With the increased efficiency of power electronics devices, this solar energy can be used to power consumers. The only drawback of solar power is that the setup required is very expensive. The output power of PV depends on many criteria such as the amount of solar radiation and temperature. As these two parameters change, so does the output, leading to useful side variations. This is completely undesirable. Therefore, it is important to have a controller that makes the performance of the solar panel completely independent of the weather conditions. Currently, there are many algorithms such as incremental inductance, perturbation and observation, and fuzzy logic. [2]-[7]. In this project, we will focus entirely on the methods of perturbation and observation. This algorithm controls the duty cycle of the boost converter and is given to the converter as a gate pulse. The battery used here is like an energy storage element. Not only does it keep the DC link voltage across the capacitor constant, it also powers the load in bad weather when the PV cannot generate the power it needs. Standalone PV systems have many practical uses. For home use, it can be used for all types of linear or non-linear loads.

2. SOLAR ENERGY

Solar energy is an important source of renewable energy. It is used as heat and radiant light from the sun. The solar heat used to heat a room can be obtained from solar energy. Solar energy can also be converted into electrical energy, which can be used for a variety of purposes. Even if there are additional costs associated with the initial installation, the long-term benefits are worth it. The introduction of solar energy is a major step towards curbing global warming. In particular, the use of solar energy as an energy source in each country is accelerating. More and more used to offset climate change.

3 SOLAR CELL

solar cell is an electrical device that converts incident light into electricity based on the photovoltaic effect. Solar cells are used to build solar panels. Solar cells are considered photovoltaic, but the light that enters the solar cell can be sunlight or an artificial source. Solar modules are made of semiconductor materials. Silicon crystals are the most commonly used semiconductor crystals. Solar cells are manufactured using high-purity silicon. A melt-and-cast process is used to process the silicon crystals into cells and cut the cast from the ingot into wafers. Solar cells absorb incident sunlight and generate electron-hole pairs. The charge carriers are then separated and the carriers are individually extracted into the external circuit. The photovoltaic system generates photovoltaics based on the principle of the photovoltaic effect. Solar cells can be connected in series or in parallel, depending on voltage and current requirements. The PV module has a glass plate on the side facing the sun to protect the wafer and at the same time allow light to pass through. The electrical energy produced by solar panels is direct current and can be used for direct current loads or stored in batteries for later use. For homes connected to the power grid, inverters can be used to convert DC power to AC power, there by powering the AC load. Modules can be connected or spliced together to form an array of specific DC voltage and current capacities, but MPPT is recommended for efficiency.

4 TYPES OF PV PANELS

PV is used not only in standalone system, but also in microgrids. PV modules can be categorized based on efficiency and space requirements & Installation size.

There are different types of PV panels available in the market such as

1. Monocrystalline Panels
2. Polycrystalline Panels
3. Hybrid Panels

4.1 Monocrystalline Panels

In this type, the cells are aligned in a particular direction, which means when the sun is incident on the cells at the correct angle; they exhibit high efficiency and work best when sun directly shining on them.

4.2 Polycrystalline Panels

In these panels, the individual crystals are not all perfectly aligned together which reduces their efficiency as compared to monocrystalline panel. However, this misalignment can be a benefitting factor because the cells work better even when light is incident from other angles

4.3 Hybrid Panels

The extra amorphous layer behind the monocrystalline cells is able to extract more energy from the incident sunlight, especially under low light conditions. They have the highest efficiency and take up less space. These, however are more expensive than monocrystalline and polycrystalline panels.

5 CHARACTERISTICS OF PV SYSTEM

The output characteristics of PV System is non-linear and it changes with IRRADIATION and TEMPERATURE. When these two factors vary, MPP point varies accordingly. With increase in irradiation the MPP shifts to right as shown in figure 1 below. For higher magnitude of voltage we get the maximum power.

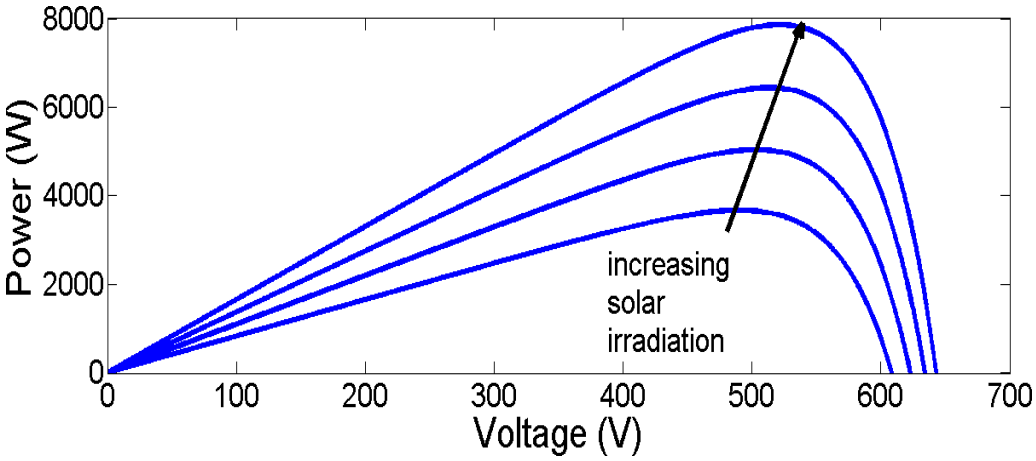

Figure 1- Power vs. Voltage graph of PV panel

In Fig.2 Current Vs Voltage graph is shown. With increase in irradiation the MPP voltage increases and there by the maximum current also increases. For the irradiation level above 300W/m^2 the MPP is almost constant.

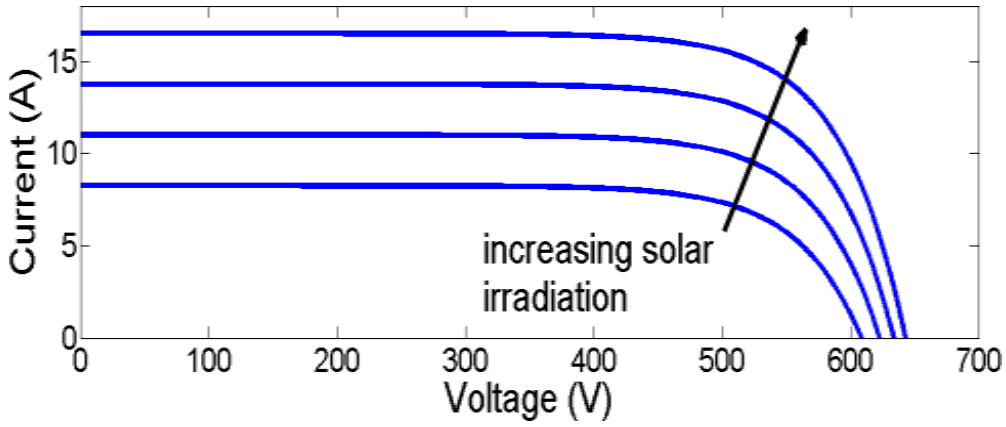

Figure 2 Current vs. Voltage graph of PV panel

6 MAXIMUM POWER POINT TRACKING (MPPT)

Normally, solar panels can only convert 30-40% of the total incident solar radiation into electrical energy. Maximum power point tracking (MPPT) is used to improve the efficiency of certain solar panels. Maximum Power Point Tracking (MPPT) is an algorithm used to extract maximum power from PV under certain conditions. The maximum output of a PV module depends on factors such as the amount of solar radiation, ambient temperature, and cell temperature. PV modules typically produce a maximum power voltage at a cell temperature of 25 ° C. However, it may drop or rise depending on the outside temperature. MPPT examines the performance of a particular PV module, compares it to the battery voltage, and then determines the most efficient voltage. H. Maximum power point voltage. The purpose of the MPPT system is to sample the output of the PV cell and then apply the appropriate resistance to get the maximum power. MPPT is most effective in colder conditions, as PV modules perform better at lower temperatures. It is also very effective when the battery is deeply discharged, as it can draw more current under low charge. MPPT devices are integrated with power electronics to form a power conversion system in the form of a solar inverter that converts direct current to alternating current

7 MPPT TECHNIQUES

There are different techniques used to track the maximum power point such as:

1. Perturb and observe
2. Incremental Conductance method
3. Current sweep
4. Constant voltage
5. Fuzzy Logic Control
6. Neural network

Perturb and Observer is one of the simplest methods due to its low time complexity value. This method uses a voltage sensor that detects the PV voltage and measures the power. If the power is increased, the algorithm is designed to achieve a constant power. However, this method can lead to output power fluctuations because the algorithm continues to perturb recursively even after the MPP is reached. This can be solved by setting an error boundary to end the recursion. It is easy to implement and is called the escalation method because it depends on the rise and fall of the power curve as a function of voltage relative to the peak power point.

In Incremental Conductance method, the controller measures incremental changes in voltage and current in the Ascending conductivity method. Although it requires more computation, it is still better at tracking changes than theperturbation and observation method. The peak power point is calculated by comparing the ascending conductance (IΔ/VΔ) with the PV generator conductance (I/V). The output voltage is the voltage at which the two ratios, i.e. the conductivity, are the same. The voltage is maintained until there are changes in the level of irradiation for which theprocess is repeated. Here, voltage and current are detected simultaneously, so changes due to radiation do not causeerrors. However, this method is more complicated than the perturbation and observation methods.

The Current Sweep method helps to obtain I-V characteristics using a PV array current sweep waveform that is updated at fixed intervals. MPP is calculated from the curve in the same time period

In constant Voltage Methiod the operating point of the photovoltaic generator is maintained close to the point of maximum power. The voltage of the photovoltaic generator is adjusted to a selected fixed reference voltage for optimum performance.

Fuzzy logic control is used to implement MPPT using microcontrollers. Fuzzy logic controllers are not limited by the need for precise models. They have the advantage of handling nonlinear and imprecise inputs, and have a fast convergence speed. A fuzzy control system works on the principle of fuzzy logic. It studies analog input values in the context of logical variables with continuous values from 0 to 1.

Neural networks are also used to implement MPPT and they are also suitable for microcontrollers. It is a family of statistical learning algorithms used in estimating approximate functions. They have three layers: input, output, and a hidden layer that has user-dependent buttons whose number can be changed. Input variables such as open circuit voltage and short circuit current; solar irradiance and temperature can be used to find outputs such as duty cycle signals, which in turn can be used to find the maximum power point and operate the converter around that point

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8 THE SIMULATION MODEL

It comprises PV panel, boost-converter and battery (as the energy storage element). Capacitor Cin is to reduce the ripples in MPP voltage. It should be smaller in magnitude otherwise more time will be consumed to obtain MPP as The Complete Setup is Shown in figure 3 and The Simulation model of Stand Alone PV System with Battery Backup and MPPT control is Shown in Figure 4.

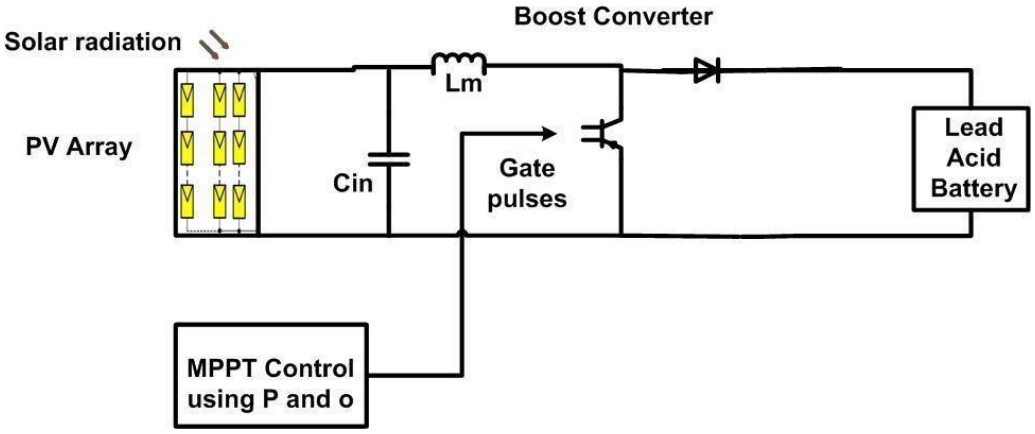

Figure 3 The Complete Setup

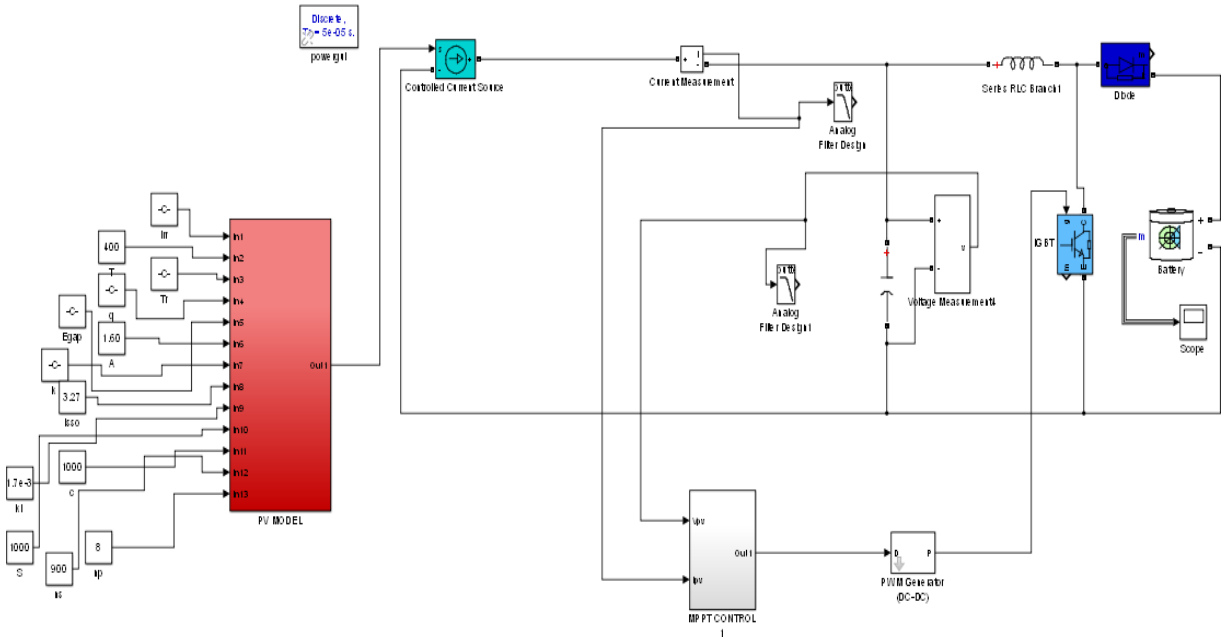

Figure 4 – The Simulation model of Stand Alone PV Ssystem with Battery Backup and MPPT control

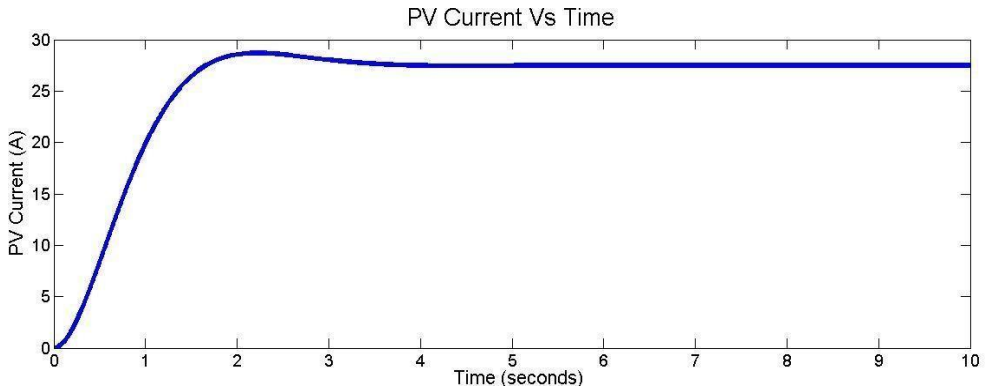

Figure 5 -PV Current vs. Time

The Figure 5 represents output current of PV panel after doing a MPP control. The current first increases but after reaching the MPP voltage it becomes constant.

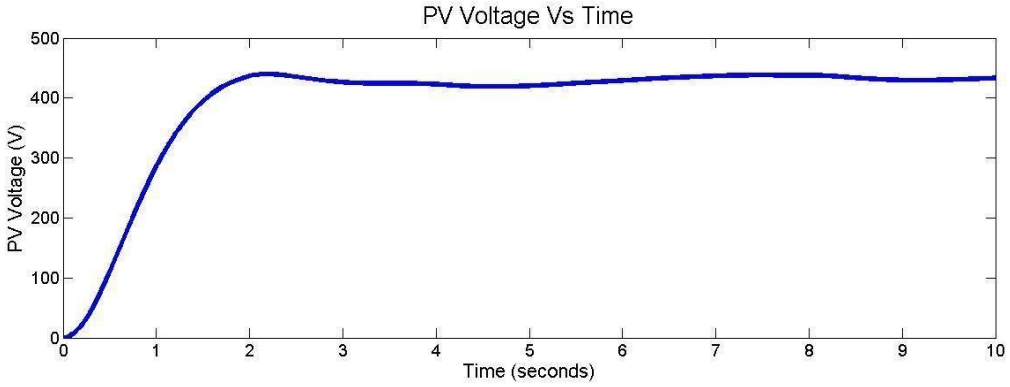

Figure 6 PV Voltage vs. Time

The Figure 6 represents the output voltage of PV panel after doing a MPP control

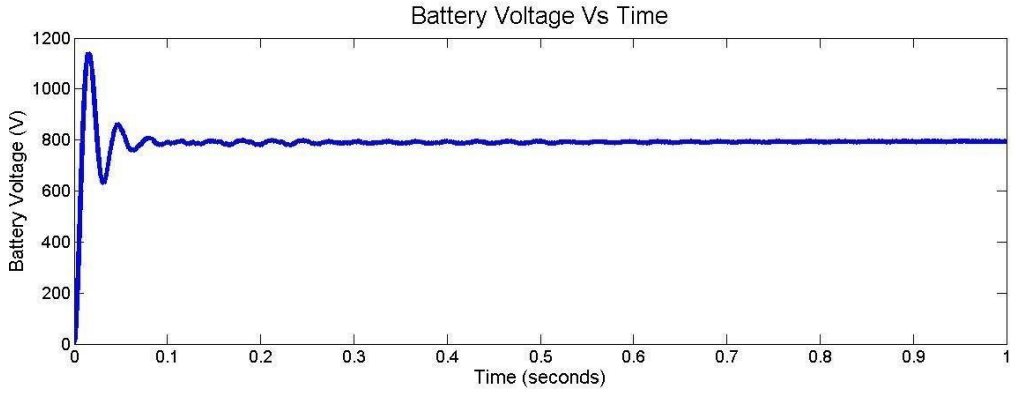

Figure 7 Battery voltage vs. Time

The Figure 7 represents battery voltage Vs time . If battery is charging more current is drawn from PV and if it is discharging, less amount of current will be drawn.

The Figure 8 Shows MAXIMUM POWER graph. It shows that once MPP is reached there will be certain perturbation as actual P-V curve will tend to decrease from MPP so then the algorithm will take its action and once perturbation occurs it will not allow further decrease of power and the output power will remain constant. This totally depends on algorithm. The more effective the algorithm is the better the output will be. The algorithm must be written in sucha way that if the obtained power is less than MPP, we should proceed in direction of MPP. Once MPP is reached perturbation will occur then after that no more changes have to be donein the code; the obtained power has to be maintained.

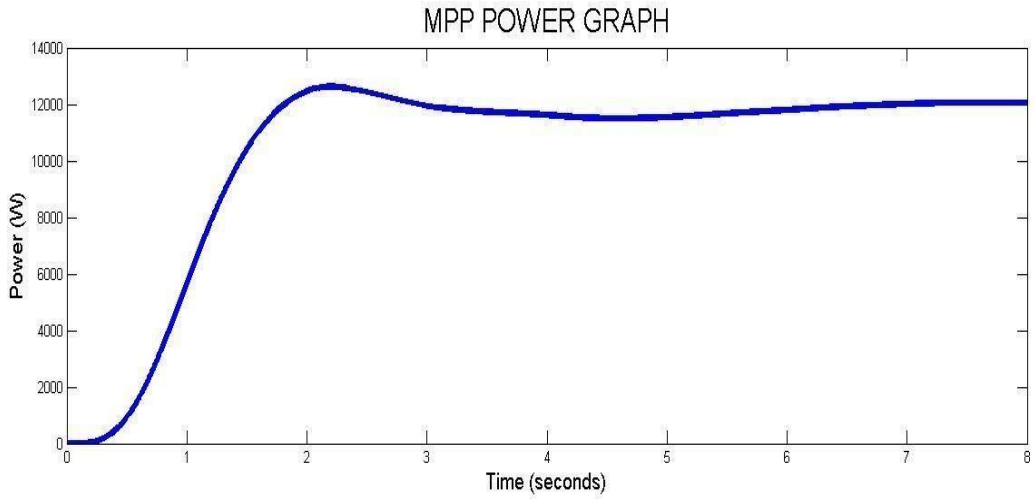

Figure 8 MPP Graph-Power vs. Time

9 CONCLUSION

A stand-alone photovoltaic system for civil applications is modeled using MATLAB/Simulink. The control diagram and mathematical model containing the MPPT (Perturbation and Observation Method) control are provided for the up-converter. The simulation results demonstrate that the boost converter successfully monitors the maximum power point (MPP) of the solar panel and the battery is charged respectively. The battery plays two roles here. One is that it acts as an electric charge and the other is that it acts as an energy storage element. The result ensures an optimal and efficient model for a reliable and high-quality stand-alone PV system.

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