Modified MPPT based Grid Connected Solar PV System with Improved Power Quality

Mammuthu P[1], V. Gopalakrishnan[2]

[1,2]Department of Electrical and Electronics Engineering, Government College of Technology, Anna University, Coimbatore, India

E-mail: [1]cpmammuthu@gmail.com

Abstract

The power demand in the world is growing at a drastic rate. Two drivers that stimulate energy consumption are emerging countries' technological economic progress and population increase. Photovoltaic energy generation is one of the most environmental friendly methods of energy creation. PV systems have recently seen an increase in demand due to the fact that they create electricity without harming the environment by directly converting solar energy into electricity. PV works at its highest power point, which is dependent on irradiance and temperature, to attain maximum efficiency. Since solar irradiance and solar temperature fluctuate over time, a photovoltaic system capable to track the MPP must be designed to generate more energy. This project introduces a novel solar panel control method known as Maximum Power Point Tracking (MPPT), wherein the suggested technique employs Variable Step Size P&O (VSS P&O) MPPT to enhance the transient responsiveness. The step size is automatically adjusted with respect to the point of operation. Simulations utilising MATLAB/ Simulink software are used to assess the suggested method's performance.

Keywords: MPPT, Power Quality, PV System, Solar MPPT

1. Introduction

In recent years, global warming and energy policy have been a prominent subject on the world agenda. Advanced countries are attempting to lessen their carbon footprint. The emissions related with Photo Voltaic generation are those associated with the manufacture of its components. They generate electricity from solar irradiance after installation and do so

without emitting greenhouse emissions. PV panels create more energy than they consume over their lifespan, which is around 25 years. They can also be put in regions where there is no other purpose for them, such as rooftops and deserts and also from isolated areas. Off-grid facilities are the latter type of installations, and they might be the most cost-effective way to offer energy in remote locations. However, grid-connected PV power generation accounts for the majority of PV power generation. Photo Voltaic electricity production, on the other hand, is more costly than other sources because of the necessary equipment [1-6].

Authorities are promoting it through incentives and tariffs, hoping that the technology is improving to the point where it can compete in the near future. Maximizing the efficiency of Photo Voltaic plants so that the energy produced grows is an important feature, as it will boost revenues and, as a consequence, minimize the price of the power produced, bringing it closer to the price of electricity generated from different sources [7-14].

2. Control Methodology

Changes in temperature and irradiation affect the maximum power output of a PV module. To discover the maximum output power, the P&O approach increases or decreases the module voltage. If dPowerpv /dVoltagepv is positive, that is to the left of the MPP, the voltage is boosted to obtain the MPP. The voltage is reduced to achieve the MPP when dPowerpv/dVoltagepv is negative. In a traditional P&O MPPT, the step size is fixed (Dd = 0.01).

The algorithm gradually increases or decreases the duty cycle until it reaches the MPP. Based on the outcome of the preceding perturbation, the step size is adjusted. If the power output increases due to the previous perturbation, the following perturbation will follow suit. If the power output reduces due to the previous perturbation, the following perturbation will go the other way. The P&O method is the most basic, and it is also the most straightforward to implement. However, owing to the sluggish tracking, the method is ineffective for quickly changing meteorological conditions. At steady state, the voltage output and current output will oscillate.

To alleviate the shortcomings of the P&O algorithm, a variable step size P&O is presented. The suggested technique improves tracking speed while lowering oscillation. In this algorithm, dPower/dVoltage is evaluated to an error, and a step is assigned based on the

value of the error. When the point of operation is far from the MPP, the algorithm returns a big step value, but when the point of operation is near to the MPP, the method returns a small step value.

The suggested method may be used in two ways. When sunrays is present, it is captured and the maximum power from the solar Photo Voltaic source is obtained and it is fed to the three-phase grid as well as associated loads in the first mode. Besides, in this mode, the similar system structure is used to improve the distribution network's power quality. When there is no sunlight, it just acts as a DSTATCOM in second mode, which is used to mitigate power quality concerns on three phase grids with the same VSC as in first mode. As a result, switching devices are used to their full potential, and the payback period of the proposed system is shortened.
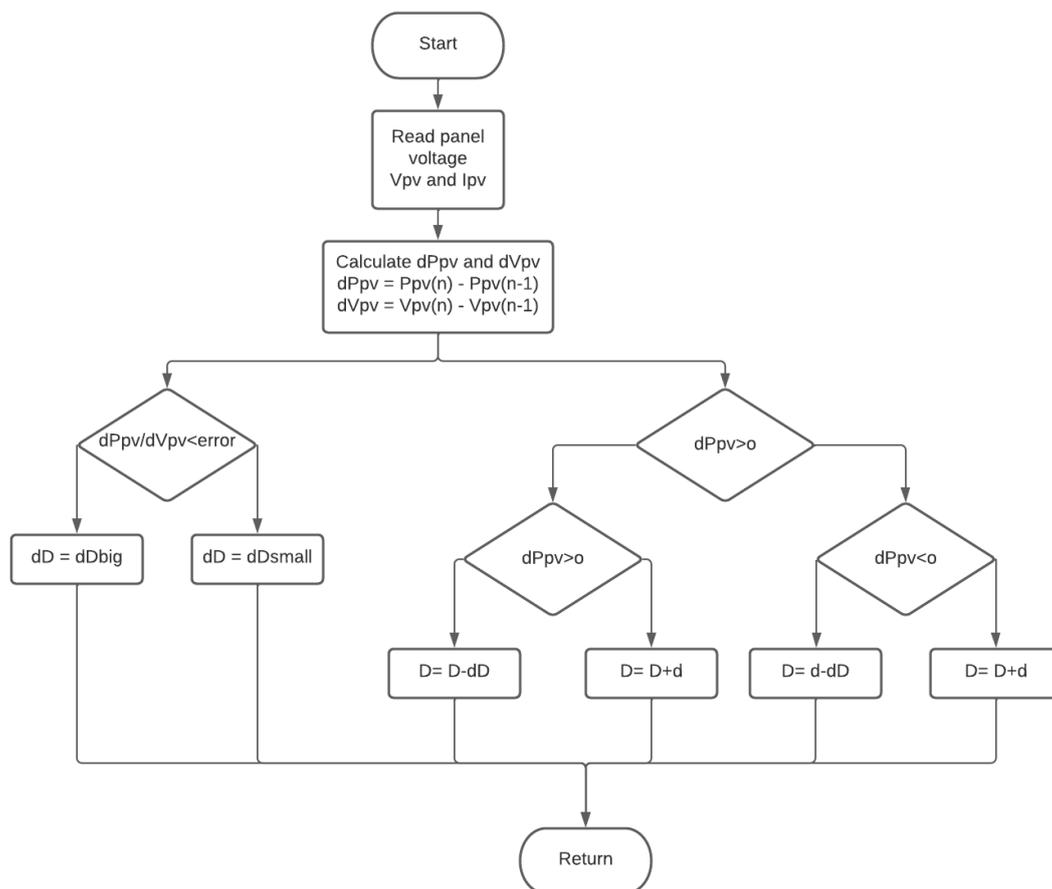

Figure 1. Variable Step P&O flowchart

The suggested algorithm has demonstrated its ability to perform several tasks, including harmonic mitigation, power factor enhancement, load balancing, and unity power

factor mode (UPF). The MATLAB platform is used to model and simulate this control. We'll look at two alternative scenarios. Simulation is used to examine the performance of a VSS P&O MPPT while it is run at various duty cycle levels. When compared to the traditional P&O method, dDbig aids in reaching the peak power point rapidly, while dDsmall lowers oscillation around the peak power point. Flow chart of the variable step size P&O algorithm is illustrated in Figure 1.

3. Boost Converter

The boost converter (also known as a step-up converter) is a dc-to-dc power converter that increases voltage while decreasing current from its input (supply) to its output (load). Because MOSFETs have a faster switching speed than IGBTs, they are commonly utilised as switches. The circuit diagram is shown in figure 2.
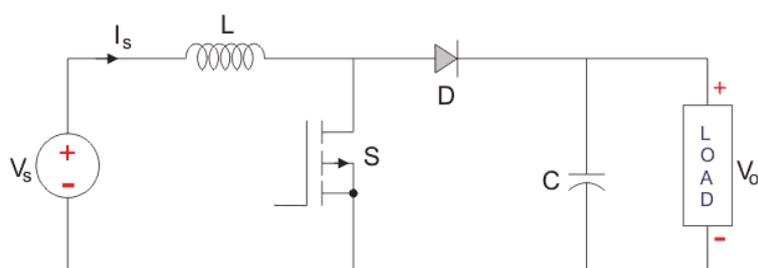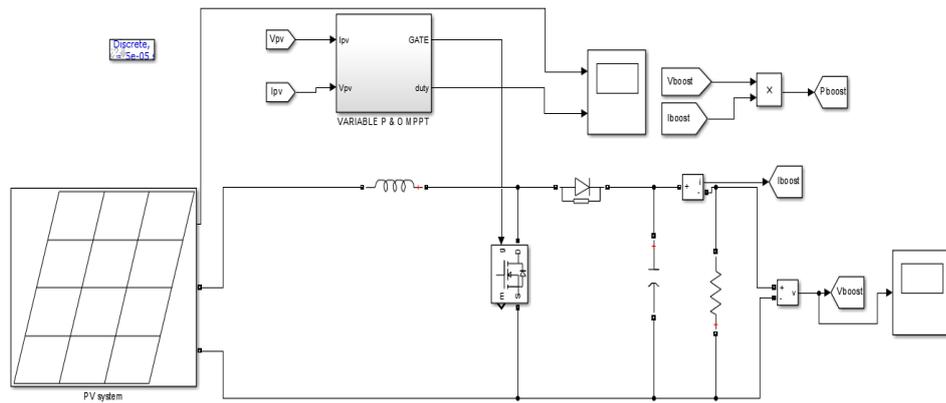

Figure 2. Boost converter

$$Duty\ ratio\ (D) = 1 - \frac{vs}{vo} \tag{1}$$

$$Inductance\ (L) = \frac{Dvs}{f * \Delta IL}\ H \tag{2}$$

$$Capacitance\ (C) = \frac{DIo}{f * \Delta Vc}\ F \tag{1}$$

4. Results and Discussion

Figure 3 depicts the suggested system, which was created with MATLAB software. The solar panel serves as an input source for the MPPT, with its voltage and current used as input.

Figure 3. Main circuit diagram

For maximal power point tracking, this system employs the variable P&O algorithm. The output from the MPPT changes depending on the power value that is computed. For the MOSFET, this output serves as a gate pulse. The boost converter converts the lower voltage value to a higher voltage value.
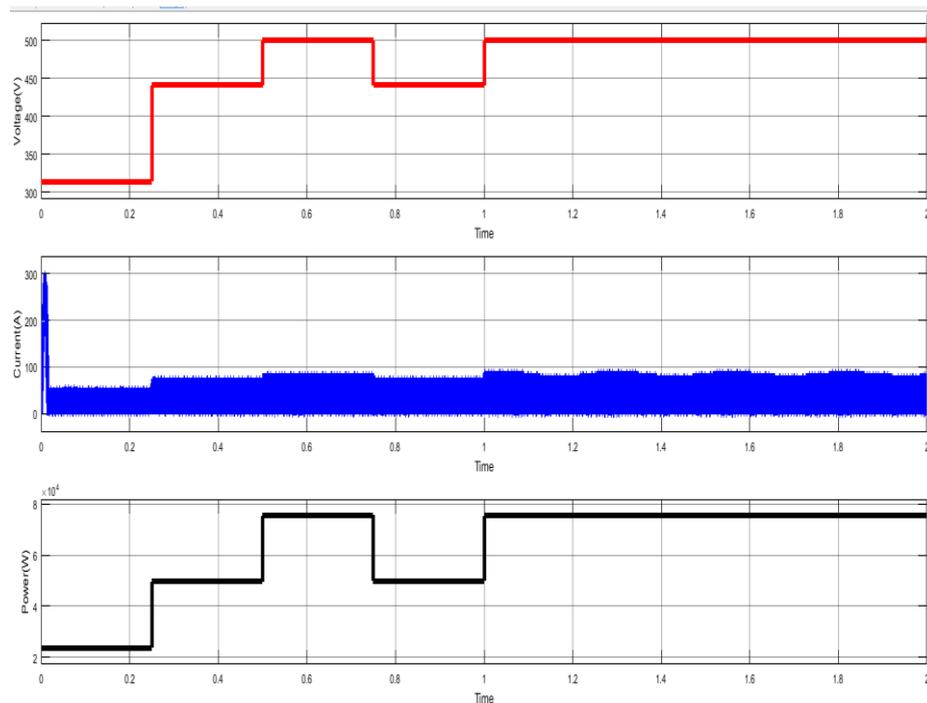
Figure 4. Simulation results from the solar panel

The above figure 4 shows the simulation result from the Solar Panel of the proposed system. It displays the voltage, current and power from the solar panel.
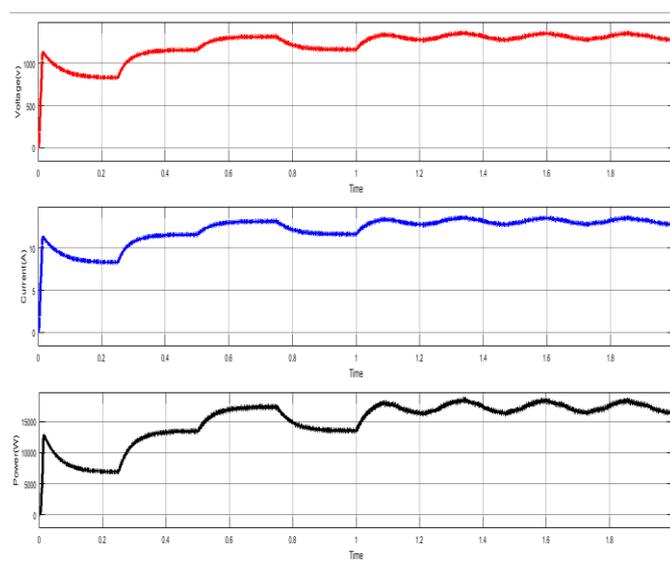
Figure 5. Output obtained from the Boost converter

The simulation result of the output from the boost converter of the proposed system is shown in figure 5. It displays the voltage, current and power from the boost converter.

5. Conclusion

This study proposes a P&O method with customizable step sizes. The suggested algorithm comprises two scenarios, each with distinct duty cycle values. In MATLAB/Simulink, the Photo Voltaic module and Maximum Power Point Tracking algorithms are simulated and evaluated under various irradiance and temperature conditions. The suggested P&O algorithm is compared to the traditional P&O method. Due to its slower reaction at fixed duty cycle, the traditional Perturb & Observe algorithm is ineffective in obtaining the highest output power under changeable weather conditions.

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