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Design and Analysis of Photovoltaic Solar Energy Connected to Three-Phase Grid Power System using MPPT Controller

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ABSTRACT –

The use of green technology, such as a solar energy system, is often used to remove or mitigate such problems. The most serious problem associated with the use of fossil energy is global warming; where increasing fossil fuels such as oil and natural gas are used to generate electricity over several decades, results in a range of environmental and health problems. The number of PV systems connected to the grid is always increasing and this is leading to various challenges such as voltage quality, power quality, islanding, etc., and these need to be increased. The photovoltaic solar system is used as a distributed generator (DG). These GDs help meet additional electricity demand, improve power quality, reduce distribution losses, etc. The discussed model is designed with Simulink block libraries and made in Matlab/Simulink software. Simulations are performed and the results are deliberated and discussed.

Keywords – Solar Cell, DC/DC converter, Grid, MPPT, MATLAB/Simulink

1 Introduction

Many concerns have arisen as a result of using fossil fuels as a primary source of energy production. In terms of power generation, India ranks sixth. Thermal power plants produce approximately 65% of India's energy, while hydropower generates 22%, nuclear power plants generate 3% and other alternative sources such as solar, wind and biomass generate the remaining 10%. India's large coal reserves account for 53.7% of the country's commercial electricity demand.

Photovoltaic power generation based on solar cells that is ready for direct conversion of solar energy to DC Electricity has the potential to be a clean energy source and can be a widely relevant affordable renewable energy source for future energy production. As a result of the development of photovoltaic processing in recent decades, the participation and role of electric utilities in PV has increased significantly. Observations on the DC side of the drive are required, so for measuring and tracking, MPPT algorithms are used for the highest operating point at each instant. Numerous approaches have been found and discussed in this decade to reduce or eliminate these measurements, system complexity is minimized and it is more cost-effective. The DC/DC converter controls the total output, while the DC/AC converter synchronizes and feeds the required power to the grid in a two-stage topology, is one of many approaches to a sensorless MPPT algorithm.

However, such strategies require at least one calculation, such as current or voltage on the dc side of the converter, as well as a large number of power switching instruments. Other methods, on the other hand, use a one-stage converter topology, which has the advantage of reducing the number of conversion steps and power switching units. There has been a decrease in the number of sensing elements in a stage topology, and on the DC side of the converter, MPPT algorithms need at least one sensing component, which involves filtering the calculated values to obtain the average of the DC quantities, requiring more controller power computational resources, and was suggested for the MPPT algorithm.

There are several ongoing research works to improve the power quality of photovoltaic systems, such as harmonic elimination or compensation strategies. When the electric power generated by renewable energy resources is supplied to the grid through the grid-connected inverter, the inverter must provide zero steady-state error, fast response and disturbance robustness. In addition, the grid-connected inverter must effectively compensate for system unbalance, reactive power and harmonics. Conventionally, simple PI control is used to regulate the inverter connected to the grid. Distortion caused by harmonics under the distorted network cannot be properly compensated using the PI controller.

2 Literature review

Jiang Nan (2015)- Solar photovoltaic (PV) generation will play an important role in the future structure of electricity worldwide. The inverter is an important installation of a photovoltaic system. Ensuring its safety and quality is a necessary link in the development of this technology.

Christopher J. Melhorn (2016) - This article describes advances in power quality monitoring equipment and software tools for analyzing power quality measurement results. Power quality monitoring has advanced from strictly troubleshooting to continuous monitoring of system

performance.

Haider Muaelou (2016)- In modern electric power systems, dependence on solar energy is increasing. Grid-connected applications are very important with deficit in conventional power plants due to fuel shortage. The design of the control strategy to connect photovoltaic (PV) systems to the electrical distribution grid is a challenging issue. This article focuses on the design of a controller and its implementation in grid-connected photovoltaic systems for power factor correction in power distribution systems. The first stage is the modeling of the components of the photovoltaic system, mainly; Photovoltaic source, DC-DC converter and network interface inverter with appropriate filter. PSCAD is used to simulate this study. The proposed controller is then designed.

Prashant. V. Thakre (2017) - to harness solar energy, various energy conversion technologies are required. Photovoltaic (PV) panels, or commonly known as solar panels, are devices used to convert sunlight into electricity.

Huang-Jen Chiu (2018)- Maximum Power Point Tracking (MPPT) is used in photovoltaic systems to maximize the output power of the photovoltaic panel, regardless of temperature, irradiation conditions and electrical characteristics of the load. A new MPPT system is developed, consisting of a DC to DC converter, which is controlled by a microcontroller based unit. **Jawad Ahmad (2019)-** In this article, the maximum power point tracker battery charger is proposed to extract the maximum power from a PV array to charge the battery. The output power of the photovoltaic system varies continuously with the change of irradiance and temperature. It is very important to improve charger efficiency.

Mohammad H. Rashid (2020)- As per the present To maintain the economic growth rate of 8-9%, India needs to generate more and more electricity. Currently, Renewable Energy (RE) systems and technologies are gaining enormous importance in the world. There are several types of ER technologies. **Siwakoti, Yam Prasad (2021) -**These models present an estimate of the position of the Sun according to the considered location, a determination of the recovered solar energy and an evaluation of the electrical energy produced by a photovoltaic surface.

N.Ravi Kumar (2021) This article presents a case study of power quality audit carried out at College of Engineering S.A in Chennai. The FLUKE 435-ii series is used for power quality behavior analysis. There are many power quality problems such as voltage sag, voltage swell, harmonics, frequency fluctuation, voltage unbalance, bad power factor, etc. Harmonic is one of the main problems. This issue causes damage to sensitive equipment. In this work, power quality problems are identified through the readings obtained by the experiment and suggestions are provided.

3 Modeling

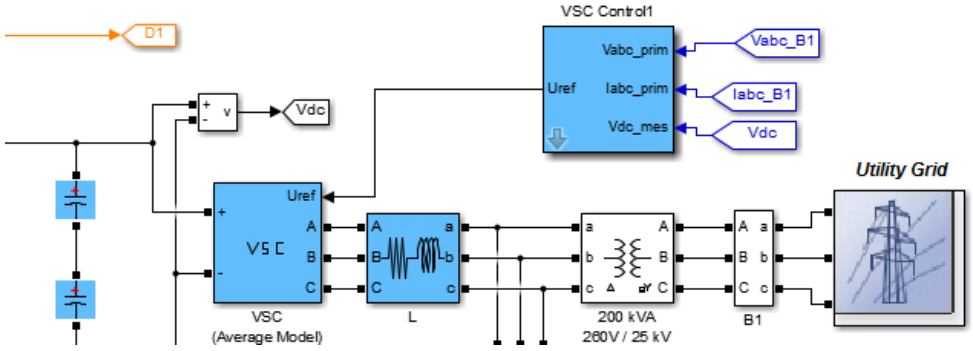

Figure 1 Grid Power Supply

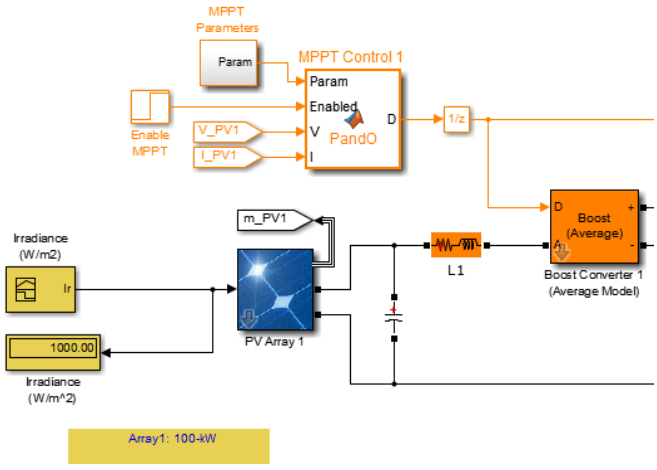

Figure 2 Array 1 with components

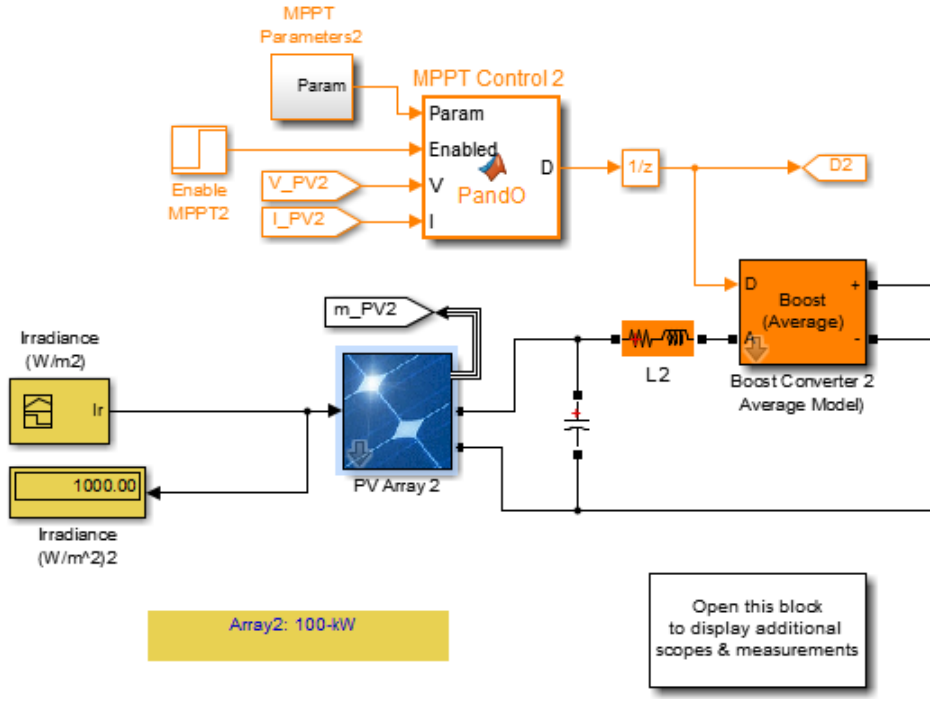

Figure 3 Array 2 with components

4 Results and discussion

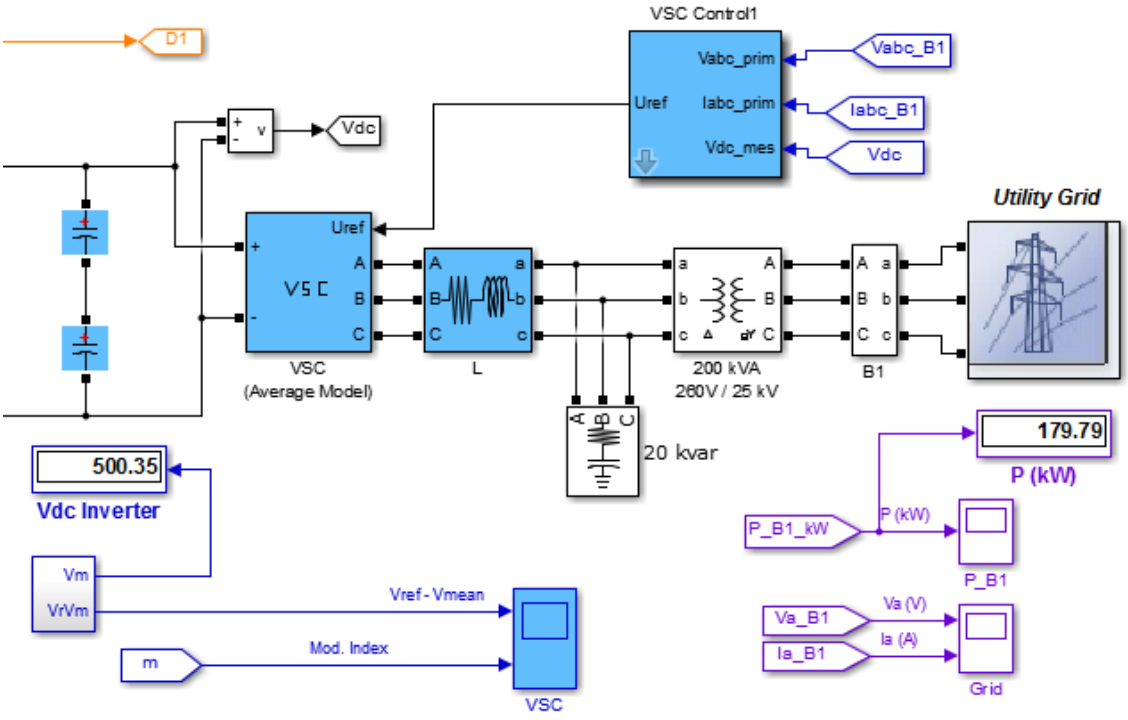

Figure 4 Grid Power Supply with Output Voltage and Power

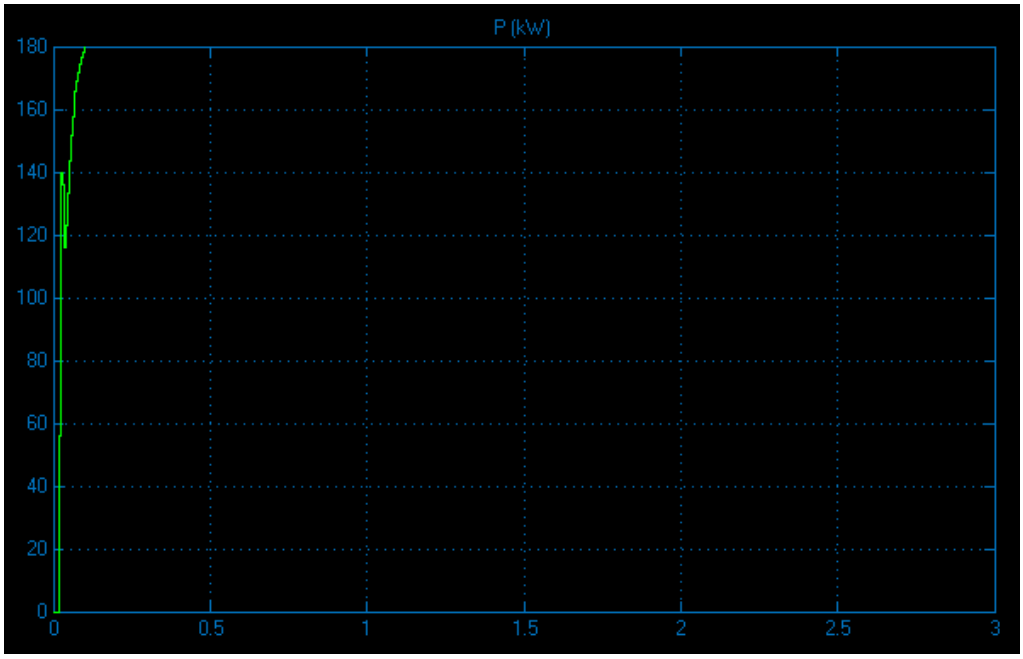

Figure 5 Output Power

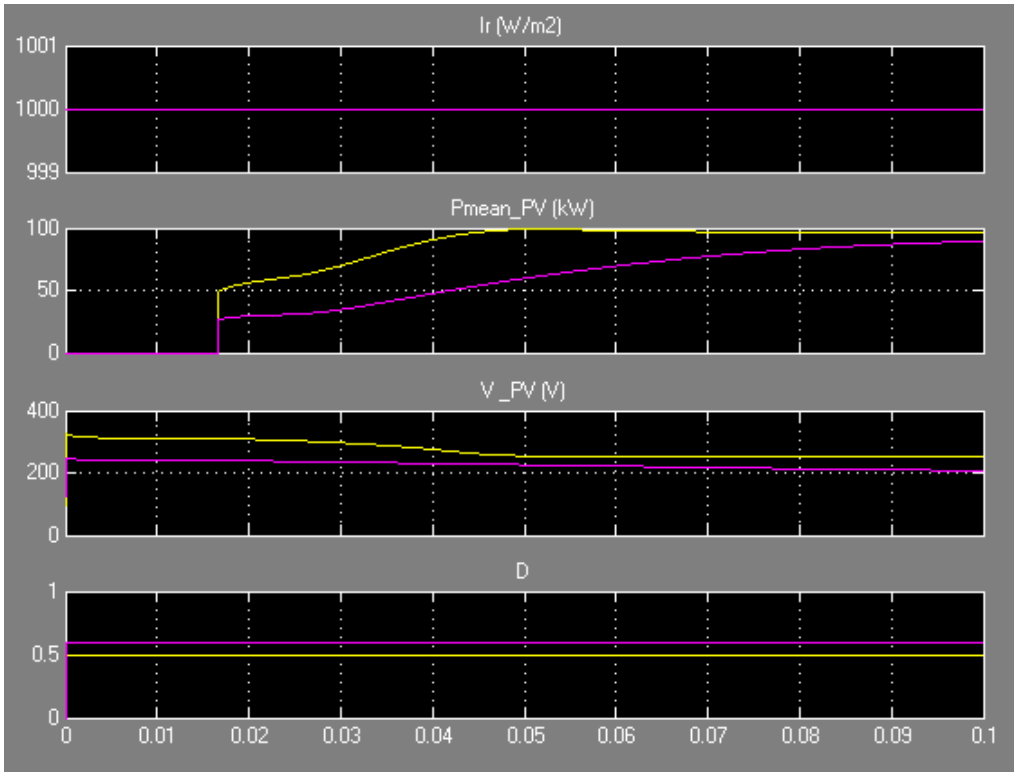

Figure 6 Output of Various Parameter

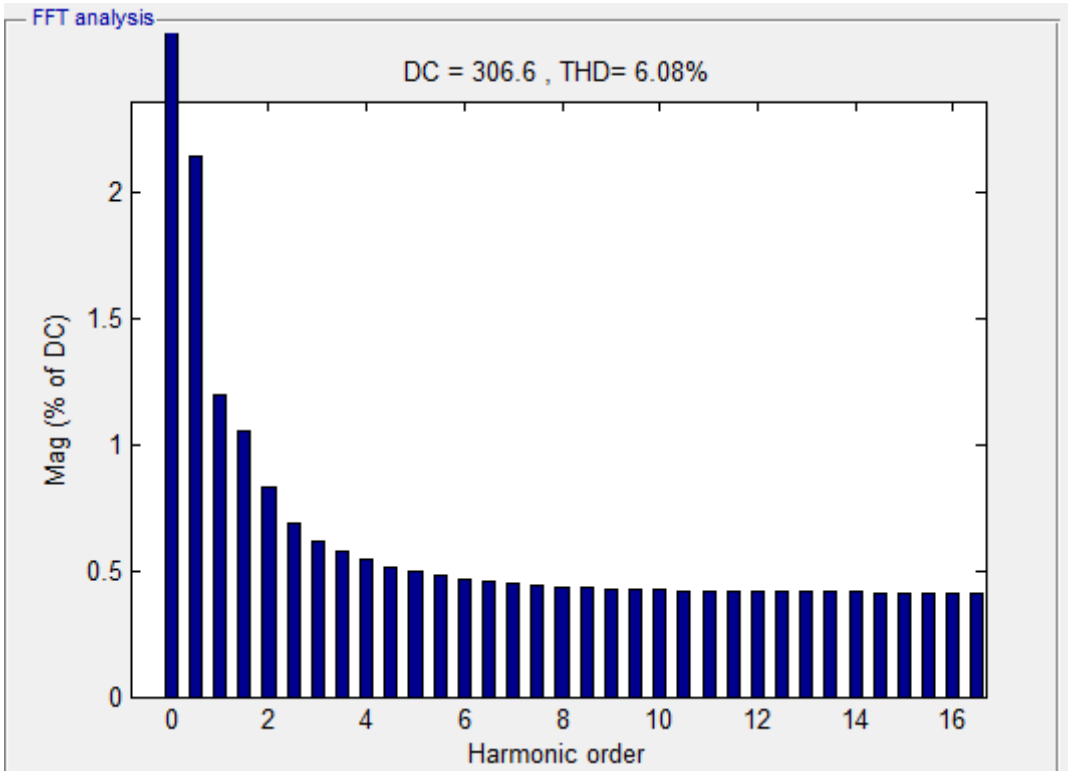

Figure 7 FFT Analysis (THD)

5 Conclusions

In this article, the photovoltaic system is modeled, all its elements are modeled, the autonomous photovoltaic system and the grid-connected photovoltaic system are simulated. The input parameters are a solar insolation of 1000 W/m2 and an operating temperature of 25°C. At this radiation intensity the current voltage and ambient temperature are plotted for both operating modes. In this work the P&O method of maximum power point tracking strategies is used and simulated. The DC/DC boost converter, inverter, is a part of the photovoltaic system. The output voltage and power is 179.79 kW by the inverter power supply (500.35 VDC), shown in Figure 4. The total harmonic distortion (6.08%) is shown in Figure 7.

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