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Design and Simulation of Grid Connected Photovoltaic system based on the MPPT Strategy

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Abstract - This paper presents the modeling & simulation of 250 KW grid connected Solar Power Plant on MATLAB. Renewable energy sources, such as solar and wind energy, provide clean, green and abundant energy. As the demand for power increases, so do power outages, so renewable energy can be used to continuously meet a constant load demand. Due to the environmental conditions, the photovoltaic generator is affected and the conversion efficiency becomes low, So a maximum power tracking known as MPPT technique is needed to detect the peak power in order maximize the energy produced. A grid-connected photovoltaic system that utilizes solar energy by converting sunlight into direct current using semiconductors, to be implemented by a fully distributed energy Resource system (DER). This project will include a photovoltaic module and will be monitored and optimized using the Maximum Power Point Tracking (MPPT) algorithm. This article uses the P&O MPPT formula. The P&O MPPT algorithm is based on calculating the PV output power and the power change by sampling the PV current and voltage. In this module, an isolation transformer is used to integrate the single-phase inverter into the grid. The switching of the boost converter and the operation of the single-phase inverter, as well as its integration into the grid, are controlled by PI controllers. A detailed mathematical and technical analysis of the simulated results will be followed using MATLAB software.

***Key Words*:** Distributed Resource System, Maximum Power Point Tracking System, Perturb and Observe Algorithm, Isolation Transformer, Photovoltaic, Boost converter

1.INTRODUCTION

The decline in non-renewable energy sources and the growing problem of environmental pollution have forced us to look for better energy sources. Research into the use of renewable energies such as solar and wind has quickly made it possible to use this abundant amount of renewable energy sources more efficiently and economically in our daily lives. As we all know, solar energy is currently the most common renewable energy source in the world. Distributed generation led by photovoltaic (PV) generation can solve all electricity needs in remote areas. The existing electricity supply system cannot cope with the peak demand for electricity. This is a major concern for many countries. The grid-connected photovoltaic system solves this \roblem considerably. Solar energy is considered the most popular renewable energy source due to its availability 24 hours a day during the day, easy start-up, lower costs and higher efficiency. The output power of photovoltaic modules is intermittent in nature and depends on the intensity of the solar radiation and the temperature of the solar cells [1].

The efficiency of commercially available solar cells is low, it is important to follow the maximum power point. Different MPPT algorithms are used for this. MPPT is used to increase the PV output voltage and to ensure that the PV is operating at the maximum power point. Several MPPT methods have been presented in the literature [2]. In this article, we implement the Perturb & Observe (P&O) algorithm for the MPPT where the voltage is slightly perturbed in the direction of power increase to find the MPPT point [3-4]. A DC-to-DC boost converter increases the input voltage by controlling the circuit [5]. After that, a single-phase grid-tied inverter is used to convert the DC input to AC. We use a low-pass filter to remove high-frequency harmonics that hinder our integration into the network. The integration of the network with the photovoltaic module is done through the implementation of an isolation transformer. All of these converters and circuits require a significant amount of control and tuning to achieve their purpose. In this case, PI controllers are used and therefore set up correctly to give the best results.

II SYSTEM CONFIGURATION

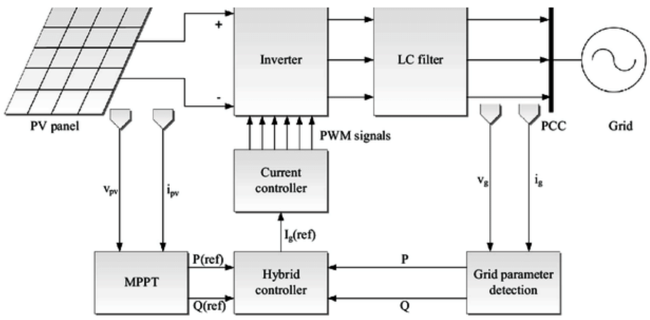

Figure 1: Block diagram of grid-connected PV System

Grid connected PV configuration is shown in Fig. 1 in which the PV is connected to the DC-DC converter which acts to control the DC output of an unregulated DC input by adjusting the duty cycle. The DC-DC boost converter is driven by PWM, which is done by varying the boost converter's duty cycle. The P&O MPPT algorithm generates the duty cycle. A single phase inverter is used to convert PV DC voltage to line frequency AC deformation. A sinusoidal pulse width modulation (SPWM) switching controller is designed to control the inverter [6]. The scheme used also ensures that the intermediate circuit voltage remains stable without changing rapidly, thus ensuring the correct operation of the system. An isolation transformer has grid. The coil provides a high impedance for high-frequency signals and a low impedance for low-frequency signals. Therefore, the series circuit suppresses AC ripples, thereby acting as a low-pass filter.

III MPPT CONTROL OF BOOST CONVERTER

A solar charge controller, also known as a solar controller, is basically a solar charger that is connected between the solar panels and the battery. Its job is to regulate the battery charging process and make sure the The working principle of an MPPT solar charge controller is quite simple: due to the varying amount of sunlight (irradiation) that falls on a solar panel during the day, the voltage and current of the panel change constantly. † To generate the most power, an MPPT scans the panel voltage to find the "sweet spot" or the best combination of voltage and current to produce maximum power. The MPPT continuously monitors and adjusts the PV voltage to generate the most power regardless of the time of day or weather conditions. Thanks to this smart technology, iciency is increased and the generated power can be up to 30% higher than that of a PWM solar charge controller.

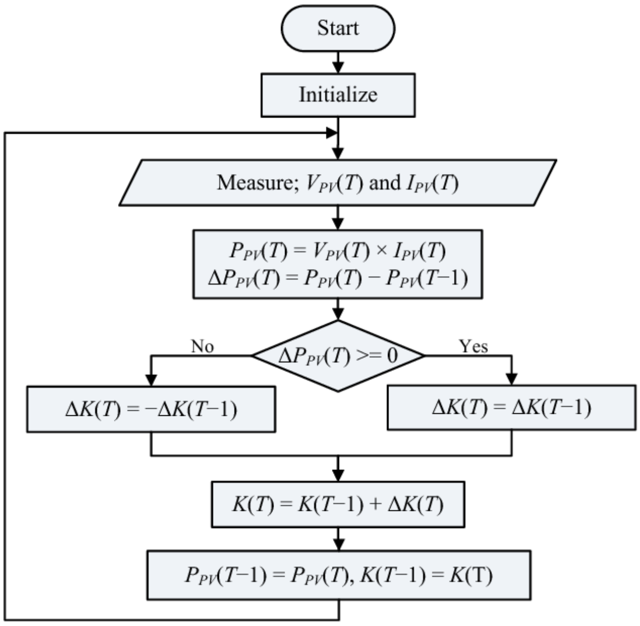

Figure 2: Flowchart of P&O MPPT algorithm

also been designed to synchronize the inverter with the mains voltage. Finally, an LR filter was connected between the inverter and the grid to meet the standard specifications of current harmonics injected into the battery is charged correctly, or more importantly, not overcharged. DC-coupled solar charge controllers have been around for decades and are used in almost all small-scale off-grid solar power systems. A maximum power point tracker, or MPPT, is essentially an efficient DC-to-DC converter used to maximize the output power of a solar system. The first MPPT was invented by a small Australian company called AERL in 1985, and this technology is now used in virtually all grid-connected solar inverters and MPPT solar charge controllers impedance matches the load impedance. The MPPT algorithm performs this impedance matching by adjusting the duty cycle D of the DC-DC converter. The input and output impedances are related to the following expression [7].

In this article, we use the P&O algorithm for MPPT. The principle of this approach is that you perturb the reference voltage by looking at the system's response to determine the direction of the next perturbation. The reference voltage perturbations are made in the direction in which the power is to increase [8].

The control circuit consists of two PI controllers with integral gain of 100 and time constant of 0.1 which are matched by trial and error, the reference voltage is supplied to the first PI controller, which is used for voltage regulation and controls the voltage of the photovoltaic system to the MPPT voltage [9]. This is followed by another PI controller that acts as a flow controller and directs the system flow to the MPPT flow. The output of the control loops is fed to the comparator which generates the PWM to drive the boost converter so that the system operates at the desired maximum power point [10].The control subsystem of the isolation transformer (IT) is one of the important parts of grid-tied inverters because it plays a key role in synchronizing the inverter with voltage, current, frequency and phase angle of the network [11].

III CONTROL SCHEME OF GRID CONNECTED INVERTER

A grid inverter is used to convert direct current (DC) electricity to alternating current (AC) and has the ability to synchronize and communicate with the electrical grid [12]. The operation of the inverter can be divided into two parts: the first part is synchronization and the second part is power transmission. During synchronization, the inverter produces the output in phase with the grid. This is done by sampling the sine wave and setting the phase shift to zero. This non shifted sine wave is rectified and compared with a high-frequency triangle wave to generate an SPWM signal [13]. To produce four sets of switching signals, an AND operation is performed between the SPWM and the square wave signal. Using this type of circuitry and zero phase shifts produces the inverter output voltage.

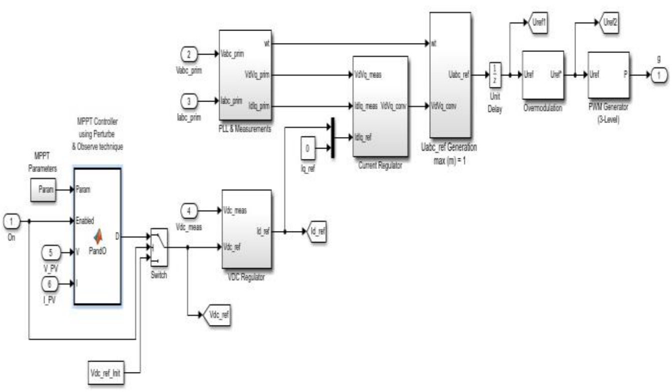

Figure 3: Control scheme of grid connected inverter

IV SIMULATION DESIGN AND RESULTS

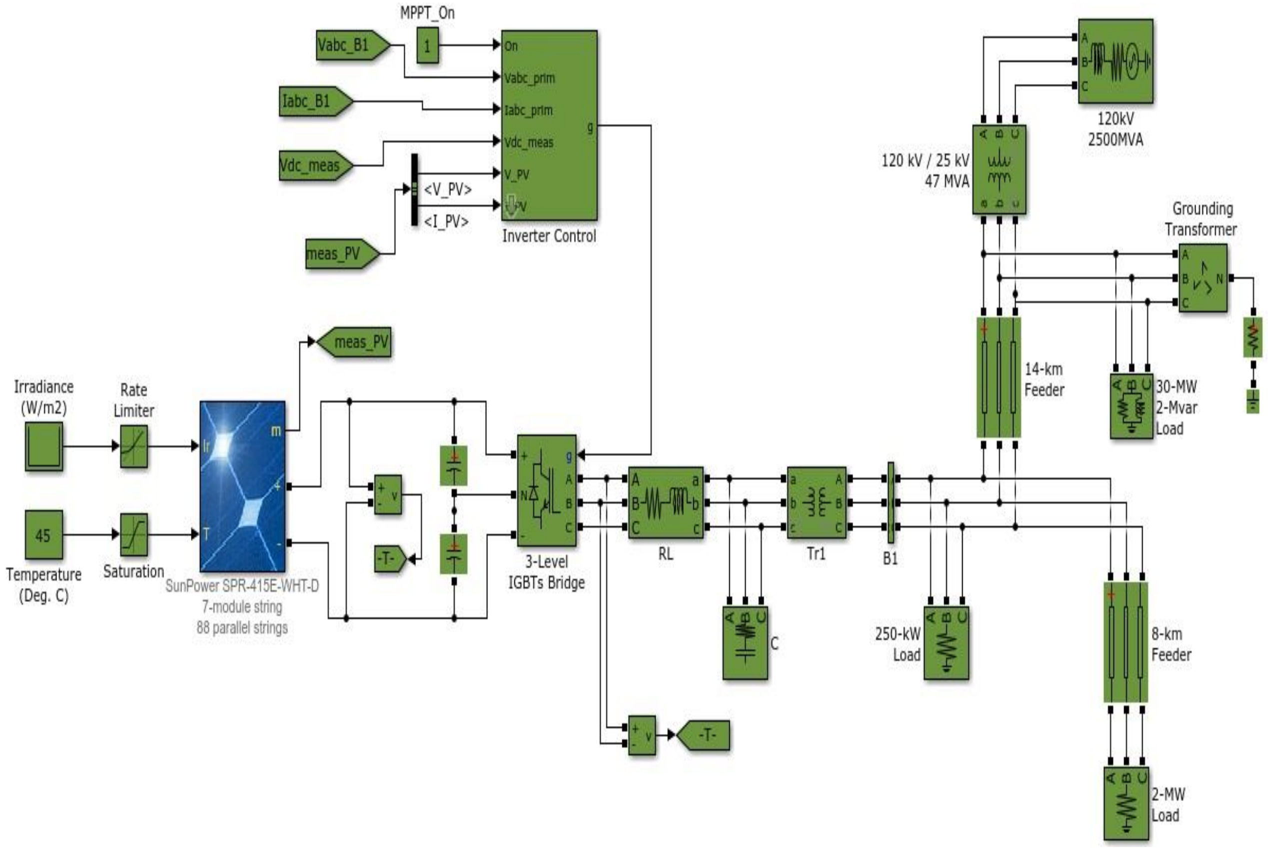

Fig.4. Simulation of Grid connected PV system with P&O as MPPT.

Figure 4 shows the simulation model for the complete system implemented in MATLAB and shows the PV module,the DC-DC boost converter, the P&O MPTT algorithm, with internal control scheme of inverter schemes used to the MPPT. The DC-DC boost converter, a single converter. Phase converter and transformer to synchronize the single-phase converter with the Gird. MATLAB simulation is used SunPower SPR-415E-WHT-D W photovoltaic systems with 7 module string and 88 parallel strings are used to verify the validity of the system and control schemes. The system parameters used to run the simulations are shown in Table 1. The system control has been optimized by setting the controller parameters and using the P&O MPPT scheme. Controlled by the same phase as the network with the inverter and the grid voltage in phase, the zero crossing of both voltages is detected. When the zero-crossing is in contact between the grid and the inverter, it is activated and connects the grid and the inverter. Once the two voltages are connected, the inverter will start sending power into the grid. The inverter used in our application delivers the power from the PV to the grid via the boost converter, where the dc link voltage ensures that there are no power losses [14-15].

Table1: PV System Parameters

Parameters	Valgue
Power of PV system	414.8
Parallel strings	88
Series-connected modules per string	7
Cells per module (Ncell)	128
Open circuit voltage Voc (V)	85.3V
Short-circuit current Isc	6.09A
Voltage at maximum power point Vmp (V)	72.9V
Current at maximum power point Imp (A)	5.69A

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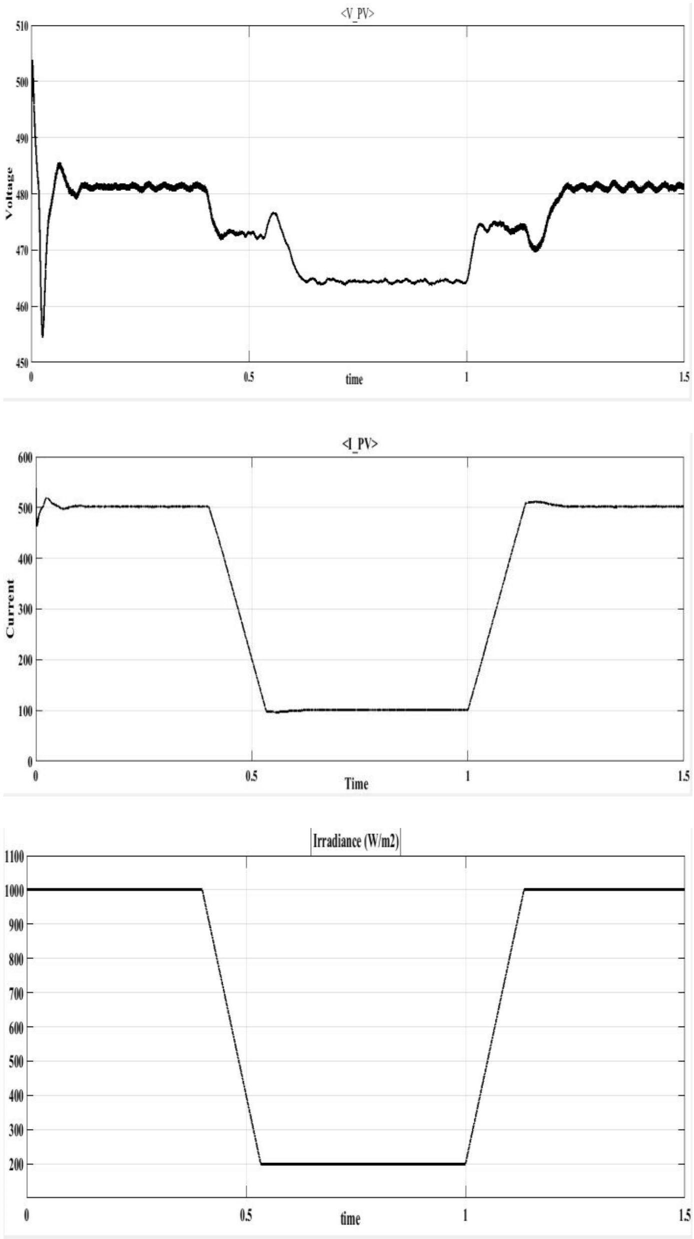
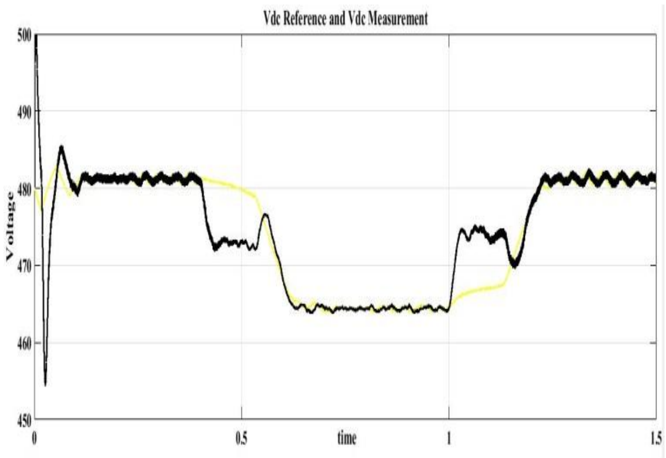
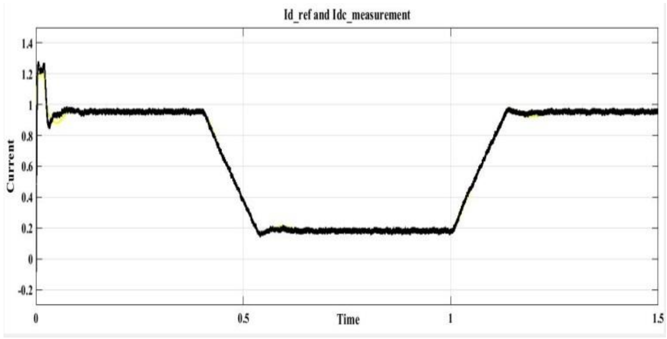


Figure 5: PV Output voltage and current with MPPT for different irradiation level at45Deg.





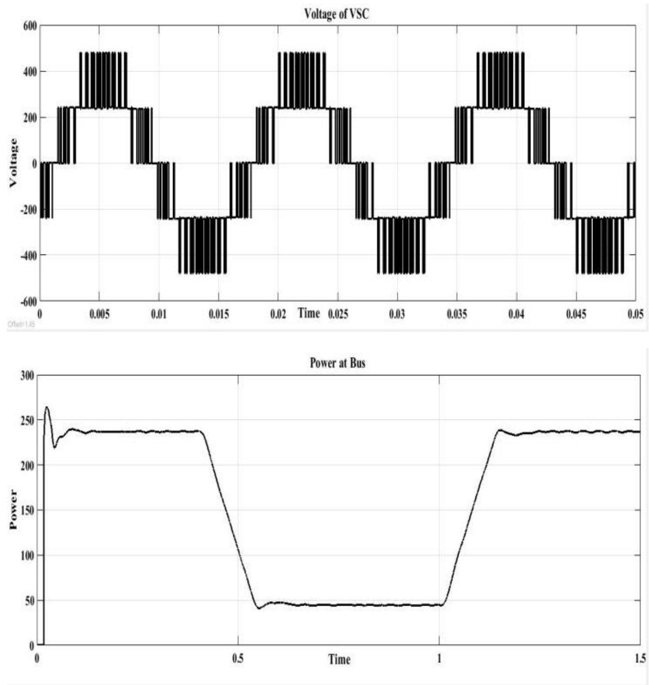


Figure 6: V_{dc}(ref) and Vdc(meas),I_{dc}(ref) and I_{dc} (meas), voltage at VSC and Power flow at bus

CONCLUSION

In this paper describes the 250kW solar PV grid connected PV system designed in MATLAB/Simulink and observes the performance evaluation of the system. Solar PV system is taken as a primary resource Photovoltaic solar plays an important role in the renewable energy domain. With the growing PV sector, it has become crucial to focus on the power conditioning for PV solar. The power conditioning unit required for a PV solar system depends upon the scale of deployment, requirements such as efficiency, reliability, flexibility and control. A grid connected PV System was implemented and its effectiveness was confirmed by the simulation results in MATLAB which gave a sinusoidal wave for the grid current. The system was also operated at the MPPT point by applying the P&O based MPPT algorithm. Control schemes are applied for the single-phase inverter, boost converter and PLL. Control scheme for the MPPT is applied by controlling the duty cycle for boost converter. The single-phase inverter is also synchronized with grid by using phase locked loop.

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