# Modeling & Simulation of Proposed 25 KW Solar PV Power Plant for SSGMCE, Shegaon

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*Abstract*— This paper represents the Modeling and simulation of 100 kW Grid connected Solar PV Power Plant (Installed in SSGMCE Shegaon Campus) on MATLAB. Solar energy is one of the renewable energy which is available in abundant form. Hence it is necessary to utilize solar energy in a proper manner to get the maximum output of it. It is necessary to use more renewable sources to fulfill increasing load demand. Due to change in environmental parameters, PV array gets influenced and conversion efficiency becomes low. So maximum power tracking known as MPPT technique is used. MPPT detect peak power in order to increase energy production. In this paper, the development of PV array model, their synchronization with grid and SIMULINK-MATLAB implement is described. This system consists of the Solar PV array, IGBT inverter, grid connection. Performance of the power plant is also described.
***Keywords:*** MATLAB Simulation, Solar PV Power Plant, MPPT Technique

## I. INTRODUCTION

Energy plays a pivotal role in our daily activities. The degree of development of a country is measured by the amount of utilization of energy by human beings. Energy demand is increasing day by day due to increase in population, urbanization and industrialization. The world's fossil fuel supply will be depleted in a few hundred years. The rate of energy consumption increasing day by day, supply is depleting resulting in an energy crisis. This is called an energy crisis. Hence alternative or renewable sources of energy have to be developed to meet future energy requirements.

A PV system depends on a highly transient energy source & which influence short term and strong variations in output. A storage system is required to store generated energy. Storage batteries are available to store generated energy. This battery storage system has a disadvantage that they lose 1 to 5 percent of energy per hour. This disadvantage of the battery can be overcome by connecting the Solar PV Power Plant to the grid. This is done with the three-phase inverter and synchronizing output of inverter with the grid. Thus, the best way to utilize maximum generated power is the connection of the system with the grid. A various modeling study of PV power system has been conducted to develop a grid-connected solar power plant model using MATLAB.[1]-[3].

Solar energy is one of renewable energy source which is most important. Due to tremendous progress in science and technology our day to day life became more comfortable, easy as well developed, with the increase in development our energy demand also increased; since most of our energy need in day to day life fulfilled by fossil fuel and another conventional source of energy, excess use of this conventional sources arose series questions of environmental pollution, fossil fuel declination and much other serious concern. So to avoid this all ill impact of conventional energy sources, it became an immense necessity of today’s era to shift towards clean, green& renewable form of energy.

Location of India is on the equatorial sun belt of earth. Due to which abundant radiant energy from the sun falls in India. In India, solar radiation and daily sunshine hours are measured by India Meteorological Department (IMD) having a nationwide network of radiation stations. 250-300 days of a year clear sunny weather is experienced in India. The annual global radiation is 1600 - 2200 kWh/ sq. m. which is as good enough as in the tropical and subtropical regions. About 6,000 million GWh of solar irradiance is received in India per year. Government of India is trying to improve the share of energy generation from solar energy and launched Jawaharlal Nehru Solar Mission. Under the First Phase of Jawaharlal Nehru National Solar Mission (JNNSM) to be implemented between 1st April 2010 and 31st March 2013 MW capacity equivalent off-grid solar PV systems and 7 million square meters solar thermal collector area to be installed in the country.[3]-[4].

## II. OVERVIEW OF GRID CONNECTED SYSTEM

Grid-connected solar systems are the most common and widely used. These systems do not need batteries for storage purpose and they use common solar inverters and are connected to the utility grid. Any excess solar power that you generate is exported to the electricity grid and we usually get paid credit for the energy we export. Unlike hybrid systems, on-grid solar systems are shut down during a blackout due to safety reasons. Due to Electrical system damage blackouts usually occurs. If the damaged grid is feeded with solar inverter would risk the safety of the people repairing the faults in the network. The hybrid solar system consists of both storage batteries and grid connection system. During the blackout the hybrid system is able to isolate solar power plant from the grid and supply through batteries.

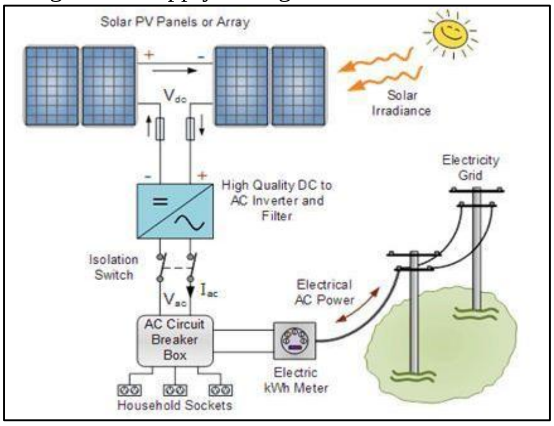

Fig. 1: Block diagram of proposed system

 

Block diagram is shown in above Fig.1. Is the simple representation of grid-connected Solar PV Power Plant. The diagram shows the flow of conversion of energy in various forms. Finally generated power transferred to the grid. The system consists of PV array, High-quality DC to AC inverter, AC breaker box, Energymeter and grid. Inverter helps in conversion of DC to AC conversion and match voltage with the grid voltage. Hence synchronization is done. Thus block diagram gives an idea about solar grid integration.

## III. Maximum Power Point Tracking

MPPT is the technique which tracks or extracts maximum power from the solar PV array. The power output of a Solar PV module changes with change in position of the sun, changes in solar insolation level and with varying temperature. On the PV (power vs. voltage) curve of the module, there is a single maxima point of power. That is there exist a peak power corresponding to a particular voltage and current. Since the module efficiency is low it is desirable to operate the module at the peak power point so that the maximum power can be delivered to the load under varying temperature and insolation conditions. Hence maximization of power improves the efficiency of the solar PV system.

A maximum power point tracker (MPPT) is used for extracting the maximum power from the solar PV module and transferring that power to the load. A dc/dc converter (step up/step down) used for the purpose of transferring maximum power from the solar PV module to the load. Maximum power point tracking is used to ensure that the panel output is always achieved at the maximum power point. Using maximum power point tracker significantly increases the more extraction of energy from the solar power plant.

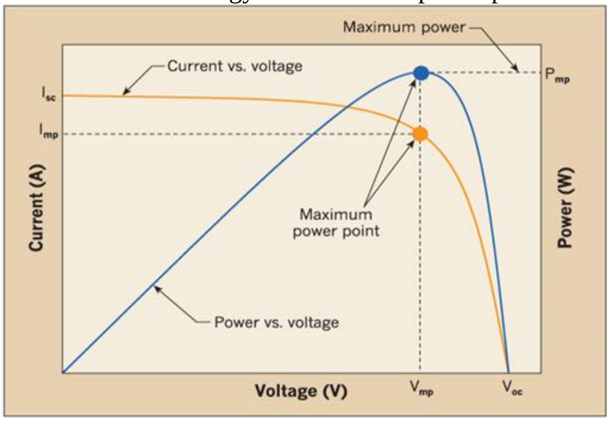


Fig. 2: Power vs. voltage and curve of the solar module

## IV. Matlab Simulation & Results

Here is a detailed model of a 25-kW PV array connected to an 11-kV grid and then ultimately to the main grid via a DC to DC converter and a three-phase three level IGBT/DIODE inverter and through the transformer.

As shown in the simulation model of 25 KW grid-connected solar power plant Fig.3. is designed as the specification which we are going to implement actually when installing the solar power plant. Inputs to the Solar panels are Solar Irradiance and temperature of the surrounding. Solar irradiance date is taken from MNRE (Ministry of Renewable Energy) portal for SSGMCE Shegaon location which is 1000 Watts/m2.

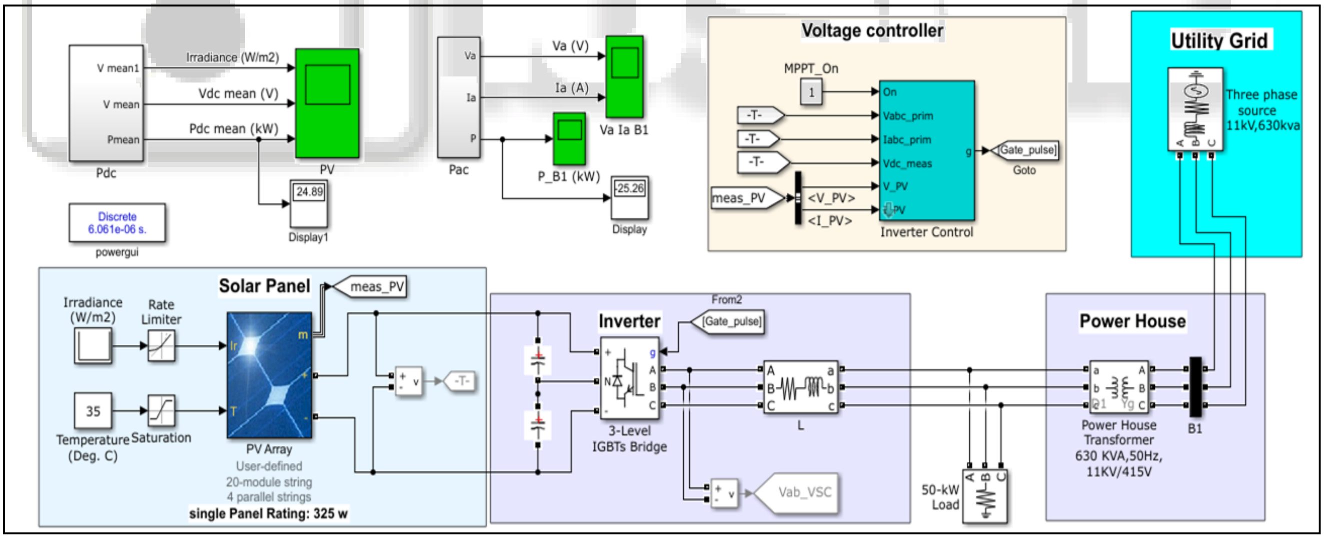


Fig. 3: Simulation Model of 25 KW grid Connected Solar Power Plant.

In MATLAB solar array are specified as the 4 strings in parallel and 20 solar panels in series. This is to fulfill the demand of the inverter that it needs the rated input voltage ranges from 200-800V.By such connections of the solar string 720V DC output voltage generated at no load condition. For the implementation of 25 KW plant 80 solar panels of power rating 325 W are connected.

The generated voltage from solar panels then feeds to Three-phase Three-Level IGBT Bridge Inverter which converts DC to three-phase AC supply. The inverter has the power to make synchronism between the output voltage and the grid voltage.

This is done by Voltage controller block. Voltage controller block is having inputs are grid voltage and current as reference and outputs of the solar array this quantity are compared to generate the gate pulse for the Inverter IGBT triggering purpose. Voltage controller mainly contains Current regulator, Voltage regulator, PLL (phase lock loop) &measurement, reference pulse generator, over-modulation block and PWM Generator (Three Level). It also contains MPPT block at the initial stage to extract maximum power from the solar panels string. The MPPT controller is based on the "Perturb and Observe" technique which is implemented with the help of the MATLAB Shown in Fig.4.

Using a voltage regulator block the gate pulse generated which given to the inverter. Then inverter generates output which is exactly in phase having voltage magnitude equal to the grid voltage supply. An inverter is provided with an input supply of grid to synchronization with the grid.

PWM inverters being more efficient are gradually replacing other types of inverters in various industrial applications. PWM technique uses constant amplitude pulses. The width of these pulses is varied to obtain output voltage control and also to reduce the harmonic content.

Various types of PWM techniques are single pulse modulation, multiple pulse modulations and sinusoidal pulse modulation. With ST-PWM control, the switches of the inverter are controlled based on comparisons of a sinusoidal control signal and a triangular reference switching signal. The sinusoidal control waveform gives the required fundamental frequency as output, whereas the other waveform i.e. the triangular waveform gives the switching frequency of the inverter. A voltage regulator is shown in Fig.4.

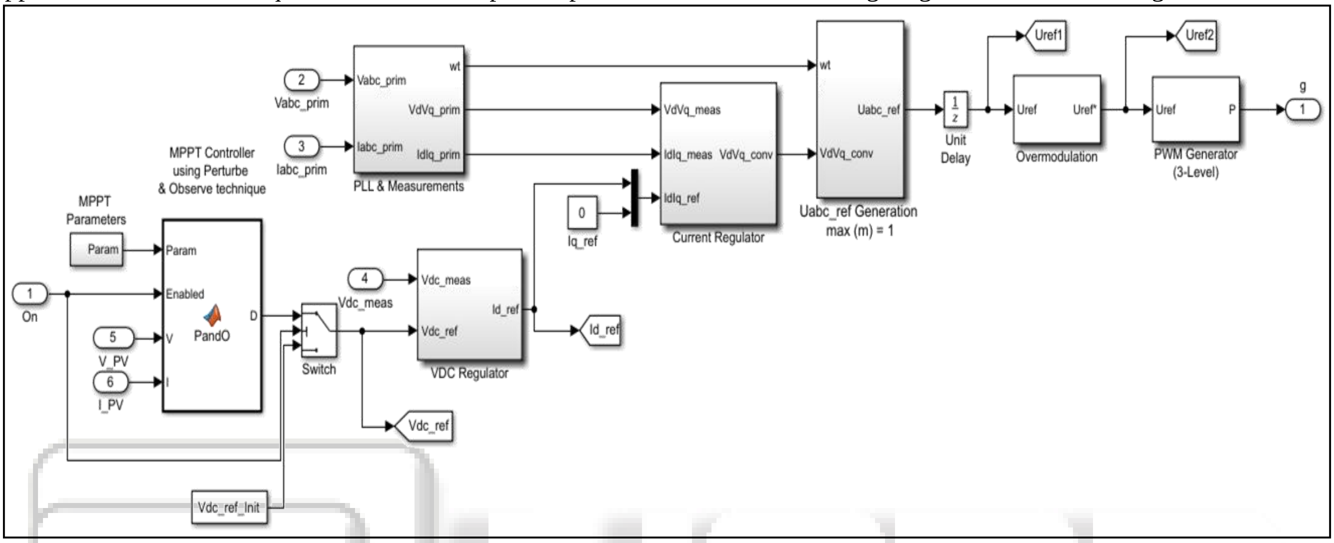


Fig. 4: Inverter Controller Block in MATLAB

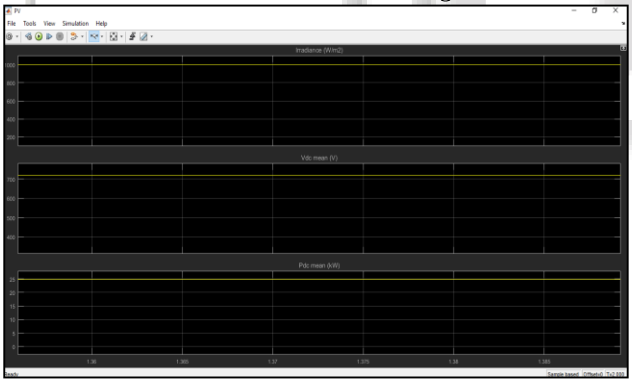

Fig. 5: Solar array parameters

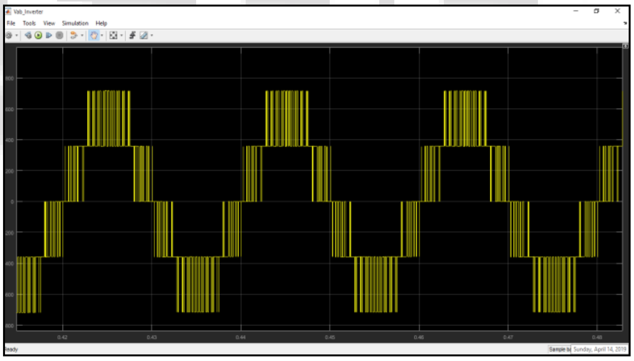

Fig. 6: Voltage waveform of Phase A

From the simulation results, it is clear that from the Fig.3. Generated power at the solar panel is 25KW shown at the display and in the graph of Fig.4. The load connected to the system at the transformer 415 V terminals is of 50 KW. The load is greater than the generated power, hence the system take remaining extra power from the grid. Extra power taken from grid at Bus B1 is shown in Fig.8. As well in the display of simulation diagram (Fig.4).If load connected to the system changes to below the generation capacity, then extra generated power will be feed to the grid by the inverter through the transformer.

This accepting and feeding of power to the grid is known as grid connection and generally called a Net-metering concept. MSEB provide us Net-meter which calculate overall energy accepted and feed to the MSEB grid. Accordingly, our electricity bill is calculated.

Fig.6. Shows the generated voltage by Inverter without application of filters for phase A. This voltage is purely in phase with Grid phase-A voltage waveform. After application, some L and C filters the voltage and current wave somewhat look alike to the grid voltage so that synchronization is done.

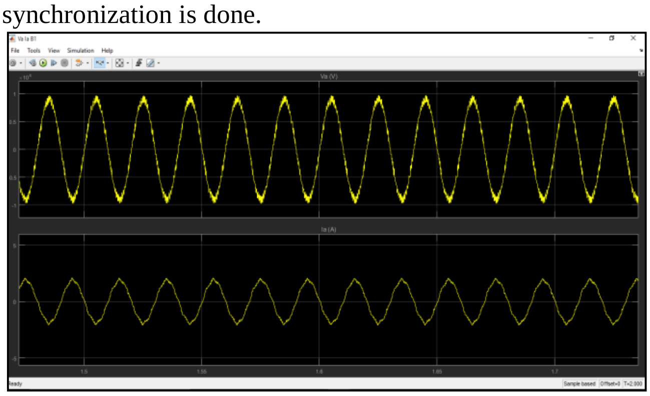

Fig. 7: Voltage and current wave at transformer bus B1

 

The filtered waveform is shown in Fig.7. shows voltage and current waveform at bus B1.

For the implementation of a grid-connected solar power plant, it is important to create a grid as available in SSGMCE campus. MSEB provided three phases 11 kV HT line to SSGMCE campus with sanctioned load of 500 KW. Hence in MATLAB simulation a three-phase source with specification 11 kV,630 KVA, 50 Hz is connected. KVA rating of source is chosen 630 KVA such that Step down transformer available in Campus is of 630 KVA rating.

HT supply is stepped down through Three phases 50 Hz, 630 KVA, 11KV/415V Transformer. Secondary of transformer is synchronized with solar power plant as well as all load of SSGMCE campus connected at this terminal through an available bus in a powerhouse.

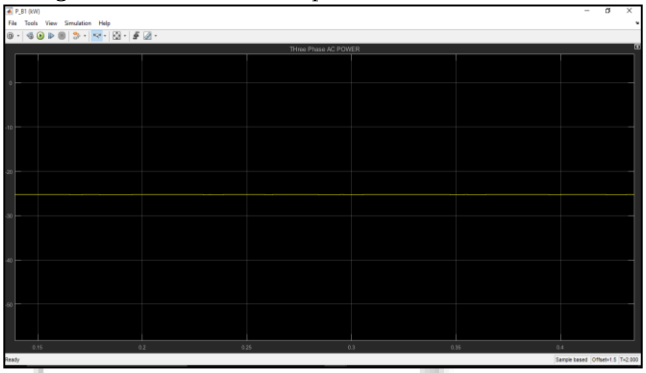

Fig. 8: AC power synchronized with grid

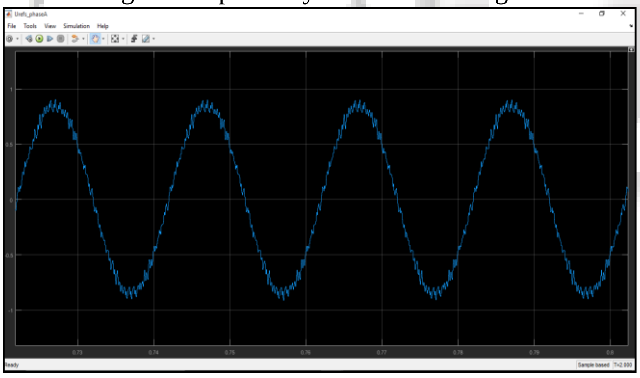

Fig. 9: Reference pulse generated in voltage controller block

## V. Conclusion

This paper proposes modeling and simulation of 25 kW PV solar power plant based on the MPPT technique. MATLAB-SIMULINK R17a is used for the simulation of the proposed system. Simulating 25 kW model simply give us an idea about import and export of power from the solar power plant to the grid and to the system from the grid. Also, the simulation shows synchronization of the solar power plant power with the grid with the help of a voltage controller block. Various graphical results are obtained to understand the nature of voltage, current, the power generated.

Installation of 25 kW grid-connected PV solar power plant in SSGMCE Shegaon campus reduces consumption of energy from a utility grid. Whenever load connected in the campus is greater than the generation capacity of solar power plant then the excess amount of energy is absorbed through the utility grid. In another case when load connected is less than the generated capacity of solar power plant then the excess amount of energy generated will be supplied to the utility grid. This system helps in reduction of the energy crisis. Installation of 25 KW in SSGMCE Shegaon college campus helps to reduce energy crisis inside college campus but also helps in the reduction of pollution.

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