Modelling and Installation of Grid Connected Rooftop Solar PV System

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Abstract: *The 100 kW Grid Connected Roof-Top (GCRT) Solar PV System erected at the SSGMCE, Shegaon Campus is modelled and simulated in this research. One of the renewable energies that is widely accessible is solar energy. In order to get the most out of solar energy, it is vital to use it properly. To meet the rising need for energy, more renewable sources must be used. A PV array's conversion efficiency decreases as a result of environmental parameter changes. Therefore, maximum power tracking, or MPPT, is employed. In order to boost energy production, MPPT detects peak power. Developing a PV array model, synchronising it with the grid, and implementing it in MATLAB Simulink are all covered in this work. This system comprises of a solar PV array, an IGBT inverter, and a grid connection. The power plant's performance is also described.*

Keywords: Grid Connected Rooftop (GCRT) Solar PV System, Maximum Power Point Tracking (MPPT), Renewable sources.

I. INTRODUCTION

Our everyday activities depend heavily on energy. The amount of energy used by people is a good indicator of a nation's level of development. A growing population, urbanisation, and industry are the main causes of the rising energy consumption. In a few hundred years, the world's fossil fuel reserves will run out. An energy crisis has resulted from supply shortages and daily increases in energy use. A crisis in energy is what this is. In order to fulfil future energy needs, alternative or renewable energy sources must be created.

A PV system relies on a very erratic energy source, which affects output's short-term and significant fluctuations. The energy created must be stored using a storage mechanism. To store created energy, storage batteries are one option. One drawback of this battery storage method is that it loses 1 to 5 percent of its energy every hour. By tying the solar PV power plant to the grid, this battery drawback can be avoided. This is accomplished by using a three-phase inverter and synchronizing the inverter's output to the grid. Therefore, tying the system to the grid is the best approach to make the most of the generated power. To create a grid-connected solar power plant model using MATLAB, several modeling studies of PV power systems have been carried out. [1]- [3].

One of the most significant renewable energy sources is solar energy. Since most of our daily energy needs are met by fossil fuels and other conventional sources of energy, excessive use of these sources has led to a number of serious concerns, including environmental pollution, the decline of fossil fuels, and other serious issues. As a result of the tremendous advancements in science and technology, our way of life has become more comfortable, simple, and developed. Therefore, switching to clean, green, and renewable forms of energy has become absolutely necessary in today's world in order to avoid all of the negative effects of conventional energy sources.

India is situated in the equatorial sun belt of the planet. Because of this, India receives a lot of solar energy. The India Meteorological Department (IMD), which maintains a state-wide network of radiation stations, measures solar radiation and the number of hours of sunshine per day in India. India experiences clear, sunny weather 250-300 days out of the year. The annual global radiation is between 1600 and 2200 KWh per square metre, which is sufficient for tropical and subtropical areas. India receives over 6,000 million GWh of solar radiation annually. The Jawaharlal Nehru Solar Mission was started by the Indian government in an effort to increase the proportion of energy produced by solar energy. Off-Grid solar PV systems with MW capacity equivalent and 7 million square metres of solar thermal collector area will be deployed nationwide as part of the Jawaharlal Nehru National Solar Mission's (JNNSM) First Phase, which will run from 1 April 2010 to 31 March 2013. [3]-[4].

OVERVIEW OF GRID CONNECTED SYSTEM

Solar systems that are grid-connected are the most prevalent and used. These systems use ordinary solar inverters and are connected to the utility grid, and they do not require batteries for storage. You can export any extra solar energy you produce to the grid, and you often receive credit for the energy you export. On-grid solar systems, in contrast to hybrid systems, are turned off during a blackout for safety reasons. Blackouts frequently happen because of damage to the electrical system. The safety of the workers fixing network flaws would be put at danger if the damaged grid was fed with solar inverters. The grid connected system and storage batteries are both parts of the hybrid solar system. In the event of a blackout, the hybrid system can disconnect the solar power plant from the grid and supply through batteries.
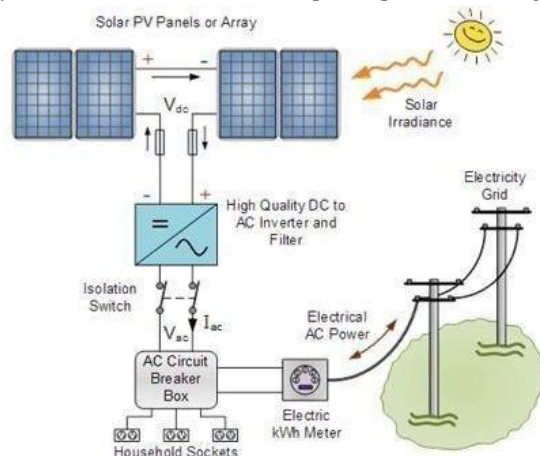

Fig.1. Block diagram of proposed system

The grid-connected Solar PV Power Plant is depicted in a block diagram, which is shown in Fig. 1 above. The flow of converting energy into different forms is depicted in the diagram. Finally, generated energy was connected to the grid. PV array, a top-notch DC to AC converter, an AC breaker box, an energy meter, and a grid make up the system. An inverter aids in converting DC to AC and balancing voltage with the grid. So, synchronization is carried out. The Block diagram, therefore, provides an understanding of 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 maximum 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.
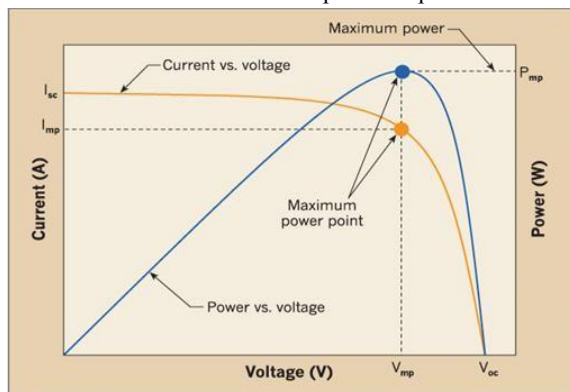

Fig. 2 Power vs. voltage and curve of the solar module

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.

IV. MATLAB SIMULATION & RESULTS

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

The specification that we will actually implement while establishing the solar power plant is illustrated in the simulation model of a 25 KW grid-connected solar power plant in Fig. 3. Solar irradiance and ambient temperature are inputs to the solar panels. For the SSGMCE Shegaon location, the MNRE (Ministry of Renewable Energy) portal provided the solar irradiance data, which is 1000 Watts/m2.
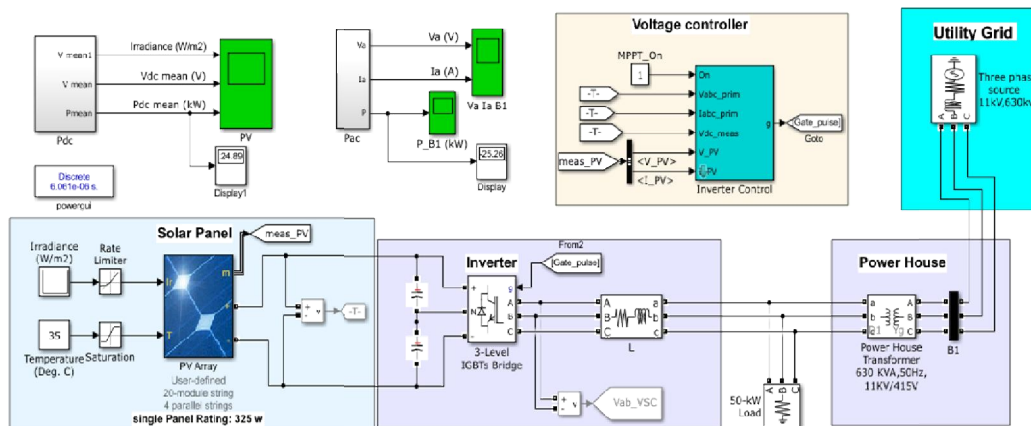

Fig. 3 Simulation Model of 25 KW grid Connected Solar Power Plant

The four strings in parallel and the 20 solar panels in series that make up a solar array are stated in MATLAB. This is done to satisfy the inverter's requirement that its rated input voltage ranges between 200-800V. By making these connections, 720V of DC output voltage from the solar string is produced when there is no load. 80 solar panels with a 325 W power rating are connected to the 25 KW plant.

The three-phase three-level IGBT bridge inverter, which converts DC to three-phase AC power, receives the voltage provided by the solar panels. The ability to synchronize the output voltage with the grid voltage is provided by the inverter.

The voltage controller block accomplishes this. The inputs of the voltage controller block serve as a reference for the grid voltage and current, and the outputs of the solar array are compared to these values in order to produce a gate pulse for the inverter IGBT triggering process. The essential components of a voltage controller are a current and voltage regulator, a phase lock loop and measurement system, a reference pulse generator, an over-modulation block, and a PWM generator (Three Level). To get the most power out of the solar panel string, it also has an MPPT block at the beginning. The "Perturb and Observe" technique, which is the foundation of the MPPT controller, is implemented with the aid of MATLAB, as shown in fig. 4.

Block the gate pulse that is generated and sent to the inverter by using a voltage regulator. When this happens, the inverter produces output that is exactly in phase and has a voltage level that is equal to the grid voltage supply. An input grid supply is given to an inverter so that it can synchronize with the grid. Because they are more effective, PWM inverters are gradually displacing other inverter types in a variety of industrial applications. Pulses with a constant amplitude are used in PWM. These pulse widths are adjusted to manage output voltage and lessen harmonic content.

Single pulse modulation, multiple pulse modulation, and sinusoidal pulse modulation are a few examples of PWM approaches. PWM techniques include sinusoidal pulse modulation, single pulse modulation, and multiple pulse modulation. The output of the sinusoidal control waveform is the necessary fundamental frequency, but the output of the triangular waveform, the other waveform, is the switching frequency of the inverter. In fig. 5, a voltage regulator is
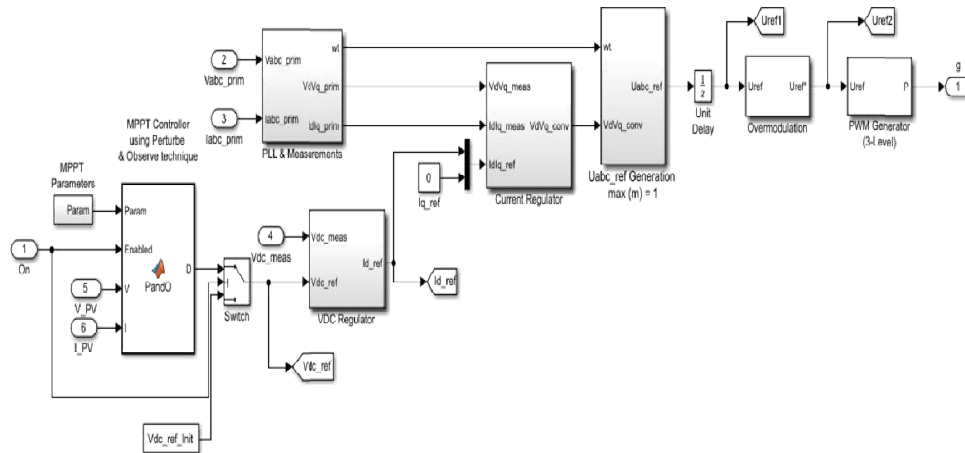
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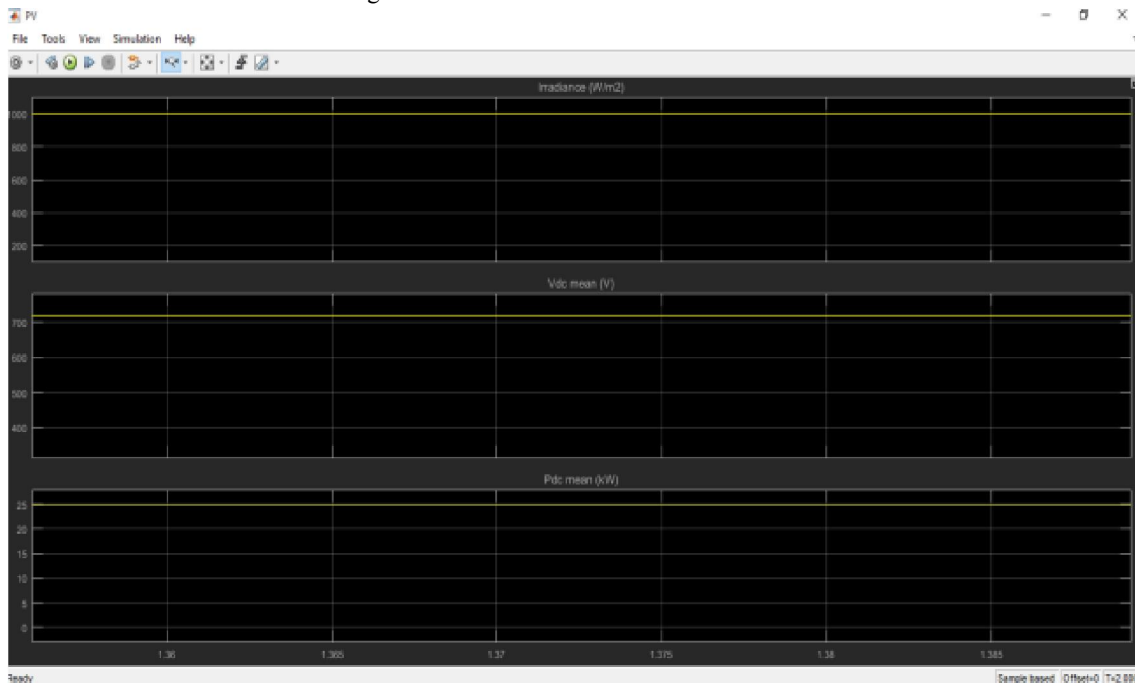Fig. 4 Inverter Controller Block in MATLAB

Fig. 5 Solar array parameters

It is evident from the simulation results shown in fig. 5. According to the display and the graph in fig. 5, the solar panel's generated power is 25 KW. The system's 50 KW load is connected to the transformer's 415 V terminals. Since the load exceeds the power generated, the system draws the remaining excess electricity from the grid. Fig. 7 displays the extra power drawn from the grid at Bus B1. Additionally, in the simulation diagram display fig.4. The surplus power generated will be fed to the grid by the inverter through the transformer if the load linked to the system decreases down below the generation capacity.

A grid connection also referred to as a Net-metering idea, is the act of receiving and supplying electricity to the grid. MSEB offers Net-meters, which determine the total amount of energy consumed and fed into the MSEB grid. Thus, our electricity bill is computed.
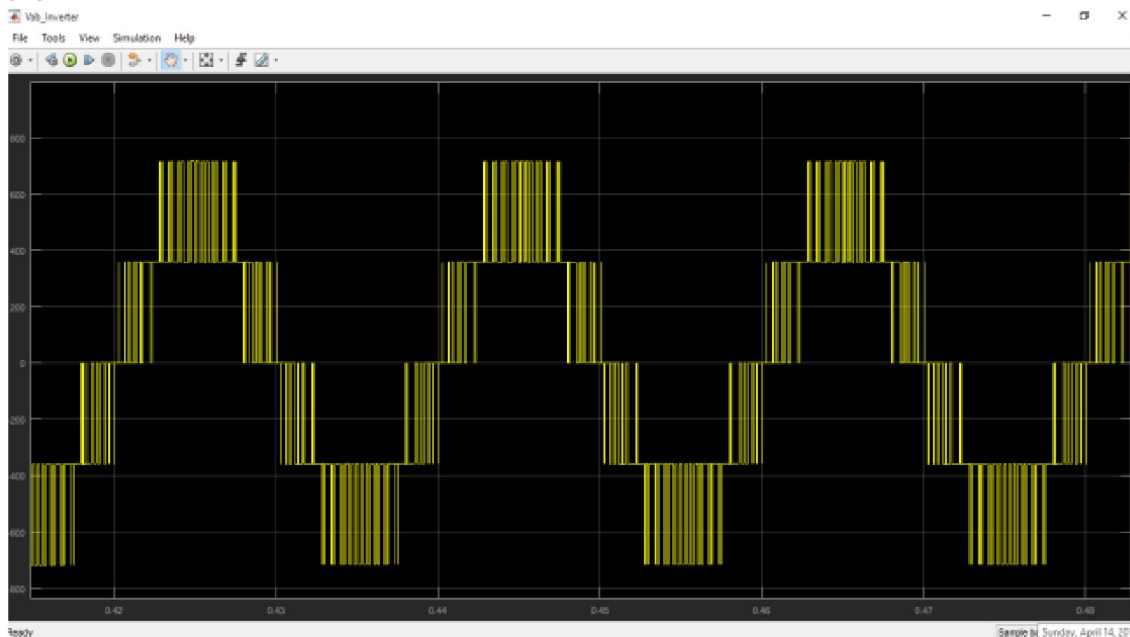
Fig. 6 Voltage waveform of Phase A

The voltage produced by the inverter for phase A is shown in fig. 6 without the use of filters. This voltage's phase relationship to the Grid phase-A voltage waveform is perfect. The voltage and current wave substantially resemble the grid voltage after the application of some L and C filters, allowing synchronization to take place.
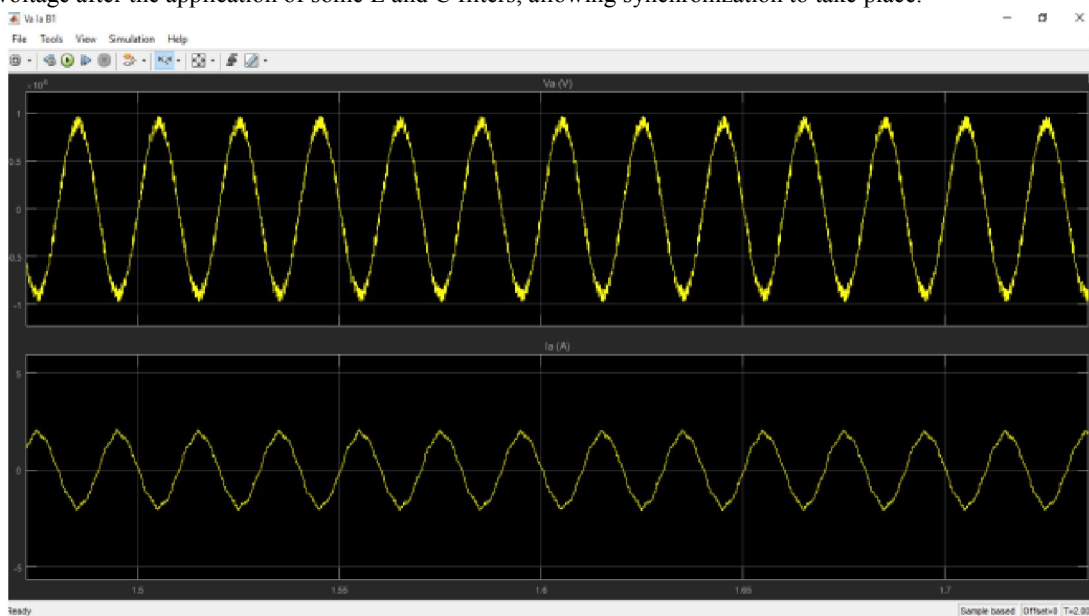

Fig. 7 Voltage and current wave at transformer bus B1

Fig. 7 depicts the waveform after filtering the waveforms for voltage and current at bus B1.

It is critical to establish a grid similar to that found on the SSGMCE campus in order to build a solar power plant that is connected to the grid. The SSGMCE campus received a three-phase 11 kV HT line from MSEB with a sanctioned load of 500 KW. As a result, a three-phase source with the specifications 11 kV, 630 KVA, and 50 Hz is connected in the MATLAB simulation. The source's KVA rating is set at 630 KVA so that the step-down transformer that is accessible on campus also has a 630 KVA rating.

HT supply is stepped down through three phases 50 Hz, 630 KVA, 11KV/415V Transformer. All of the loads on the SSGMCE campus are connected at this terminal through a bus that is available in a powerhouse, and the secondary of the transformer is synchronized with the solar power plant.
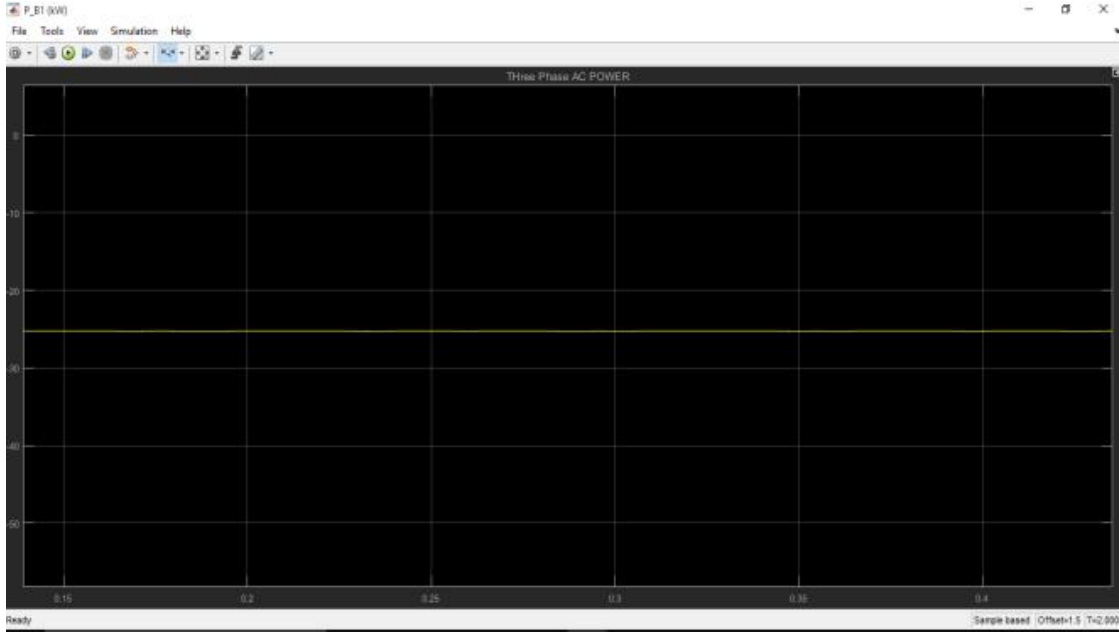

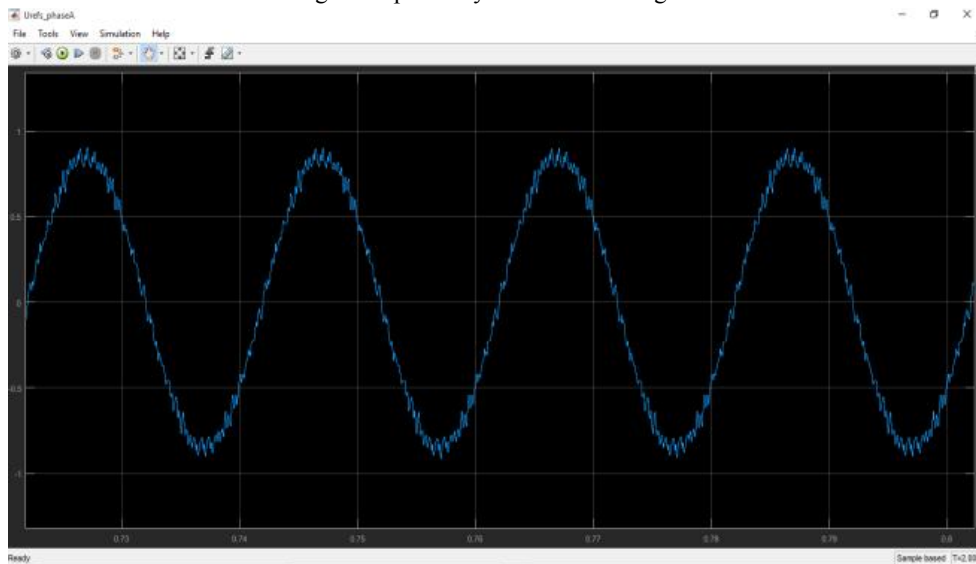Fig.8 AC power synchronized with grid

Fig. 9 Reference pulse generated in voltage controller block

V. CONCLUSION

Based on the MPPT technique, this work suggests modeling and simulation of a 25 kW PV solar power plant. For the simulation of the suggested system, MATLAB- SIMULINK is employed. The 25-kW model simulation merely provides us with a general understanding of the power import and export from the solar power plant to the grid and to the system from the grid. The simulation also demonstrates how a voltage controller block may be used to synchronize the power from a solar power plant with the grid. To better comprehend the nature of voltage, current, and power generated, several graphical representations are obtained.

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The SSGMCE Shegaon campus has grid-connected PV solar power plants that are 25 kW in size, which minimizes the amount of energy that is drawn from the utility grid. Anytime the load connected to the campus exceeds the solar power plant's capability for generation, the extra energy is absorbed by the utility grid. Another scenario is where the load connected is less than the solar power plant's capacity to produce electricity, in which case the extra energy produced will be fed into the utility grid. The energy issue is lessened with the aid of this system. The installation of a 25 KW on the campus of SSGMCE Shegaon College not only aids in the reduction of pollution, but also helps to alleviate the college's energy crisis.

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BIOGRAPHY

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