PERFORMANCE EVALUATION OF SOLAR POWER GENERATION-CASE STUDY OF 1 MW SOLAR PLANT

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ABSTRACT: *Renewable energy sources have received an increasing attention during the last years. radiation is one of the most accessible energy resources and photo-voltaic conversion is a relatively easy and cost-effective solution. The major drawback of WAAREE radiation and photo-voltaic conversion is the low energy density and the low conversion efficiency that can be reduced to unacceptable levels by several factors. Therefore, it is extremely important to monitor the conversion of every photo-voltaic generation plant, in order to keep the overall generation efficiency at an acceptable level for the grid connection. This paper proposes and discusses on inverter system and energy performance of a photo voltaic generation plant connected to the grid.*

Keywords: PV Module, Cell, Inverter, Grid.

1. INTRODUCTION

According to the realization of high efficiency and low cost photovoltaic modules, interest in photovoltaic power generation system has increased over the past decade as a clean and infinite energy. The modules have maximum operating points corresponding to the surrounding condition such as intensity of the sunlight, the temperature of the modules, cell area, and load. When energy is used as a power source, the output power has to be maximized by improving the efficiency of the power conditioning equipment used and implementing an adaptive power controller that automatically tracks the system to the point of maximum power delivered from the panel under all conditions. It is well known that a module consists of several cells connected in series in order to ensure a useful output voltage level. Assuming that the cells are identical, this level is calculated by summing each cell voltage. The functioning parameters [5] of the module depend mainly on the irradiance and on the cells temperature, as well as on the semiconductor material properties. The functioning point of the system is the intersection between the module I-V curve and the load curve. One of the major concerns in the power sector is the day to day increasing power demand but the unavailability of enough resources to meet the power demand using the conventional energy sources. Utilization of renewable energy resources is the demand of today and the necessity of tomorrow. With advancement in power electronic technology, the photovoltaic energy has been recognized as an important renewable energy resource because it is clean, abundant and pollution free.

Grid-connected photovoltaic power systems are power systems energized by photovoltaic panels which are connected to the utility grid. Grid-connected photovoltaic power systems consist of Photovoltaic panels, inverters, power conditioning units and grid connection equipment. Unlike Stand-alone photovoltaic power systems these systems seldom have batteries. When conditions are right, the grid-connected system supplies the excess power, beyond consumption by the connected load, to the utility grid. Residential grid-connected photovoltaic power systems which have a capacity less than 10 kilowatts can meet the load of most consumers. They can feed excess power to the grid, which in this case acts as a battery for the system. The feedback is done through a meter to monitor power transferred. Photovoltaic wattage may be less than average consumption, in which case the consumer will continue to purchase grid energy, but a lesser amount than previously. If photovoltaic wattage substantially exceeds average consumption, the energy produced by the panels will be much in excess of the demand. In this case, the excess power can yield revenue by selling it to the grid. Depending on their agreement with their local grid energy company, the consumer only needs to pay the cost of electricity consumed less the value of electricity generated. This will be a negative number if more electricity is generated than consumed. Connection of the photovoltaic power system can be done only through an interconnection agreement between the consumer and the utility company. Energy gathered by photovoltaic panels, intended for delivery to a power grid, must be conditioned, or processed for use, by a grid-connected inverter. This inverter sits between the array and the grid, draws energy from each, and may be a large stand-alone unit or may be a collection of small inverters, each physically attached to individual panels. The inverter must monitor grid voltage, waveform, and frequency. One reason for monitoring is if the grid is dead or strays too far out of its nominal specifications, the inverter must not pass along any energy. An inverter connected to a malfunctioning power line will automatically disconnect in accordance with safety rules, which vary by jurisdiction. Another reason for the inverter monitoring the grid is because for normal operation the inverter must synchronize with the grid waveform, and produce a voltage slightly higher than the grid itself, in order for energy to smoothly flow outward from the array.

2. ARRAY MODELLING AND CHARACTERISTICS

The power that one module can produce is seldom enough to meet requirements of a home or a business, so the modules are linked together to form an array. Most WAAREE arrays use an inverter to convert the DC power produced by the modules into alternating current that can power lights, motors, and other loads. The modules in a array are usually first connected in series to obtain the desired voltage; the individual strings are then connected in parallel to allow the system to produce more current The array is made up of number of modules connected in series called string and number of such strings connected in parallel to achieve desired voltage and current. The module used for simulation study consists of 36 series connected polycrystalline cells.

2.1 PV Model

The electrical equivalent circuit model of cell consists of a current source in parallel with a diode as shown in Fig. 1

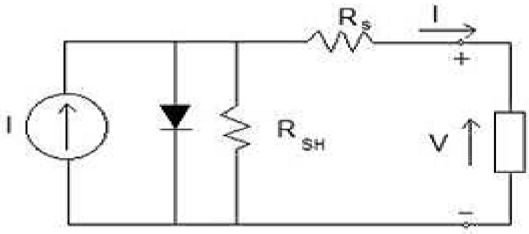


Fig 1: Electrical Equivalent Circuit Model of Cell

A Maximum Power Tracking (MPPT) circuit, which allows the maximum output power of the array. A Power Factor (PF) control unit, which tracks the phase of the utility voltage and provides to the inverter a current reference synchronized with the utility voltage. A converter, which can consist of a DC/DC converter to increase the voltage, a DC/AC inverter stage, an isolation transformer to ensure that the DC is not injected into the network, an output filter to restrict the harmonic currents into the network. The MPPT algorithm, the synchronization of the inverter and the connection to the grid are discussed. Tracking the DC voltage and current allows MPP calculation which gives the inverter to function efficiently.From the electrical equivalent circuit of the cell, output current is given by

$$I_{PV} = I_{Ph} - I_D - I_{sh} \quad (1)$$

Where

$$I_D = I_0\left(e^{\frac{q(V_{PV}+I_{PV}R_S)}{\eta kT}} - 1\right) \quad (2)$$

and

$$I_{sh} = \frac{V_{PV} + I_{PV}R_S}{R_{sh}} \quad (3)$$

The parameters q, η, k and T denote the electronic charge, ideality factor of the diode, Boltzmann constant and temperature in Kelvin respectively. Iph is photocurrent, I0 is diode reverse saturation current, I and V are the output current and voltage respectively. As the value of Rsh is very large, it has a negligible effect on the I-V characteristics of cell or array. Thus (1) can be simplified to

$$I_{PV} = I_{ph} - I_0\left(e^{\frac{q(V_{PV}+I_{PV}R_S)}{\eta kT}} - 1\right) \quad (4)$$

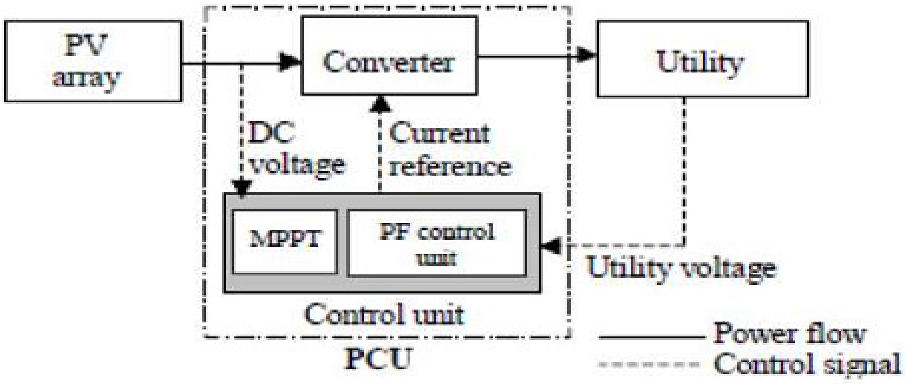
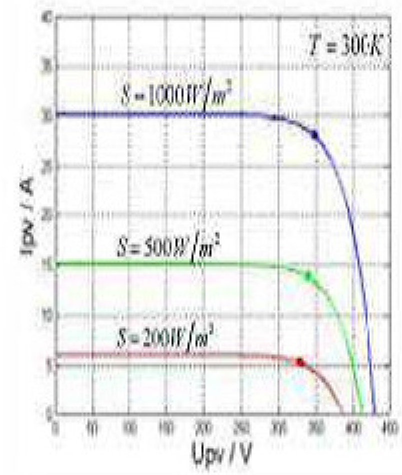


Fig 2: Schematic Diagram of Grid-Connected System

2.2 PV Module Characteristics

The model is simulated using WAAREE MSX60, 60W WAAREE module. The simulated I-V and PV characteristics of the WAAREE module at constant temperature and varying insolation are shown Fig.3 respectively. It can be seen from Fig. 3 that the decrease in isolation reduces the current largely but voltage fall is small. shows that the reduction in insolation reduces the power largely as both voltage and current are decreasing. The effect of temperature on I-V and P-V characteristics of WAAREE module is shown in Fig4. respectively. It can be seen from Fig.4 that the increase in temperature reduces the open circuit voltage largely but rise in current is very small. Fig.4 shows that the increase in temperature reduces the WAAREE output power as the reduction in the voltage is larger than the increase in current due to temperature rise.



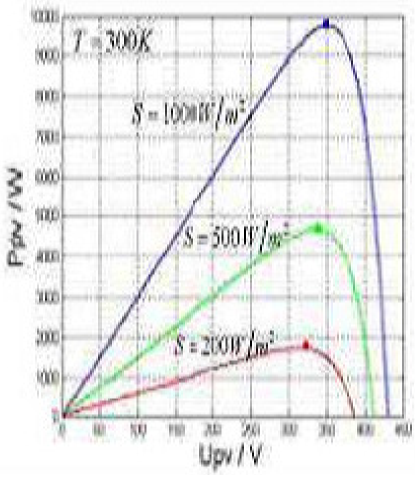


Fig.3 Fig4.

3. DESIGN DETAILS OF THE SYSTEM

3.1 Inverter and Transformer

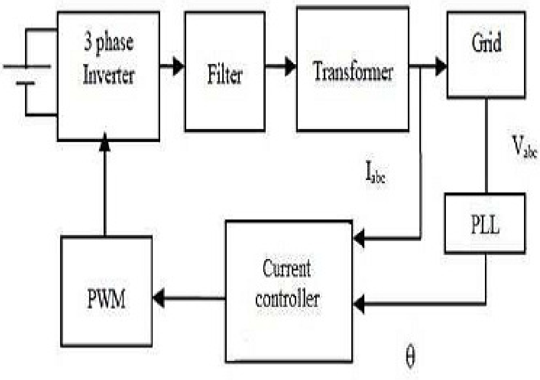


Fig 5: Block diagram of the system

The block diagram of the grid connected inverter system is given in Fig.5. The three phase full bridge inverter topology is the most widely used configuration in three phase systems. The inverter selected is current controlled voltage source inverter that uses IGBT's as the switching element which is operated at a frequency of 1050Hz. Bi-polar PWM technique is used in which switches in each pair are turned ON and OFF simultaneously and output voltage varies between –Vdc and +Vdc, where Vdc is the input voltage of inverter which is considered as battery as shown in block diagram. The output of each leg depends only on input voltage and switch status and is independent of load current. Transformer steps up the inverter output voltage. Besides this, it provides isolation and prevents injection of dc current in to the grid Generally delta-star transformer configuration is used in grid connected system because the third harmonic will get circulated in delta and does not enter in the grid.

3.2 L Filter

Output voltage wave is synchronized with the grid voltage. So the PWM inverter will inject ripple current in to the grid. The output L filter is connected to remove high switching frequency components from output current of inverter. The filter is designed taking into account the following parameters for the grid and inverter. The value of L is design based on current ripple. Smaller ripple results in lower switching and conduction losses.

3.3 Phase lock loop(PLL)

Grid synchronizations plays important role for grid connected systems. It synchronizes the output frequency and phase of grid voltage with grid current using different transformation. Different methods to extract phase angle have been developed and presented in many papers up to now [8] PLL techniques causes one signal to track another one. It keeps an output signal synchronized with a reference input signal in frequency and phase. In three phase grid connected system PLL can be implemented using the current control technique.

SPECIFICATIONS: make WAAREE WS-230, Max power (Pmax) 237.6W, Maximum power voltage (Vmp) 27.9V, Maximum power current (Imp) 8.53A, Short Circuit Current (Isc) 9.11A, Open Circuit Voltage (Voc)36.5V, Maximum System Voltage 1000V. Total Number of panel use- 12288.

Total Panels are divided into 4 Section, each section are of 250KW: 3072 panels are in a sections. All the four cable from four different sections are connected to LT panel (Low Tension Panel) and From LT Panel Cable is connected to transformer.

From transformer cable is connected to HT Panel (High Tension Panel) then from HT panel Cable is connected to 33KV grid via metering panel.

Specifications of Transformer : Total 1 No., 1250 KVA, 415V/33KV

Specifications of Inverter: Total 4 Nos., 250KW each, make - Sunny Central, Model-SC250M,

4. MATLAB/SIMULINK MODELLING AND SIMULATION RESULTS

The Matlab/Simulink model of PV module connected to grid with PLL controlled inverter

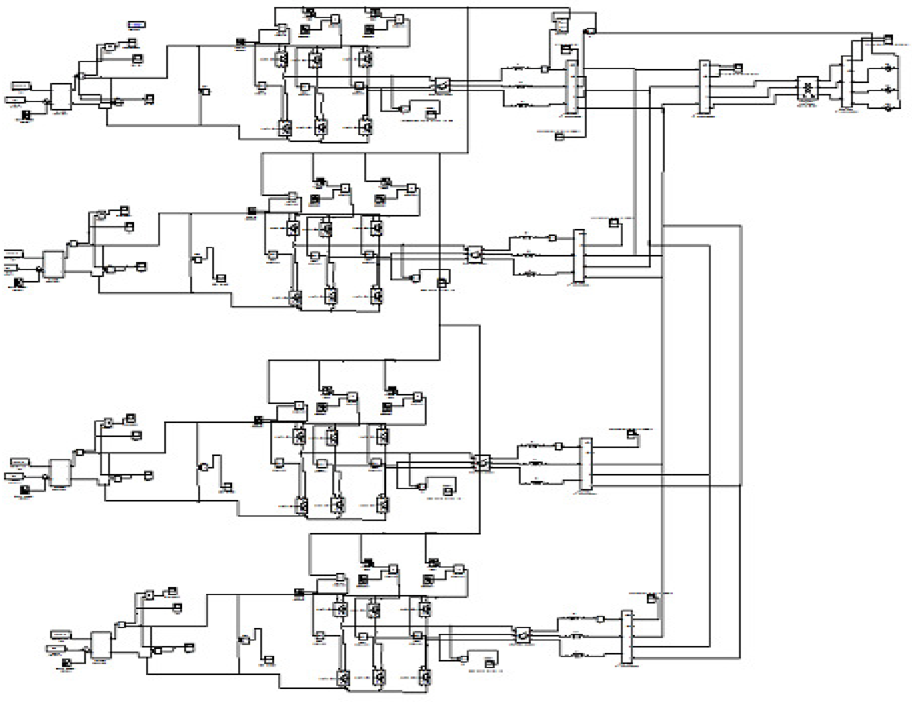


Fig 6: Matlab/Simulink model of inverter connected to the grid

The below wave form shows the 440v of cell voltage

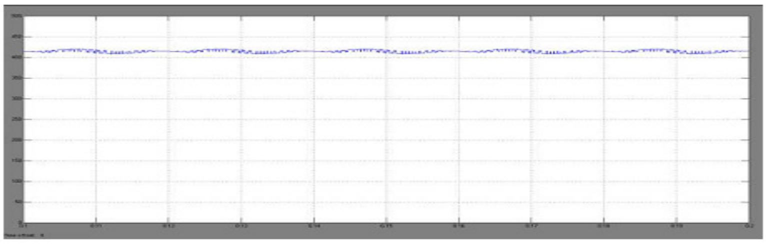


Fig 7: Simulated output wave form of Cell voltage

The below wave form shows the current generated from the Cell

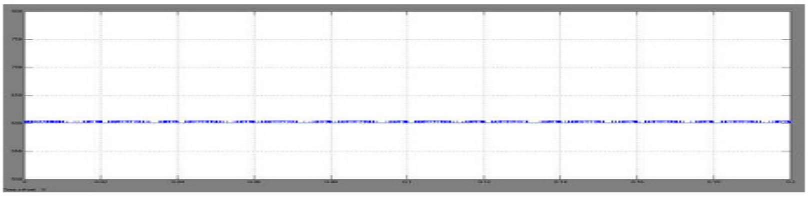


Fig 8: Simulated output wave form of cell current

The below wave form shows the 2.5kw of power

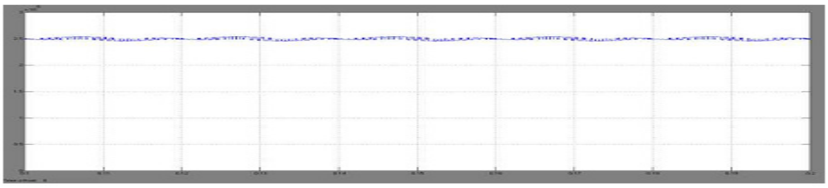


Fig 9: Simulated output wave form of cell power

5. CONCLUSION

The design of the system is carried out for feeding 1.5MVA power to the grid The Inverter is controlled in order to feed active power to the grid, using current controller. PLL is used to lock grid frequency and phase. The phase detection part of PLL is properly used in the three phase system. The inverter output current shows that the THD is within limits and the controlled injected current generates three phase balance current which controls power at the output of the transformer. To simulate the actual grid connected system, the PV model and inverter has been included.

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