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Photovoltaic Energy Conversion System Using Single-Phase Grid-Tied Inverter

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***Abstract* - A single-phase grid connected with a photovoltaic (PV) power system that will provide high voltage gain with state model analysis for the control of the system has been presented. The PV system has been provided with a boost converter which will boost the low voltage of the PV array to high dc-voltage. The output voltage of a PV array is comparatively low thus high voltage gain is necessary for grid-connection and synchronization. A full bridge inverter with bidirectional power flow is used as the second power processing stage, which stabilizes the dc voltage and the output current. Further, a maximum-power-point-tracking method is employed in the PV system to obtain a high performance. This paper proposes a single-phase two stage inverter for grid-connected photovoltaic systems for residential applications. This system consists of a switch mode DC-DC boost converter and a H-bridge inverter. The switching strategy of proposed inverter consists with a combination of sinusoidal pulse width modulation (SPWM) and square wave along with grid synchronization condition. The performance of the proposed inverter is simulated under grid-connected scenario using MATLAB. Furthermore, the intelligent PV module system is implemented using a simple maximum power point tracking (MPPT) method utilizing power balance is also employed in order to increase the systems efficiency.**

Keywords: photovoltaic (PV), grid-connected, maximum power point tracking, MPPT.

I. INTRODUCTION

Only in the last few decades when growing energy demands, increasing environmental problems and declining fossil fuel resources made us look to alternative energy options have we focused our attention on truly exploiting this tremendous resource. Each day more solar energy falls to the Earth than the total amount of energy the planet's 5.9 billion inhabitants would consume in 27 years. To harvest the vast solar energy, it would be desirable if the energy conversion units are simple, reliable, and of low cost and high efficiency. PV-electric power conversion process, power conversion in the electric converter, the control method, and the synchronization or load flow process in connecting the PV generation system to the grid. The SPV mainly consists of the following units: The Photovoltaic array, MPPT boost converter, the inverter, filter and the step-up transformer. The MPPT holds the voltage for Maximum Power Point (MPP) by taking feedback of voltage and current from PV array. Pin pointing the MPP from the VI curves have been addressed by various algorisms, out of which the most common are the Perturb and Observe (P&O) and the Incremental Conductance (INNCOND) Several modifications of these algorithms have been propose d in recent years which intelligently calculates step size, tracks MPP in sensor-less system, apply advanced intelligent fuzzy and neural technique to accurate identify the MPP Taking into consideration, the environmental condition several techniques has also been devised to extract maximum power. The generated DC is being converted to AC by Grid Tied Inventers (GTI) which is being controlled by a Phase Locked Loop and Current controller.

The inverter control matches the frequency and the phase of the output voltage with that of the grid the output of the inverter is boosted up by a step up transformer to reach the gild voltage Laired al proposed a high DC/DC boost topology which will boost the PV voltage to higher range thus avoiding the use of step up transformer AC Capacitor is placed between the DC boost convener and inverter which is responsible to hold a constant DC link voltage. Liu et al devised a compensation method that will reduce the overall DC capacitance and increase the voltage of the DC link. For the power to flow to grid, the following two conditions should be satisfied the Phase of the inviter output of the gild phase the voltage of inverter output shall exceed grid voltage It is to be noted that high voltage deference will facilitate power transfer but such action will result in increase in reactive power intake from the grid. Therefore, a voltage controller is required that shall regulate the inviter output voltage according to gild voltage parameter.

II. METHODOLOGY

Inverters can also be classified as either three-phase or single-phase. Three-phase inverters usually are implemented in large PV power plants, while smaller plants tend to prefer

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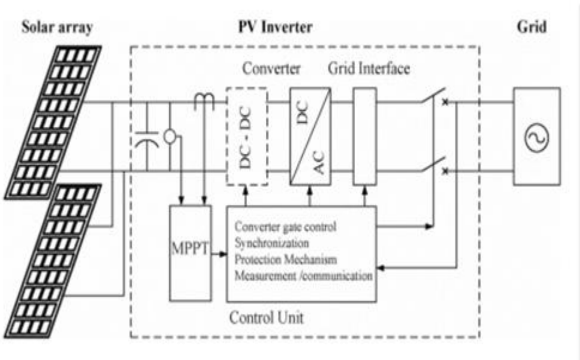
single-phase inverters due to their need for future expansion of plant capacity. The types of inverters and their configuration in the plant also vary widely: central inverters, string and multi string inverters and plants that adopt the team concept for inverters. The single-phase inverter, due to its ability to operate at a relatively low capacity with high efficiency, flexibility for future expansion, and ability to be connected both to single phase and to three-phase connections, has become very attractive for PV applications.



In this we used the grid tied system. Very Simple architecture of this system shown in figure by which we can easily guess the logic and also the idea about its implementation and method of installation of solar system. Grid tied solar system has connection for this system. It include the some component and wiring for this system. The component is PV plates, dc/ac inverter, ac manual disconnect and de manual disconnect, electric meter, and grid. Simple operation of this system simple as per the diagram the solar array absorbs the energy from the sun rays then this energy provided to the dc to ac converter as per name it perform the dc to ac power conversion. This ac power is applied to the ac disconnect this circuit is mainly placed for the safety and switching purpose.

Then it is ready for institutional or residential uses. The connection between this is play main role for the whole system which depend on the wiring of system. The good quality of wiring is necessary for the system performance. Wiring should be colored as per the standard. The wiring standard means the color of wired is used for the connection. It help to understand the connection of the system. Electrical wire insulation is color coded to designate its function and use. For troubleshooting and repair, understanding the coding is essential. The wiring label differs according to AC or DC current. There are several type of wire. The two common conductor materials used in residential and commercial solar installations are copper and aluminum Copper has a greater conductivity than aluminum, thus it carries more current.

The V-I characteristics of the PV array can also be modeled based on the physical behavior of the PV cell. In this case, a PV model called single diode model is widely used. The photovoltaic cell is described as a current source in parallel with a diode. A shunt and series resistors as representation of the cell resistances are then fitted to this branch,

$$I_{pv} = I_{LG} - I_{os}\left[e^{\frac{q(V_{pv}+I_{pv}R_{se})}{A_0kT}} - 1\right] - \frac{V_{pv}+I_{pv}R_{se}}{R_{sh}}$$

$$I_{LG} = [I_{SCR} + K_1\,(T-25)] - \frac{G_a}{100}$$

$$I_{os} = I_{or}\left[\frac{T}{T_r}\right]^3 exp\left[\frac{qE_{Go}}{A_0k}\left(\frac{1}{T_r}-\frac{1}{T}\right)\right]$$

where lpv and Vpv are the current and voltage of the PV cell, R, and Rsh are the serial and shunt resistance, and lLG and los are the light generation current and cell reverse saturation current, respectively. lscu is the short circuit current of the cell at 1000 W/m2 and 25°C of temperature. K is the short circuit temperature coefficient at lscs- T is the cell temperature and Ga is the irradiance at cell surface. lor is the cell saturation current at reference temperature T; EGO is the band gap energy, q is the electric charge, k is the Boltzmann's constant and Ao is the ideality factor of PV cell.

In this simulation, the mathematical model of the PV array is presented using several Simulink blocks in which the implicit equation is solved. An S-Function file is built into a block to solve numerically the PV cell characteristic equation and to synthesize the cell equation as array characteristic equations for PV cell and module. If the PV module contains Ns cells in series and Np cell in parallel,

$$I_{pv} = N_P\left[I_{LG} - I_{os}\left[e^{\frac{q\left(\frac{V_{pv}}{N_S}+\frac{I_{pv}R_{se}}{N_P}\right)}{A_0kT}} - 1\right]\right] - \frac{\left(\frac{V_{pv}}{N_S}+\frac{I_{pv}R_{se}}{N_P}\right)}{R_{sh}}$$

The control circuit contains the maximum power point (MPPT) block, current control, and the synchronizing block. The MPPT mechanism observes the voltage and current output of the PV module, which continuously vary according to the temperature and irradiance level. An incremental conductance algorithm is used, based on the condition that at the point of maximum power, the rate of change of output power to the array voltage is zero.

$$\frac{dP}{dV} = 0$$

$$\frac{dP}{dV} = \frac{d(VI)}{dV} = I + V\frac{dI}{dV} = 0$$

$$I + V\frac{dI}{dV} \cong I + V\frac{\Delta I}{\Delta V} = 0$$

$$\frac{\Delta I}{\Delta V} = -\frac{I}{V}$$

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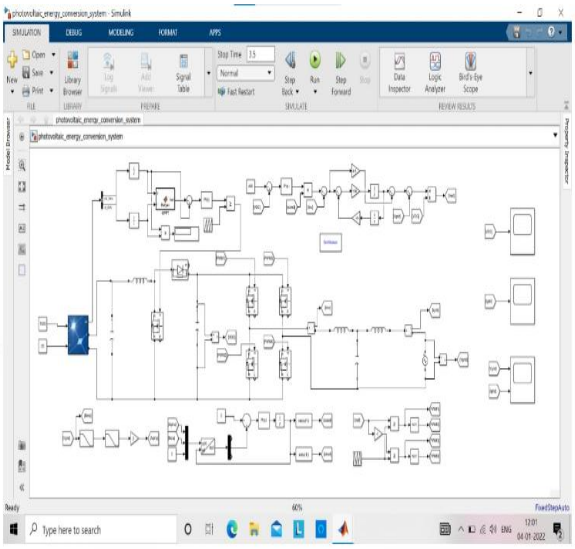
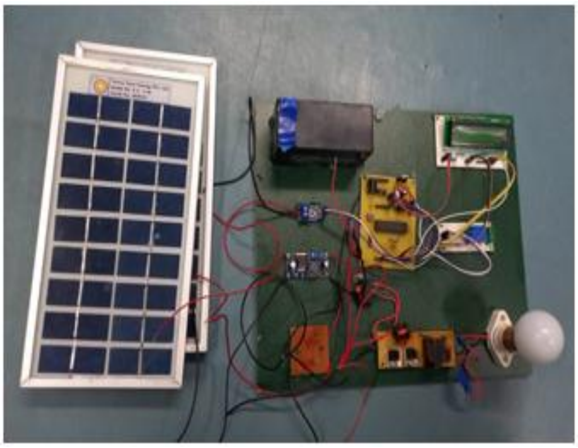
At the maximum power point, the value of incremental conductance L1l/L1V is -I/V As seen from the array characteristic curve:

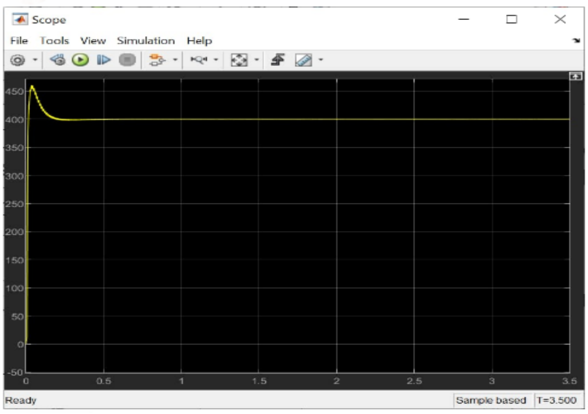
$$\frac{\Delta I}{\Delta V} = -\frac{I}{V} \quad \text{at the MPP}$$

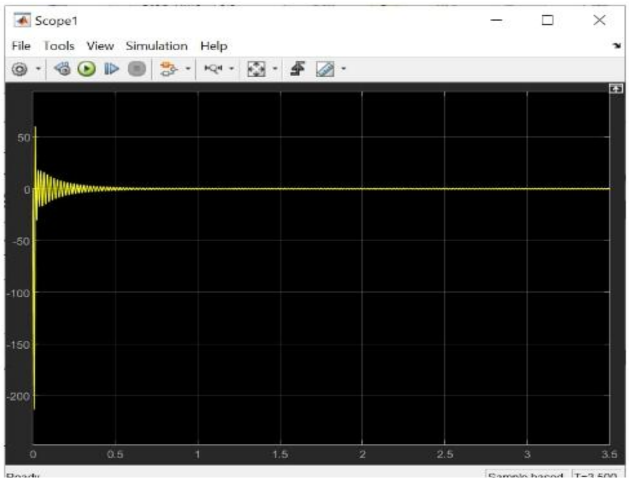
$$\frac{\Delta I}{\Delta V} > -\frac{I}{V} \quad \text{to the left of the MPP and}$$

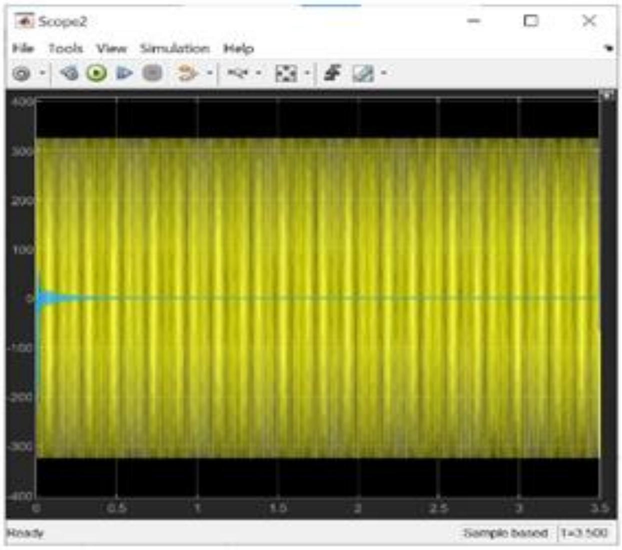
$$\frac{\Delta I}{\Delta V} < -\frac{I}{V} \quad \text{to the right of the MPP}$$











III. RESULTS AND CONCLUSION

The main purpose is to establish a model for the grid-connected photovoltaic system with maximum power point tracking function for residential application. This has investigated several aspects of PV conversion using a single-phase single-stage inverter. Imbalance and current harmonics are the main effect of implementation of single-phase and PV inverters generally in the grid.

PV conversion using a single-phase single-stage inverter. Modeling and simulation of parts of such an inverter using Simulink/Matlab has also been shown. Imbalance and current harmonics are the main effect of implementation of single-phase and PV inverters generally in the grid.

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