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GRID TIE CONTROL OF VSI FOR RENEWABLE ENERGY

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ABSTRACT: This paper presents about grid tie control of voltage source inverter for renewable energy source application. In this paper we are using two types of renewable energy source. Type I is photovoltaic (PV) through maximum power point tracking (MPPT) and Type II is wind energy. Most of (DG) systems are designed to operate with unity power factor and supply real power only to the grid. In this system both the real and reactive power flow capability in wide range.

KEYWORDS – VSI inverter, grid connected system, PV system, PWM inverter.

I. INTRODUCTION

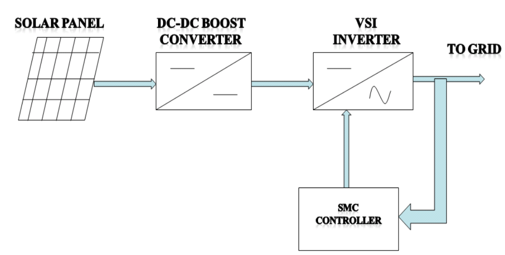
The continuously increasing energy consumption, overloads the distribution grid by creating problems such as outage s, grid instability deterioration of power quality, losses ect. To balance the energy demand and by increasing both real and reactive power is supplied through generation of renewable energy resource such as photovoltaic (PV), wind energy fuel cell, biomass ect. Among this we considered the two sources solar and wind. Because this energy is abundant, pollution free and maintenance free. Since the generated voltage from PV is DC, we need inverter for converting DC voltage from PV to AC before connecting it to grid. Grid is a voltage source of infinite capability. The output voltage and frequency of inverter should be same as that of grid frequency and voltage. The output of grid connected inverter can be controlled as a voltage or current source and pulse width modulated (PWM) voltage source inverters (VSI) are most widely use in PV systems .

Three phase voltage-fed PWM inverters are recently showing growing popularity for multi-megawatt industrial drive applications. The main reasons for this popularity are easy sharing of large voltage between the series devices and the improvement of the harmonic quality at the output as compared to a two level inverter. In the lower end of power, GTO devices are being replaced by IGBTs because of their rapid evolution in voltage and current ratings and higher switching frequency.

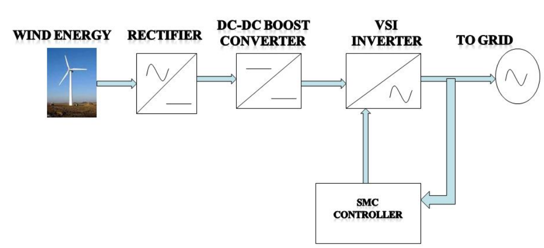
II. DEMANDS AND STANDARDS

In order to connect an inverter to the grid, the generated power has to comply with the standards given by utility companies. The standards like IEEE1547, IEC61727 & ENC61000-3-2 deals with issues like power quality, detection of islanding operation, amount of injected current into grid, total harmonic distortion (THD) etc. IEEE1547 & IEC61727 standard puts the limitation on maximum amount of injected current into the grids. This limits are very small (0.5% and 1% of rated output currents) and such small values are very difficult to measure. This problem can be resolved by introducing a line frequency transformer between inverter and grid [1]. Assuming that both grid voltage and grid current contain only fundamental components and they are in phase the instantaneous power (*p*grid) injected into the grid.

III. DESIGN DETAILS OF THE SYSTEM



Type I System block diagram



Type II system block diagram

a. Type I system

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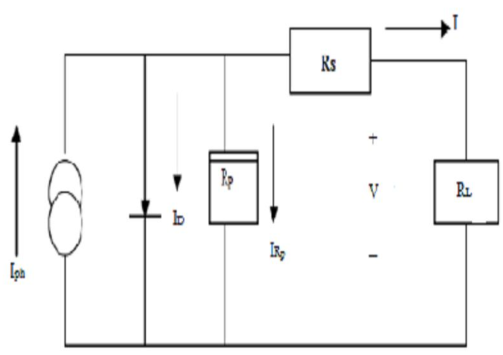
In type one system solar energy is used. Collected energy from solar panel is given to the DC-DC boost converter to boost up the voltage to required level. To connect grid we must have ac voltage so the DC is given to the voltage source inverter. The converted ac voltage is not pure sinusoidal wave. To get a pure sine wave the LCL filter is added to circuit. The *LCL* filter has several benefits, including but not limited to higher high frequency Harmonics.

b. Modeling of PV Cell

A photovoltaic cell is comprised of a P-N junction semiconductor material such as silicon that produces currents via the photovoltaic effect. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current. This electricity can then be used to power a load. Due to the low voltage generated in a PV cell (around 0.5V), several PV cells are connected in series(for high voltage) and in parallel (for high current) to form a PV module for desired output.

c. PV Cell Characteristics

A PV cell can be represented by a current source connected in parallel with a diode, since it generates current when it is illuminated and acts as a diode when it is not. The equivalent circuit model also includes a shunt and series internal resistance. Rs is the intrinsic series resistance whose value is very small. Rp is the equivalent shunt resistance which has a very high value.

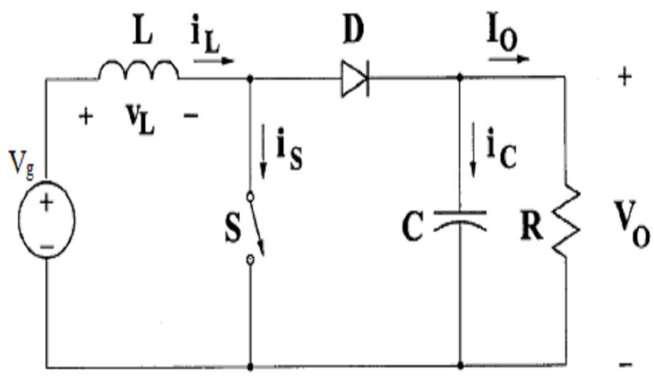


Fig(1) PV Cell Equivalent Circuit

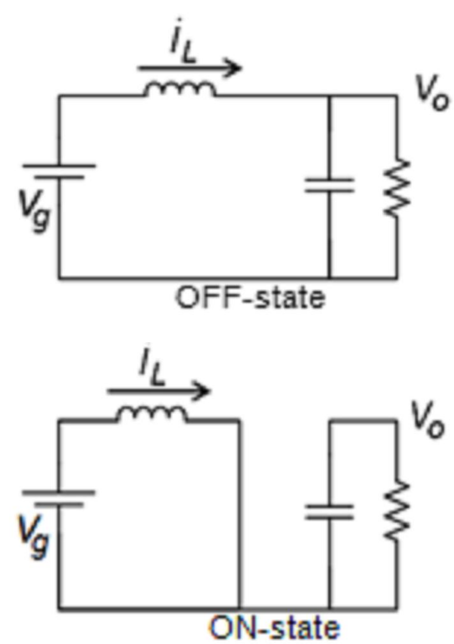
$$I = n_p I_{ph} - n_p I_{rs}\left(\exp\left(\frac{qv}{KTAn}\right) - 1\right) I \qquad (1)$$

d. Converter design

A step up or PWM boost converter. It consists of a dc input voltage source Vg, boost inductor L, controlled switch S, diode D, filter capacitor C, and the load resistance R. When the switch S is in the on state, the current in the boost inductor increases linearly and the diode D is off at that time. When the switch S is turned off, the energy stored in the inductor is released through the diode to the output RC circuit.the Fig(3) shows boost converter.



Fig(3) Circuit diagram of boost converter



When the switch is off, the sum total of inductor voltage and input voltage appear as the load voltage. When the switch is ON, the inductor is charged from the input voltage source Vg and the capacitor discharges across the load.

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The duty cycle,

$$D=\frac{Ton}{t} \text{ where } T=\frac{1}{f}$$

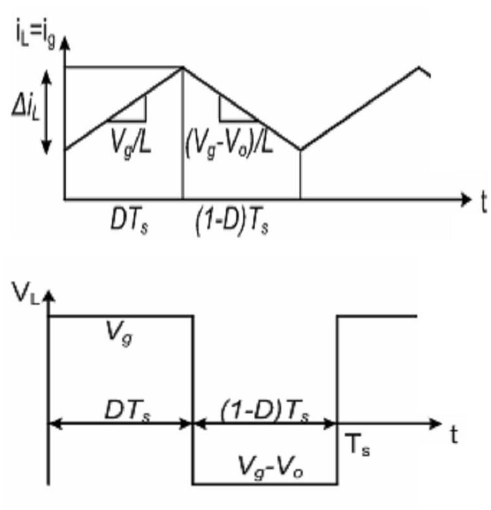

Fig 3(a) Inductor current and voltage waveform

IV. INVERTER DESIGN

Single-phase VSIs cover low-range power applications and three-phase VSIs cover the medium- to high-power applications. The main purpose of these topologies is to provide a three-phase voltage source, where the amplitude, phase, and frequency of the voltages should always be controllable. Although most of the applications require sinusoidal voltage waveforms (e.g., ASDs, UPSs, FACTS, VAR compensators), arbitrary voltages are also required in some emerging applications (e.g., active filters, voltage compensators).Fig (4) shows basic three phase vsi inverter

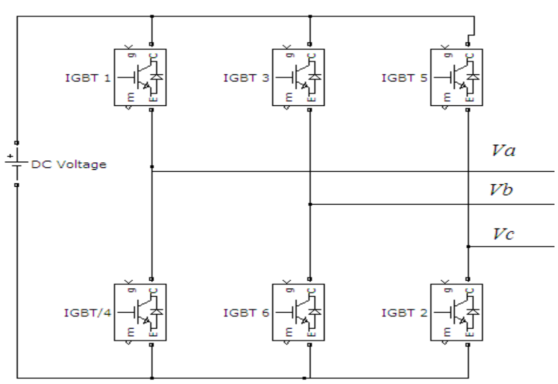

Fig (4) Three phase voltage source inverter

a. SPWM for Three Phase VSI

Output voltage from an inverter can also be adjusted by exercising a control within the inverter itself. The most efficient method of doing this is by pulse-width modulation control used within an inverter. In this method, a fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and this method is termed as Pulse-Width Modulation (PWM) Control.

To increase the amplitude of the load voltage, the amplitude of the modulating signal ***v^c*** can be made higher than the amplitude of the carrier signal ***v^Δ***, which leads to over modulation. The relationship between the amplitude of the fundamental ac output line voltage and the dc link voltage becomes nonlinear as in single-phase VSIs. The three-phase VSI. Ideal waveforms for the SPWM is shown in Fig (4.1 a)

$$\sqrt{3}\frac{v_i}{2} < V_{ab1} = V_{bc1} = V_{ca1} < \frac{4}{\pi}\sqrt{3}\frac{v_i}{2}$$

V. CONTROLLER DESIGN

All the designed controllers for power converters are in fact variable structure controllers, in the sense that the control action changes rapidly from one to another of, usually, two possible d values, cyclically changing the converter topology.

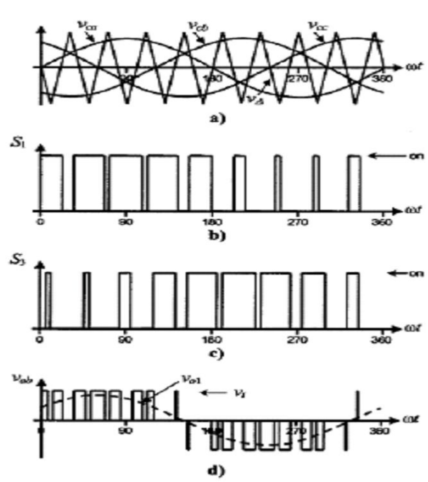

Fig4.1 (a) Waveform of three phase vsi

This is accomplished by the modulator, which creates the switching function d.t . Imposing d.t. . 1 or d.t. 0, to turn on or off the power semiconductors. As a

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consequence of this discontinuous control action, indispensable for efficiency reasons, state trajectories move back and forth around a certain average surface in the state space, and variables present some ripple.To avoid the effects of this ripple in the modeling and to apply linear control methodologies. However, a nonlinear approach to the modeling and control problem, taking advantage of the inherent ripple and variable structure behavior of power converters, instead of just trying to live with them, would be desirable, especially if enhanced performances could be attained.the smc model is shown in Fig(5 a)

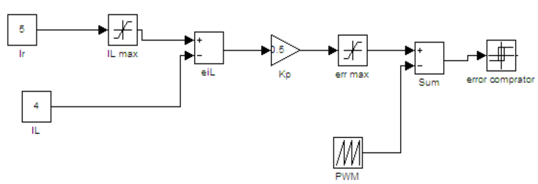

Fig (5 a)SMC model

a. Type II System

The type two system is same as type I system the difference is source only. In type II system wind energy is used. The produced ac voltage from wind turbine is first converted DC voltage, then it given to DC-DC converter ,and then given to voltage source inverter. The LCL filter is added to circuit to reduce the ripples present in the output waveform of inverter and to have a pure sinusoidal waveform.

VI. MODELING OF WIND TURBINE

The wind turbine is the first and foremost element of wind power systems. Wind turbines capture the power from the wind by means of aerodynamically designed blades and convert it to rotating mechanical power. The number of blades is normally three. This mechanical power is delivered to the rotor of an electric generator where this energy is converted to electrical energy. Electric generator used may be an induction generator or synchronous generator. The mechanical power that is generated by the wind is given by:

$$p_w = \frac{\rho}{2} c_p.(\lambda, \theta) A_r V_w^3$$

Where ρ - air density, A - rotor swept area, $Cp\ (\lambda, \beta)$ - power coefficient function, λ - tip speed ratio, β - pitch angle,v w -wind speed.

The wind turbine model is connected to a squirrel cage asynchronous generator. The mechanical energy obtained from the wind turbine is fed to the generator, which convert it to the electricalenergy.

a. Simulation of Type I system

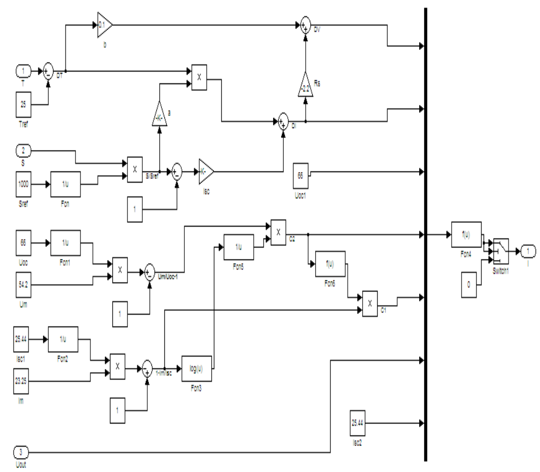

Fig (7) Simulink of pv model

The current to voltage characteristic of a solar array is non-linear, which makes it difficult to determine the MPP. The Figure (7 a) and (7 b) gives the characteristic I-V and P-V curve for fixed level of solar irradiation and temperature.

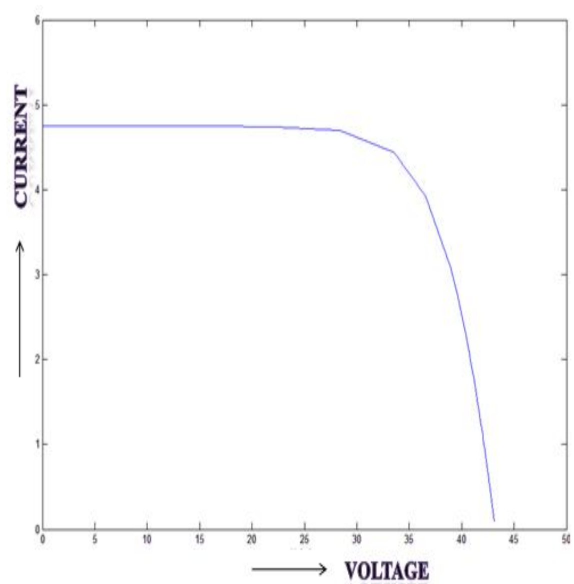

Fig (7 a) I-V curve characteristics

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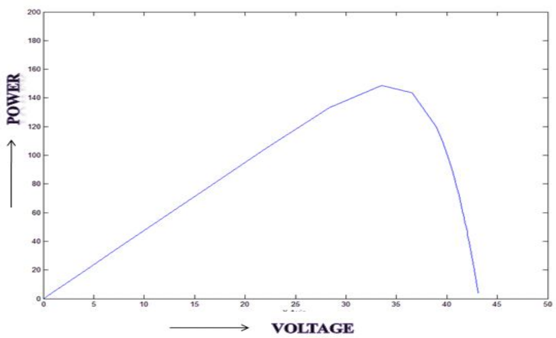


Fig (7 b) PV curve characteristics

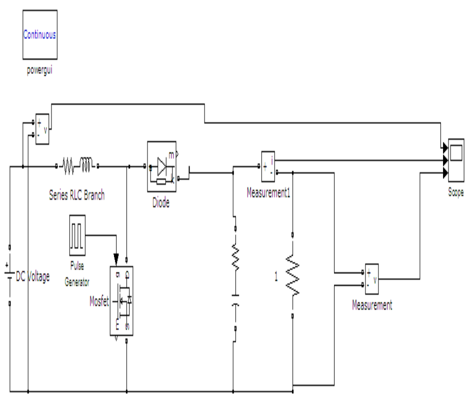


Fig (7c) Simulink of boost converter

The simulink model of pv panel is shown in Fig (7) and simulink model of boost converter is shown in Fig (7c).the output wave form of boost converter is shown in Fig (7d).the simulink model of wind turbine and output waveform is shown in Fig(7e)and (7f).

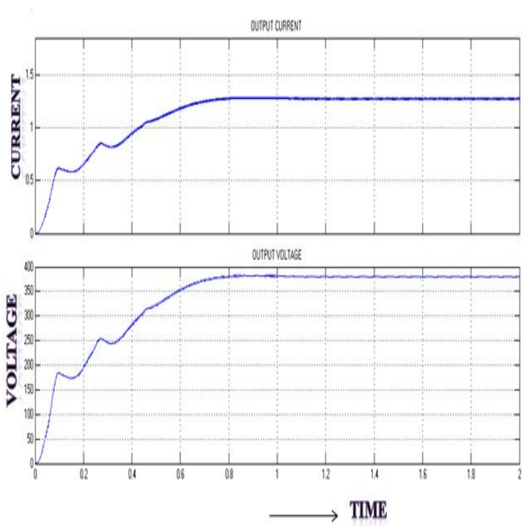
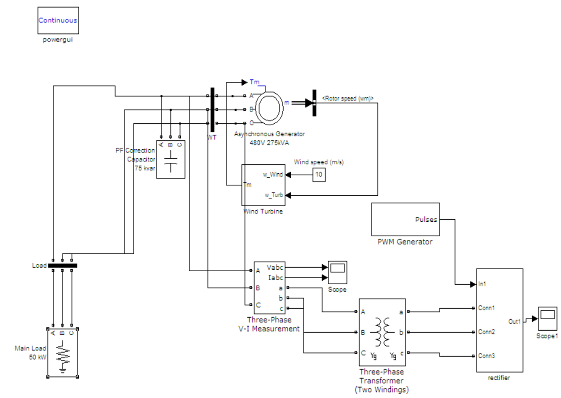


Fig (7d) Output waveform of boost converter.



Fig(7 e) Simulink model of windturbine

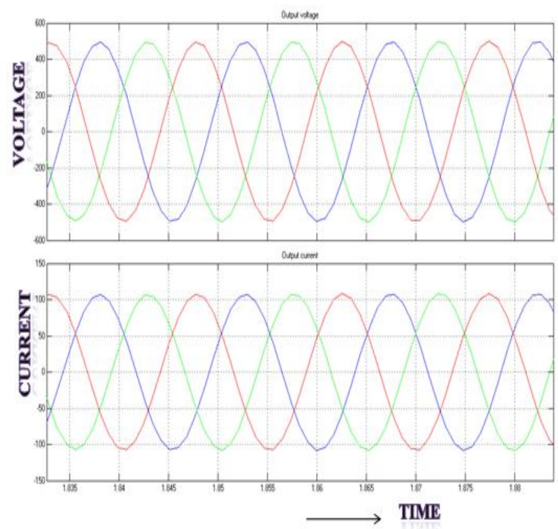


Fig (7 f) output waveform of wind turbine

VII. CONCLUSION

This paper presents a grid tie control of voltage source inverter for a two types of renewable energy source. By using this method the pure active and reactive power is delivered to the grid. This method is implemented is MATLAB simulink model and Detailed analysis is given.

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IX. BIOGRAPHY

P.Pugazhendiran was born in Tamilnadu, in 1979. Received his UG degree in Electrical and Electronics Engineering from Coimbatore Institute of Technology (CIT) in 2001 and PG degree from College of Engineering Guindy (CEG), Anna University, Chennai in 2009. His research interest includes Power quality issues, Power Converters, Renewable energy sources, Electrical Drives. He Published More than 5 Engineering Books. Teaching Experience over a decade. He published more than 10 National and International journals He is currently working at I.F.E.T College of Engineering as Associate Professor and head of the department. He is a life member of ISTE.

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