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Modeling Of PV and Wind Energy Systems with Multilevel Inverter Using MPPT Technique

M.Kowsalya [1], K.Suganyadevi[2], N.Loganayaki[3]

Abstract -The recent upsurge is in the demand of hybrid energy systems which can be accomplished by the use of the Solar and Wind energy systems with Maximum Power Point Tracking technique to track maximum power for various values of irradiance. The implementation of boost converter is to enhance the incoming voltage from PV by maintaining the constant reference voltage for various values of Irradiance (50, 100, 150, 500, 750, and 1000). These circuits are controlled are controlled by means of PI controller. A Novel Single-Phase Five-level inverter of solar energy system is proposed using coupled inductors where the voltage balancing problem is eliminated. Modeling of stand-alone self-excited induction generator is used to operate under variable speeds prime mover. The proposed dynamic model of wind energy conversion system has been designed with three phase controlled rectifier, inverter with control system and a utility grid. These systems are simulated to operate under fixed speed and fixed voltage by means of State Space Model. And the control system is employed which includes low pass filter, PLL and the impedance circuit. The feedback of low pass filter is given to the current controller so that the noise can be filtered out. The efficient extract of energy from solar and wind energy conversion system is utilized by the grid system.

Index Terms: **PV multilevel inverter, grid connected inverter, coupled Inductors, self-excited Induction Generator.**

I. INTRODUCTION

The maximum solar, wind energy can be utilized by the use of power electronic devices. For the efficient utilization of energy from solar (Photovoltaic), multilevel inverter is been proposed the incoming energy from solar is converted into AC power by multilevel inverter which obtains sine wave with less distortion. The energy source from wind energy system is not constant it may vary with frequency. In order to obtain energy with constant frequency, voltage and to interconnect with standard electric grid, inverter with control mode is required. The inverter can operate either as a current source or voltage source.

II. MODELLING OF PV SYSTEM

The most commonly used model for a PV cell is the one-diode equivalent circuit as shown. Since the shunt resistance R_{sh} is large, it normally can be neglected. The five parameters model simplified into four parameter model as shown in FIGURE IIThis simplified equivalent circuit model is used in this modeling.

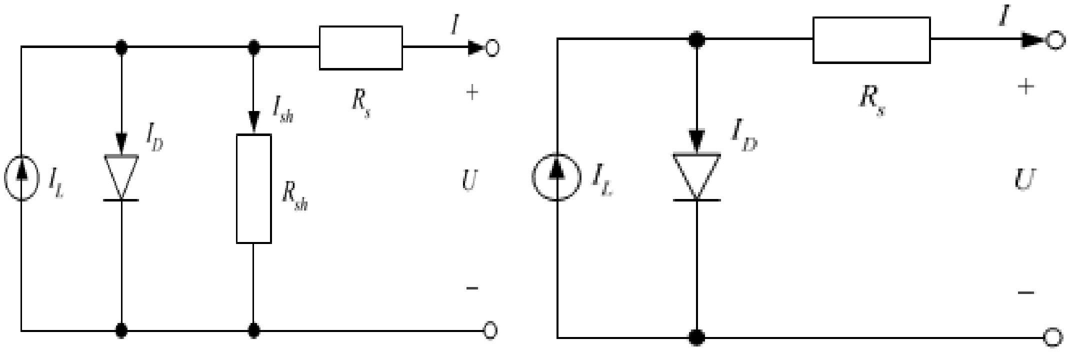

Fig.1. Simplified four parameters model.

The load current depends on light current and diode current, which is expressed as,

$$\mathbf{I = I_L - I_D = I_L - I_0 \left[\exp\left(\frac{U+IR_S}{\alpha}\right) - 1\right]} \qquad \mathbf{(1)}$$

where

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I_L = light current (A), I_0 = saturation current (A) ,I = load current (A) ,
U = output voltage (V) , R_s = series resistance (ohm),α = thermal voltage timing completion factor (V).

Light Current, I_L

The light current which depends on irradiance and temperature is given as,

$$I_L = \frac{\Phi}{\Phi_{ref}}[I_{L,ref} + \mu_{I,Sc}(T_c - T_{c,ref})] \qquad (2)$$

Where φ= irradiance (W/m2) ,φ_{ref} = reference irradiance (1000 W/m2 is used)
I_L, ref = light current at the reference condition (1000W/m2 and 25 °C)
Tc = PV cell temperature (°C), Tc,ref = reference temperature (25 °C)
$\mu_{I,SC}$ = temperature coefficient of the short-circuit current (A/°C)
Both $I_{L,ref}$ and $\mu_{I,SC}$ can be obtained from manufacturer data sheet.

Saturation Current, I_0

$$I_0 = I_{0,ref}\left(\frac{T_{C,ref}+273}{T_C+273}\right)^3 \exp\left[\frac{e_{gap}}{q\alpha_{ref}}\left(1 - \frac{T_{C,ref}+273}{T_C+273}\right)\right] \qquad (3)$$

where
I_0, ref = saturation current at the reference condition (A)
e_{gap} = band gap of the material (1.17 eV for Si materials)
Ns = number of cells in series of a PV module
q = charge of an electron (1.60217733×10-19 C)
α_{ref} = the value of α at the reference condition.

Thermal Model of PV

The temperature plays an important role in the PV performance as shown in equations (1) to (3). Therefore, it is necessary to have a thermal model for a PV cell/module. The temperature of the PV module varies with surrounding temperature, irradiance, and its output characteristics depends on the following equation and can be written as

$$C_{PV}\frac{dT_c}{dt} = k_{in,PV}\Phi - \frac{U\times I}{A} - k_{loss}(T_c - T_a) \qquad (5)$$

where CPV = the overall heat capacity per unit area of the PV cells [J/ (°C·m^2)]
$k_{in,PV}$ = transmittance-absorption product of PV cells, k_{loss} = overall heat loss coefficient [W/(°C·m^2)], T_a = ambient temperature (°C) ,A = effective area of the PV cell/module. Based on the dynamic equations for a PV module consisting of 153 cells in series has been developed using MATLAB/Simulink. Figure IIshows the block diagram of the PV model. The input quantities (solar irradiance φ and the ambient temperature together with manufacturer data are used to calculate the four parameters.

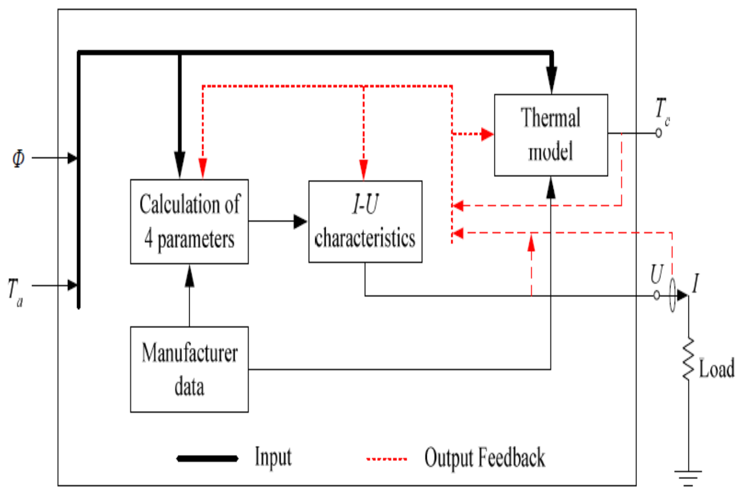

Fig 2. Block diagram of the PV model built in MATLAB/Simulink

III. WIND ENERGY CONVERSION SYSTEM

Wind energy conversion system consists of wind turbine three phase controlled rectifier, inverter with control system and grid system. The output of wind turbine is rotational speed which is coupled with Induction Generator, we obtain AC energy from the induction generator and converted into DC by means of three phase controlled rectifier, variable frequency and variable voltage is converted into fixed voltage and fixed frequency by the use of inverter with control system. The efficient energy from the above mentioned device is utilized by means of grid system.

As we obtain energy from wind energy system and which is not constant it may vary with wind speed and frequency of operation. In order to interconnect with standard electrical grid, inverter with current control mode is required to eliminate frequency fluctuations. The inverter can operate either in current controlled mode or in voltage controlled mode. Implementation in most cases is based on voltage controlled mode. The operation of the inverter with current controlled mode is explained with the below block diagram.

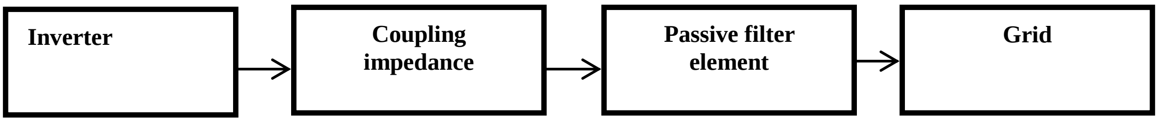

Fig 3. Block diagram of inverter with current controlled mode

Figure III shows the inverter with the current control element and it is a complex dynamic system that interacts with grid to attenuate the switching frequency components of voltage passive filter element is used. When inverter and grid system is combined it is necessary to check the stability limits of the inverter and grid combination. There are two models to calculate the stability they can be either component level models or state space model. Component level model describes the evaluation of inverter performance during every switching action. It is used for the calculation of switching losses and testing of snubber circuits but the disadvantage of this model is that the switching instances of the devices must be known in advance and requires long simulation time and this is overcome in state space model. In State Space Model the accuracy may be less but it requires less simulation time. In this model control system is employed which includes low pass filter, PLL and the impedance circuit. The feedback of low pass filter is given to the current controller so that the noise can be filtered out.

IV. SIMULATION RESULTS

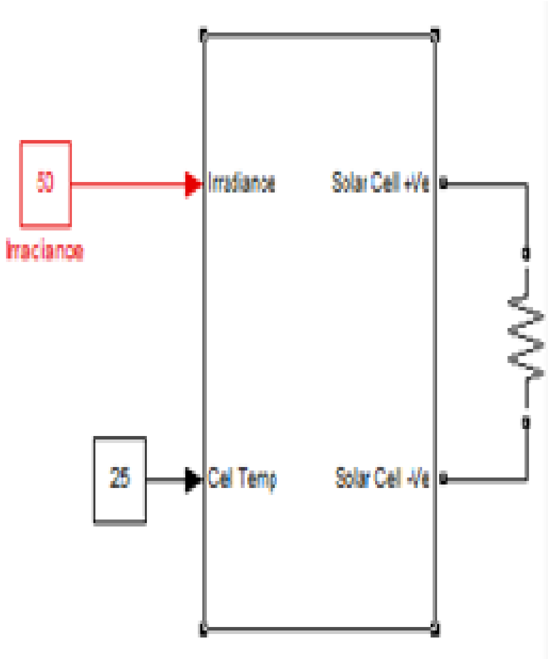

Fig.4. Simulation of PV system

Figure 4 depicts the modeling of PV system with dynamic equation in which the value of irradiance can be varied.

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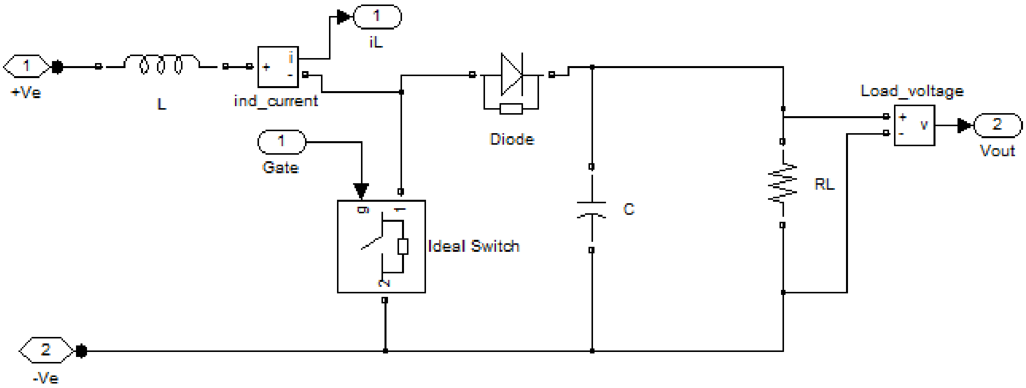

Fig 5. Simulation block for Boost Converter

Figure V depicts the Modeling of boost converter with power system components

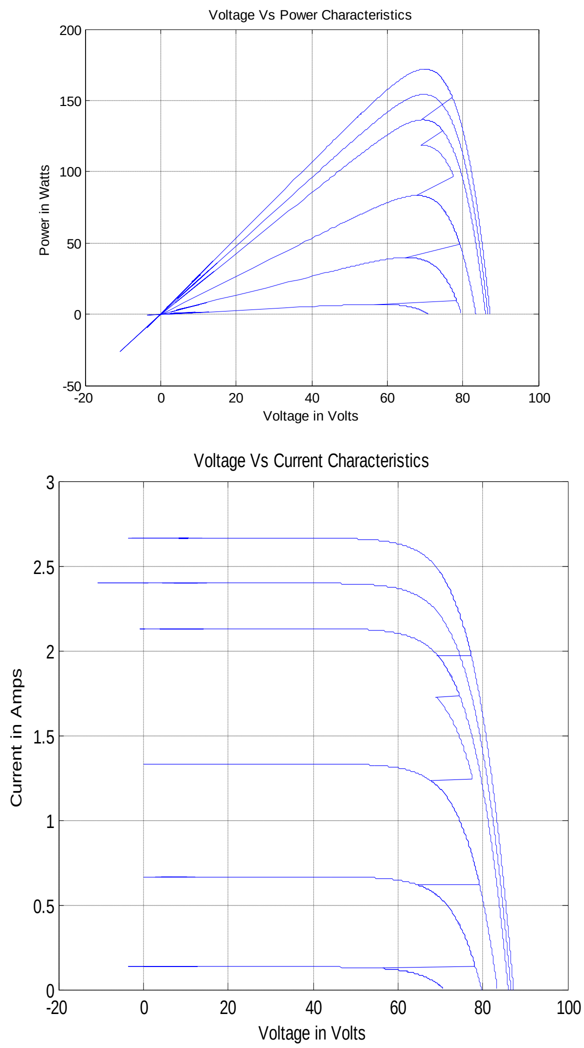

Fig 6. Simulation result for PV model

Figure VI shows the characteristics of voltage, current and power for various values of irradiance. The model I-U characteristic curves under different irradiances are given at 25°C. It is noted from the figure that the greater is the solar irradiance, the larger the short-circuit current (Isc) and the open-circuit voltage (Uoc).

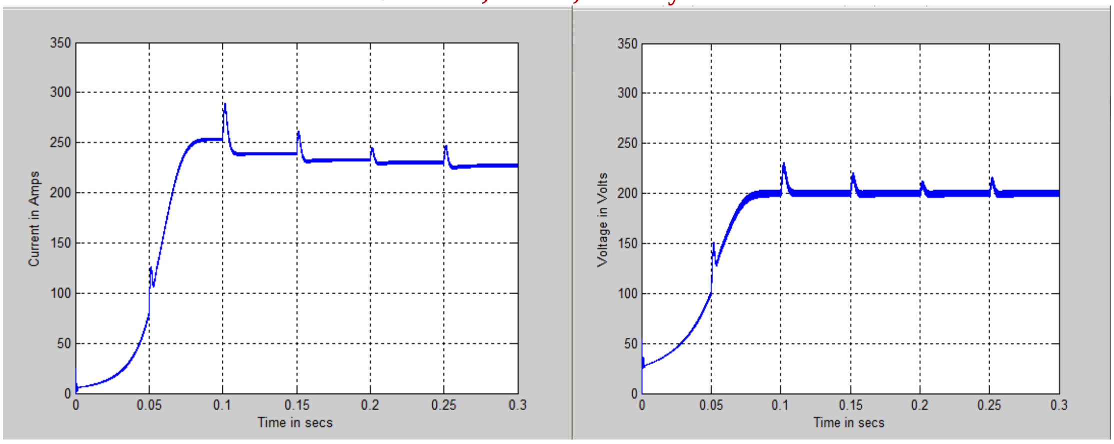

Fig. 7. Simulation result for boost converter

Figure VII depicts the constant value of 200v for various values of irradiance say 50,150,500,750 and 1000.Representing current and voltage waveform with respect to time.

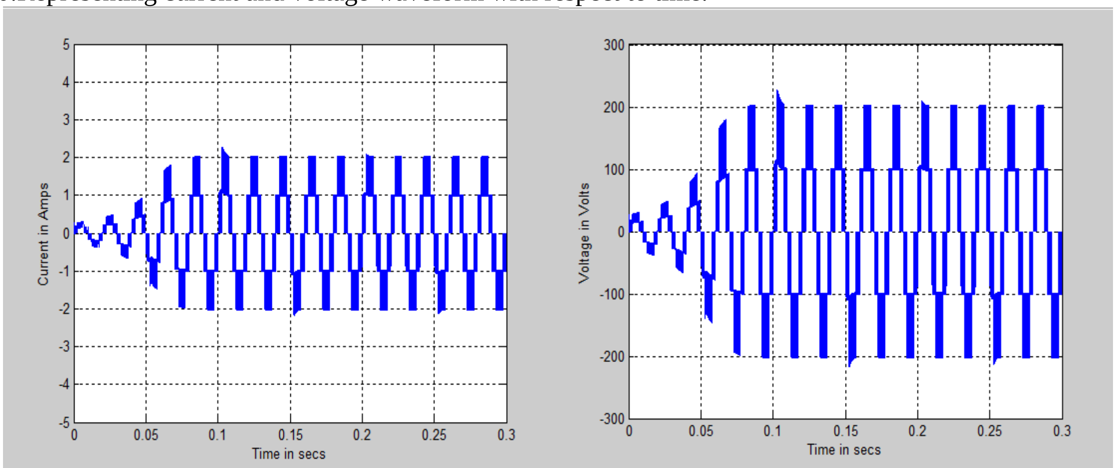

Fig .8. Simulation result for multilevel inverter

Figure VIII depicts the 5-level inverter with the constant voltage of 200v from Boost Converter for various values of Irradiance.

COMPLETE MODULE OF WIND ENERGY SYSTEM

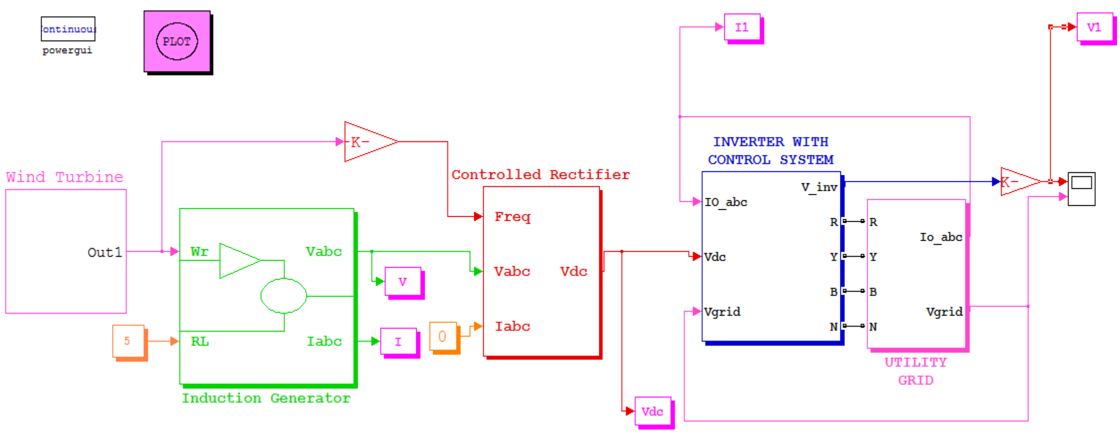

Fig.9. Simulation result for wind

Figure IX depicts the modeling of wind energy conversion system with wind turbine, induction generator and utility grid

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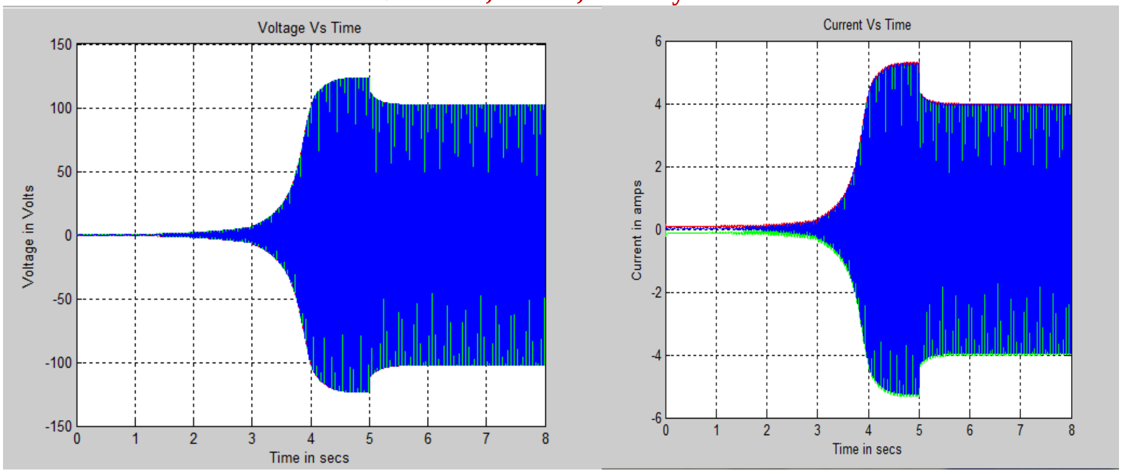

Fig.10. Simulation result for Induction Generator

V. CONCLUSION

The open circuit P-V, P-I, I-V curves we obtained from the simulation of the PV array designed in MATLAB environment explains in detail its dependence on the irradiation levels and temperatures. The various values of the voltage and current obtained have been plotted in the open circuit I-V curves of the PV array at isolation levels of 100 mW/cm2 and 80 mW/cm2. Wind energy system is separately implemented using MATLAB (R2010a) and voltage and current curves are obtained. The future enhancement of “Modeling of PV and wind energy system with multilevel inverter using MPPT technique “is to hybridize both wind and solar energy system.

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