Simulation and Performance Analysis of Three Phase PV Array Inverter

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Simulation and Performance Analysis of Three Phase PV Array Inverter

Md. Mashrur Islam, Shahriar Ahmed

***Abstract*— The requirement for a cleaner domain and the nonstop increment in power requests makes sustainable power source generation like sun based and twist progressively intriguing. Vitality generation utilizing solar vitality could be an answer for the regularly expanding force requests. This interest over-burdens the dissemination frameworks just as the power stations negatively affecting force quality and accessibility. One answer for this issue is matrix associated photovoltaic (PV) frameworks. In this paper we are displaying a three stage photograph voltaic cell-based inverter framework utilizing MATLAB programming. which comprises of PV Array, network framework and sunlight-based inverter. The framework chips away at Solar power. The objective of this undertaking is to Simulate, structure, creates and examines the execution of PV based inverter framework. The inverter is IGBT connect based controlled framework. The framework is tried on resistive and inductive burden. Voltage/current waveform investigation, control quality and framework examination are done by utilizing power quality analyzer just as burden sharing between photovoltaic exhibit is finished. In this model the consonant pay of waveform is likewise presented. Finally, the control circuit, is talked about and planned in MATLAB/Simulink intelligent programming which results sinusoidal yield from the inverter.**

***Index Terms*—3-Phase, PV Array, Inverter, Grid connected inverter, IGBT, MATLAB/Simulink.**

I. Introduction

THIS persistently expanding vitality utilization over-burdens the conveyance frameworks just as the power stations, hence negatively affecting force accessibility, security and quality. One of the answers for beating this is the Distributed Generation (DG) frameworks [1-6]. DG frameworks utilizing sustainable power sources like sun oriented or wind have the favorable position that the power is delivered in nearness to where it is expended limiting the misfortune because of transmission lines. In the most recent decade sun-based vitality innovations have turned out to be more affordable and progressively productive, which have made it an alluring arrangement being cleaner and more earth inviting vitality asset than customary ones. All things considered a PV framework is still significantly more costly than different strategies for vitality age given the high assembling expenses of PV boards [7]. One of the real focal points of PV innovation is that it has no moving parts in this way the equipment is vigorous; it has a long lifetime and low support prerequisites and above all it is one arrangement that offers ecologically neighborly power age. These days PV boards are available in regular daily existence: controlling wrist watches, little number crunchers, providing loads in remote locales and, and in particular, they are associated with the open framework, creating the green intensity of things to come [8-12]. The square graph is given underneath.

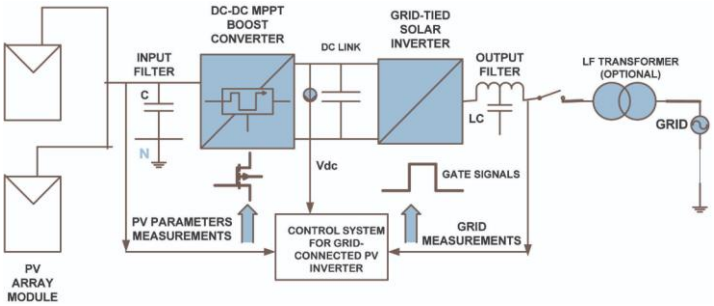

Fig. 1: Block diagram of PV system [13]

II. Theory

The capacity to produce electrical power by methods for changing over sun powered light is called Photo voltaic. It initially was portrayed in 1839 by Becquerel when he watched two disparate materials would build up an electric potential when their intersections where enlightened with photons. Present day Photovoltaic (PV) cells utilize a semiconductor p-n intersection that in the wake of engrossing light vitality, results in an expanded populace of accuse bearers of a potential identified with the band hole and furthermore into cell warming which debases the execution [14-16]. An ordinary sun-oriented cell comprises of a 0.2mm thick monocrystalline or polycrystalline silicon wafer having two layers that present diverse electrical properties upgraded by doping with polluting influences making an electric field at the intersection region. At the point when daylight impacts the sun-oriented cell the vitality from the photons makes free charges that are isolated by the electrical field, making a potential so when a heap is put between the terminals a photograph flow (I pv) is made. The most well-known material utilized in photocells today is silicon (Si) separated in monocrystalline, polycrystalline, and formless. The measure of vitality they can convey changes relying upon the material

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of the cell and the occurrence of daylight. A straightforward PV cell from a displaying viewpoint is a perfect current source in parallel with a perfect diode as found in Figure 2.1 [17]. The two parameters used to show and describe a PV cell are: the open circuit voltage (Voc) and the short out current (Isc). The Voc is the greatest voltage which a sun powered cell can give at zero current. The Isc is the most extreme current which a sunlight-based cell can give at zero voltage. The yield current from the PV cell can be discovered utilizing the condition is:

$$I = Isc - Id \quad (i)$$

Where Isc is the short circuit current that is equal to the photon generated current and Id is the current shunted thought the intrinsic diode.

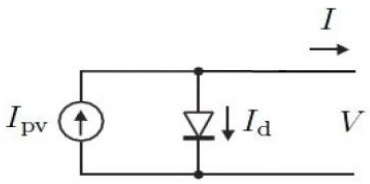


Fig.2: Ideal PV cell.

The diode current is given by Shockley's diode equation:

$$I_d = I_0 * (e^{qVd/kT-1}) \quad (ii)$$

1. Io is the reverse saturation current of the diode
2. *q* is the electro charge valued at 1.602x10−23 C
3. *Vd* is the diode's voltage
4. *k* is Boltzmann's constant valued at 1.381x10−23 J/K
5. T is the junction temperature in Kelvin combining.

Equation (i) and Equation (ii) we then obtain:

$$I = Isc - I0* (e^{\wedge}qV/kT - 1) \quad (iii)$$

All three configurations follow the same basic modeling equations. The simple PV cell model neglects to take into consideration a series of parameters [3, 17, 18] that create a more accurate model represented in Figure 2:

1. The series resistance (*Rs*): that accounts for any resistance in the current paths through the semiconductor material, the metal grid, contacts and currents controlling the system. This value also accounts for the loss associated with connecting a number of cells in series.

2. The parallel (shunt *Rp*) resistance: is a loss associated with a slight leakage current through a parallel resistive path to the device. In most models it is neglected because its effect isn't as noticeable unless a large number of cells are connected in parallel [19].

3. A recombination factor related directly to the depletion region of PV cells and to the number of cells connected in series. Usually it's represented by a second diode in the equivalent circuit, or characterized by a factor in the Equation (ii).

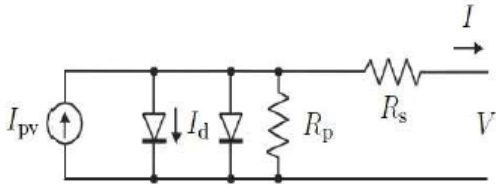


Fig.3: Precise circuitry of PV model.

Taking into account all the additional elements mentioned the Equation (iii) changes to:

$$I = I_{sc} - I_0 * (e^{q(V+I*Rs)/\,nkT} - 1) - \frac{(V+I*Rs)}{Rp} \quad (iv)$$

Where n also is sometimes described as a, being the ideality factor and its value is between 1 and 2 [4]. For the purposes of this research we have adopted the value proposed in [5] of 1.3. The equivalent final circuit of the PV module is in Figure (iii).

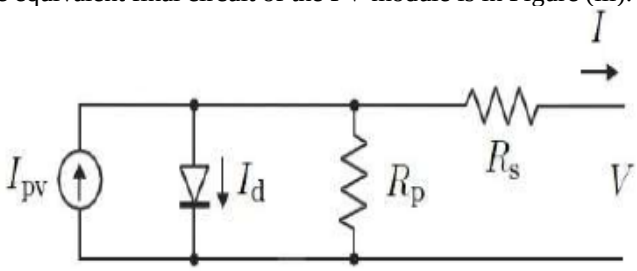


Fig.4: PV model equivalent circuitry.

The short circuit can be calculated at any given temperature using:

$$I_{sc},T = I_{sc},T_{ref} * [1+ Ki – (T – T_{ref})] \quad (v)$$

Isc at the reference temperature is found on the datasheet, and a refers to the temperature coefficient of Isc in percent change per degree. Both measurements are done under the standard irradiance of 1000W/m2. Normally the reference temperature is 25 Deg. C. The photon generated current also varies based on the irradiance (G) according to the following equation:

$$Isc,G = Isc,Gref * [G/Gref] \quad (vi)$$

Combining both equations and simplifying we then obtain a generic expression for the short circuit current. The assumption that Isc ≈ Ipv [20] is generally used since the series resistance is low and the parallel resistance is high, leading then to:

$$Ipv = (Isc+ Ki\ \Delta T\ )G/Gn \quad (vii)$$

The last term of Equation (iv) is Io that is dependent on temperature described by equation:

$$I_{0,T} = I_{0,Tref} \cdot (T/_{Tref})^{3/n} \cdot e^{-[\frac{qV}{nk} \cdot (\frac{1}{T} - \frac{1}{Tref})]} \quad (vii)$$

III. Three Phase Inverters In Simulink

Power Inverter is a device that converts a DC source into an AC source. Power inverters produce one of three different types of wave output: 1. Square Wave 2. Modified Square Wave or Modified Sine wave 3. Pure Sine Wave or True Sine Wave The three different wave signals represent three different qualities of power output. A three-phase inverter's topology was presented in Figure c.

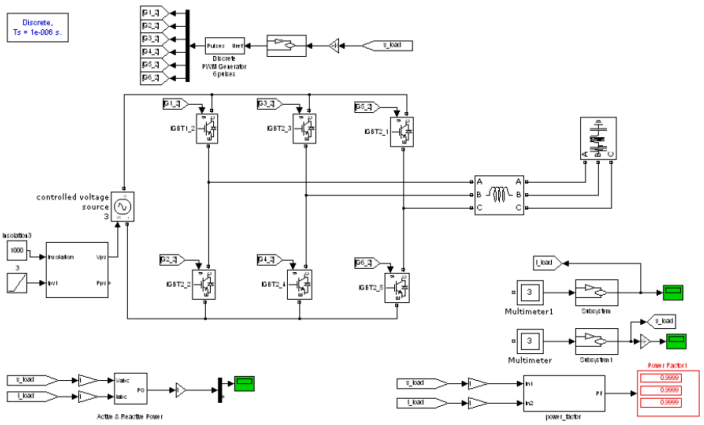


Fig.5: Three phase inverter.

Similar to the single-phase inverter the three-phase inverter can be connected or not to the grid to function properly and it is used to synchronize before switching to current control.

IV. Simulations & Results

In the given paper simulation of solar cell and total inverter system is carried out in MATLAB software.

A. PV Array Simulation

Usually the solar cells are modeled using a specific type of equivalent circuit a photovoltaic model is based on diode behavior, which gives to photovoltaic cell its exponential characteristic. In Simulink the solar cell can be modeled with three modeling systems. The solar cell from MATLAB is a solar current source, which includes solar induced current and temperature dependence. This block allows choosing one of two models: a model with 8 parameters in which describes the output current, and a model with 5 parameters if for this equation is applied the following simplifying assumptions: the impedance of the parallel resistor is infinite and the saturation current of the second diode is zero. The model with 5 parameters allows optimization of this block according to the equivalent circuit model parameters or by short circuit current and open circuit voltage. The model shown in Figure 6 represents a PV cell array connected to a variable resistor. This resistor has an input ramp which just varies resistance linearly in closed circuit until it reaches the 25 steps.

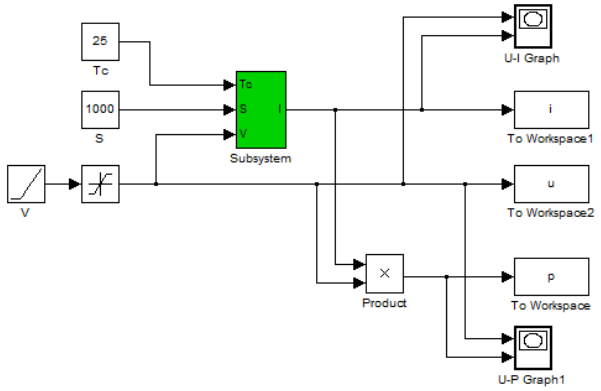
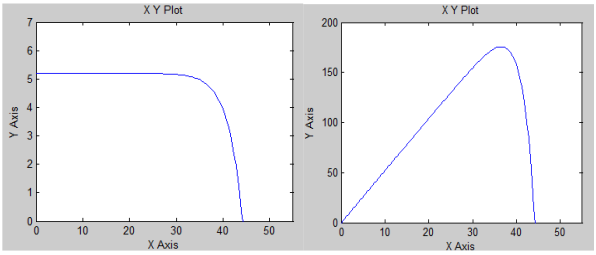


Fig.6: Simulink model of PV system.

The advantage of using of this high level of implementation is to create a simple equivalent circuit, which have much more complex parameters, including the effect of temperature in the device which is very important for behavior of this type of system. The photovoltaic panel model is validated by simulating at a value of irradiance of 1000 W /m2 and a temperature of 25°C. The values of Isc, Voc, n, Rs, TIPH1, TRSI, T and Tfix was assumed as 3.12 A, 1.2 V, 1.5, 0, 0,0, 25 Deg. C. and 26 Deg. C. respectively. The V-I and V-P characteristics of the photovoltaic array is given in Fig. 7(a) and Fig. 7(b). The V-I curve represent the standard behavior of the photovoltaic cell and photovoltaic array respectively.



(a) (b)

Fig.7: (a) V-I and (b) V-P characteristic curve of the designed PV module.

B. Simulation of total solar inverter system

The simulation of total solar inverter system is shown in Fig 8. The solar cell array is connected with IGBT based inverter which further connected to the LC filter. The output voltage is 430 V.

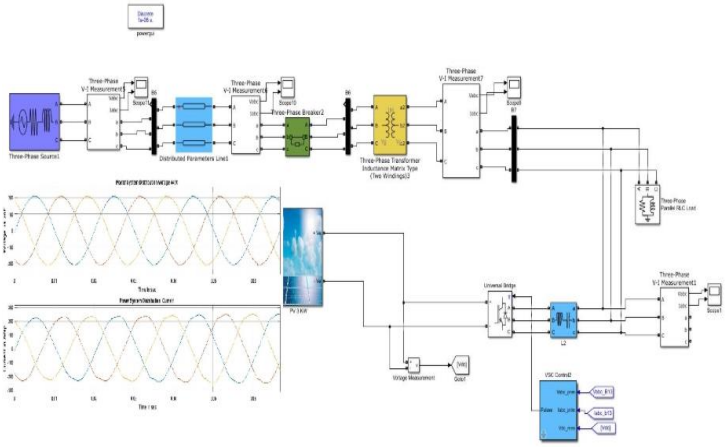


Fig.8: Simulation of Solar inverter system

Simulation was carried out in MATLAB software.

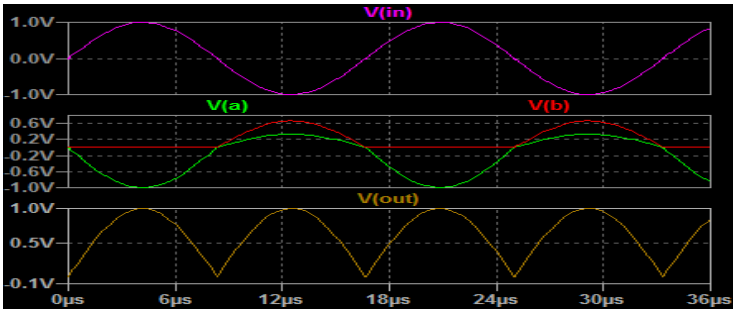


Fig.9: Without AC break Output Voltage (a) non-filtered (b) Filtered.

Fig 9 (a) and (b) shows the results for output voltages. The magnitude is 448 and angle between them is -11.21 respectively. This output is taken from LC filter. The waveforms are some more variation. But after the AC Break and timer system the variation between waveforms become less as shown in Fig. 10 (a) & (b).

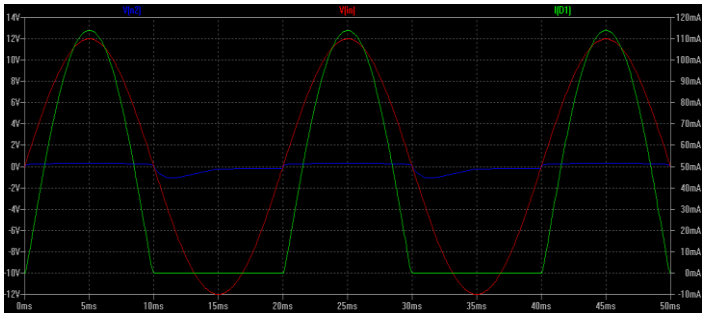


Fig.10: With AC break Output Voltage non-filtered (blue node), Filtered (red node) and the output current (green node).

V. CONCLUSION

This paper displayed a three-stage IGBT based Inverter, which utilizes single DC source and PV framework as DC source and associated with three stage network frameworks is utilized as a heap to watch the execution attributes of the inverter. Utilization of IGBT inverter lessens the expense of multiphase sun-oriented inverter significantly. By this topology, improve yield waveform from the framework. The benefit of this topology is an assistance to diminish the expense. MATLAB/SIMULINK programming enables us to display the framework associated photovoltaic (PV) framework which is valuable to comprehend and ace the execution of PV frameworks by upgrading the plan and bringing down the expenses by shortening the advancement cycles just as to improve the unwavering quality and effectiveness of the framework.

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