# DESIGN AND PERFORMANCE EVALUATION OF THREE-PHASE INVERTER FOR GRID-CONNECTED PHOTOVOLTAIC SYSTEM


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***Abstract:*** In this paper, a comprehensive study has been explored on the design and performance analysis of a three-phase grid connected inverter employing PWM modulation technique. The obligation for heavy and bulky transformers are completely eliminated by occupying the proposed inverter. The system consists of series and parallel combination of PV arrays, a DC-DC boost-converter (used as MPPT), three-phase inverter generating three-phase output voltages, and utility grid as the load. To analyze the system behavior initially, a is used formula to emulate the output of the PV Array. This simulation defines the output from the hypothetical solar array in order to constitute the input for the simulated Inverter. The basic parameters for the PV array are the insulation and temperature. Secondly, the main system has been virtually created in order to actualize the conversion from DC to AC. The basic components of this are a stabilizer (MPPT or in this case boost-converter) a 6 IGBTs 3-arm bridge, and a low pass LC Filter and grid as load. At third, the control circuit, has been discussed and designed in MATLAB/Simulink interactive software which results sinusoidal output from the inverter. The main theme of this contribution is the architecture of the virtual circuit and the components that are being used in a holistic approach. At last combining the above parts, the voltage, the current of the inverter is taken. The final results are extracted after the system optimization.



Keywords- Simulation, Boost-Converter, 3-Phase, PV Inverter, Grid-connected inverter MATLAB/Simulink.


## 1. INTRODUCTION

The demand for renewable energy has been increasing significantly over the past few decades because of shortage of fossil fuels and greenhouse effect. Among various types of renewable energy sources, solar energy and wind energy have become very popular and demanding due to advancement in power electronic techniques. Today, Photovoltaic (PV) sources are using in many applications as they have the advantages of being maintenance and pollution frees [1]. Solar-electric-energy demand has been growing consistently by 20%–25% per annum over the past 20 years, which is mainly due to the decreasing costs and prices. This decline has been driven by the following factors: 1) an increasing efficiency of solar cells; 2) manufacturing technology improvements; and 3) economies of scale [2]. PV inverter, which is the heart of a PV system, is used to convert dc power obtained from PV modules into ac power to be fed into the grid. Improving the output waveform of the inverter reduces its respective harmonic content and, hence, the size of the filter used and the level of electromagnetic interference (EMI) generated by switching operation of the inverter [3]. The aim of this work is therefore to develop new concepts which would be economically cheap for converting electrical energy, from the PV module to the grid. The work has therefore been done in the field of inverter technologies, which is used to interface an array of PV module to the grid. The inverter is developed with focus on low cost, high reliability and mass-production. There is no transformer at the output of the inverter which makes the inverter economically cheap.

## 2. RELATED WORKS

Lots of research is going on this field of off-grid and on-grid inverters .This techniques have been utilized as support for references throughout this paper. A number of notable and significant works that has been studied as support material are described below in brief.

Enrique, Isable, Eva and Gonzalez [4] presented a new topology for the power injection system that was based on the parallel association of two voltage source inverters. The aims of their topology were to inject the power from the photovoltaic generation system using the quasi-square inverter and to control the current quality using the PWM inverter. Their proposal optimizes the system design, permitting the reduction of system losses and an increase of the energy injected into the grid.

Blasko [5] investigate the equivalence of the two popular approaches to Pulse-width Modulation (PWM) in induction motor drives, namely the triangle-comparison approach and the space vector approach. It brought out the conditions wherein they were equivalent, and wherein they were not. From their research it shown that the space vector approach was more general, and offered more degrees of freedom, compared to the triangle comparison approach. Even a limited exploitation of the space vector approach, the flexibilities had been reported to have improved the drive performance significantly. This gives adequate motivation to exploit these flexibilities further.

Iwaya and Noguchi [6] discussed a single-phase three-level current source inverter (CSI) driven by a single gate-drive power supply in both chopper and inverter, and its feasibility on grid connected photovoltaic system application. Using this new topology, the complexity of the chopper and inverter circuitry was dramatically reduced by using single gate-drive power supply for all power switches. The circuit worked properly at a unity power factor operation when the quasi-sinusoidal current is injected into the grid. The simulation results provide firm evidences about the practical feasibility of the proposed system.

Selvaraj and Rahim [7] presented a novel pulse-width modulated (PWM) control scheme for single-phase five-level photovoltaic (PV) inverter topology for grid-connected Photovoltaic system. They used two reference signals identical to each other with an offset equivalent to the amplitude of the triangular carrier signal were used to generate PWM signals for the switches. A digital proportional–integral (PI) current control algorithm was used to keep the current injected into the grid sinusoidal and to have high dynamic performance with rapidly changing atmospheric conditions. The inverter offered much less total harmonic distortion and can operate at near unity power factor.

Liu, Zhou and Duan [8] discussed the special controller for grid-tied inverter. According to their research the LCL filter offered a better choice of attenuating switching frequency harmonics. However, in a grid-connected system, an LCL filter might cause resonance which was a disaster for the system's stability. In order to solve the problem, a two-current-loop control strategy, which included grid-current outer loop and filter-capacitor current inner loop, was adopted in their research work. A specific method was proposed in their paper to design the controller. The advantage of this method was to provide a way to maximize the utilization of the two feedbacks to get good system performance through parameter determination. They tested the practicability of the method by using bode diagram, and the anti-distortion ability of the system was analyzed.

Barbosa, Braga and Teixeria [9] presented a DC/AC converter with high-frequency isolation and bidirectional power flow capability for photovoltaic energy applications. The topology was based on a high-frequency inverter, a high-frequency transformer and an AC/AC converter. No additional DC-link stages were required in their proposal which reduced the components. A modulation strategy for the commutation of the AC/AC converter switches was presented with the benefits of soft-switching commutations with no extra components.

Study of the different literatures reveals that the significant research is going on in various labs all over the world to improve the efficiencies of on-grid inverters using different techniques. The above study also indicates that there is an ample scope to improve the design and performance of grid-tied inverters for domestic and industrial purposes. In this work an attempt has been taken to develop an efficient three-phase grid-connected inverter for PV system small scale motive.

## 3. DESIGN OF THREE-PHASE GRID-CONNECTED INVERTER

In this paper, the inverter is designed to work as a grid-connected system; therefore, the utility grid is used as a load. In photovoltaic applications the grid interface between source (solar array) and load (utility grid) is accomplished by an inverter. To maximize the system efficiency the inverter must be optimized in design and control. As mentioned in [11], a typical utility interactive photovoltaic inverter has to satisfy a number of designs characteristics. These are:

- The inverter input dc voltage must be $> \sqrt{2}\ V_g$, where $V_g$ = the grid voltage.
- If the PV array voltage is lower than the grid voltage, the PV array voltage has to be boosted with a further element (Boost-Converter).
- High power factor is required for the inverter for grid-connection i.e. phase should be matched.
- The output current waveform should be a sinusoidal shape.
- The inverter should be equipped with a maximum power point tracker to be able to get the maximum power possible from the photovoltaic generator at any time.
- The current harmonic distortion fed to the grid by the solar photovoltaic utility interactive inverter should not exceed the limit permitted by public utility laws.
- Isolation from the utility line must be required.
- During a power failure, an isolator should disconnect the photovoltaic inverter from the grid and connect it to an emergency load.
- The solar photovoltaic plant should be disconnected from the grid at times of too low an insulation.

### 3.1 DC voltage source of the inverter

As mentioned in the previous section, the inverter input dc voltage must be $> \sqrt{2}\ V_g$, where $V_g$ = the grid voltage. In this case the grid voltage, $V_g$ = 220 volts. So the minimum input DC voltage that has to be maintained at the input of the inverter is, $V_{DC} = 311$ volts.

The output of the PV array is of 200V DC. So the dc-dc boost converter is used to track the maximum power point (MPP) of the solar arrays as well as to step up the inverter input voltage $V_{DC}$ to be more than $\sqrt{2}$ of the grid voltage $V_g$ to ensure power flow from the PV arrays into the grid.

The block of PWM IGBT Inverter that used for simulation purpose of three-phase grid-connection is shown in Figure (1).

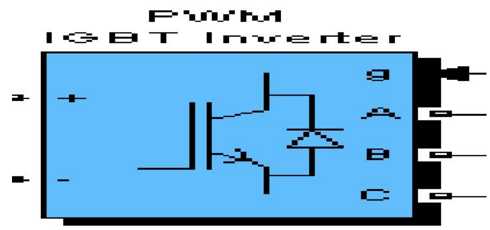


Figure (1): Block of ideal IGBT inverter

This block has two input end, one is positive of the DC voltage and another is negative of the DC voltage. At the right side of the block four ends is seen. Among them one is used for accepting PWM pulses. The other three outputs are used for three phase signal output.

### 3.2 The control circuit design for inverter

All the conditions for fulfilling appropriate circuit design requirements can be achieved by using a sinusoidal PWM control scheme. This technique will work in such a way that provides an in-phase voltage at the output of the inverter. The PWM control scheme is basically a square-wave oscillator which drives the inverter. The shape of the output voltage, voltage level and frequency are determined and controlled by this circuit in order to get the desired output of the inverter (in this case almost pure sine wave).

For the design oriented operation of the inverter as an instrument it must be capable of producing desired voltage level, keeping voltage wave shape and frequency at constant level for grid.

In this paper, the output AC voltage of the inverter is of 220V. This is accomplished by a negative feedback circuit, utilizing a pulse width modulation technique according to the requirements.

Switching of the inverter switches is controlled using a pure three-phase sinusoidal waveform as the reference which is continuously compared with a high frequency carrier signals.

The control signal (reference) equations for the three-phase are of the form:

$$V_{ref}(phase-1) = m_{index}[\sin\left(2\pi ft - \frac{120\pi}{180}\right)] \text{……….} \quad (1)$$

$$V_{ref}(phase-2) = m_{index}[\sin\left(2\pi ft - \frac{0\times\pi}{180}\right)] \text{……….} \quad (2)$$

$$V_{ref}(phase-1) = m_{index}[\sin\left(2\pi ft + \frac{120\pi}{180}\right)] \text{……….} \quad (3)$$

Above three-phase reference is taken from the grid-line (output of the inverter) and compared with a constant high frequency carrier signal.

PI voltage controller was used for controlling the IGBT switching frequency. This controller contains two constants namely proportional constant, $K_p$and integral constant, $K_i$. The value of the $K_p$and $K_i$was set as shown in table 1.

Table 1

| | |
|---|---|
| Proportional constant, $K_p$ | 0.4 |
| Integral constant, $K_i$ | 500 |
| Sampling time, $T_s$ | 20 microsec |

Carrier signal (triangular) frequency $f_c$ is set as 2000HZ.

The reference signal frequency $f_r$ is 60Hz.

So, the frequency modulation index, $M_f = \frac{f_c}{f_r}$ =2000/60=33.33.

Amplitude of the carrier signal, $Vc$ =380V

Amplitude of the reference signal, $V_{ref}$=220

So, the amplitude modulation index,

$$M = \frac{V_{ref}}{Vc}$$ =220/380=0.5789=0.6

Using MATLAB/Simulink software, the following model has been implemented for the PI voltage controller.

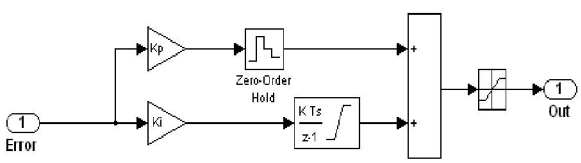


Figure (2): PI Voltage Controller

The above figure shows two gain blocks ($K_p$ and$K_i$) each of which contains the value given in table 1. The output of $K_p$ is sampled by another block namely zero order hold. Similarly the output of the $K_p$is integrated by a discrete-time integrator block. The two output signals are then added and saturated to a specified value. This output is fed to the PWM block to generate the switching signal for the IGBT inverter block. This PI voltage controller is masked with the voltage regulator to make the output voltage of the inverter to a unity power factor. Figure (3) shows this voltage regulator inside which a PI voltage controller exists.

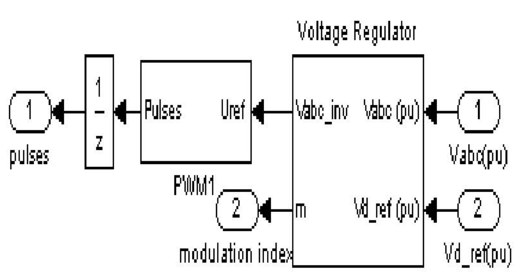


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Figure (3): PI voltage controller & Voltage regulator when masked

The whole switching system is masked to make a sub-system. Figure (4) shows this system used in this simulation purpose.

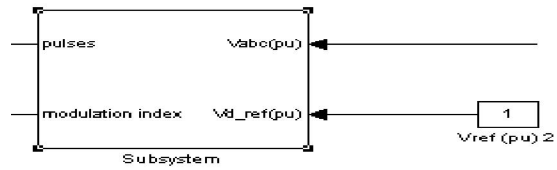


Figure (4): Subsystem for switching device

From the Figure (4), the subsystem has two inputs, one is from grid (*Vref* (pu)) and another from the output of the inverter. This two sinusoidal is compared with the triangular reference signal (which is not shown) and the error signal is fed to the PI controller. The PI controller then generate signal for PWM pulses for gate.

The switching pulses for IGBT PWM inverter block is shown in Figure (5). These pulses are used as the switching signal to make the output sinusoidal. As the switching speed was so large enlarged version of the pulses was used. The configuration setting of the Simulink was shown in Table 2.

Table 2

| | |
|---|---|
| Start time | 0 Sec |
| Stop time | 2 Sec |
| Type | Variable-step |
| Min. step size | 0.00000001 Sec |
| Solver | Ode45 (Dormand-Prince) |

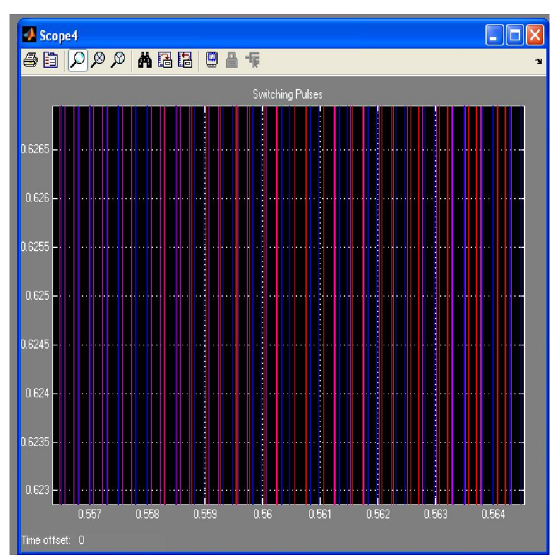


Figure (5): Switching pulses for IGBT PWM inverter

The schematic diagram of the three-phase inverter using carrier based PWM technique is shown in Figure (6). The input voltage is regulated using a capacitor as voltage depositor which is due to the boost-converter. Gating signal is obtained from the PI controller. Other three outputs are used for line voltage measurement. The low pass filter circuit is used to make the output sinusoidal. The measurement block measures the voltage amplitude.

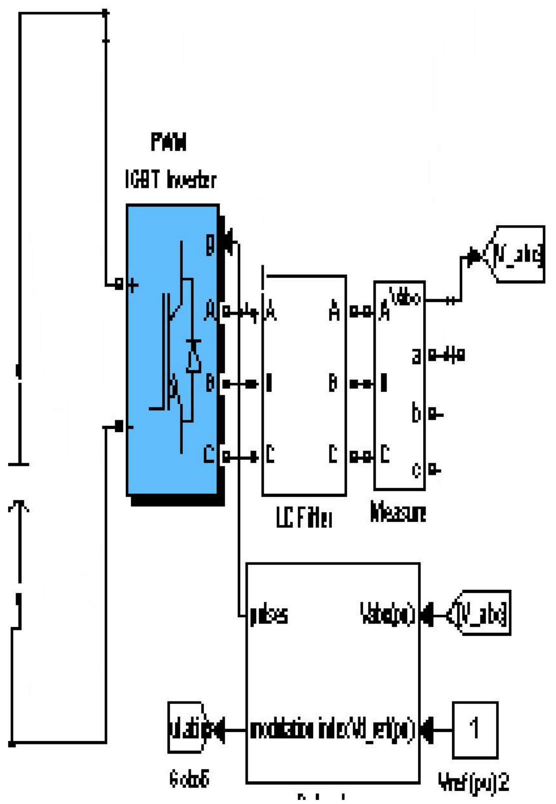


Figure (6): Schematic of the three-phase inverter circuit using MATLAB/Simulink blocks

**3.3 Design of boost-converter for CCM**

\The output from the PV module was so small (200V). This amount of voltage is smaller than the grid voltage. So boost-converter is used to boost the output to a larger value, in this case 400V.

**3.3.1 Calculation for the design of converter**

In this paper, the input of the inverter, $V_{DC}\ (V_o)$ =400V, $V_{\_vs}\ (V_{in})$ =200V and $V_r / V_0$<1%, $D$=0.75, $R$=500 Ω and $f_s$ =50000s

$$C_{\min} = \frac{DV_o}{V_r R f_s} \qquad \text{……………………… (4)}$$

$$L_b = \frac{(1-D)^2 DR}{2 f_s} \qquad \text{…………………….(5)}$$

From equation (4) and(5) $C_{\min} = 40\times 10^{-6}$F and $L_b = 234.375\times 10^{-6}$H. For simulation purpose the of L =30× $10^{-3}$ Henry and C= 5000× $10^{-6}$ F is taken.

The simulation circuit for boost-converter is shown in the Figure (7). The controlled voltage source is used to establish the input voltage to the converter. This voltage was obtained from the output of the PV module. The input voltage is DC200V. When the IGBT is on due to pulses, the inductor stores the 200V. When the IGBT is off the diode work as rectifier and put the total 400V to the output, i.e. capacitor.

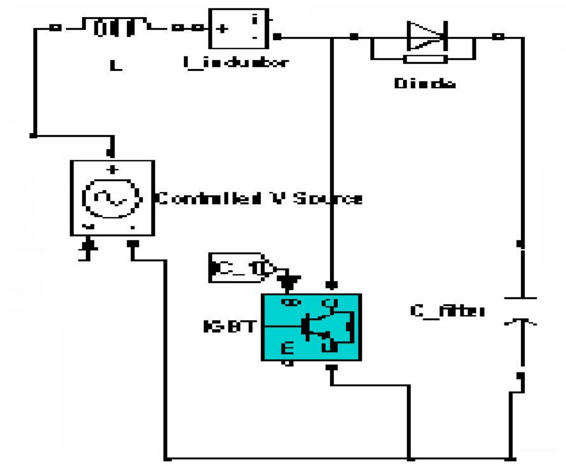


Figure (7): Boost-converter circuit

**3.3.2 The control circuit design for boost-converter**

The design procedure of the control circuit of the boost-converter is same as that of the inverter switching circuit. So for brevity of the paper the description is omitted. The control circuit is shown in Figure (8).

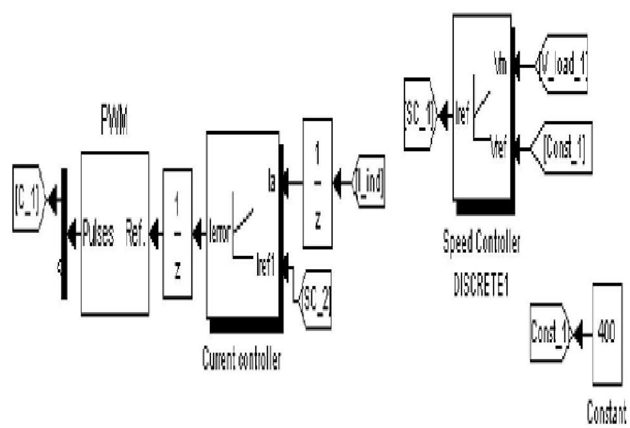


Figure (8): Control Circuit for the boost converter

### 3.4 Low Pass Filter Design

In this section the design procedure of *LC* low pass filter is described. This filter has the importance in the sense that it removes the low order distortion at the output of the inverter.

As only the harmonic content is the consideration, an *L* type *LC* low-pass filter is used which generally gives 5% distortion [12].

The low-pass is used to get approximate sine wave, so the resonant frequency of the *LC* circuit is chosen at 50Hz (denoted by $f_r$ ). Using the basic formula,

$$fr = \frac{1}{2\pi\sqrt{LC}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

And considering an AC capacitor of $5\times 10^{-6}\ F$ ; the value of inductor is obtained about $2\times 10^{-3}\ H$ . The filter circuit is shown in Figure (9).

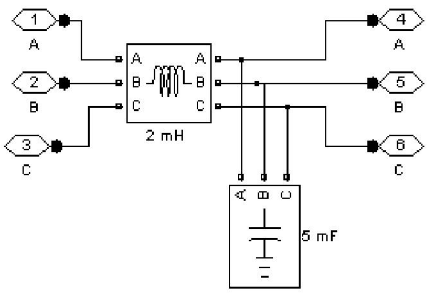


Figure (9): LC Filter used in MATLAB/Simulink

## 4. DESIGN OF GRID-CONNECTED PV SYSTEM

In grid-connected photovoltaic system, the array of photovoltaic is connected to the utility grid by an inverter. The inverter acts as an interface device between PV array and grid line. Figure (10) shows the grid-tied system in which inverter is used as interface device. This circuit has been used in the simulation purpose.

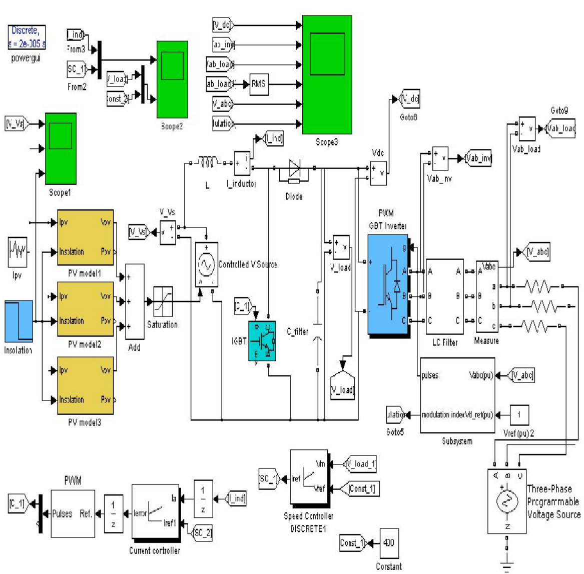

Figure (10): Grid-connected PV system

## 5. SIMULATION OF THREE-PHASE GRID-CONNECTED INVERTER

For the simulation of three-phase grid-tied inverter Figure (6) is used. The whole simulation operation is performed in MATLAB/Simulink environment.

The output phase-to-phase voltage $V_{ab}$ is obtained as in the Figure (11) when the solar insulation is decreasing from 949.5 $Wm^{-2}$ to 930 $Wm^{-2}$ and at temperature $25^0$c. The waveform shows the phase-to-phase voltage before using the filter circuit and after using the LC filter circuit. The waveform shows that the output is square wave which is due to the presence of harmonic. When low-pass filter was introduce the output of the inverter seems to almost sinusoidal. Placing the low-pass filter between the inverter and the grid it shows that the output is sinusoidal. This was measured taking the time (sec) in the x-axis and taking the voltage (volt) in the y-axis.

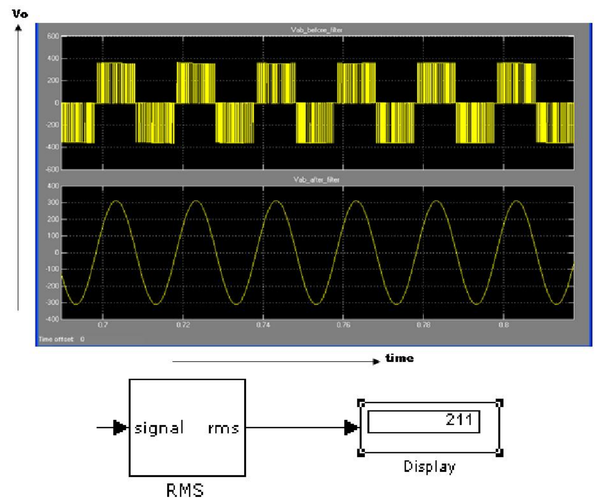


Figure (11): Output Phase-to-Phase voltage ($V_{ab}$) waveforms before and after filter circuit at temperature $25^0$c.

The output phase-to-neutral voltage $V_{an}$ is obtained as shown in the Figure (12) with the same solar insulation and temperature. In this case time domain was taken as sec in the x-axis and the voltage was in volt and in the y-axis.

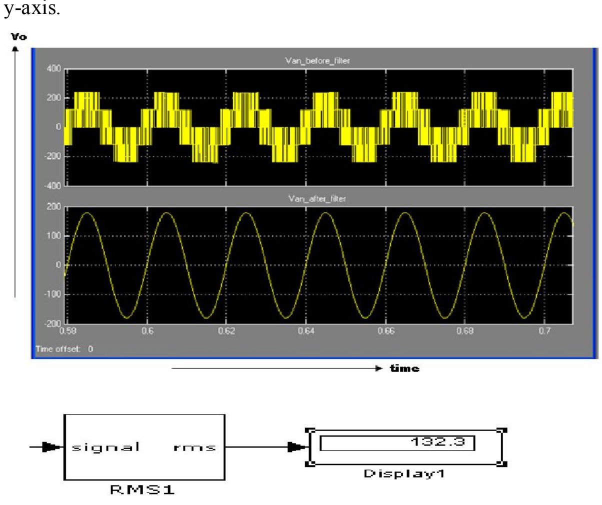


Figure (12): Output Phase-to-Neutral voltage ($V_{an}$) waveform before and after using the filter circuit at temperature $25^0$c.

The parameter settings for the IGBT switches of the three-phase inverter are given in Table 3.

Table 5: Parameter for IGBT inverter settings

| Parameters | Values |
|---|---|
| Snubber resistance, Rs (Ohms) | 5000 |
| Snubber capacitance, Cs (F) | inf |
| IGBT on state resistance, Ron (Ohms) | $10^{-3}$ |
| Forward voltage of the device, Vf (Volts) | 0.0 |
| Forward voltage of the diode, $V_D$ (Volts) | 0.0 |
| Current fall time, $t_f$ | $10^{-6}$ |
| Current tail time, $t_t$ | $2\times10^{-6}$ |

The output three-phase voltage $V_{abc}$ is obtained with the solar insulation of $949.5Wm^{-2}$ to $930Wm^{-2}$ and shown in Figure (13). This is measured in PU unit. This signal waveform was used to generate the controlling signal and compared with the reference signal.

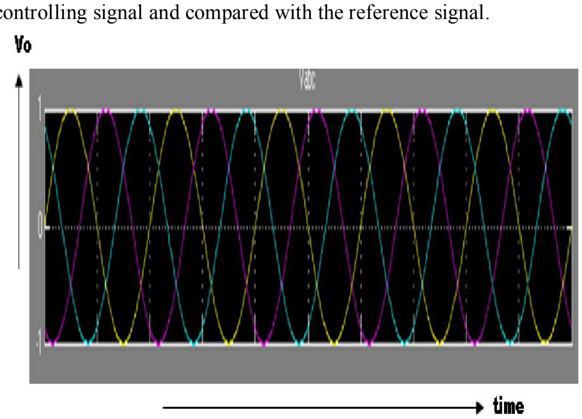


Figure (13): Output three-phase voltage (pu)

The output voltage of the module always changes with the change of solar insulation and temperature. So the output voltage of the inverter may vary accordingly. It is not desirable in this case as the inverter is connected to the grid. But the PI voltage controller opposes the change of the output voltage of the inverter. Figure (14), after a certain period of time, the output will be the desired output but for the simulation to be get slow in MATLAB and not shown detail but a part is shown.

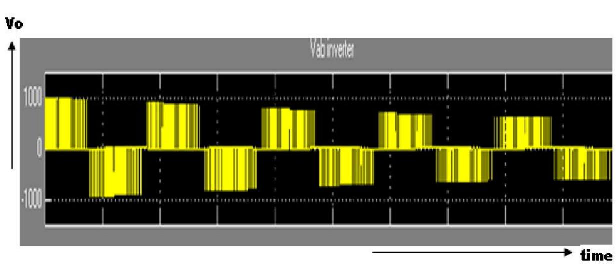


Figure (14): phase-to-phase voltage without filter circuit at $1000Wm^{-2}$ - $950Wm^{-2}$ .

The Figure (15) shows the output voltage of the PV module in volt at an insulation of $1000Wm^{-2}$ to $950Wm^{-2}$. The corresponding insulation is shown in Figure (17).

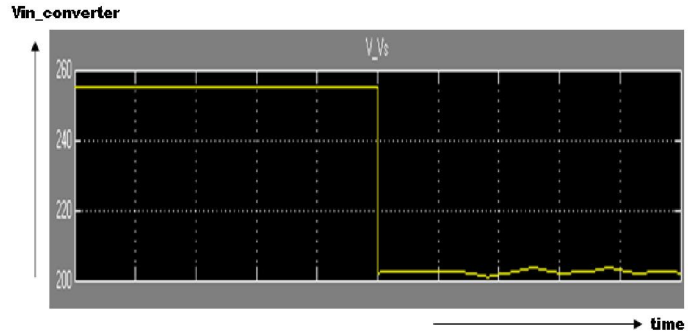


Figure (15): Output of the module at insulation $1000Wm^{-2}$ - $950Wm^{-2}$

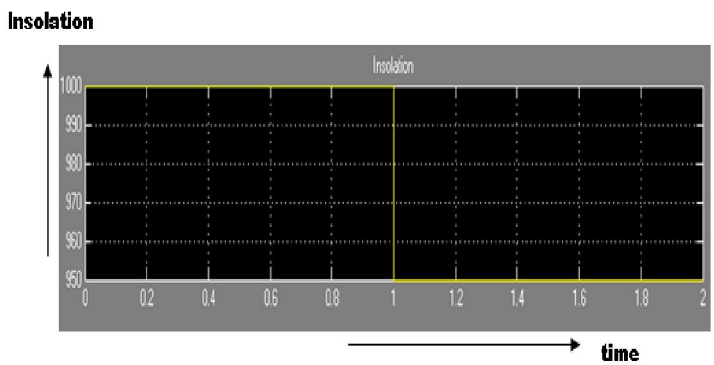


Figure (16): Insulation on the PV module

Due to this change in insulation the input voltage of the inductor changes accordingly. But the output voltage of the inverter does not change due to the PI controller function. Introducing the insulation to 950-930 $Wm^{-2}$ to the PV module the RMS voltage of the inverter is measured which is shown in Figure (17).This waveform shows that the RMS voltage has not changed or not distorted at the insulation for which the inverter was designed.

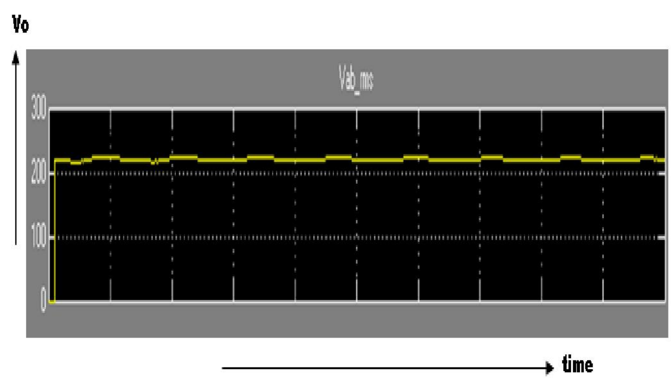


Figure (17): RMS value of the phase-phase reading at insulation $950Wm^{-2}$.

The boost-converter input and out voltage is measured for the insulation of 950-930$Wm^{-2}$ and the obtained wave form for the input and the output is show in Figure (18) and Figure (19) respectively.

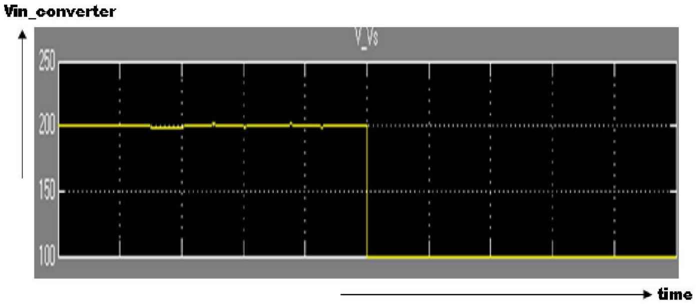


Figure (18): The input to the converter at 950 $Wm^{-2}$ -930 $Wm^{-2}$

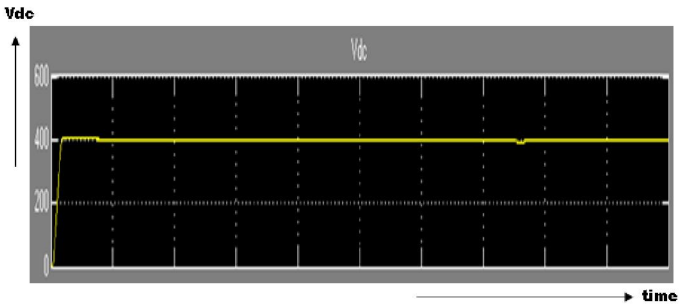


Figure (19): Output of the converter at the 950-930W/m^2

The output of the inverter may get changes due to the change of insulation. We tried to get a reading of this by changing the insulation of the solar model which is shown in Figure (20). Its corresponding inverter output is shown in Figure (15). The output may be firstly changes but after some has elapsed the inverter output will be in phase with the grid.

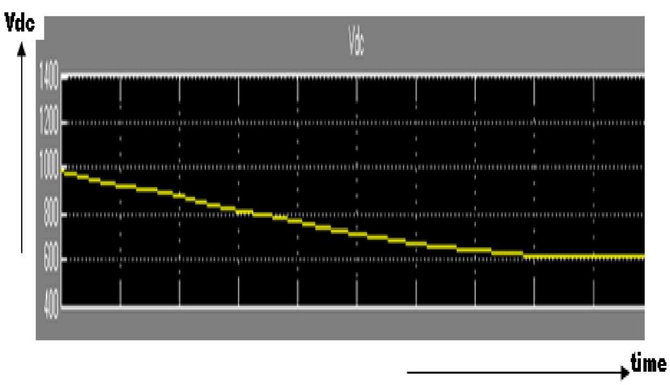


Figure (20): The output of the converter at 1000$Wm^{-2}$ -950$Wm^{-2}$

**5.1 Simulation of the grid-connected PV system by the designed inverter**

Simulation of the grid-connected Photovoltaic system using the designed 2KW inverter will be the same as above waveforms. The waveforms shown from Figure (11) to Figure (20) are the simulation result of the grid-connected inverter because the above waveforms were obtained by connecting the inverter to the grid of 220V AC with 50Hz frequency. In the simulation of the grid-connected system there had a problem with the connection of the Three-phase programmable voltage source which is shown in Figure (21).

That is why a resistance of small value was connected in series with the programmable voltage source inverter.

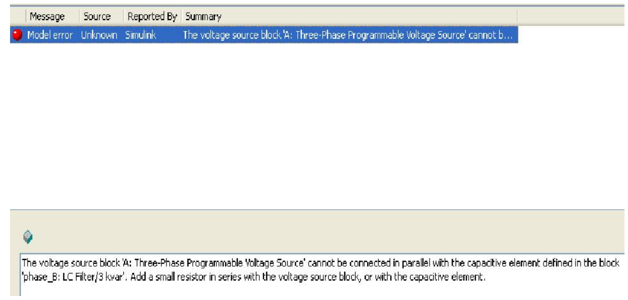


Figure (21): Error occurred in the PV system simulation

## 6. RESULT ANALYSIS

From the simulation of three-phase inverter, the phase-to-phase waveform is obtained as shown in Figure (11). When the insulation is varied from 950 $Wm^{-2}$ to 930 $Wm^{-2}$, the waveform that was obtained without using the filter circuit is shown in the first part of first Figure (11). It shows that the output waveform is almost square wave. This indicates the huge amount of harmonics present in the output waveform. This waveform was taken at temperature $25^0$C. When the LC filter circuit is introduce in the circuit the waveform of the output signal that was obtained is shown in the second part of first Figure 11(b). It is clear in the figure that the phase-to-phase waveform is almost sinusoidal with a little bit of harmonics. This indicates that the use of filter circuit eliminates the higher order harmonics which is one of the criteria that should be fulfill for the inverter.

Figure (12) shows the output line-to-neutral waveform. This waveform is taken by applying the same conditions (insulation and temperature) as adopted earlier. First, the output waveform was taken without using the Low-pass filter. From the figure, it can be observe that the waveform is almost similar to square wave indicating the existence of higher order harmonics. Then the output was taken again by introducing the filter circuit and the waveform was shown in the second part of the first Figure (12). From the figure it is clear that the output is similar to the form of sinusoidal wave with small fluctuations. For this reason low-pass filter is necessary-circuit for grid-connected inverter. The Figure (11) and (12) also shows that the output is 211V and 113.2V. This satisfies the conditions of the inverter.

By maintaining the same insulation and temperature phase-to-phase RMS waveform was taken as shown in figure (17) for the convenience of discussion. From the waveform it is seen that the RMS phase-to-phase voltage is above 211V. So the peak voltage would be 313V. As the voltage is more, this amount of voltage will be fed to the grid for proper working.

The phase-to-phase voltage should be more than 380V in this work. But most probably the design procedure has some problem that is why it is less than the desired optimum value. This may be the cause of improper selection of the parameters (Snubber resistance, on state resistance) of the IGBT inverter.

When the insulation is set from 1000 $Wm^{-2}$ - 950$Wm^{-2}$ , the inverter input DC voltage initially starts at 1000V (Figure (21)) then decreasing to 600V or somewhat less and after a few moment it become 400V. This is because the controller circuit was designed for 400V. Thus the designed PI controller enables the converter to work as an MPPT.

At this insulation range (1000$Wm^{-2}$ - 950$Wm^{-2}$) the output phase-to-phase voltage waveform is shown in Figure (15). It shows that at first the inverter output voltage is about to AC1000V and then gradually it decreases. This is because the inverter is a DC/AC converting device and the initial input voltage was almost DC1000V. When the PI controller senses this high voltage, the inverter suddenly stopped.

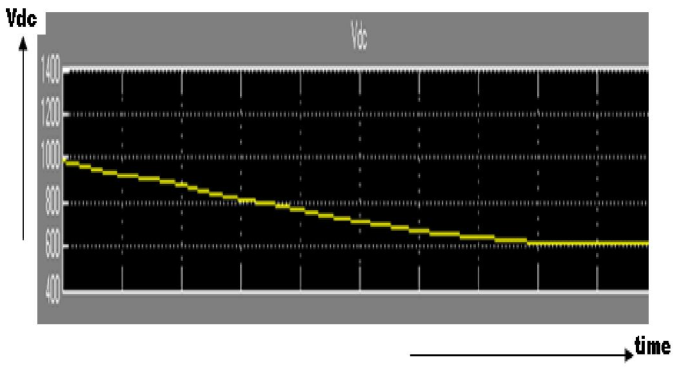


Figure (21): The output of the converter at 1000 $Wm^{-2}$ - 950 $Wm^{-2}$ insulation.

The amplitude modulation index ( $M$ ) waveform is shown in the Figure (22). From the figure it is seen that the value is always less than 1, which is maintained during designing this inverter. The index is changes a little bit with the variation of the output. This is another reason for fluctuation of the output voltage of the inverter.

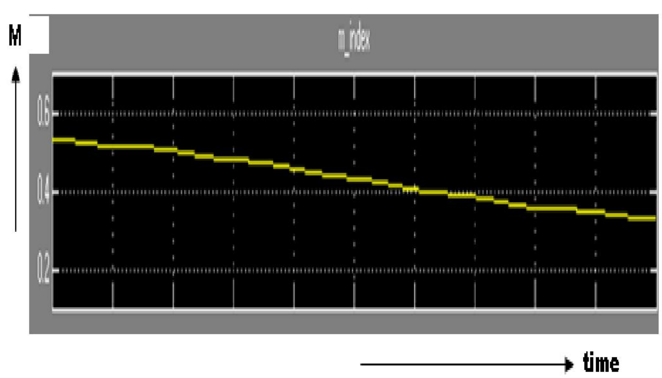


Figure (22): Amplitude Modulation Index Waveform

The waveform of Figure (12) shows the phase-to-neutral ( $V_{an}$ ) voltage waveform before and after using the LC filter. The RMS value is shown which 132.3V. So the Phase-to-neutral voltage will be $\sqrt{2}\times 132.3$ = 187.1V which is also equal to the value seen from the graph. But the value should be 220V for the grid. Due to the improper selections of the parameters of various blocks and the selection of the resistances of the snubber circuits in the IGBT block higher variations occur. The overall system has some variations due to the block parameters used also has the impact of the insulation on the system.

## 7. CONCLUSION

In this paper, a three-phase voltage-source inverter with a booster circuit power supply has been studied as a grid connected photovoltaic energy converter. The obtained results clearly reflect that though the designed inverter have some limitations, it can works properly for DC400 voltage and is quite effective to simplify the PV system with a grid connection. This inverter has a strong advantage as it does not use any transformer. That is why it not so bulky, and cost-effective. The transformer is eliminated by using a very large capacitor at the input which makes the isolation between the grid and PV array. A suited control has been developed for this inverter which makes the inverter output almost sinusoidal.

Depending on the above analysis it is clear that the designed inverter can be implemented for practical purpose.

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