International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

PV Operation in dSpace for Inverter Controller

Dr. M Shanmugavalli[1], Yokeswaran. T[2], Mukesh. P[3], Sudharsan. S[4]

[1]M. Tech, Ph. D, Professor, Department of Instrumentation and Control Engineering, Saranathan College of Engineering, Tiruchirappalli-12, India. shanmugavalli-ice@saranathan.ac.in[1]

[2,3,4] Instrumentation and control engineering, Saranathan college of engineering, Tiruchirappalli, India

yokesptk1212@gmail.com[2], [3]mukeshpadmanaban129@gmail.com, [4]sudharsansannasi@gmail.com

ABSTRACT –

A massive amount of energy is needed, and the need for energy is rising daily. Power generation, distribution, and utilization are all steadily rising. The effectiveness of the conversion from direct current (DC) solar modules to alternating current (AC) inverters determines the overall efficiency of photovoltaic (PV) systems connected to the grid. This study shows the dSPACE DS1104 platform simulation modeling of an inverter controller for photovoltaic application.

The controller platform connects its prototype hardware to the simulation model created in the MATLAB/Simulink environment. The effectiveness of the dSPACE application in connecting the PV system to the grid is validated by the results that are displayed.

***Keywords*—dSPACE; Filter; Inverter; Modulation Index; Photovoltaic; PI Controller; Sinusoidal Pulse Width Modulation.**

Introduction

A massive amount of energy is needed, and the need for energy is rising daily. Power generation, distribution, and utilization are all steadily rising. The effectiveness of the conversion from direct current (DC) solar modules to alternating current (AC) inverters determines the overall efficiency of photovoltaic (PV) systems connected to the grid. This study shows the dSPACE DS1104 platform simulation modeling of an inverter controller for photovoltaic application. Creating clean, renewable energy is now one of the main goals set for contemporary engineering and research. The most potential energy source for the future is photovoltaic energy. It is widely accessible and free of pollution everywhere in the world. DC electricity must be converted into AC power in order to use PV DC power effectively. An inverter, which houses the PV modules without any moving parts, is required for this purpose. Power electronics nowadays offer interfaces for converting DC power to AC power. The efficiency of the direct current (DC) of the solar modules to the alternate current (AC) inverter conversion determines the overall efficiency of photovoltaic (PV) systems that are connected to the grid. The carrier frequency and switching functions determine the output voltage's harmonic components. PV system generates the PWM signals for inverter switches using two reference signals. Given the use of this inverter in photovoltaic systems, a proportional-integral (PI) current control strategy is chosen to maintain the output sinusoidal current waveform that end users want. The switching technique that creates the PWM control waveform's switching edges is the key component of any PWM control system. The primary function of the converter, which interfaces the PV system to the grid through voltage synchronization, is to introduce sinusoidal current into the grid system. Inverter failure is typically the cause of PV system failure; therefore, design engineers can create sophisticated inverter controllers. For the standard output voltage of the inverter. An improved type of inverter is required to facilitate the use of solar systems.

Here, the inverter and its converter in a closed loop system are simulated using MATLAB/SIMULINK. This model is then linked to the dSPACE 1104, where the c code is generated. The code is then loaded directly into the LED panel by utilizing the build function in the control parameter window. This paper develops a simulation model and presents the findings.

MODELING OF PV SYSTEM

An electrical equivalent circuit containing a current source anti-parallel with a diode, a shunt resistance, and a series resistance can be used to simulate a solar cell. The DC current Ig, produced in response to light exposure and changes linearly with solar intensity. A considerable portion of the nonlinear I-V characteristics of the PV cell are produced by the current Id flowing through the anti-parallel diode.

A. PV CELL

Being an electrical device, the PV module generates electricity when it is exposed to sunlight. Its lifespan of more than 22 years is attributed to the

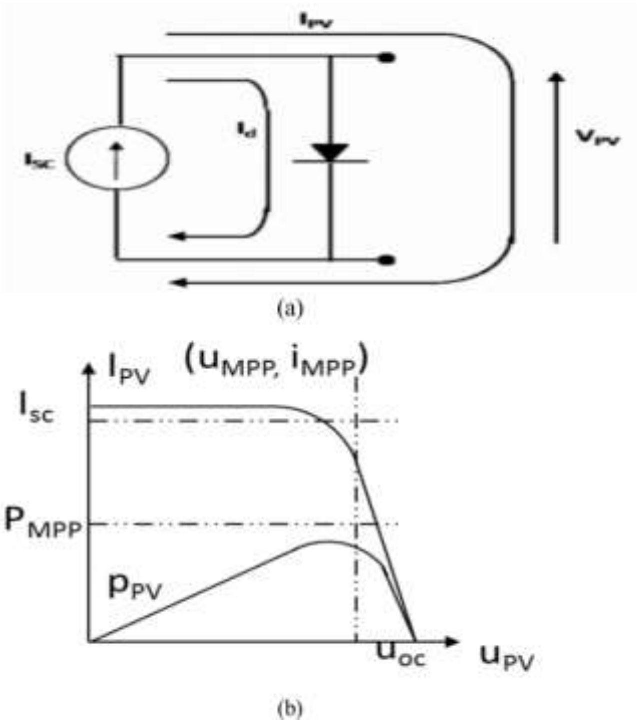

Fig. 1. (a) Electrical model (b) Model with PV cell

lack of a moving part and reduced tear. Photovoltaic cell assemblies are used to create devices that capture solar energy to produce electricity. A solar photovoltaic panel or module is made up of several integrated cells that are all aligned in the same plane. One form of solar energy is the electrical energy produced by solar modules, often known as solar power. An array is a collection of linked solar modules.

B. dSPACE Platform

The controller board's I/O ports and real-time hardware, which is based on power PC technology, making it the perfect choice for controller development in a variety of industries, including automobiles, robotics, aerospace, and drives. Your PC becomes a potent development system with the DS1104, enabling quick control prototyping. Simulink blocks for graphical configuration of A/D, D/A, digital I/O lines, incremental encoder interface, and PWM generation are provided via the real-time interface. Virtually any PC with a free 5-V PCI slot may install the board. You may simply execute your function model on the DS1104 R&D Controller Board by using Real-Time Interface (RTI). By dragging RTI blocks, you may graphically setup all I/O and minimize the amount of time needed for

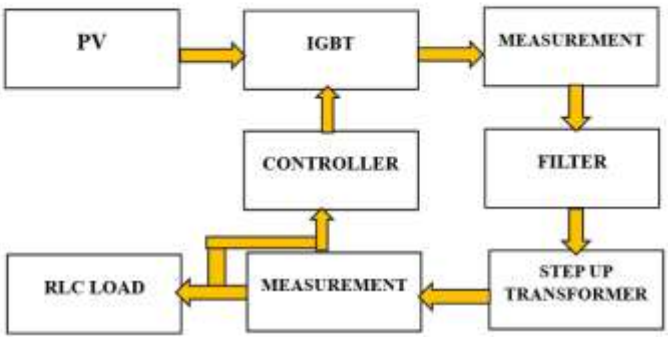

Fig. 2. Block Diagram of Simulation Model

implementation. The inverter is controlled by a dSPACE DS1104 controller, which also serves as the linkage platform by the use of dSPACE between the real hardware and the MATLAB simulation inverter models. I/O block functions are performed by the ADC and DAC. The MATLAB/SIMULINK model window's build function, which is located under the model configuration parameter, allows the SIMULINK model to generate C-code automatically. Following compiler compilation, the real-time dSPACE DS1104 processor board was connected.

C. Working Principle

The setup depicted in Fig. 2 makes up the suggested PV inverter simulation model. PV system, Inverter, Filter, Step-Up Transformer, Load, Measurement, and Additional components Controller is the primary component.

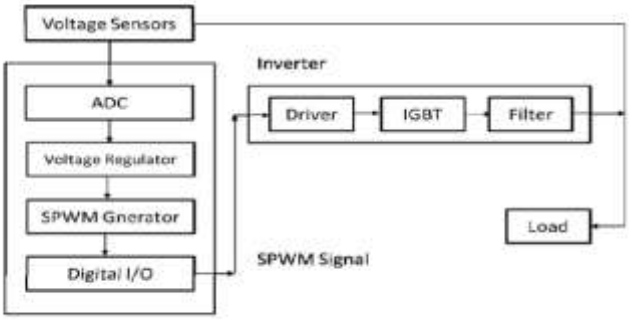

Fig. 3. Block Diagram of DS1104 controller inverter

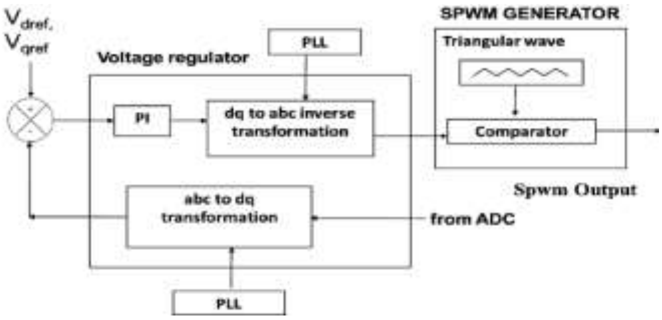

Fig. 4. Voltage regulation scheme inside DS1104 controller.

The C code is generated by the controller when simulation is built in. As illustrated in Fig. 3, the controller's control system is composed of three primary parts. In order to create a closed loop system, the voltage sensor circuit is connected to the dSPACE board and gets input from the load. A sensor is a converter that takes a physical quantity and transforms it into a signal that an electrical device or observer can read. The LEM LA-55P and LEM LV-20P sense current and voltage signals in a similar manner, and then they are inserted into the ADC channel of the dSPACE board. The dSPACE1104 board operates at a voltage of approximately 3 volts. The voltage level is secure for the controller board. As seen in Fig. 4, the signal in the ADC is transformed from analog to digital form and sent to the voltage regulation block. The three phase output voltages that are supplied to the sensor circuit are va, vb, and vc as follows:

$$\begin{aligned} v_a &= V\cos(\omega t), \\ v_b &= V\cos\left(\omega t - \frac{2\pi}{3}\right), \\ v_c &= V\cos\left(\omega t + \frac{2\pi}{3}\right), \end{aligned} \tag{1}$$

where ω is the frequency and V is the magnitude. Parks transformation, as described in (2), is used to transform the voltage regulation block signal from ADC from ABC to the dq0 reference signal, which is then compared to the Vd and Vq reference signals. It obtains a 50 Hz supply forsynchronization with the aid of PLL:

$$\begin{bmatrix} V_d \\ V_q \\ V_0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos\omega t & \cos\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t + \frac{2\pi}{3}\right) \\ -\sin\omega t & -\sin\left(\omega t - \frac{2\pi}{3}\right) & -\sin\left(\omega t + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \times \begin{pmatrix} V_a \\ V_b \\ V_c \end{pmatrix} \tag{2}$$

Then the error signal obtained goes to the PI controller which will give the voltage in regulated form. The equation for time domain PI controller is shown below:

$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt \qquad (3)$$

In order to reduce the steady state error and speed up the reaction, it is crucial to combine proportional and integral components. In this case, the controller's integral gains are denoted by Ki and the proportional gain by Kp. e(t) is the error signal. Subsequently, the signal is passed through the inverse parks transformation, resulting in an output voltage waveform that is close to a sinusoidal shape.

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} \cos\omega t & -\sin\omega t & 1 \\ \cos\left(\omega t - \frac{2\pi}{3}\right) & -\sin\left(\omega t - \frac{2\pi}{3}\right) & 1 \\ \cos\left(\omega t + \frac{2\pi}{3}\right) & -\sin\left(\omega t + \frac{2\pi}{3}\right) & 1 \end{bmatrix} \times \begin{pmatrix} V_d \\ V_q \\ V_0 \end{pmatrix} \qquad (4)$$

The 50 Hz synchronization signal from the PLL loop is also sent to the inverse park transformation block in this instance. The signal resulting from the inverse park transformation is sent to the SPWM generator in order to generate the switching signal for the inverter switches. It is composed of a triangle waveform and a comparator. In order to shape the output ac voltages to be as near to a sine wave as feasible, the SPWM modulates the switching signals for the inverter switches. This generator compares a 50 Hz control signal to a 25 kHz triangle wave that is used to produce SPWM switching signals that operate the inverter switching components. The inverter switches and their

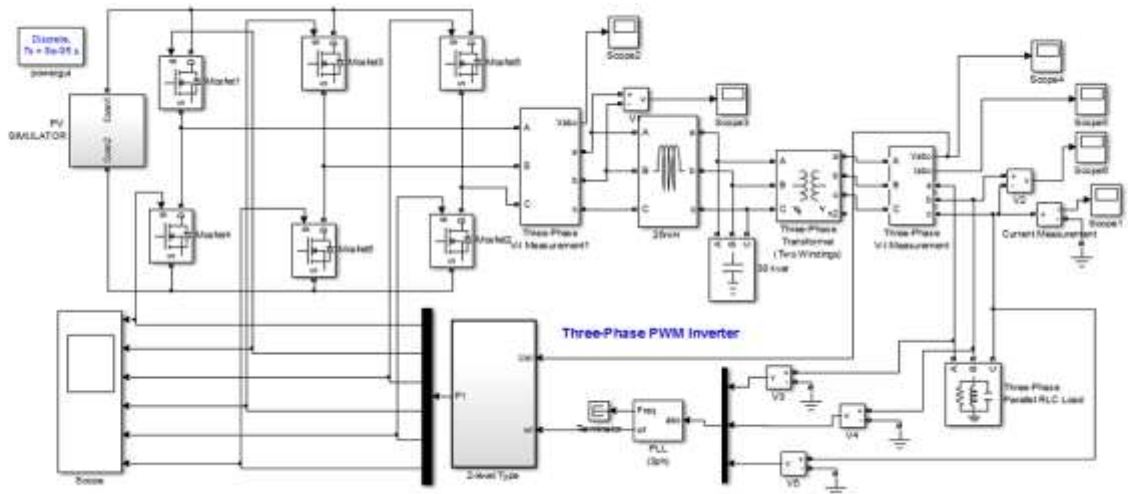

Fig. 5. The simulation model of closed loop inverter and its controller

triangular wave frequency determine the inverter switching frequencies. PWM's primary benefit is the extremely low power loss in switching devices. Practically no current flows through a switch when it is off, and virtually no voltage drops across it when it is on.

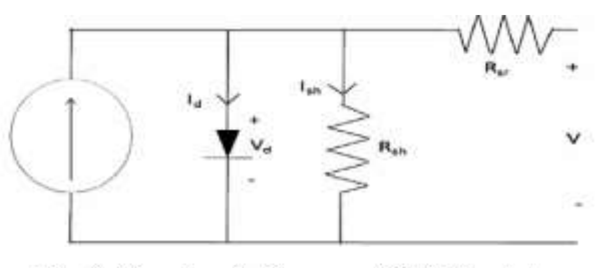

Fig. 6. The circuit diagram of PV Simulator

Since power loss is a function of both voltage and current, it is nearly non existent in both scenarios. PWM is also compatible with digital controls, which can quickly establish the required duty cycle due to its on/off nature. Typically, a high frequency transformer is used to step up the voltage and provide isolation for the PWM driven signal.

D. *Simulation Modelling*

The inverter and controller's thorough simulation model. The PV simulator is included. An electrical equivalent circuit of a current source antiparallel with a diode, a shunt resistance, and a series resistance can be used to simulate a solar cell.The inverter comes next, where a controller receives switching signals. To lessen harmonics, the low pass LC filter is connected. The output voltage of the inverter is monitored both before and after the filter. The inductor's value is 25 mH, while the capacitor's value is 30 kVAR. Next, o/p is linked to the load. Since the system is closed loop, three phase voltages are measured, sent to the PLL, and the controller receives the signal from the PLL. The simulation is conducted at the dSPACE1104 Controller Board's sample frequency of 80 usec. A controller that measures the inverter's voltages controls the system.

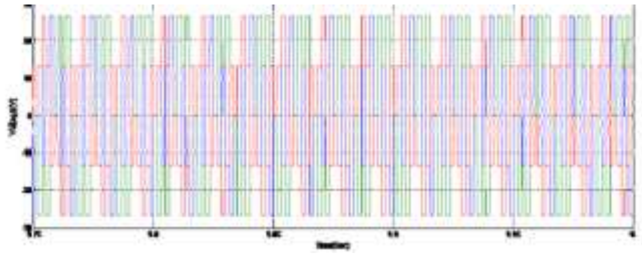

Fig. 7.Three phase inverter output voltage before filter

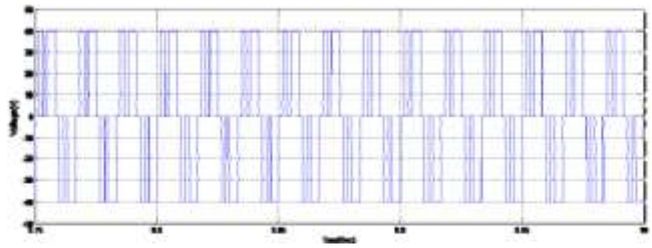

Fig 8. Single phase inverter output voltage before filter

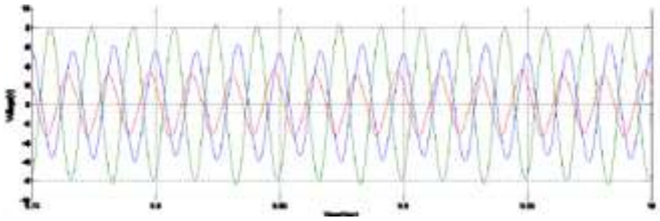

Fig 9.Three phase inverter output voltage after filter

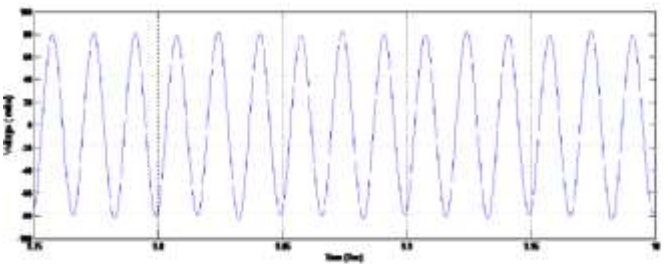

Fig. 10. Single phase inverter output voltage after filter

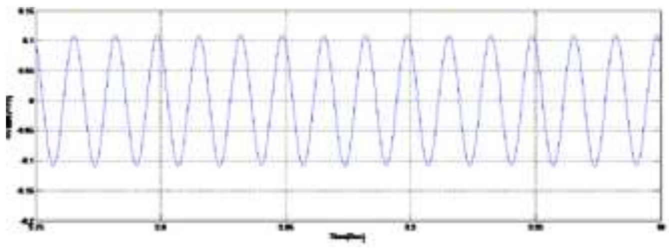

Fig. 11. Load Current of Phase

Results

Matlab/Simulink has been used to carry out and assess the simulation. MATLAB/SIMULINK tools were used to study the inverter's and its controller model's performance under various scenarios. Consequently, the waveforms of the three-phase inverter output voltage precede the filter. The suggested inverter controller's PWM switching technique resulted in a series of voltage pulses that ranged between 0 V and ±40 V, forming each phase waveform. an improved picture of the single phase voltage, or va, waveform of the inverter.

By using the LC filter, the majority of the higher-order harmonic components were decreased and removed. the inverter's three-phase ac output voltage waveforms, which only show the fundamental and lower order harmonics following the filtering circuits. The voltage waveform of the inverter's output line, vab. The patterns of the waveforms were sinusoidal .The period T, which was 0.02 seconds, or 50 Hz, was taken into consideration when determining the frequency of the output waveform. Additionally, the three-phase waveforms, which stand for the inverter output voltages va, vb, and vc, are separated from one another by 120◦. The load current's phase waveform. This current waveform resembles a sinusoidal waveform, much like the voltage waveform does. Therefore, it can be said that the improved inverter controller that was created was sufficiently efficient for photovoltaic applications.

Conclusion

This page presents a MATLAB/SIMULINK-based three-phase PV inverter controller. The outcomes demonstrated that the inverter controller generates a steady and almost sinusoidal in both line voltage and current at 50 Hz. The block name carrier generator will compare the carrier wave with the modulating wave thanks to the controller's design. The low pass filter is operating efficiently, suppressing the higher order harmonics and producing a sine waveform. The simulation's outcome demonstrated an effective reference plan for confirming the controller's desired operation. Results are provided together with the presentation of the inverter's closed loop system.

References

G. E. Ahmad, H. M. S. Hussein, and H. H. El-Ghetany, “Theoretical analysis and experimental verification of PV modules,” Renewable Energy, vol. 28, no. 8, pp. 1159-1168, 2003.

F. Blaabjerg, Z. Chen, and S. B. Kjaer, “Power electronics as efficient interface in dispersed power generation systems,” IEEE Transactions on Power Electronics, vol. 19, no. 5, pp. 1184-1194,2004.

L. Hassaine, E. Olias, J. Quintero, and M. Haddadi, “Digital power factor control and reactive power regulation for grid-connected photovoltaic inverter,” Renewable Energy, vol. 34, no. 1, pp. 315-321, 2009.

S. El-Barbari and W. Hofmann, “Digital control of a three-phase 4 wire PWM inverter for PV applications,” in Proceedings of the IEEE Industrial Electronics Society Conference (IECON ’00), 2000.

R. Frederick and B. H. Thomas, “A mcMurray inverter controller,” IEEE transactions on industrial electronics and control instrumentation, vol. 26, no. 3, pp. 156-160, 1979.

J. Selvaraj and N. A. Rahim, “Multilevel inverter for grid-connected PV system employing digital PI controller,” IEEE Transaction on Industrial Electronics, vol. 56, no. 1, pp. 149-158,2009.

S. Mekhilef and N. A. Rahim, “Xilinx FPGA based three-phase PWM inverter and its application for utility connected PV system,” in Proceedings of the IEEE Region 10 Conference on Computers, Communications, Control and Power Engineering (TENCON ’02), pp. 2079-2082, October 2002.

N. Hamrouni, M. Jraidi, and A. Chérif, “New control strategy for 2-stage grid-connected photovoltaic power system,” Renewable Energy, vol. 33, no. 10, pp. 2212-2221, 2008