Analasis Of Photovoltaic Cell An Application Of A Level Shifted Cascaded Multilevel Inverter

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Abstract- The past few years have seen many milestones in the development of streamlined, standardized requirements for utility interconnection of small-scale renewable generating facilities, particularly solar photovoltaic (PV) systems. The PV array generates DC power with a variable voltage and current. It is possible to supply DC loads directly from the PV array. Direct coupling of PV array and load is typically applied for applications exhibit intrinsic storage capabilities like water pumping or cooling systems. If AC loads are to be supplied, an inverter is required, transforming the DC power from the PV array to AC power at prescribed voltage and frequency. Battery is needed as a storage device that supplies to the load incase of indirect supply of power from the PV array. This paper focuses on the grid connected PV system. These systems are usually connected to the low voltage distribution grid. Today, grid connected PV systems, they always supply the maximum available power while voltage and frequency are determined by the mains. They are cheaper than the standalone systems and are easy to operate, as they require no storage equipment.

***Keywords*-Amplitude modulation (AM), dc-ac power conversion, insulated-gate bipolar transistor (IGBT), power electronics, pulse-width modulation, voltage-source converter (VSC)**

I. Introduction

The energy sources we have become accustomed to—the fossil fuels and nuclear fission— have ceased to be the "easy" answers to our ever-growing need for electric power. Burning oil, coal and natural gas pumps nitrogen oxide, sulfur dioxide, and mercury and other toxic metals into our atmosphere, directly cause environmental pollution. Nuclear fission produces radioactive waste, material that will remain deadly for thousands of years, for which we have yet to discover a safe method of storage. As we learn more about the inter-connectedness of all the ecosystems that permit and sustain life on our planet, the poisonous results of the various pollutants created by the use of these fuels are becoming increasingly harder to justify.

In a grid-connected PV system, PV modules, wired together to form a PV array, pass DC electricity through an inverter to convert it into AC power. If the PV system AC power is greater than the owner's needs, the inverter sends the surplus to the utility grid for use by others. The utility provides AC power to the owner at night and during times when the owner's requirements exceed the capability of the PV system.Using grid-connected PV power can have economic as well as environmental advantages. Where utility power is available, consumers can use a grid-connected PV system to supply some of the power they need and use utility-generated power at night and on very cloudy days. When the PV system supplies power to the grid as well as to a specific building or piece of equipment, the utility becomes a kind of storage device or battery for PV-generated power.

Distributed power generation systems (DPGS) are widely exploited according to the development of renewable energy systems [1,2]. DPGSs cover wide power ranges from 1kW class residential applications to several hundred MW class generation parks. Medium and small scale DPGSs are normally connected to grid systems through utility interactive inverters that inject grid current by current control mode operation

II MODEL FOR PV CELL

The building block of the PV array is the solar cell, which is
basically a p−n semiconductor junction that directly converts light energy into electricity. The equivalent circuit is shown in Fig. 1

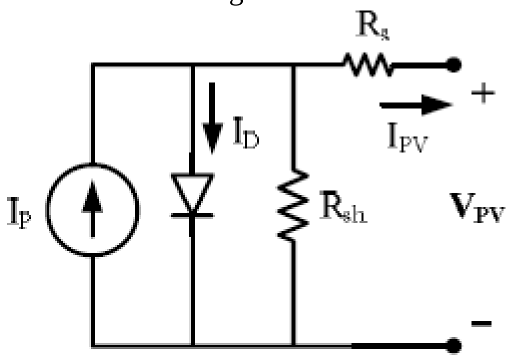


Fig. 1 Equivalent circuit for a PV cell.

To simulate a PV array, a PV simulation model which was used based on the following equation:

$$I_{PV} = n_p I_{ph} - n_p I_{rs}\left[exp\left(\frac{q}{kTA}\frac{V_{PV}}{n_s}\right) - 1\right] \quad (1)$$

Where I_{PV} is the PV array output current (A); V_{PV} is the PV array output voltage (V); ns is the number of cells connected in series; np is the number of strings connected in parallel; q is the charge of an electron; k is Boltzmann's constant; A is the p-n junction ideality factor; T is the cell temperature (K); and I_{rs} is the cell reverse saturation current. The factor A in Eq. (1) determines the cell deviation from the ideal p−n junction characteristics. The ideal value ranges between 1 and 5 and in our case, A equals 2.15. The cell reverse saturation current I_{rs} varies with temperature and the photocurrent I_{ph} depends on the solar radiation and the cell temperature as shown in the following equation:

$$I_{ph} = [I_{scr} + k_i(T - T_r)]\frac{s}{100} \quad (2)$$

where I_{scr} is the cell short-circuit current at reference temperature and radiation, k_i is the short-circuit current temperature coefficient, and s is the solar radiation in mW/cm^2.

III . Cascaded H-Bridge Multilevel Inverter Full H-Bridge

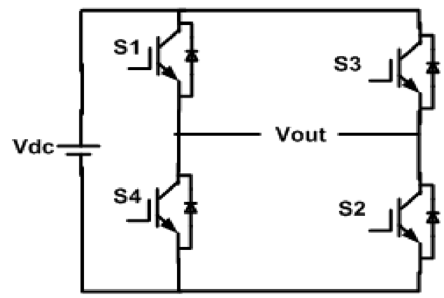


Fig.2 shows the Full H-Bridge Configuration.

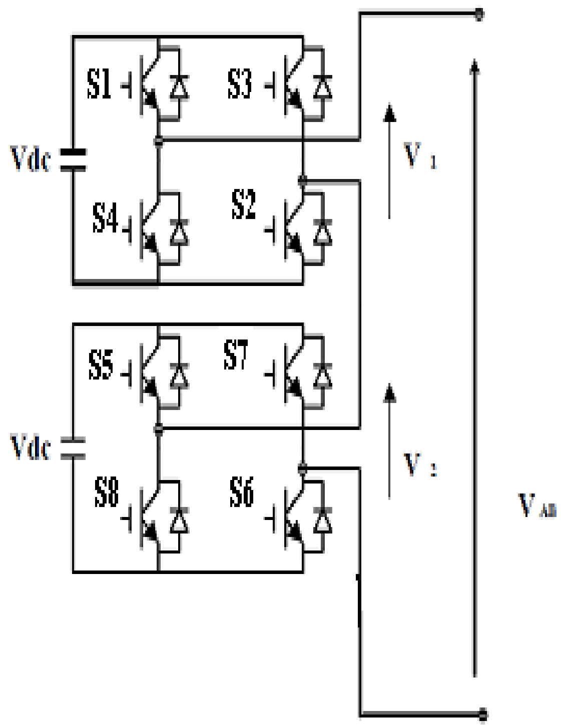
By using single H-Bridge we can get 3 voltage levels. The number output voltage levels of cascaded Full H-Bridge are given by 2n+1 and voltage step of each level is given by Vdc/n. Where n is number of H-bridges connected in cascaded. The switching table is given in Table 1 and 2.

Switches Turn ON	**Voltage Level**
S1,S2	Vdc
S3,S4	-Vdc
S4,D2	0

Table 1. Switching table for H-Bridge

Switches Turn On	**Voltage Level**
S1, S2	Vdc
S1,S2,S5,S6	2Vdc
S4,D2,S8,D6	0
S3,S4	-Vdc
S3,S4,S7,S8	-2Vdc

Table 2. Switching table for Cascaded H-Bridge



III. LEVEL SHIFTED PWM METHOD

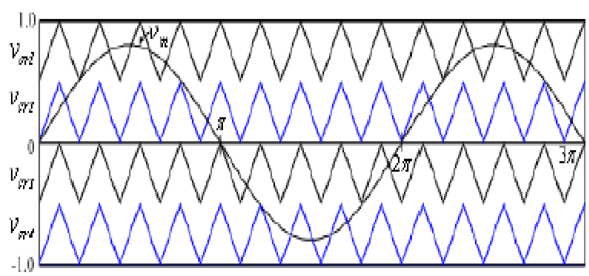


Fig.3 Level shifted carrier and reference

The Level shifted carrier pulse width modulation. An m-level Cascaded H-bridge inverter using level shifted modulation requires (m–1) triangular carriers, all having the same frequency and amplitude. The frequency modulation index is given by

$$m_f = f_{cr}/ f_m,$$

which remains the same as that for the phase-shifted modulation scheme. For PID modulation, the multilevel converter with multilevel requires (m-1) triangular carriers with same amplitude and frequency. The frequency modulation index „m_f" which can be expressed as:

$$m_f = f_{cr}/ f_m$$

where „f_m" is modulating frequency and „f_{cr}" are carrier waves frequency. The amplitude modulation index „m_a" is defined by

$$m_a = V_m / V_{cr} (m-1)$$
$$\text{for } 0 \leqslant m_a \leqslant 1$$

Where V_m is the peak value of the modulating wave and V_{cr} is the peak value of the each carrier wave [1]. The amplitude modulation index, m_a is 1 and the frequency modulation index, m_f is 6. The triggering circuit is designed based on the three phase sinusoidal modulation waves, V_a, V_b, and V_c Three of the sine wave sources have been obtained with same amplitude and frequency but displaced 120° out of the phase with each others. For carriers wave sources block parameters, the time values of each carrier waves are set to [0 1/600 1/300] while the outputs values are set according to the disposition of carrier waves. After comparing, the output signals of comparator are transmitted to the IGBTs.

IV. SIMULATION RESULTS

5.1 Modeling of Cascaded H-Bridge Multilevel Converter

Fig.7 shows the Matlab/Simulink Model of five level Cascaded H-Bridge multilevel converter. Each H-bridge DC voltage is 50 V. In order to generate three phase output such legs are connected in star/delta. Each leg gating pulses are displaced by 120 degrees.

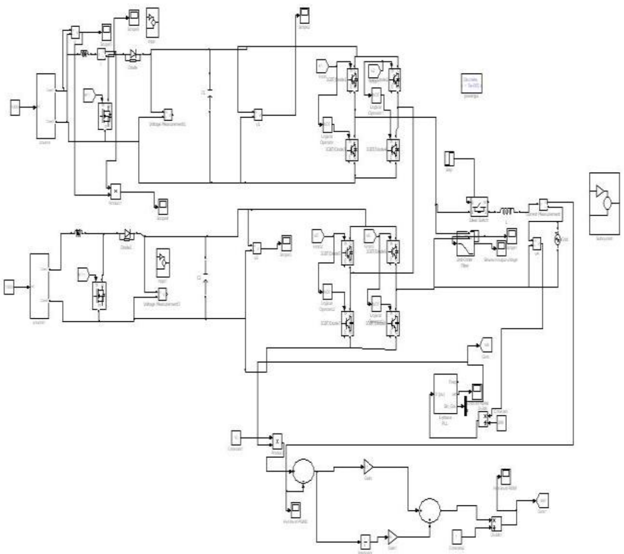


Figure. 4 Matlab/SImulink Model of CHB with grid connected

Fig.3 Shows the simulink model of the cascaded multilevel inverter which is connected to the grid. This is a closed system with PI controller.

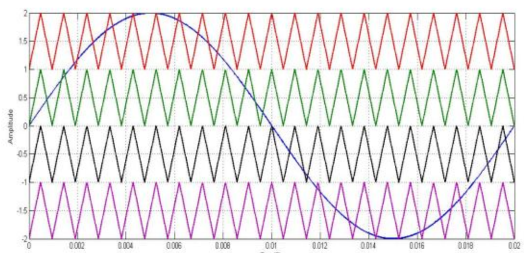


Figure. 5Carrier Signals of Phase Shifted Carrier PWM

Fig.5 shows the Phase shifted Carrier PWM wave form. Here four carriers each are phase shifted by 90 degrees are compared with sine wave.

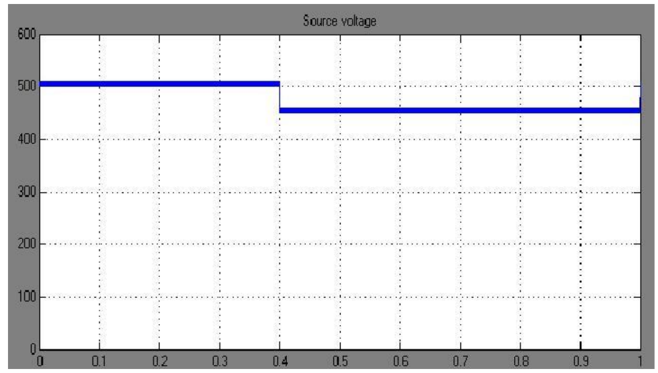


Fig.6 Source voltage

Fig.6shows the output voltage of the PV module

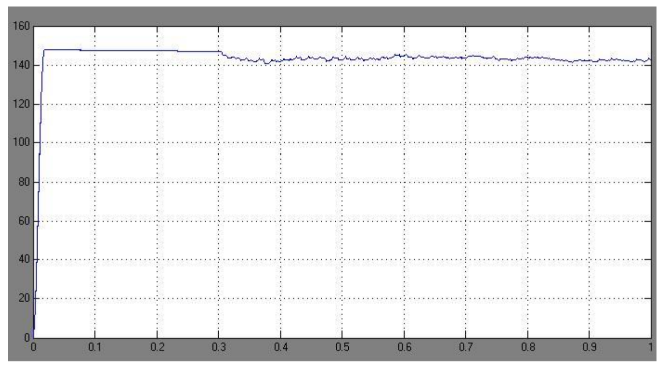


Fig.7DC-DC output voltage

Fig7shows the DC-Dc output voltage waveform which is maintained constant as the input to the CMI is a constant DC

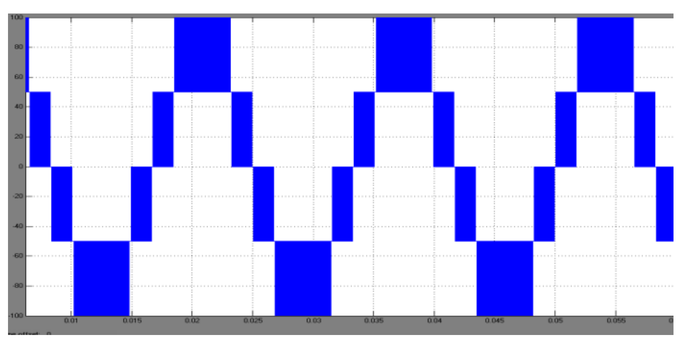


Fig.8Five level phase voltage

Fig.8shows the phase voltage of level shifted carrier PWM CHB inverter. Fig.12 shows the line voltage of level shifted carrier PWM CHB inverter. Here phase voltage has five voltage levels where as line voltage has nine voltage levels.

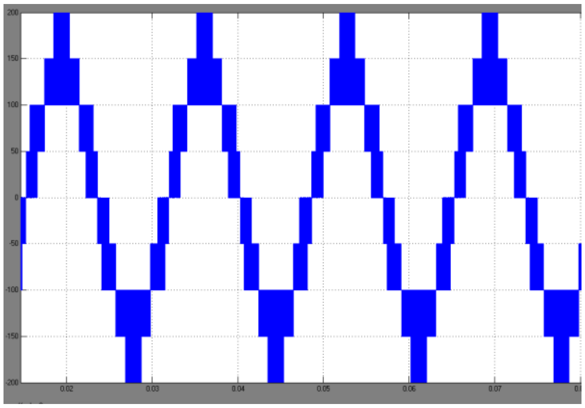


Figure. 9 Nine Level Line Voltage

VI CONCLUSION

This paper presents a cascaded multilevel inverter with photovoltaic module connected to the system. The multilevel inverter is triggered by using the level shifted PWM method, with closed loop system to maintain the synchronization with the grid. Finally a five level single H-bridge is proposed. A SIMULINK based model is developed and Simulation results are presented.

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Figure. 13 Nine Level Line Voltage

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