IJMTST
Volume: 2 | Issue: 05 | May 2016 | ISSN: 2455-3778

Performance of Photovoltaic Assisted Five Level Diode Clamped Inverter fed Induction Motor

D. Dhana Prasad[1] | A. Krishna Veni[2]

[1,2]Department Of EEE, Visakhapatnam, A.P, India.

ABSTRACT

This paper presents the simulation and analysis of Photovoltaic assisted three phase five level Diode Clamped multilevel inverter fed induction motor drive. Photovoltaic technology is one of the most promising for distributed low power generation. Its ability to produce power by directly converting solar energy has led to tremendous surge in its demand.

The Photovoltaic output DC is fed to the boost converter to step up the voltage. The use of multilevel inverters have become popular in recent years for high power applications and an effective and practical solution for increasing power and reducing harmonics of AC waveforms. So, here a five level multilevel inverter is used for generating AC voltage from five levels of DC voltages and enhance the performance of the system. The proposed system is used to reduce the amplitudes of all harmonics at the output of the inverter. The power quality improves by reducing the harmonics level. The simulation results for the proposed system are verified using Mat lab / Simulink.

The TOTAL HARMONIC DISTORTION (THD) for Diode Clamped multi-level inverter is compared with the three phase inverter and it can be observed that in the higher levels the THD is reduced.

KEYWORDS: *Solar Cell, THD, Multi-Level Inverter*

I. Introduction

Solar energy is the most low cost, competition free, universal source of energy as sun shines throughout. This energy can be converted into useful electrical energy using Photovoltaic Technology. The steady state reduction of price per peak watt and simplicity with which the installed power can be increased by adding panels which are attractive features of PV technology. However, most of the PV power generation comes from grid-connected installations, where the power is fed in the electricity network.

The efficiency of a PV plant is affected mainly by three factors: the efficiency of the PV panel (in commercial PV panels it is between 8-15%), the efficiency of the inverter (95-98 %) and the efficiency of the maximum power point tracking (MPPT) algorithm (which is over 98%).

Improving the efficiency of the PV panel and the inverter is not easy as it depends on the technology available, it may require better components, which can increase drastically the cost of the installation. Instead, improving the tracking of the maximum power point (MPP) with new control algorithms is easier, not expensive and can be done even in plants which are already in use updating their control algorithms, which would lead to an immediate increase in PV power generation and consequently a reduction in its price.

Recently the “multilevel converter” has drawn tremendous interest in the power industry. The general structure of the multilevel converter is to synthesize a sinusoidal voltage from several levels of voltages, typically obtained from capacitor voltage sources. The so called “multilevel” starts from three levels. A three-level converter, also known as a “neutral-clamped” converter, consists of two capacitor voltages in series and uses the Centre tap as the neutral. Each phase leg of the three-level converter has two pairs of switching devices in series. The Centre of each device pair is clamped to the neutral through clamping diodes.

The waveform obtained from a three-level converter is a quasi-square wave output. The diode-clamp method can be applied to higher level converters. As the number of levels increases, the synthesized output waveform adds more steps, producing a staircase wave which approaches the sinusoidal wave with minimum harmonic distortion.

II. PHOTOVOLTAIC TECHNOLOGY

Converting the sun's radiation directly into electricity is done by solar cells. These cells are made of semiconducting materials similar to those used in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity.

This process of converting light (photons) to electricity (voltage) is called the photovoltaic effect. Photovoltaic (PV) are thus the field of technology and research related to the application of solar cells that convert sunlight directly into electricity. Solar cells, which were originally developed for space applications in the 1950s, are used in consumer products such as calculators or watches, mounted on roofs of houses or assembled into large power stations. Today, the majority of photovoltaic modules are used for grid-connected power generation, but a smaller market for off-grid power is growing in remote areas and undeveloping countries.

A photovoltaic system is a system which uses one or more solar panels to convert sunlight into electricity. It consists of multiple components, including the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and modifying the electrical output. A small PV system is capable of providing enough AC electricity to power a single home, or even an isolated device in the form of AC or DC electric.

For example, military and civilian Earth observation satellites, street lights, construction and traffic signs, electric cars, solar-powered tents, and electric aircraft may contain integrated photovoltaic systems to provide a primary or auxiliary power source in the form of AC or DC power, depending on the design and power demands as shown in fig 1.

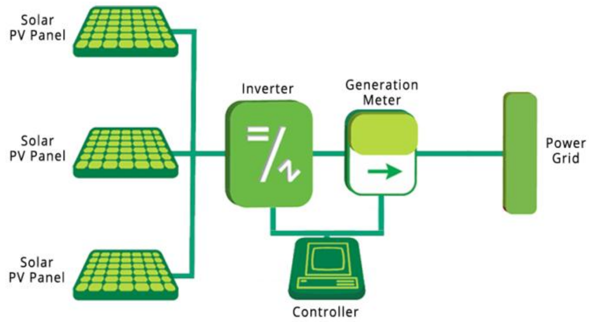

Fig 1: Schematic Diagram of Solar System

In the equivalent circuit, the current source represents the current generated by light photons and its output is constant under constant temperature and constant irradiance. The diode shunted with the current source determines the I-V characteristics of PV module. The practical equivalent circuit of a PV module is shown in the below Figure-2.

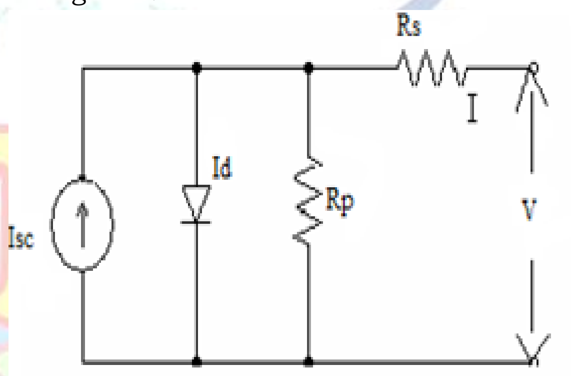

Fig 2: Equivalent circuit of PV module

Maximum power point tracking (MPPT) is a technique that grid connected inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic devices, typically solar panels though optical power transmission systems can benefit from similar technology.

Solar cell I-V curves where a line intersects the knee of the curves where the maximum power point is located.

III. BOOST CONVERTER

A boost converter is part of a subset of DC-DC converters called switch-mode converters. The circuits belonging to this class, including buck, fly back, buck-boost, and push-pull converters are very similar. They generally perform the conversion by applying a DC voltage across an inductor or transformer for a period of time (usually in the 100 kHz to 5MHz range) which causes current to flow through it and store energy magnetically, then switching this voltage off and causing the stored energy to be transferred to the voltage output in a controlled manner. The output voltage is regulated by adjusting the ratio of on/off time.

A boost converter is simply is a particular type of power converter with an output DC voltage greater than the input DC voltage. This type of circuit is used to 'step-up' a source voltage to a higher, regulated voltage, allowing one power supply to provide different driving voltages.

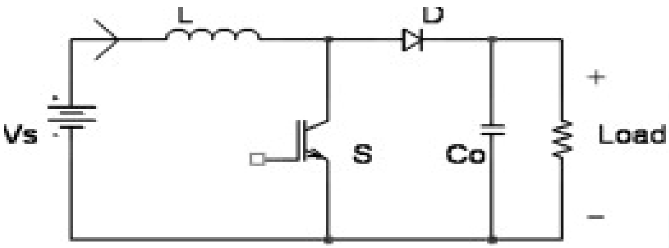

Fig 3: Standard layout of a Boost Converter

INVERTER:

Three-Phase DC AC inverter is commonly used in the industry. There are many application in industry that used this type of conversion (DC to AC) in order to operate.

In addition, the type of inverter that is used to make sure all those applications operate also have several of types.

Multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. The commutation of the switches permits the addition of the capacitor voltages, Which reach high voltage at the output, while the power semiconductors must withstand only reduced voltages FIGURE: 4.1 shows a schematic diagram of one phase leg of inverters with different numbers of levels, for which the action of the power.

DIODE CLAMPED:

A five-level diode-clamped converter in which the dc bus consists of four capacitors,C1 ,C2 ,C3 , and C4 . For dc-bus Vdc voltage, the voltage across each capacitor is Vdc/4, and each device voltage stress will be limited to one capacitor voltage level Vdc/4 through clamping diodes. To explain how the staircase voltage is synthesized, the neutral point n is considered as the output phase voltage reference point. There are five switch combinations to synthesize five level voltages across a and n.

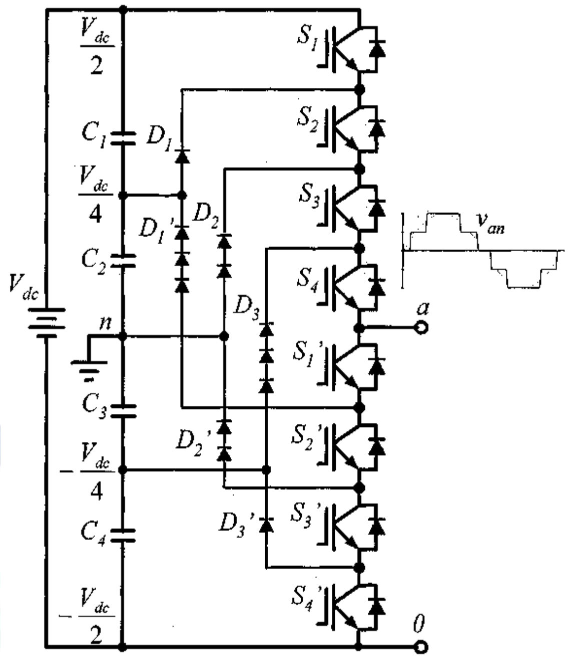

Fig4: Five level Diode clamped multilevel inverter

IV. INDUCTION MOTOR

In recent years the control of high-performance induction motor drives for general industry applications and production automation has received widespread research interests. Induction machine modeling has continuously attracted the attention of researchers not only because such machines are made and used in largest numbers but also due to their varied modes of operation both under steady and dynamic states.

Three phase induction motors are commonly used in many industries and they have three phase stator and rotor windings. The stator windings are supplied with balanced three phase ac voltages, which produce induced voltages in the rotor windings due to transformer action. It is possible to arrange the distribution of stator windings so that there is an effect of multiple poles, producing several cycles of magneto motive force (mmf) around the air gap. This field establishes a spatially distributed sinusoidal flux density in the air gap.

In this paper three phase induction motor as a load. The equivalent circuit for one phase of the rotor is shown in Figure: 5

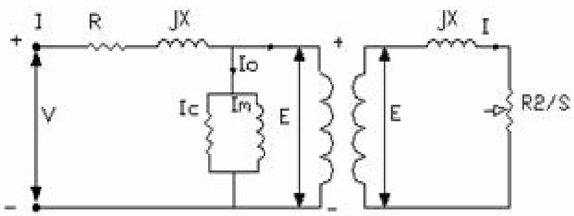

Fig 5 Steady state Equivalent circuit of an induction motor

V. Simulation Results

The simulation of Boost converter and multilevel inverter fed single phase induction motor is done in MATLAB/ SIMULINK. For the purpose of the simulation, constant irradiance and temperature is considered for the PV module. The Boost converter input and output voltage from the simulation model. It is the boosted Dc voltage from 50V to 170V of PV module. The inverter output voltage and the output current waveforms and the induction drive parameter variations are rotor currents, speed.

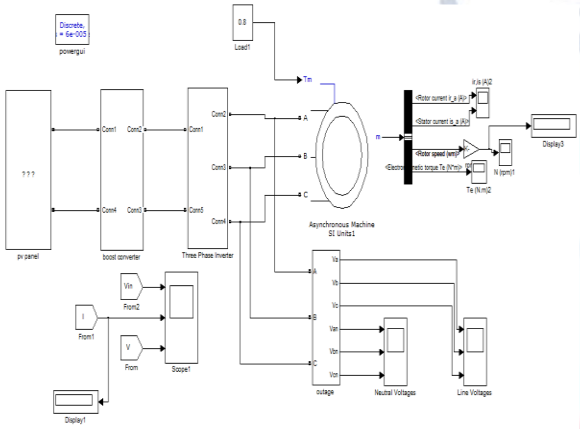

Fig 6: Simulation diagram for PV based Induction Motor with multi-level inverter

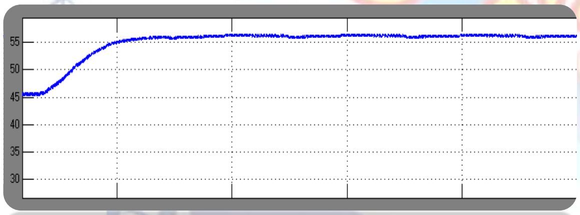

Fig 7: Simulated waveform for Vin (Photovoltaic module)

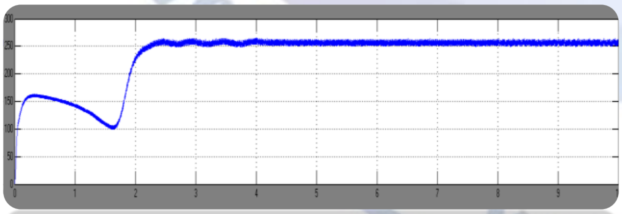

Fig 8: Simulated waveform for Boost converter

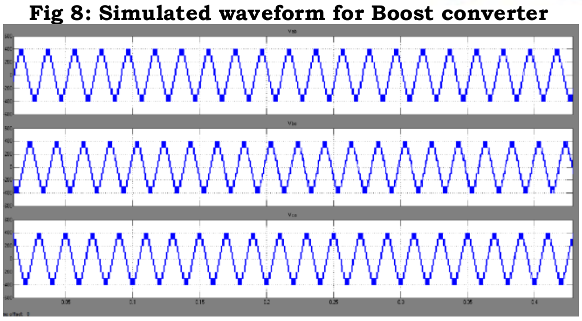

Fig 9: Simulated Five level Diode Clamped Inverter Waveforms

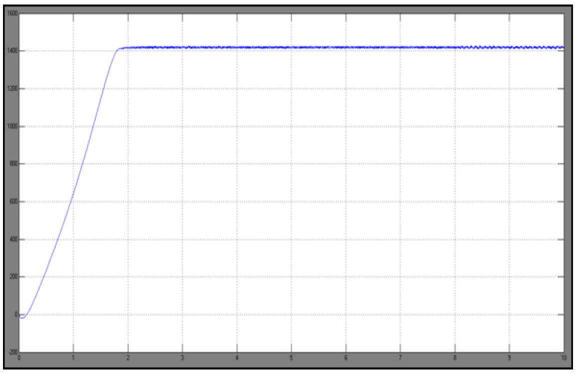

Fig 10: Speed of Induction Motor Drive

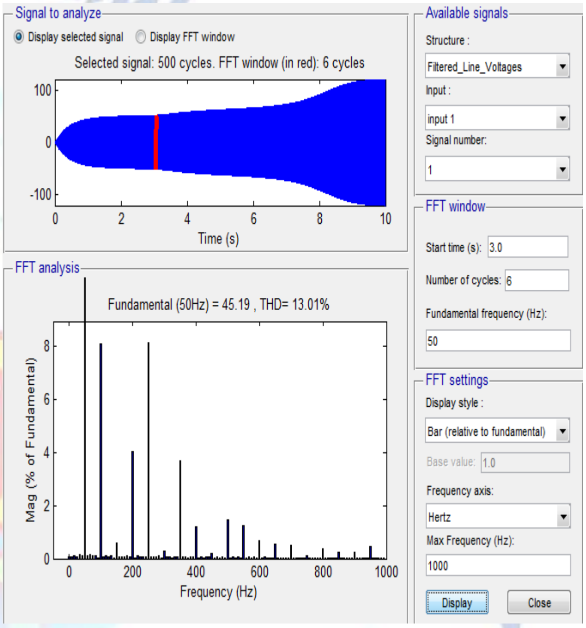

Fig 11: FFT Analysis of three phase VSI

VI. Conclusion

This paper proposes a solar power generation system to convert the dc energy generated by a solar cell array into ac energy that is fed into the utility. The proposed solar power generation system is composed of a dc–dc power converter and a five-level inverter. The seven-level inverter contains only six power electronic switches, which simplifies the circuit configuration. Furthermore, only one power electronic switch is switched at high frequency at any time to generate the five-level output voltage. This reduces the switching power loss and improves the power efficiency. The voltages of the two dc capacitors in the proposed five-level inverter are balanced automatically, so the control circuit is simplified. Experimental results show that the proposed solar power generation system generates a five-level output voltage and outputs a sinusoidal current that is in phase with the utility voltage, yielding a power factor of unity.

References

[1] D. JC. MacKay, "Sustainable Energy - Without the Hot Air", UIT Cambridge,2009

[2] "Trends in photovoltaic applications. Survey report of selected IEA countries between 1992 and 2009", International Energy Agency, Report IEA-PVPS Task 1 T1-19:2010, 2010.

[3] P. A. Lynn, Electricity from Sunlight: An Introduction to Photovoltaic, John Wiley & Sons, 2010, p. 238."Sunny Family 2010/2011 - The Future of Solar Technology",

[4] L. Piegari, R. Rizzo, "Adaptive perturb and observe algorithm for PV maximum power point tracking," Renewable Power Generation, IET, vol. 4, no. 4, pp. 317-328, July2010.

[5] M. G. Villalva, J.R. Gazoli, E. R. Filho, "Comprehensive Approach to Modeling and Simulation of PV Arrays", IEEE Transactions on Power Electronics, Vo. 24, No. 5, pp 1198-1208, May 2009

[6] T. Esram, P.L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," IEEE Transactions on Energy Conversion, vol. 22, no. 2, pp. 439-449, June 2007

[7] N. Femia, G. Petrone, G. Spagnuolo, M. Vitelli, "Optimizing sampling rate of P&O MPPT technique," in Proc. IEEE PESC, 2004, pp. 1945- 1949.

[8] M.S. Jamri and T.C.Wei, "Modeling and Control of a Photovoltaic Energy System using the State Space Average Technique" in proceeding on American Journal of Applied Science-7, 2010, pp 682-691.

[9] M. G. Villalva, J.R. Gazoli, E. R. Filho, "Comprehensive Approach to Modeling and Simulation of PV Arrays", IEEE Transactions on Power Electronics, Vo. 24, No. 5, pp 1198-1208, May 2009

[10] Power Electronics Circuits, Devices and Applications, by M.H. Rashid, 3rd Edition, Pearson Education-2004

[11] B. Wittig, W.T.Franke, F.W.Fuchs, "Design and Analysis of a DC/DC/AC Three Phase Solar Converters with Minimized DC Link Capacitance", in proceedings on 12th European conference on Power Electronics and Applications, Aalborg, 2007.

[12] L.M.Tolbert, F.Z. Peng, T. G. Habetler,b"Multilevel converters for large electric drives," IEEE Transactions on Industry Applications, vol.35, no. 1, Jan. /Feb. 1999, pp. 36-44.

[13] J. S. Lai and F. Z. Peng, "Multilevel converters – A new breed of power converters," IEEE Transactions on Industry Applications, vol. 32, no.3, May. /June 1996, pp. 509-517.

[14] J. Rodriguez, J. Lai, and F. Peng, "Multilevel inverters: a survey of topologies, controls and applications," IEEE Transactions on Industry Applications, vol. 49, no. 4, Aug. 2002, pp. 724-738.

[15] Masters, Gilbert M. Renewable and Efficient Electric Power Systems John Wiley &Sons Ltd,2004.

[16] D. Zhong B. Ozpineci, L. M. Tolbert, J. N.Chiasson, "Inductor less DC-AC cascaded H-Bridge multilevel boost inverter for electric/hybrid electric vehicle applications," IEEE Industry Applications Conference, Sept. 2007, pp. 603-608.

Authors Biography

Dhana Prasad Duggapu born on 17th July 1986, received B.Tech Degree from Vignan's Institute of Information Technology, Visakhapatnam, Andhra Pradesh, India in 2008 & M.Tech degree from Dadi Institute of Engineering & Technology, Anakapalli, Visakhapatnam, Andhra Pradesh, India in the department of Electrical & Electronics Engineering. He is presently working as an Assistant Professor in Dept. of Electrical and Electronics Engineering at Avanthi Institute of Engineering and Technology, Visakhapatnam, A.P. His area of interests on Power Electronics.

A Krishna Veni born on 23rd June 1990, received B.Tech Degree from Vignan's Institute of Information Technology, Visakhapatnam, Andhra Pradesh, India in 2011 & M.Tech degree from GMR Institute of Technology, Vijayanagarm, Andhra Pradesh, India in the department of Electrical & Electronics Engineering 2014. She is presently working as an Assistant Professor in Dept. of Electrical and Electronics Engineering at Avanthi Institute of Engineering and Technology, Visakhapatnam, A.P. Her area of interests on Power Electronics.