International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

IJIEMR Transactions, online available on 24th January 2018. Link :
http://www.ijiemr.org/downloads.php?vol=Volume-7&issue=ISSUE-01

Title: Implementation of Multilevel Inverter fed Induction motor drive with Reduced Number of Switches.

Volume 07, Issue 01, Page No: 179 – 185.

Paper Authors

*** K.MANASA, I.PRASANNA KUMAR.**

* Dept of Electrical & Electronics Engineering, NRI Institute of Technology.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

IMPLEMENTATION OF MULTILEVEL INVERTER FED INDUCTION MOTOR DRIVE WITH REDUCED NUMBER OF SWITCHES

***K.MANASA,** I .PRASANNA KUMAR**
*PG Scholar, Dept of EEE, NRI institute of technology, Agiripalli; Krishna (DT); A.P, India.
**Assistant Professor, Dept of EEE, NRI institute of technology, Agiripalli; Krishna (DT); A.P, India.

ABSTRACT— Induction motors are widely used in industries, because they are rugged, reliable and economical. Induction motor drive requires suitable converters to get the required speed and torque without or negligible ripples. Multilevel inverter technology has emerged recently as a very important alternative in the area of high power medium-voltage control and also for improving the total harmonic distortion by reducing the harmonics. Generally, the poor quality of voltage and current of a conventional inverter fed induction machine is obtained due to the presence of harmonics and hence there is a significant level of energy losses. The simulation results of proposed topology three phase 33-level multilevel inverter fed induction motor drive are verified using MATLAB.

Key Words— Multilevel Inverter, H-bridge topology, Induction Motor drive.

I. INTRODUCTION

Nowadays, multilevel inverters have received more attention for their ability on high-power and medium voltage operation and because of other advantages such as high power quality, lower order harmonics, lower switching losses, and better electromagnetic interference [1], [2]. These inverters generate a stepped voltage waveform by using a number of dc voltage sources as the input and an appropriate arrangement of the power-semiconductor-based devices [3].

Three main structures of the multilevel inverters have been presented: "diode clamped multilevel inverter," "flying capacitor multilevel inverter," and "cascaded multilevel inverter" [4]. The cascaded multilevel inverter is composed of a number of single-phase H-bridge inverters and is classified into symmetric and asymmetric groups based on the magnitude of dc voltage sources. In the symmetric types, the magnitudes of the dc voltage sources of all H-bridges are equal while in the asymmetric types, the values of the dc voltage sources of all H-bridges are different.

In recent years, several topologies with various control techniques have been presented for cascaded multilevel inverters [5]–[8]. In [4] and [9]–[15], different symmetric cascaded multilevel inverters have been presented. The main advantage of all these structures is the low variety of dc voltage sources, which is one of the most important features in determining the cost of the inverter. On the other hand, because some of them use a high number of bidirectional power switches, a high number of insulated gate bipolar transistors (IGBTs) are required, which is the main disadvantage of these topologies. An asymmetric topology has been presented in [16]. The main disadvantage of this structure is related to its bidirectional power switches, which cause an increase in the number of IGBTs and the total cost of the inverter. In [15], a new topology with three algorithms have been presented, which reduce the number of required power switches but increase the variety of dc voltage sources. In [1], [4] and [15], several algorithms for determining the magnitudes of dc voltage sources for the conventional cascaded multilevel inverter have been presented. The major advantage of this topology and its algorithms is related to its ability to generate a

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

considerable number of output voltage levels by using a low number of dc voltage sources and power switches but the high variety in the magnitude of dc voltage sources is their most remarkable disadvantage.

In this paper, in order to increase the number of output voltage levels and reduce the number of power switches, driver circuits, and the total cost of the inverter, a new topology of cascaded multilevel inverters is proposed. It is important to note that in the proposed topology, the unidirectional power switches are used. Then, to determine the magnitude of the dc voltage sources, a new algorithm is proposed. Moreover, the proposed topology is compared with other topologies from different points of view such as the number of IGBTs, number of dc voltage sources, the variety of the values of the dc voltage sources, and the value of the blocking voltages per switch. Finally, the performance of the proposed topology in generating all voltage levels through a 33-level inverter is confirmed by simulation using MATLAB.

II. DESCRIPTION OF THE PROPOSED STRUCTURE

Fig.1 shows the proposed multilevel inverter topology. Here, a simple variation of diode clamped multilevel inverter is used to generate a staircase waveform. An H-bridge is used to get an alternating signal with both positive and negative polarities. Capacitors are used to divide the DC link voltage into k distinct levels. These capacitor voltages are then added and subtracted by operating the power switches to generate 2k + level staircase voltage waveform. Diodes are used with each power switch in reverse blocking mode. Fig.2 explains the working principle of the proposed topology, where V_{bus} is the DC bus voltage, V_{ac} is the ac output voltage, Vac_1 is the fundamental component of Vac. S_1 - S_k represent the gating signals of the switches. Similarly Q_1 - Q_4 represent gating signals of H-bridge. The four switches of H-bridge are operated at the fundamental frequency of the output voltage.

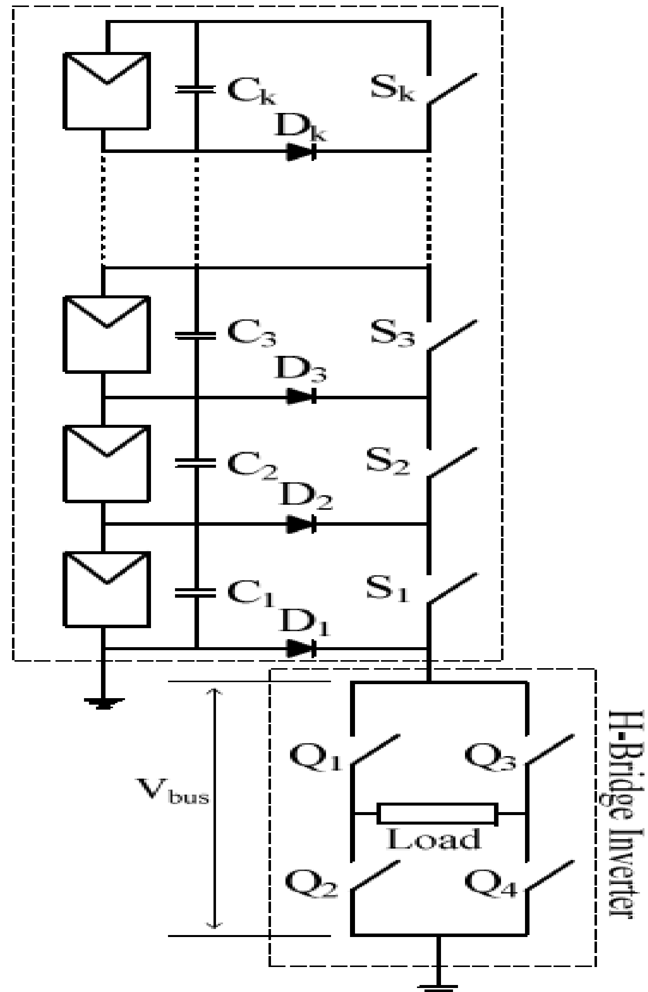

Fig.1: Our proposed topology of multilevel inverter

In the proposed topology, k power switches are required to generate k levels staircase waveform V_{bus}. Four additional switches of H-bridge inverter are used to get staircase ac waveform V of 2k + levels. Effectively, to generate 2k + level staircase voltage ac waveform, only k + 4power switches, k capacitors and k diodes are needed which results in overall lesser device count than an existing multilevel topology, to the best of our knowledge.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

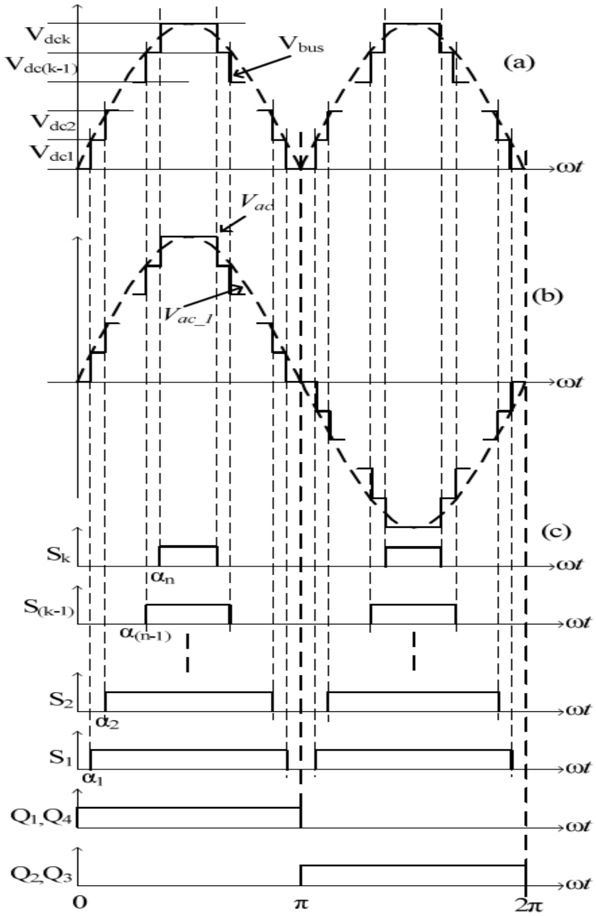

Fig.2: Output waveform and states of various switches.

III. INDUCTION MOTOR

An asynchronous motor type of an induction motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor as are found in universal, DC and synchronous motors. An asynchronous motor's rotor can be either wound type or squirrel-cage type.

Three-phase squirrel-cage asynchronous motors are widely used in industrial drives because they are rugged, reliable and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFDs) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump and compressor load applications. Squirrel cage induction motors are very widely used in both fixed-speed and variable-frequency drive (VFD) applications. Variable voltage and variable frequency drives are also used in variable-speed service.

In both induction and synchronous motors, the AC power supplied to the motor's stator creates a magnetic field that rotates in time with the AC oscillations. Whereas a synchronous motor's rotor turns at the same rate as the stator field, an induction motor's rotor rotates at a slower speed than the stator field. The induction motor stator's magnetic field is therefore changing or rotating relative to the rotor. This induces an opposing current in the induction motor's rotor, in effect the motor's secondary winding, when the latter is short-circuited or closed through external impedance. The rotating magnetic flux induces currents in the windings of the rotor; in a manner similar to currents induced in a transformer's secondary winding(s). The currents in the rotor windings in turn create magnetic fields in the rotor that react against the stator field. Due to Lenz's Law, the direction of the magnetic field created will be such as to oppose the change in current through the rotor windings. The cause of induced current in the rotor windings is the rotating stator magnetic field, so to oppose the change in rotor-winding currents the rotor will start to rotate in the direction of the rotating stator magnetic field. The rotor accelerates until the magnitude of induced rotor current and torque balances the applied load. Since rotation at synchronous speed would result in no induced

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

rotor current, an induction motor always operates slower than synchronous speed. The difference, or "slip," between actual and synchronous speed varies from about 0.5 to 5.0% for standard Design B torque curve induction motors. The induction machine's essential character is that it is created solely by induction instead of being separately excited as in synchronous or DC machines or being self-magnetized as in permanent magnet motors. For rotor currents to be induced the speed of the physical rotor must be lower than that of the stator's rotating magnetic field (n_s); otherwise the magnetic field would not be moving relative to the rotor conductors and no currents would be induced. As the speed of the rotor drops below synchronous speed, the rotation rate of the magnetic field in the rotor increases, inducing more current in the windings and creating more torque. The ratio between the rotation rate of the magnetic field induced in the rotor and the rotation rate of the stator's rotating field is called slip. Under load, the speed drops and the slip increases enough to create sufficient torque to turn the load. For this reason, induction motors are sometimes referred to as asynchronous motors. An induction motor can be used as an induction generator, or it can be unrolled to form a linear induction motor which can directly generate linear motion.

Synchronous Speed:

The rotational speed of the rotating magnetic field is called as synchronous speed.

$$Ns = \frac{120 \times f}{P} \quad (RPM) \tag{1}$$

Where, f = frequency of the supply

P = number of poles

Slip:

Rotor tries to catch up the synchronous speed of the stator field, and hence it rotates. But in practice, rotor never succeeds in catching up. If rotor catches up the stator speed, there won't be any relative speed between the stator flux and the rotor, hence no induced rotor current and no torque production to maintain the rotation. However, this won't stop the motor, the rotor will slow down due to lost of torque, and the torque will again be exerted due to relative speed. That is why the rotor rotates at speed which is always less the synchronous speed.

The difference between the synchronous speed (Ns) and actual speed (N) of the rotor is called as slip.

$$\%\ slip \quad s = \frac{Ns - N}{Ns} \times 100 \tag{2}$$

IV. MATLAB/SIMULINK RESULTS

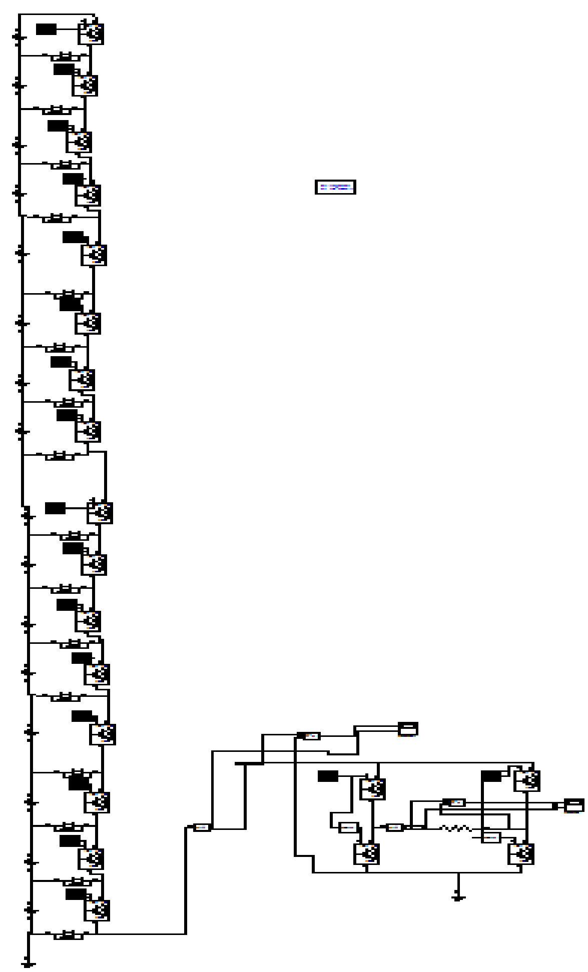

Fig.3 simulink model of proposed multilevel inverter

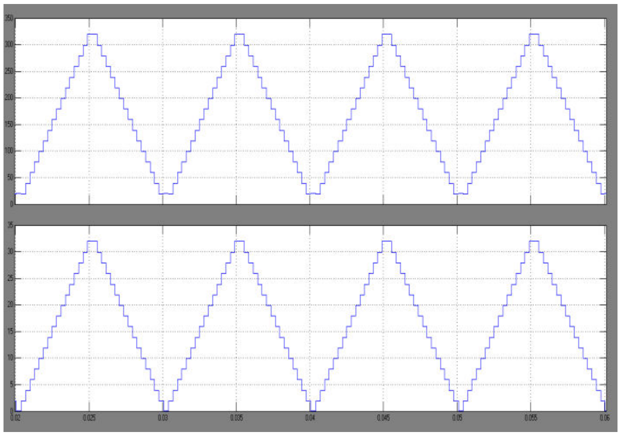

Fig.4. Simulated waveforms of DC bus voltage and current of a 33 level multilevel inverter

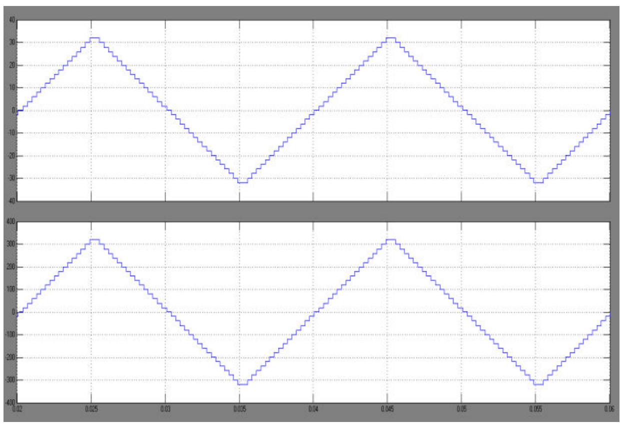

Fig.5. Simulated waveforms of AC output voltage and current of a 33 level multilevel inverter

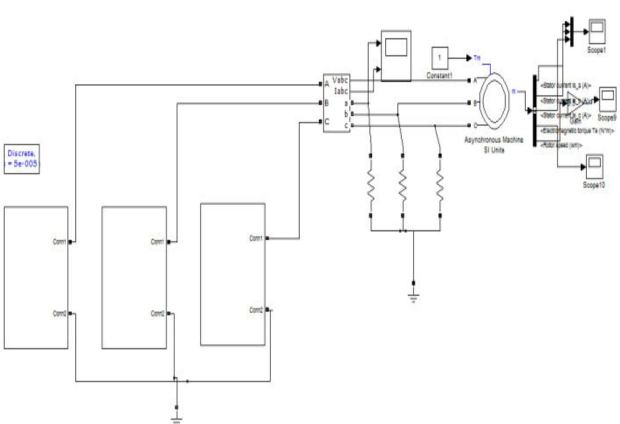

Fig.6 simulink model of proposed multilevel inverter with induction motor drive

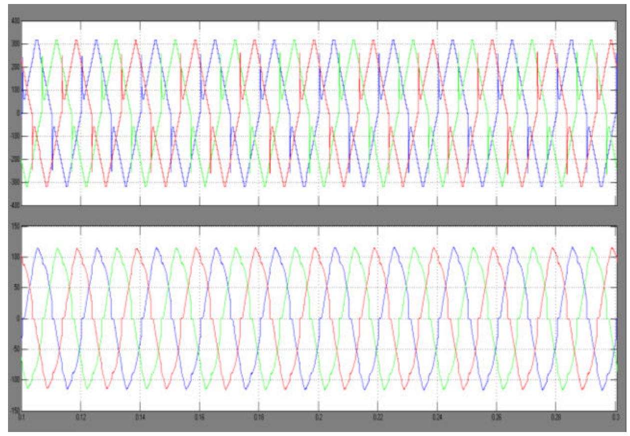

Fig.7. Simulated waveforms of three-phase output voltage and current of a 33 level multilevel inverter

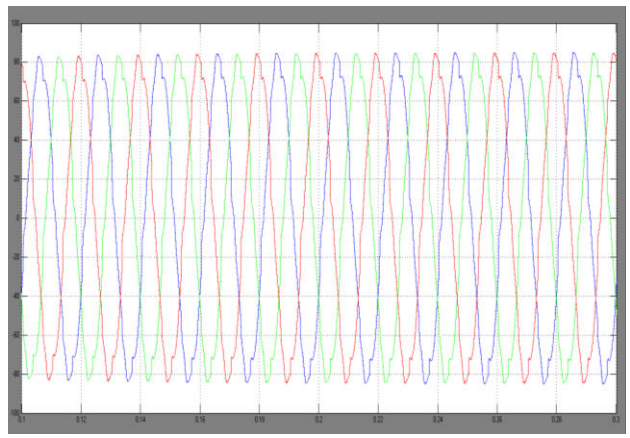

Fig.8 Stator current

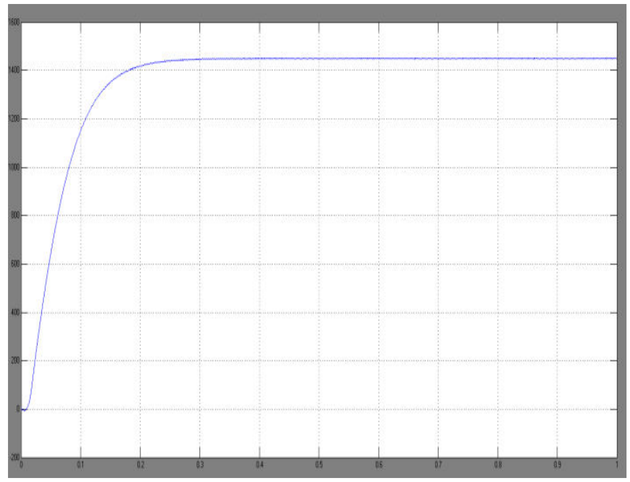

Fig.9 Speed of the induction motor

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

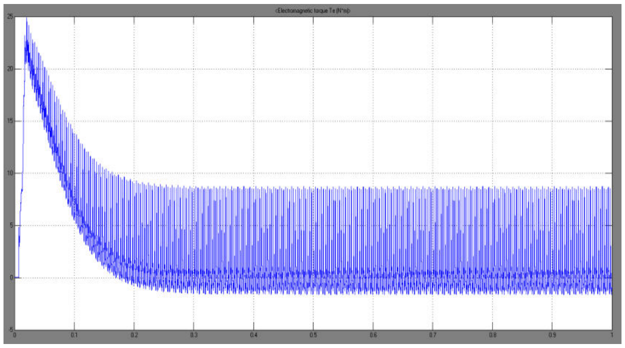

Fig.10 Torque characteristics of the induction motor

V. CONCLUSION

In this paper, a new multilevel topology in 33-level inverter fed induction motor drive is implemented. The modelling of multilevel inverter fed induction motor drive was done and simulated using Simulink. The total harmonic distortion is very low compared to that of classical inverter. The multilevel inverter fed induction motor system has been successfully simulated and the results of voltage waveforms, current waveforms, motor speed, electromagnetic torque and frequency spectrum for the output were obtained. The inverter system can be used for industries where the adjustable speed drives are required.

REFERENCES

[1] A. B. Meinel and M. P. Meinel, Applied Solar Energy: An Introduction. Addison-Wesley, 1979.
[2] Ned Mohan, Power ELectrnoics A first Course. Wiley, 2012.
[3] S. Kouro and M. Malinowski, "Recent advances and industrial applications of multilevel converters," Ind. Electron. …, vol. 57, no. 8, pp. 2553–2580, Aug. 2010.
[4] J. Rodríguez, J. S. Lai, and F. Z. Peng, "Multilevel inverters: A survey of topologies, controls, and applications," IEEE Trans. Ind. Electron., vol. 49, no. 4, pp. 724–738, Aug. 2002.
[5] E. Najafi, A. Halim, M. Yatim, and S. Member, "Design and implementation of a new multilevel inverter topology," IEEE Trans. Ind. Electron., vol. 59, no. 11, pp. 4148–4154, Nov. 2012.
[6] E. Villanueva, P. Correa, J. Rodriguez, and M. Pacas, "Control of a single-phase cascaded H-bridge multilevel inverter for grid-connected photovoltaic systems," IEEE Trans. Ind. Electron., vol. 56, no. 11, pp. 4399–4406, Nov. 2009.
[7] E. Babaei, S. Laali, and S. Alilu, "Cascaded multilevel inverter with series connection of novel H-bridge basic units," Ind. Electron. IEEE Trans., vol. PP, no. 99, p. 1, Dec. 2014.
[8] M. Malinowski, K. Gopakumar, J. Rodriguez, and M. a. Perez, "A survey on cascaded multilevel inverters," IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2197–2206, Jul. 2010.
[9] A. Nabae, I. Takahashi, and H. Akagi, "A new neutral-point-clamped PWM inverter," IEEE Trans. Ind. Appl., vol. IA-17, no. 5, pp. 518–523, Sep. 1981.
[10] T. A. Meynard and H. Foch, "Multi-level conversion: High voltage choppers and voltage-source inverters," in Proc. Eur. Conf. Power Electron. Appl., 1992, vol. 2, pp. 45-50.
[11] M. Marchesoni, M. Mazzucchelli, and S. Tenconi, "A non conventional power converter for plasma stabilization," in Proc. Power Electron. Spec. Conf., 1988, pp. 122-129.
[12] R. González, E. Gubía, J. López, and L. Marroyo, "Transformerless single-phase multilevel-based photovoltaic inverter," IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2694–2702, Jul. 2008.
[13] E. Cipriano, S. Member, and C. Brand, "Nested multilevel topologies," vol. 30, no. 8, pp. 4058–4068, Aug. 2015.
[14] S. Daher, J. Schmid, and F. L. M. Antunes, "Multilevel inverter topologies for stand-alone

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

PV systems," IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2703–2712, Jul. 2008.
[15] K. Gupta, A. Ranjan, P. Bhatnagar, L. K. Sahu, and S. Jain, "Multilevel inverter topologies with reduced device count: a review," IEEE Trans. Power Electron..., to be published.