International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 1, Issue 4, April 2014)

Modified Hybrid Multilevel Inverter for Induction Motor Using Solar energy

Satheeswaran.K
PG Scholar/Dept of EEE
K.S.Rangasamy College of Technology,
Tiruchengode, Namakkal, India
raajsathees@gmail.com

Dr.K.Ramani
Associate Professor/Dept of EEE
K.S.Rangasamy College of Technology,
Tiruchengode, Namakkal, India
kreee82@gmail.com

***Abstract*— In recent years, multilevel inverters have gained more attention for high power applications. A multilevel inverter not only achieves high power ratings, but also enables the use of renewable energy sources. Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily interfaced to a multilevel inverter system for a high power application. The proposed method is 15-level multilevel inverter which has a number of modules connected in series. Each module has one switch and one parallel connected diode where only one switch operates at a time preventing short circuit. This method involves less number of switches associated with more number of voltage levels. The stages with higher DC link have more advantages like low commutation, reduced switching losses, increased efficiency and low input stages with more number of output levels. The input supply is given from the photovoltaic cell. In this paper, a bypass diode technique is introduced to the conventional H-bridge multilevel inverter topology which reduces the number of controlled switches used in the system. It dramatically reduces the switching losses; cost and low order harmonics and thus effectively improves Total Harmonic Distortion (THD).**

***Keywords*—Hybrid multilevel inverter, Cascaded H-bridge inverter, Total Harmonic Distortion, Photo Voltaic cell**

I. INTRODUCTION

Numerous industrial applications require high power apparatus in recent years. The utility applications require medium voltage and MW power level. For a medium voltage grid, it is troublesome to connect single power semiconductor switch directly [1]-[2]. The applications of ac variable frequency speed regulations are widely popularized. High power and medium voltage inverter has recently become a research focus. Multilevel inverter have been gained more attention for high Power application in recent years which can operate at high switching frequencies while producing lower order harmonic components [3]-[4]. A multilevel inverter not only achieves high power ratings, but also enables the use of renewable energy sources. There are several topologies such as neutral point clamped or diode clamped multilevel inverter, flying capacitor based multilevel inverter, cascaded H-bridge multilevel inverter and hybrid H-bridge multilevel inverter. The main disadvantage of diode clamped multilevel inverter topology is restriction to the high power operation. The first topology introduced is the series H-bridge design [5]-[6], in which several configurations have been obtained. This topology consists of series power conversion cells which form the cascaded H- bridge multilevel inverter and power levels may be scaled easily. An apparent disadvantage of this topology is the requirement of large number of isolated voltage sources. The proposed topology for multilevel inverter has high number of steps associated with low number of power switches. In addition, for producing the levels at the output voltage, a procedure for calculating the required dc voltage source is proposed.

II. HYBRID MULTILEVEL INVERTER

The general structure of the hybrid multilevel inverter for single phase is shown in figure.1. Each H-bridge circuit is connected in series associated with it. Each of the circuit consists of four active switching elements that can make the output voltage as positive or negative polarity; or it can be simply zero volts depending on the switching condition of the switches in the circuit. A conventional multilevel inverter topology employs multiple/link voltage of equal magnitudes. It is fairly easy to generalize the number of distinct levels [7] - [8].

The S may be number of stages or dc sources and the associated number output level can be written as follows

$$N_{level} = 2^{S+1} \quad (1)$$

The number of switches used in this topology is expressed as,

$$N_{switch}=4S \quad (2)$$

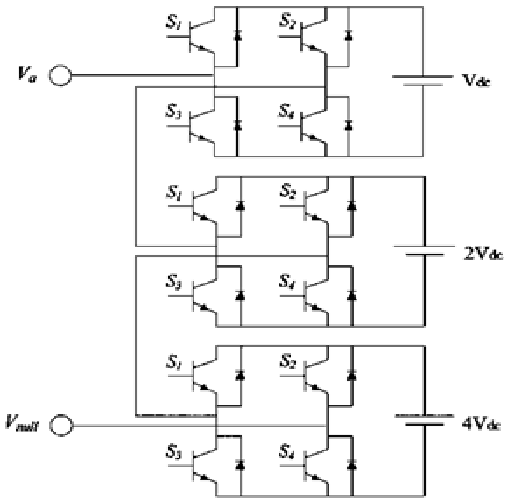


Figure.1 Topology for Hybrid Multilevel Inverter

International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 1, Issue 4, April 2014)

The advantage of the hybrid multilevel inverter is modularized structure. This will enable the manufacturing process to be done more quickly and cheaply. The drawback of this topology needs a separate dc source for each of the H-bridges and involves high number of semiconductor switches.

III. PROPOSED METHOD

A. Modified Hybrid Multilevel Inverter

The proposed multilevel inverter has a general structure of the hybrid multilevel inverter as shown in figure. 2. Each of the separate voltage source (1Vs, 2Vs, 4Vs) is connected in series with other sources via a special circuit associated with it. Each stage of the circuit consists of only one active switching element and one bypass diode that make the output voltage as positive one with several levels. The basic operation of modified hybrid multilevel inverter for producing the output voltage as +1Vdc is to turn on the switch S1 (S2 and S3 turn off) and turning on S2 (S1 and S3 turn off) for producing output voltage as +2Vdc. Similarly other levels can be achieved by turning on the suitable switches at particular intervals. The Table.1 shows the basic operation of proposed hybrid multilevel inverter. From the table it can be inferred that only one H-bridge is connected to get both positive and negative polarity. The main advantage of modified hybrid multilevel inverter is high number of levels with reduced number of switches.

TABLE I
BASIC OPERATION OF MODIFIED HYBRID MULTILEVEL INVERTER

S.NO	Intervals	On switches	Off switches	Voltage levels	Current flow path
1	I	S1	S2,S3	+1Vs	S1,D2,D3
2	II	S2	S1,S3	+2Vs	S2,D1,D3
3	III	S1,S2	S3	+3Vs	S1,S2,D3
4	IV	S3	S1,S2	+4Vs	D1,D2,D3
5	V	S1,S3	S2	+5Vs	S1,D2,D3
6	VI	S2,S3	S1	+6Vs	D1,S2,S3
7	VII	SI,S2,S3	-	+7Vs	S1,S2,S3
8	VIII	-	S1,S2,S3	0	D1,D2,D3

The S number of dc sources or stages and the associated number output level can be calculated by using the equation

N level =2S+1 (3)

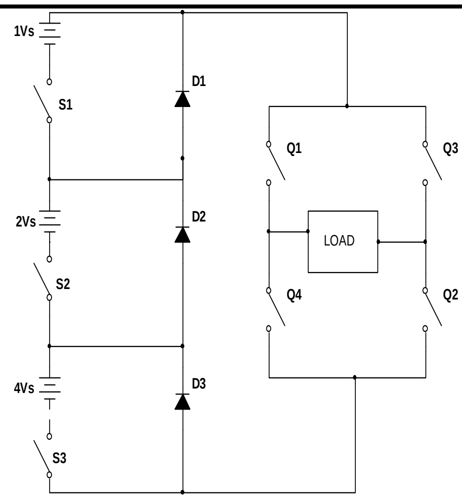


Figure.2 Topology for Modified Hybrid Multilevel Inverter

Voltage on each stage can be calculated by using the equation

V=2S-1.Vdc (4)

The number of switches used in this topology is given by the equation

N switch=S +4 (5)

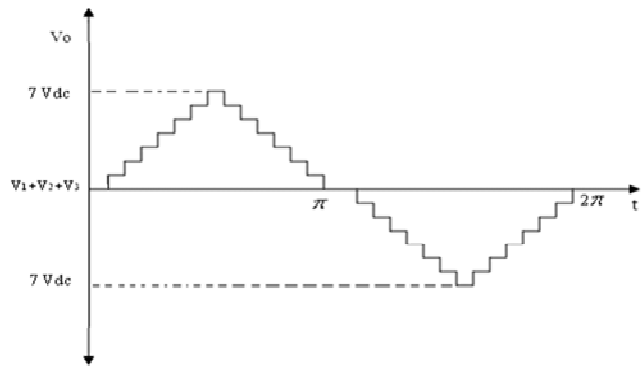


Figure .3 Typical output waveform for Modified Hybrid Multilevel Inverter

The Figure.3 shows the typical output voltage waveform of a 15-level Modified Hybrid Multilevel Inverter with 3 separate dc sources.

B. Total Harmonic Distortion (THD)

The Total Harmonic Distortion block measures the Total Harmonic Distortion (THD) of a periodic signal. The signal can be voltage or current. The THD is defined as the ratio of Root Mean Square (RMS) value of the total harmonics of the signal to the RMS value of its fundamental signal. The THD value will be zero for a pure sinusoidal voltage or current. For example, for currents, the THD is defined as

$$\text{Total Harmonic Distortion (THD)} = \frac{I_h}{I_n}$$

Where $I_h = \sqrt{(I_2^2 + I_3^2 + \ldots + I_n^2)}$, I_n=RMS value of the harmonic 'n', I_f= RMS value of the fundamental current.

C. Photo Voltaic Cell

International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 1, Issue 4, April 2014)

Solar energy is a non-conventional type of energy. Solar energy has been harnessed by humans since ancient times using a variety of technologies. Only a small fraction of the available solar energy is used. Solar powered electrical generation relies on photovoltaic system and heat engines. Solar energy's uses are limited only by human creativity. To harvest the solar energy, the most common way is to use photovoltaic panels which will absorb photon energy from sun and convert it into electrical energy. Solar technologies are broadly classified as either passive solar or active solar depending on the way they detain, convert and distribute solar energy. The following figure.4 shows the basic structure of Photo Voltaic Cell [9]-[10].

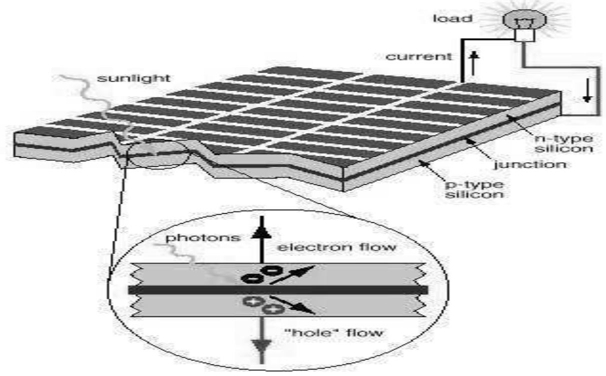


Figure .4 Basic Structure of PV Cell

From the solar radiation, Earth receives 174 Watts (W) of incoming solar radiation at the upper atmosphere. Approximately 30% is reflected back to space and only 89W is absorbed by oceans and land masses. The spectrum of solar light at the Earth's surface is generally spread across the visible and infrared region with a small part in the ultraviolet. The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 EJ per year.

IV. SIMULATION MODELS

A. Simulation Model of PV System

The equivalent circuit of a PV cell is shown in Figure.5. It consists of an ideal current source in parallel with an ideal diode.

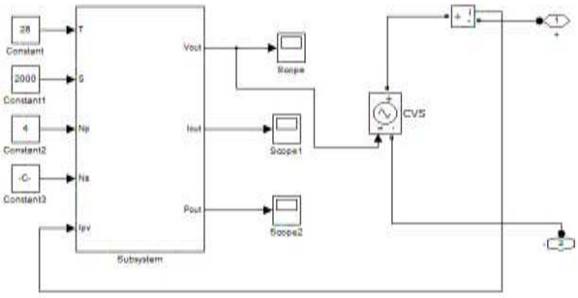


Figure .5 Simulation Diagram of PV Panel

The current source represents the current generated by photons, and its output is constant under constant temperature and constant incident radiation of light. There are two key parameters frequently used to characterize a PV cell one is the photon generated current. The photon generated current will flow out of the cell as a short-circuit current (Isc) thus, $I_{pv}=I_{SC}$. When there is no connection to the PV cell (open circuit) the photon generated current is shunted internally by the intrinsic p-n junction diode. This gives the open circuit voltage (V). It is seen that the temperature changes affect mainly the PV output current. The PV cell output equal voltage is a function of the photocurrent that mainly determined by load current depending on the solar irradiation level.

B. Simulation model of Proposed System

The simulation model of proposed system is shown in the Figure 6. The 15-level multilevel inverter has been developed using MATLAB. The proposed method is used to get sinusoidal waveform and reduced harmonics with minimum number of components. Therefore the efficiency of the multilevel inverter is increased. The low order harmonics are reduced significantly. This is used to produce the unidirectional output in both positive and negative directions.

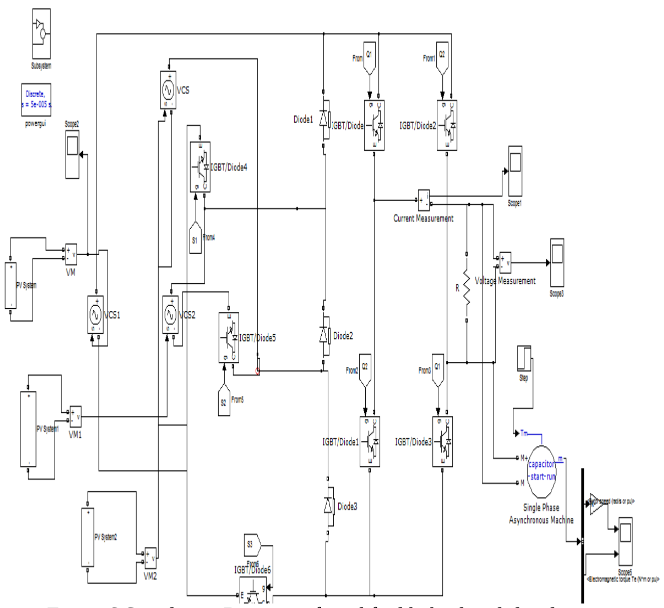


Figure 6 Simulation Diagram of modified hybrid multilevel inverter

V. PULSE WIDTH MODULATION TECHNIQUE

The duration of the pulses are varied by changing the amplitude of the sinusoidal wave form. In this method the lower order harmonics are eliminated. As the switching

International Journal of Ethics in Engineering & Management Education

Website: www.ijeee.in (ISSN: 2348-4748, Volume 1, Issue 4, April 2014)

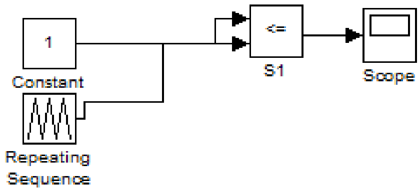
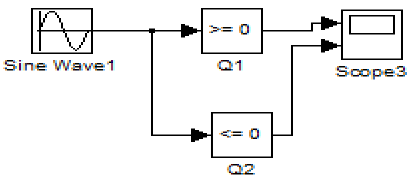


Figure 7.Pulse Width Modulation Technique

increases more harmonics can be eliminated. PWM technique is extensively used for eliminating harmful low-order harmonics in input and output voltage and current of static power. In PWM control, the inverter switches are turned ON and OFF several times during a half cycle and output voltage is controlled by varying the pulse width. At present, available PWM schemes can be broadly classified as carrier modulated Sinusoidal PWM (SPWM) and pre calculated programmed PWM schemes.

A. *Sinusoidal Pulse Width Modulation*

In this modulation technique numbers of output pulse per half cycle are more and pulses are of different width. The width of each pulse is varying in proportion to the amplitude of a sine wave evaluated at the center of the same pulse. The gating signals are generated by comparing a sinusoidal reference with a high frequency triangular signal. The RMS ac output voltage,



$$V_0 = v_s\sqrt{\frac{p\delta}{\pi}} \rightarrow v_s\sqrt{\sum_{m=1}^{2p}\frac{\delta_m}{\pi}}$$

Where p=number of pulses and δ= pulse width

V.RESULTS AND DISCUSSION

The simulation results and analysis of 15-level modified hybrid multilevel inverter with reduced number of switches is shown below. It describes he output voltage waveform and output current waveform with induction motor. The modified hybrid multilevel inverter phase voltage and current is shown in the Figure.8 and 9.

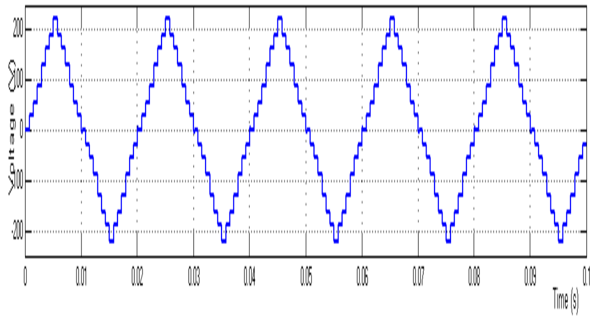


Figure 8.Output voltage waveform for modified hybrid multilevel inverter

Different levels of voltage like 33V, 66V, 132V is obtained in both polarities. It can be achieved by selection of switching pattern. The fundamental frequency of MHMLI is 50Hz.

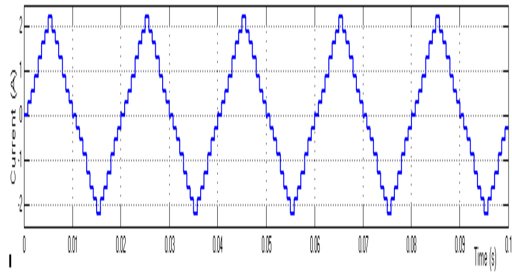


Figure 9. Output current waveform for modified hybrid multilevel inverter

The speed curve for the induction motor is shown in the Figure 10. The speed increases with time and settles after steady state.

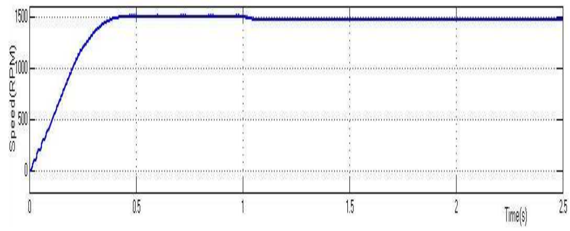


Figure 10. Speed curve for modified hybrid multilevel inverter with Induction Motor

The torque variation with time is shown in the Figure 10.

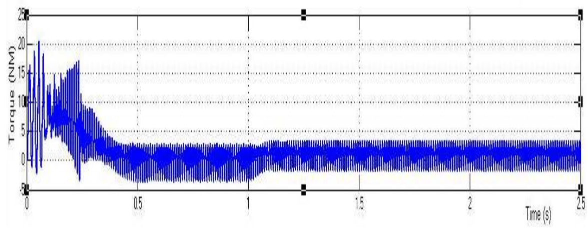


Figure 11 Torque curve for modified hybrid multilevel inverter

The hybrid multilevel inverter FFT analysis is shown in the Figure.11. The Figure 12 for proposed method.

International Journal of Ethics in Engineering & Management Education

Website: www.ijeee.in (ISSN: 2348-4748, Volume 1, Issue 4, April 2014)

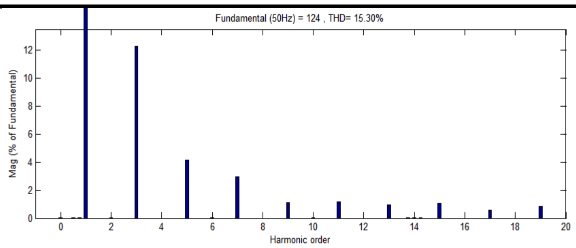


Figure .12 Spectrum analysis of total harmonic distortion for hybrid multilevel inverter

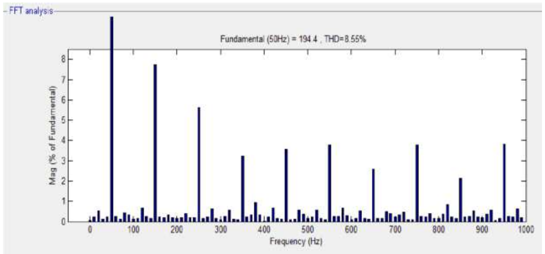


Figure .13Spectrum analysis of total Harmonic distortion for modified hybrid multilevel inverter

VI.CONCLUSION

In this paper, 15-level modified hybrid multilevel inverter is used to get sinusoidal waveform and also to increase the efficiency of the inverter. The simulation results for 15-level modified hybrid multilevel inverter have been illustrated using MATLAB software. Multilevel inverter is generally used to obtain a high resolution and produces near sinusoidal output waveform using reduced number of switches and low switching losses. The harmonic reduction is achieved to a greater extent than the other conventional inverters. The basic structure details and operating characteristics of modified hybrid multilevel inverter have been described by taking a fifteen level configuration and also extend the design flexibility. The proposed control scheme have been verified analytically and demonstrated through simulation.

REFERENCES

[1] L.G.Franquelo et.al., “The Age of Multilevel Converters Arrives”, IEEE Industrial Electronics Magazine”,vol.2,no.2,pp:28-39,June-2008.

[2] J.Rodriguez,J.S.Lai et.al… F.Z.Peng, “Multilevel inverters: Survey of Topologies, Controls and Applications”, IEEE Trans.Ind.Appl.,vol.49,no.4,pp.724-738,Aug-2002.

[3] Z.Du, L.m.Tolbert, J.N.Chiasson, and B.Opineci, “A Cascaded Multilevel Inverter Using a Single DC Power Source”. IEEEAPEC, pp.426-430.April 2006.

[4] Fang Zheng Peng “A Generalized Multilevel Inverter Topology with Self Voltage Balancing”,IEEETrans. Ind .Appl.,vol.37, no.2,March/April 2001.

[5] Ebrahim Babaei “A Cascaded Multilevel Converter Topology with Reduced Number of Switches”, IEEE Trans. Power Electron vol.23, no.6,Nov 2008.

[6] K.A.Corzine, M.W. Wielebski, F.Z Peng, and J.Wang, “Control of Cascaded Multilevel Inverters”,IEEE Trans. Power Electron.vol.19,no.3 ,pp.732-738,May 2004.

[7] K.A.Corzine, F.A.Hardick,and Y.L.Familiant, “A cascaded Multilevel Inverter H-Bridge Inverter Utilizing Capacitor Voltage Source”, Proceeding of the IASTED International Conference,Power and Energy Systems, pp.290-295.Feb.2003.

[8] K.Ramani. and A.Krishnan.“New Hybrid Multilevel Inverter Fed Induction Motor Drive–ADiagnostic Study”, International review of Elect.Engg.vol.5,no.6,pp.2562-2569.March 2010.

[9] Selvarajjeyraj and Nasrudin A.Rahim., “Multilevel Inverter for Grid Connected PV system Employing Digital PI controls”IEEE Trans. On Ind .Elect, vol.56, no.1, pp.149-158. Jan 2009

[10] VillanuevaElena,PabloCorrea. “Control of a Single-Phase Cascaded H-Bridge Multilevel forGrid-Connected PV Systems” IEEE Trans on Ind.Elect, vol.56, no.11,pp.4399-4406.Nov 2009.

[11] R. H. Baker and L. H. Bannister, “Electric power converter,” U.S. Patent 3 867 643, Feb. 1975.

[12] 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./Oct. 1981.

[13] Y. Khersonsky, “Step switched PWM sine generator,” U.S. Patent 06 556 461, Apr. 2003

[14] E. Babaei, M. T. Haque, and S. H. Hosseini, “A novel structure for multilevel converters,” in Proc. ICEMS, 2005, vol. II, pp. 1278–1283.

[15] T. A. Meynard and H. Foch, “Multi-level conversion: High voltage choppers and voltage-source inverters,” in Proc. IEEE PESC, 1992, pp. 397– 403.

[17] T. Kawabata, Y. Kawabata, and K. Nishiyama, “New configuration of high-power inverter drives,” in Proc. ISIE, 1996, vol. 2, pp. 850–855.

[18] M. R. Baiju, K. Gopakumar, K. K. Mohapatra, V. T. Somasekhar, and L. Umanand, “A high resolution multilevel voltage space phasor generation for an open-endwinding inductionmotor drive,” Eur. Power Electron. Drive J., vol. 13, no. 4, pp. 29–37, Sep.–Nov. 2003.

[19] M. Manjrekar, P. K. Steimer, and T. Lipo, “Hybrid multilevel power conversion system: A competitive solution for high-power applications,” IEEE Trans. Ind. Appl., vol. 36, no. 3, pp. 834–841, May/Jun. 2000

[20] Z. Du, L. M. Tolbert, J. N. Chiasson, and B. Ozpineci, “A cascade multilevel inverter using a single dc power source,” in Proc. IEEE APEC, 2006, pp. 426–430.

[21] B. M. Song and J. S. Lai, “A multilevel soft-switching inverter with inductor coupling,” IEEE Trans. Ind. Appl., vol. 37, no. 2, pp. 628-636, Mar./Apr. 2001.