Design Of Cascaded Multilevel Inverter

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Abstract— **There are many limitations in extracting power from renewable energy resources. To minimize the power demand and scarcity we have to improve the power extracting methods. Multilevel inverter is used to extract power from solar cells. It synthesizes the desired ac output waveform from several dc sources. This paper focuses on improving the efficiency of the multilevel inverter and quality of output voltage waveform. Nine level reduced switches topology has been implemented using pulse width modulation technique . The proposed topology is suitable for any number of levels. The harmonic reduction is achieved by selecting appropriate switching angles. It shows hope to reduce initial cost and complexity hence it is applicable for industrial applications. Simulation work is done using the MATLAB software and simulink model is presented.**

Keywords:- **multilevel inverter , cascaded H bridge , pulse width modulation, total harmonic distortion**

I. INTRODUCTION

Multilevel converters are mainly utilized to synthesis a desired single- or three-phase voltage waveform. The desired multi-staircase output voltage is obtained by combining several dc voltage sources. Solar cells, fuel cells,batteries and ultra-capacitors are the most common independent sources used. One important application of multilevel converters is focused on medium and high-power conversion. Nowadays, there exist three commercial topologies of multilevel voltage-source inverters: neutral point clamped (NPC), cascaded H-bridge (CHB), and flying capacitors (FCs). Among these inverter topologies, cascaded multilevel inverter reaches the higher output voltage and power levels (13.8 kV, 30 MVA) and the higher reliability due to its modular topology.

Diode-clamped multilevel converters are used in conventional high-power ac motor drive applications like conveyors, pumps, fans, and mills. They are also utilized in oil, gas, metals, power, mining, water, marine, and chemical industries. They have also been reported to be used in a back-to-back configuration for regenerative applications. Flying capacitor multilevel converters have been used in high-bandwidth high-switching frequency applications such as medium-voltage traction drives. Finally, cascaded H-bridge multilevel converters have been applied where high power and power quality are essential, for example, static synchronous compensators active filter and reactive power compensation applications, photovoltaic power conversion, uninterruptible power supplies, and magnetic resonance imaging. Furthermore, one of the growing applications for multilevel motor drives is electric and hybrid power trains. For increasing voltage levels the number of switches also will increase in number. Hence the voltage stresses and switching losses will increase and the circuit will become complex. By using the proposed topology number of switches will reduce significantly and hence the efficiency will improve.

II.CASCADED MULTILEVEL INVERTER

II.1 STRUCTURE OF SINGLE PHASE NINE LEVEL MULTILEVEL INVERTER

The concept of this inverter is based on connecting H-bridge inverters in series to get a sinusoidal voltage output. The output voltage is the sum of the voltage that is generated by each cell. The number of output voltage levels are $2n+1$, where n is the number of cells. The switching angles can be chosen in such a way that the total harmonic distortion is minimized. One of the advantages of this type of multilevel inverter is that it needs less number of components comparative to the Diode clamped or the flying capacitor, so the price and the weight of the inverter is less than that of the two types. In this topology, each cell has separate dc link capacitor and the voltage across the capacitor might differ among the cells. So, each power circuit needs just one dc voltage source. The number of dc link capacitors is proportional to the number of phase voltage levels .Each H-bridge cell may have positive, negative or zero voltage. Final output voltage is the sum of all H-bridge cell voltages and is symmetric with respect to neutral point, so the number of voltage levels is odd. Cascaded H-bridge multilevel inverters typically use IGBT switches. These switches have low block voltage and high switching frequency. Consider the nine level inverter; it requires 16 IGBT switches and four dc sources. The power circuit of inverter is shown in the figure 1. A cascaded H-bridges multilevel inverter is simply a series connection of multiple H bridge inverters. Each H-bridge inverter has the same configuration as a typical single-phase full-bridge inverter. The cascaded H-bridges multilevel inverter introduces the idea of using Separate DC Sources

(SDCSs) to produce an AC voltage waveform. Each H-bridge inverter is connected to its own DC source V_{dc}. By cascading

the AC outputs of each H-bridge inverter, an AC voltage waveform is produced.

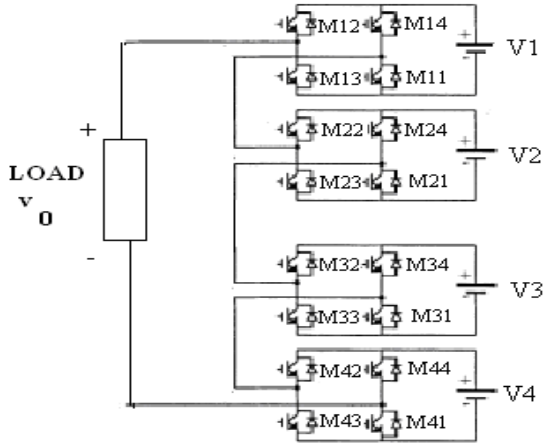

Figure 1-Stucture of single phase nine level multilevel inverter

III. MODULATION TECHNIQUE FOR CONTROL SCHEME

There are many modulation techniques for multi-level inverters. Multilevel inverter has to synthesize a staircase waveform by using the modulation technique to have the controlled output voltage .Carrier based modulation (SPWM) technique is easy and efficient. The level-shifted PWM (LS-PWM) and phase shifted PWM (PS-PWM) techniques have been the natural extensions of carrier-based sinusoidal PWM (SPWM) and for multicell converters (CHB and FC), respectively. The LSPWM , which is also known as phase-disposition PWM (PDPWM), and other carrier disposition variants. For any given number of levels in the output voltage the number of carrier to be used is given as N-1 Where N is the number of levels in the output voltage. represents the triangular shape carrier waveform and the sinusoidal reference signal showing the pulse width modulation technique used for the control. This method has the advantage of having very few commutations per cycle and is therefore the one that achieves better efficiency and enables air cooling.

III.1 SINGLE PULSE WIDTH MODULATION TECHNIQUE

In this technique, single pulse is produced in each half cycle for various switches as per their requirements in order to obtain nine level output voltage and current. The gating signals generated by it first Convert the reference signal to the square wave signal. This process is obtained by comparing reference signal to the zero crossing circuit switch which consider the positive part of the input signal is to get desired the output signal(square wave) and the negative part of the input signal is negative part of the output signal to get desired output to turns on corresponding switches. The certain d.c level gives the certain pulse width and any change in the d.c level will produce change in the pulse width.

III.2 Simulation of Cascaded Multilevel Inverter

The simulink model of the proposed nine level cascaded multilevel inverter system for various PWM techniques is shown in figure 3. This circuit comprises four single phase bridges connected in cascade and MOSFET switches are used. Four separate voltage sources of value Vdc=100V is used to energize the power circuit. The load on the inverter is resistive of value R= 50Ω Simulation of power circuit is carried out using control circuit which generates required gating signals. Three different PWM techniques are used to produce the gating signals. Using this signal, the output voltage and current waveforms are obtained and the corresponding frequency spectrum is also analyzed.

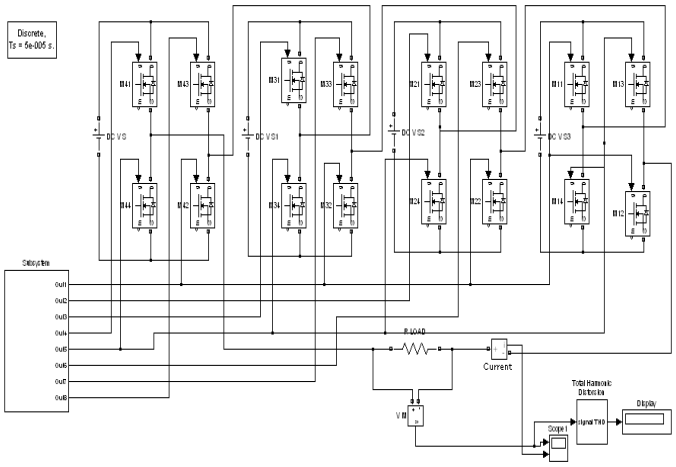

Figure 2-Simulink model of Cascaded Multilevel Inverter

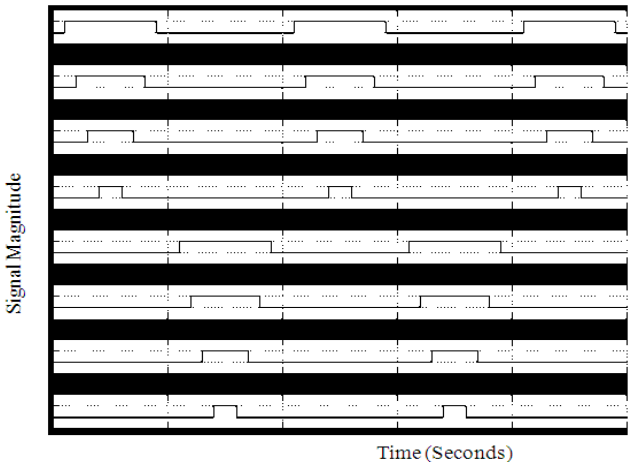

Figure-3 Gating pulses for various switches in Single PWM

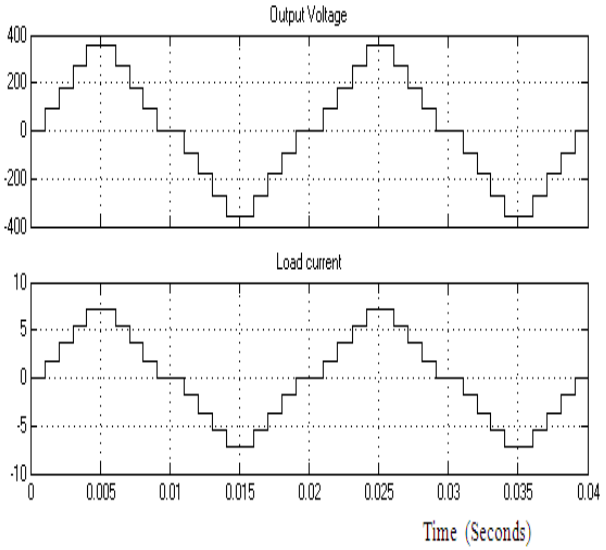

Figure 4: Simulated output voltage and current waveform for Single PWM

III.3 ADVANTAGE OF CASCADED MULTILEVEL INVERTER

The series structure allows a scalable, modularized circuit layout and packaging since each bridge has a same structure. Requires minimum number of component considering there are no extra clamping diodes or voltage balancing capacitor. Switching redundancy for inner voltage level is possible because the phase voltage is sum of each bridge output. On an average, it is observed that the number of redundant switching state is more as compared to the NPC MLI or the FC MLI. Due to the isolated independent DC sources , the potential of electric shocks is greatly reduced which render suffer on board wiring procedure. A very flexible scalability is achieved because the modularity in the system allow a racked up structure .The above features also allow for high reliability of operation.

III.4 FEATURES OF MULTILEVEL INVERTER

A multilevel inverter can eliminate the need for the step up transformer and reduce the harmonic produce by the inverter. Although the multilevel inverter structure was initially introduce as a means of reducing the output waveform content. The intriguing feature of the multilevel inverter structures is their ability to scale up the kilo-volt ampere (kVA) rating and also to improve the harmonic performance greatly without having to resort to PWM techniques. The most attractive features of multilevel inverter are as follows.

1.The output voltage and power increases with number of levels. Adding a voltage level involves adding a main switching device to each phase .

2. The harmonic content decreases as number of level increases and filtering requirement are reduced.

3.They can generate output voltages with extremely low distortion and lower dv/dt.

3. They draw input current with very low distortion.

4. They can operate with a lower switching frequency.

5. Static and dynamic voltage sharing among the switching devices is built into the structure through either clamping diode or capacitors.

6. The switching device do not encounter any voltage sharing problems. For this reason , multilevel inverter can easily be applied for high power application such as large motor drives and utility supplies.

7. the fundamental output voltage of inverter is set by the dc bus voltage V_{dc} which can be controlled through a varriable dc link.

III.5 APPLICATION

1.Reactive power compensator-when a multi level inverter draws pure reactive power , the phase voltage and current are 90°apart and the capacitor charge and discharge can be discharge can be balanced. Such a converter, when serving for reactive power compensation is called static var generator. The multilevel structure allow all the converter to be directly connected to a high voltage distribution or transmission system without the need of step down transformer .all the three multilevel inverter can be used to reactive power compensation without having voltage unbalance problem.

2.Back to Back intertie –Inter connection of two multilevel inverter with DC link in between is called as a back to back intertie. In this type of circuit the left hand side converter serves as a rectifier, while the right hand side serves as inverter. The purpose of the back to back intertie is to connect to synchronous system of different frequencies. It can be treated as Frequency connecter, Phase shifter and a power flow controller.

3.Utility compatible adjustable speed drives-An ideal utility compatible adjustable speed drives requires unity power factor, negligible harmonics and high efficiency. By extended the back to back intertie, the multilevel inverter can be used for a utility compatible adjustable speed drive with the input as a constant frequency AC source and a output has the variable frequency AC source .The major differences when using as a utility compatible adjustable speed drives and for back to back intertie , are the control design and size of capacitor.

IIII. CONCLUSION

A single phase nine-level cascaded multilevel inverter has been simulated with single PWM techniques and the quality of its output voltage is analyzed. The output voltage waveform obtained present near sinusoidal staircase output.

V. REFERANCE

[1] Muhammad H. Rashid, “power Elecronics Circuit, Devices and Application, .Third Edition”, Pearson Publication (chapter 9 pg.406-430).

[2] Bindeshwar Singh, Dr. K S Verma, “Multilevel Inverter:- A literature survey on topologies and control strategies”,IJRIC.(31st july 2012).

[3] Gobinath, Mahendran,“New Cascaded H-bridge Multilevel Inverter with improved efficiency” IJAREEIE (Vol.2,Issue 4,April 2013).

[4] P.Maruthu Pandl ,N.Devaranjan , **"** Comparative Analysis of Power Quality Issue in Cascaded Multilevel Inverter Using PWM Techniques",eurojournal**(**Vol.60 No.3 (2011), pp.458-468**)**

[5]A.S. Mane, "Performance Analysis of Multilevel Inverter" ,IOSR journal (pp 47-51).

[6] P.M.Bhagwat and V.R.Stefanovic, " Generalized structure of multilevel PWM inverter ," IEEE Transaction on Industry Application ,Vol.19, No.6 November/December 1983, pp 1057-1069.

[7] R. Lund, M. Manjrekar, P. Steimer, and T. Lipo, "Control strategy for a hybrid seven-level inverter," in *Proc. European Power Electronics Conf.(EPE'99)*, Lausanne, Switzerland, 1999,CD-ROM.

[8] J. Rodriguez, 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.

[9] Gerardo Ceglia, Víctor Guzman, Carlos Sanchez, Fernando Ibanez, JulioWalter, and María I. Gimenez "A New Simplified Multilevel Inverter Topology for DC–AC Conversion" IEEE Transactions on Power Electronics,Vol. 21, No. 5, September 2006.