DESIGN OF MULTI-LEVEL INVERTER TOPOLOGY WITH IMPROVED PERFORMANCE

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Abstract- Multilevel inverters are extremely used because of its high power ratings, reduced harmonics and electromagnetic interferences. In this paper a 31 level inverter is proposed with a new method of reduced switch circuit topology. This topology is optimized in order to utilize minimum number of switches and dc voltage sources that produce high number of output voltage steps. It employs a H-bridge inverter connected parallel with the series connection of four unidirectional switches. In normal 31 level inverter the requirement of power electronic switches are more, which causes switching losses and increased harmonic content these drawbacks are reduced by decreasing the number of switches. The number of level increases with decreased harmonics. The improved performance of the output voltage is designed and simulated using MATLAB/Simulink.

Keywords: *Multilevel inverter, Harmonic, Pulse width modulator, Total harmonic distortion.*

I. INTRODUCTION

Multilevel inverters include an array of power semiconductors and dc voltage sources, the output of which generate voltage with stepped waveform in comparison with a two-level voltage-source inverter (VSI). The multilevel voltage source inverter enables to synthesize the output voltages with reduced harmonic distortion and lower electromagnetic interference. By increasing the number of levels in multilevel inverter, output voltage have more steps in generating a staircase waveform, which has a less harmonic distortion. Although a larger number of levels increases the number of devices which must be controlled and control complexity. As a result, the most attractive applications of this technology are upto medium to high voltage ranges. A multilevel inverter achieves high power ratings, and also enables the use of renewable energy sources such as PV cells, wind and fuel cells which can be easily interfaced to the multilevel inverter system for the purpose of high power application. The advantages of multilevel inverters are their smaller output voltage step, which results in high voltage capability, lower harmonic components, low switching losses, and better electromagnetic compatibility and high power quality. It can also operate at both high switching frequency and fundamental switching frequency PWM. The on field application includes uses in laminators, pumps, compressors fans, blowers and mills. Simultaneously, several multilevel inverter topologies have been developed.

There are three different topologies have been proposed for multilevel inverters namely
1. Diode clamped multilevel inverter.
2. Flying capacitor multilevel inverter.
3. Cascaded H-bridge (CHB) multilevel inverter.

The diode clamped multilevel inverter which is also called diode clamped can be consider as the first generation of multilevel inverter introduced by Nabae et al., which is a 3 level inverter. The 3-level case of the diode clamped multilevel inverters have been widely applied in different fields. Unlike the diode clamped type, the flying capacitor multilevel inverter offers some redundant switching,which states that can be used to regulate capacitors voltage. As the control scheme becomes complicated, the number of capacitors increases by increasing the number of voltage levels. The Cascaded H-bridge multilevel inverter uses series connected H-bridge cells with the isolated dc sources connected to each cell. The CHB multilevel inverter can be divided into two groups from the point view of values of the DC voltage sources, namely the symmetric and the asymmetric topology. Now in the symmetric topology, all the values of the DC voltage sources are equal. The characteristics gives the topology better modularity. However, with the increase in the number of output voltage levels the number of switching devices also rapidly increases. If the values of the DC voltage sources are different, then these topologies are called asymmetric topologies. The Cascaded H-bridge multilevel inverters have been industrially employed in several application fields such as pumps, fans, compressors, mills, blowers. In addition, recently they have been proposed for other applications like PV power-conversion systems and wind power conversion.

II. MULTILEVEL INVERTER

Now a day's many industrial applications have begun to require high power. Some appliances in the industries however requires medium or low power for their operation. Using a high power source for all industrial loads may prove beneficial to some motors requiring high power, while it may damage other loads. Some medium voltage motor drives and utility applications require medium voltage. The multi-level inverters have been introduced during 1975, as an alternative in high power and medium voltage situations. The Multi-level inverter is like an inverter and it is used for industrial applications as an alternative in high power and medium voltage situations.

2.1 Types of Multilevel Inverter:

Multilevel inverters are three types

- Diode clamped multilevel inverter
- Flying capacitors multilevel inverter
- Cascaded H- bridge multilevel inverter

A. Diode Clamped Multilevel Inverter:

The main concept of this inverter is to use diodes and provides multiple voltage levels through the different phases to the capacitor banks which are in series. A diode transfers a limited amount of voltage, thereby reducing the stress on other electrical devices. The maximum output voltage is half of the input DC voltage. It is the main drawback of the diode clamped multilevel inverter. This problem can be solved by increasing the switches, diodes and capacitors. Due to the capacitor balancing issues, these are limited to three levels. This type of inverters provides the high efficiency because the fundamental frequency used for all the switching devices and it is a simple method of the back to back power transfer systems.

Applications of Diode Clamped Multilevel Inverter:

1. Static var compensation
2. Variable speed motor drives
3. High voltage system interconnections
4. High voltage DC and AC transmission lines

B. Flying Capacitors Multilevel Inverter:

The main concept of this inverter is to use capacitors. It is of series connection of capacitor clamped switching cells. The capacitors transfers the limited amount of voltage to electrical devices. In this inverter switching states are like the diode clamped inverter. Clamping diodes are not required in this type of multilevel inverters. The output is half of the input DC voltage. It is drawback of the flying capacitors multi-level inverter. It also has the switching redundancy within the phase to balance the flying capacitors. It can control both the active and reactive power flow. But due to the high frequency switching, switching losses will take place.

Applications of Flying Capacitors Multilevel Inverter

1. Induction motor control using DTC (Direct Torque Control) circuit
2. Static VAR generation
3. Both AC-DC and DC-AC conversion applications
4. Converters with Harmonic distortion capability
5. Sinusoidal current rectifiers

C. Cascaded H-Bridge Multilevel Inverter:

The cascaded H-bride multi-level inverter uses capacitors and switches,which requires less number of components in each level. This topology consists of series of power conversion cells and the level of power can be easily scaled. The combination of capacitors and switches pair is called as H-bridge and gives separate input DC voltage for each H-bridge. It consists of H-bridge cells and each cell can provide three different voltages such as zero, positive DC and negative DC voltages. One of the advantages of this type of multi-level inverter is that, it needs less number of components compared with diode clamped and flying capacitor inverters. The price and weight of this inverter is less than those of the two inverters. Soft-switching is possible by some of new switching methods. Multilevel cascade inverters are used to eliminate the bulky transformer requirement, in case of conventional multi-phase inverters, clamping diodes are required in case of diode clamped inverters and flying capacitors are required in case of flying capacitor inverters. But these requires large number of isolated voltages to supply each cell. Figure 1 shows the H-bridge inverter and Figure 2 shows the output voltage waveform.

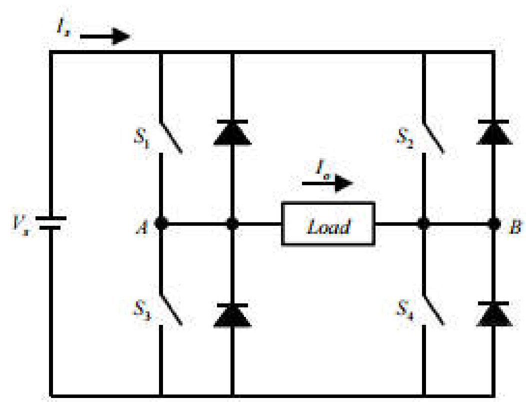

Figure 1 H-bridge inverter

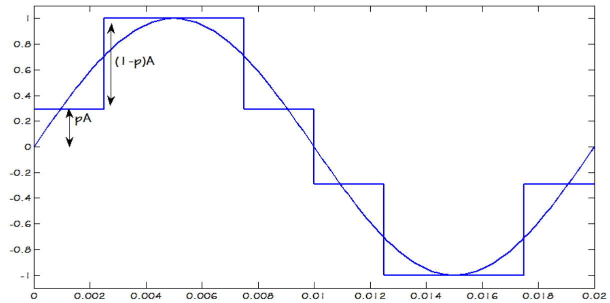

Figure 2 Output voltage waveform

Applications of Cascaded H-Bridge Multilevel Inverter

1. Motor drives
2. Active filters
3. Electric vehicle drives
4. DC power source utilization
5. Power factor compensators
6. Back to back frequency link systems
7. Interfacing with renewable energy resources.

2.2 Advantages of Multilevel Inverter:

1. Common Mode Voltage:

The multilevel inverters produces common mode voltage, with reduced motor stress and less motor damage.

2. Input Current:

Multilevel inverters can draw input current with low distortion.

3. Switching Frequency:

The multilevel inverter can operate at both fundamental switching frequencies,that are higher switching frequency and lower switching frequency. It should be noted that the lower switching frequency means lower switching loss with higher efficiency.

4. Reduced harmonic distortion:

Selective harmonic elimination techniques along with the multi-level topology results the total harmonic distortion,which becomes low in the output waveform without the filter circuit.

III. PROPOSED TOPOLOGY

In this paper, in order to increase the number of output voltage levels and to reduce the number of power switches and driver circuits, with reduced cost of the inverter, a new topology of H-bridge multilevel inverter 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,and the increased number of values of the dc voltage sources, and also the value of the blocking voltages per switch. Finally, the performance of the proposed topology is in generating all the voltage levels through a 31-level inverter which is confirmed by simulation using MATLAB Simulink. The 31 level inverter topology can be seen below in Figure. 1.

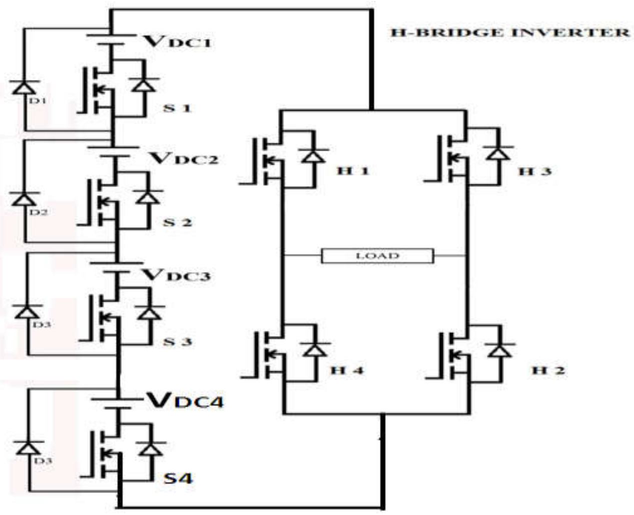

Figure 3 Thirty one level inverter with reduced switch topology

In recent years, several topologies with various control techniques have been presented for cascaded multilevel inverters, also with different symmetric cascaded multilevel inverters. The main advantages of all these structures are 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, some of them uses a high number of bidirectional power switches ,which requires a high number of insulated gate bipolar transistors (IGBTs) , which is the main disadvantage of these topologies. In asymmetric topology, 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. A new topology with three algorithms, which reduces the number of required power switches but with increase in dc voltage sources. Several algorithms have been presented for determining the magnitudes of dc voltage sources for the conventional cascaded multilevel inverter. The major advantage of this topology and its algorithms are related to its ability to generate a 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 are their most remarkable disadvantage. Figure 4 shows the output voltage waveform of 31 level inverter.

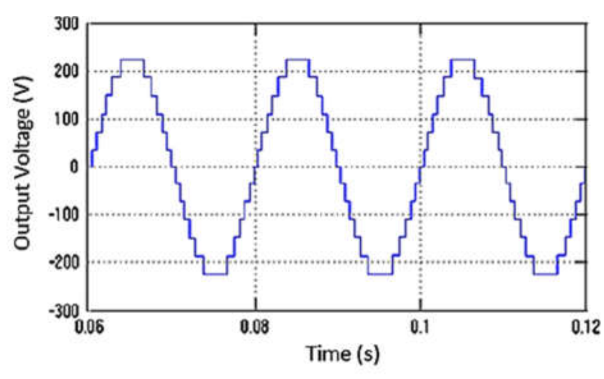

Figure 4 output voltage waveform of 31 level inverter

IV. SYSTEM IMPLEMENTATION

The Simulink model of the proposed 31 level cascaded multilevel inverter systems for reduced switch topology are described through following simulation diagrams. The simulation was done for an H-bridge inverter with reduced switch topology is described in figure 5.

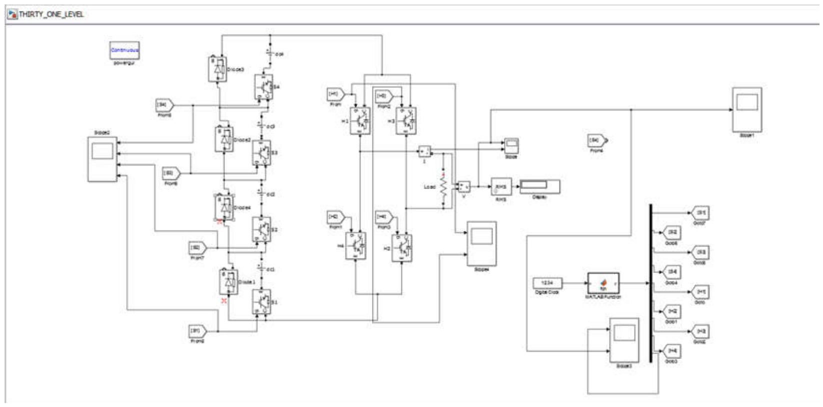

Figure 6 Simulink model of thirty one level inverter with reduced switch topology

Figure 7 shows the output voltage waveform, Figure 8 shows the gating pulse for switch S1, S2, S3, S4 and Figure 9 shows the gating pulse for switch S5 and S6.

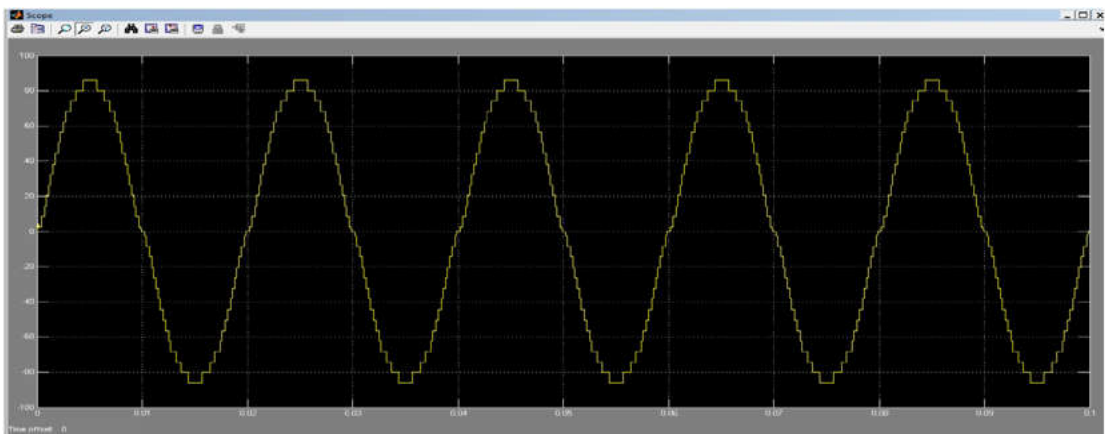

Figure 7 Output voltage waveform

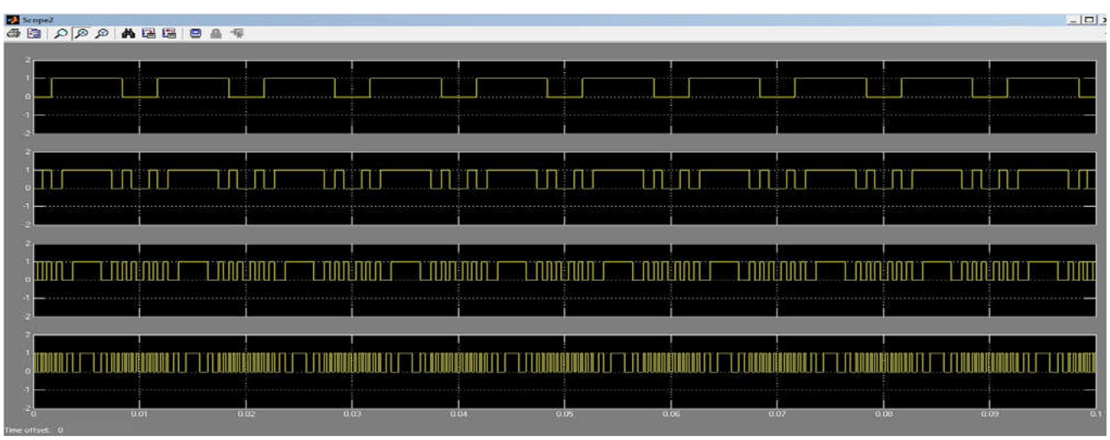

Figure 8 Gate pulse of switch S1, S2, S3 and S4

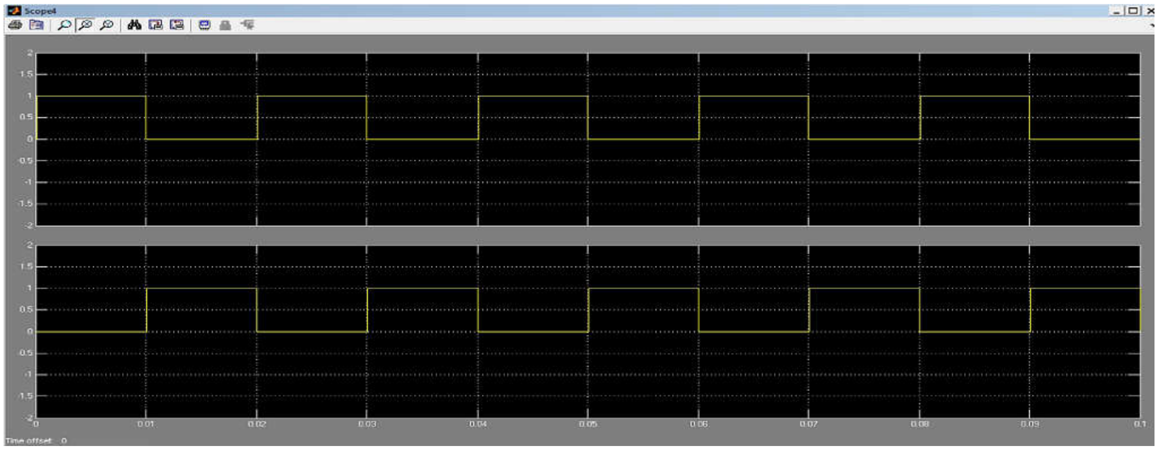

Figure 9 Gate pulse of switch S5 and S6

The output voltage waveform reveals the voltage steps which are increased to reach the sinusoidal response with reduced harmonic content.

V. CONCLUSION

The proposed topology employs eight switches and four dc voltage sources with thirty one output voltages.By increasing the voltage levels,which increases the inverter's performance by reducing the switching losses and decreasing the harmonic content. The output voltages are retrieved and simulated by using MATLAB/Simulink.

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