Cascade Multilevel Inverter as a Solution to Improve the Voltage Level and Reduce the Harmonics

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Abstract **- The cascaded multilevel inverter (CMLI) has gained much attention in recent years due to its advantages in high voltage and high power with low harmonics applications. A standard cascaded multilevel inverter requires n DC sources for 2n+1 levels at the output, where n is the number of inverter stages. This paper presents a topology to control cascaded multilevel inverter that is implemented with multiple DC sources to get 2^{n+1} - 1 levels. With using Pulse Width Modulation (PWM) technique, the firing circuit can be implemented which greatly reduces the Total Harmonic Distortion (THD) and switching losses.**

Keywords:- Hybrid Cascaded H-Bridge Multilevel Inverter (Hybrid CHBMLI), Multilevel Inverter (MLI), Pulse Width Modulation (PWM), Harmonics, Total Harmonic Distortion (THD).

I. INTRODUCTION

The H-bridge conventional inverters were used in many industrial applications for many years. Their output is of poor quality with more harmonic components and in some applications their use is not satisfactory. High switching frequency of PWM inverters results in low efficiency and high dv/dt stress. Due to these problems, the conventional H-bridge inverters and Pulse Width Modulated inverters have been substituted by new multilevel inverters .Industrial applications use multi-level inverter techniques to decrease the voltage stress developed on power devices and to produce output voltages of good quality.

The multi-level inverters improve the ac power quality by performing the power conversion in small voltage steps resulting in lower harmonics content. The harmonic content of this output voltage waveform is greatly reduced compared to two-level output voltage waveform. The use of multilevel inverters is increased considerably in different utilities like UPFC, Industrial Drives, Electric Vehicles, Renewable Energy Conversion, Distributed Generation, Active Filtering and many more. Multilevel inverters have lesser Total Harmonic Distortion, voltage stress across the switch, Electromagnetic Interference effect, and higher power rating as compared to two-level inverter. The main objective of topological development of multilevel inverters is to reduce the number of switching devices as compare to conventional MLI topologies .

In this paper, a new combined cascaded multilevel inverter with reduced number of required IGBTs and DC voltage sources is proposed. The advantages and disadvantages of the proposed topology and results are analyzed. At the end, the topology of the proposed combined cascaded multilevel inverter is experimented and the results are shown and discussed.

II. MULTILEVEL INVERTER

Now a day's many industrial applications have begun to require high power. Some appliances in the industries however require 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 the other loads. Some medium voltage motor drives and utility applications require medium voltage. The multi level inverter has been introduced since 1975 as alternative in high power and medium voltage situations. The Multi level inverter is like an inverter and it is used for industrial applications as alternative in high power and medium voltage situations.

General DC-AC Inverter Circuit:

The need of multilevel converter is to give a high output power from medium voltage source. Sources like batteries, super capacitors, solar panel are medium voltage sources. The multi level inverter consists of several switches. In the multi level inverter the arrangement switches' angles are very important.

Types of Multilevel Inverter:

Multilevel inverters are three types.

1. Diode clamped multilevel inverter
2. Flying capacitors multilevel inverter
3. Cascaded H- bridge multilevel inverter

Diode Clamped Multilevel Inverter:

The main concept of this inverter is to use diodes and provides the 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, capacitors. Due to the capacitor balancing issues, these are limited to the 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.

Ex: 5- Level diode clamped multilevel inverter, 9- level diode clamped multilevel inverter.

The 5- level diode clamped multilevel inverter uses switches, diodes; a single capacitor is used, so output voltage is half of the input DC.

The 9- level diode clamped multilevel inverter uses switches, diodes; capacitors are two times more than the 5-level diode clamped inverters. So the output is more than the input.

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

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 transfer the limited amount of voltage to electrical devices. In this inverter switching states are like in 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 phase to balance the flaying capacitors. It can control both the active and reactive power flow. But due to the high frequency switching, switching losses will takes place.

EX: 5-level flying capacitors multilevel inverter, 9-level flying capacitors multilevel inverter.

This inverter is same like that diode clamped multi inverter

In this inverter only switches and capacitors are used.

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

Cascaded H-Bridge Multilevel Inverter:

The cascaded H-bride multi level inverter is to use capacitors and switches and requires less number of components in each level. This topology consists of series of power conversion cells and power can be easily scaled. The combination of capacitors and switches pair is called an H-bridge and gives the separate input DC voltage for each H-bridge. It consists of H-bridge cells and each cell can provide the three different voltages like 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 the inverter are less than those of the two inverters. Soft-switching is possible by the some of the new switching methods.

Multilevel cascade inverters are used to eliminate the bulky transformer required in case of conventional multi phase inverters, clamping diodes required in case of diode clamped inverters and flying capacitors required in case of flying capacitor inverters. But these require large number of isolated voltages to supply the each cell.

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.

Advantages of Multilevel Inverter:

The multilevel converter has a several advantages, that is:

1. Common Mode Voltage:

The multilevel inverters produce common mode voltage, reducing the stress of the motor and don't damage the motor.

2. Input Current:

Multilevel inverters can draw input current with low distortion

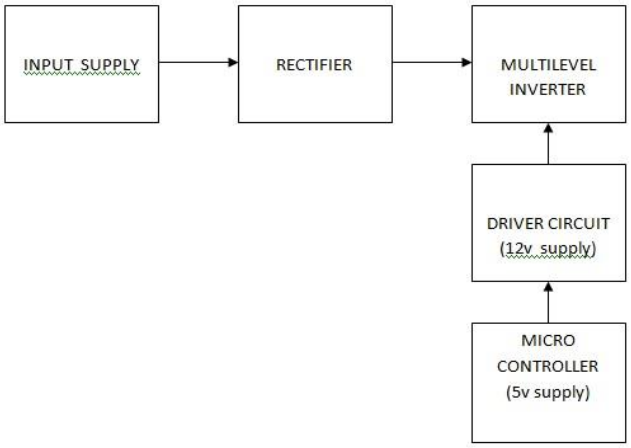
3. Switching Frequency:

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 and higher efficiency is achieved.

4. Reduced harmonic distortion:

Selective harmonic elimination technique along with the multi level topology results the total harmonic distortion becomes low in the output waveform without using any filter circuit.

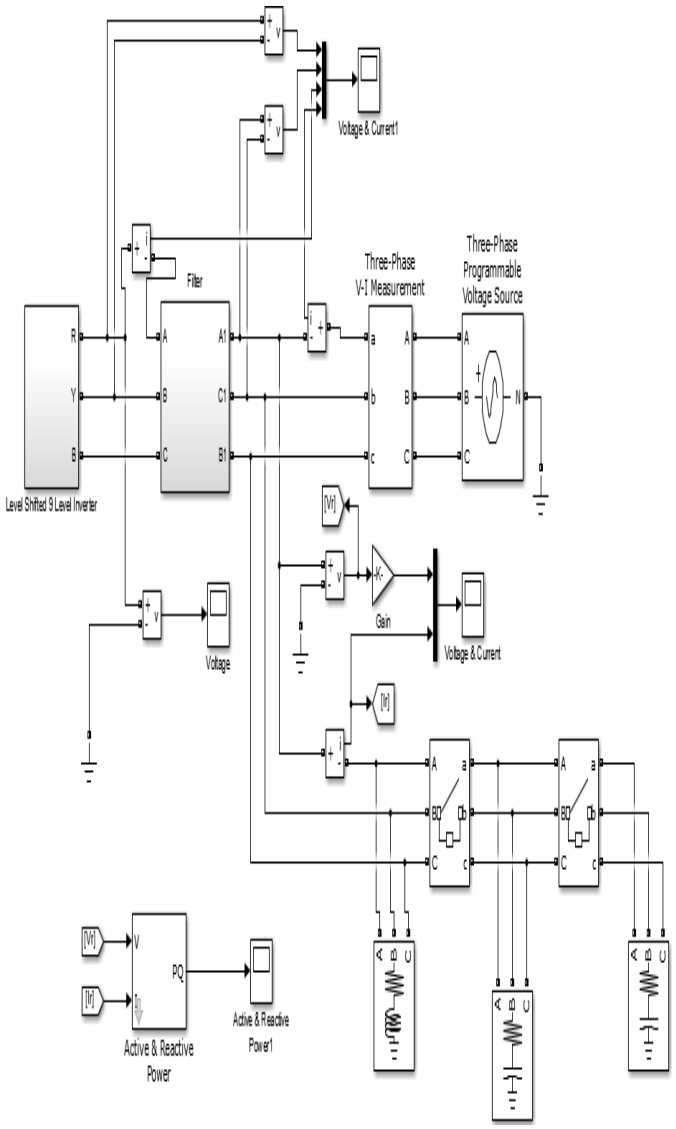
III. BLOCK DIAGRAM



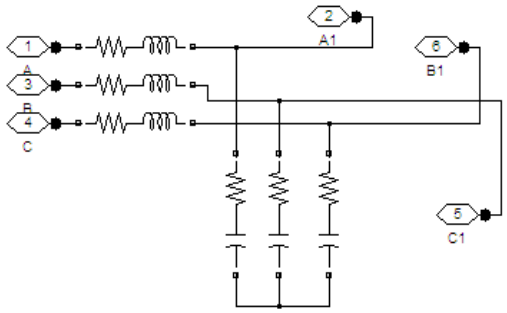
IV. SIMULATION RESULTS

Simulink model for cascade multilevel inverter as shown in fig.

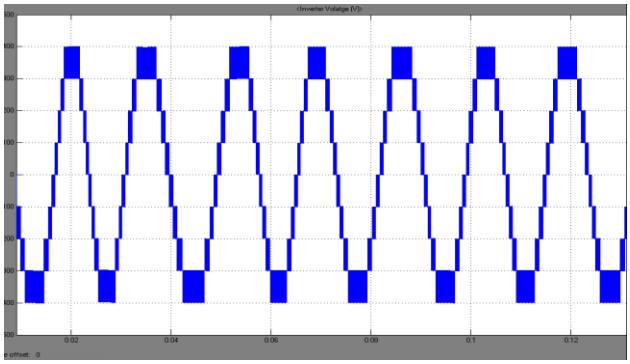
1.Matlab Simulink Model:



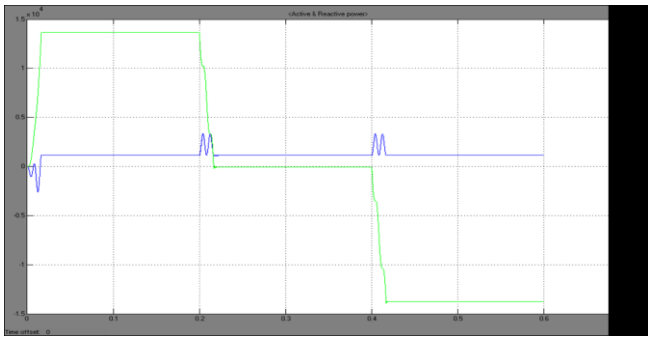
2.FILTER CIRCUIT



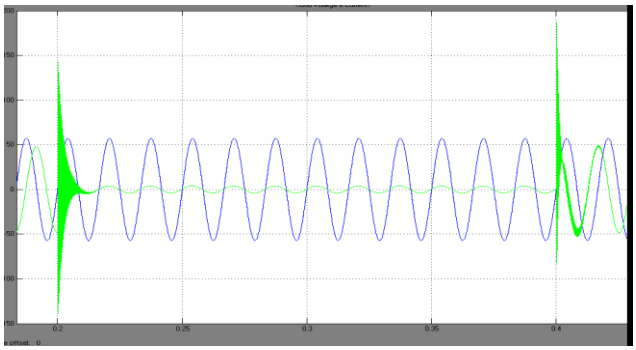
1.INPUT VOLTAGE



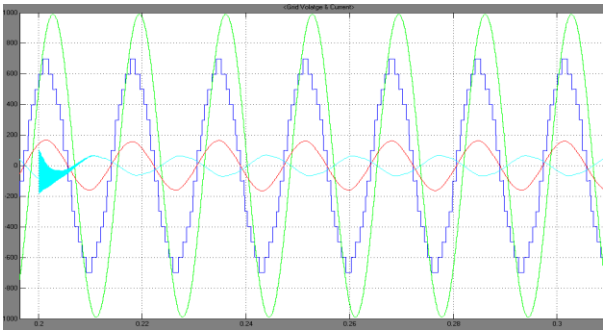
2.REAL AND REACTIVE POWER



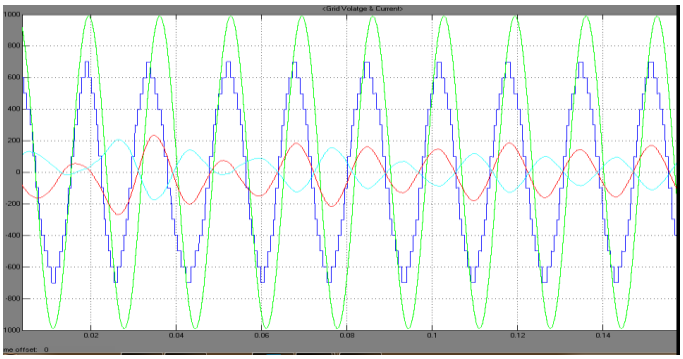
3.WITH HARMONICS



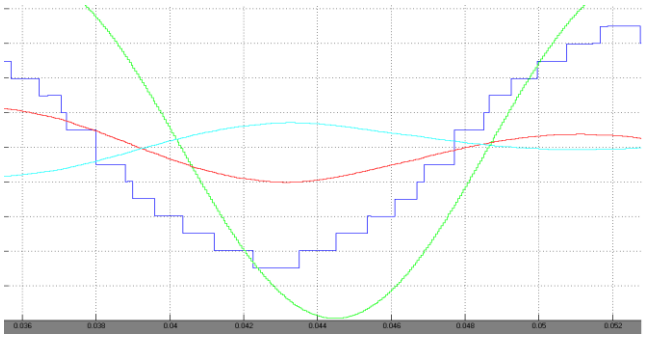
4.WITH HARMONICS



5.WITHOUT HARMONICS



6. WITHOUT HARMONICS



VI.CONCLUSION

In this paper 15 level cascaded multi level inverter has been designed with a new PWM technique. In this technique we use Diode Bridge Integrated with the H Bridge multi level inverter in such a way, such that we obtain the desired output with lesser THD. It improves the output level of inverter, provides flexibility in design and also decreases the harmonic content. The performance of inverter has been verified with the help of simulation using MATLAB. The Line voltage and line current THDs with this techniques in both cases are determined and it is observed that there is no significant difference. This technique can also be implemented in induction motor for speed motor and in remote areas.

VII.REFERENCES

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