Design and Implementation of Cascaded H-Bridge Multilevel Inverter

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Abstract - *Inverter is a static circuit which converts power from DC source to AC at specified output voltage and frequency. The output voltage can be fixed or variable at a fixed or variable frequency. A multilevel inverter is a power electronic device which is capable of providing desired alternating voltage level at the output using multiple lower level DC voltages as an input. The three most commonly used multilevel inverter topologies consist of Cascaded H-bridge multilevel inverters, Diode clamped multilevel inverters and flying capacitor multilevel inverters. A cascaded H-bridge multilevel inverter consists of a series of single phase full bridge inverter units to provide a sinusoidal output voltage. The combination of capacitors and switches pair is called an H-bridge. Each cell contains one H-bridge and the output voltage generated by this multilevel inverter is actually the sum of all the voltages generated by each cell. This type of inverter has advantage over the other two as it requires less number of components as compared to other two types of inverters and so its overall weight and price is also less.*

***Key Words*: Multilevel inverter, Simulink, H-bridge, Driver circuit, Switching Scheme**

1.INTRODUCTION

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.

Multilevel inverters include flying capacitor, Cascaded H-Bridge and diode clamped multilevel inverters. Multilevel inverters are act as most promising device in power electronics. Out of these technologies Cascaded H-Bridge multilevel inverter is one of the well known, most advantageous, much simpler and basic method/technology of multilevel inverter. For obtaining high quality that is minimum amount of ripple in output voltage and current waveform, high switching frequency with pulse width modulation techniques are required.

In Cascaded H-Bridge multilevel inverter, Number of H-Bridges are connected in series. Each H-Bridge having separate DC sources which is to be obtained from any natural sources, ultra capacitors, fuel cells or batteries to produce inverted ac output. In this paper, we are going to consider batteries as the DC source to power the H-bridge and also we are going to use 2 H-bridges in cascade to produce 5 level inverted ac output.

2.FIVE LEVEL INVERTER STRUCTURE

The number of distinct levels in the output voltage of cascaded h-bridge multilevel inverter can be determined by m=(2N+1) where "N" is the number of dc voltage sources. If the number of dc voltages sources are 2 i.e.(N=2) then the number of levels will be equal to m=2(2)+1=5, so when 2 dc sources are used, we obtain a 5 level output voltage. The 5 level inverter consist of 2 H-bridges fed by separate dc sources of equal voltage level. There are four switches namely S1, S2, S3, S4 in the first H-Bridge and there are four more switches namely S5, S6, S7, S8 in the second H-bridge.

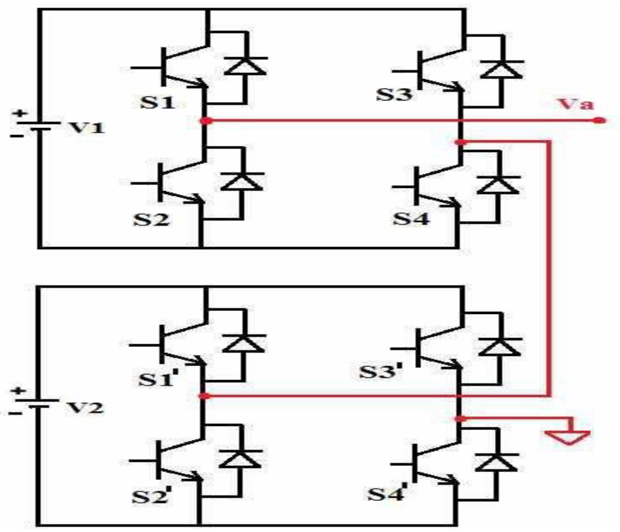

Fig -1: Five Level H-bridge Inverter Circuit

Now to obtain the appropriate multilevel output, we close the switches in the manner mentioned in the switching scheme below. For example if we want to get a output voltage of Vdc, we close the switches S1, S4, S2' and S4'. Similarly if we want to get an output voltage of 2Vdc, we close the switches S1, S4, S1' and S4'. The switching scheme table below shows all the possible output voltage configurations of the multilevel inverter.

Table -1: Switching Scheme of 5 Level Inverter

OUPUT VOLTAGE	S1	S2	S3	S4	S1’	S2’	S3’	S4’
0	0	0	0	0	0	0	0	0
+Vdc	1	0	0	1	0	1	0	1
+2Vdc	1	0	0	1	1	0	0	1
-Vdc	0	1	1	0	0	1	0	1
-2Vdc	0	1	1	0	0	1	1	0

3.SIMULATION ANALYSIS

The simulink model of the 5 level H-bridge inverter is developed using MATLAB.

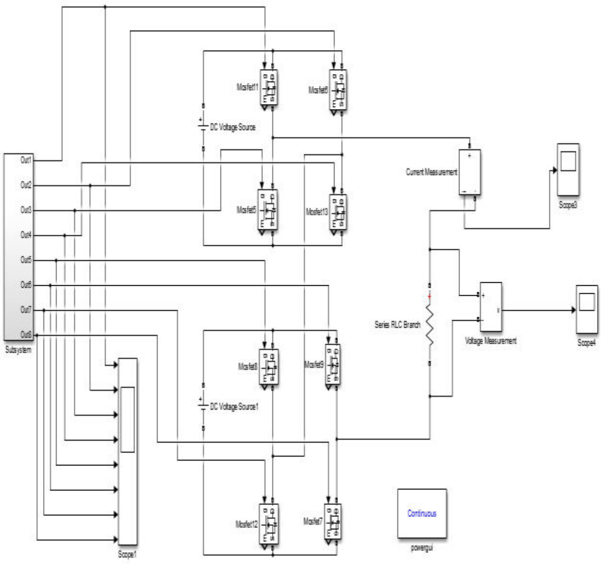

Fig -2: Simulink model of 5 level cascade d H-bridge multilevel inverter

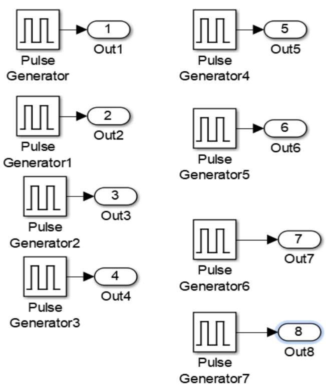

Fig -3: Pulse generator Subsystem model

The 8 pulse generators are designed as a separate subsystem to provide gate supply to all the 8 mosfet switches. Each H-bridge is supplied with a dc battery of 12V supply voltage.

The total output voltage of both the bridges in combination becomes 24V which is fed to the load. The pulse generators in the simulink model are fed with appropriate time period, pulse width and delay time according to the switching scheme. For example the pulse generator 1 which feeds the gate supply of mosfet 1 is given a time delay of 0.002 seconds, time period of 0.02 seconds and pulse width of 30% of entire period. Similarly other pulse generators are fed with the appropriate value.

4.HARDWARE IMPLEMENTATION

In the hardware implementation process we need to design three major circuits which are power circuit, driver circuit and input supply circuit. For the input supply, the 230V supply voltage is first transformed into 12V by using a step down transformer and it is then rectified by a diode bridge rectifier circuit.

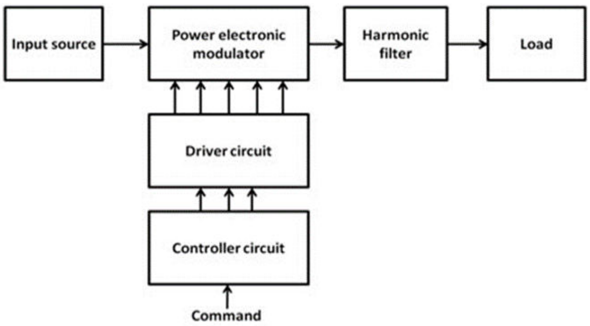

Fig -4: Block diagram of experimental setup of multilevel inverter

4.1 Driver Circuit

The driver circuit is used to improve the switching characteristics of mosfet or any other switching device. It also gives the isolation between the controller circuit and power circuit. In this hardware, MCT2E Optocoupler is used to isolate the controller circuit and the power circuit.

4.2 Microcontroller

As we need pwm outputs to drive gate signals to the mosfets so we use arduino uno microcontroller which has 6 pwm pins which are numbered as 3,5,6,9,10 and 11. The 5V supply for the microcontroller is given from the voltage regulator IC fed by the output obtained from the rectifier circuit.

4.3 Hardware Specifications:

The complete hardware specification of the proposed 5 level inverter is as follows, 5V Pulses are produced from the micro controller and the driver output is of 12V.

1. For R-Load- Input voltage is 12V for each bridge.
   Output voltage is 24V.
2. For Motor Load- Input voltage is 12V for each bridge.
   Output voltage is around 18-20V.

5.SIMULATION AND EXPERIMENTAL RESULTS

With the given inverter specifications, simulations has been carried out and the output voltage obtained from the simulink model for R and RL load has been shown in figure 5 and figure 6 respectively.

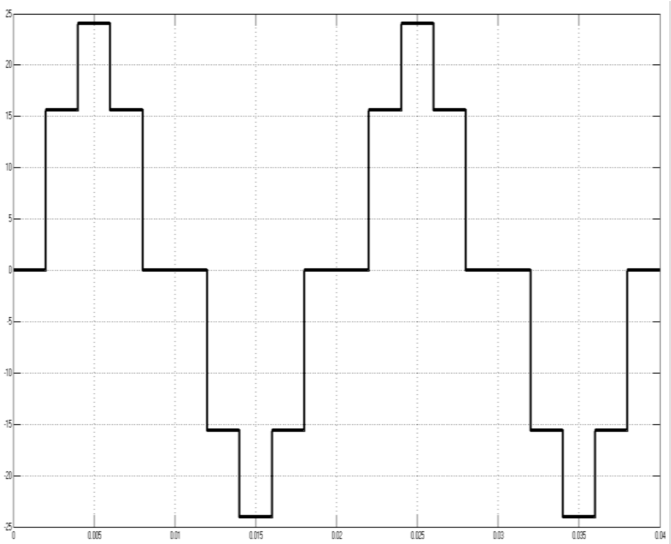

Fig -5: Output waveform of 5 level inverter for R-Load

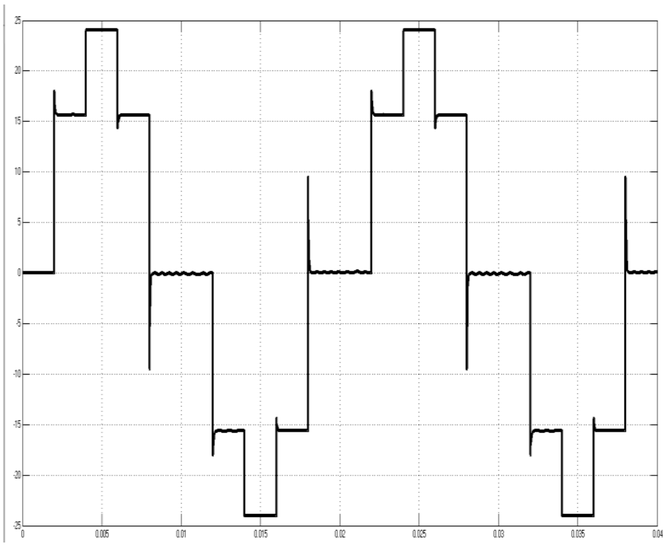

Fig -6: Output waveform of 5 level inverter for RL-Load

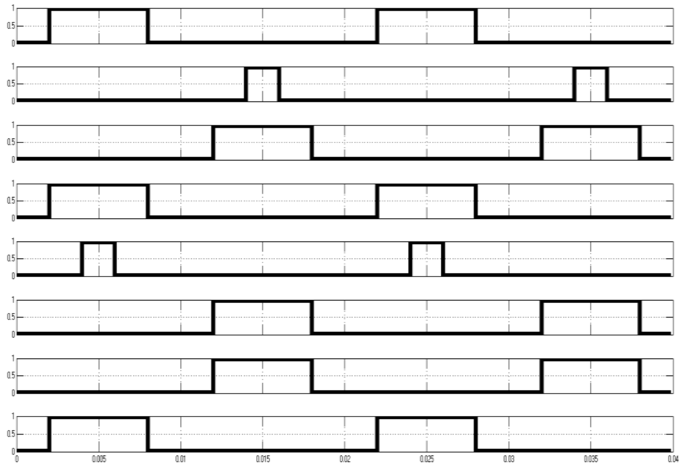

Fig -5: Pwm waveforms of pulse generator subsystem

The above waveforms show all the 8 gate pulses signals to be provided to all the mosfets. They give specified pwm output based upon their pulse width, time period and time delay for each mosfet.

6.CONCLUSION

In this paper, Simulation and hardware implementation of 5 level cascaded H-bridge multilevel inverter is done for both R and R-L Loads. Future work will be based on further increasing the number of levels of the inverter. As the number of levels are increased a nearly sinusoidal waveform is obtained which helps in reduced total harmonic distortion. So the benefits of multilevel inverters include lower total harmonic distortion, lower transient power loss due to low switching frequency, less need of ac filters and possibility to replace the MOSFET switches with IGBT's for to provide more effective power conversion. It is also concluded that to obtain more stable and higher quality power from conventional drives, the conventional 2 level inverters are needed to be replaced by multilevel inverters.

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