Scientific Journal Impact Factor (SJIF): 1.711
e-ISSN: 2349-9745
p-ISSN: 2393-8161
International Journal of Modern Trends in Engineering and Research
www.ijmter.com

Implementation of Cascaded H-bridge MULTI-LEVEL INVERTER

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Abstract: The classical two level inverter produce output with levels either V_{dc} or $-V_{dc}$. The output voltage waveform of ideal inverter should be sinusoidal but the waveform of conventional inverters is non-sinusoidal and contains certain harmonics. Large capacitor is normally connected across the DC voltage source and such a capacitor is costly and demands space. In order to overcome these drawbacks Multi level inverters are introduced. The great advantage of this kind of inverter is the *minimum harmonic distortion* obtained. Power electronics is the applications of power semiconductor devices for the control and conversion of electric power such that these devices operate as switches. An inverter is an electrical device that converts DC voltage to AC voltage; the resulting AC can be at any required frequency. Multi-level inverters are nothing but the modification of basic bridge inverters [1]. The multilevel inverter collectively converts the several levels of dc voltage to a desired ac voltage. The unique structure of multilevel inverters allows them to reach nearer to sinusoidal i.e., with low harmonics. In this project the work is done on five & nine level multilevel inverter but the multilevel can be done up to any level and how many levels we increase that much precise sinusoidal supply we can get i.e., we can reduce that many harmonics from the supply. Simulation work is done using the MATLAB software [10].

Keyword: Inverter, MATLAB, Harmonic distortion, Switches, Multilevel, Sinusoidal and Non-sinusoidal.

I. INTRODUCTION

During the last decade, multilevel inverters have attracted much attention in high power electronics applications as the solution of needs for *higher power ratings* and the *reduction of the output harmonic distortion*, *voltage stress (dv/dt)* and *EMI phenomenon*. The concept of multilevel converter has been introduced since 1975. Basically the term multilevel began with the 3-level converter. Subsequently, several multilevel converter topologies have been developed. Multi-level inverters provide more than 2 voltage levels [3]. The basic principle of a multilevel inverter is to connect semiconductor switches in series so that the converter can operate with power ratings of several megavolt amperes and at medium voltage levels that exceed the individual switch voltage ratings. Their output voltage waveform can be synthesized from several levels of capacitor voltage sources. As the number of levels increases, the synthesized output waveform approaches the sinusoidal wave with less distortion, less switching frequency, higher efficiency [2]. However, the elementary concept of a multilevel converter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform.

The most attractive features of multilevel inverters are as follows [1]:

- They can generate output voltages with extremely low distortion and lower dv/dt.
- They draw input current with very low distortion.
- They generate smaller common-mode (CM) voltage, thus reducing the stress in the motor bearings. In addition, using sophisticated modulation methods, CM voltages can be eliminated

- They can operate with a lower switching frequency.
- A multilevel inverter can eliminate the need for the step-up transformer and reduce the harmonics produced by the inverter.

With additional voltage levels, the voltage waveform has more free-switching angles, which can be preselected for harmonics elimination.

II. MULTILEVEL INVERTER TOPOLOGIES

The three different multilevel inverter structures are as follows [1]

- Diode clamped (neutral clamped)
- Capacitor clamped (flying capacitor)
- Cascade H-bridge inverter with separate DC source

2.1 CASCADE MULTILEVEL INVERTER

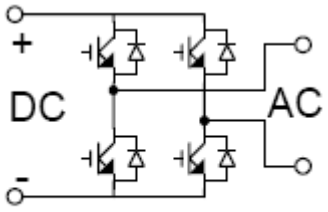


Fig. 1

A cascade multilevel Inverter consist of series of H-bridge (Full Bridge) Inverter units. Each bridge is fed from a separate DC sources which may be obtained from batteries, fuel cells, or solar cells. The general function of this multilevel inverter is to synthesize a desired voltage from several separate dc sources (SDCSs).The ac terminal voltages of different level inverters are connected in series [1]. Unlike the diode-clamp or flying-capacitors inverter, the cascaded inverter does not require voltage-clamping diodes or voltage-balancing capacitors; hence this type has more advantages than other two types. Fig 2.1 below shows one H-bridge.

2.2 BLOCK DIAGRAM

Fig.2 shows the block diagram of implementation of microcontroller based multilevel inverter. It mainly consists of 4 blocks Source**,** Cascade full bridge inverter**,** Control circuit and Load [8].

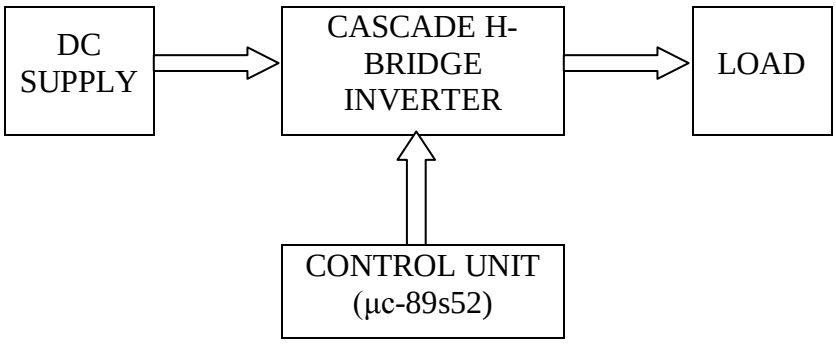


Fig.2

2.3 FIVE LEVEL INVERTER USING 2 BRIDGES

Fig. 3 shows the circuit diagram of five level inverter using 2 full H-bridge. The output voltage level can be obtained by using only 2 full bridge inverter [5].

The different output voltage level can be obtained by closing the appropreate switches as shown in switching sequence in Table 1. The output voltage of both the bridges is either added or subtracted by closing respective switches to get 5 different voltage levels i.e., v1, v2, 0, -v1, -v2.

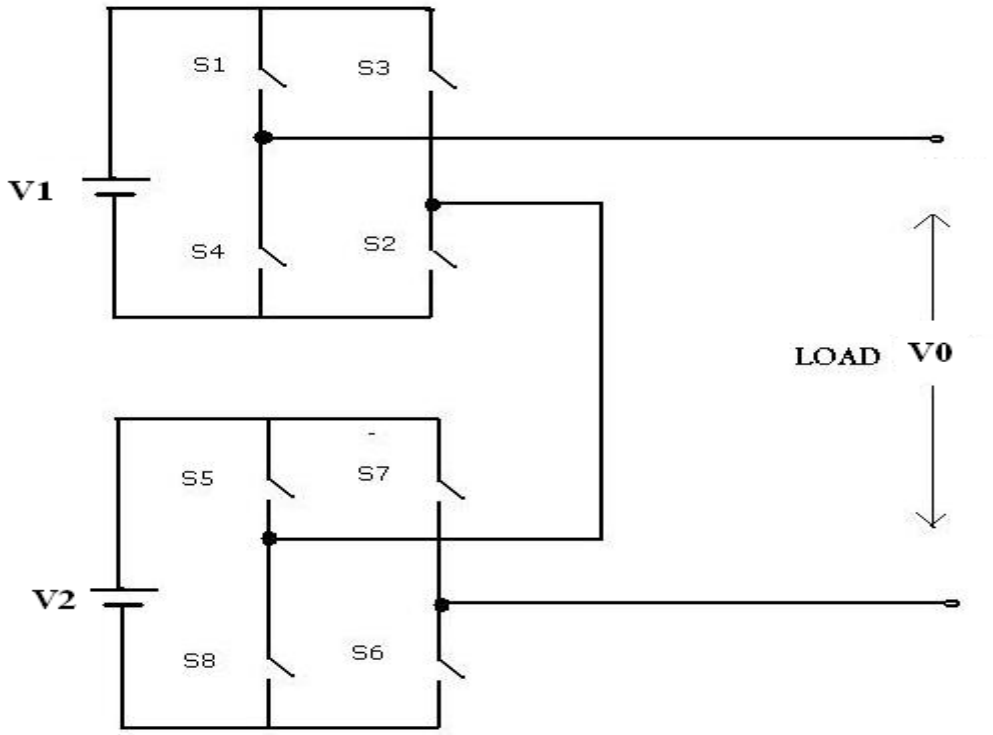


Fig. 3

Switching Sequence:

V\S	S1	S2	S3	S4	S5	S6	S7	S8
0	0	0	0	0	0	0	0	0
V1	1	1	0	0	0	0	0	0
V2	1	1	0	0	1	1	0	0
V1	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
-V1	0	0	1	1	0	0	0	0
-V2	0	0	1	1	0	0	1	1
-V1	0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0

Table 1

Table 1 shows the switching sequence for five level inverter using 2 bridges. Here level one indicates switch is ON and level zero indicates switch is OFF.According to the above switching table we implemented our microcontroller program.

Timing diagram:

Fig. 4 shows the timing diagram for 5-level inverter using 2 bridges. From this we can easily understand how different voltage levels can be generated.

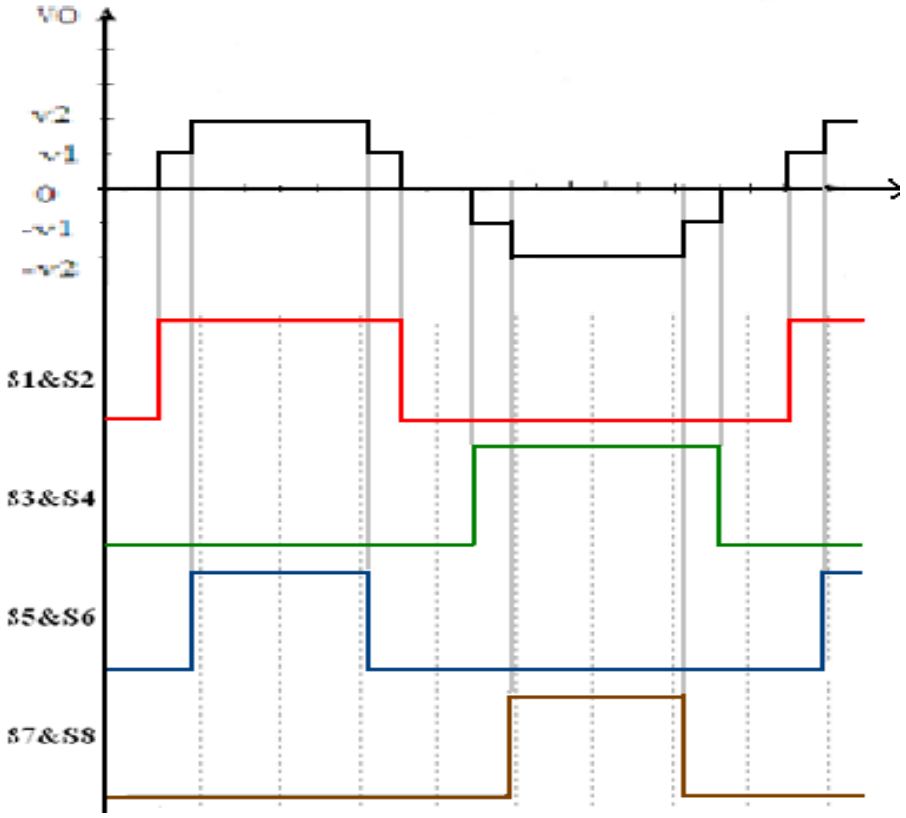


Fig. 4

Output voltage waveform:

Fig. 5 shows the output voltage wave form of 5-level using 2 bridges

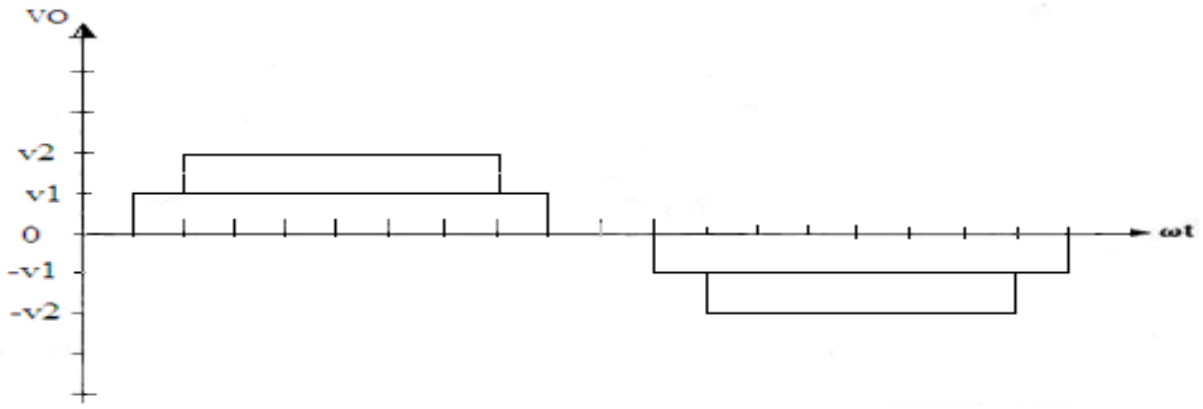
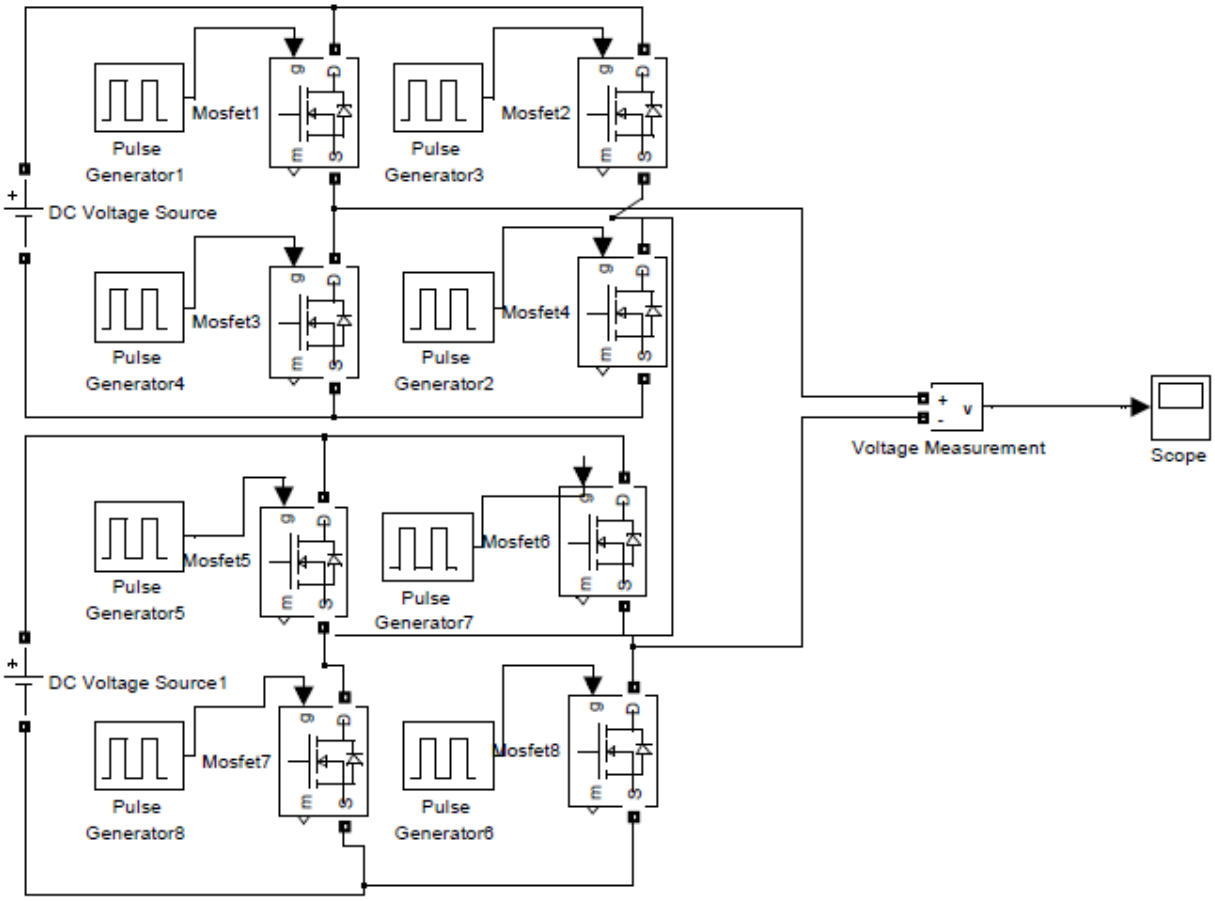


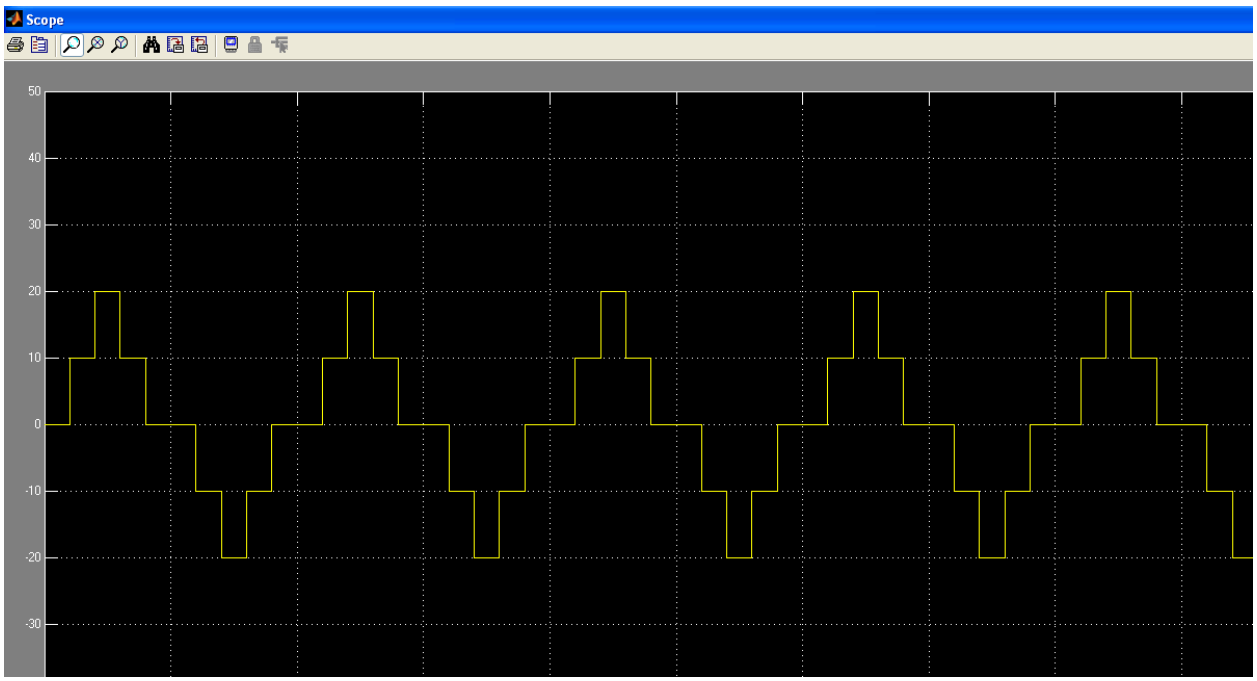
Fig. 5

III. MATLAB SIMULATION

Single Phase 2 Bridge Circuit:



Simulation Results:



IV. ADVANTAGES OF MULTILEVEL INVERTERS

Multilevel inverters have the following advantages [6]:

- They are suitable for medium to high power applications.
- They are an ideal interface between a utility and renewable energy sources such as photovoltaic's or fuel cells.
- Their efficiency is very high (>98%) because of the minimum switching frequency.
- They can improve the power quality and dynamic stability for utility systems.
- Switching Stress and EMI are low.
- Because of their modular and simple structure, they can be stacked up to an almost unlimited number of levels.

V. CONCLUSION

Microcontroller based multilevel inverter is simulated using Matlab/Simulink and the hardware is implemented. We carried out simulation of 5-level inverters in cascaded H-bridge topology. By using still more control strategy we can use this multi level inverter topology for more levels and hence it will make to almost much more nearer to sine wave, which intern reduces harmonics and which can be used for motor applications, variable speed control, in wind mills Etc.

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