SYMMETRICAL MULTILEVEL CASCADED H-BRIDGE INVERTER USING MULTICARRIER SINUSOIDAL PULSE WIDTH MODULATION TECHNIQUE

PatilSwapnil Sanjay
Government College of Engineering, Karad, India
sspatil9552@gmail.com

PatilRupaliTanaji
Government College of Engineering, Karad, India
rupalipatil269@gmail.com

WategaonkarSuraj Sanjay
Government College of Engineering, Karad, India
Surajw07@gmail.com

***Abstract*- This paper investigates and analyses an efficient multicarrier SPWM switching method for cascaded H-Bridge symmetrical multilevel inverter.The H-Bridge based symmetrical multilevel inverter can increase the number of levels of output voltage by adding number of input DC sources. If two DC sources are applied then it gives five levels at output and three DC sources gives seven levels of output. To reduce the THD as per requirement it needs output filter.In this papermulticarrierSPWM switching is provided to the multilevel inverter switches. In this switching method two signals are used, one is reference and another is carrier signal. For SPWM technique reference signal is sinusoidal wave and triangular wave is carrier signal. This type of inverters have an ability to produce waveforms with better harmonic spectrum and realistic output results. The simulation results shows that Total Harmonic Distortion is reduced with sinusoidal pulse width modulation. The simulation results shows that quality of output voltage waveform gets improved with less loss as well as lower THD.**

Keywords— Symmetrical Cascaded H-Bridge Multilevel Inverter, Multicarrier SPWM, Phase Disposed SPWM.

I. INTRODUCTION

Multilevel voltage source inverter structure is very much popular especially in application of conversion of high DC to AC power. Multilevel voltage source is preferred over three level inverter because of its capability of generating the levels of output voltage with less harmonic distortion, lower dv/dt, distortion less input current, reduced common mode voltage and ability to operate at low switching frequency. There are three presentable topologies can be considered for multilevel inverters that is as discussed below:

Diode clamped or neutral clamped, flying capacitors or capacitor clamped and cascaded H-Bridge with separate DC source for each cell. The application of multilevel inverters spreads over the area of static VAR compensation,adjustable power electronic speed drives and conditioning of power line application. Though the multilevel voltage source inverter concept has introduced before three decades, but restricted by its practical application. By usingstructure of multilevel voltage source inverter, stress on each switching device can be reduced in proportional to number of levels, due to that the inverter can handle higher voltages. By increasing levels of multilevel inverter, the voltage of output have more stepped like staircase waveform. The cascaded H-bridge multilevel inverter having several switches to increase the levels of output voltage with independent DC voltage sources. This is very simplest structure synthesize a large number of output voltage levels. The characteristics of total harmonic distortion are improved, then it needs to filter the output to meet general requirement of THD. To mitigate this problem, provide efficient multicarrier SPWM technique to switches of multilevel inverter. By providing this SPWM, this operation provides more sinusoidal waveform and less THD.This cascaded H-bridge multilevel inverter is commonly classified as symmetrical CHB as the input DC sources are equal and in series otherwise asymmetrical CHB with different values of DC sources, it will produce more output levels. To verify proposed scheme of cascaded H-bridge multilevel inverter with multicarrier SPWM function implemented inMATLAB simulation.

II. MULTILEVEL SYMMETRICAL CASCADED H-BRIDGE INVERTER

A. Conventional Switching for Symmetrical Cascaded H-Bridge Multilevel Inverter

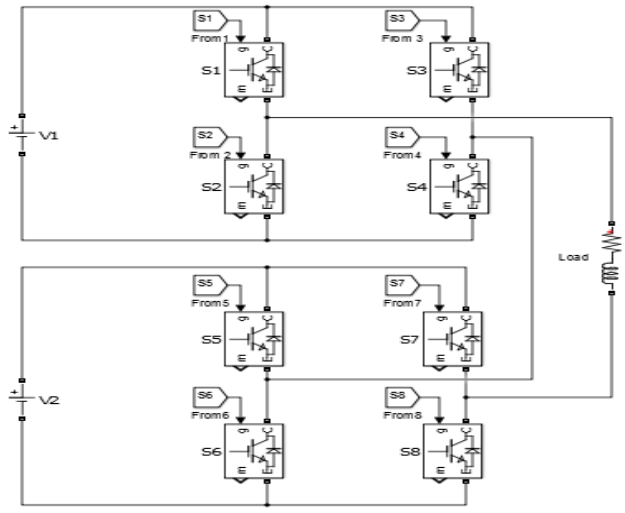

Fig1. Five level cascaded H-bridge inverter.

Fig1. Shows five level cascaded H-bridge multilevel inverter. It consists of two cells connected in series and it driven by two different independent voltage sources with same value. i.e. V_1 and V_2. It synthesizes maximum voltage waveform is the sum of both individual cells output V_{1+} V_2. The output voltage of first cell is V_1 and V_2 is for another cell then the output voltage levels become five i.e. 2m+1; m is the number of input DC voltage sources. The five level outputs are $2V, V, 0, -V, -2V$

TABLE 1

Mode	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
0	1	0	1	0	1	0	1	0
+V	1	0	1	0	1	0	0	1
+2V	1	0	0	1	1	0	0	1
+V	1	0	1	0	1	0	0	1
0	0	1	0	1	0	1	0	1
-V	0	1	1	0	0	1	0	1
-2V	0	1	1	0	0	1	1	0
-V	0	1	1	0	0	1	0	1

By providing switching sequence as given in the Table 1 then it will gives stepped output voltage as shown in Fig2. Results will indicate five levels. THD analysis of five level as shown in Fig 3. THD for five level inverter is 26.41%.

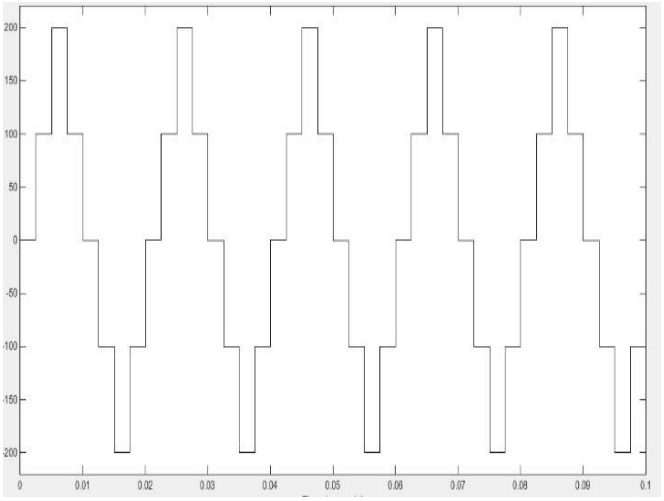

Fig2. Five level output voltage as per TABLE1.

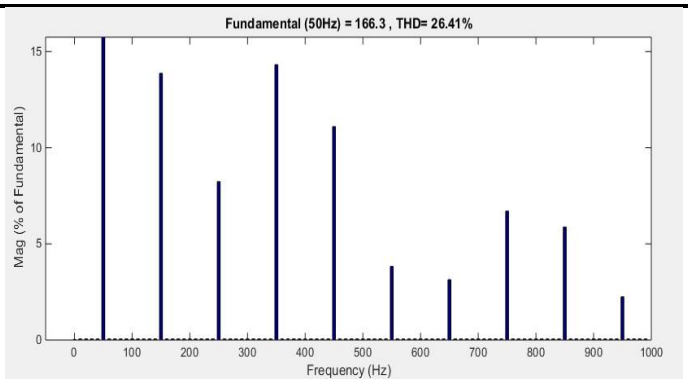

Fig3. THD of five level inverter.

If one voltage source is added in five level inverter then it gives output levels seven. If one source is added then four switches are required for that cell and connected in series with another cells. For seven level inverter conventional switching sequence is as given in TABLE 2. If this sequence is employed to particular switches then it will gives seven stepped output as shown in Fig 4. The THD analysis of this output is shown in Fig 5. THD for seven level inverter is 19.16%.

TABLE 2

Mode	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}
0	1	0	1	0	1	0	1	0	1	0	1	0
V	1	0	0	1	1	0	1	0	1	0	1	0
2V	1	0	0	1	1	0	0	1	1	0	1	0
3V	1	0	0	1	1	0	0	1	1	0	0	1
2V	1	0	0	1	1	0	0	1	1	0	1	0
V	1	0	0	1	1	0	1	0	1	0	1	0
0	0	1	0	1	0	1	0	1	0	1	0	1
-V	0	1	0	1	0	1	0	1	0	1	1	0
-2V	0	1	0	1	0	1	1	0	0	1	1	0
-3V	0	1	1	0	0	1	1	0	0	1	1	0
-2V	0	1	0	1	0	1	1	0	0	1	1	0
-V	0	1	0	1	0	1	0	1	0	1	1	0

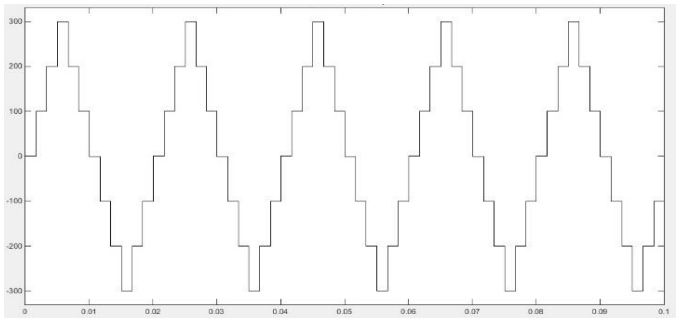

Fig4.Seven level output voltage.

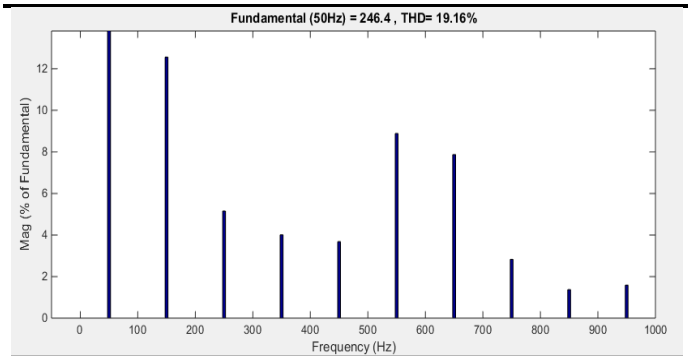

Fig5. THD of seven level inverter.

III. SPWM SWITCHING FOR CASCADED H-BRIDGE MULTILEVEL INVERTER

If we modify the switching of the inverter by multicarrier SPWM technique, it can gives more sinusoidal output voltage waveform. The modulation for cascaded H-bridge multilevel inverter divided in to two categories that is fundamental switching frequency and high switching frequency PWM known as multicarrier based PWM, space vector PWM, selective harmonic elimination and multilevel SPWM needs multiple carriers.For multicarrier SPWM techniques each independent DC voltage source needs its own carrier.

There are three alternative PWM strategies with differing phase relations:

- APOD(Alternative Phase Opposition Disposition): Every carrier waveform is in out of phase with its next carrier by 180 degree.
- POD(Phase Opposition Disposition): Carriers above zero reference are in phase and carriers below zero reference are out of phase with 180 degree.
- PD (Phase Disposition): All carriers are in phase.

In this proposed cascaded H-bridge multilevel inverter phase disposition method is employed to reduce the THD.

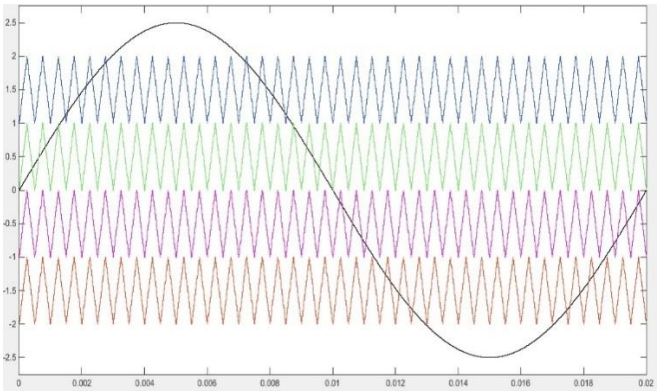

Fig6.Multicarrier phase disposition SPWM.

The phase disposition having following rules:

When number of levels are five: As number of voltage levels are five then required carriers are 5-1=4. This four carrier waveforms are arranged such that above and below the zero reference are in phase. Two carriers above and two carriers below the zero reference.

- The multilevel inverter switch ON to +2V when reference is greater than second positive carrier wave.
- The multilevel inverter switch ON to +V when reference is greater than first positive carrier.
- The multilevel inverter switches to 0 when reference is less than both positive carrier.
- Inverter switches to -V when reference is less than first negative carrier.
- Inverter switches to -2V when reference is less than second negative carrier.

When number of levels are seven: As number of voltage levels are seven then required carriers are 7-1=6.

By providing switching to multilevel inverter like as discussed above then it will gives results as shown in simulation results.

IV. SIMULATION RESULTS

The single phase cascaded five level and seven level inverter is modeled in MATLAB SIMULINK. The switching for each switch are generated from different carrier SPWM technique and THD analyzed by FFT analysis.

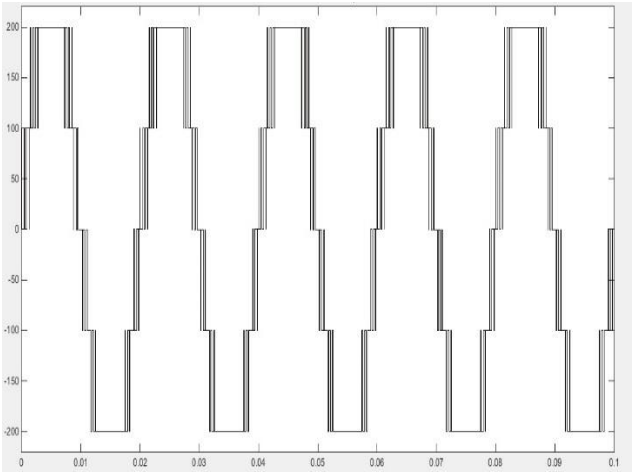

Fig 7. Five level SPWM output voltage.

Total harmonic distortion for this output is as shown in Fig 8. THD for Five level output voltage with SPWM output is 9.09%.

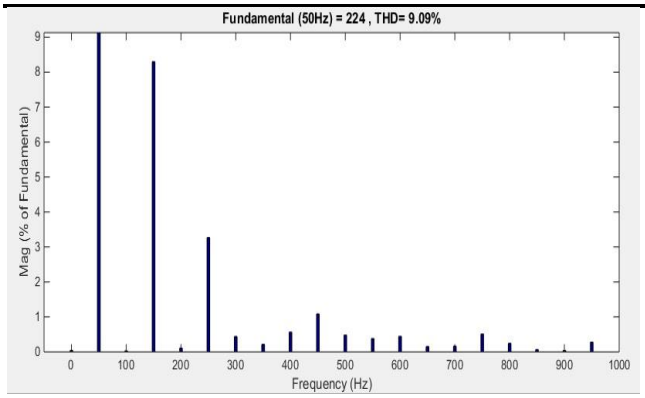

Fig 8. THD for five level SPWM output.

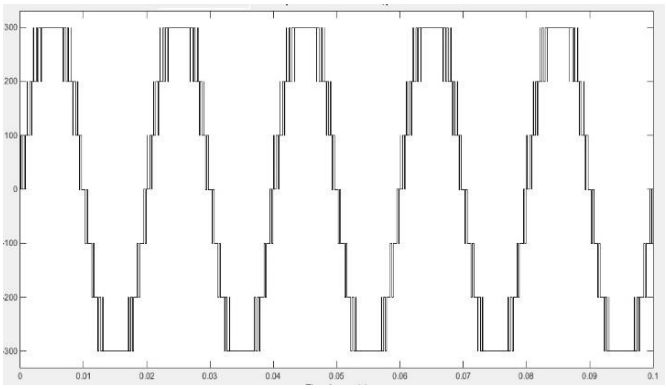

Fig 9. Seven level SPWM output voltage

Total harmonic distortion for this output is as shown in Fig 10. THD for Seven level output voltage with SPWM output is 6.44%.

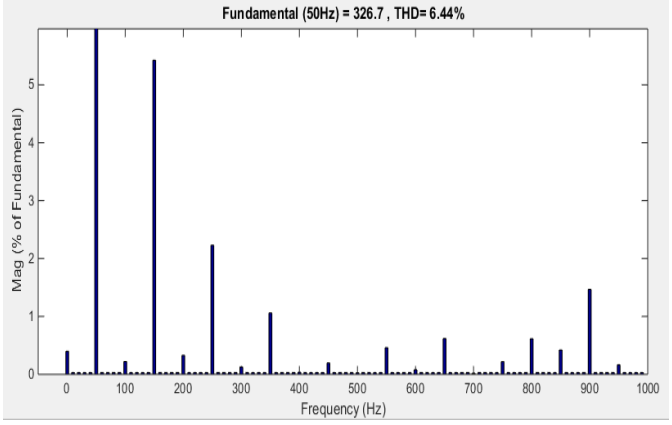

Fig 10. THD for seven level SPWM output.

CONCLUSION

This paper gives brief idea about implementation of multilevel sinusoidal pulse width modulation (Phase Disposition) for five and seven level inverter. The corresponding FFT analysis has done for single phase. It is observed that THD for five levels of voltage is 9.09% and forseven levels THD is 6.44%. By using Phase Disposition SPWM strategy it provides lower percentage of THD.

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