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Simulation of Five Level Cascaded H-Bridge Multilevel Inverter with and without OTT Filter

K.Vishnu Priya[1], A.Aswini [2]

Assistant Professor, Dept. of EIE, M.Kumarasamy College of Engineering, Karur, Tamilnadu, India[1]

Assistant Professor, Dept. of EEE, M.Kumarasamy College of Engineering, Karur, Tamilnadu, India[2]

ABSTRACT: This paper deals with the five level cascaded H-bridge multilevel inverter using sinusoidal pulse width modulation (SPWM) technique, with and without OTT filter. The MLI converts DC input voltage into staircase AC output voltage. The distortion in AC output voltage of the inverter can be reduced using OTT filter. The total harmonic distortion of 0.62 produces from five levels MLI can be reduced to 0.10 using OTT filter. Thus, the reduced total harmonic distortion (THD) is achieved. The Matlab–Simulink is used to simulate and analyze the results.

KEYWORDS: Multilevel inverter (MLI), cascaded H-bridge (CHB), OTT filter.

I.INTRODUCTION

Power electronics circuits play vital role in production of electricity using renewable energy sources. It is mainly used to convert and control the signal. It converts the sources, either it from DC/AC to AC/DC .The DC sources converted to AC source is called rectifier and the AC source converted to DC source is called inverter. The inverter converts electrical energy with efficient and reduces harmonic form. To avoid the entire harmonic content filters are used.

Multi level inverters are applied in the area of medium voltage and high power applications. It produces a desired MLI output voltage from the separate DC sources. The multilevel inverter pays attention due to its advantages in lower switching loss better electromagnetic compatibility, lower harmonics and higher voltage capability [4]. The number of output voltage levels 'n' is determined by the number of separate DC sources 's' using the formula n = 2s+1. When s=2, then the level of the inverter is n=5 obtained (five level cascade MLI). The outputs of the cascaded H-bridge cells are connected in series to synthesized voltage waveform as the sum of all of the individual cell outputs. The output voltage of cascaded H-bridge MLI is the sum of the output voltage of individual inverter and it's defined by $V_0 = V_1 + V_2$.

II. BLOCK DIAGRAM OF CASCADED H-BRIDGE MULTI LEVEL INVERTER WITH FILTER

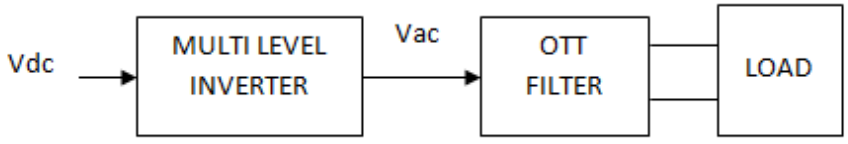

Fig.1Block diagram of the proposed system

The multilevel inverters generate output voltages with lower distortion and very low dv/dt stress. It also draws input current with very low distortion. Cascaded multilevel inverter is highly reliable and achieves the fault tolerance in its modularity, and it enables the inverter to continue operating at lower power levels after failure [1] to [5]. The distortion in the output voltage from the inverter can be reduced using filters to produce pure sinusoidal waveform shows in the fig.1. The OTT filter is generally used in the secondary side of parallel inverter. A novel design of OTT filter is connected to the MLI to reduce the THD in the output voltage of MLI.

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The separate DC voltage are V1 and V2 given to the MLI, it operates with eight switches Q1,Q2,Q3,Q4,Q5,Q6,Q7 and Q8 shows in the fig.2.The output voltage Vac of MLI is applied to OTT filter to produce pure sine wave AC output voltage. The resistive load is used.

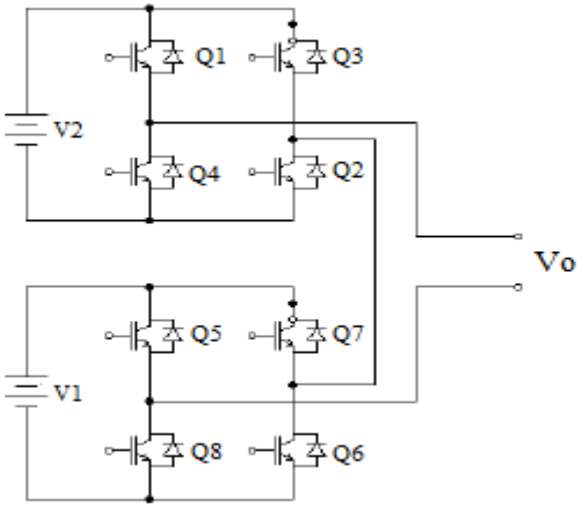

Fig.2 Five level cascaded H-bridge multilevel inverter

III.MODES OF OPERATION

The input voltages are V1=40V and V2 =40V are given. The switches Q1, Q2, Q5 and Q6 operates to produces the output voltage V_O = 80V. The switches Q1 and Q5 operates to produces the output voltage V_O=40 V. The switches Q1, Q2, Q5 and Q6 operates to produces output voltage V_O = 0V. The switches Q3 and Q7 operates to produces the output voltage V_O= -40 V. The switches Q3, Q4, Q7 and Q8 operates to produces the output voltage V_O = -80V. Thus, staircase output voltage waveform is generated.

V_O	$2V_1$	V_1	0	$-V_1$	$-2V_1$
Q1	1	1	1	0	0
Q2	1	0	1	0	0
Q3	0	0	0	1	1
Q4	0	0	0	0	1
Q5	1	1	1	0	0
Q6	1	0	1	0	0
Q7	0	0	0	1	1
Q8	0	0	0	0	1

Table 1.Eight modes of operation

IV.OTT FILTER

The main features of OTT filter is to produces a sine wave output by eliminating harmonic content to the load of MLI. It provides good load regulation while at the same time maintaining a capacitive load to the inverter over a large load power factor. Vo is the output Voltage of MLI and Vf is the output Voltage of OTT filter which is connected to the load used in the fig.3.

Total harmonic distortion (THD) is defines as the summation of all harmonic components of the voltage or current waveform compared with the fundamental component of the voltage or current waveform. THD get reduced using OTT filter.

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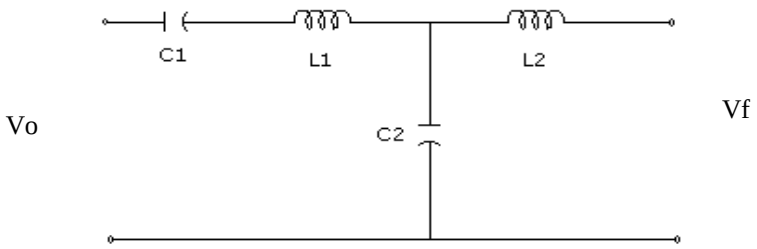

Fig.3.Equivalent circuit of the OTT filter

The formula used to calculate the components of the filter are,

$C1=\frac{1}{6*Wd*Zd}$

$C2=\frac{1}{3*Wd*Zd}$

$L1=\frac{9*Zd}{2*Wd}$

$L2=\frac{Zd}{Wd}$

where, Zd is the impedence of the filter
Wd is the radian frequency.

V.SIMULATION RESULTS

The five levels Cascaded H-Bridge multilevel Inverter with and without OTT filter is designed using Matlab-Simulink. Fig.4 shows the pulse generation for MLI circuit is obtained by comparing the sinusoidal waveform with triangular waveform and the triangular wave added with constant.

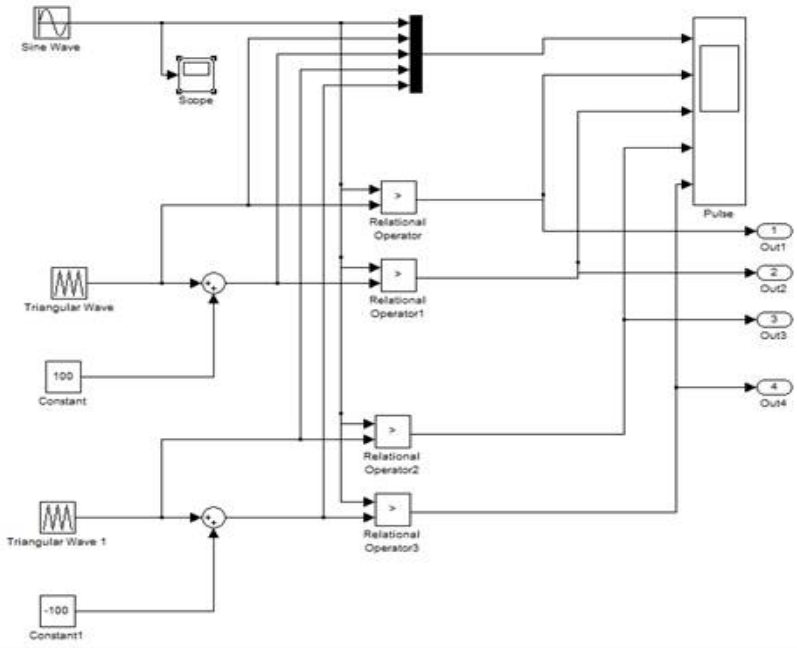

Fig. 4 Pulse generation for MLI circuit

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Fig.5 shows the input sinusoidal voltage with 50Hz and the angular frequency is 314 rad/sec is used with amplitude voltage 230V.

Thus the input voltage is Vs=Vm sinωt

=230 sin (314)t.

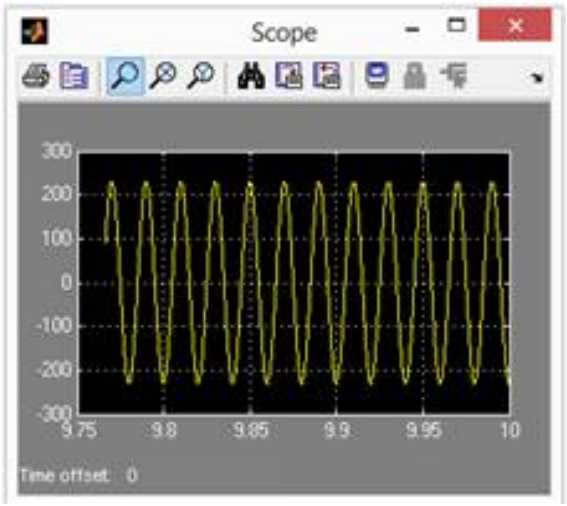

Fig.5 Input sinusoidal voltage waveform

Fig. 6 shows the pulse generation to the switches Q1, Q2, Q5 and Q6, by comparing the carrier signal (Triangular waveform) and the reference signal (Sinusoidal waveform). The pulse to be generated by comparing the two triangular wave with positive half cycle of the sinusoidal waveform and the remaining two triangular wave with negative half cycle of the sinusoidal waveform.

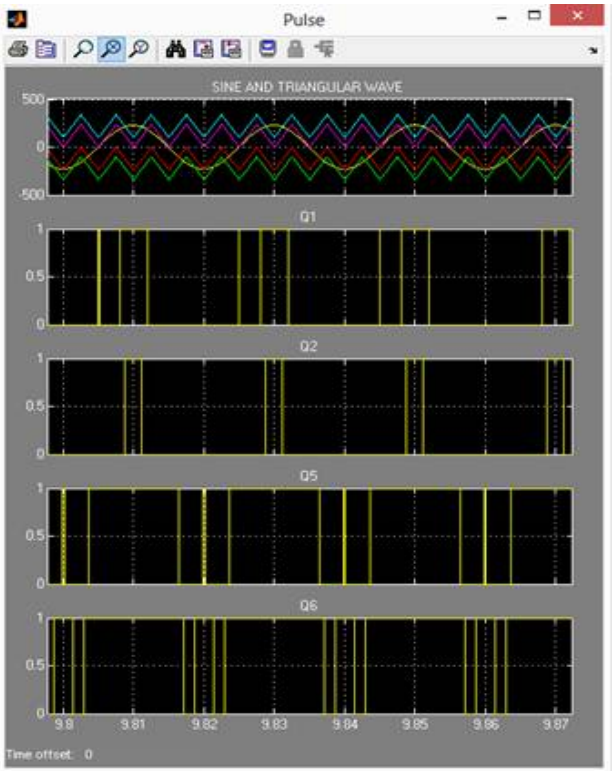

Fig.6 Pulse generated using carrier signal and reference signal

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Fig.7 shows the design of five level cascaded H-bridge multilevel inverter without OTT filter. The THD and RMS voltage is calculated across the resistive load. The RMS voltage is 40.9 V and the THD is 0.62 are obtained. The five level output voltage is obtained with harmonic distortion, which can be overcome using filter.

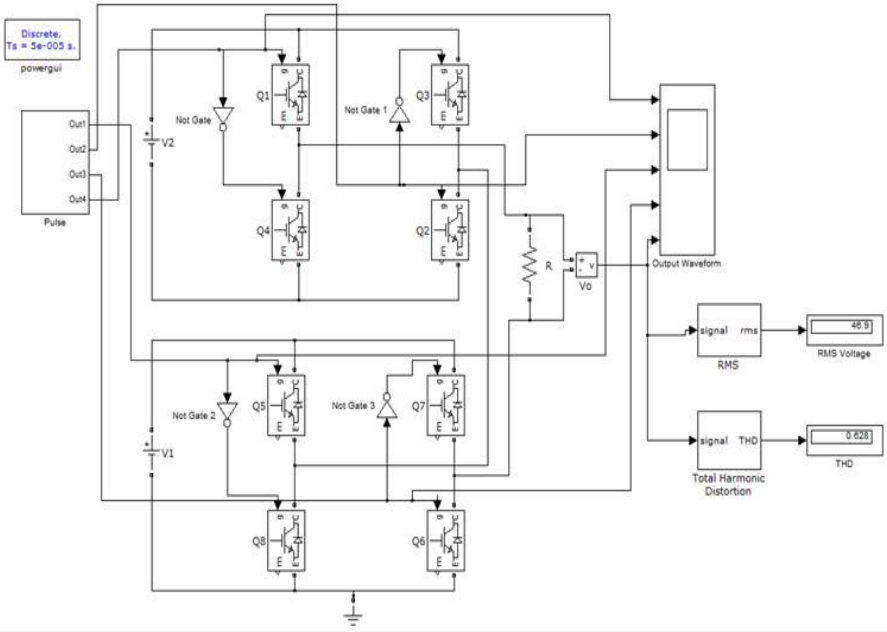

Fig.7 Design of five level cascaded H-bridge multilevel inverter without OTT filter

The output AC voltage waveform is obtained in the fig.8. The pulse generation of various switches Q1, Q2, Q5 and Q6 is shown. The THD of the output AC voltage is 0.62 is obtained.

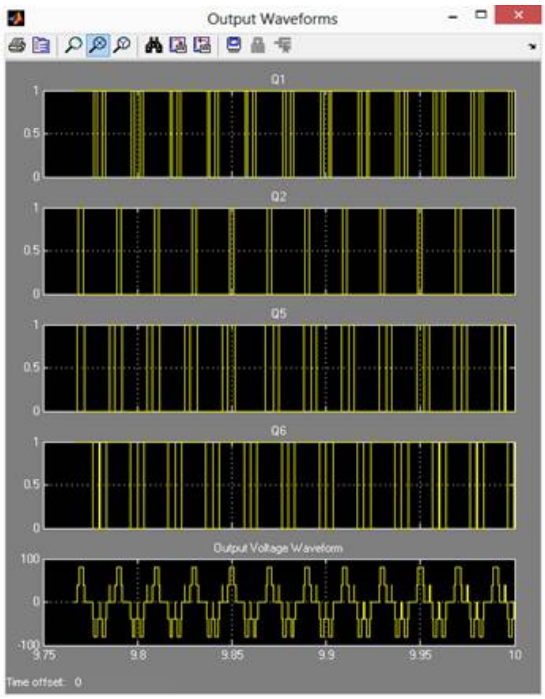

Fig.8 Pulses of the switches Q1, Q2, Q5 and Q6 and the output voltage across R Load without OTT filter

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Fig.9 shows the design of five level cascaded H-bridge multilevel inverter with OTT filter. The output of the OTT filter is connected to the resistive load. The parameters used in the OTT filter are,
C1=6.92uF
C2=13.85uF
L1=1H
L2=0.24H

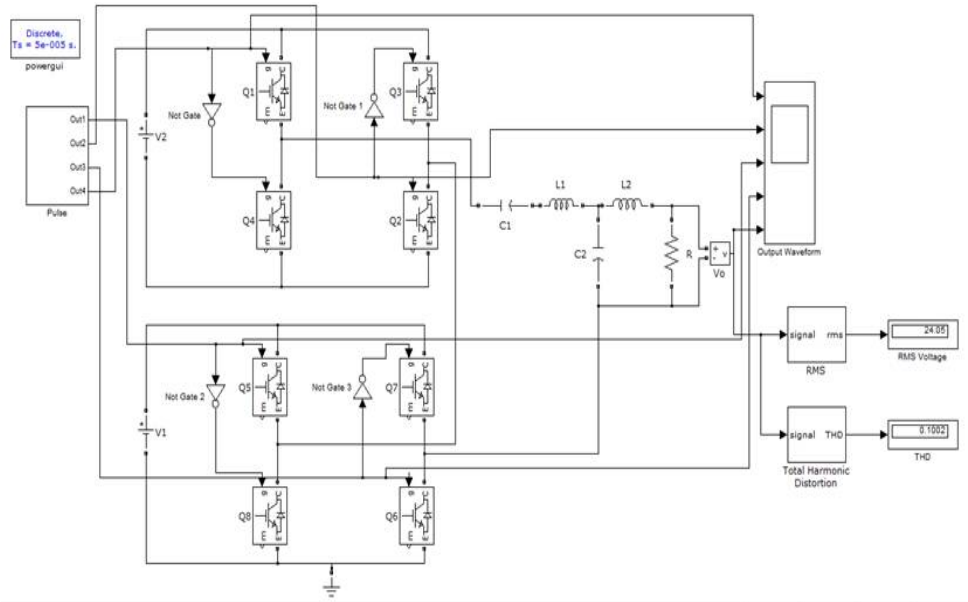

Fig.9 Design of five level cascaded H-bridge multilevel inverter with OTT filter

Fig.10 shows the pulses of the switches Q1, Q2, Q5 and Q6 and the output voltage across R Load with OTT filter. Thus, pure sinusoidal output voltage is obtained using the OTT filter with reduced THD of 0.10. The RMS voltage is 24.09V.

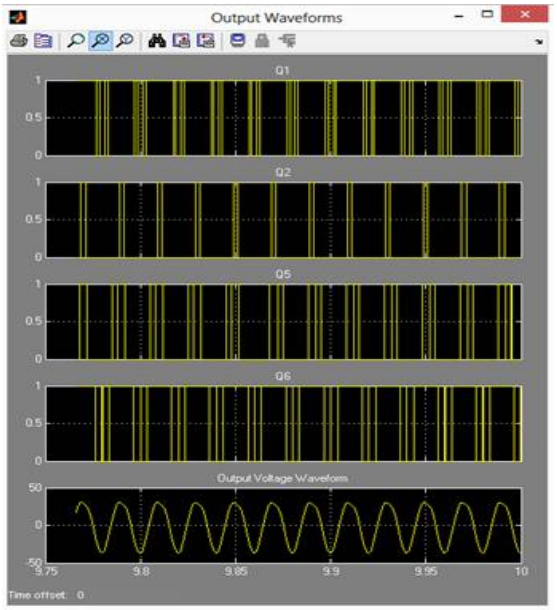

Fig.10 Pulses of the switches Q1, Q2, Q5 and Q6 and the output voltage across R Load with OTT filter

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VI.CONCLUSION

In this paper, a five level cascaded H-bridge multilevel using sinusoidal pulse width modulation with and without OTT filter is simulated. This results shows that the total harmonic distortion is reduced, when OTT filter is connected to the output of MLI. The THD of 0.62 produces from the five levels MLI can be reduced to 0.10 using OTT filter is achieved.

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