International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.43

Analysis of Five Level Cascaded Multilevel Inverter Using Variable Frequency Multi Carrier Pulse Width Modulation Techniques

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Abstract: ***Multilevel inverters are uses in the many high power application, it has many advantages due to the controllability of the series connected switches. In this paper presents the different variable frequencymulti carrier modulation pulse width modulation techniquesmodeled in MATLAB Simulink. The analysis cascaded multilevel inverter using the different modulation technique schemes is done and finally the results are compared. The main objective of this work is to select the best control and switching topology for the multilevel inverter***

Keywords: Multilevel inverter, Total harmonics distortion, Modulation techniques, MATLAB

1. Introduction

Power electronics based converters and controllers are used for different types of domestic, industrial application and many high voltage application. The main advantages of the multilevel inverter are the good power quality and reduction in the harmonics distortion and better high voltage stability. The multilevel inverter topologies classified in to three different types thatis diodeclamped, capacitor clamped and cascaded multilevel inverter. In this paper high frequency modulation techniques like variable switching frequency based phase-shifted carrier modulation and level- shifted carrier modulation is present. The main aim of present this paper to minimize total harmonic distortion and increase the stability of the output voltage. Moreover these modulation techniques are compared with sub harmonic pulse width modulation techniques. In the Fig 1 shows the classification of the different modulation technique on the basis of the frequency.

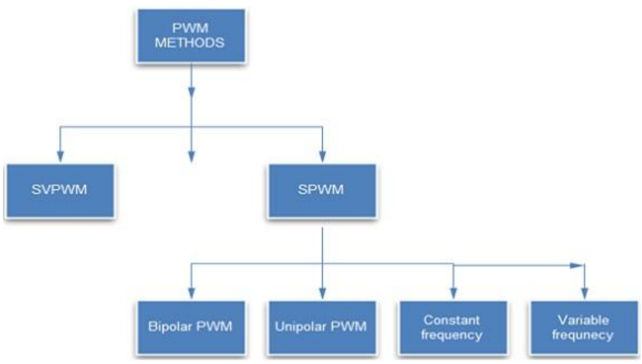

Figure 1: Classification of the modulation techniques

2. Variable Switching Frequency Pulse –Width Modulation

In a conventional constant frequency methods are the carrier wave of the same frequency is compared with reference signal but in a variable switching frequency two different frequencies are use as carrier wave and its compare with the referencesignal, it shown in the fig 2. In this proposed method, the carrier frequency of a five-level inverter is assigned to have a variable frequency of 2000 and 5000Hz as shown in the fig.

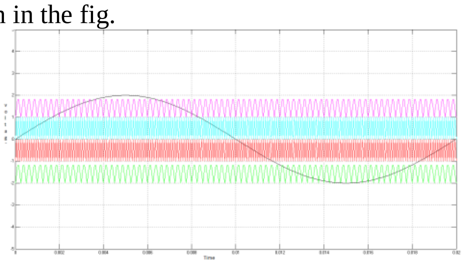

Figure 2: Variable Frequency sine wave pulse width modulation

3. Phase Shifting Pulse-Width Modulation

In a multilevel inverter the number of carrier signal

$$m=(n-1)$$

Where n=number of level of the inverter.
For 5 level inverter

$$m=(n-1)=5\text{-}1=4.$$

For phase shifting multicarrier modulation all the triangular carrier wave is Phase shifted by $360° \div (m)$
In the fig 3 shows the phase shifted multilevel modulation

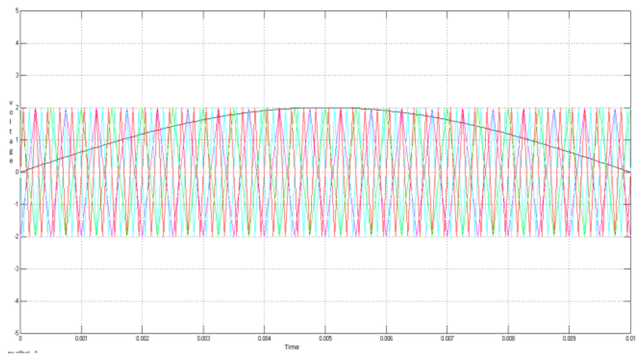

Figure 3: phase shifting pulse width modulation

4. Level Shifting Pulse- Width Modulation

4.1 Phase disposition modulation techniques:

In this modulation techniques all the carrier wave of the same amplitude are in same phase. The fig 4 shows phase disposition techniques.

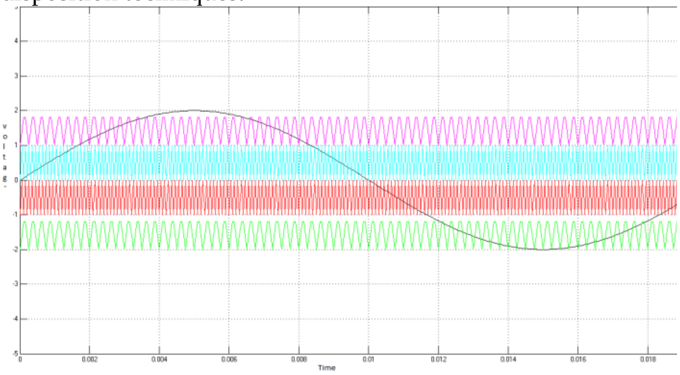

Figure 4: Phase disposition modulation techniques

4.2 Phase oppositedisposition modulation techniques

In this modulation techniques all the carrier wave of the same amplitude with reference of zero above and below are in opposite phase with each other, it's shown in the fig 5.

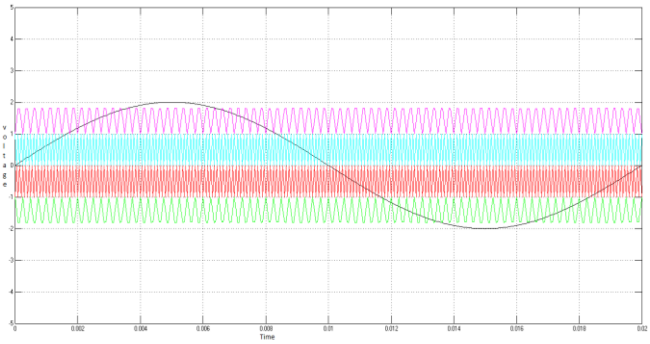

Figure 5: Phase opposite modulation techniques

4.3 Alternative Phase oppositedisposition modulation techniques:

In this modulation technique all the carrier waves of the same amplitude are in opposite phase with respect to each other it is show in the fig 6.

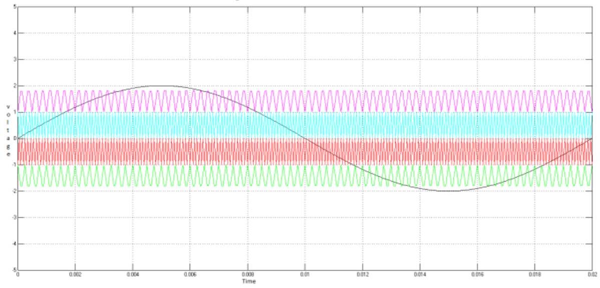

Figure 6: Alternative Phase opposite modulation techniques

5. Switching Frequency Optimal Pulse –Width Modulation

The switching frequency optimal pulse width modulation (SFOPWM) which triples harmonics voltage is added to each of the carrier waveform [1]. The method takes the instantaneous average of the maximum and minimum of the reference voltage and subtracts the value from reference voltage for obtain the modulation waveform [1].

$$Voffset = (maxV + minV) \div 2$$

$$Vsfo = V - Voffset$$

In the fig 7 shows modulation waveform of the SFOPWM. The advantage of the method is the modulation index increase the 15% as compare to the convectional PWM methods, its helps to reduce the harmonics distortion.

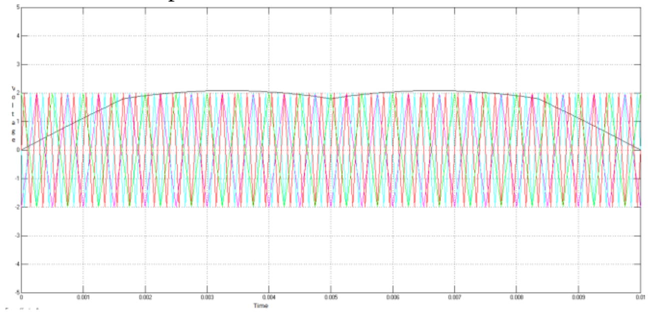

Figure 7 (a)

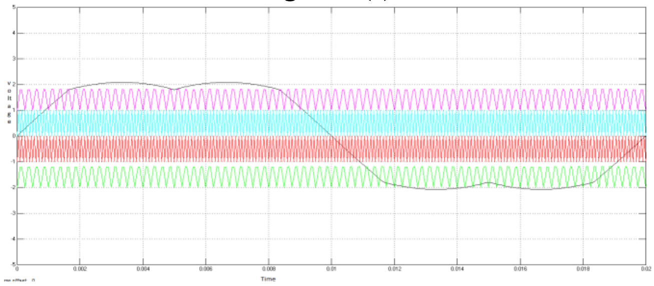

Figure 7 (b)

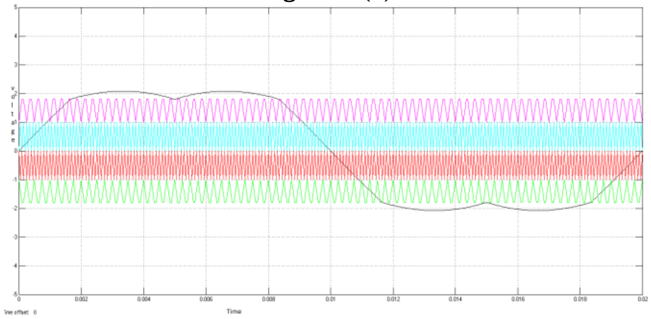

Figure 7 (c)

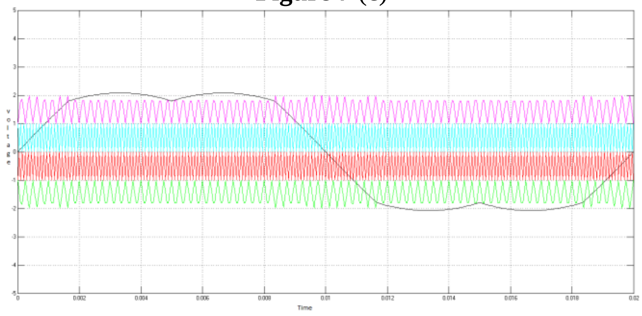

Figure 7 (d)

Fig-7 (a) SFO Phase Shifting (b) SFO PD (c) SFO POD (d) SFO APOD

6. Simulation

To verify the above modulation techniques a simulation model for single phase five level cascaded multilevel is implemented. The simulation parameters for a variable frequency 2KHz and 5KHz switching frequency each voltage source has 53 volts dc voltage apply to the single phase load R=100.

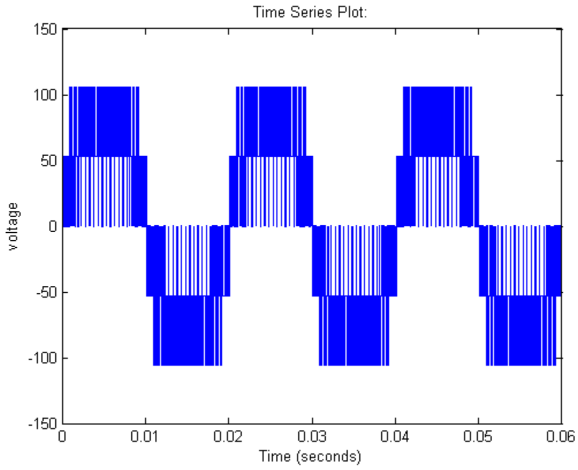

Figure 8: Output voltage Waveform of Phase shifting Method

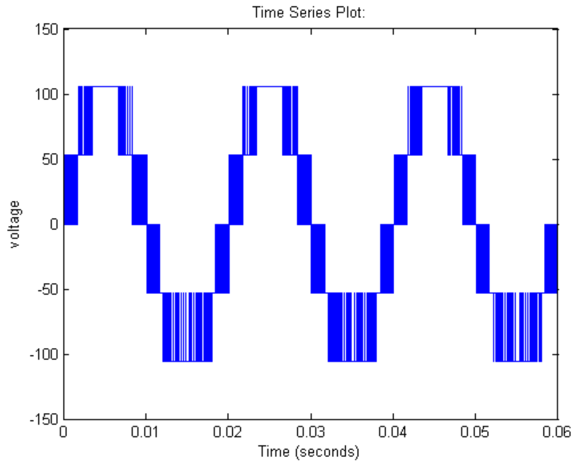

Figure 9: Output Voltage Waveform Of PD

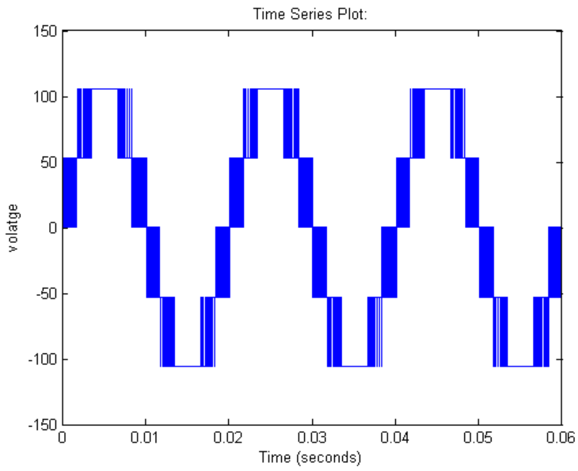

Figure 10: Output Voltage Waveform Of POD

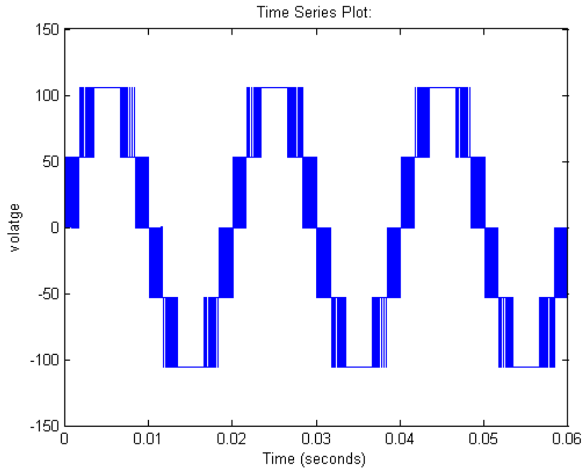

Figure 11: Output Voltage Waveform Of APOD

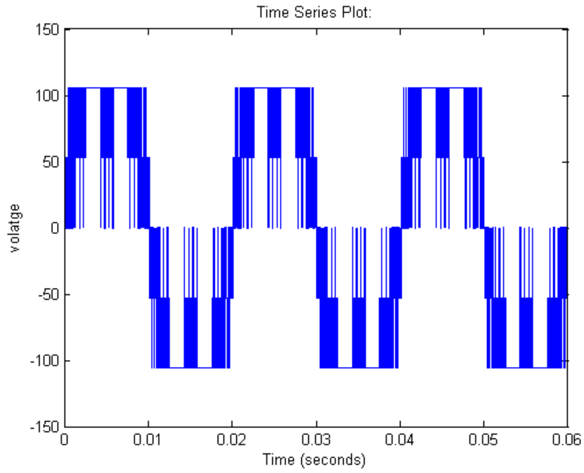

Figure 12: Output Voltage Waveform Of SFO-Phase Shifting

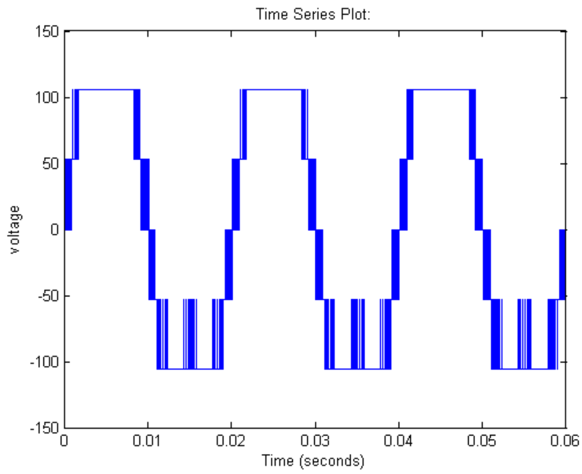

Figure 13: Output Voltage Waveform of SFO-PD

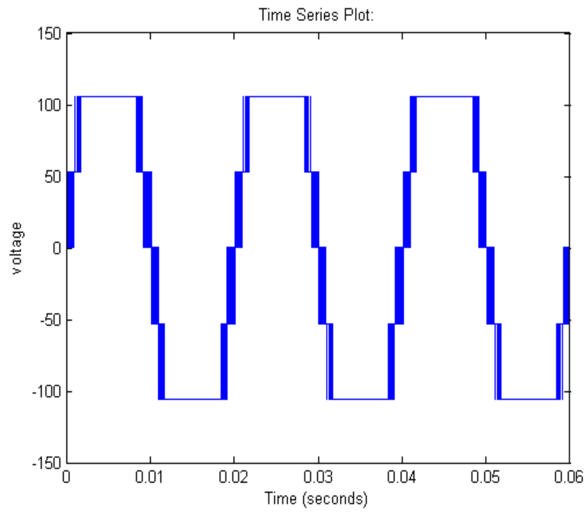

Figure 14: Output Voltage Waveform Of SFO-POD

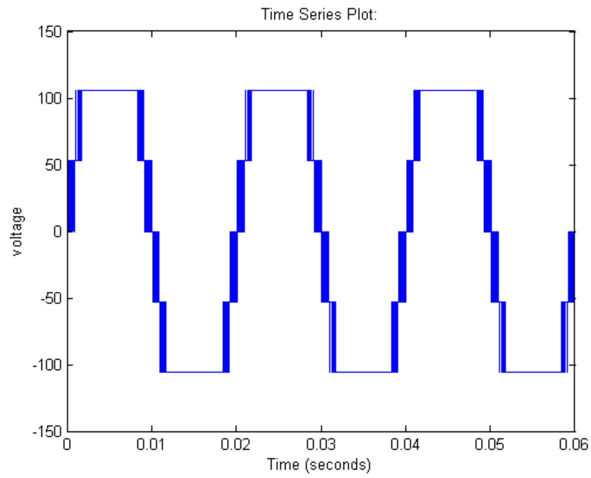

Figure 15: Output Voltage Waveform Of SFO-APOD

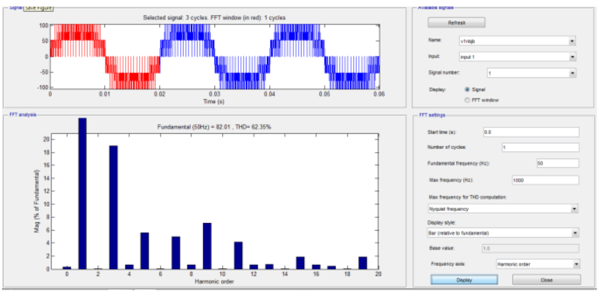

Figure 16: THD Analysis Of Phase Shifting Method.

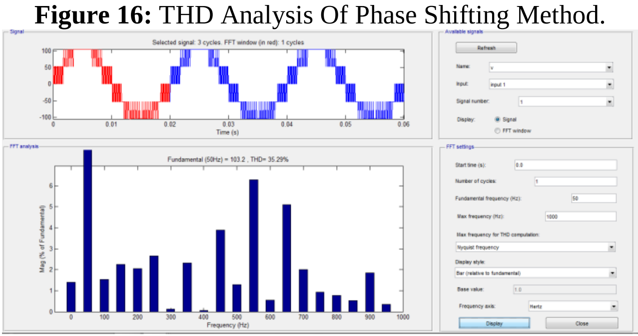

Figure 17: THD Analysis Of PD.

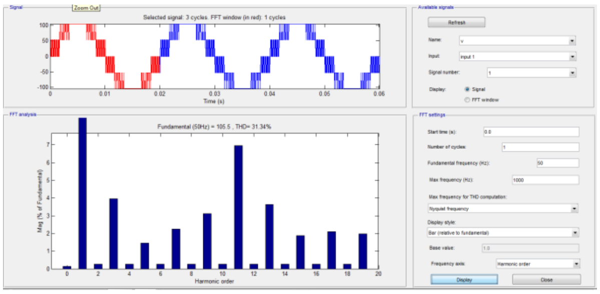

Figure 18: THD Analysis Of POD.

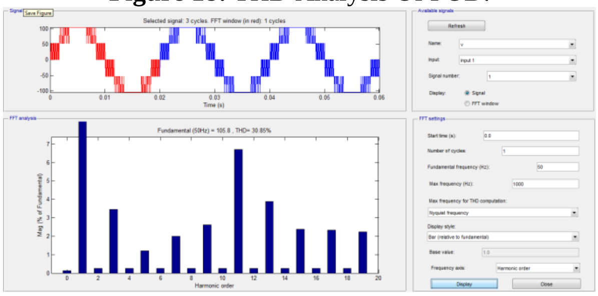

Figure 19: THD Analysis Of APOD

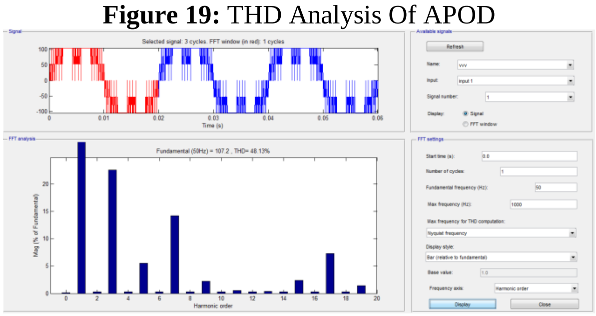

Figure 20: THD Analysis Of SFO Phase Shifting Method.

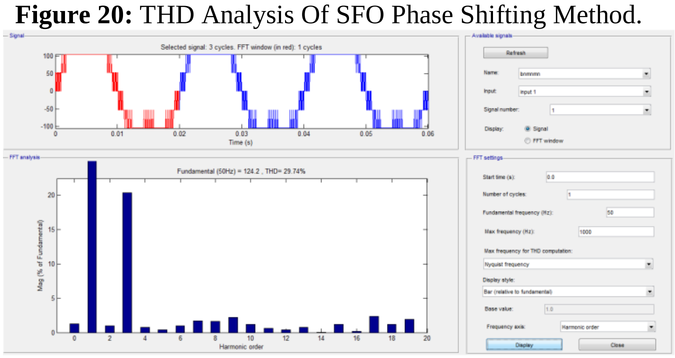

Figure 21: THD Analysis Of SFO PD.

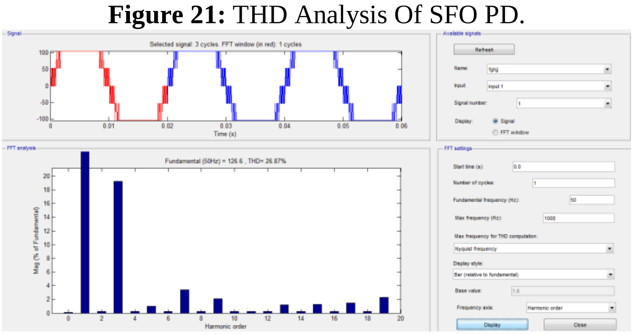

Figure 22: THD Analysis Of SFO POD.

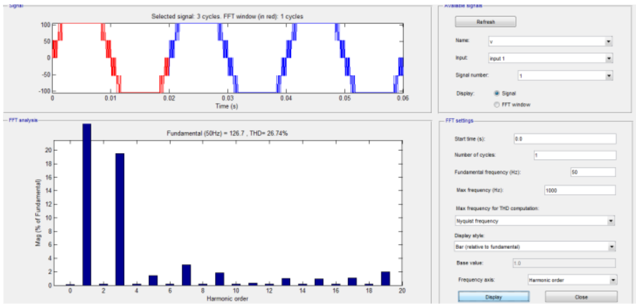

Figure 23: THD Analysis of SFO APOD.

7. Result Analysis

Modulation Technique	Output Voltage	% THD
Phase Shifting	105.4v	62.36%
Phase Dispotion	105.5v	35.29%
Phase Opposite Disposition	105.5v	31.34%
Alternative Phase Disposition	105.5v	30.85%
SFO Phase Shifting	105.4v	48.13%
SFO Phase Disposition	105.7v	29.74%
SFO Phase Opposite Disposition	105.5v	26.87%
SFO Alternative Phase Opposite Disposition	105.6v	26.74%

8. Conclusion

From this proposed work of multilevel sinusoidal pulse width modulation with variable carrier frequency for H-bridge five level inverter. The harmonics contents for alternative phase opposite disposition pulse width modulation technique contain lower harmonics than others. By increasing the level we can reduce harmonics and improve the efficiency of output voltage waveform.

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