e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-6 (December 2022)
https://doi.org/10.31033/ijemr.12.6.42

Simulation Based Analysis of 150° Conduction Mode and SPWM Technique for Three Phase Voltage Source Inverter

Dipenkumar H. Kambaliya[1] and Samir P. Darji[2]
[1]Lecturer, Dept. of Electrical Engineering, Hansaba College of Engineering and Technology, Gokul Global University, Sidhpur, Gujarat, INDIA
[2]Lecturer, Dept. of Electrical Engineering, Hansaba College of Engineering and Technology, Gokul Global University, Sidhpur, Gujarat, INDIA

[1]Corresponding Author: dipenkambaliya007@gmail.com

ABSTRACT

This paper presents Simulation based analysis of 150° conduction mode and SPWM technique for three phase voltage source inverters. Better conduction mode is consisting more levels of output voltage. Different simulations results of conduction mode and SPWM using PSIM 6.0 software is analysts. Methods are compared on the basis of number of switches, number of levels of voltage and total harmonic distortion.

Keywords-- Three Phase VSI; Conduction Modes; IGBT;THD; SPWM.

I. INTRODUCTION

Three phase VSI are more common in industrial applications. An inverter is an electrical device that converts direct current (dc) to alternating current (ac); the converted ac can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.

The main objective is to minimize the total harmonics distortion of generated output waveform of three phase voltage source inverter. Different theories have been innovated to achieve these requirements. These converters have many demerits like large size, more complicated circuits, more numbers of components are required, more weight, and higher cost.

This paper presents comparative analysis of different conduction modes three phase voltage source inverter. In inverter, a step is defined as a change in the firing from one switch to next switch in proper sequence. For one cycle of 360º, each step would be of 60º interval for a six-step inverter. Traditionally, three phase voltage source inverter uses 1200, 1800 and 1500 conduction modes. 1500 conduction mode is generated by using combinations of 1200 and 1800 modes. 1500 conduction mode produces seven levels of voltage instead of five levels. It is generated by simple design, less complexity without additional charges. It should be noticed that, THD is reduced. Also output voltage increases with the conduction periods of switches increases.

In three phase SPWM inverter for generate gate pulses by comparing two signals in which one is reference signal or modulating signal and other is carrier signal. Sine wave is used as reference wave and triangular wave is used as carrier signal. The comparator output is high when the magnitude of sine wave is greater than that of triangular wave. The modulation index is defined for SPWM inverter, the ratio of peak amplitude of reference signal to peak amplitude of the carrier signal. The output voltage of inverter is increased with increased modulation index. By using SPWM technique lower order harmonics are eliminated.

This paper presents comparative results of gate pulses, line voltages and FFT waveforms. Table I gives the comparative analysis of 1500 mode and 2-Level SPWM technique.

II. COMPARISON OF CONDUCTION MODES

Block diagram of three phase voltage source inverter system is shown in Fig. 1. DC supply as an input of three phase inverter. The AC output of three phase inverter is given to filter. After filtered output given to three phase loads. In control circuit different controllers are used. In driver circuit different driver ICs are used. Both required additional DC supply.

This work is licensed under Creative Commons Attribution 4.0 International License.

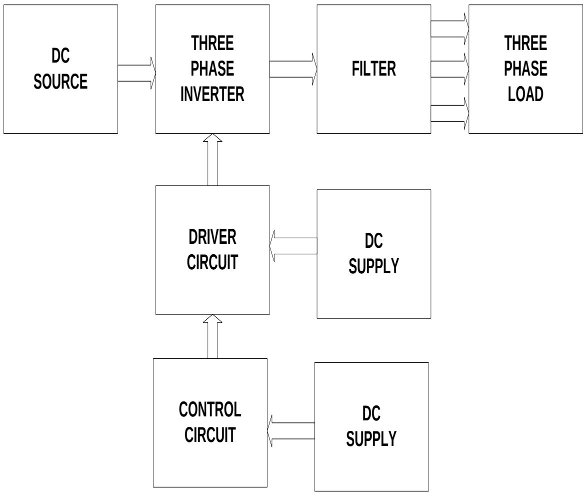


Figure 1: Block diagram of three phase VSI

For better comparison of three conduction modes, the results are achieved from software package PSIM 6.0. Fig.2 shows the simulated circuit model in PSIM 6.0.

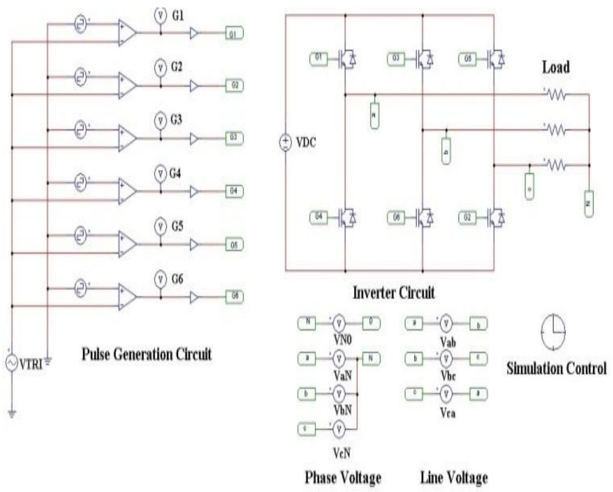


Figure2: Simulated model of three phase VSI

A. *Gate pulses*

Gate pulse of 150^0 conduction mode in the first topic in comparative analysis. Gate pulses of each switch for three different conduction mode is shown in Fig.3.

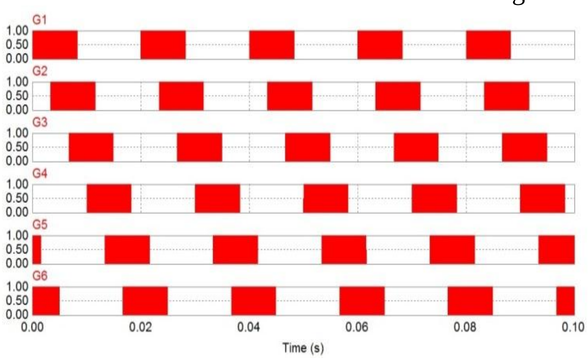


Figure 3: Gate pulses of six switches for 150^0 mode conduction

In 150^0 conduction mode a 30^0 dead time is available as a safety margin, which is more enough to avoid short circuit on dc bus. Also, utilization and switching device operation is better.

B. *Line voltages*

Line voltages of 150^0 conduction mode is the second topic in comparative analysis. Line voltage of each line for 150° conduction mode is shown in Fig.4 In 150^0 mode consists of five levels 0, ±Vdc, ±Vdc/2.

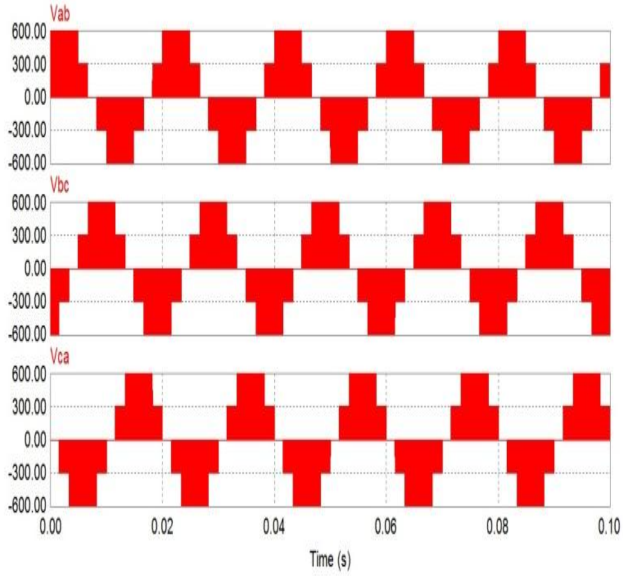


Figure 4: Line voltages waveform for 150^0 mode conduction

C. *FFT analysis of line voltages*

For 150^0 conduction mode, the line-to-line voltages are expressed in Fourier series as,

$$Vab_{\_150} = \sum_{n=1,3,5\ldots}^{\infty} \frac{\sqrt{3}Vdc}{6n\pi}\left[4 + \cos\frac{n\pi}{6} + \cos\frac{n\pi}{3}\cdot \cos\frac{2n\pi}{3}\cdot 2\cos\frac{5n\pi}{6}\cdot\cos\frac{7n\pi}{6} - \cos\frac{4n\pi}{3} + \cos\frac{5n\pi}{3} + 2\cos\frac{11n\pi}{6}\right]\cdot \sin n\left(\omega t + \frac{\pi}{6}\right)$$
(1)

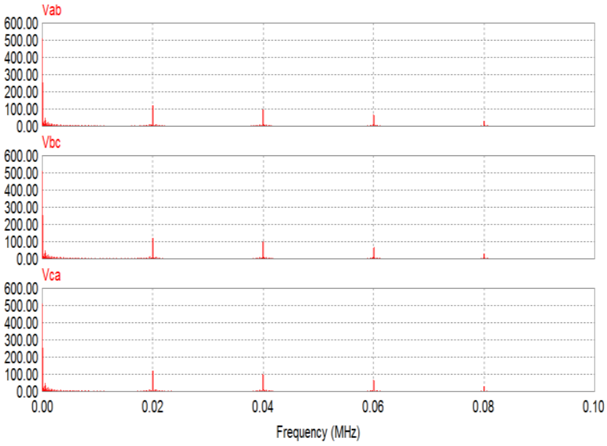
$$Vbc_{\_150} = \sum_{n=1,3,5\ldots}^{\infty} \frac{\sqrt{3}Vdc}{6n\pi}\left[4 + \cos\frac{n\pi}{6} + \cos\frac{n\pi}{3}\cdot \cos\frac{2n\pi}{3}\cdot 2\cos\frac{5n\pi}{6}\cdot\cos\frac{7n\pi}{6} - \cos\frac{4n\pi}{3} + \cos\frac{5n\pi}{3} + 2\cos\frac{11n\pi}{6}\right]\cdot \sin n\left(\omega t - \frac{\pi}{2}\right)$$
(2)

$$Vca_{\_150} = \sum_{n=1,3,5\ldots}^{\infty} \frac{\sqrt{3}Vdc}{6n\pi}\left[4 + \cos\frac{n\pi}{6} + \cos\frac{n\pi}{3}\cdot \cos\frac{2n\pi}{3}\cdot 2\cos\frac{5n\pi}{6}\cdot\cos\frac{7n\pi}{6} - \cos\frac{4n\pi}{3} + \cos\frac{5n\pi}{3} + 2\cos\frac{11n\pi}{6}\right]\cdot \sin n\left(\omega t - \frac{7\pi}{6}\right)$$
(3)

FFT of line voltages waveform for three different conduction modes are as shown in Fig.5.

This work is licensed under Creative Commons Attribution 4.0 International License.

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-6 (December 2022)
https://doi.org/10.31033/ijemr.12.6.42



(c)

Figure 5: FFT of line voltages waveform 150^0 mode conduction

III. SPWM TECHNIQUE

In this modulation technique two signals are used. (1) Carrier signal, Triangular wave is used as carrier signal. The triangular wave frequency is desired as per the frequency of switching frequency. The frequency is increases; the switching frequency of inverter increased. (2) Reference signal, sine wave is used as reference signal. The frequency of output voltage is depending on the frequency of reference signal. By used appropriate passive filter reduced total harmonic distortion in sinusoidal pulse width modulation technique.

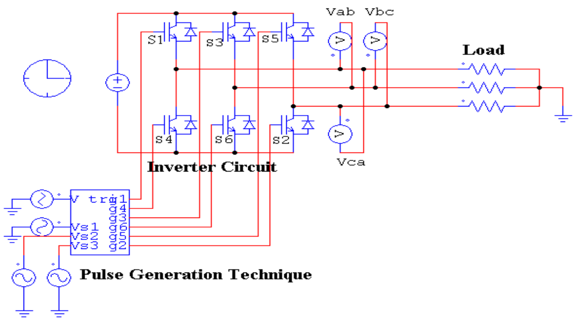


Figure 6: Simulated Model of SPWM 2-Level Inverter

A. Gate pulse generation circuit

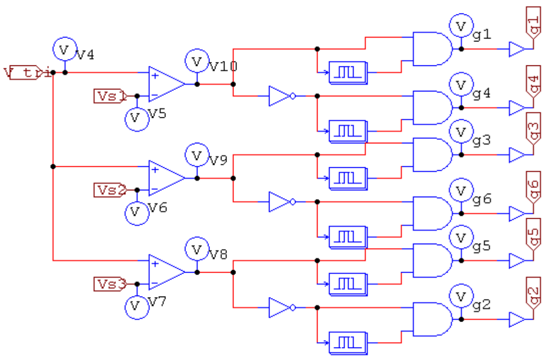


Figure 6: (A) Gate pulse generation circuit

B. Gate Pulses

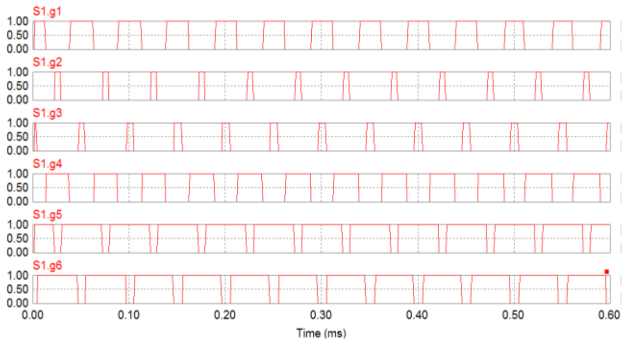


Figure 6: (B) Gate pulses of six switches for 2-Level SPWM

C. Line Voltages

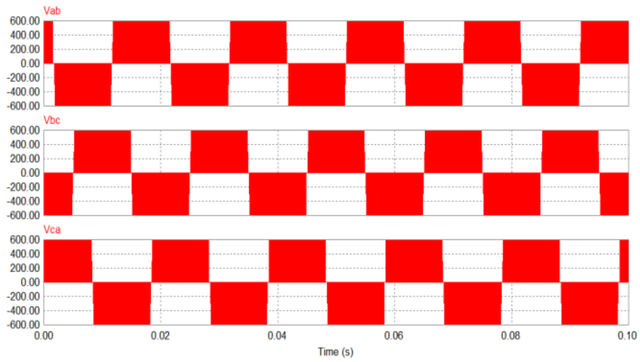


Figure 6: (C) Line voltages waveform for 2-Level SPWM

D. FFT analysis of line voltages

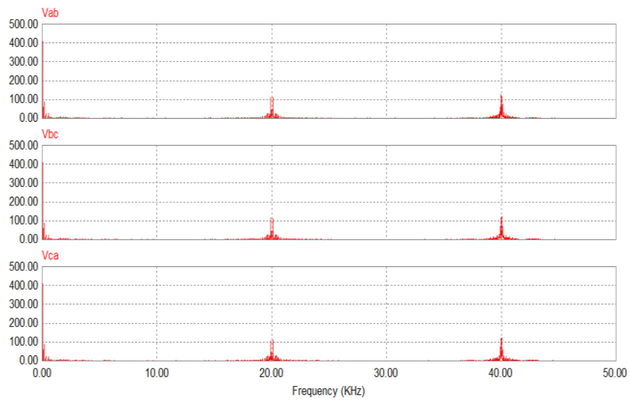


Figure 6: (D) FFT of line voltages waveform for 2-Level SPWM

Simulation diagram for SPWM based three phase voltage source inverters in Fig.6; the pulse development circuit for all six IGBT switches of an inverter with proper dead band is shown in Fig.6 (A). Fig.6 (B) shows gate pulses of all six switches, Fig.6 (C) shows line voltages of three phase VSI, Fig.6 (D) shows its FFT analysis graph. On the basis of all results the comparative table shown in Table I.

From this all-analysis Table I is prepared with different comparison points between 150^0 conduction mode and 2-Level SPWM.

This work is licensed under Creative Commons Attribution 4.0 International License.

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-6 (December 2022)
https://doi.org/10.31033/ijemr.12.6.42

Table I: Comparative Table between 150^0 mode and 2-Level SPWM

Topic	150^0	2-Level SPWM
Level of voltage	5	2
No. of switches required	6	6
Value of levels	0, ±Vdc, ±Vdc/2	±Vdc
Necessity of filter	Required	Required
THD	More	Less
Dead band Provision	Not required	Required

V. CONCLUSION

150^0 conduction mode is best suitable scheme compare to other two conduction modes for three phase voltage source inverters. A comparative study of all three conduction modes, from Table I ,150^0 conduction mode has a greater number of levels in output line voltages, number of steps per cycle is more, step size is reduced and less total harmonic distortion compare to other two conduction modes. From Table II, 2-Level SPWM has reduced filter size. 2-Level SPWM required dead band.

REFERENCES

[1] Mohamed H. Saied, M. Z. Mostafa, T. M. Abdel-Moneim and H. A. Yousef, “On Three-Phase Six-Switch Voltage Source Inverter: A 150^0 Conduction Mode”, 2004 IEEE.

[2] Ranitesh Gupta, ‘‘Comparative Study of Total Harmonic Distortion for Three Phase Voltage Source Inverter”, International Journal of Engineering Studies ISSN 0975- 6469 Volume 2, Number 2 (2010), pp. 175–182.

[3] Nirav D. Patel, Tejas. H. Panchal, Rameshvar P. Sadhu, and Mitesh N. Priyadarshi, “Comparative Analysis of Conduction Modes for Three Phase Six Switches Voltage Source Inverter” Nirma university, Ahmedabad – 382 481, 9-11 December, 2010.

[4] C.Y. Lee, W.J. Lee, “Effects of non-sinusoidal voltage on the operation performance of a three-phase induction motors”, IEEE Trans. Energy. Conver., vol.14, pp.193-201,June 1999.

[5] S. lida, S. Masukawa, and Y. Kubota, “Improved voltage source inverter with 18-step output waveforms”, IEEE Ind. Applicat. Magazine, vol.4, pp. 58-65, January/February 1998.

[6] B. Wu , High-power converters and AC Drives, CHAPTER 6, PAGES 95-117, IEEE Press, Wiley, YEAR 2006.

[7] Niravkumar D. Patel, Tejas H. Panchal, Maulik J. Shah, Hirenkumar D. Patel,“Pulse Generation Technique using MPLAB and Visual C++ 6.0 for Three Phase Inverter” Nirma university, Ahmedabad.

[8] Muhammad. H. Rashid, “Power Electronics; Circuits, Devices, and applications”, 3rd edition, Prentice Hall of India, chapter-6, pp. 226-303.

[9] Pranay S. Shete, Rohit G. Kanojiya, Nirajkumar S. Maurya, “Performance of Sinusoidal Pulse Width Modulation based Three Phase Inverter” International Conference on Emerging Frontiers in Technology for Rural Area (EFITRA) 2012.

[10] N.D. Patel, H.D. Patel, R.R. Soni, T.H. Panchal, “Development and Implementation of Spwm Logic Using DSPIC33FJ16GS402 for Three Phase Inverter”, Journal of Information, Knowledge and Research in Electrical Engineering, ISSN: 0975 – 6736| Nov 12 to Oct 13 | Volume – 02, Issue - 02

[11] M.D.Singh, K.B Khanchandani, “Power Electronics”, McGraw Hill publication,2nd edition, chapter -9,pp.535-657.

[12] Dipen Kumar H. Kambaliya, Nirav D. Patel, “Comparative Analysis of Conduction Modes and SPWM Technique for Three Phase VSI”, Indus university, Ahmedabad – 382 481, 30-31st January, 2015.

This work is licensed under Creative Commons Attribution 4.0 International License.