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Comparison of SPWM and SVPWM Methods Used for Three Phase Inverter

[1] Pritam Vikas Gaikwad, [2] Prof. M. F. A. R Satarkar
[1][2] Dr. B. A. T. University, Lonere-Raigad, MS-402103

Abstract-— **Sinusoidal PWM has been a very popular technique used in AC motor control. This relatively unsophisticated method employs a triangular carrier wave modulated by a sine wave and the points of intersection determine the switching points of the power devices in the inverter. However, this method is unable to make full use of the inverter's supply voltage and the asymmetrical nature of the PWM switching characteristics produces relatively high harmonic distortion in the supply.**
Space Vector PWM (SVPWM) is a more sophisticated technique for generating a fundamental sine wave that provides a higher voltage to the motor and lower total harmonic distortion (THD). It is also compatible for use in vector control (Field orientation) of AC motors. This abstract describes the theory of SVPWM.

Keywords- heating element, PID controller, plastic packaging system, self-tuned.

I. INTRODUCTION

AC drives are more effective than DC drives. PWM techniques are used to obtain high power variable voltage variable frequency supply in ac-dc and dc-ac converters. PWM techniques are mostly used in variable speed drives (VSD), static frequency chargers (SFC), un-interruptible power supplies (UPS) etc. The main problem faced in three phase inverter is total harmonic distortion (THD). PWM technique is used in an Inverter to control the switching of semiconductor devices. There are various PWM techniques bur Sinusoidal PWM (SPWM) is most widely used technology. In this technique a triangular wave is compared with sinusoidal wave. Drawbacks of SPWM method are poor voltage utilization and harmonic contents in an output current. These drawbacks are minimized in Space Vector PWM (SVPWM). In this method reference voltage is provided using a rotating reference vectors. In this method magnitude and frequency of the reference voltage vector controls the magnitude and frequency of fundamental component in the line side. SVPWM utilizes dc bus voltage and generates less harmonic distortion in a three phase inverter.

II. SINUSOIDAL PULSE WIDTH MODULATION (SPWM)

SPWM technique generate pulses by comparing sinusoidal wave with triangular wave. The required output voltage is achieved by varying magnitude of a modulating voltage. The variations in the amplitude and frequency of the modulating voltage change the pulse width patterns of the output voltage by keeping sinusoidal modulation. In three phase inverter, a triangular reference voltage waveform (Vref) is compared with three sinusoidal voltage waveforms (Va, Vb, Vc) having phase difference of 120̊.

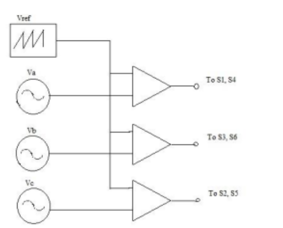

Figure 1. Control Signal Generation for SPWM

A three phase inverter is consists of six switches from S1 to S6. Switches can be IGBT/MOSFET semiconductor devices. Figure 1 shows pulse generation to control the switches. Three phase inverter consists of three legs A,B,C as shown in Figure 2. Each leg consist of two switches called as upper switch and lower switch. Output of an inverter is taken out from the middle point of each leg.

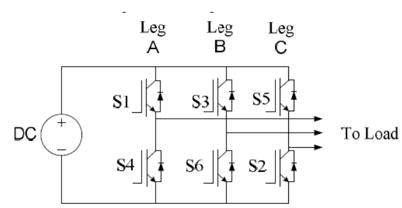

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Figure 2 Three phase Inverter

Output voltage of three phase inverter is given by equation(1),

$$1_1 = 1_{1\,1} \quad ....(1)$$

Amplitude of modulation index is given by equation (2),

$$1\ 1 = \frac{1_1}{1_{111}} \quad ...\ ...\ ...\ ....(2)$$

The frequency modulation ratio is given by equation (3),

$$1\ 1 = \frac{1_1}{1_1} \quad ...\ ...\ ...\ ....(3)$$

where, 1_1 = ı and
1_1 = ı

A. Matlab Simulation of Three Phase Inverter using SPWM

Table I: Parameters used for simulation.

Frequency= 50 Hz	Motor: squirel cage IM
Vdc= 460 volt	Rated speed= 1500 rpm
Tm=10 Nm	Ts= 5ı ı ı sec

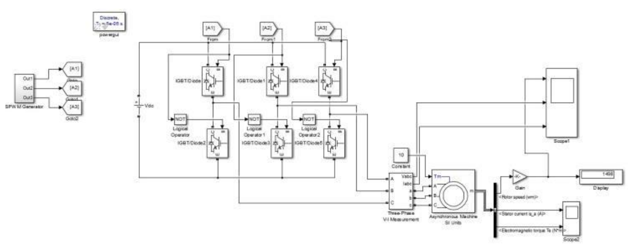

Figure 5 Stator current (Ia)

B. Simulation Results

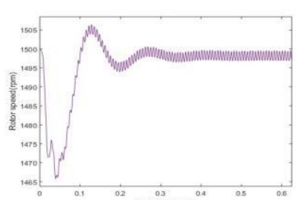

Figure 4 Rotor speed Vs Time

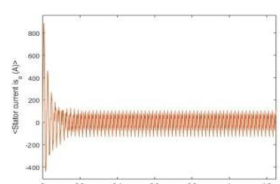

Figure 5 Stator current (Ia) Vs Time

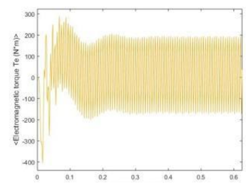

Figure 6 Electromagnetic Torque Vs Time

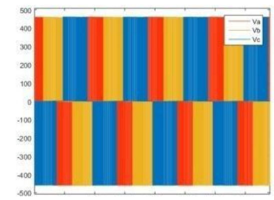

Figure 7 Vabc Vs Time

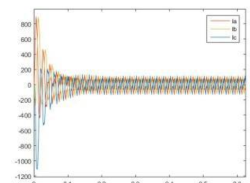

Figure 8 Iabc Vs Time

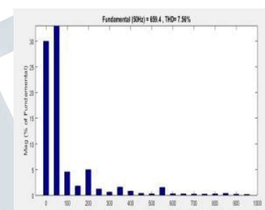

Figure 9 Total Harmonic Distortion (THD)

III. SPACE VECTOR PULSE WIDTH MODULATION

The Space Vector PWM generation module receive modulation index commands and generates the appropriate gate drive pulses for each PWM cycle.

There are eight possible switching states in a three phase inverter, which generates the output of an inverter. Each switching state of an inverter produces a voltage space vector. Vectors V1 to V6 are active vectors while vectors V0and V7 are zero voltage vectors. The magnitude of each vector is 2/ active 3Vdc.

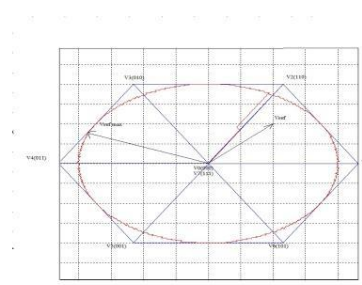

Figure 10 Space Vector diagram.

The on and off states of the upper switches S1, S2 and S3

are used to determine the output voltage.
The relation between the switching variable vectors and line to line voltage vectors is given by euation (4),

$$\left[\;\right] = \left[\;\right]\begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}\left[\;\right] \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Also, the relationship between the switching variable vectors and phase voltage vectors is given by equation

$$\left[\;\right] = \frac{\;}{\;}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\left[\;\right] \quad \ldots\ldots\ldots\ldots\ldots (5)$$

Table II: Switching vectors, phase voltages and output line to line voltages.

Voltage Vectors	Switching Vectors			Line-Neutral voltage			Line-line voltage		
	a	b	c	ııı	ııı	ııı	ııı	ııı	ııı
ıı	0	0	0	0	0	0	0	0	0
ıı	1	0	0	2/3	-1/3	-1/3	1	0	-1
ıı	1	1	0	1/3	1/3	-2/3	0	1	-1
ıı	0	1	0	-1/3	2/3	-1/3	-1	1	0
ıı	0	1	1	-2/3	1/3	1/3	-1	0	1
ıı	0	0	1	-1/3	-1/3	2/3	0	-1	1
ıı	1	0	1	1/3	-2/3	1/3	1	-1	0
ıı	1	1	1	0	0	0	0	0	0

A. Matlab Simulation of Three Phase Inverter using SVPWM

Table III: Simulation Parameters used for SVPWM.

Vdc = 400 volt	Motor: squirel cage IM
Switches: IGBT	Vrms = 400 volts
Ts = 5ı ıı sec	f = 50 Hz
Power ratings = 4kw	Pole pair = 2

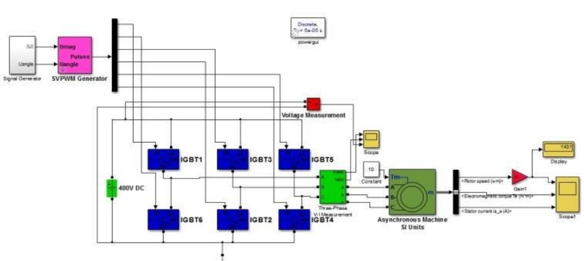

Figure 11 Matlab Simulation of SVPWM.

B. Simulation Results of SVPWM.

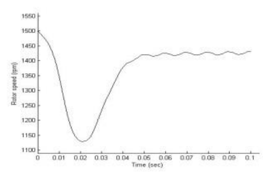

Figure 12 wm Vs Time

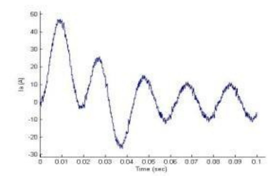

Figure 13 Ia Vs Time

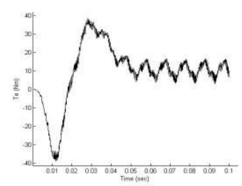

Figure 14 Te Vs Time

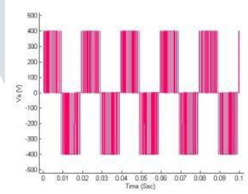

Figure 15 Va Vs Time

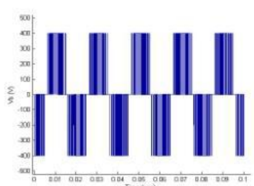

Figure 16 Vb Vs Time

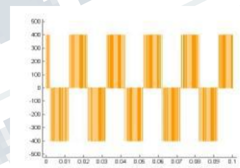

Figure 17 Vc Vs Time

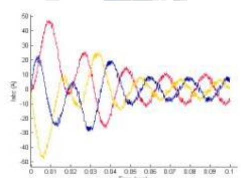

Figure 18 Iabc Vs Time

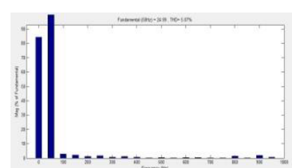

Figure 19 Total Harmonic Distortion (THD)

CONCLUSION

This paper has evaluated matlab simulation of two PWM methods, namely SPWM and SVPWM. As seen from the results of simulation of both the methods it can be concluded that SVPWM method is more superior than SPWM. Advantages of SVPWM method are higher modulation index, lower switching losses and less harmonic distortion. However SVPWM method is complex for implementation.

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