PV Based SVPWM Generator for Three Phase Inverter

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Abstract— **The speed control of induction motor can be varied by varying input voltage or frequency or both. These variable voltage and frequency are obtained from VSI. A number of PWM techniques are there to obtain variable frequency and voltage but among them Space Vector Pulse Width Modulation is mostly preferable. Major advantage of SVPWM technique is the degree of freedom of space vector placement in a switching cycle which reduces the harmonic contents in voltage and smooth's the control of induction motor. This paper presents the speed control of VSI fed three phase induction motor by using space vector pulse width modulation technique. For utilization of renewable energy sources, modeling of three-phase inverter is completed by using Space Vector based PWM (SVPWM). The experimental results have Attained THD less than 3% which is within tolerable range. The MATLAB and SIMULINK software is used for simulation and analyses purposes.**

Keywords— **Voltage source inverter, induction motor, SVPWM technique, *Renewable* Energy, THD**

I. INTRODUCTION

Now a day's the generation of electricity is mainly depends on the non-renewable energy sources. In future the generation of power depends upon the renewable energy sources like wind, water, solar etc. Majority of sources generates DC power only. So a converter is needed to convert the DC to AC called as inverter. By choosing appropriate modulation index and controlling of static switches of the inverter, the voltage and frequency levels at the output side are varied. In order to vary the output voltage and frequency of the inverter most popular PWM techniques are carrier based PWM and Space Vector pulse Width modulation (SVPWM). There is an increase in trend of utilizing SVPWM because of its easy digital implementation and maximum utilization of DC bus voltage. The main focus of this paper is to implement simple MATLAB/SIMULINK model. The reason for choice of MATLAB/SIMULINK as a development tool is because it is the most important and widely used simulation software in Electrical Engineering courses. Firstly model of a three-phase inverter is presented on the basis of space vector representation. This is followed by the basic principle of SVPWM. Finally a MATLAB/SIMULINK model for the SVPWM is presented here.

A. Pulse width modulation

Variable voltage and frequency supply for Adjustable Speed Drives (ASD) is invariably obtained from a three-phase VSI. In power electronics, converters and motors, the PWM technique is mostly used to supply AC current to the load by converting the DC current and it appears as a AC signal at load or can control the speed of motors that run at high speed or low. The duty cycle of a PWM signal varies through analog components, a digital microcontroller or PWM integrated circuits.

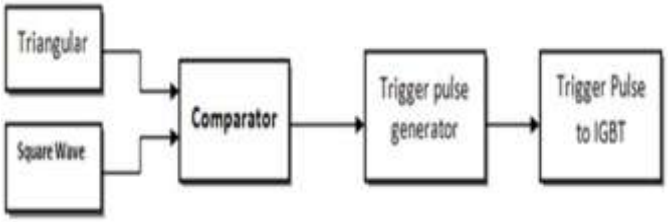

Figure 2 shows the comparator gets the inputs as reference waveform (square wave) and a carrier wave (triangular wave) is supply to the comparator to obtained PWM waveform. Triangular wave is formed by op-amp driver. Triggering pulses are produced at the instant of the carrier signal magnitude is greater then the reference signal magnitude. To turn-on the IGBT switches, firing pulses are produced, theoutput voltage during the interval triangular voltage wave stipulated the square modulating wave.

Types of PWM techniques**:**

A number of PWM techniques are there to obtain variable

Voltage and frequency supply such as,

i. Single-pulse modulation
ii. Multiple-pulse modulation
iii. Selected harmonic elimination PWM
iv. Minimum ripple current PWM
v. Sinusoidal PWM (SPWM)
vi. Space vector PWM (SVPWM)

B. Space vector PWM (SVPWM)

Space vector pulse width modulation technique is used. This technique was developed as a vector approach to pulse width modulation for inverters. It is frequently used in vector controlled applications as it is advance sophisticated computation technique for generating sine wave which provides lower THD and is most widely used pulse width modulation techniques. It is based on the principal of rotating field of Induction motor. In this technique three phase quantities are transformed to their equivalent two-phase quantities using Clark's Transformation, from these two phase quantities reference vector magnitude and angle is found. This transformation from three phase quantities in to two phase quantities results in six non-zero vector and two Zero vector. This eight vector are called as basic space vector and are denoted by V0, V1, V2, V3, V4, V5, V6, and V7. This vector gives the shape to the hexagon as shown in figure below:-

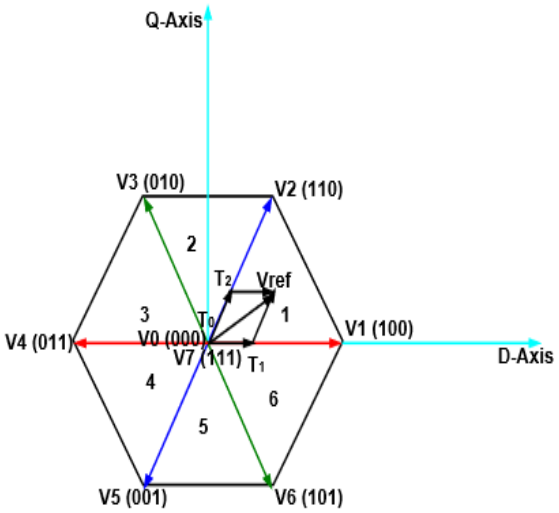

Fig.1 Sector Selection of Space Vector Modulation

For three phase voltage source inverter (2^3=8) Switching states are formed which corresponds to the eight Voltage vector which in turn shapes the output voltage as shown in table below:-

The mathematical equation that dwells with the implementation of Space vector Pulse width modulation technique can be found below.The three phase voltage can be transformed into two phase voltage by using Clark's Transformation.

$$\begin{bmatrix} v\alpha \\ v\beta \end{bmatrix} = 2/3 \begin{bmatrix} 1 & a^2+b^2=c^2 1/2 & -1/2 \\ 0 & -\sqrt{3}/2 & \sqrt{3}/2 \end{bmatrix} \begin{bmatrix} Va \\ Vb \\ Vc \end{bmatrix}$$

$$|Vref| = \sqrt{(Vd^2 + Vq^2)}$$

Where α=tan-1(Vd/Vq)

The switching states are shown below

Table 1

Switching states

Voltage Vectors	Switching Vectors			Line to Neutral Voltage			Line to Line Voltage		
	A	B	C	V_{an}	V_{bn}	V_{cn}	V_{ab}	V_{bc}	V_{ca}
V_0	0	0	0	0	0	0	0	0	0
V_1	1	0	0	2/3	-1/3	-1/3	1	0	-1
V_2	1	1	0	1/3	1/3	-2/3	0	1	-1
V_3	0	1	0	-1/3	2/3	-1/3	-1	1	0
V_4	0	1	1	-2/3	1/3	1/3	-1	0	1
V_5	0	0	1	-1/3	1/3	2/3	0	-1	1
V_6	1	0	1	1/3	-2/3	-1/3	1	-1	0
V_7	1	1	1	0	0	0	0	0	0

C. PV panel

A PV module is a packaged and a connected assembly of solar cells. It includes arrays of solar modules, inverter and battery. With a utilization of solar power, 12 volt panel is designed to drive the three-phase inverter. The corresponding VI characteristics for the relevant PV panel get simulated as a function of voltage and current with respect to time.

There are 36 solar cells connected in series-parallel configuration. In that the current controlled source drives the whole circuit.

D. Simulation diagram and results

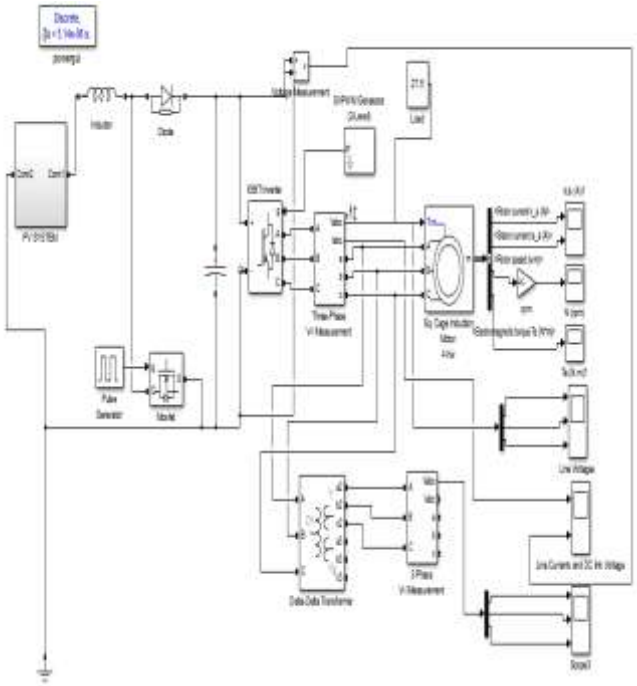

Fig.2 Simulation diagram

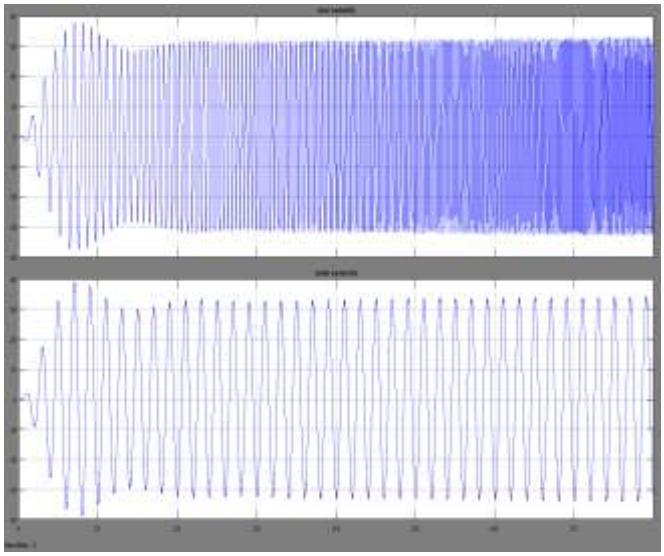

Fig.3 Stator and rotor currents

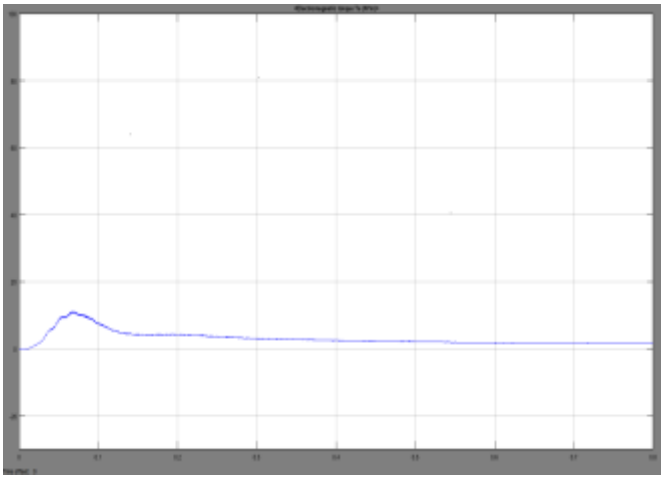

Fig.4 Electromagnetic torque

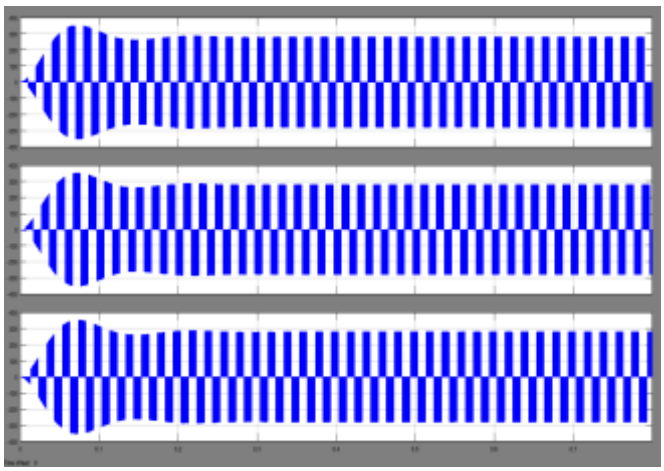

Fig.5 Line voltages

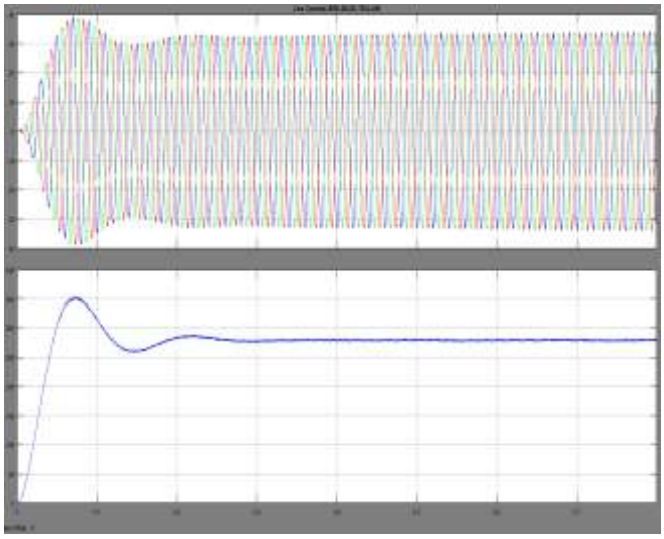

Fig.6 Line currents and DC link voltage

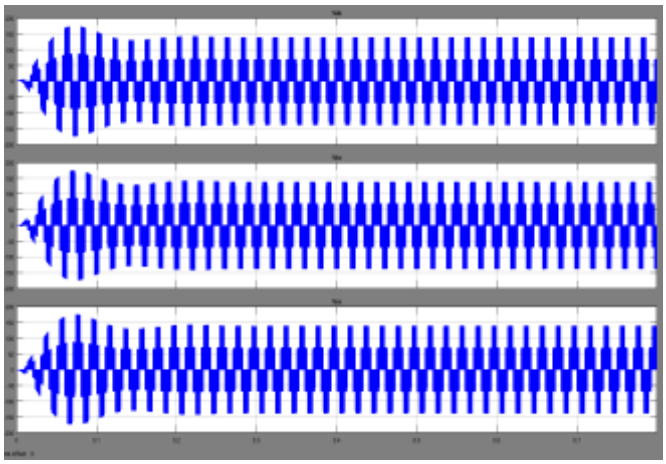

Fig.7 Output phase voltages

II. CONCLUSION

Space vector modulation technique has become the most popular and important PWM technique for three phase inverters in the application of controlling AC motors. In this paper the analysis of Space Vector PWM for three-phase inverter is presented. The Simulation analysis shows that SVPWM gives enhanced fundamental output with better quality i.e. lesser THD is observed compared to that of other PWM techniques. PWM strategies like SVPWM are implemented in MATLAB and SIMULINK software platforms. The performance is analyzed in comparison to conventional PWM techniques. SVPWM utilize a changing carrier frequency to spread the harmonics continuously to a wider area, hence the peak harmonics are reduced significantly. The implementation has proven quite improved performance which can be certainly useful for variety of applications.

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