SVPWM CONTROLLED PERMANENT MAGNET SYNCHRONOUS MOTOR

S. Angayarkanni
Department of Electrical and
Electronics Engineering,
M. A. M. School of Engg.,
Trichy, Tamilnadu, INDIA.

A. Senthilnathan
Department of Electrical and
Electronics Engineering,
M. A. M. College of Engg.,
Trichy, Tamilnadu, INDIA.

R. Ilango
Department of Electrical and
Electronics Engineering,
M. A. M. School of Engg.,
Trichy, Tamilnadu, INDIA.

Abstract - Multilevel inversion is a power conversion strategy in which the output voltage is obtained in steps. In recent years, the multilevel inverters have drawn tremendous interest in the area of high-power medium-voltage energy control. Several modulation and control strategies have been developed or adopted for multilevel inverters including the following multilevel Sinusoidal Pulse Width Modulation (SPWM), and Space Vector Modulation. In this paper simulation of SVPWM are applied for performance analysis of PMSM using voltage source inverter. The THD and speed torque analysis for PMSM are simulated using MATLAB simulink.

Keywords – Space vector pulse width modulation (SVPWM), switching state, multilevel inverter, permanent magnet synchronous motor (PMSM).

I. INTRODUCTION

Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. Recently, developments in power electronics and semiconductor technology have lead improvements in power electronic systems. Hence, different circuit configurations namely multilevel inverters have become popular and considerable interest by researcher are given on them. Variable voltage and frequency supply to A.C drives is invariably obtained from a three-phase voltage source inverter. A number of Pulse width modulation (PWM) schemes are used to obtain variable voltage and frequency supply. The most widely used PWM schemes for three-phase voltage source inverters are carrier-based sinusoidal PWM and space vector PWM (SVPWM). There is an increasing trend of using space vector PWM (SVPWM) because of their easier digital realization and better dc bus utilization.

This paper focuses on step by step development of SVPWM implemented on PMSM. The model of a three-phase voltage source inverter is discussed based on space vector theory. Simulation results are obtained using MATLAB/Simulink environment for effectiveness of the study.

II. PWM IN INVERTERS

Output voltage from an inverter can also be adjusted by exercising a control within the inverter itself. The most efficient method of doing this is by pulse-width modulation control used within an inverter. In this method, a fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and this method is termed as Pulse-Width Modulation (PWM) Control.

PWM techniques are characterized by constant amplitude pulses. The width of these pulses is however modulated to obtain inverter output voltage control and to reduce its harmonic content. The different PWM techniques are as under:

(a) Single-pulse modulation

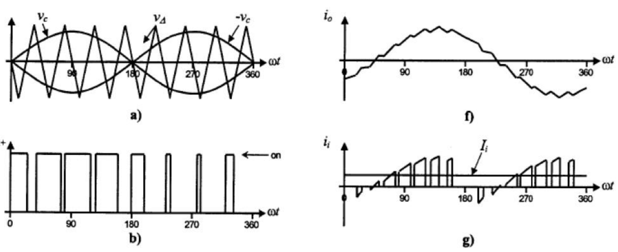
(b) Multiple pulse modulations

(c) Sinusoidal pulse width modulation.

Here we studied about Carrier based Pulse Width Modulation for open loop control of PMSM drive.

III. SPWM FOR FULL BRIDGE VSI

This is an extension of the one introduced for single-phase VSIs. In this case and in order to produce 120^0 out-of-phase load voltages, three modulating signals that are 120^0 out of phase are used. Fig.1 shows the ideal waveforms of three-phase VSI SPWM. In order to use a single carrier signal and preserve the features of the PWM technique, the normalized carrier frequency mf should be an odd multiple of 3. Thus, all phase voltages (vaN , vbN , and vcN) are identical but 120 out of phase without even harmonics , moreover, harmonics at frequencies a multiple of 3 are identical in amplitude and phase in all phases.



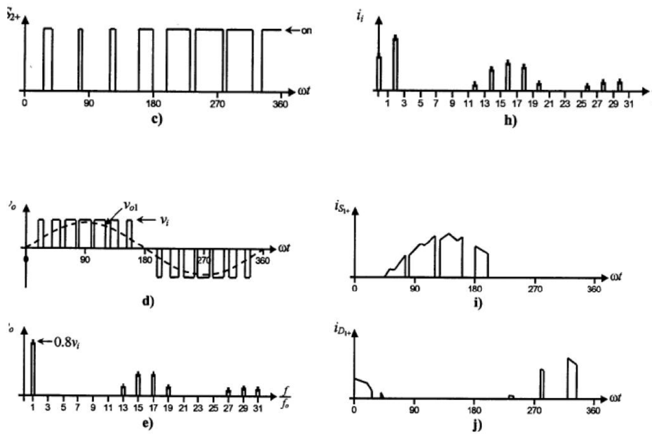


Fig.1:The full-bridge VSI. Ideal waveforms for SPWM (ma = 0.8, mf = 0. 8): (a)ac output voltage (b) switch S1+ state; (c) switch S2+ state; (d)ac output voltage; (e) ac output voltage spectrum; (f) ac output current; (g) dc current; (h) dc current spectrum; (i) switch S1+ current; (j) diode D1+ current carrier

The topology of a three-leg voltage source inverter is shown in Fig. 3. Because of the constraint that the input lines must never be shorted and the output current must always be continuous a voltage source inverter can assume only eight distinct topologies. These topologies are shown on Fig.2. Six out of these eight topologies produce a nonzero output voltage and are known as non-zero switching states and the remaining two topologies produce zero output voltage and are known as zero switching states.

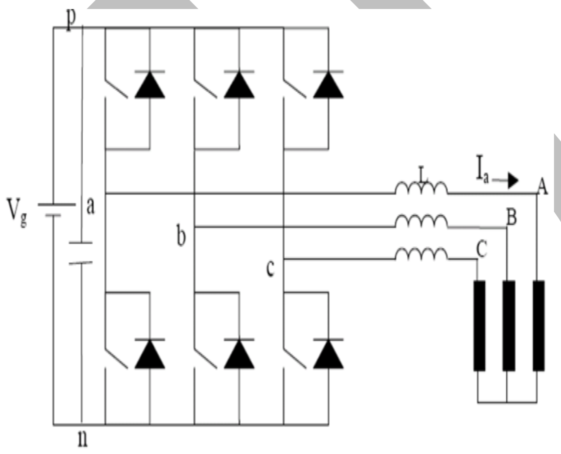


Fig 2:Topology of three phase inverter

A. Voltage Space Vectors

Space vector modulation or three-leg VSI is based on the representation of the three phase quantities as vectors in a two-dimensional (αβ) plane. This is illustrated here for the sake of completeness.

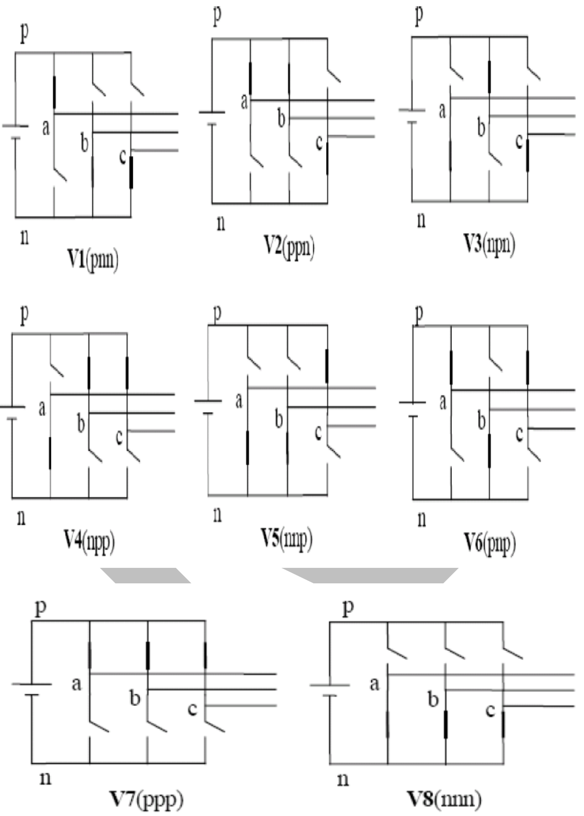


Fig 3: Eight switching state topologies of a voltage source inverter.

The effective voltage vector generated by this topology is represented as V1(pnn) in Fig. 4 Here the notation (pnn) refers to the three legs/phases a, b, c being either connected to the positive dc rail (p) or to the negative dc rail (n). Thus (pnn) corresponds to phase a being connected to the positive dc rail and phases b and c being connected to the negative dc rail.

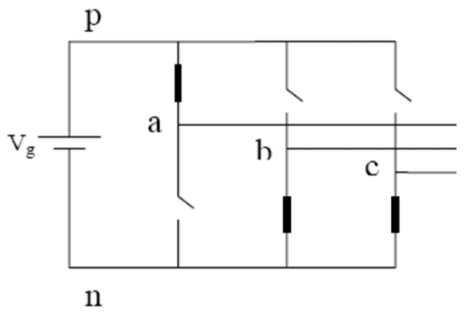


Fig 4: Topology 1-V1 (pnn) of a voltage source inverter.

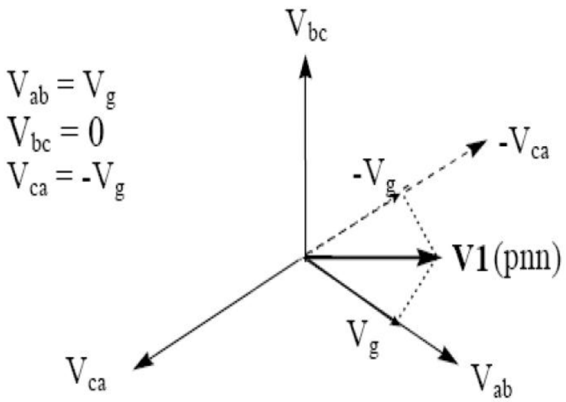


Fig 5: Representation of topology 1 in the α-β, plane

Proceeding on similar lines the six non-zero voltage vectors (V1 - V6) can be shown to assume the positions shown in Fig.3.8. The tips of these vectors form a regular hexagon (dotted line in Fig. 3.8). We define the area enclosed by two adjacent vectors, within the hexagon, as a sector. Thus there are six sectors numbered 1 - 6 in Fig. 5.

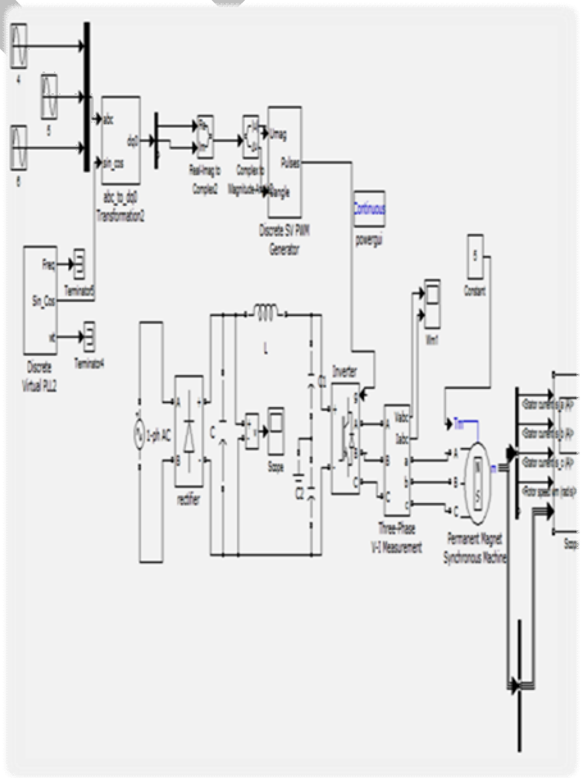
IV. PERMANENT MAGNET SYNCHRONOUS MACHINES

The Permanent Magnet Synchronous Machine (PMSM) Is Primarily Associated With High-performance Applications and Is Normally Fed by a Voltage Source Inverter (VSI). The machine is of the Synchronous Type and the Rotor Field Is Created by Permanent Magnets attached To the Rotor. The Material of the Permanent Magnets can differ but the Best materials Are of Rare Earth Type, Such As Samarium-Cobalt (Sm-Co) Or Neodymium-Iron-Boron (Nefeb). The Nefeb Magnets Combine a High Flux Density with a Large Coercive force. Unfortunately, they are still quite expensive but the price has dropped during the last decade. The advantage of using permanent magnets in the rotor circuit is that the design of the machine is simplified and that there are virtually no losses in the rotor circuit since the rotor is (ideally) free of currents. The stator winding can be wound in several ways. Machines with trapezoidal wound stator windings are called brushless dc machines and should be fed by trapezoidal currents to produce a smooth torque. Another winding method is to wound the stator sinusoidal. The combination of a sinusoidal wound stator and a permanent magnet rotor design is the basis of the permanent magnet synchronous machine. The distribution of the magnets in the rotor can vary significantly.

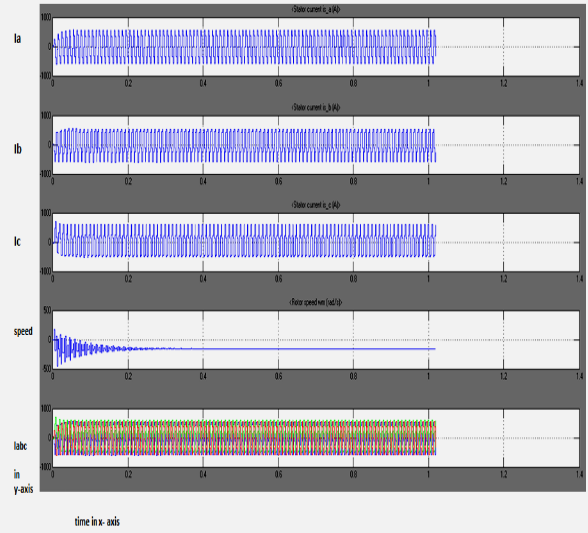
Methods for controlling PMSM drives, connected to different types of converters, have been developed both for steady state operation and high performance servo control. This paper discusses the control of the PMSM but a small discussion of the steady state behavior of the machine can be found the most advanced type of control of electrical machines is known as vector control. The term vector control includes many different control methods but they all use different types of feedback mechanisms for improved control

Torque ripple produced by a PMSM comes from two different sources. The first ones were known as cogging torque. Cogging torque is generated by the interaction of the rotor magnetic flux and angular variations in the stator magnetic reluctance. Different methods for reducing cogging torque exist and they mostly rely on changes in the design of the machine. One usual design method is known as skewing, which can be done on both the rotor and stator. Skewing can reduce the cogging torque very effectively manufacturing procedure is complicated, which increases the price of the machine. The other method for reducing torque ripple in an existing machine is to use control schemes that reduce torque ripple. The basic goal of these control schemes is to control the currents that the ripple is cancelled out (this is known as harmonic injection).

Vector control offers superior performance when compared to scalar control. Vector control eliminates almost all the disadvantages of scalar control. The main idea of vector control is to control not only the magnitude and frequency of the supply voltages but also the angle. With other words said the magnitude and angles of the space vectors is controlled.



From single phase AC source three phase voltages is obtained through three phase voltage source inverter. The firing pulse for three phase inverter is controlled by discrete SVPWM by magnitude and angle control of input signal. The output of three phase inverter is feed to sinusoidal PMSM whose stator current ,rotor current, speed and torque are analyzed. In a space-vector PWM inverter, which is widely used, the voltage utilization factor can be increased to 0.906, normalized to that of the six step operation.



V. CONCLUSION

Using SVPWM, three phase AC waveform is obtained from single phase AC supply. The output voltage is about 600 V with minimum THD. Sinusoidal – PMSM motor is connected and its performance characteristics are analyzed. Speed of the motor = 1600 RPM with torque variation of 5 to 6 Nm.

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