**International Journal of Technical Research and Applications e**-ISSN: 2320-8163,
www.ijtra.com Special Issue 40 (KCCEMSR) (March 2016), PP. 9-11

# SPEED CONTROL OF 3 PHASE INDUCTION MOTOR BY SPACE VECTOR PULSE WIDTH MODULATION

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***Abstract***— This paper presents design and implements a voltage source inverter type space vector pulse width modulation (SVPWM) for control a speed of induction motor. In recent years, the field oriented control of induction motor drive is widely used in high performance drive system. It is due to its unique characteristics like high efficiency, good power factor and extremely rugged .This scheme leads to be able to adjust the speed of the motor by control the frequency and amplitude of the stator voltage, the ratio of stator voltage to frequency should be kept constant.

***Keywords***: Induction machine [3 Phase] , Pulse Width Modulation[PWM],Space Vector PWM, Voltage Source Invertor

## I. INTRODUCTION

The Space Vector Pulse Width Modulation (SVPWM) method is an advanced, computation-intensive PWM method and possibly the best among all the PWM techniques for variable frequency drive application. Because of its superior performance characteristics, it has been finding widespread application in recent years. The PWM methods discussed so far have only considered implementation on half bridges operated independently, giving satisfactory PWM performance. With a machine load, the load neutralis normally isolated, which causes interaction among the phases. This interaction was not considered before in the PWM discussion. Pulse width modulation (PWM) inverters are studied extensively during the past decades.

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. The inverters are used to converts dc power into ac power at desired output voltage and frequency. The waveform of the output voltage depends on the switching states of the switches used in the inverter. Major limitations and requirements of inverters are harmonic contents, the switching frequency, and the best utilization of dc link voltage.

It has been shown, that SVPWM generates less harmonic distortion in both output voltage and current applied to the phases of an ac motor and provides a more efficient use of the supply voltage in comparison with sinusoidal modulation techniques.

## II. SPACE VECTOR

A three-phase mathematical system can be represented by a space vector. For example, given a set of three-phase voltages, a space vector can be defined by

$V_a = V_m \sin\omega t$ ………………….(1)

$V_b = V_m \sin(\omega t-120°)$…………. (2)

$V_c = V_m \sin(\omega t+120°)$ ………….(3)

Where Va(t), Vb(t) and Vc(t) are three sinusoidal voltages of the same amplitude and frequency but with 120 phase shifts. The space vector at any given time maintains its magnitude. As time increases, the angle of the space vector increases, causing the vector to rotate with a frequency equal to that of the sinusoidal waveforms. When the output voltages of a three-phase six-step inverter are converted to a space vector and plotted on the complex plane, the corresponding space vector takes only on one of six discrete angles as time increases. The central idea of SVWPM is to generate appropriate PWM signals so that a vector with any desired angle can be generated. In the space-vector modulation, a three-phase two-level inverter can be driven to eight switching states where the inverter has six active states (1-6) and two zero states (0 and 7). A typical two-level inverter has 6 power switches (labeled S1 to S6) that generate three-phase voltage outputs. The circuit has a full-bridge topology with three inverter legs, each consisting of two power switches. The circuit allows only positive power flow from the supply system to the load via a full-bridge diode rectifier. Negative power flow is not possible through the rectifier diode bridge. The six switching power devices can be constructed using power IGBTs. The choice of switching devices is based on the desired operating power level, required switching frequency, and acceptable inverter power losses. When an upper transistor is switched on, the corresponding lower transistor is switched off. Therefore, the ON and OFF states of the upper transistors S1;S3;S5 can be used to determine the current output voltage. The ON and OFF states of the lower power devices are complementary to the upper ones. Two switches on the same leg cannot be closed or opened at the same time. The basic principle of SVPWM is based on the eight switch combinations of three phase inverter. The switch combinations can be represented as binary codes that correspond to the top switches S1, S3, and S5 of the inverter. Each switching circuit generates three independent pole voltages Vao, Vbo, and Vco

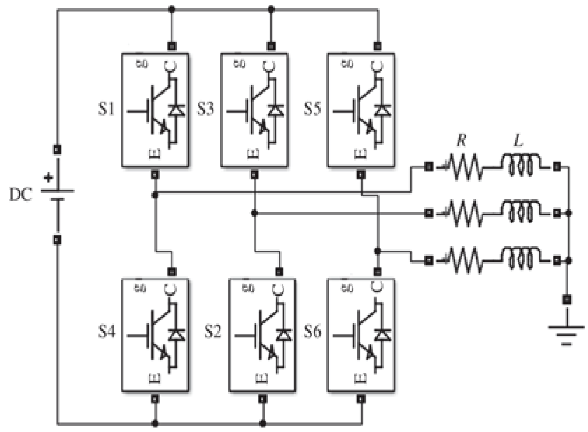



Fig.1: three-phase voltage source pwm Inverter

Consider three phase waveforms which are displaced by 120°,as mentioned in equation (1),(2),(3).These three vectors can be represented by a one vector which is known as space vector. Space vector is defined.

Vs= Va+Vb e^ j2π/3 +Vc e^ -j2π/3…….. (4)

Vs=3/2Vm [ sin ωt -jcos ωt ]…………… (5)

Space vector can represented as;

Vs = Vd + jVq

θ = tan^−1 ( Vq/Vd)

Also, the relationship between the switching variable vector [a, b, c]t and the phase voltage vector [Va Vb Vc] can be expressed below.

*A. [I] REALIZATION OF SPACE VECTOR PWM*

Vd - daxis voltage

Vq -quarture axis

Vref – reference voltage

i) Determine Vd, Vq ,Vref and angle (α):

Vd=Van-1/2Vbn-1/2Vcn

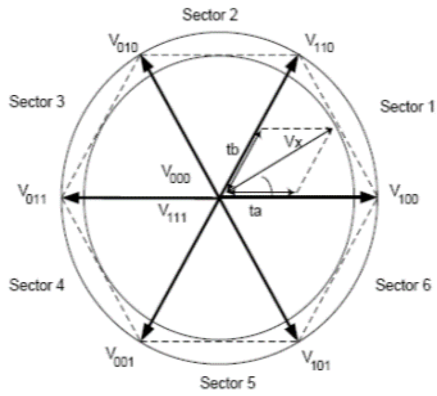
Vq =Van+ sqrt(3)/2Vbn-sqrt(3)/2

| Vref|=√ d ^2 +Vq ^2)

T1=√ tz | |/Vdc [(n/3)πcosα-cos(n/3)πsinα]

T2=√ tz | |/Vdc [-cosαsin(n-1/3) π+sinα cos(n-1/3π)]

The reference voltage vector Vref rotates in space at an angular velocity w = 2πf, where f is the fundamental frequency of the inverter output voltage. When the reference voltage vector passes through each sector, different sets of switches turned on or off. As a result, when the reference voltage vector rotates through one revolution in space, the inverter output varies one electrical cycle over time. The inverter output frequency coincides with the rotating speed of the reference voltage vector. The zero vectors (V0 and V7) and active vectors (V1 to V6) do not move in space. They are referred to as stationary vectors. Fig.5 shows the reference vector Vref in the first sector. The six active voltage space vectors are shown on the same graph with an equal magnitude of 2Vdc in third sector and a phase displacement of 600 reference voltage vector directly. It is possible to decompose the reference vector into vectors that lie on two adjacent active vectors and two zero vectors, which are located at the center of hexagon.




: *Space Vector Diagram – Line to Neutral Voltages*

III. BLOCK DIAGRAM

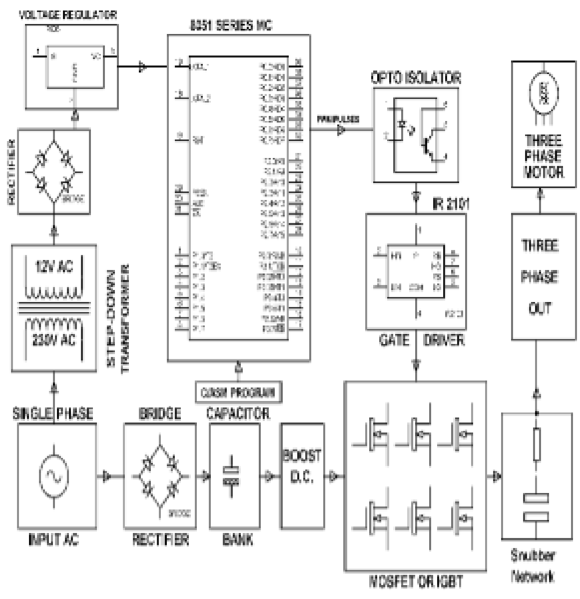



Fig. 2

### *A. METHODOLOGY*

Generally in space vector we control vector quantity of 3phase supply instead of controlling the magnitude of voltage for speed controlling. In SVPWM circuit we take 1phase AC supply from terminal pt. . Than there is 2 step down levels each of 230to12v. We step down the supply from 230-12v by step down transformer than we connect full wave bridge rectifier circuit for obtaining 12v DC supply, it's a pulsating DC. Next is filter circuit for obtaining pure DC from pulsating DC. Voltage regulator IC7805 is use for obtaining constant 5v DC supply to the output. This 5v DC supply is used for Micro-controller and other ICs in this project.

Further we use Micro-controller 8051 to generate switching pulses. Than OPTO isolator circuit for isolating low voltage side from high voltage side. IC 2101 circuit is high voltage, high speed power IGBT driver circuit. Simultaneously we fed 12v DC supply to the Boot DC circuit. It converts this 12v DC to the RMS value. This Boost DC voltage is fed to power module (IGBT circuit). The main part of SVPWM circuit is to convert and control the 3phase AC voltage and control their vector quantity.

The MOSFET combination in the inverter has eight permissible switching states. Tab. 1 summaries these states along with the corresponding line to neutral voltage applied to the motor.

| State | On Devices | Van | Vbn | Vcn | Space Voltage Vector |
|---|---|---|---|---|---|
| 0 | T2,T4,T6 | 0 | 0 | 0 | $V_0$(000) |
| 1 | T1,T4,T6 | 2/3 Vdc | -1/3 Vdc | -2/3 Vdc | $V_1$(100) |
| 2 | T1,T3,T6 | 1/3 Vdc | 1/3 Vdc | -1/3 Vdc | $V_2$(110) |
| 3 | T3,T2,T6 | - 1/3 Vdc | 2/3 Vdc | -1/3 Vdc | $V_3$(010) |
| 4 | T2,T3,T5 | -2/3 Vdc | 1/3 Vdc | 1/3 Vdc | $V_4$(011) |
| 5 | T2,T4,T5 | -1/3 Vdc | -1/3 Vdc | 2/3 Vdc | $V_5$(001) |
| 6 | T1,T4,T5 | 1/3 Vdc | -2/3 Vdc | 1/3 Vdc | $V_6$(101) |
| 7 | T1,T3,T5 | 0 | 0 | 0 | $V_7$(111) |

**Tab. 1:** *Inverter Switching States*

## IV. FUTURE SCOPE

This thesis work focuses on space vector pulse width modulation based algorithms for multilevel inverters. The SVPWM algorithms have essentially been aimed at reducing the harmonic distortion in the output voltage of multilevel inverters. The performance of all these algorithms can be evaluated in the over modulation zone. Analytical evaluation of harmonic distortion for multilevel inverters can also be carried out. More SVPWM based techniques can be developed for inverter switching at much higher frequencies and hardware implementation can also be done. All the proposed algorithms in this thesis are for time-invariant systems. Therefore, it is recommended to eliminate harmonics for time-variant systems. Further to reduce the switching losses of the inverters, discontinuous pulse width modulation algorithms have to be proposed.

## V. CONCLUSION

A SVPWM technique based on a reduced computation method was presented. The SVPWM scheme can drive the inverter gating signals from the sampled amplitudes of the reference phase voltages. The switching vectors for the inverter are derived using a simple digital logic which does not involve any complex computations and hence reduces the implementation time. SVPWM drive treats the inverter as a single unit with eight possible switching states, each state can be represented by a state vector in the two-axis Space, the eight state vectors formed a hexagon shape with six sectors. Compared to SPWM the Total harmonic distortion (THD) and lower order harmonics (LOH) contents are decreased in SVPWM. It is known that the maximum value of the peak-phase voltage that can be obtained from a 3-Ph inverter with Sinusoidal Pulse Width Modulation (SPWM) technique is equal to Vdc/2. It is therefore evident that SVPWM achieves a better DC bus utilization compared to SPWM (by about 15.4%).

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