International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 4, April - 2014

# Control Techniques Employed in Low Cost, Variable Speed Induction Motor Drives

[1] Mebin Joseph[1], Unnikrishnan L[2],
[1]M.Tech. Scholar., Department of Electrical and Electronics Engineering
[2]Asst.Professor, Department of Electrical and Electronics Engineering
Rajagiri School of Engineering and Technology,Kochi

***Abstract*— The wide application of induction motor drives is due to its peculiar features such as economically low cost, rugged construction,extreme reliability,and its robustness.The inherent incapability of variable speed operation in earlier era suppressed its application and thereby DC motors got evolved in drive applications.Rapid and regulated technologies and developments paved induction motor also into its control strategies in variable speed operation.The feasibility and effectiveness by these uncomplicated techniques led to enhancement of performance output and harmonic reductions.This paper deals with the control techniques such as Pulse Width Modulation(PWM),Space Vector Modulation(SVM) that are mainly incorporated and thus made IM more suited to drive applications.**

***Index Terms*— PWM ,Sinusoidal PWM,Space vector modulation, Hysteresis PWM,Variable Frequency Drives**

## I. INTRODUCTION

With the advent of power electronic switches and devices, control over motor drives are acquiring more predominance. The swithching power converters that which powers the IM offer an easy and efficient way to regulate both frequency as well as voltage magnitude.Thus as a result,high performance efficiency and less noise is generated.In three phase IM,the PWM is widely used especially for scalar control where the frequency and stator voltage can be controlled.SVM has its feature that it has better spectral performance and having output voltage closer to sinusoidal.The lower order harmonics in output voltage of inverter is eliminated and thereby its performance can be improved[1] [6].

Variable Frequency Drive (VFD) belongs to adjustable speed drives or variable speed drives. Variable speed drives can be electrical or mechanical. The effect of VFD to a motor drive system offers potential energy savings in a system in which load varies with time. The most effective and efficient way to change the motor speed is by varying frequency, since an IM rotates near to its synchronous speed. Thereby it accounts

several advantages such as high power factor, high efficiency even at low speeds etc. along with speed variations[2].

The power conversion from DC to AC is achieved by using an inverter. Voltage Source Inverter (VSI) drives provide higher power factor and lower harmonic distortion than phase-controlled current-source inverter (CSI).It can be easily demonstrated in Fig .1.

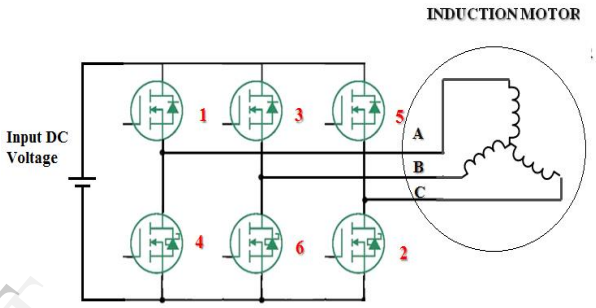


Fig .1.Three phase voltage source inverter

The input three phase AC supply is given to the rectifier and it rectifies into DC components as shown in the Fig . sss1. Switches are provided in inverter side so that control over the switches (transistors) can achieved and thereby in the IM drives too. In a six step VSI,harmonics of order three and its multiples are absent from both the line to line and line to neutral voltages and it is consequently absent from the currents.

## II. PWM INVERTERS

Inverters which have the function to convert DC input voltage to a symmetric AC output of desired magnitude and frequency balanced set of sinusoidal voltages are fed as input to the rectifier side ,which will rectify it into DC voltage and further smoothened by a dc link capacitor[4]. The output voltage may be fixed or variable at a fixed or variable frequency ,variable voltage which is obtained by varying the gain of the inverter. For this purpose Pulse Width Modulation (PWM) control is employed.

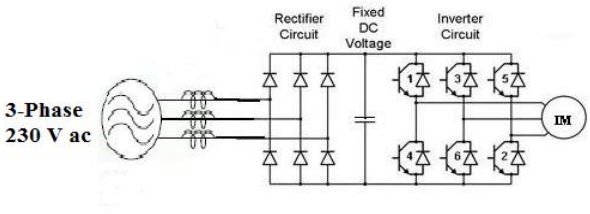


Fig . 2. PWM inverter

In PWM inverters, the gating signals for the six switches are generated by comparing a sinusoidal reference signal with triangular wave. The frequency of the reference signal determines the output frequency and its peak amplitude controls the modulation index ; which in turn controls the rms output voltage[2].The Fig.2. shows PWM inverter circuit with rectifier and inverter sides. Typical generation of a sinusoidal PWM signal is depicted. The reference signals which are equally shifted away from one another by 120º and these are compared with the instantaneous point of carrier wave ie.triangular wave, $V_{tri}$ .

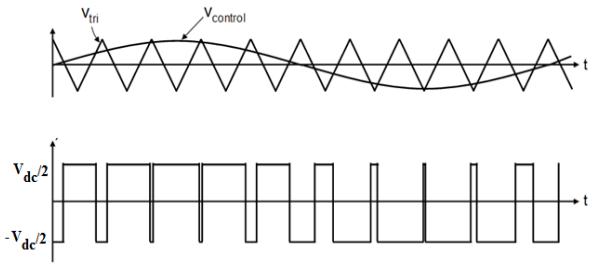


Fig . 3. PWM pulses

When a PWM signal is applied to the gate of a power transistor,it causes turn on and turn off intervals of the transistor to change from one PWM period according to same modulating signal.The frequency of a PWM signal must be much higher than that of a modulating signal.

## III. SINUSOIDAL PWM

Most commonly motors are designed for sine wave ac supply and so that the inverter output should be near to sinusoidal ac. The better way is that to choose the control wave which is in sinusoidal shape to give a PWM pattern in which the pulse width is sinusoidally modulated throughout the half cycle.PWM three phase inverters shapes and control the three phase output voltages in magnitude and frequency. Sinusoidal signal is kept as the modulating signal and several triangular signals constitutes the control principle in the case of sinusoidal PWM.

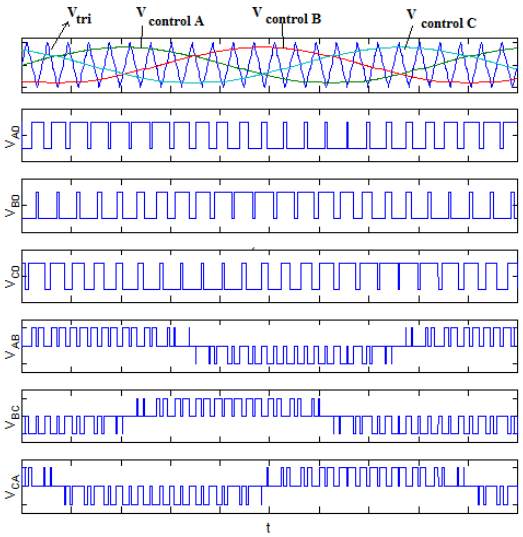


Fig . 4. SPWM waveforms

In SPWM, two parameters can be taken into account while dealing with the output waveforms.ie Amplitude modulation ratio ($m_a$) and Frequency modulation ratio ($m_f$)..The former is the ratio of peak voltage amplitude of modulating sinusoidal signal to that of triangular carrier signal .The latter is the ratio of PWM frequency to that of fundamental frequency. The frequency modulation ratio must be an odd integer, otherwise DC component may exist and even harmonics will be present at output voltage. There may be chance for the existence of sub harmonics even in the output voltage if any violation from this condition occurred. Since by maintaining $m_f$ as multiples of three, even harmonics can be eliminated and load voltage with smallest distortion can be obtained.

## III. SPACE VECTOR PWM

The objective of space vector PWM technique is to approximate the reference voltage vector by a combination of eight switching patterns. It has many advantages such as less current ripple, effective dc link voltage utilization, implementation of digital signal processor and also it is extendible to all multilevel inverters.

Two pairs of three upper and lower transistor switches S1 to S6, are provided that feeds the three phase inverter. So it refers to a special switching sequence of upper three switches. It has been shown to generate less harmonic distortion in the output voltages or currents applied to the phases of AC motor. So it provides efficient utilization of supply voltage in comparison with other direct sinusoidal modulation technique.

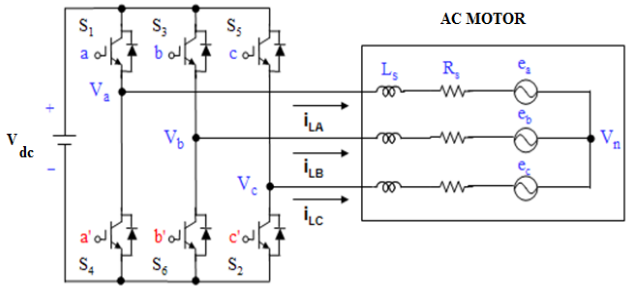


Fig . 6. SPWM in AC motors

The principle of SPWM is that it treats the sinusoidal voltage as a constant amplitude vector rotating at constant frequency.Consisting of eight active voltage vectors ,this technique approximates the reference voltage $V_{ref}$ using this vectors ($V_0$ to $V_7$).

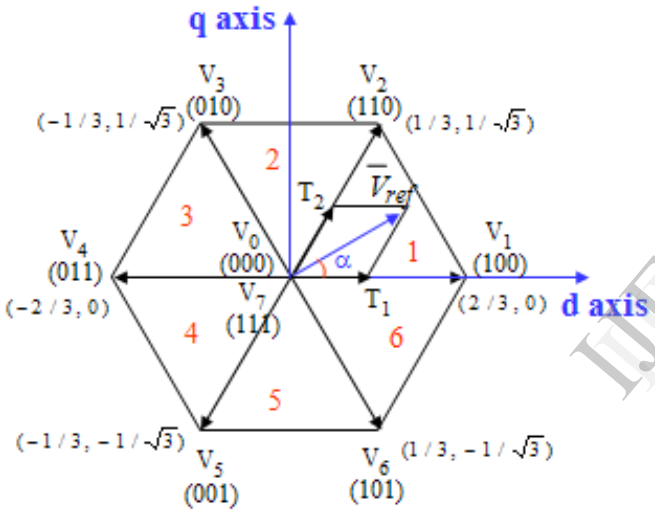


Fig . 7. Switching vectors

Six active vectors ($V_1$,$V_2$, $V_3$, $V_4$, $V_5$, $V_6$) are with different line to neutral voltage having the axis of hexagonal shape forms the switching vector. Each sector ranging from 1 to 6 is displaced at an angle of $120^0$.The dc link voltage is supplied to the load .When compared to that of sinusoidal PWM, space vector modulation provides less harmonics in output voltages or currents. Since locus of reference vector is inside of a circle with radius $1/\sqrt{3}\ V_{dc}$ ,thus the voltage utilization is said to be $2/\sqrt{3}$ times of Sine PWM.

## IV. HYSTERESIS PWM

Hysteresis PWM which is also called Bang -Bang PWM having advantages such as excellent dynamic response, low cost and easy implementation. The input current and the reference current are compared and it is given to the hysteresis controller [5].The presence of lock out circuit responds to concurrent inputs from a number of external circuits by responding to one, and only one, of these circuits at any time.

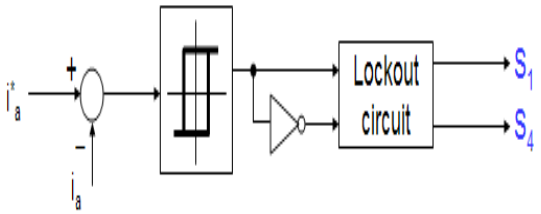


Fig . 8. Current control circuit

This method does not need any knowledge of load parameters.However ,the current control with a fixed hysteresis band has the disadvantage that the PWM frquency varies within a band because peak to peak curent ripple is required to be controlled at all parts at the fundamental frequency wave.

By comparison of the current carrier with a fixed tolerance band,switching signals are derived.That makes the the basic

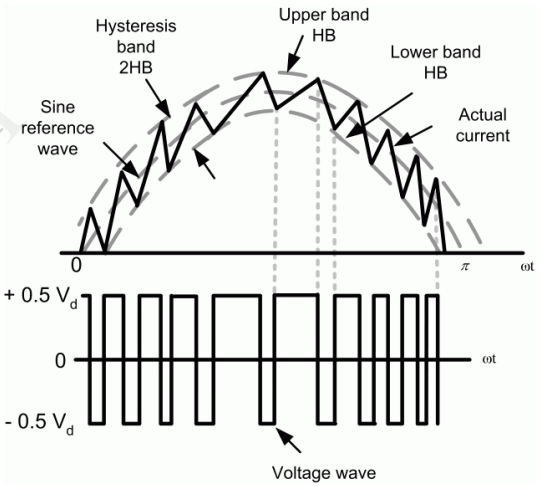


Fig . 9. Hysteresis band control

implementation of hysteresis current control and it is based on comparison of actual phase current with tolerance band around the reference current associated with hat phase.Typically,in three phase systems,this band control is negatively affected by current interactions.

The major drawbacks of hysteresis controller are large current ripple in steady state,variation of switching frequency, No intercommunication between each hysterisis controller of three phases and hence no strategy to generate zero-voltage vectors. As a result, the switching frequency increases at lower modulation index and the signal will leave the hysteresis band whenever the zero vector is turned on. The main disadvantage is that this type of modulation produces subharmonic components.

## V. CONCLUSION

Application of Induction motors are getting widespread over industrial as well as domestic areas. Since the economic low cost factor contributes the ease of use for these motors. The control techniques consisting of vector as well as scalar control strategies helps to maintain efficient, reliable and feasible operations. The non-linear loads connected to the supply in the form of inverters and motors contributes the harmonics. Effective application of different PWM controls thereby leads in reduction of harmonics and smoothening of waveforms. Thus by implementing these control strategies lot of advantages can be incorporated.

## ACKNOWLEDGMENT

The authors wish to express their sincere thanks to management and staff members especially, the EEE department of Rajagiri school of Engineering and Technology for their guidance and support. The seminars and workshops conducted in the institution paved to explore new strategies for control in induction motor.

## REFERENCES

[1] N. Mohan, W. P. Robbin, and T. Undeland, *Power Electronics: Converters, Applications, and Design*, 2nd ed. New York: Wiley, 1995.
[2] Ned Mohan, Tore M. Undeland, and William P. Robbins, "Power Electronics- Converters, Applications and Design", Wiley India Edition 2010
[3] Thida Win, Nang Sabai, and Hnin Nandar Maung , "Analysis of Variable Frequency Three Phase Induction Motor Drive", World Academy of science, Engineering and Technology 42 (2008) pp. 647-651.
[4] Muhammad H. Rashid, "Power Electronics- Circuits , Devices and Applications", Third Edition, Pearson 2004
[5] Mehmet Akbaba, "Motor Input Voltage and Rectifier Firing Angle Variation With Load Torque in Constant Current Operated Induction Motors", Mathematical and Computational Applications, Vol. 14, no.1, pp. 73-84, 2009.
[6] R. Krishnan, " Electric Motor Drives, Modeling, Analysis, and Control", Pearson 2001
[7] P. Pillay and V. Levin, " Mathematical Models for Induction Machines", pp. 606-616, IEEE, 1995.