A SURVEY AND STUDY OF DIFFERENT TYPES OF PWM TECHNIQUES USED IN INDUCTION MOTOR DRIVE

Sandeep Kumar Singh[1], Harish Kumar[2], Kamal Singh[3], Amit Patel[4]

[1]*Student, Electrical & Electronics Engineering, B.I.T Muzaffarnagar, U.P, India,* ***san62638@gmail.com***
[2]*Professor, Electrical & Electronics Engineering, B.I.T Muzaffarnagar, U.P, India,* ***hc78@rediffmail.com***
[3]*Asst. Professor, Electrical Engineering, R.G.E.C Meerut, U.P, India,* ***kamalsingh32@gmail.com***
[4]*Student, Electrical & Electronics Engineering, B.I.T Muzaffarnagar, U.P, India,* ***amitpatel1287@gmail.com***

Abstract

Switching power converters are used in industrial application to convert and deliver their required energy to the motor or load because of advances in solid state power devices and microprocessors. Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. The advantages of PWM based switching power converter over linear power amplifier are Lower power dissipation, Easy to implement and control, No temperature variation and aging-caused drifting or degradation in linearity and Compatible with today's digital micro-processors. In this paper a survey and study of different types of pwm controlled methods are shown in this paper. The different PWM techniques are Single-pulse modulation, Multiple pulse modulation and Sinusoidal pulse width modulation (Carrier based Pulse Width Modulation Technique). SVPWM technique is explained in detail which improves the quality of the current and reduce the torque ripple in induction motor drive while maintaining the other performance characteristics of the system.

Keywords: *3-Φ induction motor, pulse width modulation technique, SVPWM technique etc.*

--- *** ---

1. INTRODUCTION

The induction machine is used in wide variety of applications as a means of converting electric power to mechanical power. Pump steel mill, hoist drives, household applications are few applications of induction machines. Induction motors are most commonly used as they offer better performance than other ac motors. The three-phase induction motors are the most widely used electric motors in industry. They run at essentially constant speed from no-load to full-load. We usually prefer dc motors when large speed variations are required. Nevertheless, the 3-phase induction motors are simple, rugged, low-priced, easy to maintain and can be manufactured with characteristics to suit most industrial requirements.

The most efficient method of controlling output voltage is to incorporate PWM control within inverters. In this method, a fixed d.c. voltage is supplied to inverter and a controlled a.c. output voltage is obtained by adjusting on-off period of inverter devices. 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 PWM inverters have become popular and considerable interest by researcher are given on them. A number of Pulse width modulation (PWM) schemes are used to obtain variable voltage and frequency supply. The most widely used PWM scheme for voltage source inverters is sinusoidal PWM.

The control of IM number of Pulse width modulation (PWM) schemes are used to for variable voltage and frequency supply and main objective of this paper is analysis of Induction motor with SVPWM fed inverter and harmonic analysis of voltages & current. There is an increasing trend of using space vector PWM (SVPWM) because of it reduces harmonic content in voltage, Increase fundamental output voltage by 15% & smooth control of IM. A space vector PWM technique is also developed based on the vector space decomposition. The techniques developed in this paper can be generalized for the control of an induction machine with an arbitrary number of phases. In space vector PWM method for a three-level inverter fed induction motor drive, a number of Pulse Width Modulation (PWM) schemes are used to obtain variable voltage and frequency supply from an inverter. There is an increasing trend of using SVPWM because of their easier digital realization and better dc bus utilization.

2. PULSE WIDTH MODULATION TECHNIQUE

Because of advances in solid state power devices and microprocessors, switching power converters are used in industrial application to convert and deliver their required energy to the motor or load. PWM signals are pulse trains with fixed frequency and magnitude and variable pulse width. There is one pulse of fixed magnitude in every PWM period. However, the width of the pulses changes from pulse to pulse according to a modulating signal. When a PWM signal is applied to the gate of a power transistor, it causes the turn on and turns off intervals of the transistor to change from one

PWM period to another PWM period according to the same modulating signal. The frequency of a PWM signal must be much higher than that of the modulating signal, the fundamental frequency, such that the energy delivered to the motor and its load depends mostly on the modulating signal.

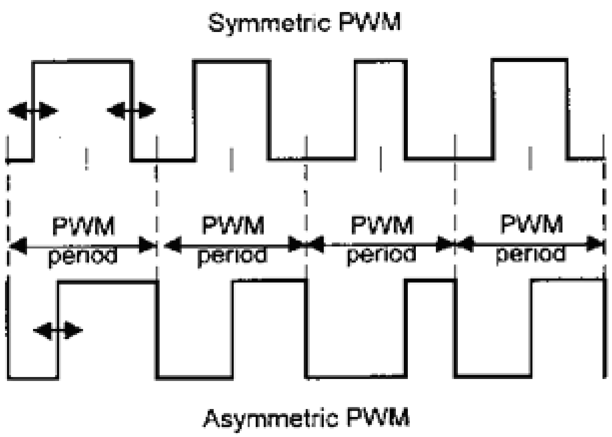

Fig-1: Symmetric and Asymmetric PWM Signals

Fig.-1 shows two types of PWM signals, symmetric and asymmetric. The pulses of a symmetric PWM signal are always symmetric with respect to the center of each PWM period. The pulses of an asymmetric PWM signal always have the same side aligned with one end of each PWM period. It has been shown that symmetric PWM signals generate fewer harmonics in the output currents and voltages. This literature is considers three popular PWM techniques for the mostly used three phase voltage source power inverter applications. This is the most popular method of controlling the output voltage and this method is termed as Pulse-Width Modulation (PWM) Control.

The advantages possessed by PWM techniques are Lower power dissipation, Easy to implement and control, No temperature variation and aging-caused drifting or degradation in linearity, Compatible with today's digital micro-processors, the output voltage control can be obtained without any additional components and with the method, lower order harmonics can be eliminated or minimized along with its output voltage control. As higher order harmonics can be filtered easily, the filtering requirements are minimized. The main disadvantage of this method is that SCRs are expensive as they must possess low turn-on and turn-off times.

3. TYPES OF PULSE WIDTH MODULATION TECHNIQUES

PWM techniques are characterized by constant amplitude pulses. The width of these pulses is however modulated to obtain output voltage control and to reduce its harmonic content. The different PWM techniques are Single-pulse modulation, Multiple pulse modulation and Sinusoidal pulse width modulation (Carrier based Pulse Width Modulation Technique). These techniques are explained below in brief :

3.1 Single pulse width modulation

In single pulse-width modulation control, there is only one pulse per half-cycle and the width of the pulse is varying to control the output voltage. Fig.-2 shows the generation of gating signals of single pulse width modulation. The gating signals are generated by:

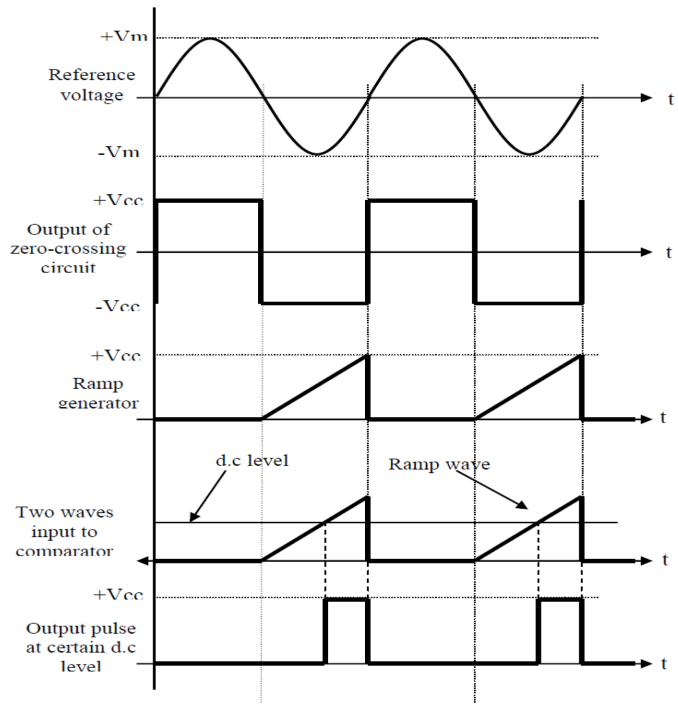

Fig-2: The generation of gating signals of single pulse width modulation

The single pulse-width modulation converts the reference signal to the square wave signal. This process is obtained by inter the reference signal to the zero-crossing circuit witch consider the positive part of the input signal is positive part of the output signal(square wave) and the negative part of the input signal is negative part of the output signal as shown in Fig.-2.

3.2 Multi-Pulse width modulation

The harmonic content can be reduced by using several pulses in each half-cycle of output voltage. The generation of gating signals for turning on and off transistors is shown in Fig.-3. The gating signals are produced by comparing reference signal with triangular carrier wave. The frequency of the reference signal sets the output frequency (f_o) and carrier frequency (f_c) determine the number of pulses per half cycle,

$$p = \frac{f_c}{2f_0} \qquad (1)$$

The variation of modulation index (M) from 0 to 1 varies the pulse from 0 to π/p and the output voltage from 0 to V_m.

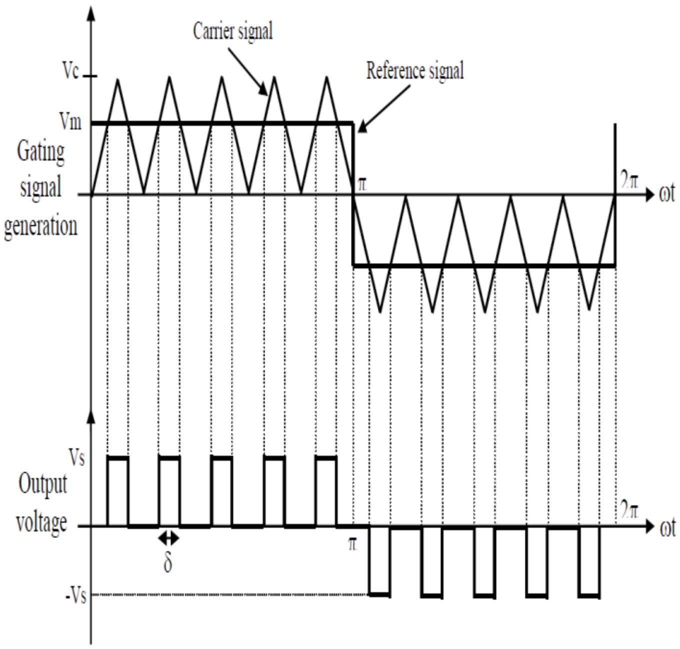

Fig-3: The generation of gating signals of multi-pulse width modulation

3.3 The Carrier-Based Pulse Width Modulation (PWM) Technique

As mentioned earlier, it is desired that the ac output voltage V_o=V_{aN} follow a given waveform (e.g., sinusoidal) on a continuous basis by properly switching the power valves. The carrier-based PWM technique fulfils such a requirement as it defines the on and off states of the switches of one leg of a VSI by comparing a modulating signal V_c (desired ac output voltage) and a triangular waveform V_Δ (carrier signal). In practice, when $V_c > V_\Delta$ the switch S+ is on and the switch S- is off; similarly, when $V_c < V_\Delta$ the switch S+ is off and the switch S- is on.

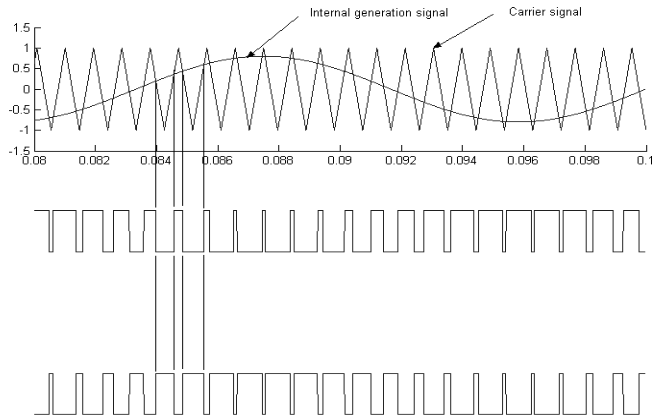

Fig-4: The generation of gating signals of Carrier-Based pulse width modulation

Fig.-4 clearly shows that the ac output voltage V_o=V_{aN} is basically a sinusoidal waveform plus harmonics. A special case is when the modulating signal V_c is a sinusoidal at frequency f_c and amplitude, $\tilde{V}_c$ and the triangular signal V_Δ is at frequency f_Δ and amplitude $\tilde{V}_\Delta$. This is the Sinusoidal PWM (SPWM) scheme. In this case, the modulation index m_a (also known as the amplitude-modulation ratio) is defined as;

$$m_a = \frac{\tilde{V}_c}{\tilde{V}_\Delta} \qquad (2)$$

and the normalized carrier frequency m_f (also known as the frequency-modulation ratio) is

$$m_f = \frac{f_\Delta}{f_c} \qquad (3)$$

4. SPACE VECTOR PULSE WIDTH MODULATION TECHNIQUE

SVPWM technique was originally developed as a vector approach to pulse width modulation for three-phase inverters. The SVPWM method is frequently used in vector controlled applications. In vector controlled applications this technique is used for reference voltage generation when current control is exercised. It is a more sophisticated, advanced, computation intensive technique for generating sine wave that provides a higher voltage with lower total harmonic distortion and is possibly the best among all the pulse width modulation techniques. It confines space vectors to be applied according to the region where the output voltage vector is located. Because of its superior performance characteristics, it is been finding wide spread applications in recent years. The main aim of any modulation technique is to obtain variable output voltage having a maximum fundamental component with minimum harmonics. Many PWM techniques have been developed for letting the inverters to posses various desired output characteristics to achieve the wide linear modulation range, less switching losses, lower harmonic distortion.

The Principle of SVPWM using a three-phase inverter is presented on the basis of space vector technique in Fig.-5. S_1 to S_6 are the six power switches that shape the output, which are controlled by the switching variables a ,a', b, b' and c, c'. When an upper transistor is switched on, i.e., the corresponding a', b' or c' is 0. Therefore, the on and off states of the upper switches S_1, S_3, S_5 can be used to determine the output voltage.

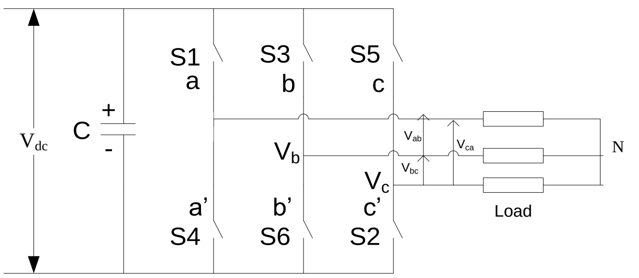

Fig-5: Power circuit of a three-phase VSI

SVPWM refers to a special switching sequence of the upper power switches of a three-phase power inverter. It has been shown to generate less harmonic distortion in the output voltages and/or currents applied to the phases of a power system and to provide more efficient use of supply voltage compared with other modulation technique. To implement SVPWM, the voltage equations in the abc reference frame can be transformed into the stationary d-q reference frame that consists of the horizontal (d) and vertical (q) axes as depicted in Fig.-6.

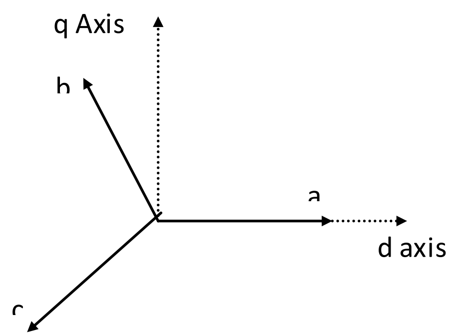

Fig-6: The relationship of (a-b-c) & (d-q) reference frame

The SVPWM technique is more popular than conventional technique because of its excellent features.

- More efficient use of DC supply voltage
- 15% more output voltage then conventional modulation
- Lower Total Harmonic Distortion (THD)
- Prevent un-necessary switching hence less commutation losses

5. CONCLUSIONS

The most efficient method of controlling output voltage is to incorporate PWM control within inverters. In this method, a fixed d.c. voltage is supplied to inverter and a controlled a.c. output voltage is obtained by adjusting on-off period of inverter devices. Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. Switching power converters are used in industrial application to convert and deliver their required energy to the motor or load because of advances in solid state power devices and microprocessors. There are so many techniques which are used for controlling of induction motor drives and SVPWM technique improves the quality of the current and reduce the torque ripple in induction motor drive efficiently while maintaining the other performance characteristics of the system.

REFERENCES

[1]. Sonal Arvind Barge & S. R. Jagtap," Harmonic Analysis of Sinusoidal Pulse Width Modulation" International Journal of Advanced Electrical and Electronics Engineering, (IJAEEE), Volume-2, Issue-5, 2013.

[2]. Fizatul Ainipatakar, Marizan sulaiman and Zulkifilieibrahim," Comparison Performance Of Induction Motor Using Svpwm And Hysteresis Current Controller" Jatit & Lls, Vol. 30 No.1, 1992-8645.

[3]. Mr. Sandeep N Panchal, Mr. Vishal S Sheth, Mr. Akshay A Pandya," Simulation Analysis of SVPWM Inverter Fed Induction Motor Drives", International Journal of Emerging Trends in Electrical and Electronics (IJETEE) Vol. 2, Issue. 4, April-2013.

[4]. R. Arulmozhiyaly and K. Baskaran," Implementation of a Fuzzy PI Controller for Speed Control of Induction Motors Using FPGA,Journal of Power Electronics, Vol. 10, No. 1, January 2010.

[5]. R. Arulmozhiyal," Space Vector Pulse Width Modulation Based Speed Control of Induction Motor using Fuzzy PI Controller,"International Journal of Computer and Electrical Engineering, Vol. 1, No. 1,1793-8198.

[6]. Yifan Zhao, Student Member, and Thomas A. Lipo, Fellow, "Space Vector PWM Control of Dual Three-Phase Induction Machine using Vector Space Decomposition," IEEE Transactions On Industry Applications, Vol. 31, No.5, 0093-9994/95.

[7]. M. SajediHir, Y. Hoseynpoor, P. MosadeghArdabili, T. PirzadehAshraf," Modeling and Simulation of Induction Motor Drive with Space Vector Control,"

[8]. Srinivasa Rao Maturu and Avinash Vujji," SVPWM Based Speed Control of Induction Motor Drive with Using V/F Control Based 3-Level Inverter" VSRD-IJEECE, Vol. 2 (7), 2012, 421-437.

BIOGRAPHIES

Sandeep Kumar Singh received B.Tech. degree in electrical engineering from U.P.T.U, Lucknow, India in 2007. He is pursuing M.Tech. in power electronics from B.I.T Muzaffarnagar, India. His main area of interest includes power electronics, control system and Basic electrical engineering.

Harish Kumar was born in city of TaJ (Agra) in India in 1978.He received the B.E (ECE) and M.E, PhD in Microwave Communication from Agra University, Agra in 2000, 2004 and 2008, respectively and also did PDF from Finland. and research work carried out at CEERI Pilani and University of Turku, Finland. He has served as a faculty member with department of Electronics and communication at IET (Agra University, Agra) SEC, GIT (Rajasthan University, Jaipur), Bhagwant group of institutions from 2001 to 2014 and currently holds rank of professor and Dean Academics at Bhagwant Institute of Technology Muzaffarnagar, U.P India he has received nine project like AICTE,UGC, NSTEDB, MSME, Govt of india. Seven project have been completed and two project going on. He is many review committee member of IEEE International Conference and also session chair of conference since 2008. He has published more than 180 research paper national and international journals/ conference's proceeding and also visited more than 22countries, his general research interests in MMIC, high power amplifier, Green ICT, Antenna design and Integrated active antenna and solar and power electronics.

Kamal Singh received B.Tech. degree in electrical engineering from Uttar Pradesh Technical University, Lucknow, India in 2008. He completed M.Tech. in power electronics and drives from M.M.M. Engg College, Gorakhpur, India in 2011.

Amit Patel received B.Tech. degree in electrical engineering from U.P.T.U, Lucknow, India in 2007. He is pursuing M.Tech. in power electronics from B.I.T Muzaffarnagar, India. His main area of interest includes power electronics, Electrical machines and Instrumentation.