Design and Implementation of SPWM and Hysteresis based VSI Fed Induction Motor

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ABSTRACT

This paper deals with the performance analysis of three phase induction motor drive fed by a PWM voltage source inverter. Here we are using two types of (PWM) techniques, one is sinusoidal pulse width modulator (SPWM) and another one is hysteresis band pulse width modulation (HBPWM) techniques. This paper work deals mainly with the performance analysis of three phase induction motor fed by PWM voltage source inverter in terms of phase current of inverter, rotor and stator current , speed ,electromagnetic torque developed and total harmonic distortion in line and phase voltage of inverter .For the implementation of the proposed drive the MATLAB/SIMLINK environment has been used. There so many types of PWM techniques, in which SPWM and HBPWM are one of them. The HBPWM approach has been selected for the research, since it has the potential to provide an improved method of deriving non-linear models which is complementary to conventional techniques. And the SPWM method, which involves the modulation of conventional sinusoidal reference signal and a triangular carrier signal, is used here to produce pulse width modulated output. The performance analysis of the inverter has been done using the parameter total harmonic distortion implemented with help of FFT block.. The impact of the PWM techniques on the performance of the inverter fed to an induction motor has been done in terms of the waveforms for inverter phase voltage, line voltage, line current, stator current, rotor current, rotor speed and electromagnetic torque developed by the motor.

Keywords: Induction Motor (IM) drive, MATLAB/SIMULINK, VSI, sinusoidal pulse width modulation (SPWM), hysteresis Pulse Width Modulation, THD.

1. INTRODUCTION

Power electronic has changed rapidly during the last thirty years and the numbers of application has been increasing, mainly due to the development of the semiconductors devices and the microprocessor technology.[1]The dc-ac converter, also known as the inverter. The filter capacitor across the input terminals of the inverter provides a constant dc link voltage. The inverter therefore is an adjustable-frequency voltage source. The configuration of ac to dc converter and dc to ac inverter is called a dc- link converter.[2]

Three phase *induction motors* are widely used motors for any industrial control and automation. It is often required to control the output voltage of inverter for the constant voltage /frequency (V/F) control of *an induction motor*.[2] *PWM (pulse width modulation)* based firing of inverter provides the best constant of an inductor motor. Amongst the various PWM techniques, the *sinusoidal PWM* and hysteresis band PWM are one of them.

In this paper we analysis the performances of induction motor in open loop. Here we used three phase *voltage source inverter* which is *SPWM* and *hysteresis PWM* techniques with power IGBT is described.[7]

2. INVERTER

Power inverter are devices which can convert electrical energy of DC from into that of AC. Inverters can be broadly classified into two types based on their operation :

1. *Voltage Source Inverter (VSI)*
2. *Current Source Inverter (CSI)*

A voltage source inverter is commonly used to supply a three-phase induction motor with variable frequency and variable voltage for variable speed applications. A voltage fed inverter (VFI) or more generally a *voltage source inverter (VSI)* is one in which the dc source has small and negligible impedance. [fig.1].The voltage at the input terminal is constant. A current source inverter is fed with the adjustable current from dc source of high impedance that is from a constant dc source. A voltage source inverter employing thyristor as switch, some types of forced commutation is required ,while the VSI made up of using GTO's, Power transistor, power MOSFET or IGBT self commutation with base or gate drive signal for their controlled turn ON and turn OFF.[2].

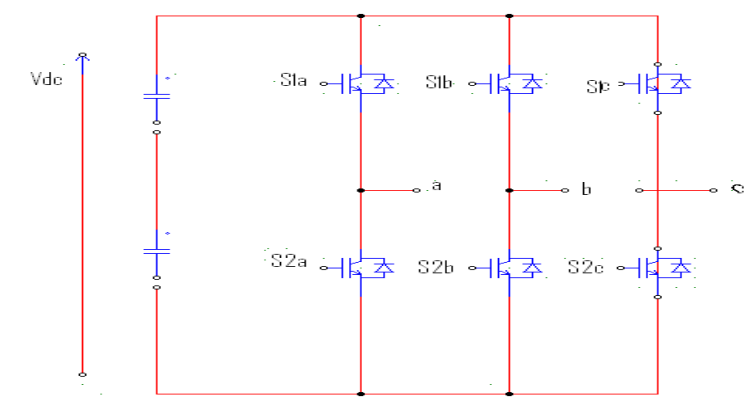


Figure1: Two Level Six Pulse Inverter

PWM Techniques Used To Implement Inverter

Pulse width modulation is a technique in which a fixed input dc 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 most popular methods of controlling the output voltage and this method is termed as the pulse width modulation technique.[6] PWM is an internal control methods and it gives better results than an external control methods. There are number of PWM methods for variable frequency voltage -sourced inverter. A suitable PWM technique is employed in order to obtain the required output voltage in the side of the inverter [2]. There are many effective techniques used to implement the three phase inverter is the Pulse Width Modulation Technique.[7] Here we are using two types of PWM techniques as given below.

1. *Sinusoidal pulse width Modulation(SPWM)*
2. *Hysteresis band Pulse Width Modulation(HBPWM)*

1. Sinusoidal Pulse Width Modulation

In *sinusoidal PWM* three phase reference modulating signal are compared against a common triangular carrier to generate the PWM signals for the three phases as per diagram given below [fig 2].

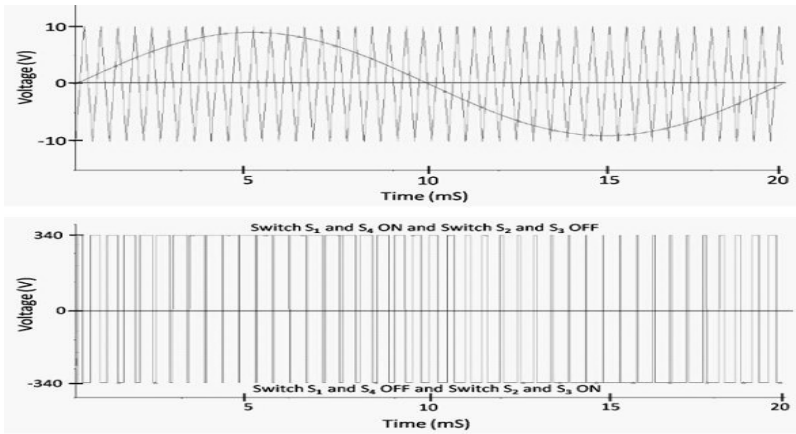


Fig 2. SPWM waveforms

A *Sinusoidal Pulse Width Modulation* technique is also known as the triangulation, sub oscillation, sub harmonic method, is very popular in industrial applications.[5] In this technique a high frequency triangular carrier wave is compared with the sinusoidal reference wave determines the switching instant. When the modulating signal is a sinusoidal of amplitude A_m, and the amplitude

of triangular carrier wave is A_c, then the ratio $m=A_m/A_c$, is known as the modulation index. It is to be noted that by controlling the modulation index one can control the amplitude of applied output voltage.[10]

2. Hysteresis band Pulse Width Modulation

The basic principle of *HB PWM* technique is that the sinusoidal reference of desired magnitude and frequency is compared with the triangular signal of fixed width hysteresis band. For hysteresis control the phase output current is fed back to compared with the reference current i_{ref}. An upper tolerance band and lower tolerance band, taken as +/-0.5% of, i_{ref} also assigned in order to define an acceptable current ripple level. Whenever the phase current exceeds the upper band, the upper switch of that leg will be turned ON while the lower switch will be turned OFF. If phase current falls below the lower band, the upper switch will be turned OFF whereas the lower switch will be turned ON[11].The hysteresis band PWM has been used because of its simple implementation, fast transient response, direct limiting of device peak current and practical insensitivity of dc link voltage ripple that permits a lower filter capacitor[11]

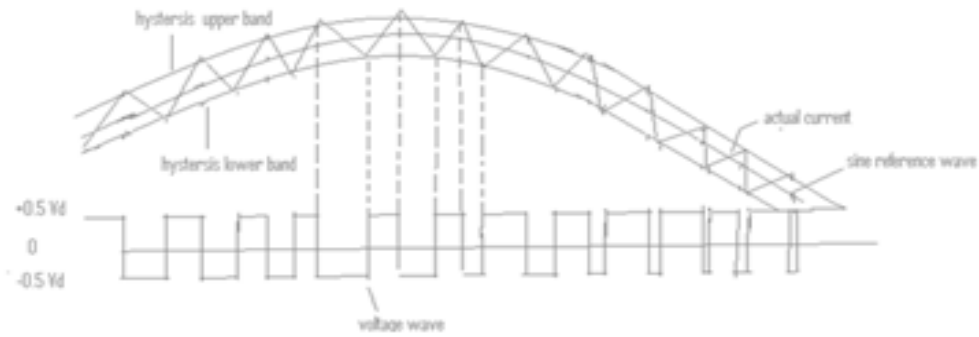


Figure3: hysteresis PWM technique

Three Phase SPWM and Hysteresis band Induction Motor Drive

Three phase voltage fed PWM inverters are growing very rapidly for many drive applications such as megawatt industrial drive etc. The main reason for using this drive is that the large series voltage between the devices is shared and improvement of the harmonics quality at the output as compared to the two level inverter. Now- a -days GTO devices replaced by IGBTs because of their rapid evolution in voltage and current ratings and also higher and better switching frequency [1]. In most variable speed drives PWM VSI are used. Usually machine design tools only consider the fundamental harmonics of the starter voltage when calculating the losses. These losses are caused by harmonics of the voltage and the current due to the PWM. A number of algorithms for PWM

voltage generations are discussed are present. Here we are using SPWM and hysteresis band PWM technique based voltage source inverter fed to an induction motor and compare the performance of both types of PWM technique in open loop.[4] The result has been given in fig [7] & [8].

Analysis of Three Phase PWM VSI

Simulation is done on a three phase induction motor fed by a PWM inverter developed in MATLAB /SIMULINK environment. The fig 4. Shows the SIMULINK diagram of the developed model. The basic circuit of the proposed scheme consist of a three phase induction motor as wound rotor type having ratings 3HP, 240V, 50Hz. The three phase induction motor drive is fed by three phase PWM based VSI inverter. For VSI we are using six IGBT switches in a bridge form and fed by DC voltage of 300V.

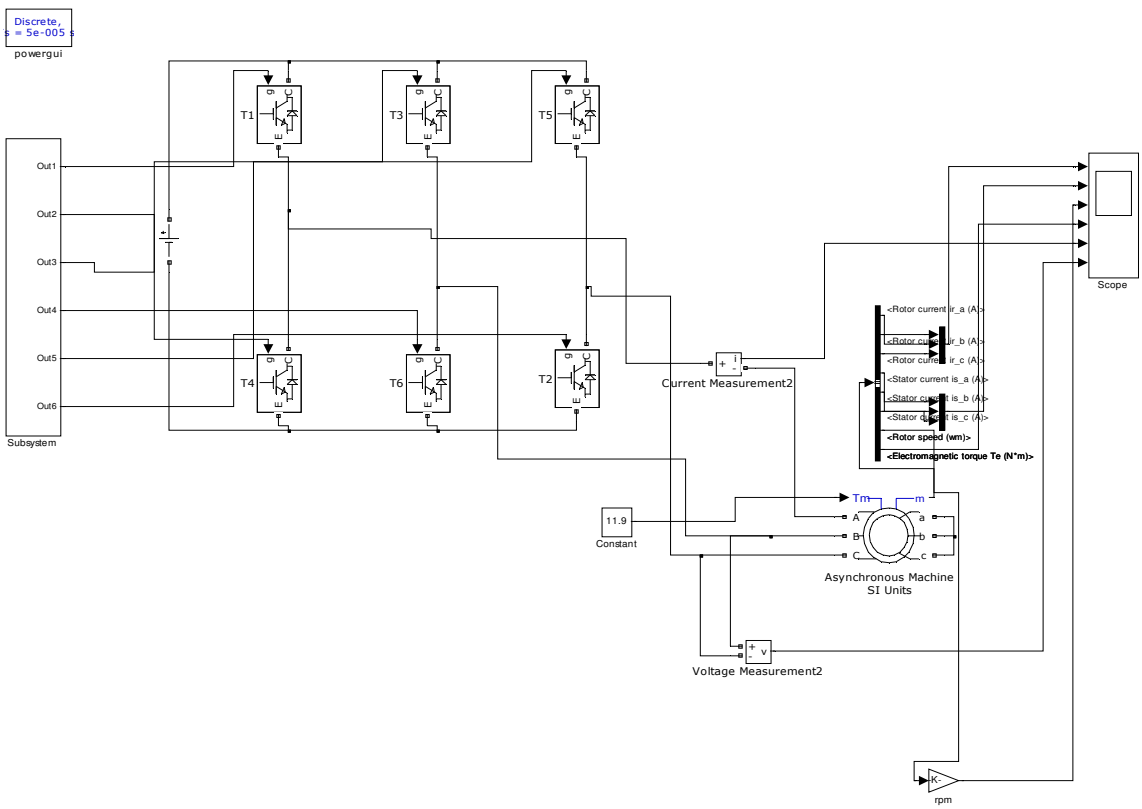


Figure4: Simulink Model for SPWM and Hysteresis PWM Based VSI Fed Induction Motor

Generation of Gating Pulses By SPWM

The gating pulses for the six IGBTs of three legs are generated. The generation of these pulses is carried out by sinusoidal pulse width modulation technique as per fig [5].

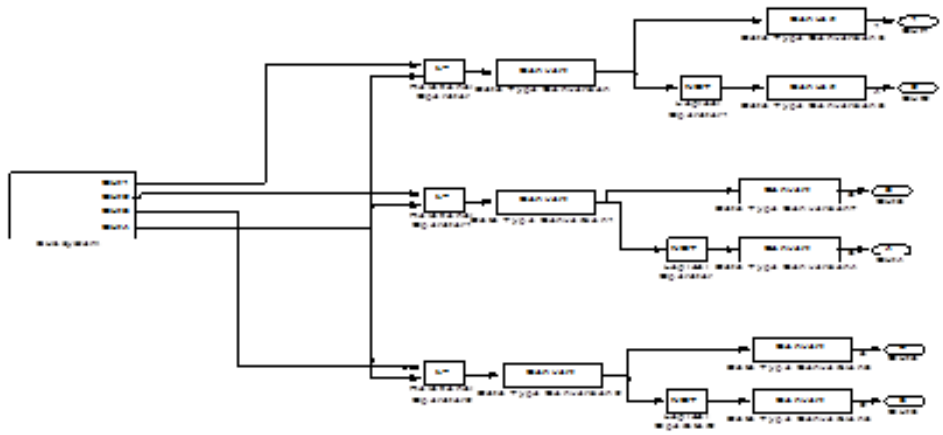
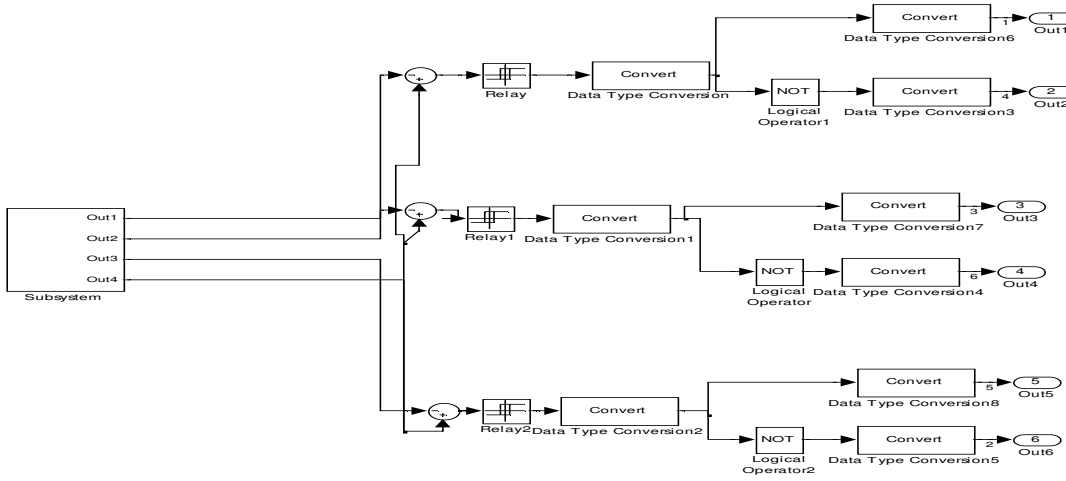


Figure 5: Simulink Model for Generating Of Gating Pulse By SPWM

Generation of Gating Pulses By HB PWM

The gating pulses for the six IGBTs of three legs are generated. The generation of this pulses is carried out by hysteresis band pulse width modulation technique as per fig [6].

Figure 6: Simulink Model of Generating Of Gating Pulse By HBPWM



Simulation Results of the SPWM AND HB PWM Fed Induction Motor Drive

Results are obtained by simulating the circuit. Here we analyse SPWM and HB PWM motor and inverter performance

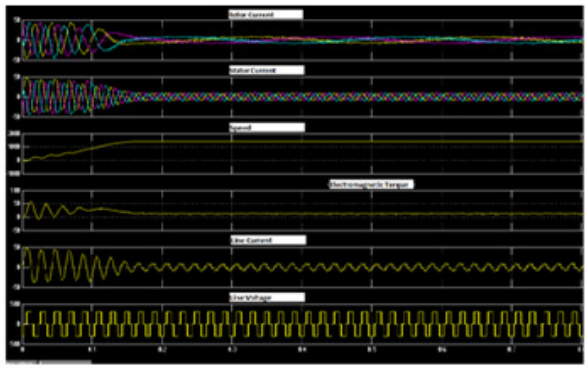


Figure 7: Simulink Result Of SPWM Fed induction Motor Drive

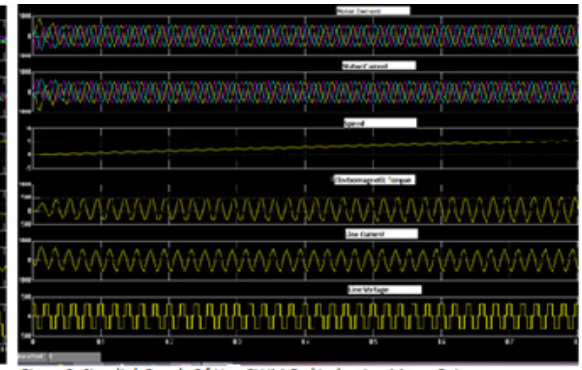


Figure8: Simulink Result Of HB PWM Fed Induction Motor Drive

Comparison Of THD Of Line Current For SPWM AND HB PWM Techniques

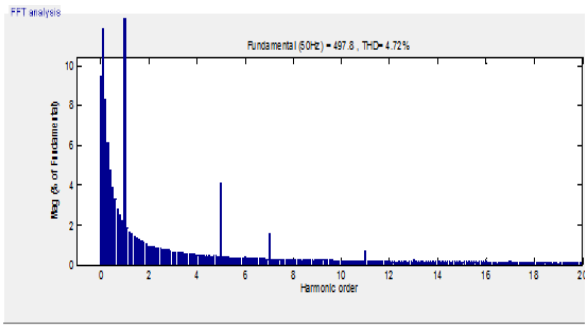


Figure9: TDH of VSI current Hysteresis PWM technique

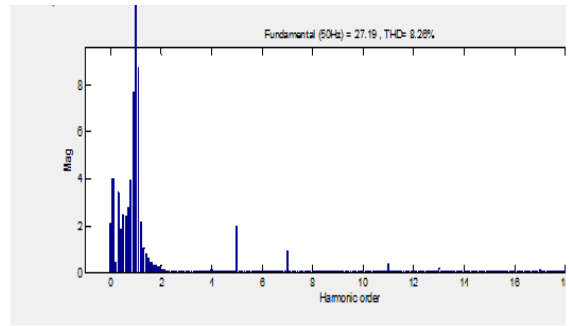


Figure10: TDH of VSI current of SPWM technique

Table:1 Comparison of VSI voltage and current of SPWM and HysteresisPWM technique

S. No.	PWM Techniques	Line Current THD (%)	Line Voltage THD (%)
1	SPWM	8.26	31.97
2	HB PWM	4.71	31.98

3. CONCLUSION

The paper presents performance analysis of three phase induction motor fed by PWM voltage source in under modulating range. For this purpose the MATLAB/SIMULINK approach has been used for the implementation of the proposed drives. The three phase inverter has been implemented. The performance analysis of the inverter has been done using the parameter total harmonic distortion implemented with help of FFT block. The THD has been calculated for the line

current and line voltage [table 1] . The main advantage of this approach is that it shows the performance of the motor as well as of the voltage source inverter based on different PWM techniques. There is appreciable improvement in THD in inverter line current in HB PWM technique, as compared to SPWM technique as given in table 1.

The motor speed is zero initially and increased to the final value as the time increase. Initially the electromagnetic torque developed by the motor is highly oscillatory and after the transient time it settles down to the vale which is equal to the load torque.

REFERENCES

[1] Sharma A.K,Saxen ,DTushar, Islam Shirazul&Yadav.Karun, "performance Analysis Of Three Phase PWM Voltage Source Inverter Fed three Phase Induction Motor Drive", International Journal of Advance Electrical and Electronics Engineering(IJAEEE) 2013.

[2] Sharma C.S, NagwaniTali, "Simulation and Analysis of PWM Inverter Fed Induction Motor Drive", International Journal of Science, Engineering and Technology Research (IJSETR)" , February 2013.

[3] Zope H Pankaj, Bhangle G Pravin, Sonare Prashant, Suralkar S.R "Design and Implementation of carrier based Sinusoidal PWM Inverter" ,(IJAEEE) October2012.

[4] Houdsworth J.A and Grant D.A, "The use of Harmonics distortion to increase output voltage of a three phase PWM inverter" , IEEE Trans. Industry Appl., vol. IA-20, pp. 1124-1228, sept./oct. 1984.

[5] "Performance of Sinusoidal pulse Width Modulation based three phase inverter ". International Conference on Emerging Frontiers in Technology for Rural Area (EFITRA) 2012 Proceedings published in International Journal of Computer Application (IJCA).

[6] Kazmierkowski M.P., Krishnan R., and Blaabjerg F.,"Control in power electronics selected problem" , Academic Press, California, USA. 2002.

[7] Kerkman R.J., Seilbel B.J., Bord D.M. , Rowan T.M. , and Branchgate D. ,"A Simplified inverter model for on-line control and simulation, IEEE Trans. Ind. Applicant., Vol. 27, NO. 3, pp.567-573. 1991.

[8] Dong G., "Sensorless and efficiency optimized induction motor control with associated converter PWM schemes" ,phD Thesis, Faculty of Gradute School, Tennessee technological University, Dec.2005.

[9] "Modeling and Simulation of Modified Sine PWM VSI Fed Induction Motor Drives." International journal of Electrical Engineering & Technology, Vol.3, Issue 2, July- September 2012.

[10] "Understanding FACTS: concept and technology of flexible AC transmission system ", by Narain G. Hingorani, LaszolGyugyi.

[11] "MODERN POWER ELECTRONIC AND AC DRIVES", by Dr.Bimal K. Bose, publication year.2001.