Design of SVPWM Inverter for Induction Motor Drive Using PID Controller

G.Jegadeeswari[1] R.Arun Kumar[2] S.Kalaivani[3] S. Parthiban[4]

PG student, Department of Electrical and Electronics Engineering
Sri Manakula Vinayagar Engineering College, Puducherry – 605107, India.

Abstract ——**This paper presents a PID controller for three phase inverter fed induction machine speed control. Thus the three phase inverter fed induction motor drive has been simulated with and without step change using PID controller. The performance comparisons of conventional PID are achieved with the help of IAE (Integral absolute error) and ITAE (Integral time-weighted absolute error).**

***Index terms*__ PID controller, induction motor, Integral absolute error, and Integral time-weighted absolute error**

I. INTRODUCTION

Nowadays, induction motor plays a vital role in industrial purposes. As compared to DC machine, it gives less cost and easy maintenance. However, the speed control of induction motor is more complex, which gives non-linear in nature. Therefore, speed variation can be achieved for this kind of machine by acting on the supply net frequency. There is no effective and simple way to vary the frequency of a supply until the present power electronics were developed.

On the other hand, in electric traction, the use of power is either DC or AC. Three phase DC/AC inverter is the only possible interface due to their flexible voltage and frequency variation. As mentioned above, a three phase DC/AC inverter used in traction is supplied by power either in AC or DC.

In the case of AC supply, it is directly connected to the three phase DC/AC inverter through step up/down transformer and an AC/DC rectifier. The control problem in the induction motor is to design a controller ensuring a wide range of speed point for a three phase system and induction motor.

In the present work, a PID controller is designed to control the motor speed by varying its reference value and to regulate the motor speed. It will be formally proved that the PID controller actually stabilizes the controlled system and does meet its tracking objectives with a good accuracy.

II. METHODOLOGY

The block diagram of the proposed work for both PID controllers is shown in fig 1. The block diagram consists of DC supply as voltage source which is connected to a three-phase IGBT based inverter which is fed to an induction motor. A conventional PID controller is used for the control of triggering pulse of inverter switch. By varying the triggering pulse of the inverter a constant (V\F) ratio is maintained for obtaining the speed of the induction motor.

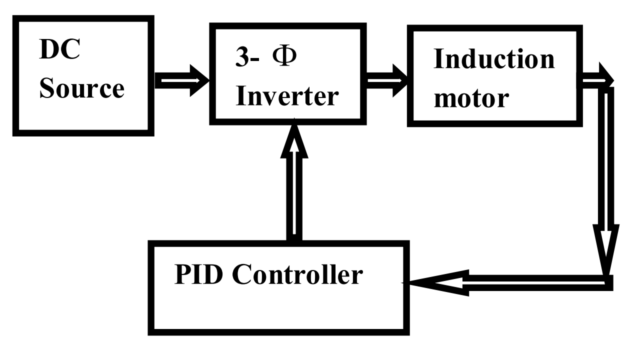

Fig 1: Overall Block diagram of proposed technique

The inverter used here is a three phase IGBT inverter which has the ability of decreasing and increasing the output voltage according to the requirement. The usage of inverter allocates the operation of induction machine even in low load conditions.

ISSN: 2278 – 7798

III. SPACE VECTOR MODULATION

In the SVPWM algorithm, the d-axis and q-axis voltages are converted into three phase instantaneous reference voltages. The unreal switching time periods relative to the instantaneous values of the reference phase voltages and can be defined as

$$V_\alpha + jV_\beta = \frac{2}{3}\left(V_a + e^{\frac{j2\pi}{3}}V_b + e^{\frac{-j2\pi}{3}}V_c\right) \tag{1}$$

Realization of Space Vector PWM

- Step 1. Determine V_d, V_q, V_{ref}, and angle (α)
- Step 2. Determine time duration T_1, T_2, T_0
- Step 3. Determine the switching time of each transistor (S_1 to S_6)

Vref can be initiating with one zero vector and two active. For sector 1 (0 to $\pi/3$): Vref can be located with V0, V1 and V2. Vref in terms of the duration time can be considered as:

$$V_{ref} * T_c = V_1\frac{T_1}{T_c} + V_2\frac{T_2}{T_c} + V_0\frac{T_0}{T_c} \tag{2}$$

$$V_{ref} = V_1T_1 + V_2T_2 + V_0T_0 \tag{3}$$

The total cycle is given by:

$$T_c = T_1 + T_2 + T_0 \tag{4}$$

The position of Vref, V_1, V_2 and V_0 can be described with its magnitude and angle:

$$V_{ref} = V_{ref}\, r^{j\theta} \tag{5}$$

$$V_1 = \frac{2}{3}V_{DC} \tag{6}$$

$$V_2 = \frac{2}{3}V_{DC}e^{\frac{j2\pi}{3}} \tag{7}$$

$$V_o = 0 \tag{8}$$

$$T_c = \begin{pmatrix}\cos\theta\\ \sin\theta\end{pmatrix} T_1\left(\frac{2}{3}\right)V_{DC}\begin{pmatrix}1\\0\end{pmatrix} + T_2\left(\frac{2}{3}\right)V_{DC}\begin{pmatrix}\cos\left(\frac{\pi}{3}\right)\\ \cos\left(\frac{\pi}{3}\right)\end{pmatrix} \tag{9}$$

Dividing these in real and imaginary parts simplifies the calculation for each duration time:

Real part:

$$T_cV_{ref}\cos\theta = T_1\left(\frac{2}{3}\right)V_{DC} + T_2\left(\frac{1}{3}\right)V_{DC} \tag{10}$$

Imaginary part:

$$T_cV_{ref}\sin\theta = T_2\left(\frac{1}{\sqrt{3}}\right)V_{DC} \tag{11}$$

T1 and T2 are then given by:

$$T_1 = T_c\frac{\sqrt{3}V_{ref}}{V_{DC}}\sin\left(\frac{\pi}{3} - \theta\right) \tag{12}$$

$$= T_c.a.\sin\left(\frac{\pi}{3} - \theta\right) \tag{13}$$

$$T_2 = T_c\frac{\sqrt{3}V_{ref}}{V_{DC}}\sin(\theta) \tag{14}$$

$$= a.\sin(\theta) \quad 0 < \theta < \frac{\pi}{3} \tag{15}$$

IV. PID CONTROLLER DESIGN

In the control of dynamic systems, no controller has enjoyed both the success and the failure of the PID control. Of all control design techniques, the PID controller is the most widely used. Over 85% of all dynamic controllers are of the PID variety. There is actually a great variety of types and design methods for the PID controller as shown in fig 4.6.

The acronym PID stands for Proportional-Integral-Differential control. Each of these, the P, the I and the D are terms in a control algorithm, and each has a special purpose. Sometimes certain of the terms are left out because they are not needed in the control design. This is possible to have a PI, PD or just a P control. It is very rare to have an ID control.

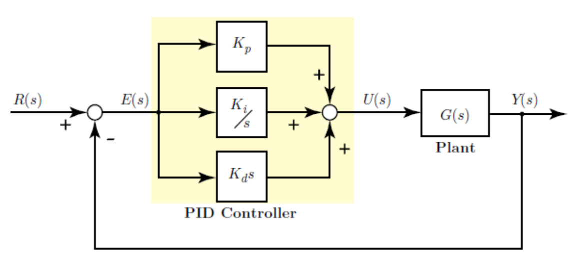

Fig: 2 PID controllers

V. RESULTS AND DISCUSSION

ISSN: 2278 – 7798

The Matlab/Simulation results are shown in the following figures 3-6. Simulation is performed for the proposed circuit with MATLAB/SIMULINK version R2010a.

The response of induction motor with PID controller is shown in the figures 5 and 6. The output voltage of three phase inverter Va, Vb, Vc which is shown in fig 3 gives the maximum output voltage of 520 V. The switching pattern of SVPWM for inverter fed induction motor drive is shown in fig: 4

The reference value speed is considered as 1000 rpm for Simulation results which are obtained under different operating conditions. The result obtained with the PID controlled drive is given in Figures 5 and 6. The performance of the drive during Step change in speed and load torque with PID controller (load torque of 11 N-m is applied at 0.5 sec and removed at 1.5 sec) is shown Figure 6. The steady state phase response is shown in Figure 7. It is observed that the ripple content in the current wave forms are less, the torque ripple reduced.

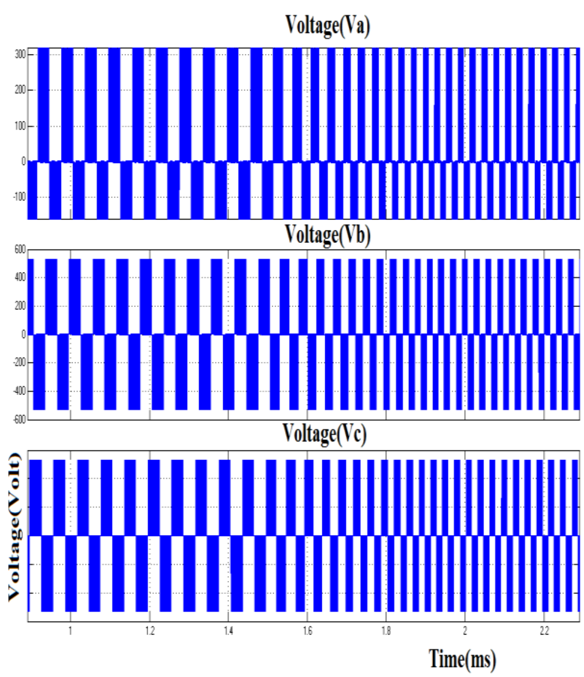

Fig: 3 Inverter output voltages

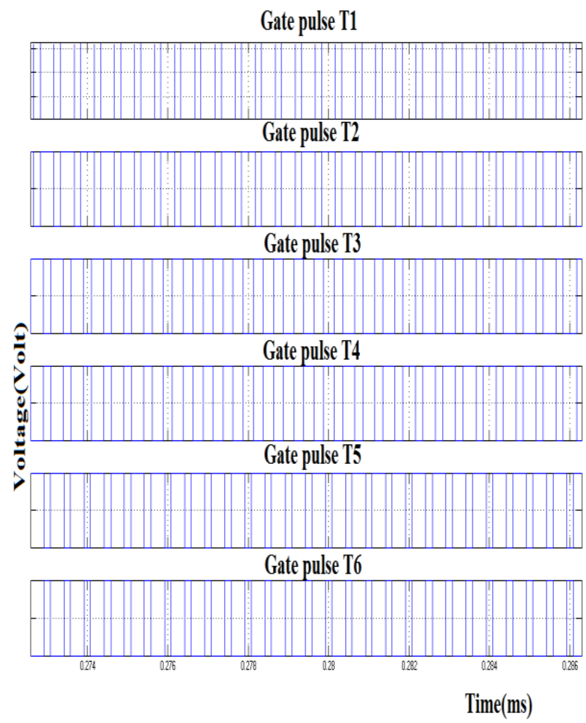

Fig: 4 switching pattern of SVPWM for inverter fed induction motor drive

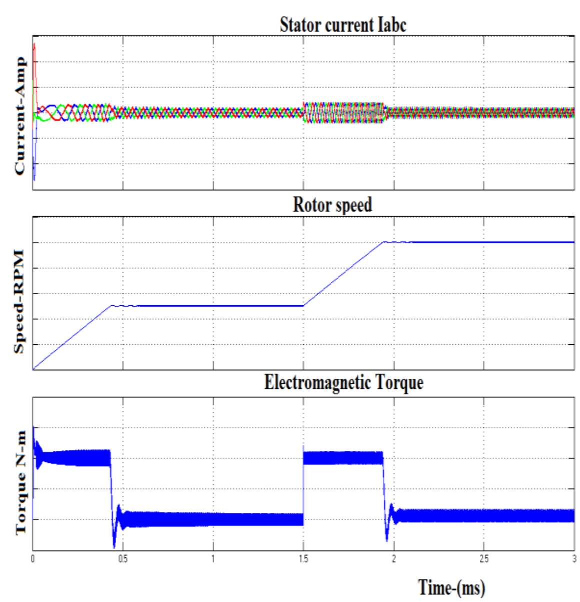

Fig: 5 Performance of induction motor with step change in load torque and speed

ISSN: 2278 – 7798

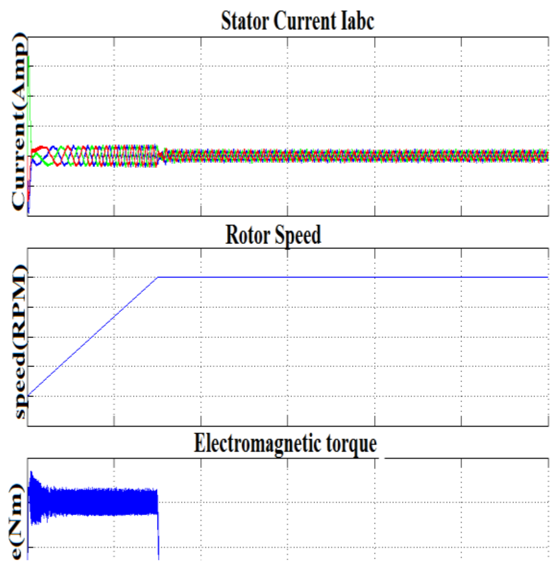

Fig: 6 Performance of induction motor without step change in load torque and speed

5.1 PERFORMANCE MEASUREMENT OF PID CONTROLLER

The performance measurement of PID controller is achieved with the help of IAE (Integral absolute error) and ITAE (Integral time-weighted absolute error). The IAE and ITAE value of PID controller for induction motor drive is shown in the table below. The performance measurement is shown in table 1.

Table: 1 performance measurement of PID controller

Controller	***IAE***	***ITAE***
PID	212.7	391.7

VI. CONCLUSION

This paper presents a speed control of induction motor using PID controller. In large perspective the overall performance of a drive under different operating conditions is improved with conventional PID controller. The performance measure of conventional PID controller is achieved with the help of IAE (Integral absolute error) and ITAE (Integral time-weighted absolute error).

It has been formally established that the controllers actually meets the performance comparisons which is shown in table 1 and it has been designed to achieve, satisfactory rotor speed reference tracking over a wide range of speed reference variation. These results have been confirmed by a simulation study.

APPENDIX

Parameters	**Rated values**
Power	50 hp
Voltage	460 V
Frequency	60 Hz
Stator/rotor resistances	0.087/0.228 Ω
Stator/rotor inductances	0.8e-3 H
Mutual inductance	34.7e-3 H
Pole pairs	2
Inertia	1.662 J

REFERENCE

[1] A. El Fadili, F. Giri, A. El Magri, R. Lajouad, F.Z. Chaoui,. 2012 Towards a global control strategy for induction motor: Speed regulation, flux optimization and power factor correction... GREYC Lab., University of Caen, Caen, France

[2] B.K. Bose. 1986. Power electronics and ac drives. Prentice hall Inc., Englewood Cliffs,

[3] Pradeep B Jyoti, J.Amarnath, and D.Subbarayudu, Volume 4, Issue 3, May - June (2013), pp. 121-127, Application of Neuro-Fuzzy Controller In Torque Ripple Minimization Of Vector Controlled Vsi Induction Motor Drive.

ISSN: 2278 – 7798

[4] A. El Fadili, F. Giri, A. El Magri, L. Dugard, H. Ouadi.2011 American Control Conference on O'Farrell Street, San Francisco, CA, USA June 29 - July 01, 2011, Induction Motor Control in Presence of Magnetic Saturation: Speed Regulation and Power Factor Correction

[5] Lingji Chen*, Kumpati S. Narendra, Automatica 37 (2001) 1245}1255, Nonlinear adaptive control using neural networks and multiple models

[6] Jasinski M, Cichowlas M, Kazmierkowski MP. Direct control for AC/DC/AC converter-fed induction motor with active filtering function. Int J Computer Math Electrical Electronic Eng 2006; 25:235–42.

[7] Mohammad. Abdul Mannan, Toshiaki Murata, Junji Tamura,Takeshi Tsuchiya, "Indirect Field oriented control for high performance induction motor drives using space vector modulation with consideration of core loss", in proc. IEEE 34th Annual conf. power electronics, pp.1449-1454 ,2003.

[8] C.Attainese, V.Nardi, and G.Tomasso, "Space vector modulation algorithm for power losses and THD reduction in VSI based drives," Electrical power components and systems, vol.35, pp.1271-1283, 2007.

[9] B.Karthikeyan1 & D.Sri Vidhya2, International Journal of Communications and Engineering *Volume 05– No.5, Issue: 02 March2012*, Performance Analysis Of Neuro-Fuzzy Based Speed Control Of Three Phase Induction Motor.

[10] Ashok Kusagur,Dr. S. F. Kodad, Dr. B V. Sankar Ram, Modeling, Design & Simulation of an Adaptive Neuro-Fuzzy Inference System (ANFIS) for Speed Control of Induction Motor, International Journal of Computer Applications (0975 – 8887)Volume 6– No.12, September 2010

Jegadeeswari G was born in Pondicherry, India on June 15, 1990. She received her M.Tech degree in Power Electronics and Drives (First class with Distinction) at Sri Manakula Vinayagar Engineering College, Pondicherry University, India in 2014. She received her B.Tech degree in Electrical and Electronics Engineering (With First class) from Regency Institute of Technology, Yanam, (AP). Pondicherry University 2011. She works in the field of Power electronics and induction motor drive Applications.

Arun Kumar R was born in Pondicherry, India on September 29, 1991. He is a PG scholar pursuing his M.Tech in Power Electronics and Drives (First Class) at Sri Manakula Vinayagar Engineering College, Pondicherry University, India in 2015. He received his B.Tech degree in Electrical and Electronics Engineering at Manakula Vinayagar Institute of Technology, Pondicherry University in 2013.

Kalaivani S was born in Cuddalore, India on December 2, 1990. She received her M. Tech degree in Power Electronics and Drives at Sri Manakula Vinayagar Engineering College, Pondicherry University, India in 2014. She received her B.E degree in Electrical and Electronics Engineering from Thangavelu College of Engineering, Chennai, and (T.N) .Anna University in 2012.

Parthiban S was born in Pondicherry, India on March 27, 1992. He is a PG scholar pursuing his M.Tech in Power Electronics and Drives (First Class) at Sri Manakula Vinayagar Engineering College, Pondicherry University, India in 2015. He received his B.Tech degree in Electrical and Electronics Engineering at Manakula Vinayagar Institute of Technology, Pondicherry University in 2013.

ISSN: 2278 – 7798