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Comparative Study of PWM Control and PI Control of Induction Motor

Rohitash Singh[1], Saurabh Kr. Bajpai*[2], Harinder Singh Sandhu[3]
[1]Department of Electrical Engineering, SRGC, Muzaffarnagar, India
[2]Department of Electrical Engineering, Shobhit University, Saharanpur, India
[3]Department of Electrical Engineering, AIET, Faridkot, India
*Corresponding author, email: rohit_singh81@rediffmail.com[1], saurabhbajpai897@gmail.com[2],
harindersinghsandhu@gmail.com[3]

Abstract

The induction motor is without doubt the most used electrical motor because of its unique characteristics. Most of its applications need fast and intelligent speed control system. This paper presents comparison of the intelligent and advanced speed control methods based on PWM technique and PI controller to achieve maximum torque and efficiency. Simulation is carried out in MATLAB environment and results are investigated for speed control of induction motor without any controller and with PI controller on full load condition.

***Keywords**: Induction Motor, PWM Technique, PI controller*

1. Introduction

Be it domestic application or industry, motion control is required everywhere. The systems that are employed for this purpose are called drives. Such a system, if makes use of electric motors is known as an electrical drive. In electrical drives, use of various sensors and control algorithms is done to control the speed of the motor using suitable speed control methods [1-3]. The basic block diagram of an electrical drive is shown Figure 1.

Earlier, only DC motors were employed for drives requiring variable speeds due to ease of their speed control methods [1,4]. The conventional methods of speed control of an induction motor were either too expensive or too inefficient thus restricting their application to only constant speed drives. However, modern trends and development of speed control methods of an induction motor have increased the use of induction motors in electrical drives extensively. In most of industrial drive control applications, the standard method to control squirrel cage induction motors is based on the field-oriented or vector control principle in order to achieve the best dynamic behavior [5]. There are essentially two general methods of vector control. One called the direct or feedback method, and the other, the indirect or feed forward method.

Induction motor can be controlled with the help of PWM Control and conventional PI controller with the use of vector control technique. The conventional proportional integral controller increases the order of the system, improves damping, and reduces maximum overshoot, decreases bandwidth and increase the rise time [6-8]. In this article we will discuss the PWM Control and conventional PI controller. Finally we will present the simulation result for speed control of induction motor using these controllers with a brief discussion.

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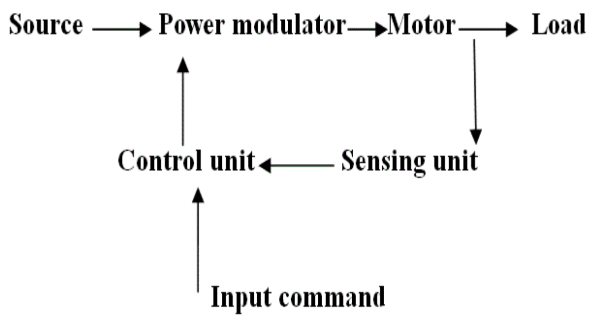


Figure 1.1 Block diagram of induction motor drive

2. Induction Motor Control

The dynamic analysis of the symmetrical induction machines in the arbitrary reference frame has been intensively used as a standard simulation approach from which any particular mode of operation may then be developed. Matlab/Simulink has an advantage over other machine simulators in modeling the induction machine using dq0 axis transformation. It can be a powerful technique in implementing the machine equations as they are transferred to a particular reference frame [4-6]. Thus, every single equation among the model equations can be easily implemented in one block so that all the machine variables can be made available for control and verification purposes as Figure 2.

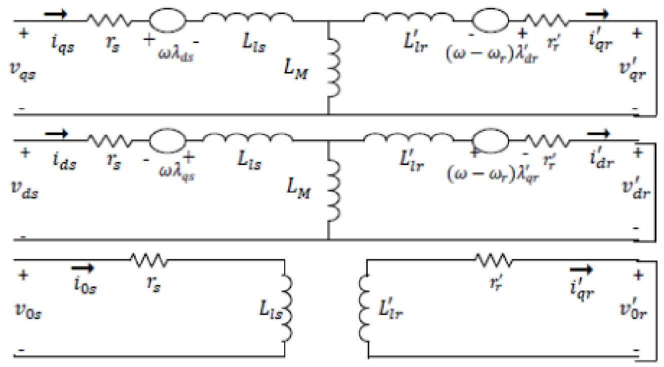


Figure 2. dq0 equivalent circuit of an induction motor

$$\frac{d\psi_{qs}}{dt} = \omega_b \left[V_{qs} - \frac{\omega_e}{\omega_b}\psi_{ds} + \frac{R_s}{X_{ls}}(\psi_{mq} - \psi_{qs})\right] \tag{1}$$

$$\frac{d\psi_{ds}}{dt} = \omega_b \left[V_{ds} - \frac{\omega_e}{\omega_b}\psi_{qs} + \frac{R_s}{X_{ls}}(\psi_{md} - \psi_{ds})\right] \tag{2}$$

$$\frac{d\psi_{qr}}{dt} = \omega_b \left[V_{qr} - \frac{(\omega_e - \omega_r)}{\omega_b}\psi_{dr} + \frac{R_r}{X_{lr}}(\psi_{mq} - \psi_{qr})\right] \tag{3}$$

$$\frac{d\psi_{dr}}{dt} = \omega_b \left[V_{dr} - \frac{(\omega_e - \omega_r)}{\omega_b}\psi_{qr} + \frac{R_r}{X_{lr}}(\psi_{md} - \psi_{dr})\right] \tag{4}$$

Where

$$\psi_{mq} = X_{ml}\left[\frac{\psi_{qs}}{X_{ls}} + \frac{\psi_{qr}}{X_{lr}}\right] \tag{5}$$

$$\psi_{md} = X_{ml}\left[\frac{\psi_{ds}}{X_{ls}} + \frac{\psi_{dr}}{X_{lr}}\right] \quad (6)$$

$$X_{ml} = \frac{1}{\frac{1}{X_m} + \frac{1}{X_{ls}} + \frac{1}{X_{lr}}} \quad (7)$$

Then substituting the values of the flux linkages to find the currents

$$i_{qs} = \frac{1}{X_{ls}}(\psi_{qs} - \psi_{mq}) \quad (8)$$

$$i_{ds} = \frac{1}{X_{ls}}(\psi_{ds} - \psi_{md}) \quad (9)$$

$$i_{qr} = \frac{1}{X_{lr}}(\psi_{qr} - \psi_{mq}) \quad (10)$$

$$i_{dr} = \frac{1}{X_{lr}}(\psi_{dr} - \psi_{md}) \quad (11)$$

Based on the above equations, the torque and rotor speed can be determined as follows

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\frac{1}{\omega_b}(\psi_{ds} i_{qs} - \psi_{qs} i_{ds}) \quad (12)$$

$$\omega_r = \int \frac{P}{2J}(T_e - T_L) \quad (13)$$

Where
P = number of poles
J = moment of inertia (Kg/m^2)
For squirrel cage induction motor, the rotor voltages V_{qr} and V_{dr} in the flux equations are set to zero since the rotor cage bars are shorted. After driving the torque and speed equations in term of d-q flux linkages and currents of the stator, the d-q axis transformation is used to the machine input (stator) voltages.

3. PI Controller

The combination of proportional and integral term is important to increase the speed of the response and also to eliminate the steady state error. The PID controller block is reduced to P and I blocks only as shown in Figure 3. The proportional and integral terms is given by

$$u(t) = K_p e(t) + K_i \int e(t)\, dt \quad (14)$$

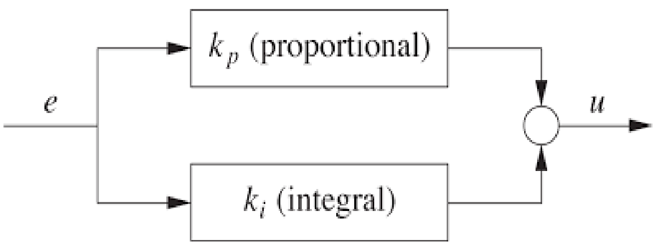


Figure 3. Block diagram of PI controller

4. Development of Simulink Model

The speed performance of induction motor is checked first without any controller and then with the help of PWM Control and PID controller. The simulink model is developed in the MATLAB which is shown in following Figures 4, 5 and 6.

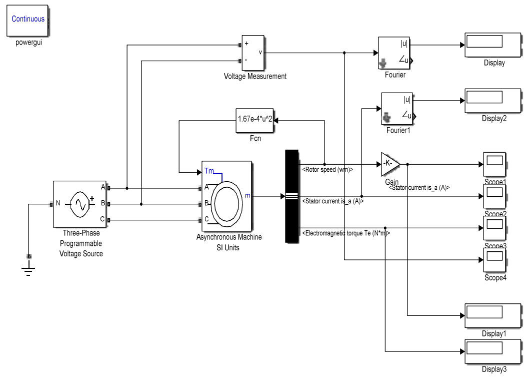


Figure 4. SIMULINK model of 3-Φ induction motor without controller

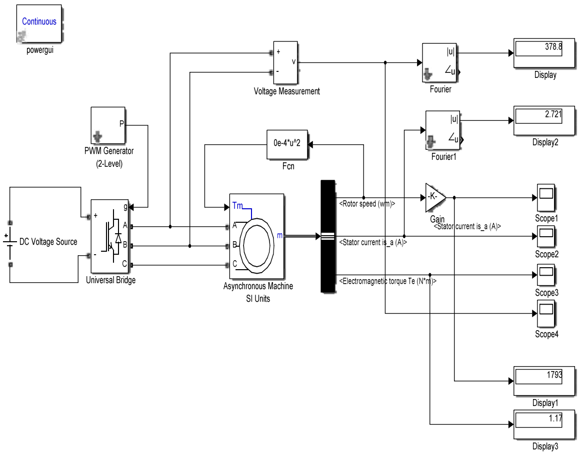


Figure 5. SIMULINK model of 3-Φ induction motor with PWM control

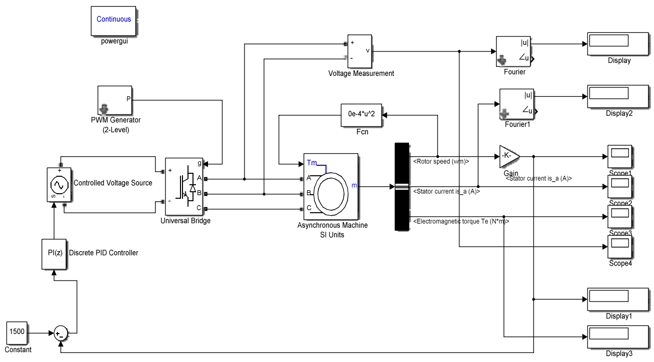
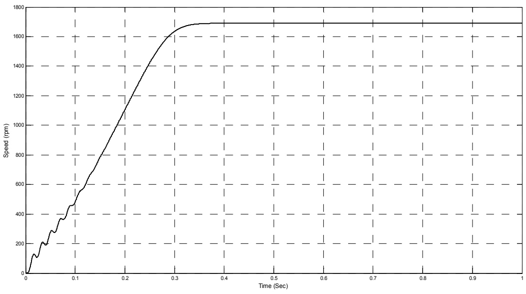


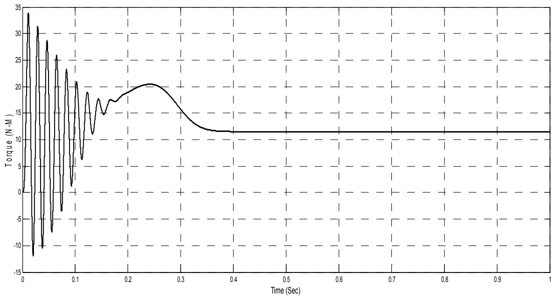
Figure 6. SIMULINK model of 3-Φ induction motor with PI controller

5. Simulation Result

In this paper, a 3-Φ, 3 hp, 220 V, 50 Hz squirrel cage induction motor has been simulate in SIMULINK to study the dynamic performance of the motor with and without controllers and the results are obtained for the speed v/s time on full load condition. The speed response of Induction motor is checked for without controller, with PWM control and PI controller which are shown in Figure 7, 8 and 9.

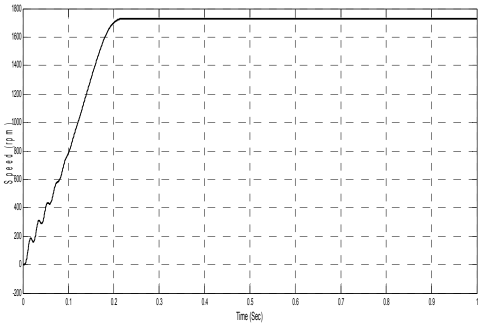


(a) Speed

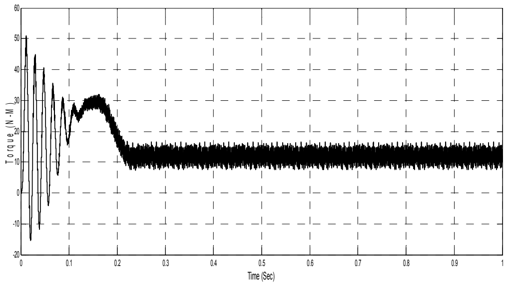


(b) Torque

Figure 7. Performance parameters of induction motor at full load without controller

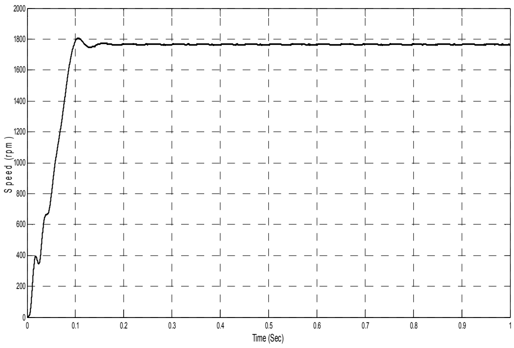


(a) Speed

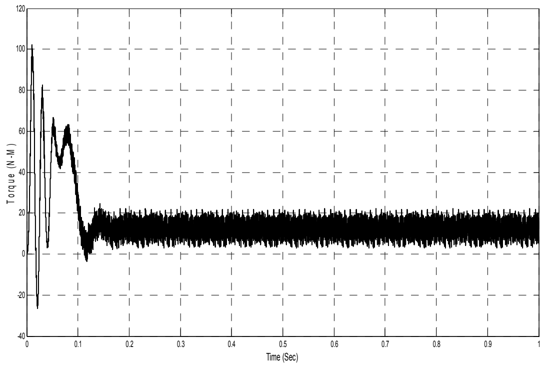


(b) Torque

Figure 8. Performance parameters of induction motor at full load with PWM control



(a) Speed



(b) Torque

Figure 9. Performance parameters of induction motor at full load with PI control

6. Comparison

The following figure shows the comparative speed responses without controller and with PWM control and PI controller.

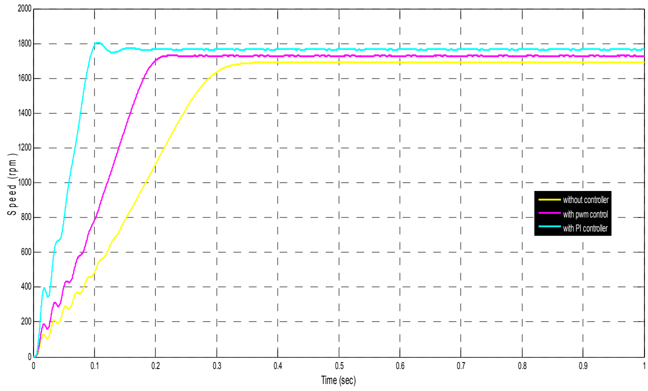


Figure 10. Comparison of speeds response

From this we come to know that PI controller is better to improve the speed performance of induction motor. The speed of induction motor using PID controller settled early. The comparative results are also

Table 1. Comparison of speed of induction motor, without controller and with controllers

Parameters	Without controller	With PWM control	With PI controller
Speed (rpm)	1691	1728	1765
Settling time (sec)	0.34	0.28	0.22
Rise time (sec)	0.31	0.21	0.09
Stator current (A)	9.5	7.78	6.32

7. Conclusion

Simulation is carried out in MATLAB environment for speed control of induction motor for full load condition, using PWM control and PI controller. The results are checked and compared. From the comparison we conclude that, the PI controller gives better speed response.

References

[1] Aleck W Leedy. "Simulink / MATLAB Dynamic Induction Motor Model for Use as A Teaching and Research Tool". *International Journal of Soft Computing and Engineering (IJSCE)*. ISSN: 2231-2307, 2013; 3(4).

[2] Sifat Shah, A Rashid, MKL Bhatti. "Direct Quadrate (D-Q) Modeling of 3-Phase Induction Motor Using Matlab/Simulink". *Canadian Journal on Electrical and Electronics Engineering*. 2012; 3(5).

[3] Sunita Kumari Jain, Fanibhushan Sharma, Mukesh Kumar Baliwal. "Modelling and Simulation of an Induction Motor". *International Journal of Engineering Research and Development* e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com. 2014; 10(4): 57-61.

[4] CS Sharma, Tali Nagwani. "Simulation and Analysis of PWM Inverter Fed Induction Motor Drive". ISSN: 2278 – 7798 *International Journal of Science, Engineering and Technology Research (IJSETR)*. 2013; 2(2).

[5] Madhavi L Mhaisgawali, Prof Mrs SP Muley. "Induction Motor Speed Control using PID Controller". *International Journal of Technology and Engineering Science*. 1(2): 151 – 155.

[6] E Anbarasu, M Karthikeyan. "Modelling of Induction Motor and Fault Analysis", ISSN: 2319-5967 ISO 9001:2008 Certified *International Journal of Engineering Science and Innovative Technology (IJESIT)*. 2013; 2(4).

[7] Manish Kumar Singh, Madhur Chauhan, Amit Kumar Singhal, Nitin Saxena. "A Methodology to Develop a Simulink Model of Three Phase Induction Motor". *International Journal of Emerging Technology and Advanced Engineering ISSN 2250-2459 (Online)*, 2014; 4(1).

[8] A Sangeetha, B Parthiban. "Review of Modeling and Dynamic Analysis of Three Phase Induction Motor Using MATLAB Simulink". *International Journal of Science, Engineering and Technology Research (IJSETR).* 2014; 3(3).