International Journal of Information & Computation Technology.
ISSN 0974-2239 Volume 4, Number 12 (2014), pp. 1185-1193

http://www. irphouse.com

Speed Control of 3-Phase Induction Motor Using Self-Tuning Fuzzy PID Controller and Conventional PID Controller

Kamini Devi[1], Shailendra Gautam[2], Deepak Nagaria[3]

[1]*M.Tech (Control System), Electrical Engineering, N.I.T.M. College, Gwalior (M.P), INDIA*
[2]*M.Tech (Power Electronics), Electrical Engineering, T.I.T. College, Bhopal (M.P), INDIA*
[3]*Reader and Head Electrical Engineering B.I.E.T., Jhansi (U.P.), INDIA*

ABSTRACT

This paper presents a rule-based fuzzy logic controller applied to a scalar closed loop Volts/Hz induction motor (IM) control with slip regulation and its simulation results. They are also compared with those of a PID controller. The IM is model in terms of d-q windings, with synchronous frame associated with the frequency ω_s of the stator excitation. The results obtained in the simulation are interesting, considering the presence of strong non-linearity in the IM model. A fuzzy logic control for a speed control of Induction motor the simulation developed by using Fuzzy MATLAB Toolbox and SIMULINK. The fuzzy logic controller is also introduced to the system for keeping the motor speed to be constant when the load varies. This is the low maintenance and robustness induction motors have many applications in the industries.

Keywords: Fuzzy Logic Controller, Induction Motor, V/F Speed Control, PID Controller, MATLAB Simulink.

Introduction

The Fuzzy Logic Toolbox draws upon these capabilities to provide a powerful tool for fuzzy system design, analysis, and simulation. This technical brief describes the use of the Fuzzy Logic Toolbox to solve a typical control design problem. It can also add control where it was previously impractical, as applications such as fuzzy-controlled washing machines have shown. However, fuzzy control need not be a dramatic departure from conventional control techniques such as proportional integral derivative (PID) feedback systems This paper will focus only on FLC techniques and the comparison with the classical PID controller. [1, 2]

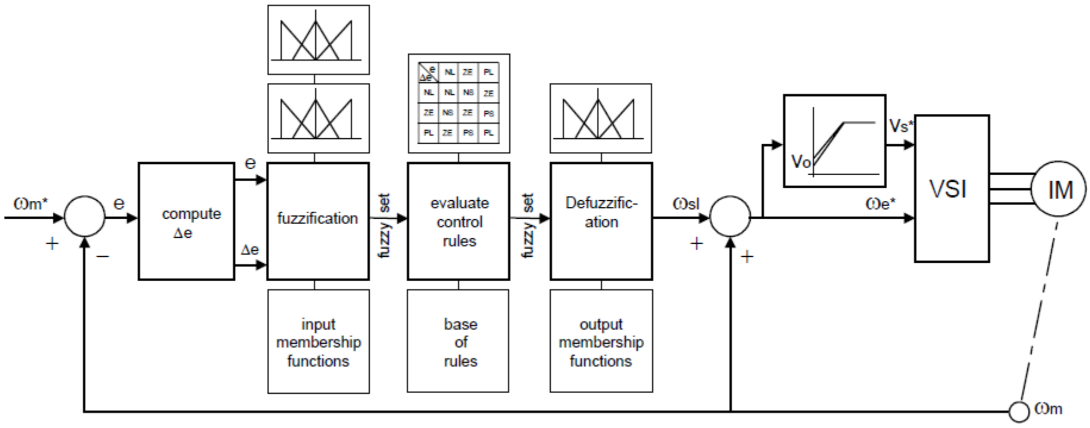


Fig1: basic block diagram of speed control of induction motor using FLC

Fuzzy Logic Controller:

MATLAB Fuzzy logic Toolbox is use to design fuzzy logic controller. Basically, the Fuzzy Logic controller consists of four basic components: fuzzification, a knowledge base, inference engine, and a defuzzification interface.The addition of fuzziness to data in fuzzy logic is called the fuzzification .fuzzy linguistic description are formal representation of system made through fuzzy IF-THEN rules. They encoded knowledge about a system in statements of the form- IF (a set of conditions) are satisfied then (a set of consequents) can be inferred. The conversion of a fuzzy set to single crisp value is called defuzzification. [3, 4]

In Mamdani type FIS the crisp result is obtained by defuzzification, in the Mamdani FIS can be used for both multiple inputs and single output and multiple inputs multiple outputs system [5].

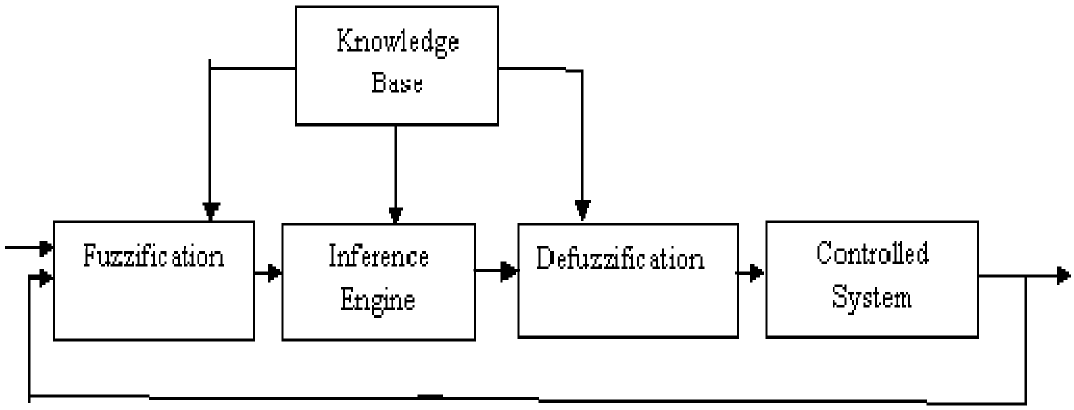


Fig.2. Basic configuration of fuzzy logic controller

PID Controller:

PID controllers are composed of three basic control modes i.e. proportional mode integral mode and derivative mode. They are simple to implement and provide good performance. A PID controller does not "know" the correct output to bring the system to the set point. It moves the output in the direction which should move the process toward the set point and needs to have feedback to perform [8].

The PID controller has the following form in the time domain:

$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt} \quad (1)$$

Table1: Basic control action [8]

Proportional control	$u(t) = k_p e(t)$
Integral control	$u(t) = k_i \int_0^t e(t)dt$
Derivative control	$u(t) = k_d \frac{de(t)}{dt}$

V/F control

The *base speed* of the induction motor is directly proportional to the supply frequency and the number of poles of the motor. Since the number of poles is fixed by design, the best way to vary the speed of the induction motor is by varying the supply frequency. The torque developed by the induction motor is directly proportional to the ratio of the applied voltage and the frequency of supply. By varying the voltage and the frequency, but keeping their ratio constant, the torque developed can be kept constant throughout the speed range. *Figure 3* shows the typical torque-speed characteristics of the induction motor, supplied directly from the main supply. *Figure 4* shows the torque-speed characteristics of the induction motor with V/F control [7]

$$\emptyset_{ag} = constant = \frac{E_{ag}}{f} = \frac{V}{f} \quad (2)$$

Where: V = *applied voltage*, f = *supply frequency*, E_{ag} = *counter e.m.f*

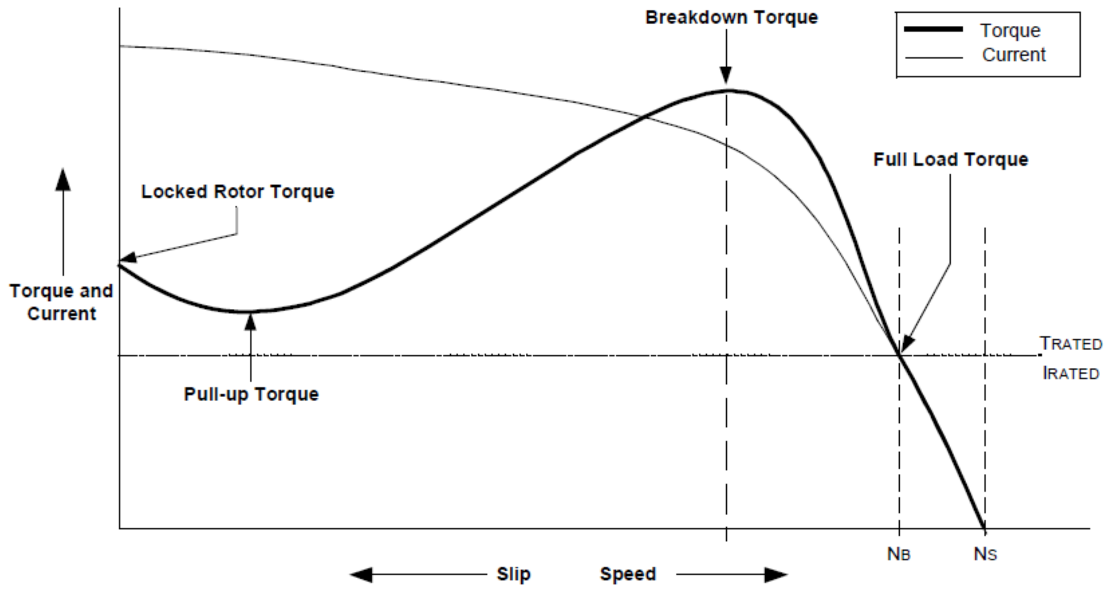


Fig.3. Torque-speed characteristics of induction motor [7]

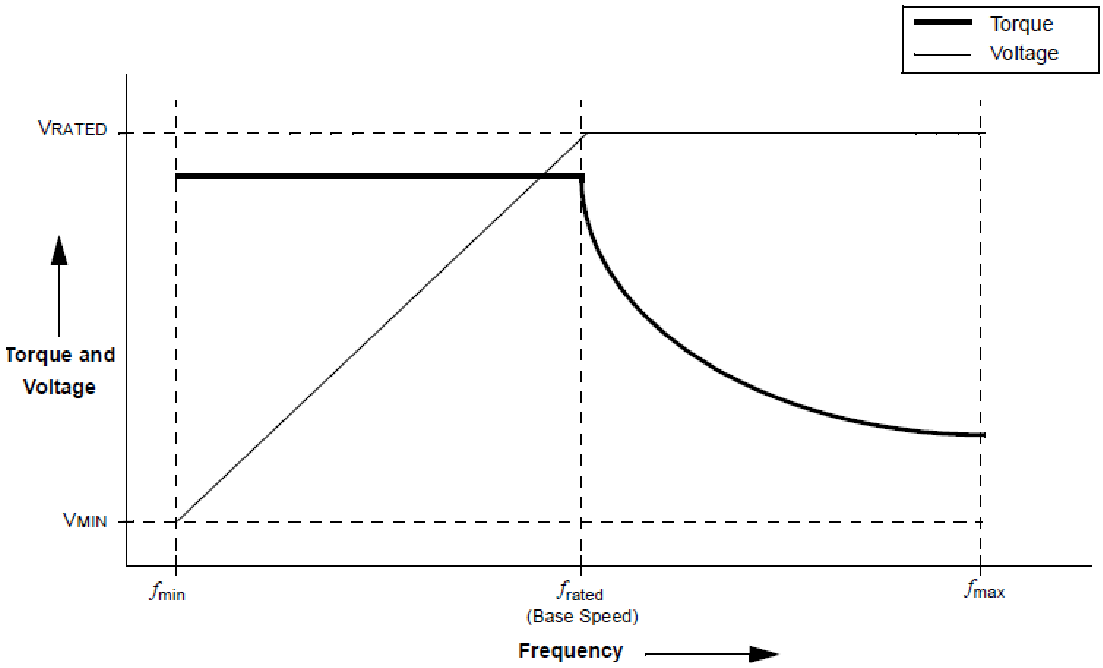


Fig.4. torque-speed characteristics of induction motor VF control [7]

Induction Motor Dynamic Model

The induction motor is modelled with Matlab/Simulink program running under three phase sinusoidal symmetrical excitation and is at vectorized form in conformity with state vector formulation. Synchronous frame is used where [1]

$\omega_k = \omega_m$ and theta k = ω_0 , and where:

ω_0 = base frequency. (Rad/sec)

ω_m = rotor frame frequency. (Rad/sec)

ω_k = dq frame frequency. (Rad/sec)

ω_s = synchronous frame frequency. (Rad/sec)

λ_s =stator flux, λ_r =rotor flux *(pu)*

R_s, R_r =stator and rotor resistance *(pu)*

V_s , V_r =stator and rotor voltage (pu)

i_s, i_r =stator and rotor current (pu)

L_s , L_r= stator and rotor inductance *(pu)*

L_m = magnetizing inductance (pu)

L_{sl} = stator leakage inductance (pu)

L_{sl} = rotor leakage inductance (pu)

T_e = electromagnetic torque (pu)

T_L = load torque (pu)

B_m = viscous friction coefficient. (pu)

d, q=direct and quadrature axis

p=number of poles

H= inertia constant (s)

Operators: ⊗ =cross product; • =dot product

Flux linkage- current relation

On d axis:

$$\lambda_{sd} = L_s i_{sd} + L_m i_{rd} \quad (3)$$

$$\lambda_{rd} = L_m i_{sd} + L_r i_{rd} \quad (4)$$

Where

$$L_s = L_m + L_{sl} \quad (5)$$

$$L_r = L_m + L_{rl} \quad (6)$$

On q axis:

$$\lambda_{sq} = L_s i_{sq} + L_m i_{rq} \quad (7)$$

$$\lambda_{qr} = L_m i_{qs} + L_r i_{qr} \quad (8)$$

Electrical system Equation

$$V_s = R_s i_s + \frac{1}{\omega_0}\left(\frac{d\lambda_s}{dt}\right) + \omega_k M_{(Pi/_2)}\lambda_s \quad (9)$$

$$V_r = R_i i_r + \frac{1}{\omega_0}\left(\frac{d\lambda_r}{dt}\right) + (\omega_k - \omega_m)M_{(Pi/_2)}\lambda_r \quad (10)$$

$$\lambda = \begin{bmatrix}\lambda_d \\ \lambda_q\end{bmatrix}, i = \begin{bmatrix}i_d \\ i_q\end{bmatrix}, M_{(Pi/_2)} = \begin{bmatrix}0 & -1 \\ 1 & 0\end{bmatrix} \quad (11)$$

Mechanical system Equations

$$T_e = 2H\frac{d\omega_{mec}}{dt} + B_m\omega_{mec} + T_L \quad (12)$$

$$T_e = \lambda_s \otimes i_s = M_{(Pi/_2)}.\lambda_s \bullet i_s \quad (13)$$

$$\omega_{mec} = \frac{2}{P}\omega_m \tag{14}$$

Simulation Result

The response of the controller will be investigated with the Matlab/Simulink® simulation program, the Fuzzy logic, and SimPower Systems toolbox. [1]

6.1 implementation of speed control of induction motor using fuzzy logic controller

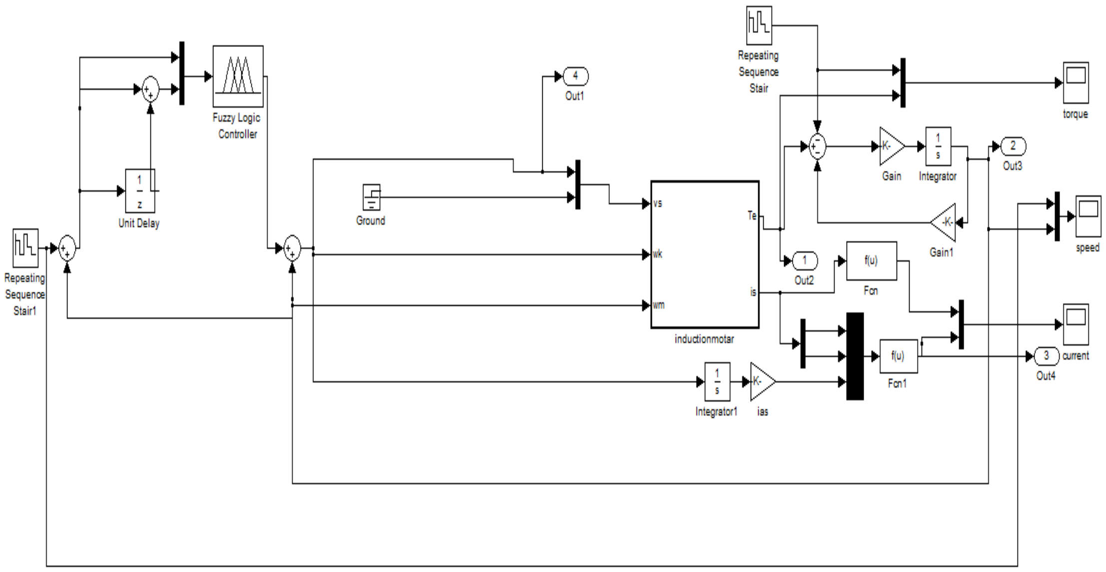
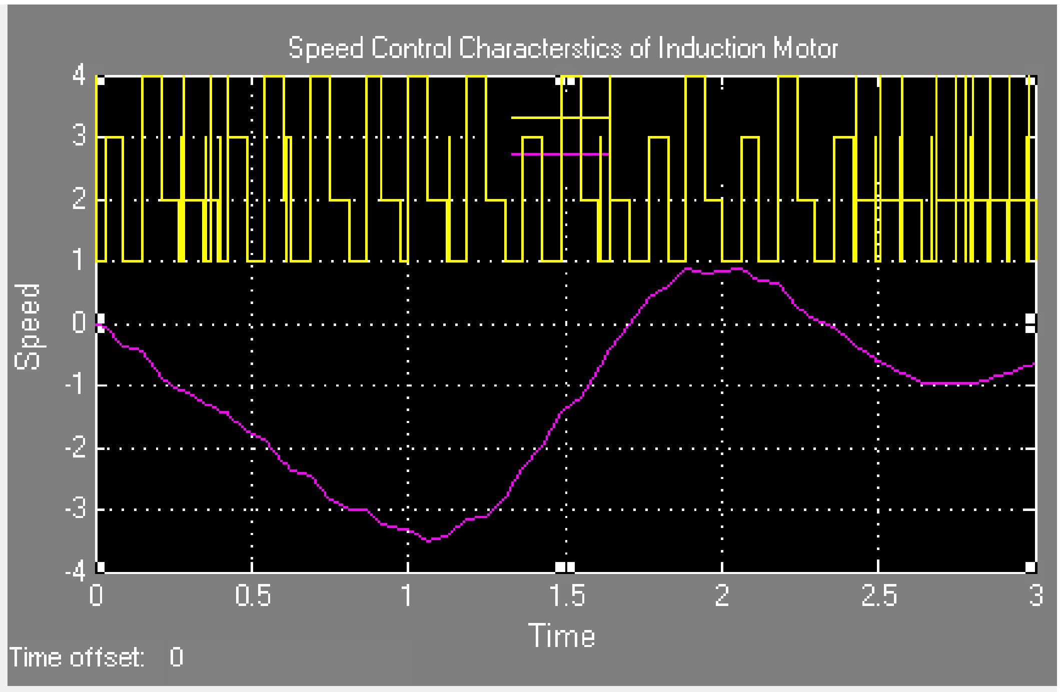
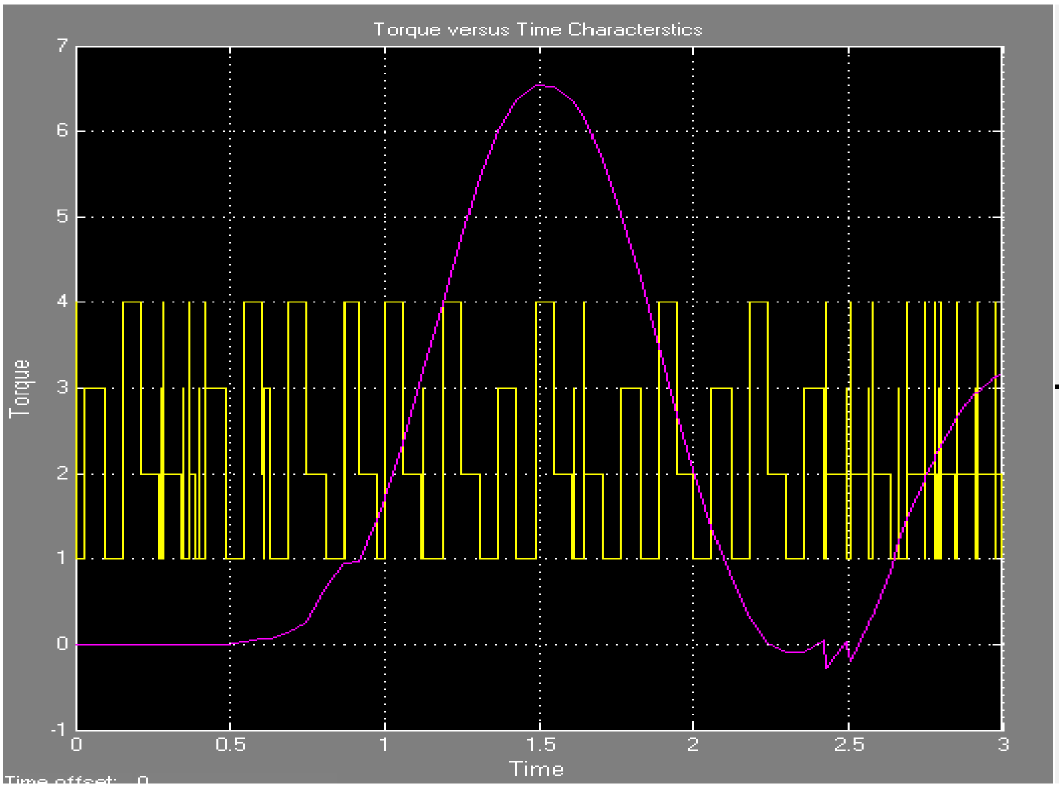
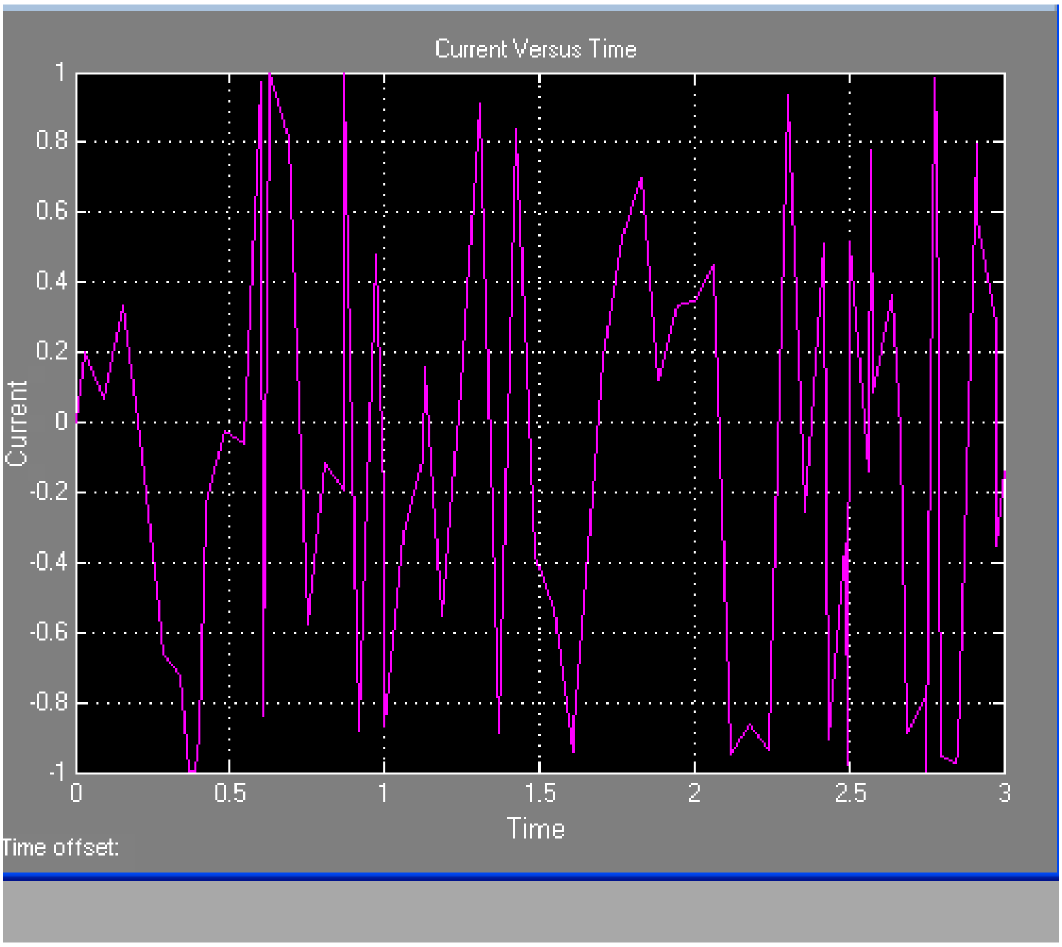


Fig.5.Circuit diagram of speed control of induction motor using FLC in Simulink

6.1.1 *Result of Speed, Torque and Current Characteristics of Induction Motor*







Conclusion

This paper shows that the result of fuzzy logic controller PID shows better output as compared to conventional PID. This paper shows that both simulation and experimental results confirmed that the fuzzy logic approach is feasible and can be an interesting alternative to conventional control, even when the system model is known and linear.

References

[1] A fonso, J.L., Fonseca, J., Martins, J.S., Couto, C.A., "*Fuzzy logic techniques applied to the control of a three-phase induction motor*", Industrial Electronics, ISIE '97, Proceedings of the IEEE International Symposium on, 3, Guimaraes, Portugal, 1179-1184, (1997).

[2] Bose Bimal K., "*Modern Power Electronics and AC Drives*", Prentice Hall PTR, Upper Saddle River, (2002).

[3] Mohd Shahrieel Mohd Aras, Eric Chee Sai Hoo, Mohd Hendra bin Hairi, Syed Najib Bin Syed Salim, Intan Azmira binti Wan Abd Razak, "*Comparison of*

Fuzzy Control Rules using MATLAB Toolbox and Simulink for DC Induction Motor-Speed Control", 2009 International Conference of Soft Computing and Pattern Recognition.

[4] S. Rajasekaran, G.A. Vijaylakshmi Pai"*Neural Networks, fuzzy logic, and genetic algorithms synthesis and applications"*, Prentice Hall India, Eastern Economy Edition,(2005)

[5] Trapti Yadav, Deepti yadav, Nidhi Singh"*Self Tuning PID Controller using Fuzzy Inference Mamdani and Sugeno method on the AVR System*". International Journal of Applied Engineering Research ISSN: 0973-4562, Volume 8 No.12, 2013

[6] Ravi Maloth, "*Speed Control of Induction Motor Using Fuzzy Logic Controller*", National Conference on Electrical Sciences -2012 (NCES-12) ISBN: 978-93-81583-72-2

[7] Rakesh Parekh*, "VF Control of 3-Phase Induction Motors Using PIC16F7X7 Microcontrollers*", Microchip Technology Inc. ANN889

[8] Adel A. A. El-Gammal, "*A Modified Design of PID Controller For DC Motor Drives Using Particle Swarm Optimization PSO"* March, 2009.

[9] Bao-Gang Hu, George K. I. Mann, *"A systematic study of fuzzy Pid controllers-Function based evaluation approach"*.IEEE Transactions on Fuzzy Systems, vol.9, no. 5, October 2001.