Matlab Simulation Model Design of Fuzzy Controller based V/F Speed Control of Three Phase Induction Motor

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***Abstract*— During the past many years, fuzzy control has emerged in concert of the foremost active and fruitful areas for analysis within the applications of fuzzy theory, particularly within the realm of industrial processes, that don't lend themselves to regulate by standard ways owing to a scarcity of quantitative knowledge concerning the input-output relations. Fuzzy management is predicated on fuzzy logic-a system of logic that's abundant nearer in spirit to human thinking and linguistic communication than ancient logical systems. The fuzzy logic controller (FLC) based on fuzzy logic provides a way of changing a linguistic management strategy supported knowledgeable information into associate degree automatic control strategy.**

This methodology transfer a replacement method for speed system for induction motor that relies on fuzzy logic rather than obsolete indirect vector control PI controller as a speed regulator in outer speed loop. In obsolete methodology for speed system of a induction motor drive uses a voltage supply pulse width modulation inverter-fed vector management indirectly that has low preciseness for the speed control giving dangerous speed regulation characteristics and decreasing the performance of the total induction motor drive. To prevail over this PI controller by a involuntary sensing fuzzy system that relies on fuzzy set theory.

The execution of this automatic sensing fuzzy system may be inquired through digital simulation that relies on MATLAB-SIMULINK package. By victimization this digital simulation system the performance of fuzzy system may be seen by making variable in operation conditions by varied reference speeds and at totally different load torques.

The simulation study gives the comparative study of fuzzy controller, PI controller and PID controller.

Consequences of this digital simulation system show improved performance characteristics of the steered fuzzy system over the obsolete PI controller as a speed regulator in outer speed loop.

Keywords*— *Speed control, Three phase induction motor, fuzzy logic controller.

I. INTRODUCTION

The use of induction motors has redoubled hugely since the day of its invention. They are being used as actuators in varied industrial processes, robotics, house appliances (generally single phase) and different similar applications. The rationale for its day by day increasing quality can be primarily attributed to its strong construction, simplicity in style and value effectiveness. These have conjointly verified to be a lot of reliable than DC motors. Except for these benefits, they have some unfavorable options like their time varied and non-linear dynamics.

The field of power electronics has contributed immensely in the form of voltage-frequency converters which has made it possible to vary the speed over a wide range. However, the highly non-linear nature of the induction motor control dynamics demands strenuous control algorithms for the control of speed. The conventional controller types that are used for the aforementioned purpose are may be numeric or neural or fuzzy. The controller types that are regularly used are: Proportional Integral (PI), Proportional Derivative (PD), Proportional Integral Derivative (PID), Fuzzy Logic Controller (FLC) or a blend between them.

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The conventional control methods possess the following difficulties:

- Dependence on mathematical model of the system.
- Effect of load disturbance, motor saturation and thermal deviations.
- Decent performance exhibited only at one operating speed when classical linear control is employed.
- Need single coefficient for getting better result.

The advantages provided by a FLC are listed below:

- Simple design.
- Provide human intelligence to controller.
- It is cost effective.
- No mathematical modeling of the system is required.
- Linguistic variable are used as membership function for both input and output variable.
- Non-linearity of the system can be handled easily.
- Quick system response.
- More reliability.
- High degree of precision.

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II. PROPOSED METHODOLOGY

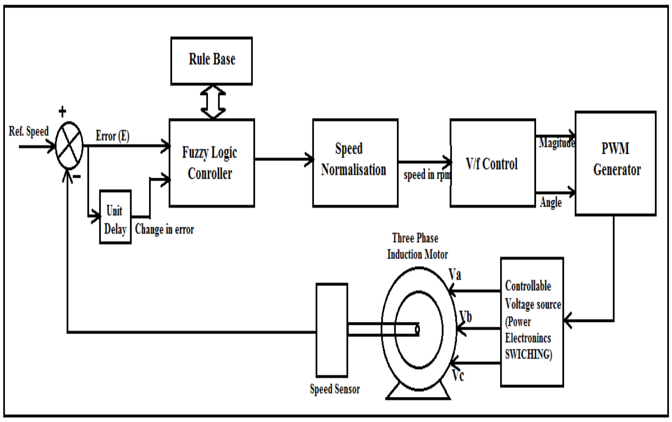

Fig.1.Block diagram of proposed methodology

Figure 1 shows the proposed methodology of fuzzy controller based speed control induction motor drive. In this methodology design of fuzzy logic controller introduce for speed control of induction motor. Fuzzy logic controller are total 49 fuzzy rule base system. The input for fuzzy controller are reference speed and actual speed error and change in error of same. Depending on input parameter fuzzy controller execute fuzzy rule base and control the magnitude and angle of V/f controller. That V/f controller output control the firing pulse of voltage source of induction motor using PWM generator circuit gain controlling technique.

III. SIMULATION MODEL

The proposed approach implemented using MATLAB digital simulation model. Figure 3 shows the complete simulation model of speed control of 230V, 1Hp, 60Hz induction motor drive.

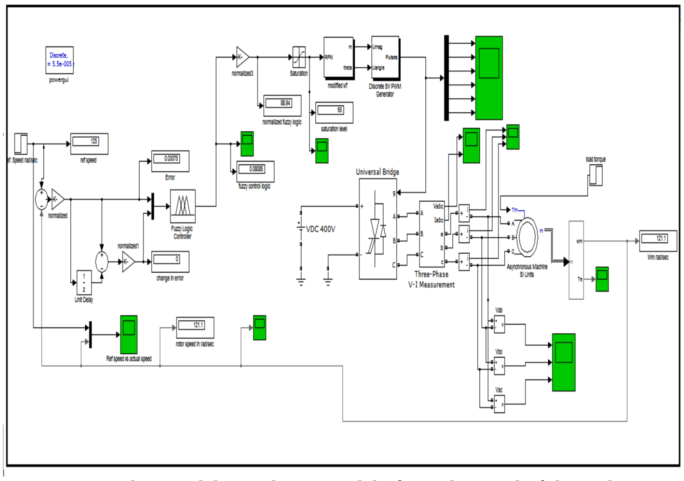

Fig.4. Complete matlab simulation model of speed control of three phase induction motor using fuzzy logic

TABLE I. Matlab Simulation Model parameter specification

Sr. No.	*Name of simulation block*	*Parameter specification of block*
1	Asynchronous Machine SI Units	Mechanical input = Torque Tm Rotor type = squirrel cage Nominal power = 4391.5 W Voltage (line-line) = 230V Frequency = 60 Hz Rotor Resistance = 0.25 Ohm Rotor inductance = 1.3262 mH Stator resistance = 0.5 Ohm Stator inductance = 1.989 mH
2	Universal Bridge	Number of bridge arm = 3 Snubber resistance Rs = 0.1 Mohm Switch = diode/IGBT

A. V/f Controller subsystem

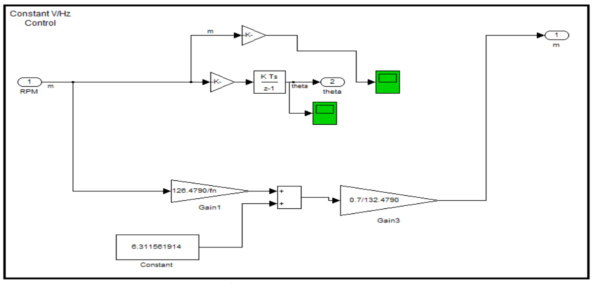

Fig.5. constant V/f control system simulation model

B.Fuzzy logic controller subsystem

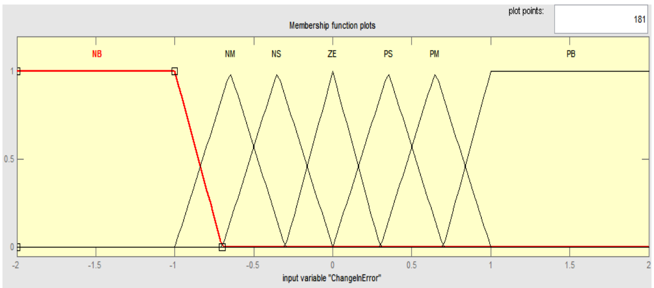

Fig.6. Fuzzy membership functions for error input signal.

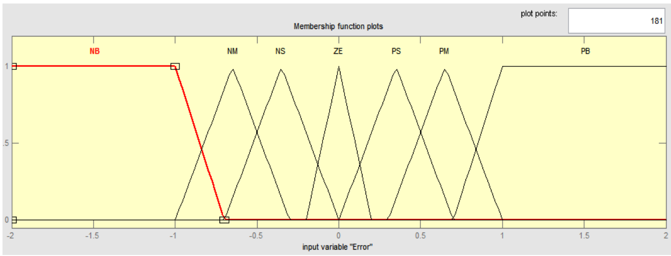

Fig.7. Fuzzy membership functions for change in error signal.

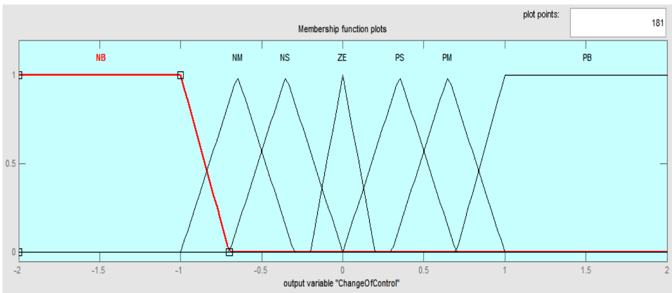

Fig.8. Fuzzy membership functions for fuzzy logic controller response.

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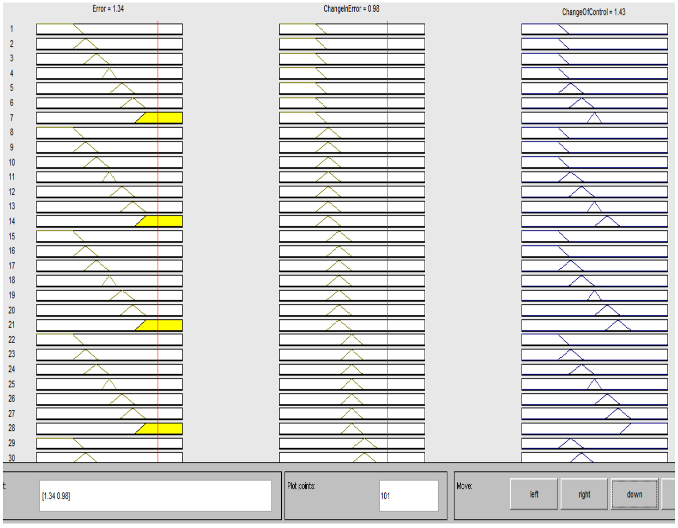

Fig.9. Fuzzy rule base for fuzzy logic controller output decision.

Figure 9 shows the fuzzy rule base system. Total 49 rules are generated based on error and change in error membership functions for generation of fuzzy logic controller output decision. Figure 9 shows the response of fuzzy logic controller for input of error signal 1.34 and change in error signal of 0.98 then change of control is 1.43. Figure 9 also shows the defuzzified value for real time control signal generation.

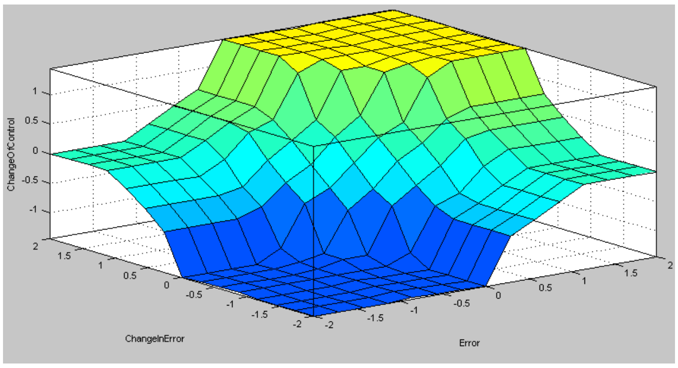

Fig.10. Fuzzy logic controller controllable region.

Figure 10 shows the fuzzy logic controller controllable reason for 49 fuzzy rule bases. The fuzzy rule base generated using error and change in error membership functions.

IV. SIMULATION RESULTS

In this section we discuss the simulation result of three phase induction motor speed control using fuzzy logic controller. The simulation results are broadly classified as speed control response for constant speed and for variable speed. Also similar results are compared with PI and PID controller speed control response.

A. Three phase induction motor parameter for constant speed control using FLC

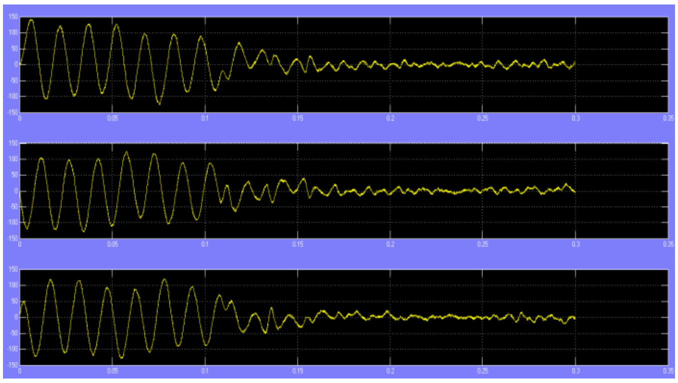

Fig.11. Three phase line current of three phase induction motor for 1200 rpm constant reference speed.

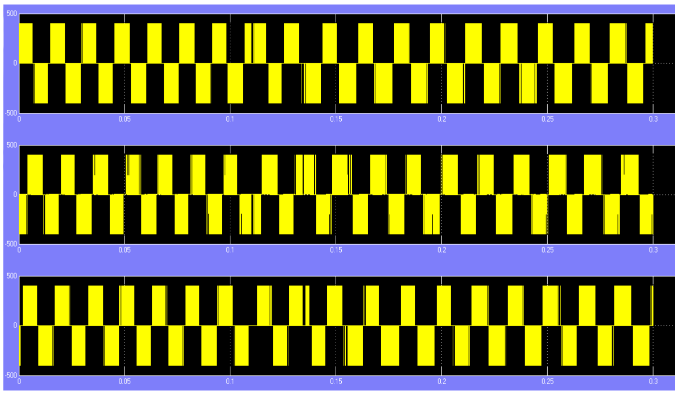

Fig.12. Three phase line voltage of three phase induction motor for 1200 rpm constant reference speed.

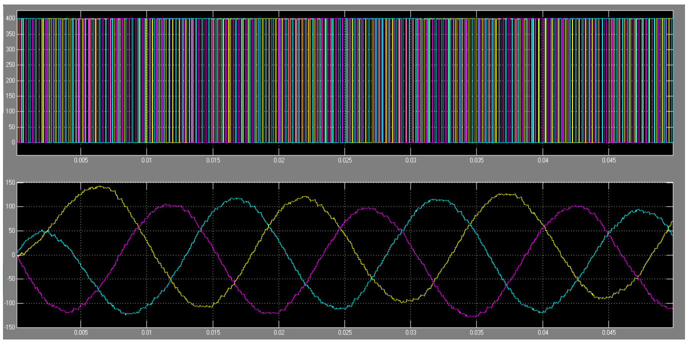

Fig.13.Three phase voltage and current of three phase induction motor for 1200 rpm constant reference speed.

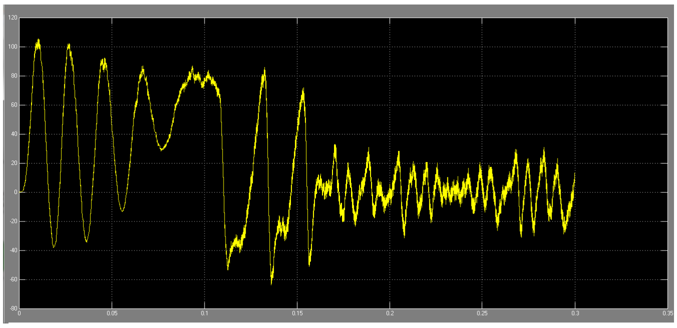

Fig.14. Three phase induction motor electromagnetic torque response for constant 1200 rpm reference speed.

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B. Result for constant Speed control by Fuzzy logic controller

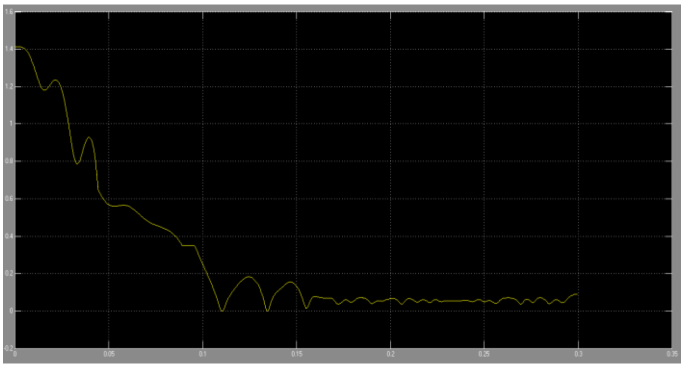

Fig.15. Fuzzy logic controller decision logic for constant 1200 rpm speed control.

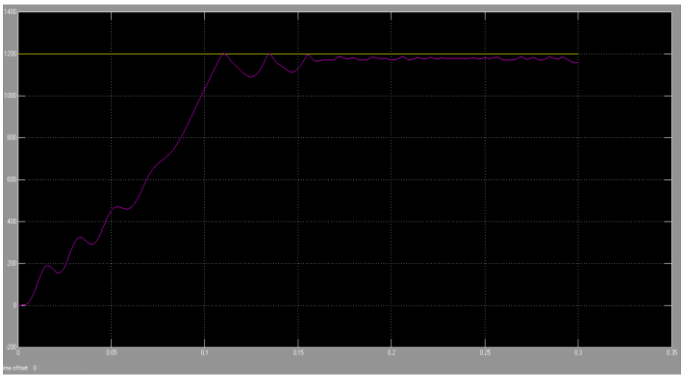

Fig.16. Speed response of three phase induction motor using fuzzy logic controller for constant 1200 rpm reference speed.

Figure 16 shows that 1200 rpm is speed requirement of user or this is reference speed for three phase induction motor shown by yellow line. Purple line shows the speed response of three phase induction motor using design fuzzy rule base fuzzy logic controller.

C. Result for constant speed using PI Controller

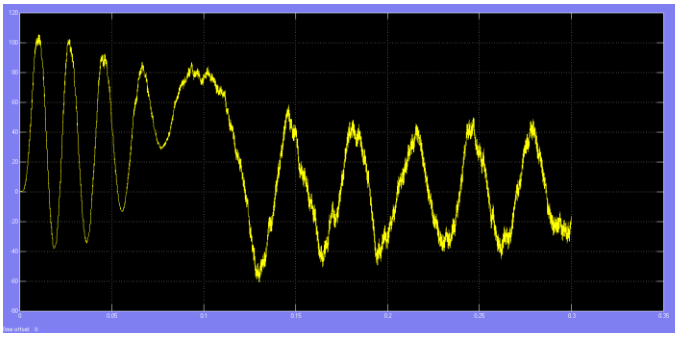

Fig.17. Electromagnetic torque of three phase induction motor for constant speed using PI controller.

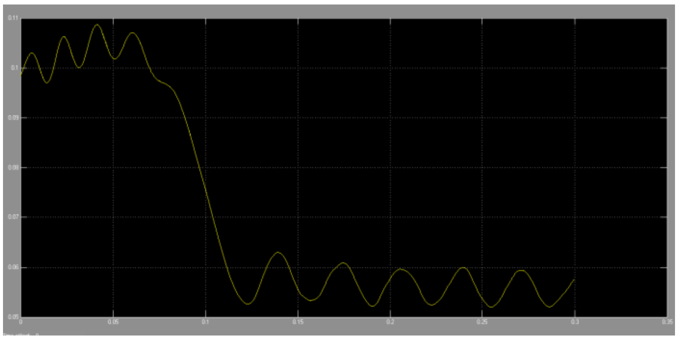

Fig.18. PI controller response for controlling gain of V/f controller for constant speed response.

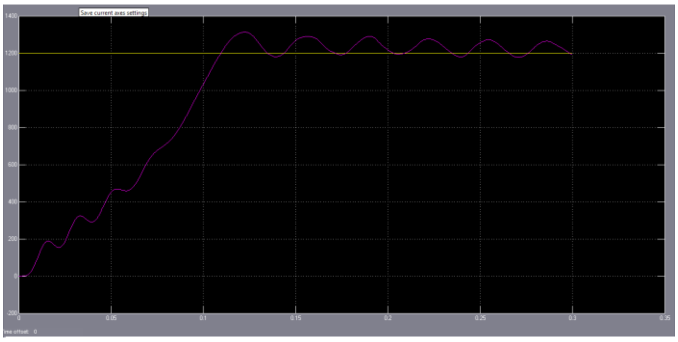

Fig.19. Speed control by PI controller for constant speed response.

D. Result for constant Speed control by PID controller

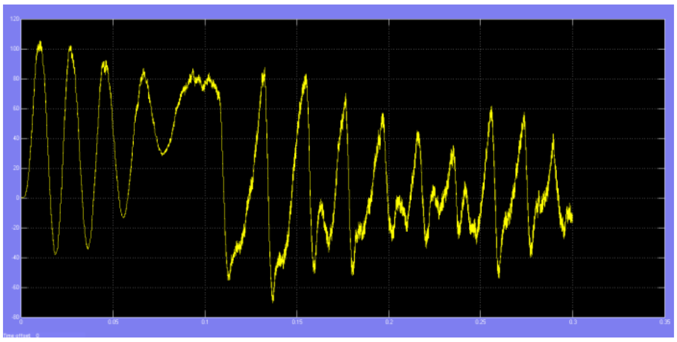

Fig.20. Electromagnetic torque of three phase induction motor for constant speed using PID controller.

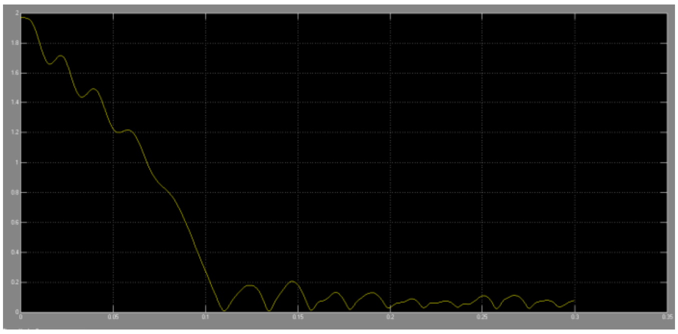

Fig.21.PID controller response for controlling gain of V/f controller for constant speed response.

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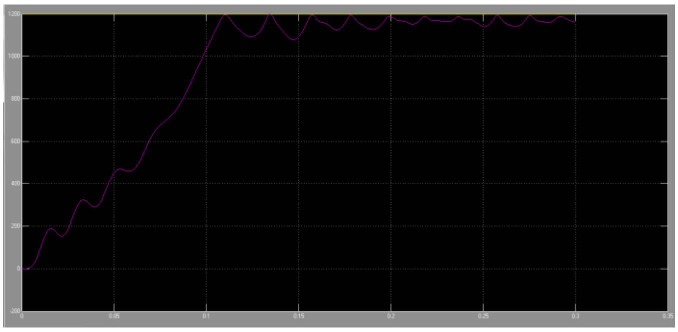

Fig.22. Speed control by PI controller for constant speed response.

From figure 14, 17, 20 it clear that fuzzy logic controller maintain the electromagnetic torque of three phase induction motor as compared with PI and PID controller for constant 1200 rpm speed control.
From figure 15, 18, 21 it clear that the gain control by fuzzy logic controller is smooth small variation in response or decision as compared with PI and PID controller. PI and PID controller are contain more disturbance and time delay for controlling the V/f controller gain.
From figure 16, 19, 22, it clear that speed control by fuzzy logic controller is nearer follows the constant reference speed of 1200 rpm. But Pi and PID controller not follows the exact reference speed which causes disturbance between reference speed and actual speed as compared with FLC.
Similar results are occurs for variable speed control of three phase induction motor using fuzzy logic, PI and PID controller.

E. Result for varble speed using FLC

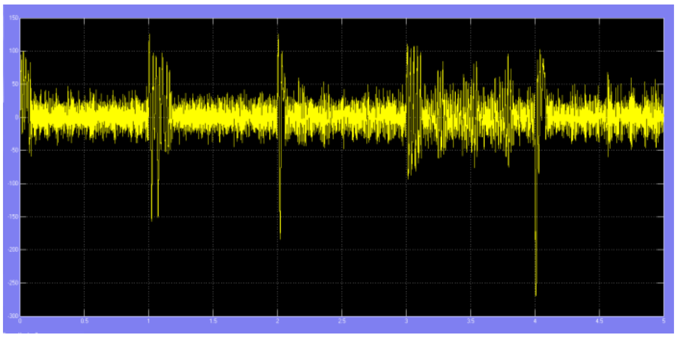

Fig.23. Electromagnetic torque of three phase induction motor for variable speed control using fuzzy logic controller.

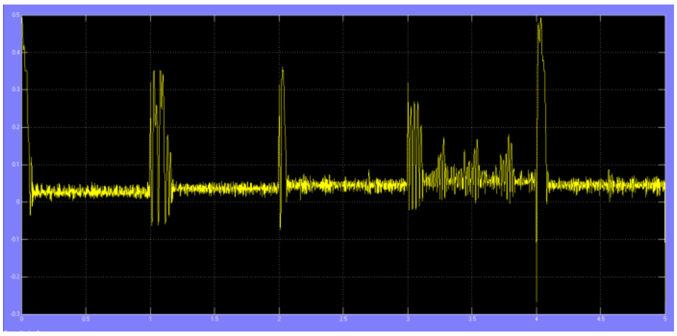

Fig.24.Fuzzy logic controller response for controlling gain of V/f controller for variable speed control response.

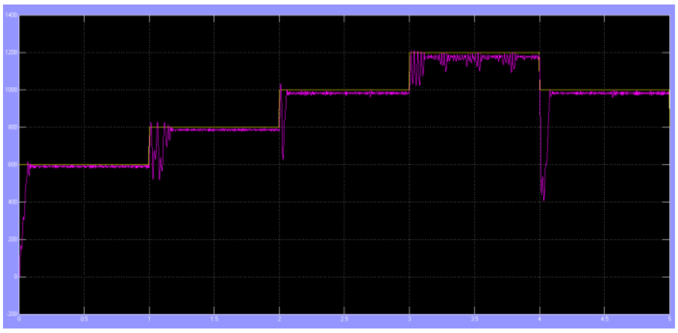

Fig.25.Speed control by fuzzy logic controller for variable speed control.

F. Result for variable speed using PI controller

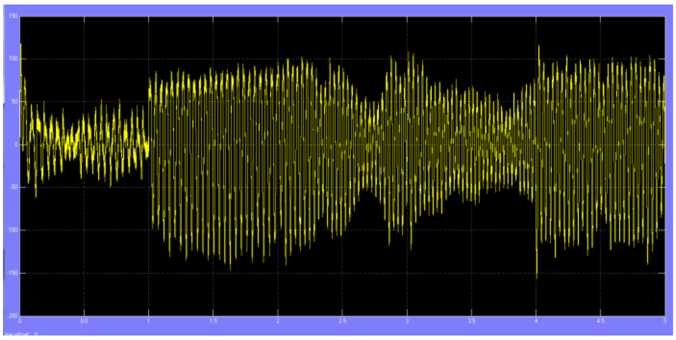

Fig.26. Electromagnetic torque of three phase induction motor for variable speed control using PI controller.

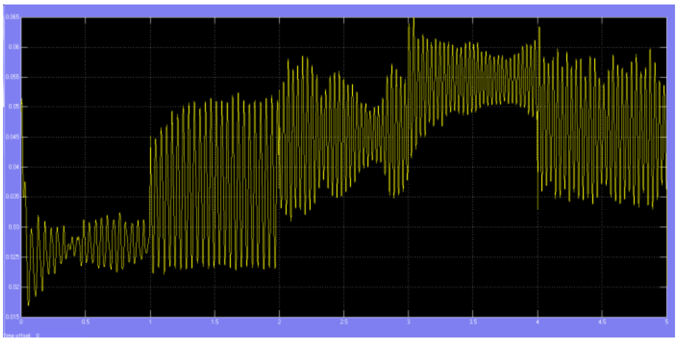

Fig.27.PI controller response for controlling gain of V/f controller for variable speed control response.

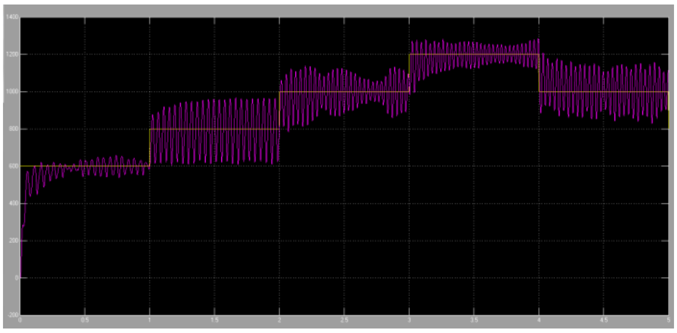

Fig.28.Speed control by PI controller for variable speed control

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G. Result for variable speed using PID controller

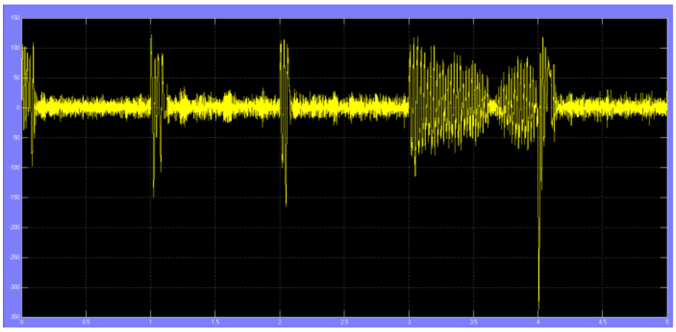

Fig.29. Electromagnetic torque of three phase induction motor for variable speed control using PID controller.

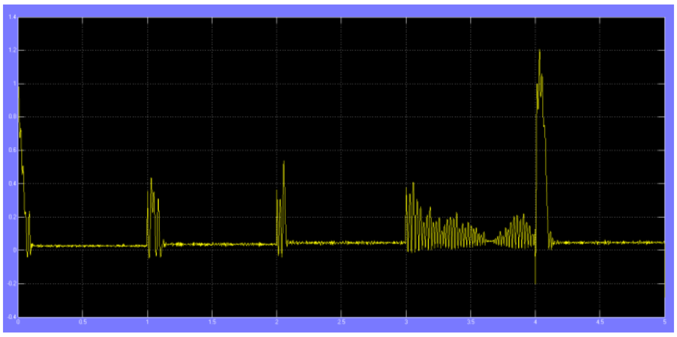

Fig.30. PID controller response for controlling gain of V/f controller for variable speed control response.

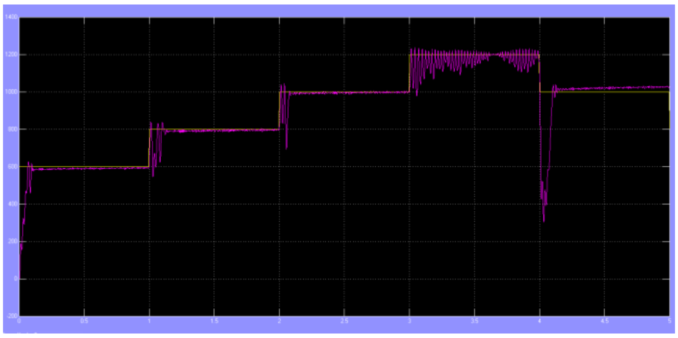

Fig.31. Speed control by PID controller for variable speed control

V. CONCLUSION

This paper design MATLAB simulink model of fuzzy logic based speed control of three phase induction motor drive. That fuzzy logic controller control the gain of V/f controller of three phase induction motor based on actual speed of motor and reference speed of motor. This system utilized 49 fuzzy rule based for generation of gain for V/f controller.

MATLAB simulation result shows that fuzzy logic controller provide smooth speed control and faster response of speed control for both constant speed control and variable speed control.

Hence Fuzzy logic controller is more advantageous compared with PI and PID controller for speed control of thre phase induction motor.

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