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Implementation of Three Phase Induction Motor Control Drive Using PID and FUZZY Technique and Their Comparison

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Abstract: ***The induction motors were characterized by complex, highly non-linear and time-varying dynamics, and hence their speed control is a challenging problem in the industry. The advent of vector control techniques has solved induction motor control problems The development of any for the design of such control systems undoubtedly requires the synthesis of many concepts from artificial intelligence. The most commonly used controller in the industry field is the proportional plus-integral-plus derivative (PID)controller. Fuzzy logic controller (FLC) provides an alternative to PID controller, especially when the available system models are inexact or unavailable. However it further needs to be improved in terms of overshoot and settling time. So control strategies based on soft computing could be good alternative. This paper describes the implementation of controllers based on PID and Fuzzy Logic strategies. A comparative performance analysis demonstrates that the clever exploring of Fuzzy Logic control strategies circumvents the demerits of PID control strategies.***

Keywords: PID, Fuzzy Controller, Simulink Model, Three phase inverter, Induction motor

1. Introduction

The demand for control of electric power for electric motor drive system and industrial control existed for many years. Power electronics have revolutionized the concept of power control for power conversion and for control of electrical motor drives. Variable-speed drives are created when a motor is combined with a power electronics converter. Variable speed AC motor drives have been continuously developed during the last decades owing to the advances in power electronics, control theory and microprocessors technology. By introducing variable speed to the driven load, it is possible to optimize the efficiency of the entire system and it is in this area that the greatest efficiency gains are possible. AC motor drives are widely used to control the speed of conveyor systems, blower speeds, pump.

Speeds, machine tool speeds, and other applications that require variable speed. Control deals with the steady state and dynamic characteristics of closed loop system. The development in microprocessor and microcontroller technology has a great impact on the control and synthesizing the control strategy for power semiconductor devices. There are many closed loop control strategy are used such as Proportional control, derivative control ,integral control, and some combination of this such as PI, PD, PID in all this PID is mostly used because of other has sluggish performance to avoid oscillations, another problem with proportional-only control is that power application is always in direct proportion to the error.

To resolve problems, many feedback control schemes include mathematical extensions to improve performance. The most common extensions lead to proportional-integral-derivative control, or PID control. PID is best one but still it has some limitations such as it require much time to settle down hence some other control strategy are used such as FUZZY, ANN, NEURO-FUZY etc In which Fuzzy logic is an attempt to get the easy design of logic controllers and yet control continuously-varying systems. Basically, a measurement in a fuzzy logic system can be partly true, that is if yes 1 is and no is 0, a fuzzy measurement can be between 0 and 1

2. System Block Diagram

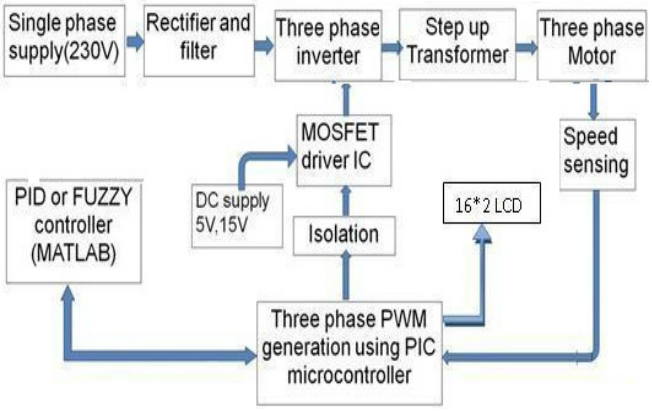

Figure 1: System Block Diagram

For the operation of the inverter, variable frequencies are generated by the microcontroller and applied to voltage source inverter through gate drive circuit. As this is closed loop system, The inverter frequency changes as error between actual speed and reference speed is increased or decreases. The gate drive circuit is consists of opto-isolator to provide isolation for microcontroller and the other gate drive circuitry, which is work on low voltage from the high power circuit side. The basic three phase voltage source inverter consists of six power MOSFETs with built in anti parallel diodes. The IRF–460 N-CHANNEL MOSFET is semiconductor device which works as a switch. It operates at highest possible turn-ON and turn-OFF speeds, extremely high dv/dt capability and maintaining the most accurate operation of the inverter.

AC voltage from the power grid is rectified using the power bridge and capacitor is used as a filter, the output of filter gives pure DC to the three phase inverter as DC source. Depending upon the frequency generated by microcontroller, the power supplied to the motor is varied. And the error between actual speed and reference speed is minimized.

A. Three Phase Inverter Design

Three phase inverter designed using power MOSFETs is as shown in fig.2. The inverse diode associated with the device is sufficient to operate the circuit at higher frequencies. MOSFET technology promises to use much simpler and efficient drive circuits with significant cost benefits compared to bipolar devices. . The positive terminal of the DC voltage is applied at the Drain terminals of MOSFET

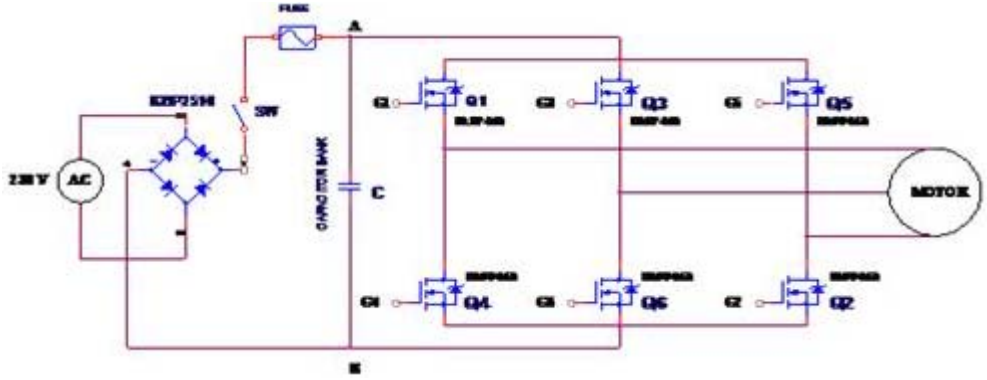

Figure 2: Three Phase Inverter Design

B. Isolation Circuit

opto-coupler is an electrical component that is used to isolate high power circuitry to digital or control devices by optical means. It is a combination of light emitting diode (LED) and a silicon phototransistor. The input signal is applied to an LED and the output is taken and output is taken from the phototransistor. An opto-coupler connects input and output sides with a beam of light modulated by input current.

When any variations in input side voltages, it can produce changes in the LED current, which changes the current through the phototransistor. Thus a signal voltage is coupled from the input circuit to the output circuit. The circuit arrangement with internal structure for the opto-coupler is as shown in fig. The big advantage of an opto-coupler is the electrical isolation between the input and output circuits. Opto-coupler devices are essentially digital or switching devices, so they are best for transferring either on-off control signals or digital data

Q_1, Q_3 and Q_5 and the negative terminal is connected to terminals of MOSFET Q_2, Q_4 and Q_6. Output from the gate drive circuit is connected to the Gate terminals of the MOSFET. Only two MOSFETs remain on at any instant time. The conduction sequence of MOSFET is 61, 12, 23, 34, 45, 56, and 61. This gating sequence is generated so that MOSFETs of the same branch cannot be conduct at the same time. There must be some short time delay between turn off MOSFET and turn on MOSFET.

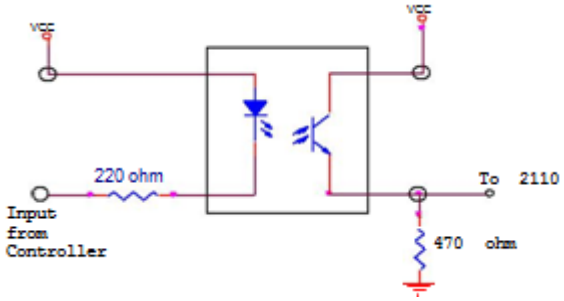

Figure 3: Real Time Controlling of three Phase Induction Motor

C. Microcontroller PIC 16F877A

The role of PIC16F877A is to generate PWM of desired frequency using timer/ counter module [4, 6]. It also monitors the sensed speed by Hall Effect sensor and sends it serially to Simulink designed for PID and Fuzzy control technique. According to present speed the Simulink model will generate thee control signal which is fed back to microcontroller for PWM variation. Microcontroller also displays the current speed in RPS (Rotation per Second) on 16x2 LCD.

D. Hall Effect Speed Sensor

When a current-carrying conductor is placed into a magnetic field, a voltage will be generated perpendicular to both the current and the field. This principle is known as the Hall Effect. Hall effect sensor is used to measure the speed of motor in rps to get maximum resolution. Accuracy is +-1% at 12000rpm

A. PID Controller Simulink Design in MATLAB

Actual tuned PID output response and real-time speed of induction motor. Depending upon set speed and error in speed is generated which is applied to the PID controller and depending on this error PID gives the output which is passed over to PIC microcontroller to maintain the speed. Program in microcontroller develops a decision signal such that if

speed of motor is increasing the PID Algorithm gives large error output and depending upon error the three phase half-bridge inverter frequency is accordingly decreased to slow down the motor speed. In the same way, if speed is found to be decreasing then frequency for inverter is increased. .

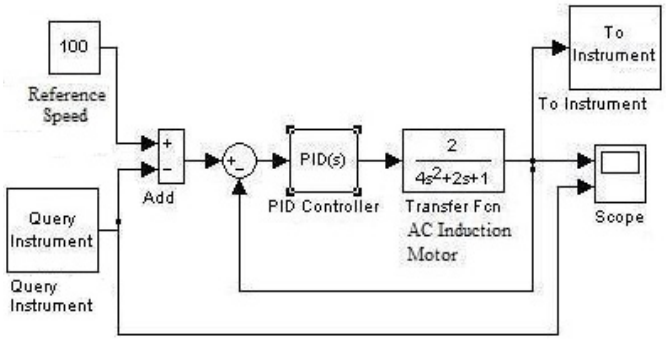

Figure 4: PID Simulink Model

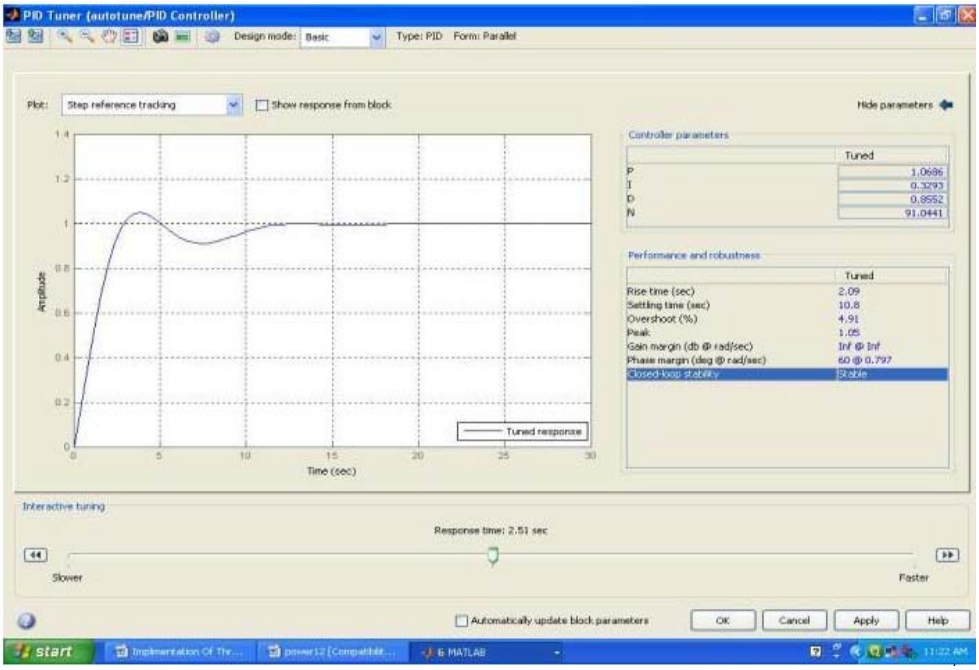

Figure 5: PID response

B. PID Controller Simulink Design in MATLAB

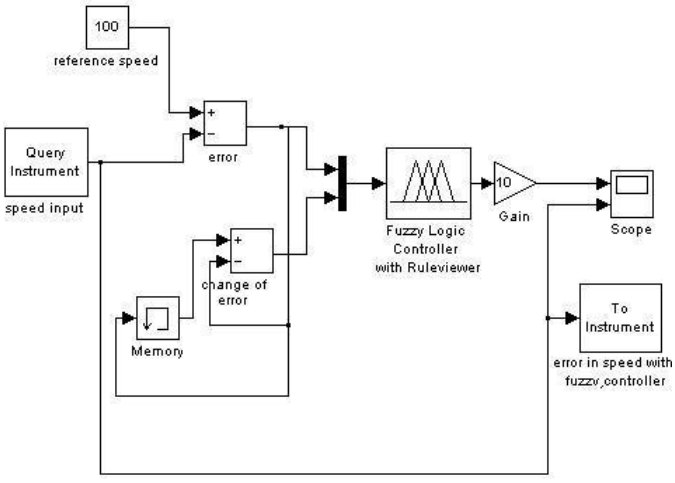

Figure 6: FUZZY Simulink Model

Fig.6 shows Simulink design model for Fuzzy Controller. It contain query instrument for accepting the real time present speed of motor through serial port of PIC. The *constant* is set to a reference speed. *Error* block generates the output which is the error between actual speed and set speed. This is error applied to one input of Fuzzy controller and other to store the error in memory to provide it to *change of error block* which gives error between previous error output and actual error at present state. Multiplexer combine both input and gives it to Fuzzy controller. Real time scope is used to observe actual behavioral of a system. To *instrument block* is used to send output of Fuzzy Controller to PIC microcontroller. The Fuzzy Inference Scheme (FIS) for Fuzzy controller is design using Mamdani method. It contains structure of minimum and maximum operation. Direct method operates on an inference rule such as-

"IF x is A and y is B THEN z is C" Where A, B and C are fuzzy sets. In this rule there are two main parts, the part following IF called premise and part following THEN is called consequence. Hence x and y are called premise variables and z is the consequence variable

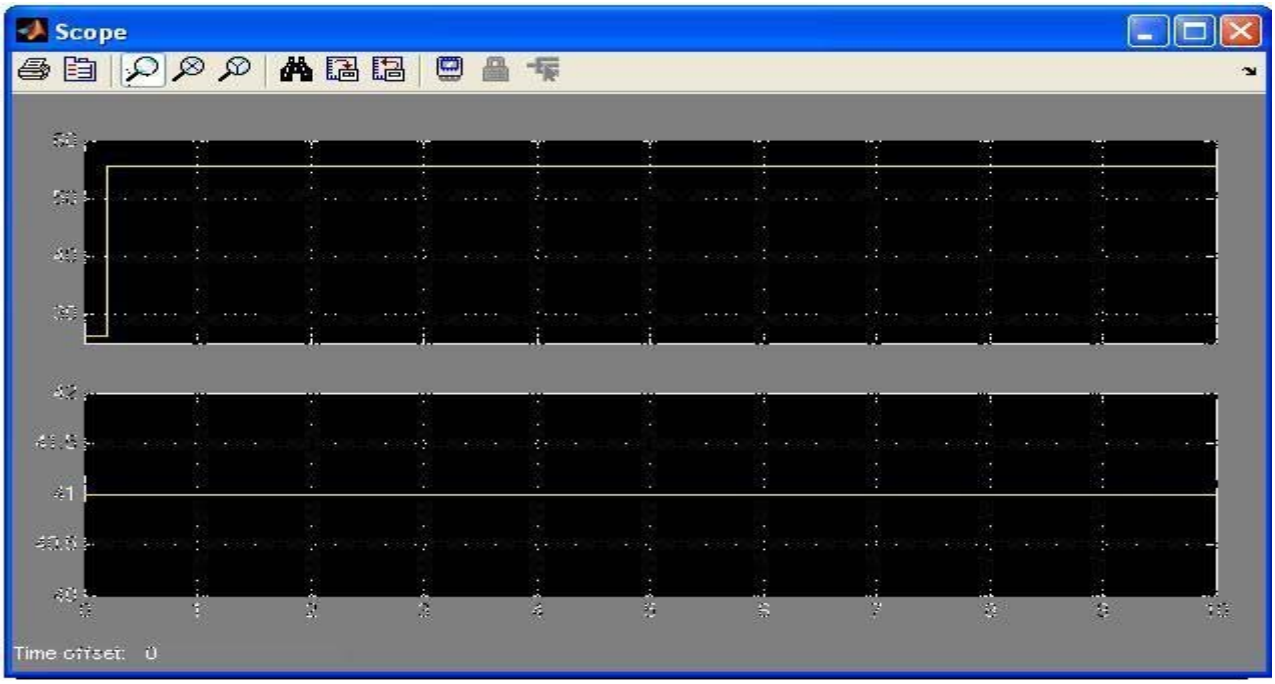

Figure 7: FUZZY response

3. Results and Discussion

Many conventional control strategies are useful for speed controlling purpose. Instead of all conventional strategies, PID and FUZZY controllers are very different in nature and are efficient for speed controlling of three phase ac induction motor. They provide precise controlling action within their limits. PID controller is very much useful because it uses auto tuning. Once it is tuned it tracks the output according to the provided input. But it has a limitation that it has more settling time. Still it is used as a standard reference for comparison with other control strategies. Fuzzy controlling is another mean for this application. The main advantage is that it provides minimum settling time than PID controller. The designing of Fuzzy Controller is particularly rule based which simplifies the implementation. The experimental results of both the controllers are compared and analyzed as shown in Table 1. It is found that speed controlling by FUZZY controller is better than PID controlling method. Also, it is real time matlab interface for such non-linear application in linear fashion.

As we observe that the controlling speed of three phase induction motor by using variable frequency drive. The motor speed varies from zero to the base speed, in constant torque operation up to the base speed while in constant power the speed of motor is above base speed.

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