Research Paper

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An Implementation of Fuzzy to Minimize Electrical Losses in Induction Machine Vector Control

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ABSTRACT

An induction motor is a motor that is difficult to control so it requires synchronous speed due to dynamic load changes which are controlled by the torque current while the field current is kept constant. Thus, in this paper, we implement an adaptive PID controller method with an induction motor using MATLAB which coordinates the speed of two decoupled loads with a three-phase induction motor, where an adaptive Self Tuning Regulator (STR) PID controller is designed and realized to regulate the speed of a three-phase induction motor. using MATLAB software and AVR Atmega16 microcontroller as input and output from the plant with communication using serial RS232. The results show that after coordinating the system with each motor which is given a neural controller and FOC, the motor speed results are obtained which gradually provide synchronous speed so it can be concluded that this system can work well to slow down the plant response.

Keywords: Induction Motor, Motor Speed, neural method, PID controller

1. INTRODUCTION

Induction motors are alternating current motors that are most widely applied in the industrial world [1]. This is because this motorbike has a strong, simple construction and requires less maintenance than a DC motor. Apart from that, induction motors also provide good efficiency and constant rotation for each load change. Motors are basically used as a source of load to run certain tools or help humans in carrying out their daily tasks. This is possible because this type of motorbike has advantages both from a technical and economic perspective, such as having sturdy construction and easy maintenance. Even though it has advantages as above, induction motors also have weaknesses, including that induction motors are non-linear motors, the method for controlling speed is complicated, besides that a converter is needed which can cause harmonics. So the author tries to make an analytical arrangement of the weaknesses of the induction motor above, in this case to maintain the performance and appropriate efficiency of the motor so that it can be used in the long term with stability and reliability that can be maintained.

From this problem, to estimate or reduce the motor's weakness, an analysis method is used which can change the couple system to a decouple system, with the system the gain current and motor load current can be controlled separately so that the torque and flux can also be regulated separately.

2. RESEARCH METHODOLOGY

2.1. Method Design

Design of a 3 Phase Inverter for Induction Motor Speed Regulation. [3] The module input voltage is obtained from a single-phase line voltage of 50 to 210 VAC and is used as a voltage supply for a three-phase induction motor with a maximum output of 310VDC.

The maximum speed of an induction motor is 1100 rpm with a frequency of 50Hz and a minimum of 150rpm with a frequency of 5Hz. An induction motor is an electromagnetic device that converts electrical energy into mechanical energy. Of the various electric motors available, induction motors are the most widely used type of alternating current motor. This is because induction motors have strong construction and good working characteristics.

2.2. Dynamic Modeling of Three Phase Induction Motors

A three-phase machine can be described as a comparable two-phase machine. The depiction of an induction motor in two phases is symbolized in the axes d(direct) and q(quadrature). Images of three-phase and two-phase coils can be seen in this figure.

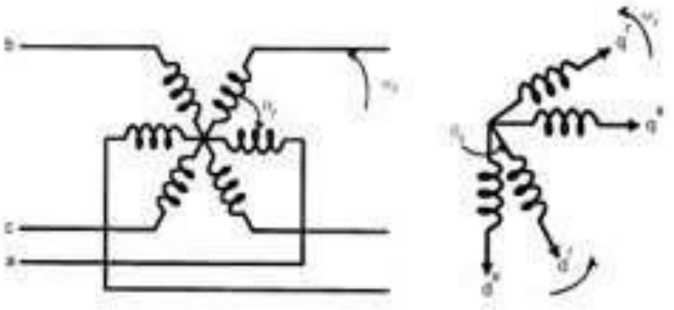

Figure 1. (a) Coupling Effect on Three Phase Stator and Rotor Coils (b) Two Phase Coils.

2.3. Vector Control Method

One way to control an induction motor is vector control. Vector Control or also called Field Oriented Control (FOC) is a method of regulating the field in an AC motor, where the system is [4]. With a temini inisis system, the gain current and motor load current can be controlled separately, thus the torque and flux can also be regulated separately.

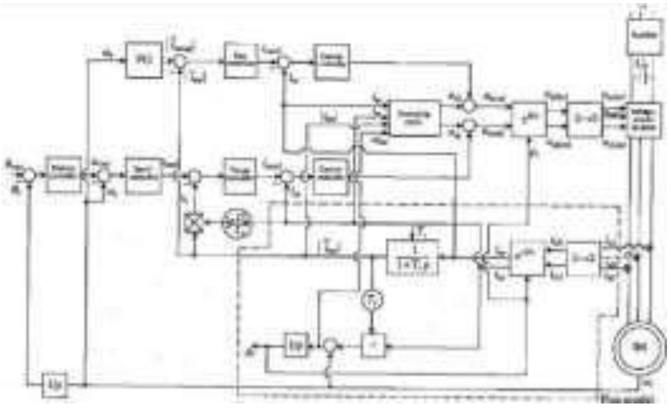

Figure 2. Indirect Vector Control Block Diagram

2.4. PID controller

This controller calculates the error value which is the difference between the reference value (setpoint) and the sensor's measured output. The image below shows the block diagram of a PID controller

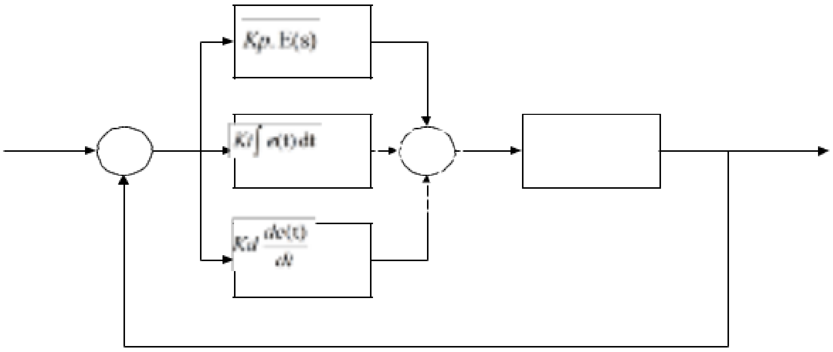

Figure 3. PID controller

2.5. Regulator Self-Tuning Method

With this method, every change that occurs in the plant will be estimated, where the estimated process variables will be used to design a new controller to update PI parameters. The working principle of the regulatory self-tuning method can be checked in detail in the block diagram as in the figure below

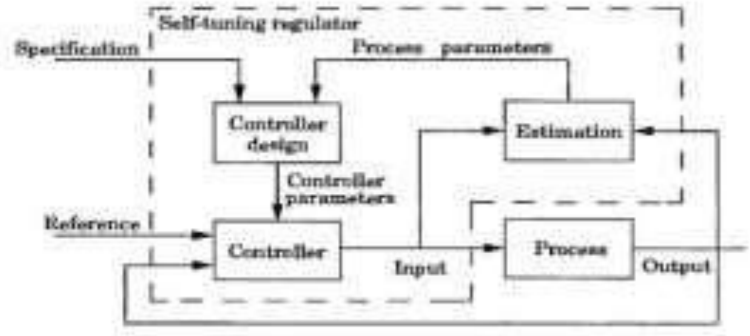

Figure 4. Regulator f-tuning block diagram

The regulator self-tuning method consists of 2 loops. The first loop is a closed loop system in general which includes the controller, plant and feed back signal, while the other loop involves the estimation process, designing a new controller and tuning controller parameters.

3. ANALYSIS AND DISCUSSION

3.1. Result Analysed

The system designed is a system to control the speed tracking of a three-phase induction motor in a centrifugal plant. The time required for each cycle depends on the inertia of the fugal centrifuge used. Apart from that, the stages in the centrifugal process, such as starting, spinning and breaking, are also different for each centrifugal machine, depending on the quality of the liquid being spun.

The Fuzzy PID controller is found in the PLC program which directly regulates the speed of the 3 phase induction motor to match the desired input. The control signal from PID Fuzzy is a voltage of 0–5 VDC. This voltage will enter the inverter to be converted into frequency (Hz). The DC voltage that can be read by the inverter ranges from 0 to 10V with a resulting frequency range of 0–50Hz. This is not in accordance with the inverter specifications. Therefore, a voltage amplifier circuit is needed twice so that the DC voltage output by the PLC becomes 0-10 volts. When the inverter gets the appropriate DC voltage, the voltage will be converted into frequency (Hz), so that it can rotate a 3-phase induction motor.

The induction motor shaft is designed to be coupled with a rotary encoder sensor which can detect speed (rpm) by converting the number of pulses produced in each motor rotation. The output of the rotaryencoder sensor can be directly read by the QD62 (HighSpeedCounter) module on the Mitsubishi PLC to be processed as a feedback signal. Identification Method

The identification process is carried out in an open loop and static manner by providing a step signal and looking at the response in the form of speed. The input signal is obtained from the set point given to the PLC, then the results of the plant response are read by the rotary encoder which will then be displayed on the computer through the data acquisition process with the Mitsubishi PLC. Data collection for the identification process was carried out 3 times for each load condition (minimum, nominal and maximum).

Three identification methods were applied to one data sample to obtain the most suitable method. The results of the smallest RMSE values from various methods are then applied to two other data samples. The three identification methods are the second order Viteckova, Latzel, and Strecj's methods. The Strejc's method was chosen because it has the smallest validated RMSE value compared to the other two methods.

3.2. Fuzzy PID Controller Design

The PID controller design is done analytically. Search for controller parameters Kp, τi, and τd adjusted to the plant model. In this research, the search for PID controller parameters was carried out on the model for each load condition. The PID controller parameters that have been obtained are used as constraints in designing the PID parameter reasoning mechanism.

In this system the main control is PID control while the fuzzy logic control works to help minimize over shoot/under shoot that occurs and also minimize recovery time from stem response. The designed fuzzy logic control system has 2 inputs, namely

3.3. Error and delta error

Meanwhile, delta error is the difference between the current measurement error and the previous error. The configuration of the Fuzzy PID system can be seen in the figure below.

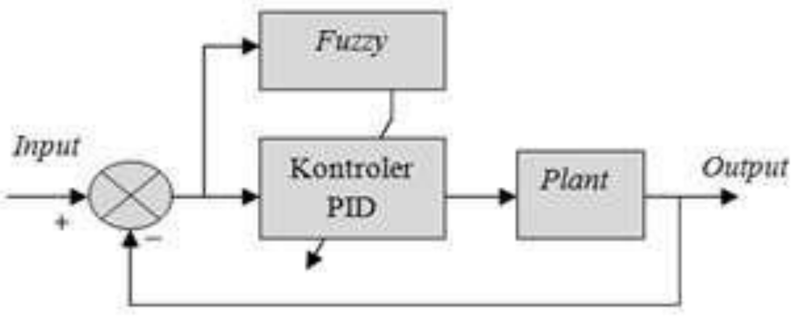

Figure 5. Fuzzy PID block diagram

The formation of input and output membership functions is based on the PID parameters that have been obtained for minimum, nominal and maximum load conditions. The design is carried out on the input membership function, output membership function, rule-base and normalization. The input to fuzzy logic to reason about the parameters Kp, τi, and τd is in the form of error (e) and delta error (Δe) which are divided into 3 linguistic terms, namely minimum, nominal and maximum as in the picture below.

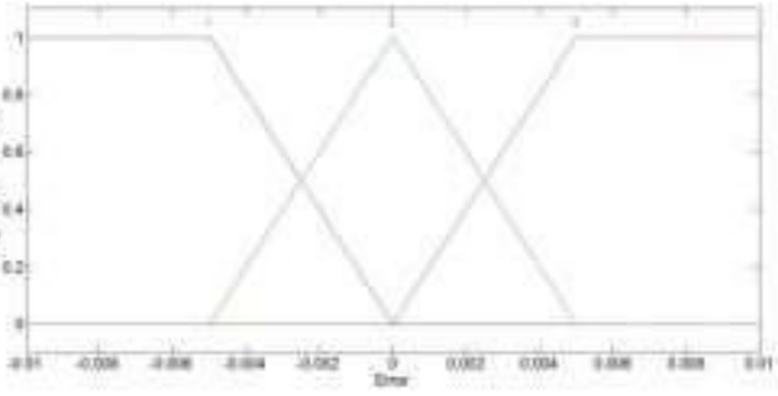

Figure 6. Membership function error(e)

From the calculation data, the error and delta error values obtained are between -0.005 to 0.005 and -0.0066 to 0.0066. The normalized value of Ke is 200 and the normalized data Kde is 150. The linguistic value of the membership function is defined by the numbers 1, 2, and 3. For value 1 is Negative (N), value 2 is Zero (Z), and value 3 is Positive (P).

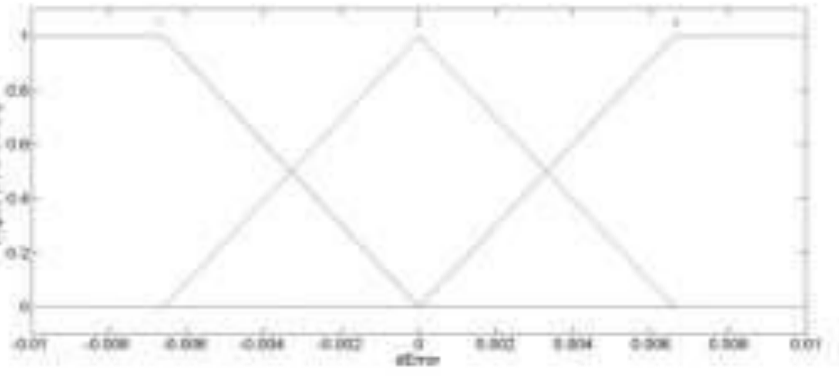

Figure 7. Membership function delta error (Δe)

Fuzzy's output membership function is in the form of a control signal. In this case the control signal is in the form of an amplifier. The Fuzzy output membership function is defined with amplifiers Kp, τi, τd for minimum load, nominal load and maximum load. The linguistic value of the Fuzzy output membership function is defined as 1 (small), 2 (medium), and 3 (large).

3.4 Discussion

In this section the simulation has been carried out using Matlab/Simulink. As in the image below:

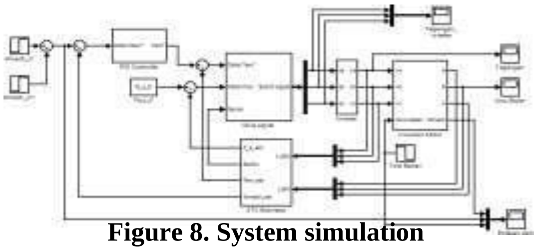

Figure 8. System simulation

Image Simulation system Sampling time 1000 µs, reference flux taken at 2.85, 3 phase induction motor nominal voltage 380 V, f = 50 Hz, number of poles 4, slip 3%, has the following complementary data: Rs = 1.77 Ω, Rr = 1.34 Ω, XLs = 5.25 Ω, XLr = 4.57 Ω, Xm = 139.0 Ω, J = 0.025 Kg.m2, B = 0.01 Nm.sec/rad. For PI control it consists of Kp=25, Ki=8. Following are the simulation results:

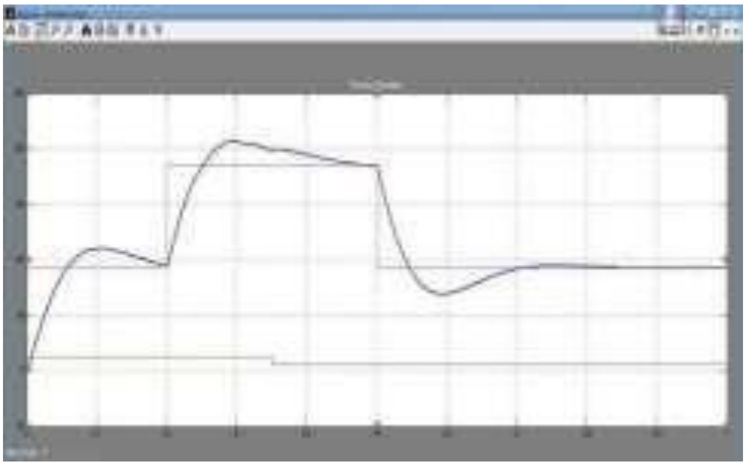

Figure 9. Rotor Rotation Response

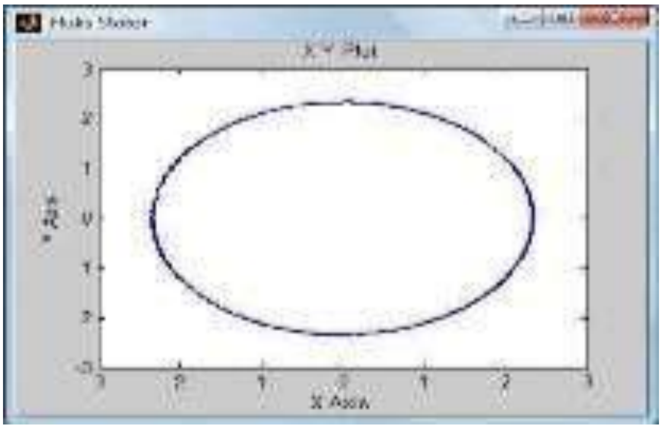

Figure 10. Stator Flux

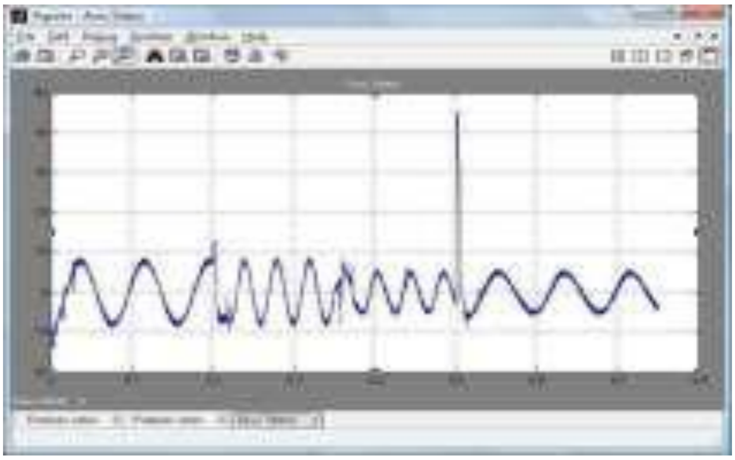

Figure 11. Stator current

4. CONCLUSION

From the analysis and test results of three-phase motors using FIELD ORIENTED CONTROL (FOC) AND PID, the following conclusions can be drawn: The induction motor in this research uses an alternating current motor which is most widely applied in the industrial world because it has a strong, simple construction and requires less maintenance compared to a DC motor and is an electromagnetic device that converts electrical energy into mechanical energy. Of the various electric motors available, induction motors are the most widely used type of alternating current motor. Where synchronous speed itself is the rotational speed of the magnetic field in the machine. This synchronous speed is influenced by the machine frequency and the number of poles on the machine. Induction motors always rotate below synchronous speed because the magnetic field generated in the stator will produce flux in the rotor so that the rotor can rotate.

Declaration by Authors

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