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Performance and Analysis of Three phase Induction motor drive using Artificial Intelligence Module

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ABSTRACT: In this project, for analysing the performance of 3Φ induction motor drive which is having its previous methodologies to obtain the performance parameters such as speed regulation and optimization of stator flux and torque ripples of a three phase induction motor drive for it to achieve its high efficiency. Initialising with control techniques as Direct Torque Control (DTC) implementing the controller strategies like Proportional Integral controller and Fuzzy logic controller combined, demanding a minimisation of torque ripples and its co – factors that which influence the performance prediction of an induction motor.Comparing the modules where PI controller and Field Oriented control method included, it permits an independent control of torque and flux by decoupling the stator current into two orthogonal components. However is very sensitive to flux which is mainly affected by parameter variations. Whereas in case of Direct Torque Control method the voltage vectors are selected based on the difference between the reference, actual torque and stator flux linkage. The proposed DTC technique gives better performance in the three-phase IMD than conventional DTC technique

KEYWORD: pi controller,fuzzy logic controller,induction motor,torque

I. INTRODUCTION

The change in steady-state speed of a machine, expressed in percent of rated speed, when the machine load is reduced from rated load to zero. The definition of regulation is usually taken to mean the net change in a steady-state characteristic, and does not include any transient deviation or oscillation that may occur prior to reaching the new operation point. This same definition is used for stating the speed regulation of electric motors as well as for certain drive systems, such as steam turbines.Speed regulation is most often defined as the percentage change in speed of a motor or variable speed drive due to a specified change in load torque. The percentage change is usually a percentage of the base speed, where the base speed is the maximum speed or the maximum speed in the constant torque speed range.Speed regulation is the percentage of speed change, generally this is only calculated on devices which are attempting to maintain a constant speed. For example, on some industry motors, they need to maintain a constant RPM. When the motor has weight bearing on it, it is called a load, andthespeedmaychangelightly.

1.TORQUE AND TORQUE RIPPLES:

Torque is defined to be the rate of change of the angular momentum of an object. In some disciplines, the terms "moment" and "moment of force" are synonymous with "torque". Other disciplines reserve use of the term "torque" for instances when the angular velocity and/or the moment of inertia of an object are changing.

Standard torque

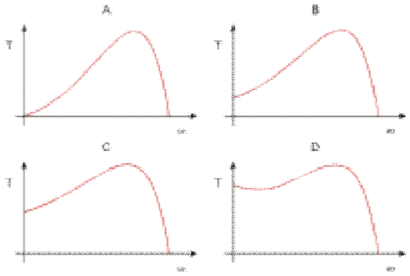

Figure 1. standard torque

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Speed-torque curves for four induction motor types: A) Single-phase, B) Poly phase cage, C) Poly phase cage deep bar, D) Poly phase double cage

The typical speed-torque relationship of a standard poly phase induction motor is as shown in the curve at right. Suitable for most low performance loads such as centrifugal pumps and fans, motors are constrained by the following typical torque ranges

- Breakdown torque, 175-300 percent of rated torque
- Locked-rotor torque, 75-275 percent of rated torque
- Pull-up torque, 65-190 percent of rated torque.

2.EFFICIENCY OF AN MOTOR

It is generally termed as the ratio of the output power to the input power which is given as a fundamental equation

$$\% \eta = op / ip * 100$$

PI CONTROLLER:

Similar Like the P-Only controller, the Proportional-Integral (PI) algorithm computes and transmits a controller output (CO) signal every sample time, T, to the final control element (e.g., valve, variable speed pump). The computed CO from the PI algorithm is influenced by the controller tuning parameters and the controller error, e(t).PI controllers have two tuning parameters to adjust. While this makes them more challenging to tune than a P-Only controller, they are not as complex as the three parameter PID controller. Integral action enables PI controllers to eliminate offset, a major weakness of a P-only controller. Thus, PI controllers provide a balance of complexity and capability that makes them by far the most widely used algorithm in process control applications.The main limitation in using a proportional controller to regulate experimental ozone concentrations is that proportional controllers generate zero output when the actual concentration equals the target concentration. Adding an integral controller to a proportional controller can potentially increase the precision in regulating experimental ozone concentration because the controller generates a constant output when the actual and target ozone concentration are equal. The realized precision of a proportional-plus-integral (PI) controller in regulating an ozone treatment in a large open-top chamber was assessed by analyzing hourly ratios of the ozone concentration inside a chamber and of the ambient bulk air

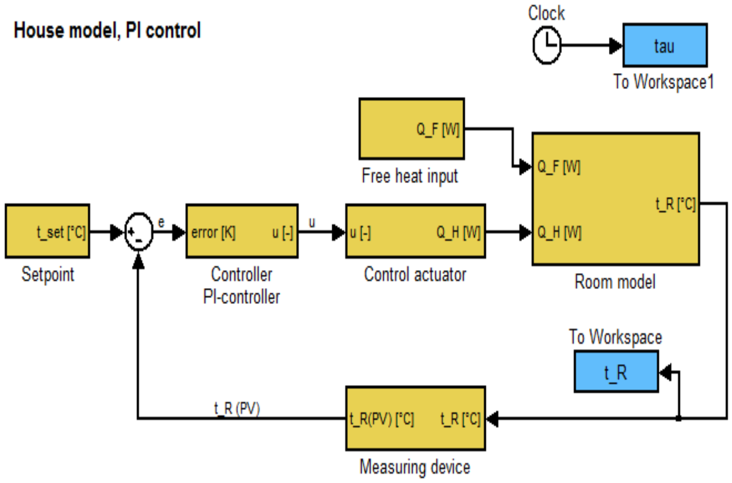

Figure 2.block diagram of PI Control

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II. SYSTEM ANALYSIS

PI CONTROLLER :

Simulink model - of the PI-algorithm:

The content in the controller block is now - according to (5) - which we will use in this course:

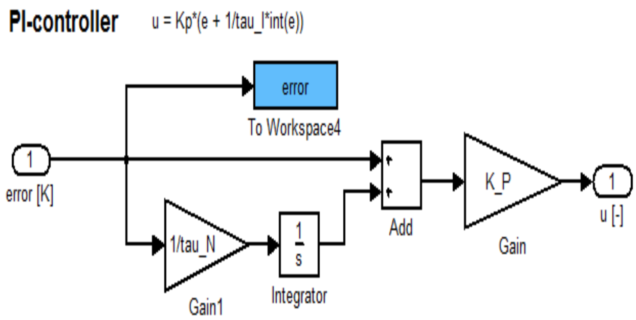

Figure 3. PI-controller

Function of the Integral Term:

While the proportional term considers the current size of e(t) only at the time of the controller calculation, the integral term considers the history of the error, or how long and how far the measured process variable has been from the set point over time.Integration is a continual summing. Integration of error over time means that we sum up the complete controller error history up to the present time, starting from when the controller was first switched to automatic.Controller error is e(t) = SP – PV. In the plot below the integral sum of error is computed as the shaded areas between the SP and PV traces.

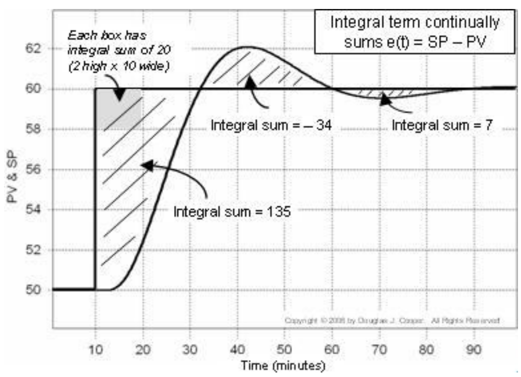

Figure 4. Integral sum of error

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Challenges of PI Control:

There are challenges in employing the PI algorithm:

- The two tuning parameters interact with each other and their influence must be balanced by the designer.
- The integral term tends to increase the oscillatory or rolling behavior of the process response.

Because the two tuning parameters interact with each other, it can be challenging to arrive at "best" tuning values.

Field Oriented Control:

Vector control, also called field-oriented control (FOC), is a variable frequency drive (VFD) control method which controls three-phase AC electric motor output by means of two controllable VFD inverter output variables:

- Voltage magnitude
- Frequency.

High Level Schematic

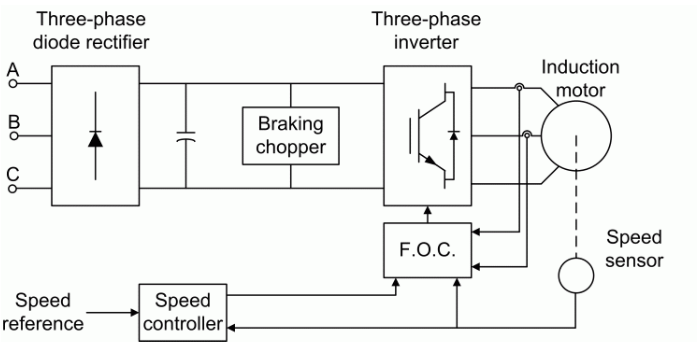

Figure 6.high level schematic of FOC

SIMULINK SCHEMATIC:

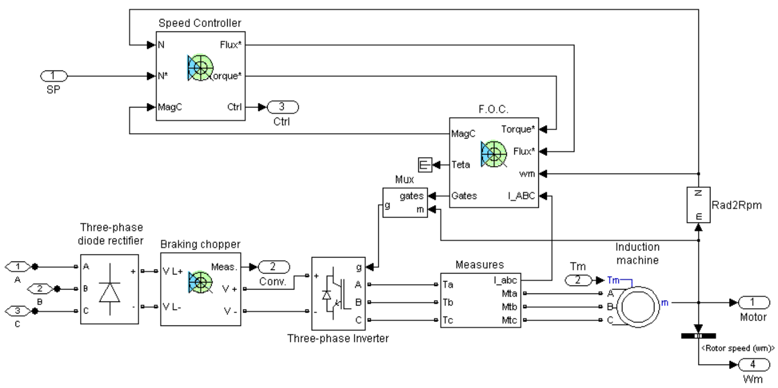

Figure 7.output of the torque and the flux of FOC block

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DIRECT TORQUE CONTROL METHOD :

AC drives were only used in small demanding applications, regardless the advantages of AC motors opposite to DC motors, since the high switching frequency inverters cost was rather competitive. With the developments in the power electronics areas, the vector controls methods, which use fast microprocessors and DSP ‘s , made possible the use of induction motors in typically DC motors dominated area’s since the current components producing torque and flux are decoupled , achieving the system separately excited DC motor similar features . The overview of induction motor control methods are shown in fig

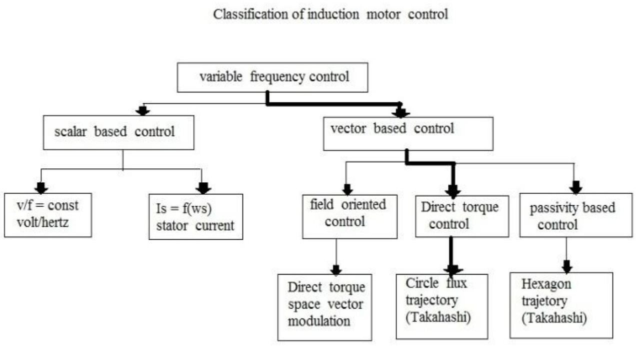

Figure 9.block diagram of direct torque control

DIRECT TORQUE CONTROL:

Various techniques are used for controlling the torque of the induction motors. Among those method, the DTC technique, which is conventient and is very relatively easy to implement. DTC was considered as an alternative to field oriented control scheme to overcome those weakness. It operates based on the measured voltage and current. DTC , the torque and flux are directly controlled by using the selection of optimum voltage vectors. The switching logic control facilitate the generation of the stator voltagespace vector, with a suitable choice of the switching pattern of the inverter, on the basis of the knowledge of the sector in which the stator flux lies, and the amplitudes of the stator flux and the torque . the sector identification depends on the accurate of the stator flux position. Its main advantages are the absence of coordinate transformation, modulation specific block, and the absolute position determination. However, there are some problems during start up and at low speed values, like the difficultly in start up current control and high influence of the motor parameters, as well as variable switching frequency and the need of flux and speed estimators.The DTC technique may be implemented with or without speed sensors, depending on the method used to estimate the stator flux. With the inclusion of a speed estimate in the system, it is possible to obtain gains in hardware complexity reduction and bigger mechanical endurance, making possible the operation in a hostile environment and decreasing the maintenance needs.

PRINCIPLE OF DIRECT TORQUE CONTROL :

The DTC scheme is very simple; in its basic configuration it consists of hysteresis controllers , torque and flux estimator and a switching table . The configuration is much simpler than the vector control system due to the absence of coordinate transformation between stationary frame and synchronous frame and PI regulators. It also does not need a pulse width modulator and a position encoder, which introduce delays and require mechanical tranducers respectively. DTC based drives are contolled in the manner of a closed loop system without using the current regulation loop. DTC scheme uses a stationary d-q reference frame having its d-axis aligned with the stator q-axis. Torque and flux are controlled by the stator voltage vector defined in this reference frame.The basic concept of DTC is to control directly both the stator flux linkage and electromagnetic torque of machine simultaneously by the selection of optimum inverter switching modes. The use of a

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switching table for voltage vector selection provides fast torque response, low inverter switching frequency and low harmonic losses without the complex field orientation by restricting the flux and torque errors within respective flux and torque hysteresis bangs with the optimum selection being made.The diagram of DTC for an induction motor is shown in fig2.2 Te* and fs* are torque and flux reference values; Te and fs are the estimated torque and stator flux values; ω* is the command speed value; ω is the real speed value and Ɵis the stator flux angle.

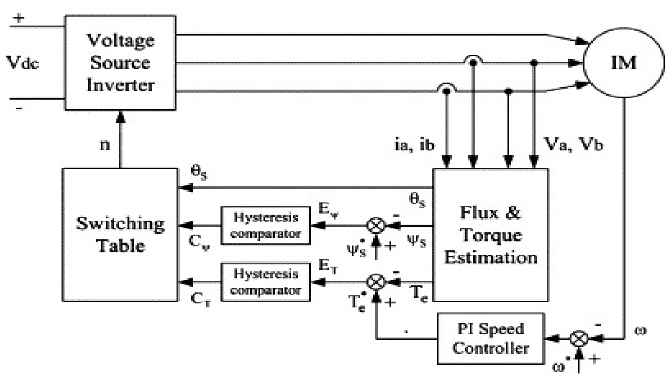

Figure 10. Block diagram of the Basic DTC

A PI controller is used to determine the reference torque , based on the difference between the reference and the instantaneous speed of the motor. The basic idea of the DTC concept is to choose the best vector voltage, which makes the flux rotate and produce the desired torque.

SPEED CONTROL:

Speed control is necessary for torque and flux control of induction motors .It is also possible to implement a speed controller in closed loop using the DTC method .For that ,it becomes essential to know the rotor mechanical speed .To meet this requirement it has been developed a rotor speed estimations ,as referred earlier ,there are speed sensors ,and fuzzy logic based models and observers .However ,due to methods complexity and to the implementation available means ,closed loop estimator have been chosen.

ADVANTAGES OF DTC

In the direct torque controlled induction motor drive, supplied by a voltage source inverter, it is possible to control directly the stator flux linkage and the electromagnetic torque by selection of optimum inverter switching ,modes.

In addition it has the following advantages:

- High dynamic performance
- Instantaneous electromagnetic torque
- Relatively simple
- No speed or position encoder is required.
- Transformations are less when compared to FOC.
- Not as parameter sensitive as FOC

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DISADVANTAGE OF DTC:

The selected voltage vector is applied for the entire switching period and thus allows the electromagnetic torque and stator flux to vary for the whole switching period .This cause

- High torque and flux ripples.
- No constant switching frequency.
- Slow torque response and high current distortion.
- High settling time and peak overshoot.
- Problem during Low speed operation.
- Deterioration of the drive.

Due to these disadvantages a new concept of fuzzy logic is introduced in order to maintain constant speed and reduce the flux and torque ripples in the system.

FUZZYLOGIC CONTROLLERS:

Fuzzy logic has rapidly become one of the most successful of today's technology for developing sophisticated control system. With it aid complex requirement so may be implemented in amazingly simple, easily minted and inexpensive controllers. The application range from consumer products such as cameras ,camcorder ,washing machines and microwave ovens to industrial process control ,medical instrumentation ,and decision support system .many decision-making and problem solving tasks are too complex to be understand quantitatively however ,people succeed by using knowledge that is imprecise rather than precise . fuzzy logic is all about the relative importance of precision .fuzzy logic has two different meanings .in a narrow senses ,fuzzy logic is a logical system which is an extension of multi valued logic .but in wider sense fuzzy logic is synonymous with the theory of fuzzy sets . Fuzzy set theory is originally introduced by Lotfi Zadeh in the 1960,s resembles approximate reasoning in it use of approximate information and uncertainty to generate decisions. Several studies show, both in simulations and experimental results, that Fuzzy Logic control yields superior results with respect to those obtained by conventional control algorithms thus, in industrial electronics the FLC control has become an attractive solution in controlling the electrical motor drives with large parameter variations like machine tools and robots.

Fuzzy logic controller (FLC)

Fuzzy logic expressed operational laws in linguistics terms instead of mathematical equations. Many systems are too complex to model accurately, even with complex mathematical equations; therefore traditional methods become infeasible in these systems. However fuzzy logics linguistic terms provide a feasible method for defining the operational characteristics of such system .Fuzzy logic controller can be considered as a special class of symbolic controller. The configuration of fuzzy logic controller block diagram is shown in

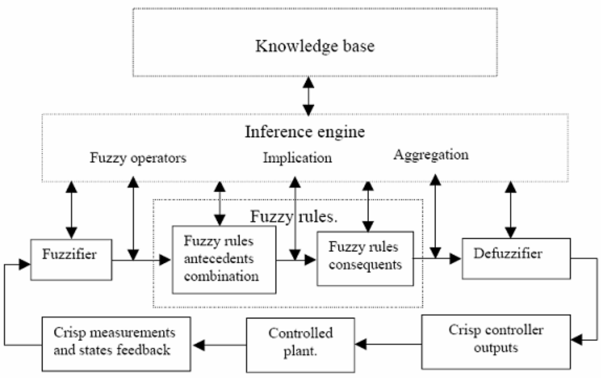

Figure 11.Block diagram for Mamdani type Fuzzy Logic Controller

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The fuzzy logic controller has three main components

1. Fuzzification.
2. Fuzzy inference.
3. Defuzzification.

SIMULATION MODEL:

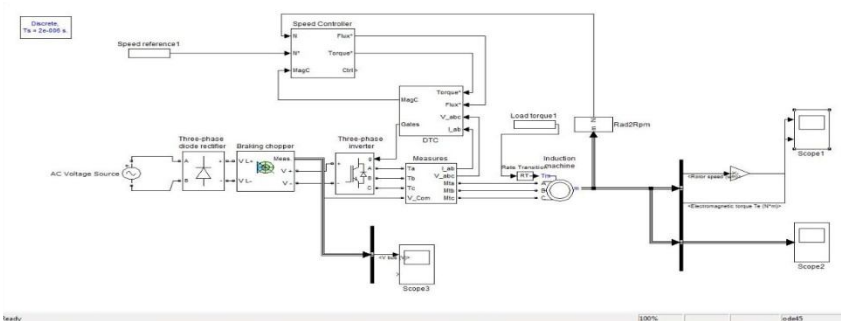

Figure 13. circuit diagram of DTC with Fuzzy logic

Simulation Results of DTFC:

The simulation results for stator axis current is shown in the figure

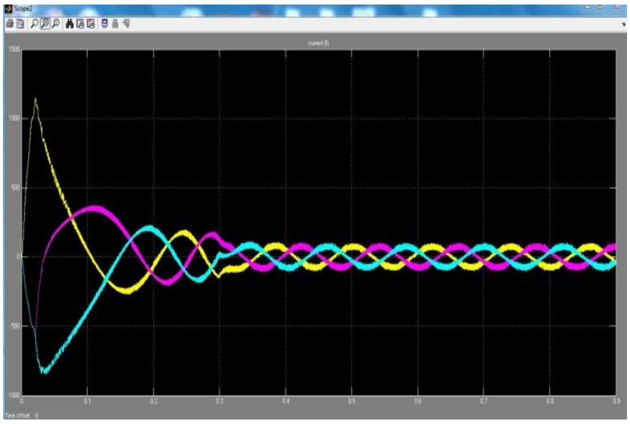

Figure 16.simulation results for stator current

The simulations results of voltage and current

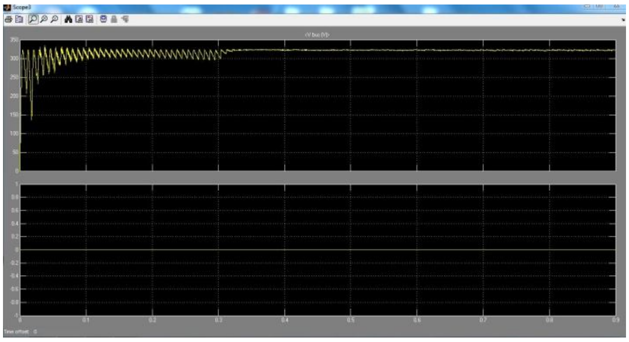

Figure 17. simulation result for voltage and current

CONCLUSION

In this project FLDTC of induction motor has been proposed . An improved torque and flux response was achieved with the FLDTC than the conventional DTC. The performance was tested by simulation.

- The main improvements observed from the simulation are:
- Reduction of torque and current ripples in transient and study state response.
- No flux dropping caused by sector changes circular trajectory.
- Fast stator flux response in the transient state.

The hardware result shows that the speed regulation of the Three phase induction motor was achieved and examined.

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