CONTROL OF STARTING CURRENT IN THREE PHASE INDUCTION MOTOR USING FUZZY LOGIC CONTROLLER

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Abstract- Variable speed drives are growing and varying. Drives expanse depend on progress in different part of science like power system, microelectronic, control methods, and so on. With the use of space vector technique to electrical drive control the, efficiency and reliability of drives increase and volume, weight and cost of them decrease. Due to the improved operating characteristics they give to the equipment control, Escalators pumps, elevators and conveyor belts all operate more effectively if they are soft started. In turn, the SVPWM method and FLC method reduces maintenance, conserves energy and plays a significant part in improving plant performance and operating costs.
This paper presents a novel design of a Sugeno fuzzy logic control scheme for controlling some of the parameters, such as starting current, speed, torque, flux, voltage, etc. of the induction motor. Induction motors are characterized by highly non-linear, complex and time-varying dynamics and inaccessibility of some of the states and outputs for measurements, and hence it can be considered as a challenging engineering problem. The development of advanced control techniques has partially solved induction motor's speed control problems; because they are sensitive to drive parameter variations and the performance may deteriorate if conventional controllers are used.
Further, the Sugeno control strategy coupled with rule based approach in a fuzzy system when employed to the induction motor yields excellent results compared to the other methods as this becomes a hybrid & integrated method of approach.

Keywords- *PI controller Fuzzy Logic Controller, Simulink Matlab, Induction motor, IGBT inverter, vector control technique, closed loop, Parameter, Robustness.*

1. INTRODUCTION- An important factor in industrial progress during the past five decades has been the increasing sophistication of factory automation which has improved productivity manifold. Manufacturing lines typically involve a variety of variable speed motor drives which serve to power conveyor belts, black start power plants, robot arms, overhead cranes, steel process lines, paper mills, and plastic and fibre processing lines to name only a few. Prior to the 1950s all such applications required the use of a DC motor drive since AC motors were not capable of smoothly varying speed since they inherently operated synchronously or nearly synchronously with the frequency of electrical input. To a large extent, these applications are now serviced by what can be called general-purpose AC drives. In general, such AC drives often feature a cost advantage over their DC counterparts and, in addition, offer lower maintenance, smaller motor size, and improved reliability. However, the control flexibility available with these drives is limited and their application is, in the main, restricted to fan, pump, and compressor types of applications where the speed need be regulated only roughly and where transient response and low-speed performance are not critical control of the induction machine is considerably more complicated than its DC motor counterpart, with continual advancement of microelectronics, these control complexities have essentially been overcome. Such that power electronic equipment used widely in motor drives is IGBTs. In the last few decades, the induction motor has evolved from being the constant speed motor to a variable speed, variable torque machine. When application require large amount of power and torque, the induction motor become more efficient to use. With the use of variable voltage, variable frequency (VVVF), the use of induction motor has increased. Variable frequency IGBT inverter fed space vector control method is widely used to control the speed harmonic, and starting current , voltage, rotor speed , output torque of a3 phase squirrel cage induction motor (IM) over a wide range by varying the stator frequency. In particular the IGBT fed space vector control are widely preferred in industries for individual medium to high power variable speed drive system, driving a group of motors connected in parallel at economic cost. The "Insulated Gate Bipolar Transistors (IGBT) is a common choice in modern VFD. The IGBT can switch on and off several thousand times per second and precisely control the power delivered to the motor as shown in figure1. The IGBT uses "pulse width modulation" (PWM) technique to simulate a sine wave current at the desired frequency to the motor is shown in figure 2. In the last few years, fuzzy logic has met a growing interest in many motor control applications due to its non-linearity's handling features and independence of the plant modelling.

2. METHODOLOGY OF WORK- A simulation model of such induction motor drive system is developed and its dynamic response is verified by observing starting current voltage and torque and control to established acceptability of the model. Here we used transistors based drives. The transistor based drives are capable of both turn on and turn off. In this paper to control the starting current we use two types of controllers. The fuzzy logic controller (FLC) operates in a knowledge-based way, and its knowledge relies on a set of linguistic if-then rules, like a human operator. This paper

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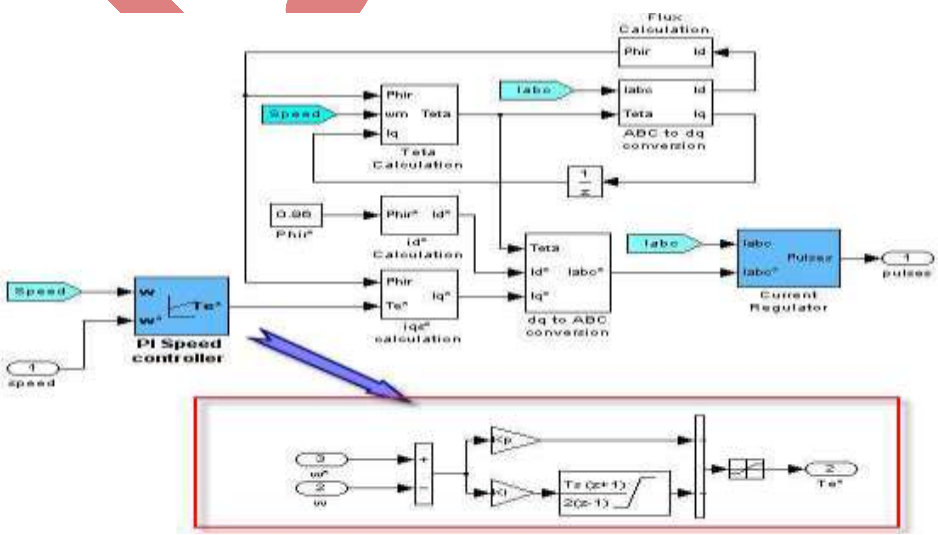
presented a rule-based fuzzy logic controller applied to a scalar closed loop induction motor control with slip regulation & they also compared their results with those of a PI controller. They used a new linguistic rule table in FLC to adjust the motor speed, and starting current. In this context, the fuzzy logic concepts play a very important role in developing the controllers for the plant as this controller does not require that much complicated hardware & uses only some set of rules. The principal motivations for such a hybrid implementation is that with fuzzy logic, neural networks & rough sets issues, such as uncertainty or unknown variations in plant parameters and structure can be dealt with more effectively, hence improving the robustness of the control system. Classical control systems like PI, PID control have been used, together with vector control methods, for the speed control of induction machines. The main drawbacks of the linear control approaches were the sensitivity in performance to the system parameters variations and inadequate rejection of external perturbations and load changes. As an attempt to solve all these deficiencies, problems & difficulties encountered in designing the controller as mentioned in the above paragraphs, we have tried to devise a control strategy using the Sugeno fuzzy scheme for the speed control of IM in our paper which has yielded excellent results & this has been applied to the control of electrical drive systems (induction motor). The results of our work have showed a very low transient response and a non-oscillating steady state response with excellent stabilization.

3. COTROL SCHEME (VECTOR CONTROL PRINCIPLE) - AC motors, particularly the squirrel cage induction motor (SCIM), enjoy several inherent advantages like simplicity, reliability, low cost and virtually maintenance free electrical drives. However, for high dynamic performance industrial application, their control remains the challenging problem, because they exhibit significant non-linearity and many of the parameters, mainly the rotor resistance, vary with the operating condition. Field orientation control (FOC) or vector control of an induction motor achieves decoupled torque and flux dynamics leading to independent control of the torque and flux as for a separately excited DC motor. FOC methods are attractive but suffer from one major disadvantage: they are sensitive to motor parameter variations such as the rotor time constant and an incorrect flux measurement or estimation at low speeds consequently, performance deteriorates and a conventional controller such as a PI is unable to maintain satisfactory performance under these conditions. Large majority of variable speed Applications require only speed control in which the torque response is only of secondary interest, more challenging applications such attraction applications, servomotors and the like depend critically upon the ability of the drive to provide a prescribed torque whereupon the speed becomes the variable of secondary interest. The method of torque control in ac machines is called either vector control or, alternatively field orientation.

4. FUZZY LOGIC CONTROLLER- In the second design approach the basic fuzzy logic controller (FLC), regarded as a kind of variable structure controller (VSC) for which stability and robustness are well established is developed. This follows the interpretation of linguistic IF–THEN rules as a set of controller structures that are switched according to the process states. The mathematical technique called fuzzy logic offers a new approach to improving voltage/frequency/current control. Fuzzy logic has evolved from branch of mathematics into a useful engineering tool.
Fuzzy logic has been implemented in this development of improved motor control because:

1) Fuzzy logic overcomes the mathematical difficulties of modelling highly non-linear systems.
2) Fuzzy logic responds in a more stable fashion to imprecise readings of feedback control parameters, such as the dc link current and voltage.
3) Fuzzy logic control mathematics and software are simple to develop and flexible for each modification.



4.DIAGRAMS AND TABLES

PI speed Controller

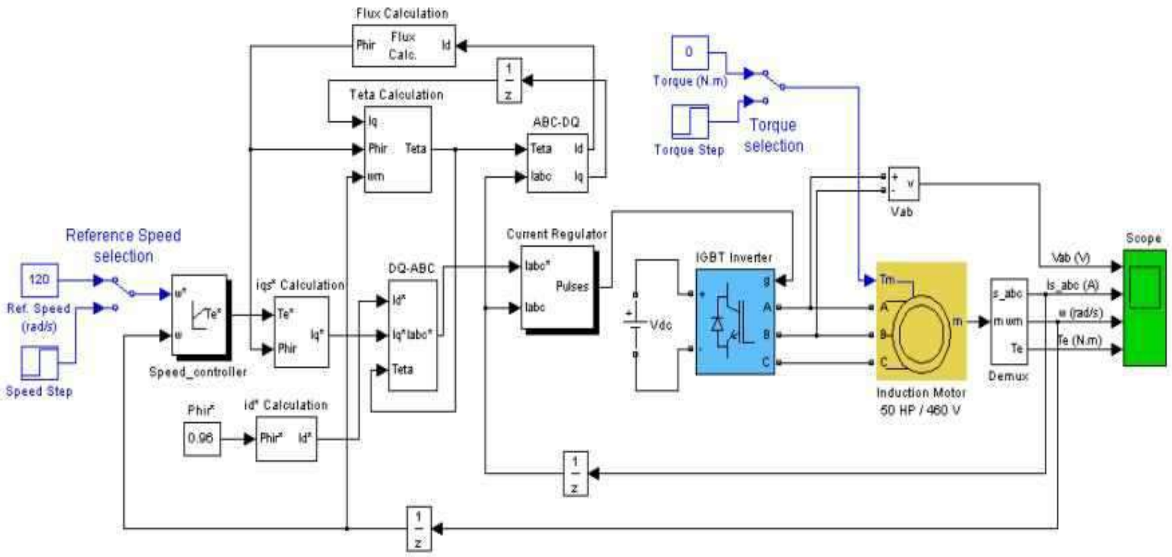


FIGURE2 Simulation model without using PI controller

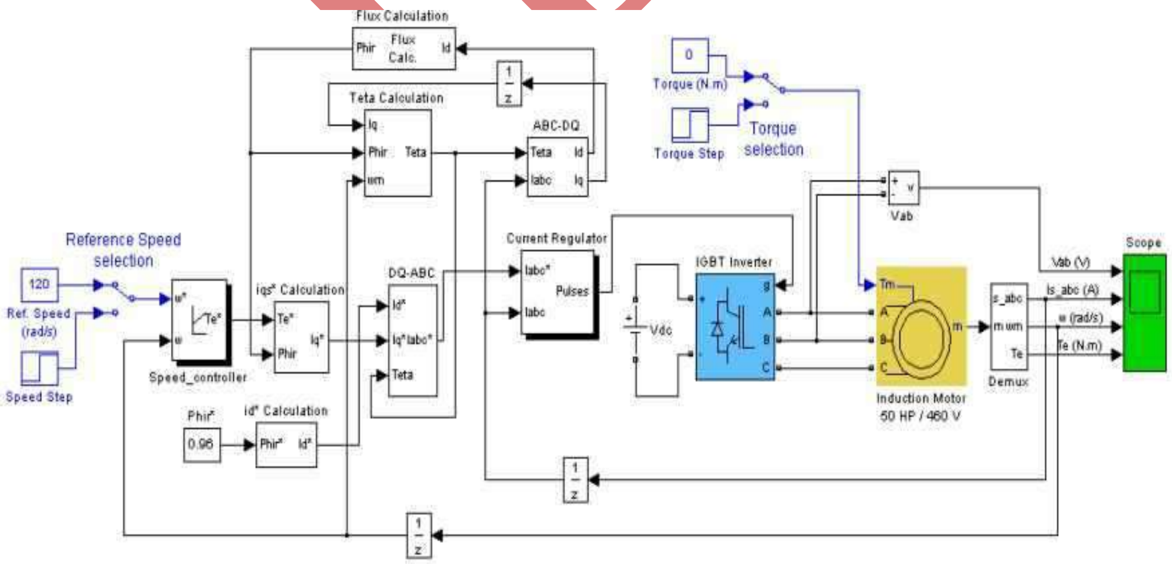


FIGURE3 PI Vector Control Induction motor diagram

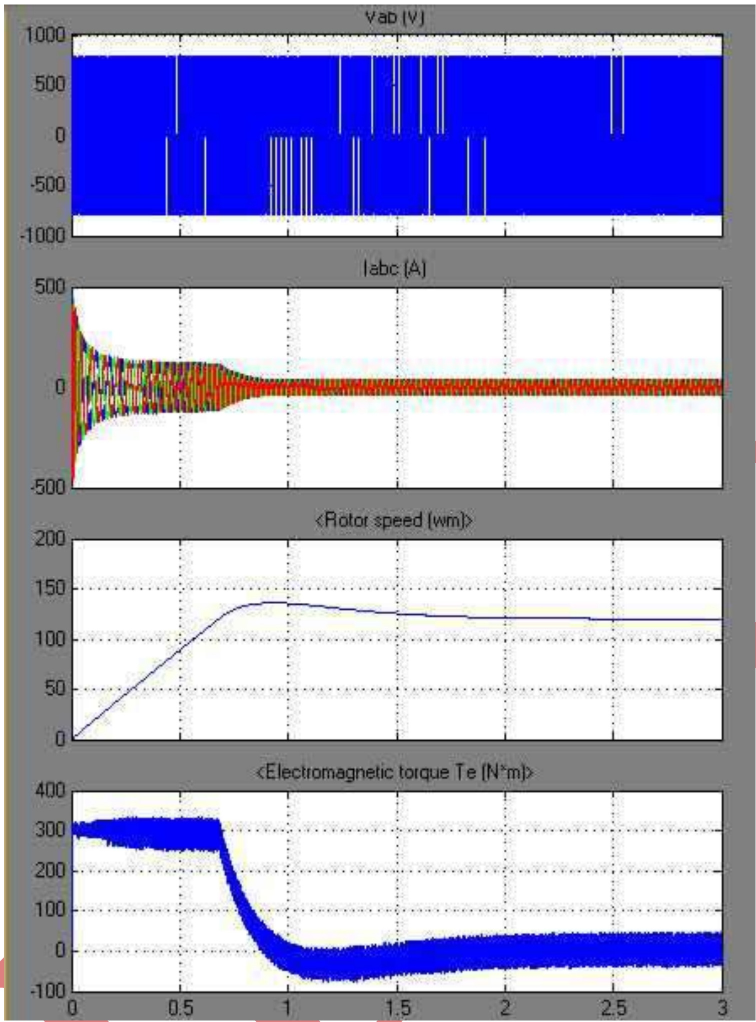


Figure4. Output Variable of a classic controlled induction Motor from Top to Bottom: Voltage, Current, Rotor Speed, and Output Torque.

Observation Table-1

Time Cycle (in seconds)	**Vab(V)**	**Iab(A)**	**Rotor speed(rpm)**	**Torque(Nm)**
0	800	500	0	0
0.5	0	200	90	350
1	0	100	140	350
1.5	800	100	130	350
2.0	800	100	120	350
2.5	0	100	120	300
3	800	100	120	300

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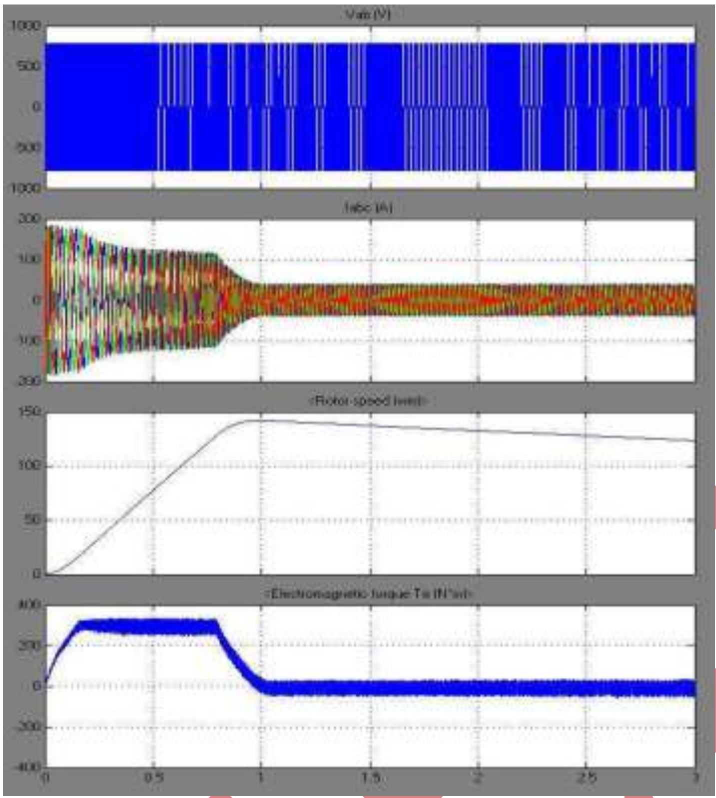

Figure5. Output Variable of a Fuzzy Logic Controlled induction Motor from Top to Bottom: Voltage, Current, Rotor Speed, and Output Torque

Observation Table-2

Time Cycle (in seconds)	Vab(V)	Iab(A)	Rotor speed(rpm)	Torque(Nm)
0	800	200	0	0
0.5	800	130	70	300
1	0	70	145	300
1.5	800	70	140	250
2.0	0	70	135	250
2.5	800	70	133	230
3	800	70	130	230

5.TABLE FOR FUZZY RULE BASE

NB=negative big, NM=negative medium, NS=negative small, ZE=zero, PS=positive small, and PM=positive medium, PB=positive big). The rule base table can be read according to the following example:

IF ERROR (E) is ZERO (Z) AND CHANGE IN ERROR (CE) is NEGATIVE SMALL (NS), THEN OUTPUT (DU) is NEGATIVE SMALL (NS).
Speed correction control is needed because the perturbation approach alters motor speed and output power. The motor's output rotor speed should be maintained as constant as possible

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CE \ E	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NS	NS	Z
NM	NB	NM	NM	NM	NS	Z	PS
NS	NB	NM	NS	NS	Z	PS	PS
Z	NB	NM	NS	Z	PS	PM	PB
PS	NS	NS	Z	PS	PS	PM	PB
PM	NS	Z	PS	PM	PM	PM	PB
PB	Z	PS	PS	PB	PB	PB	PB

6.SIMULATION RESULTS & DISCUSSIONS

In this paper two case studies have been studied. In Both simulations, it is used simulink and Power sym toolboxes of MATLAB software. In the first case study, a 50 HP induction motor is started and controlled by a PI controller as shown in the figure 1. 3phase voltages and currents are measured and plotted in the first 3 seconds of its action. Also acceleration curve and output torque are investigated. In the second case, the same motor is started and controlled by a Fuzzy Logic Based controller The outputs are improved regarding to magnitude of starting currents and also time response of acceleration. For example amplitude of current with a classic PI controller is about 500 A during start-up as shown in the fig. 4. While with fuzzy logic controller this value reduced to 200 A as shown in the fig. 5.

7. CONCLUSION

In this paper two case studies have been studied. In Both simulations, it is used simulink and powersym toolboxes of MATLAB software. An AC induction motor can consume more energy than it actually needs to perform its work, particularly when operated at less than full load conditions. A systematic approach of achieving robust speed control of an induction motor drive by means of Sugeno based fuzzy control strategy has been investigated in this paper. Simulink models were developed in Matlab 7 with the Sugeno based fuzzy controllers (hybrid controller) for the starting current control of IM. The control strategy was also developed by writing a set of 49 fuzzy rules according to the Sugeno control strategy. The main advantage of designing the Sugeno based fuzzy coordination scheme to control the starting current of the IM is to increase the dynamic performance & provide good stabilization. Simulations were run in Matlab 7 & the results were observed on the corresponding scopes. Graphs of speed, torque, starting current, voltage, etc. vs. time were observed. With a fuzzy logic controller we can control the amplitude of starting current and also save more energy during this time.

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