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AN INTELLIGENT CONTROL FOR 6/4 SRM USING MATLAB

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Abstract-- *Switched reluctance motor is one of the special electrical machines with several features like robust construction, less expensive having good scope in all kind of application. In this motor we need feedback control to determine the rotor position to excite the windings. In conventional method they use sensor control techniques like Hall Effect sensor control, optical sensor etc. It leads to continuous monitoring otherwise it can damage. In order to avoid this, sensor less control for detecting the rotor position of switched reluctance motor. Here, fuzzy logic controller is used to determine the position of the rotor for 6/4 switched reluctance motor with relational operator and it produce pulse to control the motor using MATLAB.*

Keywords---*SRM, rotor position, sensorless control, fuzzy logic controller, hysteresis controller.*

I. INTRODUCTION:

In today's scenario special electrical machine playing the vital role in all kind application. According to this view, SRM having better performance when compare with other motors like PMSM, BLDC etc.[10]. For using SRM as a drive, we need to control the gate pulse which is used to give the pulsated dc supply to each phase of the winding. In order to control the phases, rotor position estimation is very important. It can be achieved by estimating the angle of rotor at a particular instant and its next phase get excited.to determine the angle of rotor can be performed by two types. They are Rotor angle estimation using sensor and sensorless rotor estimation. Within that sensor less operation is giving the best reliability for control of motor. For sensor less operation, there are several techniques involved, but intelligent control techniques are newly emerging technique.in this proposed system, fuzzy logic controller are used to estimate the position of the rotor, using current flux as a input and rotor angle as a output the we can estimate the speed and it again fed back to speed controller the determination of torque, torque ripple and its efficiency for switched reluctance motor is to be calculated.

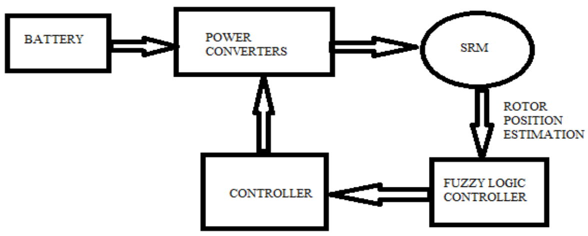

Figure1.Simplified Block Diagram for Proposed System

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II. SWITCHED RELUCTANCE MOTOR:

Switched reluctance motor is a doubly salient singly excited synchronous motor. It having robust construction and there is no winding or permanent magnet in rotor.so there is no need of high initial torque to rotate the machine. It is made up of aluminum metal or stainless steel for their structure.in 6/4 motor rotor excitation is comprises of three phases. Each phase get excited at an equal interval [1].

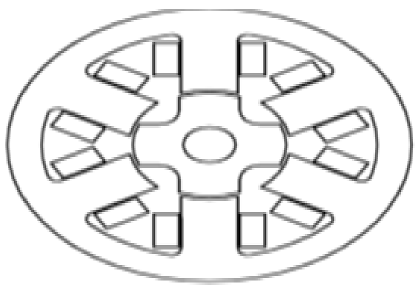


Figure 2.Construction of Switched Reluctance Motor.

2.1. PRINCIPLE OF OPERATION:

The rotor is aligned whenever diametrically opposite stator poles are excited. In a magnetic circuit, the rotating member prefers to come to the minimum reluctance position at the instance of excitation. While two rotor poles are aligned to the two stator poles, another set of rotor poles is out of alignment with respect to a different set of stator poles.[1]Then, this set of stator poles is excited to bring the rotor poles into alignment. Likewise, by sequentially switching the currents into the stator windings, the rotor is rotated. The movement of the rotor, hence the production of torque and power, involves switching of currents into stator windings when there is a variation of reluctance. Therefore, this variable speed motor drive is referred to as a switched reluctance motor drive.

2.2 LINEAR CHARACTERISTICS OF SRM:

The flux current curve of switched reluctance motor using finite element analysis using MATLAB is obtained[14].

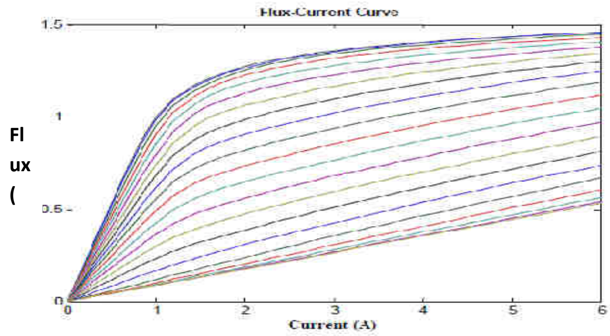


Figure 3. Flux-Current Curve

The relationship between the speed and flux with respect to motor's rotor position is estimated using the finite element analysis is shown in the figure:

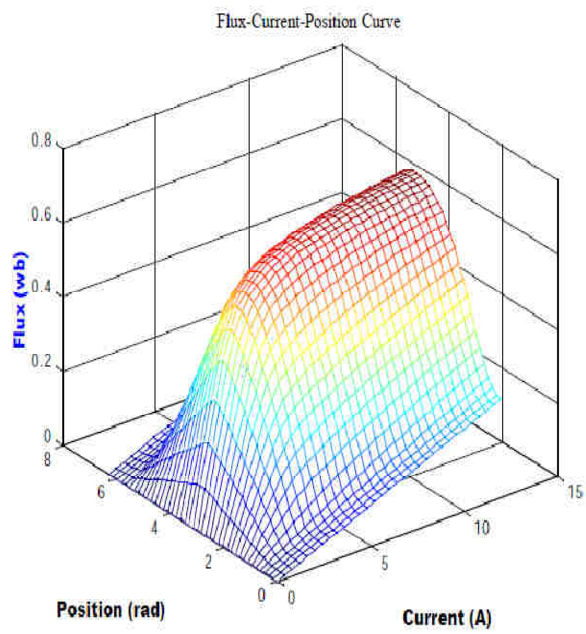


Figure 4. Flux-Current-Position Curve

2.3.FLUX ESTIMATION FROM FARADAY'S LAW:

The flux estimation from the phase current and voltage of the motor for determining the rotor estimation[1]&[11]. It can be obtained by taking integration of phase voltage with the current and resistance at each phase, and then the equation is stated as:

$$V = IR + \frac{d\lambda}{dt} \quad (1)$$

$$V - IR = \frac{d\lambda}{dt} \quad (2)$$

$$\lambda = \int (V - IR)dt \quad (3)$$

2.4. EXCITATION SEQUENCE OF SRM:

Switched reluctance motor is needed to control for the speed operation. The phase of this motor is excited based on the switching sequence. The switching sequence determines the direction of rotation of the motor. Using this table rotor motion takes place.

Phase/ rotor angle	**0**	**30**	**60**	**90**	**120**	**150**	**180**
Phase 1	On	Off	Off	On	Off	Off	On
Phase 2	Off	On	Off	Off	On	Off	Off
Phase 3	Off	Off	On	Off	Off	On	Off

Table 1.1 Excitation sequence of switched reluctance motor

III. FUZZY LOGIC CONTROLLER:

Several intelligent techniques are involved in emerging application. Fuzzy logic control is one of the intelligent techniques in the areas of isolated system like sensorless operation. Fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions.it has following components like fuzzification, fuzzy interference system and defuzzification.it converts crisp sets into fuzzy sets using fuzzifying technique and it goes to fuzzy interference system. Here rules are framed. These rules process the fuzzy value and give output as a fuzzy value. This fuzzy value is again fed into the defuzzifier to covert the fuzzy value onto crisp value.[3],[5],[7].

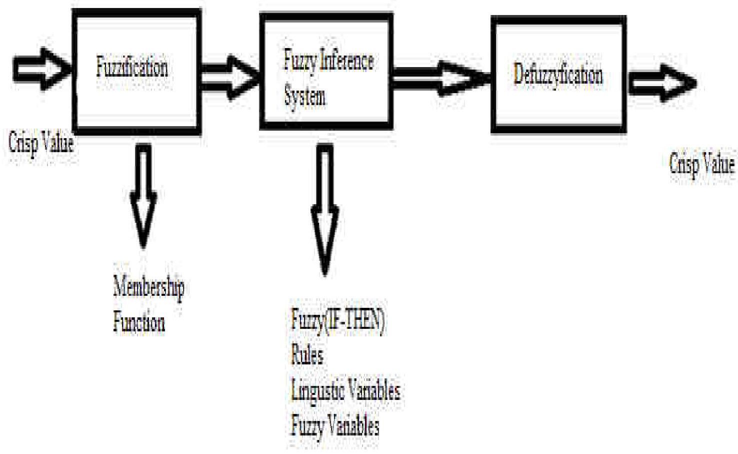


Figure 6. Block diagram of Fuzzy Logic Controller

3.1. Fuzzification:

A process that converts conventional expressions to fuzzy terms quantified by fuzzy membership functions[11].

3.2. Fuzzy Interference System:

Fuzzy inference systems (FISs) are also known as fuzzy rule-based systems, fuzzy model, fuzzy expert system, and fuzzy associative memory. This is a major unit of a fuzzy logic system. The decision-making is an important part in the entire system. The FIS formulates suitable rules and based upon the rules the decision has made [2].

This is mainly based on the concepts of the fuzzy set theory, fuzzy IF THEN rules, and fuzzy reasoning. FIS uses “IF. . . THEN.. . ” statements, and the connectors present in the rule statement are “OR” or “AND” to make the necessary decision rules. The basic FIS can take either fuzzy inputs or crisp inputs, but the outputs it produces are almost always fuzzy sets. When the FIS is used as a controller, it is necessary to have a crisp output. Therefore in this case defuzzification method is adopted to best extract a crisp value that best represents a fuzzy set. The whole FIS is discussed in detail in the following subsections.

This fuzzy inference system was having two methods.

1. Mamdani's Fuzzy interfence system
2. Sugeno or Takagi–Sugeno–Kang method

3.3. Defuzzyfication:

Center of Mass. This technique takes the output distribution and finds its center of mass to come up with one crisp number[5]. This crisp number is obtained in a process known as defuzzification.

This is computed as follows:

$$z = \frac{\sum_{j=1}^{q} z_j u_c(z_j)}{\sum_{j=1}^{q} u_c(z_j)} \ldots\ldots\ldots\ldots,(4)$$

,where z is the center of mass and u_c is the membership in class c at value z_j . An example outcome of this computation is shown:

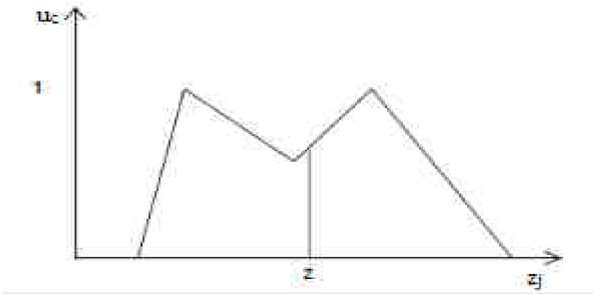
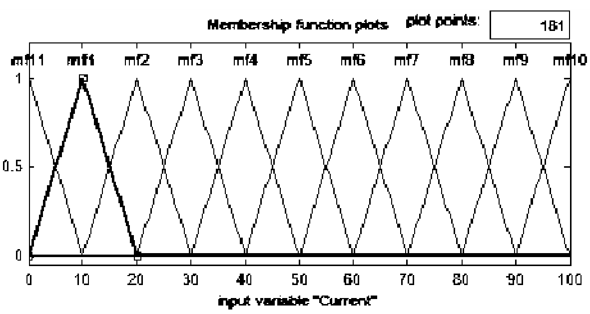
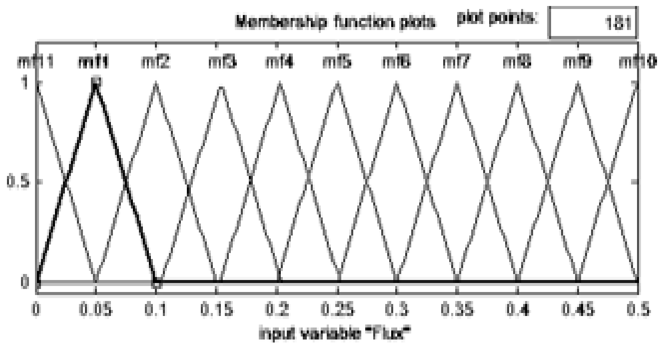


Figure 7.Centre of Mass

IV.ROTOR POSITION ESTIMATION USING FUZZY LOGIC CONTROLLER:

To model a fuzzy rotor position estimator for SRM, the SRM magnetization curve (Flux linkage-current-rotor position) termed a fuzzy rule base where the several rotor position data's are stored in fuzzy rule-base tables, the position information can be taken from the rule base tables during operation. This rule base table provides several values of rotor position from the inputs of the fuzzy model.





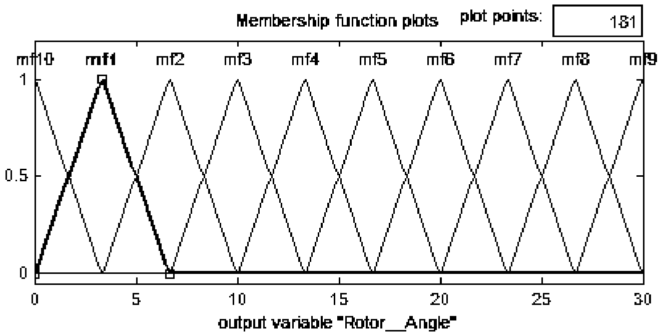


Figure 8. Membership Functions of ψ,I,Ɵ of One Phase

The generated fuzzy rule base is used for mapping the input values of flux linkage and current to output value of rotor position in terms of an angle. A variable in fuzzy logic has sets of values, which are characterized by linguistic labels, such as SMALL, MEDIUM, and LARGE etc.[10]. These labels are represented numerically by fuzzy sets. Each set is again characterized by membership function varies from 0 to 1. Thus fuzzy sets can be viewed as mathematical representation of linguistic values. Crisp value is the member of a fuzzy set, with a degree of membership varying from 0 (non-member) to 1 (full member). Fuzzy logic system can be simply represented into four parts: the fuzzifier, the rule base, the interference engine and the defuzzifier.The input domains are flux linkage and current are defined to have a domain of 0–0.5 and 0–100 A respectively. Similarly, the domain of the angle is defined as 0–90degrees. Here the fuzzy sets were chosen to be isosceles triangular shape [2].

V. DESIGN PARAMETER:

Here using MATLAB/Simulink software[6] is used to analysis the motor with fuzzy logic controller.Here using specific model with the parameters below shown:

Sl.no	Parameter	value	unit
1	Stator Resistance	0.05	ohm
2	Inertia	0.05	kg.m.m
3	Friction	0.02	N.m.s
4	Initial Speed	0	rad/s
5	Initial Position	0	rad
6	Magnetization Characteristic Table	'srm64_60kw.mat'	MAT file
7	Rotor Vector Angle	[0 10 20 30 40 45]	degrees
8	Stator Current Vector	0:25:450	A

Table 1.2 Specific Model configurations for SRM in MATLAB

For Fuzzy Logic Controller Design:

	PARAMETER
1.Inputs	Current(1-200A),flux(0=0.05 ϕ)
2.Output	Rotor angle(0=90 Θ)
3.Fuzzy interference method	Mamdani
4.Defuzzification	Centre of mass

Table 1.3 Fuzzy Logic Controller in MATLAB

VI.SIMULATION CIRCUIT & RESULT:

The simulation of the proposed system is compare the result of the pulse which is generated by the position sensor with fuzzy logic control.[2] Using this thus the estimation of rotor position can be possible and determine which phase can be excited.[6][8].

In this proposed system thus the fuzzy logic controller is used to analyze the current and flux at the each phase and determine the rotor position. This output compare with reference value, which produce discrete pulses. This pulses help to control the excitation of the motor .The estimation of flux can be possible by sensing the voltage and current with constant resistance, and then it finally integrated to get the flux. the optimized output pulses are shown below.

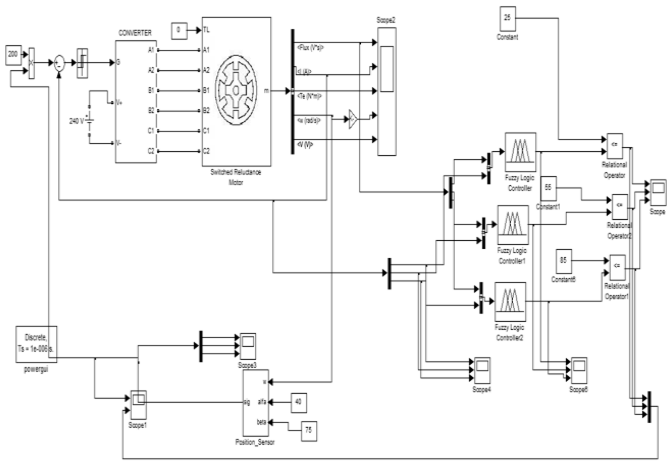


Figure 9. Simulation Circuit

6.1.FUZZY ESTIMATION:

Thus the logic for detecting the exciting phase winding is performed by the fuzzy logic controller. Each phase is excited it can be detected by the producing the signal using the reference value allotted to each phase.When it determines the phase it produce signal ,this signal is tuned as a pulses which can be given to the gate supply to the assymetric bridge converter.

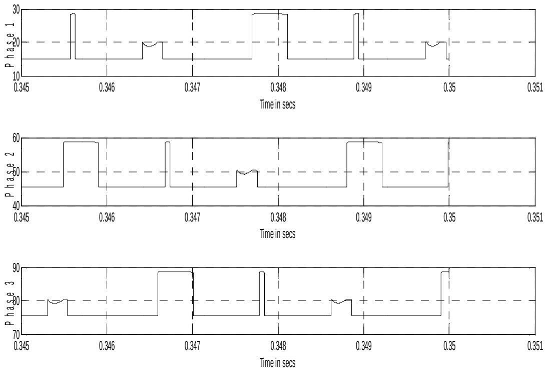


Figure 10.Rotor Estimation with FUZZY for

Phase 1,Phase 2 & Phase 3.

6.2.WITH POSTION SENSOR:

Optical sensor and hall effect sensors used to detect the speed of the SRM in conventional method so the speed is sensed using sensors and it converted into discrete signal finally the each angle is compared by the AND gate using the optimization with turn on and turn off angle of current and flux .Then this estimated output is sent to the speed comparator and this fed signal using current controller mostly hysteresis controller then it giving pulse to control the phases excitation of SRM.

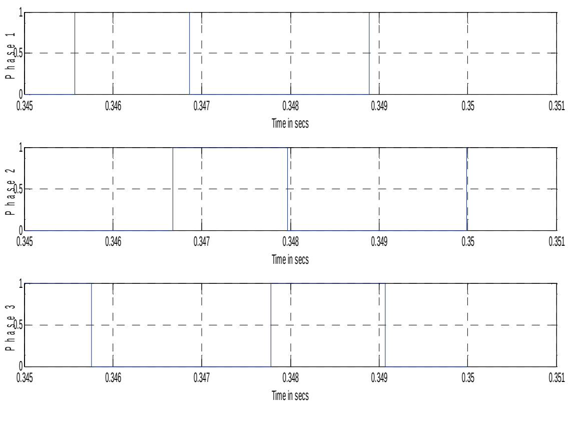


Figure 11.With Position Sensor for Phase 1,Phase 2 & Phase 3

6.3.WITH FUZZY LOGIC:

The maximum flux and the current is sensed using current transformer, current can directly sense, using current sensor but the flux can be calculated by voltage and the resistance of each phase. Then we can estimate the maximum current and flux linkages. By providing the rules to the fuzzy controller with fuzzifing and defuzzifying technique the rotor estimated angle is obtained. Again it optimized and it fed back to the converter to energise the next phase of the switched reluctance motor.

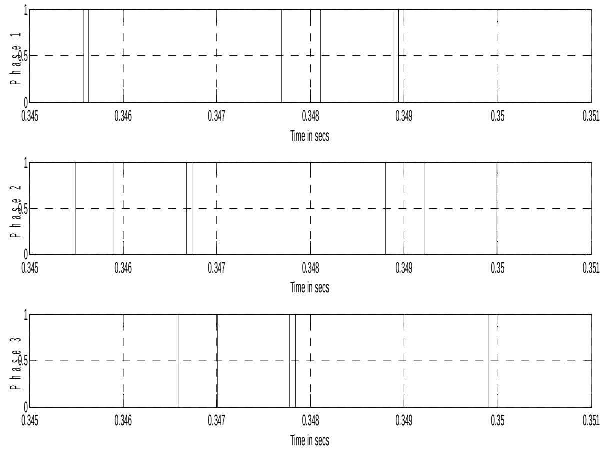


Figure 11.With Fuzzy Logic for Phase 1,Phase 2

& Phase 3.

VII. CONCLUSION:

In order to eliminate the sensor for control the speed of the SRM motor this fuzzy logic controller provides better output with less cost and maintenance free controller, because of using discrete input and output. Design of this controller is economical and we can optimize based on our requirement.it is very efficient technique and we can reduce the torque ripple and adjust the motor as per our need. This paper discussed about rotor position Estimation using intelligent technique were model free and high reliability at various operating conditions. Here we used the relationship of flux linkage and rotor position characteristics to estimate the rotor position. This proposed system has proved that proper designed Fuzzy based rotor position estimation of SRM operates within acceptable limits. This proposed technique control of SRM drive is suitable for real world problems.

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