Sensorless Position Estimation of Switched Reluctance Motor Using Fuzzy Logic

Saikumar Bellamkonda[1] | Ashish Vodnala[2] | Punyesh Lankapalli[3] | Bharadwaj Polusani[4] | Ranjit Kumar N[5]

[1,2,3,4] EEE Dept, SNIST,
[5]Asst Prof, EEE Dept, SNIST,

Abstract: The switched reluctance is one among the motor that's rugged in construction thus it's acceptable for vibrating and temperature zone but the most disadvantage of switched reluctance motor is large torque ripple. This produces vibration and noise at intervals the motor, thus on decrease the ripples the fuzzy logic controller is implemented. Attributable to the fuzzy logic controller output force of the switched reluctance motor is regulated among the hysterisis band. This paper describes the mathematical model of SRM motor and also the fuzzy logic technique. In addition to this the simulink model of switched reluctance motor with fuzzy management technique is supposed and tested through MATLAB/Simulink code. The parameters like speed and torque are described graphically.

KEYWORDS:Fuzzy Logic Control, SRM Motor, FLC Controller and Switched Reluctance Motor

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INTRODUCTION:

The switched reluctance is one among the motor that's rugged in construction thus it is appropriate for vibratory and high temperature zone. The torque made by the switched reluctance motor isn't dependent of phase currents polarity. Thus the less variety of semiconductor switches employed in the facility converters. Additionally to the current the loss occurred within the SRM motor is from the stator coil solely. Hence it is cooled simply. The switched reluctance motor are mostly employed in electrical vehicles, vacuums cleaner, washer, servo sort and speed variable applications. The switched reluctance motor simulink model consists of 3 main blocks. They're position device block, device block and switched reluctance block. The position device block consists of a position sensor device that is coupled to the rotor of switched reluctance motor. Hence the input and turn-off angles of the switched reluctance motor phases is measured precisely to regulate the developed torque switch angles measured are used. At identical time the measured current and reference current compared to come up with drive signal for insulated gate bipolar semiconductor. Hence the currents are independently controlled by hysteresis controller alone. The device block consists of 3 legs and every leg consists of 2 insulated gate bipolar semiconductor and 2 FW diodes. R Krishnan has bestowed the careful switched reluctance motor drive modeling, simulation, analysis, style and applications.

CONSTRUCTION AND OPERATING PRINCIPLE OF SWITCHED RELUCTANCE MOTOR

Actually in electrical machines the switched reluctance motor is that the best one once compare to variable types of electrical machines. Construction wise there is no permanent magnet or conductors among the rotor of switched reluctance motor. The rotor of switched reluctance motor consists of steel lamination stacked on to a shaft. Because of easy mechanical construction the cost of motor is low. T. J. E. Miller has explained the Switched Reluctance Motors and their management techniques [2]. The Figure [1] shows the cross sectional view of a switched reluctance motor. From figure [1] we tend to see the 8/6 pole arrangement.The automation and rotor poles of switched reluctance motor three phase supply is given to the 8/6 switched reluctance.

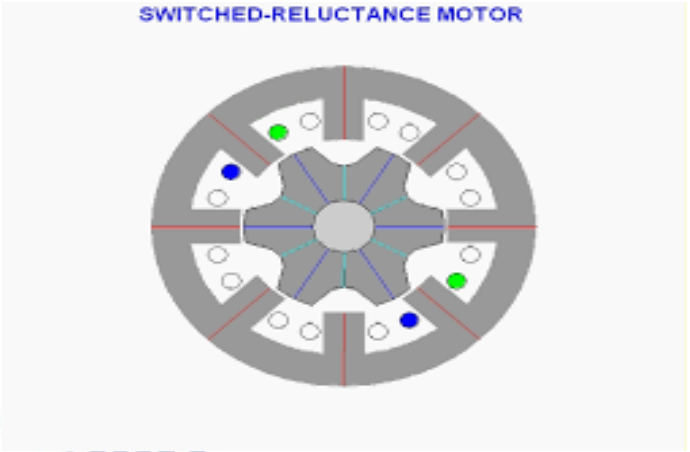


Figure 1: 8/6three phase SRM motor

On the premise of torque production the electrical machine is assessed in to a pair of types. so the means of torque production is because of variable relucatnce and therefore the alternative way of torsion production is because of magnet. In switched reluctance motor the force is made because of variable reluctance. Therefore it's known as switched reluctance motor.

BLOCK DIAGRAM OF FUZZY LOGIC CONTROLLER

The approximate data, just about reasoning and uncertainty to reasoning and uncertainty to generate decision are called fuzzy set theory. Truly for choosing formal logic controller there area unit 2 main reasons like Modelling will be developed for non-linear system and its adaptational characteristics.

A. Fuzzification: Fuzzification is nothing however the method of mapping the fuzzy membership perform with multiple measured crisp inputs. At identical time it converts computer file in to appropriate price .Hence this appropriate price is taken into account as a label of fuzzy sets. Fuzzification performs a scale mapping conjointly. In scale mapping transfer of input variables to corresponding universe of discourse takes place. The fuzzy membership functions within the type of quadrangle, triangle and bell membership functions area unit shown in figure [3].

The on top of equations a, b and c represents triangle membership perform, quadrangle membership perform and bell membership perform severally. The boundaries

E\DE	NM	NS	ZE	PS	PM
NM	NM	NM	NM	NS	ZE
NS	NM	NM	NS	ZE	PS
ZE	NM	NS	ZE	PS	PM
PS	NS	ZE	PS	PM	PM
PM	ZE	PS	PM	PM	PM

[Va/1,Va/2,Va/3] represent triangle membership perform.

The limits [Va/1,Va/2,Va/3,Va/4] represent quadrangle membership perform.

B. Fuzzy Inference Fuzzy inference is nothing but by using fuzzy logic there is a process of mapping the given input to the output and on the basis ofthis mapping decision are made or pattern discerned.

C. Defuzzification: The outputs of the interference mechanism area unit the output variables. The formal logic controller converts internal fuzzy output variables in to crisp values. So system will use these variables. Therefore it's referred to as as defuzzification.

$$\psi = L\{\theta, I\}I \rightarrow Equation\{2\}$$

FLC SPEED CONTROL ALGORITHM

Step 1: The Switched reluctance motor speed signal is sampled.

Step 2: Calculate speed error and alter in speed error.

Step 3: verify fuzzy sets for speed error.

Step 4: verify membership for speed error.

Step 5: verify fuzzy sets for amendment in speed error.

Step 6: verify membership for amendment in speed error.

Step 7: Finding management action as per fuzzy rule and calculate Δis.

Step 8: causing management command to the system when calculation.

Input and output variables of fuzzy membership function are selected as follows,

PB-Positive Big

PM-Positive Medium

PS-Positive Small

NB-Negative Big

NM-Negative Medium

NS-Negative Small

Z-Zero

In Input variables the value of speed error is −1 ≤ωe ≤+1 and value of change in speed error is −1 ≤ωce ≤+1. In output variables the value of change in torque reference current −1 ≤Δiqs ≤+1. The triangular shaped function is chosen as membership functions because of the best control performance and simplicity

MATHEMATICAL MODEL OF SWITCHED RELUCTANCE MOTOR

The numerical and analytical modeling of switched reluctance machine has been explained clearly by Zhang zhihui and Somesan Liviu [3-4]. A New Torque and Flux Control Method for Switched Reluctance Motor Drives have been developed by A. D. Cheok [5]. S Mir designed the Torque Ripple Minimization in Switched Reluctance Motors Using Adaptive Fuzzy Control model [6].

Mathematical equations for switched reluctance motor:

$$V = R_s I + \frac{d\psi\{\theta, I\}}{dt} \rightarrow Equation\{1\}$$

's=Resistance / phase ψ = flux linkage / phase

Voltage equations,

$$V = R_s I + \frac{d\{L(\theta, I)I\}}{dt} \rightarrow Equation\{3\}$$

$$V = R_s I + L\{\theta, I\}\frac{dI}{dt} + I\frac{d\theta}{dt}\frac{d_L\{L(\theta, I)\}}{d\theta} \rightarrow Equation\{4\}$$

$$V = R_s I + L\{\theta, I\}\frac{dI}{dt} + \frac{d_L(\theta, I)}{d\theta}\omega_m I \rightarrow Equation\{5\}$$

$$e = \frac{d_L(\theta, I)}{d\theta}\omega_m I = K_b \omega_m I \rightarrow Equation\{6\}$$

$$K_b = \frac{d_L(\theta, I)}{d\theta} \rightarrow Equation\{7\}$$

The instantaneous power is given by,

$$P_I = VI = R_s I^2 + I^2\frac{dL\{\theta, I\}}{dt} + L\{\theta, I\}I\frac{dI}{dt} \rightarrow Equation\{8\}$$

$$\text{Time}, t = \frac{\theta}{\omega_m} \rightarrow Equation\{9\}$$

Air gap power is given by,

$$P_a = \frac{1}{2} I^2 \frac{dL\{\theta, I\}}{dt} \rightarrow Equation\{10\}$$

$$P_a = \frac{1}{2} I^2 \frac{dL\{\theta, I\}}{d\theta} \frac{d\theta}{dt} \rightarrow Equation\{11\}$$

$$P_a = \frac{1}{2} I^2 \frac{dL\{\theta, I\}}{d\theta} \omega_m \rightarrow Equation\{12\}$$

$$P_a = \omega_m T_e \rightarrow Equation\{13\}$$

Torque from above equations obtained as,

$$T_e = \frac{3}{2}\left\{\frac{P}{2}\right\} \frac{L_m}{L_s' L_r} \overline{\psi_s} * \overline{\psi_r} \rightarrow Equation\{15\}$$

$$T_e = \frac{3}{2}\left\{\frac{P}{2}\right\} \frac{L_m}{L_s' L_r} \psi_s \psi_r \sin\gamma \rightarrow Equation\{16\}$$

The stator flux assessment is done on the basis of stator voltage model and current model. The equation 17, 18 and 19 represents stator voltage equations. In case of current model equation 20 and 21 are used.

$$\psi_{ds}{}^s = \int \{V_{ds}{}^s - i_{ds}{}^s R_s\} dt \rightarrow Equation\{17\}$$

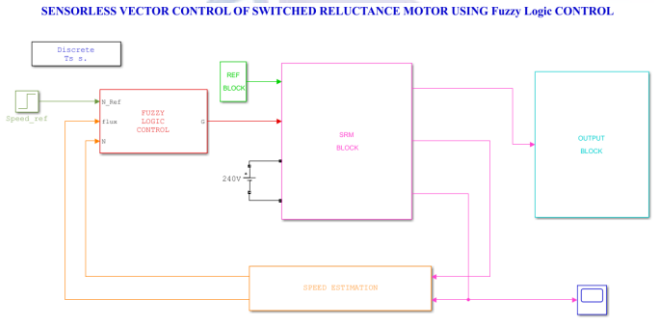
$$\psi_{qs}{}^s = \int \{V_{qs}{}^s - i_{qs}{}^s R_s\} dt \rightarrow Equation\{18\}$$

$$\psi_s = \sqrt{\psi^s{}_{ds}{}^2 + \psi^s{}_{qs}{}^2} \rightarrow Equation\{19\}$$

$$\frac{d}{dt}\overline{\psi_r} = \left\{\frac{\{L_m i_s - \psi_r\}}{T_r} - \omega_r \psi_r\right\} \rightarrow Equation\{20\}$$

$$\overline{\psi_s} = \left\{\frac{L_m}{L_r}\psi_r + \sigma L_s i_s\right\} \rightarrow Equation\{21\}$$

SIMULATION MODEL OF SWITCHED RELUCTANCE MOTOR WITH FUZZY LOGIC CONTROL



In the MATLAB simulation of switched reluctance motor the following specification are used: Number of phases = 3, Number of stator and rotor poles = 8/6, Frequency [F] = 50 Hz, DC supply voltage [Vdc] = 240 volts, Stator resistance [Rr] = 0.01 ohms/phase, Moment of inertia [J] = 0.0082 Kgm/sec, Unaligned inductance = 0.7 m H, Aligned Inductance = 20 m H.

SIMULATION RESULTS

[A]Torque

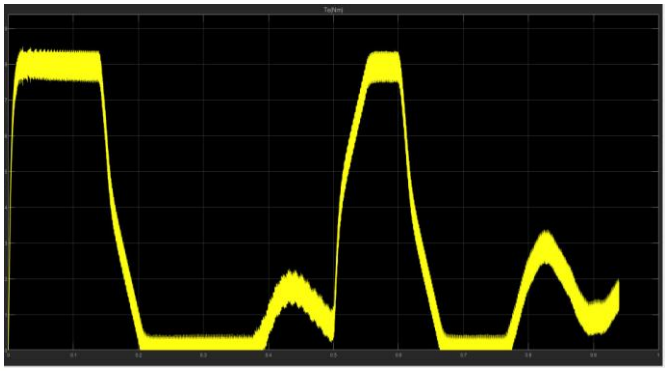


Figure 7: Torque in Newton-Meter

[B] Speed

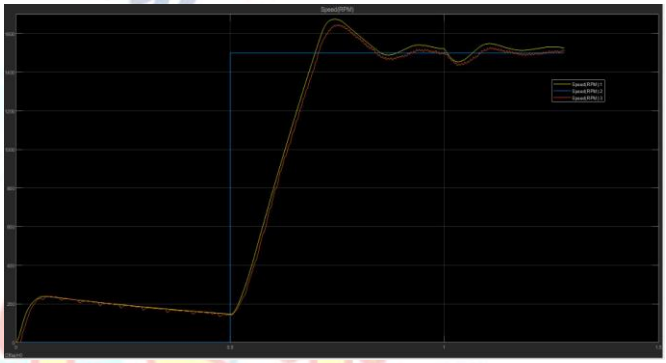
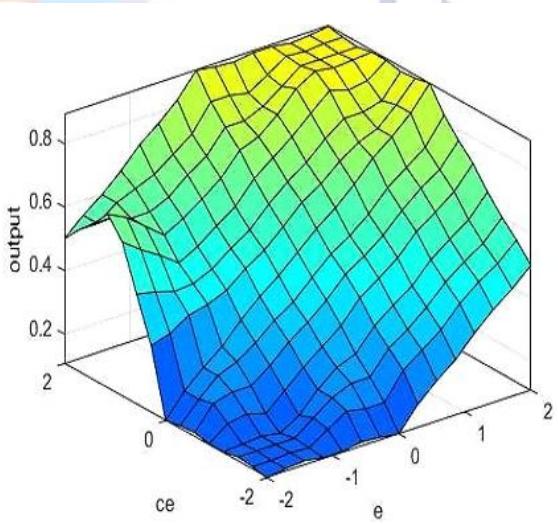


Figure 8: Speed in Revolution per Minutes

3-D OUTPUT DIAGRAM:



CONCLUSION

According to the on top of the review, it appears that there's no abundant work has appeared on the result of variation of stator-and rotor pole/pole pitch magnitude relation on the typical force developed by the SRM, as well as, no abundant work has appeared on the switched reluctance motor's controller, therefore the project objectives are: to propose the best and the

simplest style for the switched reluctance motor betting on the effect of variation of stator-and rotor pole/pole pitch magnitude relation on the typical force developed by the SRM by victimization the foremost effective simulation tools to propose a brand new controller for SRM.

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