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Comparative Analysis of Different Controllers for Adjustable Speed Switched Reluctance Motor using Closed Loop Operation

Padmashree V. Kulkarni[1], H. V. Govindaraju[2], Babitha S.[3]

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Abstract: Controllers are designed to enhance speed performance as well as lowering the torque ripple of switched reluctance motors. Development of controllers in this paper involves the use of fuzzy sets for various membership functions, the PI and PID controllers in MATLAB SIMULink environment. Here, SRM speed and torque regulated over a large bandwidth using Fuzzy, PI, and PID controllers. Furthermore, the simulated speed is measured and matched with the reference speed; speed errors are processed by the controller. Finally, simulation results are obtained for speed, and torque for PI, PID, and Fuzzy Logic controllers, and comparison is performed with respect to speed response and torque ripple. The results obtained using the Matlab platform may help further the analysis and improvement of controller design for switched reluctance motors.

Keywords: *Closed loop operation, Fuzzy Logic Controller, Proportional Integral Controller, Proportional Integral Derivative Controller, Switched Reluctance Motor*

1. Introduction

In recent years, SRM (Switched Reluctance Motors) motors have become increasingly popular due to their features such as simplicity of design, lower cost, robust construction, and lower power density. The SRM characteristics are non-linear because the inductance depends on both rotor position and current. SRM stator windings have twisted field windings like a DC motor and no windings or magnets on the rotor. The machine is doubly sailent because the stator and rotor poles are prominent poles. As per pole concern number of poles in stator will be either 6 or 8.position sensor is mounted on the shaft of the machine. It helps to determine the position of the rotor with the help of control circuit. Control circuit collect the information and provides input the converter circuit for proper excitation of motor. Controller also monitors motor current which in turn protects motor from any faults. One phase of the winding is formed by connecting the diametrically opposing windings of the stator in series. Because of its efficiency and durability in a variety of applications, including conventional industrial uses, aircraft, multi-purpose machines, compressors, fans, pumps, electric vehicle centrifuges, and vacuum cleaners, the successful development of this machine will revolutionise washing machines and private laundries will operate without interruption 24/7. When both commutating phases are in their excitation period, the self-adaptive phase torque obeys a linear distribution law. A novel control technique can smooth out the torque ripple caused by the SRM nonlinearity and the torque generation features of the phase community [20-22].

Torque strategy was experimentally implemented in the Basic Drive System (BDS). The torque ripple reduction control is affected by the on/off switch and current profile.

Normal DC acoustic noise levels are controlled by a hysteresis control strategy and a control technique for reducing torque ripple. Torque-free operating at low, middle, and maximum speeds is possible by combining rotation angle, turn off angle, and phase torque distribution coefficient k. Both the stator and rotor are made from a single stack of laminations. In the simplest configuration, opposing poles of the stator bearing windings are connected in series to form a diametrically opposite pattern of bipolar field.

The machine's phase numbers is determined by the number of stator poles. Each phase is energized by a controlled switch supplied by DC power. The rotor can be driven in both directions by changing the phases of the stator. Each phase is switched on and off at least every 45°; this is known as fundamental switching frequency of SR motor. During each switching period, phases which are connected in series are energized simultaneously.

Torque ripple is due to the sequential switching of each phase of the stator winding. There are two ways in which torque ripple can be minimized one by a magnetic design

[1]*Associate Professor, Department of Electrical and Electronics Engineering, Don Bosco Institute of Technology, Bengaluru, India*
ORCID ID: 0000-0002-6424-9556
[2]*Associate Professor, Department of Electrical and Electronics Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India*
ORCID ID: 0000-0003-1267-4064
[3]*Associate Professor, Department of Electronics and communication Engineering, Don Bosco Institute of Technology, Bengaluru, India*
ORCID ID: 0000-0001-9547-6690
** Corresponding Author Email: padmashrieee81@gmail.com*

approach and another by an electronic control approach. Under the machine design approach, the structure of stators and rotor poles can be modified to reduce torque ripple, but only at the expense of specific motor output. The electronic approach involves amending the controlling parameters such as supply voltage, turn off, and turn on angles, and different levels of current. This approach may result in less torque but needs to design different controller.

The most popularly used SRM configurations are 6:4 and 8:6, with other possible configurations being 6:8, 10:4, and 12:8. Low power density problems can be solved by using solutions such as permanent magnets or specialized rotor designs, but these solutions are costly and complicate the manufacturing process. Due to the advancement of microelectronics and power electronics, as well as the development of control algorithms and embedded systems, SRM is now recognized as an emerging and potential technology in a broad array of applications.

A normal approach to energise the SRM is done by using asymmetric bridge converter. Here frequency of switching is 10 times slower than the AC motors. The number phases in converter corresponds to number phases of motor. When both the switches on either side of converter is tuned on, then the corresponding phase which is connected will be activated. When the current in the converter rises beyond the regulated value switch turns off. The energy which is stored during excitation of winding makes the current to maintain in the same direction which is called back EMF. This Back EMF is supplied back via through diodes and capacitor, which helps in improvising efficiency.

2. Literature Review

In [1], the authors describe the study of electric vehicle wheel usage and the design of an SRM analysis. The stator/rotor pole, current density, input current, and outer diameter of the C-Core stator Double Rotor SRM, the C-Core stator Flat-type Segmented Rotor SRM, and the double-sided Segmented Internal Rotor SRM are constructed and compared. The analysis considers the important performance parameters of the electric motor In-bike applications like torque per active mass, torque per active volume, torque ripple. As a result of the axial magnetic configuration's field distribution, the machine 3D finite element analysis (FEA) is carried out using Magnet7.5 software. The most suitable of the three configurations is selected and the test results are displayed. Today, SRM is replacing shunt motors and BLDC motors due to higher speed and better efficiency. SRM is modeled in Matlab Simulink environment. Speed control with PID controllers is presented in the Simulink environment [2].

Due to increasing demand in EV applications, Switched Reluctance is used [3, 19] because of its robust structure, reliable structure, non-saliency, and good torque-to-inertia ratio. The controlling techniques are also studied and categorised. The torque ripple minimization and the speed of switching reluctance's motors with the help of fuzzy logic control and DTC are focussed on [4]. To improve the performance, switching must be done at exact angles. To get those exact angles, fuzzy logic along with the DTC method is used in [5]. A new methodology in the direction of the design and development of mathematical models using the LabVIEW environment is carried out with different controllers. To reduce the torque ripple, a controller is designed in the LAB View platform using proportional and integral controllers. Proportional and integral controller VI subsystems are developed using the control system tool-box. The gains of the PI controller are selected with different combinations of Kp and Ki values, to minimize the torque ripple and settling time. Waveforms for speed, torque, voltage, and current are plotted for 800 rpm and, load torque of 0.6N-m. In [6], SRM drive systems with fuzzy speed controllers and PID current controllers are developed using Matlab Simulink for a variety of speeds. To confirm the accuracy of the simulation data, experimental data was generated for these speeds with the controller included in the DS1103 Ace kit. It has been proven that fuzzy logic speed controllers are efficient and not affected by any changes in parameters or disturbance. In [7], a research procedure was developed to regulate the Switched Reluctance Generator voltage using the fuzzy logic control algorithm. A control strategy is developed to control the upstream switches of the converter. Results are tabulated for both open loops and closed loops with variable speed and load. Auto-tuning PI controller is executed using a PLC in [8]. The PI controller gains are obtained through Fuzzy, which is implemented in Matlab, and the exchange of data between a MATLAB (or Simulink) and Programmable Logic Controller is done through objects that link process embedding's/components. Switched reluctance motors provide an alternative with increased demand in conventional industrial drives [9]. To meet the increase in demand, a broad analysis of different control strategies for reducing torque ripple and improving the speed performance is needed. An analysis based on control strategies is done to review the best controller for improving performance of a switched reluctance motor. Among various techniques, fuzzy logic techniques are preferred as they have a significant impact on reducing torque fluctuations in switched reluctance motors.

Different SRM control modes are: Current control, Speed control, Torque control and information regarding types of converters gives an idea for selecting the best controller, and converter which aids in increasing the speed performance of SRM [10]. SRM can be used in place of permanent magnet synchronous motors as they are elegant and hard to work in harsh environments. The study is done on the design of 20 KW 4 phase SRM considering different SRM parameters like slot filling factor (SFF), winding excitation (LIVE) voltage, switching pattern (SWP), and simulation results provide good results on overall performance and harmonics of SRM that can be optimal for electric vehicles (EVs) [11]. Different techniques are used to reduce current and torque ripple; one such technique is MPC. Here MPC is compared with traditional control algorithms, which give better outcomes in terms of accuracy, response, and stability. The proposed controller in [12] was tested with different loading conditions and proved that MPC is better than the current hysteresis controller. The converter is designed using the C programming language. To achieve a speed greater than the rated speed while maintaining the power constant, different controllers, such as fuzzy and PI, are considered. Here, the position of the rotor and ref current are considered inputs, which in turn produce compensating current as outputs with a seven-membership-fuzzy logic controller. Fuzzy logic controllers give better performance compared to PI, as justified by simulation results in [13].

3. Proposed Methodology

A switched reluctance motor is a single-excitation, double sailent machine that generates electromagnetic torque using the variable reluctance principle. The stator and rotor both have prominent poles, but only the stator has windings. SRMs, like DC motors, use field coils to wound the stator windings. The rotor, on the other hand, is free of any coils or magnets. Salient pole rotors' projecting magnetic poles are made of soft magnetic material. The rotor reluctance provides a force that matches the rotor poles with the stator poles when stator windings are energized. To sustain continuous rotation, the windings of the stator poles are successively switched using an electronic control system to direct and attract the magnetic fields of the rotor poles, as shown in Figure 1. If two neighbouring stator poles are equidistant from a rotor pole, the rotor pole is said to be “completely misaligned" and it is referred to as the rotor pole's maximum magnetic reluctance. In the aligned position, the rotor poles are precisely aligned with the stator poles which are also known as minimal reluctance of the rotor pole.

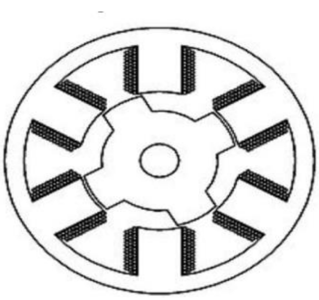

Fig. 1. Shows a 6:4 SRM drive with 6 stator poles and 4 rotor poles.

The voltage equation (1) - (5) of SRM is given by,

$$V = ri + d\Psi / dt \quad (1)$$

$$\psi = Li = N\varphi \quad (2)$$

$$For\ r = 0,$$

$$V = L\,(di/dt) + i\,(dL/d\theta)\,(d\theta/dt) \quad (3)$$

$$V = L\,(di/dt) + i\,\omega\,(dL/d\theta) \quad (4)$$

$$T = ½\, i2\,(dL/d\theta) \quad (5)$$

As a result of this equation, the developed torque is only affected by the magnitude of current and direction (DL/DΘ), but it is not affected by the direction of current.

3.1. SRM Drive System

Figure 2 depicts the block diagram of the SRM [24] drive system. SRM control system main modules include the speed regulator, rotor position block, and current regulator. A speed regulator regulates the speed by comparing the motor’s actual speed to a speed reference. The speed increases to the reference value by increasing the reference current (Iref) if motor speed is below the reference speed. On the other side, speed can be decreased by reducing the reference current (Iref). The Rotor position blocks produces switching signals for the converter circuit based on the rotor's position and turn on and turn off signals. The current regulator compares the stator current and reference current in each phase. If the error crosses the positive hysteresis band value, a signal is sent to the converter for applying positive voltage on the stator winding to generate positive current on the winding.

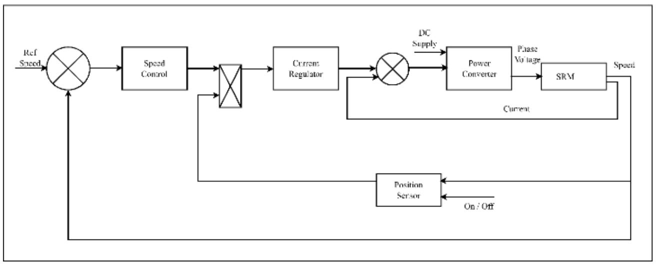

Fig. 2. Block diagram for SRM drive System

4. Results and Discussions

SRM has a robust application for variable-speed drive operation. The drive's performance is improved by monitoring the speed using different controllers to moderate speed ripple, which in turn leads to a reduction in torque ripple. Conventional PI and PID controllers [23] are the speed controllers employed here as well as Fuzzy logic controllers. The position sensor detects the rotor's position and sends the output to error detector. The comparison of the actual speed and the reference speed is made by error detector and sends an error message to controller block. The controller can be a type of fuzzy logic or a PI that sends signals to the converter to control motor speed by appropriate excitation of the corresponding phase winding.

4.1. SRM Speed Control using Proportional Integral Controller

A "PI controller" is an integral plus proportional controller. A PI controller reduces steady-state error while increasing response time and overall system stability. It does not reduce the rise time, but it does eliminate the oscillations. In this case the reference speed is compared to the actual speed and the speed error difference is passed to the PI controller to generate a reference current which is compared to the actual current. The error current will be given as input to the hysteresis current controller which will produce a gate signal for the controller. Figures 3–5 illustrate the Simulink model for a PI controller equipped with SRM and the resulting output waveform. The simulation is performed at a set speed of 1000 rpm. The actual motor operates at 960 RPM with a settling time of around 0.3 s. From simulation results, it is clear that the proportional integral controller improves accuracy with respect to steady state error and stability of disturbance signal rejection.

4.2. SRM Speed Control using Proportional Integral Derivative Controller

Superior control dynamics are provided by the PID controller, such as zero steady-state error, quick response (short rising time), zero oscillations, and improved stability. The presence of derivative controller along with PI controller is used to prevent overshoot and oscillations in the system's output response, mathematically, a PID controller is represented by the symbol Eq. (6).

$$Y(t) = K_v e(t) + K_i \int e(t) + K_{dde}(t)/dt \quad (6)$$

The Simulink Model of a PID controller with SRM and their resultant output waveform are shown in figures 6–8. The simulation is set to run at a speed of 1000rpm.

The actual motor has a maximum speed of 980rpm with a settling time of around 0.2s. From simulation results, it is clear that a PID controller improves steady state error as compared to a PI controller.

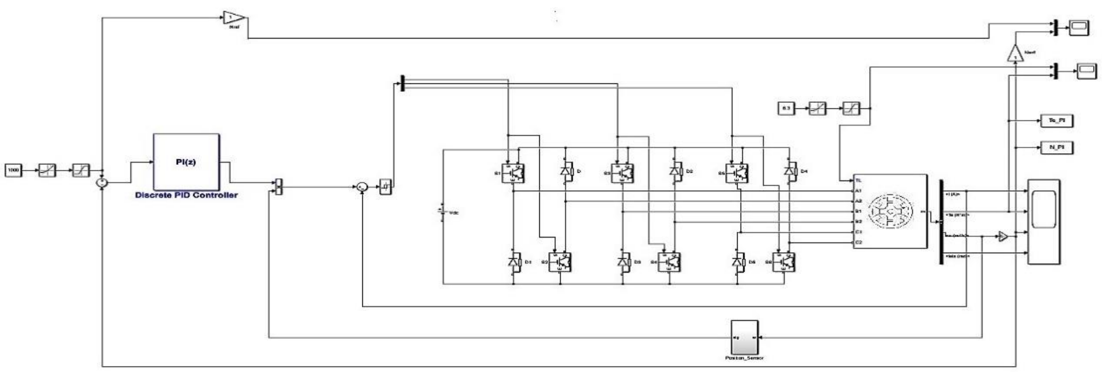

Fig. 3. Simulink model of SRM with PI Controller

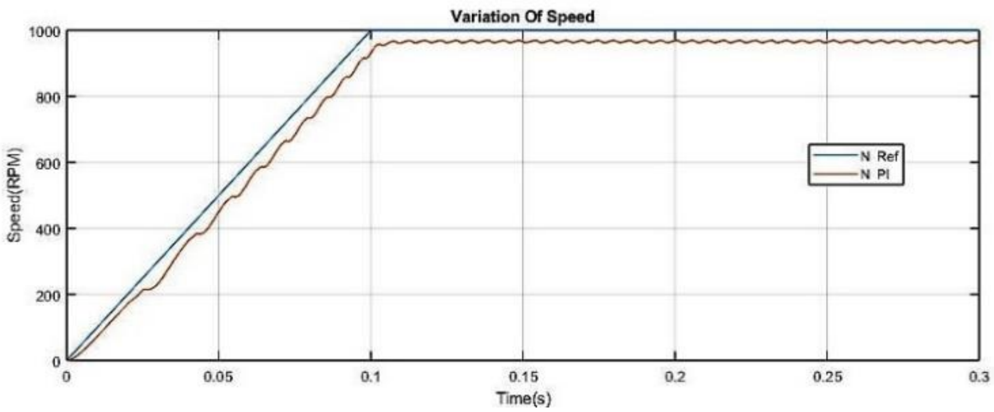

Fig. 4. Variation of Speed

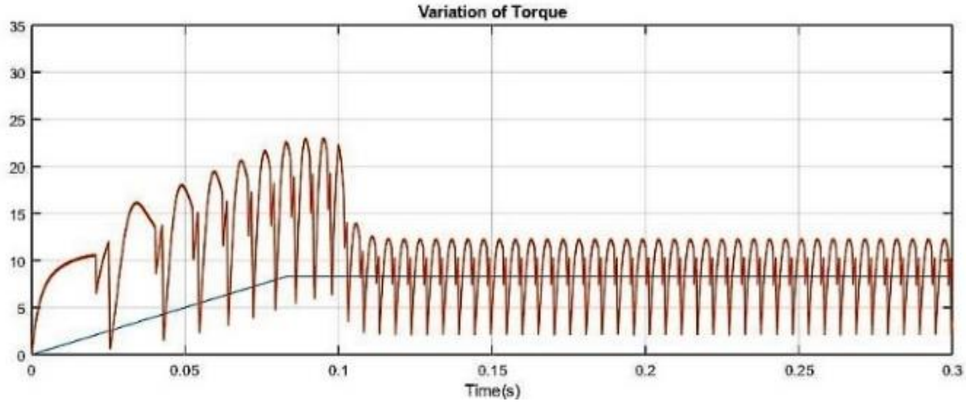

Fig. 5. Variation of Torque

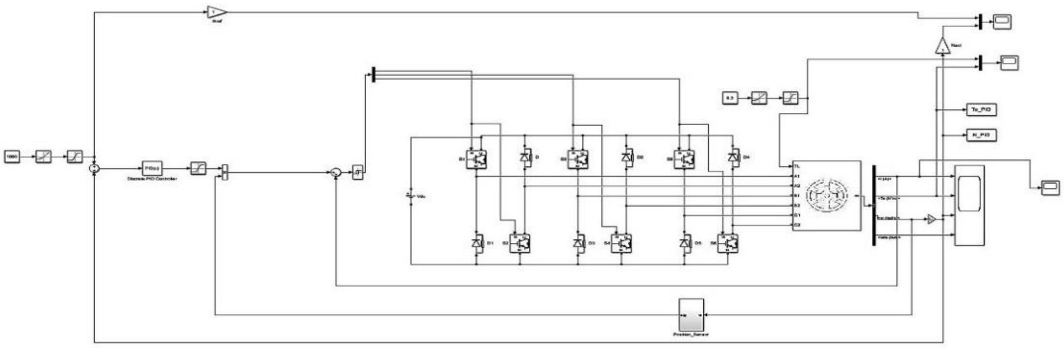

Fig. 6. Simulink model of SRM with PID Controller

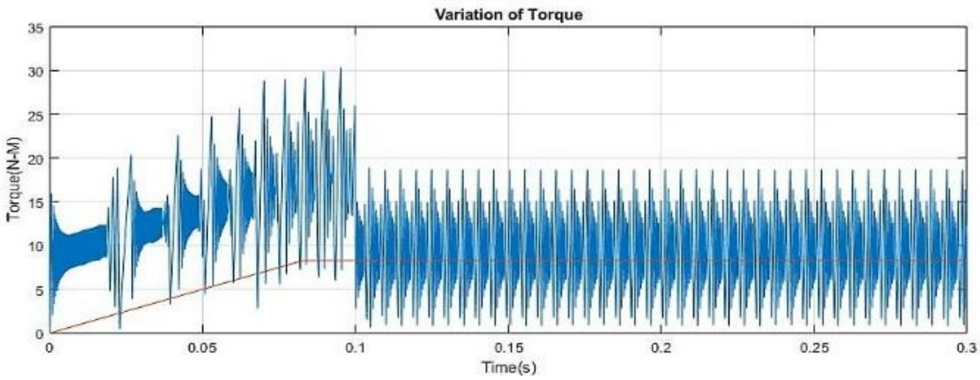

Fig. 7. Variation of Torque

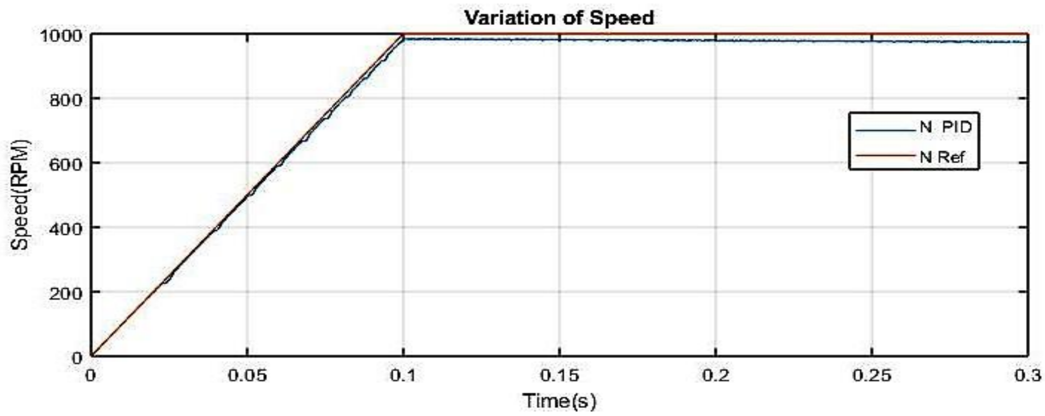

Fig. 8. Variation of Speed

4.3. SRM Speed Control using Fuzzy LOGIC CONTROLLER

The fuzzy controller's distinguishing feature is that it does not require any mathematical model of the structure. Fuzzy logic is analogous to the human emotional and reasoning processes; unlike the traditional control approach of point-to-point control, fuzzy logic control is sub-point or sub-area control. The fuzzy controller's output is formed from the fuzzy results of both the inputs and the outputs utilising their related membership functions. Based on this value, the sharp input is transformed to various members of the related member functions. A fuzzy logic controller's output is determined by its memberships, which can be thought of as input regions. A membership function is a curve that describes how each point in the input space represents a membership value (or degree of participation) from 0 to 1.

The membership function is a graphical depiction of the size of each input's contribution. The rules employ the input membership values as weighting factors to assess their effect on the end inference's fuzzy result set. After inferring, scaling, and combining the attributes, they are decomposed into a distinct output that drives the system.

In fuzzy logic controller design, triangular membership functions are used as they provide advantages such as simplicity, speed, and computational efficiency, which are good compared to other membership functions. Here, the centroid method is used for defuzzification. The SRM specifications utilised in the simulation are shown in Table 1. Figures 9–11 illustrate the Simulink model for SRM with a fuzzy controller and the resulting output waveform.

Table 1. SRM Specifications

Sl.NO	Parameter	Rating
1.	Type	8/6
2.	Unaligned inductance	0.67mH
3.	Aligned Flux	0.9wb
4.	Max current	65A

Table 2. Simulation results for different controllers

Controller	**Rise Time (TR) in sec**	**Settling Time(TS) in sec**	**Speed (rpm)**
PI	0.11	1	910
PID	0.102	0.115	985
PI+Fuzzy	0.102	1	970
PID+Fuzzy	0.1	0.105	995

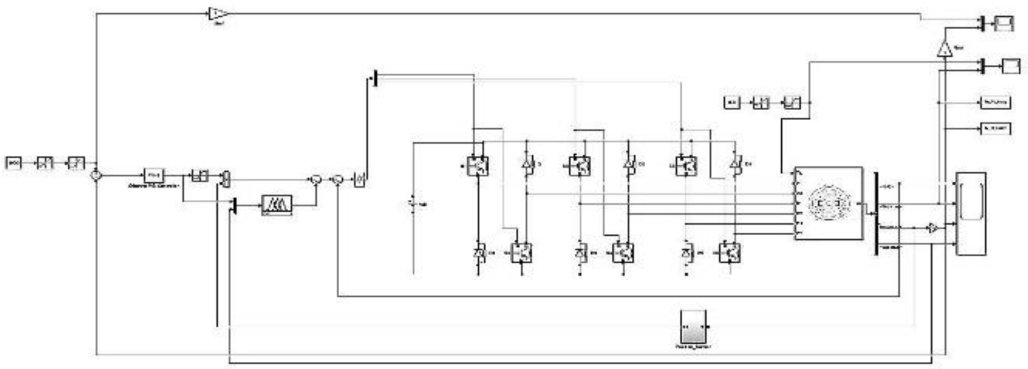

Fig. 9. Simulink model of SRM with Fuzzy Controller

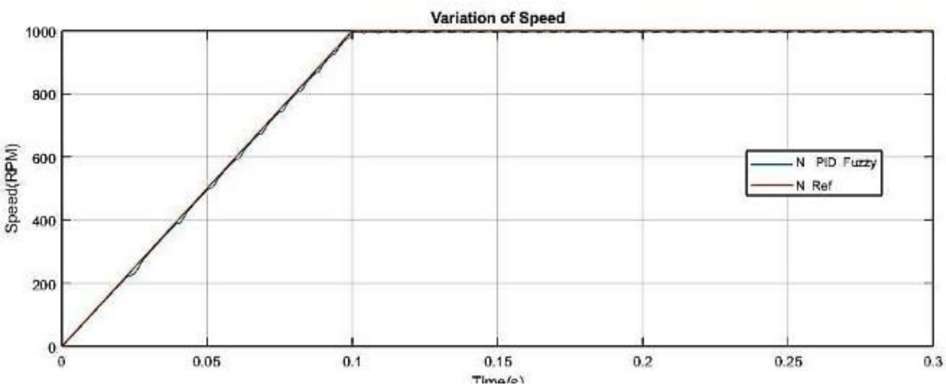

Fig. 10. Variation of speed for Fuzzy Controller

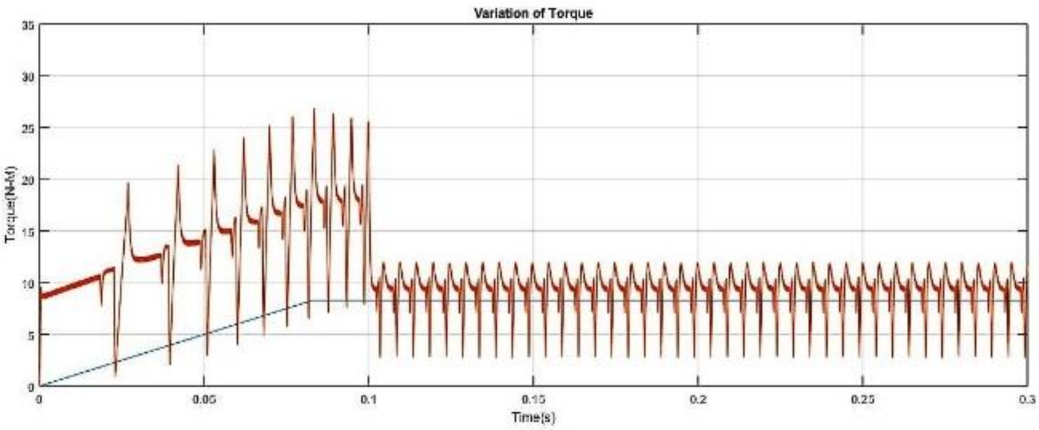

Fig. 11. Variation of torque Fuzzy Controller

5. Conclusions

The performance of switched reluctance motor is studied under different controllers in order to analyse the variation of torque and speed. When the motor is starting from idle, the torque is very high and decreases as the speed increases. The aspect of speed variation with respect to torque is same for most of motors and same applies for SRM. As a result of its simple form, it may replace induction machines in any application that has the same properties. In SRMs, torque is proportional to square of current. As a result, this motor consumes less power than comparable machines of the same capacity and size. In this paper, MATLAB and SIMULINK are used to simulate the speed control SRM.. An asymmetric bridge converter powers the 4 rotor poles and 6 stator slots. So, the construction is simple, and speed control is easy. Furthermore, the Performance of the SRM has been simulated with various controllers, including PI, PID, and Fuzzy Logic Controllers. From the simulation data obtained, it can be concluded that PID combined with Fuzzy logical controllers can enhance SRM drive speed response with a shorter settling time than other controller types. Speed attainment to the reference value can be obtained with the aid of combination of PID and Fuzzy logic controller.

Conflicts of Interest

All authors declare that they have no conflicts of interest.

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Author Contributions

Mrs. Padmashree V. Kulkarni has identified **the** Initial problem identification, algorithm write-up, analysis, drafting of the manuscript, simulation **and** final formatting and applied for the journal. **Dr. H. V. Govindaraju** was responsible for the Literature survey and helped in the initial review process. **Mrs. Babitha S** was responsible for the Complexity analysis of the research, evaluation of the research work. All authors worked together to implement and evaluate the integrated system, and approved the final version of the paper.

References

[1] L Ananda Padmanaban & P.sarvanan "Design, analysis and comparison of switched reluctance motors for electric vehicle application ", VOL. 64, NO. 2, 239–247, 2023.

[2] Kavana E, Rudranna Nandihalli "Speed Control of Switched Reluctance Motor", *JETIR*, Volume 9, Issue 6, ISSN-2349-5162, June 2022.

[3] Hafeezul Haq, Halil Ibrahim "FLC-DTC Method for Torque Ripples Minimization of 8/6 Switched Reluctance Motors Drive", *JAREE-Journal on Advance Research in Electrical Engineering*, Volume4, Number 1, April 2020,pp .51-55.

[4] Padmashree V. Kulkarni, Jyoti Koujalagi, Babitha S" LabVIEW Based Model of Switched Reluctance Motor using PI Controller", *International Journal of Recent Technology and Engineering (IJRTE),* ISSN: 2277-3878, Volume-8, Issue-6, March 2020.

[5] Zeki OMAÇ, "Fuzzy-logic-based robust speed control of switched reluctance motor for low and high speeds", *Turkish Journal of Electrical Engineering & Computer Sciences*, 2019, pp 316 – 329.

[6] Ghunter P. Viajante, Eric N. Chaves, Luiz C. Miranda, Marcos A. A. Freitas, Carlos A. Queiroz, Josemar A. Santos "Design and Implementation of a Fuzzy Control System Applied to a 6x4 SRG", *International Conference on Environment and Electrical Engineering, IEEE*,2019.

[7] Ali Uysal, Serdar Gokay, Emel Soylu, Tuncay Soylu, Serkan Caska," Fuzzy proportional-integral speed control of switched reluctance motor with MATLAB/Simulink and programmable logic controller communication", *Measurement and control*, Vol. 52(7-8), 2019, 1137–1144.

[8] Maheshbabu Valeti,D.sussitra, "Methods of torque ripple minimization techniques on switched reluctance motor", *IJRTE Journal of Recent technology and Engineering*, volume 8 ,Issue 24, 2019,204-208.

[9] Reyad Abdel-Fadil, László Számel, "State of the Art of Switched Reluctance Motor Drives and Control Techniques," *Twentieth International Middle East Power Systems Conference (MEPCON)*, Cairo University, Egypt, 2018 pp. 779–784.

[10] Abid Ali Shah Bukhari,1 Belema Prince Alalibo, Wenping Cao, Zhengyu Lin, Shahid Hussain Shaikh, Toufique Ahmed Soomro , Shahzeb Ansari Fayyaz Ali Jandan "Switched reluctance motor design for electric vehicles based on harmonics and back EMF analysis," I*ET Journals*,2018, pp 1–6.

[11] Ganesh Velmurgan,serhiy Bozhko,Tao Yang"A Review of Torque ripple minimization techniques in switched reluctance Machine", *IEEE*, 2018,978-1-5386-4192-7.

[12] Reyad Abdel-Fadil, László Számel, "Enhancement of the Switched Reluctance Motor Performance for Electric Vehicles Applications Using Predictive Current Control," *International Conference and Workshop in Óbuda on Electrical and Power Engineering*, *IEEE*, 2018.

[13] P.Pranay Kumar," Torque ripple minimization of a switched reluctance Motor using Fuzzy logic control current compensation technique", *International Journal of pure and applied Mathematics*, volume 120,No .6,2018.

[14] Control and Simulation in LabVIEW by V Hans-Petter Halvorsen.2017.

[15] Vikramarajan Jambulingam, "Fuzzy Logic Controller Design for Switched Reluctance Motor", *International Journal of Science and Research (IJSR)*, Volume 5, Issue 4, April 2016, 2319-7064

[16] Humor Nagy,Mircea Ruba ,Horia Hedesiu,claudia Martis"Rapid control Prototyping of a speed control strategy for a switched reluctance Machine", *International conference and exposition on electrical and power engineering*, 2016,664-668.

[17] Mrs.K. Radha Rani, Ms.S K.Salma, Sri A. Raghunath and Sri K. Praveen Kumar, "Comparative Study of Speed Control of 6/4 Switched Reluctance Motor Using Hybrid Fuzzy Logic Controller", *IJCTA*, Vol.8, No.1, 2015, 253-263.

[18] Mou-Lin Jin* and Ming-Chun Ho, " LabVIEW-based Fuzzy Controller Design Of A Lighting Control System", *Journal of Marine Science and Technology*, Vol. 17, No. 2, 2009, pp 116-121.

[19] Liu, L. ., Huang, Y. ., Zhao, M. ., & Ruan, Y. . (2023). Parametric Modeling and Optimization of Switched Reluctance Motor for EV. *The Applied Computational Electromagnetics Society Journal (ACES)*, 37(09), 948–958. https://doi.org/10.13052/2022.ACES.J.370904

[20] H. Torkaman1 , E. Afjei2 , N. Ghadimi3 , A. Gorgani, " Comparative Electromagnetic Evaluation of Different Structures of Switched Reluctance Motors", *International Review of Electrical Engineering*, Vol. 7, N. 2, 3885-3890.

[21] Jun Cai, Zhiquan Deng, "A Fault-Tolerant Sensorless Control Method For Switched Reluctance Motor s", Vol. 7, N. 2, 3857-3865.

[22] V. Wilson and P. G. Latha, "Review on Solutions to Acoustic Noise Problems in Switched Reluctance Motor Using Radial Force Improvement with Two Stage Commutation for EV Applications," *International Review of Electrical Engineering (IREE*), vol. 17, no. 2. Praise Worthy Prize, p. 164, Apr. 30, 2022. doi: 10.15866/iree.v17i2.21379.

[23] Abdelhakim Idir, Khatir Khettab, Yassine Bensafia, "Design of an Optimally Tuned Fractionalized PID Controller for DC Motor Speed Control Via a Henry Gas Solubility Optimization Algorithm", *International Journal of Intelligent Engineering and Systems*, Vol.15, No.3, pp. 59-70, 2022.

[24] S., B. ., Govindaraju, H. V. ., Kulkarni, P. V. ., S., R. ., & Koujalagi, J. P. . (2023). Real Time Implementation of Fuzzy Controller to Minimize Torque Ripple in Switched Reluctance Motor. *International Journal of Intelligent Systems and Applications in Engineerin*g, 11(3), 308–317. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/3171

[25] Chhabra, G. (2023). Comparison of Imputation Methods for Univariate Time Series. International Journal on Recent and Innovation Trends in Computing and Communication, 11(2s), 286–292. https://doi.org/10.17762/ijritcc.v11i2s.6148

[26] Wanjiku , M., Levi, S., Silva, C., Ji-hoon, P., & Yamamoto, T. Exploring Feature Selection Methods in Support Vector Machines. Kuwait Journal of Machine Learning, 1(3). Retrieved from

http://kuwaitjournals.com/index.php/kjml/article/view/131

[27] Shukla, A., Juneja, V., Singh, S., Prajapati, U., Gupta, A., & Dhabliya, D. (2022). Role of hybrid optimization in improving performance of sentiment classification system. Paper presented at the PDGC 2022 - 2022 7th International Conference on Parallel, Distributed and Grid Computing, 541-546. doi:10.1109/PDGC56933.2022.10053333 Retrieved from www.scopus.com