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Analysis, Monitoring and Control of Speed Variations for Various Applications of SRM Motor with ESP32 and Thing speak.

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Abstract. Due to the growing demand for and growth in the electric vehicle (EV) market in a future civilization with advanced technology. Electric vehicles outperform traditional ones in terms of performance. Because they are environmentally friendly, EVs can help create a green and sustainable environment. They provide convenience with eco-friendliness that conventional cars cannot. Over the past 20 years, the switching reluctance motor (SRM) drive has been created and researched as a revolutionary electrical drive. The brushless switching reluctance motor drive has developed to the point that it may be used in the industrial sector as a reliable, durable, and cost- effective brushless drive with a wide speed range. In this paper, artificial intelligent controllers like Fuzzy Logic Controllers (FLC), and PID are discussed where SRM speed fluctuations are monitored and controlled by a controller using simulation analysis. Experimental analysis is carried out with prototype model. Here various speed variations are controlled and monitored using the ESP32 and Thing Speak cloud platform.

1 Introduction

Due to the greater price of permanent magnets and their scarcity as electric vehicles began to be produced in large quantities, reluctance motors gained a lot of attention at that time, with cost and dependability being the main factors. Its control mechanisms work well, and its design is remarkably simple and robust. It has the intrinsic ability to operate over a broad range of continuous power and can operate safely at very high speeds. Researchers see reluctance motors as a more tempting alternative to other types of machines for traction applications because of these well-known advantages [1]. Electric vehicles are getting more and more common these days. Price, security and efficiency are the important factors for an electric vehicle. Engineers developing electric vehicles are thought of as ways for meeting these specifications. As a result, low-cost, exceptionally secure, and highly effective high-quality vehicle parts are created. Electric motors that satisfy these parameters include switched reluctance motors (SRM). Switched Reluctance Motor (SRM)'s is easily built, are affordable, and have a very wide speed range. Switched reluctance motor is useful and practical in a wide range of things. To deliver continuous driving or torque generation, SRM

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employs successive pole excitation.
A position sensor is required for motor drive for high-grade control while arranging the rotor. Additional significant problems with SRM performance include associated audible sound, vibration, and torque ripple [2]– [4]. Research has been done on SRM position control without sensors. Based on power electronic devices at low speeds as well as high rates, position estimate approaches are used for switching techniques based on phase induction fluctuation. The suggested approach makes use of a digital controller for an SRM drive without sensors [5]– [6]. Position sensor-less control strategies are two kinds for SRMs: flux-linkage-based strategies and inductance-based strategies. Phase inductance relies on the rotor position; hence rotor position is determined by injecting current pulses into the inactive phase [7]– [8]. Simulation and testing are utilized to validate the relative attribute of a PI parameter adaptive speed regulator [9]. The references [10]– [11] describe the fuzzy PI direct instantaneous torque control simulation experiment for SRM. The goal of the speed loop is to generate a reference current based on the difference between the desired and actual speed. Some of the frequently used speed loop control approaches include fuzzy control, PID control, iterative learning control, and synovial film control [12]- [14]. For an SRM to be controlled, precise rotor position is required. In a common speed control system, the rotor's location is determined by a rotary encoder. The switchingreluctance drive system requires an accurate position of rotor indication to optimal performance controlling. Speed sensor issues can generally be caused by air particles like dust, hot temperatures, strong vibrations, and electromagnetic fluctions. These problems could lead to the wrong driving signals being generated [15], which could hurt motors. According to this study, SRM speed changes can be monitored and controlled using the esp32 and thingspeak. Which results in a 25% deviation from the rated speed in the speed change.

2 System Design

A three-phase switched reluctance machine (SRM) is represented by the Switched Reluctance Machine building block. While the rotor has a number of nonmagnetic poles, the stator has three pole pairs that support the three motor windings. By turning on a pair of stator poles, the motor exerts a force on the nearby rotor poles, pushing them in the direction of alignment. The motor design is depicted in Figure 1.

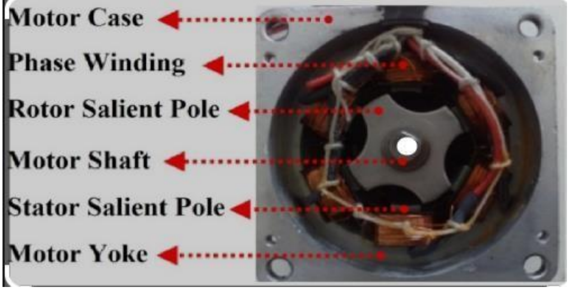
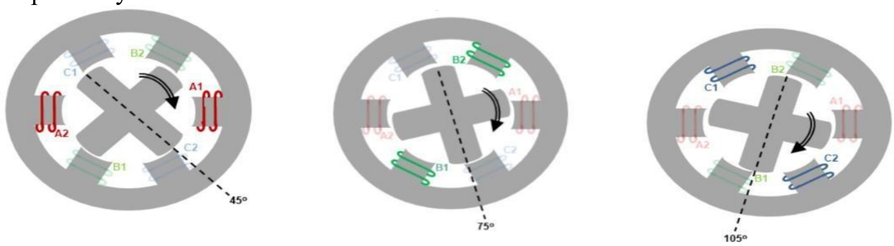


Fig. 1. Three-phase switched reluctance motor (SRM) of 6/4 in front opened view .

At the rotor position in Fig.2, wingdings A1 and A2 are given a positive voltage. The resulting magnetic field's reluctance torque causes the poles of rotor to move into alignment with the newly energized stator poles. When the motor reaches the rotor position shown in fig. 2, A1 and A2 windings are deactivated while windings B1 and B2 are activated to maintain the rotation in clockwise of rotor. This action maintains the rotor's clockwise rotation because the rotor tries to align with the B1 and B2 windings. When the motor reaches position in fig. 2, the B1 and B2 windings are finally de-energized and the C1 and C2 windings are powered. This process is repeated every 90 degrees because the rotor has four poles. The turn- on and turn- off angles in this illustration are held constant at 45 degrees and 75 degrees, respectively, with regard to stator windings A1 and A2. When phases A, B, and C are activated, the rotor angles are 45, 75, and 105 degrees with regard to the phase A axis, respectively.



Rotor position 1 Rotor position2 Rotor position 3

Fig. 2. Speed Regulation of a 6/4 Switched Reluctance Motor

Applications of SRM: Equipment for oilfields like vertical pumps, beam pumps, well-testing equipment, etc. are utilized in the textile industry, as are textile tools like rapier looms and towel looms, which are used in electric cars. Mining equipment includes things like conveyors, shearers, winches, ball mills, drilling equipment, coal crushers, etc.It uses in screw presses and other mechanical devices.

3 Control Methodologies

To operate SRM, various control strategies can be used. In this study, PID controllers and fuzzy logic controllers are discussed.

3.1 PID Controller

All necessary dynamics are provided by PID controllers, including (D mode) nothing but quick response to input changes then the increasing in control signals can be seen,that will reduces errors E(s) which is shown in Fig.3 to (I mode) nothing but to zero, and appropriate action inside the control error region that eliminates oscillations (P mode).When the system is in derivative mode, the systems stability will defintely increases and allows for increasing the gain K and will decreases the time integral constant which is represented as Td in given Fig.3 which speeds up controller response.

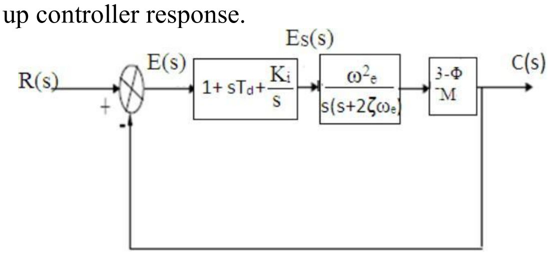


Fig. 3. Transfer function block diagram of PID Controller

When high level order captive systems (processes with many energy storages) have dynamics that are different from those of the integrator (as in many thermal processes), a PID controllig are utilised. PID controllers are frequently employed in industry, but they are also effective for controlling moving objects (including those that follow courses and trajectories) when stability and accurate reference following are necessary. The majority of conventional autopilots use PID type controls. After looking at the transfer function of the PID-general controller, we can now recognise the three terms as follows: Zero steady state error, settling and rising times under five and two seconds, and little to no overshooting are permitted.

3.2 Fuzzy Logic Controller

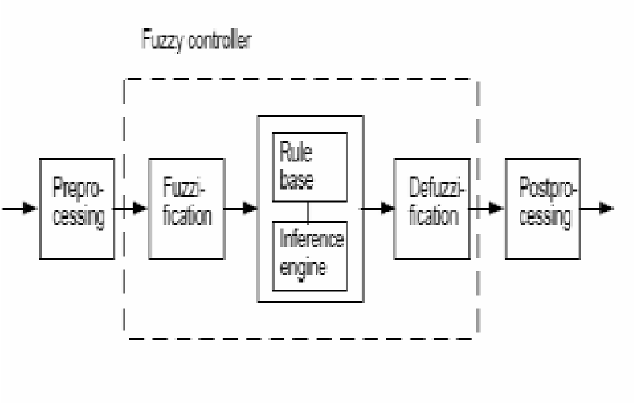


Fig. 4. Fuzzy Logic Controller

By a set of linguistic rules, we can be able to control the action of FLC primarily. All these rules are selected by the system. The variables which are in number form are converted into linguistic variables in Fc and the mathematical models of the systems are not required. Fig.4 shows that the fuzzy logic controller unit consists of fuzzification, and defuzzification, an interference engine.For every input and output, the FC is described using fuzzy sets. Triangular membership is utilised for convenience. fuzzing utilising the universe of active dialogue.Mamdani employing the "min" operator. employing the "height" method of defuzzification.

Table 1. Fuzzy Subsets

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

Fuzzification:
Seven fuzzy subsets are mentioned in Table.1—PM5 (Positive Medium), NB (Negative Big), NS (Negative Small), ZE (Zero), PS (Positive Small), NM (Negative Medium) , and PB—are used to assign membership function values to the linguistic variables (Positive Big). Using the membership CE(k) E(k) function and fuzzy subset partitioning, the form is modified to fit the system. The input scaling factor normalizes the input error value and error change.

3.3 Fuzzy Subsets:

The input values fall between -1 and +1 such that the scaling factor of input of this system has been created as shown in Fig.5 . Because of these kinds of arrangement's triangle membership function, it is assumed that only one dominant subset of fuzzy will be there in only one domain for each E(k) input.

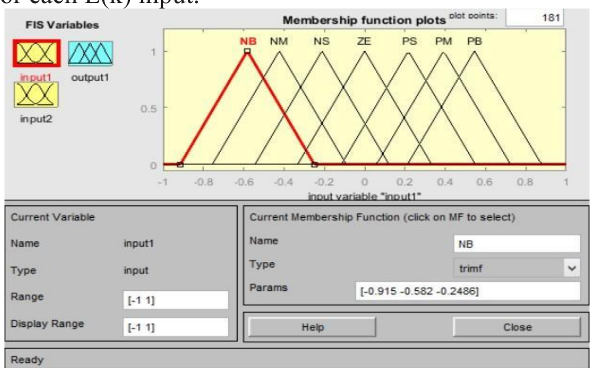


Fig. 5. Input Membership Function Plots

3.4 Interference Method:

In the literature, a number of composition techniques, including Max-Min and Max-Dot, have been proposed. This study uses the Min technique. Each rule's output membership function is determined by the minimum and maximum operators.Fig.6 displays the FLC's rule set as shown below.

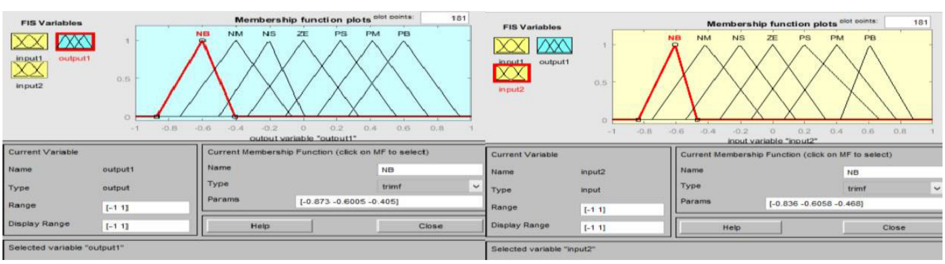


Fig. 6. Output Membership Function Plots

3.5 Defuzzification:

A defuzzification stage is necessary because a plant often needs a non-fuzzy control value. The "height" approach is used to calculate the FLC's output, and the FLC results will affect the controlling of output.

4 Simulation Results and Discussions

The main first five components are the hysteresis current controller module,thePI controller module,the SRM motor module,the power converter and the position detector module which make the simulation module for the switched reluctance motor speed control system as shown in Fig 7.

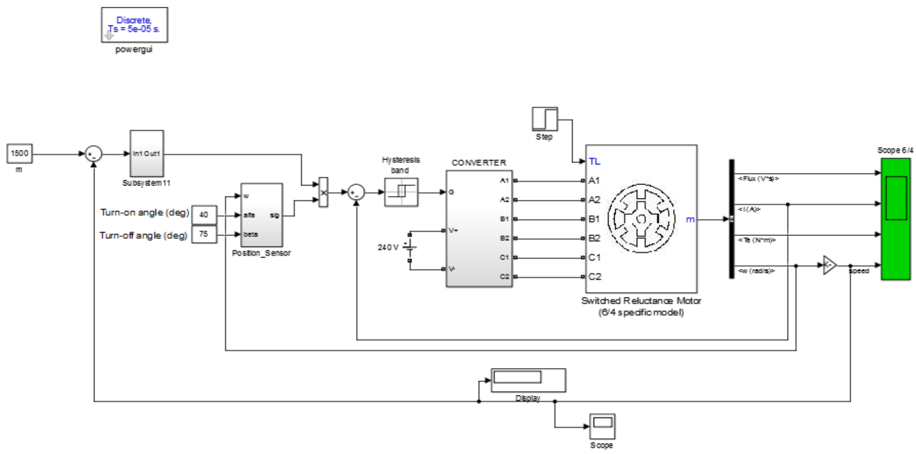


Fig. 7. Simulation model of Closed Loop Speed Control Of SRM

The simulation module is created by using Matlab/Simulink.When the phase winding is energized, the relative position of rotor and stator position is determined by the position detection module and the speed control. The simulation model is shown in Fig 7. Each phase winding inductance has a 90-degree shifting period. The parameters are established, the angle is compared to a 90° odd angle, and the displacement angle is determined by the mod function using the initial value of the reverse integrator.

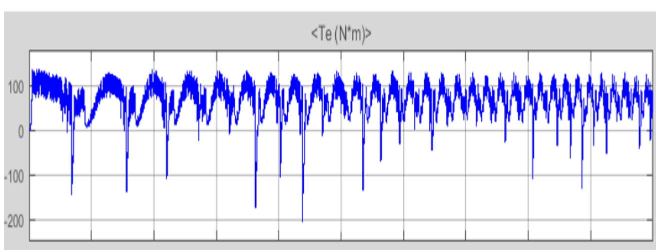


Fig. 8. Output waveform of Torque

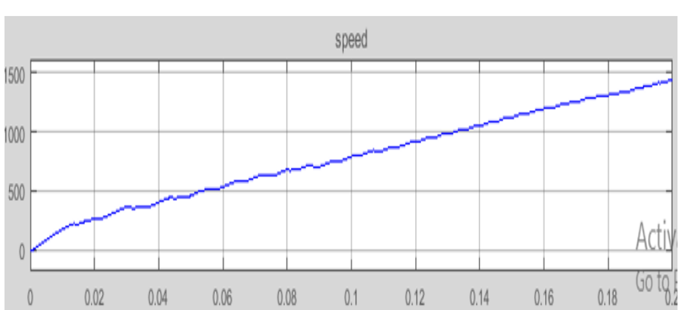


Fig. 9. Output waveform of Speed

Fig.8 shows the output waveforms of torque of SRM.And Fig.9 shows the output waveform of speed. The speed of srm increases continuously upto 1500 rpm.

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5 Hardware Prototype and Results

The hardware for the suggested circuit is depicted in Fig. 10. The proposed circuit, as stated in the working principle, keeps track of the SRM's instantaneous speed.

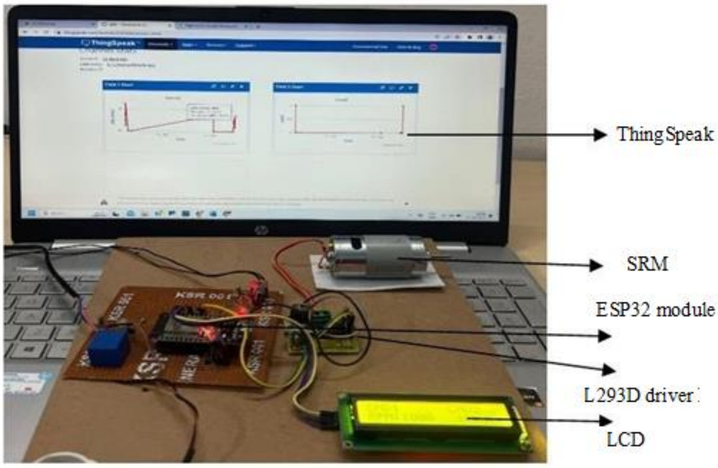

Fig. 10. Hardware unit of Proposed Project for closed loop speed control of SRM.

The SRM with a voltage of 12 volts is chosen as the motor in this study. Fig. 10 shows the constructed experiment platform. The SRM receives the output from the L293D motor driver in this experiment. The Esp32 module receives its input supply through an adapter. The 7805-voltage regulator, which links to the Esp32 module, converts the input supply to 3.3 volts. The Esp32 module will give the L293 motor driver with power so that it can increase the voltage from 3.3 volts to the SRM's maximum supply.25 percent of the rated speed can be decreased or increased using the Esp32 module to adjust the speed.The L293D motor driver receives a maximum voltage of 3.3 volts from the ESP32 microprocessor.The 1117 Voltage Regulator steps up the 3.3 volts to 12 volts, which is the module's maximum supply voltage, when the first order is issued to the motor drive. Three different cases studies are carried out showing the speed variations and the data uploaded to cloud to monitor from anywhere and everywhere.

5.1 Case i :

The first casestudy from the prototype model analysis the full speed from SRmotor. The command instructions are given.

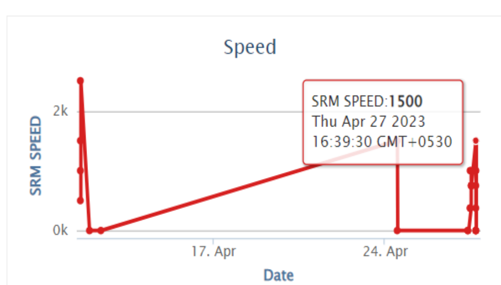

Fig. 11. Display of SRM speed when CMD1 is given.

The SRM receives the step-up voltage. SRM thus rotates at a speed of 1500 rpm.The output speed of SRM is shown on the LCD Fig.11. The output speed graph of SRM is displayed by ThingSpeak.

5.2 Case ii :

This case study from the prototype model analysis the 75% speed from SRmotor. The command instructions are given with reference from the feedback.

Fig. 12. Display of SRM speed when second CMD1 is given.

The L293D motor driver receives a maximum voltage of 3.3 volts from the ESP32 microprocessor. The 1117 Voltage Regulator steps up the relative voltage, which is 75% of the provided voltage, when the motor drive receives the next order. The SRM receives the step-up voltage. SRM then moves forward at a specific pace.The LCD shows the SRM's output speed as depicted in Fig. 12. The output speed graph of the SRM at a given voltage is displayed by ThingSpeak.

5.3 Case iii:

This case study from the prototype model analysis the 50% speed from SRmotor. The command instructions are given with reference from the feedback. The L293D motor driver receives a maximum voltage of 3.3 volts from the ESP32 microprocessor. The 1117 Voltage Regulator steps up the relative voltage, which is 50% of the provided voltage, when the motor drive receives the next order.

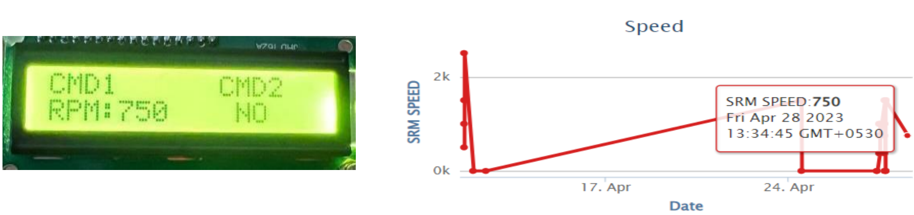

Fig. 13. Display of SRMspeed when third CMD1 is given.

The SRM receives the step-up voltage. SRM then moves forward at a specific pace.The output speed of the SRM is displayed on the LCD as in Fig. 13. The output speed graph of the SRM at a given voltage is displayed by ThingSpeak.

6 Conclusion

The Switched Reluctance Motor (SRM) gives high effective performance even in rasping conditions like high temperature and dusty environment. In this research paper, the speed control of switched reluctance motor is designed through MATLAB software and simulated results shows better performance interms of presenting the torque and speed characteristics graphically using the Fuzzy logic controller and PID Controller.The system hardware prototype is build utilizing an ESP32 module microcontroller and driver circuit. Hence, the speed control of SRM is executed using hardware prototype module. The potential of switched reluctance motor is highly greater particularly in motion control used for various applications.

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