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Speed Control Of BLDC Motor Using Fuzzy Logic Controller

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Abstract

The development of a fuzzy logic controller for a brush less direct current (BLDC) motor drive is covered in the project you submitted. This strategy was chosen because BLDC motors are difficult to regulate due to their non linearity and other characteristics. BLDC motors are controlled using traditional PID controllers. The goal of the speed reference tracking and output speed stabilization Fuzzy Logic controller with a Gaussian membership function was to keep up with load disruptions. This study includes a BLDC motor mathematical model. It also contains the dynamic derivation of BLDC motor settings. It is used in the MATLAB Simulation programme. The simulation results show that, compared to the PID controller, the proposed fuzzy logic controller significantly improved control performance in both the conditions of controlling speed control performance and disturbance variations in load.

Keywords: BLDC motor, PI controller, PID Controller, Fuzzy controller.

Introduction

That customers require. This is where BLDC motors and the control electronics that go along with them are useful. Modern home appliances can operate with the speed control, energy economy, and low noise operation that BLDC motors can offer. In order to provide further capabilities like remote control and programmable settings, BLDC motors can also be linked with other electronics. The high efficiency of BLDC motors is one of their main benefits.BLDC motors can function at up to 90% efficiency,which is far higher than those of conventional electric motors. As a result, they use less energy and generate less heat, which can extend the life of motors and cut customer energy expenses. BLDC motors can also be adjusted to run at different speeds, which can increase their efficiency even more. Low maintenance needs are another benefit of BLDC motors. Brushes and commutators, which are frequent causes of wear and failure in conventional electric motors, are absent from BLDC motors. In light of this, BLDC motors can have longer lifespans and demand less during the course of their existence. Last but not least, BLDC motors are small and may be made to fit into small areas. They are therefore perfect for usage in home appliances since space is frequently at a premium. Moreover, BLDC motors may be made to run quietly, which is crucial for devices like hoover cleaners and air conditioners where noise can be a major problem. Typical BLDC motor use Because of its great efficiency, high power density, and minimal maintenance needs, BLDC motors are widely employed in a variety of sectors.

Literature Survey

Several strategies for developing a controller based on a BLDC motor have been put out in earlier works. Due to their characteristics, the fuzzy speed controller was picked by the designer. A helpful methodology for developing a workable solution for complicated system control is provided by fuzzy logic. The fuzzy logic controller system suggested by Soong TC et al. (2011) shown good dynamic performance in both simulation and testing. The introduction of a novel concept for the digital control of a trapezoidal BLDC motor is a revolutionary digital control technique for BLDC motor drives. According to Rodriguez (2007), the suggested digital controller is a good fit for applications. where the impact of speed ripple is minimal. However, it is crucial to remember that various control methods have varying benefits and restrictions based on the precise specifications of the application. Generally speaking, the selection of a controller for BLDC motors depends on the unique requirements of the application, designer, and pricing. should compare various control strategies and select the one that most closely matches the application's requirements. According to the initial work by Tunay R.N. et al., a fuzzy logic controller is more reliable and quick than other traditional control methods and can successfully control the speed of BLDC motors.The report also emphasises the fuzzy logic controller's ease of use and adaptability. Furthermore mentioned is the usage of model-based programming on DSP, suggesting that the fuzzy speed control method may be implemented practically. In their second publication, Kwon C. J. et al. suggest an adaptive fuzzy tuning approach for BLDC motor speed control. The simulation findings particularly highlight the efficiency and quick response of the suggested approach. This indicates that the adaptive fuzzy tuning strategy can enhance the robustness of the control system and guarantee stable motor operation when there are changes in the motor characteristics and load torque. In his third paper, Ruse C. combines sliding mode control and fuzzy logic to control the speed of a BLDC motor. The simulation and experimental results indicate that a fuzzy sliding mode control system performs better than a pure sliding mode control system in terms of performance.

Problem Identification

It's crucial to pick the right speed controllers for the motor in order to obtain the appropriate degree of performance.

Proportional-integral (PI) controllers are frequently employed for speed control in the case of permanent magnet motors. Yet, when dealing with complex control scenarios like non-linearity, load disturbances, and parametric fluctuations, typical PI controllers have limits. Additionally, they need exact linear mathematical models, which PMBLDC machines with nonlinear models might not be able to provide. Fuzzy Logic (FL) control can be applied to speed control to improve the dynamic behaviour of the motor drive system and make it immune to load perturbations and parameter variations.To enhance the dynamic behaviour of the motor drive system and make it resistant to load perturbations and parameter changes, fuzzy logic (FL) control can be applied to speed control. Compared to other controllers that use mathematical models and are sensitive to parametric fluctuations, fuzzy logic control offers greater speed response quality. Fuzzy logic controllers are very simple to implement and intrinsically resistant to load perturbations. As a result, applying fuzzy logic to speed control of permanent magnet motors can lead to better performance and robustness when there are load disruptions and parametric variations.

Methodology

BLDC motor operate using a similar principle as brushed dc motor where a rotating magnetic field is created to turn the rotor. However instead of using brushes to make contact with the commutator and change the polarity of the stator winding. BLDC motors use electronic commutation to switch the current to the appropriate winding at the right time. The back emf generated by the rotor passing over the stator winding helps to regulate the amount of current flowing through vehicles, drones, and industrial automation equipment. A revolving magnetic field is produced in the motor's stator using the inverter. The rotor rotates as a result of this field's interaction with the rotor's permanent magnets. The inverter generates a three-phase ac output by switching the dc voltage from a power source in a predetermined sequence. A six-step waveform is produced by a six-step inverter, which only energises two of the three pole pairs at once. By changing the pulse frequency and current of the inverter, the frequency and amplitude of the ac output can be changed. A closed loop system monitors the rotor position, modifies the frequency and current of the electrical signal, and controls the torque and speed of the motor.inverter accordingly. By measuring the strength of the magnetic field as the rotor poles pass over the sensor, a hall effect device can normally be used to determine the location of the rotor. by modifying the inverter's frequency and current settings The speed and torque of the motor may be accurately regulated in accordance with the position of the rotor. Because to this, the motor can be utilised for a variety of purposes, from tiny fans and pumps to massive industrial gear.

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Modelling of BLDC motor:

$$V_a = RI_a + (L - M)\, di_a/dt + e_a$$

$$V_b = RI_b + (L - M)\, di_b/dt + e_b$$

$$V_c = RI_c + (L - M)\, di_c/dt + e_c$$

The motion equation is defined as

$$d\omega_m/dt = (2PJ)\,(T_e - T_L - B\omega_r)$$

$$d\theta/dt = \omega_r$$

$$e_{abc} = f_{abc}(\theta_r) \times e$$

$$E = k_e\omega_r$$

$f_a(\theta_r)=$

$$\begin{bmatrix} \left(\frac{6}{\pi}\right)\theta_r & \left(0<\theta_r\le\frac{\pi}{6}\right) \\ 1 & \left(\frac{\pi}{6}<\theta_r\le 5\frac{\pi}{6}\right) \\ -\left(\frac{6}{\pi}\right)\theta_r+6 & \left(5\frac{\pi}{6}<\theta_r\le 7\frac{\pi}{6}\right) \\ -1 & \left(7\frac{\pi}{6}<\theta_r\le 11\frac{\pi}{6}\right) \\ \left(\frac{6}{\pi}\right)\theta_r-12 & \left(11\frac{\pi}{6}<\theta_r\le 2\pi\right) \end{bmatrix}$$

$f_b(\theta_r)=$

$$\begin{bmatrix} -1 & \left(0<\theta_r\le\frac{\pi}{6}\right) \\ \left(\frac{6}{\pi}\right)\theta_r-4 & \left(\frac{\pi}{6}<\theta_r\le 5\frac{\pi}{6}\right) \\ 1 & \left(5\frac{\pi}{6}<\theta_r\le 7\frac{\pi}{6}\right) \\ -\left(\frac{6}{\pi}\right)\theta_r+10 & \left(7\frac{\pi}{6}<\theta_r\le 11\frac{\pi}{6}\right) \\ -1 & \left(11\frac{\pi}{6}<\theta_r\le 2\pi\right) \end{bmatrix}$$

$f_c(\theta_r)=$

$$\begin{bmatrix} 1 & \left(0<\theta_r\le\frac{\pi}{6}\right) \\ -\left(\frac{6}{\pi}\right)\theta_r+2 & \left(\frac{\pi}{6}<\theta_r\le 5\frac{\pi}{6}\right) \\ -1 & \left(5\frac{\pi}{6}<\theta_r\le 7\frac{\pi}{6}\right) \\ \left(\frac{6}{\pi}\right)\theta_r-8 & \left(7\frac{\pi}{6}<\theta_r\le 11\frac{\pi}{6}\right) \\ 1 & \left(11\frac{\pi}{6}<\theta_r\le 2\pi\right) \end{bmatrix}$$

$$T_a = e_a i_a/\omega_r$$

$$T_b = e_b i_b/\omega_r$$

$$T_c = e_c i_c/\omega_r$$

Implementation

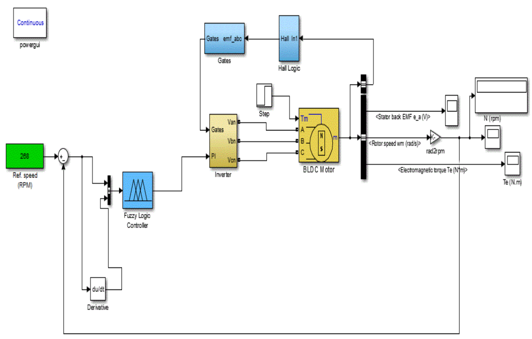
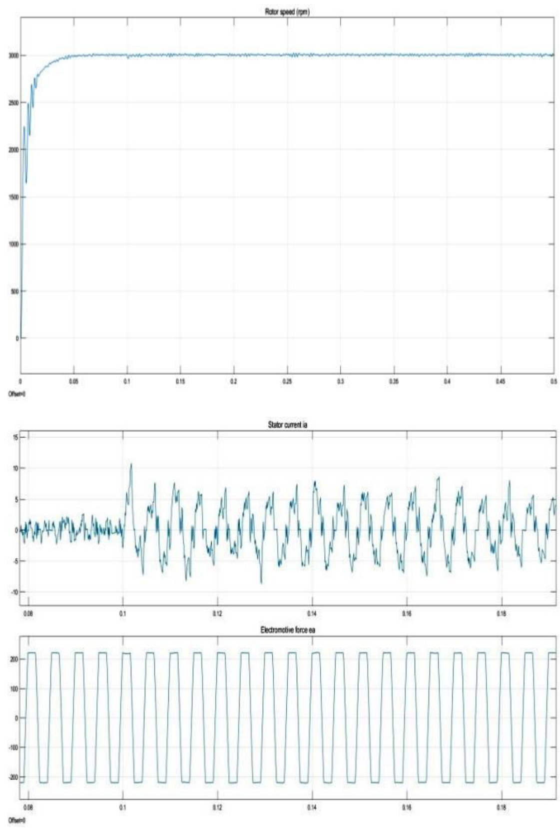


Fig. MATLAB schematic of BLDC motor using fuzzy logic controller

Results



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Conclusion

It appears that the thesis is describing the use of a fuzzy logic controller (FLC) for the speed control of a PMBLDC motor drive. The thesis includes a description of the modelling and simulation of the complete drive system, and the effectiveness of the model is established by performance prediction over a wide range of operating conditions. the thesis also includes a comparison of the performance of the fuzzy logic controller and a conventional PI controller through simulation runs. The results confirm the validity and superiority of the fuzzy logic controller. The use of the fuzzy logic controller has reduced the manual tuning time of the classical controller. The performance of the PMBLDC motor drive with respect to the PI controller, FLC controller, and experimental verification with a conventional PI controller using a DSP processor is also discussed in the thesis. The fuzzy logic speed controller has improved the performance of the PMBLDC drive.

Future scope

which is to simulate a BLDC motor using MATLAB Simulink and develop a FLC to control its variable speed. The scope of the FLC is limited to Gaussian membership functions, but you also plan to develop other membership functions to compare their effectiveness.

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