PERFORMANCE ANALYSIS OF PMBLDCM BY USING AI FUZZY MECHANISM

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Article History: Received: 12.12.2022 **Revised:** 29.01.2023 **Accepted:** 15.03.2023

Abstract:

This article, fuzzy control technique for operation of brushless [BL] direct current drives is presented. Fuzzy algorithm and PMBLDCM mathematical model are present. Function of fuzzy are to keep the brushless [BL] direct current drives on the track while changes happens in speed due to load variations.
The inverter, which receives its input from the rotor dynamics position and current, feeds the BLDC motor. The fuzzy is now the ideal control for solving this major issue. The creation of simulation structure in MATLAB-Simulink is used to demonstrate the efficacy as well as torque ripples of the suggested approach. The simulation results demonstrate proposed fuzzy technique [FLC], for both conditions managing speed reference changes and load disturbance variations, significantly outperforms the PI controller in terms of control and performance. To avoid chattering as well as boost up stability of control mechanism fuzzy appeared in drive. Development of fuzzy boundary layers enables a more seamless transition to the comparable control. Better disturbance rejection abilities and less overshoot in response.

Keywords - FLC, drive, BL drive, BLDC torque ripples, PI.

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DOI: 10.31838/ecb/2023.12.s3.174

1. Introduction

Permanent Magnet [PM] rotor and wound stator make up a PMBLDC machine. Three phase inverters are used to regulate the BL drive. Most important requirement of such drive is need of position sensor required in its control strategy it helps to control exact commutation sequence of Inverter Bridge hence drive operate smoothly. It works on the rotor position after every 60 degree commutation.

A BL drive is highly stable than dc motor the reason is commutation overcomes such issues like brush sparking with commutator wear [1].

Drive consists of four main components to a brushless DCM. Power converter, sensors, control algorithm, , & motor [BLDCM]. In this structure Power transfers from source to BLDCM through power converter, which then translates such energy in the form of mechanical energy. Position sensors is one of the standout features who detect dynamic status of rotor it may either electromagnetic torque or supply in terms of voltage or current pulses which inject to the semiconductor convertor unit who operate the drive [2].

For permanent magnet brushless DC machines, both current source and voltage source based drives are employed. In the motor's back emf waveform is square type. Yet, a machine with a non-sinusoidal back emf minimises losses for a given power level and shrinks the size of the inverter.

Because of its good efficiency, high torque density, dependability, extended life, and small size, brushless DC (PMBLDCM) drive are attracting a lot of attention in industrial applications. Due to its benefits, BLDC motors are often used in variable speed drives [3].

In this study, a fuzzy [FLC] is used as a controller, and the outcomes are compared to those of conventional controllers. FLC's benefits include flexibility, affordability, and ease of control. Applications requiring speed control are appropriate.

The three main parts that make up FLC's structure are the fuzzifier, which is used to define fuzzy sets it will utilized or measure the input.

The next thing is a fuzzy operated on the basis of rule; it provides decision-making capabilities to drive system it needs and bases its reasoning for doing so on a rule establishes the control strategy. Next one is a defuzzifier; it merges chosen courses of action into required control signal [4].

Objectives

Construct Fuzzy AI system who increase the performance of PMBLDCM. 2. To simulate maintained converter and differentiate the result output. 3. Make a Study between simulation outcomes with FLC & without FLC strategy.

Controllers

Pi Controller

When we observe industrial close loop control systems which carries PID / PI. Such a mechanism control very popular in an every industry process. this help to reduce the discrepancy between actual process parameter and required set point . It calculates the difference between two quantity & recommending proper action which can modify the process appropriately [4]. P [Proportional] is having distinct calculating methods and Integral also, used by the PI controller. With the use I[Integral] we can achieve outcome from recent error while p[proportional] predicts outcome on the current error. The control element receives a correction from these two mode sum. The PI controller's ease of design and straightforward construction make it popular in industry. PI mathematically present like this

$$\text{PI output} = K_p\ e(t) + K_i \left(\int_0^t e(t)\,dt\right)$$

From the above equation e(t) is (Set magnitude – Actual magnitude) . The drive is made up of a MOSFETs establish current-controlled VSI [voltage source inv.] methodology with Pulse Width Modulation & referral current generator, during this close loop process outcome we achieve from[4] .

$$e(t) = \omega_{ref} - \omega_m(t)$$

We got required set point.

Fuzzy strategy

Fuzzy has particular parts that help a design process. The controller between preprocessing block & after processing block is depicted in Figure. Fuzzification, Defuzzification, & Fuzzy Interface blocks make up this fuzzy logic controller.

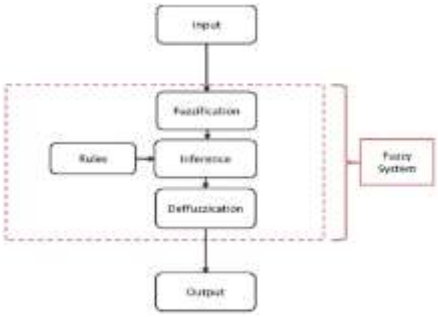


Fig.1basic working Structure of fuzzy

Such technique of fuzzy who map provided input with output, it known fuzzy inference. mapping offers a foundation by which choices we can made or patterns can be identified.

The application of fuzzy PI controller with variable sampling effect. It is effective because fuzzy gain scheduling PI controllers are utilized for fixed sampling times for various speeds [4]. The speed control application in this case uses the fuzzy [5].

This study, a fuzzy utilized to operate speed & outcomes are compared to those of a traditional PI controller. The proportional integral (PI) controller was abandoned in favor of the fuzzy, which then applied to speed loop circuit. Speed error (E) is the input variable, and the controller uses E to calculate speed error change (EC).

Controller analyses speed error signal's pattern & change output according to it. Fuzzy receives two signals as inputs: the error $E = \omega_{ref} - \omega_m$ and the change in error [CE] , which is connected to the derivative [7].

$$\frac{dE}{dt} = \frac{\Delta E}{dt} = \frac{CE}{Ts}$$

Where $CE = \Delta E$ in the sampling time T_s CE is proportional to $\frac{dE}{dt}$

In a brushless dc motor drive, the controller's output current (cop) is i*qs current. To create real control signal (ACS) or current i*qs, the signal is summed or integrated, and K_1 and K_2 are nonlinear coefficients or gain factors, including the summation process [8].

$$\int cop = \int K1Edt + \int K2CEdt \quad ACS = K1 \int Edt + K2E$$

Which is nothing more than a nonlinear gain, fuzzy P-I controller. We can create a fuzzy for P & PID by extending the same approach with nonlinear adaptive gains.

The membership functions are triangular-shaped because they result in the finest control performance and are the most straightforward. Seven levels of the fuzzy membership function are employed for all variables. The 7-7 rule base table utilized in the method is shown in Table 1. The following seven membership functions have been used: Positive Big (PB), Positive Small (PS), Negative Big (NB), Positive Medium (PM), Negative Medium (NM), Negative Small (NS) & Zero (Z).

e /CE	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

Table 1: Membership Functions

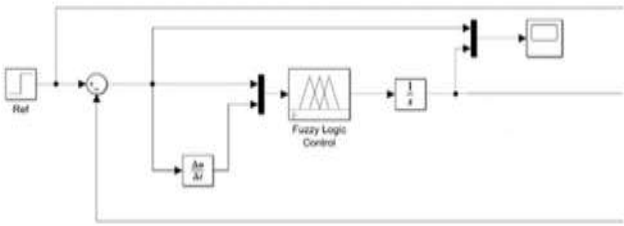


Fig: 2 Fuzzy methodologies

The motor will be subjected to a load throughout the simulation in order to assess how well the FLC reduces output ripple in terms of current or torque. The model will be run multiple times with different input and FLC values in order to enhance the FLC design.

Related Work

Performance of Pmbldcm without Fuzzy

Following simulation shows the BL drive control by PI simulation circuit. Simulation's outcomes are displayed in fig.

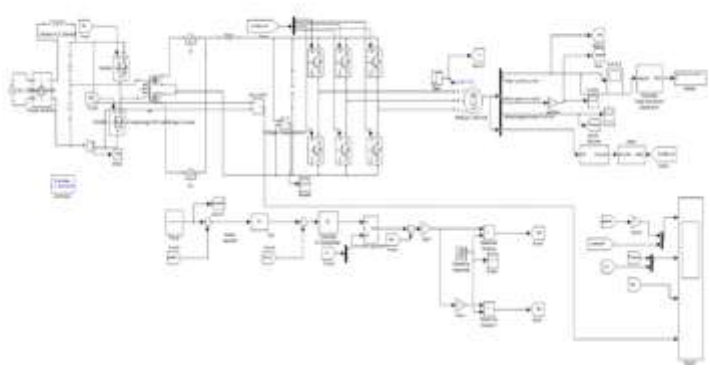
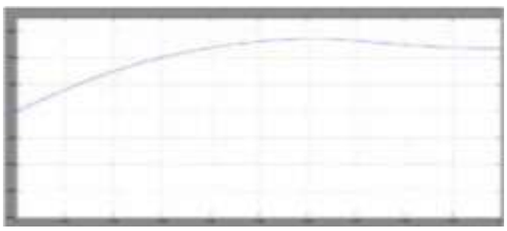


Fig 1: Simulations of PMBLDC drive without fuzzy.

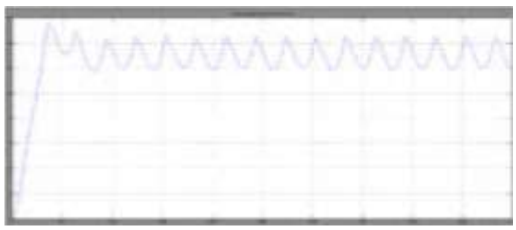
Results from the simulation are compared to actual {speed & time}. Motor's maximum angular velocity with PI controller is 478 Rpm, which is lower than rated run that is 500 rpm. The motor's dynamic response is not linear, and speed raise to a max before leveling off 478 rpm. Hence, the dynamic reaction cannot be described as linear.

The torque Response of the PI is shown in the figure. The electromagnetic change in the motor's speed is revealed by the simulation result. The electromagnetic torque increases to a maximum of 12 N-m before stabilizing at 11.55N-m.

Repulsions in the torque are seen.



I) Response of Speed

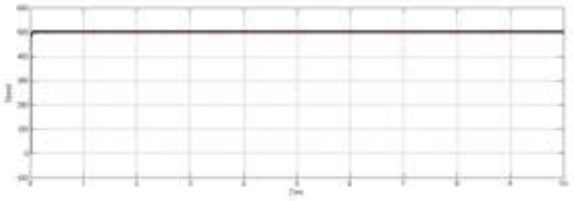


II) Response of Torque

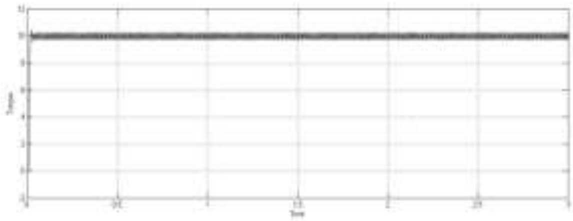
2. Methodology

Performance of Pmbldcm Fuzzy
Simulation output for speed responses using a fuzzy is shown in graphs from the simulation are compared to real speed & time. The motor's rated speed is 500 rpm, but I was only able to get speed of 478 rpm. We observe that drive shows dynamic linear performance & that there is very little repulsion in operational dynamic behavior.

The torque response of the fuzzy controller is shown in figure. The electromagnetic change in the motor's speed is revealed by the simulation result. Up to 9.45 N-m, the electromagnetic torque increases before becoming constant. We can see that a quick increase in torque improves the motor's performance and results in a good dynamic response with a minimum amount of repulsions.



I) Response of Speed



II) Response of Torque

3. Conclusion

Both a conventional PI and a fuzzy controller were used to simulate the performance of speed control BL drive system. Simulation results show that the fuzzy outperforms PI in terms of dynamic response.

Future Scope
The torque ripple issue with BLDC motors would be addressed by the suggested converter. The power system and electrical machine sectors have seen success with the current converter. The ANN approach can also be used to solve problems with harmonics and torque ripple.

4. References

Malani P. Chavhan, Sanjay M. Sindhe, “Modelling of Brushless DC motor with various loading conditions for electric vehicle application”, International Journal of Engineering Research and Development, Volume: 12, Issue: 6, June 2016, e-ISSN: 2278-0067X, p-ISSN:2278-800X.

Sheeba Joice, P. Nivendhita, “Simulation of speed control of brushless dc motor with fizzy logic controller”, International Journal of Electrical, Electronics and Data Communication, ISSN: 2320-2084, Volume-2, Issue-4, April-2014.

P.Suganthi, S. Nagapavithra, S. Umamaaheswari, “Modelling and simulation of closed loop for BLDC motor”, IEEE conference on Emerging Devices and Smart System (ICEDSS 2017).

Sudhanshu Mitra, Amit Ojha, “Performance analysis of BLDC motor drive using PI and fuzzy logic control scheme”, IRJET, volume: o2 Issue: 06, sep-2015, e-ISSN: 2396-0056, p-ISSN: 2395-0072.

Krishna Gopi, R.,Moulali, S.“Design of coupled inductor based closed loop controller for two-switch buck-boost converter with induction motor applications”,International Journal of Applied Engineering ResearchVolume 12(1), 2017, Pages 506-514.

G.S.N.V.Akhil Raj, R.Devi VaraPrasad, Munukutla Naga Chaitanya, “Performance Analysis of Indirect Field Oriented Induction Motor using Fuzzy-PI Controller”, International Journal of Applied Engineering Research, ISSN: 0973-4562, Volume No.12, Special Issue, 497-505, 2017.

Sudharshan Reddy.K., Sai Priyanka.A,Dusarlapudi.K, Vijay Muni.T,” Fuzzy logic based iUPQC for grid voltage regulation at critical load bus” (IJITEE), Vol:8(5),2019.

Adil Usman, Bharat Singh Rajpurohit, “Speed Control of a BLDC motor using fuzzy logic controller”, IEEE conference on power electronics, Intelligent.