International Journal of Engineering & Technology, 7 (4.19) (2018) 481-484

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Fuzzy with PID based Sensorless Brushless DC Motor Control

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Abstract

In this Work, the controller with fuzzy and PID used to execute the speed calculation of a brushless dc motor. The proposed strategy is basic and solid. Amid regenerative braking mode, it saves energy in a rechargeable battery. The proposed controller is coordinated utilizing the fuzzy logic toolbox in MATLAB. The work proposes the idea of fuzzy with PID controller for controlling the speed of BLDC motor. The goals of the undertaking are to analyze the execution of PI and the proposed fuzzy with PID controllers utilizing MATLAB software for the controlling the speed of BLDC motor. The executions of the two controllers are compared based on different control framework time domain parameters. Simulation consequences of the two controllers have been exhibited and it is discovered that the control idea with fuzzy with PID controller outflanks customary controller in a large portion of the angles.

Keywords: *BLDC Motor, PID Controller, Fuzzy.*

1. Introduction

In a traditional brushed DC motor, the brushes are arranged for electrical contacts to the commutator. The effective outline of the FLC relies upon the correct determination and tuning of the parameters of the controller. The parameters of the FLC are typically dictated by the experimentation strategy or by methods for training information. The controller pick up is balanced, in view of the error and change in the error of the speed.
In the survey, either the membership functions or scaling factors or the standards are balanced for self tuning the FLC. Yet, each parameter is not completely used in tuning the parameters of the controller. Disregard Chung Wang and Yi-Hwa Liu (2010) proposed a changed PI-like fuzzy logic controller for exchanged hesitance motor drive. This strategy depended on the redevelopment of the control rules and the modification of the output scaling factors, for self tuning of the FLC. The starting peak of the altered controller was gotten by an experimentation strategy, and just the output scaling factors were considered for the analysis.
Many finished these strategies are pertinent just for linear frameworks, for the most part tuned off-line. This, in turn, influences the execution of the drive. Hence, there is a requirement for enhanced or changed controllers that can adjust to any non-linear circumstance and can be tuned on-line to accomplish the coveted execution.
The need of the AI controller has turned into a zone of extreme research. Despite the fact that AI innovation has progressed hugely as of late, the survey demonstrates that, the genuine use of this innovation in the territory of Power Electronics and motor drives is extremely constrained. This has been especially valid on account of a FLC and GA to the motor drives. At the point when BLDC motor drives are connected to variable speed applications like washers, air compressors, hard plate drives and related applications, the speed of the drive is truly influenced by obscure load qualities and sudden variety of parameters. Along these lines, the controllers of this class of the drive frameworks ought to be versatile to any sudden changes in the framework.

2. Design of FLC for BLDC Motor Drive

The utilization of the FLC to a framework depends on the learning base of the framework. This learning base comprises of the enrollment capacities portraying the fuzzy factors and a rule table comprising of straightforward "IF… THEN … "explanations.
A fuzzy logic controller does not require complex numerical models as on account of the PI controller. The outline of a FLC does not have an all around characterized approach. The perplexing and dull processes associated with the modeling of the framework are done by a specialist. In this manner, the achievement in planning a savvy fuzzy controller depends really on the information of the master framework. The FLC is a heuristic approach that effortlessly inserts the learning and key components of human reasoning in the outline of nonlinear controllers. Fig 2.1 demonstrates the a fuzzy logic controller module.

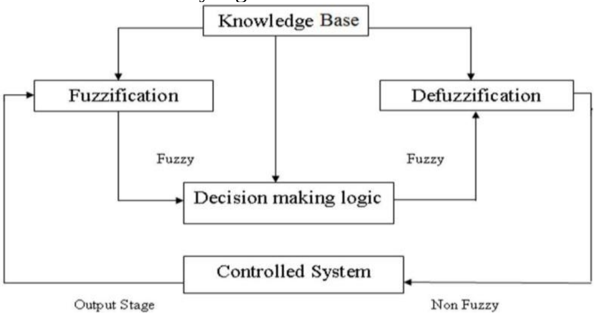

Fig. 1: Fuzzy logic controller

The inputs error and difference in error are given to the FLC to generate the change in the reference current, i_{ref} the output. The linguistic variable K for the error and difference in error is defined as

K= {NL, NM, NS, ZE, PS, PM, PL}

where, K is the collection of linguistic variables.

The seven linguistic variables as given in equation (5.3), are defined as:

NL - Negative Large

NM - Negative Medium

NS - Negative Small

ZE - Zero

PS - Positive Small

PM - Positive Medium

PL - Positive Large.

The membership functions of the seven linguistic variables for the two inputs (error and difference in error) and one output are shown in Fig.2 All membership functions are assumed to be triangular type.

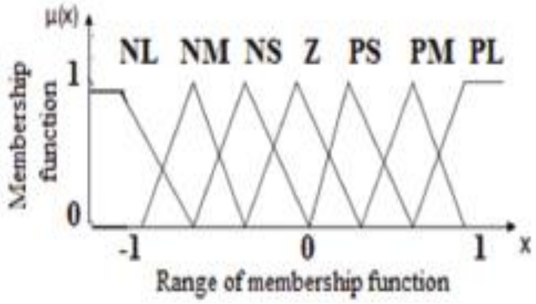

Fig. 2: MF for e, ce and output

Two inputs and a single output are considered for the Mamdani type of fuzzy controller with 49 rules

e → / ce ↓	NL	NM	NS	ZE	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	ZE
NM	NL	NL	NL	NM	NS	ZE	PS
NS	NL	NL	NM	NS	ZE	PS	PM
ZE	NL	NM	NS	ZE	PS	PM	PL
PS	NM	NS	ZE	PS	PM	PL	PL
PM	NS	ZE	PS	PM	PL	PL	PL
PL	ZE	PS	PM	PL	PL	PL	PL

3. Proposed System

The proposed framework comprises of Brushless DC motor, fed from three phase VSI, speed controller, commutation logic and position sensor. Brushless DC motor is driven by a three phase inverter with MOSFET as switch. The PWM gate signals for terminating the machine in the inverter is created by the commutation logic. The position of the rotor is traced by the hall sensors. At whatever point rotor magnetic posts go close to the hall sensor, they create a signal level, i.e,1 for high and 0 for low, which are utilized for distinguish the position of shaft. The commutation logic area creates backemf(bemf) regard of the hall signals. The gate pulses are then created regard of the back emf.

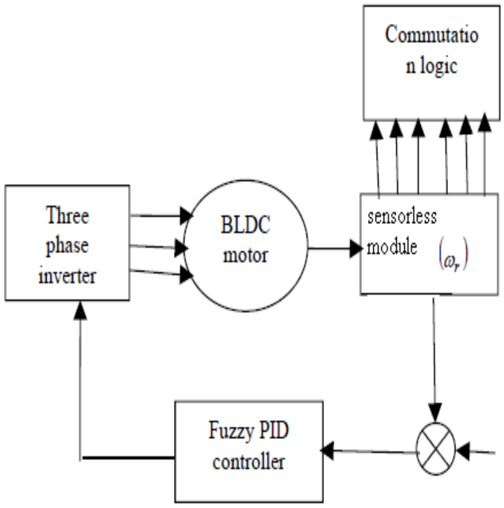

Fig. 3: Block diagram of proposed system

The following truth tables show the generation of emf based on hall signal as well as the gate signal generation based on emf.

Table 1: EMF generation based on hall signal output

H_A	H_B	H_C	E_A	E_B	E_C
0	0	0	0	0	0
0	0	1	0	-1	1
0	1	0	-1	1	0
0	1	1	1	0	1
1	0	0	1	0	-1
1	0	1	1	-1	0
1	1	0	0	1	-1
1	1	1	0	0	0

Table 2: Gate signal generation from EMF

E_A	E_B	E_C	Q1	Q2	Q3	Q4	Q5	Q6
0	0	0	0	0	0	0	0	0
0	-1	1	0	0	0	1	1	0
-1	1	0	0	1	1	0	0	0
-1	0	1	0	1	0	0	1	0
1	0	-1	1	0	0	0	0	1
1	-1	0	1	0	0	1	0	0
0	1	-1	0	0	1	0	0	1
0	0	0	0	0	0	0	0	0

3.1. Fuzzy with Proportional Integral and Differential Controller

The real speed is detected and the speed controller part produces the error signal. Fuzzy with PID controller is utilized as the speed controller in the proposed framework. The proposed controller is a parallel blend of 2 controllers-fuzzy with Proportional Integral controller and fuzzy Proportional Differential controller. Speed error (e (k)) and difference in speed error (ce (k)) are the inputs to the two controllers. In view of the error signal, exchanging happens between these controllers. The fuzzy with Proportional Integral controller enhances the unfaltering state reaction of the framework and limits the consistent state error. The fuzzy Proportional Differential controller enhances the transient reaction of the framework and limits the ascent time. The fuzzy with Proportional Integral Differential controller is appeared in fig 4.

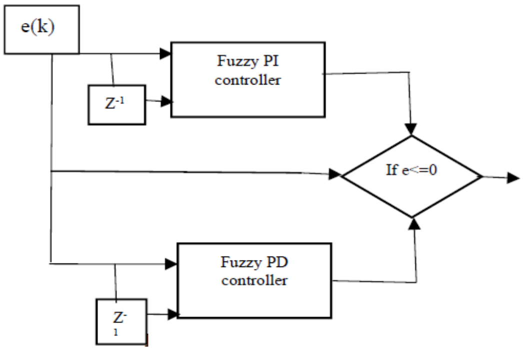

Fig. 4: Fuzzy with PID controller

The switching activity between the two controllers happens as indicated by the control signal. The fuzzy variable error and difference in error has 7 sets:

NL - Negative Large, NM - Negative Medium, NS - Negative Small, ZE - Zero, PS - Positive Small, PM - Positive Medium, PL - Positive Large. each set having their own participation work. Triangular participation capacities are utilized. As the following stage, the fuzzy IF– THEN induction rules are picked.

Table 3: Rules for fuzzy with PID controller

e/ce	NB	NM	NS	ZE	PS	PM	PB
NB	PB	PB	PB	PB	NM	ZE	ZE
NM	PB	PB	PB	PM	PS	ZE	ZE
NS	PB	PM	PS	PS	PS	ZE	ZE
ZE	PB	PM	PS	ZE	NS	NM	NB
PS	ZE	ZE	NM	NS	NS	NM	NB
PM	ZE	ZE	NS	NM	NB	NB	NB
PB	ZE	ZE	NM	NB	NB	NB	NB

3.2. Simulation model - Speed Control using Fuzzy with PID Controller

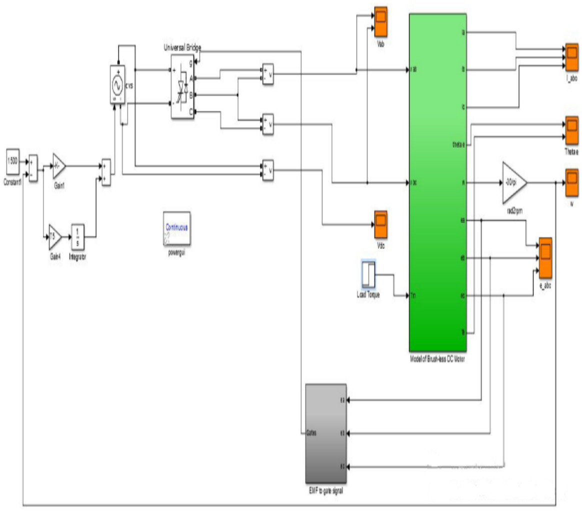

Fig. 5: Speed control with Fuzzy with PID controller

4. Results

From the speed response curve, the settling time, overshoot and steady state error can be calculated which is found to be 0.016s, 0 and 0 respectively.

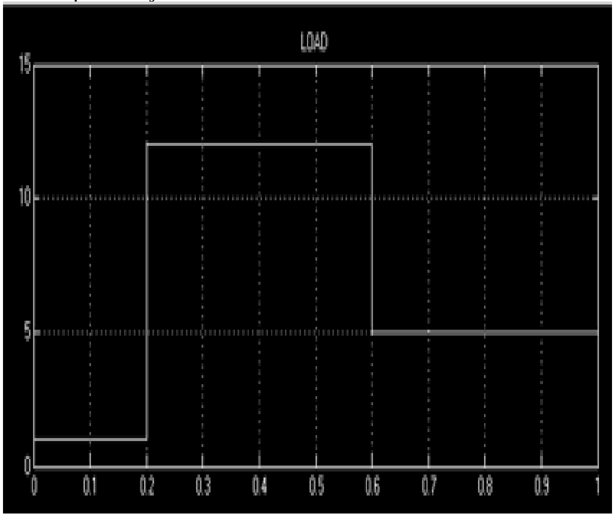

Fig. 5: Load Torque

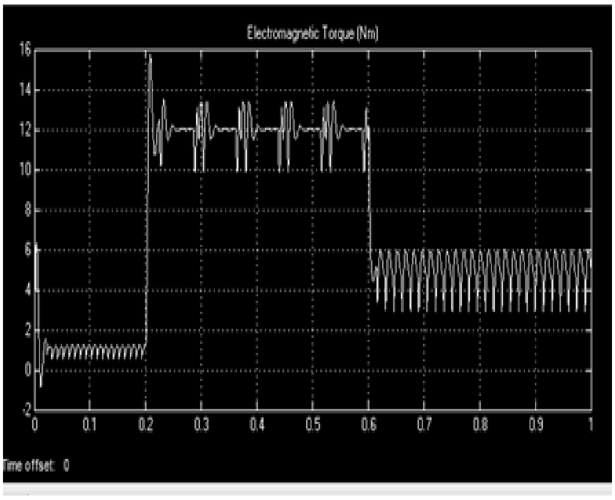

Fig. 6: Motor Torque

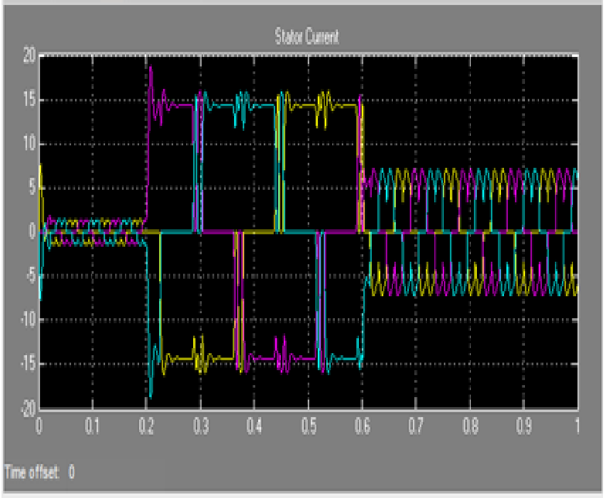

Fig. 7: Stator currents of BLDC

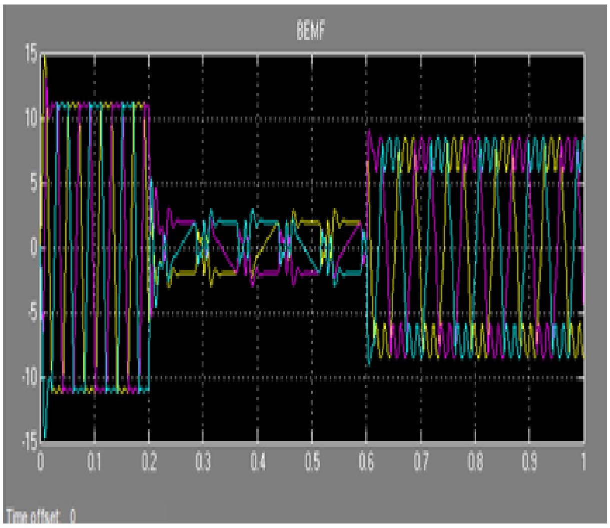

Fig. 8: Back EMF of BLDC

Reference speed – 3000 rpm

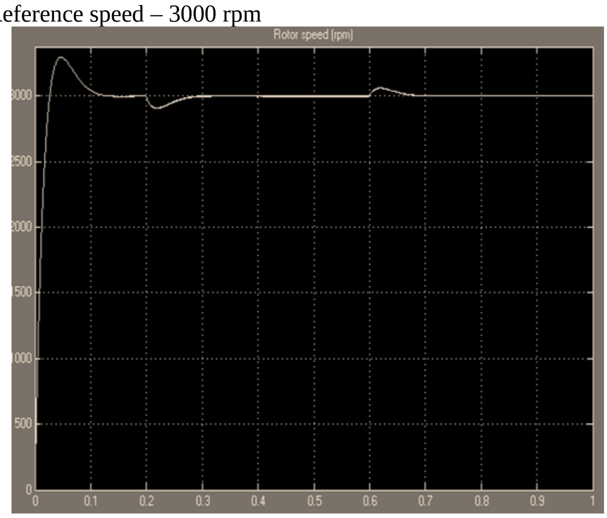

Fig. 9: Speed of the BLDC Motor

Table 4: 8 BLDC motor specifications

Description	Value
Voltage	12V DC
Current	2A
Power	30 W
Speed	3000 rpm

5. Conclusion

The execution of three phases BLDC motor with regular PI and fuzzy with PID speed controllers are investigated based on different control framework parameters, The fuzzy with Proportional Integral Differential controller beats regular Proportional Integral controller. It has the consolidated preferences of both fuzzy Proportional Integral and fuzzy Proportional Differential controllers. From the outcomes of the two controllers it is discovered that the control calculation with fuzzy with PID controller beats regular PI controller in a large portion of the perspectives.

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