Simulation Of Fuzzy Logic Controller for The Speed Control Of BLDC Motor

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ABSTRACT

The design of a three-phase brushless DC (BLDC) motor drive employing fuzzy logic for feedback and control (FLC). The PWM that powers the inverter and, in turn, the BLDC motor is generated by a Fuzzy Logic Controller. As a result, the BLDC motor is connected to the inverter. The appropriate winding may be energised if a Hall sensor is employed to determine the rotor's position. The rotor's magnetic flux is created by the rotor magnets, which increases efficiency in BLDC motors. This technique may be used to dynamic systems since it produces a steady state response speed control of a brushless DC motor. This research shows closed-loop speed control of a brushless DC motor (BLDC), as well as a Fuzzy logic Controller with a quicker rising time and a MATLAB Simulink-based software architecture.

Keywords:*BLDCmotor,FLC,Hall Sensor.*

I. INTRODUCTION

Given the steering angle and the EV's speed, we compute the Ackermann-Jeantand steering model by calculating the reference speed for each of the EV's front wheels while turning. The Fuzzy Logic Controller (FLC) regulates the speed of each motor separately to achieve the desired velocity. The switching signals for each switch device in the power inverter are generated by a hysteresis current controller. [1]. The speed of an electric automobile is controlled in this research using an ATMEGA328P low-cost, high-performance microcontroller in combination with a four-switch, three-phase inverter. The vehicle's speed might be boosted if the energy efficiency of an electric motor is maximised. Engines work together to optimally distribute available power [2]. The simulation results for the proposed model for BLDC motor driving are presented in this work. This model generates a sine-like wave with low total harmonic distortion using the LTSpice, MATLAB, and Proteus softwares[3]. We compared the results of a conventional DTC with those of a modified adaptive DTC with a PID controller and the results of an Artificial Neural Network based DTC technique using MATLAB simulation [4]. A battery-powered automobile with independent rear-wheel-drive systems was shown in this study. The rear wheels were driven by two brushless DC motors (BLDCMs) with a fuzzy logic speed controller regulating the speed (FLSC). In the electronic differential, the AckermannJeantaud steering model [5] was used.

II. WORKING

A brushless DC motor and a feedback logic controller are used in the proposed design to manage the motor's speed. The PWM for the inverter is created using a Fuzzy Logic Controller, which is then utilised to power the BLDC motor. We can control the pace at which something responds while keeping a steady state by using a Fuzzy Logic Controller. Figure 1 depicts the block diagram.

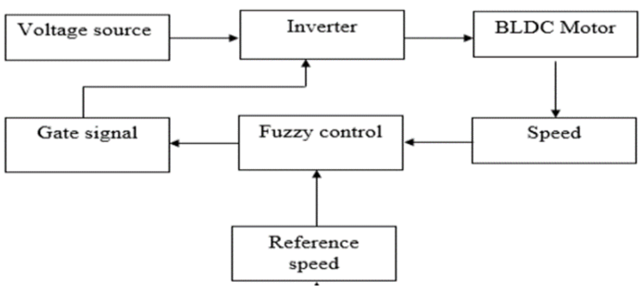


Fig 1 Block Diagram

A.BLDC MOTOR

Brushless DC motors are widely used in industries across the world. You may pick between DC and AC motors, as well as brushed and brushless motors, at the most basic level. Brushless direct current (DC) motors are precisely what their name implies: motors without brushes. Brush DC motors were in use for many years before brushless DC motors were commonly available, so it's generally helpful to explain how the former works first. A brushed DC motor has permanent magnets on the outside and an armature within that spins. Externally fixed permanent magnets are represented by the stator. The rotor is the armature that houses the electromagnet and rotates.

When power is applied to the armature of a brushed DC motor, the rotor rotates 180 degrees. The poles of the electromagnet must swap locations in order to go ahead. Because the brushes make contact with the stator and change the magnetic field, the rotor may rotate 360 degrees. Brushes are not required for reversing direction in a brushless DC motor since the electromagnetic field is successfully reversed. Permanent magnets on the rotor and electromagnets on the stator are used in brushless DC motors. Because the computer charges the electromagnets in the stator, the rotor spins indefinitely.

The use of an electric switch circuit rather than a mechanical commutator is the primary design difference between brushed and brushless motors. Because the magnetic fields formed by the stator and rotor revolve at the same frequency, a BLDC motor is a synchronous motor. Brushless motors are available in single phase, two phase, and three phase configurations. The most popular kind is the three-phase BLDC. The figure below shows the cross-section of a BLDC motor.

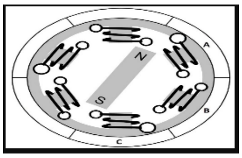


Fig 2 Cross section ob BLDC motor

B.INVERTER

Inverters (also known as dc to ac converters) are classed as either voltage source inverters (VSIs) or current source inverters (CSIs) depending on the kind of supply source and the power circuit architecture (CSIs). This group of devices is made up of three-phase iterations of half- and full-bridge voltage source inverters. Single-phase VSIs are used in low-power applications, whereas three-phase VSIs are used in medium- and high-power applications. The fundamental goal of these topologies is to provide a three-phase voltage source that can be regulated in terms of amplitude, phase, and frequency. Motor drives, active filters, unified power flow controllers, and uninterrupted power supplies all require three-phase dc/ac voltage source inverters, which use the pulse width modulation technique to deliver variable frequency and ac voltage magnitudes.

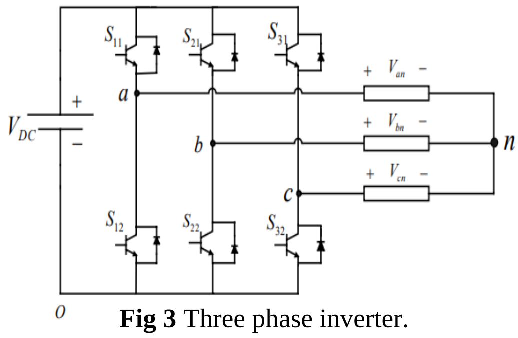


Fig 3 Three phase inverter.

C.FUZZY LOGICCONTROLLER

First, there are seven fuzzy sets, one for each of the inputs and outputs, for a total of seven fuzzy sets.

Expanding second-order fuzziness across the infinite conversational universe

For connotation, we utilise Mamdani's min operator.

Fourth, we use the centroid defuzzification approach.

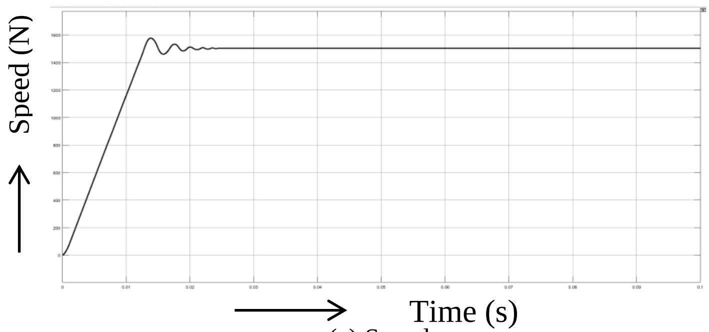
The FLC accepts error (e) and change in error (ce) as inputs and outputs an active current component. The FLC's inputs and outputs are shown in Table 1. Both 'e' and 'ce' use the same set of seven membership functions to transform continuous data to fuzzy data. Triangle membership functions are often used because they are straightforward to create. The symbols 'NB' (Negative Big), 'NM' (Negative Medium), 'NS' (Negative Small), 'ZE' (Zero), 'PS' (Positive Small), 'PM' (Positive Medium), and 'PB' (Positive Big) are used to represent the seven membership functions (Positive Big). The use of discrete intervals of 'e' and 'ce' values distinguishes membership functions. The tabular data is used to determine the fuzzy logic controller's output. For each input, 49 rules will be constructed, totaling seven inputs and outputs. Table 1 shows the results for valid input values. Fuzzification, a technique that employs seven fuzzy sets to translate numerical input and output variables into language variables, is used because Fuzzy Logic Computing depends on domain experience rather than accurate mathematical modelling. The rules of the system are made up of a combination of fuzzy sets of error and changes in error. These rules make up the system's rule base, which is given in Table III. The system's output is the outcome of an inference made using fuzzy knowledge. A BLDC model was created using FLC in the simulation programme MATLAB Simulink utilising the aforementioned lookup table as inspiration.

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

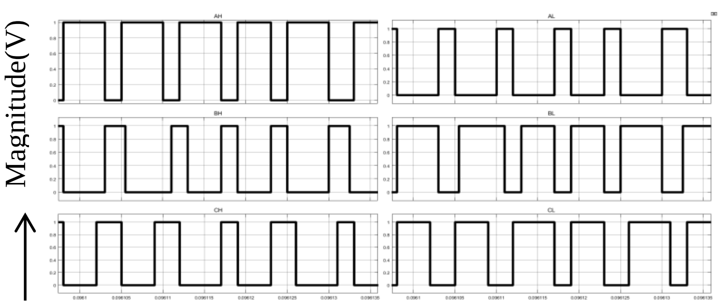
Table 1 Truth table for fuzzy logic

III SIMULATION RESULTS

In this section, the speed,pulses, stator current and inverter output current are evaluated through simulations.

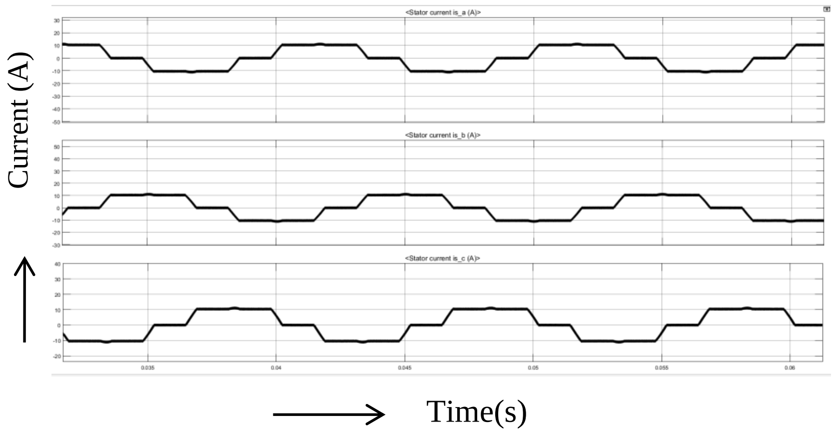


(a) Speed

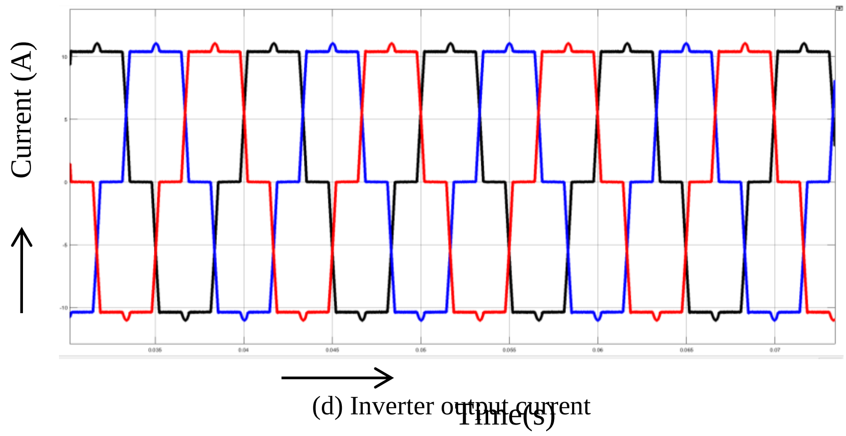


Time (s)

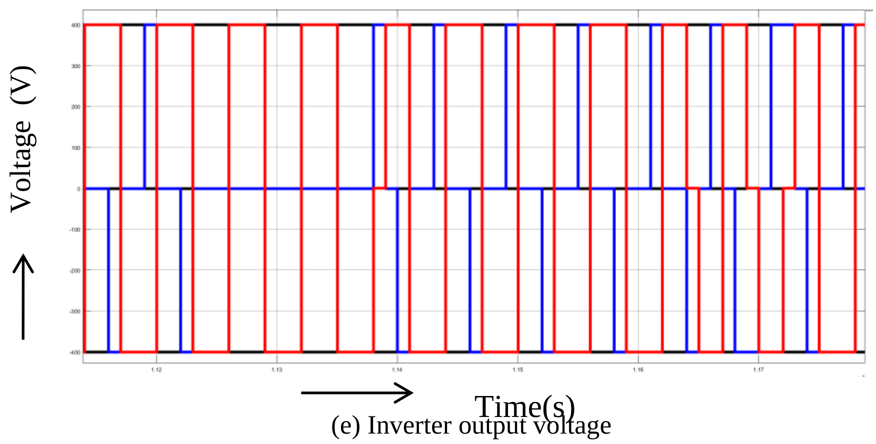
(b) Pulses



(c) Stator current



(d) Inverter output current



(e) Inverter output voltage

IV CONCLUSION

A Fuzzy Logic Controller is used to control the rotational velocity of a BLDC motor. The Fuzzy Logic Controller analyses the measured and goal velocities, calculates the divergence from the ideal, and then produces the appropriate pulses to obtain the desired result. The inverter changes the motor's speed based on the switching pulses received from the FLC. The FLC's initial acceleration and ultimate plateau are both much shorter. MATLAB simulation is used to assess the efficiency of the proposed strategy.

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