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Designing of Closed Loop Speed Control for BLDC Motor

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Abstract: Brushless Less DC motors has a specific characteristics like high starting torque, high efficiency and it has long life it has also termed as permanent magnet synchronous motor. Due to the construction that suitable for the critical application it is widely used in the industrial area. By comparing BLDC motor with the induction motor and DC motor it has several advantage such as long life and no need of mechanical commutation. In order to make the system stable in these project we have used the Proportional Integral Derivative controller and the fuzzy logic controller. In the BLDC Motor for giving the gate signal the angle value of theta is given. In order to find the error in the output side the feedback controller is used and it is directly connected to the multilevel inverter for getting the desired output the feedback is given to input. By using the MATLAB Simulation the BLDC motor characteristics such as back emf, speed, current has been determined.

Keywords: BLDC motor, Fuzzy logic controller, Inverter circuit model, PID controller.

I. Introduction

The DC motor main problem is maintenance and also the brushes are the main issue. In recent trends the brushless DC motor is the load utilised as it has high efficiency and reliability of the machine leads towards less maintenance [4]. The brushless DC motor is activated by electronically commutated method by means of voltage source inverter by modifying the frequency based on load. The rotor position modified by maintaining the electronic switches with stator winding properly energised in correct way so as to get continuous rotating EMF on motor. In this way the electromagnetic interference sparking and friction can be eliminated.

By controlling the amplitude and frequency of the stator voltage the speed of the Brushless DC motor is controlled and the ratio of stator voltage to frequency is maintained constant. By comparing with the conventional controller the paper is able to perform higher for various parameter [5]. The hybrid Fuzzy proportional integral controller is used that switches the controller in order to get the better performance of Brushless DC motor. By using the Pulse width Modulation technique the switching logic is generated based on the overshoot, oscillation and other frictional losses [6]. With the Xilinx FPGA Software 400E processor the fuzzy control model is implemented in the actual time. Under the various load condition the speed to be maintained constant is introduced [7]. The different ratings of motor the proposed system makes the offset free command tracking, it neglects the overshoot and frequent dynamic response. By using the MATLAB/SIMULINK software it is verified and by comparing with the common control systems the proposed system effectiveness is compared [8].

In order to get the desired level of feedback the control signal is directly given to the motor and feedback of error voltage also given to the inverter itself are discussed in this paper.

II. Brushless DC Motor

In the Brushless DC motor the motor will rotate continuously by the solid state switches or by making the thyristor ON the motor winding will get energized [1]. The Fig. 1 shows the basic brushless DC motor driver circuit it with the power semiconductor switch as MOSFET. The Brushless DC motor is operated both in the three phase conduction and single phase conduction.

The equation regarding the torque and EMF equation was given in (1)-(3).

$$Vab = R(ia - ib) + L\, d/dt\, (ia - ib) + (ea - eb) \quad (1)$$

$$Vca = R(ic - ia) + L\, d/dt\, (ic - ia) + (ec - ea) \quad (2)$$

$$Vbc = R(ib - ic) + L\, d/dt\, (ib - ic) + (eb - ec) \quad (3)$$

Equation of motion is given as,

$$Ta = BWm + J\ d/dtWm + TL \quad (4)$$

The voltage equations becomes,

$$Vab = R(ia - ib) + L\, d/dt\, (ia - ib) + (ea - eb) \quad (5)$$

$$Vbc = R(ib - 2\,ib) + Ld/dt(ib - 2\,ib) + (eb - ec) \quad (6)$$

BLDC motors have three Hall Effect sensors for position control. Based on the requirement the speed of the motor can be controlled by MOSFT Gate driver circuit. For accurate speed control generally obtained by PID and fuzzy controller. The four quadrant BLDC drive yields good efficiency for various speed conditions.

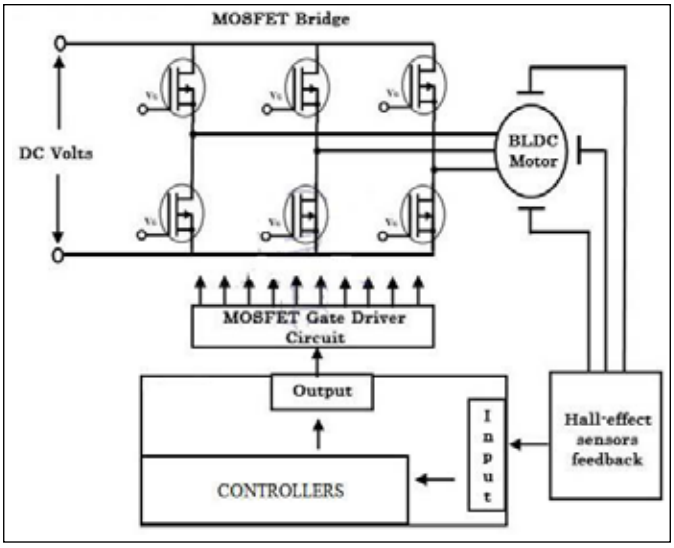

Fig. 1: Circuit Diagram of Brushless DC Motor Drive

III. Controllers

A. PID Controller

A Proportional-Integral-Derivative controller (PID controller) is used to calculate an error value from the error detector as the difference between set speed and motor speed. Based on the value the control action takes place. The signal from the controller is fed to MOSFET Gate driver circuit.

Transfer function of PID controller: KP + K1/S + Kd S

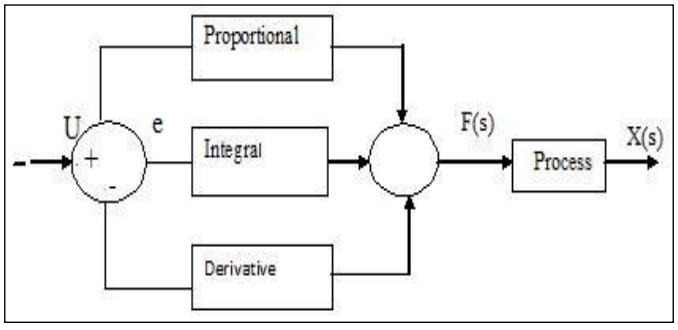

Fig. 2: Block Diagram of PID Controller

B. Fuzzy Controllers

The four basic elements of any Fuzzy logic control system is shown in Fig. 3. These are fuzzification interface, fuzzy interference engine, fuzzy rule matrix, defuzzification interface.

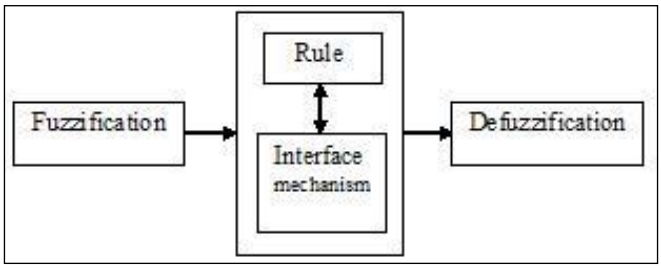

Fig. 3: Fuzzy Logic Controller

- *Fuzzification*: By using the predefined membership function the values for fuzzification is choosed. The exponential, sinusoidal, trapezoidal and triangular are the other membership functions are used for fuzzification.
- *Rule Matrix*: The fuzzy operators and fuzzy set is explained by Rule matrix and is explained in standard statement.
- *Inference Mechanism*: The mapping is done between the input and output values by using the fuzzification method and it is allowed by interference mechanism [2]. The Mamdani and the Sugeno method is the most common methods used for interference mechanism, in this method we are using the Mamdani method.
- *Defuzzification*: The required Crisp Value is converted from the fuzzy reasoning Mechanism is done by using the Defuzzification method.

IV. Simulation Model of Speed Control of BLDC Motor Using Matlab

A. Circuit Diagram of Brushless DC Motor

The Fig. 4 explains the function circuit for Brushless DC motor speed control by using efficient controller are fuzzy and PID controller.

Fig. 5 Brushless DC motor simulation model. The major blocks of BLDC model block are Inverter circuit block, Controller block and Subsystem 1.

In this paper, fuzzy merged with PID controller was activated Fig. 4 shows the proposed system of the three phase brushless DC motor.

The working reliability of BLDC Motor is explained by means of simulink. The duty cycle of the semiconductor device such as MOSFET is controlled by Fuzzy and PID controllers. Stator of the BLDC.

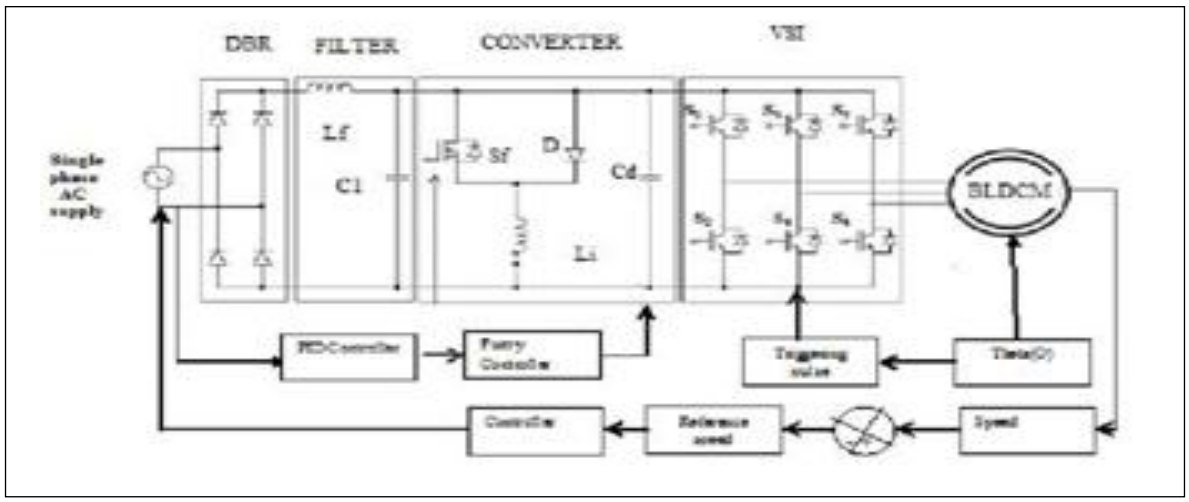

Fig. 4: Function Circuit for Brushless DC Motor

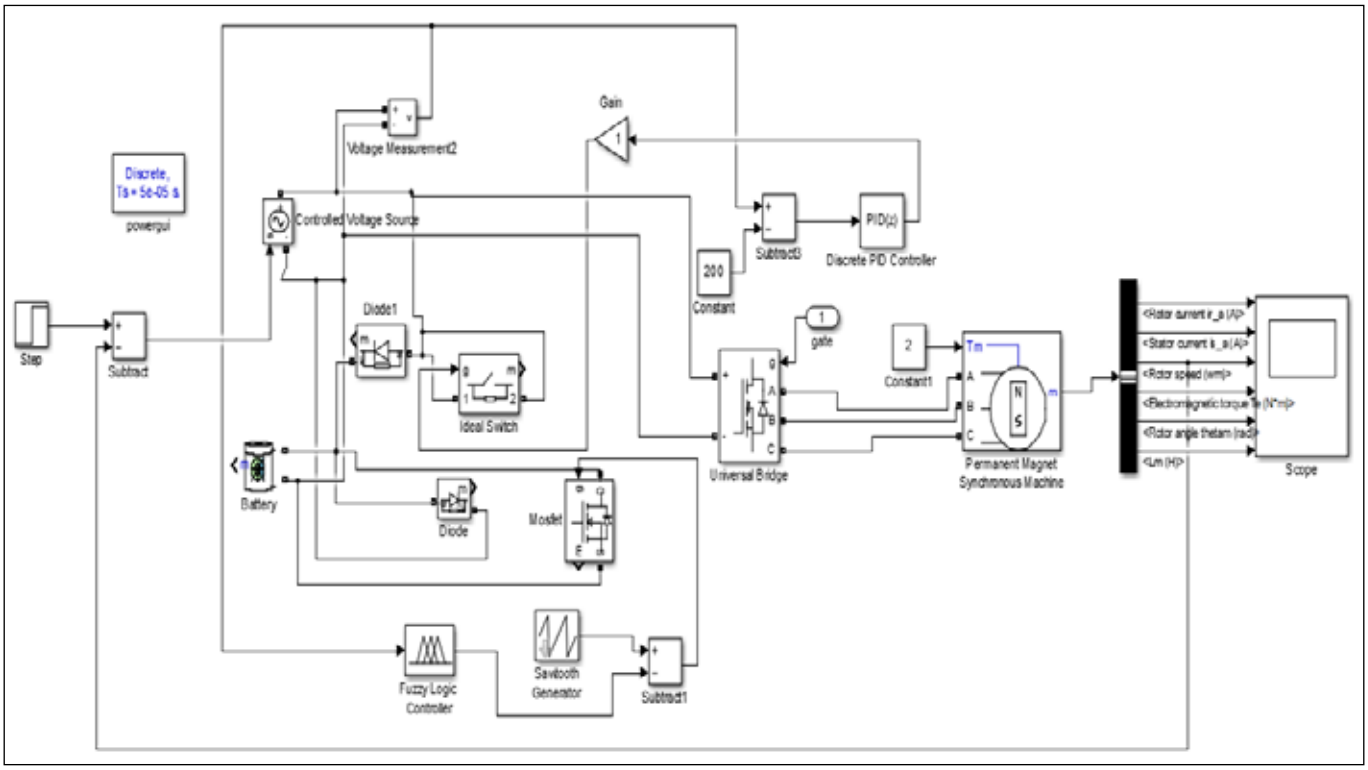

Fig. 5: Brushless DC Motor Simulation Model

V. Performance Analysis of BLDC Motor

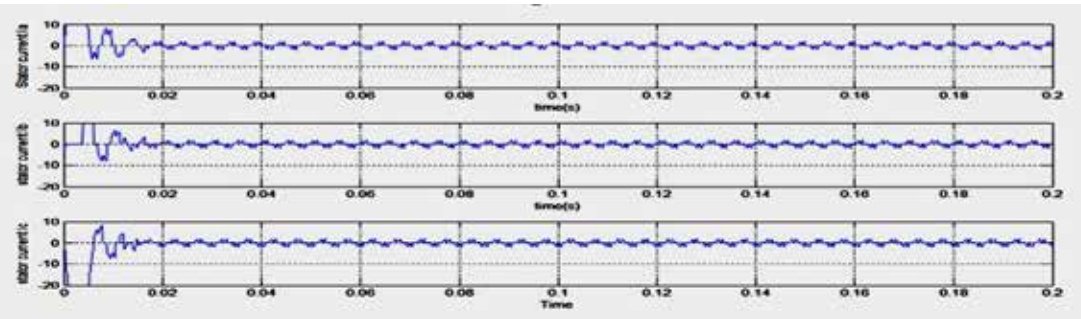

Fig. 6: Stator Current Waveforms

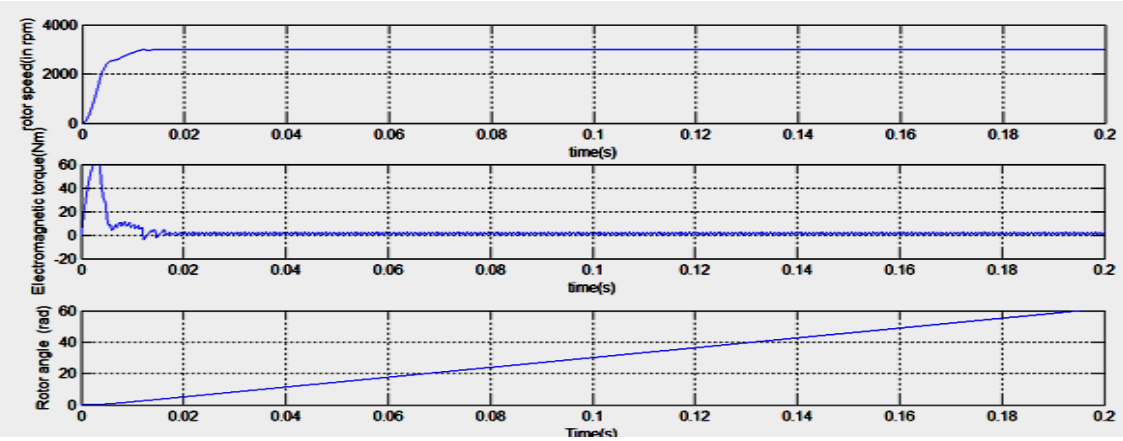

Fig. 7: Waveform for Speed, Torque and Rotor Angle

Speed/Time Waveform Table

Reference Speed (rpm)	Reference Time (s)
1800	0.01
1600	0.02
1400	0.03
1200	0.04

Fig. 8: Waveform of Speed

Fig. 8 show the curve for speed in BLDC Motor at no load condition where reference is set at 1500 rpm.

Reference Speed Vs Time for Closed Loop

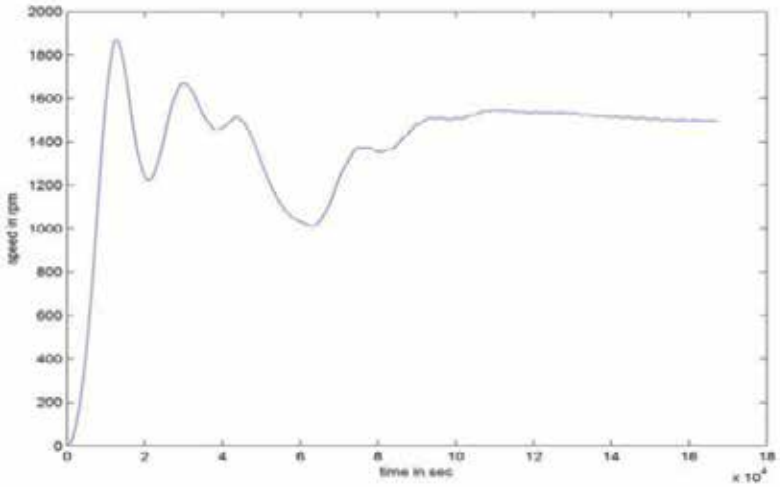

Fig. 9: Speed Vs Time

Time to attain the rated speed of motor is 0.04s at 1500 rpm.

VI. Conclusion

By using the fuzzy logic based controller and PID Controller in BLDC motor the speed is controlled under the various load condition. By output voltage from the inverter is used to control the speed of the motor. For the different load condition the gate signal is triggered. By using the MATLAB SIMULATION software the various characteristics such as load current, output speed and back emf is analysed under the different load condition. The performance of motor is improved for the wide range of load in the proposed system.

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