

# Speed Control of BLDC using Fuzzy Logic

Shruti <sup>1</sup>

PG Scholar, Department of EEE, NMAMIT, Nitte, Udupi, Karnataka, India<sup>1</sup>

**ABSTRACT:** Due to high power density and ease of control, brushless dc motor finds its usefulness in various fields such as in battery operated vehicle, wheel chairs and in much industrial application. Three phase semiconductor bridge is used to control this motor. Speed control is achieved in permanent magnet motors usually through conventional controllers. But these conventional controllers pose difficulties when the BLDC control systems is non linear or if there is some load disturbance and parametric variations. To overcome with these problems, an artificial intelligent technique such as fuzzy logic is used. The proposed system is modelled using MATLAB/Simulink.

**KEYWORDS:** Brushless DC motor; Fuzzy Logic;

## I. INTRODUCTION

The appliances used in home are one amongst the fastest-growing products in market over future years. The most important appliances are fridge, vacuum cleaners, freezers, etc. These appliances have relied on traditional motor technologies such as single phase AC induction, together with split phase, and universal motor. These traditional motors are generally operated at constant-speed directly from main AC power which is not related to the efficiency. Customers currently demand for lower energy costs, higher performance, reduced acoustic noise, and additional convenience options.

Brushless DC motors are most popular as little power unit control motor because of its good efficiency, noiseless operation, compact type, dependability. However, the issues hostile in motors in variation of speed over last decades. Technology development in semiconductors, multiprocessors, drivers management scheme and brushless DC motor production are combined to modify reliable, efficient product for a broad vary of adjustable speed applications. Two main factors to be considered for the motors used in industries are reliability and controllability. These factors can be achieved by making a good choice of controller. In this paper management of speed is achieved by FLC. A simulation of the motor is done under closed loop condition. The simulations results show that fuzzy logic provide a good control of speed.

## II. CONSTRUCTION AND PRINCIPLE OF OPERATION

Brushless motor is considered to be an electronically commutated motor. It requires electrical switches for realizing commutation of current and hence motor is rotated continuously. These switches are connected in H-bridge structure. Figure 1 shows BLDC connected to driver circuit.

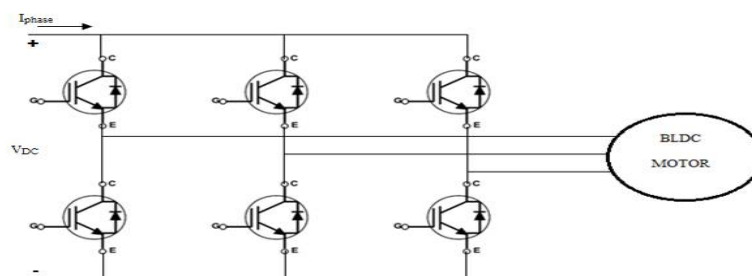


Figure 1: BLDC motor with driver circuit

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Three hall sensors are required for a three phase BLDC motor which is used to detect the position of rotor. Three sensors are placed on stator at 120 degree intervals. These windings are placed in a star formation. Each hall sensors changes its state for every 60 degree rotation and completes the whole cycle by taking six steps. Rotor pole pairs are used to determine number of cycles required to complete a mechanical rotation. Hence, number of cycles is same as rotor pole pairs.

### III. BLOCK DIAGRAM OF THE SYSTEM

Figure 2 shows basic block diagram used in the system.

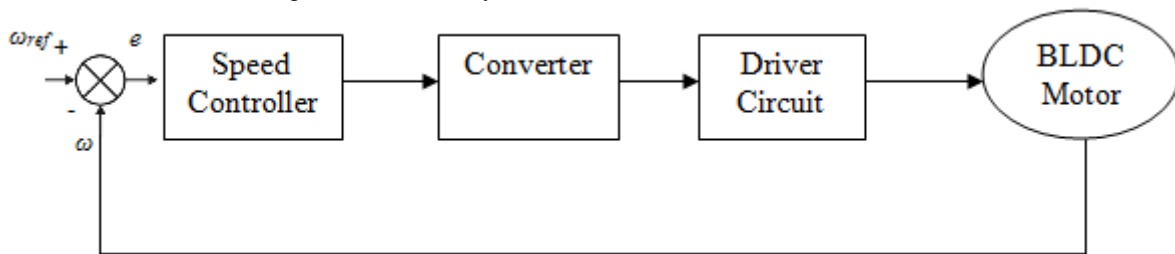


Figure 2: Block diagram

The basic block diagram consists of power inverter, speed controller and BLDC motor. Power is transformed from source to the motor drive by three phase driver circuit and electrical energy is converted to mechanical energy. The command signal which is classified as electromagnetic torque, DC voltage, rotor speed and so on is present in the motor which controls the position sensor of the rotor. By using FLC speed control is attained.

### IV. SPEED CONTROL TECHNIQUE FOR BLDC MOTOR

#### FUZZY LOGIC CONTROLLER

FLC is an algorithm which is dependent on lingual strategy of control. It acquires human thinking about controlling the systems without mathematical modeling. Fuzzy logic's lingual terminology is often exhibited using some of the logical insinuation like If-Then rules. These logical rules describe a scale of values which is known as fuzzy membership function. Block diagram of fuzzy logic controller is given below,

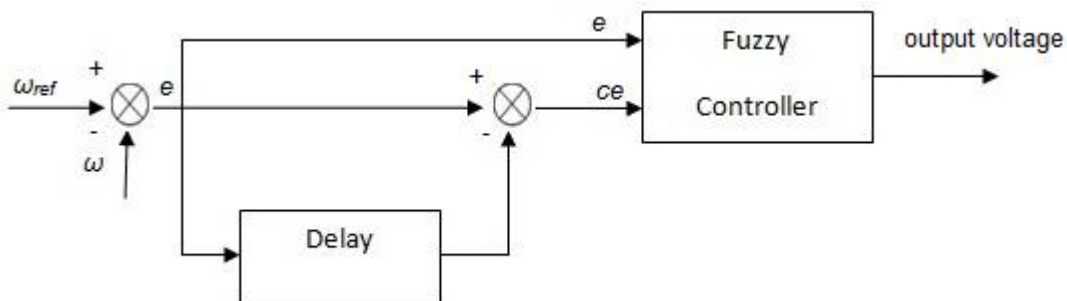


Figure 3: Fuzzy controller block diagram

There are two types of fuzzy logic controller. They are Sugeno Takagi architecture and Mamdani architecture. For controlling speed, Mamdani architecture of fuzzy logic is used. Inputs are error ( e ) and change in error ( ce ). Difference of reference speed ( ω\_ref ) and the original speed ( ω ) gives the speed error. Output voltage is the controller output.

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Membership function chosen is the triangular shaped function because of its simplicity and good controlling operation. Error, change in error and output voltage is the membership function used here. Seven level of membership function are applied for all the variables.

### IV. SIMULATION

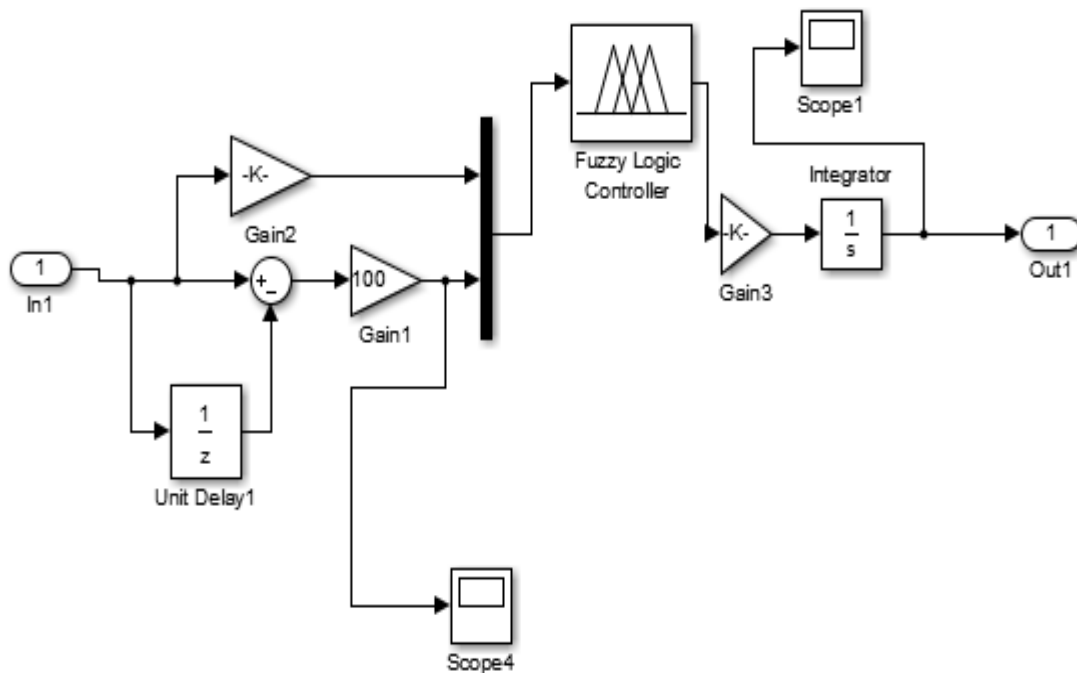
For analysis, the motor is simulated under closed loop condition as in fig. 3. Simulation is done by using fuzzy logic controller. Motor simulated by fuzzy logic controller used seven membership functions to acquire a desired speed. The waveforms of stator current, rotor speed, torque and dc voltage is obtained in the output scope. Table 2 shows the parameters used for simulation.

**Table 2: Motor parameters**

Motor Parameters	Values
Input voltage, $V_{dc}$	300V
Stator resistance, $r_s$	2.8750 $\Omega$
Stator inductance, $L_s$	8.5mH
Pole pairs	4

### SIMULINK MODELS

Figure 4 shows the speed controller model which is used as a subsystem in the proposed system.



**Figure 4: Speed controller model of proposed system**

Figure 5 shows the complete simulink model of the proposed system. Here the speed of 2000rpm is given as an input reference speed. The speed from the motor is given i.e. original speed is given as feedback. By taking difference of two,

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error is calculated and it is given to speed controller block. Taking difference between present and previous error, error change is calculated. According to this, FLC calculates change in voltage that should be given to the motor.

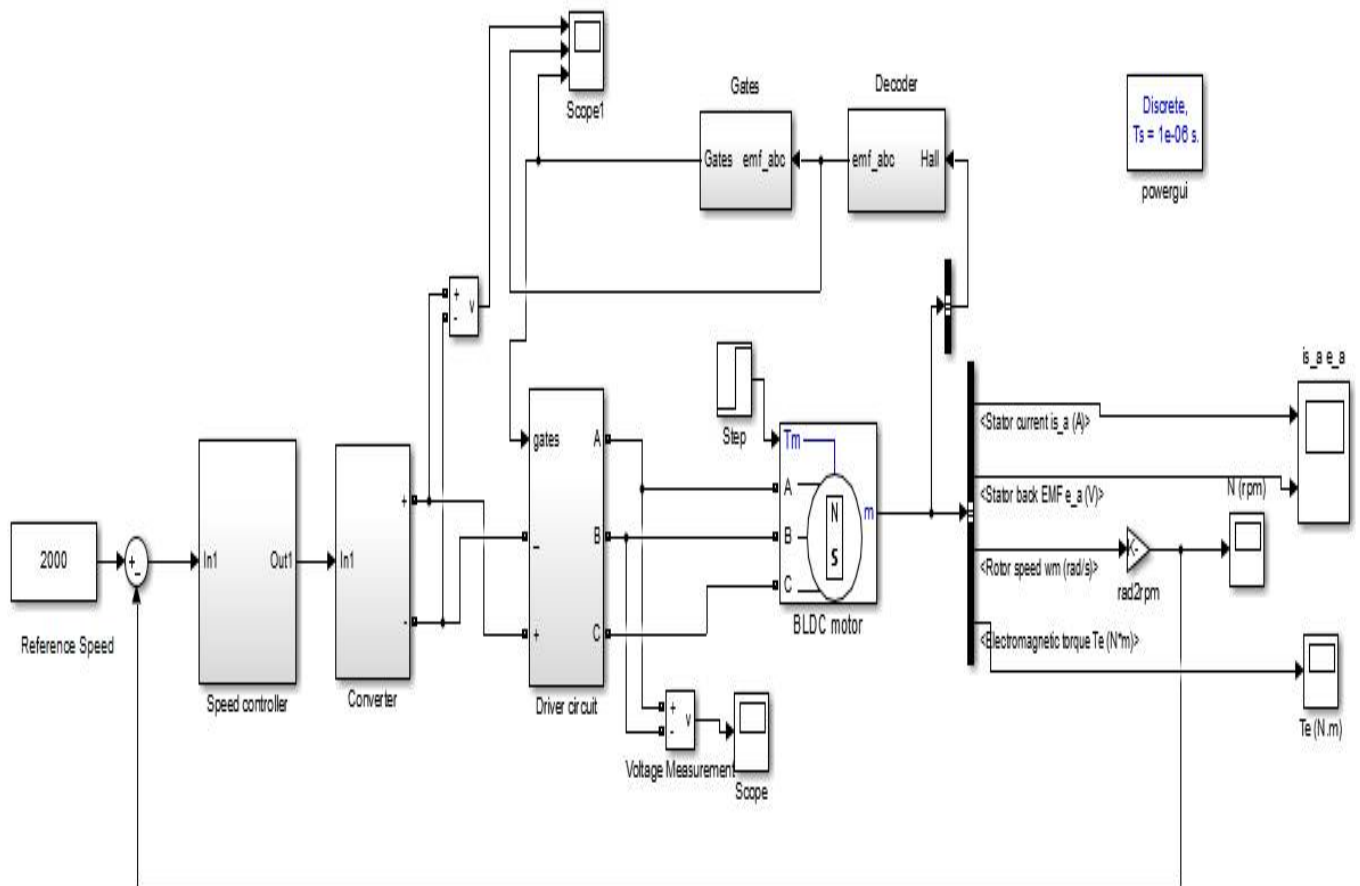


Figure 5: Simulink model of proposed system

## SIMULINK WAVEFORMS

Figure 6 shows stator current response of motor. Initially the current is high and during acceleration it decreases.

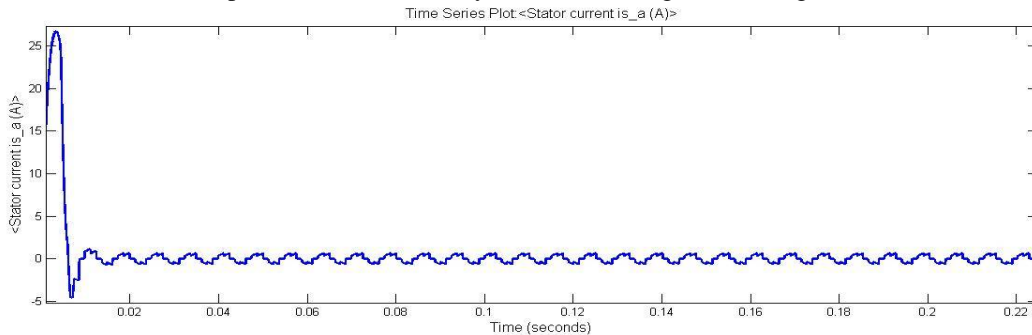
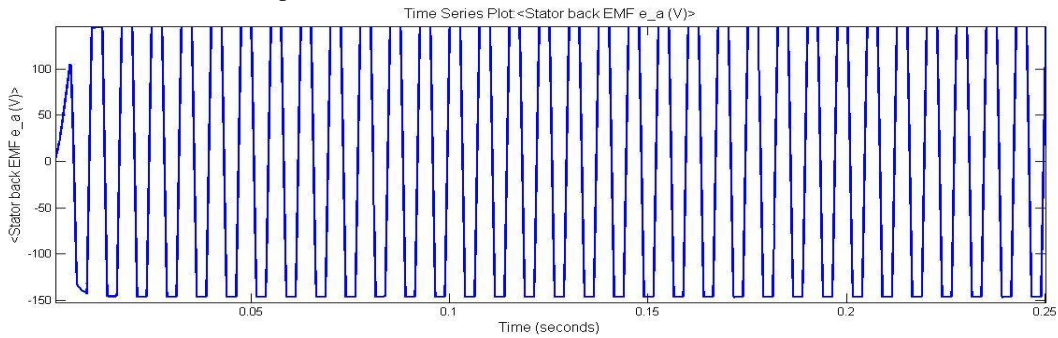


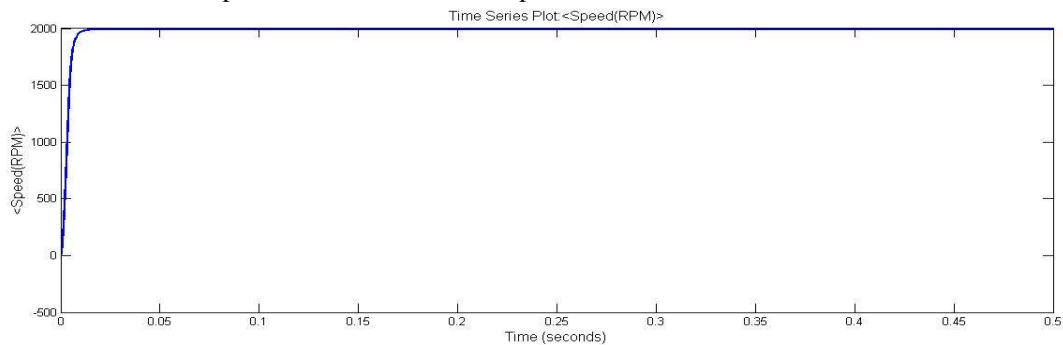
Figure 6: Stator current response

Figure 7 shows Stator back EMF response.



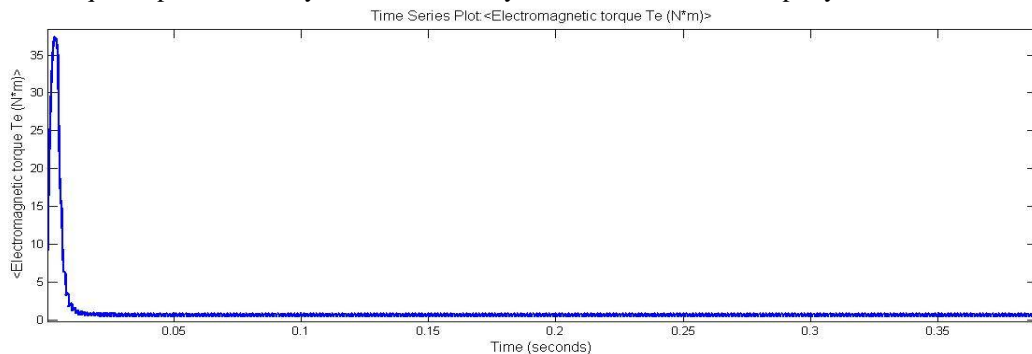
**Figure 7: Stator back EMF response**

Figure 8 shows rotor speed response where, reference speed is set constant for 2000rpm and load torque is varied from 0.4 to 0.6N-m at 0.5sec. The speed is controlled for 2000rpm.



**Figure 8: Rotor speed response**

Figure 9 shows torque response. Initially it climbs to nearly 38N\*m and stabilizes rapidly to its reference value.



**Figure 9: Electromagnetic torque response**

## V. CONCLUSION

In this paper the control scheme for BLDC motor using FLC is proposed. The advantages of FLC are: (1) The fuzzy rule can be modified easily (2) Robustness is increased. The simulation shows that speed control of BLDC, using FLC, proves that the desired speed can be attained in shorter response time and by analysing results it reveals that FLC is a good controller and it is capable of controlling BLDC over a wide range of speed. And also it proves that FLC is much efficient compared to other conventional controller

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