Design and Analysis of Parameters in Brushless DC Motor with and without Fuzzy Logic Controller

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ABSTRACT

The Brushless DC motor does not require commutator and due to its electrical and mechanical characteristics it is more reliable than the DC motor. BLDC motors are available in many different power ratings. Three phase motors are most common of brushless dc motors which will be helpful in solving problems, The BLDC motor drive system consists of a dc power supply switched to the stator phase windings of the motor through an inverter by power switching devices. This paper shows the behavior of back emf in three phase star connected brushless dc motor through the simulink model and analyzing the speed with fuzzy logic controller. Three phases are displaced by 120^0. Thus we observed the behavior of back emf and speed with and without controller.

Keywords - BLDC, Back EMF, Fuzzy Logic Controller.

1. INTRODUCTION

BLDC motor is conventionally defined as a permanent magnet synchronous motor, Here EMF is considered with a trapezoidal waveform shape. As the name implies, BLDC motors do not use brushes for commutation; instead, they are electronically commutated. Recently, high performance BLDC motors are widely used for variable speed drive systems of the industrial applications and electric vehicles. It has all the good advantage of DC drives and eliminating the drawbacks using electronic commutation. So in this motor current and torque, voltage and rpm are related linearly. [1].The optimization of the permanent magnet pole shape is performed for making balance of the back EMF between the outer and inner windings. [2]

In this paper, mathematical modeling of a BLDC motor and its parameters are described by simulink model using fuzzy logic controller and without using any controller. A comparison can also concluded through these parameters by analyzing the different results from simulink models. Thus, simplicity of control and performance makes the BLDC motor the best choice for low-cost and high-efficiency applications. [3]

2. MODEL AND MATHEMATICAL EXPRESSION OF BLDC MOTOR.

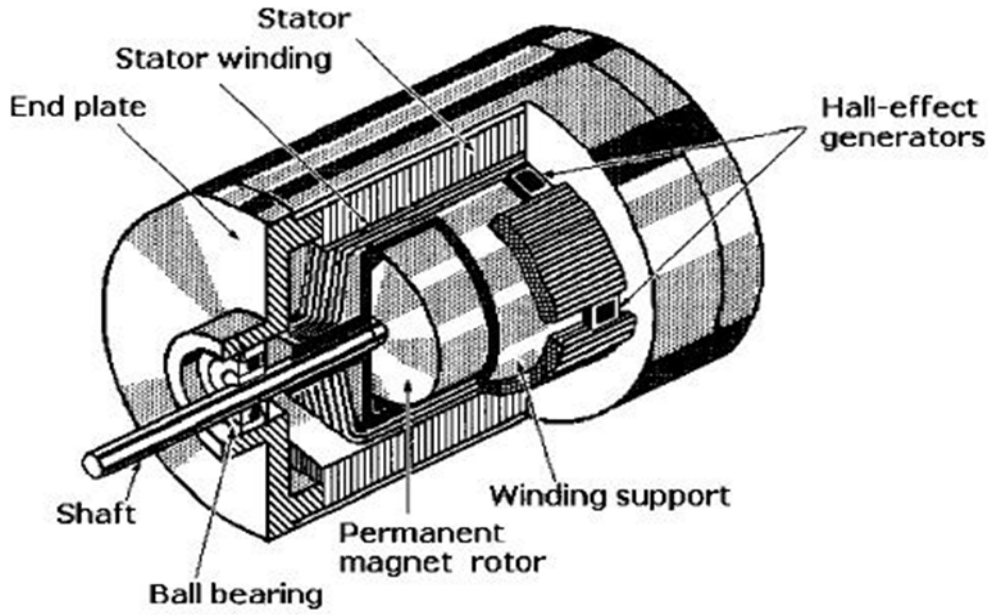

Fig.1: BLDC Motor – schematic diagram

The model of the armature winding for the BLDC motor is expressed as follows

$$V_A = RI_a + L\frac{di_a}{dt} + e_a \quad (1)$$

$$V_B = RI_b + L\frac{di_b}{dt} + e_b \quad (2)$$

$$V_C = RI_c + L\frac{di_c}{dt} + e_c \quad (3)$$

Where,

L is the armature self-inductance.[H]

R is the armature resistance.[Ω]

V is the terminal voltage.[V]

e_a,e_b,e_c is the back EMF.[V]

I_a, I_b, I_c is the input current.[A]

In the 3-phase BLDC motor, the back-EMF is related to a function of rotor position and the back-EMF of each phase has 120o phase angle difference so equation of each phase should be as follows:

$$e_a = B_e f(\theta_e)\omega \quad (4)$$

$$e_b = B_e f(\theta_e - \frac{2\pi}{3})\omega \quad (5)$$

$$e_c = B_e f(\theta_e + \frac{2\pi}{3})\omega \quad (6)$$

Where,
B_e = back EMF constant of one phase[V/rad.s^{-1}]
θ_e = electrical angle
ω = rotor speed [rad.s^{-1}]

3. POWER LOSSES IN BLDC MOTOR

In the BLDC motor, the power losses consist of core losses in the magnetic core, copper losses in the winding and mechanical losses

3.1Copper Losses

The copper losses are I^2R losses. All three-phase windings must be taken into account. Thus, the total armature copper loss (P_{cu}) is equated as follows.

$$P_{cu} = I^2{}_a + I_b{}^2 + I^2{}_c$$

3.2 Core Losses

Core losses are the open circuit losses due to hysteresis property and induced eddy current in the core, which exist as long as the excitation winding energized.

3.3 Mechanical Losses

Mechanical losses are caused by friction and the dynamic drag to oppose the motion of the rotor or so-called the friction and windage losses[4]

Thus to overcome these losses. Certain parameters should be strong enough. The analysis of speed also a part of it. Which result in better outcomes

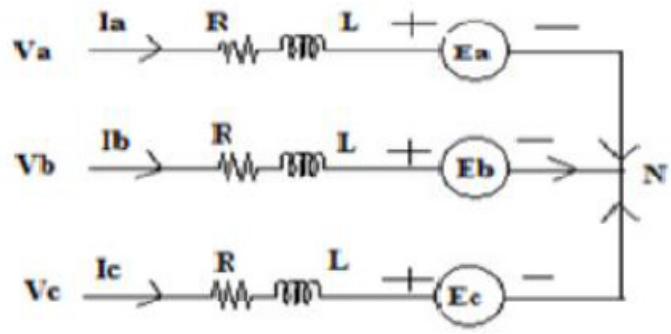

Fig.2: Equivalent circuit diagram of stator winding.

The above diagram shows the arrangement of resistance and inductance in three phase motors by which the EMF get displaced by 120^0.and we get the balanced resultants

4. MODEL OF BLDC MOTOR WITHOUT CONTROLLER.

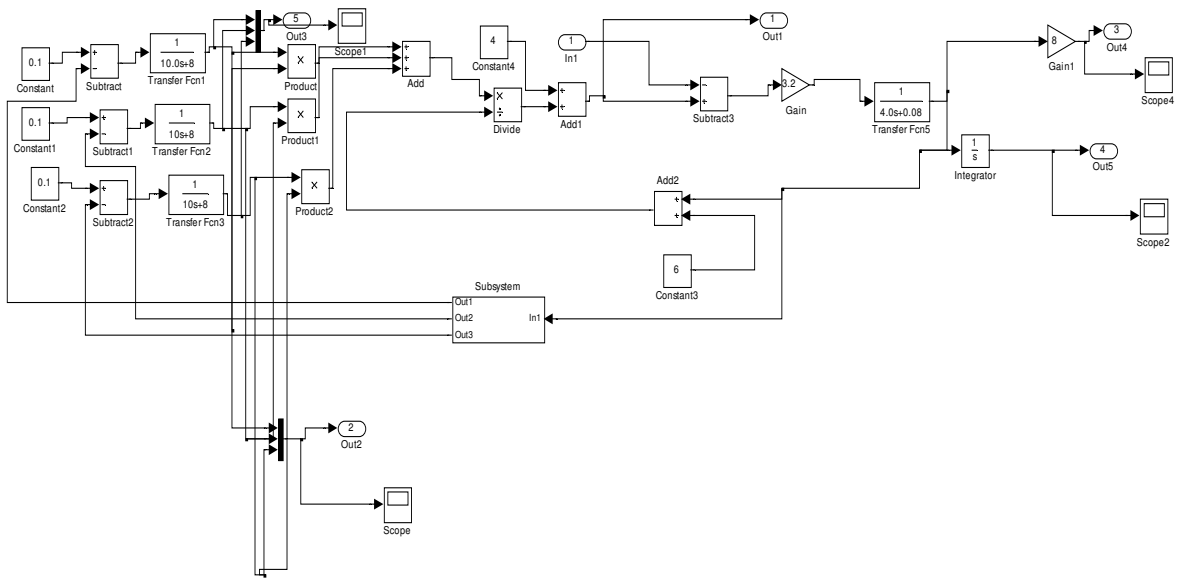

Fig.3: Simulink model of brushless dc motor without controller

In this model, without controller the parameters like current, torque, speed and back EMF can be calculated. For simplicity the analysis of back EMF and speed are calculated for three phase brushless dc motor

Results:

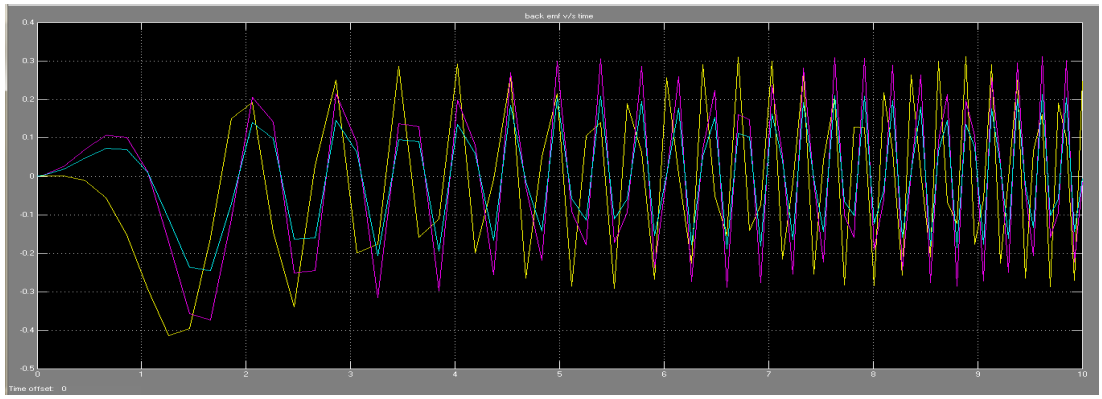

Fig.4: Output waveform for back EMF.

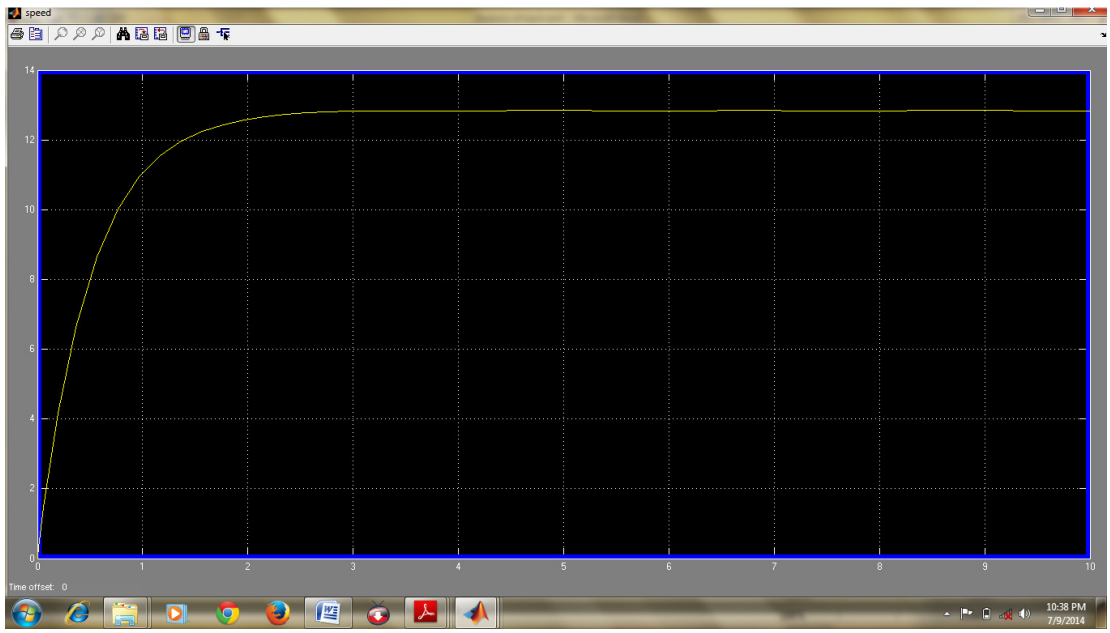

Fig.5: Speed of BLDC motor without controller

5. BLDC MOTOR WITH FUZZY LOGIC CONTROLLER.

Many machine design and control schemes have been developed to improve the performance of BLDC motor drives. The model of motor drive has to be known in order to implement an effective control in simulation. Furthermore, fuzzy logic controllers (FLCs) have been used to analyze BLDC motor drives.

In this paper, a comprehensive simulation model with a fuzzy logic controller is presented. MATLAB/fuzzy logic toolbox is used to design the FLC, which is integrated into simulations with Simulink [5].

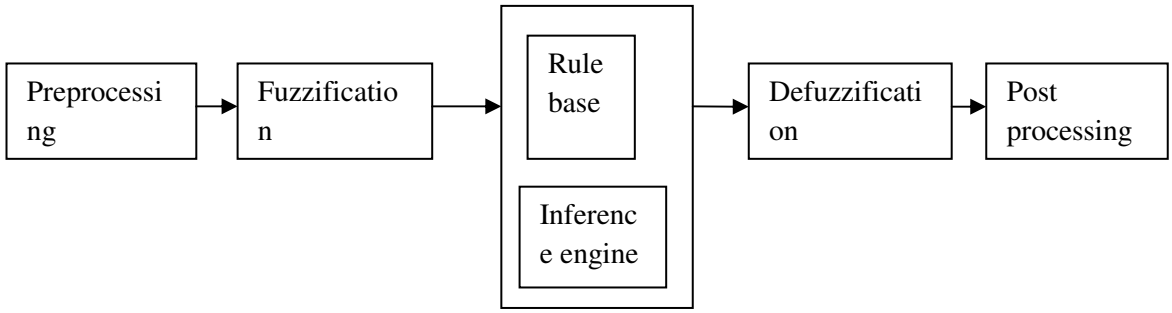

Fig.6: Fuzzy Logic Controller-Schematic Diagram

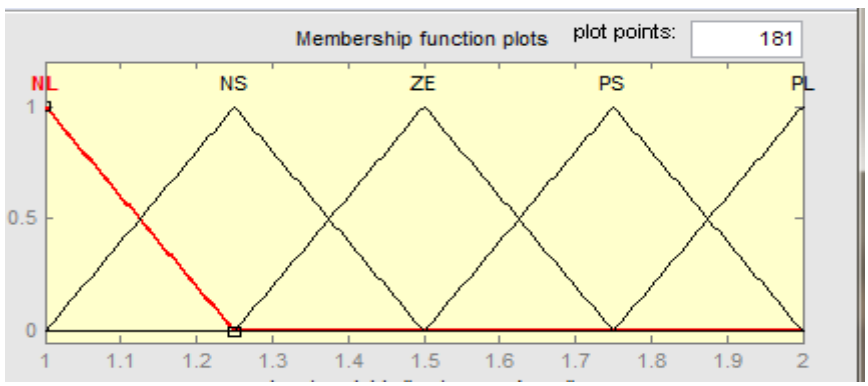

Fig.7: Membership functions of fuzzy logic controller.

5.1 BLDC with FLC

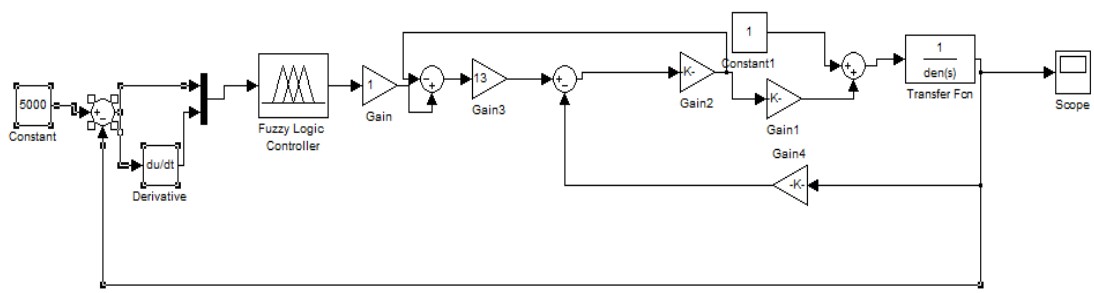

Fig.8: simulation diagram of BLDC motor using fuzzy logic controller.

Result

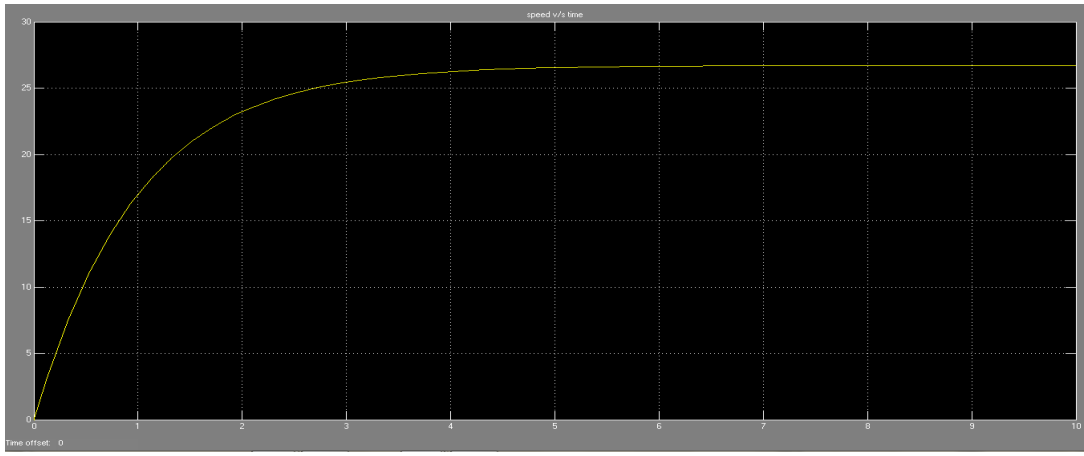

Fig.9: Result of Speed with Fuzzy Logic Controller

6. CONCLUSION

In this paper, speed regulation and back EMF with trapezoidal back-EMF of brushless DC motor is obtainable. the speed result can be determined by fuzzy logic controller or without using controller. But in case of back EMF without controller the result is far better. For further implementation another controllers can be used for best results. Thus, simplicity of control and performance makes the BLDC motor the best choice for low-cost and high-efficiency applications.

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