Review Paper on Speed of Brushless D.C. Motor – A Comparative Study

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Abstract---In this paper the detail of BLDC motor is shown. BLDC motor is used in many way. we can control the speed by different methods. but here the comparison study of different methods is shown. conventional methods like pi, pid don't give better result for speed control. these methods don't increase the speed of response .but fuzzy control & neuro-fuzzy system give better output then these methods .in this paper we compare the result of speed with different method.

Keywords: Introduction, principle operation of the motor, mathematical model of the motor, speed of the motor for various methods, acknowledgement, conclusion..

I. INTRODUCTION

BLDC motor is widely used in different type of applications like Industrial, Home Appliances, Electronics equipments etc. it has numerous advantages compared to other motors like DC Motor and Induction Motor. As the name suggests i.e. It does not require any type of brushes for commutation purpose. It requires electronic switches. Moreover It has better Speed Torque Characteristics compared to other motors. it require sensing elements to sense the rotor position of the motor, however we can use hall sensor for sensing. It offers long operating life, noiseless operation, high efficiency & high dynamic response.

A. Stator

The stator consists of stacked steel laminations. It has stator windings connecting in star phase. One or more coils are placed in the slots and they are interconnected to make a winding.

B. Rotor

The rotor is made of permanent magnet & can vary from two to eight pole pairs with north & south poles. Ferrite magnets are used to make a permanent magnet. The rotor & hall sensor of the motor is shown below,

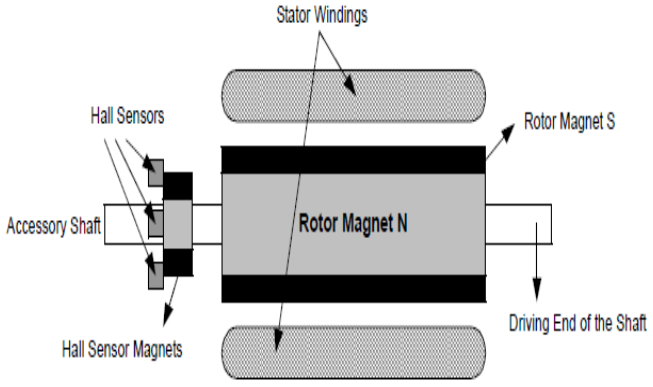

Fig. 1: rotor & hall sensor of the motor

II. PRINCIPLE OF OPERATION

Brushless dc motor defined as permanent magnet synchronous motor. It is generally controlled with three phase semiconductor bridge.

BLDC motor works according to six states, and in every state two phase working principle is similar.

The motor require sensor for rotor position. The equivalent circuit of BLDC motor is shown below,

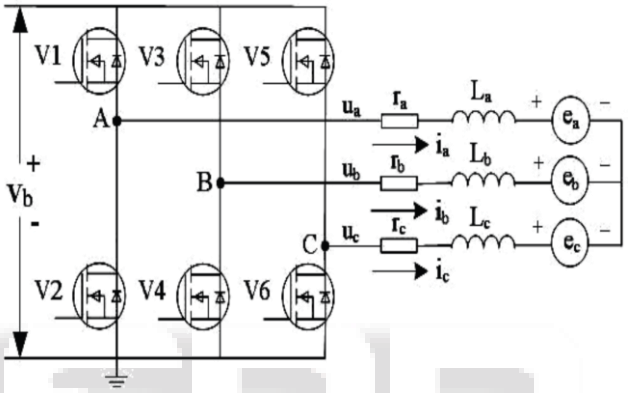

Fig. 2: Equivalent ckt of the motor

In this circuit three phase VSI system is connected with the rotor of the BLDC motor & also we use hall sensor for sense the rotor position. where. ra, rb & rc are the resistances. & la, lb & lc are the inductances of three phase.

The commutation sequence of the motor according to rotor position is shown below,

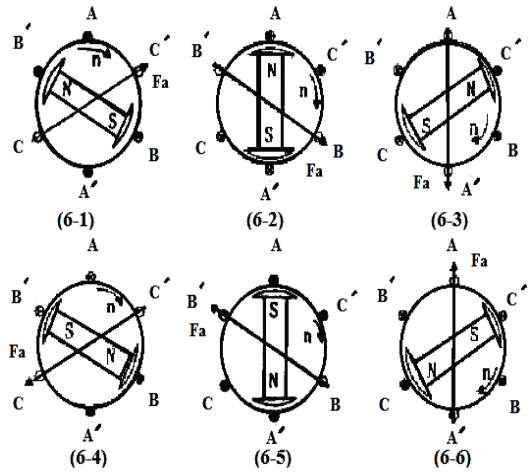

Fig. 3: commutation Process

Six MOSFETs work in conducting sequence so that magnetic field generated by three phase of motor mak rotor circumrotate.the black arrow in this figure shows the direction of magnetic field.

The back emf waveform of the motor is also described below,

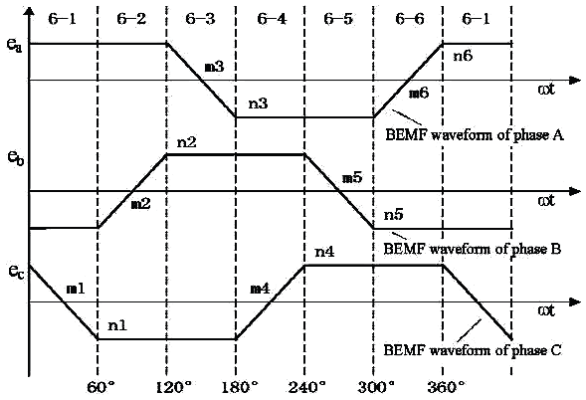

Fig. 4: back Emf

In this diagram back emf for every phase are shown. Block diagram of the motor for using fuzzy logic is shown below,

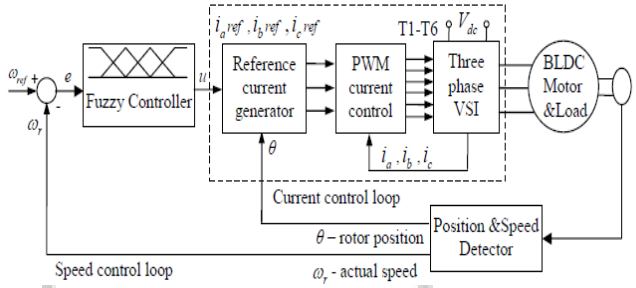

Fig. 5: Block diagram using Fuzzy logic

In this diagram, there are two loops first is speed control loop & second one is the current control loop. Here BLDC motor is fed by inverter. & reference speed is compare by the actual speed.

III. MATHEMATICAL MODEL OF BLDC MOTOR

Typical mathematical modeling of the motor is described by the following equations,

$$\begin{bmatrix} ua \\ ub \\ uc \end{bmatrix} = \begin{bmatrix} R & 0 & 0 \\ 0 & R & 0 \\ 0 & 0 & R \end{bmatrix} \times \begin{bmatrix} ia \\ ib \\ ic \end{bmatrix} + \begin{bmatrix} L_m - M & 0 & 0 \\ 0 & L_m - M & 0 \\ 0 & 0 & L_m - M \end{bmatrix} \frac{d}{dt} \begin{bmatrix} ia \\ ib \\ ic \end{bmatrix} + \begin{bmatrix} ea \\ eb \\ ec \end{bmatrix}$$

Where, R and M are the resistance & mutual inductance of the stator, and ua, ub & uc are the Phase voltage, ia, ib, ic are the Phase current & ea, eb & ec are the back emf voltage of the stator.

Electromagnetic torque is expressed by,

$$T_e = \frac{Z_p}{2\omega_e}(e_a i_a + e_b i_b + e_c i_c)$$

Where ω_e & Z_p are the electrical speed & number of magnetic poles.

The equation of motion is described below,

$$T_e = T_L + J\frac{d\omega_r}{dt} + B\omega_r$$

Where T_L, ω_r J, & B are load torque, angular velocity, inertia moment, and friction constant.

The motion equation is expressed is expressed as,

$$\frac{d\omega_m}{dt} = \left(\frac{P}{2J}\right)(T_e - T_L - B\omega_r) \text{ and } \frac{d\theta}{dt} = \omega_r$$

Where ω_m and ω_r are rotor speed in mechanical rad/s and in electrical rad/s.

Trapezoidal back- emf is expressed as,

$$\begin{pmatrix} ea \\ eb \\ ec \end{pmatrix} = E\begin{bmatrix} f_a(\theta) \\ f_b(\theta) \\ f_c(\theta) \end{bmatrix}, (E = K_e\omega_r)$$

Where K_e is the back emf constant & $f_a(\theta), f_b(\theta)$ and $f_c(\theta)$ are the function of rotor position.

IV. SPEED OF THE MOTOR USING VARIOUS METHODS

Here is a speed of the motor is shown for different methods,

A. Using PI Controller

The speed of the motor using pi controller is shown below, for this speed is obtained through MATLab Simulink.

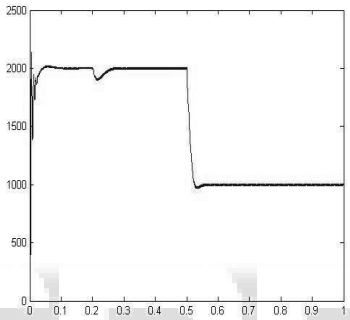

Fig. 6: speed of motor using pi controller

In this diagram the overshoot is described, so we could not opt the linear graph for speed. That's why this is one of the reason why it is not used in recent.

B. Using PID controller

The diagram for PID control is shown below,

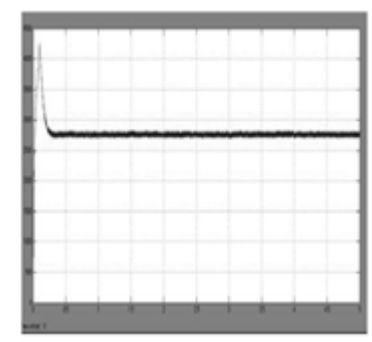

Fig. 7: speed for PID controller

With PID control the program tends to complicated because a special algrorithm is necessary as compensation on the reduction of current sensor. With PID control we don't get accurate result of speed.

C. Using fuzzy logic controller

In this diagram, we can see a small starting overshoot. Therefore the same is to be considered as nearly linear graph and this way it provides good result compared to above methods.

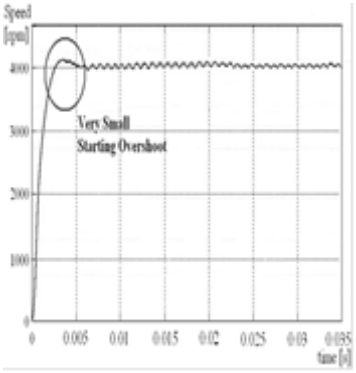

Fig. 8: Speed for fuzzy logic

D. Using Neuro-Fuzzy controller

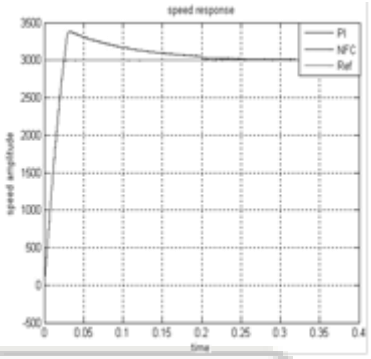

Fig. 9: speed for neuro fuzzy method

From the figure neuro-fuzzy control give the better result than other methods. It gives lower overshoot & shorter settling time

V. CONCLUSIONS

By this way paper can be concluded that Neuro Fuzzy Control System is much better to PI, PID & FUZZY Control. Moreover it gives better speed response, lower overshoot & that's why, it is used for any type of non linear system. We can opt comparatively good result for the same method. Recently, particularly this method is useful for controlling purpose, because it is a combination of both neural network & fuzzy logic. Both these techniques are belongs to artificial intelligence.

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