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Speed Control of BLDC Motor using PID Controller in Matlab

CH.B. Srikanth M.tech (Phd),Y. Jagadeesh, B.Balaji Arun, P.Vijay, M. Jyoshna

CH.B.Srikanth M.tech (Phd), professor, Dept. of EEE, Visakha institute of engineering and technology, India.
Y. Jagadeesh, student, Dept. of EEE, Visakha institute of engineering and technology, India
B. Balaji Arun, student, Dept. of EEE, Visakha institute of engineering and technology, India
P. Vijay, student, Dept. of EEE, Visakha institute of engineering and technology, India.
M. Jyoshna, student, Dept. of EEE, Visakha institute of engineering and technology, India.

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Abstract - ***This project presents the design and implementation of a speed control system for a Brushless DC Motor (BLDC) using PID Controller . The objective is to regulate the speed of the BLDC Motor efficiently and accurately, whereas the PID serves as the executing unit, In which the VSC converter employed to provide the appropriate voltage input to the BLDC Motor. For the steady state behavior of the motor we use PID Controller, which in general is tuned to achieve desired speed responses. The total integration of all these components results to achieve the precise speed control for the BLDC Motor. The experimental results validate the proposed approaches performance and it is potential for various industrial and automation applications. The suitability of proposed system at practical operating conditions is demonstrated through simulation results using MATLAB/ Simulink followed by an experimental validation.***

Key Words*: *Burshless DC motor (BLDC), PID Controller, VSC , Modelling

1.INTRODUCTION

In this modern Industrial era the electrical motors plays a major key role in industrial development, As we know that motors are classified according power fed to them as Ac motors, Dc motors. One of the most important motors in commercial segment is BLDC motor which is usually known as electronically commutated motor ,The BLDC motors works on both low voltage DC, high voltage AC. BLDC motors are increasing its popularity in automotive sector for light load vehicles like two wheeler, cars which are most efficient and reliable as there is no mechanical commutator.

The speed control of a BLDC motor in commercial segment is a important task there are many methods are usually used for speed controlling of BLDC motor like PI controller. But the experiment gives best results with PID controller using voltage source converter.

1.1 BLDC Motor

Brushless DC motors have gained widespread acceptance in various industrial and consumer applications due to their high efficiency, reliability, and controllability. Unlike traditional brushed motors, BLDC motors rely on electronic commutation, making them suitable for applications requiring precise speed control. Among the various methods employed for regulating BLDC motor speed, A BLDC motor is a special type of DC motor that does not apply a brush for transport, instead an electronic process system is used for this purpose. The BLDC motor is usually a synchronous motor composed of a trapezoidal back EMF waveform and a permanent magnet. The current trend shows that high-performance BLDC motor technologies are widely used for global industrial applications and variable speed drives in electric vehicles. In fact, these types of motors depend on its control circuit. These types of motors rely on its control circuit and still developing a high performance circuit is a challenging task for researchers. The structure of the BLDC motor tuning control project selection, modelling simulation and so on. The design structure of a BLDC motor is a complex task and depends on many issues such as project selection, modeling, simulation, etc. In terms of the rapidity framework of the BLDC motor, a host of modern control solutions have been proposed.

1.2 Proposed controller

The methods used for the speed control of the BLDC Motor use the dual closed loop speed control in which the one loop is used to limit the current or govern the current control or for the control of the gate pulses. The other loop is for speed control which is used to get the desired speed as per the requirement. The required speed can be either set as an integer value or can be given as step input. The reference speed is given as a constant value which can be changed based on the requirement and accordingly the desired speed can be obtained. The methods used in this paper are namely speed control using PID controller, using CurrentController and a closed loop speed control. These methods are compared based on the values of current total harmonic distortion (THD), output current (RMS value) and on the values of rise time and settling time of the speed response of various methods.

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2. Modelling

2.1 Modelling of BLDC motor

The analysis of BLDC motor is based on the assumption for simplification and accuracy. The BLDC motor is type of unsaturated. The stator resistances for all the winding are equal and the self and mutual inductance are constant. Semiconductor devices of inverter are ideal and iron losses are negligible. Meanwhile, the back-EMF wave-forms of all phases are equal. Based on the equivalent circuit of BLDC motor and VSI system , the dynamic equations of BLDC motor using the assumption can be derived as

$$V_a = RI_a + (L-M)\, di_a/dt + e_a \quad (1)$$

$$V_b = RI_b + (L-M)\, di_b/dt + e_b \quad (2)$$

$$V_c = RI_c + (L-M)\, di_c/dt + e_c \quad (3)$$

2.2 Modelling of Back EMF

Basically it is an electronic motor and requires a three-phase inverter in the front end In self-control mode the inverter acts like an electronic commutator that receives the switching logical pulse from the absolute position sensors. The drive is also known as an electronic commutated motor Basically the inverter can operate in the following mode.

120 degree angle switch on mode

Inverter operation in this mode with the help of the wave six switches of the inverter (T1 – T6) operate in such way so as to place the input dc current Id symmetrical for 120 degrees angle at the center of each phase voltage wave. The angle shown is the advance angle of current wave with respect to voltage wave in the case zero. It can be seen that any instant ,two switches are on, one in the upper group and another is lower group. For example instant t1 T1 and T6 are on when the supply voltage Vdc and current Id are placed across the line ab (phase A and phase B in series) so that Id is positive in phase a . But negative in phase b then after 120 degree interval (the middle of phase A).T6 is turned off and T2 is turned on but T1 continues conduction of the full 180 dgree angle. This switching commutates –Id from phase b to phase c while phase a carry +Id the conduction pattern changes every 120 degree angle indication switching modes in full cycle. The absolute position sensor dictates the switching or communication of devices at the precise instant of wave. The inverter basically operating as a rotor position sensitive electronic commutator.

2.3 Proposed controller modeling

PID controller is used for controlling the speed of BLDC motor. The feedback speed from the motor is compared with the reference speed. The error speed is then passed through the PID controller which then is given directly to the controlled Voltage Source. The voltage source is a DC Voltage Source which gives supply to the MOSFET bridge. The bridge converts the DC supply into the 3-phase AC supply which is then given to the motor.

The motor gives various outputs including stator currents, Hall Effect signals, back EMF voltages, electromagnetic torque and speed of the rotor (in rps). The output from the Hall Sensors is then used to determine the position of the rotor of the motor. These signals form a closed loop in which these signals are converted into the EMF signals and again converted to the gate signals using different topologies and is converted to the gate signals based on the number of switches connected in the MOSFET bridge. These signals serve as the gate signals for controlling the voltage which in turn control the input voltage to the motor which in turn helps in controlling speed of the motor. The foundational frequency transferring performance G(s) of the PID controller can be represented by (1) and (2),

$$G(s) = K_p + K_i/s + K_d s \quad (1)$$

$$G(s) = (K_d s^2 + K_p s + K_i)/s \quad (2)$$

The time derivative output U(t) of the controller for control of the plant is equal to Kp times the magnitude of error pulse Kdtimes the derivative of time function error signal e(t) and Kitimes the integral can be represented by (3).

$$U(t) = K_p e(t) + K_i \int e(t)dt + K_d\, de(t)/dt \quad (3)$$

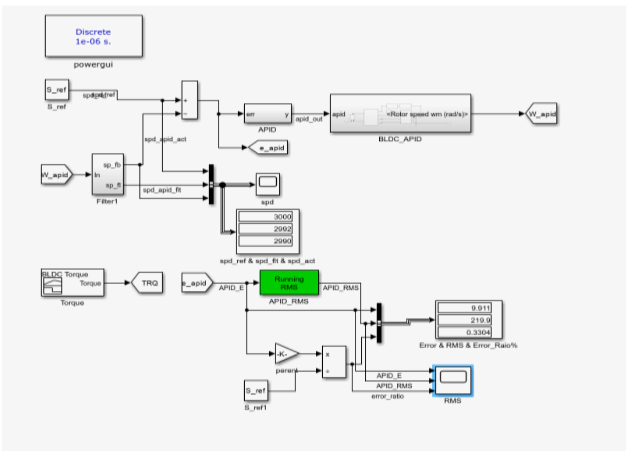

Fig.no 2-motor's speed response with PID controller in SIMULINK

3.Results

The speed control of BLDC motor done through the simulink Matlab, the BLDC motor has been modified according to requirements

Table 1. Machine parameters

Parameters	Value
Stator Phasor resistance(Rs)	0.7 ohm
Armature inductance	2.72e-3 H
Flux linkage established by magnets	0.105 Wb
Voltage constant	87.9646 (V/krpm)
Torque constant	0.84 (N/A)
Inertia	08e-3 J
Viscous damping	1e-3
Pole pairs	4
Static friction	0
Number of phases	3
Back EMF	Trapezoidal
Mechanical Input	Torque
Back EMF flat area (degrees)	120^0

3.1. Speed control using PIDcontroller

The speed control is achieved by proportional and integral derivative controller. The output waveforms for speed characteristics shown These characteristics of the BLDC motor can help in determining which method is best among. In order to reduce the instability the PID control method is proposed and enhanced speed performance compared to the conventional methods. The 5% error is allowed for the error in the value of the actual speed, as the error may occur due to the switching states, friction force in the machine or due to the operation under variable frequency.

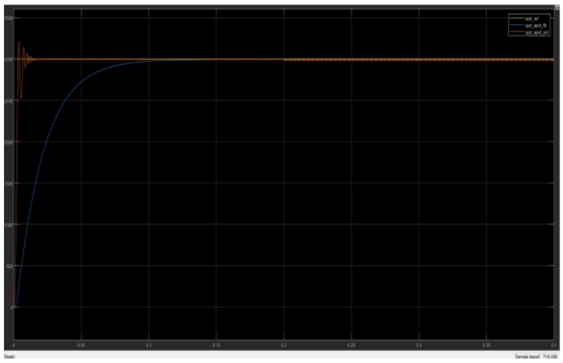

Fig.no 3 BLDC motor speed response with PID controller

3. CONCLUSIONS

A BLDC motor controller has been successfully designed based on PID controller scheme and compared its performance with other controller. From the results, it is observed that the PID controller provides the best performance compared to the other controller logic. The design has been validated by MATLAB simulation .

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