Study of Digital Controllers for Brushless DC Motor Drives

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Abstract—Brushless DC (BLDC) motors are one of the most interesting motors, not only because of their efficiency, and torque characteristics, but eliminating the disadvantages of using Brushes. BLDC motors have a very wide range of speed, so speed control is a very important issue for it. There are a lot of parameters which need to be in focus while talking about a speed controller performance like starting current, starting torque, rise time, etc. Here we are using two methods for controlling the speed PID Controllers and PI controllers. A controller is a device, historically using mechanical, hydraulic, pneumatic or electronic technique often in combination, but more recently in the form of a microprocessor or computer, which monitors and physically alters the operating conditions of a given dynamic system. These both controllers are different in complexity and performance. In this paper, the PI and PID speed controllers for the BLDC motors will be proposed. A simulation study is conducted to evaluate the efficiency of the proposed speed controllers. Further, a comparative study is performed to validate the system effectiveness.

***Keywords*—BLDC Motor, Speed Control, PI Controller, PID Controller.**

I INTRODUCTION

THE BLDC motors are used in variety of applications requiring low-cost, compact, high performance drive system for smooth operation over a wide speed range. The brushless motor have applications in the field of aero space and biomedical, also these motors are used in applications in turn table drives in record players and lower power drives in computer peripherals, instruments and control system etc. These motors are also used for cooling fans for electronic circuits and heat sinks. The BLDC drive is thus one the popular drive system used in industrial applications.

Because of the absence of brushes and commutator, brushless dc motors have a number of advantages compared to conventional dc motors.
A few of these are:

- Higher speed ranges
- Higher efficiency
- Better speed versus torque characteristics
- Long operating life
- Noiseless operation
- Higher dynamic response

They require practically no maintenance, have long life, high reliability, low inertia and friction, and they have a faster acceleration and can be run at much higher speeds up to 100,000rpm

BLDC drive main disadvantage is higher cost which arises due to complex electronic speed controllers to run.

Basically BLDC drives operation with inverter is an electronic motor and requires a three-phase inverter in the front end as shown in Fig.1. 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.

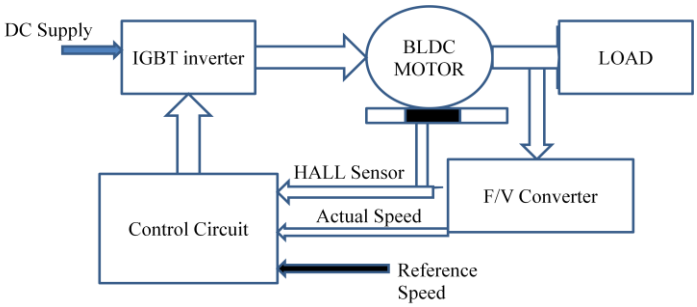

Fig 1. Block diagram of the BLDC motor drive system [1]

The BLDC servomotor drive system consisting of BLDC servomotor and IGBT inverter is modeled [1]-[3].

The control circuit consists of the controller like P, PI and PID which are conventionally used in the control application for a few decades. The main disadvantage is that the steady state responses of these controllers under different operating conditions such as parameter variation and load disturbances are work satisfactorily [1]. Fuzzy logic controllers are well suited to control systems with uncertain, complex, inaccurate or non-linear dynamics such as BLDC motor control systems. Fuzzy logic controller (FLC) can be easily designed and implemented knowing the behaviors of the system and it can greatly reduce the effects of non-linearity on the BLDC motor control system. [4]

The structure of this paper is as follows. In Section II we provide some existing solutions schemes with respect to the domain. Finally, Section III concludes the paper.

II. SIMULATION OF BLDC MOTOR AND CONTROLLERS IN MATLAB

The Modeling of the BLDC motor is very comprehensively implemented and analyzed in [1]-[4] and [10]-[12].The modeling consists of MATLAB simulation of a) current and

voltage generation, b) emf generation and c) gate signal generation i.e.(Pulse Width Modulation)PWM generation for the IGBT inverter circuit.

For the IGBT inverter 120^{O} Conduction Mode is used. Also the PI and PID gain parameters are as in [1] & [2]

Analysis with PI and PID controller.

The speed reaction and its equivalent error due to difference in speed and with system parameters $J1$=350e-6 kg-m^2 J2= 560e-6 kg-$m^2$and $R1$=0.57Ω R2=1.14 Ω and the load given to the motor is 100% which is made known in Fig. 2

The reaction of the PI controller based drive is analyzed with the error in speed for the difference in reference speed as in analyzed.

The PID controller based system for the same step change in response of the speed and system parameters as above is applied to the drive system and the response obtained is as under

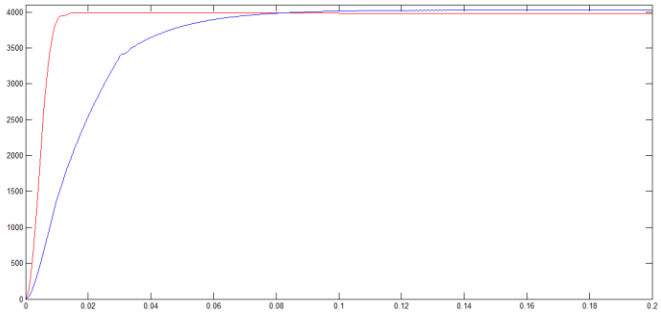

Fig.2 PID controller-based BLDC drive system for the given change in reference speed.

(a) Input speed; (b) Actual speed

III. Conclusion

To study the performance of the controllers and their application for wide range of speed control of BLDC servomotor drive under different operating condition as in [1] several methods have been proposed. The aim is to study the conventional controller's [1] [2] [5] behavior under various parameter variations. The speed response of the BLDC drive designed [5] with consistently same rise time and settling time when subject of to load disturbance, parameter variations and step change in reference speed.

By several parameters variation like resistance and loading conditions the PI and PID controllers are tested. The PID controller is said to be better as the error is less and the response of the system time is also improved.

References

[1] R. Shanmugasundram, K. Muhammad Zakariah and N. Yadaiah, "Implementation and Performance Analysis of Digital Controllers for Brushless DC Motor Drives", IEEE Trans. Mechatronics, vol. 19, no. 1, February 2014.

[2] V. M. Varatharaju, B. L. Mathur and K. Udhyakumar, "Speed control of PMBLDC motor using MATLAB/Simulink and effects of load and inertia changes," in Proc. 2nd Int. Conf. Mech. Electr. Technol.,, Sept 10-12, 2010.

[3] S. Srikant and G. Raghu Chandra," Modeling and PID control of the brushless DC Motor with the help of genetic algorithm," in IEEE- Internation conference on Advances in Engineering, Science and Management (ICAESM-2012), March 30-31, 2012.

[4] R.Shanmugasundram, K.Muhammed Zakariah and N.Yadaiah, "Digital Implementation of Fuzzy Logic Controller for Wide Range Speed Control of Brushless DC Motor," in ICVES, 2009.

[5] P. Pillay and R. Krishnan, "Modeling, simulation, and analysis of permanent-magnet motor drives, part ii: The brushless dc motor drive," IEEE Trans. Ind. Appl., vol. 25, no. 2, Mar./Apr. 1989, pp. 274–279.

[6] A. K. Wallace and R. Spee, "The effects of motor parameters on the performance of brushless dc drives," IEEE Trans. Power Electronics., vol. 5, no. 1, pp. 2–8, Jan. 1990.

[7] Chang-liang Xia, "Permanent Magnet Brushless DC Motor Drives and Controls", John Wiley & Sons Publication, ISBN: 978-1-118-18833-0, April 2012,pp. 119-121.

[8] Kaliappan, E. and C. Chellamuthu, "Simplified Modeling, Analysis and Simulation of Permanent Magnet Brushless Direct Current Motors for Sensorless Operation", American Journal of Applied Sciences 9, vol. 7, 2012.

[9] Gopal K. Dubey, "Fundamentals of Electrical Drives", Narosa Publication, 2nd Edition, ISBN: 978-81-7319-428-3, 2011, pp.267-273.

[10] Ming-Fa Tsai, Tran Phu Quy, Bo-Feng Wu, and Chung-Shi Tseng, "Model Construction and Verification of a BLDC Motor Using MATLAB/SIMULINK and FPGA Control", IEEE conference on Industrial Electronics and Applications, No.6, pp.1797-1802,2011.

[11] Vinatha U, Swetha Pola, Dr K.P.Vittal, "Simulation of Four Quadrant Operation & Speed Control of BLDC Motor on MATLAB / SIMULINK".

[12] B. Indu Rani, Ashly Mary Tom, "Dynamic Simulation of Brushless DC Drive Considering Phase Commutation and Back emf Waveform for Electromechanical Actuator", IEEE conference, 2011.