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Review of Various Digital Controllers for Brushless DC Motor Drives

[1] Sagar Bhaisare, [2] C.J. Sharma, [3] Diksha Radke, [4] Abhay Halmare, [5] Vedanti Hardas
[1] [2] [3] [4] [5]Asst.Prof, KDK College, Of Engineering, Nagpur, Maharashtra, India

***Abstract*: -- Brushless DC (BLDC) motor are now a day's becoming popular in battery operated vehicles, fuel pumps, medical equipment, printers and in many other domestic, industrial and aerospace applications because of its lightweight, high operating speed and excellent speed-torque characteristics. The BLDC drive system thus with the user in such applications use conventional controllers like P, PI, and PID which achieve satisfactory transient and steady-state response. However, the major problem associated with the PID controller is that they do not yield better transient and steady-state responses under different operating conditions such as parameter variation and load disturbances. These papers give a detailed study of the various controller used for the BLDC drive system, also the usefulness and error tracking capability of the digital controller in control application is given.**

***Index Terms* – BLDC drive, Brushless dc (BLDC) servomotor drive, fuzzy 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.

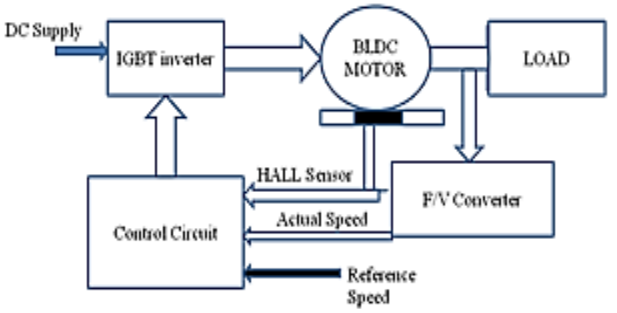

Fig 1. Block diagram of the BLDC motor drive system [1]

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.

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II. RELATED WORK

In [1] design and digital implementation of a fuzzy controller for achieving improved performance of Brushless dc (BLDC) servomotor drive was done. The performance of Fuzzy and PID controller-based BLDC servomotor drives is investigated under different operating conditions such as change in reference speed, parameter variations, load disturbance, etc. R. Shanmugasundram et al reported that the fuzzy controller based BLDC servomotor drive can provide an improved speed response with consistently same rise time, and settling time when the system is subjected to load disturbance, parameter variations, and step change in reference speed. In [2] the procedure of deriving a model for the brush less dc motor with 120-degree inverter system and its validation in the MATLAB/Simulink platform. A typical Hall-sensor controlled VSI driven BLDC motors, where the inverter operates using 120- degree commutation method was applied. Moreover a nonlinear simulation model of the BLDC motors drive system with PI controller was proposed. The performance of the developed PI algorithm based speed controller of the drive has revealed that the algorithm devises the behavior of the PMBLDC motor drive system had worked satisfactorily. But the PI can only give satisfactory transient and steady-state responses but not optimum responses under various parameter variations.

In [3] the design of an optimal controller for the position control of BLDC motor. Genetic Algorithm was proposed as a global optimizer to find the optimized PID gains for position control of BLDC motor. A PID controller using the Ziegler-Nichols frequency response method was also developed and its performance with the response of Genetic Algorithm based controller. It was reported that that the controller performance with GA optimized gains is much more efficient than the ZN method in terms of rise time, settling time, overshoot and set point tracking. Whereas the Genetic Algorithm based controller proves to be quite complicated when the system is under different parameter variation.

In [4] the design and digital implementation of fuzzy logic controller using ADUC812 microcontroller was done. The BLDC motor was subjected to disturbances by changing the load and the transient & steady-state behavior of the system. But the system has not been implemented in different operating conditions such as change in reference speed, parameter variations, and load disturbance. In [5] the modeling simulation and analysis of the BLDC motor drive was done with phase variable model and it is used to examine the performance of the drive when it is fed by the hysteresis and pulse-width-modulated (PWM) current controllers. The BLDC rotor and the stator windings are wound such that the back emf is trapezoidal, which implies that the mutual inductance between stator and rotor is non-sinusoidal. Therefore there is no advantage in transforming the machine equations into the two axis equations. The modeling done here is based on particular assumptions of the parameters which are expected to vary in actual working of the system which is not given by the authors.

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 to that of the Fuzzy logic controller designed in [1]. 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.
This paper enlists the controller design and the behavioral aspects of these controllers according to the different operating conditions. The performance of the conventional controllers based drive system fail to provide improved performance under parameter variations. The Fuzzy controller based BLDC servomotor is expected to have improved speed response when subjected to the parameter variations.

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