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ANALYSIS OF VARIOUS DIGITAL CONTROLLERS FOR BRUSHLESS DC MOTOR DRIVES

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Abstract: Brushless DC (BLDC) motors are now a day's becoming popular in many other domestic, industrial and aerospace applications for the reason that of its light weight, high working speed and exceptional speed-torque characteristics. The Brushless-DC drive system thus with the used in such applications use usual controllers like P, PI and PID which are having reasonable transient and steady state response under changing parameters. However the most important problem associated with these is that they do not include superior transient and steady state effect which is bound to change at different operating conditions such as variation in parameters and disturbances in load. Fuzzy based controllers are said to be more versatile for such conditions. This papers gives a detail 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.

Keywords: BLDC drive, Brushless dc (BLDC) servomotor drive, Fuzzy controller, PI, PID controller**.**

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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 aerospace and biomedical, also these motors are second-hand in applications in turn table drives in record players and lower power drives in computer peripherals, instruments and control system etc. These motors are too used for cooling fans for electronic circuits and heat sinks. The drive is thus one the accepted 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.

Some numbers of them are:

- Senior speed ranges
- High efficiency
- Enhanced speed against torque characteristics
- Extended operating life
- Soundless operation(quiet)
- Superior dynamic response

They require virtually no repairs, have long life, high dependability, low inertia and friction, and they have a quicker acceleration and can be run at much superior speed up and about to 100,000rpm

The disadvantage of this drive is higher cost which is due to complicated electronic speed controllers.

The operation of this drive consists with the inverter a motor and which requires a three-phase DC to AC converter in the frontage which is shown in Fig.1. In self systematize form the converter is like an electronic on/off device that receives the logical pulse of switching from the set position sensors. This motor is also called as an electronic ON/OFF motor.

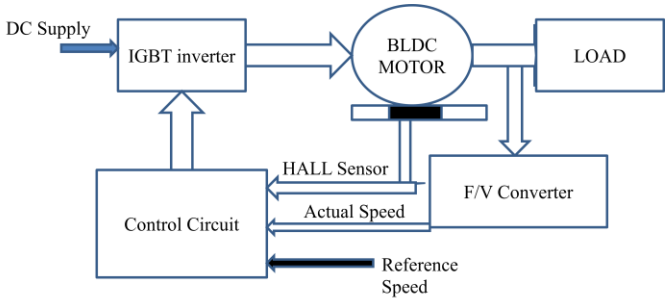

Fig 1. General figure of the motor drive system [2]

The system is made up of the servomotor and DC-AC converter which is modeled in MATLAB Simulink.

The main components of motor drive are summarized below:

- **Motor**

The advantage of this motor has certainly put this motor far ahead of the different the motor drive for a variety of applications. The study also suggests the lower size of this motor for aerospace applications and other different applications.

- **Control Circuit**

The control circuit consists of the controller like P, PI and PID which are conventionally used in the control application for the past decades and so. The main benefit is that they are easy to use and less cost but the main disadvantage is that the error and transient occurring in the system are high.

- **IGBT Inverter**

A DC to AC converter is defined as a inverter. The converter produces a sinusoidal output waveform with reverence to magnitude of the voltage, frequency and phase viz. a,b,c with help from a DC-power supply. To produce this definite waveform the inverter switches has to be turned ON and OFF at definite times, given by the preferred modulation strategy. Inverters are generally used for intermediate voltage applications and as well as for the high power applications.

The structure of this paper is as follows. In Section II gives a brief on Modeling and Simulation of the motor and controllers in MATLAB. Section III gives the detail modelling and analysis of the

FUZZY logic controller and gives detail analysis of the system designed. Finally, Section IV concludes the paper

I. Modeling and 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 reference speed from 1000–2500–4000–2500–1000 r/min and with system parameters $J1$=350e-6 kg-m^2 and $R1$=0.57Ω , and the load given to the BLDC motor is 100% are made known in Fig. 2 and Fig.3 respectively.

The PI controller reaction is shown in Fig.2 beneath.

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

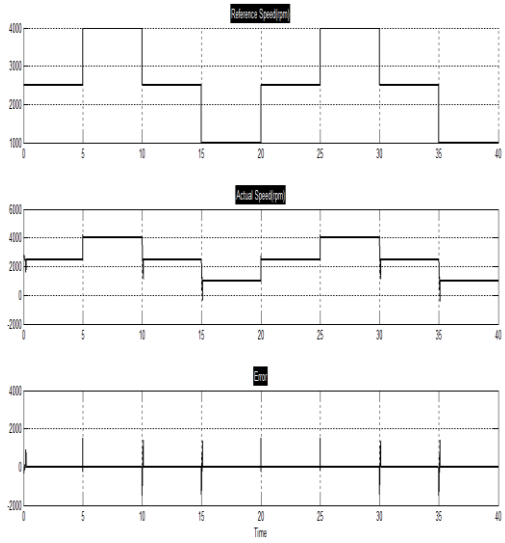

Fig.2 PI controller-based BLDC system for the given change in reference speed.

(a) Reference speed; (b) Actual speed; (c) Error.

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.

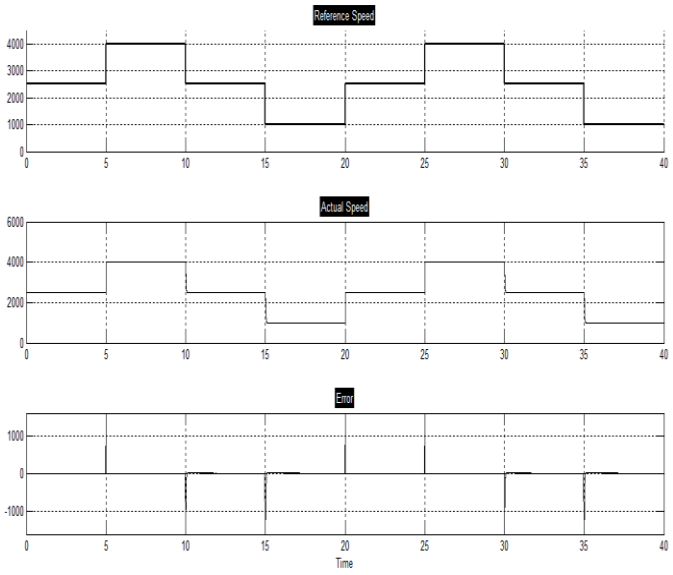

Fig.3 PID controller-based BLDC drive system for the given change in reference speed.

(a) Reference speed; (b) Actual speed; (c) Error.

Similarly the different values of the inertia, resistance and also the various loading condition are taken and the drive system with PI and PID are analyzed.

II. Design of Fuzzy logic controller based drive.

The very first step in design of the Fuzzy Logic Controller (FLC) is to define the inputs and output of the system. Here with the help of detail analysis of the PI and PID based system the inputs are taken as error in speed and the change in error in that speed & the output is the control signal for voltage generation. The said FLC based system is design using MATLAB tool for Fuzzy Inference System (fis).

The rules are made with the help defining the fuzzy input variables “E” and “CE” which is quantized further. The fuzzy output variable is “ΔC” which are further given according to the system behavior. The surface view after rules making is as given below.

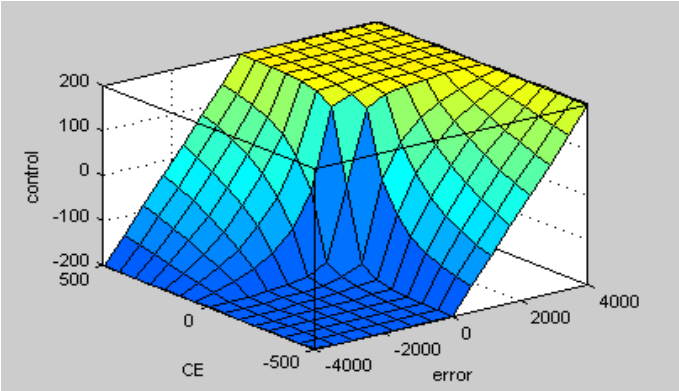

Fig.4 Surface view of the rules designed.

The 3x3 Fuzzy Associated Matrix is as shown in table below:-

CE / E	NE	ZE	PE
NCE	D	D	I
ZCE	D	NC	I
PCE	I	I	I

Table: 1 3x3 Fuzzy Associated Matrix.

After design of the FLC based controller the BLDC drive is analyzed in the same manner as that of the PI and PID based system. The output response of the Fuzzy based drive is as shown below.

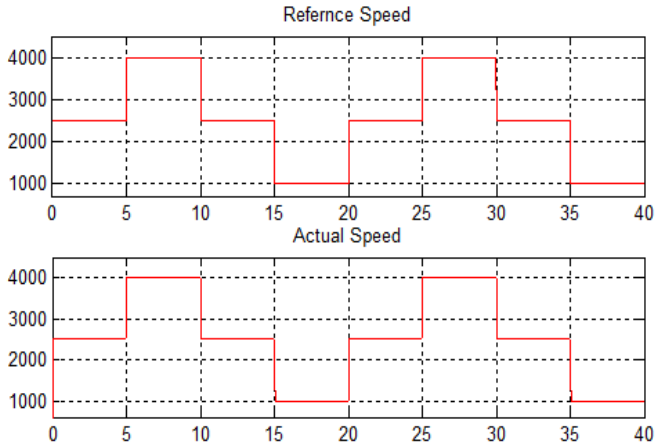

Fig.5 Fuzzy logic controller-based BLDC drive for the given change in speed.

(a) Reference speed; (b) Actual speed

III. CONCLUSION

This paper enlists the controller design and the behavioral aspects of the different controllers according to the various operating conditions. To study 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.

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.

The conventional controllers apart from the PID based system, the controller fail to give improved show under constraint variations. The Fuzzy controller based motor drive system as expected, have improved speed response when subjected to the parameter variations and operating conditions, which makes it the better controller in comparison with the conventional controllers.

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