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Fuzzy PID Controller Based Speed Control of BLDC Motor

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ABSTRACT

In this paper we have designed a BLDC motor whose speed can be controlled using a fuzzy PID controller .Reference model of BLDC motor is designed to observe the ideal response of the motor drive system .The proportional ,integral ,derivative gains of the PID controller are adjusted according to fuzzy logic .In this first we design 75 fuzzy rules of each parameters of PID controller. Here FLC has two inputs ,one is motor speed error and other is change in speed error. The proposed controller is evaluated using MATLAB simulink. The simulation results shows that both transistery performance and steady state performance are better than that of conventional PID. The simulation output shows that fuzzy PID controller resizes a good dynamic behavior of BLDC motor and a perfect speed tracking with minimum steady state error , overshoot.

KEYWORDS: - Fuzzy pid controller, BLDC motor, MATLAB simulink, Fuzzification , Defuzzification Inference engine.

1.INTRODUCTION

A bldc motor can generate full torque at zero speed. In brushless DC motor, the permanent magnets are on the rotor, and electromagnets are on stator. Brushless DC motor , including high torque to weight ratio, increased reliability , efficiency producing more torque per Watt , reduce noise longer lifetime by eliminating brush and commutator erosion, elimination of ionizing sparks from commutator.

Fuzzy PID controller is tuned by obtaining the tuning rule from PID domain to fuzzy domain. The purpose controller is evaluated using simulink software of Matlab.

As fuzzy logic controller has given two inputs, one is motor speed error between reference and actual speed, second is change in speed error(speed error derivatives). The output of FLC i,e. the parameters of PID controllers are used to control the speed of BLDC motor.

STRUCTURE OF PAPER

The paper is organized as follows: In Section 1, the introduction of the paper is provided along with the structure, important terms, objectives and overall description. In Section 2 we discuss related work. In Section 3 we have the complete information speed control of BLDC motor. Section 4 shares information about the Fuzzy pid controller, its advantages and disadvantages. Section 5 tells us about the methodology and the process description. Section 6 tells us about the future scope and concludes the paper with acknowledgement and references.

OBJECTIVES

In this paper, From the speed response of the system for a fuzzy pid controller as shown in simulation results, it is clear that settling time and overshoot for bldc motor controlled by fuzzy pid controller is much lesser than that of conventional pid controller and also the simulation results shows that both the transitory performance and steady performance are better than that of conventional pid.

2.RELATED WORK

In BLDC motor due the absence of brush, maintenance required is less so they have long operating life. BLDC motors offer additional advantages such as high speed range, high torque to weight ratio.

In DC motor, commutation is carried out by brush and slip ring arrangement. But brushless DC motors are electronically commutated instead of using brush. Conventional brushed DC motor cannot be used for high speed applications due to their disadvantages such as periodic replacement of brushes and continuous maintenance of commutator . Thus instead of DC motors, squirrel cage induction motors were used widely in industries but induction motor also has the disadvantages of low power factor and low starting torque. A brushless DC motor have many applications in industrial automation equipments and instrumentation due to their gaining characteristics such as ability to operate at high speed, high efficiency and high dynamic response which is useful for reliable operation of industries feature edges in the context of isolating features for measurement. The bldc motor is a combination of a permanent magnet ac motor and electronic commutator. In bldc motor inverter has replaced commutator of that conventional dc motor

3.SPEED CONTROL OF BLDC MOTOR

By controlling the input DC voltage or current we can control the speed of brushless dc motor. As the voltage is high more is the speed.

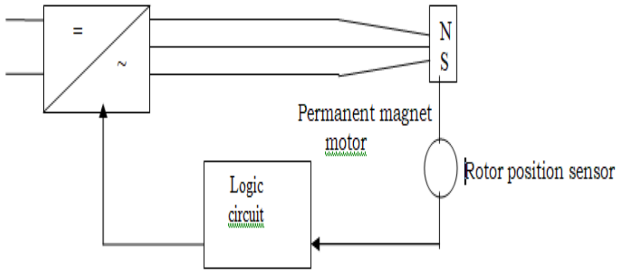


Figure1. Functional block diagram of BLDC motor

Modeling of bldc motor

The armature voltage equation is given by

Va = Eb+IaRa+La(dIa/dt)

The torque balance equation is given by

Tm = Jm dw/dt+Bmw+TL

Lets take field flux as ϕ

And back emf constant as k

Equation for back emf will be

Eb = kϕ w

Tm = kϕ Ia

Taking laplace transform of motors armature voltage equation

Ia(S) = (Va-Eb)/(Ra+LaS)

Now taking equation 2 into consideration we have

Ia(S) = (Va-kϕw)/Ra(1+LaS/Ra)

and

w(S) = (Tm-Tl)/JS = (kϕIa-TL)JmS

Ta = La/Ra

After simplifying above mode we will get

W(S) = [(Ra/km)Ia(S)-TLRa(km)^2](1/Tem)

Now replacing by km in equation

W(S)/Va(S) = (1/km)/(1+Stem+S^{2}TaTem)

As Ta<<Tem

Hence the equation can be written as

w(S)/Va(S) = (1/km)/(1+5Tem)(1+STa)

4.FUZZY PID CONTROLLER

The fuzzy pid controller uses the change of the output -$\frac{y(k)-y(k-1)}{e(k)-e(k-1)}$ instead of change of error, as the second input signal to the FIS . Doing so prevents the step change in reference signal from directly triggering derivative action. Fuzzy pid controller is tuned by carrying tuning rules from pid domain to fuzzy domain as a nonlinear controller can control a nonlinear process more efficiently. Fuzzy controller can provide better performance in terms of raise time and smaller overshoot.

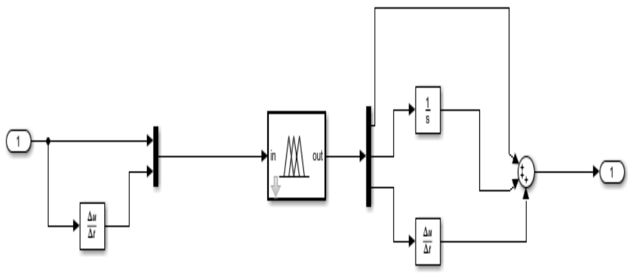


Figure2. Fuzzy logic controller simulink model

Fuzzification

It is a method of converting crisp quantity into fuzzy quantity. The success of this work depends on how good their stage is conducted. In this stage the crisp variable ew(k) and dew(k) are converted into fuzzy variables ew and dew respectively. The membership functions associated to control variables have been chosen with triangular shape as shown in figure. Each universe of discourse is divided into seven overlapping fuzzy sets NL NM NS ZE PS PM PL

Inference engine

To provide relationship between input and output variables ew and cew are processed by inference engine . The rules are established using knowledge of the system behavior and experience of the control engineers. Each rules expressed in following form

If(ew is negative large)

And (cew is positive large)

Then(*qs xi is zero)

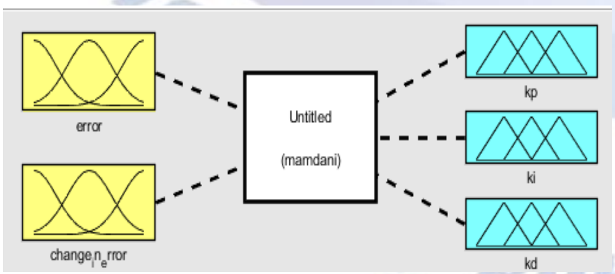


Figure3. Inference engine

Rule base

The rules are in 'if then format and formally the if side is called the condition and then side is called conclusion. A rule base controller is easy to understand and easy to maintain for non specialist end user and an equivalent controller could be implemented using conventional technique.

Defuzzification

The process of defuzzification is a means to change the fuzzy output of the inference engine to a clearly defined (crisp) output by applying membership functions such as those utilized by the fuzzifier. A defuzzification interface that changes the outcomes of the inference mechanism into useable inputs that will 'feed' the process and move it forward.

Adjusting fuzzy membership function

The membership function is a way to express graphically the participation level of individual inputs. It allocates a value to the inputs that can also serve as functional overlaps between the inputs. In so doing, the membership function strongly influences the output response. A critical determining factor of the membership function is configuration or, as it is usually termed, "shape". The various potential shapes include Gaussian, triangular, trapezoidal, generalized bell and sigmoidal. Of these, the triangular shape is the one most commonly applied, and the degree of membership function is usually in the [0 1] range.

5.METHODOLOGY

The objective of this project is to obtain good performance charecterstics of Brushless DC motor , including high torque to weight ratio, increased reliability , efficiency producing more torque per Watt , reduce noise longer lifetime by eliminating brush and commutator erosion, elimination of ionizing sparks from commutator.Fuzzy PID controller is tuned by obtaining the tuning rule from PID domain to fuzzy domain.

The purpose controller is evaluated using simulink software of Matlab. The bldc motor is a combination of a permanent magnet ac motor and electronic commutator. In bldc motor inverter has replaced commutator of that conventional dc motor as shown in figure. The commutator acts like a three phase frequency converter , rotor position sensor used to sense position of bldc rotor.

Process Description

The following diagram makes it easier to understand how we proceed.

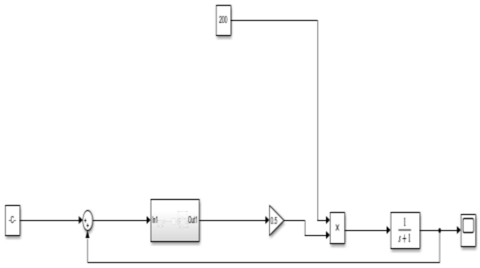


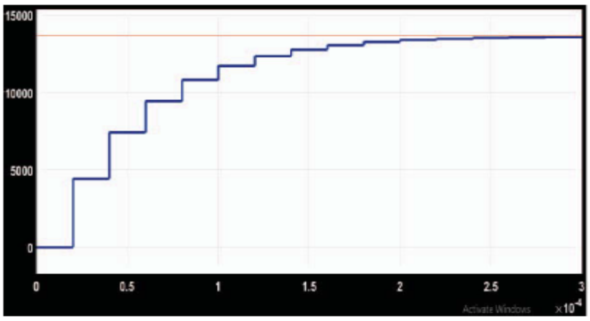
Figure4. Simulink model of BLDC motor with Fuzzy pid controller

6. SIMULATION RESULTS

From speed response of system for different controller as shown in the simulation results . First two graphs shows the speed response by Fuzzy PID controller. For set speed of 157.07 rpm the response values of Fuzzy PID controller is as shown in Figure below.

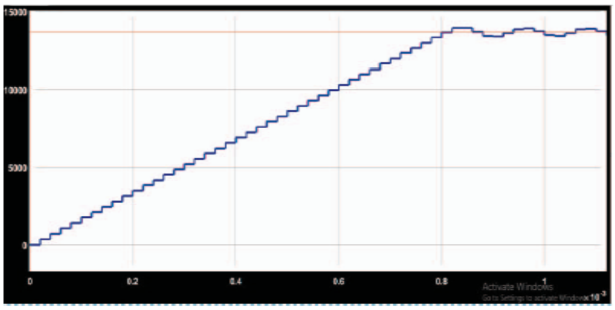
Graph1.

Output of reference model. Settling time= 0.3 msec



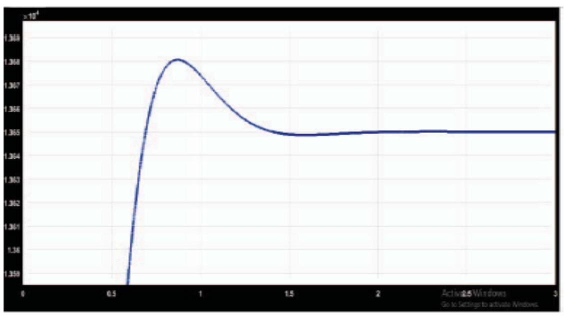
Graph2.

Output of BLDC motor. Settling time= 0.8 msec



Graph3.

Output of Fuzzy Pid controller. Settling time= 1.5 msec



7.FUTURE SCOPE AND CONCLUSION

In this paper, From the speed response of the system for a fuzzy pid controller as shown in simulation results , it is clear that settling time and overshoot for bldc motor controlled by fuzzy pid controller is much lesser than that of conventional pid controller and also the simulation results shows that both the transitory performance and steady performance are better than that of conventional pid.

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