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Comparison of PI DC Motor Speed Controller and Fuzzy PI DC Motor Speed Controller

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High performance motor drives are very much essential for industrial application. Most of the industries demand variable speed operation of motor. As synchronous motor is a constant speed motor so it is used in industries which demands constant speed operation of motor. Conventional control techniques require accurate mathematical models describing the dynamics of the system under study. These techniques result in tracking error when the load varies fast and overshoot during transients. If advance control strategies are used instead, the system will perform more accurately or robustly. It is therefore, desired to develop a controller that has the ability to adjust its own parameters and even structure online, according to the environment in which it works to yield satisfactory control performance. An interesting alternative that could be investigated is the use of fuzzy logic control (FLC) methods. In the last decade, FLC has attracted considerable attention as a tool for a novel control approach because of the variety of advantages that it offers over the classical control techniques. Unlike other conventional control schemes, FLC is a model-free controller. It does not require an exact mathematical model of the controlled system and therefore, is less sensitive to system parameter changes. In addition, rapidity and robustness are the most profound and interesting properties in comparison to the traditional control methods. This paper presents the study of speed control of DC motor using proportional integral controller with and without fuzzy logic control.

Keywords : PI, Fuzzy logic, Controller, BLDC Motor, Speed Control

I. INTRODUCTION

DC motors are motors which run on direct current either from a DC supply or a battery. Direct current defines electricity at a constant voltage. When a battery or DC supply is connected to DC motor leads. The motor converts electrical energy into mechanical energy. A DC motor relies on the fact that magnet poles repels and unlike magnetic poles attracts each other. A coil of wire with a current running throughout it generates an electromagnetic field associated with the center of the coil. By switching the current on or off in a coil its magnetic field can be switched on or off or by switching the direction of the current in the coil the direction of the generated magnetic field can be switched 180°. DC motor typically has a stationary set of magnets in the stator and an armature with a series of two or more windings of wire wrap in insulated stack slots just about iron pole pieces with the ends of the wires terminating on a commutator. The armature includes the escalating bearings that keep it in the center of the motor and the power shaft of the motor and the commutator connections. The winding in the armature continue to loop all the way around the armature and uses either single or parallel conductors (wires), and can circle numerous times around the stack teeth. The total amount of current sent to the coil, the coil's size and what it's wrapped around state the strength of the electromagnetic field created. The string of turning a particular coil on or off dictate what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields intermingle with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a force on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor. At high power levels DC motors are cooled using forced air. The commutator allows each armature coil to be activated in turn. The current in the coil is typically supplied via two brushes that make moving contact with the commutator. Now, some brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes to wear out or create sparks.

II. PROBLEM IDENTIFICATION

The nonlinear characteristics of a DC motor such as saturation and friction could degrade the performance of conventional controllers. Many advanced model based control methods such as variable structure control and model reference adaptive control have been developed to reduce these effects. However, the performance of these methods depends on the accuracy of the system models and parameters. Generally, an accurate non-linear model of an actual DC motor is difficult to find, and parameter values obtained from system identification may be only approximated values. Control system that could be able to give a fast response in order to maintain the speed of the DC motor at the desired value with a minimum overshoot, minimum steady state error, and minimum settling time and fast rising time are very important and crucial in industrial application. Conventional control has proven for a long time to be good enough to handle control tasks on system control; however this implementation relies on an exact mathematical model of the plan to be control and not a simple mathematical operation. The fuzzy logic control, unlike conventional control system, is able to model inaccurate or imprecise models. The fuzzy logic approach offers a simpler, quicker and more reliable solution that is clear advantages over conventional techniques.

The objectives of this project are as follows:

i) To design a fuzzy logic controller as another type of controller that can be used on to control speed of the DC motor.

ii) To analyze the performance comparison between PI and Fuzzy Logic Controller in order to control speed of the DC motor by simulation.

iii) To evaluate and validate performance of the design FLC defuzzification output by using microcontroller.

III. METHODOLOGY

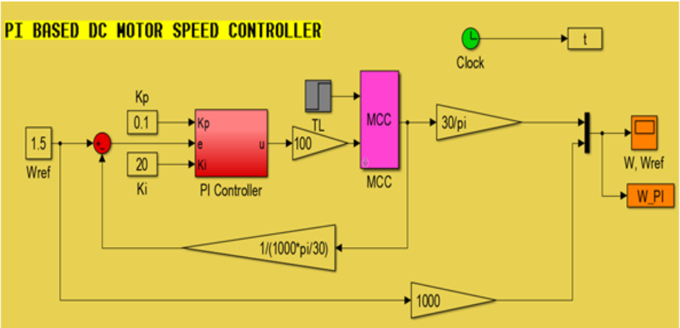

Figure 3.1: Simulink model of DC motor speed control using PI controller

A reference input W_{ref} of constant value 1.5 is given to the summation block. The reference input and the feedback signal are given to the summation block and the output error signal is given to the proportional integral controller block.

Kp and Ki have the values 0.1 and 20 respectively. The Kp and Ki are fed to the multipliers. The output is fed to the integrator.

A motor control centre (MCC) is an assembly to control some or all electric motors in a central location. It consists of multiple enclosed sections having a common power bus and with each section containing a combination starter, which in turn consists of motor starter, fuses or circuit breaker, and power disconnect. A motor control centre can also include push buttons, indicator lights, variable-frequency drives, programmable logic controllers, and metering equipment. It may be combined with the electrical service entrance for the building.

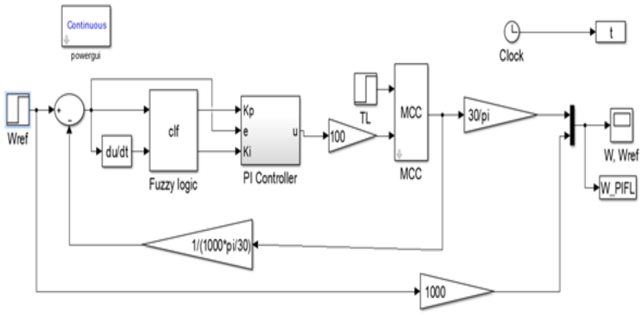

Figure 3.2: Simulink model of DC motor speed controller using Fuzzy PI Controller

A reference input W_{ref} of constant value 1.5 is given to the summation block along with the feedback gain. The output error signal thus generated is fed to the fuzzy logic controller, proportional integral controller and differentiator.

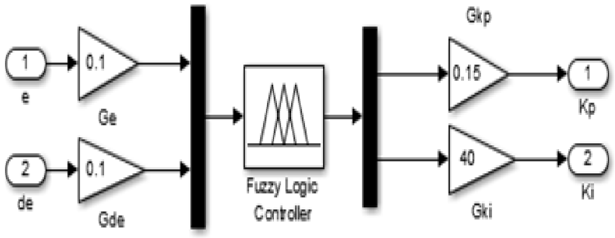

Figure 3.3: Block of Fuzzy Logic Controller

The fuzzy logic controller generates the value of Kp and Ki. These Kp and Ki along with the error signal is fed to the proportional integral controller. The output of the proportional integral controller is multiplied with a constant gain of amplitude 100 and then is fed to the motor control center.

IV. RESULT

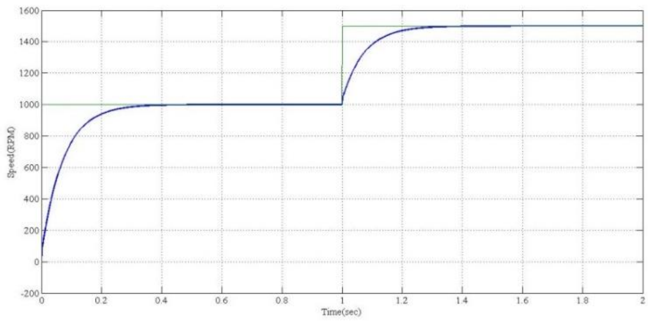

Figure 4.1: Speed vs time plot of the PI controller without fuzzy control

From the figure 4.1 it can be seen that there is a gradual increase in the speed of the dc motor due to the closed loop proportional integral controller. The speed of the motor gradually reaches the final set value.

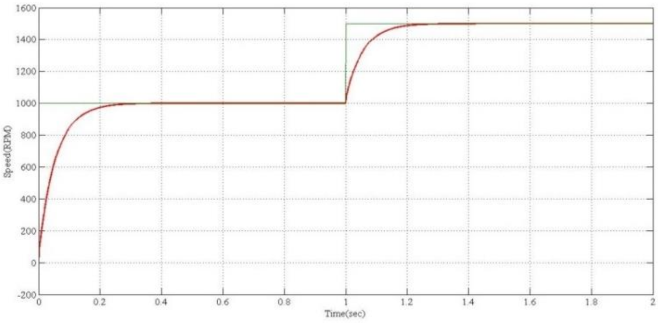

Figure 4.2: Speed vs time plot of the PI controller with fuzzy control

The figure 4.2 shows the speed vs time plot of the proportional integral controller with fuzzy controller. The fuzzy controller generates the step output. The speed of the motor directly reaches to the final value set. There is no gradual increase or decrease in the speed.

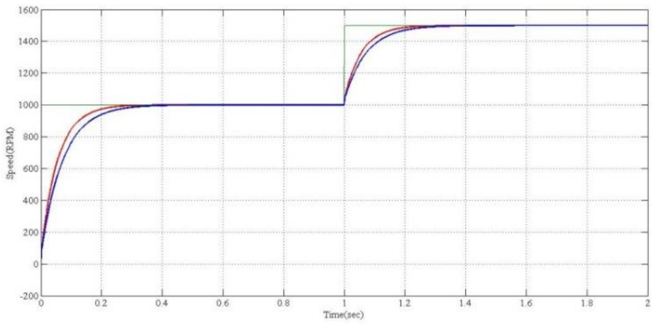

Figure 4.3: Speed vs time plot of the PI & Fuzzy PI Controller

From the figure 4.3 it can be seen that there is a gradual change in speed is faster for Fuzzy PI as campare to conventional PI. It means settling time is less for fuzzy PI controller.

V. CONCLUSION

The aim of this study is to compare the two controllers namely, Fuzzy PI and PI controller for the speed controller of a separately excited motor. The control system includes a hysteresis current controller as well as speed controller. The results of application of PI controller are compared to those obtained by the fuzzy PI controller under variable reference speed, variable load and variable parameter conditions and are summarized in Table 1 below. The paper compares the performance of fuzzy PI controller with that of PI controller and it is shown that the fuzzy PI controller provides slightly better results in terms of the settling time and steady-state error. As a result, tuning the controller gains using fuzzy based algorithms will provide better dynamic response for the speed control of dc motor drives.

Table 1: Comparison of PI and Fuzzy PI DC motor controller

Controller	Transient performance	Steady state performance	Complexity	Computational time
Fuzzy PI	Good	Good	Moderate	Medium
PI	Moderate	Moderate	Simple	Moderate

In this study, where the speed control of the DC motor is performed, the classical control method and the fuzzy logic method are compared. The reaction of the system when the load is changed is investigated for both PI controller and fuzzy logic controller cases. The change in speed with time for constant torque case and the case when the torque is changed after 1 second of operation has been presented in graphical form. According to our simulation results, the fuzzy logic method is obviously superior to the classical control method.

VI. FUTURE SCOPE

- This study can also be further done using Proportional Integral Derivative controller.

- The fuzzy logic control algorithm can be extended for image processing to recognize objects and to analyse the scenes.
- Path planning and path tracking to achieve autonomous control.
- Implementation in real time for real robots.
- Brushless DC motors.

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