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Speed Control of DC Motor using Fuzzy Logic with Pic Microcontroller

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Abstract:

This paper displays knowledge into the speed control of DC engine utilizing a fuzzy logic controller to meet the fancied speed. Fuzzy logic is a standout amongst the best uses of fuzzy rules in which the factors are semantici.e. linguistic instead of numeric. A fuzzy logic controller (FLC) depends on an arrangement of control tenets (fuzzy standards) among semantic factors. The proposed fuzzy controller brings about a superior reaction contrasted with the fundamental fuzzy controller and typical reaction of DC motor. It comprises of two note-worthy parts: hardware usage and programming advancement. In the hardware part, H-connect DC engine driver will be outlined and created. The outlined H-connect DC control converter will be utilized as the equipment interface between DC motor and PIC16F877Amicrocontroller. A recurrence to-voltage converter (FVC) and simple to-computerized converter (ADC) will be utilized to change over and give the real speed motion. The product part expects to plan and build up an advanced fuzzy logic speed controller by shifting the beat width for DC motor applications utilizing MATLAB/simulink. In outline, this paper would like to exhibit the ability of fuzzy logic in planning a controller for a DC motor.

Keywords: fuzzy logic, Dc motor,

I. Introduction

The control frameworks are the indispensable and real part of the cutting edge society. They comprise of subsystems and procedures which are amassed for controlling reasons for some procedures in cutting edge industry. For household or modern works movement control is required. The frameworks that are utilized for such controls are called drives. In electric drives utilization of different sensors and control calculation is done to control the speed of engine. The open loop frameworks comprise of information transducers that change over the flag in fancied electrical shape utilized by controller. The controller encourage drives a plant or a procedure. The information is likewise called reference and yield is a control variable.

The drawbacks of open loop framework are touchy to unsettling influences and failure to adjust for those unsettling influences. This might be evacuated by utilizing closed loop frameworks. The closed loop frameworks defeat the issue for unsettling influences by measuring yield reaction and nourishing that through input framework and looking at them at summing intersections. On the off chance that there is any contrast in the two reactions, the framework drives the plant to make an amendment. On the off chance that no such contrast is discovered, it doesn't drive the plant since plant reaction is as of now a coveted reaction.

The nearby circle frameworks have real favourable position of exact control than open circle framework. The impact of unsettling influences, clamor and ecological variables can be made incapable. Transient and consistent state reaction can be enhanced with incredible adaptability by upgrading the controller. The DC engines are costly because of brushes and commentators. DC motors have low torque to volume and torque to idleness proportions. On other hand the attributes are very direct and are simple to control. DC motors are by and large utilized for high power application like in machine instruments and apply autonomy. It is fascinating to realize that half of enterprises utilize PID or altered PID plans. Since PID can be balanced nearby, numerous sorts of tuning principles have been proposed. The numerical model of plant proposes that PID control can give best results. In the field of control frameworks, it is outstanding that fundamental and altered PID frameworks have demonstrates their value in giving

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palatable reaction in spite of the fact that as a rule they may not give ideal control.

To accomplish that ideal control fuzzy controllers can be utilized. Fuzzy logic control (FLC) is one of the effective utilizations of fuzzy set hypothesis presented by L.A. Zadeh in 1973. From that point forward FLC has been a to a great degree dynamic and productive research region with numerous modern applications. FLC has advanced as an option or correlative to different control systems in region of building. Fuzzy logic gives non direct controllers which are fit for performing distinctive complex non direct control activities, notwithstanding for dubious nonlinear frameworks. Not at all like customary controllers, for outlining a FLC it is not important to have an exact learning of framework model, for example, posts and zeros of the framework exchange work. Impersonating the human way of taking in, the following blunder and rate of progress of mistake of data sources are required for the outline of fuzzy induction framework.

II. DC motor model

The electric motor is an engine that changes over electrical vitality into mechanical vitality. There are two sorts of engine which are AC engine, and DC engine. A basic DC engine utilizes power and attractive field for delivering torque which turn the engine. Permanent magnet DC engine (PMDC) beats to AC engine since it gives better speed control on high torque loads and use in wide modern application. DC motor are more usable as it intended to use with batteries and sun oriented cells vitality sources, which give transportability where we required it and in this way give financially savvy arrangement, since it is impractical to have AC control supply in each place, DC engine demonstrate its reaction at both voltage and current. The connected voltage portrays the speed of engine while current in the armature windings demonstrates the torque. In the event that connected load expanded in the shaft of engine, then so as to manage its speed engine draws more present from supply what's more, if supply is not ready to give enough current then engine speed will be influenced.

By and large, one might say that connected voltage influence speed while torque is controlled by current. DC engines give more successful results if cleaving circuit is utilized. Low power DC engine as a rule use in lifting and transportation purposes as low power AC engines do not have great torque capacity. DC engine utilized as a part of railroad motors, electric autos, lifts, automated applications, auto windows and wide check of little apparatuses and complex modern blending process where torque can't be bargained. There are a few sorts of DC engine however most regular are brushed DC engine, brushless DC engine, stepper engine, and servo engine. These DC engines have three winding systems, for example, shunt DC engine, arrangement DC engine, and compound DC engine.

Speed Control of a DC Motor

The speed of DC engines can be balanced inside wide limits so that this gives simple controllability and superior. DC engines utilized as a part of numerous applications for example, as yet moving plants, electric trains, electric vehicles, electric cranes, and automated controllers require speed controllers to play out their undertakings. Speed controller of DC engine is completed by method for voltage control in 1981 firstly by Ward Leonard. The managed voltage sources utilized for DC engine speed control have increased more significance after the presentation of thyristor as exchanging gadgets in power hardware. At that point semiconductor parts, for example, MOSFET, IGBT, and GTO have been utilized as electric exchanging gadgets [6].

When all is said in done, the control of framework is troublesome because of their high nonlinearity properties. To defeat this trouble, Fuzzy Logic Controller can be produced. The best utilizations of Fuzzy Logic Controller are the time variation framework that is nonlinear [7]. A standout amongst the most imperative, FLC applications, all things considered, is the metro framework in the city Sendai of Japan in 1987 [8]. These days, Fuzzy Logic Controller applications are effectively utilized as a part of numerous fields including programmed center cameras, family materials for example, dishwashers furthermore vehicle industry.

The speed reaction of a DC engine presented to settled armature voltage was researched for both under stacked and emptied working conditions. The main, the DC engine was worked for a required reference speed under stacked and emptied working conditions utilizing PI control technique. At that point, to make execution examination, the speed of

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the framework intended for working at settled speed under various load conditions are mimicked at MATLAB/Simulink environment.

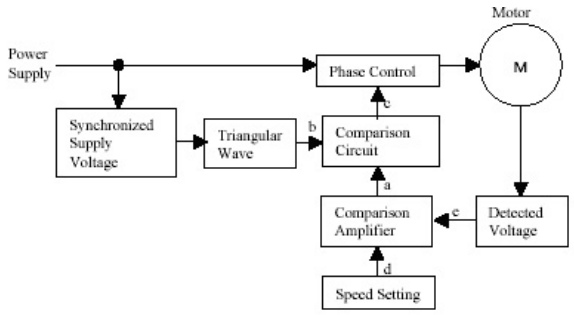

Figure 1: Block Diagram of DC motor

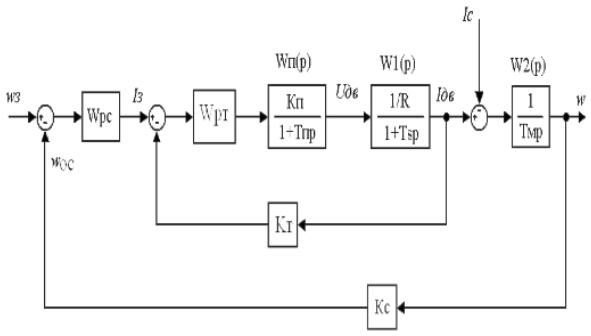

Figure 2: Transfer Function of DC motor

The torque created by the DC engine creates in electromagnetic constrain connected to rotor windings. The electromagnetic constrain on conductor is relative to current moving through the conductor, consequently torque created by DC engine is relative with current coursing through windings of rotor. The consistent of proportionality Kt

T = KtI

The adequacy of back emf is in corresponding to rakish speed of rotor. The steady of proportionality Ke

E = Keω

By and large, the torque created by a DC engine is relative to the armature current and the quality of the attractive field. In this illustration we will accept that the attractive field is steady and, in this way, that the engine torque is corresponding to just the armature current i by a consistent consider Kt as demonstrated the condition underneath. This is alluded to as an armature-controlled engine.

$$T = K_t i$$

The back emf, *e*, is proportional to the angular velocity of the shaft by a constant factor *Ke*.

$$e = K_e \dot{\theta}$$

In SI units, the motor torque and back emf constants are equal, that is, *Kt* = *Ke*; therefore, we will use *K*to represent both the motor torque constant and the back emf constant.

From the figure above, we can derive the following governing equations based on Newton's 2nd law and Kirchhoff's voltage law.

$$J\ddot{\theta} + b\dot{\theta} = Ki$$

$$L\ \frac{di}{dt} + Ri = V - \mathrm{K}\ \dot{\theta}$$

Transfer Function

Applying the Laplace transform, the above modelling equations can be expressed in terms of the Laplace variables.

$$s(Js + b)\theta(s) = KI(s)$$

$$(Ls + R)I(s) = V(s) - Ks\ \theta(s)$$

We arrive at the following open-loop transfer function by eliminating *I*(*s*) between the two above equations, where the rotational speed is considered the output and the armature voltage is considered the input.

$$P(s) = \frac{\theta(\dot{s})}{V(s)} = \frac{K}{(Js + b)(Ls + R) + K^2}$$

III. Fuzzy logic

Fuzzy controllers are extremely straightforward for all intents and purposes. They comprise of an info stage, a preparing stage, also, a yield arrange. The info arrange maps sensor or different information sources like switches, thumbwheels, and so on, to the suitable participation capacities and truth values. The preparing stage summons each proper govern and creates an outcome for every, then joins the aftereffects of the guidelines. The yield arrangechanges over the consolidated result once more into a particular control yield esteem. Principles can be comprehended in parallel in equipment, or consecutively in programming. The consequences of the considerable number of standards that have let go are "defuzzified" to a fresh esteem by one of a few techniques. Defuzzification is the procedure of creating a quantifiable result in fuzzy logic, given fuzzy rules

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and relating enrolment degrees. It is normally required in fuzzy logic frameworks. These will have various standards that change various factors into a fuzzy logic result, that is, the outcome is depicted as far as enrolment in fluffy sets. Defuzzification is translating the participation degrees of the fuzzy logicsets into a particular choice or genuine esteem.

The general procedure is as per the following

- Document the framework's operational determinations and sources of info and yields. Document the fluffy sets for the sources of info.
- Document the administer set.
- Determine the defuzzification strategy.
- Run through test suite to approve framework, modify points of interest as required.
- Complete record and discharge to creation.

Step 1: initializing the inputs, outputs

We need to initialize inputs, outputs, universe of discourse.

Input: the error between the reference and actual speed and change in error.

Output: armature voltage

Step 2: defining fuzzy membership functions and rules

The inputs and outputs are converted into linguistic form numerical form. Changing over a fresh amount to fluffy esteem is known as fuzzification. The correct fresh estimations of sources of info are changed to semantic factors. Huge numbers of the amounts that are thought to be fresh and deterministic are really not deterministic by any means. They convey significant vulnerability. In the event that the type of vulnerability happens to emerge in light of imprecision, equivocalness or dubiousness, then the variable is presumably fluffy and can be spoken to by an enrollment work (S.N. Sivanandam and S.N. Deepa, 2010). The fuzzification changes over the information into appropriate semantic qualities, which might be seen as names of fuzzy sets.

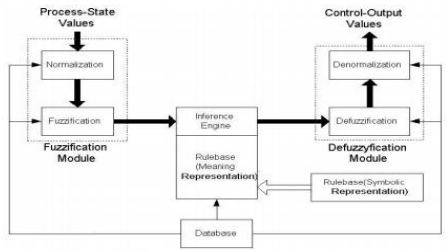

Figure 3: Block Diagram of Fuzzy logic controller.

Step 3: member function

Participation capacities portray the fluffiness in a fuzzy set – whether the components in the set are discrete or consistent in a graphical frame for inevitable use in the scientific formalisms of fluffy set hypothesis. The enrollment work basically typifies all fluffiness for a specific fuzzy set; its portrayal is the substance of a fuzzy property or operation. Since all data contained in a fluffy set is portrayed by its participation work, it is valuable to build up a dictionary of terms to depict different uncommon components of this capacity. The participation of a protest in a fuzzy set can be approximated. The participation to oblige different "degrees of participation" on the genuine consistent interim is [-1, 1]. Be that as it may, there are endless number of qualities in the middle of the end focuses [-1, 1], which can speak to different degrees of participation for a component. A fresh set has a one of a kind participation work, though a fuzzy set can have a boundless number of participation capacities to speak to it (Hiyama 1997). The primary power and quality of enrollment capacity is that it utilizes some measure of cover.

IV. Proposed methodology

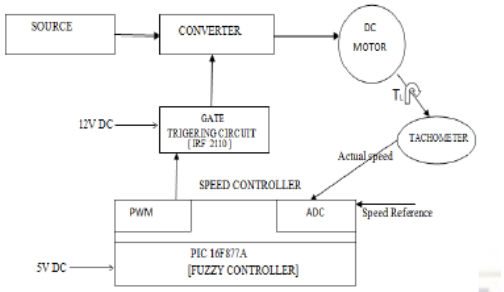

Figure 4: Block Diagram of Proposed Methodology

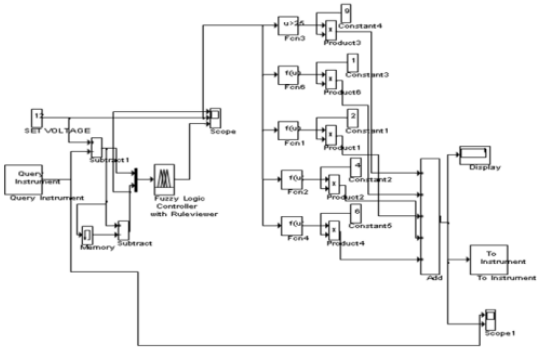

Figure 5: Circuit diagram in Simulink

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V. Implementation:

The depiction of the equipment circuit and their vital waveforms of converter circuit are appeared. The amended 12V DC supply is given to 7812 and 7805 voltage controller to acquire a steady 12V and 5V DC supply. This supply is given to driver circuit and microcontroller for its operation. The beat from microcontroller is given to drive the controller converter changes to control DC engine. PMI Servo circle DC engine with Tachometer is associated with the PIC microcontroller .The voltage heartbeat to trigger the MOSFET's with an exchanging recurrence of 4KHZ

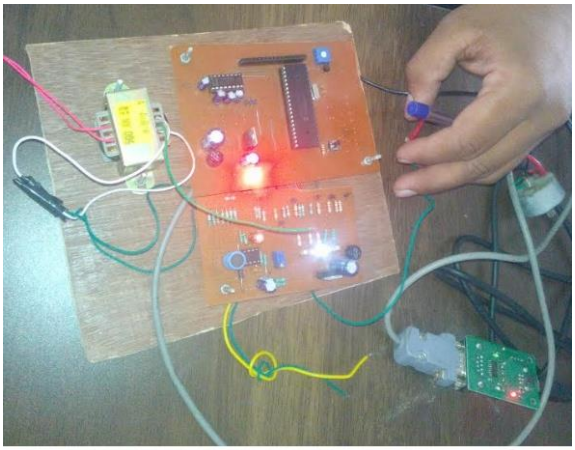
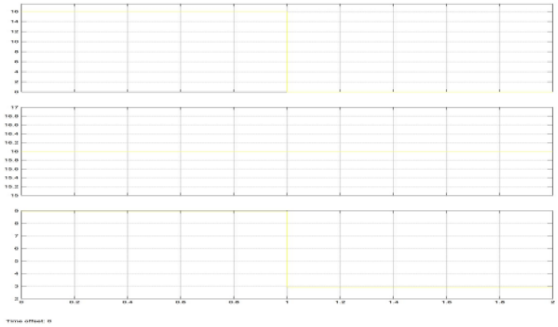


Figure 6: The real time implementation of DC motor using PIC microcontroller

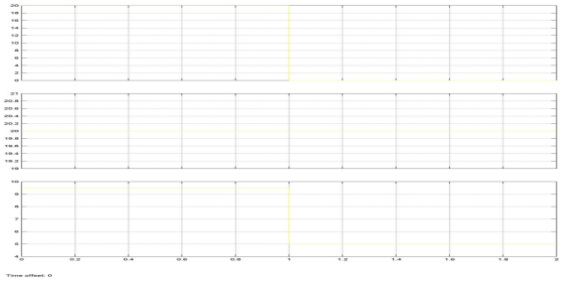
The snapshot of real time implementation of speed control of DC motor using PIC microcontroller and respective output voltage is show. Voltages with different values are taken as input and respective simulation result are shown.

VI. Simulation result

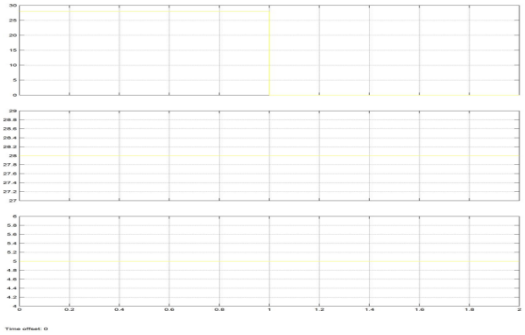
FOR 16V INPUT VOLTAGE



FOR 24V INPUT VOLTAGE



FOR 28V INPUT VOLTAGE



VII. Conclusion

Late advancements in science and innovation give a wide range extent of uses of elite DC engine drives in zone, for example, moving factories, concoction handle, electric trains, automated controllers and the home electric appliances. They require speed controllers to perform undertakings. Subsequently, a fluffy based DC engine speed control framework was planned utilizing PIC microcontroller. It is a closed loop ongoing control framework, which keeps up the wanted speed notwithstanding when there is a variety of load. In this paper, an extensive examination of DC drive framework has been performed by utilizing fuzzy logic controller. The recreation model is executed in MATLAB/simulink environment. From the yield speed wave shape , we can see that the speed gets to be consistent at 0.6 sec for an open circle framework while it gets to be consistent at 0.1 sec for a fuzzy PI . Additionally in Fuzzy PI we have a smooth speed control with less overshoot and no motions. In the equipment part, the fuzzy logic control calculation was created utilizing Mikro C, an abnormal state programming dialect for programming a PIC microcontroller. The C-structure programming overpower the troubles may experienced if programming the microcontroller utilizing Embedded C dialect. The fuzzy logic calculation customized will be

aggregated into the memory framework .As the outcome, the fuzzy logic created can give exact PWM motion keeping in mind the end goal to drive the DC driver. At that point, the PIC microcontroller is interfaced between the DC enginewhat's more, DC speed drive to keep running continuously and troubleshoot.

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