OVERSPEED CORRECTION SCHEME FOR DC MOTOR USING ARTIFICAL INTELLIGENT APPROACH

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ABSTRACT

The conventional PI, PD and PID controllers were used as a control strategy for various industrial processes from many years due to their simplicity in operation. They used mathematical models to control the plant for different process control applications. A fuzzy controller for DC speed motor fed by DC Chopper, H-Bridge converter is developed and presented in this paper. Fuzzy logic based control systems were introduced by Lotfi Zadeh to optimize the speed and process control parameters in better way. During implement this project, we have an experienced in modeling the physical quantities such as dc motor, and modeling a mathematical equations for dc motor, develop simulink block for PI controller and then develop fuzzy logic speed controller using MATLAB Simulink blocks.

ABSTRAK

Pengawal konvensional seperti PI, PD dan PID telah digunakan sebagai strategi kawalan untuk pelbagai proses kawalan industri bertahun-tahun sehingga sekarang disebabkan pengendalian operasi yang mudah dan kos yang murah. Biasanya pengawal ini dibina daripada model matematik seterusnya digunakan untuk mengawal pelbagai proses sistem kawalan bergantung kepada operasi loji tersebut. Melalui projek ini, sistem kawalan kelajuan Fuzzy Logik bagi motor arus terus yang dipacu menggunakan kawalan pemenggal dan juga kawalan pemacu *H-Bridge* akan diterangkan dan seterusnya direka bagi mengawal kelajuan motor tersebut. . Sistem kawalan fuzzy logik diasaskan oleh Lotfi Zadeh dengan tujuan untuk mengoptimumkan kawalan kelajuan dan proses dengan lebih baik lagi. Dalam projek ini juga, kita akan melihat bagaimana model matematik diterbitkan bagi motor arus terus , merekabentuk blok simulink bagi PI dan seterusnya membina kawalan kelajuan fuzzy logik bagi motor arus terus dengan menggunakan perisian seperti MATLAB

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CHAPTER 1

INTRODUCTION

1.1 Project Background

DC motors are used in industrial applications because the speed-torque relationship can be varied to almost any useful form. DC motors are often applied wherethey momentarily deliver three or more times their rated torque. DC motors feature a speed, which can be controlled smoothly down to zero, immediately followed by acceleration in the opposite direction also. DC motors can respond quickly to changes in control signals due to the high ratio of torque to inertia[1].

Nowadays, there are dozens of industrial scheme controller to control the mechanical, chemical and electrical parts. An artificial intelligent (A.I) is one of the scheme methods which demonstratevarious techniques including Artificial Neural Network (ANN), Fuzz Logic Control (FLC), Fuzzy Logic Neural (FLN) etc. This project proposed the FLC to control or regulate the over speed of dc series motor. A simple most PWM dc-dc chopper is used as the driver converter in the digital simulation to control the dc motor armature voltage. Thisproject will present simulationresults (FLC) and the tuning criteria as well as controlvalidation results for different speed referencetrajectories specifically under load condition, and varyingmechanical load (load torque) dynamics through simulation at machine laboratory. The control output is adjusted online by the level of the excursionerror vector comprising the speed error and itsderivative. This is to ensure that the statetrajectory is the most optimal in reducing the controlsensitivity toany excursions in load and plant modelparameters, moreover it also provides optimal tracking withminimum overshoot, undershoot, fast rise andsettling times. The proposed FLC based controller gives betterresults in comparison with classical A.I controller [2].

1.2 Problem Statements

During the start-up, the DC motor normally has high starting current and torque, consequently the speed of motor become very high and sometimes will turn to over speed and unstable especially when it is in no-load or under load condition. At the same time the armature current will increase rapidly and turn the coil to overheat and then burnt.

This project will focus on dc motor which has a poor speed regulation and then try to achieve the speed correction. The fuzzy logic control will be implemented through simulink simulation while the real performance of dc motor will try to conduct, visualize and monitor at Machine Laboratory of Jabatan Kejuruteraan Elektrik, Politeknik Kota Kinabalu.

1.3 Objective

The main objective is to develop speed control of dc motor using fuzzy logic controller (FLC). The objective of this project is as follows:

a) To carry out the dc motor mathematical model
b) To setup a proper experimental procedure for over speed testing
c) To analyse the performance based on the FLC simulation

1.4 Scopes of the project

The scopes of this project are:

a) To investigate FLC controller which are used as a main control technique in simulation. Three main stages of FLC namely the fuzzifier, rule-base fuzzy set and the defuzzifiction.

b) In the experiment, the test apparatus will be equipped with dc motor 0.3kW contains of multifunction machine, machine test system and control and dc power supply stabilizer.

c) The performance analyses will focus on current armature (I_a) and load torque (T_L) as well as speed (N) of the motor.

While doing the experiment in lab, there are limitations that already expected specifically the circuit of dc-dc converter switching due to unavailable of few equipment in lab. However the switching circuit will be performed using Matlab Simulink.

CHAPTER 2

LITERATURE REVIEW

2.1 Fuzzy Logic Theories

2.1.1 Fuzzy Logic Controller

The Fuzzy Logic tool was introduced in 1965, also by Lotfi Zadeh [3], and is a mathematical tool for dealing with uncertainty. It offers to a soft computing partnership the important concept of computing with words'. It provides a technique to deal with imprecision and information granularity. The fuzzy theory provides a mechanism for representing linguistic constructs such as "many," "low," "medium," "often," "few." In general, the fuzzy logic provides an inference structure that enables appropriate human reasoning capabilities. Figure 1 shows the proposed fuzzy logic control structure with the modified defuzzifier stage.

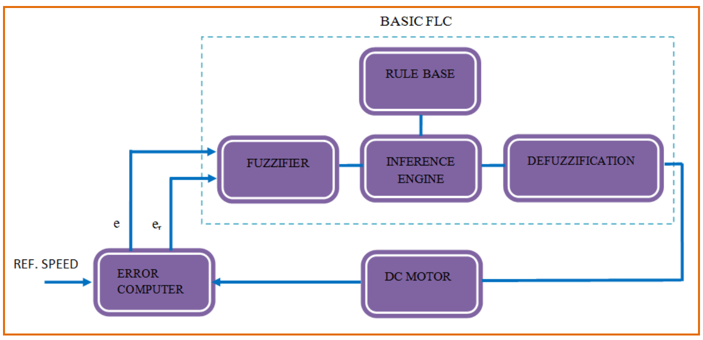

Figure 2.1: Fuzzy logic Structure

The FLC involves three stages namely fuzzification, rule-base and defuzzification. There are several method that used in the Mamdani[3,4] applied the fuzzy set theory for developing fuzzy logic controllers (FLCs). In general, a FLC consists of a set of linguistic conditional statements which are derived from human operators and represents the expert's knowledge about the system being controlled. These statements define a set of control protocol relating the control conditions to control actions by 'If-Then' rules.

2.1.2 Fuzzification

In fuzzy logic system the linguistic variables are used instead of numerical variables. Fuzzification is an important concept in the fuzzy logic theory. Fuzzification is the process where the crisp quantities are converted to fuzzy (crisp to fuzzy). By identifying some of the uncertainties present in the crisp values, we form the fuzzy values. The conversion of fuzzy values is represented by the membership. The process of converting a numerical variable (real number or crisp variables) into a linguistic variable (fuzzy number or fuzzy variable) is called fuzzification.

$$e(k) = w_r(k) - w(k)$$

$$\Delta e(k) = e(k) - e_{old}(k)$$

In this project, the motor variables are speed (w) and current (Ia). The speed of dc motor is controlled by FLC. The error $e(k)$ and change in error $\Delta e(k)$ is given as input to the FLC. The error is found by comparing the actual speed $\omega(k)$ with reference speed $\omega_r(k)$. From the error $e(k)$ and old error $e_{old}(k)$ the change in error $\Delta e(k)$ is calculated. In in order to use the same FLC for different reference speed it has to be normalized and finally the error and change in error are fuzzified.

Seven linguistic variables are used for the input variable $e(k)$ and $\Delta e(k)$. That are negative big (NB),negative medium (NM), negative small (NS), zero (Z), positive small (PS), positive medium (PM) and positive big (PB). The triangular membership function is used for simplicity and also to reduce the calculations.

The FLC can be considered as a fuzzy reasoning process; it attempts to utilize expert knowledge in emulating human control capabilities. This manifests in the form of qualitative information about the process and this information is articulated in 'If-Then' rules. For example, one of the control rules may process the error (e) and the change in error $\Delta e(k)$ to synthesize a change in control for improving the system performance.

2.1.3 Defuzzification

Defuzzification means the fuzzy to crisp conversions. The fuzzy results generated cannot be used as such to the applications, hence it is necessary to convert the fuzzy quantities into crisp quantities for further processing. This can be achieved by using defuzzification process. The defuzzification has the capability to reduce a fuzzy to a crisp single-valued quantity or as a set, or converting to the form in which fuzzy quantity is present. Defuzzification can also be called as "rounding off" method. Defuzzification reduces the collection of membership function values in to a single sealer quantity. The output of an entire fuzzy process can be union of two or more fuzzy membership functions. There are seven methods used for defuzzifying the fuzzy output functions. They are:

(1) Max-membership principle,

(2) Centroid method,

(3) Weighted average method,

(4) Mean–max membership,

(5) Centre of sums,

(6) Centre of largest area, and

(7) First of maxima or last of maxima

The most widely used method is centroid method. This can be called as center of gravity or center of area method. It can be defined by the algebraic expression

$$z^* = \int \frac{\mu_{\underset{\sim}{C}}(z)\, z\,\mathrm{d}z}{\mu_{\underset{\sim}{C}}(z)\,\mathrm{d}z} \tag{2.1}$$

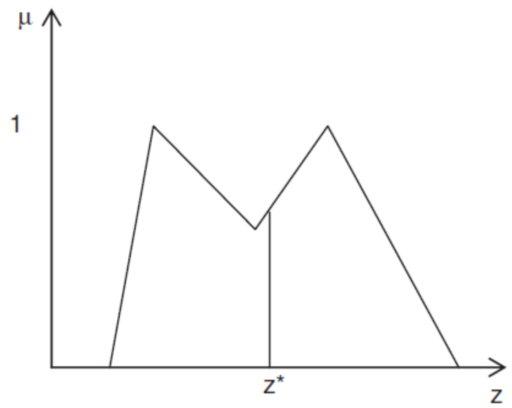

Figure 2.2: Centroid method

On this project the defuzzified output is the duty cycle *dc(k)*. The change in duty cycle *Δdc (k)* can be obtained by adding the old duty cycle *old_dc(k)* with the duty cycle dc(k) which is given in equation below [5].

$$\Delta dc(k) = dc(k) + old\_dc(k)$$

2.1.4 Rules Base System

Rules form the basis for the fuzzy logic to obtain the fuzzy output. The rule based system is different from the expert system in the manner that the rules comprising the rule-based system originate from sources other than that of human experts and hence are different from expert systems. The rule-based form uses linguistic variables as its antecedents and consequents. The antecedents express an inference or the inequality, which should be satisfied. The consequents are those, which we can infer, and is the output if the antecedent inequality is satisfied. The fuzzy rule-based system uses **IF–THEN** rule-based system, given by, **IF** antecedent, **THEN** consequent.

The control rules that relate the fuzzy output to thefuzzy inputs are derived from general knowledge of the system behaviour and also the perception and experience.The general rule can be written as

If e(k) is X and Δe (k) is Y, then Δdc(k) is Z

where ,

X, Y and Z are the fuzzy variable for e(k),Δe(k) and Δdc(k) respectively [6].

The rule table for the designed fuzzy set controller isgiven in the Figure 2.3 and Table 21. The element in the first row andfirst column means thatIf *error is NB*, and change in *error* is NB then *output* is NB [5].

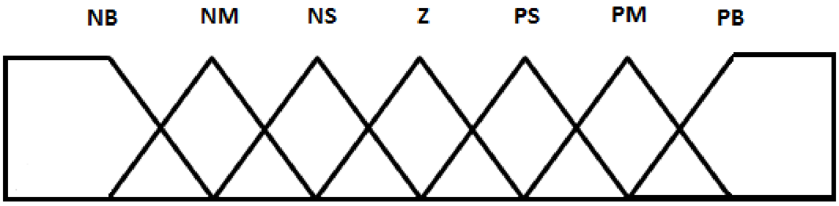

Figure 2.3: Membership function

Table 2.2: Set of Fuzzy Logic Control variables structure

Change in Error \ Error	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	Z
NM	NB	NB	NB	NM	NS	Z	PS
NS	NB	NB	NM	NS	Z	PS	PM
Z	NB	NM	NS	Z	PS	PM	PB
PS	NM	NS	Z	PS	PM	PB	PB
PM	NS	Z	PS	PM	PB	PB	PB
PB	Z	PS	PM	PB	PB	PB	PB

2.2 Fuzzy Inference System

Fuzzy inference systems (FISs) are also known as fuzzy rule-based systems, fuzzy model, fuzzy expert system, and fuzzy associative memory. This is a major unit of a fuzzy logic system. The decision-making is an important part in the entire system. The FIS formulates suitable rules and based upon the rules the decision is made. This is mainly based on the concepts of the fuzzy set theory, fuzzy IF–THEN rules, and fuzzy reasoning. FIS uses “IF. . . THEN. . . ” statements, and the connectors present in the rule statement are “OR” or “AND” to make the necessary decision rules. The basic FIS can take either fuzzy inputs or crisp inputs, but the outputs it produces are almost always fuzzy sets. When the FIS is used as a controller, it is necessary to have a crisp output. Therefore in this case defuzzification method is adopted to best extract a crisp value that best represents.

The working of FIS is as follows. The crisp input is converted in to fuzzy by using fuzzification method. After fuzzification the rule base is formed. The rule base and the database are jointly referred to as the knowledge base. Defuzzification is used to convert fuzzy value to the real world value which is the output. The steps of fuzzy reasoning (inference operations upon fuzzy IF–THEN rules) performed by FISs are:

i. Compare the input variables with the membership functions on the antecedent part to obtain the membership values of each linguistic label. (this step is often called fuzzification.)
ii. Combine (through a specific t-norm operator, usually multiplication or min) the membership values on the premise part to get firing strength (weight) of each rule.
iii. Generate the qualified consequents (either fuzzy or crisp) or each rule depending on the firing strength.
iv. Aggregate the qualified consequents to produce a crisp output. (This step is called defuzzification.)
v.

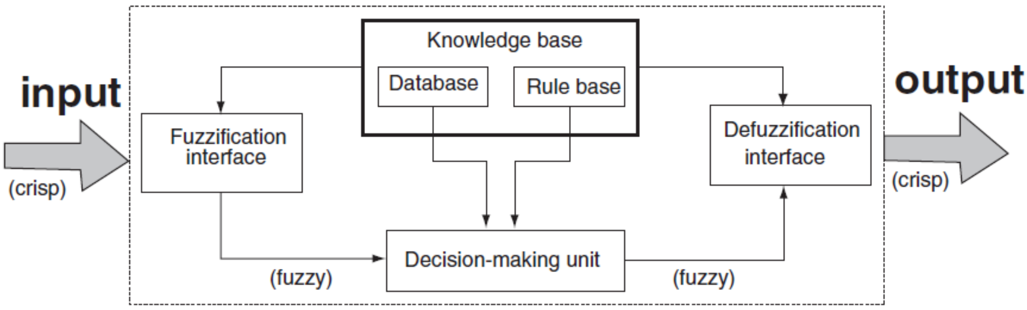

Figure 2.4: Fuzzy Inference System

2.2.1 Fuzzy Inference Methods

The most important two types of fuzzy inference method are Mamdani's fuzzy inference method, which is the most commonly seen inference method. This method was introduced by Mamdani and Assilian (1975). Another well-known inference method is the so-called Sugeno or Takagi–Sugeno–Kang method of fuzzy inference process. This method was introduced by Sugeno (1985). This method is also called as TS method. The main difference between the two methods lies in the consequent of fuzzy rules. Mamdani fuzzy systems use fuzzy sets as rule consequent whereas TS fuzzy systems employ linear functions of input variables as rule consequent. All the existing results on fuzzy systems as universal approximators deal with Mamdani fuzzy systems only and no result is available for TS fuzzy systems with linear rule consequent.

2.2.2 Mamdani's Fuzzy Inference Method

Mamdani's fuzzy inference method is the most commonly seen fuzzy methodology. Mamdani's method was among the first control systems built using fuzzy set theory.

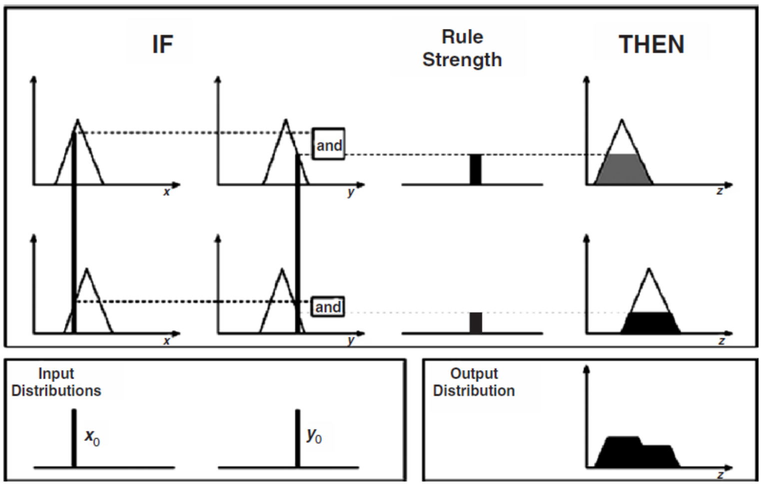

Figure 2.5: A two input, two rule Mamdani FIS with crisp inputs

To compute the output of this FIS given the inputs, six steps has to be followed;

i. Determining a set of fuzzy rules
ii. Fuzzifying the inputs using the input membership functions
iii. Combining the fuzzified inputs according to the fuzzy rules to establish a rule strength
iv. Finding the consequence of the rule by combining the rule strength and the output membership function
v. Combining the consequences to get an output distribution
vi. Defuzzifying the output distribution (this step is only if a crisp output (class) is needed).

2.2.3 Advantages of Sugeno and Mamdani Method

The advantages of the Sugeno Method are;

i. It is computationally efficient.
ii. It works well with linear techniques (e.g., PID control).
iii. It works well with optimization and adaptive techniques.
iv. It has guaranteed continuity of the output surface.
v. It is well suited to mathematical analysis.

The advantages of the Mamdani Method are;

i. It is intuitive.
ii. It has widespread acceptance.
iii. It is well suited to human input.

Fuzzy inference system is the most important modeling tool based on fuzzy set theory. The FISs are built by domain experts and are used in automatic control, decision analysis, and various other expert systems.

2.3 Direct current motor

A DC motor is a mechanically commutated electric motor powered from direct current (DC). The stator is stationary in space by definition and therefore so is its current. DC motors have a rotating armature winding but non-rotating armature magnetic field and a static field winding or permanent magnet. Different connections of the field and armature winding provide different inherent speed or torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems called DC drives.

DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines.

2.3.1 Permanent magnet DC motor

Permanent Magnet DC motors are useful in a range of applications, from battery powered devices like wheelchairs and power tools, to conveyors and door openers, welding equipment, X-ray and tomographic systems, and pumping equipment, to name a few. They are frequently the best solution to motion control and power transmission applications where compact size, wide operating speed range, ability to adapt to a range of power sources or the safety considerations of low voltage are important. Permanent magnet DC motors are much more efficient, lighter and compact than comparably sized wound DC motors because the permanent magnets replace the field windings of wound DC motors. The PM DC motors are constructed in two broad categories: brushed commutator and brushless. The PM DC commutator motor uses a rotating armature winding with a stationary field of permanent magnets; a PM DC brushless motor has a reverse construction: a rotating field of permanent magnets and a stationary armature winding that is externally commutated by an electronic control.

2.3.2 DC brush motor

The brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent) and rotating electrical magnets. Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor.

2.3.3 DC brushless motor

Typical brushless DC motors use a rotating permanent magnet in the rotor, and stationary electrical current or coil magnets on the motor housing for the rotor, but the symmetrical opposite is also possible. A motor controller converts DC to AC. This design is simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.

2.3.4 Connection of DC motor

There are three types of electrical connections between the stator and rotor possible for DC electric motors such as series, shunt and compound and each has unique speed or torque characteristics appropriate for different loading torque profiles.

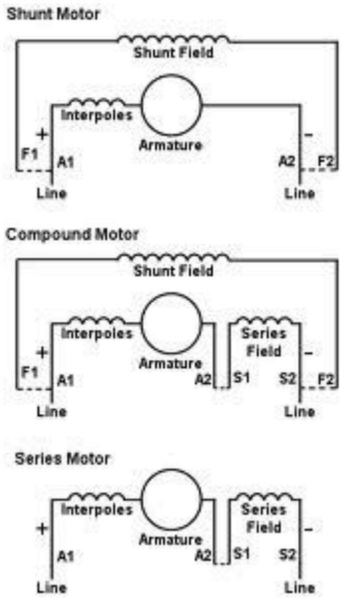

Figure 2.6: Connection of dc motor

2.4 A review of research study

There are several techniques or a study that has been implemented by researchers related to dc motor speed control using PI, PID or FLC.

Table 2.3: Study Research Area

No	Authors and year	Title of studies	Technique used	Practical Application	Remarks
1.	Iracleous, D. P. Alexandridis, A. T. (1995)	Fuzzy tuned PI controllers for series connected DC motor drives	Fuzzy Controller using P-I	Experiment is done using Fuzzy Logic control	Speed variation of a compressor for temperature & humidity balance but showed no significant result on energy

					efficiency.
2.	Soliman, Hussein F., Mansour, M. M., Kan&l, S. **A., A.M.** Sharaf	A robust tunable Fuzzy logic Control scheme control for speed regulation of dc series motor drives	FLC controller	Simulation is done using FLC using dc-dc converter	The FLC-defuzzification stage utilizes a modified *"weighted centre of area"* ***WCOA*** switching criterion based on the speed error excursion.
3.	Perez, C. Strefezza, M. (2008)	Speed control of a DC motor by using fuzzy variable structure controller	Fuzzy Logic Controller & VSC	This strategy control combines fuzzy and sliding mode control algorithms	The parameters of the fuzzy controller are adjusted by using the VSC for a better response and robustness
4.	Tan, H. L. Rahim, N. A. Hew, W. P. (2001)	A simplified fuzzy logic controller for DC series motor with improve performance	PI type fuzzy controller (FPI)	DC series motor connected to a single-phase full-bridge converter.	Performances of the proposed model are compared in terms of several performance measures such as peak overshoot, rise-time, settling time and steady-state waveform
5.	Muruganandam, M. Madheswaran, M. (2009)	Performance analysis of fuzzy logic controller based DC-DC converter fed DC series motor	Fuzzy Logic Controller and DC-DC (chopper) converter	This system has been designed to have two loops with an inner ON/OFF current controller and an outer fuzzy speed controller	The performance o f the proposed controller is compared with the reported results and found that the fuzzy based DC-DC drive can have better control

CHAPTER 3

METHODOLOGY

3.1 Project Methodology

This project adopt the methods involving developing artificial intelligent controller for dc motor specifically to regulate the over speed that occurs in dc motor. A fuzzy logic control scheme by speed and current error vector(e, e_r(k),) as a fuzzy input vector is used inassociation with a fuzzy ruleassignment table in achieving fast speed regulation.[7]

The research is conducting in phase basis as follows:

i. Feasibility or studies areas
ii. Artificial intelligent studies
iii. Developing fuzzy logic controller model using simulink
iv. Performance, Result and Analysis

3.2 Flowchart of the project

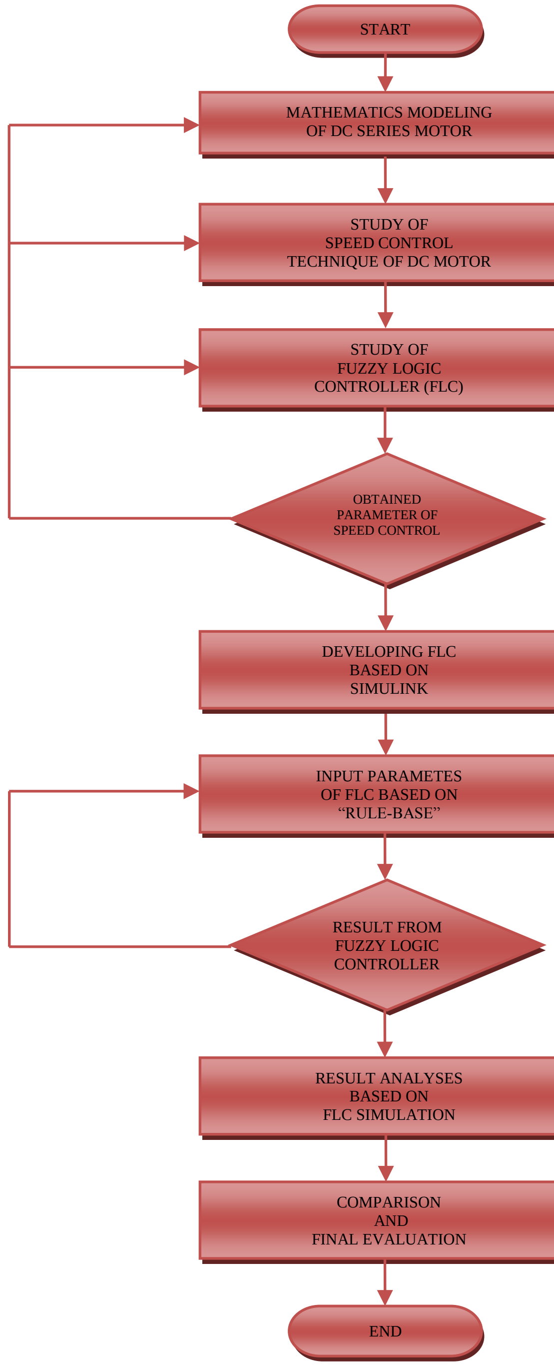

Figure 3.1: Flowchart

3.3 Develop a Mathematical model of dc motor

To access to the problem formulation, a mathematical equation of PM DC motor need to be evaluate to identify the parameters of permanent magnet dc motor. However the evaluation of permanent magnet dc motor model is only described in details at chapter 4.

3.4 PID controller design

The next discussion is the proportional-integral-derivative controller. A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller)widely used in industrial control systems – a PID is the most commonly used feedback controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired setpoint. The controller attempts to minimize the error by adjusting the process control inputs.[8]

$$\mathrm{u}(t) = \mathrm{MV}(t) = K_p e(t) + K_i \int_0^t e(\tau)\, d\tau + K_d \frac{d}{dt} e(t)$$

The PID controller calculation (algorithm) involves three separate constant parameters, and is accordingly sometimes called three-term control, the proportional, the integral andderivative values, denoted *P*, *I*, and *D*. Heuristically, these values can be interpreted in terms of time: *P* depends on the *present* error, *I* on the accumulation of *past* errors, and *D* is a prediction of *future* errors, based on current rate of change.The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, or the power supplied to a heating element.

In the absence of knowledge of the underlying process, a PID controller has historically been considered to be the best controller. By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the setpoint and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability.[12]

Some applications may require using only one or two actions to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are fairly common, since derivative action is sensitive to measurement noise, whereas the absence of an integral term may prevent the system from reaching its target value due to the control action.

3.5 PI controller design

A PI Controller (proportional-integral controller) is a special case of the PID controller in which the derivative (D) of the error is not used. The controller output is given by [8]

$$\Delta = SP - PV$$

Where Δ is the error or deviation of actual measured value (PV) from the setpoint (SP)

The lack of derivative action may make the system steadier in the steady state in the case of noisy data. This is because derivative action is more sensitive to higher-frequency terms in the inputs. Without derivative action, a PI-controlled system is less responsive to real (non-noise) and relatively fast alterations in state and so the system will be slower to reach set point and slower to respond to perturbations than a well-tuned PID system may be.

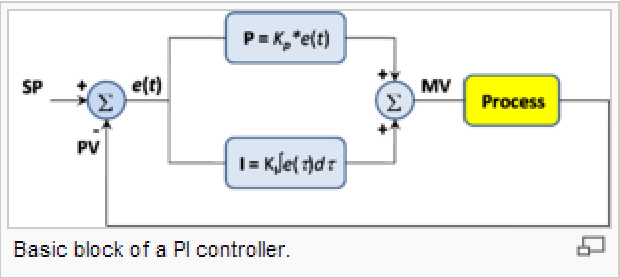

Figure 3.2: Basic block of PI controller

3.6 Fuzzy Logic Controller (FLC)Design

The fuzzy logic foundation is base on the simulation of people's opinions and perceptions to control any system. One of the methods to simplify complex systems is to tolerate to imprecision, vagueness and uncertainty up to some extent [4]. It is not required to know exact system model to design FLC. FLC may not give satisfactory results because it is don’t care the exact value. To defining Input and Output: The goal of designed FLC in this study is to minimize speed error. The bigger speed error the bigger controller input is expected. The proposed strategy minimized error of reference model and response of PMDC motor by combination model reference PID control, PI control and Fuzzy Logic control. We should use proper system for reference model therefore second order critically damped system selected as the reference model. The transfer function is written as:

$$G(s) = \frac{\Omega(s)}{E(s)} = \frac{K_t}{\left[\left(L_a s + R_a\right)\left(Js + B\right) + K_b K_t\right]}$$

Proper reference model and fuzzy controller can improve the performance of PMDC motor. In this paper the model of proposed controller is simulate in simulink by modified the previous PID and PI controller simulink circuit and then replace it with fuzzy logic controller.

3.7 DC motor drives

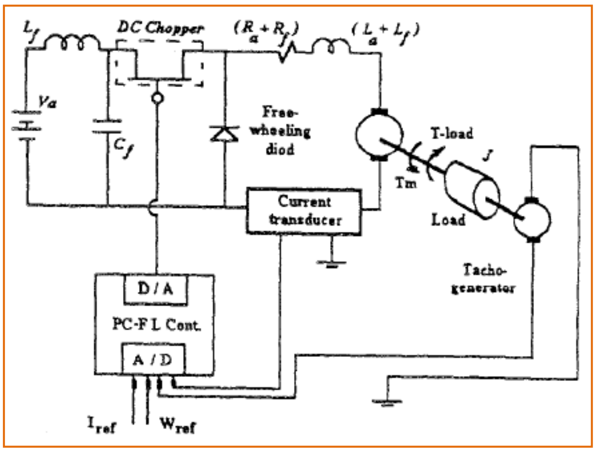

Figure 3.3: DC chopper converter drives of dc motor

Figure 3.2 and 3.3illustrates the dc motor drive scheme with the PI and dc chopper drives. The DC motor is fed by the DC source through a chopper that consists of GTO thyristor and freewheeling diode D1. The motor drives a mechanical load characterized by inertia J, friction coeficient B, and load torque TL. The hysteresis current controller compares the sensed current with the reference and generates the trigger signal for the GTO thyristor to force the motor current to follow the reference. The speed control loop uses a proportional-integral controller which produces the reference for the current loop. Current and Voltage Measurement blocks provide signals for visualization purpose.[9]

The control output is adjusted online to ensure a minimum combined speed and current excursion en-or index. By using this circuit, the artificial intelligent controller will be design using Fuzzy Logic controller. Both of PI controller and Fuzzy logic controller output response then recorded and anylize.

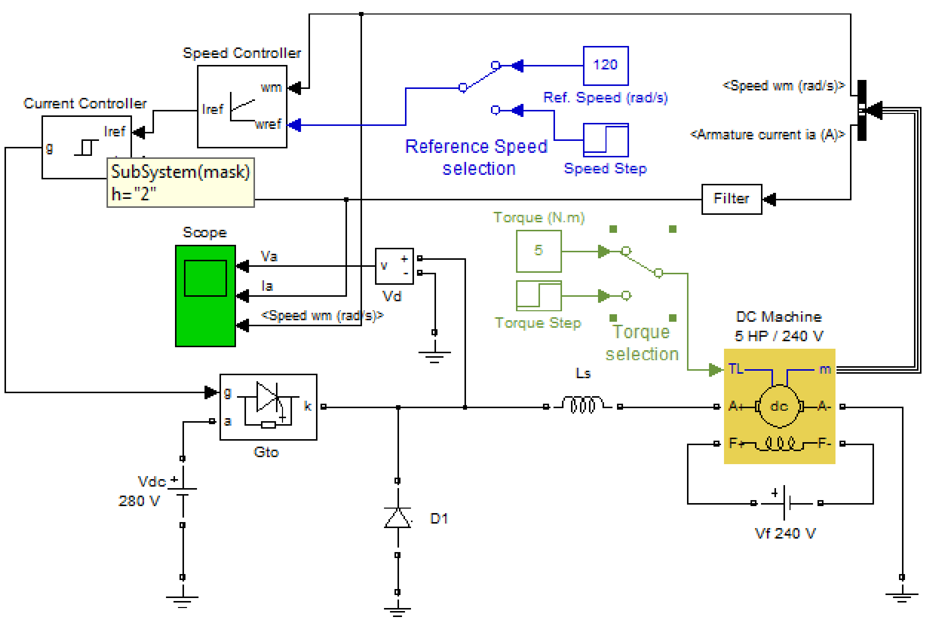

Figure 3.4: DC motor with dc chopper drive

3.8 Performance and result analyses

The expected results of this project using fuzzy logic control are:

(i) Minimizingthe over speed of motor

(ii) Minimizingthe over shoot current

(iii) Improved speed regulation through armature current and torque control

(iv) Evaluation of performance and result through graph

CHAPTER 4

DESIGN A SIMULINK MODEL
OF DC MOTOR

4.1 DC motor speed control method

The speed of a DC motor can be varied by controlling the field flux, the armature resistance or the terminal voltage applied to the armature circuit. The three most common speed control methods are field resistance control, armature voltage control, and armature resistance control [10]. In this section, Simulink models of these three methods and feedback control method for DC motor drives for dynamic analysis are presented [11].

4.2 Simulink design of field resistance control

In the field resistance control method, a series resistance is inserting in the shunt-field circuit of the motor in order to change the flux by controlling the field current. Theoretically when the field resistance increases it will result in an increase in the no-load speed of the motor and in the slope of the torque-speed curve [10].

Figure 4.2 shows the Simulink implementation of the field resistance control method. A DC motor block of *SimPowerSystems* toolbox is used to design the simulink.

The DC motor block implements a separately excited DC motor. An access is provided to the field connections (F+, F-) so that the motor model can be used as a shunt-connected. The field circuit is represented by an RL circuit (Rf and Lf in series) and is connected between the ports (F+, F-). The armature circuit consists of an inductor L_a and resistor R_a in series with an electromotive force E_A and is connected between the ports (A+, A-). The load torque is specified by the input port T_L.

The electrical and mechanical parameters of the motor could be specified using its dialog box. Observe that 240 V DC source is applied to the armature and field circuits. An external resistance R_{f1} is inserted in series with the field circuit to realize the field resistance speed control. The output port (*port m*) allows for the measurement of several variables, such as rotor speed, armature and field currents, and electromechanical torque developed by the motor.

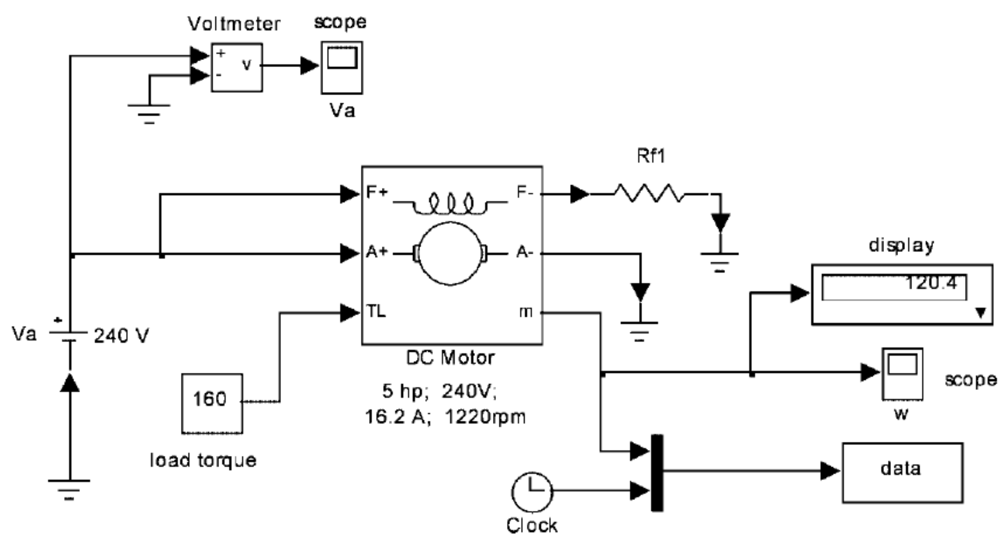

Figure 4.2: Field Resistance speed control

Through the scope and display block, the waveform and steady-state value of Figure 4.2 the rotor speed can be easily measured in radian per second (rad/s), or the corresponding data can be written to MATLAB’s workspace using the data box to make use of other graphical tools available in MATLAB.

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