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SPEED CONTROL OF DC MOTOR USING PLC

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ABSTRACT:-A speed controller for DC motor is designed and illustrate desing fuzzy logic-based programmable logic controller (PLC). The DC motor is an attractive part of electrical equipment in many industrial applications requiring variable speed and load specifications due to its ease of controllability. The planned framework is comprised of three fundamental parts including programmable rationale regulator, beat width adjustment (PWM) bipolar drive and DC engine. In the control segment, PLC is utilized as continuous regulator and fluffy rationale calculation is planned dependent on nonlinear model of DC engine, and its boundaries are advanced in MATLAB programming. At that point, it is executed utilizing rslogix5000 PLC and programming language stepping stool for speed control. At last, with great outcomes, the viability of the regulator is effectively demonstrated under various burden conditions. The acquired outcomes exhibit the viability of the PLC canny regulator in improving the precision and speed control of DC engine. The proposed system is suitable for different industrial applications such as subway cars, trolley buses, or battery-operated vehicles.

Keywords: PLC, DC motor, Speed Control using PLC, PWM.

I. INTRODUCTION

Electric machines are a means of energy converting device. Motors take electrical energy and produce mechanical energy. A DC motor in simple words is a device that coverts electrical energy (Direct current system) into mechanical energy.DC shunt motor because of their self regulating capabilities, ideal for application where precise speed control is required. It used due to their simplicity, ease of application, reliability and favorable cost have long been a backbone of industrial application. The DC shunt motors are used in various applications such as defense, industries, Robotics likes Lathe machines, centrifugal pumps, fans, blowers, conveyors, spinning machines etc.

The methods of speed control of DC motors are Normally simpler and less expensive than that of ac Drives. Due to the commentators, dc motors are not Suitable for very high speed applications and require More maintenance than ac motors. PLC output provide a variable dc output voltage , whereas choppers can provide a variable dc voltage from a fixed dc voltage. Due to their ability to supply a continuously variable dc voltage, controlled rectifiers and dc choppers made a revolution in modern industrial control equipment and variable speed drives. Many industrial drives and processes take power from dc voltage sources. In most cases, conversion of the dc source voltage to different levels is required. For example, subway cars, trolley buses, or battery-operated vehicles take power from a fixed dc source.

However, their speed control requires conversion of a fixed voltage dc source to a variable voltage dc source for the armature of the dc motor.

PLC is widely used to control industrial processes and different environmental conditions. Moreover, availability of PLC and its basic features such as mathematical operations and improving graphical user in programming and communications makes it ready to be used in motor speed control systems. Therefore, in this paper, using fuzzy logic method based on PLC, a DC motor speed control system is designed and llustrated. The server-side software has been developed with no deside connectivity along within formation visualization and decision support features. A novel algorithm has been developed for soil-moisture prediction, which is based on Machine Learning techniques applied on the sensor node data and the weather forecast data. The algorithm show simproved accuracy and less error. The proposed approach could help in making effective irrigation decisions with optimum water usage.

1.1 DC Motor Model

Direct current (DC) motors convert electrical energy into mechanical energy through the interaction of two magnetic fields. One field is produced by a magnet of poles assembly, the other field is produced by an electrical current flowing in the motor windings. These two fields result in a torque which tends to rotate the rotor.

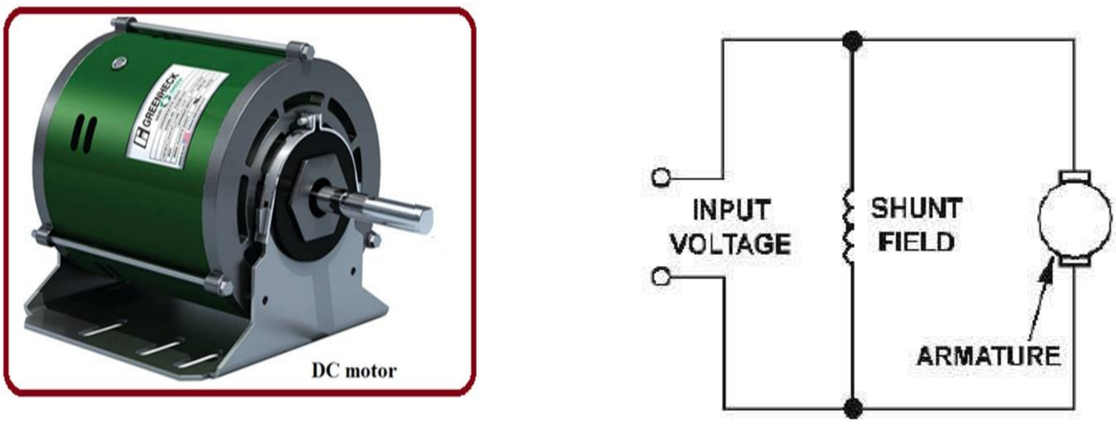

Fig1. DC Shunt Motor

- **Speed Control Of DC Motor**
  Speed control means intentional change of the drive speed to a value required for performing the specific work process.

$$N = \frac{V_a - I_a Ra}{\varphi}$$

It is obvious that speed can be control by varying

- Change Terminal voltage
- Change of armature resistance
- Change of flux

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II. SYSTEM DESCRIPTION

The given system comprises of a Simatic S7-1200 PLC, a dc motor, a rectifier circuit & a tachogenerator. The PLC consists of 2 input modules namely the main supply and feedback from the motor, and one output module namely the PWM output which goes to the Gate terminal of IGBT to control the duty cycle. The hardware implementation of speed control consist the motor driver circuit PLC software and DC motor which speed we are going to control.

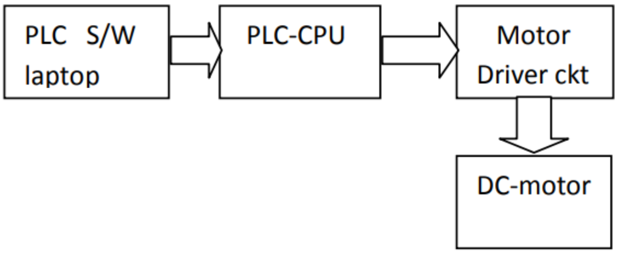
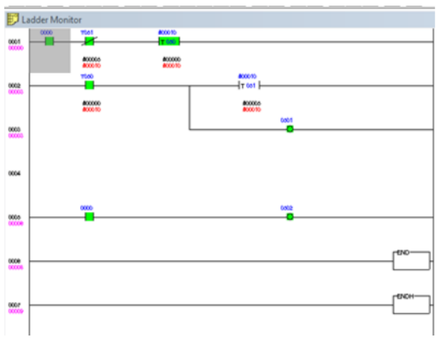


Fig: Block diagram for speed control

2.1 PLC :

A programmable logic controller, commonly known as PLC, is a solid state, digital, industrial computer using integrated circuits instead of electromechanical devices to implement control functions. It was invented in order to replace the sequential circuits which were mainly used for machine control. They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation and communication, to control machines and processes. Here we are using the simens S7-1200 the ladder logic which generate the PWM wave which is as shown below.

2.2 Ladder diagram:



In ladder logic we have used two timer timer1 and timer2, timer1 for active low and timer2 for active high.

2.3 Working:

PLC is an important part of industrial systems. We used PLC to control motor speed. At first, then PLC according to the program generate the control signal to reach the desired speed. The analog signal from the motor driver circuit is transmitted to the motor. According to the received control signal, drive transfer required voltage to the motor. Every moment by tachometer measures motor speed at any moment and produces signals for having optimum speed in the shortest time and low steady state error and low overshoot in stable state. Speed control of a motor means the intentional variation of speed according to requirement of the workload connected with the motor. .However control of speed by electrical means has greater advantages over mechanical speed controls. The dc motors offer easy speed control and that's why dc motors are preferred over other types of motors in many applications. Various speed control method can be obtained.

III . METHODOLOGY

Speed control of an engine implies the deliberate variety of speed as indicated by the necessity of the responsibility associated with the engine. This should be possible by mechanical methods, for example, by utilizing ventured pulleys, a bunch of switch gears ,a rubbing grasp component, and so forth Anyway control of speed by electrical methods enjoys more prominent upper hands over mechanical speed controls. The dc engines offer simple speed control and that is the reason dc engines are liked over different sorts of engines in numerous applications. Different speed control technique can be gotten from its demeanor which is:-

N=V - IaRa/K

Where:- N=speed of motor
Ia=armature current
Ra=armature resistance
Φ=field flux
So it can be concluded that speed of dc motor depends upon
a. The applied voltage
b. The field flux
c. Drop in armature circuit resistance Ia Ra
And accordingly speed can be controlled by varying the above factors.

3.1 Proposed System (Linear Quadratic Regulator)

Linear quadratic regulator design technique is well known in modern optimal control theory and has been widely used in many applications. Under the assumption that all state variables are available for feedback, the LQR controller design method starts with a defined set of states which are to be controlled. In general, the system model can be written in state space equation as follows :

$$\dot{x} = Ax + Bu$$

The minimization of it is just the means to the end of achieving acceptable performance of the system. For the design of a linear quadratic regulator controller, the performance index (J) is given by

$$J = \int_0^\infty (x^T Q x + u^T R u) dt$$

Where Q is symmetric positive semi definite (≥0) state weighting matrix of order nXn, and R is symmetric positive definite (> 0) control weighting matrix of order mXm. The choice of the element Q and R allows the relative weighting of individual state variables and individual control inputs as well as relative weighting state vector and control vector against each other.

3.2 Speed Controlof DC Motor Using Linear Quadratic Regulator

The flow chart in Figure shows. The mathematical modeling is doing to find the mathematical model for the DC motor where we will get the state-space model.

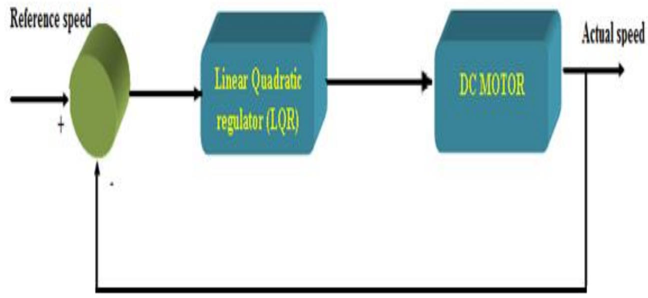
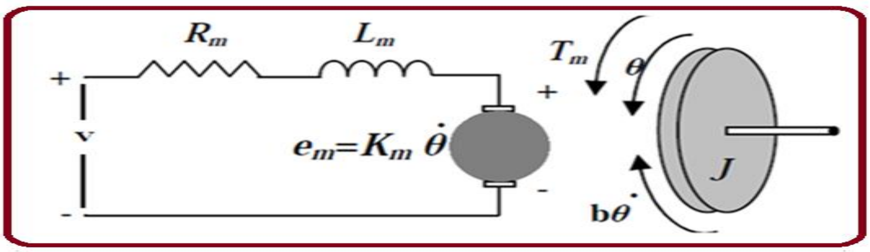


Fig.2 Block diagram DC motor control system used by LQR Controller.

This followed by getting the LQR controller from the state-space model. The simulink result by using LQR controller Show the fig , the Flow chart of Linear-Quadratic Regulator (LQR) with speed analysis of DC motor .

3.3 **Modeling of DC Motor**



The mathematical model and electrical and mechanical equations of the DC motor, as shown in figure.

$$\frac{d\,i_a}{dt} = -\frac{R_a}{L_a}\dot{i}_a - \frac{K_b}{L_a}\dot{\theta} + \frac{V_a}{L_a}$$

$$\frac{d\theta}{dt} = \frac{K_T}{J}\dot{i}_a - \frac{Bm}{J}\dot{\theta}$$

From above equation,

$$\begin{bmatrix} \frac{di_a}{dt} \\ \frac{d\theta}{dt} \end{bmatrix} = \begin{bmatrix} \frac{-R_a}{L_a} & \frac{-K_b}{L_a} \\ \frac{K_T}{J} & \frac{-Bm}{J} \end{bmatrix} \begin{bmatrix} i_a \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \frac{1}{L_a} \\ 0 \end{bmatrix} [V_a]$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} i_a \\ \dot{\theta} \end{bmatrix}$$

3.4 **Design Of Linear Quadratic Regulator for speed control DC Motor**

The linear quadratic regulator (LQR) is a well-known design technique that provides practical feedback gains. For the derivation of the linear quadratic regulator, assume that the plant to be written in state-space form as :

$$\dot{x} = Ax + Bu$$

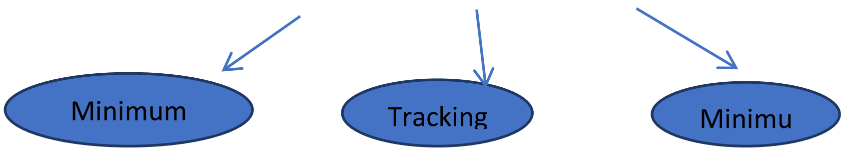
And that all of the n states x are available for the controller. The feedback gain is a matrix K of the optimal control vector.

$$u(t) = -Kx(t)$$

So as to minimize the performance index.

For the design of a linear quadratic regulator controller, performance index (cost function) used to find four objectives. The performance index (J) is given by

$$J = \int_0^\infty (x^T Q x + u^T R u) dt$$



Where, R is positive definite matrix
Q is positive semi-definite matrix

There are two main equations which have to be calculated to achieve the feedback gain matrix K. Where P is a symmetric and positive definite matrix obtained by solution of the ARE is defined as:

$$A^T P + PA - PBR^{-1}B^T P + Q = 0$$

The above equation is called Algebraic Riccati EquationWhere A,B are basic Matrix and Q is positive semi-definite matrix.Where P is symmetric matrix.
There are two main equations which have to be calculated to achieve the feedback gain matrix K. Where P is a symmetric and positive definite matrix obtained by solution of the ARE is defined as:

$$\dot{x} = Ax - BKx = (A - BK)x$$

LQR is a method in modern control theory that used state-space approach to analyses such a system. Using state space methods it is relatively simple to work with Multi- Input Multi-Output (MIMO) system. Linear- Quadratic Regulator (LQR) optimal control problems have been widely investigated in the literature.

3.5 Application

DC motors are widely used in industrial applications, robot manipulators and home appliances, because of their high reliability, flexibility and low cost, where speed and position control of motor.There are many applications of DC motors, where we need a variable speed of DC motor. For example, it has applications in electric cars, trucks, and aircraft. These are three examples where we need variable speed.

IV. RESULT

The main parts of the plan include DC motor, PLC controller and PWM driver. PWM driver acts as an interface between DC motor and PLC. PLC is equipped with the digital and analog input-output modules. PLC- based controller provides a signal for PWM driver which is dependent on variables such as error, change in error, and fuzzy rules. We

take the e and ce as the antecedent part of the suggested FLS to generate the duty ratio control signal then pass it to PWM for accomplishing fuzzy PWM control signal. The duty ratio is the consequent part of the suggested FLS.
In figure, using PLC, the speed control system response curve of DC motor at a speed of 1750 rpm is shown for different load conditions. Table 4 also compares the performance of he controller for the load torque of 50, 30 and 10 N.m respectively.

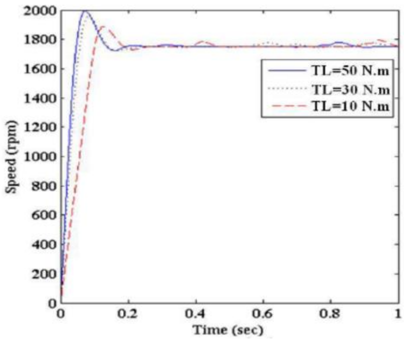


Fig3. The velocity response curves with TL=50, 30 and 10 N.m

V. CONCLUSION

DC engine can be controlled either by programming or straightforwardly by equipment. Programming controlling requirements PCs which are cumbersome and everyday person can't bear for it, so equipment controls are being used. This Dissertation needs to build up the DC engine regulator utilizing Linear Quadratic Regulator (LQR) To make the engine work. Besides, the reproduction results so got show that the LQR regulator gives most noteworthy worth of percent overshoot and longer settling time. The outcome is a control that is destined to be steady. Straight quadratic controller is the best regulator since it directs the mistake to nothing and it doesn't have level of overshoot and time settling. So it can balance out the framework speedier better than Fuzzy regulator since it has Fast variation ,Smoot activity, Reduce the impact of Non-linearity, Learning capacity , Easily plan.

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