IJIREEICE

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

ISO 3297:2007 Certified

Vol. 5, Issue 3, March 2017

# Modelling and Simulation of Speed Control of DC Shunt Motor using PID Controller

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**Abstract:** This paper represent simulation of constant speed dc motor using MOSFET.A review study of importance of proportional integral derivative (PID) controller for speed control of dc motor is done. Many industrial applications require high performance rotating electric drives. A proposed DC drive have a precise speed control, stable operation in complete range of speed and good transient behavior with smooth and stepless control. The purpose of developing a simulation using PID control system is to get steady state and transient response of drive system. Once the type of controller has been decided then the design and analysis are done. Design of PID parameters is important because these parameters have a great impact on the performance of control system. This paper design PID controller to supervise and control the speed response of the dc motor and MATLAB program is used for simulation of PID controllers.

**Keyword:** DC shunt motor, modeling, simulation, PID controller.

## I. INTRODUCTION

The DC motors have been popular in the industry control area for a long time, because they have many good characteristics, for example: high start torque characteristic, high response performance, easier to be linear control etc. The speed of a DC motor is given be the relationship,

$$N=\frac{V-IaRa}{k\phi}$$

This Equation show that the speed is dependent on the supply voltage V, the armature circuit resistance Ra, and field flux Φ, which is produced by the field current. This paper describes the MATLAB/ SIMULINK of the DC motor speed control method namely field resistance, armature voltage, armature resistance control method and feedback control system for DC motor drives [4].When speed control over a wide range is required, combination of armature voltage control and field flux control is used.

This combination permits the ratio of maximum to minimum speed to be 20 to 40. With closed loop control, this range can be extended up to 200.The parameters of the PID controller kp, ki and kd (or kp, Ti and Td) can be manipulated to produce various response curves from a given process as we will see later.

## II. DC MOTOR MODELLING

DC shunt motor is operated on direct current. As such, the field winding and armature are connected in parallel combination, and in electrical terminology a parallel combination is known as shunt. This type of motor is "shunt- wound". DC motor and the type of winding is called a shunt winding.

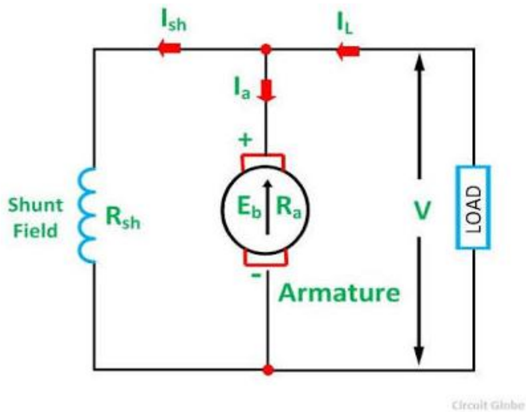


Fig.1 DC Motor

**VOLTAGE AND CURRENT EQUATION OF DC SHUNT MOTOR-**

Consider the voltage and current being supplied from the electrical terminal to the motor be given by E and I total respectively. This supply current in case of DC shunt motor is split up into two parts. Ia flowing through the armature winding of resistance Ra and Ish flowing through the field winding of resistance Rsh. The voltage across both winding remains the same .From there we can write Itotal = Ia+ Ish.

**CHARACTERISTICS OF DC SHUNT MOTOR**

1. Ta/IaCharacteristics-

Assuming ϕ to be practically constant (though at heavy loads, ϕ decreases somewhat due to increased armature reaction) we find that Ta directly proportional to Ia. Hence, the electrical characteristics as shown in above figure.2. is practically a straight line through the origin.

 DOI 10.17148/IJIREEICE.2017.5309 

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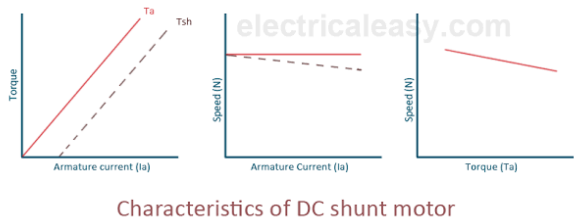


Fig.2 Characteristics Of DC Shunt Motor

Shaft torque is shown by dotted line. Since a heavy starting load will need a heavy starting current, shunt motor should never be started on heavy load.

2. N/Ia Characteristics-
If ϕ is assumed constant, then N is directly proportional to Eb. As Eb is also practically constant, speed is, for most purpose, constant as shown in figure 2. But strictly speaking, both Eb and ϕ decrease with increase in load. However, Eb decreases slightly more than ϕ so that on the whole, there is some decrease in the speed. The drop varies from 5 to 15% of full-load speed, be in dependent on saturation, armature reaction and brush position. Hence, the actual speed curve is slightly dropping as shown by the dotted line in figure 2. But, for all practical purposes, shunt motor is taken as constant speed motor.
Because there is a no appreciable change in the speed of shunt motor from no- load to full-load, it may be connected to loads which are totally and suddenly thrown off without any fear of excessive speed resulting.

3. N/Ta Characteristics-
From the above two characteristics the N/Ta characteristics is drawn in figure 2.

## III. CONTROL SYSTEM DESIGN

Types of controller-
1.Proportional control-In proportional controller it examines the magnitude of the error and it reacts proportionally. A larger error receives larger response and a small error receives small response. In mathematical term the proportional term (Pout) express as,

$$Pout= Kp^{*}.e$$

Where,
Pout= Proportional portion of controller output
Kp= Proportional gain
e = Error signal
e = Set point-Process variable

2.Integral control-The integral type of controller overcomes the offset, integral control attempts to correct to small error (offset).Integral examines the error overtime and increase the importance of even small error multiplied by time. The error has persisted a small error at time zero has zero important. Integral can also be adjusted and adjustment is called the reset rate. Reset rate is time factor. The shorter the reset rate, the quicker the correction of an error. In hardware based system the adjustment can be done by potentiometer changing the time constant of RC circuit. Most of the today's application use software based control given as,
$Iout=1/Ti \int e\, dt = Ki \int e\, dt$
Where,
Iout: Integral portion of controller output
Ti: Integral time, or reset time
Ki: Integral gain
e = Error signal
e = Set-point-Process Variable

3. Derivative control-The derivative controller gives the control output with the rate of change in the error signal. Derivative will cause a greater system response to a rapid rate of change than to a small rate of change. In other words, if a system's error continues to rise, the controller must not be responding with sufficient correction. Derivative senses this rate of change in the error and provides a greater response. Derivative is adjusted as a time factor and therefore is also called rate time. It is essential that too much derivativeshould not be applied or it can cause overshoot or erratic control. In mathematical term, the derivative term (Dout) is expressed as:
$Dout = Td.d/dt.e= Kd.d/dt.e$
Where,
Dout: Derivative portion of controller output
Td: Derivative time
Kd: Derivative gain
e = Error signal
e = Set-point-Process Variable
To design steady state system and improve step response of the PID controller prpper tunning constant have to be done.

i. Kp improved the rise time.
ii. Kd improved the overshoot.
iii. Ki eliminates the steady state error.

Table 1 Effect of Increasing Parameters

| Param eters | Rise Time | Overshoot | Settling Time | Steady State Error |
|---|---|---|---|---|
| Kp | Decrease | Increase | Small Change | Decrease |
| Ki | Decrease | Increase | Increase | Eliminate |
| Kd | Small Change | Decrease | Decrease | Small Change |

## IV. SOFTWARE USED

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problem and solutions are expressed in familiar mathematical notation. Typical uses include Math and computation Algorithm development Data acquisition

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ISSN (Print) 2321 – 5526

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Electrical, Electronics, Instrumentation and Control Engineering
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Modelling, simulation, and prototyping Data analysis, exploitation, and visualization Scientific and engineering graphics Application development, including graphical user interface building. The name MATLAB stands for Matrix Laboratory. MATLAB was originally written to provide easy access to matrix software developed by linpack and eispack projects. Today, MATLAB engines incorporate thelapack and blas libraries, embedded the state of the art in software for matrix computation.

**LIBIRARY OF COMPONENT AVAILABLE IN SIMPOWER SYSTEM-**

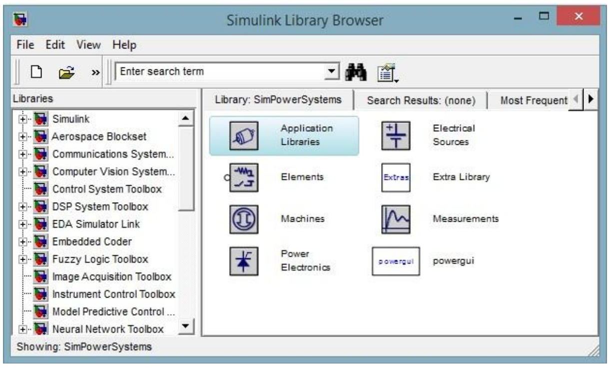

Fig. 4 Simulink Library Browser

**STARTING SIMULINK -**
Simulink is started from the MATLAB command,hit the New Simulink Model button at the top of the MATLAB command window as shown below.

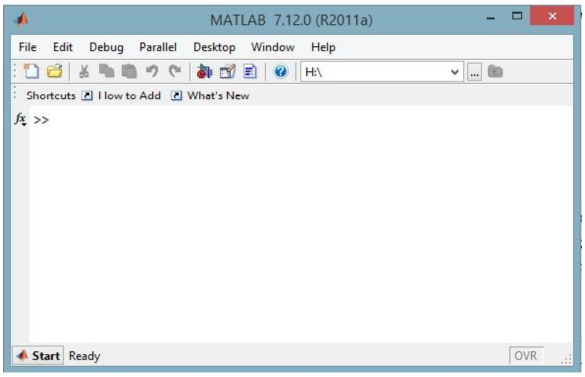

Fig 5. Command Window InMATLAB

When it starts, Simulink brings up two windows. The first is the main simulink windows which appears as,

In Simulink, a model is a collection of blocks which, in general, represents a system. In addition, to drawing a model into a blank model window, previously saved model files can be loaded either from the File menu or from the MATLAB command prompt. As an example, saving the file in the directory we are running MATLAB from Simple.mdl. Open this file in Simulink by entering the following command in the MATLAB command window.(Alternatively, we can use this file the open option in the File menu in Simulink, or by hitting Ctrl+O in Simulink.).

Fig 6 Simulink Library Browser

## V. MATLAB REPRESENTATION

By implementing simulation model in MATLAB simulink the response of PID controller is as shown and output waveform is-

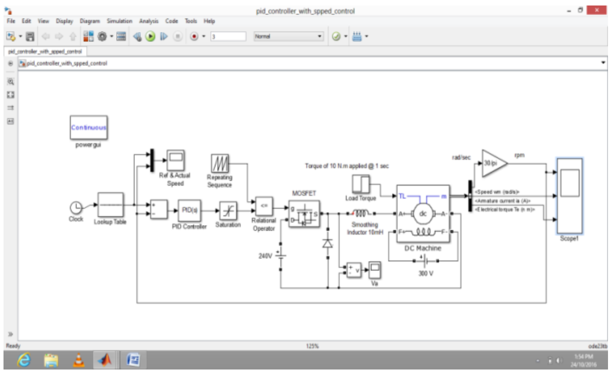

Fig.7Simulink Block Diagram

**DESCRIPTION OF MATLAB BLOCKS**

**1. DC Machine**
The DC machine block implements a wound-field or permanent magnet DC machine. For the wound-field DC machine, access is provided to the field terminals (F+,F-) so that the machine model can be used as a shunt-connected or a series- connected DC machine. The torque applied to the shaft is provided at the Simulink input TL.The armature circuit (A+,A-) consist of an inductor La and resistor Ra in series with a counter electromotive force(CEMF) E.

**2. MOSFET**
The metal oxide semiconductor field effect transistor (MOSFET) is semiconductor device conductor controllable by the gate signal (g>0). The MOSFET device is connected in parallel with an internal diode that turns on when the MOSFET device is reversed bias (vds<0) and no gate signal is applied (g=0). The model is simulated by an

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ideal switch controlled by a logical signal (g>0 or g=o), with a diode connected in parallel.

The MOSFET device turns positive signal is on when applied at thr gate input (g>0) whether the drain source voltage is positive or negative. If no signal is applied at the gate input (g=0), only the internal diode conducts when voltage exceeds its forward voltage vf. With a positive or negative current flowing through the device the MOSFET turns off when the gate input becomes zero. The current I is negative and flowing in the internal diode (no gate signal or g=0), the switch turns off when the current I becomes zero.

**3. Clock**

The clock block output the current simulation time at each simulation step. This block is useful for other blocks that need the simulation time. When you need the current time within a discrete system use the Digital clock block

**4. PID Controller**

Implement a continuous or a discrete time controller (PID,PI, PD, P, OR I) in Simulink model. PID controller gains are tunable either manually or automatically tuning requires Simulink control design software.

The controller block output is a weighted sum of the input signal, the integral the input signal, and the derivative of the input signal. The weights are the proportional, integral, and derivative gain parameters. A first-order pole filters are derivative action.

Configurable option in the PID Controller block include:

1. Controller type (PID, PI, PD, P, OR I)
2. Controller form (parallel or ideal)
3. Time domain (continuous or discrete)
4. Initial comditions and reset trigger
5. Output saturation limits and built-in-wind up mechanism
6. Signal tracking for bumpless control transfer and multi loop control.

**5. Powergui**

The powergui blocks to choose one of these methods to solve your circuit:

1. Continuous, which uses a variable step solver from Simulink
2. Ideal switching continuous
3. Discretization of the electrical system for a solution at fixed time steps
4. Phasor solution

The powergui block also opens tools for steady state and simulation results analysis and for advanced parameter design.

You can use multiple powergui blocks in a system that contains two or more independent electrical circuits that you want to simulate with different powergui solvers.

When you use more than one powergui block in model:

1. Do not place a powergui block in the top-level diagram.
2. Place every independent model in a different subsystem.
3. Place a single powergui block in the top level diagram of every subsystem.

**6. Scope**

The simulink scope block displays time domain signals with respect to simulation time.

Scope display features:

1. Simulation control-debug models from a scope window using run, step forward, and step backward toolbar buttons.
2. Multiple signal-Plot multiple signals on the same y-axis (display) using multiple input ports.
3. Multiple y-axes- display multiple y-axes all of the y-axes have a common time range on the x-axis.
4. Modify parameters-modify scope parameter values before and during a simulation.
5. Axis autoscaling —during or at the end of a simulation. Margins are drawn at the top and bottom of the axes.
6. Display data after simulation-if a scope is closed at the start of a simulation, scope data is still written to the scope during a simulation. As a result, if you open the scope after a simulation, the scope displays simulation results for attached input signals.

Output waveform for the response of the PID controller-

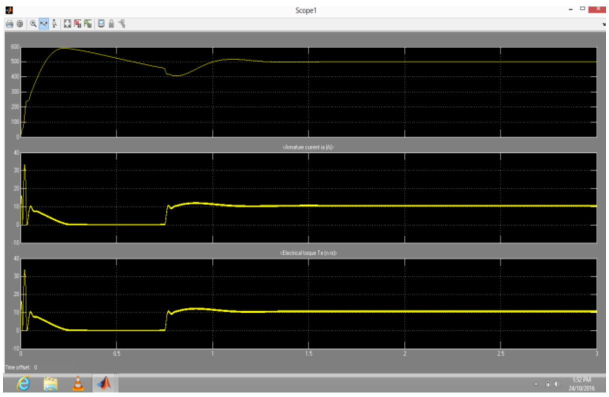

Fig. 8 Simulink Result

## VI. CONCLUSION

Accurate performance of a motor is desired feature for any industrial application. As the age of motor increases its performance also deceases with aging, so it is desired to evaluate the performance of motor from time to time for efficient operation. A proportional controller Kp will have the effect of reducing the rise time and reduce but never eliminate the steady state error. An internal controller Ki will have the effect of eliminate the steady state error but it may make the transient response worse. A derivative

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controller Kd will have the effect of increasing the stability of the system and reducing the overshoot and improve the transient response. MATLAB used for simulation of entire project is sophisticated and user friendly software. It must be mentioned that the efficiency of the speed algorithm can be improved by using more efficient learning techniques and dynamic weight selection algorithm.

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DOI 10.17148/IJIREEICE.2017.5309