EEL3040

Control System

Lab-2 Report

By-B22EE024

Dhyey Findoriya

Contents

1. Objective

(a) **Aim:** Modeling of P-controller based d.c. motor in Simulink using state space model (using differential equations) and transfer functions based model.

(b) **Software:** Matlab-Simulink.

(c) **Theory:** This experiment will illustrate the modeling and design of separately excited d.c. motor using state space model and transfer function block diagram. Thereafter, a P-controller will be designed to control the speed of the motor.

2. Modeling and Design of D.C. Motor

(a) State Space Variables

$$\frac{d\omega}{dt} = \frac{1}{J}(K_t i - \omega) \tag{1}$$

$$\frac{di}{dt} = \frac{1}{L}(V - Ri - K_e\omega) \tag{2}$$

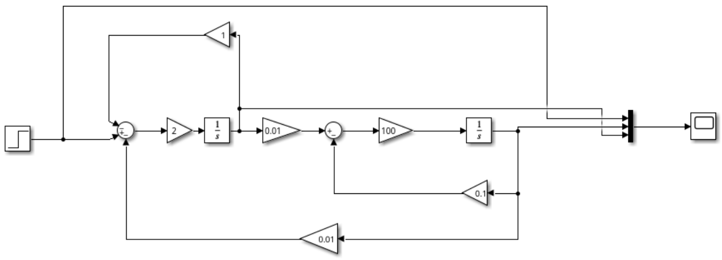
$$\frac{d\theta}{dt} = \omega \tag{3}$$

(b) Designing Mathematical Model of D.C. Motor using State Space Variables

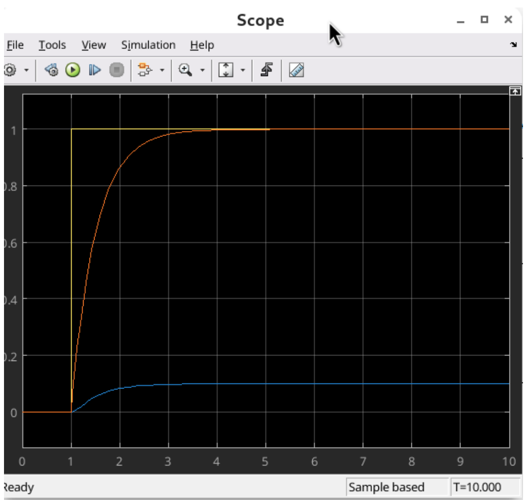
- ω = speed
- θ = rotation angle
- i = armature current
- R = armature resistor
- L = inductance of armature coil
- J = Moment of inertia

- b = Friction constant
- K_e = Back-emf proportion constant
- K_t = Torque constant
- V = Input voltage

In the diagram given below I have used 2 integrators and some adders for our purpose. In **MUX** we are observing the input voltage, Revolutions, and current via MUX for combined input. The Gain blocks used are constant values which we need to multiply to variables to get our desired results.



(c) Scope Diagram



Nomenclature for Scope Diagram:

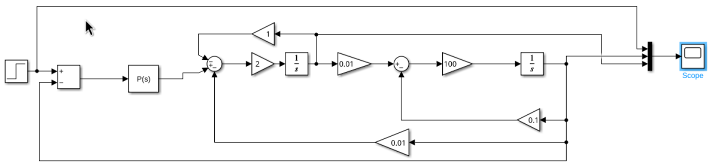
- Orange - ω (Speed)
- Yellow - Input Voltage
- Blue - Current

3. Feedback Control System

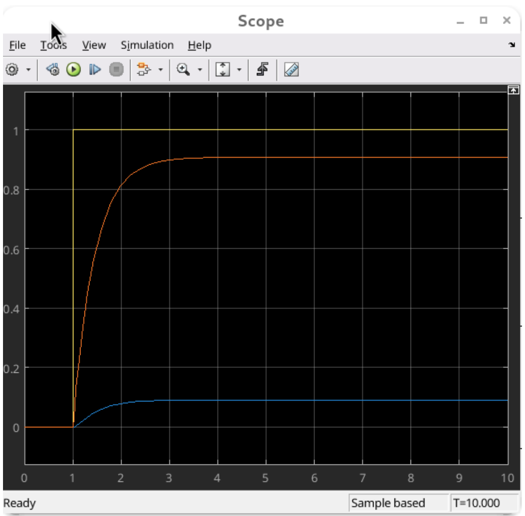
(a) Mathematical Model

Now, our motive is to control the speed of the motor using P-controller. For controlling speed (ω) of the motor, we will use a proportional controller. P controller regulates a constant gain say K_p in a feedback control system.

This gain regulates the speed error, $e_\omega = \omega_{desired} - \omega$. The speed error passes from the P-controller and becomes the input voltage, v. The final Simulink model of the DC motor with the proportional controller is:



(a) Scope Diagram



4. Linear Dynamic Model of DC-DC Boost [Post Lab Work]

(a) Mathematical Model

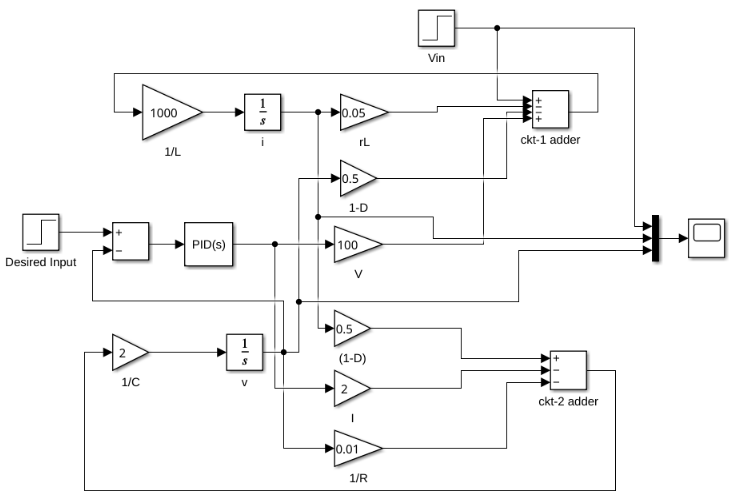
The mathematical model of the DC-DC boost converter can be described by the following differential equations:

$$\frac{di}{dt} = \frac{1}{L}\left(V_{in} - i \cdot r_L - (1-D)\cdot V + D \cdot V\right) \tag{4}$$

$$\frac{dv}{dt} = \frac{1}{C}\left((1-D)\cdot i - D \cdot i - \frac{V}{R}\right) \tag{5}$$

Parameters and Values

Parameter	Value
V_{in}	50 V
L	1 mH
C	500 mF
R	100 Ohms
r_L	0.05 Ohms
V	100 V
D (Duty Cycle)	0.5
I	$\frac{V}{R(1-D)} = 2$



As we have two equations in hand, I made both equation diagrams differently and combined them, and reused them in other diagrams as per equation demand. The gain blocks are inserted with already calculated values which can also be seen in the Simulink diagram as above.

(a) **Scope Diagram**