[redacted]

Given the following machine parameters of a permanent magnet dc motor, design the needed controller according to the steps and criteria stated in this project.

Table 1: DC Motor Parameters

Motor Parameter	Value
k_E	**0.0772** V/rad/s
k_T	**0.067** Nm/A
R_a	**0.7454** Ω
L_a	**4.8** mH
J_{eq}	**6.87x10**$^{-5}$ Nm/rad/s^2
B	**0.0003** Nm/(rad/s)
$T_{friction}$	**0. 0756** Nm
K*pwm*	**42**
V_d	**42V**
$w_{m,rated}$	**418**rad/s (or **4000**rpm)
i_{rated}	**5A**

Design a cascaded controller to control the speed of this dc motor that meets the following criteria:

a. **Maximum overshoot for speed is within 20%**
b. **The settling time is less than 1 second**
c. **Steady state error for speed = 0**
d. **The speed controller has a current limit output I_a^* of $\pm$ 5 A**
e. **The control voltage output v_a from the current controller has a limit of $\pm$ 42V.**

Design Steps:

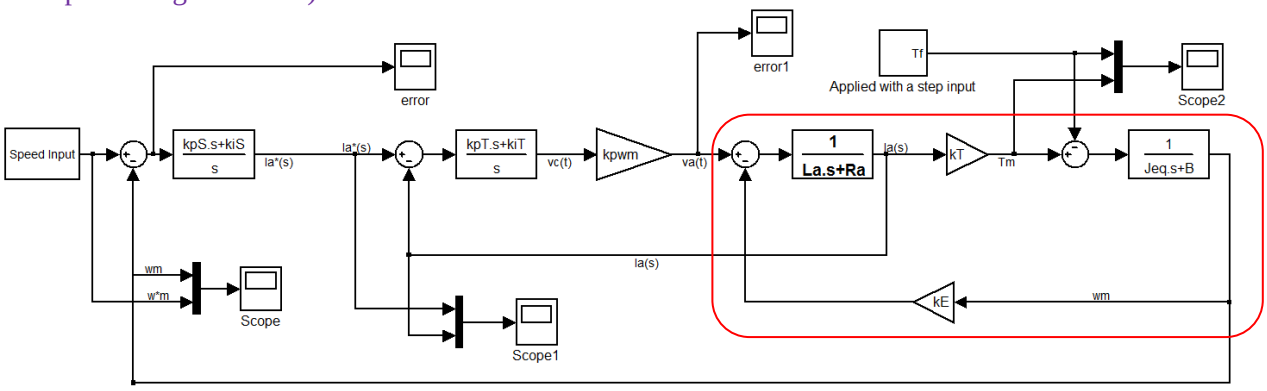
1. Design a torque (current) controller as the inner loop controller.
2. Design a speed controller as the outer loop controller.
3. Verify and validate your design with MATLAB/Simulink simulation against the criteria.
4. You may test the response of the controller by giving a step change in speed from 200 rad/s to 400 rad/s.

The final project format is given in the file: Final Project Submission Instruction. In the Section: Theoretical/Simulated/Calculated Data & Discussions, please include:

- Brief description of the cascaded controller design
- The description of your model block by block.
- The final simulation results including speed (reference and real), armature current (reference and real), and the input armature voltage of the motor.

The following page provides some hints about the project:

1. The block diagram of the project is shown as the following (the part enclosed by the red frame is representing the motor)



2. The m file providing the initial values is as the following

```
clear all;
clc;

kE=0.0772;
kT=0.067;
Ra=0.7454;
La=4.8e-3;
Jeq=6.87e-5;
Tf=0.0756;
kpwm=42;
B=3e-4;
tau=La/Ra;
Ga=1/Ra;
```

Note the controller tuning parameters have the following ranges:

```
kiT=[10 40]
kpT=[0 2]

kiS=[0 0.1]
kpS= [0 0.1]
```