UNIVERSITY OF RUHUNA

FACULTY OF ENGINEERING

Department of Electrical & Information Engineering,

EE5351: Control System Design

Laboratory Session-1

The Quanser QUBEServo3® is a direct drive rotary servo system. Its motor armature circuit schematic is shown in Figure 1.1 and the electrical and mechanical parameters are given in Table 1.1.

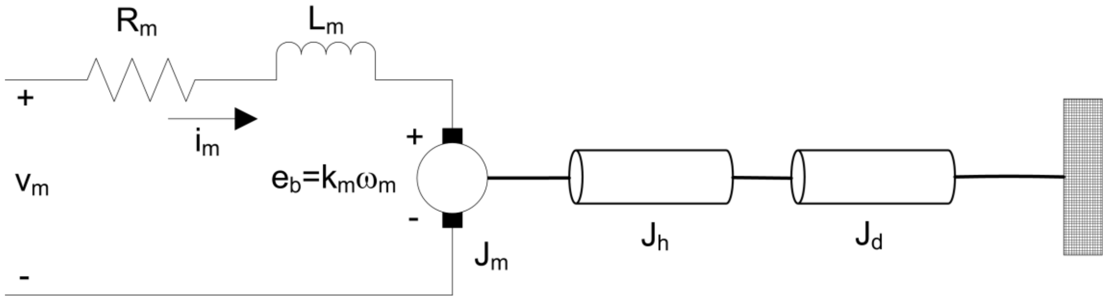

Figure 1.1: QUBEServo3® DC motor and load

The DC motor shaft is connected to the load hub. The hub is a metal disk used to mount the disk and has a moment of inertia of $\mathbf{J_h}$. A disk load is attached to the output shaft with a moment of inertia of $\mathbf{J_d}$.

Table 1.1 QUBEServo3® System Parameters

Terminal Resistance ($\mathbf{R_m}$)	8.4 Ω
Rotor inductance ($\mathbf{L_m}$)	1.16 mH
Equivalent rotor inertia ($\mathbf{J_{eq}}$)	$2.09\text{x}10^{-5}$ kgm^2
Torque constant ($\mathbf{k_t}$)	0.042 Nm/A
Voltage constant ($\mathbf{k_m}$)	0.042 Nm/A

Q1) You are required to obtain the transfer function of the DC motor and load.

i) Write the dynamic equations of the DC motor and load.

ii) Obtain the transfer function of the DC motor and load for speed control [$\omega_m(s)/V_m(s)$] and position control [$\theta_m(s)/V_m(s)$] separately.

iii) Obtain the time domain speed response for applied input voltage of 3V using MATLAB® and Simulink® separately.

iv) Due to the negligible rotor inductance, obtain the simplified transfer functions of the transfer functions obtained in part (ii).

v) Model the simplified transfer function in Simulink® as a block diagram.

vi) Obtain the state space model of the DC motor and load by taking armature current (i_m) and rotor speed ($\boldsymbol{\omega_m}$) as state variables.

vii) Obtain the simplified state space model of the DC motor and load by taking rotor position ($\boldsymbol{\theta_m}$) and rotor speed ($\boldsymbol{\omega_m}$) as state variables.

viii) Using Simulink®, plot the time domain speed responses related to the transfer functions/ block diagrams obtained in part (ii), (iv), (v), (vi) and (vii) in a single plot for applied input voltage of 3V.

Q2) Consider the Simulink® model named as "QUBEServo3_DCM_Speed.mdl" given in LMS.

i) Obtain the time domain speed response for applied input voltage of 3V.

ii) Compare and contrast the results obtained in Q1 part (vi) and Q2 part (i).

Q3) Consider the Simulink® model named as "QUBEServo3_DCM_Position.mdl" given in LMS.

i) Modify the model as a unity feedback system with a reference input ($\boldsymbol{\theta_d}$) of 1 rad. Add a gain block with unity gain ($\mathbf{k_p}$=1).

ii) Calculate the steady state error of the position control system.

iii) Increase the proportional gain ($\mathbf{k_p}$) from 1 to 2 in the step of 0.25 and calculate the steady state error and the system overshoot for each k_p value.

Note:

- Students are supposed to include comments in the MATLAB scripts.
- Answers should be prepared in MS word document.
- All MATLAB commands typed, results obtained in the MATLAB command window, MATLAB .m files and SIMULINK models should be copied to your document and to a zipped folder. Graphs should be with titles, axis labeled and gridlines.