UNIVERSITY OF MORATUWA

Faculty of Engineering

Department of Electronic & Telecommunication Engineering

B.Sc. Engineering

Semester 4 Examination

EN 2142 – ELECTRONIC CONTROL SYSTEMS

Time Allowed: 2 hours | November 2011

INSTRUCTIONS TO CANDIDATES

1. This paper contains **SIX (06)** questions on **FOUR (04)** pages.
2. This examination accounts for **80%** of the module assessment. The marks assigned for each question and sections are included in square brackets.
3. This is an **OPEN** book examination. You are allowed to use **ONLY/ANY** written **AND/OR** printed material
4. Time allowed is 2 hours
5. Answer **ANY FIVE (05)** questions

1 a A motor cycle shock-absorber is shown in Fig. 1 [6]

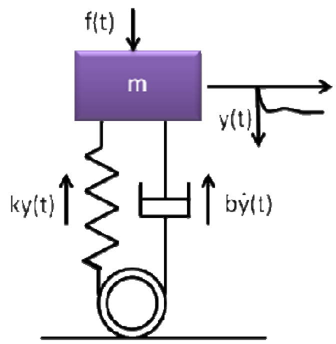

Fig. 1

where k and b are spring constant and daming coefficient. Draw the free-body diagram and derive the ordinary differential equation of the shock-absorber dynamic model

b Derive the transfer function G(s)=Y(s)/F(s) of the shock-absorber, where Y(s) and F(s) are the Laplace transforms of response y(t) and external force f(t). [8]

c Determine the characteristic equation of the shock-absorber for k=175N/cm, b=600Ns/cm, and m=75kg, and determine the poles of the shock-absorber model. [6]

2 a A feedback control system through a single feedback gain is shown IN Fig. 2 [6]

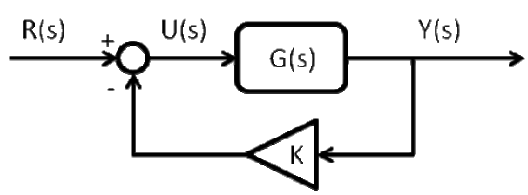

Fig. 2

Derive the closed loop transfer function and show that closed loop poles can be positioned using feedback gain K.

b For $G(s)=3/(s^2+4s+3)$ determine the value of K for closed loop system to be critically damped [6]

c Show that an additional gain of K+1 is needed to maintain zero steady state error. [8]

3 a A robot arm open loop control system is shown in Fig. 3. [6]

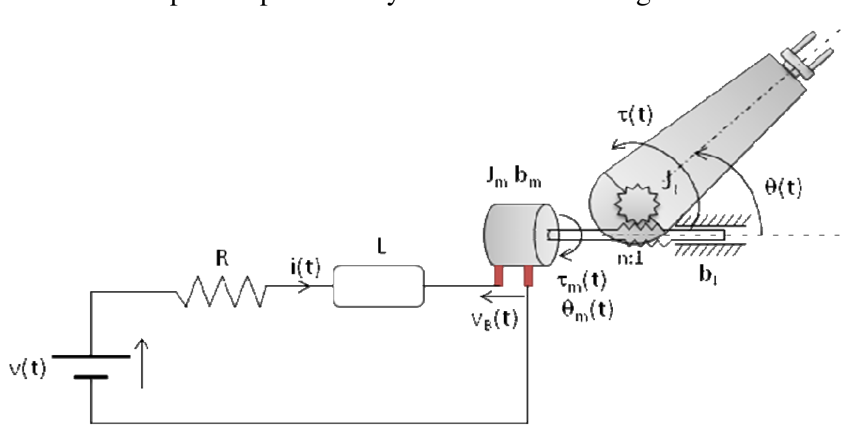

Fig. 3

Draw the unity gain negative feedback control block diagram and determine the closed loop transfer function of the robot arm.

b Determine the closed loop transfer function assuming following parameters: [8]
$L = 0.062H$, $R = 2.5\Omega$, $n = 20$, $k_\tau = 0.026$ Nm/A, $k_B = 0.02$ Vs/rad, $J_{eq} = 0.00004$ kg/m2, $b_{eq} = 0.001$ Nms/rad.

c Determine the steady state error of the robot arm for unit step input. [6]

4 a Root locus design method is used to locate poles at desired locations. However, it is not possible to locate poles arbitrarily. Explain this statement giving reasons. [4]

b Derive the gain and phase conditions of the root locus design method. [4]

c For the open loop plant $G(s)=1/(s+3)(s^2+6s+20)$, determine the followings: [8]
   i. parts of the root locus on the real axis
   ii. asymptote angles
   iii. asymptote intersection point

and sketch the root locus.

d Determine the maximum stable feedback gain using Routh array method. [4]

5 a A second order control system is given by the transfer function [5]
$G(s)=24/(s^2+3s+43)$. Determine the natural undammed frequency ω_n and damping ratio ζ .

b Determine the followings for unit step input. [5]
   i. Rise time and settling time.
   ii. 1% settling time.
   iii. Peak overshoot.

c Explain the peculiar features of second order systems referring to controller design and system modeling. [5]

d Explain how you could identify a second order system by observing its stable step response. [5]

6 a Describe phase margin and gain margin referring to frequency domain controller design [4]

b The Bode plots of the plant $(s+5)(s+6)/\{(s^3+14s^2+13s+2)(s^2+13s+2)\}$ is shown in Fig. 4. A phase lag of -180^o is observed at 0.7rad/s and 0dB gain is observed at 0.8rad/s [8]

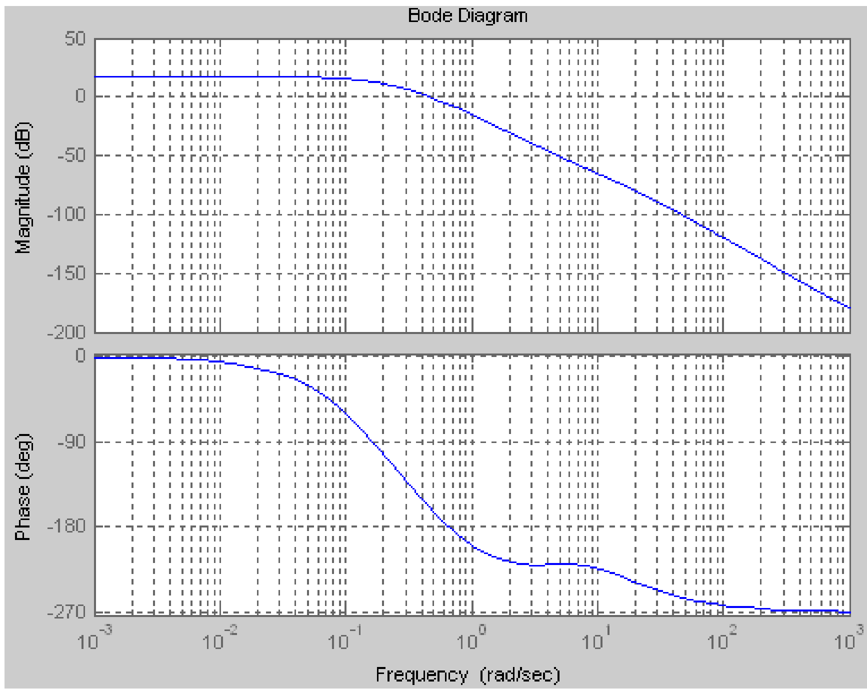

Fig. 4

Determine the gain margin and phase margin

c What is the gain required to improve control bandwidth to 3rad/s. [4]

d Propose a method to keep the system stable after bandwidth adjustment. [4]

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