NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering Honours Degree in Industrial & Manufacturing Engineering

Industrial Instrumentation and Control – TIE 3214

SECOND SEMESTER EXAMINATION: AUGUST 2009

Time allowed: 3 hours
Instructions: Answer FIVE (5) questions. The marks allocated to each question are given in square brackets against the question in the right hand column
Semi-log, normal graph papers and Laplace Transforms Tables are provided

Question 1
Figure Q1 below shows a generic LRC circuit

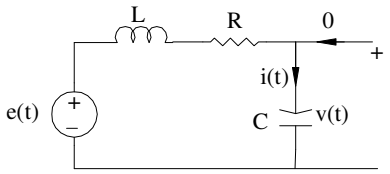

Figure Q1 Generic LRC circuit

a) Show that the circuit above can be represented by a one second order differential equation of the form

$$\ddot{v}(t) + \alpha\dot{v}(t) + \beta v(t) = \gamma e(t) \qquad [6]$$

b) Find two varieties of the system's characteristic equation, one in terms of the circuit parameters L,R, and C and the other in terms of one of the more general parameters ω_n and ξ. [2]

c) Assume that L and C are fixed and that $0 \leq R \leq \infty$. Find the range of values of R that will yield
   i. Purely imaginary characteristic roots, [2]
   ii. Complex characteristic roots, and [2]
   iii. Real characteristic roots [2]

d) For a fixed value of ω_n and $0 \leq \xi \leq \infty$, find the range of values of ξ that will yield
   i. Purely imaginary characteristic roots, [2]
   ii. Complex characteristic roots, and [2]
   iii. Real characteristic roots [2]

Question 2

a) With the aid of a block diagram, define the transfer function of a system. [2]

b) In what way do the open loop and closed loop systems differ? [3]

c) Evaluate the following transfer functions for the block diagram shown in Figure Q2.1 below

i. $\frac{Z(s)}{U(s)}$ [4]

ii. $\frac{Y(s)}{U(s)}$ [4]

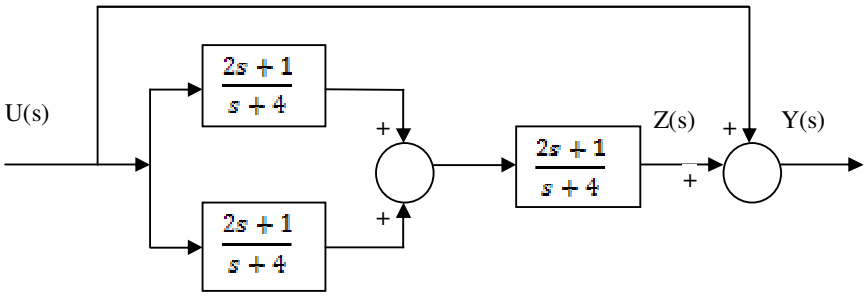

Figure Q2.1

d) Determine the closed-loop transfer function $\frac{Y(s)}{U(s)}$ as a rational function of s for the block diagram in Figure Q2.2 below

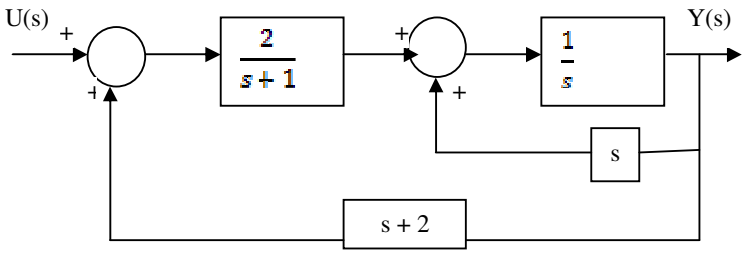

Figure Q2.2

[7]

Question 3

a) i) What is the Initial Value Theorem? [3]

ii) What is the Final Value Theorem? [3]

iii) Use the initial and final value theorems to determine the initial and final values of the corresponding casual time signals.

a) $I(s) = \frac{s-2}{s(s+2)}$ [2]

b) $H(s) = \frac{8}{s^2 + 10s + 169}$ [2]

c) $V(s) = \frac{s^5 + 10}{s^3 (s+1)}$ [2]

b) Define the error transfer function of a system [3]

c) With aid of a diagram explain what is called transient error and steady state error [5]

Question 4

The transfer function of a system, G(s), is given as:

$$G(s) = \frac{2s+1}{(s+1)(s+2)(s+5)(s+6)}$$

(a) Determine the poles and zeros of the system. [2]
(b) Construct the Routh-Hurwitz array for the system [10]
(c) Determine whether the system is stable or not. Justify your answer [4]
(d) Write the commands in Matlab to produce the unit step response of the system [4]

Question 5

a) Draw the Bode plot for the system whose transfer function is given as

$$G(s) = \frac{1}{s(s+4)(s+6)}$$ [10]

b) On the plot show clearly
   i) the gain cross over frequency [1]
   ii) the gain margin [1]
   iii) The phase cross over frequency [1]
   iv) The phase margin [1]
c) Determine from the Bode plot if the system is stable [2]
d) Write the Matlab command to plot the Bode diagram for the system [4]

Question 6

a) Draw the Nyquist diagram for the system whose transfer function G(s) is given as

$$G(s) = \frac{1}{s(s+4)(s+6)}$$ [10]

b) On the diagram show clearly
   i) the gain margin [4]
   ii) the phase margin [4]
c) From the diagram investigate the stability of the system [2]

Question7

A system has an open loop transfer function of

$$G_o(s) = \frac{1}{s(s+6)}$$

a) Draw the root locus diagram for the system [8]
b) What is the gain when there is
   i) Critical damping [4]
   ii) A damping ration of 0.6 [4]
c) Write the Matlab command to produce the root locus for the system [4]

END OF EXAM