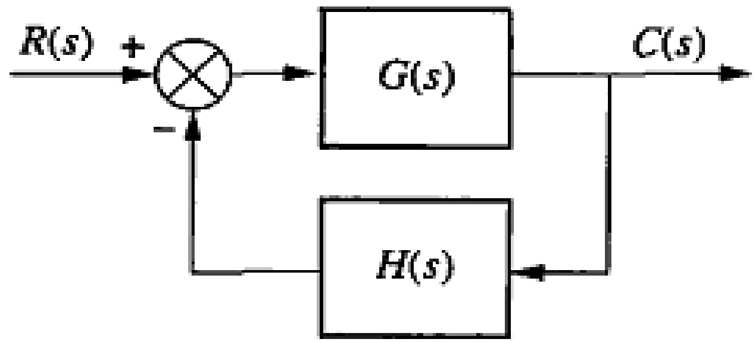
Lab 2 – Stability and Time Domain Analysis

XMUT315 Control Systems Engineering

Laboratory 2 - Stability and Time Domain Analysis

1. Stability Analysis.
2. Time Domain Analysis.
3. Steady State Analysis.

1. Given a negative feedback system as shown in the figure below, perform the following tasks.



$$G(s) = \frac{K}{s(s+2)^2} \quad \text{and} \quad H(s) = 1$$

a. Determine the equivalent transfer function of the negative feedback system. [5 marks]

b. Using Matlab, find two values of gain that will yield closed-loop overdamped response. [5 marks]

c. Repeat part (b) for underdamped response. [5 marks]

d. For (b) and (c) cases, plot in Matlab on one graph the time domain response of the system. [5 marks]

e. Using Simulink, plot the step response of the system at each value of gain calculated to yield overdamped, underdamped, critically damped, and marginally stable responses. [15 marks]

f. Plot the step responses in Simuilink for two values of gain, K, above that calculated to yield marginal stability. [5 marks]

g. At the output of the negative feedback system, cascade the following transfer function.

$$G_1(s) = \frac{1}{s^2 + 4}$$

Determine the overall transfer function equation of the system with the compensator. Set the gain, K, at a value that calculated for marginal stability and plot the step response in Simulink. Repeat for K calculated to yield plot just above marginal stability that leads to unstable system..

[10 marks]

h. From your plots, discuss the conditions that lead to unstable responses and discuss the effect of gain upon the nature of the step response of a closed-loop system. [5 marks]

2. Given the transfer function of a control system below, perform the following tasks .

$$G(s) = \frac{b}{s^2 + as + b}$$

a. Evaluate percent overshoot, settling time, peak time, and rise time for the following values: a = 4, b = 25. Also, plot the poles.

[10 marks]

b. Calculate the values of a and b so that the imaginary part of the poles remains the same but the real part is increased two times over that of (a), and repeat (a). [5 marks]

c. Calculate the values of a and b so that the imaginary part of the poles remains the same but the real part is decreased 1/2 time over that of (a), and repeat (a). [5 marks]

d. Using Simulink, set up the systems. Using the Simulink LTI Viewer, plot the step response of each of the three transfer functions on a single graph. Also, record the values of percent overshoot, settling time, peak time, and rise time for each step response.

[10 marks]

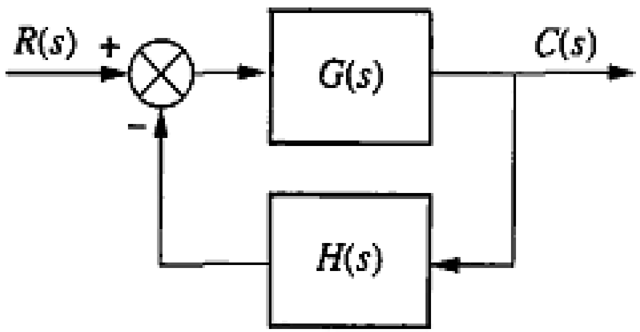
e. Make a table of calculated and experimental values of percent overshoot, settling time, peak time, rise time, and pole location.

[5 marks]

f. Discuss the effects of pole location upon the time response for both first- and second-order systems. Discuss any discrepancies between your calculated and experimental values.

[2.5 marks]

3. For the negative feedback system of figures given below, perform the following tasks.



$$G(s) = \frac{K(s+6)}{(s+4)(s+7)(s+9)(s+12)}$$

$$H(s) = 1$$

a. Calculate the steady-state error in terms of K for the following inputs: $5u(t)$, $5tu(t)$, and $5t^2(t)$. [5 marks]

b. Using Simulink, plot on one graph the error signal of the system for an input of $5u(t)$ and K = 50, 500, 1000, and 5000. Repeat for inputs of $5tu(t)$ and $5t^2u(t)$. [5 marks]

c. Use your Simulink plots compare the expected steady-state errors to those calculated. Explain the reasons for any discrepancies.

[2.5 marks]