AMERICAN UNIVERSITY OF BEIRUT

Department of Electrical and Computer Engineering

EECE440 Signals and Systems - Spring 2006

Lecturer: Prof. Fadi N Karameh

Quiz 1, March 22, 2006

Directions:

- You will have 1.5 hrs for this quiz.
- Write down your initials *in ink* on all the pages. DO IT NOW!
- Enter ALL your work and your answers on the answer booklet. You can use the back of these pages for scratch. I will ONLY grade the work you neatly transfer to the assigned spaces on the booklet.
- Answers must be explained or derived. DO NOT just write down an answer, unless otherwise indicated.
- It is a good idea to read the whole test before you begin. Problems are divided into several parts with percentages indicated. *You might be able to solve different parts independently.*
- DO NOT talk to any of your colleagues under any circumstances. You will be penalized without warning.

YOUR NAME HERE:

Please space below empty for graders to use.

Problem 1

Problem 2

Problem 3

Problem 4

Problem 5

Problem 6

Total ____________

PROBLEM 1 (12%)

a) Consider the CT system given by

$$y(t) = \frac{x(t)}{\sin(4t)}$$

Determine if the system is

i- Linear

ii- Time invariant.

For both cases, either prove the statement or give a counterexample.

b) Consider the DT system given by

$$y[n] = Odd\{x[n+1]\} = \frac{x[n+1] + x[1-n]}{2}$$

Determine whether the system is time invariant or not. That is, either prove the statement or give a counterexample.

c) Optional (extra 5%): Find the steady state response of the causal CT LTI system

$$H(s) = \frac{1}{s^4 + ks^3 + s^2 + s + 1}$$

to an input $x(t) = \cos(5t + 45^o)$.

PROBLEM 2 (10%)

Consider the CT LTI system shown in figure 1. If the input $x_1(t)$ is given by $x_1(t) = u(t)$ (unit step function), the corresponding output is given by $y_1(t) = u(t) - 2u(t-1) + u(t-2)$.

Determine and *sketch* the output of the cascaded system $y_2(t)$ if the input $x_2(t)$ is as given in the figure.

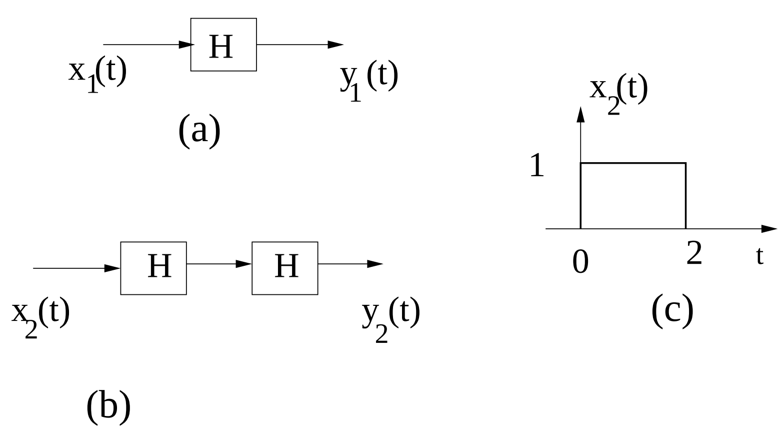

Figure 1: Problem 2

PROBLEM 3 (15%)

Consider the system shown in figure 2. This is a long ladder circuit where $x(t)$ is the input voltage and $y(t)$ is the current in the last 1Ω resistor of the circuit (note there are 100 resistors of value 2Ω).

Find the current $y(t)$ in terms of the input voltage $x(t)$.

Hint: Ladders have steps.

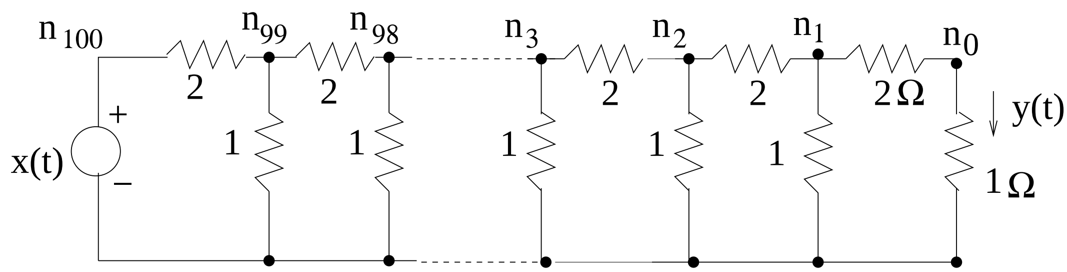

Figure 2: Problem 3

PROBLEM 4 (15%)

Consider the CT LTI system described by:

$$\frac{d^2y}{dt^2} + 4\frac{dy}{dt} = \frac{dx}{dt} + x$$

a) Draw a block diagram description of the above system, using integrators, adders and gains.

b) Write the state space description of this system in matrix form.

c) Find the zero state response (ZSR) if the input is $x(t) = e^{-2t}u(t)$.

PROBLEM 5 (30%)

Consider the causal CT LTI system shown in figure 3.

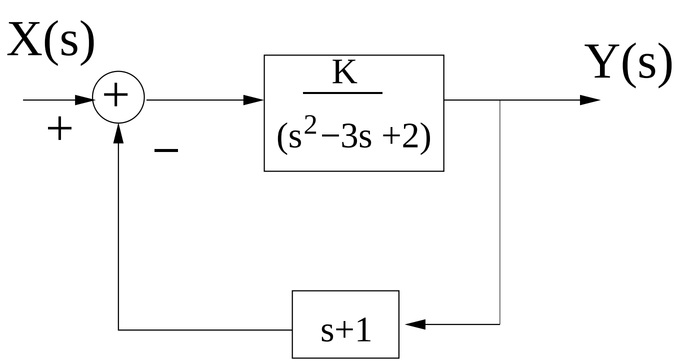

Figure 3: Problem 5

a) Find the closed loop transfer function from the input to the output $H(s) = \frac{Y(s)}{X(s)}$.

b) For what values of K is this system BIBO stable? explain.

c) If the input to the system is $x(t) = \cos(2t)$, $-\infty < t < \infty$, you are told that the corresponding output is $y(t) = A\sin(\alpha t)$. (i) Find the value of K that makes this possible. (ii) Find also α and A.

d) If sensor noise affects the system as shown in figure 4, find the *maximum* steady state attenuation of the noise effect at the output $y(t)$ that can be achieved for a unit step noise $n(t) = u(t)$.

e) Can you suggest a controller $F(s)$ to be placed in cascade with the $(s+1)$ term in the feedback loop such that the noise effect $n(t) = u(t)$ is *completely blocked* at the output $y(t)$ at steady state?

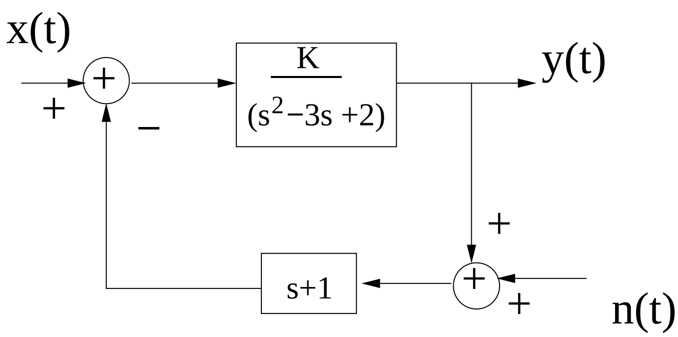

Figure 4: Problem 5 (e)

PROBLEM 6 (18%)

A pole zero plot is a schematic for the location of the poles and zeros in the s-plane. A pole is represented with an "×" while a zero is represented by a "∘".

For each pole-zero plot shown in Figure 5 below, find the frequency response, among those given in the same figure, that could result from the pole-zero plot.

- Explain the reasoning of your choices.
- *NO GRADE* will be given without a clear justification that I am convinced of.
- Note that the bode plots DO NOT change their asymptotic behavior outside the given range of frequencies.

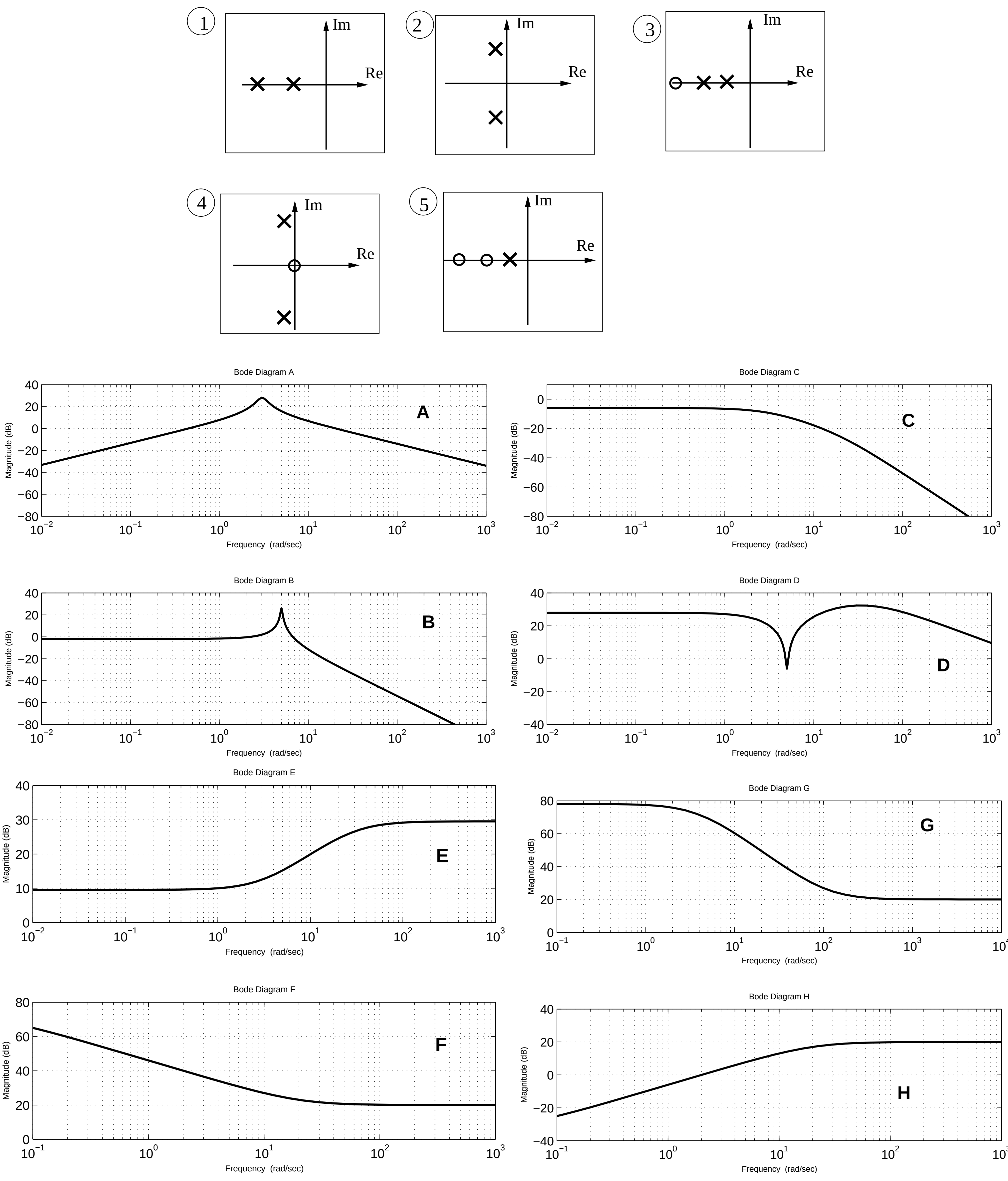

Figure 5: Problem 6