MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

2.004 Dynamics and Control II
Fall 2007

Problem Set #4

Posted: Friday, Sept. 28, '07 **<u>Due:</u> Friday, Oct. 5, '07**

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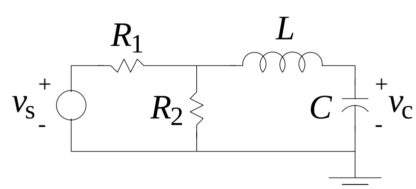
1. **(a)** Problem 21(a) from Nise textbook, Chapter 2 (page 113). **(b)** After you find the transfer function, locate the zeros and poles, draw them on the s–plane, and determine the type of the response of the system (undamped, underdamped, critically damped, or overdamped).

2. Problem 25 from Nise textbook, Chapter 4 (page 236).

3. Derive the transfer function of the electrical network shown below with the source voltage $v_s(t)$ as input and the voltage $v_c(t)$ across the capacitor as output, where $R_2 = 10\Omega$, $L = 1$ mH, $C = 10\mu$F and

i) $R_1 = 5\Omega$;

ii) $R_1 = 100\Omega$.



For each case,

a) locate the zeros and poles and draw them on the s–plane;

b) determine the type of the response (undamped, underdamped, critically damped, or overdamped);

c) if you find that the system is *underdamped*, determine the natural frequency, the damped frequency, the settling time and the percent overshoot (%OS); if, on the other hand, you find that the system is *overdamped*, determine the two time constants;

d) determine the steady–state value directly from the transfer function;

e) plot the response to a step voltage of magnitude 5 V and verify that it matches your answers to the previous questions.

4. Consider again the system of a compliant mass driving a shaft that we modeled in PS01/4.a and derived the transfer function for in PS02/4. Substitute numerical values $M = 1$ kg, $J = 1$ kg $\cdot$ m^2, $f_v = 2$ kg/ sec, $r = 0.1$ m, and two cases of translational compliance

i) $K = 0.1$ N/ m;

ii) $K = 1.0$ N/ m.

For each case,

a) find the poles of the system (you can use the `roots` function in MATLAB , or any numerical analysis software of your choice);

b) determine if the system has dominant poles;

c) *sketch* by hand the step response of the system as accurately as you can from the transfer function but without solving for the exact solution. Do not use any numerical analysis tools for this part of the problem.