ECE 3510 Exam 2 Study Guide

The 2^{nd} Exam will be on Friday 3/5/10.

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2/26/09

The first part will be **closed book**, **no-calculator,** but will include the information shown below, if needed.

When you hand in the first part you will get the second part, which will be **open book, notes, & calculator**.

The exam will cover **Download old exams from HW page on class web site.**

1. Steady-state and transient sinusoidal response.

   Ex. Find the steady-state (sinusoidal) magnitude and phase of the following transfer function.

$$|H(j\cdot\omega)| = ? \qquad \angle H(j\omega) = ?$$

$$\omega := 8\cdot\frac{rad}{sec} \qquad H(s) = \frac{\frac{5}{sec}\cdot s - \frac{30}{sec^2}}{s^2 + \frac{54}{sec^2}} = \frac{\frac{5}{sec}\cdot(j\cdot\omega) - \frac{30}{sec^2}}{(j\cdot\omega)^2 + \frac{54}{sec^2}} = \frac{\frac{5}{sec}\cdot j\cdot 8\cdot\frac{rad}{sec} - \frac{30}{sec^2}}{-\left(8\cdot\frac{rad}{sec}\right)^2 + \frac{54}{sec^2}} = \frac{\frac{40}{sec^2}\cdot j - \frac{30}{sec^2}}{-\frac{64}{sec^2} + \frac{54}{sec^2}}$$

$$= \frac{40\cdot j - 30}{-64 + 54} = \frac{40\cdot j - 30}{-10} = 3 - 4\cdot j \qquad |H(j\cdot\omega)| = \sqrt{3^2 + 4^2} = 5$$

$$\angle H(j\omega) = \tan^{-1}\left(-\frac{4}{3}\right) = -36.9\cdot deg$$

(If units are not given, assume units like these)

2. Effect of initial conditions. Closed-book part, given:

$$Y(s) = \frac{b_2\cdot s^2 + b_1\cdot s + b_0}{s^2 + a_1\cdot s + a_0}\cdot X(s) + \frac{s\cdot y(0) + \frac{d}{dt}y(0) + a_1\cdot y(0) - b_2\cdot s\cdot x(0) - b_2\cdot s\cdot\frac{d}{dt}x(0) - b_1\cdot s\cdot x(0)}{s^2 + a_1\cdot s + a_0}$$

   I will give the basic eq. like eq. 3.70, p.42

   May ask question like points on p. 43

   May give H(s), a's & b's and y(0).. and ask for effect of initial conditions

3. The advantages of state space over classical frequency-domain techniques. Closed-book part.

   Multiple input / multiple output systems

   Can model nonlinear systems

   Can model time varying systems

   Can be used to design optimal control systems

   Can determine controllability and observability

4. **Electrical analogies of mechanical systems**, particularly translational and rotational systems. Open-book part.

5. Control system characteristics and the objectives of a "good" control system. See p. 60
   - Stable
   - Tracking
     - fast   smooth   minimum error (often measured in steady state)
   - Reject disturbances
   - Insensitive to plant variations
   - Tolerant of noise

   Be able to relate these to poles and zeros on the real and Imaginary axis (where possible)   Closed-book part.

6. Elimination of DC steady-state error, p. 61 - 63.
   1. System stable
   2. C(s) or P(s) has pole @ 0
   3. C(s) and P(s) No zero @ 0

7. Rejection of constant (DC) disturbances, p. 63 - 65.
   1. System stable
   2. C(s) has pole @ 0
   3. or P(s) has zero @ 0   But bad for DC response

8. **Routh-Hurwitz method**.

Example: $D(s) = s^3 + 20 \cdot s^2 + 59 \cdot s + 32$

s^3	1	59	0
s^2	20	32	
s^1	$\dfrac{20 \cdot 59 - 1 \cdot 32}{20} = 57.4$	$\dfrac{20 \cdot 0 - 1 \cdot 0}{20} = 0$	
s^0	$\dfrac{57.4 \cdot 32 - 20 \cdot 0}{57.4} = 32$	$\dfrac{57.4 \cdot 0 - 20 \cdot 0}{57.4} = 0$	

Be able to do this with variable such as "k"

Open-book part

9. **Root - Locus method**

a) **Main rules** (memorize, could be in closed-book part)

1. Root-locus plots are symmetric about the real axis.
2. On the real axis, spaces left of an odd number of O-L poles and zeros are always part of the locus. (Essentially, every other space on the real axis (counting leftward) is part of the plot.)
3. Each O-L pole originates ($k = 0$) one branch. (n)

   Each O-L zero terminates ($k = \infty$) one branch. (m)

   All remaining branches go to ∞. $(n - m)$

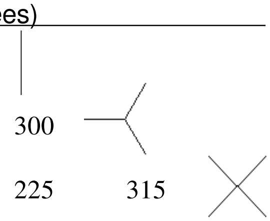
   These remaining branches approach asymptotes as they go to ∞.
4. The origin of the asymptotes is the *centroid*.

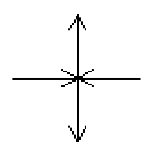
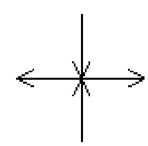
$$\text{centroid} = \sigma = \frac{\sum_{all} OLpoles - \sum_{all} OLzeros}{n - m}$$

(# poles - # zeros)

5. The angles of the asymptotes

n - m	angles (degrees)			
2	90	270		
3	60	180	300	
4	45	135	225	315



6. The angles of departure (and arrival) of the locus are almost always:  OR: 

b) Additional rules.

The breakaway points are also solutions to: $\displaystyle\sum_{all} \frac{1}{(s + -p_i)} = \sum_{all} \frac{1}{(s + -z_i)}$ Open-book part only.

Memorize

Gain at any point on the root locus: $k = \dfrac{1}{|G(s)|}$

Memorize

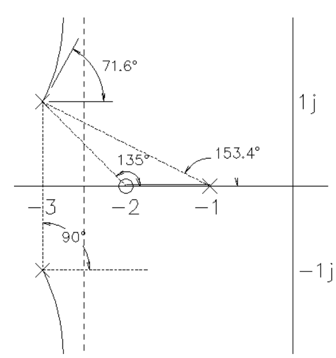
Phase angle of $G(s)$ at any point on the root locus: $\arg(G(s)) = \arg(N(s)) - \arg(D(s)) = \pm 180^o, \pm 540^o, \ldots$

Or: $\arg\left(\dfrac{1}{G(s)}\right) = \arg(D(s)) - \arg(N(s)) = \pm 180^o, \pm 540^o, \ldots$

Departure angles from complex poles: Ex.

$180 - 90 - 153.4 + 135 = 71.6\deg$

Open-book part only.



10. Homeworks 7 - RL4
    I' ll scan through for problems

11. Labs 2 - 5a
    Position control
    DC motor characteristics
    PI control

12. Download old exams from HW page on class web site.