# EE 482 LINEAR CONTROL SYSTEMS Fall 2013 (Safonov)

**Text:**

Dorf, *Modern Control Systems*, $12^{th}$ *Edition*. Upper Saddle River, NJ: Prentice-Hall. ISBN 0136024580
http://www.pearsonhighered.com/product?ISBN=0136024580

**Instructor:**

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Office Hours: TTh 2:00-3:00 PM

**Prerequisite:** EE301 Introduction to Linear Systems

**Web:** For course materials and grades, login to GPP Blackboard at
https://www.uscden.net/webapps/login/

**Discussion Section:** Friday 12:00-12:50, OHE 132

**TA:**

Eugenio Grippo <egrippo@usc.edu>
Office Hours: TBA

**Grades:**

10% homework, 40% Midterm Exam, 50% Final Exam

**Computer:**

Matlab software will be used for some of the homework exercises. You can download Matlab at for personal use from http://software.usc.edu or use it on the computers in USC computer labs. New students visit
http://www.usc.edu/firstlogin
to setup your USC computer account. For more information about Matlab see
http://www.mathworks.com/products/studentversion

**Academic Integrity:**

For an overview of *Student Conduct Code* policies and sanctions, see the tutorial at http://www.usc.edu/student-affairs/SJACS/forms/tio.pdf
University policies regarding academic integrity are futher described in *SCampus* http://web-app.usc.edu/scampus/university-governance All violations will be reported to the Office of Student Judicial Affairs and Community Standards.

**Students with Disabilities:** Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

1. (a) Introduction, perspective, examples of typical control problems. Homework: Modeling techniques; linear systems, principle of superposition, convolution integrals, Laplace transforms.

   (b) Laplace transformation models: Partial fraction expansion and impulse response, pole-zero plot; signal flow diagram and direct solution of multi-input-output transfer function matrices from node equations.

2. (a) Feedback system characteristics: Sensitivity reduction, transient response control, noise attenuation, steady-state error improvement; definitions and formulas; examples.

   (b) Feedback system performance specifications: Steady-state spec's, transient response spec's, parameter variation tolerance spec's, noise tolerance spec's; the concept of compromise design.

3. (a) Two-dominant-pole model: Damping ratio, natural frequency, relationships of pole locations to transient spec's; model order reduction by partial fraction expansion and justification of the two-dominant-pole assumption.

   (b) Miscellaneous: Steady-state error, final-value theorem, performance indices, introduction to the concept of stability.

4. (a) Stability: Relation to pole location, Routh-Hurwitz stability criterion.

   (b) Root locus: The concept of root-locus, relation to open-loop pole-zero plot; phase angle and magnitude conditions.

5. (a) Root locus behavior: Asymptotic behavior for large and small gains; behavior on real axis.

   (b) Root locus behavior at break-away points.

6. (a) Root locus: Sketching examples.

   (b) Root locus: Use for parameter variation analysis; root sensitivity.

7. (a) Frequency response model: Review of Fourier transform; Bode plot, polar plot, and log magnitude vs. phase angle plot.

   (b) Frequency response model: Relation to open-loop pole-zero plot.

8. (a) Frequency response model: Procedures for sketching Bode plot given the pole-zero plot; determination of transfer function from Bode plot.

   (b) Frequency response model: Concepts of minimum and non-minimum phase systems; two-dominant-pole system; resonant peak and resonant frequency, relation to damping ratio and natural frequency.

9. (a) Performance spec's in the frequency domain: Determination of transient properties (rise-time, etc.) from a closed-loop frequency response; determination of steady-state error from open-loop frequency response.

   (b) **MIDTERM EXAM**: Thursday October 24, 2013, during class.

10. (a) Nyquist stability criterion: Cauchy's "principle of the argument" and the proof of the Nyquist criterion.

    (b) Nyquist stability criterion: Procedures for handling imaginary-axis poles.

11. (a) Gain and phase margin: Definition and interpretation; relation to damping ratio of dominant closed-loop poles.

    (b) M-circles: Derivation, relation to damping ratio of dominant closed-loop poles; Nichols' chart.

12. (a) Compensation: Root-locus approach.

    (b) Compensation: Frequency response approaches using Bode plot and Nichols' chart.

13. (a) Compensation: Examples

    (b) Compensation: Examples

14. (a) Robust Control Systems: Uncertain models and parameter variation, QFT, small gain theorem.

    (b) **USC THANKSGIVING RECESS**: 11/27-11/30/2013

15. (a) Robust Control Systems: $H$-infinity optimal loop-shaping.

    (b) Review

16. **EE482 FINAL EXAM**: 2:00–4:00 PM, Tuesday, December 17, 2013.