EE 302: Control Systems

Syllabus

- **Introduction:** Motivation, examples of control systems, feedback control systems.
- **Mathematical modelling:** Mathematical modelling of: electrical systems, mechanical systems, electro-mechanical systems. Laplace transforms, transfer functions, electrical analogues of other dynamical systems. State-space modelling of dynamical systems. Block diagrams, block diagram reductions. Signal flow graph, Mason's gain formula. Linearity, time-invariance versus nonlinearity and time-variance. Linearization. Distributed parameter systems.
- **Time response of dynamical systems:** Obtaining solutions from mathematical models. Poles and zeros and their effects on solutions. Step response of standard second order systems, time-domain specifications and their formulae.
- **Stability:** Definition of stability. Routh-Hurwitz test. Lyapunov theory.
- **Properties of feedback:** Basic idea of feedback control systems. Error analysis. P, PI, PD, PID controllers.
- **Design of controllers:** The root-locus technique, steps in obtaining a root-locus. Design of controllers using root-locus. Pole placement with state feedback, controllability. Pole placement with output feedback, observability, Luenberger observer. LQR control.
- **Frequency domain analysis:** Bode plot, Nyquist plot, Nyquist stability criterion, gain and phase margins, robustness.
- **Design of compensators:** Lead compensator, lag compensator, lead-lag/lag-lead compensators, their design.

Objective

- To be able to obtain a working mathematical model of a system.
- To be able to do time-domain and frequency-domain analyses of the model to predict the system's behavior.
- To be able to design control systems that meet design specifications.

Tools

- Laplace transform theory, state-space theory, theory of ordinary differential equations, matrix theory.
- Block diagrams and signal flow graphs.
- Stability analysis via Routh-Hurwitz method and Lyapunov method.
- Root-locus technique.
- Frequency response techniques (Bode plot and Nyquist plot).
- State variable methods.

Textbooks

- **Franklin G.F., Powell J.D., Emami-Naeini A.**, *Feedback Control of Dynamic Systems*, Pearson, Upper Saddle River, New Jersey, 5th edition, 2006.
- **Ogata K.**, *Modern Control Engineering*, Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition, 2000.
- **Kuo B.C.**, *Automatic Control Systems*, Prentice-Hall of India Pvt Ltd., New Delhi, 6th edition, 1991.