

CE 51400 Building Controls

Sem. 2, Lecture 3, Cr. 3.

Restrictions: Senior status in the College of Engineering or graduate-level standing. Concurrent pre-requisites: CE 41300 Building Envelope Design and Thermal Loads and CE 41400 Building Mechanical and Electrical System Design, or graduate standing.

Description: This course is designed to provide students with the knowledge of fundamentals, design, and analysis for building control systems. It primarily consists of three parts. The first part covers basic concepts, terminology, procedures and computations of control systems including block diagrams & transfer functions, open-loop & closed-loop control, control system modeling, time response, root locus techniques, design via root locus, and digital control systems. The second part focuses on issues surrounding the building controls: interfacing components such as sensors and actuators, problems encountered, and state-of-the-art solutions for building energy efficiency and thermal comfort. The third part aims to develop students' ability to convert control system concepts into real building control systems. The course provides a hands-on opportunity for students to complete three projects associated with the three primary components during the semester: indoor environmental quality assessment, building HVAC system commissioning and its control analysis, and new control algorithm development for building energy efficiency, occupant health, and individual productivity.

Level: Undergraduate/Graduate Level

Course instructor: Ming Qu

Course outline:

- **Introduction to building controls, sensors, and indoor environmental quality (IAQ):** building function and controls; building indoor environmental quality analysis and diagnostics; gains and control action; temperature, humidity, pressure, flow rate sensors; and IAQ project. (3 weeks)
- **Controlled devices and various controls:** actuators; self- powered, system- powered, electric controls, pneumatic, analog and electronic controls; and IAQ project (2 weeks)
- **HVAC system controls overview:** sensors; various building HVAC systems; operation and controls of these systems (0.5 week)
- **Control System Concepts:** PID control; Laplace transfer functions for building thermal control; system modeling; block diagrams; signal flow graphs (3 weeks)
- **System Responses:** First-order system response; second-order system response; system responses and stability; and HVAC control system project (2.5 weeks)
- **Root Locus:** Root locus; and control system design by using root locus (1 week)
- **Introduction to Direct Digital Control (DDC) System and Z-transform:** DDC structure, hardware and software; DDC software (EIKON); Control logic and programming; demand control and new control algorithm; and control programming project. (3 weeks)