Practical Techniques in Control Engineering
2-day Short Course

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This course provides a bridge between recent developments in control theory and their practical application in the laboratory and industry. Beginning with an overview of fundamental tradeoffs and issues that affect control-system performance, the course will systematically cover topics in linear and nonlinear modeling, linear, robust, and nonlinear controller synthesis, and fixed-gain and adaptive tuning. In addition, controller implementation issues such as saturation and state constraints will be discussed. The theoretical foundation of each topic will be reviewed along with a discussion of practical ramifications and limitations. The course is suitable for students, instructors, and researchers who wish to obtain a broad perspective of the control engineering enterprise as well as control engineers from all industrial applications seeking a coherent, self-contained overview of recent developments relevant to control practice.

Day 1

1. DEFINING THE ISSUES AND CHALLENGES IN CONTROL ENGINEERING
1.1. Course Overview
1.2. Control System Design: Strategy, Physics, Architecture, and Hardware
1.3. Fundamental Tradeoffs: Plant Properties and Achievable Performance

2. DEVELOPING LINEAR MODELS FOR CONTROL
2.1. Linear Plant Modeling: Representation and Properties
2.2. Empirical Linear Modeling: System Identification

3. SYNTHESIZING LINEAR CONTROLLERS FOR PERFORMANCE AND ROBUSTNESS
3.1. Uncertainty Measures and Robust Synthesis
3.2. Optimality-Driven Synthesis: H2 and Hinfinity Methods
3.3. Robust Control and Loop Shaping: Classical and Modern Methods

4. REDUCING MODEL DEPENDENCE IN CONTROLLER SYNTHESIS
4.1. Minimal-Information Control: The Art and Science of PID Tuning
4.2. Adaptive Control: What Do You Need to Know, and How Well Do You Need to Know It?
4.3. Adaptive Stabilization and Command Following

Day 2

5. DEVELOPING NONLINEAR MODELS FOR CONTROL
5.1. Nonlinear Plant Modeling: Model Properties and Structure
5.2. Nonlinear Identification Methods for Block-Structured Models

6. INEXACT APPROACHES TO NONLINEARITY
6.1. Treating Nonlinearity as Uncertainty: Absolute Stability, LMIs, and IQCs
6.2. Treating Nonlinearity as Linearity: Gain Scheduling, LPV's, and Frozen Linear Methods

7. EXACT APPROACHES TO NONLINEARITY (11:30-12:30)
7.1. Feedback Linearization and Nonlinear Inversion: Methods and Pitfalls
7.2. Backstepping Methods: A Constructive Nonlinear Approach

8. IMPLEMENTING REAL CONTROL SYSTEMS IN REAL HARDWARE
8.1. Facing the Reality of Constraints: Traditional and Modern Approaches

9. FITTING THE PIECES TOGETHER
9.1. Adaptive Disturbance Rejection with Applications to Noise and Vibration Control: From Tonal to Broadband
9.2. A Case Study: Chatter Control