ELECTRONICS & ROBOTICS CLUB
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Control Theory Bootcamp

Assignment 2: Implementing Controllers

PID-Based Temperature Control in a Smart Greenhouse — Submission Deadline: 23:59, 23 June 2025

Objective

Design, simulate, and tune a PID controller using MATLAB Simulink to regulate the internal temperature of a smart greenhouse. The aim is to maintain the temperature at a desired setpoint despite external fluctuations.

Background

Greenhouses create controlled environments for plant growth. Temperature regulation is crucial, and this can be achieved using feedback control. PID controllers are widely used for this purpose due to their simplicity and effectiveness.

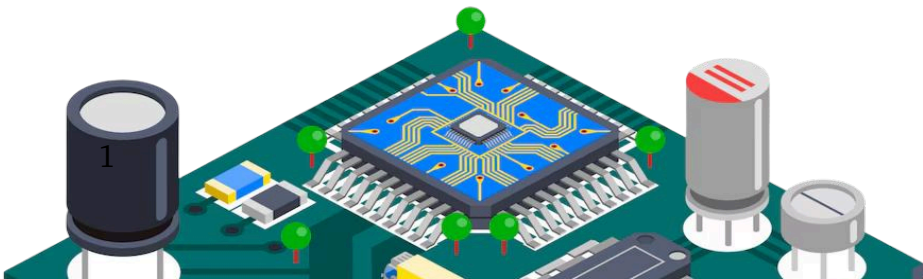
System Dynamics

The thermal dynamics of the greenhouse can be modeled by the following differential equation:

$$\frac{dT_{\text{in}}(t)}{dt} = -\frac{1}{\tau}\left(T_{\text{in}}(t) - T_{\text{out}}(t)\right) + \frac{K}{\tau}u(t)$$

Where:

- $T_{\text{in}}(t)$: Internal temperature [°C]
- $T_{\text{out}}(t)$: External ambient temperature [°C]
- $u(t)$: Control input (heating/cooling power), $u(t) \in [-100, 100]$
- τ: Time constant (e.g., 200 seconds)
- K: System gain (e.g., 0.5)



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The external temperature follows a sinusoidal profile:

$$T_{\text{out}}(t) = 22 + 8\sin\left(\frac{2\pi t}{86400}\right)$$

Tasks

1. System Modeling in Simulink

- Implement the system using Simulink blocks (Integrator, Gain, Sum, Signal Generator).
- Simulate sinusoidal external temperature input.

2. PID Controller Design

- Use a PID Controller block to generate the control input $u(t)$.
- Set a desired internal temperature setpoint (e.g., 25°C).
- Tune the controller gains manually and with Simulink's PID Tuner.

3. Simulation and Analysis

- Analyze step response characteristics (rise time, overshoot, settling time).
- Add actuator saturation and simulate sudden disturbances.
- Plot internal temperature, external temperature, and control input over time.

4. Reporting

- Include block diagram screenshots, PID parameter values, and performance plots.
- Comment on the controller effectiveness, tuning process, and observations.