C06 Control-Method Comparison

Open loop, on-off, hysteresis, proportional, and PI or PID control

Technology Commons

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Student: _____ **Date:** _____

Use one simulated temperature process for all five activities. Plot setpoint and measured temperature on the same graph. Apply identical initial conditions and disturbances so the control methods can be compared fairly.

Activity 1: Open loop

Predict the response to a fixed 40% heater command. At $t = 10$ min, apply the same heat-loss disturbance used in later activities.

Required: block diagram, expected graph, simulated data, final error, and one limitation.

Time (min)	Setpoint (°C)	Measured (°C)	Command (%)
0	22		40
5	22		40
10	22		40
15	22		40
20	22		40

Activity 2: On-off control

Use one switching threshold at 22°C. Record cycling or chatter near the threshold. Identify the highest and lowest measured temperatures.

Design question: What physical factors make the temperature continue changing after the command switches?

Activity 3: On-off control with hysteresis

Use a 21°C turn-on threshold and a 23°C turn-off threshold. Compare switching frequency and temperature variation with Activity 2.

Required design change: Adjust the hysteresis band once. Provide evidence that the change improved one chosen criterion and state the trade-off.

Activity 4: Proportional control

Use $u = K_P e$ with output limited to 0% through 100%. Compare at least three K_P values.

K_P	Rise time	Overshoot	Steady-state error	Stability comment
low				
medium				
high				

Activity 5: PI or PID control

Begin from the best proportional result. Add integral action to reduce remaining error. Add derivative action only if the data are clean enough to justify it.

$$u_k = K_P e_k + K_I \sum e \Delta t + K_D \frac{e_k - e_{k-1}}{\Delta t}$$

Required: tuned gains, output limits, one windup observation or prevention method, final graph, performance table, one design change, and a written engineering conclusion comparing all five methods.

Performance summary

Method	Rise time	Overshoot or cycling	Steady-state error	Main advantage	Main limitation
open loop					
on-off					
hysteresis					
P					
PI or PID					

Common assessment rubric

Category	Level 1	Level 2	Level 3	Level 4
Mathematical reasoning and GUESS	limited setup or unit use	partly correct method	correct method and units	precise, efficient reasoning with independent checks
Schematic quality and conventions	major symbol or connection errors	mostly readable with some errors	correct, labelled, and readable	exceptionally clear with purposeful layout and complete references
Simulation or verification evidence	limited or incomplete evidence	some valid evidence and comparison	complete evidence with comparison	well-chosen evidence that tests assumptions and limitations
Physical construction and safe practice	frequent prompting required	generally safe with some prompting	safe, organized, and approved work	consistently anticipates hazards and supports team safety

Category	Level 1	Level 2	Level 3	Level 4
Testing and troubleshooting	guesses without a test plan	partial plan using some evidence	logical tests identify the likely cause	efficient tests distinguish alternatives and verify the repair
Design decisions	choice has limited justification	some criteria support the choice	clear criteria and trade-offs support the choice	constraints, evidence, and iteration produce a strong decision
Documentation and communication	incomplete or difficult to follow	understandable with gaps	clear tables, labels, results, and conclusion	concise, polished communication makes the evidence easy to audit