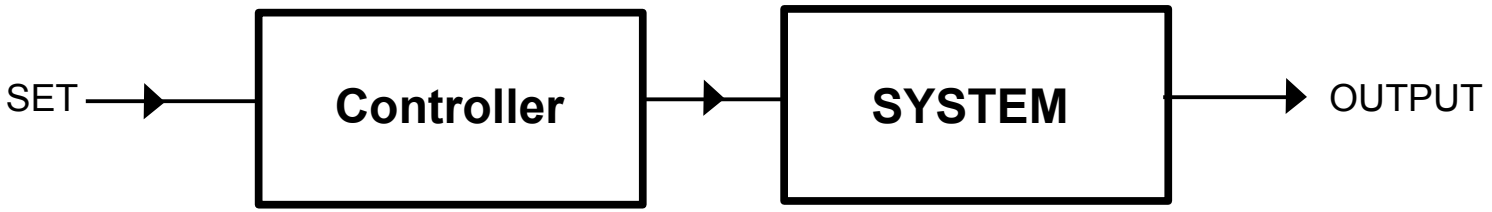
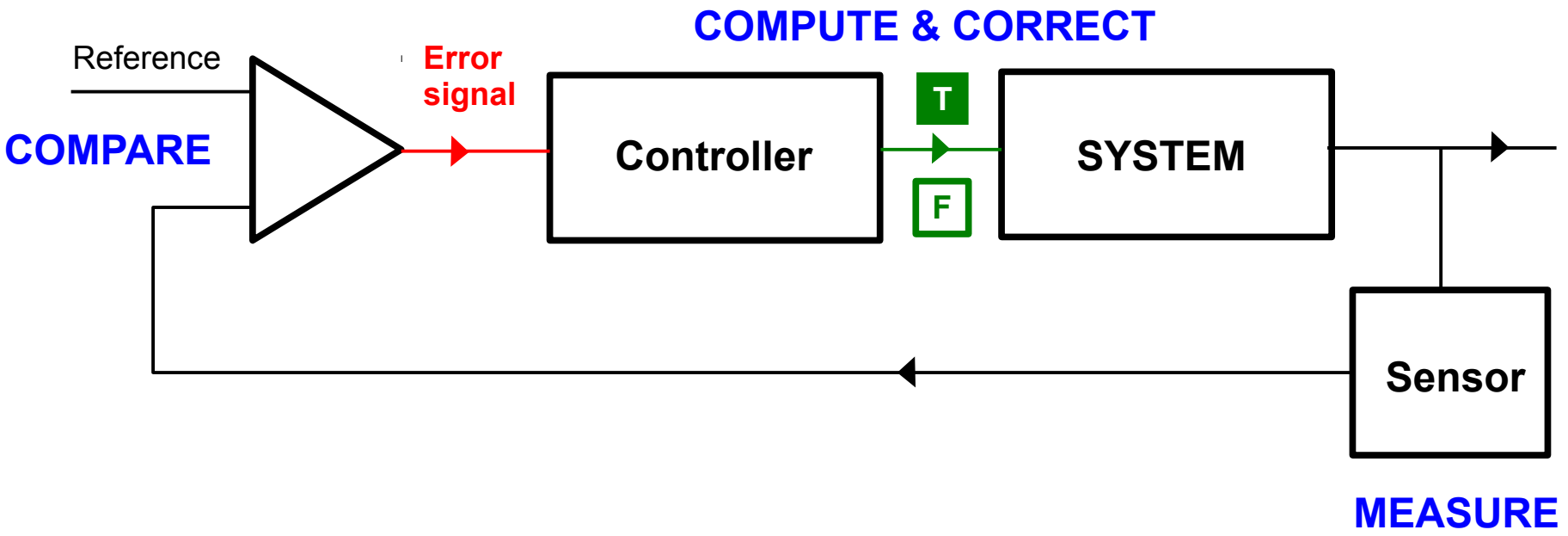
Lab 13: Controls (Part 2)

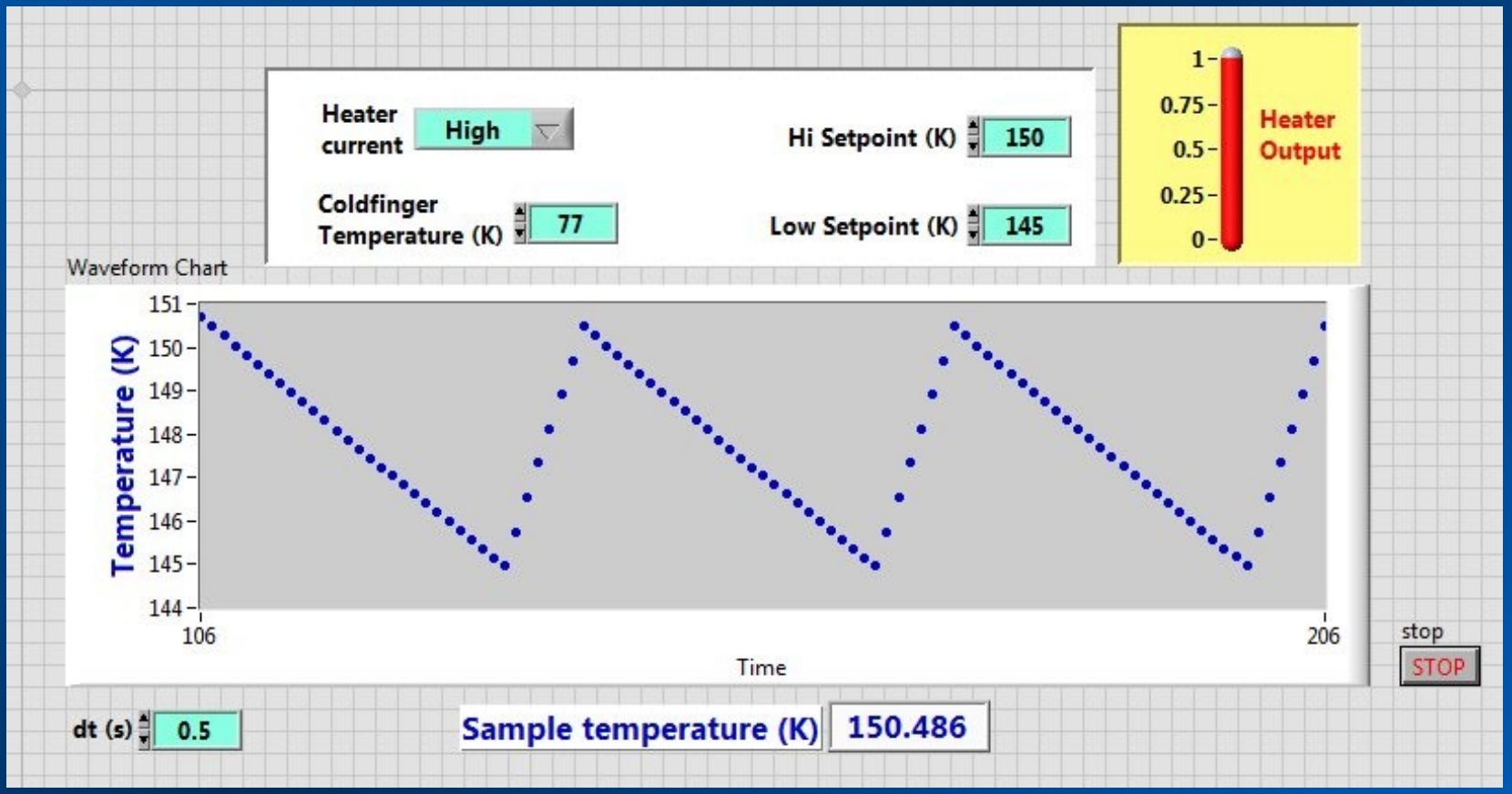
OPEN LOOP



CLOSED LOOP

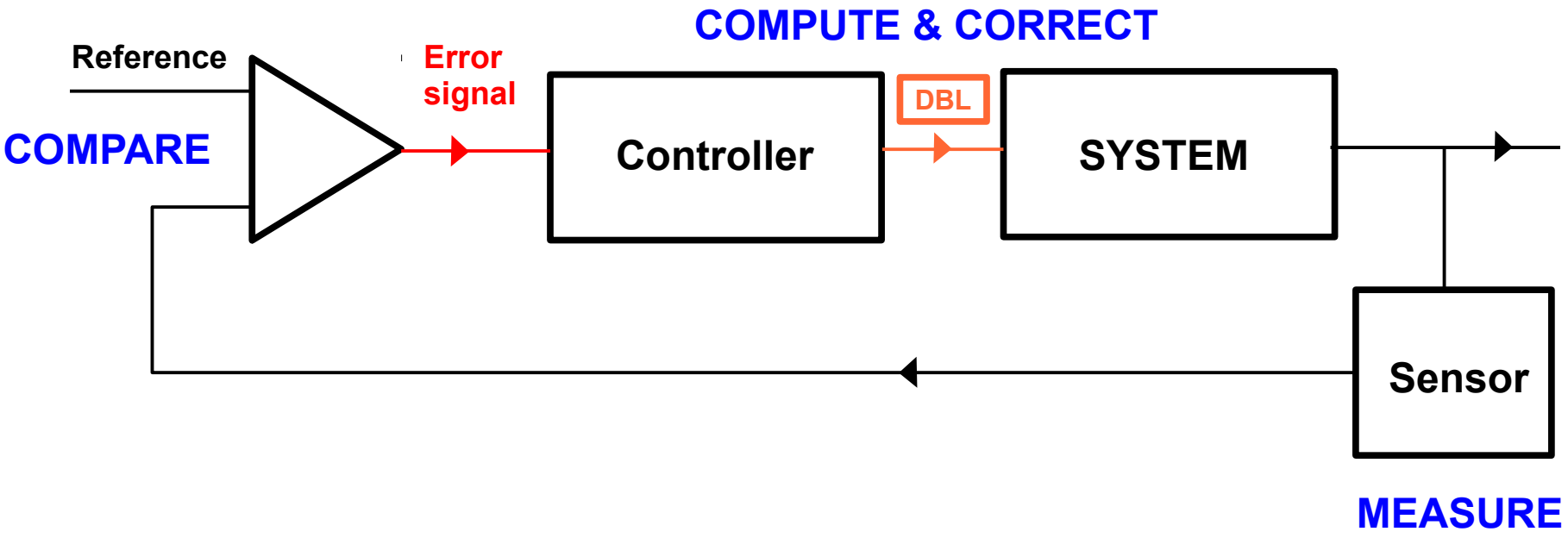

COMPUTE & CORRECT
Reference
Error
signal
COMPARE
Controller
T
F
SYSTEM
Sensor
MEASURE

HYSTERETIC CONTROLLER: ON or OFF



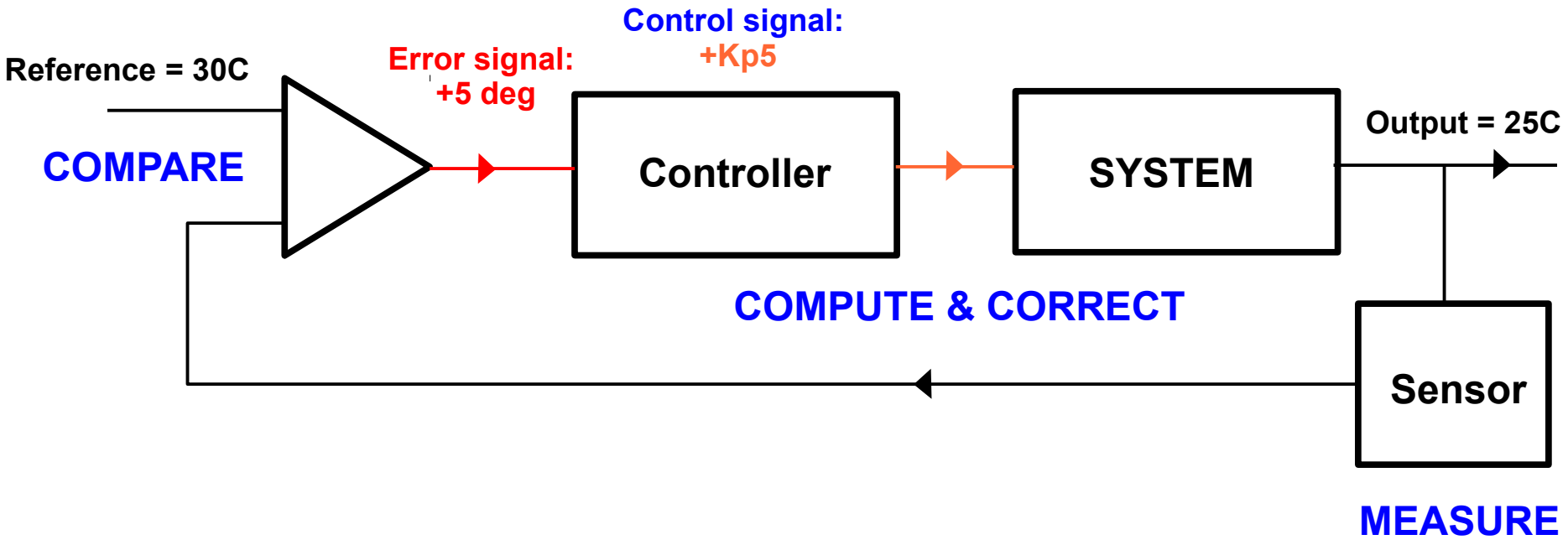
The control signal does not have to be Boolean T/F or ON/OFF

Error signal has magnitude/phase information



EXAMPLE: Temperature Controller with single setpoint

Kp: proportionality constant



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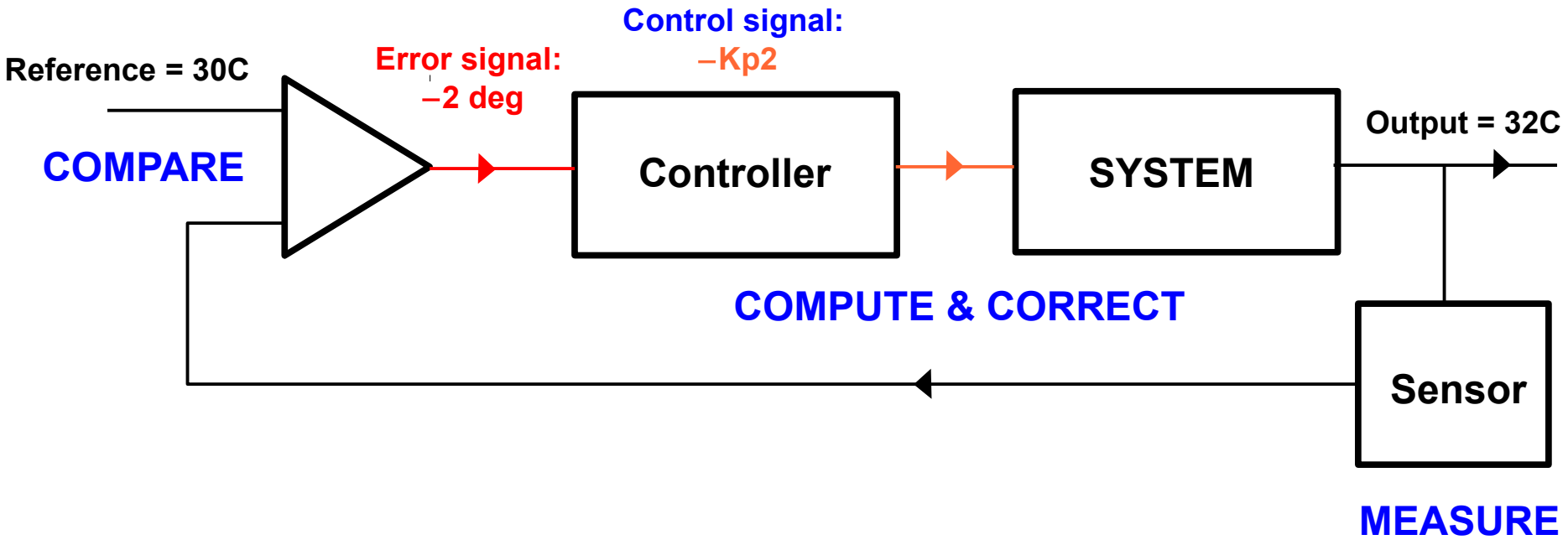
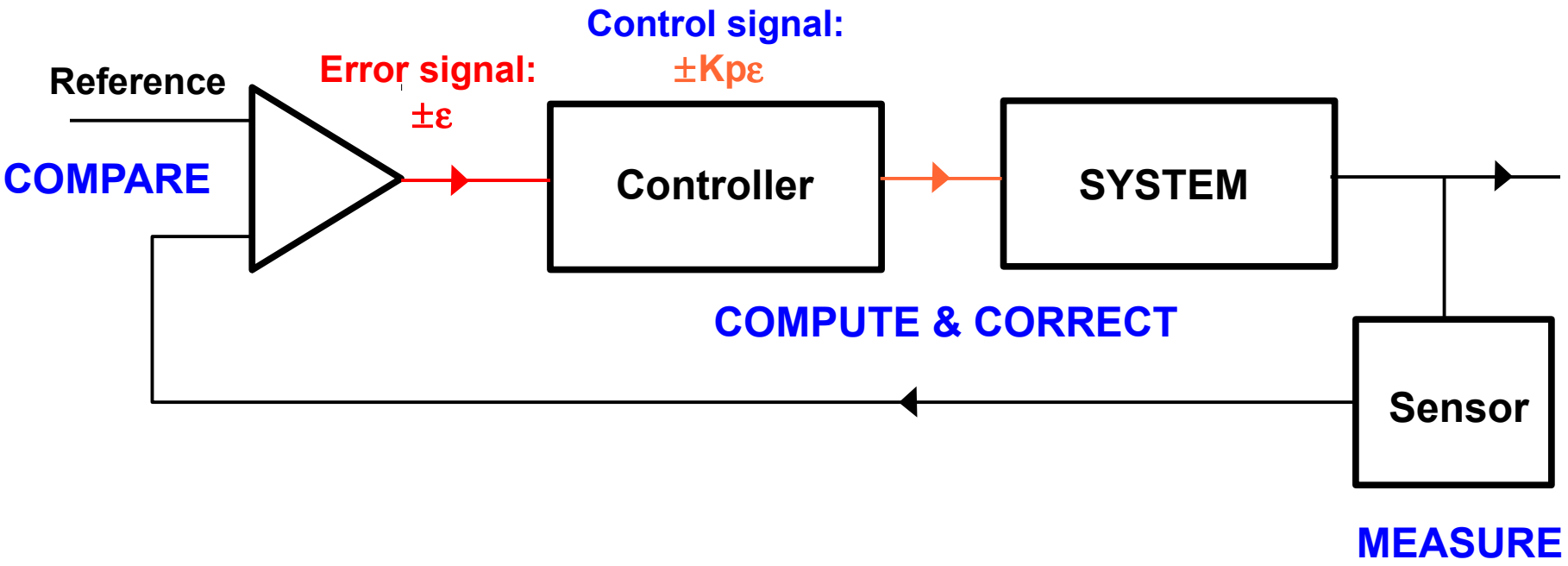


Proportional Control

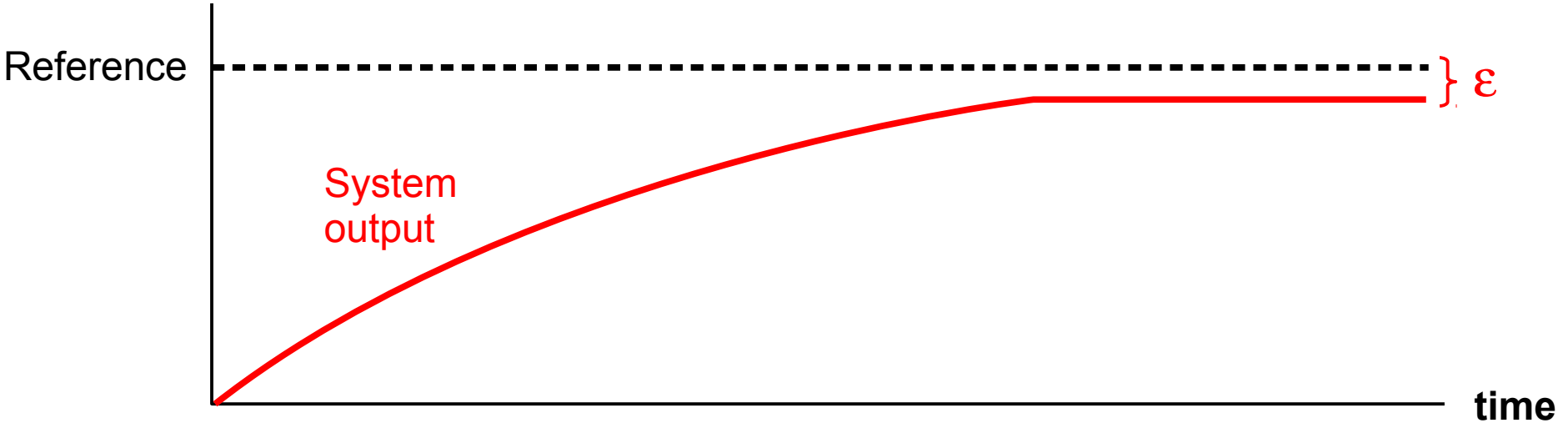
System controlled on a continuum; not simply ON or OFF

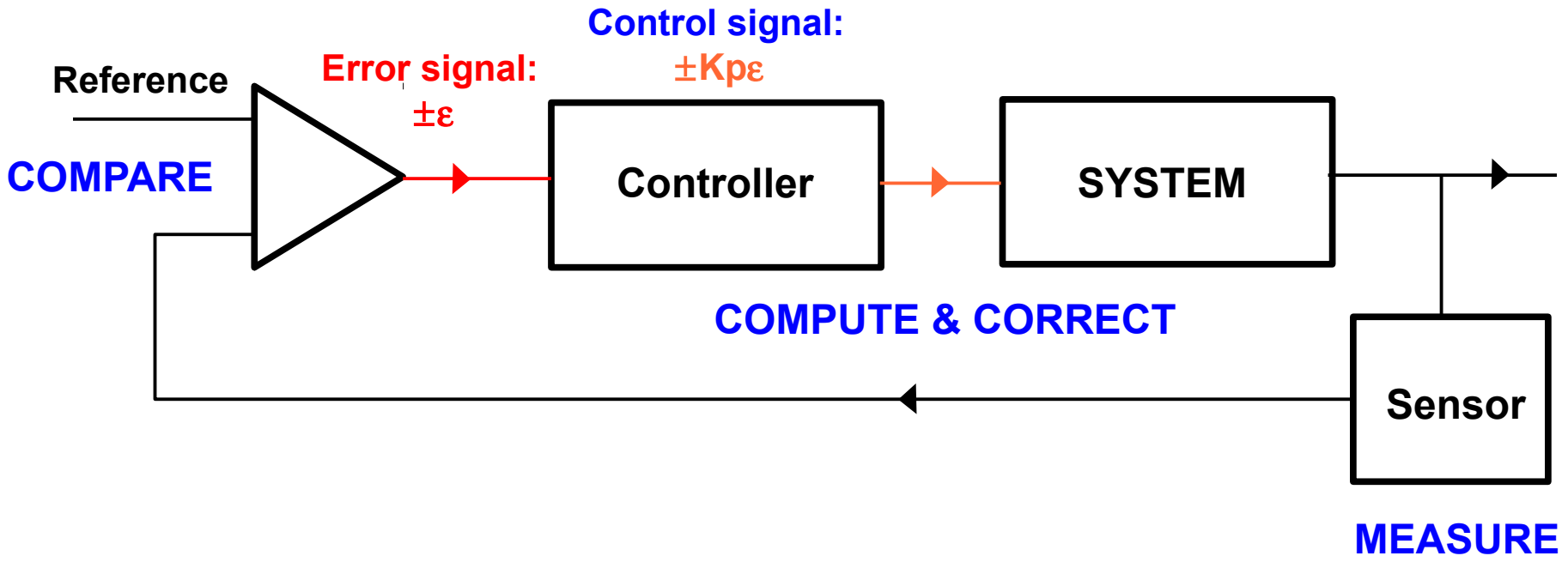
Single setpoint

Control signal proportional (Kp) to instantaneous error signal (ε)



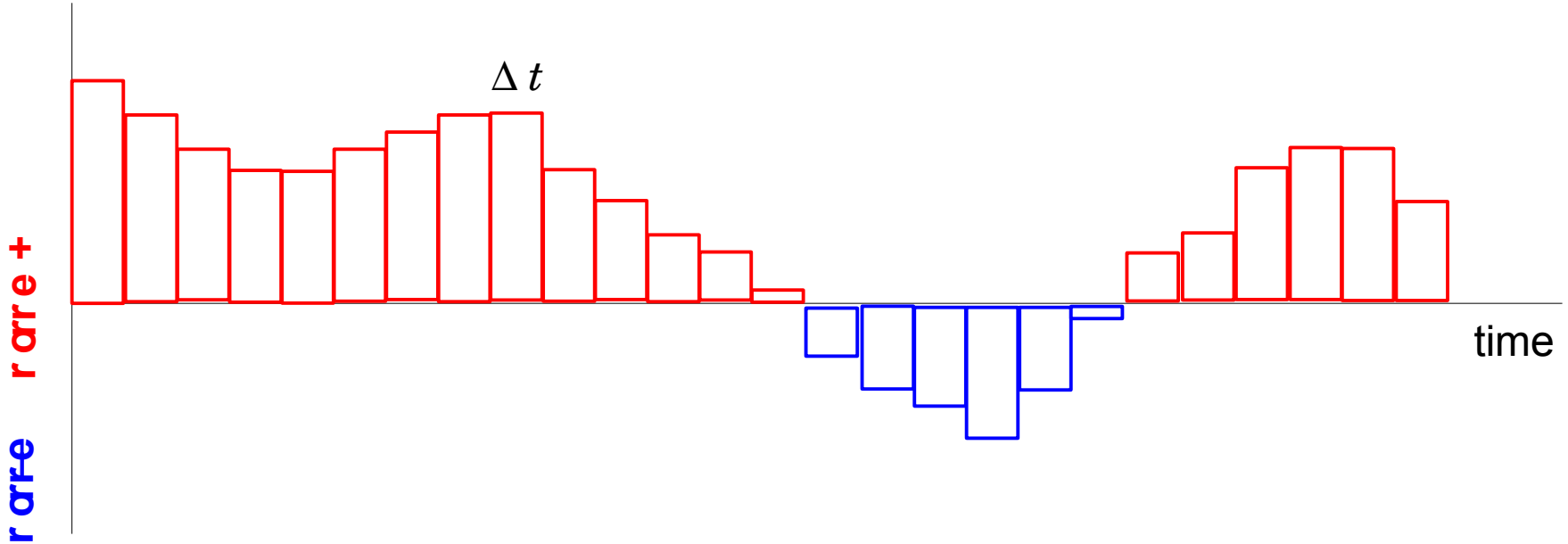
Proportional Control





Proportional control uses the current (instantaneous) error signal

We can do more if we account for the time history of the error signal

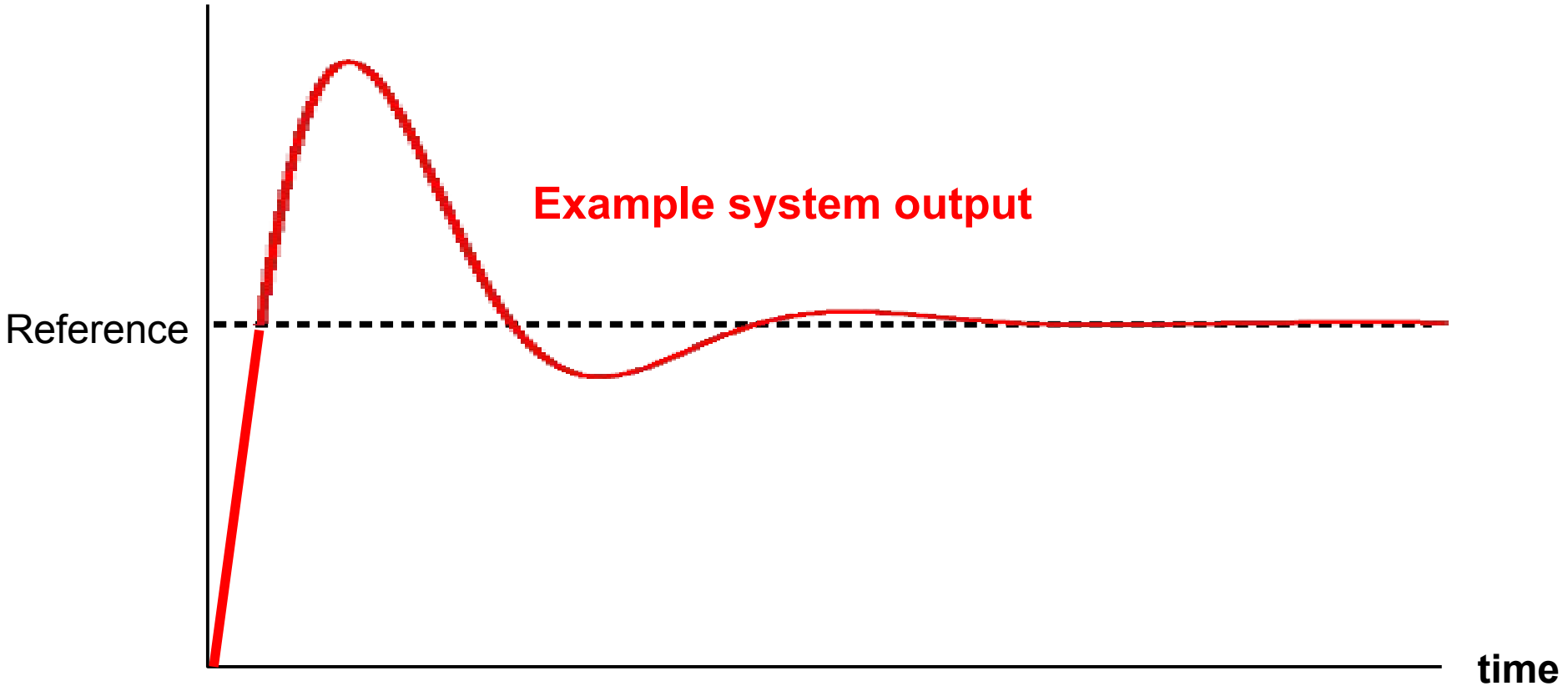


Integrate the error signal: $$\int_0^t \varepsilon(\tau)d\tau = \sum_i \varepsilon_i \Delta t$$

Control Signal: Proportional + Integral

$$K_P\ \varepsilon(t) + K_I \int_0^t \varepsilon(\tau) d\tau$$

$$K_P\ \varepsilon_i + K_I \sum_i \varepsilon_i \Delta t$$



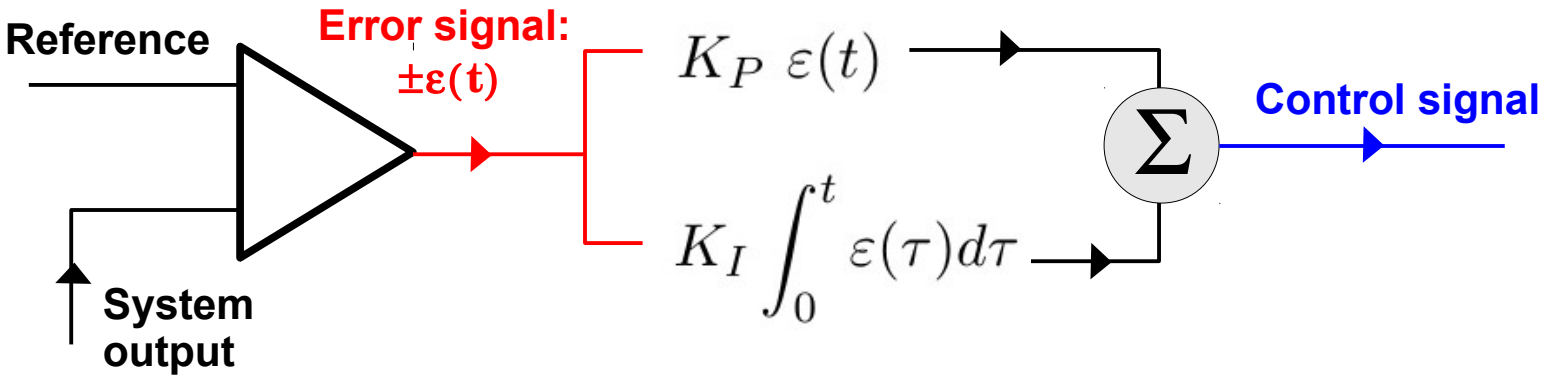
P-I Controller

- Converges to setpoint faster

- No offset

- Has overshoot

- Oscillates above/below setpoint



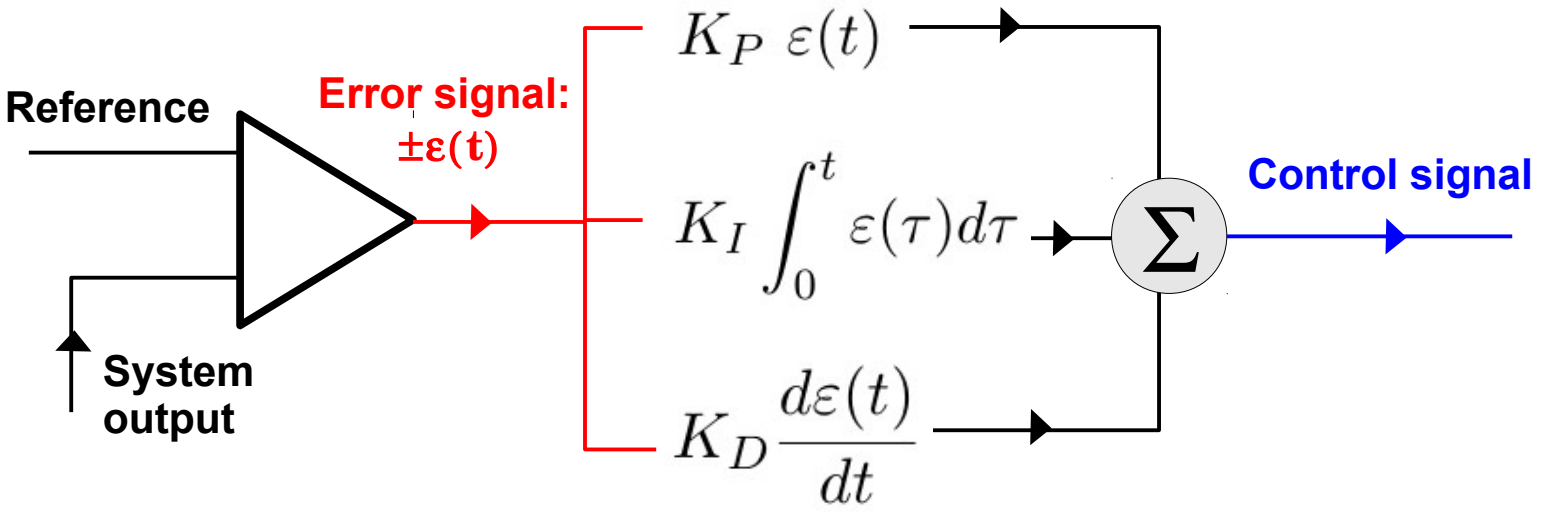
P-I-D Controller

- Take time derivative of error signal

- Can reduce oscillations/overshoot of P-I controller

- Difficult to setup; very susceptible to noise spikes

- Rarely used



Next LabView assignment:
Modify the Thermostat VI to do P-I control

Use the same heater2.vi from the class website inside While Loop (Wait time = dt)
Heater current now controlled by P-I
One temperature setpoint
Use shift-register summation for integral
Heater current has 3 selectable levels: 0.1 (Low), 0.5 (Medium), or 1 (High)
Display real-time temperature data on Waveform Chart
Include heater current indicator

Program logic must handle **two new issues** due to P-I control**:**

1) Negative control signal $\Rightarrow$ Force heater current to zero

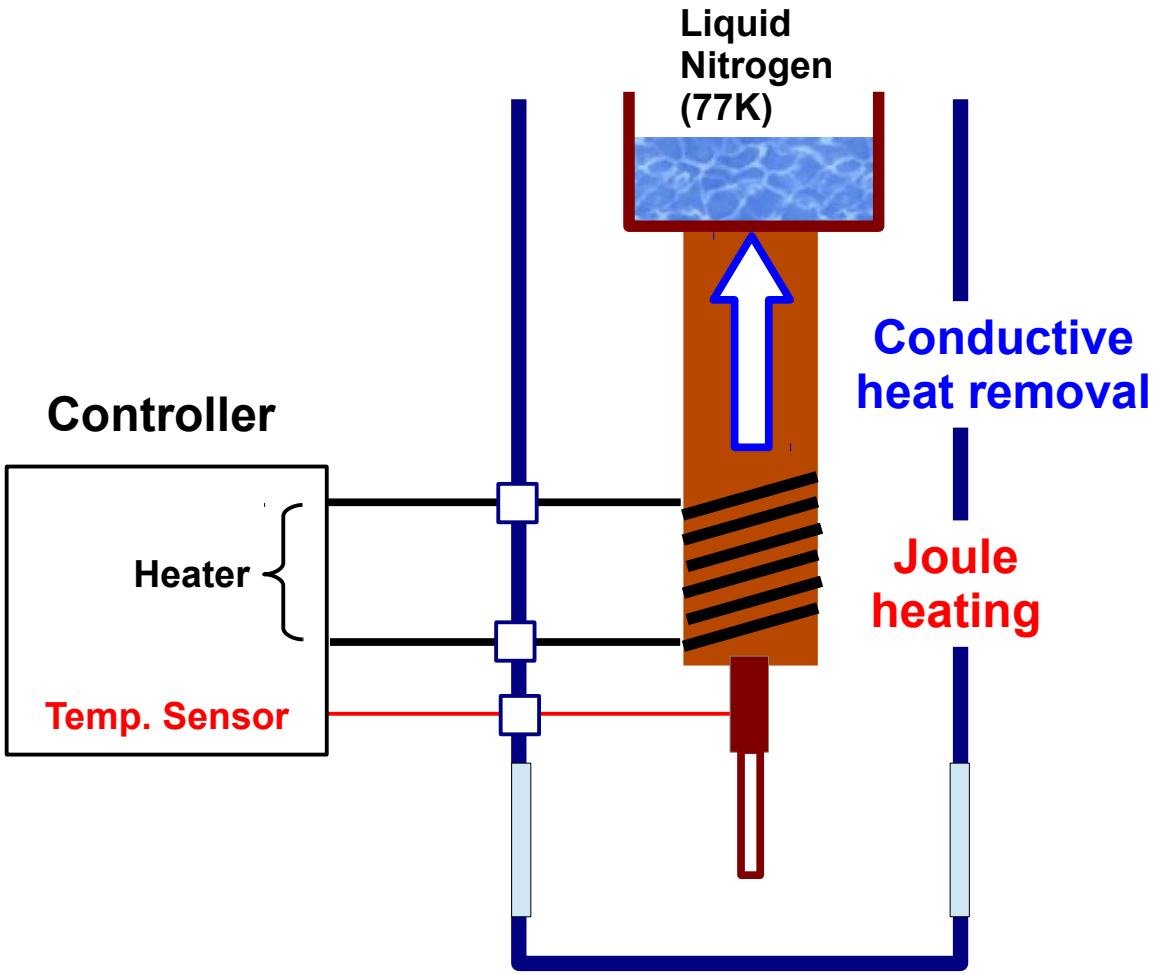
2) Control signal greater than current capacity $\Rightarrow$ Clamp at max current

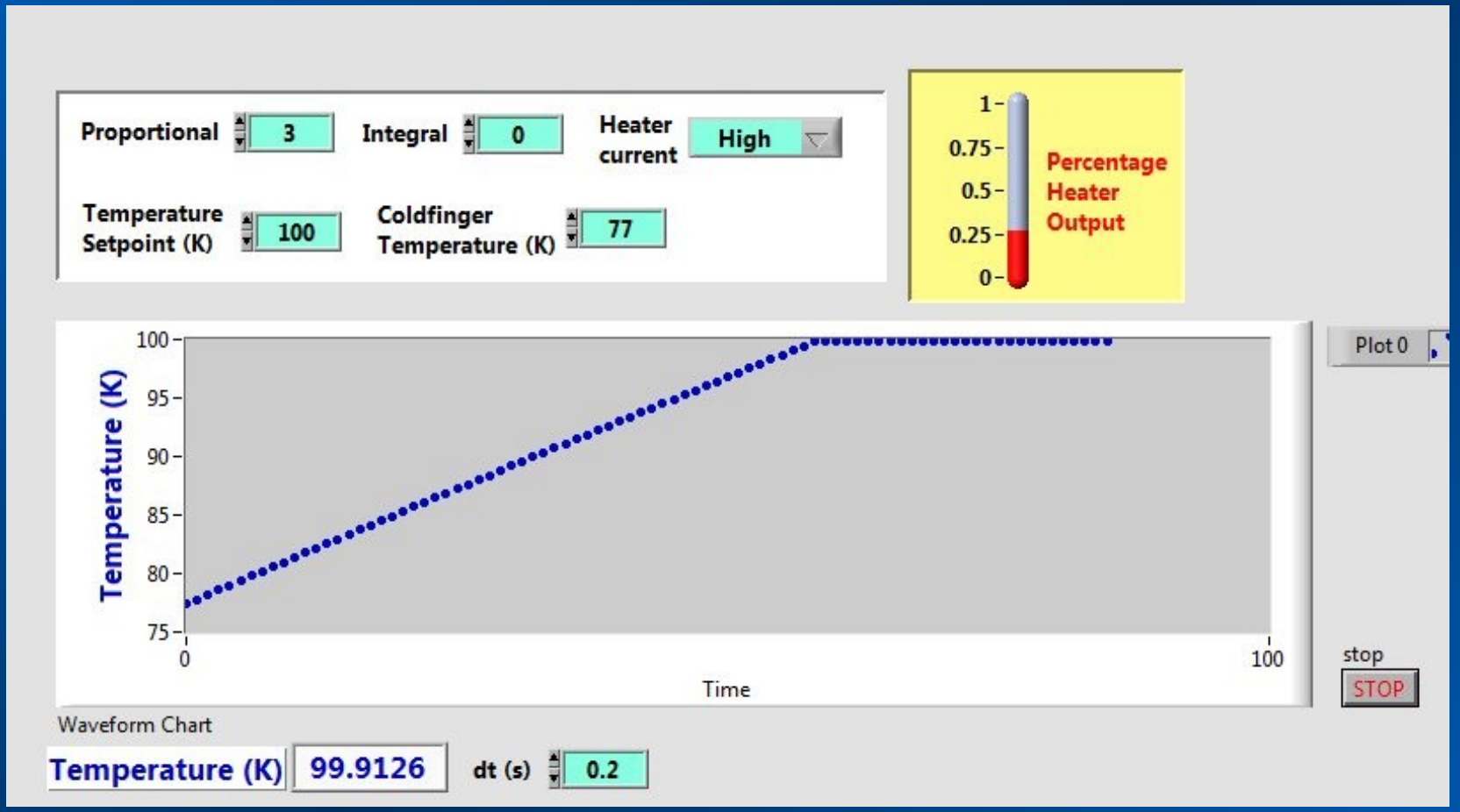
This VI will perform P-I temperature control in next week's lab

How do we interpret a **negative** control signal?

Controller wants system to cool

We have no direct control of cooling: Turn off heater and wait




Proportional
3
Integral
0
Heater current
High
Temperature Setpoint (K)
100
Coldfinger Temperature (K)
77
1
0.75
0.5
0.25
0
Percentage Heater Output
Temperature (K)
100
95
90
85
80
75
0
100
Time
Plot 0
stop
STOP
Waveform Chart
Temperature (K)
99.9126
dt (s)
0.2

About this week's lab

Assigned LabView program will control a resistive heater

VI will be heavily modified for DAQmx input and output

Remove heater2.vi, shift register, ambient temperature, etc

Change units from degrees K to degrees C

Cooling will be primarily convective, but not ideal

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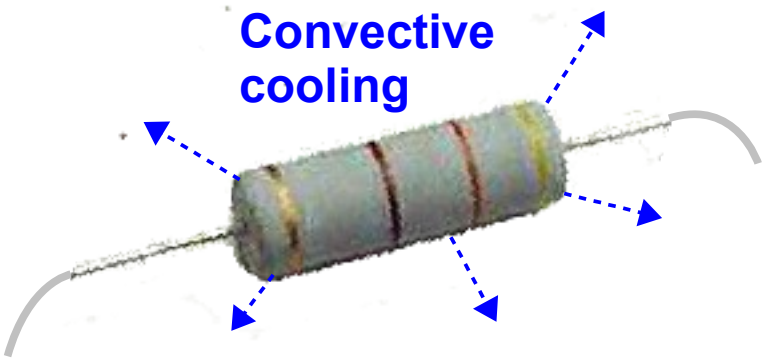
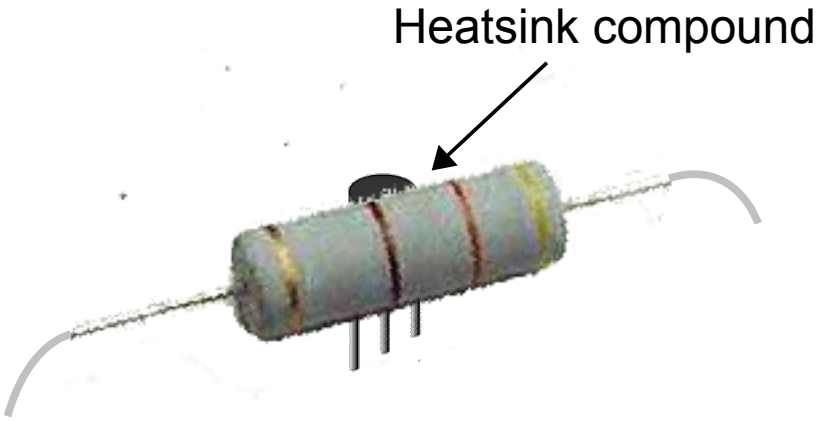


Temperature Sensor:
Zener diode based IC



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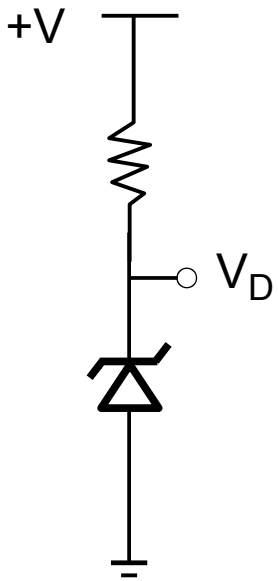

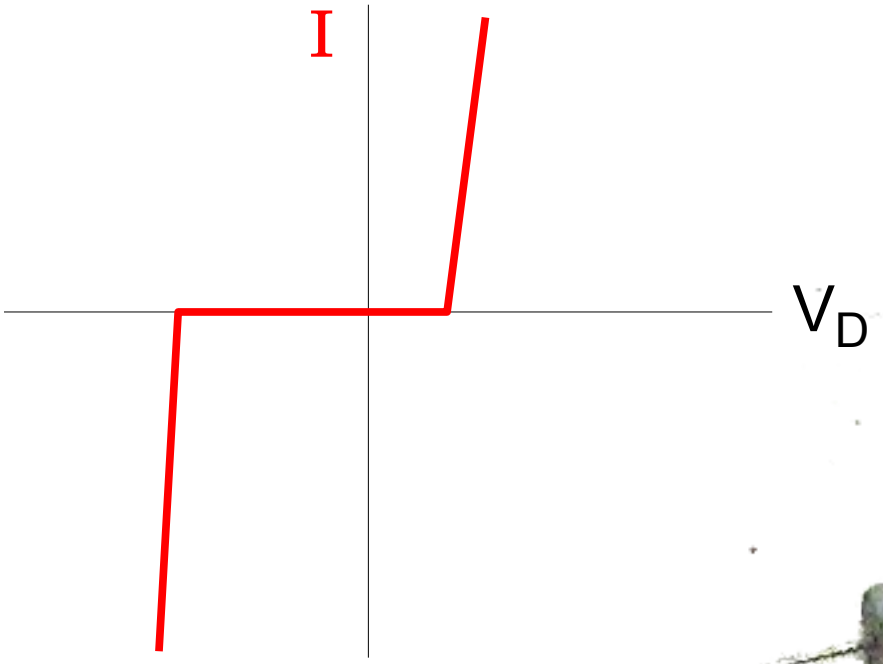

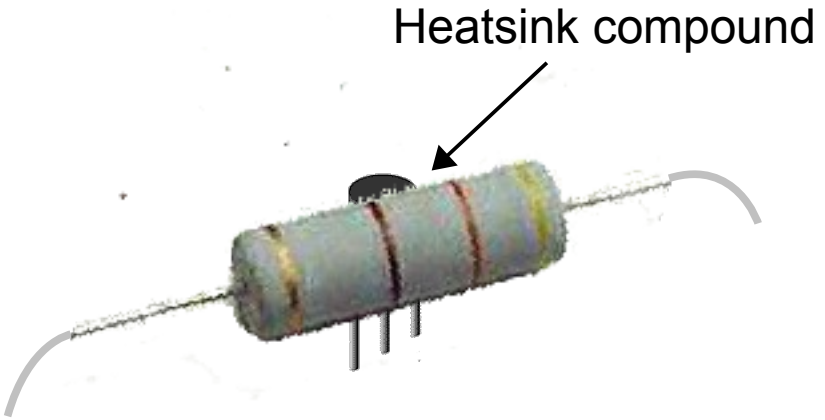

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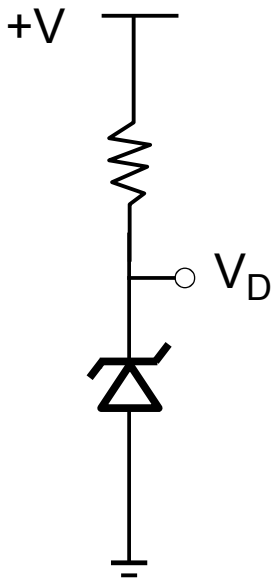

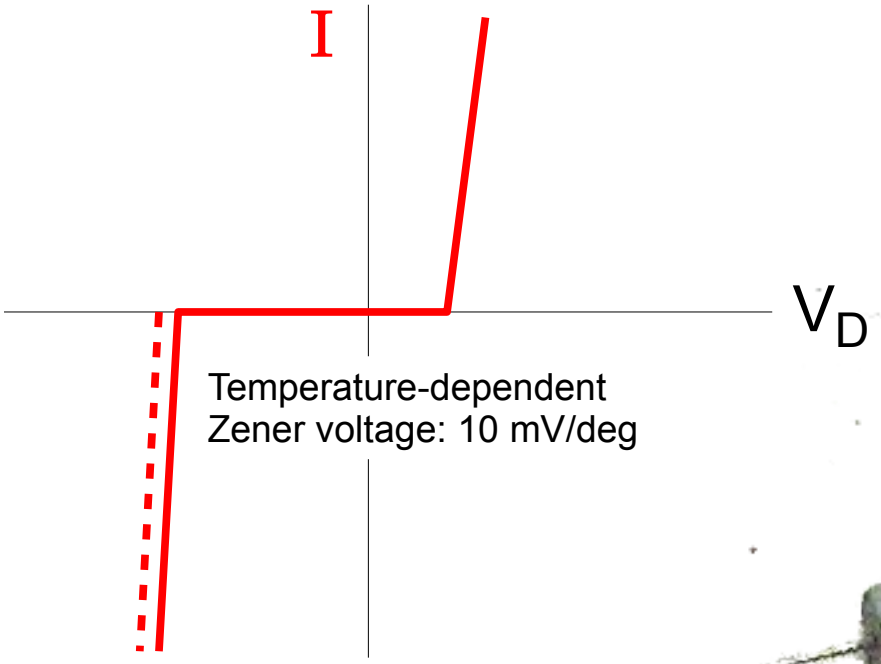

Temperature-dependent
Zener voltage: 10 mV/deg