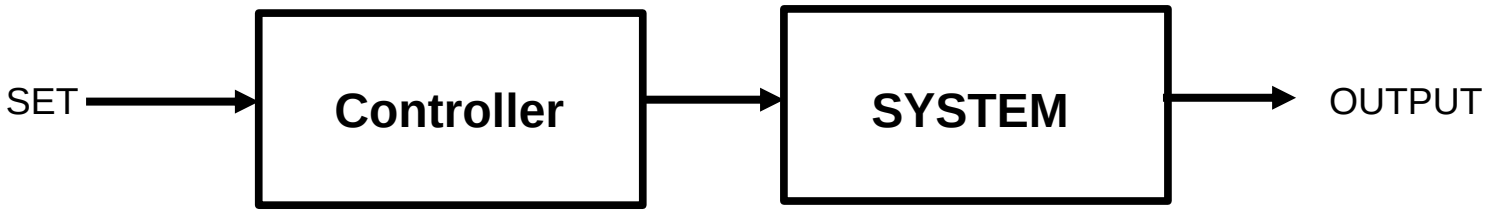
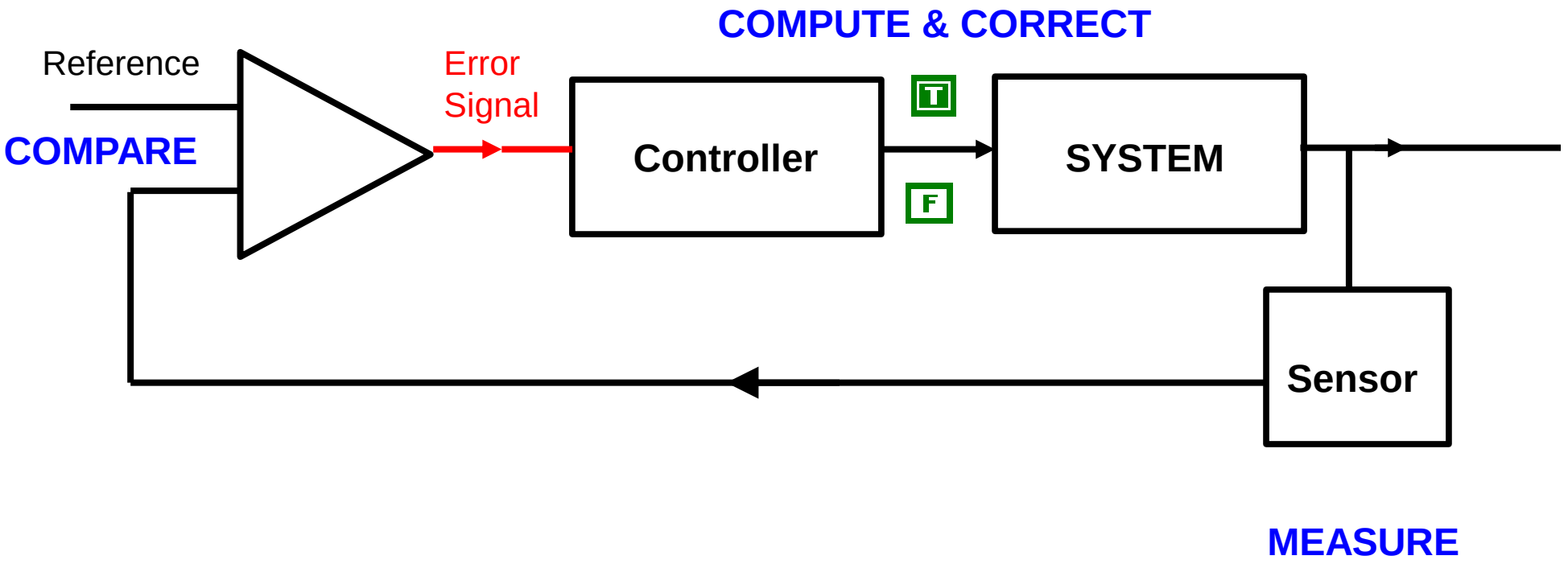
Lab 13: Controls (Part 2)

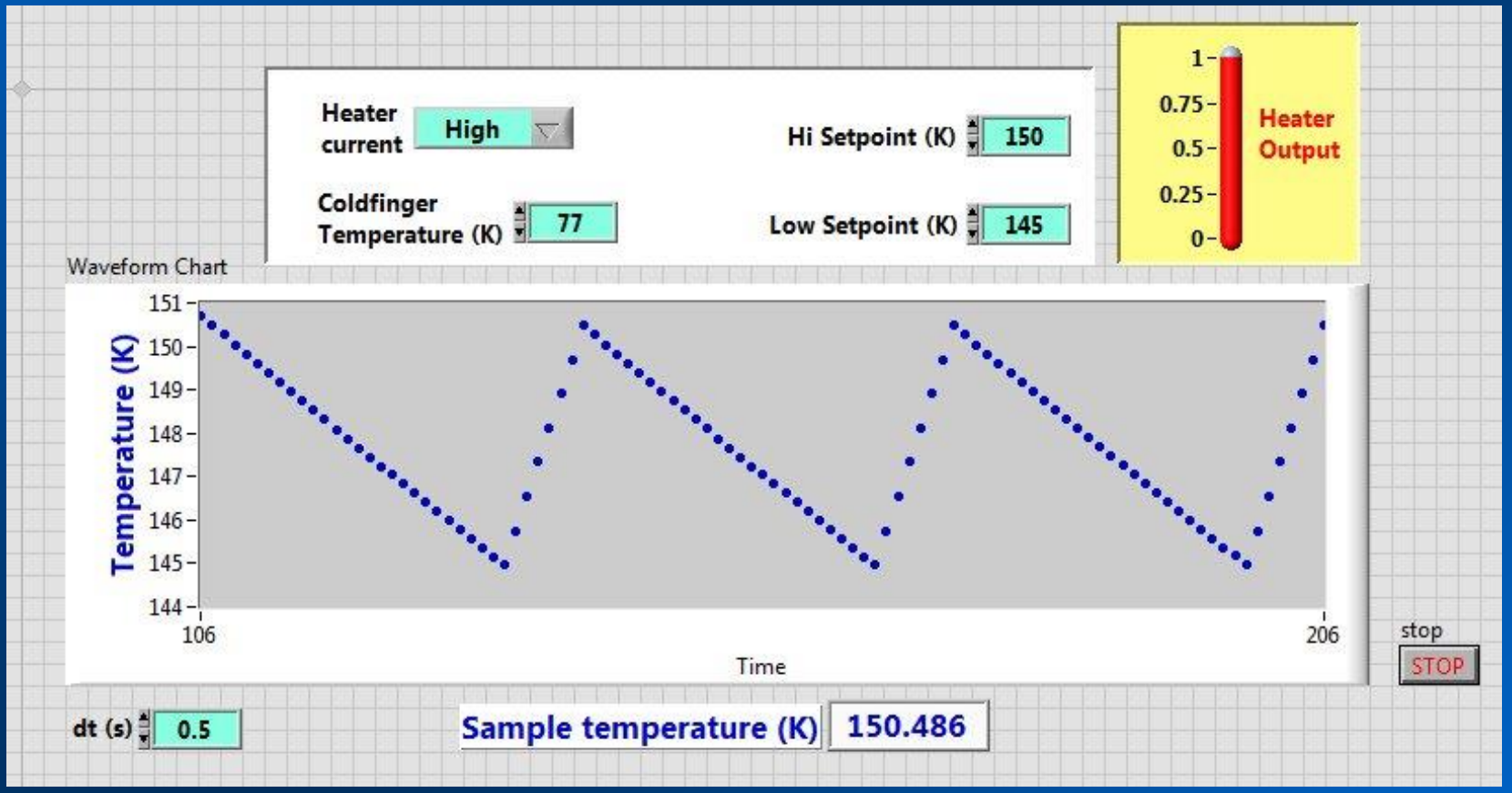
OPEN LOOP



CLOSED LOOP

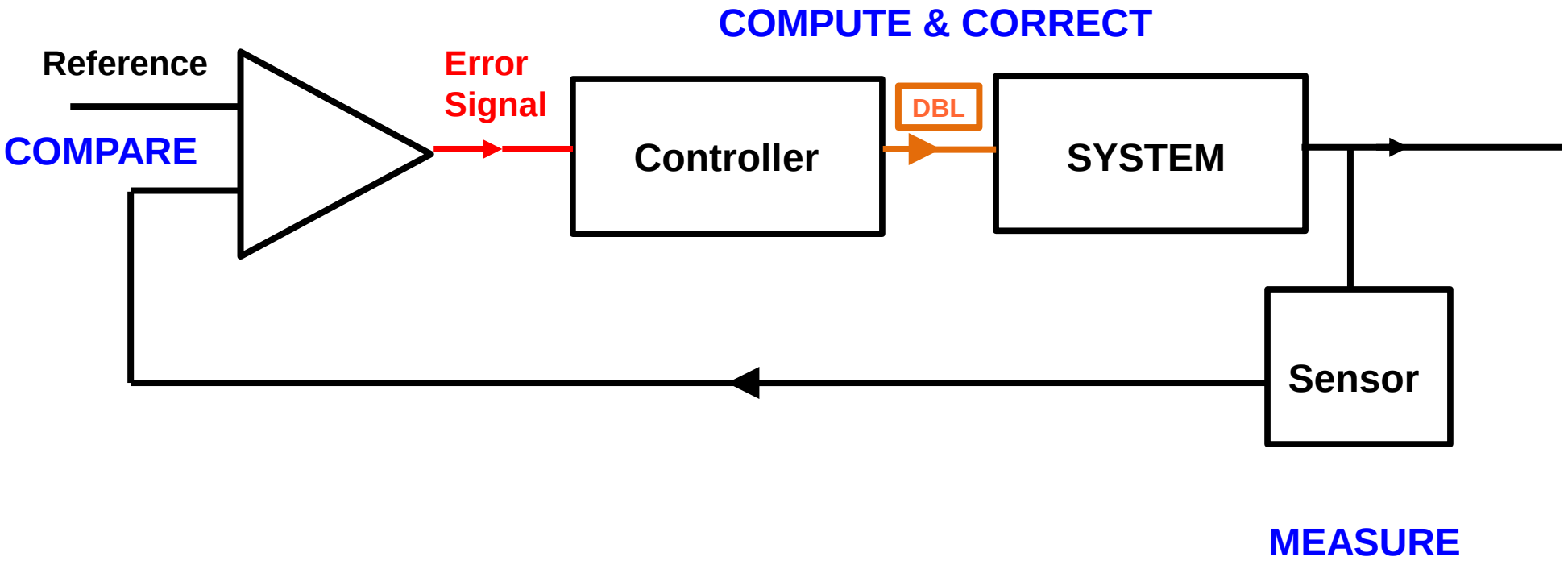

COMPUTE & CORRECT
Reference
Error
Signal
COMPARE
Controller
T
F
SYSTEM
Sensor
MEASURE

HYSTERETIC CONTROLLER: ON or OFF



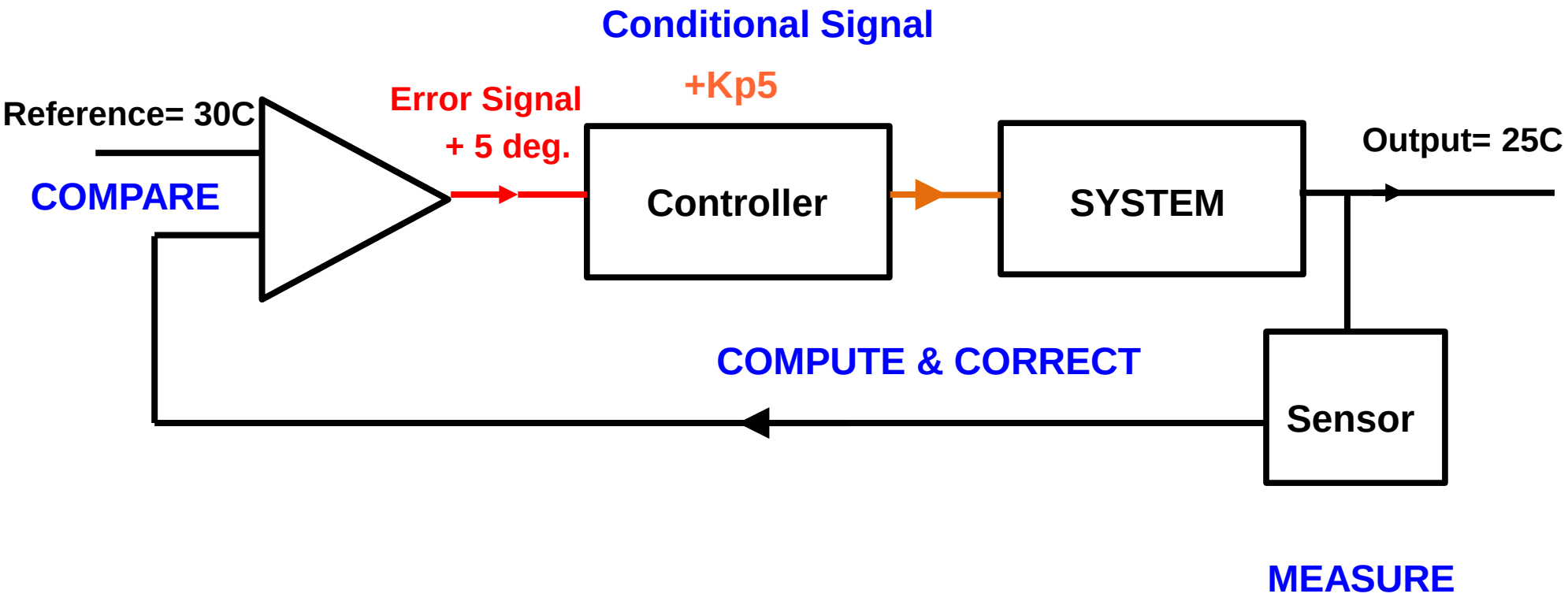
The control signal does not have to be Boolean T/F or ON/OFF

Error signal has magnitude/phase information



EXAMPLE: Temperature Controller with single setpoint

Kp: proportionality constant



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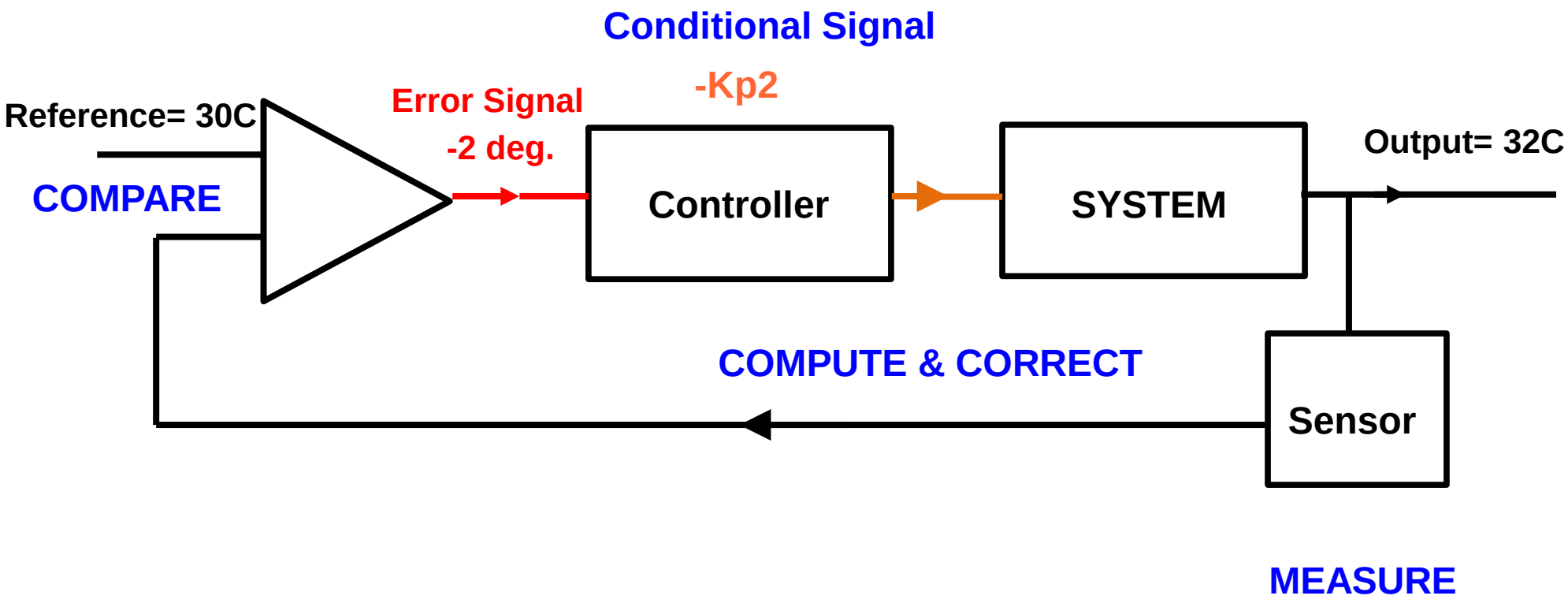

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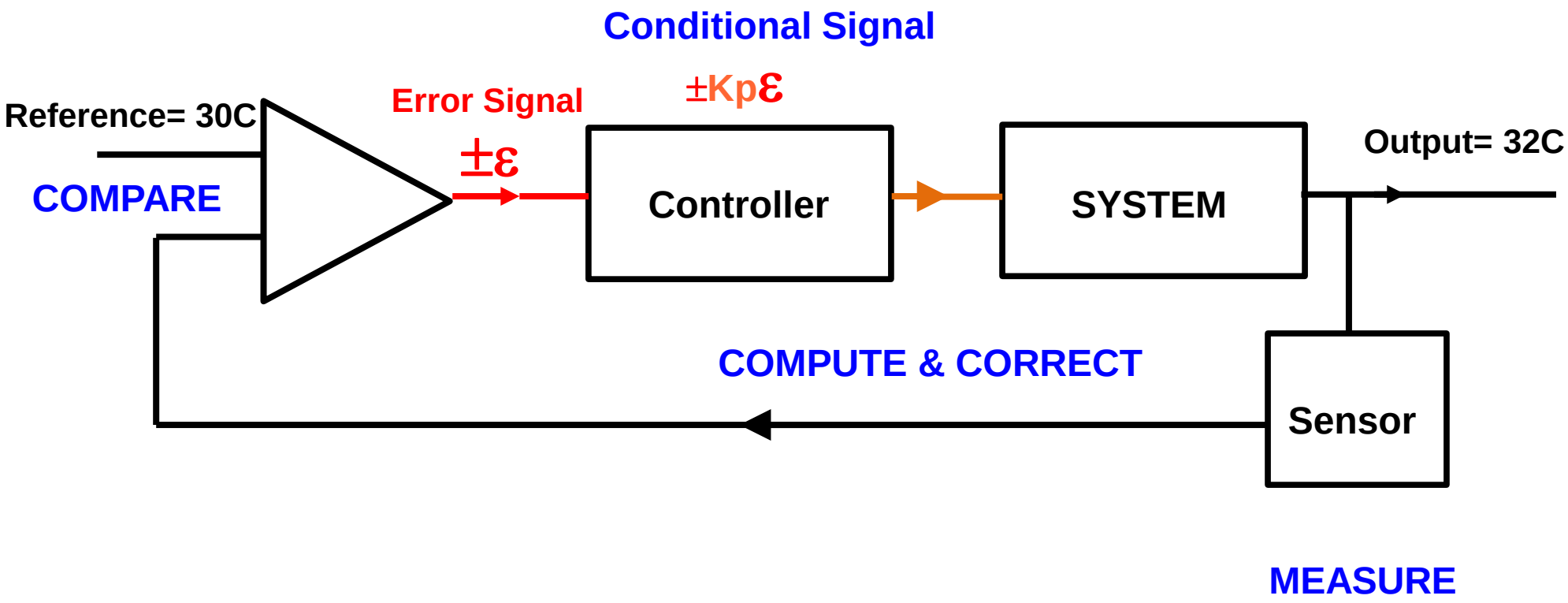
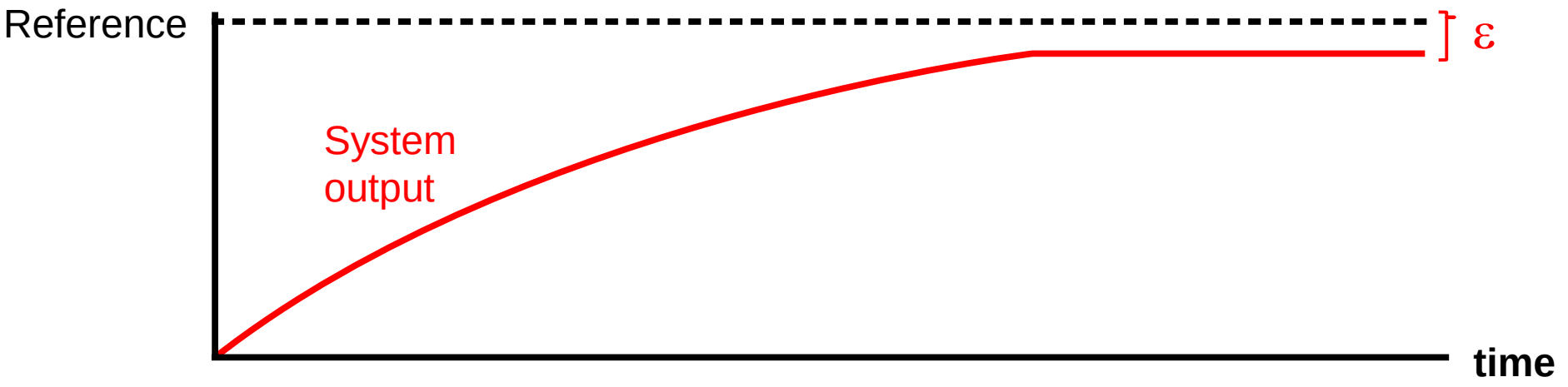
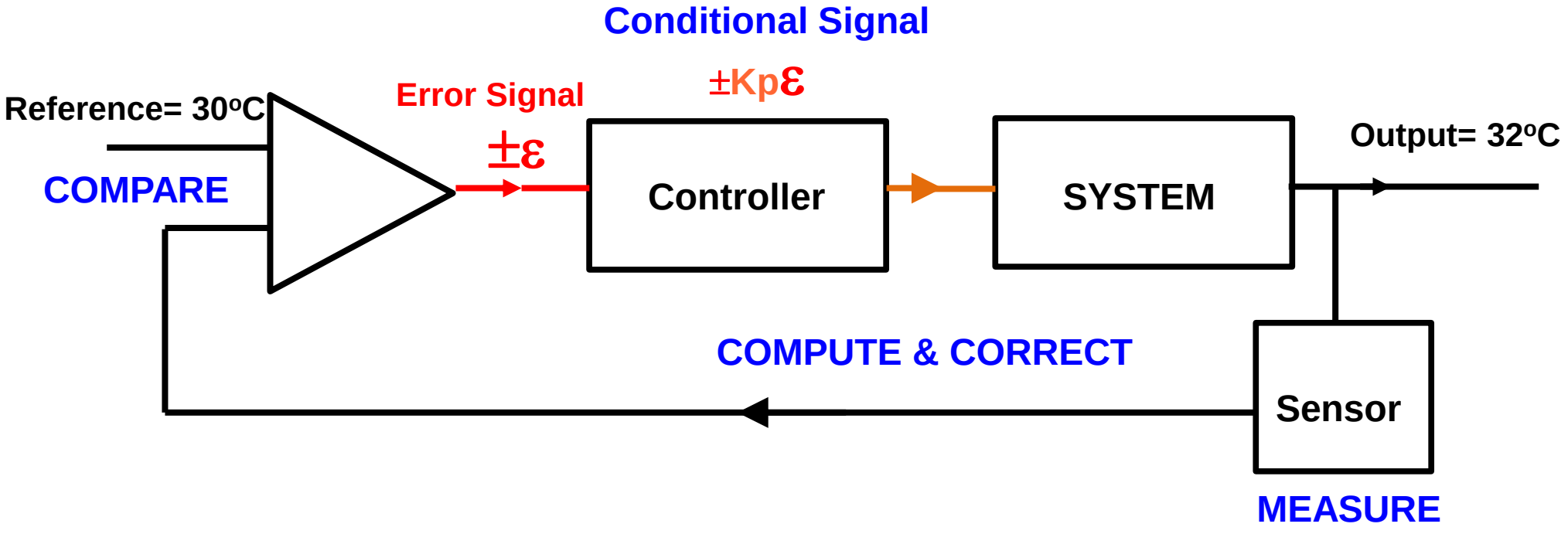


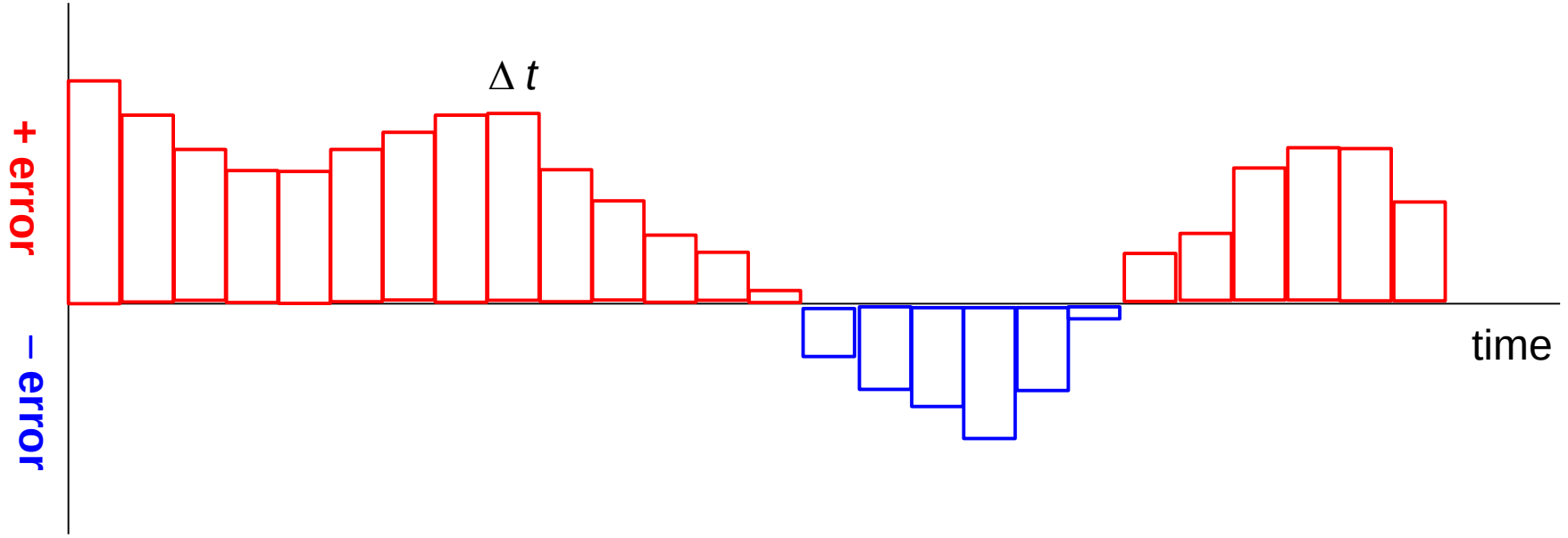
Proportional Control





Proportional control uses the current (instantaneous) error signal

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

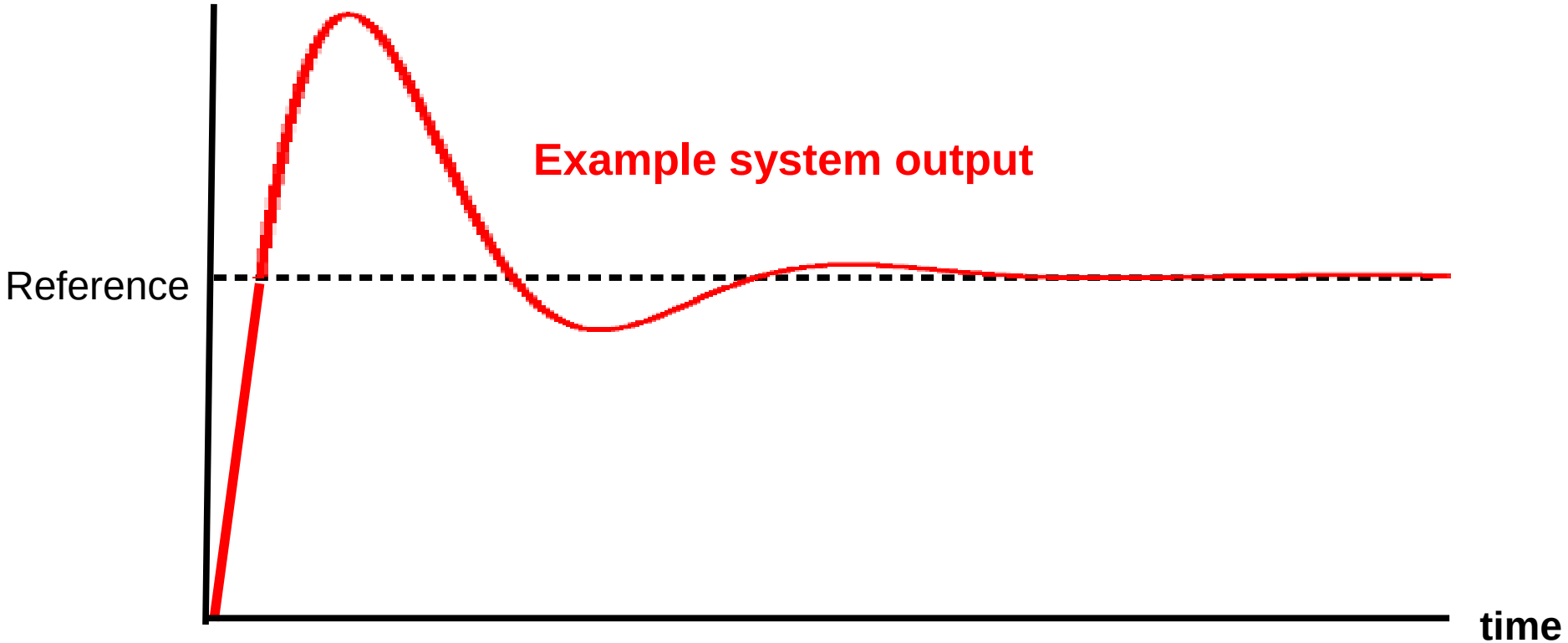


Integrate the error signal: $$\int_0^t \varepsilon(\tau)d\tau = \sum_i \varepsilon_i \Delta t$$

Control Signal: Proportional + Integral

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

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



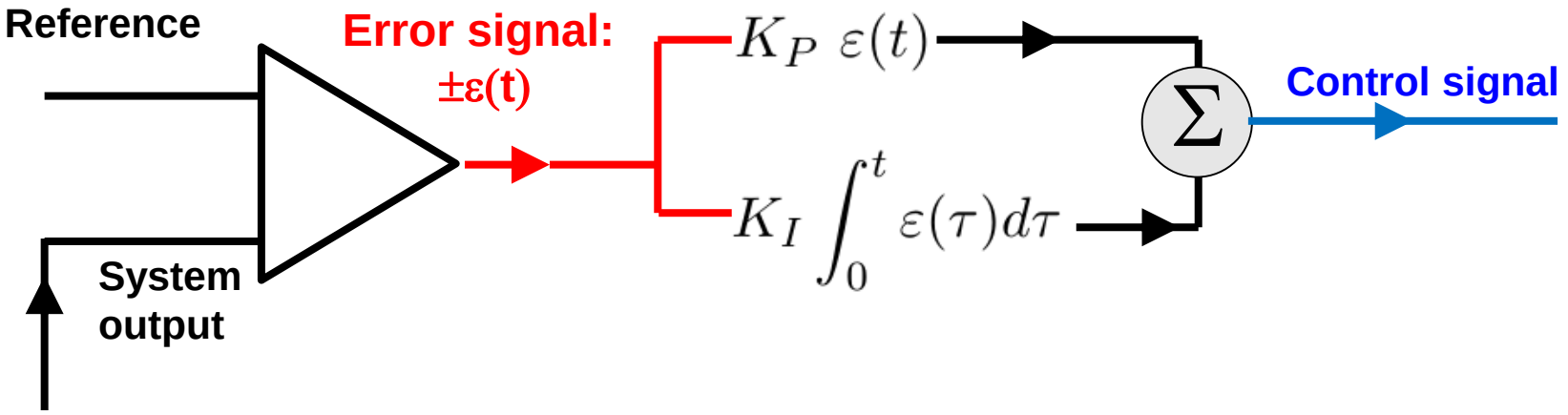
P-I Controller

- Converges to setpoint faster

- No offset

- Has overshoot

- Oscillates above/below setpoint



P-I-D Controller

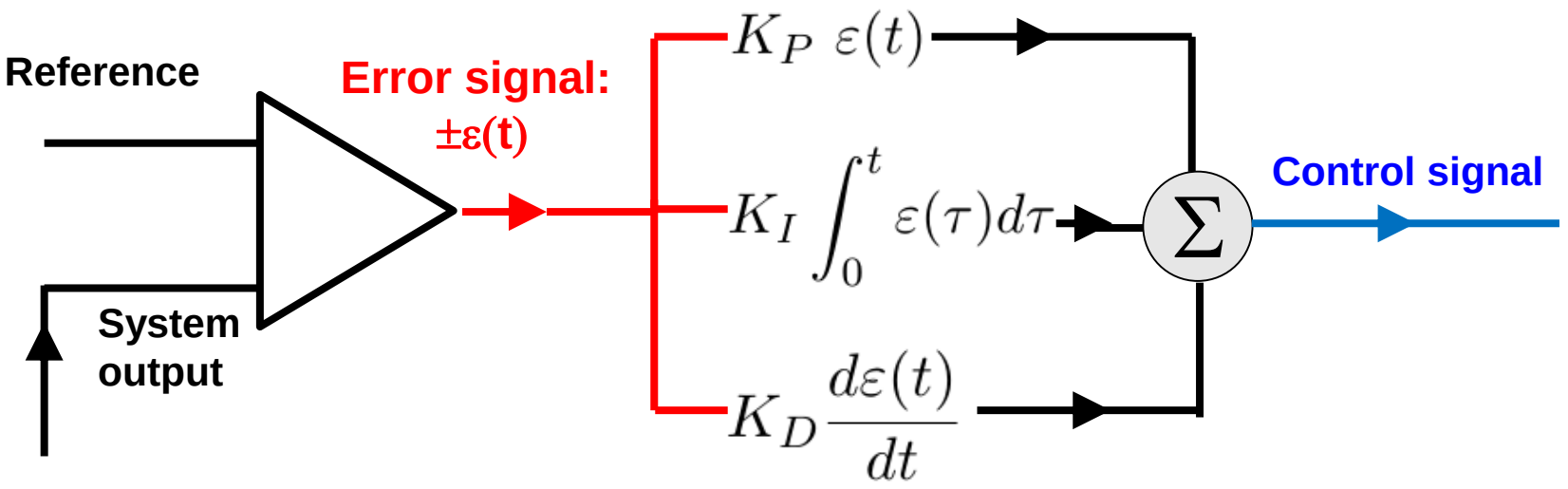
- Take time derivative of error signal

- Can reduce oscillations/overshoot of P-I controller

- Difficult to setup; very susceptible to noise spikes

- Rarely used

- **FAST CHANGES!!!**



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

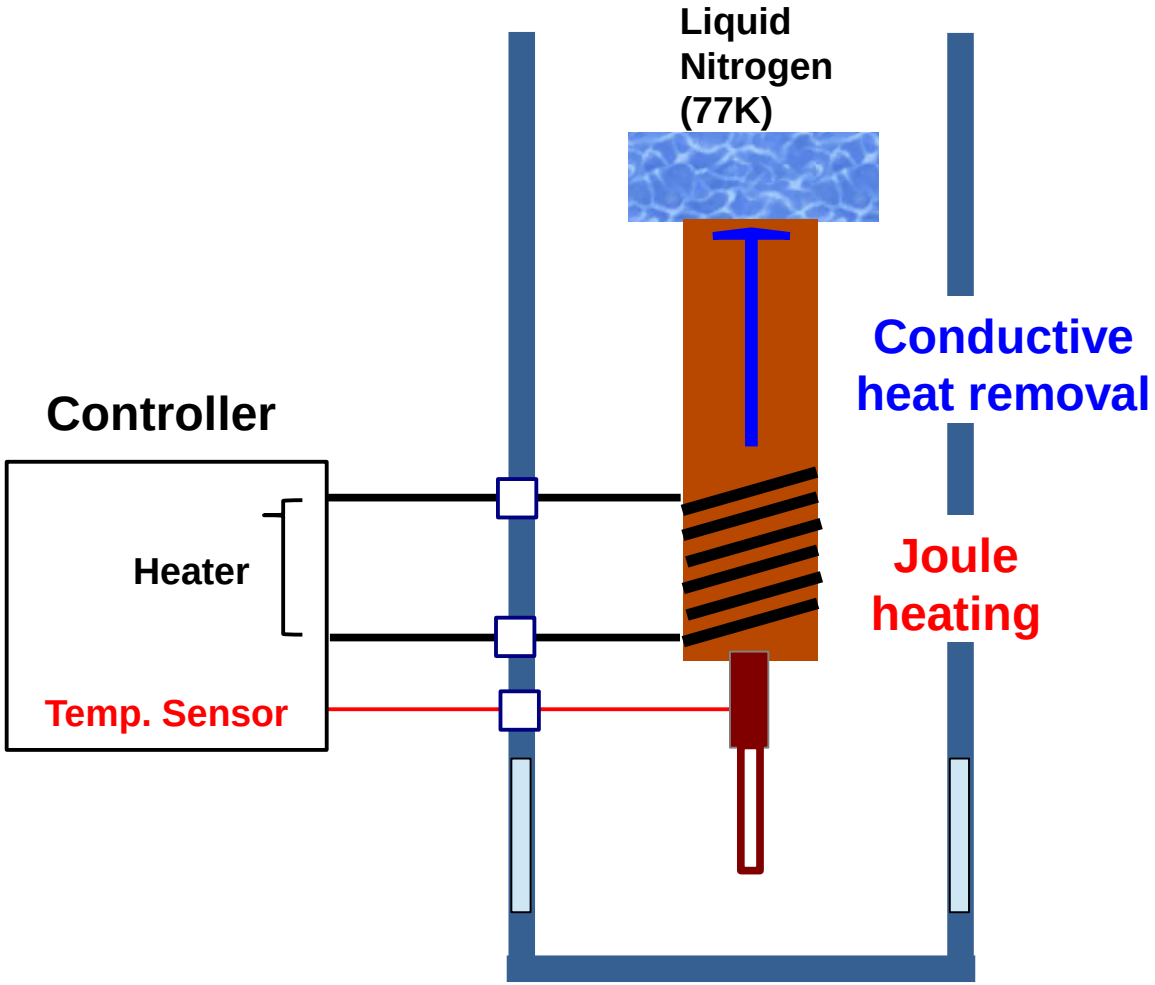
2) Control signal greater than current capacity $\Rightarrow$ Clamp at max current

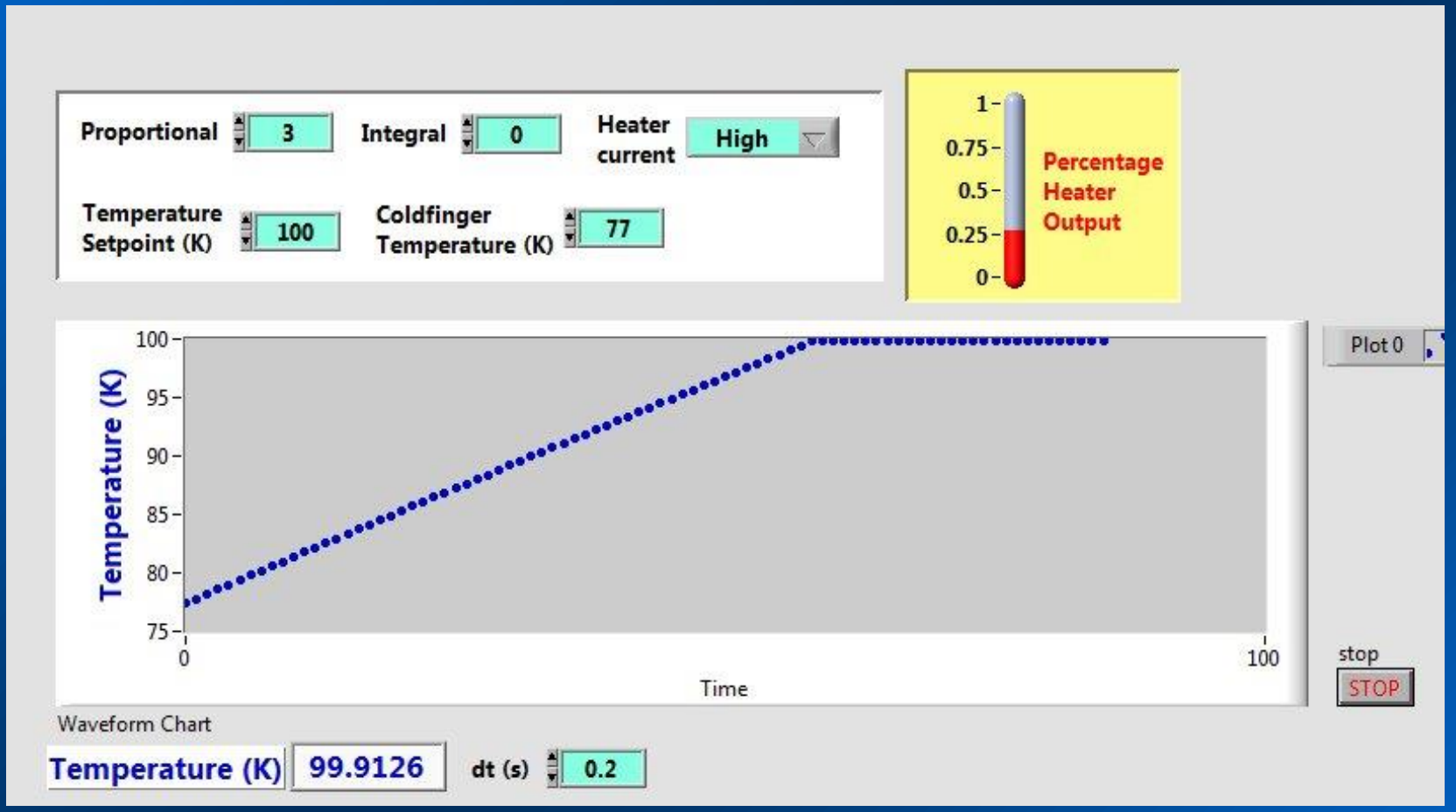
This VI will perform P-I temperature control in next week's lab

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

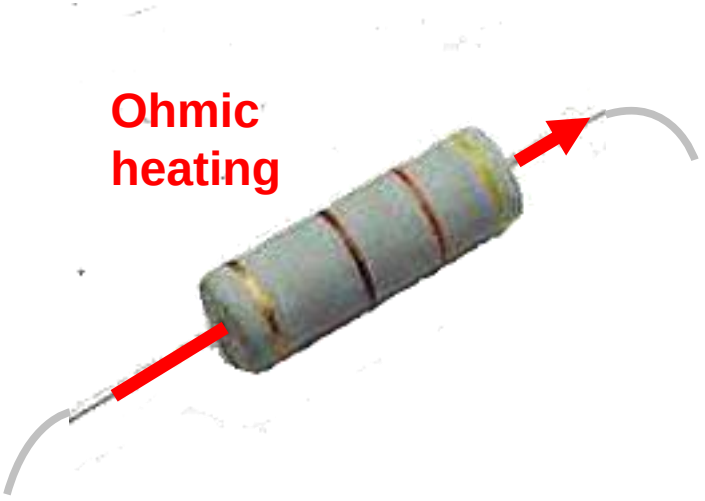
Assigned LabView program will control a resistive heater

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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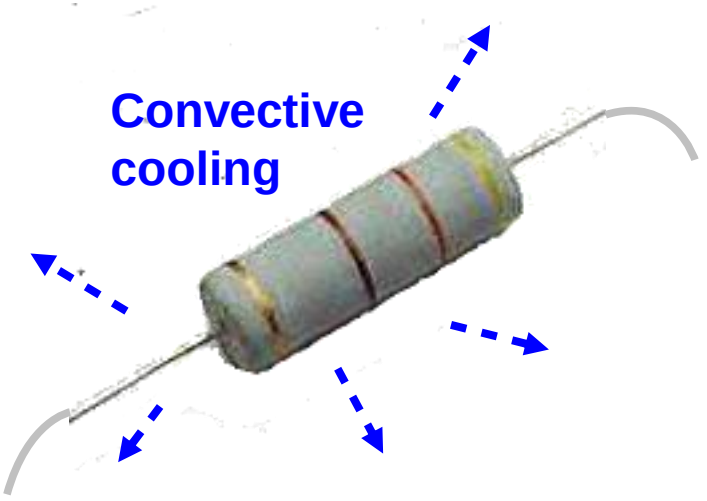
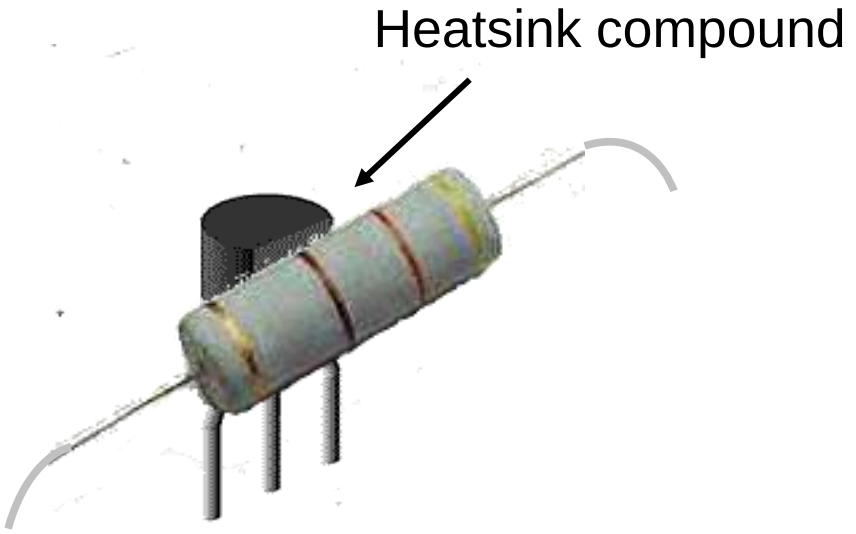


Temperature Sensor:
Zener diode based IC



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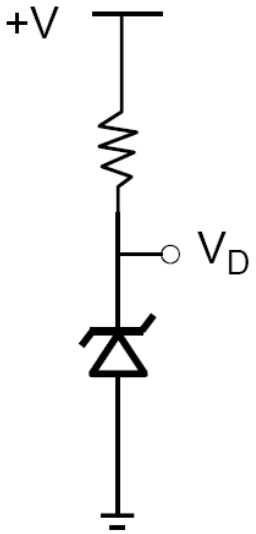

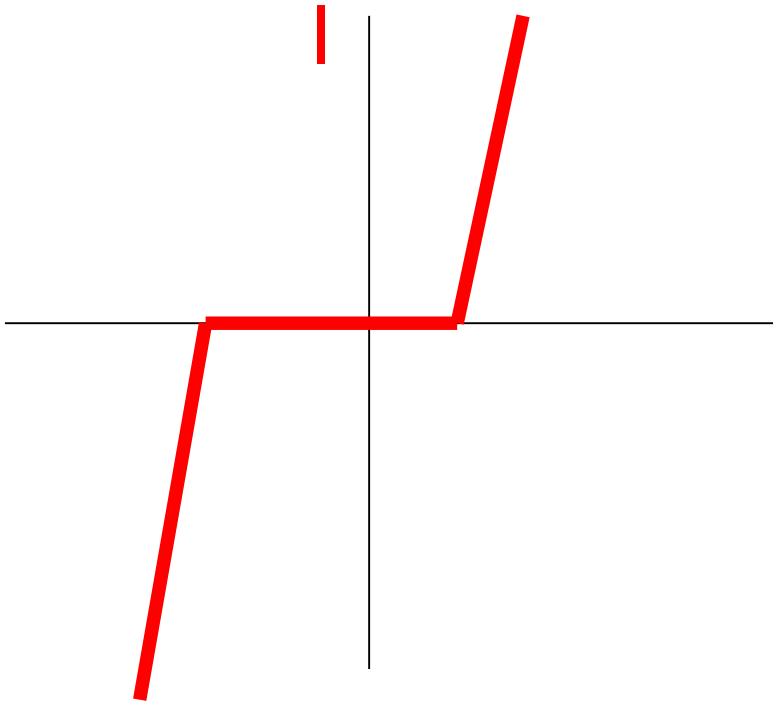

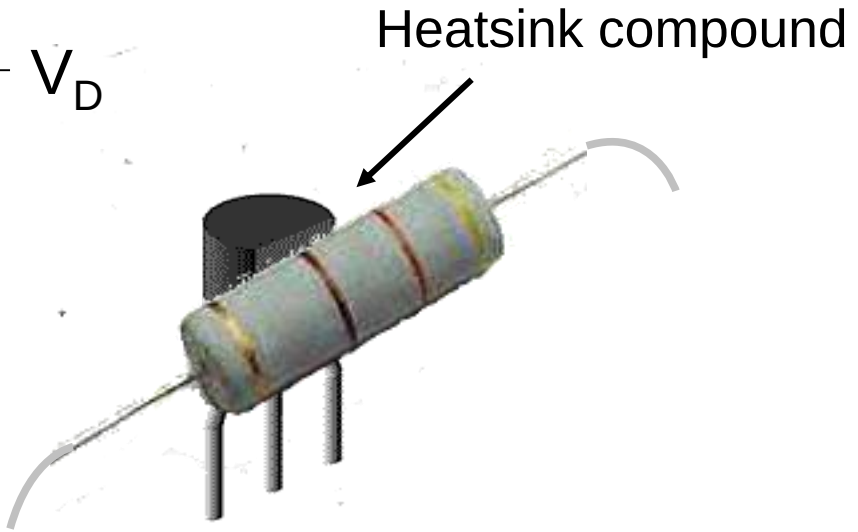

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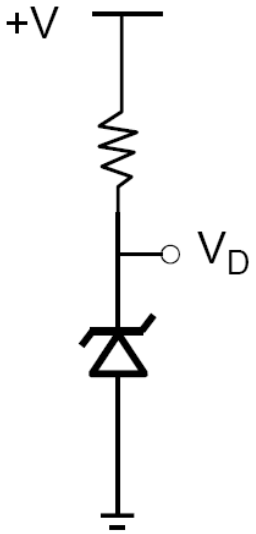

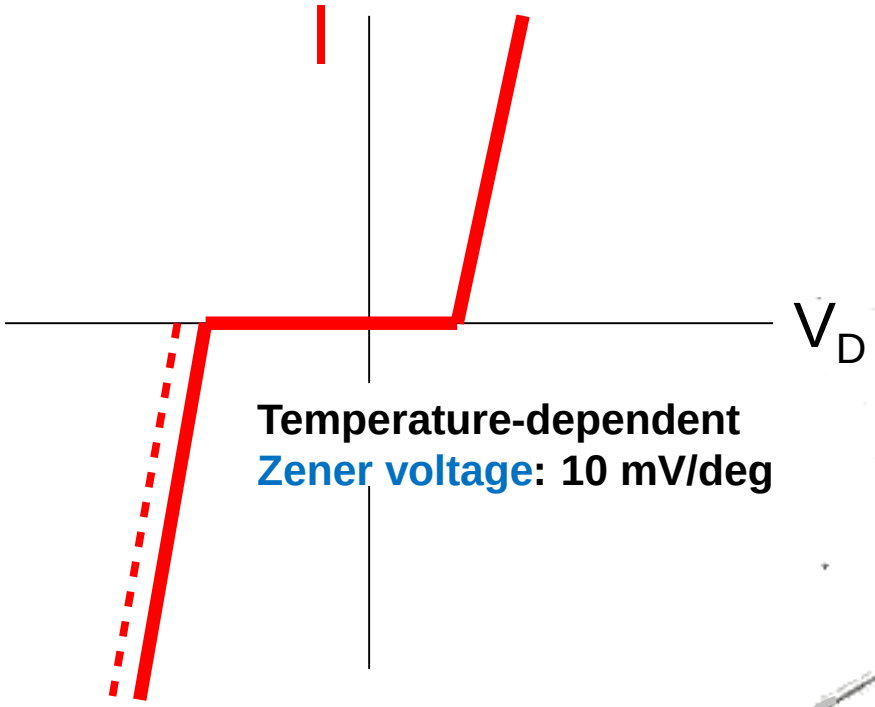
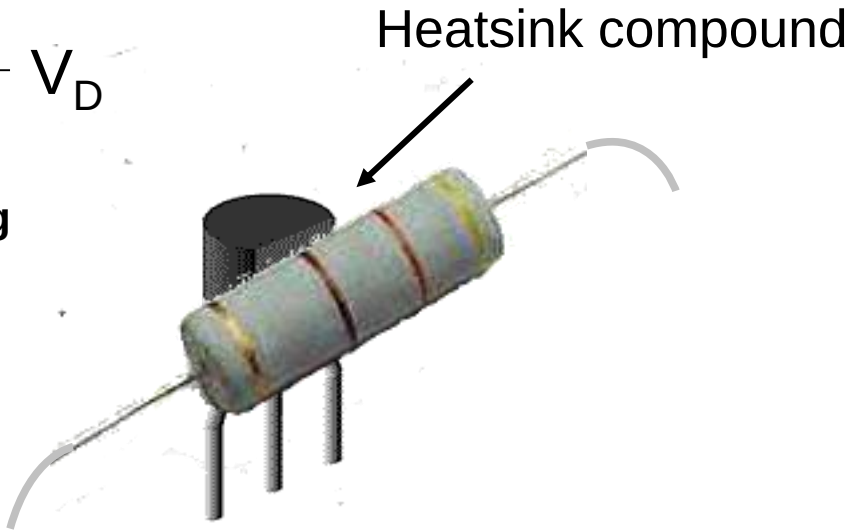
Temperature-dependent Zener voltage: 10 mV/deg