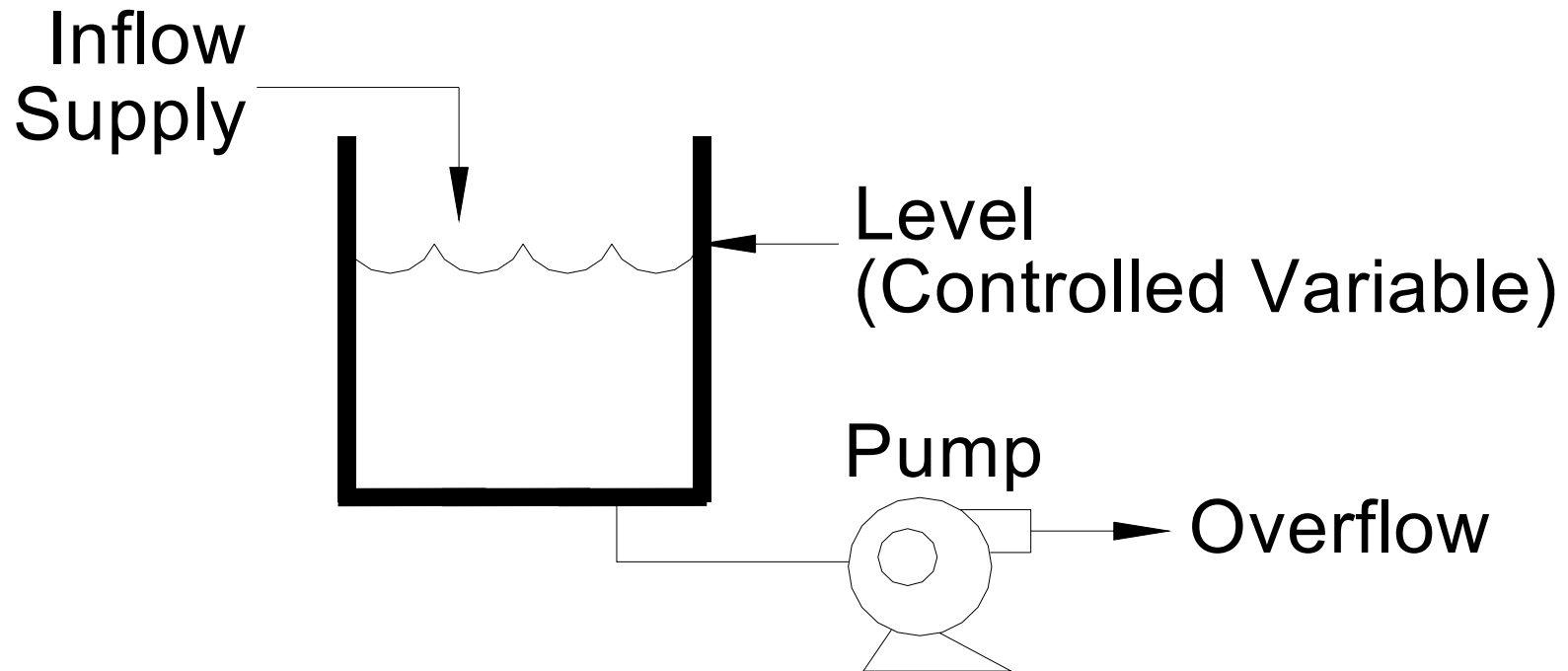




Basic Process Control

Basic Control Principles

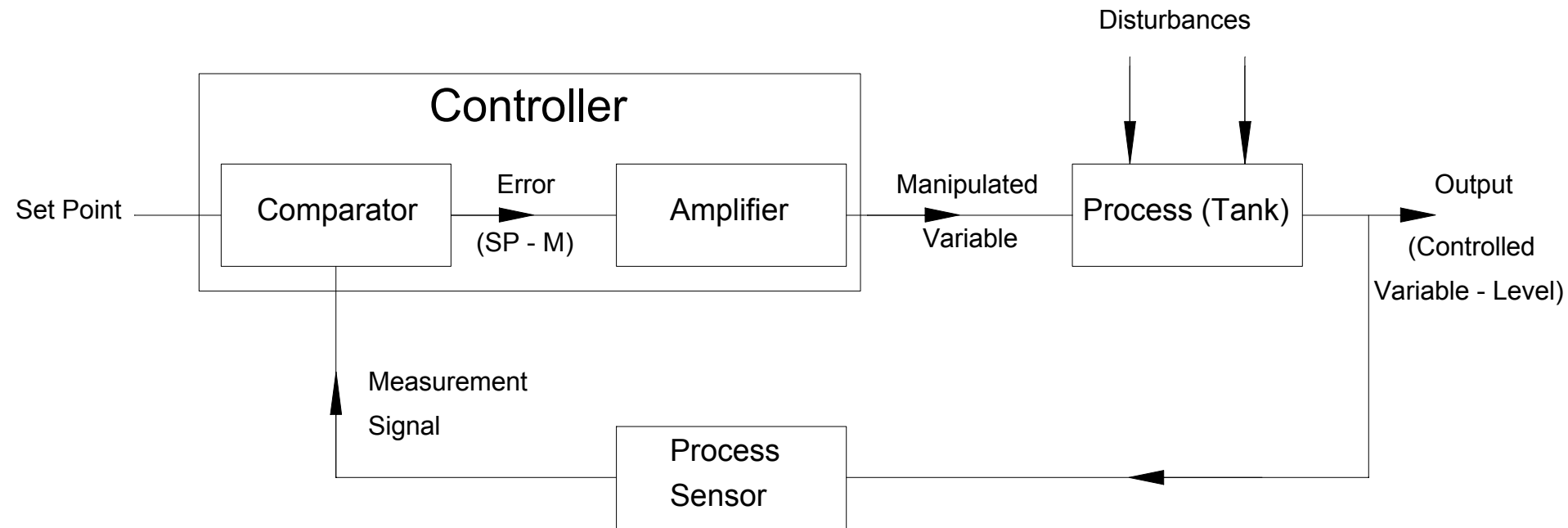




Open vs Closed Loop

- Closed loop
 - Automatic control
- Open Loop
 - Manual control
 - Person takes the place of the controller

Feedback Control

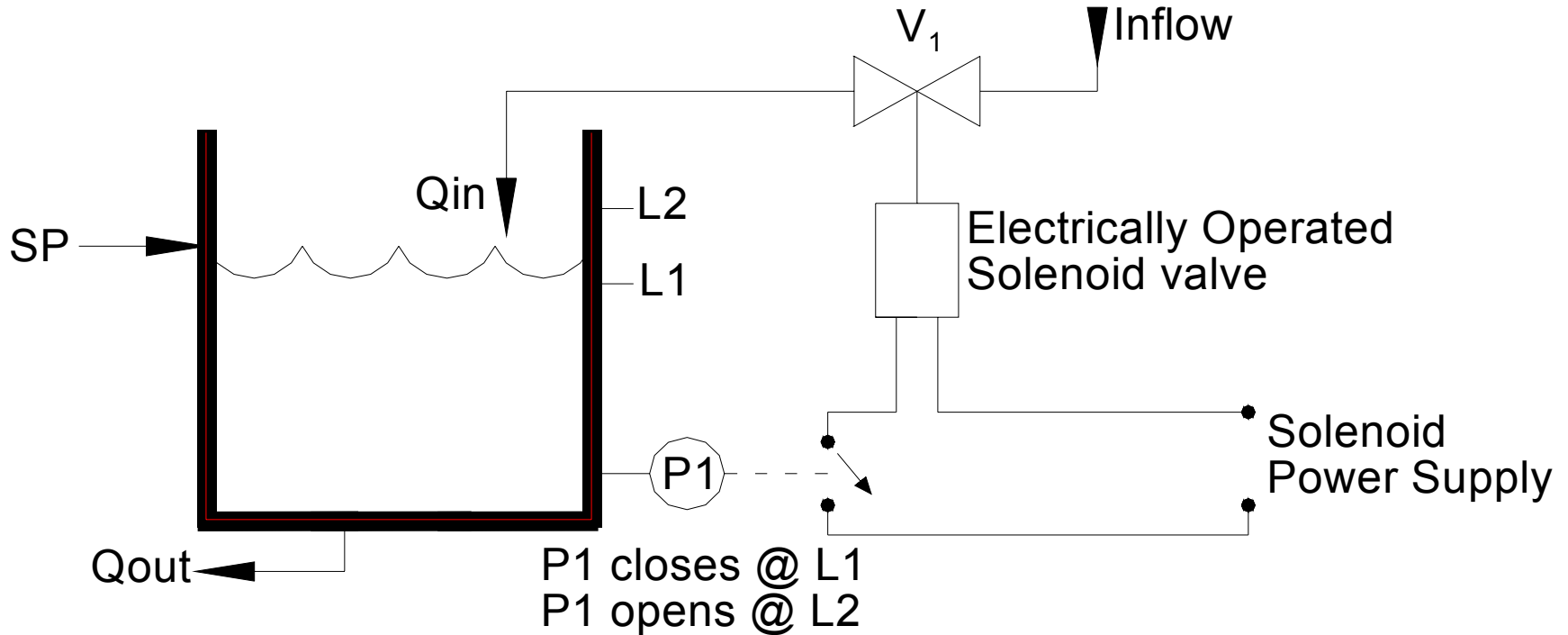




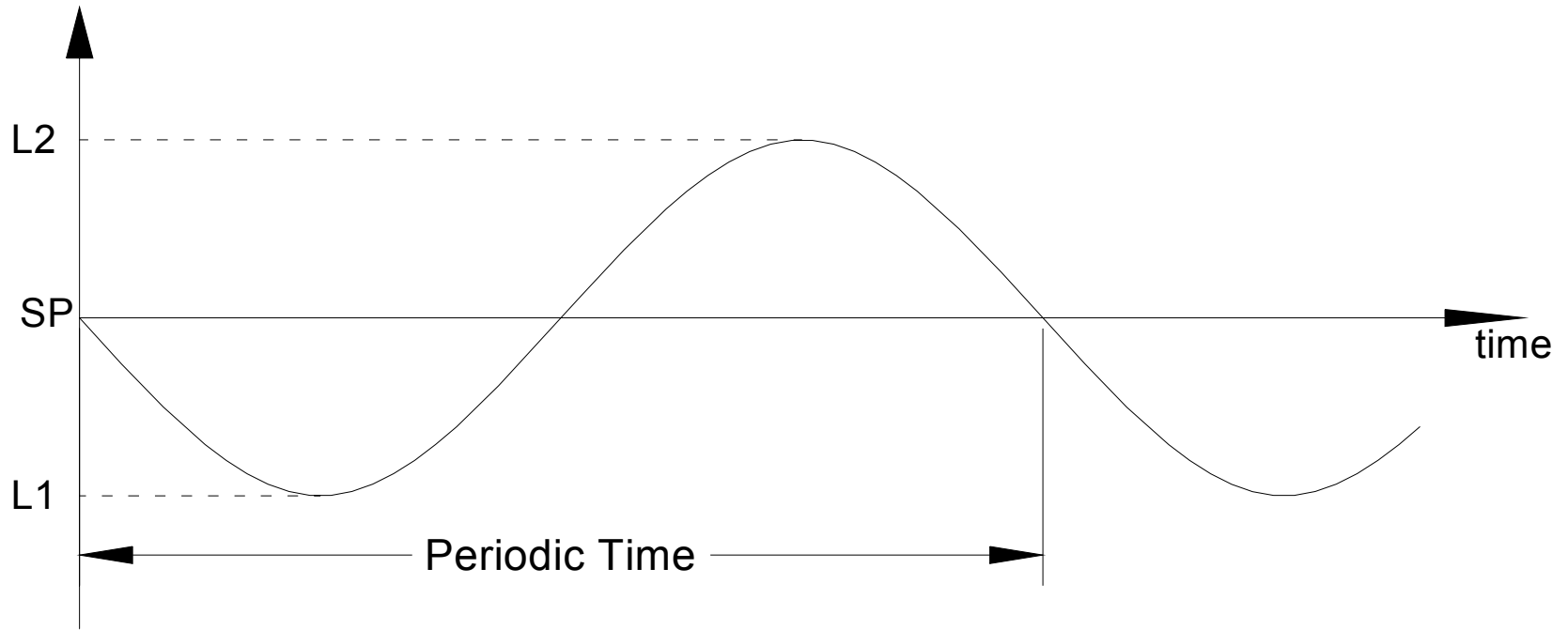
Feedback vs. Feedforward

- Feedback
 - Control action after an error exists
- Feedforward
 - Reacting to the disturbance before the error occurs

Typical ON/OFF Control System



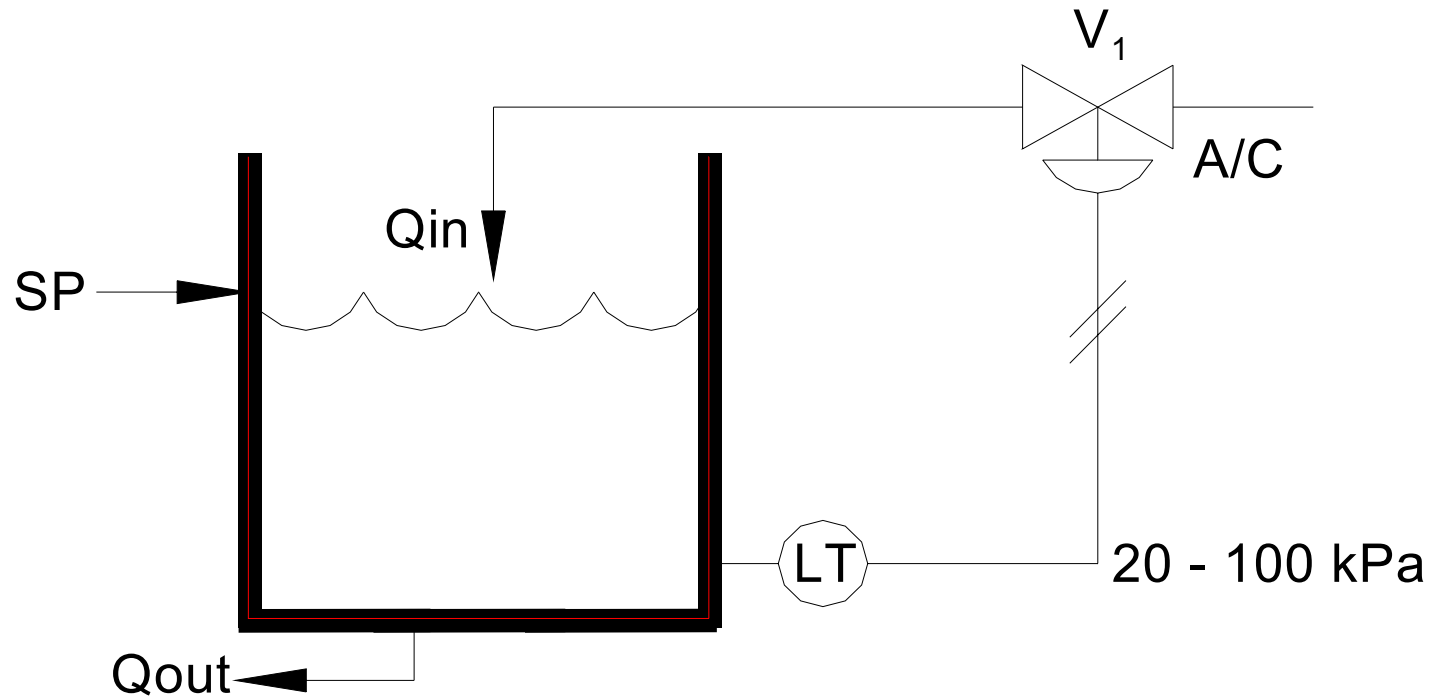
Typical ON/OFF Response



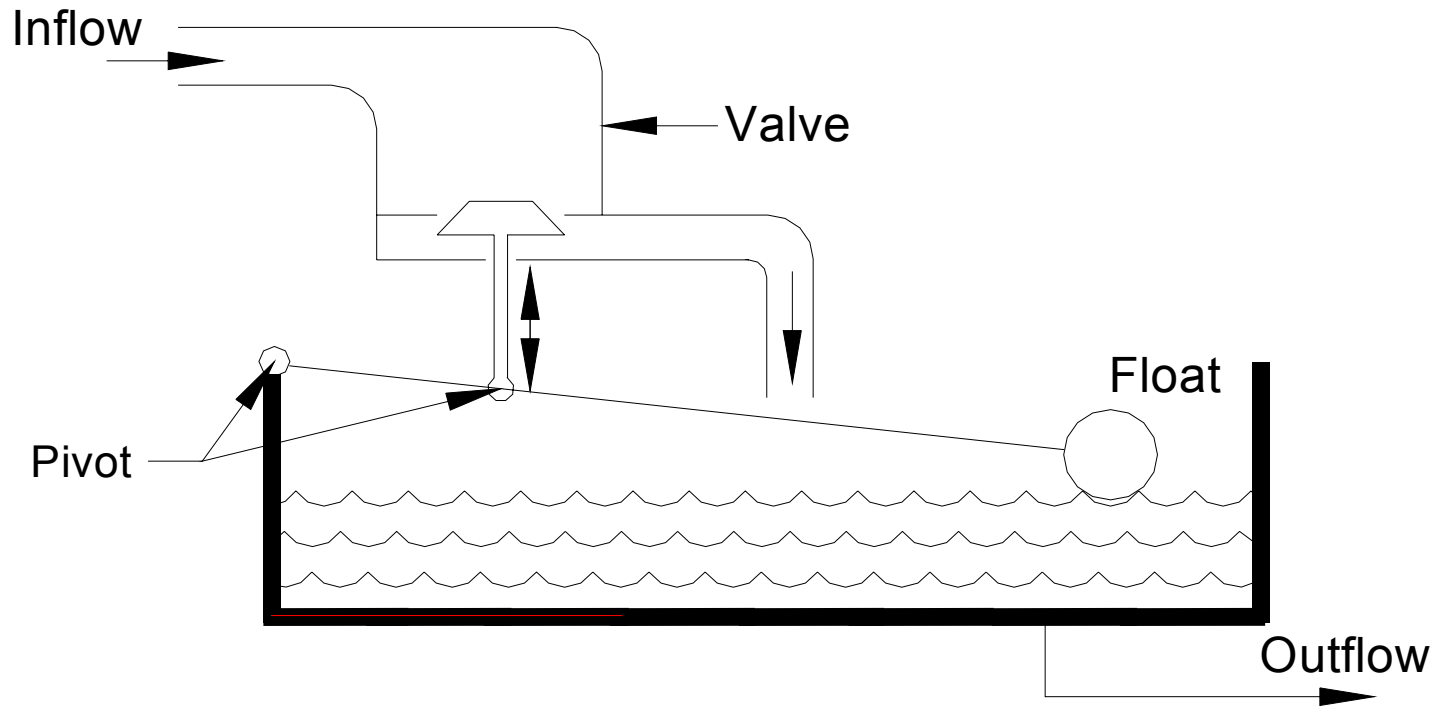


Proportional Control

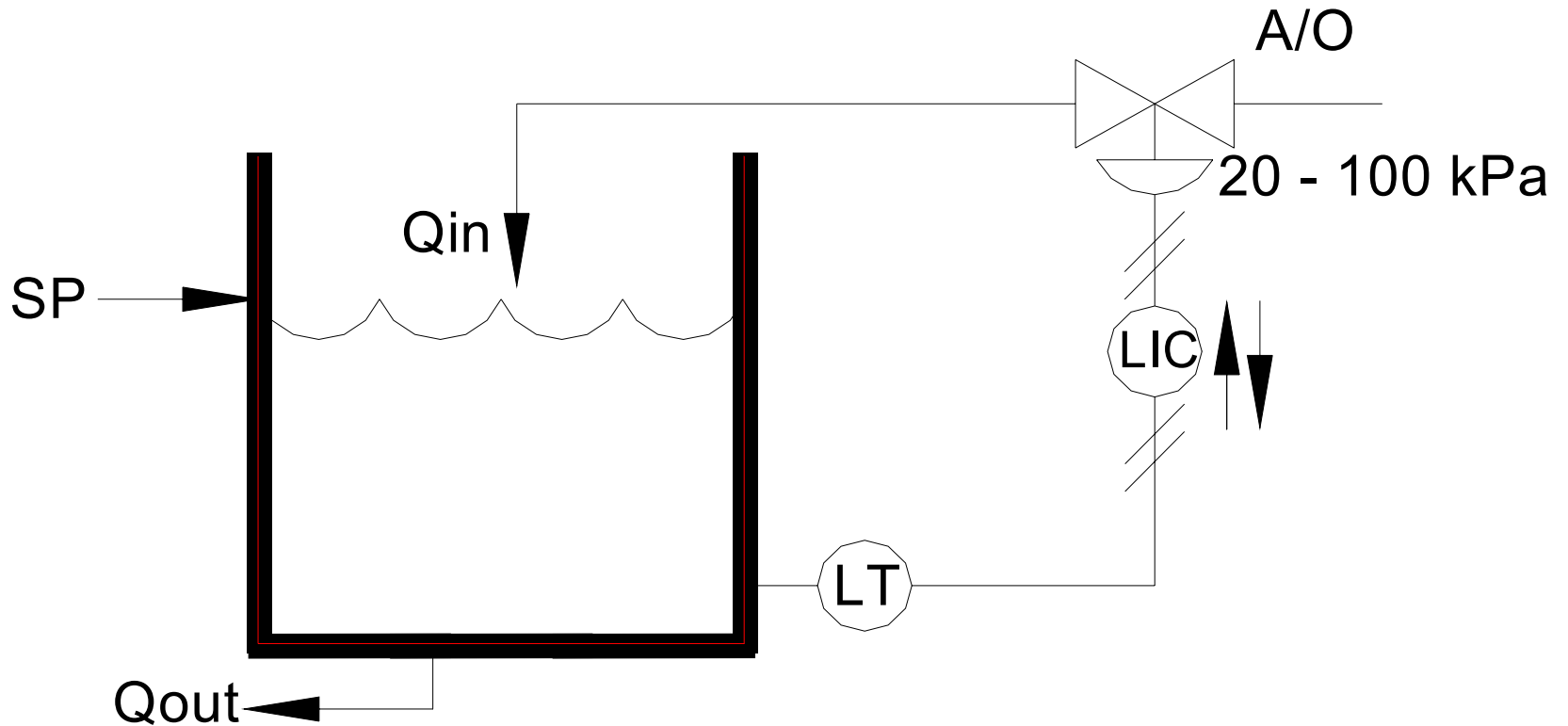
Level Control of Open Tank



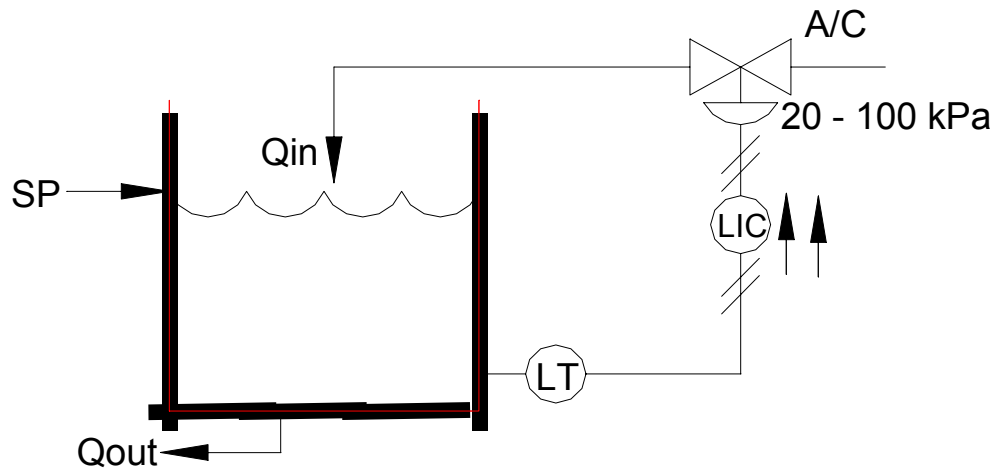
Simple Proportional System



Open Tank Control

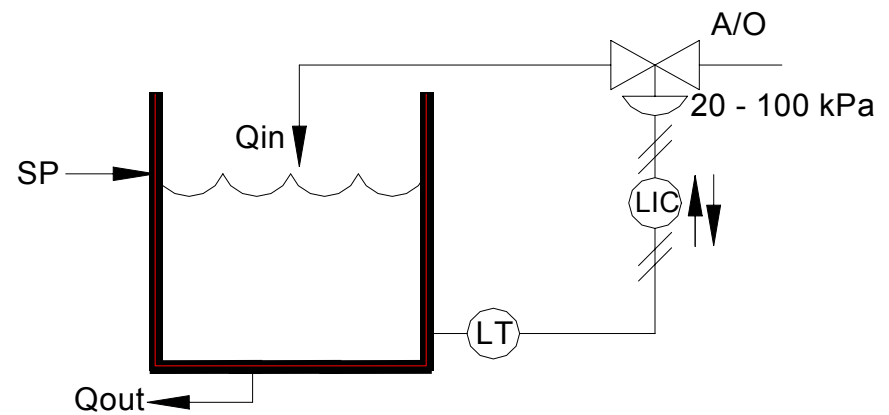


Controller Action

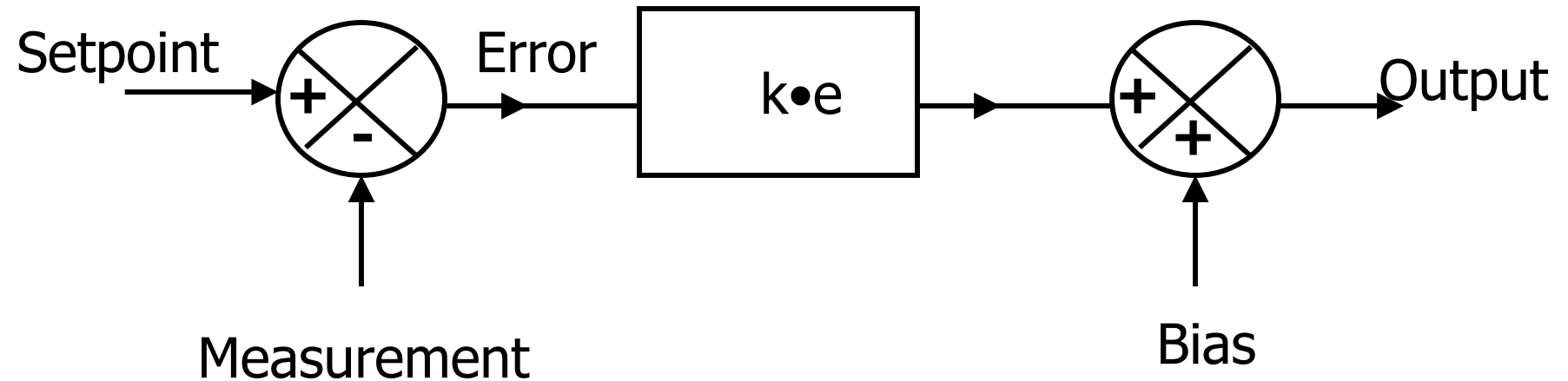


Direct

Reverse



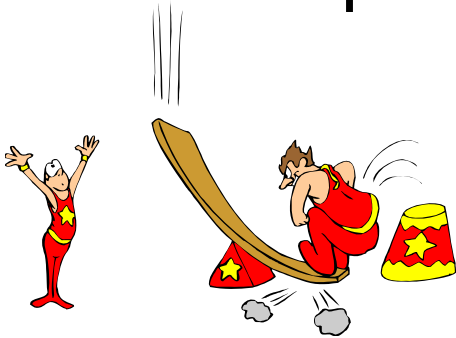
Proportional Control



$$m = k(SP - M) + \text{bias}$$

Proportional Band and Gain

Proportional Band – the input change required to change the output 100%

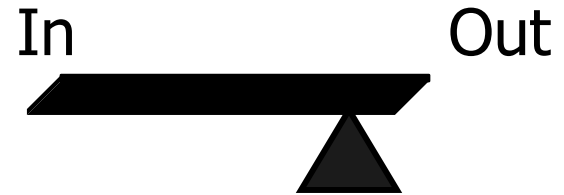


$$gain = \frac{\Delta output}{\Delta input}$$

$$gain = \frac{100\%}{PB}$$

Narrow, Wide, High & Low

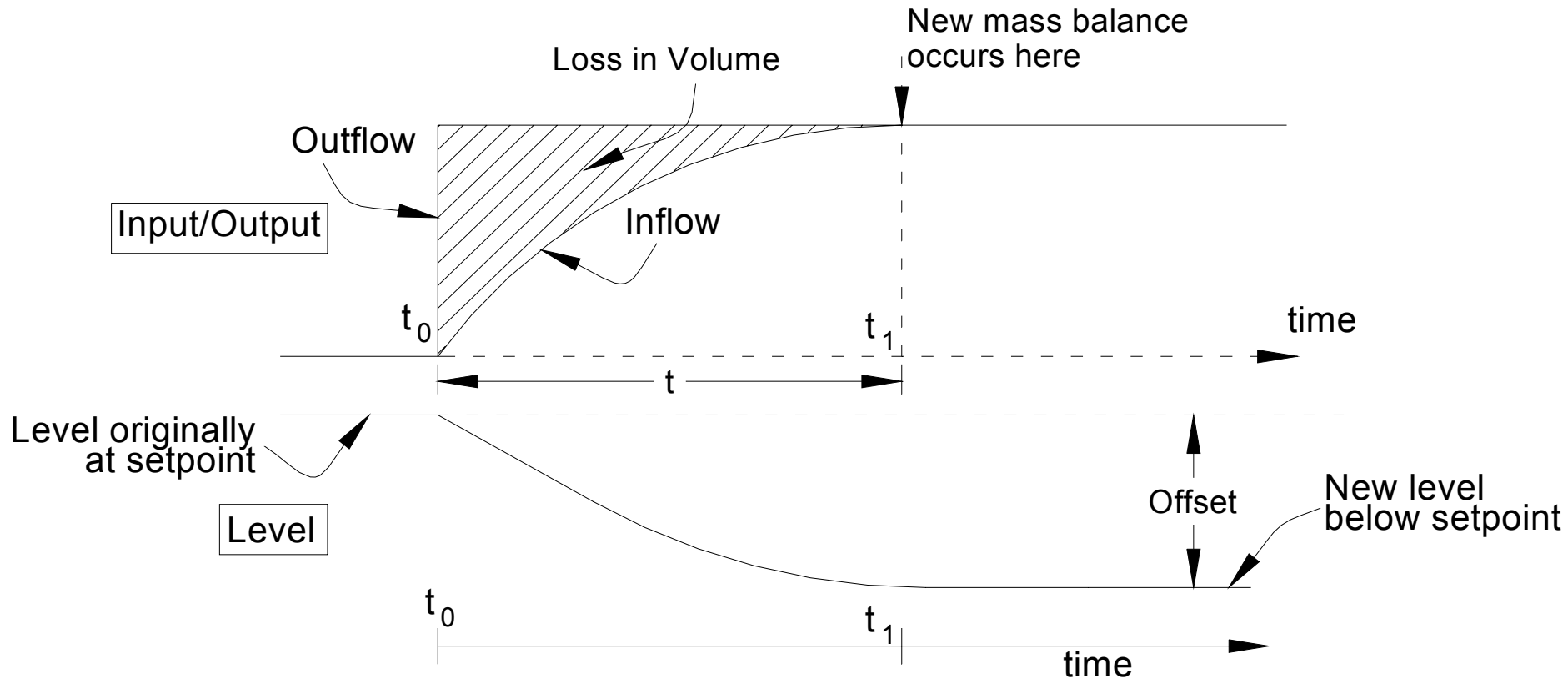
Wide PB – Low Gain



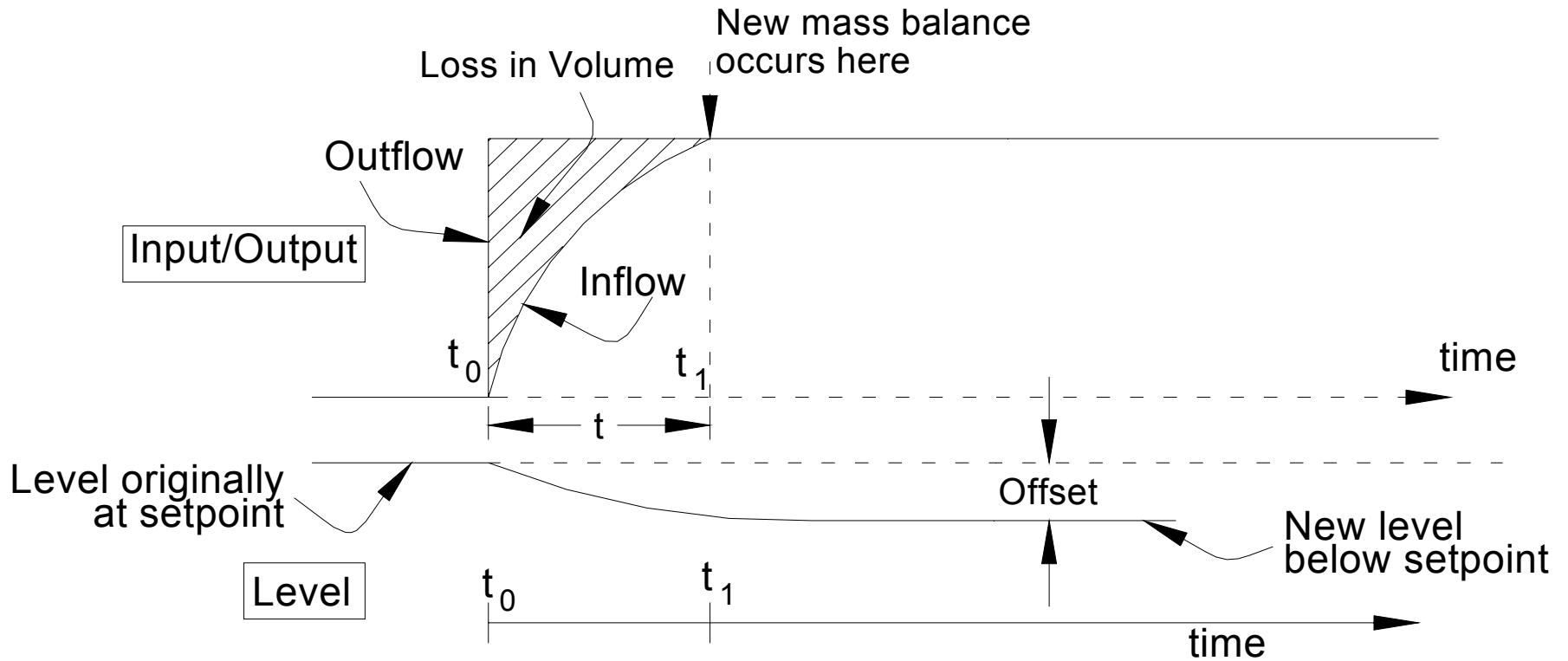
Narrow PB – High Gain



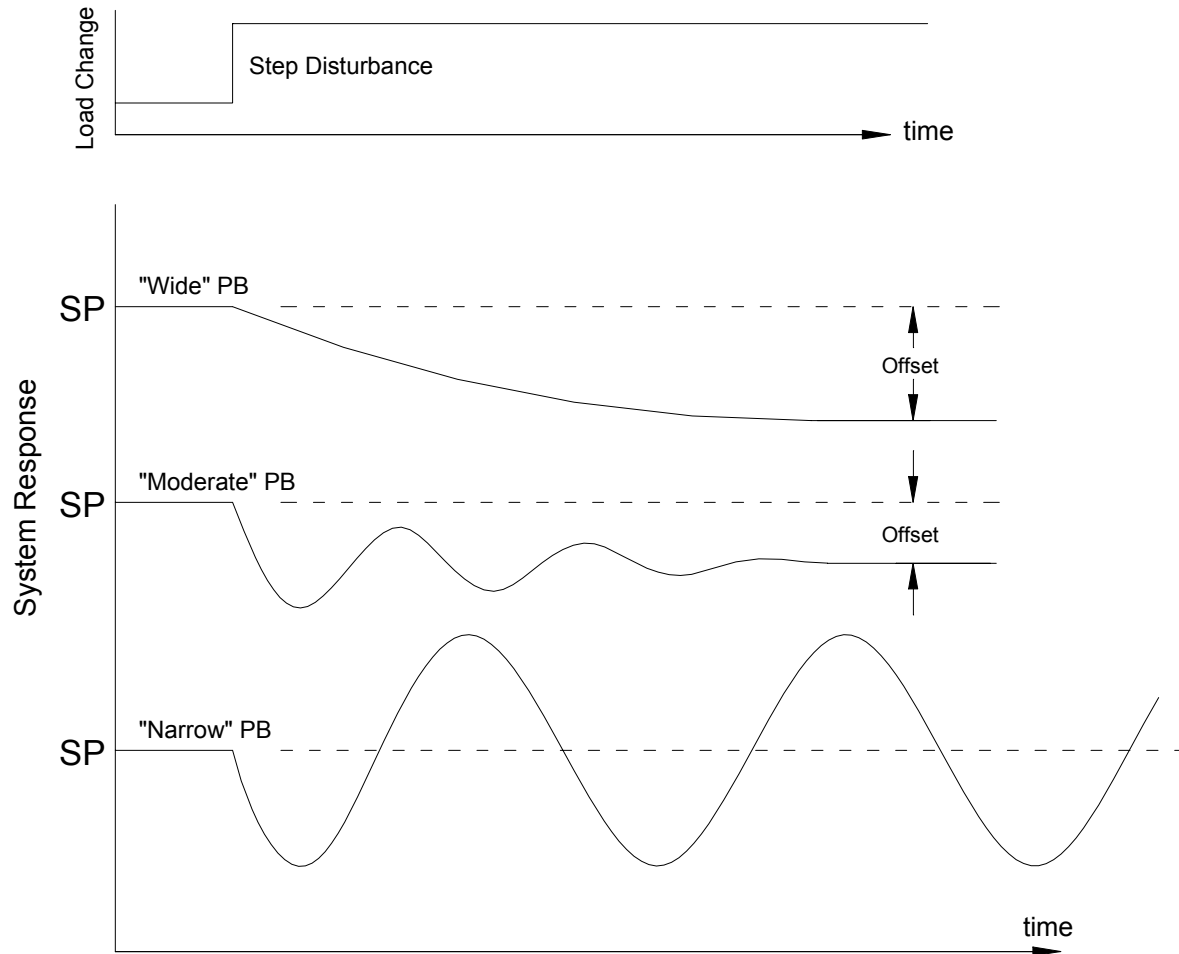
Proportional Control Response Curve



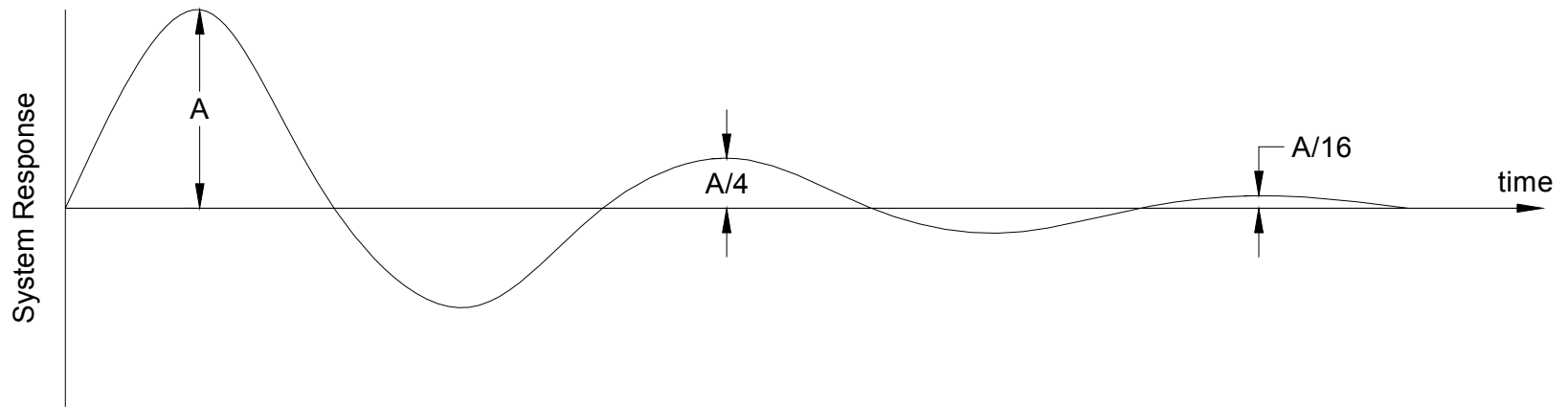
Proportional Response with Narrower PB



Response Versus PB, Proportional Control Only



$\frac{1}{4}$ Decay Response Curve





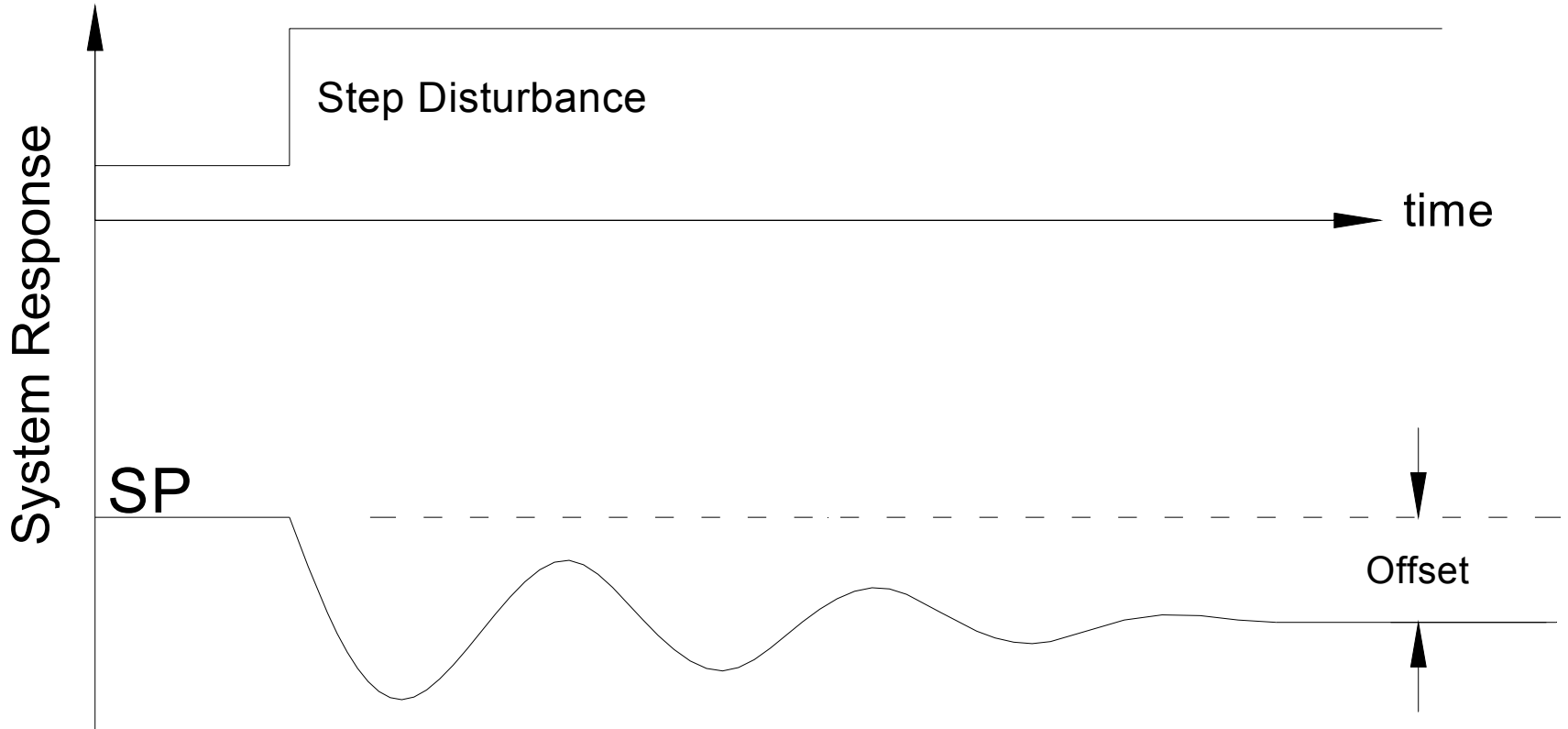
For You To Do

- Read pp. 89-105
- Answer Questions pp. 121-122, #1-19

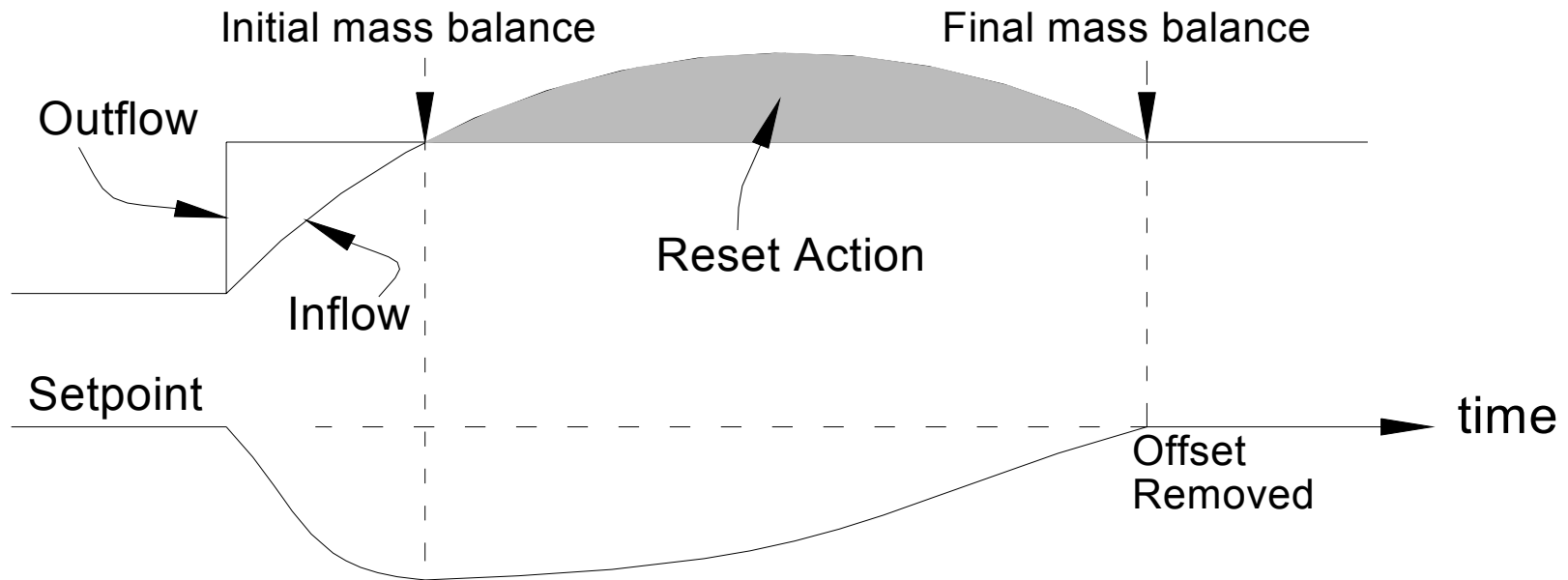


Reset or Integral

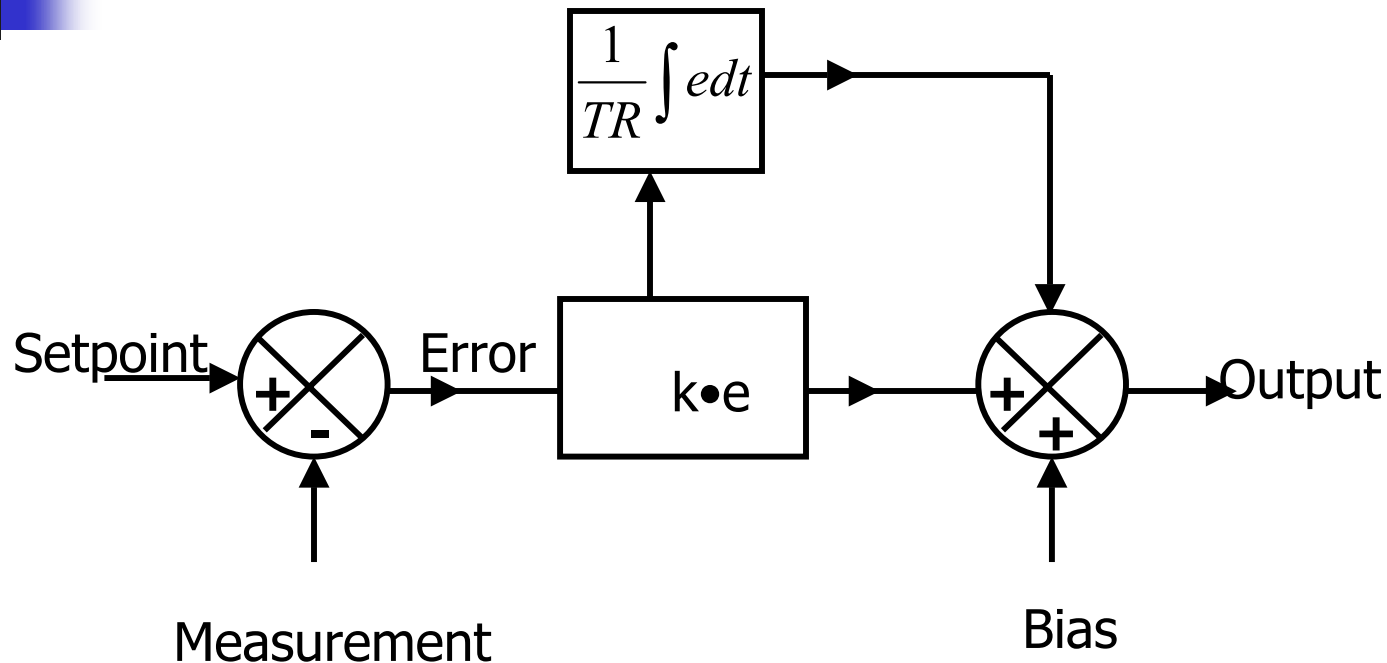
Response Curve: Proportional Control Only



Additional Control Signal Restores Process to Setpoint



Integral Action



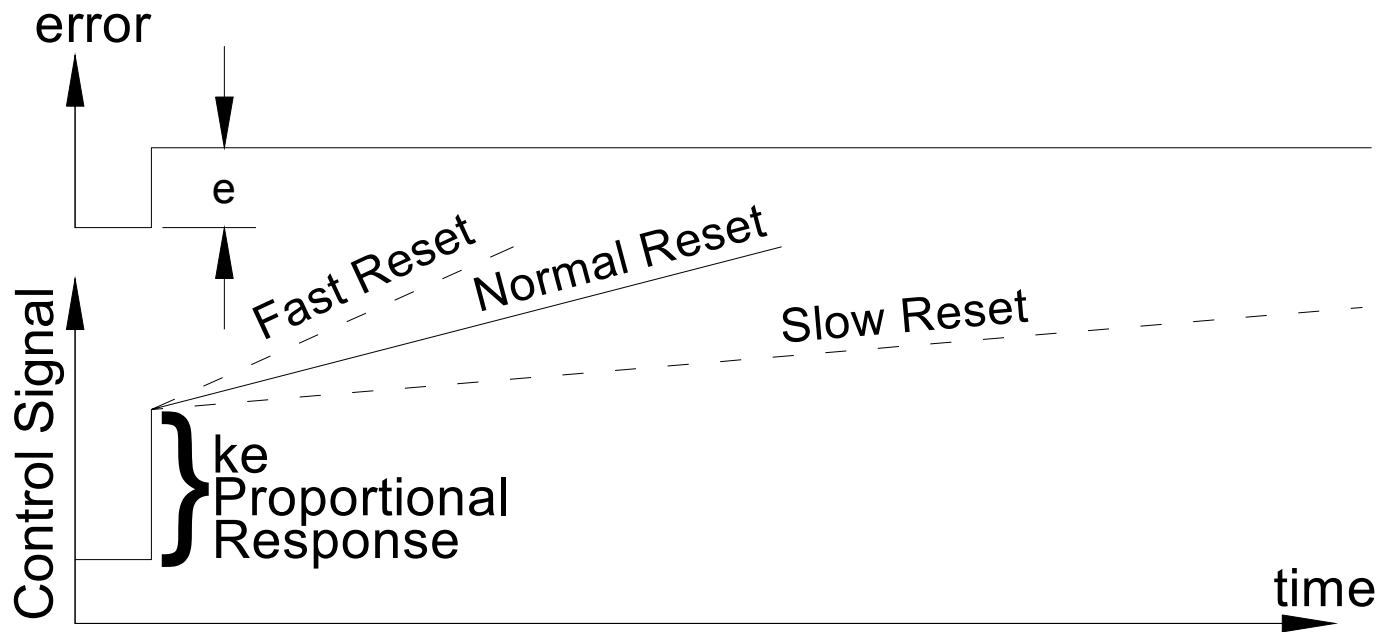
$$m = ke \left(+ \frac{1}{TR} \int edt \right) + bias$$



Units

- Minutes per repeat
 - MPR
 - The length of time that it will take the integrator to add an amount equal to the proportional response
- Repeats per minute
 - RPM
 - The number of times the proportional response is repeated in one minute

Proportional Plus Reset, Open Loop Response





A problem

Output initially 50%, Gain = 2, reset = 2 minutes per repeat

A direct acting controller control is subjected to a sustained error of 5%

What is the output after 4 minutes?

Proportional Response = $k_e = 2 \times 5 = 10\%$

Integral Action- in 4 minutes the control will go through 2 repeats.

Integral action = $2 \times 10 = 20\%$

Total output change is proportional + integral = 30%



A Couple More Things

- Reset Windup
- Instability because of lag



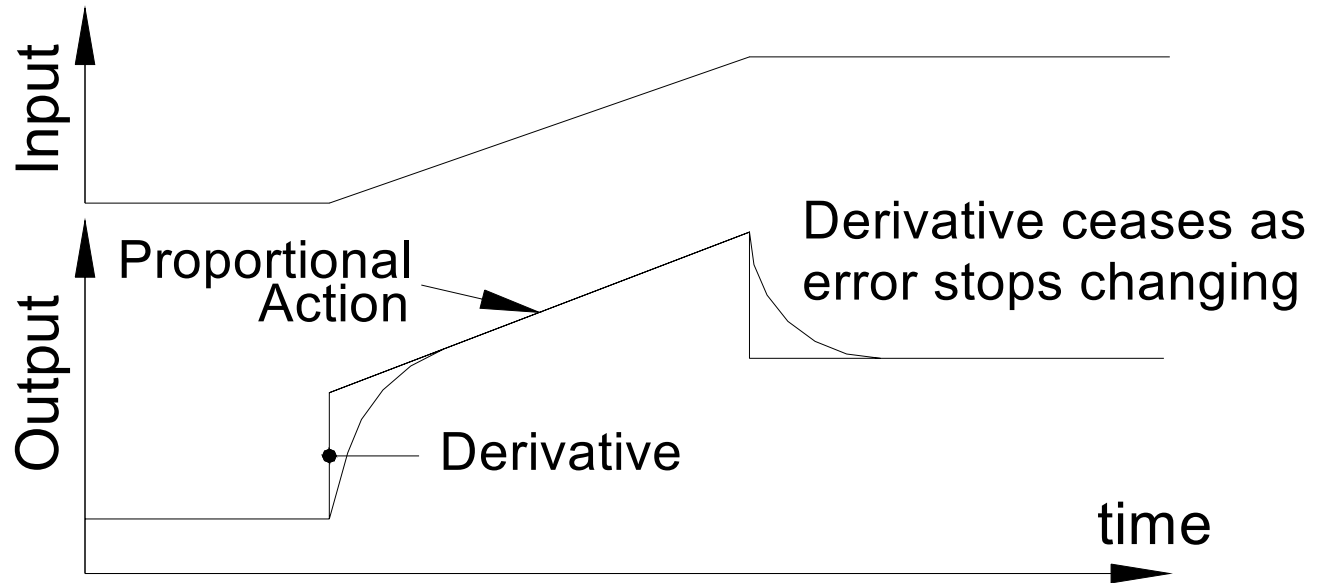
For You to Do

- Read over text pp. 89 –110
- Answer questions pp. 121-122, 1-24

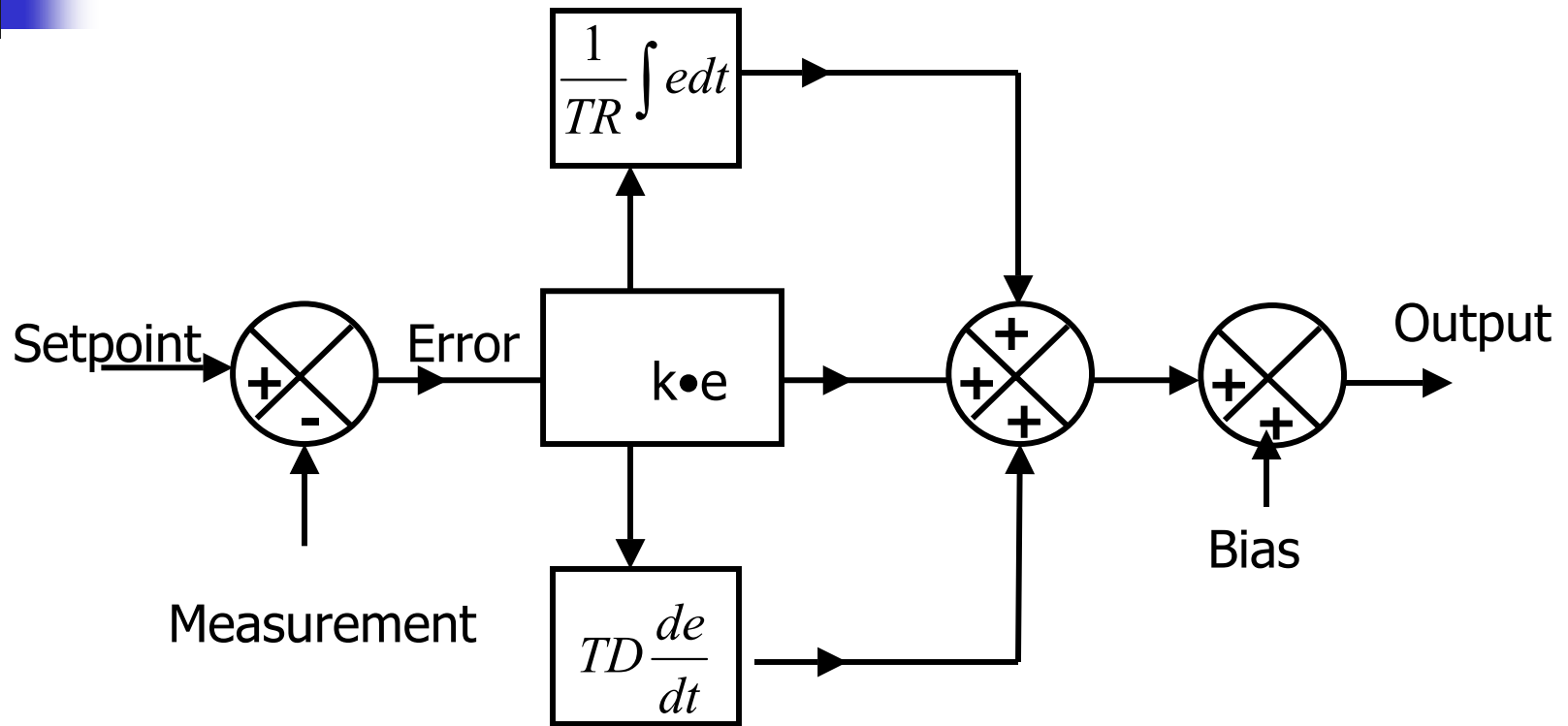


Rate or Derivative

Proportional and Derivative – Open Loop Pressure

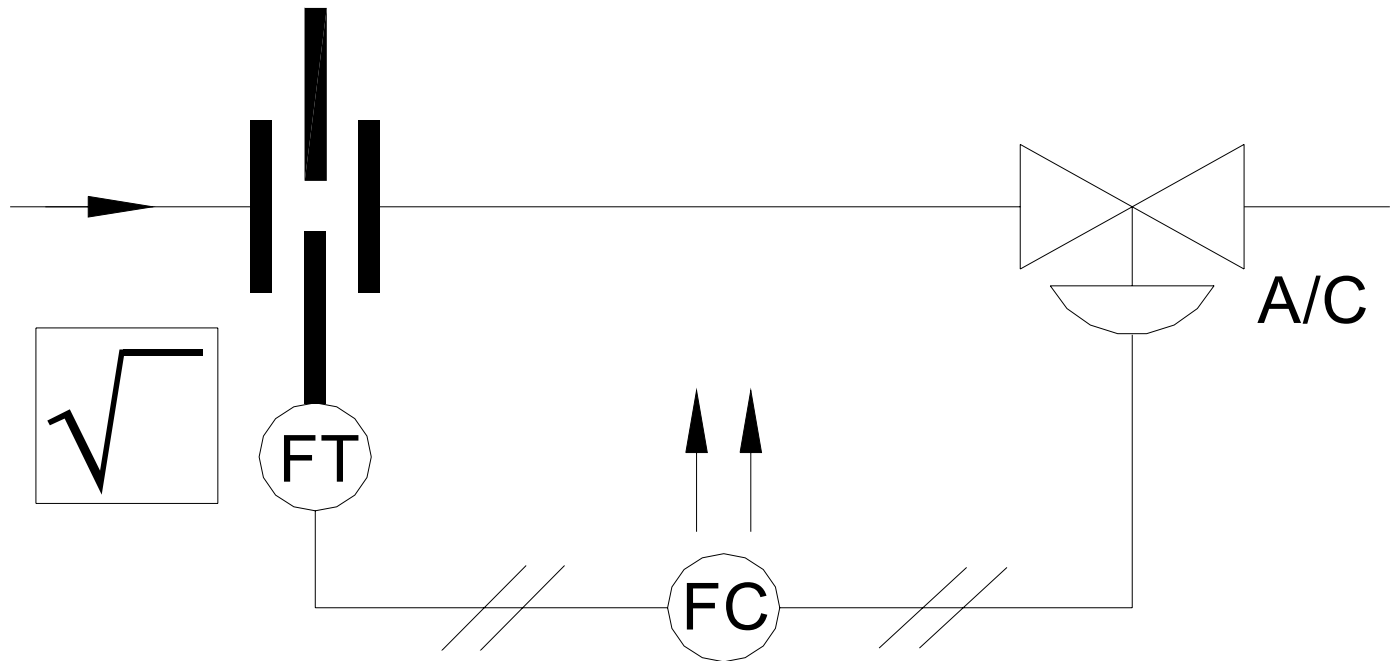


Derivative Control

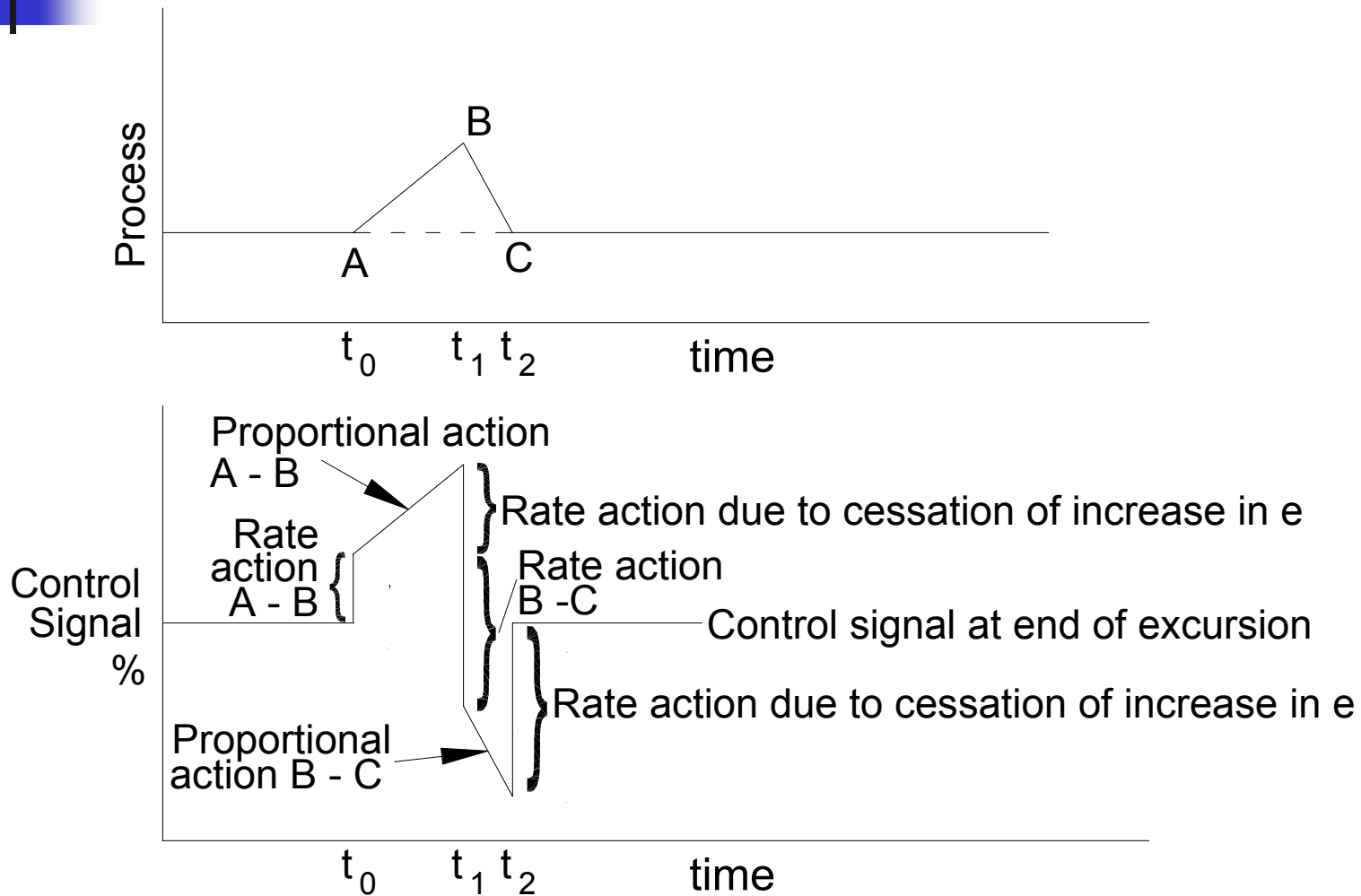


$$m = ke \left(+ \frac{1}{T_R} \int edt \right) + kT_D \frac{de}{dt} + bias$$

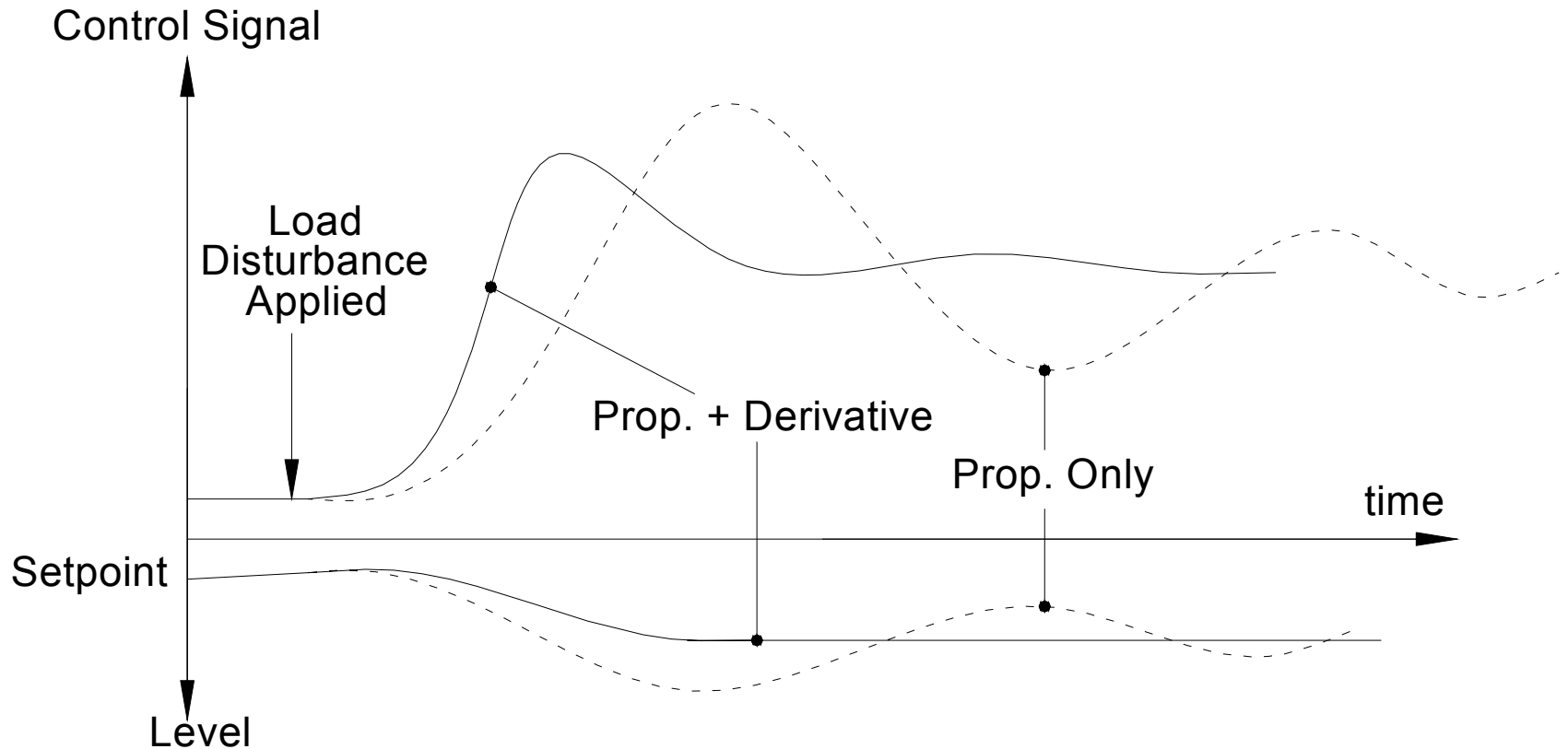
Simple Flow Control System



The open Loop Response of Proportional Plus Derivative (PD) Action to Rapidly Changing Error Signals



Large System Under Proportional and Proportional Plus Derivative Control

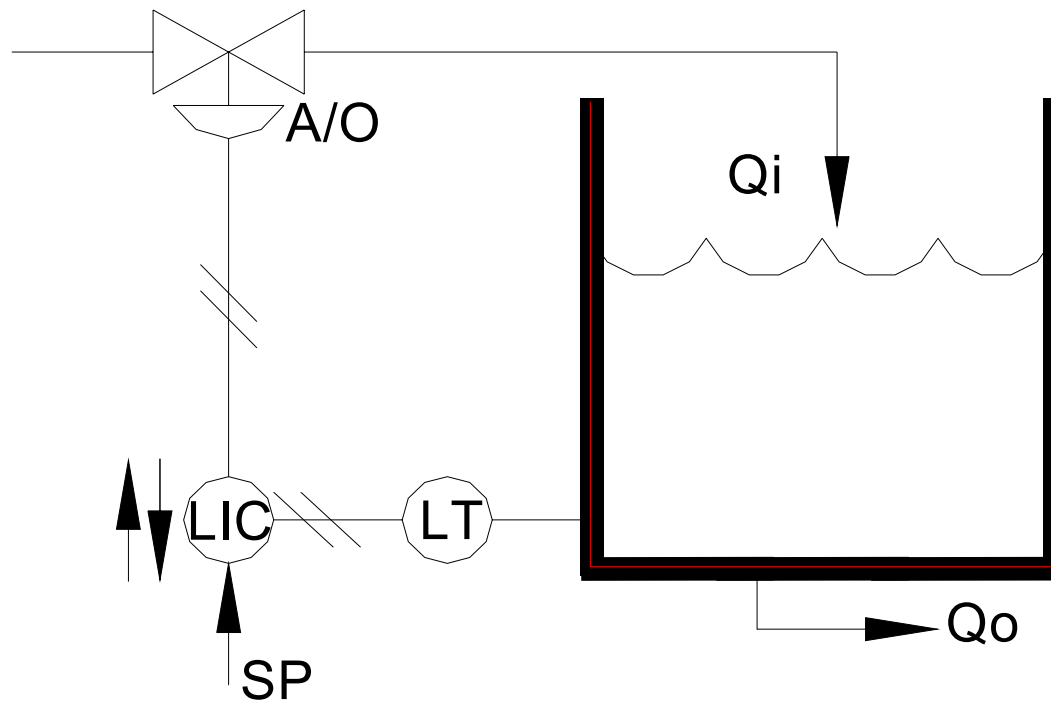




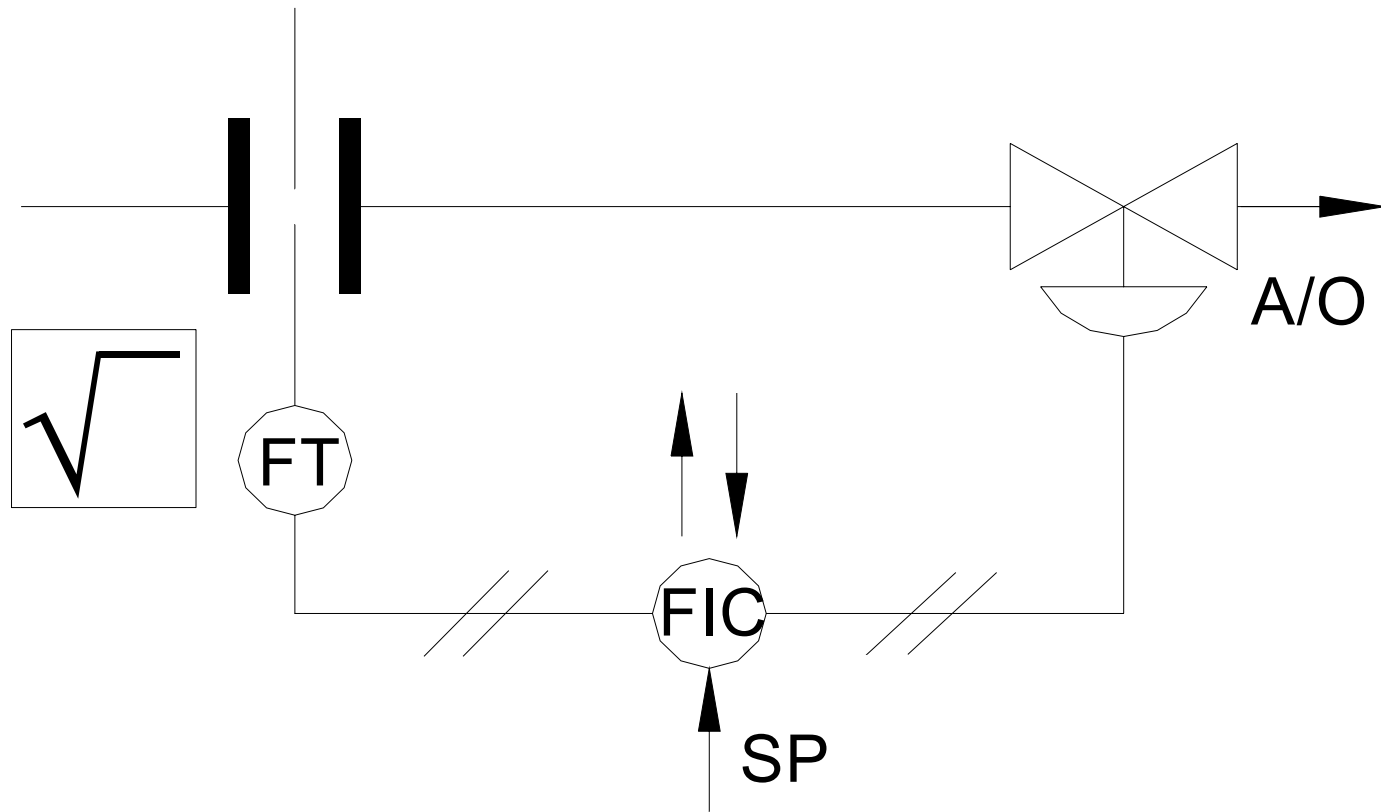
Multiple Control Modes

- Virtually all controls have a proportional response
- Integral and derivative are added to improve performance
- Majority have proportional and integral
- Some, typically heat exchangers have derivative added

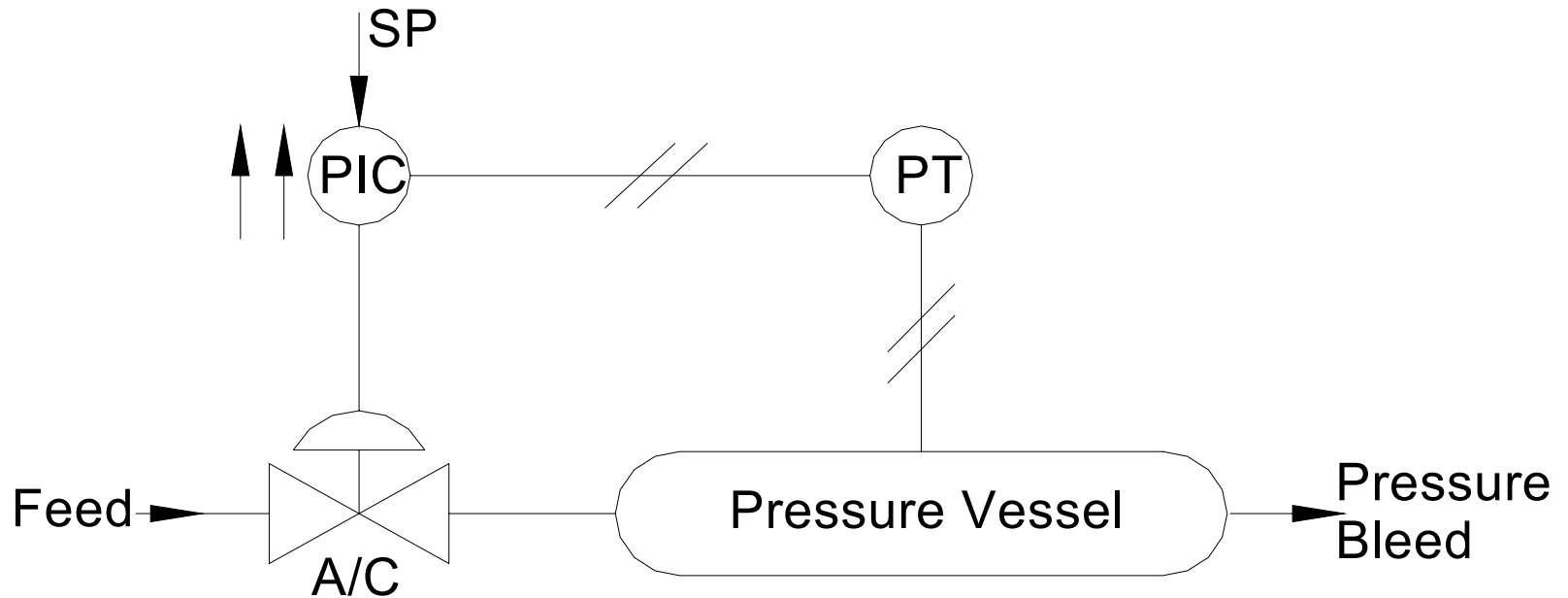
Open Tank Level Control With Valve In Inflow



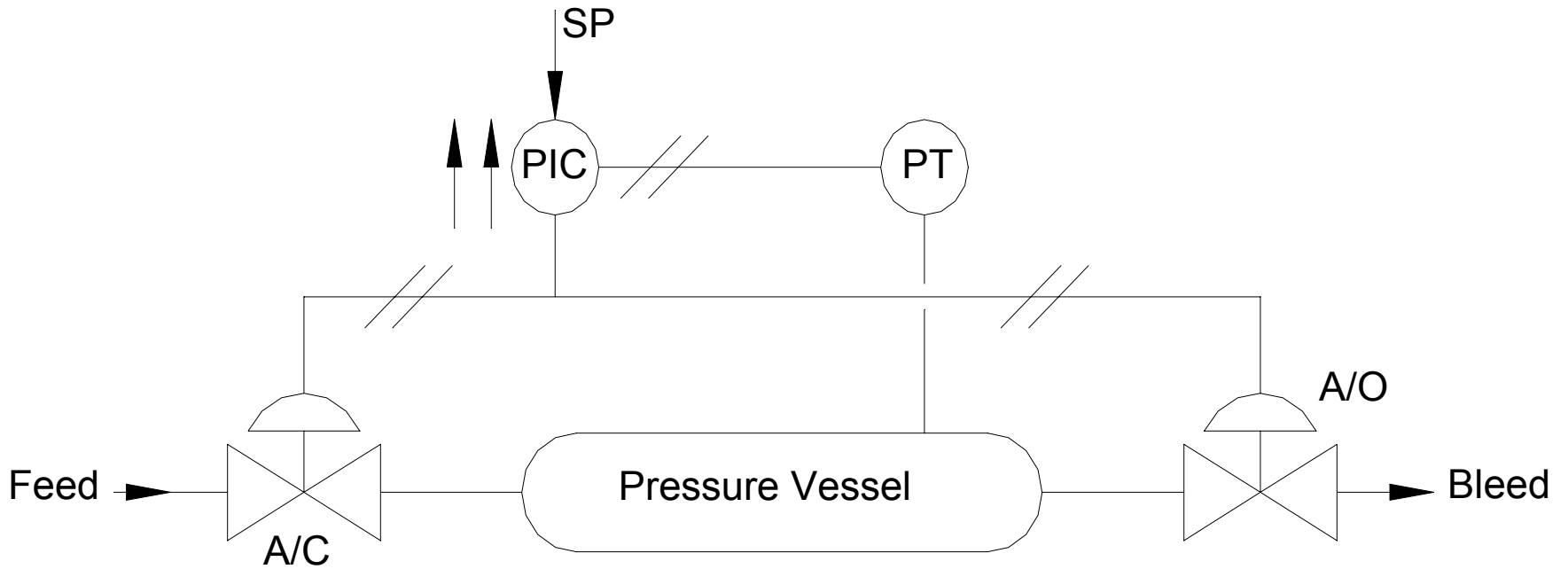
Typical Flow Control Loop



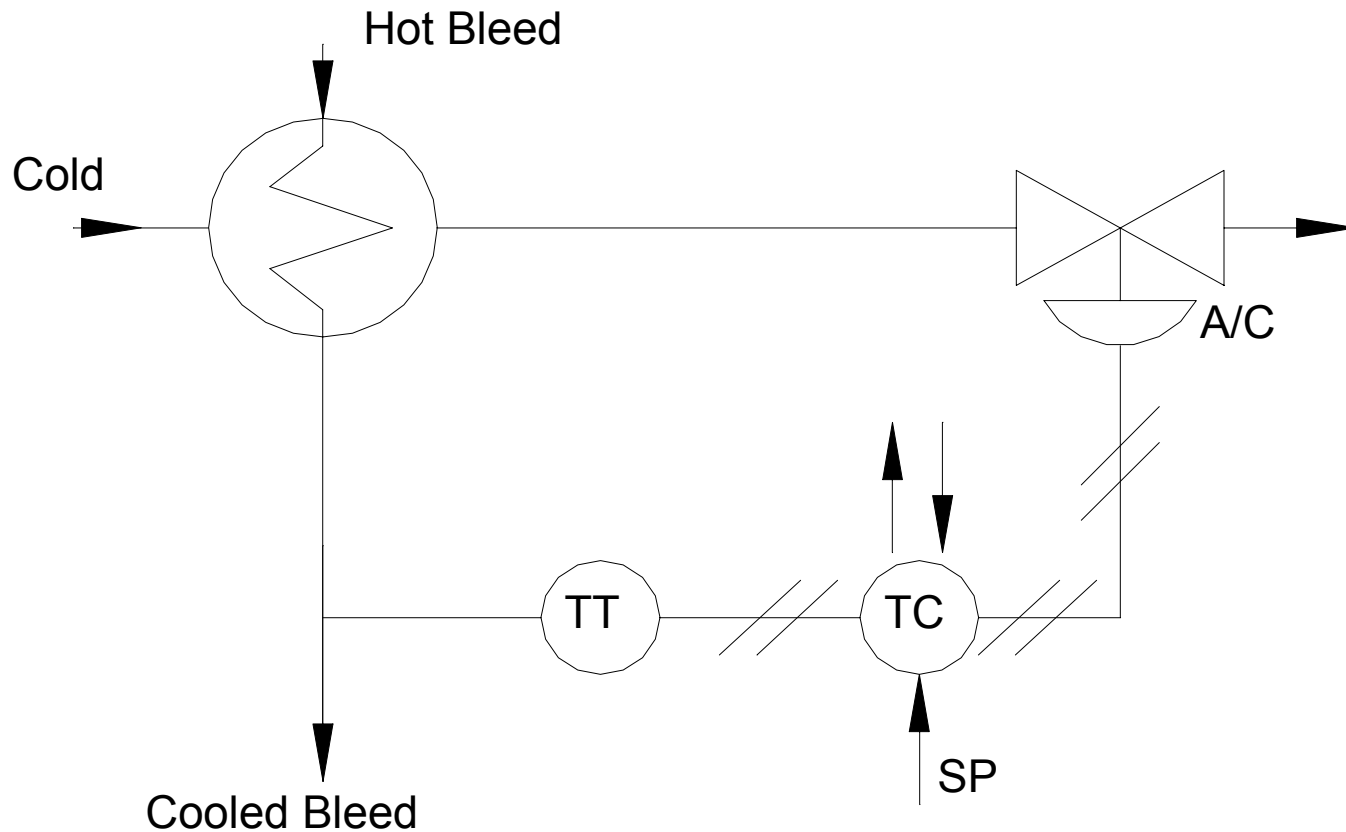
Pressure Control – Constant Bleed



Split Ranged Feed and Bleed Pressure Control



Representative Hot Bleed/Cold Service Water Heat Exchanger





For You To Do

- Read pp. 106-120
- Answer Questions pp. 122-123, #20-38