

Proportional Control

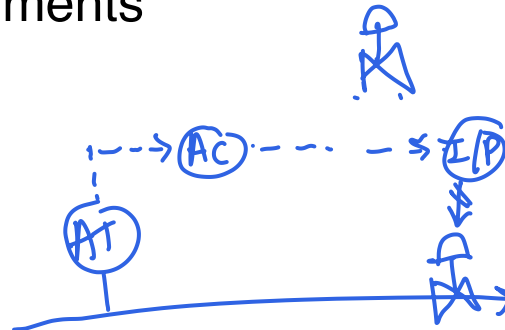
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Process Dynamics and Control

Basic components in a control loop

- Process being controlled ←
 - System of interest
- Sensor-transmitter combination
 - Composition analyzer-transmitter (AT) - measure composition and transmits electrical signal
- Feedback controller (AC)
 - Feedback controller (AC) - takes AT electrical signal and calculates appropriate output electrical signal
how? : proportional control
- Current-to-pressure transducer (I/P)
 - Current-to-pressure transducer (I/P) - converts electrical signal to pneumatic (air) signal
- Final control element - adjusts manipulated variable
 - Control valve - takes in electrical or pneumatic signal and changes flow rate
- Transmission lines between instruments
 - Electrical cables - - - -
 - Pneumatic tubing - - - -



Proportional controller has output proportional to the error signal

- Objective: deviation (error) from set point is 0
 - Error signal = Set point - Measured controlled variable

$e(t)$ $y_{sp}(t)$ $y_m(t)$

usually $y_{sp} \neq f(t)$
if fixed set pt

$$e(t) = y_{sp}(t) - y_m(t)$$

set pt. - preset
Const.

- Proportional control

- bias \bar{p} - determined by manual reset

• when $e(t)=0$,
sys. at s.s.
 $\Rightarrow p(t) = \bar{p}$

- K_c - sign - \oplus or \ominus
value - \uparrow sensitive to $e(t)$

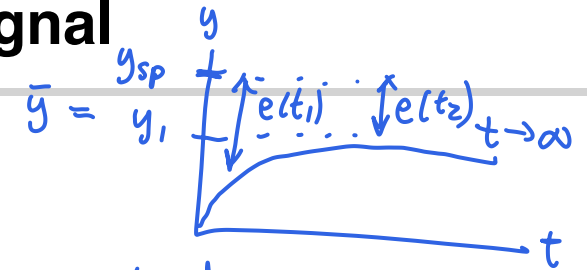
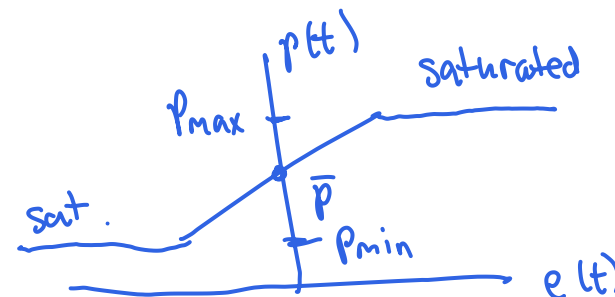
(electrical) controller output

$$p(t) = \bar{p} + K_c e(t)$$

steady state value (bias)

controller gain

error signal

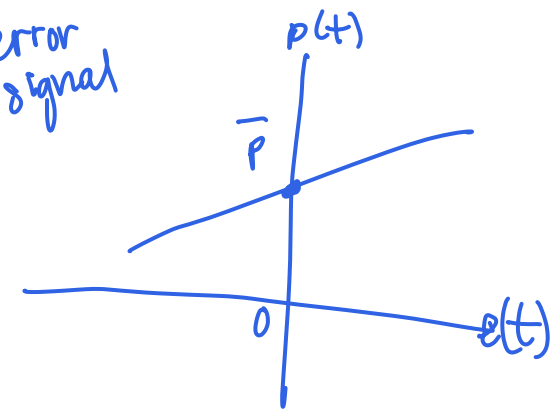


error \neq dev. var

$$e(t) \neq y'(t)$$

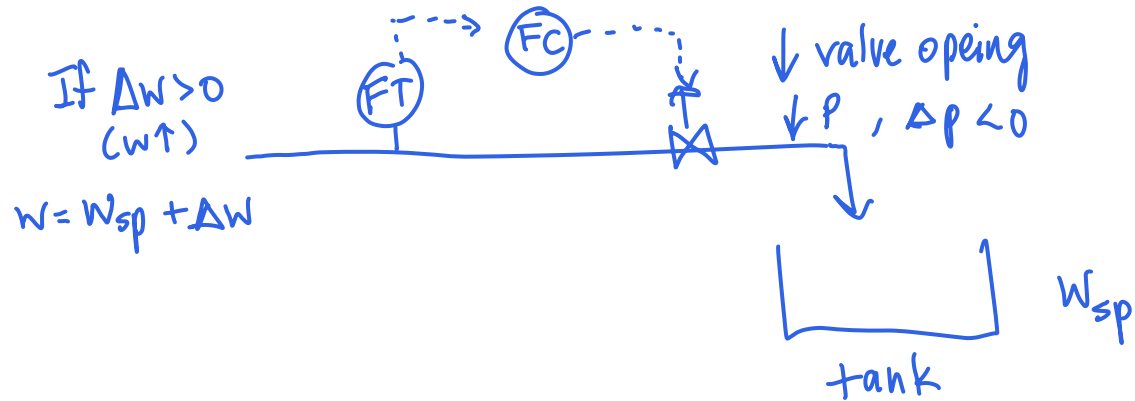
$$y'(t) = y(t) - \bar{y}$$

$y_m(t)$ \uparrow steady-state
 $t \rightarrow \infty$



Controller gain could be positive or negative ← Sign

- Want to maintain constant flow rate w to tank



$$p(t) = \bar{p} + K_c e(t) \downarrow$$

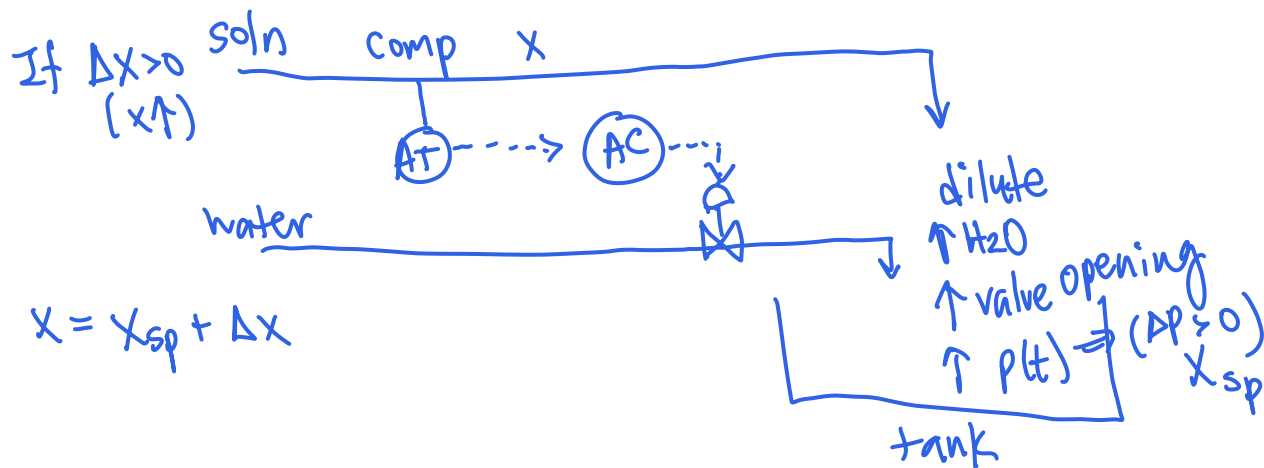
$K_c > 0 \Rightarrow \text{positive } \checkmark$

$$e(t) = w_{sp} - w(t)$$

$$= w_{sp} - (w_{sp} + \Delta w)$$

$$= -\Delta w < 0$$

- Want to maintain constant composition x in tank



$$p(t) = \bar{p} + K_c e(t) \uparrow$$

$K_c < 0 \Rightarrow \text{negative } \checkmark$

$$e(t) = x_{sp} - x(t)$$

$$= x_{sp} - (x_{sp} + \Delta x)$$

$$= -\Delta x < 0$$

Transfer function for proportional controller is the controller gain

Ex. Show that the proportional controller transfer function is

$$\frac{P'(s)}{E(s)} = K_s$$

- Proportional controller:

$$p(t) = \bar{p} + K_c e(t)$$

original

$$p'(t) = p(t) - \bar{p}$$
$$= \cancel{\bar{p}} + K_c e(t) - \cancel{\bar{p}}$$

deviation

$$\mathcal{L} [p'(t) = K_c e(t)]$$

$$P'(s) = K_c E(s)$$

$$G(s) = \frac{\text{out}}{\text{in}} = \frac{P'(s)}{E(s)} = K_c = \text{controller gain}$$

Proportional band can be used instead of controller gain

- Proportional band

$$\text{PB} \equiv \frac{1}{K_c} \times 100\%$$

prop. band \nearrow \nwarrow controller gain

Advantages and disadvantages of proportional controllers

- Advantage
 - Simple ✓
 - Great if exact value of controlled value is not important: prevent overflow/empty
- Disadvantage
 - **Offset** - steady-state error
 - Set point change
 - Sustained disturbance



crude estimate

