Proportional Control

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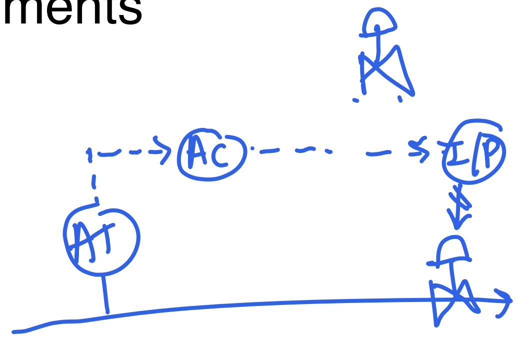
Process Dynamics and Control

Basic components in a control loop

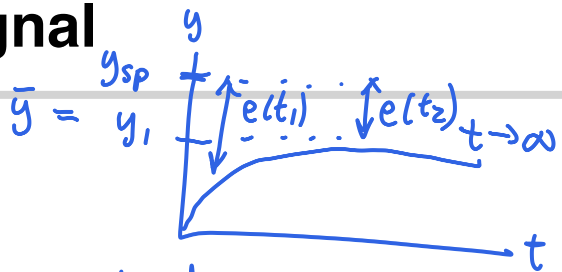
- Process being controlled
  - System of interest
- Sensor-transmitter combination AT

  in: liq/gas output
  - 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?: prortional 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

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

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

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

set pt. - preset
const.

⚠ error $\neq$ dev. var

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

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

$\parallel$ $y_m(t)$ — $\bar{y}$: steady-state $t \to \infty$

- Proportional control

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

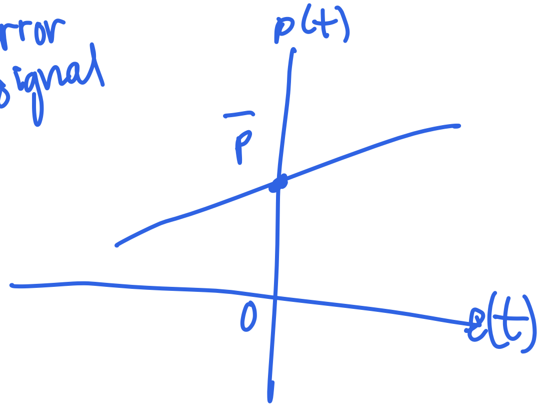
(electrical) controller output

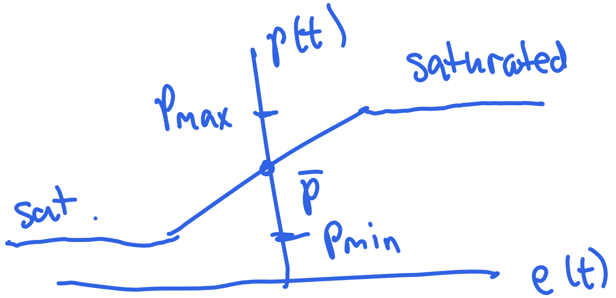
steady state value (bias)

controller gain

error signal

- bias $\bar{p}$ - determined by manual reset
  - when $e(t)=0$, sys. at s.s $\Rightarrow p(t) = \bar{p}$
- K_c - sign - ⊕ or ⊖
  value - ↑ sensitive to $e(t)$

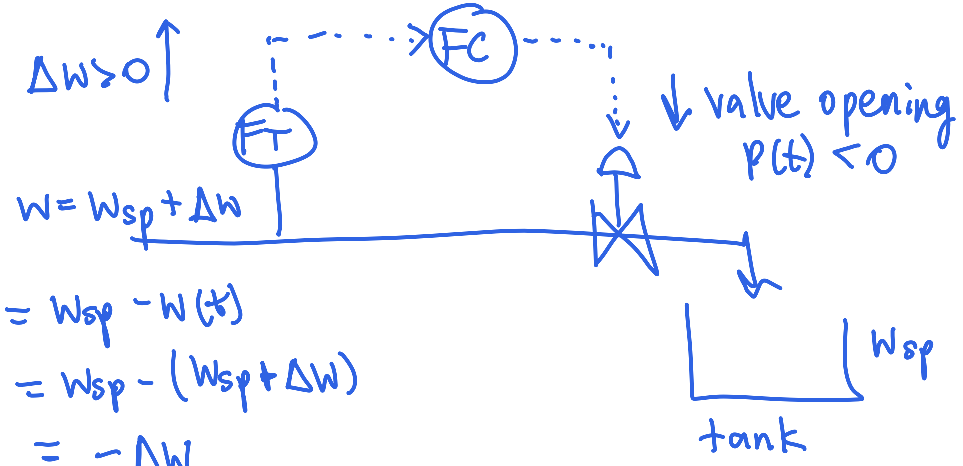




Controller gain could be positive or negative ← sign

- Want to maintain constant flow rate w_{sp} to tank

If $\Delta w > 0$ ↑



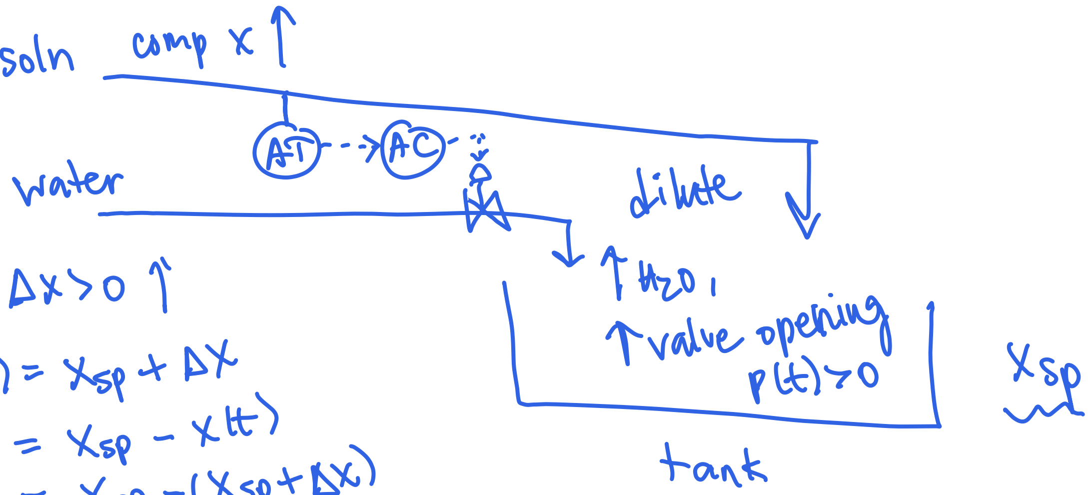
$$e(t) = w_{sp} - w(t)$$
$$= w_{sp} - (w_{sp} + \Delta w)$$
$$= -\Delta w$$

$$\overset{<0}{p(t)} = \bar{p} + \overset{?}{K_c}\,\overset{<0}{e(t)}$$

↑ >0

$K_c > 0$ is positive

- Want to maintain constant composition x in tank



If $\Delta x > 0$ ↑

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

$$\overset{>0}{p(t)} = \bar{p} + \overset{?}{K_c}\,\overset{<0}{e(t)}$$

↑ <0

$K_c < 0$ is negative

Transfer function for proportional controller is the controller gain

Ex. Show that the proportional controller transfer function is

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

- Proportional controller:

deviation

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

original

$$p'(t) = p(t) - \overline{p}$$

$$= \cancel{\overline{p}} + K_c e(t) - \cancel{\overline{p}}$$

deviation

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

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

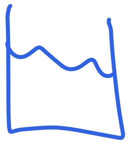
$$G(s) = \frac{\text{out}}{\text{in}} = \boxed{\frac{P'(s)}{E(s)} = K_c} = \text{controller gain}$$

Proportional band can be used instead of controller gain

- Proportional band

$$\underset{\text{prop. band}}{\mathrm{PB}} \equiv \frac{1}{\underset{\text{controller gain}}{K_c}} \times 100\%$$

Advantages and disadvantages of proportional controllers

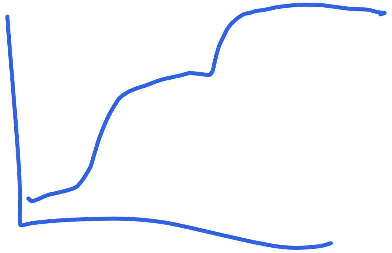


- Advantage
  - Simple
    - Great if exact value of controlled value is not important: prevent overflow/empty

crude estimate

- Disadvantage
  - **Offset** - steady-state error
    - Set point change ← $y_{sp}(t)$
    - Sustained disturbance

not fixed = change.



← new s.s.