# Proportional Control

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**Process Dynamics and Control**

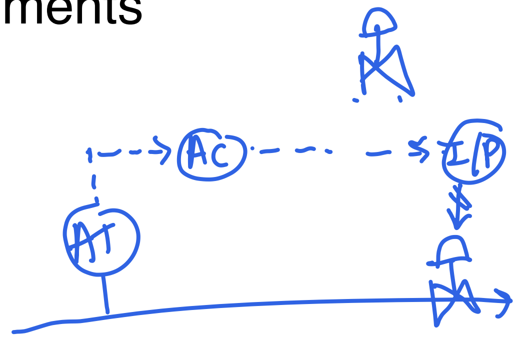
# Basic components in a control loop

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

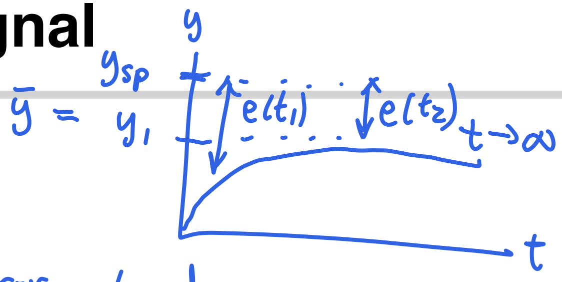
  in: liq/gas  output

    - 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 ≠ dev. var

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

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

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

- Proportional control

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

(electrical) controller output

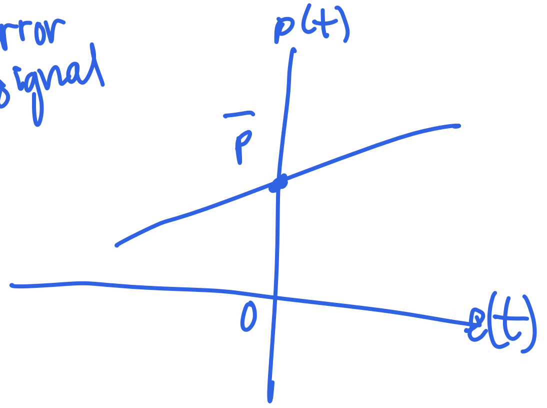
steady state value (bias)

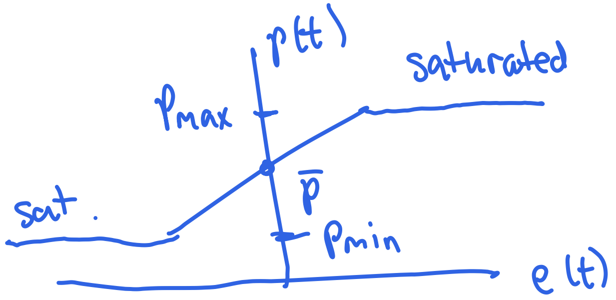
controller gain

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 $e(t)$



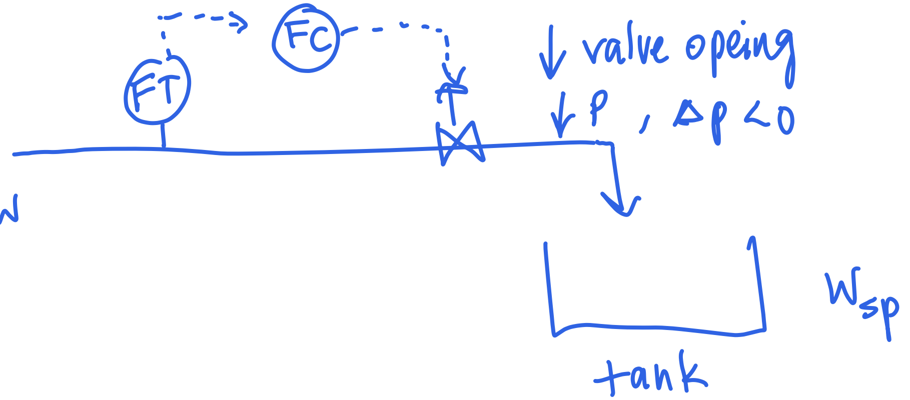



# Controller gain could be positive or negative ← sign

- Want to maintain constant flow rate $w$ to tank

If $\Delta w > 0$ $(w\uparrow)$

$w = w_{sp} + \Delta w$




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

$K_c > 0 \Rightarrow$ positive ✓

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

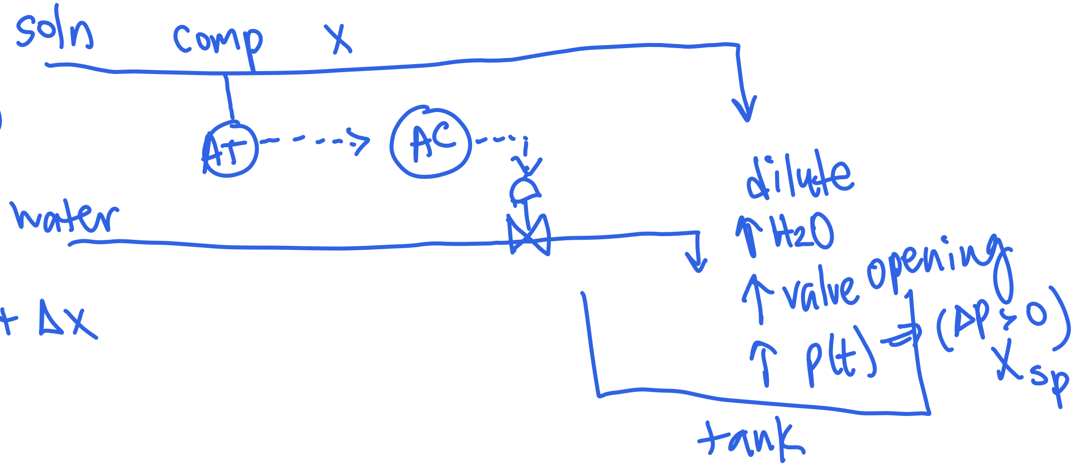
$= w_{sp} - (w_{sp} + \Delta w)$

$= -\Delta w < 0$

- Want to maintain constant composition $x$ in tank

If $\Delta x > 0$ $(x\uparrow)$

$x = x_{sp} + \Delta x$




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

$K_c < 0 \Rightarrow$ negative ✓

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

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

$= -\Delta x < 0$

# Transfer function for proportional controller is the controller gain

**Ex.** Show that the proportional controller transfer function is

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

- 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

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

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

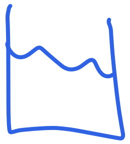
$$G(s) = \frac{\text{out}}{\text{in}} = \boxed{\frac{P'(s)}{E(s)} = K_c} = \text{controller gain}$$

# 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

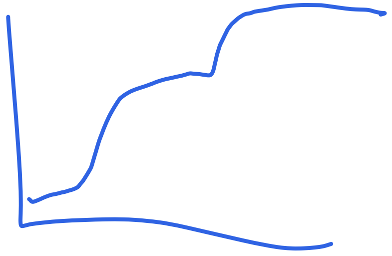


- Advantage
  - Simple
    - Great if exact value of controlled value is not important: prevent overflow/empty

crude estimate

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

not fixed = change.



← new s.s.