

Ch. 28: Basic Closed-loop Control

1.

Assuming the system is first-order,

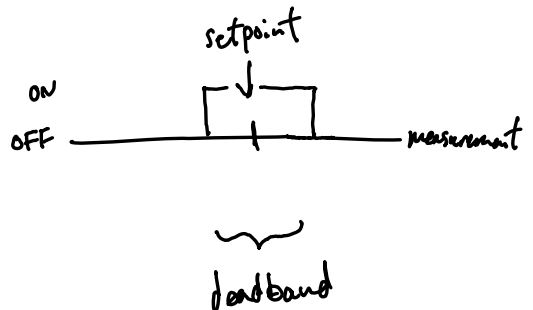
integral gain (I) contributes to instability

derivative gain (D) contributes to stability

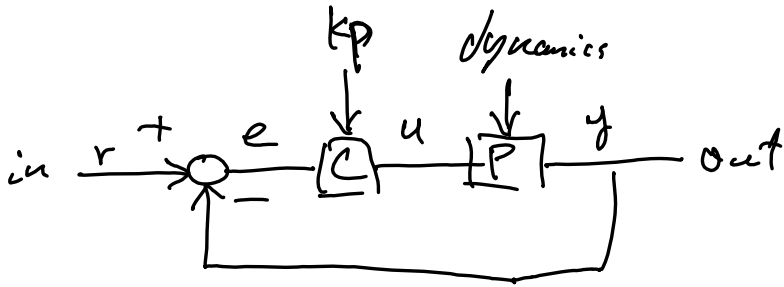
2.

[if measurement $> \text{setpoint} + \frac{1}{2} \text{deadband}$
turn output off
if measurement $< \text{setpoint} - \frac{1}{2} \text{deadband}$
turn output on

*: with deadband



3.



$$u = k_p \cdot \text{error}$$

$$\text{error} = \text{in} - \text{out}$$

$$\text{assume } P = 1 \rightarrow u = y$$

$$\begin{aligned} \text{out} = u &= k_p \cdot (\text{in} - \text{out}) \\ &= k_p \cdot \text{in} - k_p \cdot \text{out} \end{aligned}$$

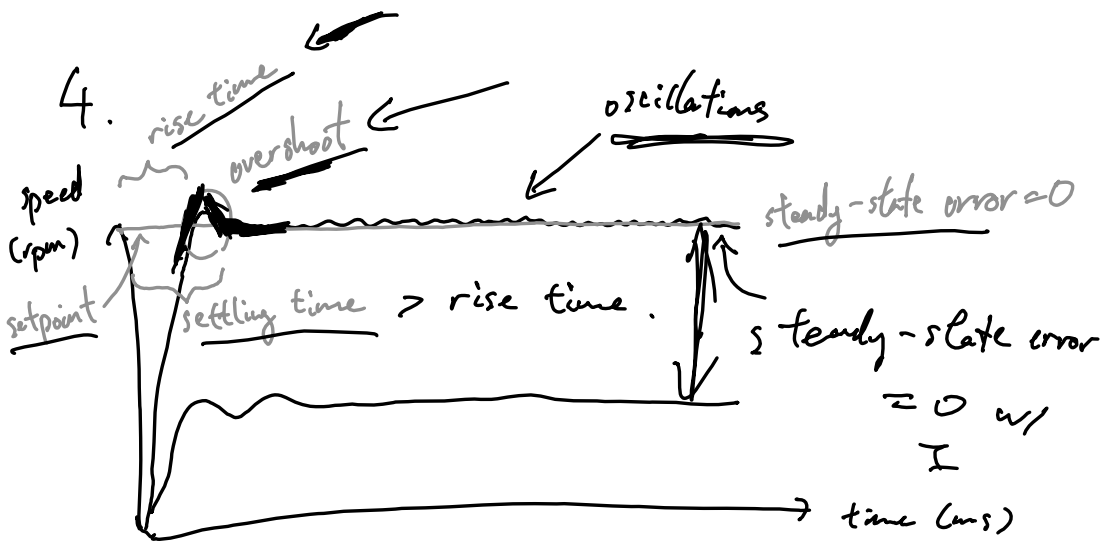
$$\text{out} (1 + k_p) = k_p \cdot \text{in}$$

$$\frac{\text{out}}{\text{in}} = \frac{k_p}{1 + k_p}$$

$$\text{as } k_p \rightarrow \infty, \frac{\text{out}}{\text{in}} = 1$$

$$\text{as } k_p \rightarrow 0, \frac{\text{out}}{\text{in}} = 0$$

if 1, setpoint reached



a) Decrease integrain gain slightly
(oscillation $\approx$ instability)

b) rise time stays the same. $\leftarrow$
overshoot decreases $\leftarrow$
settling time decreases $\leftarrow$
steady-state error stays the same ($= 0$) $\leftarrow$

5. overdamped.



- System can tolerate increased gain because duty cycle never reaches 100%
- Increase proportional gain to get 100% duty cycle at the beginning of transient response (but not all the time because system becomes nonlinear)

$\uparrow P \Rightarrow \uparrow$ rise time.

10.

Rule of thumb:

$$\text{control period (ms)} \leq \frac{\text{mechanical time constant (ms)}}{7-10}$$

min. loop rate

$$= \text{max. period} = \frac{\downarrow 30 \text{ ms}}{7} \approx 4 \text{ ms}, \text{ or } \underline{\underline{250 \text{ Hz}}}$$

11.

System must tolerate "swinging" of the output around the setpoint (or edges of the deadband)