EE 250: Control Systems Analysis
Module III: s-plane analysis
Lecture 13: Need for feedback control

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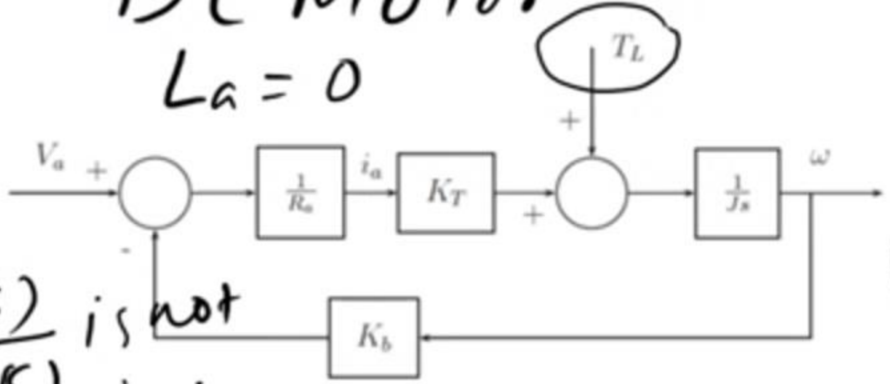
1. Disturbance Rejection Load disturbance

DC Motor

$L_a = 0$

Transfer fn



$$\frac{\omega(s)}{T_L(s)} = \frac{\frac{1}{Js}}{1+\frac{K_T K_b}{R_a J s}} = \frac{1}{R_a J s + K_T K_b}$$

$V_a = 0$

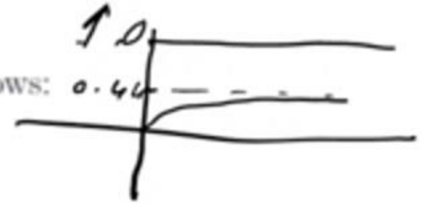
$\frac{\omega(s)}{V_a(s)}$ is not interesting

$K_T = K_b$

Given, $K_T = 1.5$, $R_a = 1\Omega$ and $J = 1$, we have

$$\frac{\omega(s)}{T_L(s)} = \frac{1}{s+2.25}$$

For a unit step disturbance torque $T_L(s) = \frac{1}{s}$, output is evaluated as follows:



$\boxed{\text{Desired } \omega_{ss} = 0}$

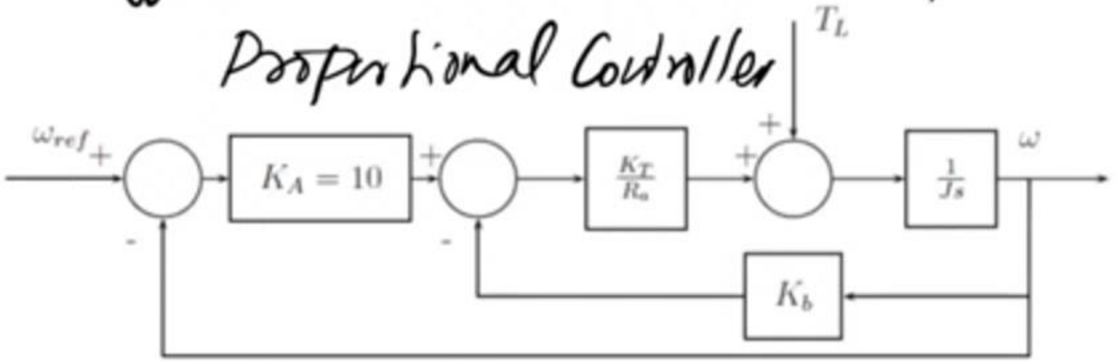
$$\omega(s) = \frac{1}{s(s+2.25)}$$

$$\Rightarrow w(t) = 0.444(1 - e^{-2.25t})$$

$\omega_{ss} = 0.444$

1. Effect on Disturbance Rejection

Proportional Controller



$$\frac{\omega(s)}{T_L(s)} = \frac{1}{s + 17.25}$$

$T_L = 1/s$

$$\omega(s) = \frac{1}{s(s+17.25)}$$

$$\Rightarrow w(t) = 0.0571(1 - e^{-17.25t})$$

$\omega_{ss} = 0.0571$

Without feedback $\frac{\omega(s)}{T_L(s)} = \frac{1}{s+2.25}$

$\omega_{ss} = 0.444$

$$\frac{\omega(s)}{T_L(s)} = \frac{\frac{1}{Js}}{1 + \frac{K_T K_b}{R_a J s} + \frac{K_T K_A}{R_a J s}}$$

$$= \frac{s}{s^2 + 2.25s + 15}$$

$K = \frac{10}{s}$

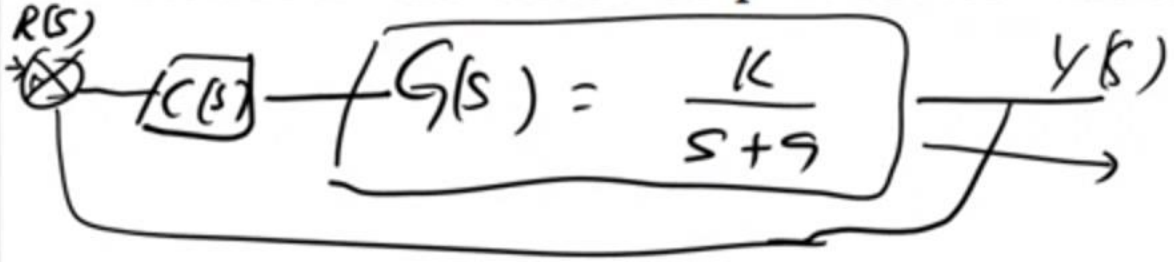
$T_L = 1/s$

$$\omega(s) = \frac{1}{s^2 + 2.25s + 15}$$

$$\Rightarrow \omega(t) = 0.2698e^{-1.125t} sin(3.7059t)$$

$\omega_{ss} = 0$

2. Reduces the effect of parameter uncertainties



$$\frac{K}{s+9.1} \text{ or } \frac{K}{s+8.9}$$

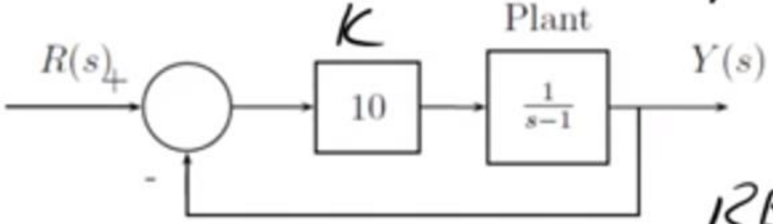
3. Provides stability to an open-loop unstable system

$$G(s) = \frac{1}{s+1}$$

open loop unstable

$$G(s) = \frac{1}{s-1}$$

$$e^{t}$$



$$\frac{Y(s)}{R(s)} = \frac{10}{s+9}$$

stable system

$$R(s) = 1/s$$

$$Y(s) = \frac{10}{s(s+9)}$$

Given openloop $G(s)$,

the closed loop feedback control

- → Disturbance rejection
- → Reduces the effect of parametric uncertainties
- → Stabilis