

Fall 2022 (111-1)

控制系統
Control Systems

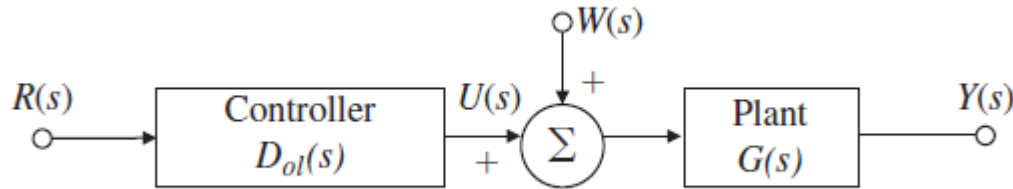
Unit 4E

Feedforward Control by Plant Model Inversion

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NTU-EE

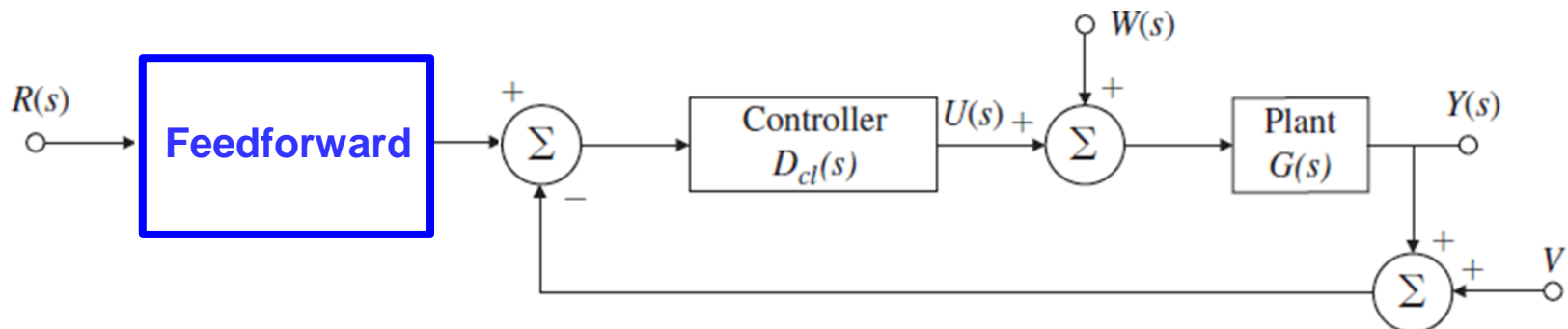
Sep 2022 – Dec 2022



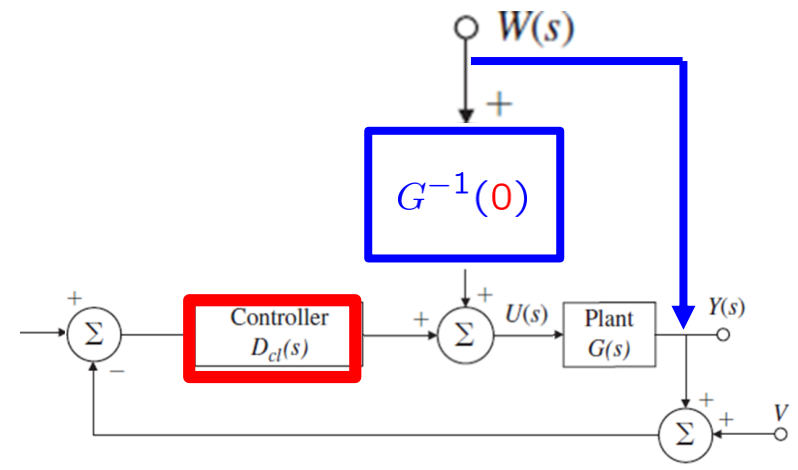
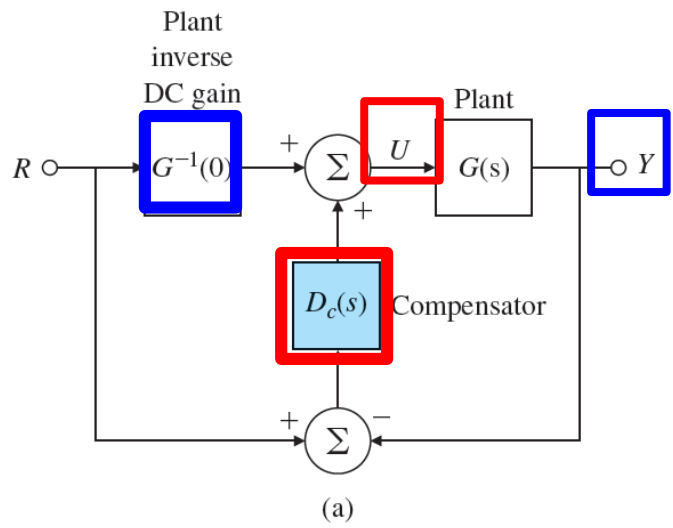
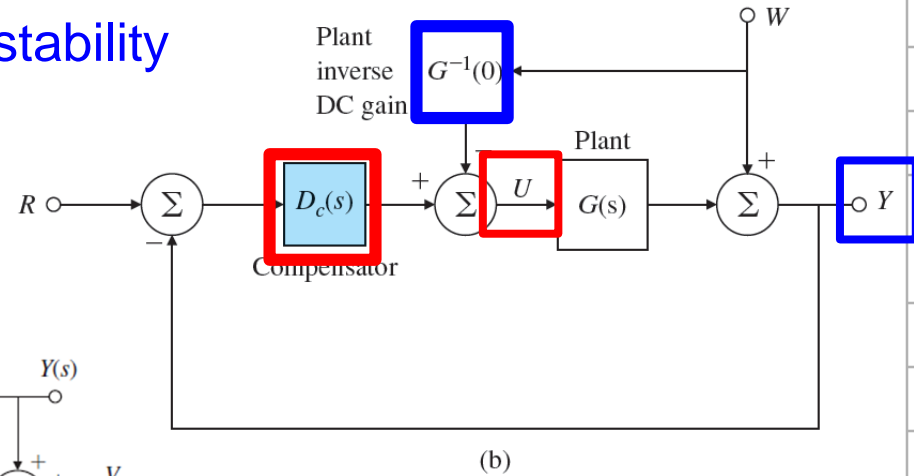
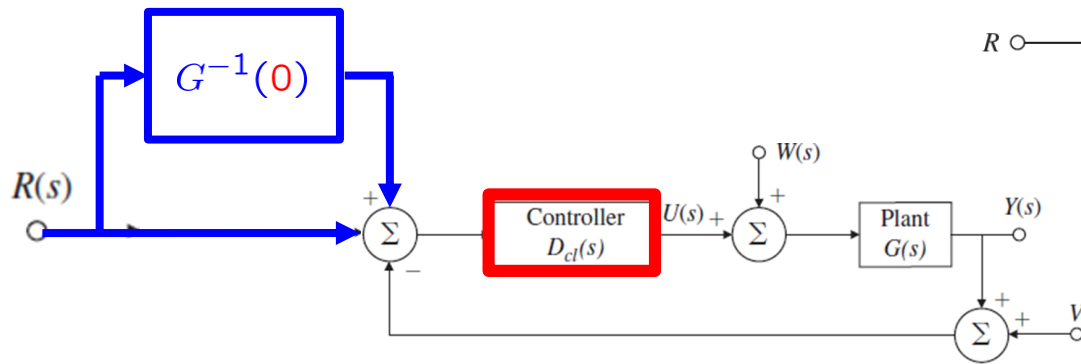
$$D = G^{-1}$$

$$Y = G U = G (G^{-1} R) = R$$

$$G(s) = \frac{b_1 s + b_2}{s^2 + a_1 s + a_2} \quad G^{-1}(s) = \frac{s^2 + a_1 s + a_2}{b_1 s + b_2}$$



- **P Controller** yields a steady-state error
- **I Controller** reduces errors, but decreases damping/stability
- Use some **Feedforward Control**



- Feedforward control structure for: (a) tracking; (b) disturbance rejection

Examples

● Example 4.10: Feedforward Control for DC motor

$$G(s) = \frac{A}{s^2 + a_1s + a_2} = \frac{1}{s^2 + 1.4s + 1}$$

$$1 + k_P G(s) = 0$$

$$k_P = 1.5 \text{ or } 6$$

$$\Rightarrow G(0)^{-1} = 1$$

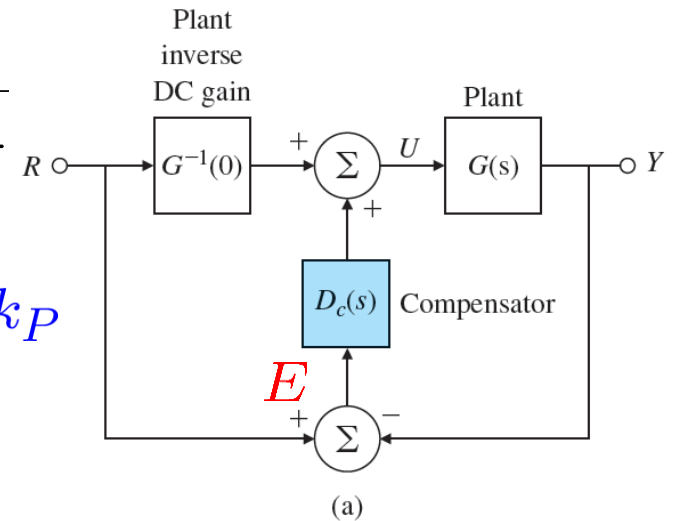
$$Y(s) = G(s) U(s)$$

$$Y(s) = G(s) [k_P E(s) + R(s)]$$

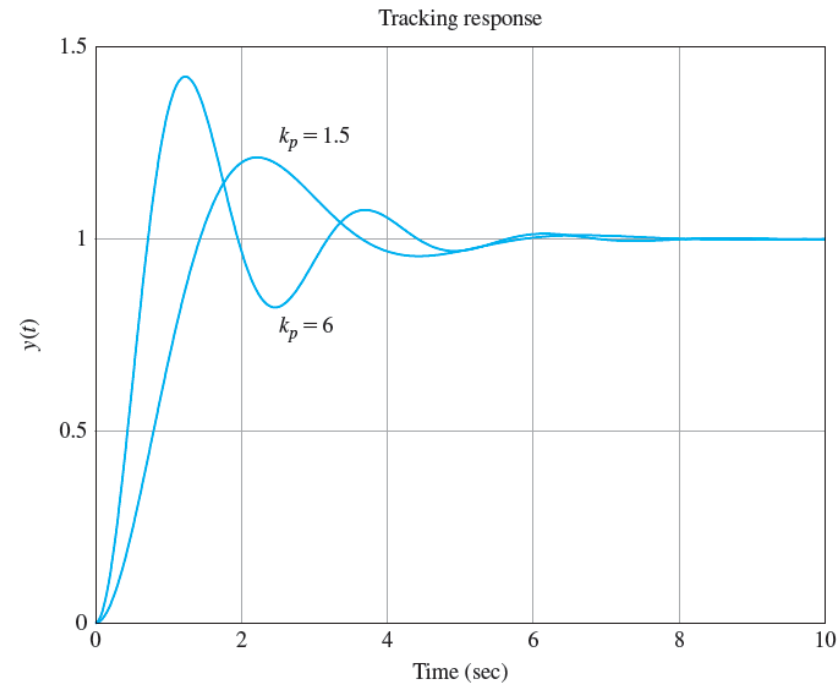
$$E(s) = R(s) - Y(s)$$

$$T(s) = \frac{Y(s)}{R(s)} = \frac{(1 + k_P) G(s)}{1 + k_P G(s)}$$

● For Tracking



$$D_c(s) = k_P$$



- Example 4.10: Feedforward Control for DC motor
- For Disturbance Rejection

$$G(s) = \frac{A}{s^2 + a_1s + a_2} = \frac{1}{s^2 + 1.4s + 1}$$

$$1 + k_P G(s) = 0$$

$$k_P = 1.5 \text{ or } 6 \quad D_c(s) = k_P$$

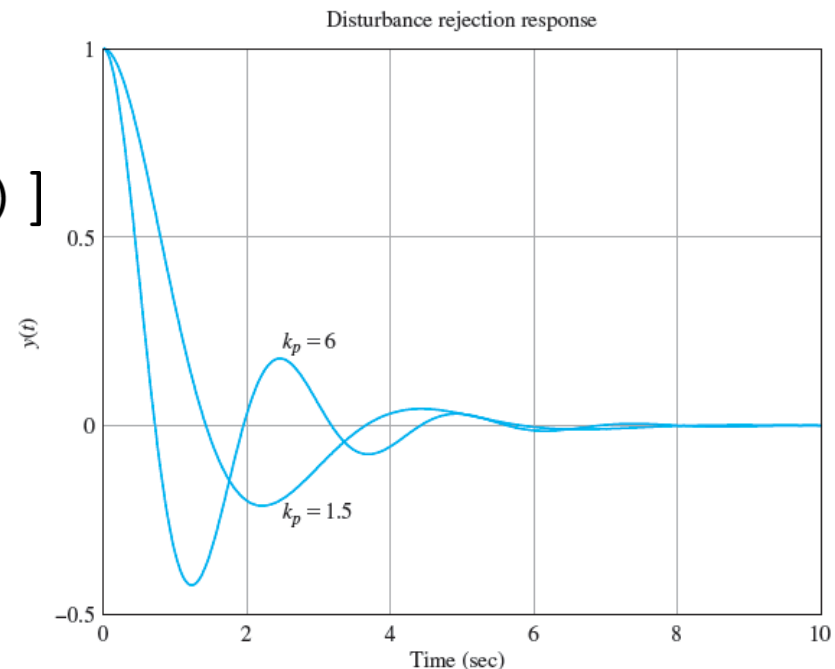
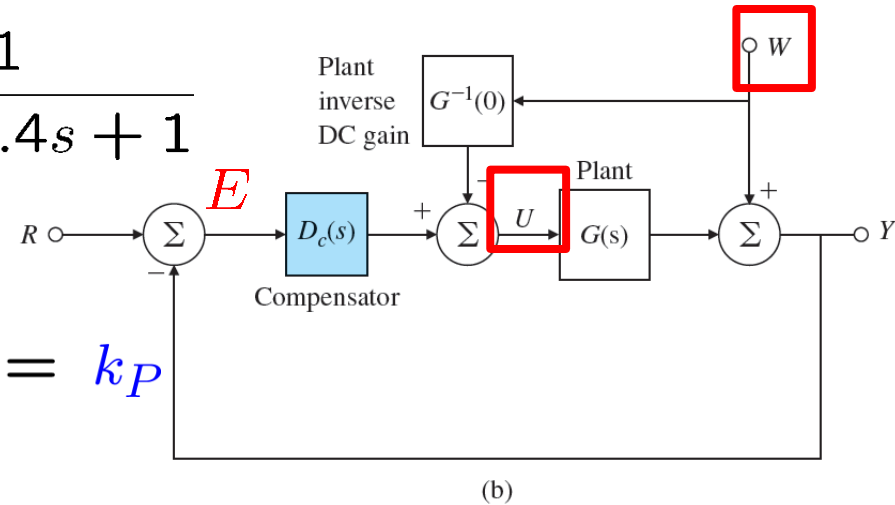
$$\Rightarrow G(0)^{-1} = 1$$

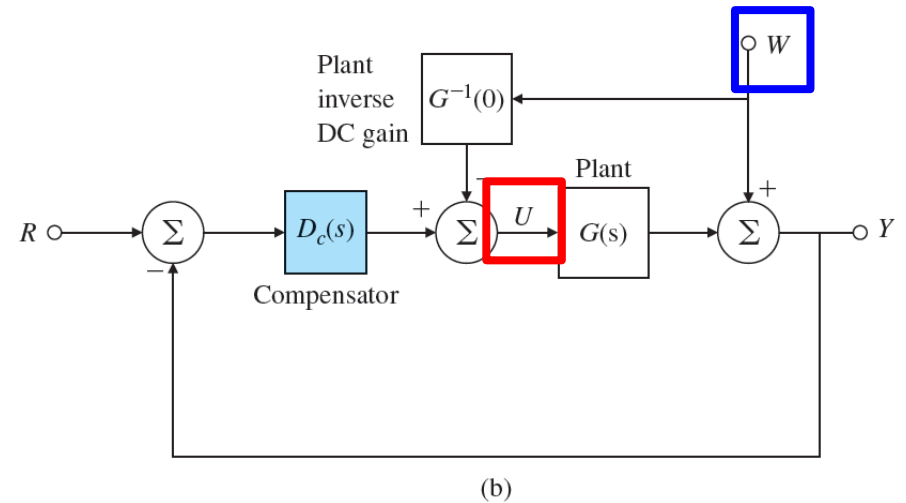
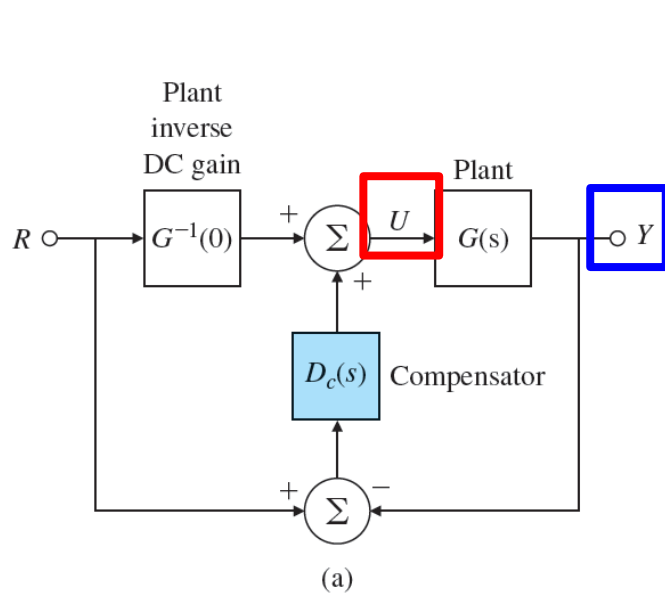
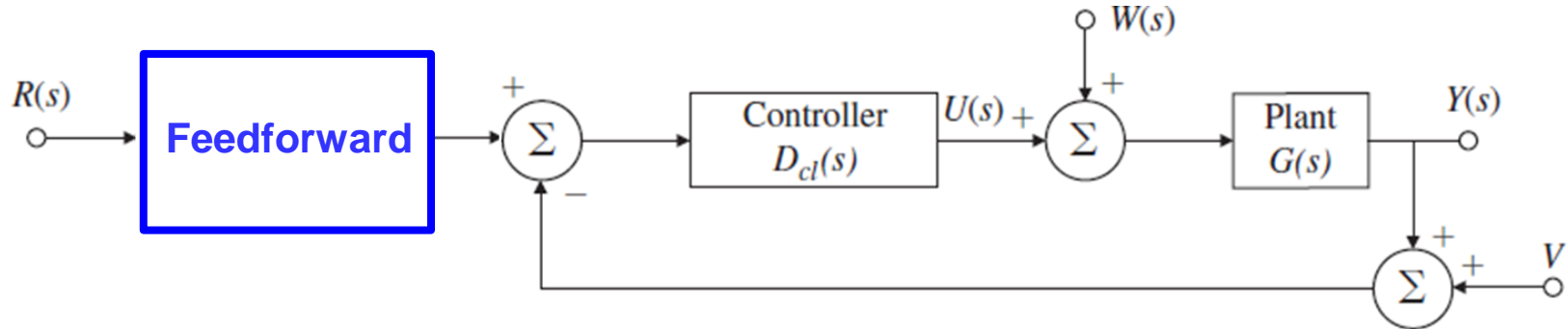
$$Y(s) = W(s) + G(s) U(s)$$

$$Y(s) = W(s) + G(s) [k_P E(s) - W(s)]$$

$$E(s) = R(s) - Y(s)$$

$$T_w(s) = \frac{Y(s)}{W(s)} = \frac{1 - G(s)}{1 + k_P G(s)}$$





- Feedforward control structure for: (a) tracking; (b) disturbance rejection