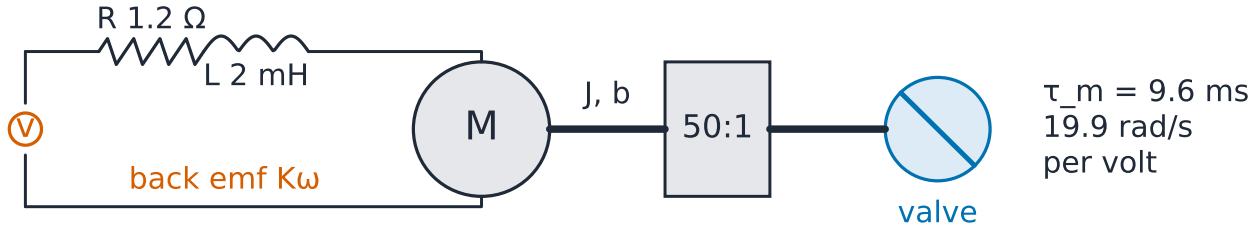
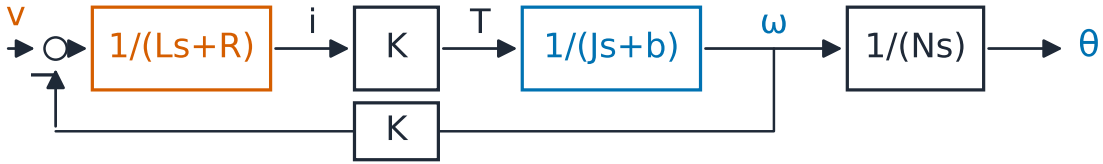
Exercise walk-through

12.2
Electromechanical systems

University Mechanical Engineering

The valve actuator





$K = 0.05$: **19.9** rad/s per volt, $\tau_m = JR/K^2 = \mathbf{9.6}$ ms, $\tau_e = 1.7$ ms; stall 10 A, 0.5 N · m.

Through the gearbox

1. **Valve gain** $19.9/50 = \mathbf{0.398}$ rad/s per volt; 12 V $\to$ 4.78 rad/s, 90° in $\geq$ 0.33 s.
2. **Load** 5 N · m at the stem $\to$ 0.125 N · m at the motor $\to$ $\mathbf{3.0}$ V.
3. **Current limit** 5 A $\to$ 0.25 N · m $\to$ $\mathbf{10}$ N · m at the valve, twice the load.

Decision

The model is valid while voltage and current stay inside their limits.

Exercises 2.1·2.2

2.1 Find the steady speed per volt (two decimals, rad/s per V) and the no-load speed at 24 V (nearest rad/s). [3]

2.2 Find τ_m (one decimal, ms) and τ_e, and the stall current and torque. [4]

Exercises 2.1·2.2

2.1 Find the steady speed per volt (two decimals, rad/s per V) and the no-load speed at 24 V (nearest rad/s). [3]

2.1

- Gain $= K/(bR + K^2) = 0.08/(4 \times 10^{-5} + 0.0064) =$ **12.42** rad/s per V.
- $\omega = V(\Omega/V) = 24 \times 12.42 =$ **298** rad/s (2850 rpm).

2.2 Find τ_m (one decimal, ms) and τ_e, and the stall current and torque. [4]

2.2

- $\tau_m = JR/(bR + K^2) = 10^{-4}/0.00644 =$ **15.5** ms.
- $\tau_e = L/R = 3 \times 10^{-3}/2 =$ **1.5** ms.
- Stall: $i = V/R = 12$ A, $T = Ki =$ **0.96** N · m.

Exercise 3.1

3.1 The motor drives a valve through a $30:1$ gearbox with efficiency 0.85. The valve stem needs $8\ \mathrm{N\cdot m}$. (a) Find the motor torque, current and the voltage that just holds the valve (two decimals). (b) Find the valve's top speed with no load and under load at 24 V (two decimals, rad/s), and the shortest 90° move under load (three decimals, s). (c) A 6 A current limit is set: find the valve torque it allows and the mechanical power at the motor shaft while moving under load. [9]

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3.1 The motor drives a valve through a $30:1$ gearbox with efficiency 0.85. The valve stem needs 8 N $\cdot$ m. (a) Find the motor torque, current and the voltage that just holds the valve (two decimals). (b) Find the valve's top speed with no load and under load at 24 V (two decimals, rad/s), and the shortest 90° move under load (three decimals, s). (c) A 6 A current limit is set: find the valve torque it allows and the mechanical power at the motor shaft while moving under load. [9]

3.1

- (a) $T_m = T_L/(N\eta) = 8/(30 \times 0.85) = \mathbf{0.314}$ N $\cdot$ m.
- $i = T_m/K = \mathbf{3.92}$ A; at rest no back emf, so $V = iR = \mathbf{7.84}$ V.
- (b) No load: $298/30 = \mathbf{9.94}$ rad/s.
- Under load only $24 - 7.84 = 16.16$ V drives speed: $16.16 \times 12.42/30 = \mathbf{6.69}$ rad/s.
- $90° = 1.571$ rad: $t \geq 1.571/6.69 = \mathbf{0.235}$ s.
- (c) $T_{valve} = KiN\eta = 0.08 \times 6 \times 30 \times 0.85 = \mathbf{12.2}$ N $\cdot$ m, 1.5 times the load.
- $P = T_m\omega_m = 0.314 \times (6.69 \times 30) = \mathbf{63}$ W.