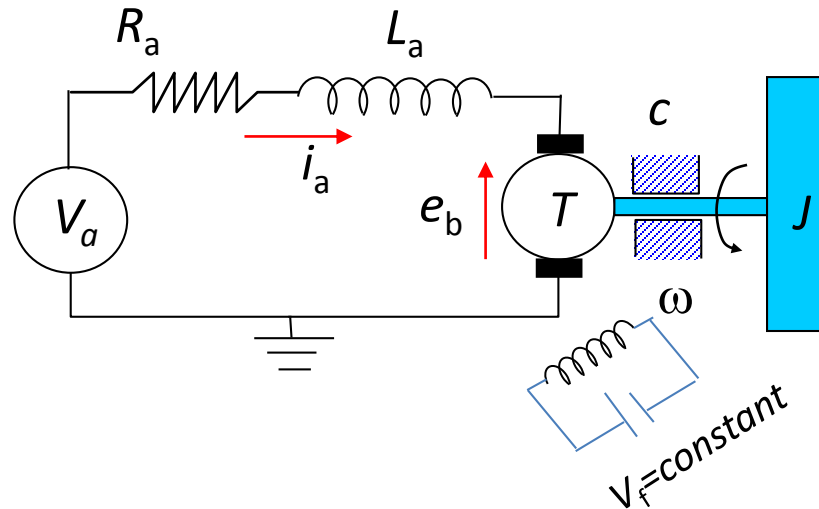


EE3114 Systems and Control

Tutorial - 1

Semester B, 2017-18

Armature-Controlled D.C. Motor



Motor Toque:
(electrical eq.)

$$T_m(t) = K_{ma} i_a(t)$$

K_{ma} is a constant
depending on flux

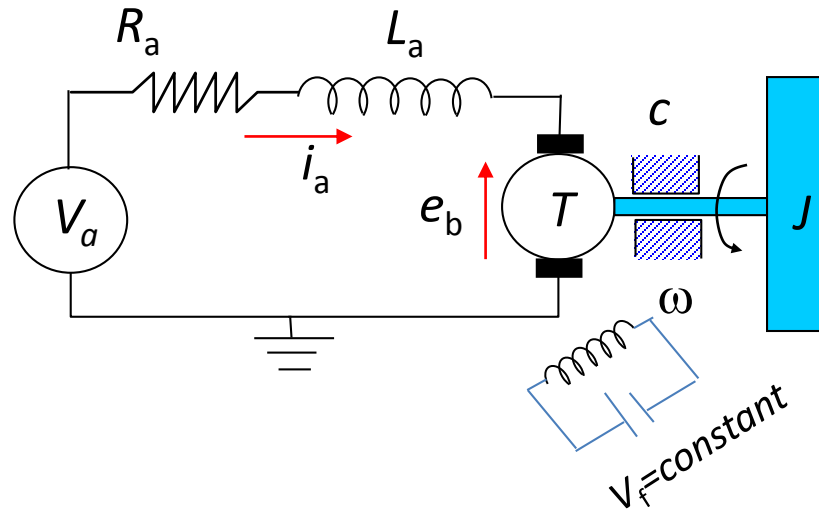
Motor Toque:
(mechanical eq.)

$$T_m(t) = J\dot{\omega}(t) + c\omega(t)$$

J is inertia moment
 c is friction constant

$$\Rightarrow (Js + c)\omega(s) = K_{ma} I_a(s)$$

Armature-Controlled D.C. Motor



$$L_a \frac{di(t)}{dt} + R_a i(t) + K_b \omega(t) = V_a(t) \quad \text{Kirchhoff Law}$$

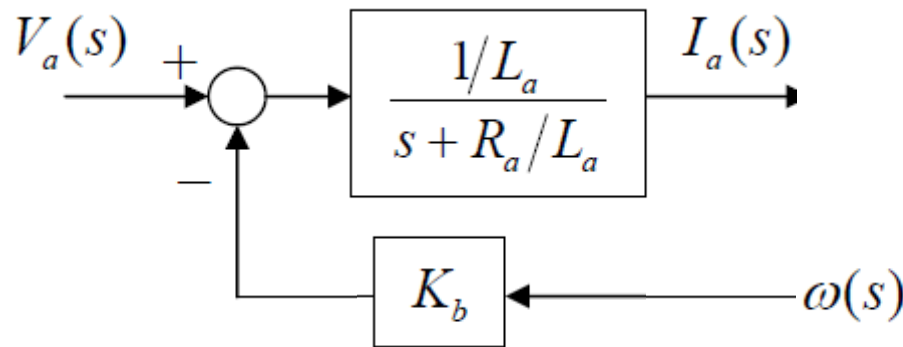
➔ $(L_a s + R_a) I_a(s) + K_b \omega(s) = V_a(s)$

+

$$(Js + c) \omega(s) = K_{ma} I_a(s)$$

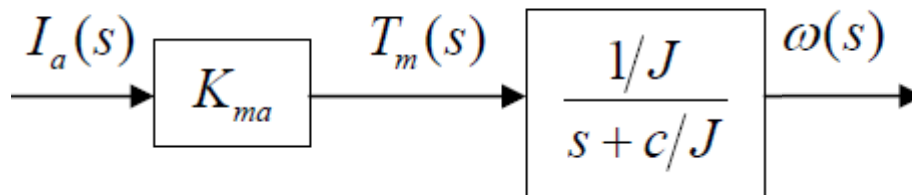
Block Diagrams of Components

$$(L_a s + R_a)I_a(s) + K_b \omega(s) = V_a(s)$$



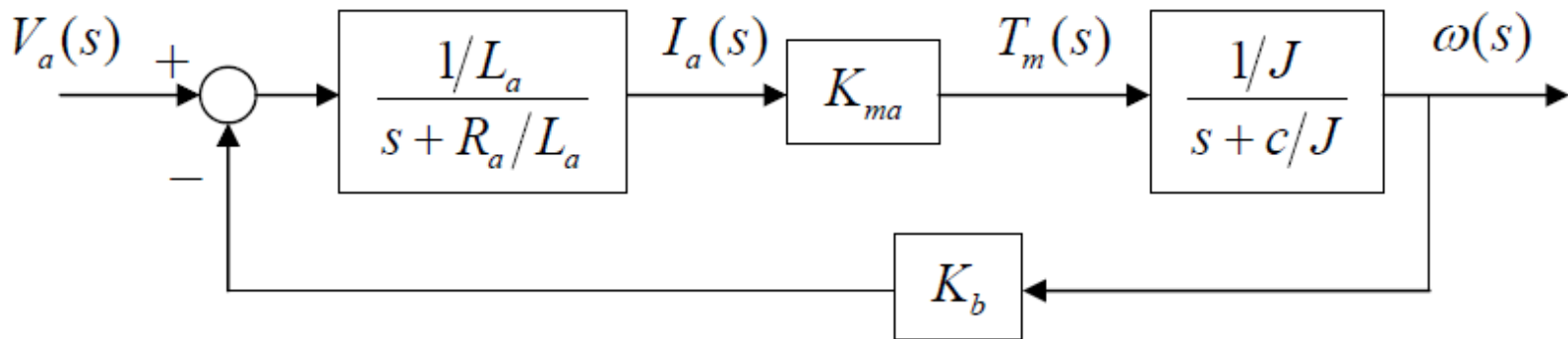
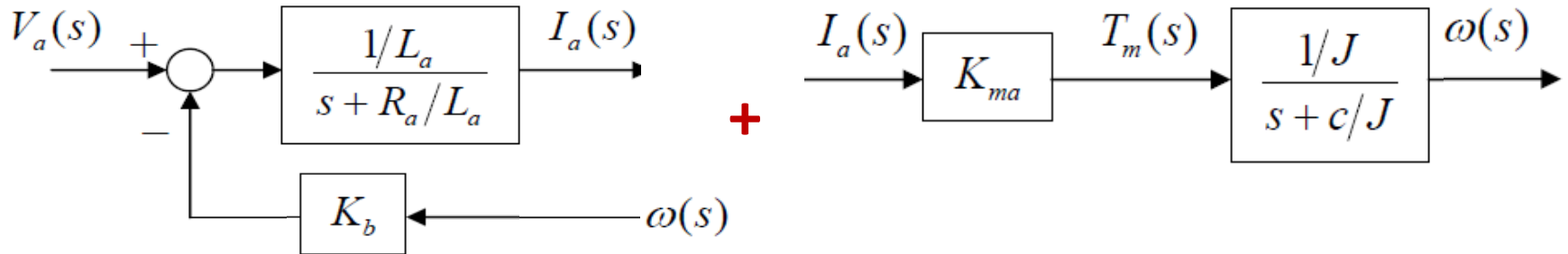
← Verify This

$$(Js + c)\omega(s) = K_{ma}I_a(s)$$



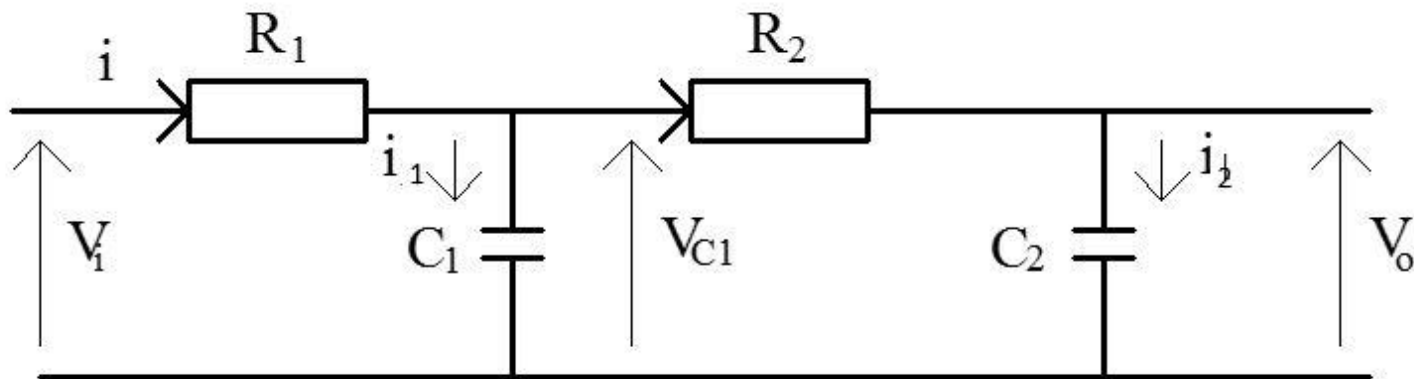
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Block Diagram of Armature-Controlled D.C Motor



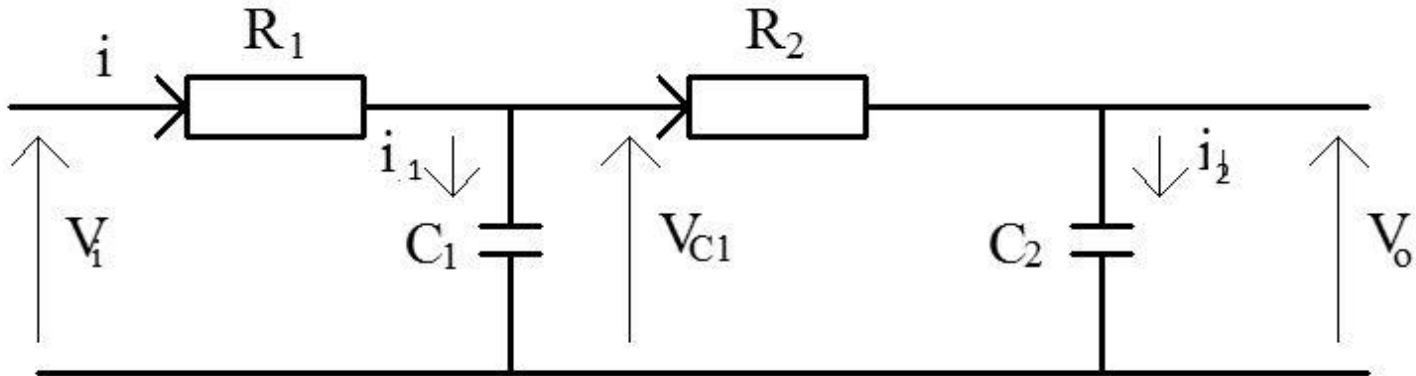
Exercise

Show the frequency-domain block diagram of the following RC network:



Steps: First, find the circuit equations
Then, find their Laplace Transforms
Then, Find the overall transfer function
Finally, build the block diagram

Answer



First, find the circuit equations

$$i = \frac{V_i - V_{C1}}{R_1}$$

$$i_2 = \frac{V_{C1} - V_o}{R_2}$$

$$i = i_1 + i_2$$

$$V_{C1} = \frac{\int i_1 dt}{C_1}$$

$$V_o = \frac{\int i_2 dt}{C_2}$$

$$i = \frac{V_i - V_{C1}}{R_1}$$

$$i_2 = \frac{V_{C1} - V_o}{R_2}$$

$$i = i_1 + i_2$$

$$V_{C1} = \frac{\int i_1 dt}{C_1}$$

$$V_o = \frac{\int i_2 dt}{C_2}$$

➡ Then, find their Laplace Transforms

$$I(s) = \frac{V_I(s) - V_{C1}(s)}{R_1}$$

$$I_2(s) = \frac{V_{C1}(s) - V_o(s)}{R_2}$$

$$I(s) = I_1(s) + I_2(s)$$

$$V_{C1}(s) = \frac{I_1(s)}{C_1 s}$$

$$V_o(s) = \frac{I_2(s)}{C_2 s}$$

$$I(s) = \frac{V_I(s) - V_{C1}(s)}{R_1} \quad I_2(s) = \frac{V_{C1}(s) - V_o(s)}{R_2} \quad I(s) = I_1(s) + I_2(s)$$

$$V_{C1}(s) = \frac{I_1(s)}{C_1 s} \quad V_o(s) = \frac{I_2(s)}{C_2 s}$$

➡ Then, find the overall transfer function

$$\begin{array}{ccc}
 I(s) = I_1(s) + I_2(s) & & I_2(s) = \frac{V_{C1}(s) - V_o(s)}{R_2} \\
 \downarrow & & \downarrow \\
 \frac{V_I(s) - V_{C1}(s)}{R_1} = C_1 s V_{C1}(s) + C_2 s V_o(s) & \leftarrow & V_{C1}(s) = R_2 I_2(s) + V_o(s) \\
 & & = R_2 C_2 s V_o(s) + V_o(s) \\
 \downarrow & & \\
 V_I(s) = [R_1 C_1 R_2 C_2 s^2 + (R_1 C_1 + R_2 C_2 + R_1 C_2)s + 1] V_o(s)
 \end{array}$$

➡ Finally, build the block diagram

$$V_I(s) = [R_1 C_1 R_2 C_2 s^2 + (R_1 C_1 + R_2 C_2 + R_1 C_2)s + 1]V_o(s)$$

$$\frac{V_o(s)}{V_I(s)} = \frac{1}{[R_1 C_1 R_2 C_2 s^2 + (R_1 C_1 + R_2 C_2 + R_1 C_2)s + 1]}$$

