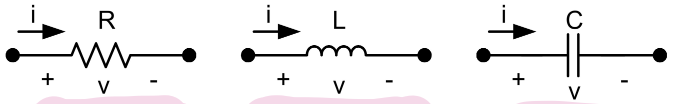
CH2

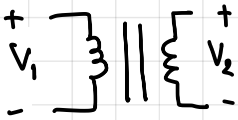
ไฟฟ้า



$v=Ri$ $\quad V(s)=RI(s)$

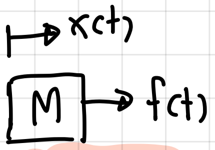
$v=L\frac{di}{dt}$ $\quad V(s)=sLI(s)$

$i=C\frac{dv}{dt}$ $\quad V(s)=\frac{1}{sC}I(s)$

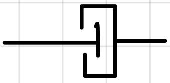


$$\boxed{\frac{v_1}{v_2}=\frac{i_2}{i_1}=\frac{N_1}{N_2}}$$

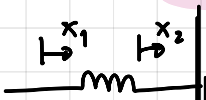
กล



$f(t)=M\ddot{x}$



$f(t)=B(\dot{x}_2-\dot{x}_1)$

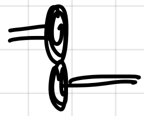


$f(t)=k(x_2-x_1)$

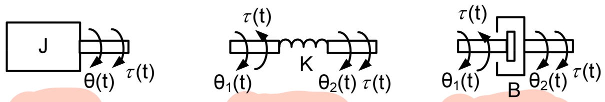
$\dot{x}=v \quad \ddot{x}=a$

$\dot{\theta}=\omega$

∴ เกียร์

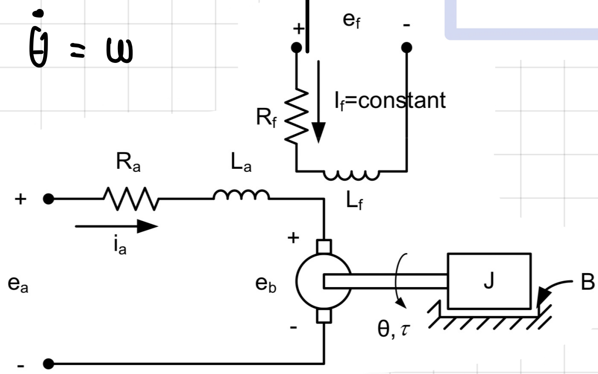


$$\boxed{\frac{\tau_1}{\tau_2}=\frac{\theta_2}{\theta_1}=\frac{r_1}{r_2}}$$



$\tau(t)=J\ddot{\theta}$ $\quad \tau(t)=K(\theta_2-\theta_1)$ $\quad \tau(t)=B(\dot{\theta}_2-\dot{\theta}_1)$

แม่เหล็ก (เชื่อม ไฟฟ้า + กล)



ลวดตัดสนามแม่เหล็ก

$$\boxed{e_b=k\phi\omega=k_m\omega}$$

⇓ Laplace

$E_b(s)=k_m\omega(s)$

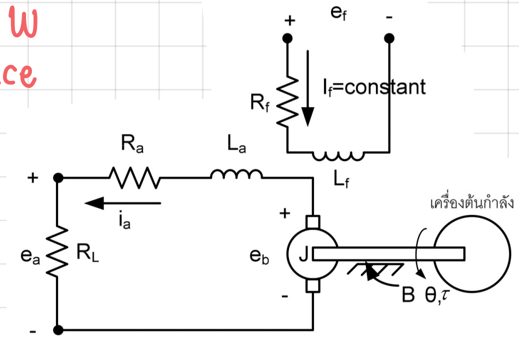
☆ จาก $\theta\to\omega$ Laplace

แรงต้านกลับในสนามแม่เหล็ก

$$\boxed{\tau=k\phi i_a=k_m i_a}$$

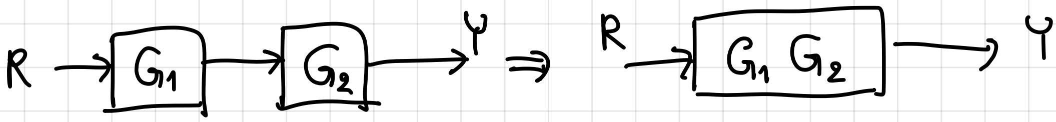
⇓ Laplace

$\tau(s)=k_m I_a(s)$



Block Diagram Algebar

casecade



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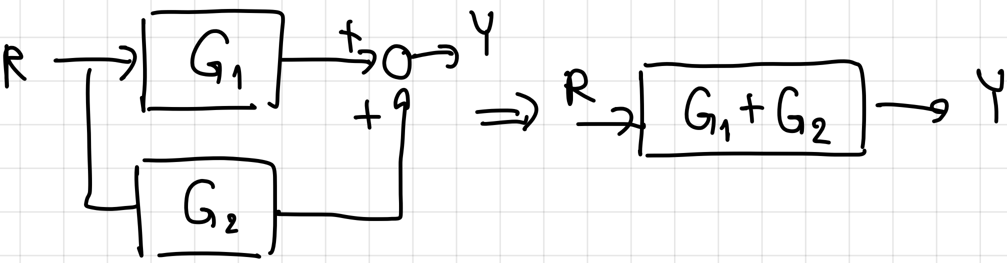
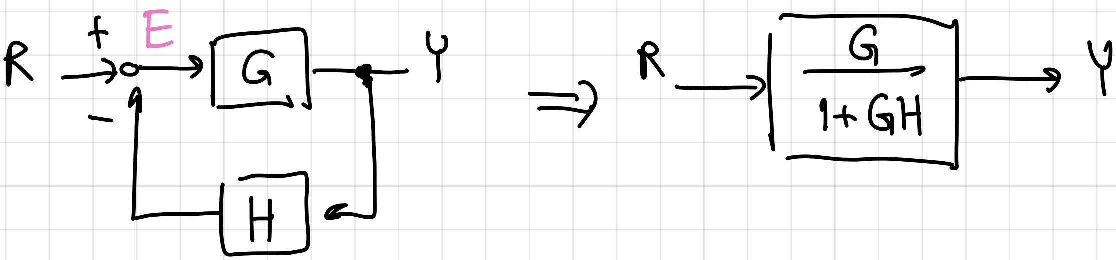


Feedback



สรุปสูตร บท 3-4

$\boxed{T_s = 4\tau}$

$$R(s) \rightarrow \boxed{\frac{1}{s}} \rightarrow \boxed{\frac{K}{\tau s+1}} \rightarrow C(s)$$

1st Order (Unit Impluse)

$$R(s) \rightarrow \boxed{\frac{K}{\tau s+1}} \rightarrow C(s)$$

Laplace

$$\frac{Ke^{-t/\tau}}{\tau}$$

— ผลตอบสนองชั่วครู่ $-Ke^{-t/\tau}$

— ผลตอบสนองในสถานะอยู่ตัว K ($\frac{C_{ss} = K}{1}$) → Unit step = 1

กรณีให้ค่าเริ่มต้นเป็น $0 \rightarrow r(t) = u(t)$

force ← Laplace $R(s) = \frac{1}{s}$

$$C(s) = \frac{K}{s} - \frac{K}{s+1/\tau}$$

→ transition ของ natural หายไปที่ $T_s = 4\tau$

$$c(t) = K(1 - e^{-t/\tau})$$

⚠ จากทฤษฎีบท ค่าสุดท้าย

DC gain → $\boxed{K = G(0)}$

Sentability (เสถียรภาพ) ใช้วิธี Routh-Hurwitz

$$\begin{array}{c|c} s^2 & \\ s^1 & \\ s^0 & \end{array}$$

กรณี 1. $\begin{bmatrix} x & x \\ 0 & x \end{bmatrix} \rightarrow \begin{bmatrix} x & x \\ \varepsilon & x \end{bmatrix}$, 2. $\begin{bmatrix} x & x \\ 0 & 0 \end{bmatrix} \rightarrow$ diff $x \; x$ → แทน 0 0

Sensitivity (ความไว)

$$\boxed{S_b^T = \frac{\Delta T(s)/T(s)}{\Delta b/b} = \frac{\Delta T(s)}{\Delta b}\frac{b}{T(s)} = \frac{\partial T(s)}{\partial b}\frac{b}{T(s)}}$$

↳ ใกล้ 0 ดี เพราะไม่ค่อยเปลี่ยนแปลง

แก้โดยเปลี่ยน PID

$$\boxed{G_c(s) = K_P + \frac{K_I}{s} + K_D s}$$

Error

N	R(s): 1/s	R(s): $1/s^2$	R(s): $1/s^3$	Error constants
0	$\frac{1}{1+K_p}$	∞	∞	$K_p = \lim_{s\to 0} G_C G_P$
1	0	$\frac{1}{K_v}$	∞	$K_v = \lim_{s\to 0} sG_C G_P$
2	0	0	$\frac{1}{K_a}$	$K_a = \lim_{s\to 0} s^2 G_C G_P$

Unit step

$$\boxed{K_p = \lim_{s\to 0} G(s), \quad e_{ss} = \frac{1}{1-K_p}}$$

Unit ramp

$$\boxed{K_v = \lim_{s\to 0} sG(s), \quad e_{ss} = \frac{1}{K_v}}$$

Paraboric

$$\boxed{K_a = \lim_{s\to 0} s^2 G(s), \quad e_{ss} = \frac{1}{K_a}}$$

2 st order

รูปปกติ $\boxed{\dfrac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}}$

ζ = อัตราส่วนการหน่วง (damping ratio)

ω_n = ความถี่ธรรมชาติ (natural frequency)

สมการลักษณะเฉพาะ (characterisetic equaation)

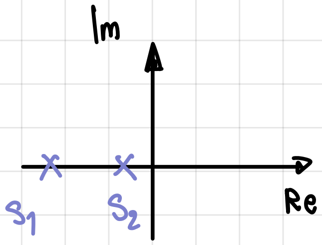
$$s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$$

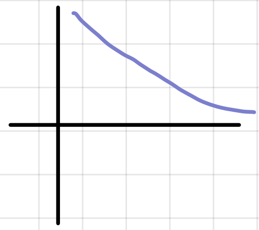
มี 4 แบบ

1. overdamped $\quad \zeta > 1$ เรโช:

$$s = -\zeta\omega_n \pm \omega_n\sqrt{\zeta^2 - 1} = s_1, s_2$$

$$C_n(t) = Ae^{s_1 t} + Be^{s_2 t}$$

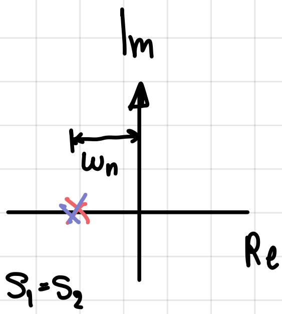


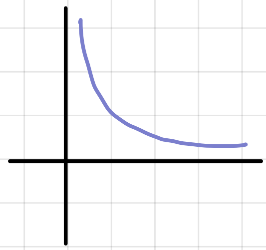


2. critical damped $\quad \zeta = 1$

$$s = -\omega_n, -\omega_n$$

$$C_n(t) = (At + B)e^{-\omega_n t}$$

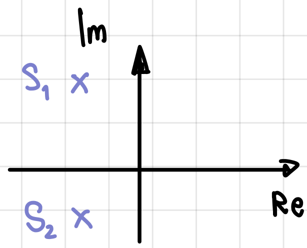


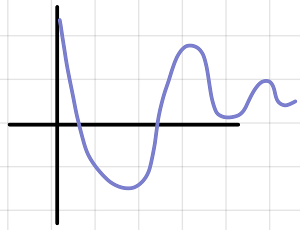


3. underdamped $\quad \zeta < 1$

$$s = -\zeta\omega_n \pm j\omega_n\sqrt{1-\zeta^2} = s_1, s_2$$

$$C_n(t) = Ae^{-\zeta\omega_n t}\sin(\omega_n\sqrt{1-\zeta^2}\,t + \phi)$$

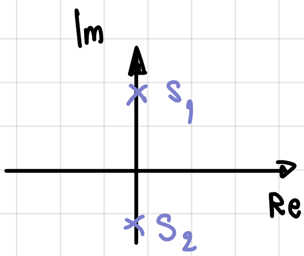


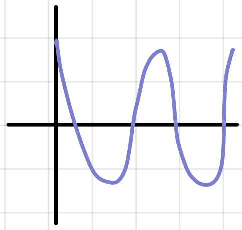


4. undamped $\quad \zeta = 0$

$$s = \pm j\omega_n$$

$$C_n(t) = A\sin(\omega_n t + \phi)$$





$$\boxed{P.O. = e^{-\pi\zeta/\sqrt{1-\zeta^2}} \times 100}$$

กรณี underdamped

$$\boxed{T_p = \frac{\pi}{\omega_d}} \qquad \boxed{\omega_d = \omega_n\sqrt{1-\zeta^2}}$$

$$\boxed{c(t) = 1 - \frac{1}{\beta}e^{-\zeta\omega_n t}\sin(\omega_d t + \theta)} \qquad \boxed{\beta = \sqrt{1-\zeta^2}} \qquad \boxed{\theta = \tan^{-1}(\beta/\zeta)}$$