*** Sistem Order Kedua**
Second Order Systems

→ Double Integrator

$X(s) \rightarrow \boxed{\frac{1}{s^2}} \rightarrow Y(s)$ percepatan $\rightarrow \boxed{\int dt} \rightarrow$ kecepatan $\rightarrow \boxed{\int dt} \rightarrow$ posisi

Diketahui $x(t) = \delta(t)$
Ditanyakan $y(t) =$???

→ Bentuk umum Sistem Order Kedua

$X(s) \rightarrow \boxed{G(s)} \rightarrow Y(s)$

ξ - zeta
ω_n omega-n

$$G(s) = \frac{K}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

ξ = nisbah redaman (damping ratio)
ω_n = frekuensi alamiah tak teredam [radian/sec] (undamped natural frequency)

$G(s) = \frac{10}{s^2+4}$ ✓

$G(s) = \frac{10}{s^2+4s+4} = \frac{10}{(s+2)^2}$ ✓

$\boxed{x(t) = \delta(t) \longrightarrow y(t) \text{ tergantung pada } \xi}$

* $\xi > 1$ teredam lebih (overdamped) $G(s) = \frac{K}{(s+a)(s+b)}$ $a = \xi\omega_n + \omega_n\sqrt{\xi^2-1}$, $b = \xi\omega_n - \omega_n\sqrt{\xi^2-1}$

* $\xi = 1$ teredam kritis (critically damped) $G(s) = \frac{K}{(s+a)^2} \rightarrow a = \omega_n$

* $0 < \xi < 1$ teredam kurang (underdamped) $a = \xi\omega_n + j\omega_n\sqrt{1-\xi^2}$, $b = \xi\omega_n - j\omega_n\sqrt{1-\xi^2}$

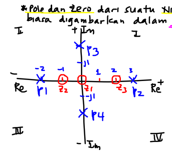
$\omega_n\sqrt{1-\xi^2} = \omega_d$ d = damping

* $\xi = 0$ tak teredam (undamped) $G(s) = \frac{K}{s^2+\omega_n^2}$

$\omega_n = 2\pi f_n$
rad/sec — Hertz

* $\xi < 0 \rightarrow$ tidak stabil

*Pole dan zero dari suatu Nisbah Alih biasa digambarkan dalam bidang kompleks



Pole - ×
Zero - O
Contoh

$$G(s) = \frac{s(s+1)(s-2)}{(s+2)(s-3)(s^2+4)}$$

Zero: $z_1 = 0$, $z_2 = -1$, $z_3 = 2$
Pole $p_1 = -2$ $p_2 = 3$
$s^2+4 = 0 \rightarrow p_3 = j2$, $p_4 = -j2$
$j = \sqrt{-1}$

* Isyarat-isyarat uji (Test Signals)

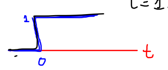
* Isyarat denyut satuan $\delta(t)$, (sudah dipelajari)

$$\delta(t)\begin{cases} = 0, & t \neq 0 \\ \neq 0, & t = 0 \end{cases}$$

* Isyarat undak satuan $u(t)$
Unit step function

Definisi:

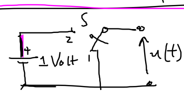
$$u(t)\begin{cases} = 0, & t < 0 \\ = 1, & t \geq 0 \end{cases}$$



* Realisasi matematis

$\delta(t) \rightarrow \boxed{\int dt} \rightarrow u(t)$
integrator
$1 \rightarrow \boxed{\frac{1}{s}} \rightarrow \mathcal{L}\,u(t) = \frac{1}{s}$

* Realisasi secara fisik



Saklar S dipindahkan dari posisi 1 ke posisi 2 pada $t = 0$

Isyarat $u(t)$ →
$u(t)\begin{cases} = 0, & t < 0 \\ = 1, & t \geq 0 \end{cases}$

Transformasi Laplace
$U(s) = \frac{1}{s}$

$e = 1 + 1 + \frac{1}{2} + \frac{1}{6}$
$= 2{,}718\ldots$

Isyarat $u(t-T)$ →
$u(t-T)\begin{cases} = 0, & t < T \\ = 1, & t \geq T \end{cases}$

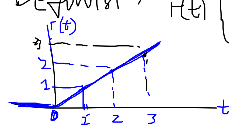
$\mathcal{L}\,u(t-T) = \frac{1}{s}e^{-Ts}$

Isyarat $u(t) - (t-T)$
$u(t) - u(t-T)\begin{cases} = 0, & t < 0 \\ = 1, & 0 \leq t < T \\ = 0, & t \geq T \end{cases}$

$\mathcal{L}\,u(t) - u(t-T) = \frac{1}{s}(1 - e^{-Ts})$

* Isyarat tanjak satuan $r(t)$
Unit Ramp function

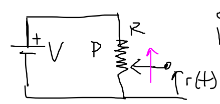
Definisi: $r(t)\begin{cases} = 0, & t < 0 \\ = t, & t \geq 0 \end{cases}$



Realisasi matematis

$u(t) \rightarrow \boxed{\int dt} \rightarrow r(t)$
$\frac{1}{s} \rightarrow \boxed{\frac{1}{s}} \rightarrow \frac{1}{s^2}$

Realisasi fisik:



P: Potensimeter digeser dengan kecepatan tetap
$r(t)$ naik 1V/sec

$u(t) - u(t-T) \rightarrow \boxed{\int dt} \rightarrow$???
0 T

Pekan depan 27/11/13
MIDTEST (Open book, NO Laptop)
Bobot 40%
Bahan seluruhnya s/d kuliah 20/11/13
Jangan lupa, Bawa Tabel Laplace

* Sistem Order Pertama
(First Order Systems)

→ Contoh:
* Simple Integrator

$x(t) \rightarrow \boxed{\int dt} \rightarrow y(t) = \int x(t)\,dt$

Transf Laplace

$X(s) \rightarrow \boxed{\frac{1}{s}} \rightarrow Y(s) = \frac{X(s)}{s}$

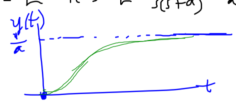
$e^{-\infty} = \frac{1}{e^{\infty}}$

$x(t) = e^{-at}, t \geq 0 \rightarrow y(t) = \ldots ?$

$X(s) = \mathcal{L}\,x(t) = \mathcal{L}\,e^{-at} = \frac{1}{s+a}$ (dari Tabel)

$Y(s) = \frac{1}{s}X(s) = \frac{1}{s}\frac{1}{s+a} = \frac{1}{s(s+a)}$

$y(t) = \mathcal{L}^{-1}\,Y(s) = \mathcal{L}^{-1}\frac{1}{s(s+a)} = \frac{1}{a}(1 - e^{-at})$



* Simple Lag

$X(s) \rightarrow \boxed{\frac{1}{s+a}} \rightarrow Y(s)$

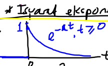
$x(t) = u(t) \longrightarrow y(t) = \ldots ?$

$X(s) = \mathcal{L}\,x(t) = \mathcal{L}\,u(t) = \frac{1}{s}$

$Y(s) = \left(\frac{1}{s+a}\right)\frac{1}{s} = \frac{1}{s(s+a)} \longrightarrow y(t) = \mathcal{L}^{-1}\,Y(s) = \mathcal{L}^{-1}\frac{1}{s(s+a)} = \frac{1}{a}(1 - e^{-at})$

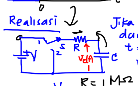
next: Isyarat eksponensial

* Isyarat eksponensial e^{-at}



$$x(t)\begin{cases} = 0, & t < 0 \\ = e^{-at}, & t \geq 0 \end{cases}$$

Realisasi

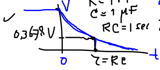


Jika saklar S dipindah dari posisi 1 ke 2 pada $t = 0$, maka tegangan $v_c(t) = Ve^{-at}, t \geq 0$

$R = 1\,M\Omega$
$C = 1\,\mu F$
$RC = 1$ sec

$a = \frac{1}{RC}$
$\frac{1}{a} = RC$

$RC = \tau$ (tau)
konstanta waktu "time constant"



$t = \tau = \frac{1}{a}$, $v_c(t) = Ve^{-1}$
$= 0{,}3678$ V