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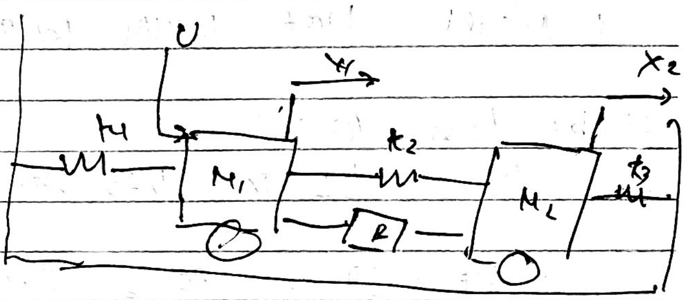
NIM = 08171173 3002
Prodi : Teknik Biomedis

1.) Plant : Induction Motor
Sensor = Speed sensor Scope
Eror detektor = PID Controller
Kontroler = PWM Generator
Aktuator = IGBT inverter

2.) a.) Pada Persamaan x_1



$k_1 U - k_1 x_1 + k_2 x_1 - B \frac{dx_2}{dt} + B \frac{dx_1}{dt} = M\, a$

$-k_1(x_1 - U) + k_2 x_1 - B\left(\frac{dx_2}{dt} - \frac{dx_1}{dt}\right) = M_1 \cdot a \quad \ldots (1)$

Persamaan x_2

$\Sigma F = M_2 \cdot a$

$k_2 x_2 + k_2 x_1 - B\left(\frac{dx_3}{dt} - \frac{dx_2}{dt}\right) = M_2 \cdot a$

Salah dibelakangnya

Sambungan →.

d.) + Persm Kirchoff

$U = L\frac{di}{dt} + R_i + e_h \quad \ldots (1)$

+ Pers GGL

$e_h = k_b\, \omega(t) \quad \ldots 2$

+ Pers Newton Hk 2

$T = J\, \alpha(t) + b\, \omega(t)$

$= J\frac{d\,\omega(t)}{dt} + b\, \omega(t) \quad \ldots (3)$

+ Pers Torsi

$T = k_a \cdot i \quad \ldots (4)$

Subtitusi pers 1 → 2.

$U(t) = L\frac{di}{dt} + Ri + k_b\, \omega(t) \quad \ldots (5)$

Persm 3 → 4

$k_a \cdot i = J\frac{d\,\omega(t)}{dt} + b\, \omega(t) \quad \ldots (6)$

Rubah Menjadi laplace pers 5

$U(s) = LsI + RI + k_b\, \omega(s)$

$U(s) - k_b\, \omega(s) = I(Ls + R) \quad \ldots (7)$

Laplace pers 6

$k_a \cdot I(s) = Js\, \omega(s) + b\, \omega(s) \quad \ldots (8)$

Substitusi persamaan 5 → 6

$$ka \cdot \frac{U(s) - kb\,\omega(s)}{Ls + R} = Js\,\omega(s) + b\,\omega(s)$$

$$ka\,U(s) - ka\,kb\,\omega(s) = (Ls + R)(Js\,\omega(s) + b\,\omega(s))$$

$$ka\,U(s) = JLs^2\omega(s) + Lbs\,\omega(s) + JRs\,\omega(s) + Rb\,\omega(s) + ka\,kb\,\omega(s)$$

$$ka\,U(s) = \omega(s)\,[JLs^2 + (Lb + JR)s + (Rb + ka\,kb)]$$

$$\frac{\omega(s)}{U(s)} = \frac{ka}{[JLs^2 + (Lb + JR)s + (Rb + ka\,kb)}$$

4.) a.) Diketahui =

Nim = 081711733002 | V = x v/rpm = 8 v/rpm | v = y(t) = 2 v(t)

x = 0+8 = 8 | y = 0+2 = 2 | z = 2

Dit - Model Mat. dalam bentuk Fungsi $\frac{\Omega(s)}{V_i(s)}$ $\left(\frac{rad}{volt.det}\right)$

Jawab = $V_{o\,ss}$ = 10 volt

$$\omega_{ss} = \frac{10}{8}\ rpm = 1{,}25\ rpm$$

$$= 1{,}25 \times \frac{2\pi}{60} = \frac{7{,}85}{60} = 0{,}13\ rad$$

$$V_i(s) = \frac{2}{s}$$

$$V_{iss} = \lim_{s \to 0} s \cdot \frac{2}{s}$$

$$k = \frac{\omega_{ss}}{V_{iss}} = \frac{0{,}13}{2} = 0{,}065$$

Sehingga dapat diketahui $\tau = 2 = 2$

$$\frac{\Omega(s)}{V_i(s)} = \frac{0{,}065}{2s + 1}$$

b) diket $\zeta = 2$ $\quad \frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n(s) + \omega_n}$

$\omega_n = 8$ rad/s

Jawab =

$$\omega_d = \omega_n \sqrt{1 - (2)^2}$$

$$= 8\sqrt{3}\,i$$

$$6 = \zeta\,\omega_n$$

$$= 2 \cdot 8 = 16$$

Waktu naik

$$\beta = \tan^{-1}\left(\frac{\omega_d}{6}\right) = \tan^{-1}\left(\frac{8\sqrt{3}\,i}{16}\right) \simeq 40{,}89$$

$$t_r = \frac{\pi - \beta}{\omega_d} = \frac{3{,}14 - 40{,}89}{8\sqrt{3}\,i} = \text{---}\ s$$

Waktu Puncak

$$t_p = \frac{\pi}{\omega_d} = \frac{3,14}{8\sqrt{3}i} \approx 0,226 \text{ s}$$

Overshot Maksimi

$$M_p = e^{-(\zeta/\omega_d)\pi} = e^{-\left(\frac{1/2}{8\sqrt{3}}\right)3,14}$$

$$= 0,10266$$

$$M_p = 2,66\,\%$$

Waktu turun

kriteria 2% : $t_s = \frac{4}{6} = \frac{4}{16} = 0,125$ s

5% : $t_s = \frac{3}{6} = \frac{3}{16} = 0,187$ s

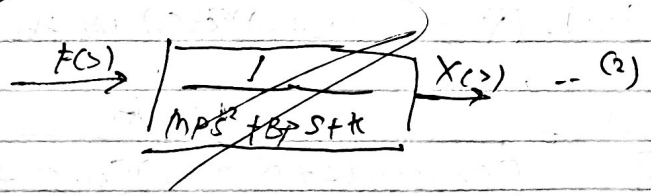
2. A) Gaya yg bekerja pada sistem

$$F - F_{pegas} - F_{damper} = M_p \frac{d^2x}{dt^2}$$

$$F = M_p \frac{d^2x}{dt^2} + B_p \frac{dx}{dt} + Kx$$

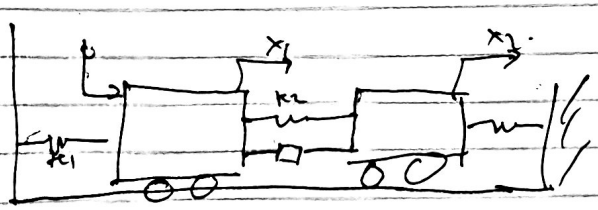
$$F(s) = (M_p s^2 + B_p s + K) X(s)$$

$$X(s) = \frac{F(s)}{M_p s^2 + B_p s + K}$$



$$F = K_p I(s) \quad \text{... (1)}$$

2A)



Tinjau

→ v ← F_b

F_{K1}

F_{K2}

$$F_{m1} = M_1 \frac{d^2x_1}{dt^2} \qquad F_{K1} = K_1 x_1$$

$$F_b = b \frac{d(x_1 - x_2)}{dt} \qquad F_{K2} = K_2 (x - x_2)$$

$U(t) = \sum F_{x1}$

$= M_1 \frac{d^2x_1}{dt^2} + b\frac{d(x_1-x_2)}{dt} + k_1 x_1 + k_2(x_1-x_2)$

Laplace

$U(s) = m_1 s^2 x_1(s) + k_1 x_1(s) + bs(x_1(s) - x_2(s)) + k_2(x_1(s) - x_2(s))$

$U(s) = x_1(s)(m_1 s^2 + k_1 + k_2 + bs) - x_2(s)(bs + k_2)$.

Tinjau M_2

$F_{m2} = m_2 \frac{d^2x_2}{dt^2}$ $\qquad F_{k3} = k_3 x_2$

$F_b = b \frac{d}{dt}(x_2 - x_1)$ $\qquad F_{k2} = k_2(x_2 - x_1)$

$\sum F_{x2} = 0$

$0 = m_2 \frac{d^2y}{dt^2} + b\frac{d}{dt}(x_2 - x_1) + k_3 x_2 + k_2(x_2 - x_1)$

Laplace =

$0 = m_2 s^2 x_2(s) + bs(x_2(s) - x_1(s)) + k_3 x_2(s) + k_2(x_2(s) - x_1(s))$

$x_1(s) = \left(\frac{m_2 s^2 + bs + k_3 + k_2}{bs + k_2}\right) x_2(s)$.

Substitusi hasil $m_2 \rightarrow m_1$

$U(s) = \left[\left(\frac{m_2 s^2 + bs + k_3 + k_2}{bs + k_2}\right) x_2(s)\right][m_1 s^2 + k_1 + k_2 + bs] - x_2(s)[bs + k_2]^2$

$(bs + k_2)(U(s)) = [(m_2 s^2 + bs + k_2 + k_3) x_2(s)][m_1 s^2 + k_1 + k_2 + bs] - x_2(s)[bs + k_2]^2$

Maka

$\frac{x_2(s)}{U(s)} = \frac{bs + k_2}{[(m_2 s^2 + bs + k_3 + k_2)(m_1 s^2 + k_1 + k_2 + b_1) - (bs + k_2)^2]}$