Pada keadaan tunak (steady state)

$\frac{di_a(t)}{dt} = 0 \qquad \frac{d\omega(t)}{dt} = 0$ semua konstan

(1) $0 = \frac{1}{L_a}(E_a - E_b - I_a R_a) \rightarrow E_b = E_a - I_a R_a$

(2) $0 = \frac{1}{J}(T - B\omega) \longrightarrow T = B\omega$

(3) $T = K_m I_a \longrightarrow B\omega = K_m I_a$

$K_m = \frac{B\omega}{I_a}, \quad I_a = \frac{B\omega}{K_m}$

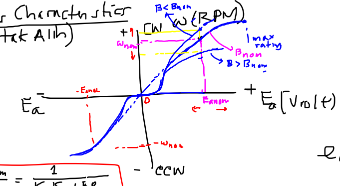
(4) $E_b = K_b \omega$

$K_b\omega = E_a - I_a R_a = E_a - \left[\frac{B\omega}{K_m}\right] R_a$

$(K_m K_b + BR_a)\omega = E_a$

Keadaan nominal ω_{nom} [rad/sec] $= K E_{anom}$ [Volt] $\rightarrow$ $\boxed{K = \frac{\omega_{nom}}{E_{anom}} = \frac{1}{K_m K_b + BR_a}}$

Transfer Characteristics
(Watak Alih)



* Model MATEMATIK

Hukum Ohm

$e_a(t) - e_b(t) = i_a(t) R + L\frac{di_a(t)}{dt}$

$sI_a(s) \leftarrow \frac{di_a(t)}{dt} = \frac{1}{L}\left[e_a(t) - e_b(t) - i_a(t) R\right]$ --- (1)

Hukum Newton $\quad$ ω omega, Ω . OMEGA

$T(t) = J\frac{d\omega(t)}{dt} + B\omega(t)$

$s\omega(s) \leftarrow \frac{d\omega(t)}{dt} = \frac{1}{J}\left[T(t) - B\omega(t)\right]$ ——— (2)

Sifat Motor

$T(t) = K_m i_a(t)$ ---------- (3)

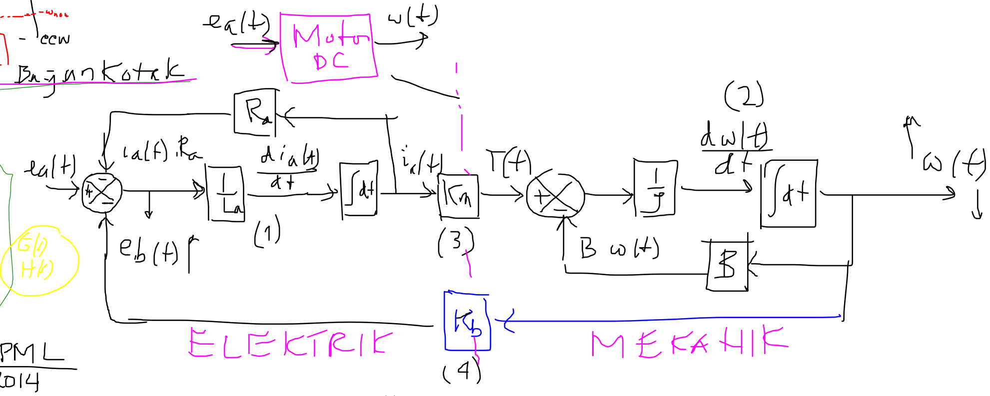
$K_m = \frac{T_{nom}}{I_{a\,nom}}$

Sifat Generator

$e_b(t) = K_b \omega(t)$ ---------- (4)

G(s)
H(s)

Bagan Kotak



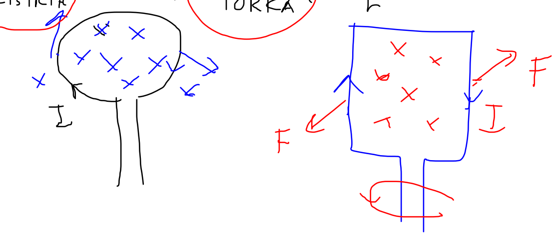
PPML
2014

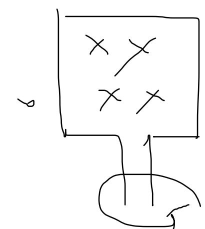
* Pemodelan Motor Dc Terkendali Jangkar
(Medan Magnet Tetap)

Tegangan → Motor Listrik → [RPM]

Energi Listrik $\qquad$ Energi Mekanik

ARUS LISTRIK → TORSI TORKA (torque)

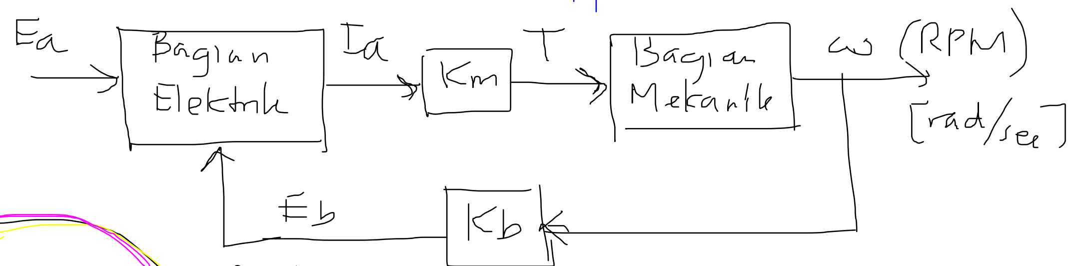




Tugas 1: Type/Merk
Data Sheet Motor.

* Kapasitas (HP, Watt)
* Nominal :

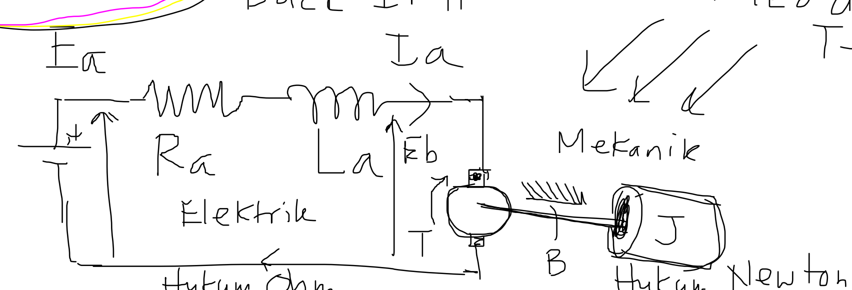
- Ea, Ia, ω, B, T
- Ra, La, J
- Km, Kb



GGL lawan
Back EMF

Model FISIK:

Medan Magnit Tetap

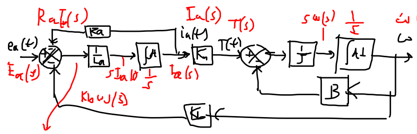


* Tugas 2 (dikumpul 02/10/2014)

Dengan analisis transien menggunakan Tabel Laplace, tentukan SOLUSI ANALITIK dari

* $\omega(t) = \mathcal{L}^{-1}\,\omega(s) = \mathcal{L}^{-1}\,G(s)\,E_a(s)$
* $i_a(t) = \mathcal{L}^{-1}\,I_a(s) = \mathcal{L}^{-1}\,H(s)\,E_a(s)$

$E_a(s) = \mathcal{L}\,e_a(t) = \mathcal{L}\,E_{anom}\,u(t) = \dfrac{E_{anom}}{s}$



$L_a s\,I_a(s) = E_a(s) - R_a I_a(s) - K_b\,\omega(s)$

$(L_a s + R_a)\,I_a(s) = E_a(s) - K_b\,\omega(s)$

$I_a(s) = \dfrac{E_a(s) - K_b\,\omega(s)}{L_a s + R_a}$

$T(s) = K_m I_a(s) = \dfrac{K_m\left(E_a(s) - K_b\,\omega(s)\right)}{L_a s + R_a}$

$J s\,\omega(s) = T(s) - B\,\omega(s)$

$T(s) = (Js + B)\,\omega(s)$

$(Js+B)\,\omega(s) = \dfrac{K_m E_a(s) - K_m K_b\,\omega(s)}{L_a s + R_a}$

$(L_a s + R_a)(Js + B)\,\omega(s) = K_m E_a(s) - K_m K_b\,\omega A$

$\left[(L_a s + R_a)(Js+B) + K_m K_b\right]\omega(s) = K_m E_a(s)$

$G(s) = \dfrac{\omega(s)}{E_a(s)} = \dfrac{K_m}{L_a J s^2 + (J R_a + B L_a)s + (B R_a + K_m K_b)}$

$= \dfrac{K_m / L_a J}{s^2 + \frac{J R_a + B L_a}{L_a J} s + \frac{B R_a + K_m K_b}{L_a J}}$

$\approx \dfrac{K_o}{s^2 + 2\xi\omega_n s + \omega_n^2}$

$K_o = K_m / L_a J \qquad \omega_n^2 = \dfrac{B R_a + K_m K_b}{L_a J}$

$2\xi\omega_n = \dfrac{J R_a + B L_a}{L_a J}$

ξ : "zeta"

"x" Arial

↓

ξ symbol

$T(s) = K_m I_a(s) = (Js + B)\,\omega(s)$

$I_a(s) = \dfrac{Js + B}{K_m}\,\omega(s)$

$= \dfrac{Js + B}{K_m}\,G(s)\,.\,E_a(s)$

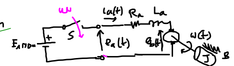
$H(s) = \dfrac{I_a(s)}{E_a(s)} = \dfrac{Js + B}{K_m}\,.\,G(s)$

$= \dfrac{Js + B}{L_a J s^2 + (J R_a + B L_a)s + (B R_a + K_m K_b)}$

$I_a(s) = H(s)\,.\,E_a(s)$

* Analisis Transien

Saklar S ditutup pada $t = 0$



$e_a(t) = E_{anom}\,u(t)$

$u(t)\begin{cases} = 0, & t < 0 \\ = 1, & t \geq 0 \end{cases}$ unit step function (isyarat undak satuan)

Model Nisbah Alih
(Transfer Function)

$e_a(t) \rightarrow \boxed{g(t)} \rightarrow \omega(t) \qquad e_a(t) \rightarrow \boxed{h(t)} \rightarrow i_a(t)$

↓ Transformasi LAPLACE ↓

$E_a(s) \rightarrow \boxed{G(s)} \rightarrow \omega(s) \qquad E_a(s) \rightarrow \boxed{H(s)} \rightarrow I_a(s)$

$E_a(s) = \mathcal{L}\,e_a(t)$

$= \mathcal{L}\,E_{anom}\,u(t)$

$= E_{anom}\,\mathcal{L}\,u(t)$

$= \dfrac{E_{anom}}{s}$

$\omega(s) = G(s)\,E_a(s) \qquad I_a(s) = H(s)\,.\,E_a(s)$

$\omega(t) = \mathcal{L}^{-1}\,\omega(s) \qquad i_a(t) = \mathcal{L}^{-1}\,I_a(s)$

$\boxed{E_a(s) = \dfrac{E_{anom}}{s}}$

$E_a(s) = \dfrac{E_{anom}}{s}$

$\omega(s) = G(s)\,.\,E_a(s) = \dfrac{K_o E_{anom}}{s(s^2 + 2\xi\omega_n s + \omega_n^2)}$

$\omega(t) = \mathcal{L}^{-1}\,\omega(s)$:

$\xi > 1 \longrightarrow \omega(s) = \dfrac{K_o E_{anom}}{s(s+a)(s+b)} \rightarrow$

$\xi = 1 \longrightarrow \omega(s) = \dfrac{K_o E_{anom}}{s(s+a)^2} \rightarrow$

$0 < \xi < 1 \longrightarrow \omega(s) = \dfrac{K_o E_{anom}}{s(s^2 + 2\xi\omega_n s + \omega_n^2)} \rightarrow$

$I_a(s) = \dfrac{(Js + B)\,E_{anom}}{s\left[L_a J s^2 + (J R_a + B L_a)s + (B R_a + K_m K_b)\right]}$

$i_a(t) = \mathcal{L}^{-1}\,I_a(s) = \mathcal{L}^{-1}\,\dfrac{K_1}{s^2 + 2\xi\omega_n s + \omega_n^2} + \mathcal{L}^{-1}\,\dfrac{K_2}{s(s^2 + 2\xi\omega_n s + \omega_n^2)}$

Verifikasi :

* $t = 0 \longrightarrow \omega(0) = 0 \leftarrow$

$i_a(0) = 0 \leftarrow$

* $t \to \infty \longrightarrow \omega(\infty) = \omega_{nom}\,[\text{rad/sec}]$

$i_a(\infty) = I_{a\,nom}\,[\text{Amp}]$