ECE 330 Final Exam Equation Sheet

$\sin(x) = \cos(x - 90°)$ $\quad\bar{V} = \bar{Z} \cdot \bar{I}$ $\quad\bar{S} = \bar{V} \cdot \bar{I}^*$ $\quad\bar{S}_{3\phi} = \sqrt{3} V_L I_L \angle\theta$ $\quad$ 1 hp = 746 W

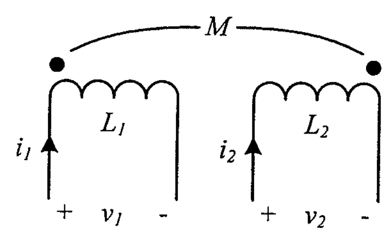
$0° < \theta < 90°\ (lag)$
$-90° < \theta < 0°\ (lead)$

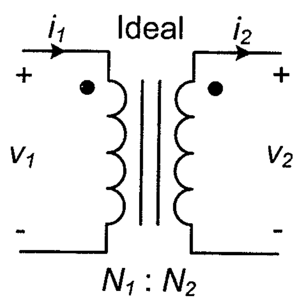
$\bar{I}_L = \sqrt{3} I_\phi \angle(\theta_i - 30°)$
$\bar{V}_L = \sqrt{3} V_\phi \angle(\theta_v + 30°)$

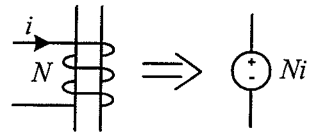
$\bar{Z}_Y = \bar{Z}_\Delta / 3$ $\quad\mu_0 = 4\pi \cdot 10^{-7}\ Vs/Am$

$\oint_c \vec{H} \cdot d\vec{l} = \int_s \vec{J} \cdot \vec{n}\, ds$ $\quad\oint_c \vec{E} \cdot d\vec{l} = -\int_s \frac{d}{dt}\vec{B} \cdot \vec{n}\, ds$ $\quad\mathcal{R} = \frac{l}{\mu A}$ $\quad mmf = Ni = \mathcal{R}\phi$

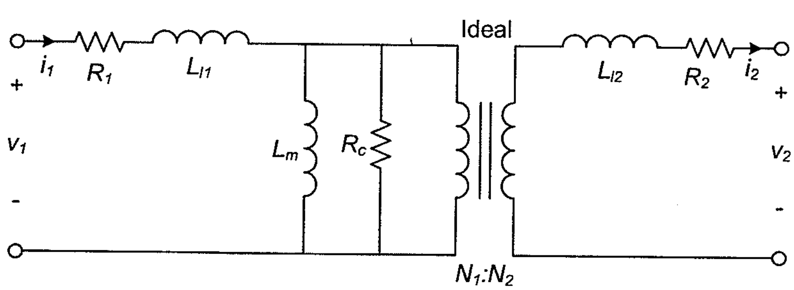
$B = \mu H$ $\quad\phi = BA$ $\quad\lambda = N\phi$ $\quad L = \frac{\partial\lambda}{\partial i}$ $\quad M_{12} = \frac{\partial\lambda_1}{\partial i_2}$ $\quad k = \frac{M}{\sqrt{L_1 L_2}}$







$v_1 = L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$ $\quad\frac{V_1}{V_2} = \frac{N_1}{N_2}$ $\quad\frac{I_1}{I_2} = \frac{N_2}{N_1}$ $\quad V_1 I_1 = V_2 I_2$



$vr = \frac{v_{2-noLoad} - v_{2-load}}{v_{2-load}}$

$W_m = \int_0^\lambda i\, d\hat{\lambda}$ $\quad W_m' = \int_0^i \lambda\, d\hat{i}$ $\quad W_m + W_m' = \lambda i$ $\quad f^e = \frac{\partial W_m'}{\partial x} = -\frac{\partial W_m}{\partial x}$ $\quad i = \frac{\partial W_m}{\partial \lambda}$

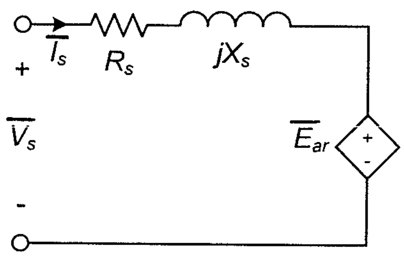
$\underset{a\to b}{EFE} = \int_a^b i\, d\lambda$ $\quad\underset{a\to b}{EFM} = -\int_a^b f^e\, dx$ $\quad\underset{a\to b}{EFE} + \underset{a\to b}{EFM} = W_{m,b} - W_{m,a}$ $\quad\lambda = \frac{\partial W_m'}{\partial i}$

$M\frac{dv}{dt} = \sum forces\ in + x\ direction$ $\qquad \underline{\dot{x}} = \underline{f}(\underline{x}, \underline{u})$ $\qquad$ Equilibrium: $\underline{f}(\underline{x}_{eq}, \underline{u}_{eq}) = 0$

$\underline{x}(t_{n+1}) = \underline{x}(t_n) + \Delta t \cdot \underline{f}\left(\underline{x}(t_n), \underline{u}(t_n)\right)$

Linearization:
$$\Delta\dot{x}_1 = \frac{\partial f_1}{\partial x_1}\Delta x_1 + \frac{\partial f_1}{\partial x_2}\Delta x_2 + \cdots + \frac{\partial f_1}{\partial u}\Delta u$$
$$\Delta\dot{x}_2 = \frac{\partial f_2}{\partial x_1}\Delta x_1 + \frac{\partial f_2}{\partial x_2}\Delta x_2 + \cdots + \frac{\partial f_2}{\partial u}\Delta u$$

Stability: $A = \begin{bmatrix} \frac{\partial f_1}{\partial x_1} & \frac{\partial f_1}{\partial x_2} \\ \frac{\partial f_2}{\partial x_1} & \frac{\partial f_2}{\partial x_2} \end{bmatrix}$ $\qquad |\lambda I - A| = 0$ $\qquad$ stable if $\text{Re}\{\lambda\}<0$

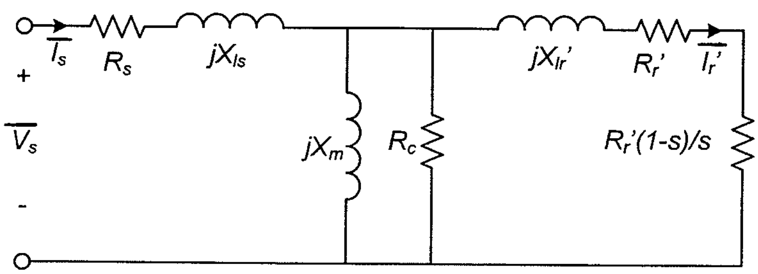


$N_s = \frac{120 f_s}{P}$

$\overline{E_{ar}} = \frac{\omega_s M I_r}{\sqrt{2}} \angle\delta$ $\qquad \delta < 0 \rightarrow$ motor

For $R_s = 0$: $P_T = \frac{3V_s|\overline{E_{ar}}|}{X_s}\sin(-\delta)$ $\qquad Q_T = \frac{3V_s^2}{X_s} - \frac{3V_s|\overline{E_{ar}}|}{X_s}\cos(\delta)$

$T^e = \frac{P_m}{\omega_m}$ $\qquad \omega_m = \frac{2}{P}\omega_s$ $\qquad$ (for synchronous machine, $P_m = P_T$ in formulas above)



$s = \frac{\omega_s - \frac{P}{2}\omega_m}{\omega_s}$

$f_r = s f_s$

$P_{AG} = 3\left|\overline{I_r}'\right|^2 \frac{R_r'}{s}$ $\qquad P_m = (1-s)P_{AG}$ $\qquad T^e = \frac{P}{2\omega_s}\frac{3\left|\overline{V_{TH}}\right|^2 R_r' s}{\left[(sR_{TH} + R_r')^2 + s^2(X_{TH} + X_{lr}')^2\right]}$

$s_{max,T} = \frac{R_r'}{\sqrt{R_{TH}^2 + (X_{TH} + X_{lr}')^2}}$ $\qquad T_{max}^e = \frac{P}{4\omega_s}\frac{3\left|\overline{V_{TH}}\right|^2}{(X_{TH} + X_{lr}')}\left(\text{at } R_{TH} = 0\right)$