EE301 FALL 2011 EQUATION SHEET

Voltage, Current, Resistance

$V = \frac{W}{Q}$ $\left(V = \frac{J}{C}\right)$ $R = \frac{\rho \ell}{A}$

$I = \frac{Q}{t}$ $\left(A = \frac{C}{sec}\right)$

$Q = 1.602x10^{-19}\ C/e^{-}$

battery life = $\frac{\text{capacity (Amp•hr)}}{\text{discharge rate (A)}}$

Ohm's Law and Power

V = IR [V] $\rightarrow$ I = $\frac{V}{R}$ [A]

$P = IV = I^2R = \frac{V^2}{R}$ [W]

$\eta = \frac{P_{out}}{P_{in}} \times 100\%$

1 Hp = 746 W

KVL & KCL

KVL (Closed Loop)

$\sum V = 0$ or $\sum E_{RISE} = \sum V_{DROP}$

KCL (In and Out of a Node)

$\sum I = 0$ or $\sum I_{IN} = \sum I_{OUT}$

VDR & CDR

VDR: series resistors

$V_x = E\left(\frac{R_X}{R_T}\right)$

CDR: parallel resistors

$I_x = I_T\left(\frac{R_{EQ}}{R_X}\right)$

CDR: two parallel resistors

$I_1 = I_T\left(\frac{R_2}{R_1 + R_2}\right)$

Series and Parallel Resistances

$R_T = R_1 + R_2 + \ldots R_n$ (series)

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_n}$ (parallel)

$R_T = \frac{R_1 R_2}{R_1 + R_2}$ (2 parallel)

Capacitors

$i_C = C\frac{dv_C}{dt}$

$v_C(t) = E(1 - e^{-t/\tau})$ charging

$v_C(t) = Ee^{-t/\tau}$ discharging

$\tau = R\,C$ time constant

$W = \frac{1}{2}Cv^2$ (J)

Inductors

$v_L = L\frac{di}{dt}$

$i_L(t) = I_0(1 - e^{-t/\tau})$ charging

$i_L(t) = I_0 e^{\frac{-t}{\tau}}$ discharging

$\tau = \frac{L}{R}$

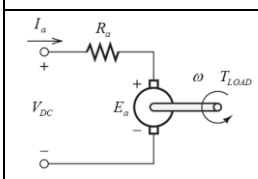
$W = \frac{1}{2}Li^2$ (J)

Max Power Transfer

$P_{MAX} = \frac{V_{TH}^2}{4R_{TH}}$

$Z_{LD} = Z_{TH}^*$

DC Motors



$V_{DC} - I_a R_a - E_a = 0$

$\omega = 2\pi\left(\frac{RPM}{60}\right)$ (rad/sec)

$T_d = K_v I_a$ (N·m)

$E_a = K_v \omega$

$1\ W = 1\ N \cdot m/sec$

$P_{in} = P_{\substack{elec\\loss}} + P_{\substack{mech\\loss}} + P_{out}$

Electrical

Mechanical

$P_{in} = V_{DC} I_a$

$P_d = E_a I_a = T_d \omega = K_v I_a \omega$

$P_{out} = T_{LOAD}\omega = 746 * hp$

$P_{\substack{elec\\loss}} = I_a^2 R_a$ Electrical Loss (W)

$P_{\substack{mech\\loss}} = T_{loss}\omega$ Mechanical Loss (W)

$P_d = P_{in} - P_{\substack{elec\\loss}} = P_{out} + P_{\substack{mech\\loss}}$

Linear Motors

$\vec{F}_d = I\vec{L}x\vec{B}$ (N)

$E_{induced} = (\vec{u} \text{ x } \vec{B})L$

$I = \frac{V_B - E_{induced}}{R}$

$u = \frac{V_B - IR_{rail}}{BL}$ $\left(\frac{m}{sec}\right)$

$P_{out} = F_{load}u = E_{ind}I$

$P_{IN} = V_B I$

$1\ T = \frac{V \cdot sec}{m^2} = \frac{N}{A \cdot m}$

AC Real and Reactive Power

$\vec{Z} = R + Xj$ $\vec{S} = \vec{V}\vec{I}^*$

$\vec{S} = P + Qj = \vec{E}(\vec{I}_T)^* = \frac{E^2}{(\vec{Z}_T)^*} = I^2\vec{Z}_T$

$S = VI$ (VA) $S^2 = P^2 + Q^2$

$P = \frac{V^2}{R} = I^2R = VI\cos\theta$ (W)

$Q = \frac{V^2}{X} = I^2X = VI\sin\theta$ (VAR)

$F_p = \cos(\theta) = P/S$

Sinusoidal Eqns

$e(t) = E_m \sin(\omega t + \theta)$

$e(t) = E_m \sin(2\pi ft + \theta)$

$e(t) = E_m \sin(2\pi \frac{t}{T} + \theta)$

$\omega = 2\pi f$ $f = 1/T$

$\Delta\theta = \frac{\Delta t}{T}(360^\circ)$

$E_{RMS} = 0.707 * E_{PK}$

$E_{PK} = 1.41 * E_{RMS}$

AC Impedance

$\vec{Z} = R + Xj$

$\vec{Z}_R = R + 0j = R\angle 0°$

$\vec{Z}_L = jX_L = X_L\angle 90°$

$\vec{Z}_C = -jX_C = X_C\angle -90°$

$X_L = \omega L = 2\pi fL$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}$

Transformers

$a = \frac{N_p}{N_s} = \frac{\vec{E}_{pri}}{\vec{E}_{sec}} = \frac{\vec{I}_{sec}}{\vec{I}_{pri}}$

$\vec{E}_{sec} = \frac{1}{a}\vec{E}_{pri}$

$\vec{I}_{sec} = a\vec{I}_{pri}$

$\vec{Z}_{pri\cdot reflected} = a^2\vec{Z}_{sec}$

3 Phase AC Power

$Q_T = \sqrt{3}V_L I_L \sin\theta_\phi = 3Q_\phi$ (VAR)

$P_T = \sqrt{3}V_L I_L \cos\theta_\phi = 3P_\phi$ (W)

$S_T = \sqrt{3}V_L I_L = 3S_\phi$ (VA)

Y Generator or Y LOAD

$\vec{V}_{ab} = \sqrt{3}\angle 30^\circ \vec{V}_{an}$

Δ LOAD

$\vec{I}_a = \sqrt{3}\angle -30^\circ \vec{I}_{ab}$

$\Delta \rightarrow Y$

$\vec{Z}_Y = \frac{\vec{Z}_\Delta}{3}$

AC Generator

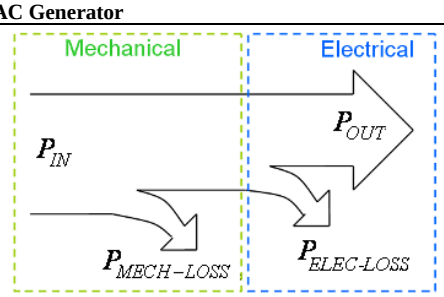
$\omega_{rotor} = \left(\frac{2}{Poles}\right)2\pi f$ (rad/sec)

$N_P = \frac{120f}{Poles}$ (RPM)

$P_{IN} = T_{IN}\omega_{rotor} = 746 * hp$

$P_{ELEC-LOSS} = 3I_L^2 R_{armature}$

$P_{OUT} = \sqrt{3}I_L V_L \cos\theta$



$P_{IN} = P_{OUT} + P_{MECH-LOSS} + P_{ELEC-LOSS}$