EE301 FALL 2009 EQUATION SHEET

Voltage, Current, Resistance

$V = \frac{W}{Q} \quad \left(V = \frac{J}{C}\right)$

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

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

$R = \frac{\rho l}{A}(\Omega)$

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

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

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

Capacitors

$C = \frac{Q}{V} = \epsilon_r \epsilon_0 \frac{A}{d}$ (F)

$\epsilon_0 = 8.854x10^{-12}$ F/m

$i_C = \frac{dq}{dt} = C\frac{dv_C}{dt} = C\frac{\Delta v_C}{\Delta t}$

$v = v(t_0) + \frac{1}{C}\int_{t_0}^{t} i\,dt = v_0 + \frac{1}{C} i\Delta t$

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

Dielectric breakdown:

$V = Kd$ (kV/mm)

Inductors

$v = N\frac{d\phi}{dt}$

$v = L\frac{di}{dt} = L\frac{\Delta i}{\Delta t}$

$i_L = i(t_0) + \frac{1}{L}\int_{t_0}^{t} v\,dt = i_0 + \frac{1}{L}v\Delta t$

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

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)

Max Power Transfer

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

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

DC Motors

$P_{in} = P_{out} + P_a + P_{loss}$

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

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

$P_a = I^2 R_a$ — Electrical Loss (W)

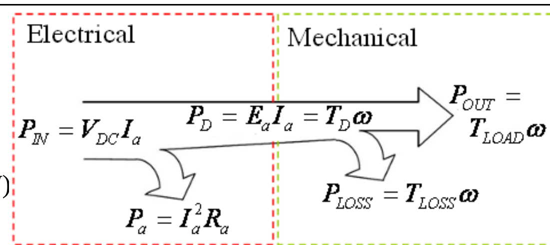
$P_{loss} = T_{loss}\omega$ — Mechanical Loss (W)

$P_d = P_{in} - P_a = P_{out} + P_{loss}$

$P_d = E_a I_a = T_d\ \omega = K_v I_a \omega$ — Power Developed (W)

$T_d = K_v I_a$ — Torque Developed (N·m)

$\omega = 2\pi(\text{RPM}/60)$ — AngularVelocity(rad/sec)



$E_a = K_v\omega$

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

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

Linear Motors

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

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

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

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

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

$P_{IN} = V_B I$

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

AC Real and Reactive Power

$Z = R + Xj$

$S = VI$ (VA)

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

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

$S^2 = P^2 + Q^2$

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

Sinusoidal Eqns

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

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

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

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

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

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

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

AC Impedance

$\mathbf{Z}_R = R + 0j = R\angle 0^\circ$

$\mathbf{Z}_L = jX_L = X_L\angle 90^\circ$

$\mathbf{Z}_C = -jX_C = X_C\angle -90^\circ$

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

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

Transformers

$a = \frac{N_p}{N_s} = \frac{e_{pri}}{e_{s\sec}} = \frac{i_{\sec}}{i_{pri}}$

$E_{\sec} = \frac{1}{a}E_{pri}$

$I_{\sec} = aI_{pri}$

$\mathbf{Z}_{P\text{-}reflected} = a^2\mathbf{Z}_{LD}$

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

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

Δ LOAD

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

AC Generator

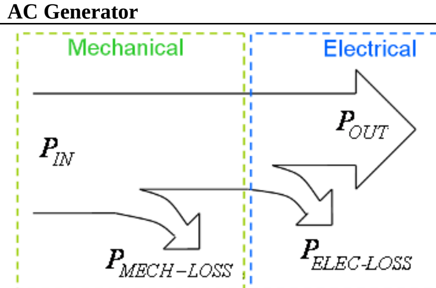
$\omega_{rotor} = \left(\frac{2}{Poles}\right)2\pi f$ (rad/sec)

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

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

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

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



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