EE 320 Final Exam
Equation Sheet

Fall 2011

For a 'wye' system: $V_L = \left(\sqrt{3}\angle 30°\right)V_\emptyset$

For a 'delta' system: $I_L = \left(\sqrt{3}\angle -30°\right)I_\emptyset$

$Z_\Delta = 3Z_Y$

For a three-phase system: $S_T = \sqrt{3}V_L I_L$

For power factor correction: $C = \frac{Q}{\omega V^2}$

For Magnetic Circuits:

$\emptyset = BA$ $\quad B = \mu_o \mu_r H$ $\quad \mu_o = \frac{4\pi x 10^{-7} H}{m}$ $\quad mmf = NI = \emptyset\Re$

$L = \frac{N^2}{\Re}$ $\quad \Re = \frac{l_{path}}{\mu_o \mu_r A_{path}}$

For Synchronous Machines:

$E_a = \frac{L_{SF} I_F \omega_e}{\sqrt{2}}\angle\delta$ $\quad P_{total} = \frac{3V_s E_a}{X_s}\sin(\delta)$ $\quad T_{dev} = \frac{P_{total}}{\omega_m}$

Buck Chopper Relationships

$$D = \frac{T_{S1}}{T_{sw}} \approx \frac{V_{out,ave}}{V_{IN}} \qquad I_{L,ave} = I_{R,ave} = \frac{V_{out,ave}}{R_{Load}} = \frac{P_{out}}{V_{out,ave}} \qquad I_{C,ave} = 0$$

$$\Delta I_L = \frac{(1-D)V_{out,ave}}{Lf_{sw}} = \left.\frac{2V_{out,ave}}{R_{big}}\right|_{L=L_{crit}} \qquad I_{L,\max} = I_{L,ave} + \frac{\Delta I_L}{2} \qquad I_{L,\min} = I_{L,ave} - \frac{\Delta I_L}{2}$$

$$P_{crit} = \frac{V_{out,ave}^2}{R_{big}} \qquad L_{crit} = \frac{(1-D)R_{big}}{2f_{sw}}$$

$$C_{\min} = \frac{\Delta I_L}{8f_{sw}\Delta V_{Cpp}} = \left.\frac{1}{4R_{big}f_{sw}\dfrac{\Delta V_{Cpp}}{V_{out,ave}}}\right|_{L=L_{crit}} \qquad I_{C,rms} = \frac{\Delta I_L}{\sqrt{12}} \qquad P_{C,esr} = I_{C,rms}^2 R_{esr}$$

$$R_{esr} \approx \frac{DF}{2\pi f_{sw}C} \qquad f_{c,res} = \frac{1}{2\pi\sqrt{L_{es}L C}} \qquad R_{esr,\max} = \frac{\Delta V_{Cpp}}{\Delta I_L} \qquad C_{\min,esr} = \frac{DF}{2\pi f_{sw}R_{esr,\max}}$$

Buck Chopper FET Turn-On, Turn-Off, and Conduction Losses

$$T_{SW,on} \approx (R_{DR} + R_{Gext})\left[\frac{Q_{GS2}}{V_{DR} - \left(\dfrac{V_{GS,TH} + V_{Miller}}{2}\right)} + \frac{Q_{GD}}{V_{DR} - V_{Miller}}\right]$$

$$T_{SW,off} \approx (R_{DR} + R_{Gext})\left[\frac{Q_{GS2}}{\left(\dfrac{V_{GS,TH} + V_{Miller}}{2}\right)} + \frac{Q_{GD}}{V_{Miller}}\right]$$

$$P_{FET,sw} = \frac{1}{2}V_{IN}f_{sw}\left(T_{SW,on}I_{L,\min} + T_{SW,off}I_{L,\max}\right) + \frac{2}{3}V_{IN}Q_{rr}f_{sw}$$

$$P_{FET,cond} = DI_{L,rms}^2 R_{DS,on}$$

Buck Chopper Main Diode Conduction, Switching, and Blocking Losses

$$P_{dio,cond} = (1-D)V_F I_{L,ave} \qquad P_{dio,sw} = \frac{1}{3}V_{IN}Q_{rr}f_{sw} \qquad P_{dio,rev} = DV_{IN}I_{rev}$$

Gate Drivers: $R_{Gext} \approx \dfrac{V_{DR}}{I_{o+}}$

Thermal Management: $T_J = \left(R_{\theta,JC} + R_{\theta,CS} + R_{\theta,SA}\right)P_{diss} + T_A$

Rules of Thumb: $\frac{1}{10}P_{\max} \le P_{crit} \le \frac{1}{3}P_{\max}$ $\qquad V_{rated} \approx 1.7V_{Block,\max}$ $\qquad V_{GS} > 2V_{GS,TH}$