Cheat Sheet for EE464

$$FormFactor = \frac{V_{rms}}{V_{avg}} CrestFactor = \frac{V_{peak}}{V_{rms}}$$

$$DistortionFactor = \frac{I_{1rms}}{I_{rms}}$$

ϕ : *phase difference between fundamentals of current and voltage*

$$DisplacementPowerFactor = \cos(\phi)$$

$$TruePowerFactor = \frac{P}{S} = DPF\frac{I_{1,RMS}}{I_{RMS}}$$

$$THD = \sqrt{(\frac{I_{rms}}{I_{1rms}})^2 - 1}$$

Voltages on inductors during on-off times(for ease of waveform drawing) Buck:(Vd-Vo):-Vo;Boost:Vd:-(Vo-Vd); BuckBoost:Vd:-Vo

Converters

$$\boxed{V_o = V_s\left(\frac{D}{1-D}\right)\left(\frac{N_2}{N_1}\right)} \quad \boxed{\frac{\Delta V_o}{V_o} = \frac{D}{RCf}} \quad \boxed{(L_m)_{\min} = \frac{(1-D)^2R}{2f}\left(\frac{N_1}{N_2}\right)^2}$$

$$L_m = \frac{V_sDT}{\Delta i_{L_m}} = \frac{V_sD}{\Delta i_{L_m}f}$$

$$I_{L_{m,\max}} = I_{L_m} + \frac{\Delta i_{L_m}}{2} = \frac{V_sD}{(1-D)^2R}\left(\frac{N_2}{N_1}\right)^2 + \frac{V_sDT}{2L_m}$$

$$I_s = \frac{(I_{L_m})DT}{T} = I_{L_m}D$$

$$I_{L_{m,\min}} = I_{L_m} - \frac{\Delta i_{L_m}}{2} = \frac{V_sD}{(1-D)^2R}\left(\frac{N_2}{N_1}\right)^2 - \frac{V_sDT}{2L_m}$$

equate this to zero for dcm boundary

$$\Delta V_{o,\mathrm{ESR}} = \Delta i_C r_C = I_{L_{m,\max}}\left(\frac{N_1}{N_2}\right)r_C$$

$$\boxed{(\Delta i_{L_m})_{\text{closed}} = \frac{V_sDT}{L_m} \qquad (\Delta i_{L_m})_{\text{open}} = \frac{-V_o(1-D)T}{L_m}\left(\frac{N_1}{N_2}\right)}$$

$$\boxed{i_C = i_D - i_R = i_{L_m}\left(\frac{N_1}{N_2}\right) - \frac{V_o}{R}}$$

Figure 1: Flyback Formulas

$$\boxed{V_o = V_sD\left(\frac{N_2}{N_1}\right)} \quad \boxed{\frac{\Delta V_o}{V_o} = \frac{1-D}{8L_xCf^2}} \quad D\left(1+\frac{N_3}{N_1}\right) < 1$$

$$\Delta V_{o,\mathrm{ESR}} = \Delta i_C r_C = \Delta i_{L_x} r_C = \left[\frac{V_o(1-D)}{L_xf}\right]r_C$$

$$\Delta i_{L_m} = \frac{V_sDT}{L_m} \quad I_{L_x} = \frac{V_o}{R}; \quad \Delta i_{L_x} = \frac{V_o(1-D)}{L_xf}$$

Figure 2: Forward (single switched) Converter Formulas

$$\boxed{V_o = 2V_s\left(\frac{N_S}{N_P}\right)D} \quad \boxed{\frac{\Delta V_o}{V_o} = \frac{1-2D}{32L_xCf^2}} \quad I_{L_x} = \frac{V_o}{R}$$

$$\Delta V_{o,ESR} = \Delta i_{L_x} r_C = \left[\frac{V_o(\frac{1}{2}-D)}{L_xf}\right]r_C$$

Figure 3: Push Pull Formulas

$$\boxed{V_o = V_s\left(\frac{D}{1-D}\right)} \quad \Delta V_{C_1} = \frac{I_oDT}{C} = \frac{V_oD}{RC_1f}$$

$$\Delta i_{L_1} = \frac{V_sDT}{L_1} = \frac{V_sD}{L_1f} \quad \boxed{\Delta V_o = \Delta V_{C_2} = \frac{V_oD}{RC_2f}}$$

$$\Delta i_{L_2} = \frac{V_sDT}{L_2} = \frac{V_sD}{L_2f} \quad \boxed{C_1 = \frac{D}{R(\Delta V_{C_1}/V_o)f}}$$

$$I_{L_1} = I_s = \frac{V_oI_o}{V_s} = \frac{V_o^2}{V_sR} \quad \boxed{C_2 = \frac{D}{R(\Delta V_o/V_o)f}}$$

$$I_{L_2} = I_o$$

Figure 4: Sepic Converter Formulas

$$SwitchUtilization = \frac{Po}{Psw} = \frac{Io.Vo}{q.Vswmax.Iswmax} \tag{1}$$

Inverters

$$m_f = \frac{f_s}{f_1}, m_a = \frac{V_{control}}{V_{triangle}}$$

$$m_a < 1 : linear, m_a > 1 : overmodulation$$

$$\boxed{V_o = -V_s\left(\frac{D}{1-D}\right)} \quad \boxed{\frac{\Delta V_o}{V_o} = \frac{1-D}{8L_2C_2f^2}}$$

$$\Delta v_{C_1} \approx \frac{1}{C_1}\int_{DT}^{T} I_{L_1}d(t) = \frac{I_{L_1}}{C_1}(1-D)T = \frac{V_s}{RC_1f}\left(\frac{D^2}{1-D}\right)$$

$$\boxed{\Delta v_{C_1} \approx \frac{V_oD}{RC_1f}}$$

$$\boxed{\Delta i_{L1} = \frac{V_sDT}{L_1} = \frac{V_sD}{L_1f}} \quad \boxed{\Delta i_{L_2} = \frac{V_sDT}{L_2} = \frac{V_sD}{L_2f}} \quad I_{L_2} = \left|\frac{P_o}{-V_o}\right|$$

$$\boxed{L_{1,\min} = \frac{(1-D)^2R}{2Df} \quad L_{2,\min} = \frac{(1-D)R}{2f}} \quad I_{L_1} = \frac{P_s}{V_s}$$

Figure 5: Cuk Converter Formulas

Switch Selection

Peak Switch Current

$$\hat{I}_{sw} = \frac{1}{(1-D)}\frac{N_2}{N_1}I_o + \frac{N_1}{N_2}\frac{(1-D)T_s}{2L_m}V_o$$

Peak Switch Voltage

$$\hat{V}_{sw} = V_d + \frac{N_1}{N_2}V_o = \frac{V_d}{(1-D)}$$

Figure 6: Flyback switch considerations

$$\boxed{V_o = 2V_s\left(\frac{N_S}{V_P}\right)D} \quad \boxed{V_o = V_s\left(\frac{N_S}{N_P}\right)D}$$

Full Bridge **Half Bridge**

Figure 7: Full and Half Bridge Relations

$$(V_o)_h = \frac{1}{\sqrt{2}} \cdot 2 \cdot \frac{V_d}{2}\frac{(\hat{V}_{Ao})_h}{V_d/2} = \frac{V_d}{\sqrt{2}}\frac{(\hat{V}_{Ao})_h}{V_d/2}$$

Figure 8: Rms Voltage of Harmonics Full Bridge Inverter

Cuk Converter

$$Vc1 = Vo + Vd \tag{2}$$

$$V_{rms} = \frac{2\pi}{\sqrt{2}}.N_2.f.B_{max}.A \tag{3}$$

Signal Analysis

Linearization with State-Space Averaging

$$A = dA_1 + (1-d)A_2$$

$$B = dB_1 + (1-d)B_2$$

$\dot{x} = Ax + Bv_d$ (for switch off, (1-d)Ts)

$$v_o = Cx$$

$$C = dC_1 + (1-d)C_2$$

$$\dot{\tilde{x}} = AX + BV_d + A\tilde{x} + [(A_1 - A_2)X + (B_1 - B_2)V_d]\tilde{d}$$

$$\frac{V_o}{V_d} = -CA^{-1}B$$

$$T_p(s) = \frac{\tilde{v}_o(s)}{\tilde{d}(s)} = C[sI - A]^{-1}[(A_1 - A_2)X + (B_1 - B_2)V_d] + (C_1 - C_2)X)]$$

$$I_o = I_{lm}(1-D) \quad I_s = I_{lm}(D) \quad AtSS : AX + BV_d = 0$$

For analysis, first derive generalstate space for on and off ccts, then decide which matrices are needed and which are 0. Cct analysis and derive matrices

Topology	V_{sw}	I_{sw}	$V_{01,max}$	q
Push Pull	$2V_{d,max}$	$\sqrt{2}\frac{I_{o,max}}{n}$	$\frac{4}{\pi\sqrt{2}}\frac{V_{d,max}}{n}$	2
Half B.	$V_{d,max}$	$\sqrt{2}I_{o,max}$	$\frac{4}{\pi\sqrt{2}}\frac{V_{d,max}}{2}$	2
Full B.	$V_{d,max}$	$\sqrt{2}I_{o,max}$	$\frac{4}{\pi\sqrt{2}}V_{d,max}$	4

Table 1: Swith Utilization doesnt change$(1/2\pi)$ for n:1 trans. ratio and in linear region scaled by $(m_a\pi)/4$