Cheat Sheet for EE464

$$\text{Form Factor}=\frac{V_{rms}}{V_{avg}} \qquad \text{Crest Factor}=\frac{V_{peak}}{V_{rms}}$$

$$\text{Distortion Factor}=\frac{I_{1rms}}{I_{rms}}$$

ϕ : phase difference between fundamentals of current and voltage

$$\text{Displacement Power Factor}=\cos(\phi)$$

$$\text{True Power Factor}=\frac{P}{S}=\text{DPF}\frac{I_{1,RMS}}{I_{RMS}}$$

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

Magnetic Circuits

$$\text{Flux Linkage}=\lambda=N\phi \qquad B=\frac{\Phi}{A} \qquad NBA=\Phi N=\lambda$$

$$\mathcal{F}=\Phi\mathcal{R}=NI \qquad L=\frac{N\phi}{I}=N^2/\mathcal{R} \qquad \mathcal{R}=\frac{l}{\mu A}$$

$$B=\mu H \qquad L=\frac{\lambda}{I} \qquad E=\frac{1}{2}\frac{B^2}{\mu}=\frac{1}{2}LI^2$$

Converters

Flyback

$$\frac{V_o}{V_s}=\frac{D}{1-D}\frac{N_2}{N_1} \qquad \frac{\Delta V_o}{V_o}=\frac{D}{RCf} \qquad L_{m,min}=\frac{(1-D)^2R}{2f}(\frac{N_1}{N_2})^2$$

$$I_C=I_{L_M}\frac{N_1}{N_2}-\frac{V_o}{R} \qquad L_m=\frac{V_sDT}{\Delta i_{L_m}} \qquad \Delta V_o=\Delta i_C r_C=I_{L_{m,max}}\frac{N_1}{N_2}r_C$$

$$\hat{V}_{sw}=V_s+\frac{N_1}{N_2}V_o=\frac{V_s}{(1-D)} \qquad I_{L_m}=\frac{V_sD}{(1-D)^2R}\frac{N_2}{N_1}^2\pm\frac{V_sDT}{2L_m}$$

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

Forward

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

$$\Delta I_{L_M}=\frac{V_sDT}{Lm} \qquad L_x=\frac{V_o}{R} \qquad \Delta I_{L_x}=\frac{V_o(1-D)}{L_xf}$$

$$\Delta V_o=\Delta i_C r_C=\Delta i_{L_x}r_C=r_C\frac{V_o(1-D)}{L_xf}$$

Push-Pull

$$\frac{V_o}{V_s}=2\frac{N_2}{N_1}D \qquad \frac{\Delta V_o}{V_o}=\frac{1-2D}{32L_xCf^2} \qquad I_{L_x}=\frac{V_o}{R}$$

$$\Delta V_o=\Delta i_{L_x}r_C=r_C\frac{V_o(\frac{1}{2}-D)}{L_xf}$$

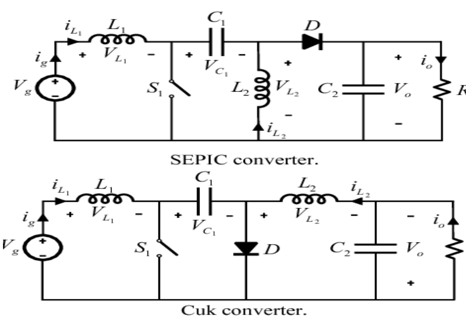

Figure 1: Sepic and Cuk Converter Schematics

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

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

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

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

$$I_{L_2}=I_o$$

Figure 2: Sepic Converter Formulas

Cuk Converter

$$Vc1=Vo+Vd \tag{1}$$

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

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

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

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

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

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

Figure 3: 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 4: Flyback switch considerations

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

Full Bridge **Half Bridge**

Figure 5: Full and Half Bridge Relations

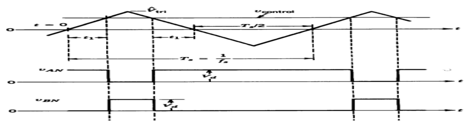

Figure 6: Bipolar Switching

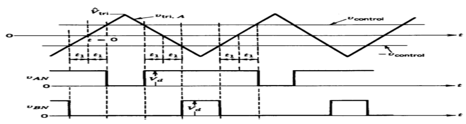

Figure 7: Unipolar switching

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)

$$v_o=Cx$$

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

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

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

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

Signal Analysis

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

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 $(m_a\pi)/4$