

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

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

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

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

Voltages on inductors during on-off times(for ease of waveform drawing) Buck:(Vd-Vo):-Vo;Boost:Vd:- (Vo-Vd); BuckBoost:Vd:-Vo Cuk,SEPIC,Flyback:Buck-Boost Topologies;Cuk in-out filter,SEPIC + polarity.Boost:CurrentConv.(Lto source,Dhigh).Rest from buck

Converters

$$\begin{aligned} V_o &= V_s \left(\frac{D}{1-D} \right) \left(\frac{N_2}{N_1} \right) & \frac{\Delta V_o}{V_o} &= \frac{D}{RCf} & (L_m)_{min} &= \frac{(1-D)^2 R}{2f} \left(\frac{N_1}{N_2} \right)^2 \\ I_{L_{m,max}} &= I_{L_m} + \frac{\Delta i_{L_m}}{2} & L_m &= \frac{V_s DT}{\Delta i_{L_m}} = \frac{V_s D}{\Delta i_{L_m} f} & I_s &= \frac{(L_m)DT}{T} = I_{L_m} D \\ &= \frac{V_s D}{(1-D)^2 R} \left(\frac{N_2}{N_1} \right)^2 + \frac{V_s DT}{2L_m} & & & & \\ I_{L_{m,min}} &= I_{L_m} - \frac{\Delta i_{L_m}}{2} & & & & \\ &= \frac{V_s D}{(1-D)^2 R} \left(\frac{N_2}{N_1} \right)^2 - \frac{V_s DT}{2L_m} & & & & \\ \Delta V_{o,ESR} &= \Delta i_C r_C = I_{L_{m,max}} \left(\frac{N_1}{N_2} \right) r_C & & & & \end{aligned}$$

Figure 1: Flyback Formulas

$$\begin{aligned} V_o &= V_s D \left(\frac{N_2}{N_1} \right) & \frac{\Delta V_o}{V_o} &= \frac{1-D}{8L_x C f^2} & D \left(1 + \frac{N_3}{N_1} \right) &< 1 \\ \Delta V_{o,ESR} &= \Delta i_C r_C = \Delta i_{L_x} r_C = \left[\frac{V_o(1-D)}{L_x f} \right] r_C \\ \Delta i_{L_m} &= \frac{V_s DT}{L_m} & I_{L_x} &= \frac{V_o}{R} & \Delta i_{L_x} &= \frac{V_o(1-D)}{L_x f} \end{aligned}$$

Figure 2: Forward (single switched) Converter Formulas

$$\begin{aligned} V_o &= 2V_s \left(\frac{N_s}{N_p} \right) D & \frac{\Delta V_o}{V_o} &= \frac{1-2D}{32L_x C f^2} & I_{L_x} &= \frac{V_o}{R} \\ \Delta V_{o,ESR} &= \Delta i_{L_x} r_C = \left[\frac{V_o \left(\frac{1}{2} - D \right)}{L_x f} \right] r_C \end{aligned}$$

Figure 3: Push Pull Formulas

$$\begin{aligned} V_o &= V_s \left(\frac{D}{1-D} \right) & \Delta V_{C1} &= \frac{I_o DT}{C} = \frac{V_o D}{RC_1 f} \\ \Delta i_{L1} &= \frac{V_s DT}{L_1} = \frac{V_s D}{L_1 f} & \Delta V_o &= \Delta V_{C2} = \frac{V_o D}{RC_2 f} \\ \Delta i_{L2} &= \frac{V_s DT}{L_2} = \frac{V_s D}{L_2 f} & C_1 &= \frac{D}{R(\Delta V_{C1}/V_o)f} \\ I_{L1} &= I_s = \frac{V_o I_o}{V_s} = \frac{V_o^2}{V_s R} & C_2 &= \frac{D}{R(\Delta V_o/V_o)f} \\ I_{L2} &= I_o \end{aligned}$$

Figure 4: Sepic Converter Formulas

$$SwitchUtilization = \frac{Po}{P_{sw}} = \frac{I_o V_o}{q V_{swmax} I_{swmax}} \quad (1)$$

Inverters

$$\begin{aligned} m_f &= \frac{f_s}{f_1}, m_a = \frac{V_{control}}{V_{triangle}} \\ m_a < 1 : linear, m_a > 1 : overmodulation \end{aligned}$$

$$\begin{aligned} V_o &= -V_s \left(\frac{D}{1-D} \right) & \frac{\Delta V_o}{V_o} &= \frac{1-D}{8L_2 C_2 f^2} \\ \Delta v_{C1} &\approx \frac{1}{C_1} \int_{DT}^T I_{L1} d(t) = \frac{I_{L1}}{C_1} (1-D)T = \frac{V_s}{RC_1 f} \left(\frac{D^2}{1-D} \right) \\ \Delta v_{C1} &\approx \frac{V_o D}{RC_1 f} \\ \Delta i_{L1} &= \frac{V_s DT}{L_1} = \frac{V_s D}{L_1 f} & \Delta i_{L2} &= \frac{V_s DT}{L_2} = \frac{V_s D}{L_2 f} & I_{L2} &= \left| \frac{P_o}{-V_o} \right| \\ L_{1,min} &= \frac{(1-D)^2 R}{2Df} & L_{2,min} &= \frac{(1-D)R}{2f} & I_{L1} &= \frac{P_s}{V_s} \end{aligned}$$

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

$$\begin{aligned} V_o &= 2V_s \left(\frac{N_s}{N_p} \right) D & V_o &= V_s \left(\frac{N_s}{N_p} \right) D \\ \text{Full Bridge} & & \text{Half Bridge} & \end{aligned}$$

Figure 7: Full and Half Bridge Relations

$$(V_o)_h = \frac{1}{\sqrt{2}} \cdot 2 \cdot \frac{V_d}{2} \frac{(\hat{V}_{Ao})_h}{V_{d2}} = \frac{V_d}{\sqrt{2}} \frac{(\hat{V}_{Ao})_h}{V_{d2}}$$

Figure 8: Rms Voltage of Harmonics Full Bridge Inverter

Cuk Converter

$$V_{C1} = V_o + V_d \quad (2)$$

$$V_{rms} = \frac{2\pi}{\sqrt{2}} \cdot N_2 \cdot f \cdot B_{max} \cdot A \quad (3)$$

Current Source Converter:

$$(V_o = V_d \left(\frac{N_2}{N_1} \right) \left(\frac{1}{2(1-D)} \right)) \quad (4)$$

Signal Analysis

$$\begin{aligned} \dot{\hat{x}} &= AX + BV_d + A\hat{x} \\ \text{Linearization with State-Space Averaging} & & & + [(A_1 - A_2)X + (B_1 - B_2)V_d] \hat{d} \\ A &= dA_1 + (1-d)A_2 & \frac{V_o}{V_d} &= -CA^{-1}B \\ B &= dB_1 + (1-d)B_2 & \frac{T_p(s)}{\hat{d}(s)} &= \frac{\tilde{v}_o(s)}{\hat{d}(s)} \\ \dot{x} &= Ax + Bv_d \text{ (for switch off, (1-d)Ts)} & &= C[sI - A]^{-1}[(A_1 - A_2)X + (B_1 - B_2)V_d] \\ v_o &= Cx & &+ (C_1 - C_2)X] \\ C &= dC_1 + (1-d)C_2 \end{aligned}$$

$I_o = I_{lm}(1-D) \quad I_s = I_{lm}(D) \quad \text{AtSS} : AX + BV_d = 0$
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 π) for n:1 trans. ratio and in linear region scaled by $(m_a\pi)/4$