

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

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

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

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

Converters

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

Figure 1: Flyback Formulas

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

Figure 2: Forward (single switched) Converter Formulas

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

Figure 3: Push Pull Formulas

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

Figure 4: Sepic Converter Formulas

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

Inverters

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

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

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

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

Figure 8: Rms Voltage of Harmonics Full Bridge Inverter

Cuk Converter

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

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

Signal Analysis

Linearization with State-Space Averaging

$$\mathbf{A} = d\mathbf{A}_1 + (1-d)\mathbf{A}_2$$

$$\mathbf{B} = d\mathbf{B}_1 + (1-d)\mathbf{B}_2$$

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}v_d \text{ (for switch off, (1-d)Ts)}$$

$$v_o = \mathbf{C}\mathbf{x}$$

$$\mathbf{C} = d\mathbf{C}_1 + (1-d)\mathbf{C}_2$$

$$\dot{\hat{\mathbf{x}}} = \mathbf{A}\mathbf{X} + \mathbf{B}V_d + \mathbf{A}\hat{\mathbf{x}}$$

$$+ [(A_1 - A_2)X + (B_1 - B_2)V_d] \bar{d}$$

$$\mathbf{V}_o = -\mathbf{C}\mathbf{A}^{-1}\mathbf{B}$$

$$\mathbf{V}_d = \frac{\bar{v}_o(s)}{\bar{d}(s)}$$

$$T_p(s) = \frac{\bar{v}_o(s)}{\bar{d}(s)}$$

$$= \mathbf{C}[\mathbf{s}\mathbf{I} - \mathbf{A}]^{-1}[(A_1 - A_2)X + (B_1 - B_2)V_d]$$

$$+ (C_1 - C_2)X]$$

Signal.png

$$I_o = I_{lm}(1-D) \quad I_s = I_{lm}(D)$$