Cheat Sheet for EE463

Performance Parameters

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

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

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

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

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

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

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

Single Phase Diode Rectifier

$$V_{av} = \frac{2\sqrt{2}V_s}{\pi}$$

u: commutation period

$$\cos(u) = 1 - \frac{2\omega L_s I_d}{\sqrt{2}V_s}$$

$$I_{d,avg} = \frac{\int_b^f i(\theta)d\theta}{\pi}$$

$$I_{d,shortcircuit} = \frac{V_s}{\omega L_s}$$

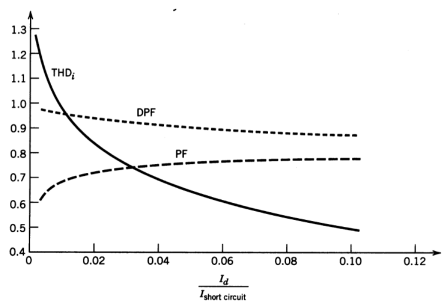


Figure 1: Characteristics of source current wrt w*Ls (battery on load side)

Three Phase Rectifier

- **Half Wave**

$$V_{av} = \frac{3\sqrt{6}V_s}{2\pi}$$

  Crossing points (integration) on the waves are from $\pi/6$ to $5\pi/6$

- **Full Wave**

  Full Bridge Rectifier Average Output V_s:rms value of source voltage

$$V_{av} = \frac{3\sqrt{6}V_s}{\pi} - \frac{3wL_sI_d}{\pi}$$

Single Phase Controlled Rectifiers-Thyristors

- Idealized Circuit α : firing angle

$$V_{av}(\alpha) = \frac{2\sqrt{2}V_d}{\pi} \cdot \cos\alpha$$

- Effect of Ls

$$\cos(\alpha + u) = \cos(\alpha) - \frac{2\omega L_s I_d}{\sqrt{2}V_s}$$

$$V_d = 0.9V_s cos(\alpha) - \frac{2\omega L_s I_d}{\pi}$$

- Inverter Mode

$$ExtinctionAngle = \gamma = 180 - (\alpha + u)$$

Three Phase Controlled Rectifiers-Thyristors

- Idealized Circuit α : firing angle

$$V_{av}(\alpha) = \frac{3\sqrt{2}V_{LL}}{\pi} \cdot \cos\alpha$$

- Effect of Ls

$$\cos(\alpha + u) = \cos(\alpha) - \frac{2\omega L_s I_d}{\sqrt{2}V_{LL}}$$

$$V_d = \frac{3\sqrt{2}}{\pi}V_{LL}cos(\alpha) - \frac{3\omega L_s I_d}{\pi}$$

- Output Waveforms

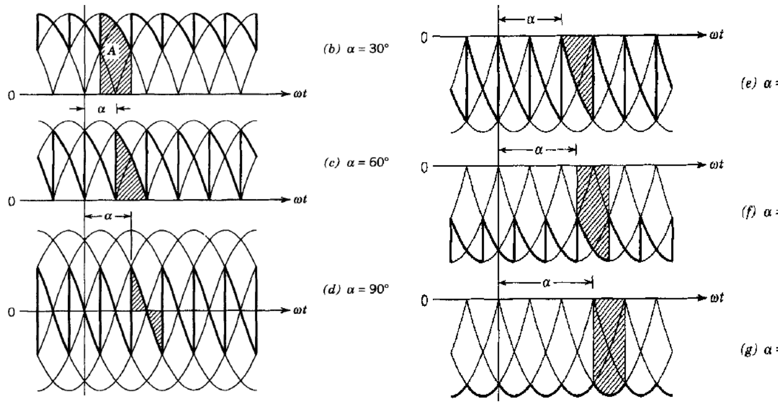


Figure 2: Output Voltage Waveforms

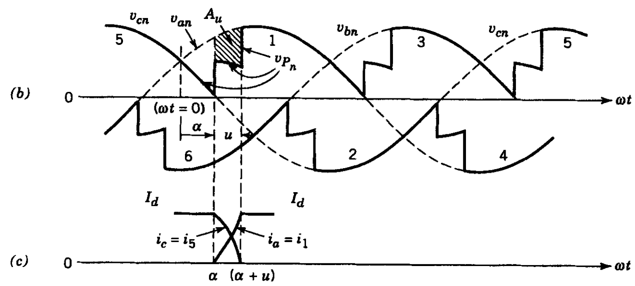


Figure 6-25 Commutation in the presence of L_s.

Figure 3: Effect of Commutation

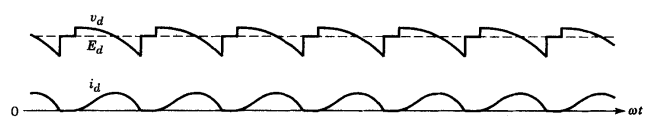


Figure 6-30 Waveforms in a discontinuous-current-conduction mode.

Figure 4: Discontinuous Current Conduction Mode

Trigonometric

$$\sin A \cos B = \frac{1}{2}\left[\sin(A - B) + \sin(A + B)\right]$$

$$\sin A \sin B = \frac{1}{2}\left[\cos(A - B) - \cos(A + B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A - B) + \cos(A + B)\right]$$

$$\cos A + \cos B = 2\cos(\frac{A + B}{2})\cos(\frac{A - B}{2})$$

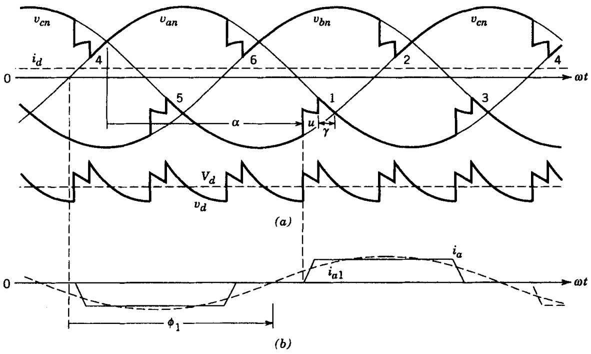


Figure 6-32 Waveforms in the inverter of Fig. 6-31.

Figure 5: Inverter Waveforms

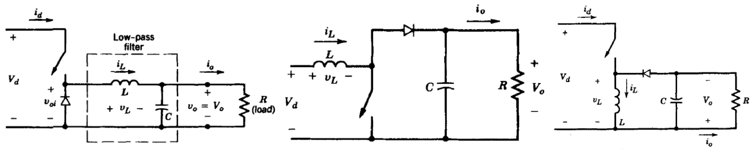
$$\cos A - \cos B = -2\sin(\frac{A+B}{2})\sin(\frac{A-B}{2})$$
$$\sin^2(A) = \frac{1}{2} - \frac{\cos(2A)}{2}$$

Symmetry	*Condition Required*	a_h and b_h
Even	$f(-t) = f(t)$	$b_h = 0 \quad a_h = \frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\, d(\omega t)$
Odd	$f(-t) = -f(t)$	$a_h = 0 \quad b_h = \frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\, d(\omega t)$
Half-wave	$f(t) = -f(t + \frac{1}{2}T)$	$a_h = b_h = 0$ for even h; $a_h = \frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\, d(\omega t)$ for odd h; $b_h = \frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\, d(\omega t)$ for odd h

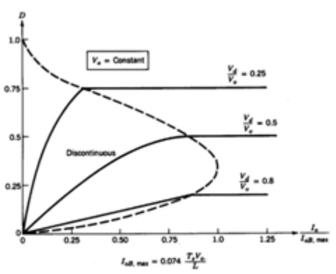
Figure 6: Fourier Transform Table

Power Flow

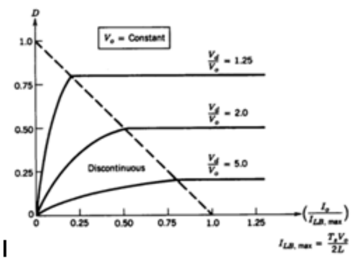
$$P = V_s I_{s1} cos(\phi) = V_d I_d$$
$$S = V_s I_s$$

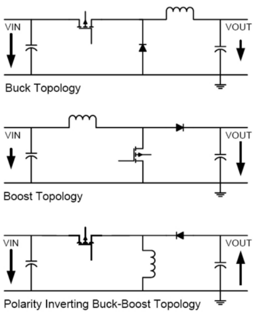


In order to keep Vo constant



With Constant Vo (Vd can vary)





Convection Thermal Resistance

$$R_c = \frac{1}{Ah}$$

Conduction Heat Loss

$$P = \frac{\Delta T}{R}$$

Fluid Temperature Rise

For a liquid cooled system

$$\Delta T = \frac{P}{Q.d.C_p}$$

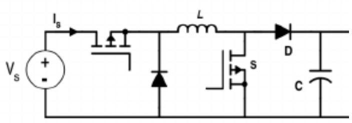
Radiation Heat Loss (Black body radiation)

q_R: radiation heat flow (W/m2)

$$q_R = \rho \epsilon F(T_1^4 - T_2^4)$$

$$\zeta = \frac{L}{2R\sqrt{LC}}$$

Positive Output Buck-Boost Converter



BUCK

$$\frac{I_o}{I_d} = \frac{V_d}{V_o} = \frac{1}{D} \qquad I_o = i_{L,\text{peak}}\frac{D+\Delta_1}{2}$$

$$I_{LB} = \frac{T_s V_d}{2L} D(1-D) \quad \therefore \frac{V_o}{V_d} = \frac{D}{D+\Delta_1} \quad \Delta_1 = \frac{I_o}{4I_{LB,\max}D} \quad \frac{V_o}{V_d} = \frac{D^2}{D^2 + \frac{1}{4}(I_o/I_{LB,\max})}$$

$$I_{LB} = \frac{1}{2} i_{L,\text{peak}} = \frac{t_{\text{on}}}{2L}(V_d - V_o) = \frac{DT_s}{2L}(V_d - V_o) = I_{oB}$$

$$I_{LB} = \frac{T_s V_o}{2L}(1-D) \qquad D = \frac{V_o}{V_d}\left(\frac{I_o/I_{LB,\max}}{1 - V_o/V_d}\right)^{1/2}$$

BOOST

$$\frac{V_o}{V_d} = \frac{T_s}{t_{\text{off}}} = \frac{1}{1-D} \qquad I_{oB} = \frac{T_s V_o}{2L} D(1-D)^2 \qquad I_{LB,\max} = \frac{T_s V_o}{8L}$$

$$I_{oB,\max} = \frac{2}{27}\frac{T_s V_o}{L} \qquad I_{oB} = \frac{27}{4} D(1-D)^2 I_{oB,\max} \quad \therefore \frac{V_o}{V_d} = \frac{\Delta_1 + D}{\Delta_1}$$

$$I_d = \frac{V_d}{2L} DT_s(D + \Delta_1) \qquad I_o = \left(\frac{T_s V_d}{2L}\right) D\Delta_1 \qquad D = \left[\frac{4}{27}\frac{V_o}{V_d}\left(\frac{V_o}{V_d} - 1\right)\frac{I_o}{I_{oB,\max}}\right]^{1/2}$$

$$\therefore \frac{\Delta V_o}{V_o} = \frac{DT_s}{RC}$$

$$V_{ripple,buck} = V_o(1-D)(\frac{f_c}{f_s})^2\frac{\pi^2}{2}$$
$$I_{ob} = \frac{T_s V_o D(1-D)^2}{2L}$$
$$V_{ripple,boost} = \frac{V_o D T s}{RC}$$

Snubber Circuit

$$fr = \frac{1}{2\pi\sqrt{LpCp}}$$
$$R = \sqrt{\frac{Li}{Ci}}$$
$$\frac{LpI^2}{V^2} < Cs < \frac{ton}{10R}$$
$$Pr = CsV^2 fs$$