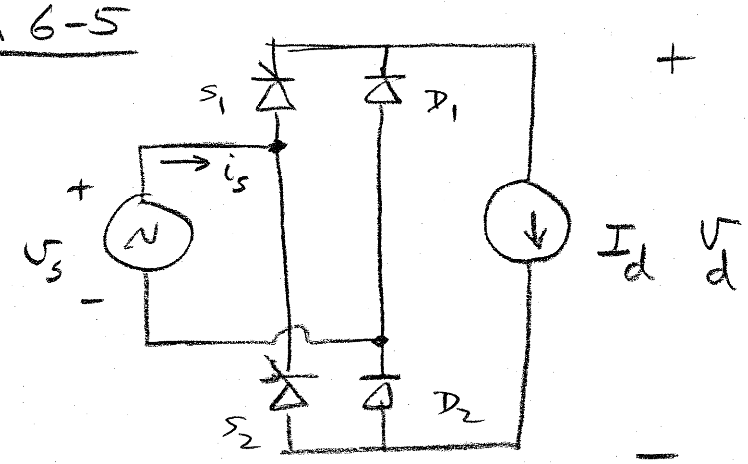
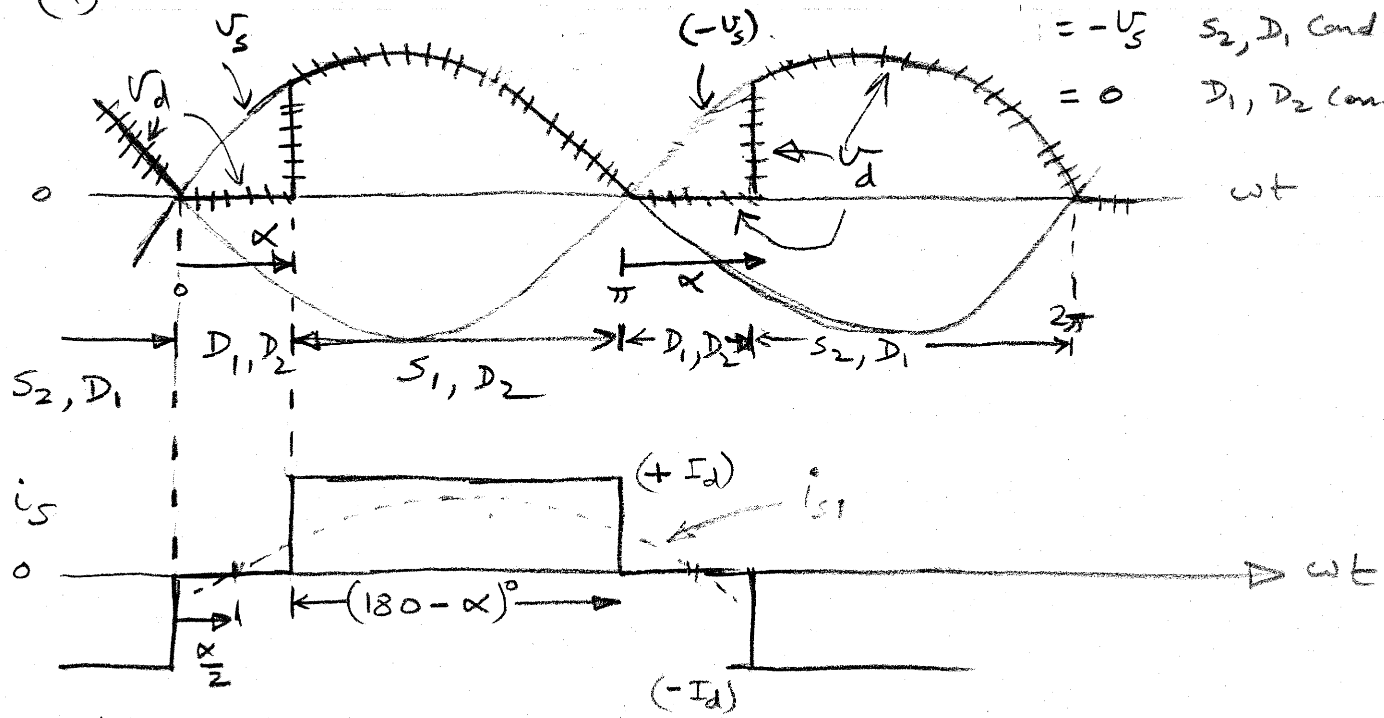
Problem 6-5



$v_d = v_s$ S_1, D_2 cond.
$= -v_s$ S_2, D_1 cond.
$= 0$ D_1, D_2 cond.

(a)



$$V_{do} = 0.9\, V_s$$

$$V_{d\alpha} = \sqrt{2}\, V_s \int_{\alpha}^{\pi} \sin \omega t \cdot d(\omega t) \Big/ \pi = \frac{\sqrt{2}\, V_s}{\pi}\left[\cos\alpha + 1\right]$$

$\text{DPF} = \cos\left(\frac{\alpha}{2}\right)$ by observation of i_s waveform

$$I_s = I_d \sqrt{\frac{180^\circ - \alpha^\circ}{180^\circ}}$$; I_{s1} (rms) can be calculated by equating power:

rms value

$$V_s I_{s1} \cdot \text{DPF} = V_{d\alpha} I_d$$

$$\therefore \quad I_{s1} = \frac{V_{d\alpha}\, I_d}{V_s \underbrace{\cos\frac{\alpha}{2}}_{\text{DPF}}}$$

(b) $V_{d\alpha} = \frac{1}{2} V_{do}$

$$\therefore \frac{\sqrt{2} V_s}{\pi}(1+\cos\alpha) = \frac{1}{2} \times 0.9 V_s$$

or $$\cos\alpha = \frac{\pi \times 0.9}{2\sqrt{2}} - 1$$

$$\therefore \alpha = 90^\circ$$

$$\therefore DPF = \cos\left(\frac{\alpha}{2}\right) = 0.707$$

$$I_s = I_d \sqrt{\frac{180-90}{180}} = 0.707 I_d$$

$$I_{s1} = \frac{0.5 \times 0.9 V_s}{V_s \cos\left(\frac{90^\circ}{2}\right)} I_d = 0.636 I_d$$

$$\therefore PF = \frac{I_{s1}}{I_s} \cdot DPF = 0.636$$

$$\% THD_i = \frac{\sqrt{I_s^2 - I_{s1}^2}}{I_{s1}} \% = \frac{\sqrt{0.707^2 - 0.636^2}}{0.636} \times 100$$

$$= 48.55\%$$

(c) In a full-bridge converter,

$$V_{d\alpha} = V_{do} \cos\alpha \qquad [\text{Eq } 6\text{-}6]$$

$\therefore$ for $V_{d\alpha} = 0.9 V_o$, $\alpha = 60^\circ$

$$DPF = \cos\alpha = 0.5 \qquad [\text{Eq } 6\text{-}16]$$

$$PF = 0.9 \cos\alpha = 0.45 \qquad [\text{Eq } 6\text{-}17]$$

$$\% THD_i = 48.43\%$$

(d) Comparison of (b) and (c) shows that the Power Factor is better in the half-controlled converter.