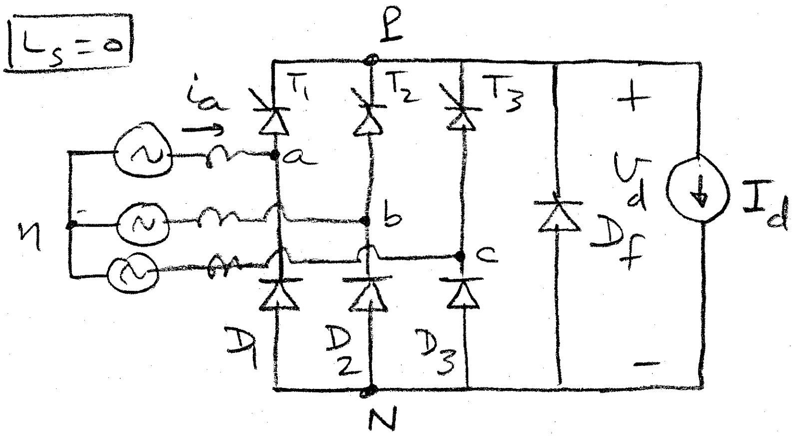
Problem 6-15

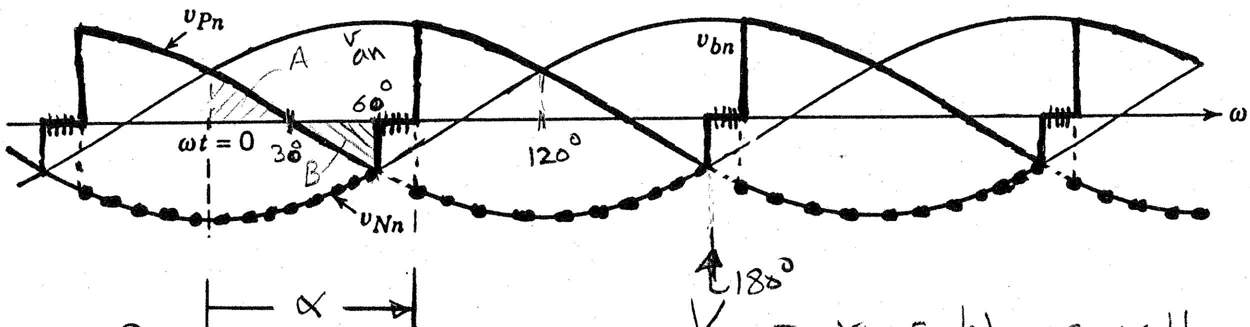
$\boxed{L_s = 0}$



$$V_d = v_{Pn} - v_{Nn}$$

D_f will not conduct, so long that $v_d(t) > 0$. Considering the waveforms shown in Fig. 6-20 a, so long as $\alpha < 60°$, $v_{Pn}(t)$ will always be greater than v_{Nn}. Hence for $0 < \alpha < 60°$, D_f will not conduct.

For a value of α greater than 60°, the v_d will become equal to zero for the interval $\omega t = 60^\circ$ and α, as shown below:



V_{ph} = rms phase voltage

<u>$\alpha > 60^\circ$</u>

v_{Pn} waveform repeats every 120°. To calculate V_{Pn} (avg), consider $\omega t = 0$ to $\omega t = 120^\circ$ interval. Areas A and B cancel each other. With the time origin $\omega t = 0$ shown as above,

$$V_{Pn} = \left[\sqrt{2}\, V_{ph} \int_{\alpha}^{120^\circ} \sin(\omega t + 30^\circ) \cdot d(\omega t)\right] \Big/ \left(\frac{2\pi}{3}\right)$$

$$= \frac{\sqrt{2}\, V_{ph}}{\frac{2\pi}{3}} \left[\cos(\alpha + 30^\circ) - \cos 150^\circ\right]$$

The waveform v_{Nn} also repeats every 120°. To calculate, consider the interval from α to $\alpha + 120^\circ$.

$$\therefore\ V_{Nn} = \left[\sqrt{2}\, V_{ph} \int_{\alpha}^{180^\circ} \sin(\omega t + 150^\circ) \cdot d(\omega t)\right] \Big/ (2\pi/3)$$

$$= \frac{\sqrt{2}\, V_{ph}}{\left(\frac{2\pi}{3}\right)} \left[\cos(\alpha + 150^\circ) - \cos(330^\circ)\right]$$

$$V_d = V_{Pn} - V_{Nn} = \frac{3 V_{LL}}{\sqrt{2}\pi}(1 + \cos\alpha) \qquad \text{where, } V_{LL} = \sqrt{3}\, V_{ph}$$

$$V_{do} = \frac{3\sqrt{2}}{\pi} V_{LL} \qquad \text{Eq 6-36}$$

$$\therefore \quad V_d = 0.5\, V_{do}(1 + \cos\alpha)$$

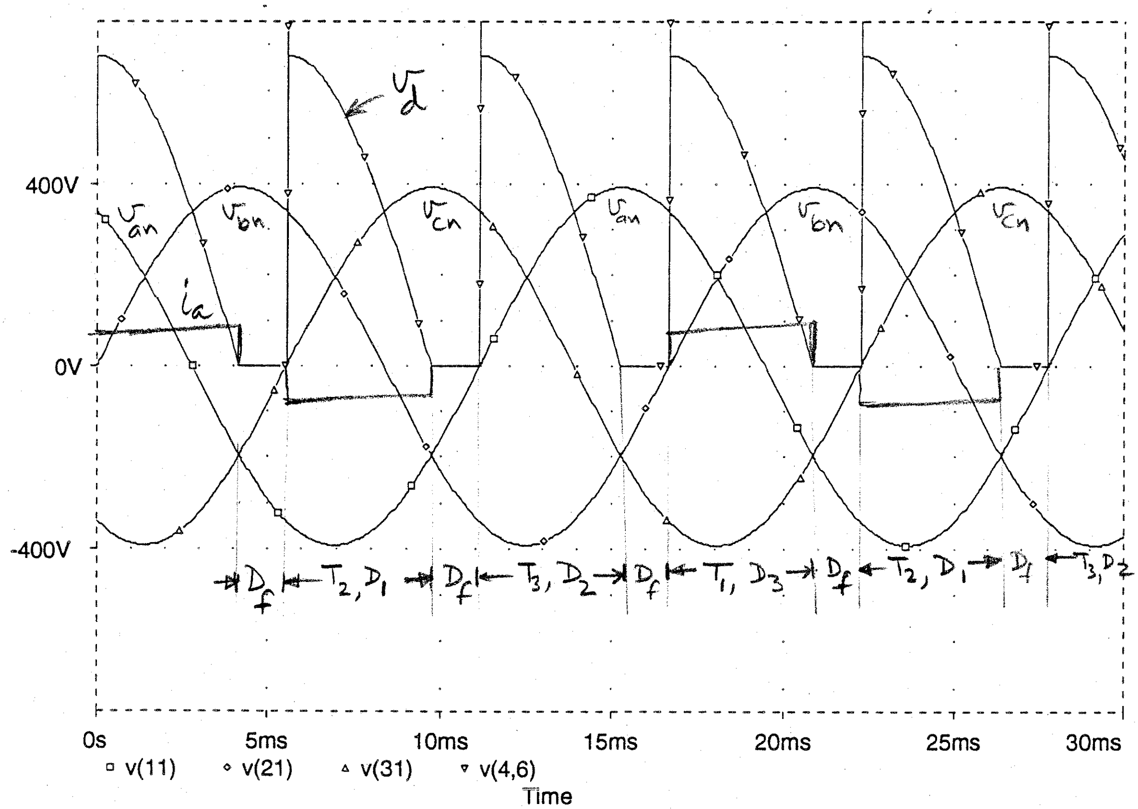
If $V_d = 0.5\, V_{do}$, then

$$0.5\, V_{do}(1 + \cos\alpha) = 0.5\, V_{do}$$

or

$$(1 + \cos\alpha) = 1$$

$$\therefore \quad \alpha = 90^{\circ}$$



$\phi_1 = -15^{\circ}$ (lagging) $\therefore$ DPF = 0.966 (lagging)

$THD_i = 78\%$ $\therefore$ PF = 0.76