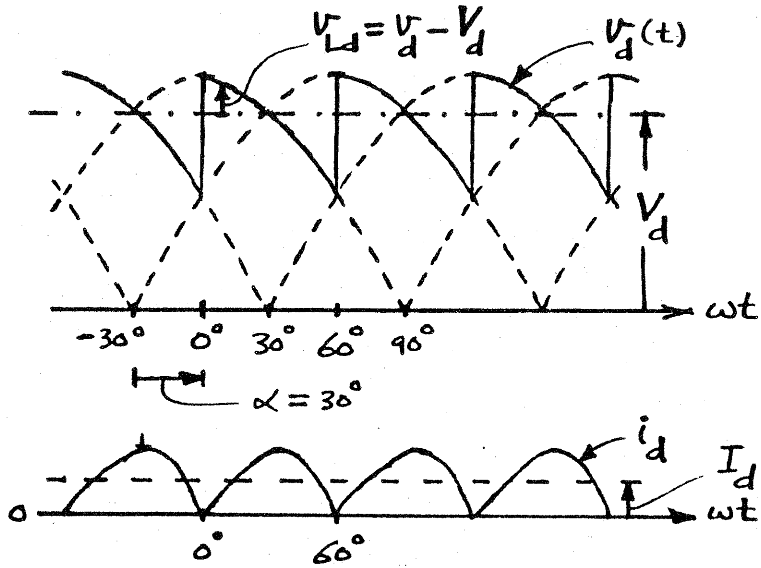
Problem 6-14




Redefine $\omega t = 0$ to be at the start of the commutation ($\alpha = 30^o$). Then,

$$v_d(\omega t) = \sqrt{2}\, V_{LL} \cos\omega t \qquad 0^o < \omega t < 60^o$$

$$V_d = 1.35\, V_{LL} \cos 30^o = 1.169\, V_{LL}$$

$$i_d(\omega t) = \frac{1}{\omega L_d} \int v_{Ld}\, d\omega t \qquad 0° < \omega t < 60°$$

$$= \frac{1}{\omega L_d} (\sqrt{2}\ V_{LL} \sin\omega t - 1.169\, V_{LL}\, \omega t + K) \quad , \quad K = \text{a constant of integration}$$

Calculate K:

$i_d(0) = 0$ in the figure above

$\therefore$ $K = 0$ and,

$$i_d(\omega t) = \frac{\sqrt{2}\, V_{LL}}{\omega\ L_d} (\sin\omega t - 0.8266\ \omega t) \qquad 0 < \omega t < \frac{\pi}{3}$$

Calculate the average current $I_d$:

$$I_d = \frac{1}{\pi/3} \int_0^{\pi/3} i_d\ d\omega t$$

$$= \frac{3\sqrt{2}\,V_{LL}}{\pi\omega L_d}\left[-\cos\omega t - \frac{0.8266}{2}(\omega t)^2\right]_0^{\pi/3}$$

$$= \frac{3\sqrt{2}\,V_{LL}}{\pi\omega L_d}\left[-\frac{1}{2} + 1 - 0.4532\right]$$

Therefore, the minimum dc current $I_{dB}$ at $\alpha = 30^o$ is

$$I_{dB} = 0.1403\,\frac{\sqrt{2}}{\pi}\,\frac{V_{LL}}{\omega L_d} = 0.0632\,\frac{V_{LL}}{\omega L_d}\ .$$