Prob 9A Solution

load 1 $\quad V_{LL} = 440 \quad V_{LN} = \frac{440}{\sqrt{3}}\angle 0^\circ = 254.03\angle 0^\circ$

assume V_{LN} at load is at 0°

$$I_{line_{load1}} = \frac{100000}{V_{LL}\cdot\sqrt{3}} = 131.2\angle -36.87^\circ$$

$P_{load_1} + jQ_{LOAD_1} = 80\,kW + j\,60\,kVAR$

load 2

$$I_{line_{load2}} = \frac{120000}{V_{LL}\sqrt{3}(.96)} = 164.02\angle 16.26^\circ$$

$P_{load_2} + jQ_{LOAD_2} = 120\,kW + j(-35\,kVAR$

$I_{load\,Total} = 264.4\angle -7.12^\circ$

V_{LN} highside $= \frac{4400}{\sqrt{3}}\angle 0^\circ = 2540\angle 0^\circ$

I_{line} high side $= \left(1/10\right) I_{load\,Total} = 26.4\angle -7.12^\circ$

$V_{LN\,gen} = V_{LN\,highside} + I_{line\,highside} \times (2+j4)$

$= 2.608\,kV\angle 2.16^\circ$

$V_{LL\,gen} = 4516\angle 32^\circ$

Solution to Problem 9B

$A \equiv a$

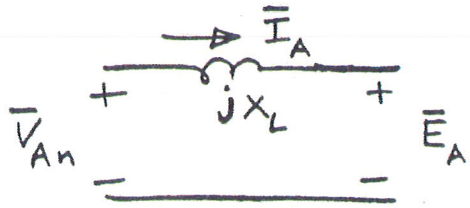
$\bar{v}_{AN} = \frac{V_d}{2} + \bar{v}_{An} = \frac{300}{2} + 112.5 \sin \omega_1 t$

N: negative terminal of the dc-bus

(a) $d_A = \frac{\bar{v}_{AN}}{V_d} = 0.5 + 0.375 \sin \omega_1 t$

Similarly d_B & d_C.

(b)



for purposes of drawing phasors, we will advance both voltages by 90° so that

$\bar{v}_{An}(t) = 112.5 \cos \omega_1 t \quad V$

and, $e_A(t) = 106.14 \cos(\omega_1 t - 6.6°) \quad V$

$\therefore \quad \bar{V}_{An} = 112.5 \angle 0° \ V, \quad \bar{E}_A = 106.14 \angle -6.6° \ V$

$\bar{V}_{An} = \bar{E}_A + jX_L \bar{I}_A$

$X_L = 2\pi f_1 L$
$= 2\pi \times 45 \times 5 \times 10^{-3}$
$= 1.414 \ \Omega$

$\bar{I}_A = \frac{\bar{V}_{An} - \bar{E}_A}{jX_L}$

$= \frac{112.5\angle 0° - 106.14 \angle -6.6°}{j1.414} = 9.97 \angle -30.1° \ A$

$\therefore \quad \bar{i}_A(t) = 9.97 \cos(\omega_1 t - 30.1°)$ but in fact,

$\bar{i}_A(t) = 9.97 \sin(\omega_1 t - 30.1°)$, taking away the advance by 90°.

Similarly $\bar{i}_B$ and $\bar{i}_C(t)$.

$$\bar{i}_{dA}(t) = d_A(t)\ \bar{i}_A(t)$$

$$= (0.5 + 0.375 \sin \omega_1 t)\ 9.97 \sin(\omega_1 t - 30.1^\circ)$$

$$= 4.985 \sin(\omega_1 t - 30.1^\circ) + 3.74 \sin\omega_1 t \cdot \sin(\omega_1 t - 30.1)$$

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

$$\therefore\ \bar{i}_{dA} = 4.985 \sin(\omega_1 t - 30.1^\circ) + 1.87 \cos(30.1^\circ) - 1.87 \cos(2\omega_1 t - 30.1)$$

$$= \underbrace{1.618}_{dc} + \underbrace{4.985 \sin(\omega_1 t - 30.1^\circ)}_{\text{fund. freq.}} - \underbrace{1.87 \cos(2\omega_1 t - 30.1^\circ)}_{2^{nd}\ \text{harmonic}}$$

(c)

$$\bar{i}_d = \bar{i}_{dA} + \bar{i}_{dB} + \bar{i}_{dc}$$

The fundamental frequency components in $\bar{i}_{dA}$, $\bar{i}_{dB}$ and $\bar{i}_{dc}$ combine to zero. The same happens to the 2nd harmonic components. Therefore,

$$\bar{i}_d = 3 \times 1.618 = 4.854\ A$$