Problem 6-23

The rms value of the distortion voltage component V_{dis} can be approximately calculated by considering the six voltage notches in one cycle of the voltage waveform.

All notch widths are equal to t_{notch}. There are two deep notches, each with a depth of V_{notch}. There are 4 shallow notches, each with a depth (or height) of $\frac{V_{notch}}{2}$.

Therefore, the rms value of the voltage distortion can be approximated as

$$V_{dis} \approx \left[\frac{2 \times V_{notch}^2 \, t_{notch} + 4 \times \left(\frac{V_{notch}}{2}\right)^2 t_{notch}}{1/f_1} \right]^{1/2}$$

where f_1 is the line frequency of 60 Hz. (see Reference 4 of Chapter 6)

$$\therefore V_{dis} = \sqrt{3 \, V_{notch}^2 \, t_{notch} \, f_1}$$ in line-line voltage.

It is reasonable to assume that the fundamental frequency line-to-line voltage at the point of common coupling equals 460V (rms).

(a) In problem 6-21 A, at the point of common coupling

$$V_{notch} = \frac{A_{n_{cc}}}{t_{notch}} = \frac{6980}{25.78} = 270.75 \text{ V}$$

$$\therefore V_{dis} = \sqrt{3 \times 270.75^2 \times 25.78 \times 10^{-6} \times 60}$$

$$= \sqrt{340.2} = 18.4\ V$$

$$\therefore \%THD = \frac{V_{dis}}{V_{LL1}} \times 100 = \frac{18.4}{460} \times 100 \simeq 4\ \%$$

(b) In problem 6-22, at the point of common coupling

$$V_{notch} = \frac{A_{n_{cc}}}{t_{notch}} = \frac{6980}{158.5} \simeq 44\ V$$

$$\therefore V_{dis} = \sqrt{3 \times 44^2 \times 158.5 \times 10^{-6} \times 60} = 7.4\ V$$

$$\therefore \%THD = \frac{V_{dis}}{V_{LL1}} \times 100 = \frac{7.4}{460} \times 100 = 1.61\%$$