DC to AC Converters

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EXERCISE 29

Using the following circuit, the conversion of an AC Voltage with a specific frequency and R.M.S. value to another AC Voltage with the same or different frequency and variable R.M.S. value is achieved. At first, the input power supply is converted to DC Voltage through rectification and smoothing and then it is converted to AC Voltage, through an inverter, with the desirable frequency and R.M.S. value. For this circuit:

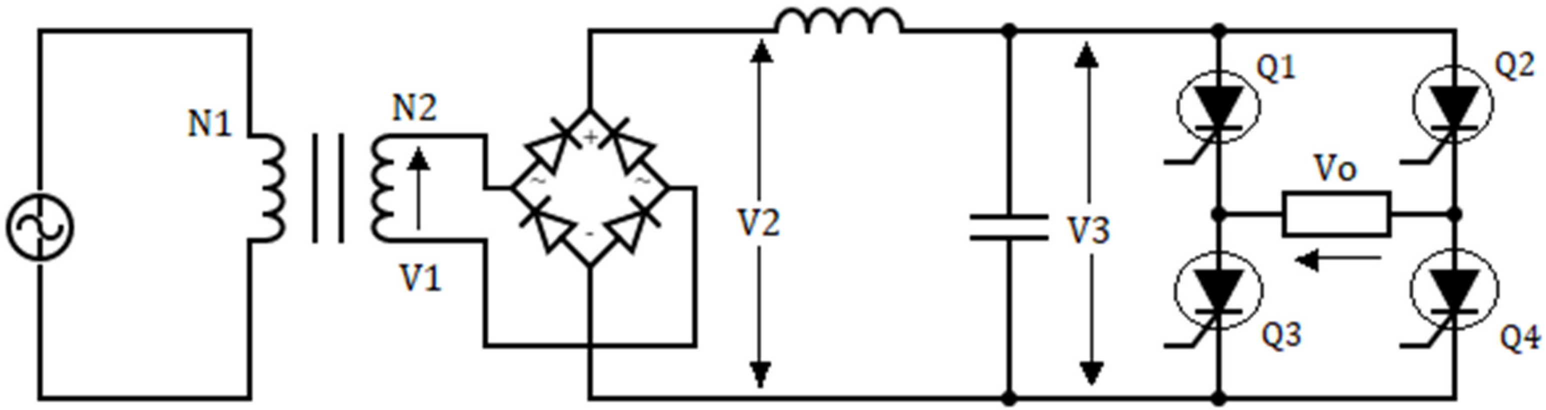
A) Design the waveforms of the circuit's Voltages.

B) Calculate the transformer's turns ratio so that when the width of pulses of the output Voltage is 120^o, the R.M.S. value of the fundamental component is 110 Volts.

Solution

A) The circle around the thyristors shows that the commutation circuit of the thyristors is not considered in this analysis.

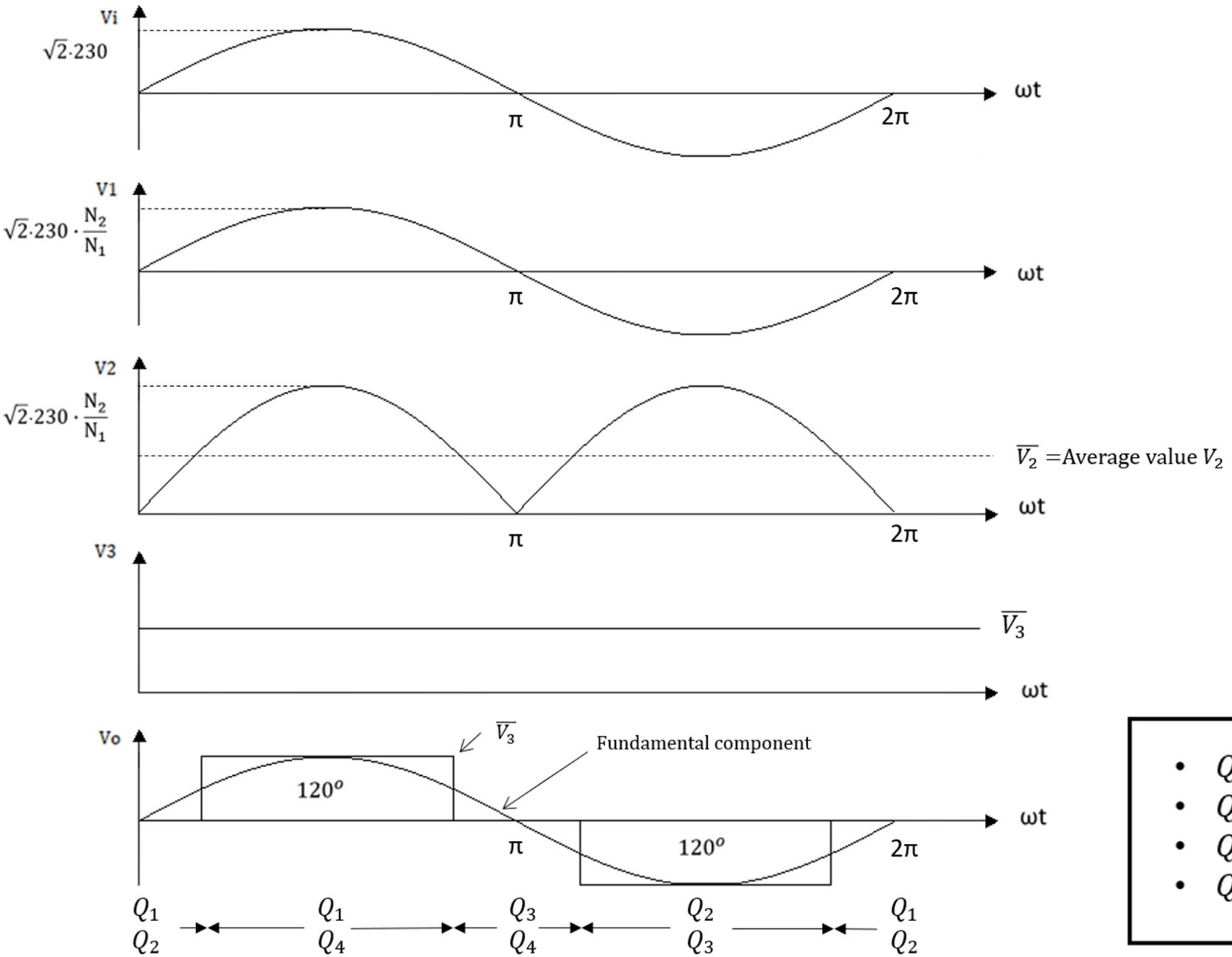
$V_i = \sqrt{2}\cdot 230\cdot \sin\omega t$

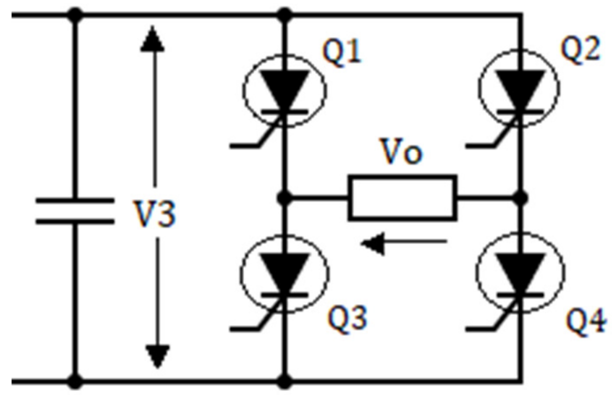


Define the R.M.S. voltage values shown in the circuit:

- $V_i = 230\, Volts$
- $V_1 = 230 \cdot \frac{\mathrm{N}_2}{\mathrm{N}_1}$ Volts
- $V_2 = 230 \cdot \frac{\mathrm{N}_2}{\mathrm{N}_1}$ Volts
- The average value of V3 (DC component) is:

$$\overline{V_3} = \frac{1}{\pi}\int_0^{\pi} 230\sqrt{2}\cdot\frac{\mathrm{N}_2}{\mathrm{N}_1}\cdot\sin(\omega t)\, d\omega t = \frac{2\cdot 230\sqrt{2}}{\pi}\cdot\frac{\mathrm{N}_2}{\mathrm{N}_1} = 207\cdot\frac{\mathrm{N}_2}{\mathrm{N}_1}\, Volts$$





- Q_1 , Q_2 closed , $V_o = 0$
- Q_1 , Q_4 closed , $V_o = \overline{V_3}$
- Q_3 , Q_4 closed , $V_o = 0$
- Q_2 , Q_3 closed , $V_o = -\overline{V_3}$

B) The almost square output waveform Vo, as it was previously shown, can be represented by the following Fourier series:

$$Vo = \sum_{n=1,2,3,..}^{\infty} V_{o1,n}\cos(n\omega t) + \sum_{n=1,2,3,..}^{\infty} V_{o2,n}\sin(n\omega t)$$

Where: $\mathrm{V}_{o1,n} = \dfrac{2}{\pi}\int_0^{\pi} V_{in}\sin(n\omega t)d(\omega t)$

$$\mathrm{V}_{o2,n} = \frac{2}{\pi}\int_0^{\pi} V_{in}\cos(n\omega t)d(\omega t)$$

The waveform is odd, with a 90^{o} symmetry so the equation becomes: $\mathrm{V}_o = \sum_{n=1,3,5,..}^{\infty} V_{o1,n}\sin(n\omega t)$

Where: $V_{o1,n} = \dfrac{8}{T}\int_0^{T/4} \overline{V_3}\sin(n\omega t)d(\omega t) = \dfrac{8}{2\pi}\int_{(\pi-\delta)/2}^{\pi/2} \overline{V_3}\sin(n\omega t)d(\omega t) = \dfrac{4\overline{V_3}}{n\pi}[-\cos(n\omega t)]_{(\pi-\delta)/2}^{\pi/2} =$

$$= \frac{4\overline{V_3}}{n\pi}[-\cos(n\frac{\pi}{2}) + \cos(n\frac{\pi-\delta}{2})] = \frac{4\overline{V_3}}{n\pi}\cos(n\frac{\pi-\delta}{2})$$

So: $V_o = \sum_{n=1,3,..}^{\infty} \dfrac{4\overline{V_3}}{n\pi}\cos[\dfrac{n(\pi-\delta)}{2}]\sin(n\omega t)$ (1)

From equation (1) the amplitude of the 1st harmonic component, for δ=120°, is:

$$\widehat{V_{o1}} = \frac{4\overline{V}_3}{\pi}\cos(\frac{60}{2}) = \frac{4*207(N2/N1)}{\pi}\cos(\,30^o) = 228\left(\frac{N2}{N1}\right)\,Volts$$

The R.M.S. value of the fundamental component of the output voltage V_o must be 110 Volts, so:

$$\frac{\widehat{V_{o1}}}{\sqrt{2}} = \frac{228(N2/N1)}{\sqrt{2}} = 110 \;\; \Rightarrow \;\; \frac{N_1}{N_2} = \frac{228}{110\sqrt{2}} = 1{,}465$$