Fully Controlled Rectifier - 3 (PE_rectifier_4.sqproj)

Question: For the fully controlled rectifier circuit shown in Fig. 1,

(a) Find the firing angle (α) to get an average output current $I_{out} = 5\,\text{A}$.

(b) Find the input power factor in the above case.

(Assume that the inductance is large enough to give a constant load current in steady state.)

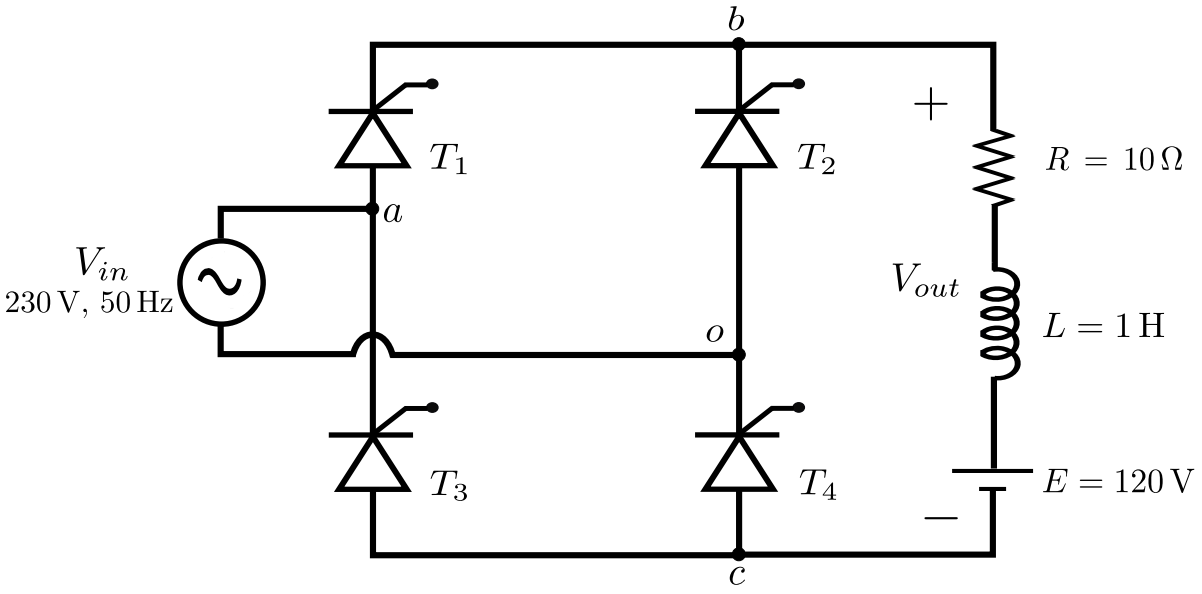

Figure 1: Fully controlled rectifier with RLE load.

Solution:

(a) For the fully controlled rectifier circuit shown in Fig.1, it is given that the load current is constant. Applying KVL in the load side, the average output voltage,

$$V_{out} = I_{out}R + E \tag{1}$$

Thyristors T_1 and T_4 conduct from α to $\pi+\alpha$ and thyristors T_2 and T_3 conduct from $\pi+\alpha$ to $2\pi+\alpha$ and this continues. Therefore by solving KVL, we get output voltage waveform as shown in Fig.2. From the plot, the average output voltage

$$V_{out} = \frac{1}{\pi} \int_{\alpha}^{\pi+\alpha} 230\sqrt{2}\,\sin(\omega t)\,d(\omega t) \tag{2}$$

$$V_{out} = \frac{2}{\pi}\,(230\sqrt{2}\,\cos\alpha) \tag{3}$$

From eqns. 1 and 3, the firing angle,

$$\alpha = cos^{-1}\left(\frac{5\times 10+120}{\frac{2}{\pi}\,(230\sqrt{2})}\right) = 34.7^{\circ} \tag{4}$$

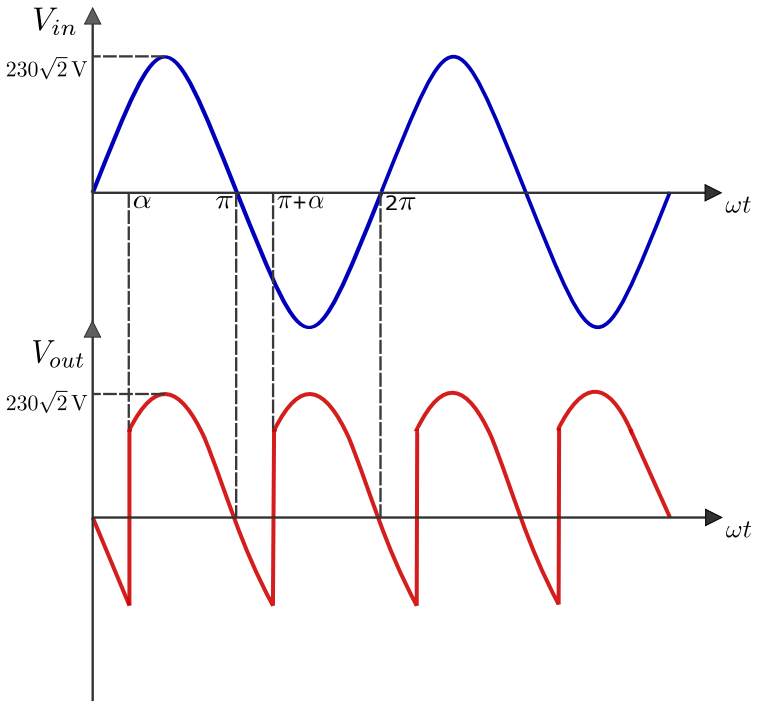

Figure 2: Plots of V_{in} and V_{out} vs ωt

(b) Since the load current is constant, the rms load current I_{or} is equal to 5 A. Let us assume that there is no power loss in thyristors. Then input power is equal to ouput power.

$$V_{in}.I_{or}\ \cos\phi = EI_{out} + I_{or}^2 R \tag{5}$$

Input power factor,

$$\cos\phi = \frac{120 \times 5 + 25 \times 10}{230 \times 5} = .739 \text{ lag} \tag{6}$$

SequelApp Exercises:

For the circuit shown in Fig. 1, find the following for E = -120 V.

(a) The firing angle (α) to get an average output current $I_{out} = 5$ A.

(b) The input power factor in the above case.

Verify your answers using SequelApp.