Fully Controlled Rectifier - 1 (PE_rectifier_2.sqproj)

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

(a) Find the firing angle (α) of thyristor to get an average output voltage $V_{out} = 145\,\text{V}$.

(b) Find the average current through all the thyristors.

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

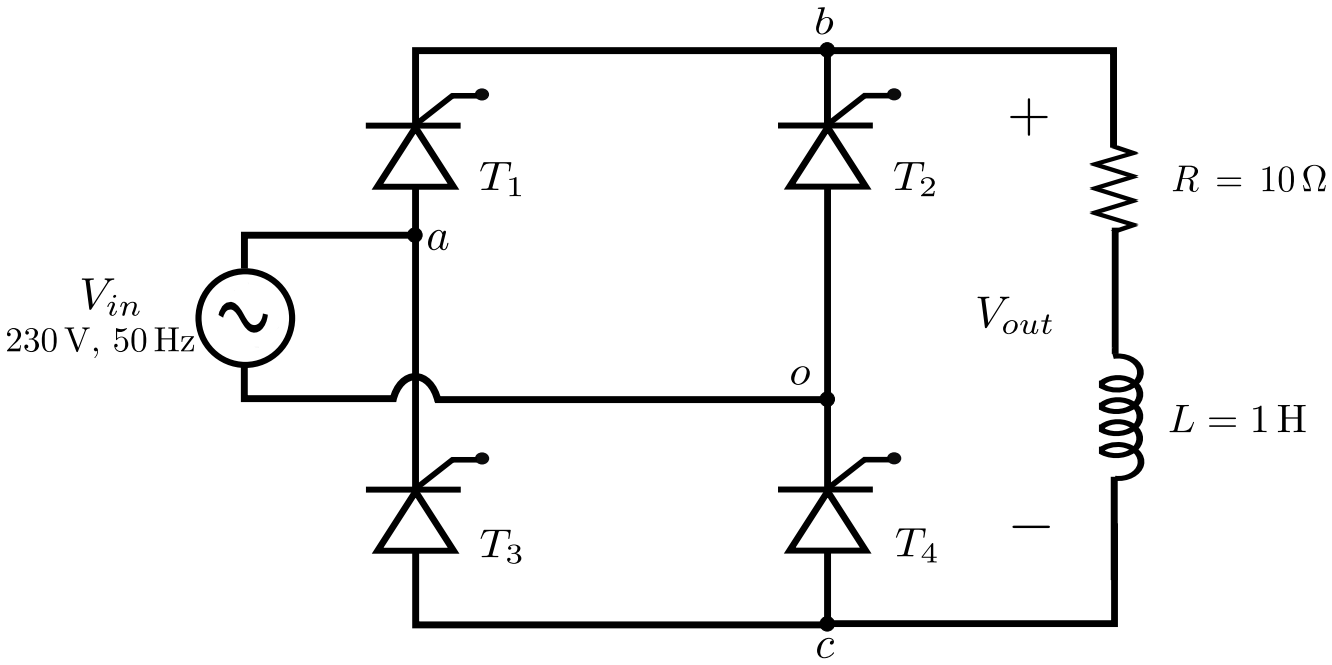

Figure 1: Fully controlled rectifier with RL load.

Solution:

(a) For the circuit shown in Fig. 1, thyristors T_1 and T_4 are fired at α in the positive half cycle of V_{in} and thyristors T_2 and T_3 are fired at $\pi+\alpha$ in the negative half cycle. Since

current is continuous through the load, either of these thyristor combinations will conduct at any time in a complete cycle, and both the combination won't conduct together as one thyristor combination is fired when voltage across other combination is negative.

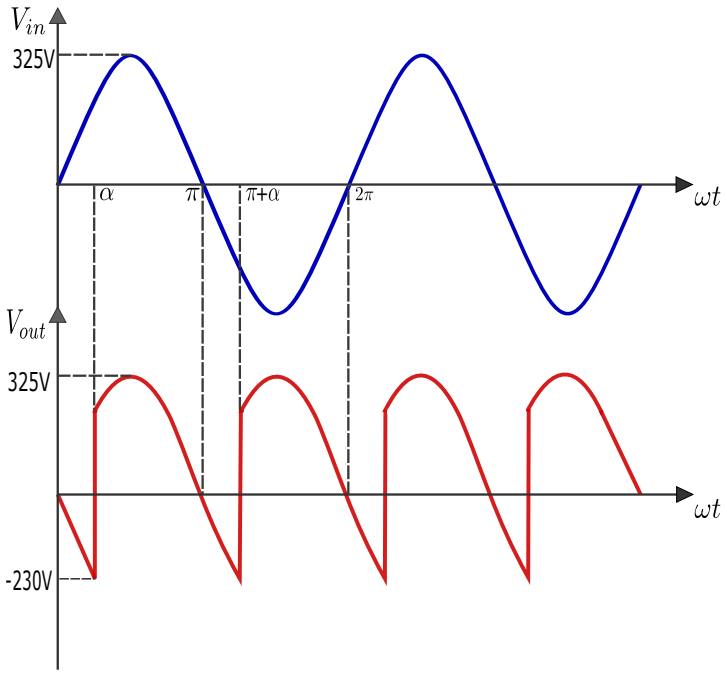

Figure 2: Plots of V_{in} and V_{out} vs ωt

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 as shown in Fig. 3

The output voltage (V_{out}) is equal to V_{in} from α to $\pi+\alpha$ and -V_{in} from $\pi+\alpha$ to $2\pi+\alpha$ and this continues (solving KVL in both conduction period). This is shown in Fig. 2.

From the graph, average output voltage,

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

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

Given, $V_{out} = 145$V.

The firing angle,

$$\alpha = \cos^{-1}\left(\frac{145\,\pi}{2 \times 230\sqrt{2}}\right) \approx 45^{\circ} \tag{3}$$

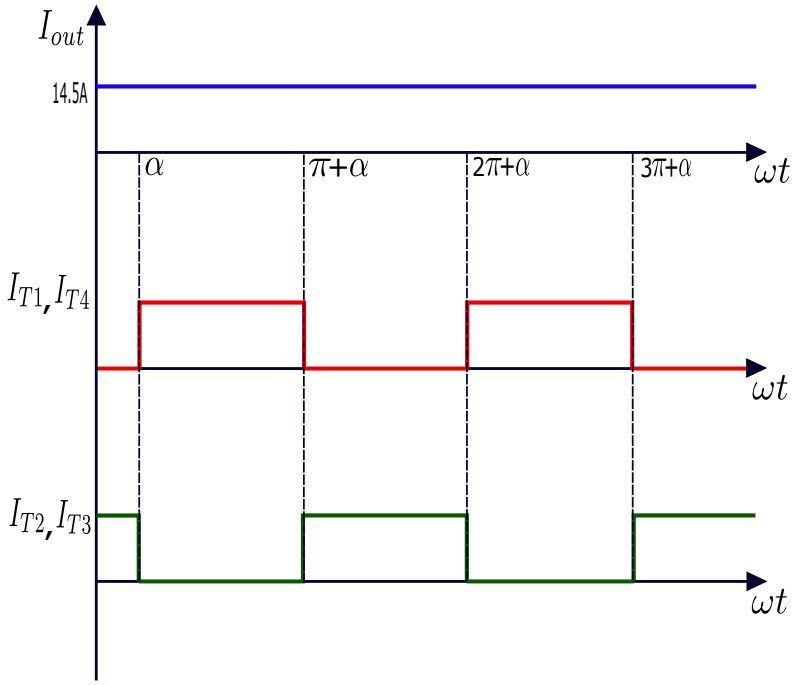

Figure 3: Plots of I_{out}, I_{T1}, I_{T2}, I_{T3}, I_{T4} vs ωt

(b) In the plots shown in Fig. 3, we noticed that the average value of current through all the thyristors are same since amplitude and time duration are the same. Let us denote the average current through thyristor as I_T. From the plot,

$$I_T = \frac{I_{out}\pi}{2\pi} = \frac{I_{out}}{2} \tag{4}$$

The average value of voltage across inductor is zero in a complete cycle.

$$I_{out} = \frac{V_{out}}{R} \tag{5}$$

From (4) and (5)

$$I_T = \frac{V_{out}}{2R} = 7.25\text{A} \tag{6}$$

SequelApp Exercises:

For the circuit shown in Fig. 1, find the value of the firing angle (α) of the thyristor for the following cases:

(a) Average output voltage $V_{out} = 100$V.

(b) Average thyristor current $I_T = 6$A.

Values of V_{in}, R, L are as shown in Fig. 1. Verify your answers using SequelApp.