Single Phase Asymmetrical Semi-Controlled Rectifier - 1 (PE_rectifier_10.sqproj)

Question: For the circuit shown in Fig. 1,

(a) Find the average output voltage (V_{out}) for the firing angle $\alpha = 30°$.

(b) Find the RMS values of current through thyristors and diodes.

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

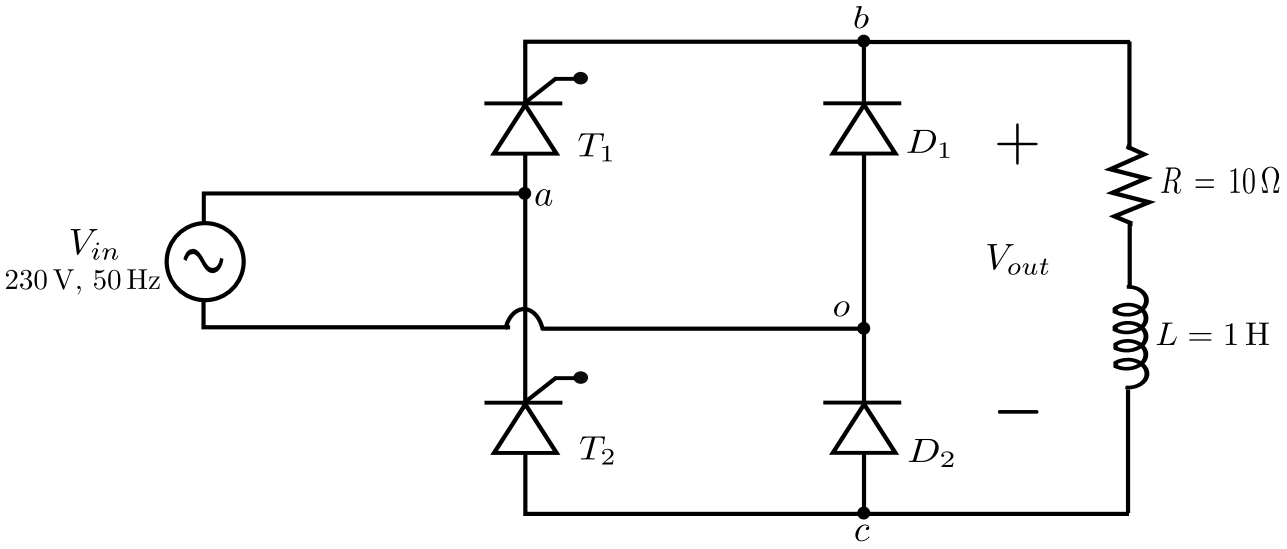

Figure 1: Asymmetrical Semi-Controlled rectifier with RL load.

Solution:

(a) For a 1-phase asymmetrical semi-controlled rectifier shown in Fig. 1,the thyristor T_1 is fired at $\alpha = 30$. From α to π thyristor T_1 and diode D_2 conduct. By solving KVL,

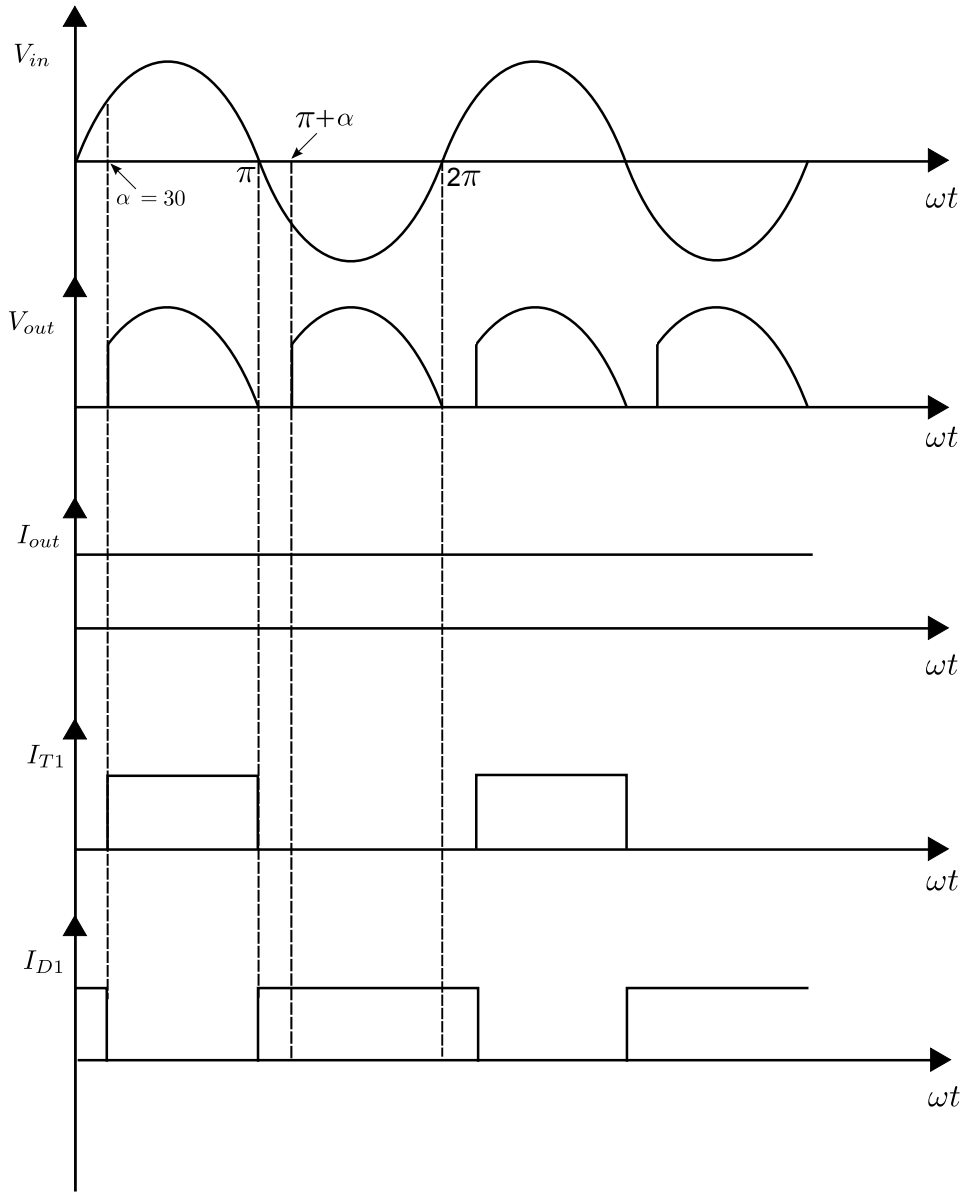

Figure 2: Plot of $V_{in}, V_{out}, I_{out}, I_{T1}, I_{D1}$

output voltage is equal to input voltage in this duration. At $\omega t = \pi$ input voltage V_{in} reverses its polarity and since current is continuous in the load, the current freewheels through D_1 and D_2 until thyristor T_2 is fired. The output voltage V_{out} is zero in this duration.

In the negative half cycle, the thyristor T_2 is fired at $\pi + \alpha$ .From $\pi + \alpha$ to 2π thyristor

T_2 and diode D_1 conduct. By solving KVL, output voltage is equal to $-V_{in}$ in this duration. At $\omega t = 2\pi$ input voltage V_{in} reverses its polarity and since current is continuous in the load, the current freewheels through D_1 and D_2 until thyristor T_1 is fired in the next cycle. The output voltage V_{out} is zero in this duration.

The output voltage waveform is shown in Fig. 2. From the waveform, the average value of output voltage,

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

$$V_{out} = \frac{230\sqrt{2}}{\pi} \left(1 + \frac{\sqrt{3}}{2}\right) = 193.2\,\text{V} \tag{2}$$

(b) The current through thyristor and diode is shown in Fig. 2.

The RMS value of thyristor current,

$$I_T^{rms} = I_{out}\sqrt{\frac{\pi - \alpha}{2\pi}} = 12.4\text{A} \tag{3}$$

The RMS value of diode current,

$$I_D^{rms} = I_{out}\sqrt{\frac{\pi + \alpha}{2\pi}} = 14.66\text{A} \tag{4}$$

SequelApp Exercises:

For the circuit in Fig. 1, find the following:

(a) The firing angle (α) required to get an RMS thyristor current of 10 A.

(b) The RMS value of diode current and the average output voltage in this case.

Verify your answers using SequelApp.