Fully Controlled Rectifier - 2 (PE_rectifier_3.sqproj)

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

(a) Find the minimum value of firing angle (α) required to turn on the thyristors.

(b) For α=45°, find the average output voltage (V_{out}), average output current (I_{out}), and power (P) delivered to the battery E.

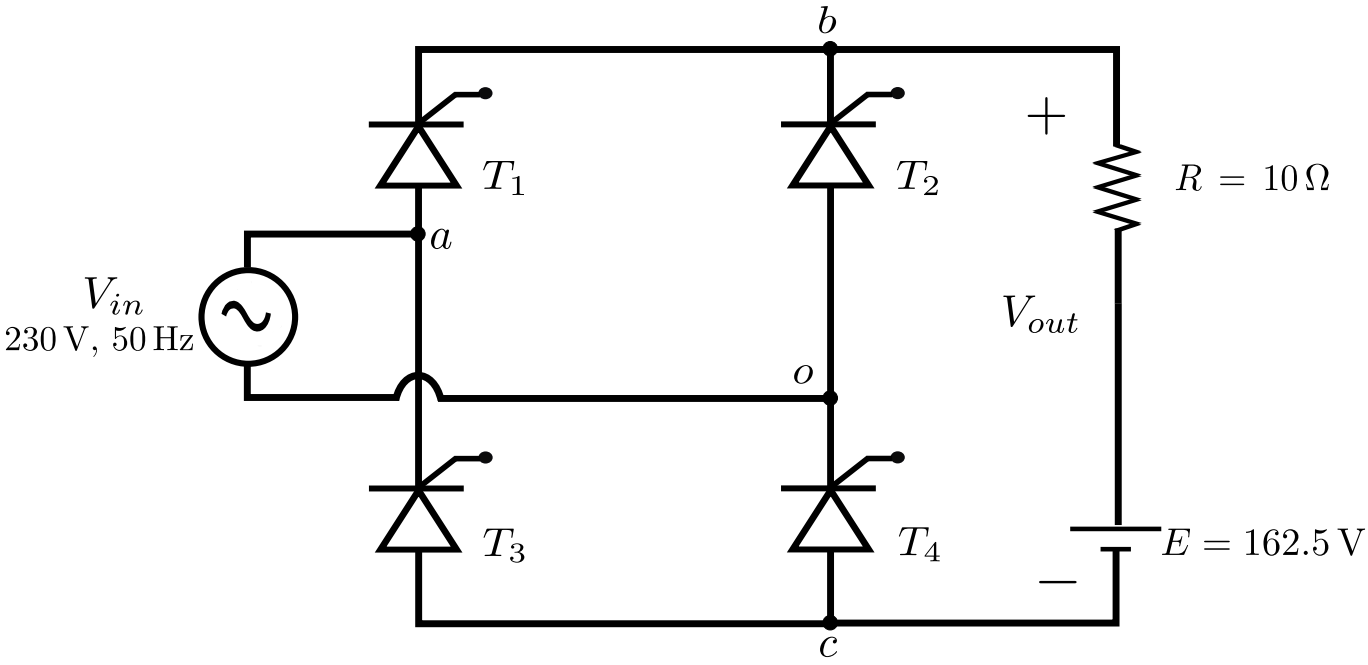

Figure 1: Fully controlled rectifier with RE load.

Solution:

(a) Let us assume the minimum firing angle as θ. We know that thyristor should be fired when the voltage across it is positive.

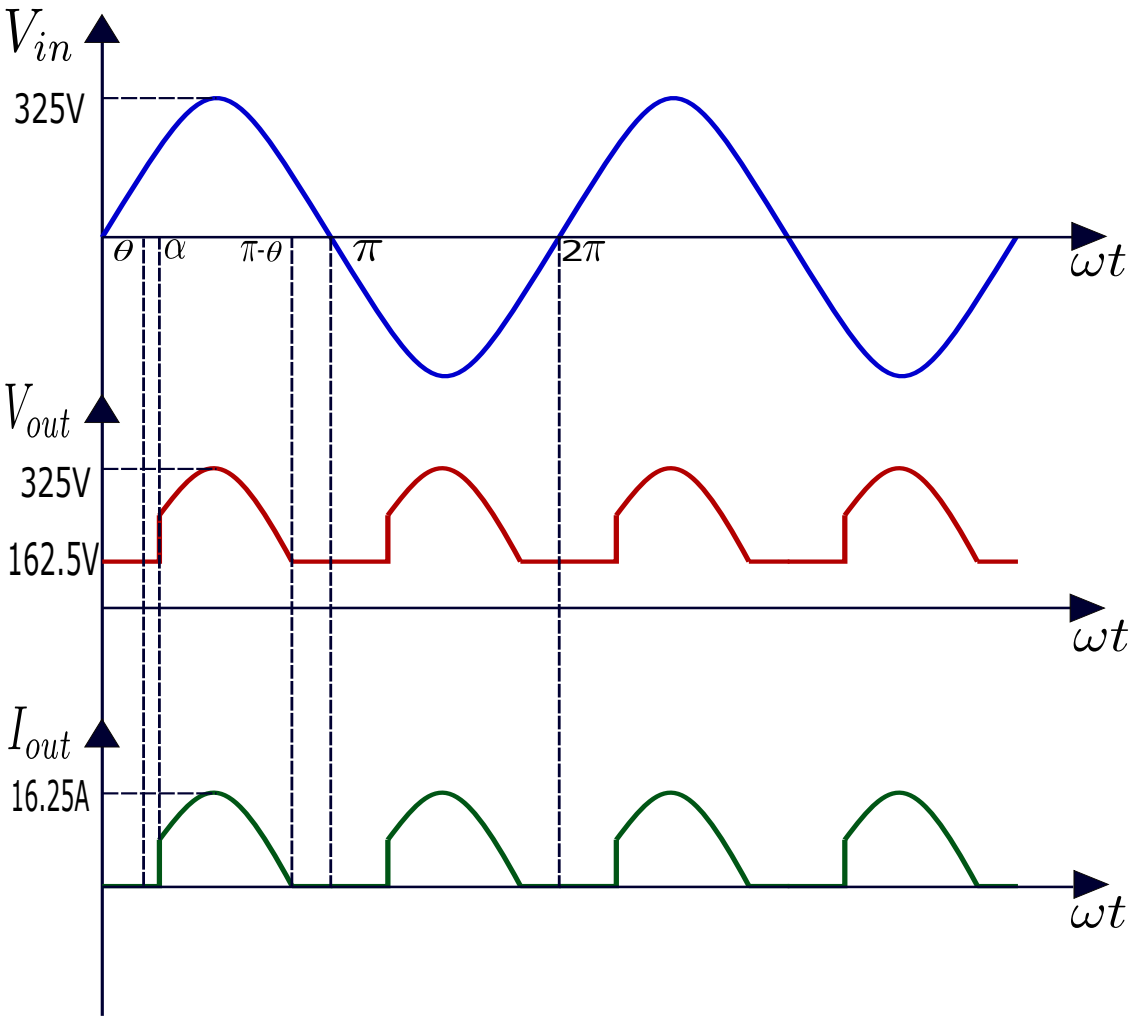

Figure 2: Plots of V_{in}, V_{out} and I_{out} vs ωt

In positive half cycle, voltage across thyristors T_1 and T_4 is negative when V_{in} is less than E and is positive when V_{in} is greater than E. Minimum firing angle, θ is the angle at which V_{in} is equal to E.

$$V_m \sin\theta = E \tag{1}$$

$$a = \sin^{-1}\left(\frac{E}{V_m}\right) \tag{2}$$

$$\theta = \sin^{-1}\left(\frac{162.5}{325}\right) = 30^\circ \tag{3}$$

(b) As shown in Fig. 2, the current starts flowing through load when thyristors are fired. i.e. from $\alpha = 45°$ and as it is RE load the thyristor turns off at 150° (the angle after which voltage across the thyristor is negative). So the load current is zero from 150° to 180°. By KVL, the output voltage is identical to input voltage when the current flows through load and it is equal to E when current does not flow. So, the average output voltage,

$$V_{out} = \frac{1}{\pi}\left(\int_0^{\pi/4} E.d\omega t + \int_{\pi/4}^{5\pi/6} V_m \sin\omega t.d\omega t + \int_{5\pi/6}^{\pi} E.d\omega t\right) \tag{4}$$

$$V_{out} = \frac{1}{\pi}\left(V_m(\cos\alpha + \cos\theta) + E(\alpha + \theta)\right) \tag{5}$$

$$V_{out} = \frac{1}{\pi}\left(325(\cos\frac{\pi}{4} + \cos\frac{\pi}{6}) + 162.5(\frac{\pi}{4} + \frac{\pi}{6})\right) = 230\text{V} \tag{6}$$

From Fig 2, the average current through load

$$I_{out} = \frac{1}{\pi R}\int_{\pi/4}^{5\pi/6}(V_m \sin\omega t - E)d\omega t \tag{7}$$

$$I_{out} = \frac{1}{10\pi}\left(V_m(\cos(\frac{\pi}{4}) - \cos(\frac{5\pi}{6})) - E(\frac{5\pi}{6} - \frac{\pi}{4})\right) = 6.75\text{A} \tag{8}$$

The power delivered to DC source E,

$$P = E \times I_{out} = 1.09\text{KW} \tag{9}$$

SequelApp Exercises:

For the circuit shown in Fig. 1, Find the Average output voltage (V_{out}) and power delivered (P) to DC source for the following cases other circuit parameters same as in figure.

(a) The firing angle $\alpha = 60$.

(b) $E = 200\,\text{V}$ and firing angle $\alpha = 60$.

Verify your answers using SequelApp.