AC voltage controller - 1 (PE_AC_Controller_1.sqproj)

Question: For the single phase AC voltage controller shown in Fig. 1,

(a) Find the minimum firing angle (α) which will enable control of power flow into the load.

(b) For the above firing angle, find the power transferred to the load and the source power factor.

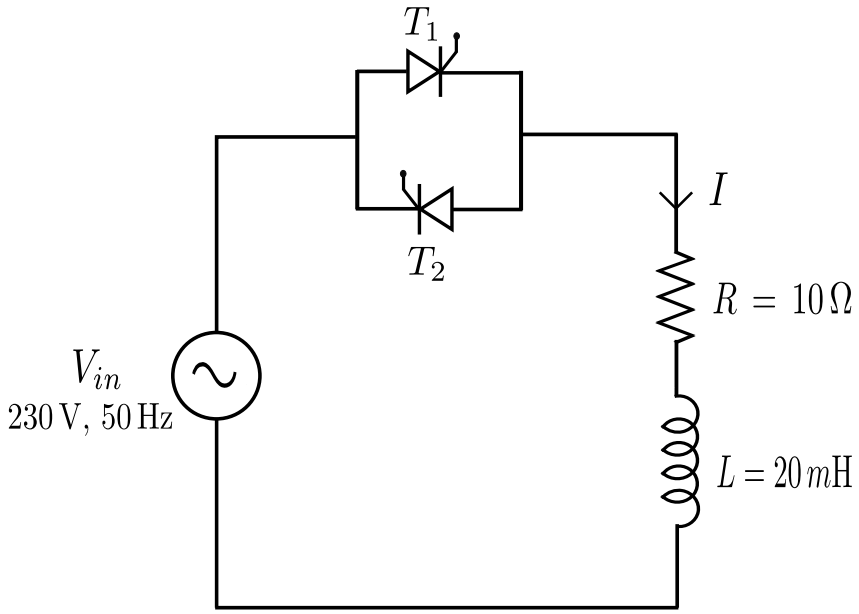

Figure 1: Single phase AC voltage controller

Solution:

(a) For the circuit shown in Fig. 1, the thyristor T_1 is forward biased during $\omega t = 0$ to π. The firing angle α should be in this interval. At $\omega t = \pi$ the source and load voltages are zero, but load current is non-zero due to the presence of inductance. The current still flows through thyristor T_1 until the extinction angle β. Thyristor T_2 cannot be fired until β since it is reverse biased by voltage drop in T_1.

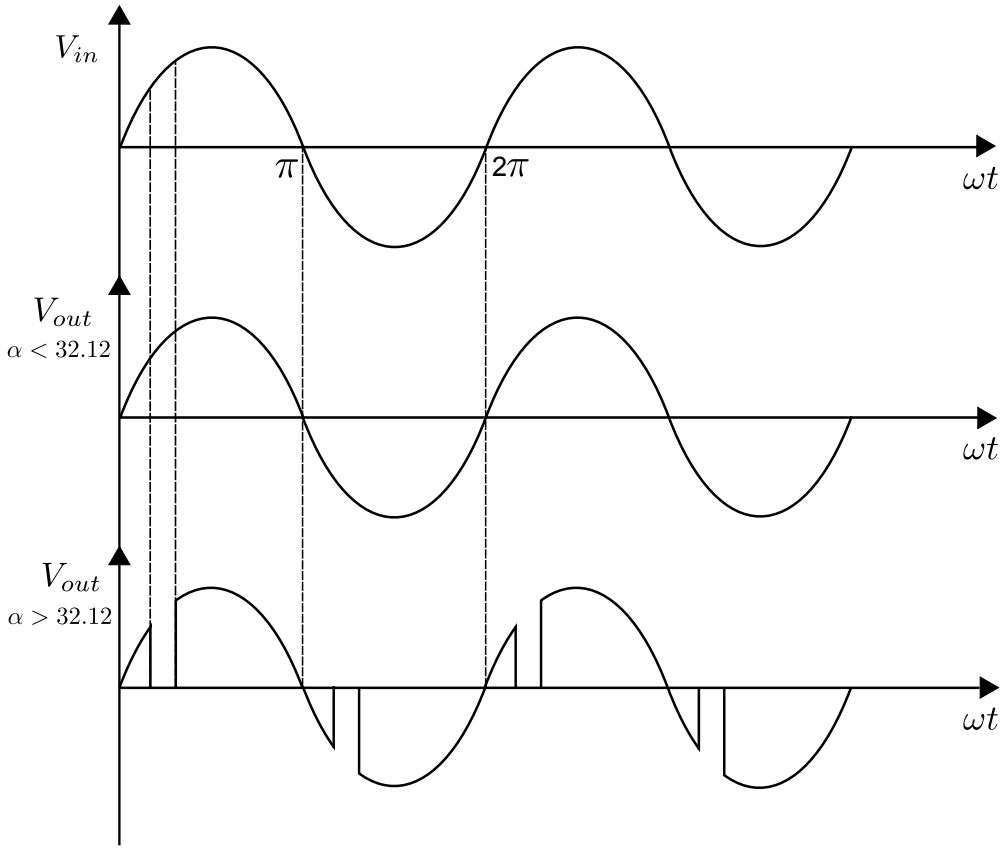

Figure 2: Output waveforms of single phase AC voltage controller

Solving KVL for the circuit.

For $\alpha < \omega t < \beta$,

$$V_{out} = V_m \sin(\omega t) = RI + L\frac{dI}{dt} \tag{1}$$

The solution of this equation,

$$I = \frac{V_m}{Z}\sin(\omega t - \phi) + Ae^{(-R/L)t} \tag{2}$$

where,

$$Z = \sqrt{(R^2 + \omega L^2)} \tag{3}$$

$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right) \tag{4}$$

The current flows through thyristor for ϕ duration after the source voltage reverses its polarity. So this is the minimum firing angle α of the circuit. The minimum firing angle required for controlling the power flow to load,

$$\alpha = \tan^{-1}\left(\frac{\omega L}{R}\right) = 32.12^{\circ} \tag{5}$$

(b) The current through the load for $\alpha = 32.12$,

$$I_{rms} = \frac{V_{in}}{Z} = \frac{230}{11.8} = 19.5\,\text{A} \tag{6}$$

The power transferred to the load for $\alpha = 32.12$,

$$P = I_{rms}^2 R = 3.8\,k\text{W} \tag{7}$$

As thyristors are considered as ideal and lossless, input power is equal to output power.

$$V_{in} I_{rms} \cos\phi = I_{rms}^2 R \tag{8}$$

The power factor for $\alpha = 32.12$,

$$\cos\phi = \frac{I_{rms}^2 R}{I_{rms} V_{in}} = 0.847 \tag{9}$$

SequelApp Exercises:

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

(a) The value of R required to enable control power flow into the load at a firing angle $\alpha = 20^{\circ}$.

(b) For the above firing angle, find the power transferred to the load and the source power factor.

Verify your answers using SequelApp.