Diode circuits-4 (`EC_diode_4.sqproj`)

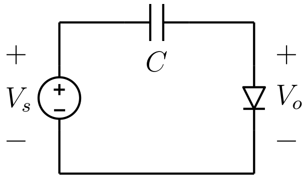

Figure 1: Diode circuit example.

Question: In the diode circuit shown in Fig. 1, the input voltage is $V_s = V_m \sin \omega t$, with $V_m = 5\,\mathrm{V}$ and $f = 1\,\mathrm{kHz}$. Plot $V_o(t)$ in steady state. Assume $V_{\mathrm{on}} = 0.7\,\mathrm{V}$ for the diode.

Solution:

Let us assume that the capacitor is initially uncharged, i.e., $V_c = 0\,\mathrm{V}$ at $t = 0$. When V_s increases beyond $V_{\mathrm{on}} = 0.7\,\mathrm{V}$, the diode conducts, and the capacitor charges. The charging time constant is small because of the small diode resistance in the conducting state. In other words, we can assume the charging to happen *instantaneously*, i.e., $V_c(t)$ would simply follow $V_s(t)$ except that a voltage V_{on} gets dropped across the diode. During this time, $V_c(t)$ is given by

$$V_c(t) = V_s(t) - V_{\mathrm{on}}. \tag{1}$$

The output voltage remains equal to V_{on} up to $t = T/4$ (0.25 msec in Fig. 2).

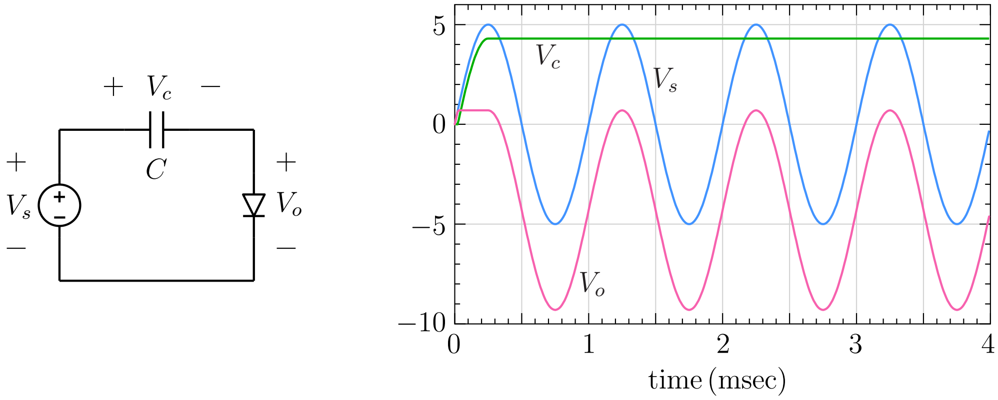

Figure 2: V_s, V_c, V_o versus time for the circuit of Fig. 1, assuming the capacitor to be initially uncharged.

At $t = T/4$, V_c has reached its maximum value. After this point, V_c stays constant because, for V_c to decrease, the diode needs to conduct in the reverse direction which is not possible. The output voltage in the steady state is therefore

$$V_o(t) = V_s(t) - V_c^{\text{max}} = V_s(t) - (V_m - V_{\text{on}}), \tag{2}$$

a level-shifted version of the input voltage, as seen in Fig. 2.

SequelApp Exercise: What are the maximum and minimum values of $V_o(t)$ (in steady state) in the following cases? Verify your answers using SequelApp.

1. $V_s(t) = (5 + 5\,\sin\omega t)$ Volts.
2. $V_s(t) = (1 + 5\,\sin\omega t)$ Volts.
3. Let the input voltage be $V_s = V_m\,\sin\omega t$. For the minimum output voltage to be $-5\,\text{V}$, what value of V_m is required?
4. With V_m the same as that obtained in Q-3, suppose we now add a DC bias $V_{DC} = 2\,\text{V}$ to the input voltage. How will $V_o(t)$ change?