Tutorial 6 Semiconductor diodes

Question 1: for the diode circuit as shown in Figure 1, sketch the output voltage v_o for a sinusoidal input signal v_I. Assume the capacitor is initially uncharged, and RC time constant is large.

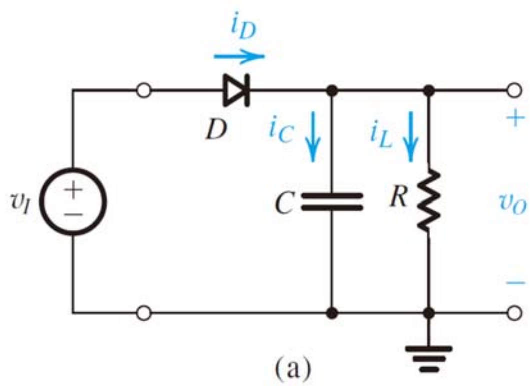
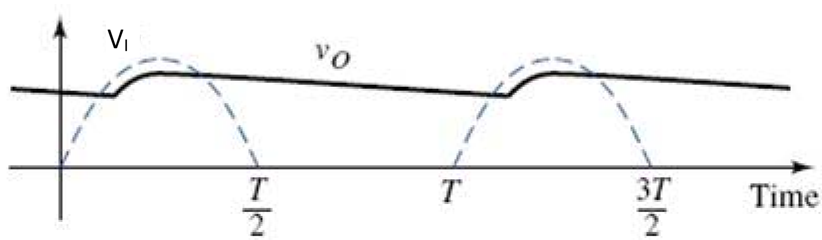


Figure 1

Solution:

When the signal voltage reaches its peak and begins to decrease, the voltage across the capacitor also starts to decrease, which means the capacitor starts to discharge. The only discharge current path is through the resistor. If the RC time constant is large, the voltage across the capacitor discharges exponentially with time. During this time period, the diode is cut-off. If the RC time constant is large, there is only a small difference between the time of the peak input voltage and the time the diode turns off.

During the next positive cycle of the input voltage, there is a point at which the input voltage is greater than the capacitor voltage, and the diode turns back on. The diode remains on until the input reaches its peak value and the ca-pacitor voltage is completely recharged. Since the capacitor filters out a large portion of the sinusoidal signal, it is called a filter capacitor. The steady-state output voltage of the RC filter is shown as follows.



Question 2.

In the circuit shown in figure 2 find the diode current i_d, assuming the diode current voltage relationship can be approximated in this situation by $i_d \sim 10^{-5}(e^{40v_d})$. Note: don't take the diode as a simple switch with constant turn-on voltage in this question.

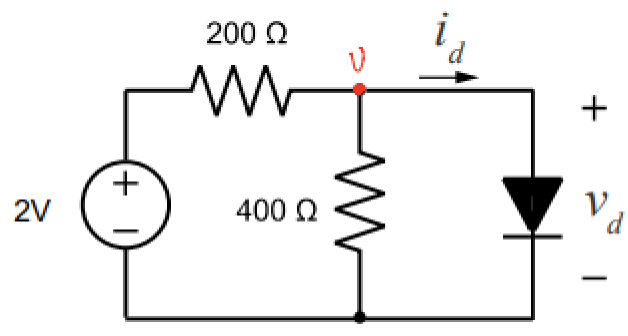


Figure 2.

Solution:

Use Thevenin equivalent theorem to simplify linear part of circuit:

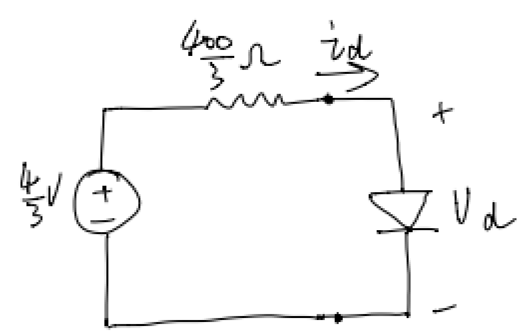
a. Find open-circuit voltage by applying voltage division:

$$v_1 = \frac{400}{400 + 200} \times 2 = 1.33V$$

b. Find equivalent resistor by moving source:

$$R_{th} = \frac{200 \times 400}{200 + 400} = 133.33\ \Omega$$

The Thevenin equivalent circuit becomes:



For the linear part of circuit, i and v must satisfy:

$$v_d = 1.33 - 133i_d \quad or \quad i_d = 0.01 - 7.52 \times 10^{-3} v_d$$

For diode, $i_d = 10^{-5}(e^{40v_d})$. Thus,

$$i_d = 0.01 - 7.52 \times 10^{-3} v_d = 10^{-5}(e^{40v_d})$$

Solving this equation for v_d gives:

$$v_d = 0.1693\ V$$