HW5 Solutions

Part 1 (Practice Problems):

Q1. Textbook Problem 9.6

Sketch *i* versus *v* to scale for the circuits shown in Figure P9.6. The reverse-breakdown voltages of the Zener diodes are shown. Assume voltages of 0.6V for all diodes including the Zener diodes when current flows in the forward direction.

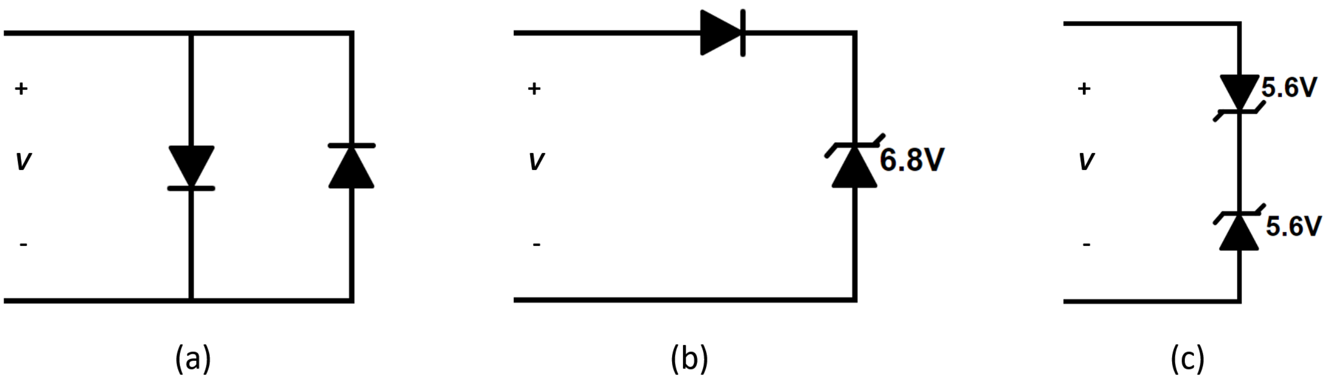
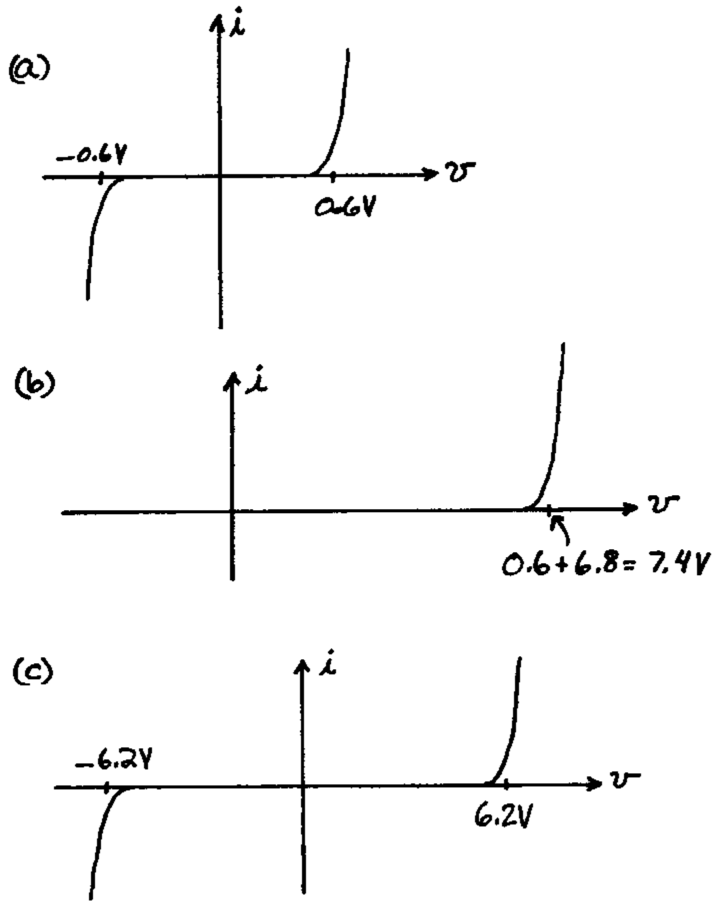


Figure P9.6

Solution:



Q2. Textbook Problem 9.37

Find the values of *I* and *V* for the circuits of Figure P9.37, assuming that the diodes are ideal.

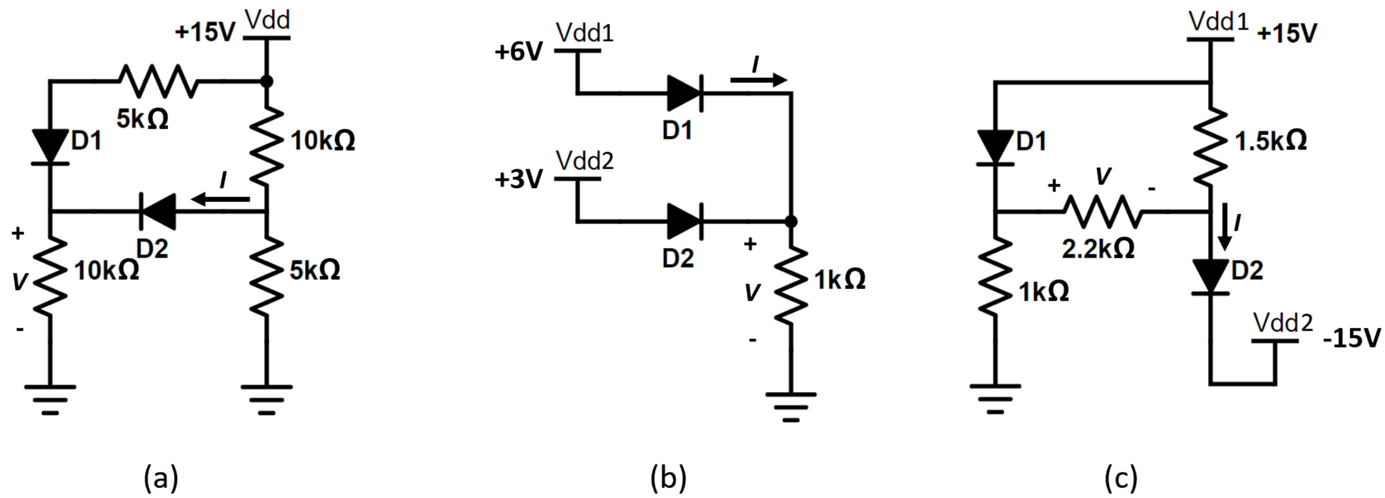


Figure P9.37

Solution:

(a) D_1 is on and D_2 is off. $V = 10V$ and $I = 0A$.
(b) D_1 is on and D_2 is off. $V = 6V$ and $I = 6mA$.
(c) Both D_1 and D_2 are on. $V = 30V$ and $I = 33.6mA$.

Q3. Textbook Problem 9.59

Consider the battery-charging circuit shown in Figure 9.25 on page 476, in which $v_s(t) = 20\sin(200\pi t)$, $R = 80\Omega$, $V_B = 12V$, and the diode is ideal.

a. Sketch the current $i(t)$ to scale versus time.
b. Determine the average charging current for the battery.

[Hint: The average current is the charge that flows through the battery in one cycle divided by the period.]

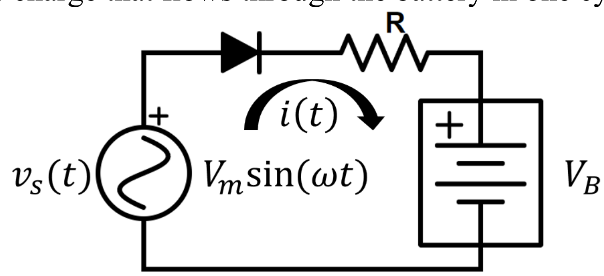


Figure 9.25

Solution:

(a) The current pulse starts and ends at the times for which

$$v_s(t) = V_B$$
$$20\sin(200\pi t) = 12$$

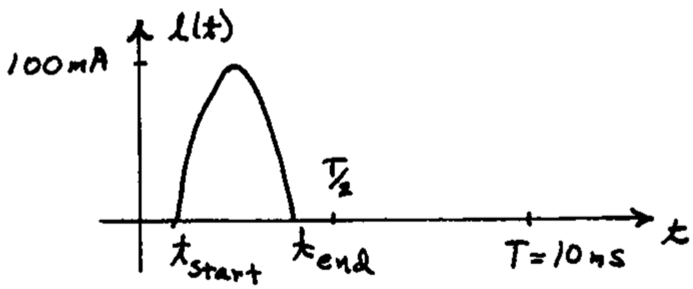
Solving, we find that

$$t_{start} = \frac{\sin^{-1}(0.6)}{200\pi} = 1.024ms$$
$$t_{end} = \frac{T}{2} - t_{start} = 3.976ms$$

Between these two times, the current is

$$i(t) = \frac{20\sin(200\pi t) - 12}{80}$$

A sketch of the current to scale versus time is



(b) The charge flowing through the battery in one period is

$$Q = \int_{t_{start}}^{t_{end}} i(t)dt = \int_{t_{start}}^{t_{end}} \frac{20\sin(200\pi t) - 12}{80} dt = \left[-\frac{1}{800\pi}\cos(200\pi t) - \frac{12t}{80}\right]_{t_{start}}^{t_{end}}$$
$$Q = 194\mu C$$

Finally, the average current is the charge divided by the period.

$$I_{avg} = \frac{Q}{T} = \frac{194 \times 10^{-6}}{10 \times 10^{-3}} = 19.4mA$$

Q4. Textbook Problem 9.63

Sketch to scale the output waveform for the circuit shown in Figure P9.63. Assume that the diodes are ideal.

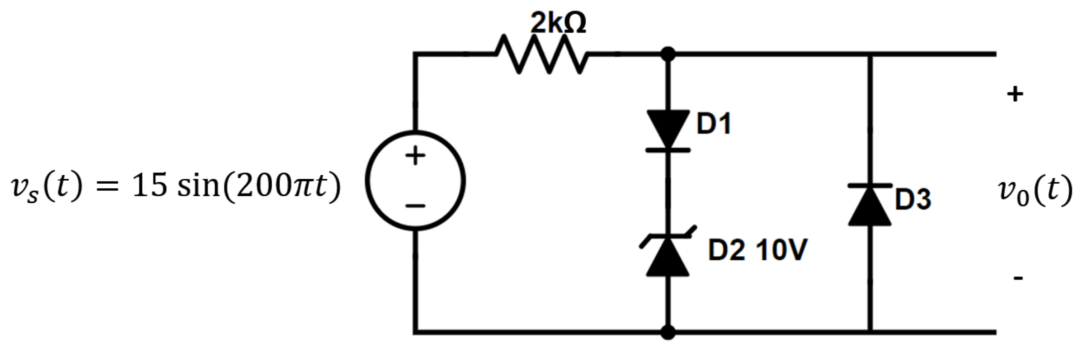
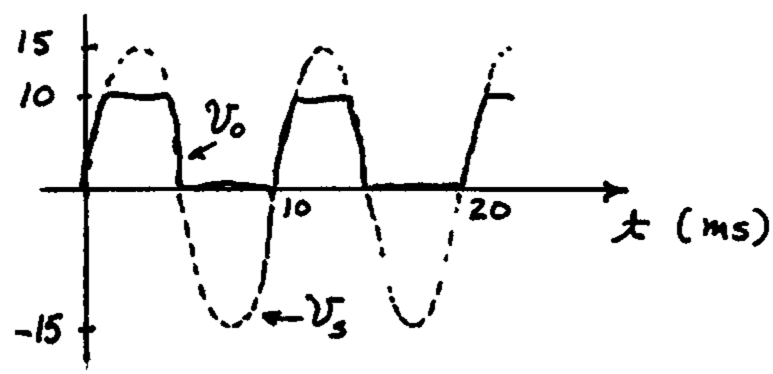


Figure P9.63

Solution:

When the source voltage is negative, diode D_3 is on and the output $v_0(t)$ is zero. For source voltages between 0 and $10V$, none of the diodes conducts and $v_0(t) = v_s(t)$. Finally, when the source voltage exceeds $10V$, D_1 is on and D_2 is in the breakdown region so the output voltage is $10V$. The waveform is:



Q5. Textbook Problem 9.28

Consider the voltage regulator shown in Figure P9.28. The source voltage V_s varies from 10 to 14V, and the load current i_L varies from 50 to 100mA. Assume that the Zener diode is ideal. Determine the largest value allowed for the resistance R_s so that the load voltage v_L remains constant with variations in load current and source voltage. Determine the maximum power dissipation in R_s.

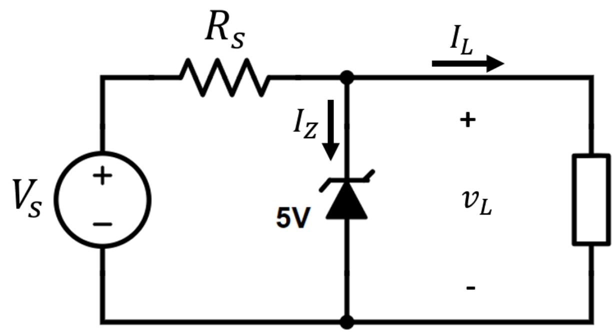


Figure 9.28

Solution:

We need to choose R_s so the minimum reverse current through the Zener diode is zero. Minimum current through the Zener occurs with minimum V_s and maximum i_L. Also, we can write:

$$i_Z = \frac{V_s - v_L}{R_s} - i_L$$

Substituting values, we have

$$i_Z = 0 = \frac{10 - 5}{R_s} - 0.1$$

Solving for the resistance, we find $R_s = 50\Omega$.

Maximum power dissipation in the resistance occurs for maximum V_S.

$$P_{max} = \frac{\left(V_{s,max} - v_L\right)^2}{R_s} = \frac{(14 - 5)^2}{R_s} = 1.62W$$