

ASSIGNMENT #3
(9.17, 9.38, 9.43, 9.50, 9.60) - F

Problem 9.17

Solution:

Known quantities:

The circuit of Figure P9.16 using the offset diode model.

Find:

A plot of v_L versus v_S .

Analysis:

The circuit can be represented as shown in the following on the right.

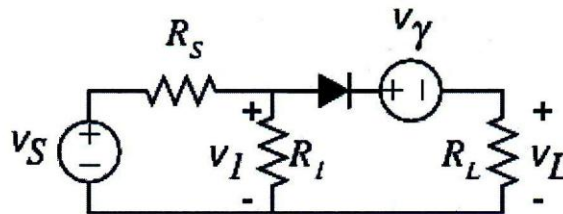
For $v_1 < V_\gamma$, the diode is reverse biased, and

$$v_L = 0.$$

In term of v_S , we have

$$v_L = 0 \Leftrightarrow v_S < V_\gamma \left(1 + \frac{R_S}{R_1}\right)$$

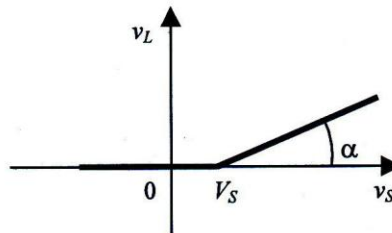
For $v_1 \geq V_\gamma$, i.e. $v_S \geq V_\gamma \left(1 + \frac{R_S}{R_1}\right)$ the diode is forward biased, and



$$v_1 = \frac{\frac{v_S}{R_S} + \frac{V_\gamma}{R_L}}{\frac{1}{R_S} + \frac{1}{R_1} + \frac{1}{R_L}}$$

$$v_L = v_1 - V_\gamma = \frac{\frac{v_S}{R_S} - V_\gamma \left(\frac{1}{R_S} + \frac{1}{R_1}\right)}{\frac{1}{R_S} + \frac{1}{R_1} + \frac{1}{R_L}}$$

$$\text{Where } V_S = V_\gamma \left(1 + \frac{R_S}{R_1}\right), \alpha = \tan^{-1} \left(\frac{\frac{1}{R_S}}{\frac{1}{R_S} + \frac{1}{R_1} + \frac{1}{R_L}} \right)$$



Problem 9.38

Solution:

Known quantities:

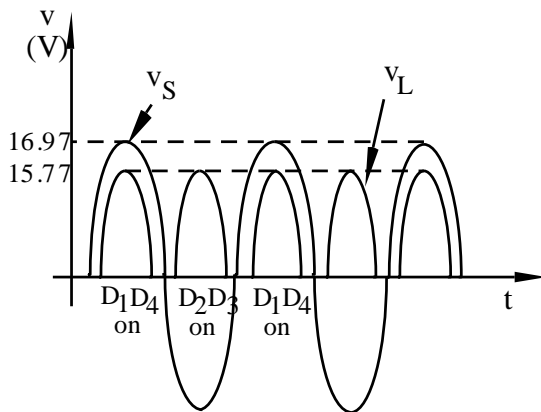
The full-wave rectifier of Figure P9.38, with a 12 V rms supply.

Find:

- Sketch the input source voltage $v_S(t)$, and the output voltage $v_L(t)$, and state which diodes are on and which are off if the diodes have an offset voltage of 0.6 V and the frequency of the source is 60 Hz.
- Sketch the output voltage if $R_L = 1,000 \Omega$ and a capacitor, placed across R_L to provide some filtering, has a value of 8 :F.
- As part b, with the capacitance equal to 100 :F.

Analysis:

- The input source voltage is shown below, together with the rectified load voltage. (12 V rms = 16.97 V peak)



- The time constant, $\mathcal{G} = CR$, is: $CR = 1000 \times 8 \times 10^{-6} = 8 \text{ ms}$.

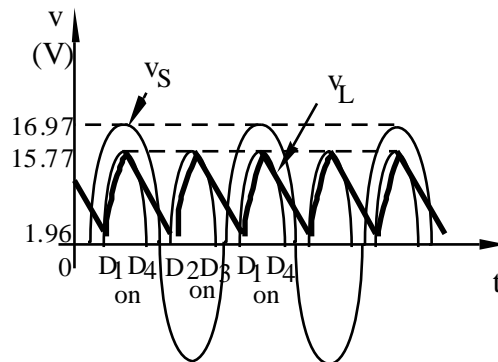
The period of the input sinusoid is: $T = \frac{1}{f} = \frac{1}{60} = 16.7 \text{ ms}$.

Since the capacitor initial voltage is: $v_C(0) = 16.97 - 1.2 = 15.77 \text{ V}$, and the final value is $v_C(\infty) = 0 \text{ V}$

$v_C(t)$ is given by: $v_C(t) = 15.77 e^{-t/\tau}$.

Therefore, at $t = T$, we have $v_C(T) = 15.77 e^{-T/\tau} = 1.96 \text{ V}$.

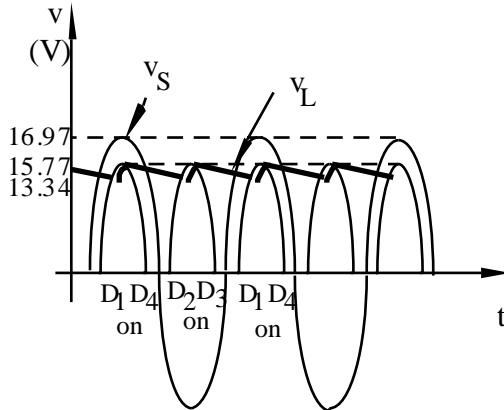
The output waveform is shown below:



(c) The time constant is $CR = 1000 \times 100 \times 10^{-6} = 100 \text{ ms}$.

Note that $CR \gg T$; $v_C(0) = 16.97 - 1.2 = 15.77 \text{ V}$, and the final value is $v_C(\infty) = 0 \text{ V}$; $v_C(t)$ is given by: $v_C(t) = 15.77 e^{-t/\tau}$ and therefore $v_C(T) = 15.77 e^{-T/\tau} = 13.34 \text{ V}$.

The output waveform is shown below.



Problem 9.43

Solution:

Known quantities:

The full-wave power supply of Figure P9.43. The diodes are 1N461 with a rated peak reverse voltage equal to 25 V, and are fabricated from Silicon. $n = 0.05883$, $C = 80 \mu\text{F}$, $V_{line} = 170 \cos(377t) \text{ V}$.

Find:

- The actual peak reverse voltage across each diode.
- The reasons for which these diodes are or are not suitable for the specification given.

Analysis:

a) At $Tt = 0$, $D1$ is on. At $Tt = B$, $D1$ is off and the reverse voltage across it is maximum.

$$V_{so} = V_{io} n = 170 \cdot 0.05883 = 10 \text{ V}$$

$$\text{KVL: } -v_{s1}(t) + v_{D1} + v_L(t) = 0$$

$$\text{At } Tt = 0, -V_{so} + V_{D-on} + V_m = 0 \Rightarrow V_m = V_{so} - V_{D-on} = 10 - 0.7 = 9.3 \text{ V}$$

$$\text{At } Tt = B, -(-V_{so}) + V_{D1} + V_m = 0 \Rightarrow V_{D1} = -V_{so} - V_m = -10 - 9.3 = -19.3 \text{ V}$$

b) The actual peak reverse voltage (19.3 V) is less than the rated peak reverse voltage (25 V) by a barely adequate margin of safety. Therefore, the diodes are suitable for the specifications given.

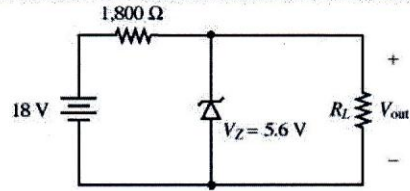
Problem 9.50

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Solution:

Known quantities:

Figure P9.50. The output voltage at 5.6 V.



Find:

Determine the minimum value of R_L for which the output voltage remains at just 5.6 V.

Analysis:

$$\frac{R_{L_{\min}}}{R_{L_{\min}} + 1800} (18) = 5.6 \Rightarrow 12.4 R_{L_{\min}} = 10080 \Rightarrow R_{L_{\min}} = 812.9 \Omega$$

Problem 9.60

Solution:

Known quantities:

The circuit of Figure P9.60(b); Zener diode i-v character; $V_Z = 0.77V$;

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Find:

The output voltage V_{out} .

Analysis:

(a) The voltage across the diode is

$$V_Z = V_S \frac{50 + 50}{100 + 50 + 50} = 6 < 7.7 \text{ V}$$

Therefore, the Zener diode is off. Thus, the output voltage is:

$$V_{out} = 6 \frac{50}{100} = 3 \text{ V}$$

(b) The voltage across the diode is

$$V_Z = 20 \frac{100}{200} = 10 > 7.7 \text{ V}$$

In this case, the Zener diode is on and the output voltage is:

$$V_{out} = 7.7 \frac{50}{100} = 3.85 \text{ V}$$

