MECH 368 – ELECTRONICS FOR MECHANICAL ENGINEERS

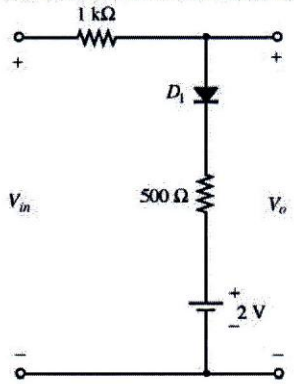
ASSIGNMENT #2
(9.14, 9.22, 9.23, 9.33, 9.56, 9.61, 9.63) - F

Problem 9.14

Solution:

Known quantities:

The circuit of figure of P9.14.



Find:

The range of V_{in} for a forward-biased D_1.

Analysis:

Assume diode D_1 is conducting; the diode current is

$$I = \frac{V_{in} - 2}{1500} \geq 0$$

Since the current is positive, the initial assumption was correct. Therefore, the range of V_{in} is: $V_{in} \geq 2V$.

Problem 9.22

Solution:

Known quantities:
The circuit of Figure P9.22.

Find:

The range of V_{in} for which D_1 is forward biased

Assumptions:
The diodes are ideal.

Analysis:

If diode D_2 is conducting, the voltage at the node to the left of D_1 will be 5 V and D_1 will conduct. To ensure that D_2 is conducting, voltage V_{in} must be greater than 5 V.

Assume D_2 is cut off. D_1 will conduct as long as V_{in} is greater than zero. Thus, the value for D_1 to conduct is

$V_{in} > 0$

Problem 9.23

Solution:

Known quantities:
The configurations of Figure P9.23.

Find:
Determine which diodes are forward-biased and which are reverse-biased. Determine the output voltage.

Assumptions:
The drop across each forward biased diode is 0.7 V.

Analysis:

a) D_2 **and** D_4 **are forward biased;** D_1 **and** D_3 **are reverse biased.**

$$v_{out} = -5 + 0.7 = -4.3 \text{ V}$$

b) D_1 **and** D_2 **are reverse biased;** D_3 **is forward biased.**

$$v_{out} = -10 + 0.7 = -9.3 \text{ V}$$

The figure corresponding to the question is wrong. The –10V supply should be +10V.

c) Correct Answer: D_2 **is reverse biased;** D_1 **is forward biased.**

$$v_{out} = -5 + 0.7 = -4.3 \text{ V}$$

Problem 9.33

Solution:

Known quantities:
The circuit of Figure P9.33. The input voltage is sinusoidal with an amplitude of 5 V.

Find:
The average value of the output voltage.

Assumptions:
$V_\gamma = 0.7 \text{ V}$.

Analysis:

The capacitor will charge to $5 \text{ V} - 0.7 \text{ V} = 4.3 \text{ V}$ **and, therefore, the input sine wave will be shifted up 4.3 V to produce the output. As a result, after the cycle (the capacitor builds up its stored charge during the third quarter cycle), the average value of the output will be 4.3 V.**

Problem 9.56

Solution:

Known quantities:

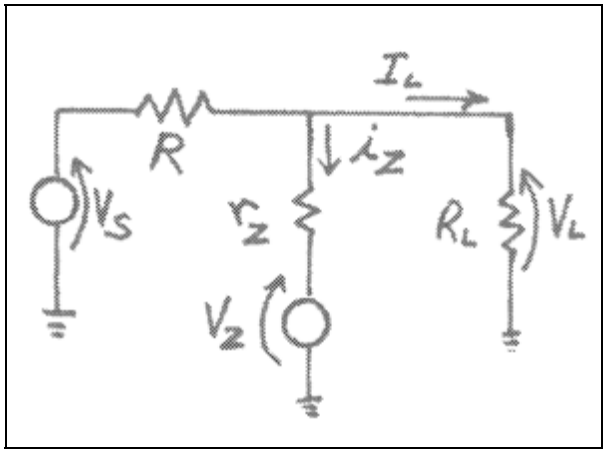
$V_Z = 12\,\mathbf{V} \pm 10\%$, $R_Z = 9\,\Omega$, $I_{Z-\min} = 3.25\,\mathbf{mA}$, $I_{Z-max} = 80$ mA, $V_S = 25 \pm 1.5\,\mathbf{V}$, $I_L = 31.5 \pm 21.5\,\mathbf{mA}$.

Find:

Determine the maximum and minimum value of R to maintain the Zener diode current within its specified limits.

Analysis:

Construct DC equivalent circuit:



$$KCL \quad \frac{V_L - V_S}{R} + I_Z + I_L = 0$$

$$KVL \quad -V_Z - I_Z R_Z + V_L = 0$$

Then:

$$V_L = V_Z + I_Z R_Z$$

$$R = \frac{V_S - V_L}{I_Z + I_L} = \frac{V_S - V_Z - I_Z R_Z}{I_Z + I_L}$$

A maximum Zener current is caused by:

Minimum value of R
Maximum source voltage
Minimum load current
Minimum Zener voltage.

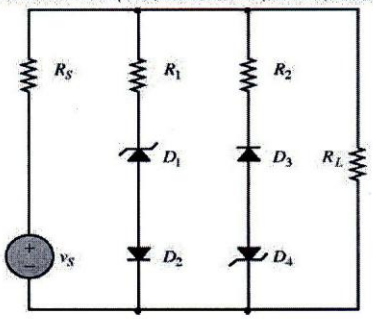
$$R_{\min} = \frac{V_{S-\max} - V_{Z-\min} - I_{Z-\max} R_Z}{I_{Z-\max} + I_{L-\min}} = 166.4\ \mathbf{\Omega}$$

A minimum Zener current is caused by:

Maximum value of R **Minimum source voltage**
Maximum load current **Maximum Zener voltage.**

$$R_{\max} = \frac{V_{S-\min x} - V_{Z-\max} - I_{Z-\min} R_Z}{I_{Z-\min} + I_{L-\max}} = 182.6\ \Omega$$

Problem 9.61



Solution:

Known quantities:

The voltage limiter circuit of Figure P9.61;

Find:

Plot R_L versus v_S.

Analysis:

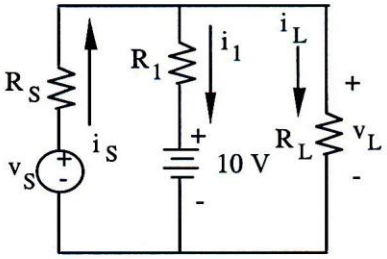
Three cases need to be considered:

(a) When $V_L > 10$ V, D_1 will conduct

(b) When $V_L < -5$ V, D_4 will conduct

(c) When $-5\text{ V} < V_L < 10\text{ V}$, all 4 diodes will be cut off.

For case (a), the circuit is shown on the right.



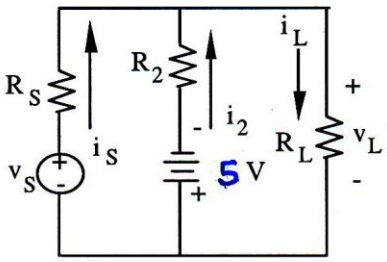
By KCL, $i_S = i_1 + i_I$, and

$$\frac{V_S - V_L}{10} = \frac{V_L - 10}{1} + \frac{V_L}{40}$$

Therefore, $V_L = \dfrac{4V_S + 400}{45}$ V

$V_S > 12.5$ V

For case (b), the circuit is shown on the right.



By KCL, $i_S + i_2 = i_L$, and

$$\frac{V_S - V_L}{10} + \frac{-5 - V_L}{10} = \frac{V_L}{40}$$

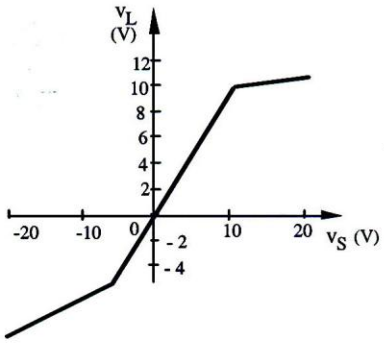
Therefore, $V_L = \dfrac{4V_S - 20}{9}$ V

$V_S > -6.25$ V

For case (c), we have $V_L = \dfrac{4}{5}V_S$ and

$-6.25\text{ V} < V_S < 12.5\text{ V}$

The v_L-v_S curve is shown on the right:



Problem 9.63

Solution:

Known quantities:
The range for the input voltage $0 \le v \le 10$ V for the circuit of Figure P9.63.

Find:
Determine the *i-v* characteristic of the circuit.

Analysis:
With the variables defined in the circuit below, we can compute the following currents:

$$I_1 = \frac{v}{100},\ I_2 = \frac{v}{100} \text{ for } v \ge 4 \text{ V},\ I_3 = \frac{v}{100} \text{ for } v \ge 6 \text{ V}$$

For $0 \le v \le 4$ V, $I = 0.01v$

For $4 \le v \le 6$ V, $I = 0.02v - 0.04$

For $6 \le v \le 10$ V, $I = 0.03v - 0.1$

The resulting i-v characteristic is shown below: