3.10 PLAN: - This is a load line analysis for different supply voltages. Writing a voltage equation for the fig 3.4, we obtain:

\[ V_{SS} = V_{SS} - \frac{I_0}{R} \]

Thus the slope of the load line is \(-\frac{1}{R}\)

\[ \text{Diagram: Load line graph showing } V_{SS} \text{ vs } I \]

3.53 PLAN: - To analyze the circuit for dc and ac sources.

\[ \text{Diagram: DC circuit analysis} \]

This is the large signal (OC) equivalent circuit.

The diode is forward biased with \(V_{D} = 0.6 \text{V}\) and \(I_D = \frac{(15 - 0.6)}{10} \approx 14.4 \text{mA}\)

The dynamic resistance of the diode is \(R_D = \frac{nV_I}{I_{DA}}\)

\[ R_D \approx 1.81 \Omega \]
The small signal (ac) equivalent circuit is

\[ \frac{1}{r_d} \]

\[ 0.1 \cos(\omega t) \]

\[ r_d \]

\[ V_d(+) \]

The o/p voltage is

\[ V_d(+) = 0.1 \cos(\omega t) \frac{r_d}{r_d + 1000} \]

\[ = (181 \times 10^{-6}) \cos(\omega t) \]

The total o/p voltage is sum of ac + dc

\[ V_o(+) = 0.6 + (181) \cos(\omega t) \]

Influence:- This problem is a good example of analysis of ac & dc equivalent circuits separately and adding the individual results to get the final o/p.

3.57

The small signal equivalent circuit for changes in the source voltage is

\[ \Delta V_{ss} \]

\[ r_d \]

\[ r_L \]

\[ \Delta V_{load} \]

The change in load voltage is given by

\[ \Delta V_{load} = \Delta V_{ss} \frac{r_d r_L}{R + r_d r_L} \]

Source Regulation = \( \frac{\Delta V_{load}}{\Delta V_{ss}} \times 100 \)
The small signal equivalent circuit for changes in the load current is

\[ \Delta I_{\text{load}} = \frac{V_{\text{load}}}{R_L} \]

The change in load voltage due to change in load current is

\[ V_{\text{no-load}} - V_{\text{full-load}} = \Delta V_{\text{load}} \]

\[ = (R_d + R_L) \Delta I_{\text{load}} \]

\[ = \frac{V_{\text{full-load}}}{R_L} \]

Load Regulation = \frac{V_{\text{no-load}} - V_{\text{full-load}}}{V_{\text{full-load}}} \times 100\%

\[ = \frac{R_d}{R_d + R_L} \times 100\%

Inference: This problem illustrated the voltage regulator parameters for the given circuit.
3.58. Plan: This is a simple substitution problem to evaluate diode parameters.

a) \( r_d = \frac{nV_T}{I_{oa}} \)

\[ r_d = 26 \Omega \]

b) \( \Delta V_0 = 1 n_0 r_d \)

\[ = 0.1 m \times 26 \]

\[ \Delta V_0 = 2.6 mV \]

c) \( i_0 = I_0 \left[ \exp \left( \frac{V_0}{nV_T} \right) - 1 \right] \)

\[ V_0 = nV_T \ln \left( \frac{i_0 - 1}{I_0} \right) \]

For \( i_0 = 1 mA \), we find \( V_0 = 0.65854 V \) and for \( i_0 = 1.1 mA \), \( V_0 = 0.66102 V \). For a difference of \( \Delta V_0 = 2.48 mV \) which is 4.8\% lower than the result using dynamic resistance.

3.59

\[ r_d = \left[ \left( \frac{d i_0}{d V_0} \right)^2 \right]^{-1} \]

\[ = 1.67 \times 10^6 \times \left( 1 + \frac{V_0}{5} \right)^4 \]

For \( I_{oa} = -1 mA \), \( V_{oa} = -4.5 V \) & \( r_d = 1675 \Omega \).

For \( I_{oa} = -10 mA \), \( V_{oa} = -4.77 V \) & \( r_d = 7.485 \Omega \)

\[ i_0 = \frac{-10^{-6}}{(1 + V_0/5)} \]
Inference: For a Zener diode, in the reverse breakdown region, the current rapidly increases to \( -\infty \) after crossing the max. reverse bias voltage.

\[ I_L = \frac{V_L}{R_L} = \frac{5}{100} \]

\[ I_L = 50mA \]

\[ I_{source} = \frac{8-5}{20} \]

\[ I_{source} = 150mA \]

\[ I_{zener} = I_{source} - I_L \]

\[ I_{zener} = 100mA \]

\[ \text{Vripple out} = 1 \times \frac{R_L'}{R_L' + 20} \]

\[ 10 = 1 \times \frac{R_L'}{R_L' + 20} \]

\[ R_L' = 0.202 \Rightarrow \text{which yields } R_d = 0.202 \times R \]

Inference: This problem explained the calculation of dynamic resistance of a Zener diode.