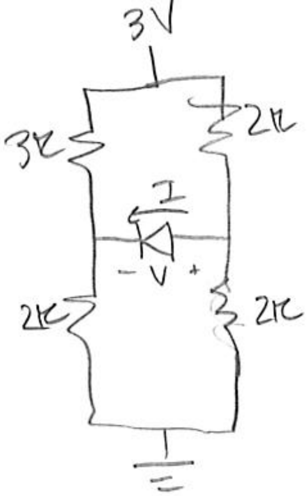
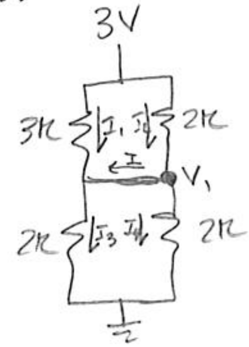
3.69



a) Ideal Diode model

Assume Diode on as initial guess



$$I = I_2 - I_4 = I_3 - I_1$$

$$V_1 = 3V \cdot \frac{2//2k\Omega}{3//2 + 2//2}$$

$$V_1 = 3V \cdot \frac{1k\Omega}{\frac{1}{\frac{1}{3k\Omega}+\frac{1}{2k\Omega}} + 1k\Omega}$$

$$V_1 = 3V \cdot \frac{1k\Omega}{\frac{6}{5}k\Omega + 1k\Omega}$$

$$V_1 = 3V \cdot \frac{5}{11}$$

$$I_2 = \frac{3V - 3V \cdot \frac{5}{11}}{2k} = \frac{3V \cdot \left(\frac{6}{11}\right)}{2k} = \frac{9}{11}\ mA$$

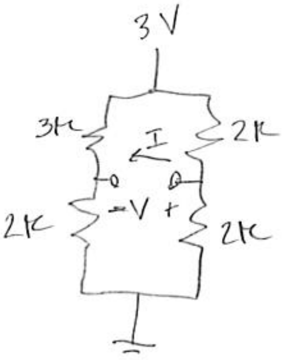
$$I_4 = \frac{3V \cdot \frac{5}{11}}{2k} = \frac{15}{22}\ mA$$

$$I = I_2 - I_4 = \left(\frac{18}{22} - \frac{15}{22}\right) mA = \frac{3}{22}\ mA = 136\mu A$$

$I = 136\mu A$, $V = 0V$ is q-point our initial guess right

b) Constant Voltage Drop model

Assume Diode off.



$$V = 3V \cdot \frac{2k\Omega}{2k + 2k\Omega} - 3V \cdot \frac{2k\Omega}{3k\Omega + 2k\Omega}$$

$$= 3\left(\frac{1}{2} - \frac{2}{5}\right) V$$

$$= 3\left(\frac{1}{10}\right) V$$

$$= 0.3\ V$$

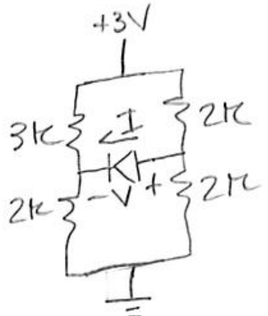
Because $V = 0.3V < V_{on} = 0.6V$, our assumption that the diode is off is right

so $V = 0.3V$, $I = 0A$ is q-point

3.69 (con)

c) The constant voltage drop model should be more correct because the model more closely matches the real I-V characteristic for a diode.

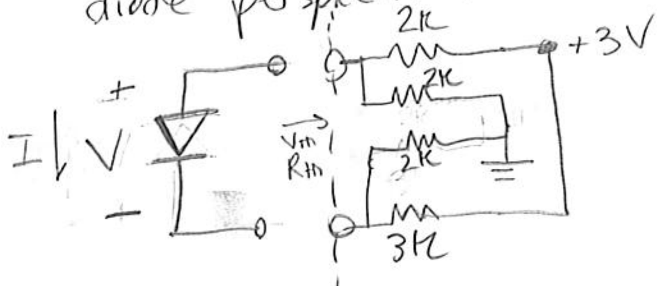
d)



We need to relate the I, V of diode to the circuit, and then plug that into the following equation for diode:

$$I = I_s\left(\exp\left(\frac{V}{V_T}\right)-1\right)$$

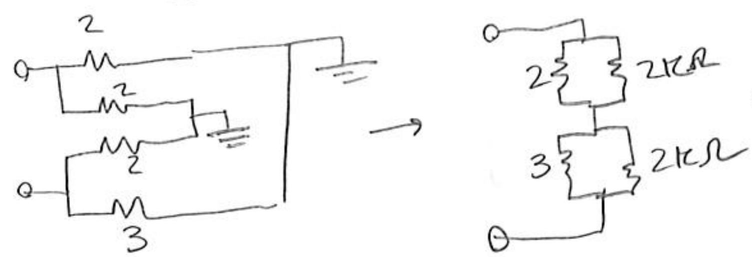
To do this, we can find the thevenin equivilent from diode perspective.



Break circuit as shown and find Thevenin equivilent.

$$V_{oc} = V_{th} = 3V\left(\frac{2k\Omega}{2+2k\Omega}\right) - 3V\left(\frac{2k\Omega}{2k+3k\Omega}\right) = 0.3V$$

$R_{th} =$

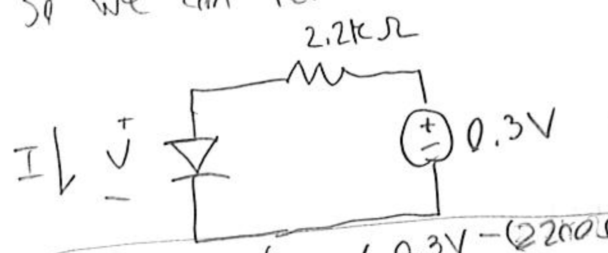


$\Rightarrow R_{th} = 2k\Omega // 2k\Omega + 3k\Omega // 2k\Omega$

$R_{th} = 1k\Omega + 1.2k\Omega$

$= 2.2k\Omega$

So we can rewrite the circuit as...



$\Rightarrow V = 0.3V - (2.2k\Omega)I$

plug this into Diode equation

$$I = 10^{-15}\left(\exp\left(\frac{0.3V-(2200\Omega)I}{0.025V}\right)-1\right) A$$

→ Solve by Iteration or by computer → $I = 162\ pA$

$V = 0.3V - (2.2k\Omega)I \approx 0.3V$

3.72

Ideal Diode Model

a) Diode is forward Biased, so assume short circuit.
Therefore $V = -5V$. $I = \frac{+5V-(-5V)}{16k\Omega} = 625\mu A$

b) Diode is forward Biased, So assume short circuit.
Therefore $V = +3V$. $I = \frac{+3V-(-7V)}{16k\Omega} = 625\mu A$

c) Diode reverse biased, assume ~~short circuit~~. open circuit.
Therefore $V = +7V$, $I = 0A$

d) Diode reverse biased, assume open circuit.
$\Rightarrow V = -5V$, $I = 0A$

$V_{on} = 0.7V$ Model

a) Assume Diode off. then there is 10V across the diode which is greater than V_{on}. This is inconsistent w/ assumption that diode is off, so that must be false. Therefor diode must be on.

$V = -5V + V_{on} = -4.3V$, $I = \frac{+5V-(-4.3V)}{16k\Omega} = 581\mu A$

b) similar logic to a) indicates diode is again on.

$V = +3V - V_{on} = 2.3V$, $I = \frac{+2.3V-(-7V)}{16k\Omega} = 581\mu A$

c) Assume Diode off. Then there is $-10V$ across the diode, which is less than $V_{on} = +0.7V$. This is consistent with our assumption that the Diode is off, so the diode is indeed off.

$V = +7V$, $I = 0A$

d) Same logic as in c) allows us to conclude that the diode is off. therefore

$V = -5V$, $I = 0A$

3.74

Ideal Diode Model

a) D_1 and D_2 on

$I_2 = \frac{6V}{43k\Omega} = \underline{140\mu A}$, $\underline{V_2 = 0V}$

$I_1 = -I_2 + \left(\frac{9V}{22k\Omega}\right) = -140\mu A + \frac{9V}{22k\Omega} = \underline{270\mu A}$

$\underline{V_1 = 0V}$

b) D_2 off, D_1 on

$I_1 = \frac{6V}{43k\Omega} = \underline{140\mu A}$ $\quad \underline{V_1 = 0V}$

$\underline{I_2 = 0A}$, $\underline{V_2 = -9V}$

c)

Assume: D_1 off, D_2 on – (we see later this assumption is wrong)

$\cancel{I_2 = \frac{15V}{22+43k\Omega} = \underline{230\mu A} \quad \underline{V_2 = 0V}}$

$\cancel{I_1 = 0A, \quad V_1 = \left(-9V + \left(\frac{22}{43+22}\right)(15V)\right) \times -1 = +3.9V}$

This is inconsistent w/ our original assumption, so D_1 is on, not off.

Assume: D_1 on, D_2 on.

$I_2 = \frac{9V}{22k\Omega} = \underline{409\mu A} \quad \underline{V_2 = 0V}$

$I_1 = I_2 - \frac{6V}{43k\Omega} = \underline{270\mu A}$, $\underline{V_2 = 0V}$

These are consistent w/ our assumption of Both Diodes on, so these should be correct.

3.74 (con)

Ideal Diode Model (con)

d) D_1 off, D_2 on

$I_2 = \frac{15V}{22+43k\Omega} = \underline{230\mu A}$ $\underline{V_2 = 0V}$

$\underline{I_1 = 0A}$, $V_2 = (-9V + (\frac{22}{43+22})(15V)) = \underline{-3.92V}$

3.74, Constant Von Model ($V_{on} = 0.65V$)

a) $I_2 = \frac{V_{on} - V_{on} - (-6V)}{43k\Omega} = \frac{6V}{43k\Omega} = \underline{140\mu A}$ $\underline{V_2 = V_{on} = 0.65V}$

$I_1 = \frac{9V - V_{on}}{22k\Omega} - I_2 = \frac{9V - 0.65}{22k\Omega} - 140\mu A = \underline{240\mu A}$ $\underline{V_1 = V_{on} = 0.65V}$

b) D_2 off, D_1 on

$I_1 = \frac{6V - V_{on}}{43k\Omega} = \frac{6V - 0.65V}{43k\Omega} = \underline{124\mu A}$ $V_1 = V_{on} = \underline{0.65V}$

$I_2 = \underline{0A}$ $\underline{V_2 = -9V}$

c) D_1 on, D_2 on

$I_2 = \frac{-V_{on} - V_{on} - (-9V)}{22k\Omega} = \frac{-0.65 - 0.65 + 9V}{22k\Omega} = \underline{350\mu A}$ $V_2 = V_{on} = \underline{0.65V}$

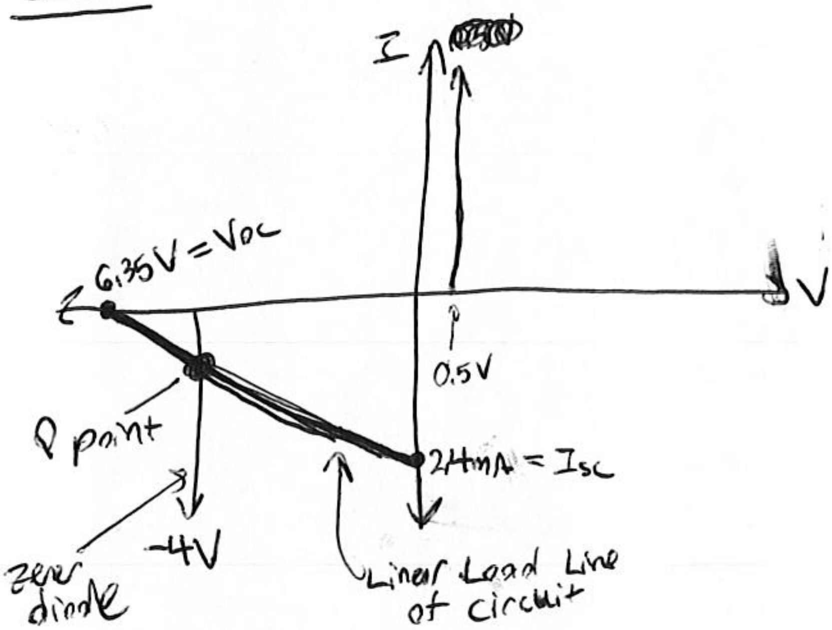
$I_1 = I_2 - \frac{6V + V_{on}}{43k\Omega} = 350\mu A - \frac{6V + 0.65V}{43k\Omega} = \underline{195\mu A}$ $V_1 = V_{on} = \underline{0.65V}$

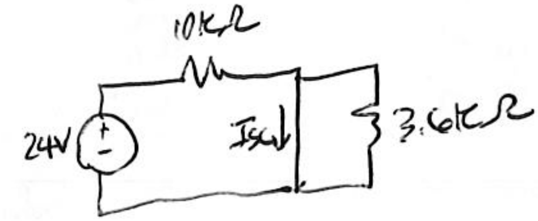
d) D_1 off, D_2 on

$I_2 = \frac{15V - V_{on}}{43+22k\Omega} = \frac{15V - 0.65V}{43+22k\Omega} = \underline{221\mu A}$ $\underline{V_2 = 0.65V}$

$I_1 = 0A$ $V_1 = -9V + V_{on} + \frac{22}{43+22}(15V - V_{on}) = -3.49V$

3.81



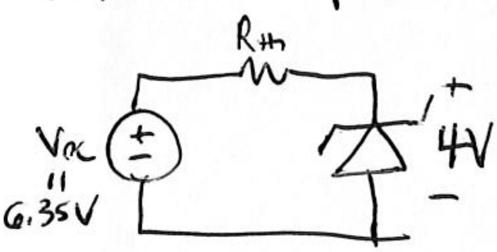


$$V_{oc} = \frac{3.6}{10+3.6} 24V = 6.35V$$

$$I_{sc} = \frac{24V}{10k\Omega} = 2.4mA$$

From thevenin and Norton equivilent from the diode perspective

What is Q point?



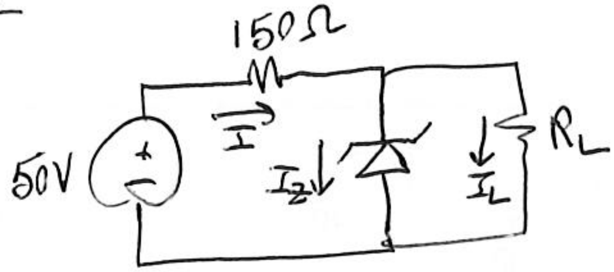
$R_{th} = 10k\Omega // 3.6k\Omega$

$R_{th} = 2.65k\Omega$

$V = -4V$ from graph

$$I = \frac{V_{oc}+V}{R_{th}} = \frac{6.35V - 4V}{2.65k\Omega} = \underline{889\mu A}$$

3.86



$$I = I_Z + I_L \Rightarrow I_Z = I - I_L = I - \frac{V_Z}{R_L} = \frac{50V - V_Z}{150\,\Omega} - \frac{V_Z}{R_L} = I_Z$$

$$I_L = \frac{V_Z}{R_L}$$

$$I = \frac{50V - V_Z}{150\,\Omega}$$

$$I_Z = \frac{50V - V_Z}{150\,\Omega} - \frac{V_Z}{R_L}$$

a) for $R_L = 100\,\Omega$ $\quad I_Z = \frac{50V - 15V}{150} - \frac{15V}{100\,\Omega} = 83.3mA$

$$\text{Power} = V_Z I_Z = (15V)(83.3mA) = \boxed{1.25W}$$

b) for $R_L = \infty\,\Omega$ $\quad I_Z = \frac{50V - 15V}{150\,\Omega} = 233\,mA$

$$\text{Power} = V_Z I_Z = (15V)(233mA) = \boxed{3.5W}$$

3.104 – ~~This problem statement is ambiguous~~ → see eq. 3.63 to 3.67

a) ~~$V_{DC} = V_p - V_{on}$~~

$$V_i = V_p \sin(\omega t)$$

$$-V_{DC} = V_p - V_{on}$$

$$V_{RMS} = 18V, \text{ so } V_p = V_{RMS} \cdot \sqrt{2} = 18V \cdot \sqrt{2} = 25.5V$$

$$-V_{DC} = 25.5V - 1V = 24.5V \Rightarrow \boxed{V_{DC} = -24.5V}$$ (Note diode direction)

b) $$V_r = \frac{(V_p - V_{on})}{R} \frac{T}{2C} = \frac{24.5V}{0.5\Omega} \cdot \frac{1/60Hz}{2C} = 0.25V$$

Solve for C, $\boxed{C = 1.63 \text{ F}}$ is the minimum capacitence

c) $$PIV = 2V_p = 2 \cdot 25.5V = 51V$$

d) With the defintion of V_i as in the problem, the ~~surge current of the eq.~~ surge current is the same for the full wave rectifier as the half wave rectifier. therefore use eq. 3.57.

$$I_{SC} = \omega C V_p = (2\pi)(60Hz)(1.63F)(25.5V) = 15600A$$

assume minimum capacitence.

e) $$I_p = I_{DC} \frac{T}{\Delta T}$$

$$\Delta T = \frac{1}{\omega}\sqrt{\frac{2V_R}{V_p}} = \frac{1}{2\pi(60Hz)}\sqrt{\frac{2(0.25V)}{25.5V}} = 372 \times 10^{-6} \text{ seconds}$$

$$I_{DC} = \frac{-V_{DC}}{R} = \frac{-24.5V}{0.5\Omega} = -49.0A, \quad I_p = (49.0A) \cdot \frac{1/60Hz}{372 \times 10^{-6} \text{ seconds}} = 2190A$$