TOTAL: ______/20

ECE 548: Electronic Design I

Homework #3

Due: Friday, March 29th, 2019 (11pm)

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Note:

- **Please use this sheet as a cover page.**
- **Your work must be hand-written (no typing please).**
- **Homework must be submitted electronically through Canvas in a PDF format.**

Do the following problems from Microelectronic Circuit Design by Jaeger & Blalock (5th Edition)

(Pages 137 – 142)
Solve at least 5 of the following list of problems:

3.58, 3.59, 3.63, 3.68, 3.76, 3.89, 3.92, 3.106

(Note: the Q-point refers to the 'operating point' where the load line meets the diode equation.)

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ECE 548 Homework #3 3.58, 3.63, 3.76, 3.92, 3.106

Prob # 3.58

A diode has $I_S = 0.1 fA$ and is operating at $T = 300k$

(a) What are the values of V_{DO} and r_D if $I_D = 200\mu A$?

$V_T = \frac{kT}{q}$ $V_T = \frac{(1.38 \times 10^{-23})(300k)}{(1.602 \times 10^{-19} c)}$

$V_T = 0.0258V$

$V_D = V_T \ln(1 + I_D/I_S)$

$V_D = (0.0258v) \ln(1 + (200\mu A)/(0.1 fA))$

$V_D = 0.732v$ $r_{DO} = V_T / I_D$

$V_{DO} = V_D - V_T$ $r_{DO} = (0.0258V)/(200\mu A)$

$V_{DO} = (0.732v - 0.0258v)$ $\boxed{r_{DO} = 129 \Omega}$

$\boxed{V_{DO} = 0.7062 v}$

(b) If $I_D = 2.0 mA$

$V_D = (0.0258v)(1 + (2.0mA)/(0.1fA))$

$V_D = 0.790v$ $r_{DO} = (0.0258v)/(2.0mA)$

$V_{DO} = (0.790v - 0.0258v)$ $\boxed{r_{DO} = 12.9 \Omega}$

$\boxed{V_{DO} = 0.764v}$

(c) If $I_D = 20mA$?

$V_D = (0.0258v)(1 + (20mA)/(0.1fA))$ $r_{DO} = (0.0258v)/(20mA)$

$V_D = 0.852v$ $\boxed{r_{DO} = 1.29 \Omega}$

$V_{DO} = (0.852v - 0.0258v)$

$\boxed{V_{DO} = 0.8262 v}$

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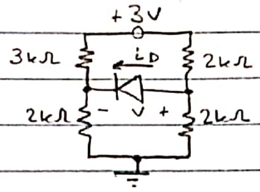
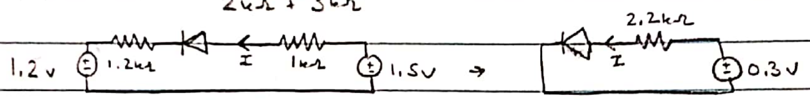
Problem # 3.63

Find the Q point for the circuit in Fig P3.63 using



(a) the ideal diode model

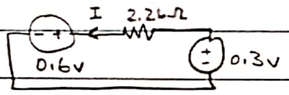
$V_{TH} = 3v \left(\frac{2k\Omega}{2k\Omega + 3k\Omega} \right)$ $V_{TH} = 1.2v$



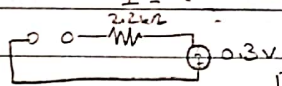
$I = 0.3V / 2.2k\Omega$ $I = 0.136mA$

$\boxed{Q_{point} = 0.136mA, 0V}$

(b) The constant voltage drop model with $V_{on} = 0.6V$



$I = (0.3v - 0.6v) / (2.2k\Omega)$ $I = -0.136 mA$



$\boxed{Q_{point} = 0A, 0.3V}$

(c) Discuss the results.

The constant voltage drop model is the most realistic model because diodes usually only activate around 0.6V.

(d) Use iterative analysis to find the actual Qpoint. $I_s = 0.1fA$

$i_D = I_s \wedge (V_D / V_{TH})$

$i_D = (0.1fA) \wedge (0.3v / 25mv)$

$i_D = 0$

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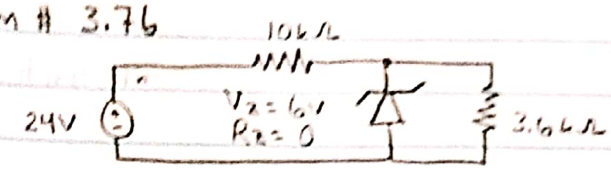
Problem # 3.76



(a) Find the Qpoint for the Zener Diode

$R_{TH} = 10k\Omega \parallel 3.6k\Omega$

$R_{TH} = \frac{10k\Omega * 3.6k\Omega}{10k\Omega + 3.6k\Omega}$ $R_{TH} = 2.65k\Omega$

$V_{TH} = 24v\left(\frac{3.6k\Omega}{10k\Omega + 3.6k\Omega}\right)$ $V_{TH} = 6.35V$

$I = \frac{V_{TH} - V_Z}{R_{TH}}$ $I = \frac{6.35v - 6v}{2.65k\Omega}$ $I = 0.132mA$

$\boxed{Q_{point} = 0.132mA, 6v}$

(b) Repeat if $R_Z = 100\Omega$

$R_{TH} = R_{TH(2)} + 100\Omega$ $R_{TH} = 2.75k\Omega$

$I = \frac{V_{TH} - V_Z}{R_{TH}}$ $I = \frac{6.35v - 6v}{2.75k\Omega}$ $I = 0.127 mA$

$\boxed{Q_{point} = 0.127mA, 6v}$

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Prob # 3.92

3.3v 30A DC ripple < 1.5% half wave rec. 60Hz w/ Cap filter

(a) What is the size of the Cap filter?

$$(0.015)(V_r) = \left(\frac{V_p - V_{on}}{R}\right)\left(\frac{T}{C}\right)$$

$$C = \left(\frac{V_p - V_{on}}{R}\right)\left(\frac{T}{0.015 V_r}\right)$$

$$C = (I_p)\left(\frac{1}{f}\right)\left(\frac{1}{0.015 V_r}\right)$$

$$C = (30A)(1/60Hz)(1/(0.015)(3.3v))$$

$$\boxed{C = 10.1\ F}$$

(b) What is the PIV rating?

$$PIV = 2V_p$$

$$= 2(V_{DC} + V_{on})$$

$$= 2(3.3v + 1) \quad \text{w/ Assume } V_{on} = 1V$$

$$\boxed{PIV = 8.6v}$$

(c) What is the rms value of the trans voltage needed for the rec.

$$V_{rms} = V_p / \sqrt{2} \qquad V_{rms} = (V_{DC} + V_{on}) / \sqrt{2}$$

$$V_{rms} = (3.3v + 1v) / \sqrt{2}$$

$$\boxed{V_{rms} = 3.041v}$$

(d) What is the value of the peak repetitive diode current in diode.

$$\Delta T = \frac{1}{\omega}\sqrt{\frac{2V_r(0.015)}{V_p}} \qquad \Delta T = \frac{1}{2\pi(60Hz)}\sqrt{\frac{2(3.3v)(0.015v)}{(3.3v + 1v)}}$$

$$\Delta T = 0.402ms$$

$$I_p = I_{dc}\frac{T}{\Delta T} \qquad I_p = I_{dc}(1/f / \Delta T)$$

$$I_p = (30A)(1/60 / (0.402ms))$$

$$\boxed{I_p = 1243.78A}$$

(e) What is the surge current at $t = 0^+$?

$$I_{surge} = \omega C V_p \qquad I_{surge} = (2\pi(60Hz))(10.1F)(3.3v + 1)$$

$$\boxed{I_{surge} = 16,372,72mA \sim 16,373A}$$

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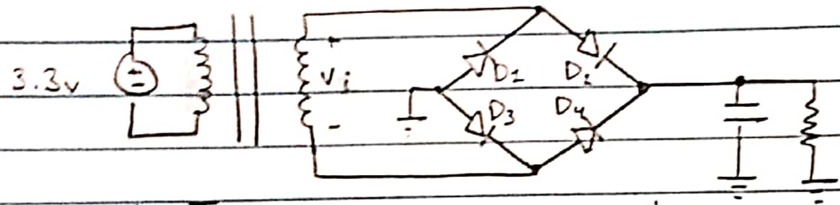
Prob # 3.106

Repeat Prob # 3.92 for a full wave bridge rectifier.

(a)



$V_r = \left(V_p - V_{on}\right)\left(\frac{T}{2RC}\right)$ vs $V_r = \left(V_p - V_{on}\right)\left(\frac{T}{RC}\right)$

$2C_{full} = V_{half}$ $\boxed{C = 5.05F}$

(b) PIV

$PIV = V_p$ $PIV = (V_{dc} + 2V_{on})$

$PIV = (3.3v + 2(1v))$ $\boxed{PIV = 5.3v}$

(c) V_{rms}

$V_{rms} = \frac{V_p}{\sqrt{2}}$ $V_{rms} = \frac{(V_{dc} + 2V_{on})}{\sqrt{2}}$

$V_{rms} = \frac{(3.3v + 2(1v))}{\sqrt{2}}$ $\boxed{V_{rms} = 3.75v}$

(d) $\Delta T = \frac{1}{\omega}\sqrt{\frac{2V_r(0.015)}{V_p}}$ $\Delta T = \frac{1}{2\pi(60Hz)}\sqrt{\frac{2(3.3v)(0.015)}{(3.3v + 2(1v))}}$

$\boxed{\Delta T = 0.363\ ms}$

(e) $I_p = I_{dc}\left(T/\Delta T\right)$

$I_p = (30A)\left(1/60Hz\right)/(0.363ms)$

$\boxed{I_p = 1377.41\ A}$

[For questions and further details see solution to problem # 3.92]

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