ECSE-2050 **Introduction to Electronics**
Summer 2020 **Name** _____

Homework 7

Reading Section 4.5

Problem 1) Rectifiers

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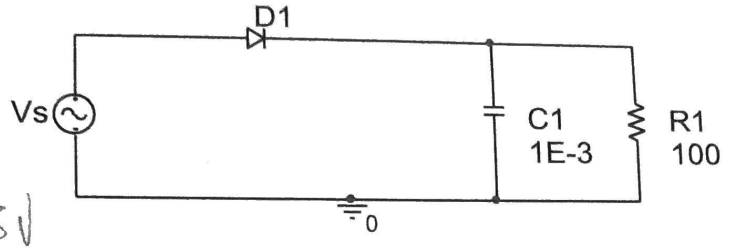

2.5V

The source in the above circuit is a 60 Hz, 10V signal. The diode is ideal with a turn-on voltage of 2.5V.

a) Estimate the peak voltage $10-2.5 = 7.5V = V_p$
Estimate the ripple voltage $\text{peak}/fRC = 1.25V$
$7.5V - \frac{1}{2}(1.25) = 6.875V$ ← Estimate the average load voltage
Estimate the average power consumed by the load → $6.875^2/100 = .47W$
Estimate the conduction time for the diode → $\frac{1}{2\pi 60}\sqrt{\frac{2\cdot 1.25}{7.5}} = 1.53ms$
$\frac{7.5}{100} + (100\pi)^2 \cdot .0015 \cdot 10 \cdot 10^{-3}$ ← Estimate the maximum diode current
$= 2.25A$
Estimate the average current through the diode when it is on. →
Estimate the average power produced by the source over one cycle.
What is the power efficiency of this circuit, PLoad/Psource?

$\frac{7.5-1.25/2}{100} + \frac{(100\pi)^2 \cdot 10^{-3}}{2}$
$= 1.156A$

$\frac{.47}{11.25} = 0.042$

$\frac{10 \cdot 2.25}{2} = 11.25W$

How do the part b answers change if the source is replaced with a 60 Hz, 110 V source?

b) Estimate the peak voltage $110-2.5 = 107.5V = V_p$
Estimate the ripple voltage $V_p/fRC = 17.92V$
$107.5 - \frac{17.9}{2} = 98.55V$ ← Estimate the average load voltage
Estimate the average power consumed by the load → $98.55^2/100 = 97.1W$
Estimate the conduction time for the diode → $\frac{1}{\omega}\sqrt{2V_r/V_p} = 1.53ms$
Estimate the maximum diode current → $V_p/R_1 + (\omega^2 \Delta t_c V_p) = 24.99A$
$\frac{V_p - V_R}{R_1} + \frac{\omega^2 V_R \Delta t_c}{2}$ ← Estimate the average current through the diode when it is on.
$= 12.45A$
Estimate the average power produced by the source. → $110 \cdot 24.99/2 = 1374.45W$
Estimate the average power consumed by the diode. → $V_T \cdot I_{max} = 62.475W$
What is the power efficiency of this circuit, PLoad/Psource?

$97/1374.45 = 0.071$

c) Why is the power efficiency better in the part b circuit relative to the part a circuit?

The diode is on for a longer time of the input cycle for part B, meaning the load gets more current.

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1.A $V_p = 7.5V$

$V_R = 1.25V$

$V_{L\,avg} = 6.875V$

$P_{L\,avg} = .47W$

$\Delta T_C = 1.53ms$

$I_{D\,max} = 2.25A$

$I_{avg} = 1.156A$

$P_{avg\,S} = 11.25W$

efficiency $= 0.042$

1B: $V_p = 107.5V$

$V_R = 17.92V$

$V_{L\,Avg} = 98.55V$

$P_{L\,Avg} = 97.1W$

$\Delta t_C = 1.53ms$

$I_{D\,max} = 24.99A$

$I_{D\,Avg} = 12.95A$

$P_{Avg\,S} = 1374.45W$

$P_D = 62.475$

efficiency $= 0.071$

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Problem 2) Full-wave rectifiers

Design a full-wave rectifier circuit that meets the following specifications

- Voltage source with 110V amplitude at 60Hz
- Ripple voltage less than 5% of the peak voltage
- Average load (resistive) current of 2A
- Assume the diodes are ideal with a turn on voltage of 2.5V

Estimate the peak voltage

Estimate the ripple voltage

Estimate the average load voltage

Estimate the average power consumed by the load

Estimate the conduction time for the diode

Estimate the maximum diode current

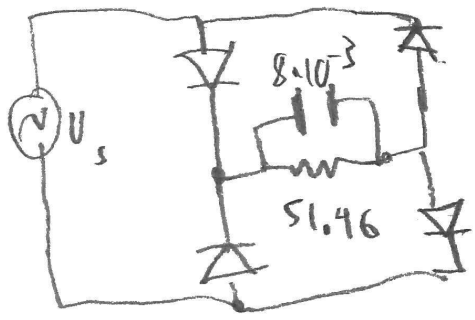
Estimate the average current through the diode when it is on.

Estimate the average power produced by the source over one cycle.

What is the power efficiency of this circuit, PLoad/Psource?

$V_p = V_0 - 2V_\gamma =$ (105V = V_p) $V_R = V_p / fRC$ $RC > \frac{1}{3}$ choose $RC = .42$

$R = 105 - \frac{105/60.4}{2} = 51.459$ $RC = .42 = .42/51.459 = 8 \cdot 10^{-3}\,F$



$V_R = \frac{105}{60 \cdot .42} =$ (4.2V)

$V_L = V_p - \frac{V_R}{2} =$ (102.9V)

$P_{avg} = \frac{V_L^2}{R} =$ (209.76W) $\Delta T_c = \frac{1}{w}\sqrt{\frac{2V_L}{V_p}} =$ (.747 ms)

$I_{Dmax} = \frac{V_p}{R} = \frac{C w V_0 \Delta t_c}{2} =$ (97.53A)

$I_{Avg} = \frac{V_p - \frac{V_R}{2}}{R} + \frac{C V_0 w^2 \Delta t_c}{2} =$ (49.65A)

$P_{avgs} = V_s \cdot \frac{I_{max}}{2} =$ (5353.15 W)

$P_L / P_s = \frac{205.76}{5353.15} =$ (0.0384)