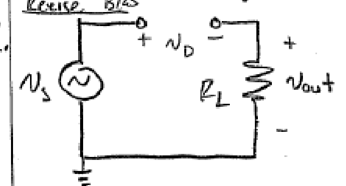
EE462 - Prelab 4 Solution

Stephen Maloney | EE462 Prelab 4

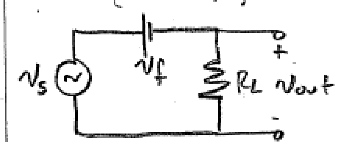
Reverse Bias

1.



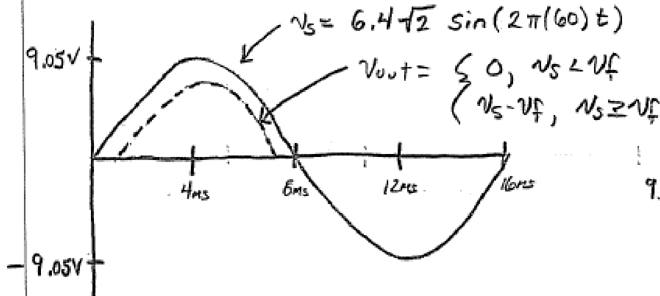
$v_D < v_f$; $v_D = v_s$

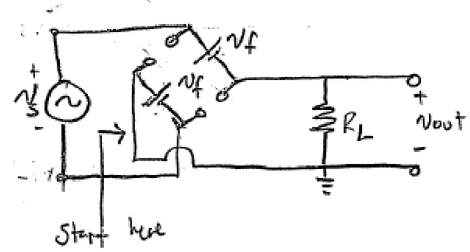
[$v_s < v_f$; $v_{out} = 0$]



$-v_s + v_f + v_{out} = 0$

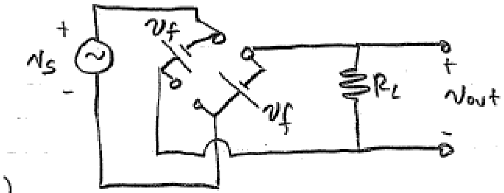
$v_{out} = v_s - v_f$, $v_s \geq v_f$





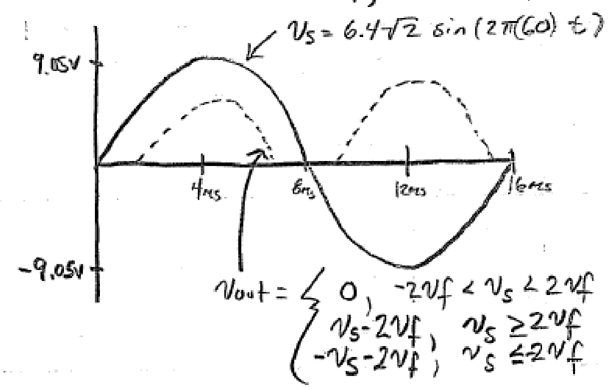
$v_f - v_s + v_f + v_{out} = 0$

$v_{out} = v_s - 2v_f$, $v_s > 2v_f$



$-v_s - v_f - v_{out} - v_f = 0$

$v_{out} = -v_s - 2v_f$, $v_s \leq -2v_f$



Matlab Equations

$v_s = 6.4\sqrt{2}\ \sin(2\pi f t)$

$$v_{out} = \begin{cases} 0, & v_s < v_f \\ v_s - v_f, & v_s \geq v_f \end{cases}$$

$$I_{out} = \begin{cases} 0, & v_s < v_f \\ \frac{v_s - v_f}{R_L}, & v_s \geq v_f \end{cases}$$

$$v_{out} = \begin{cases} 0, & -2v_f < v_s < 2v_f \\ v_s - 2v_f, & v_s \geq 2v_f \\ -v_s - 2v_f, & v_s \leq -2v_f \end{cases}$$

$$I_{out} = \begin{cases} 0, & -2v_f < v_s < 2v_f \\ \frac{v_s - 2v_f}{R_L}, & v_s \geq 2v_f \\ \frac{-v_s - 2v_f}{R_L}, & v_s \leq -2v_f \end{cases}$$

Average Power Output for the Half Wave Rectifier (mW):

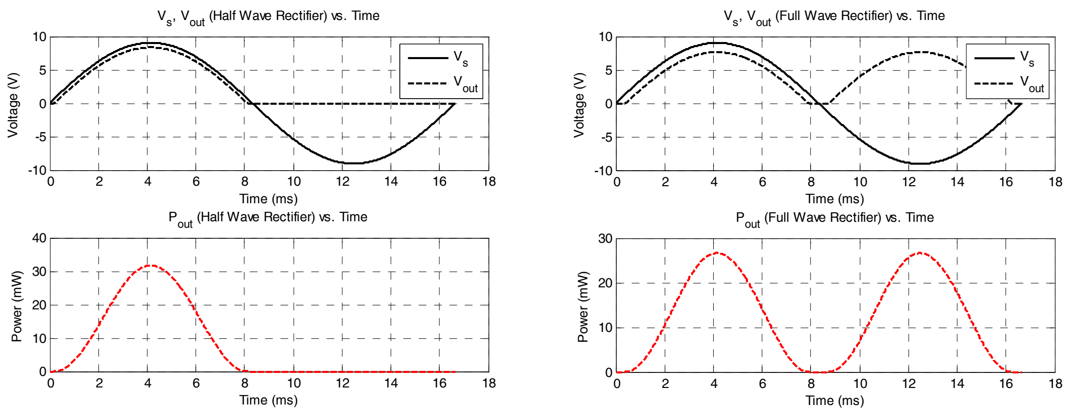
```
PavgOut =

    7.5845

Average Power Output for the Full Wave Rectifier (mW):

PavgOut =

   12.1451
```




```
% EE462 - Prelab 4 - Problem 1
% Stephen Maloney

clear all; clc; close all;

f = 60;
T = 1/f;
Vf = .7;
Rl = 2.2e3;

n = 10000;  %Granularity of approximate integrals; increase for better accuracy

t = linspace(0, T, n);
Vs = 6.4*sqrt(2)*sin(2*pi*f*t);

% Half wave Rectifier
fBias = find(Vs >= Vf);

Vout = zeros(1, length(Vs));
Vout(fBias) = Vs(fBias)-Vf;

Iout = Vout/Rl;
Pout = Vout.*Iout;

% Quick check to make sure things look reasonable
subplot(2, 1, 1);
plot(t*10^3, Vs, 'k', t*10^3, Vout, 'k--', 'LineWidth', 2); grid on;
title('V_s, V_o_u_t (Half Wave Rectifier) vs. Time'); xlabel('Time (ms)'); ylabel('Voltage (V)');
legend('V_s', 'V_o_u_t');

subplot(2, 1, 2);
plot(t*10^3, Pout*10^3, 'r--', 'LineWidth', 2); grid on;
title('P_o_u_t (Half Wave Rectifier) vs. Time'); xlabel('Time (ms)'); ylabel('Power (mW)');

%Trapezoidal Integration by Approximation
Pout = 1/T*Pout; %Put the 1/T term inside the integral
disp('Average Power Output for the Half Wave Rectifier (mW):');
PavgOut = (T-0)/(2*n)*(2*sum(Pout) - Pout(1) - Pout(n)) * 10^3

%Full Wave Rectifier
clear Iout PavgOut Pout Vout fBias
```

```
Vout = zeros(1, length(Vs));
fBias = find(Vs >= 2*Vf);
Vout(fBias) = Vs(fBias) - 2*Vf;

clear fBias
fBias = find(Vs <= -2*Vf);
Vout(fBias) = -Vs(fBias) - 2*Vf;

figure;
subplot(2, 1, 1);
plot(t*10^3, Vs, 'k', t*10^3, Vout, 'k--', 'Linewidth', 2); grid on;
title('V_s, V_o_u_t (Full Wave Rectifier) vs. Time'); xlabel('Time (ms)'); ylabel('Voltage (V)');
legend('V_s', 'V_o_u_t');

Iout = Vout/Rl;
Pout = Vout.*Iout;

subplot(2, 1, 2);
plot(t*10^3, Pout*10^3, 'r--', 'LineWidth', 2); grid on;
title('P_o_u_t (Full Wave Rectifier) vs. Time'); xlabel('Time (ms)'); ylabel('Power (mW)');

Pout = 1/T*Pout;
disp('Average Power Output for the Full Wave Rectifier (mW):');
PavgOut = (T-0)/(2*n)*(2*sum(Pout) - Pout(1) - Pout(n)) * 10^3
```

2. a) $C \approx \dfrac{\left(V_m - \frac{V_r}{2}\right) T}{V_r R_L}$

$R_L = 2.2k\Omega$
$V_m = 6.4\sqrt{2} - V_f$
$V_r = .5V$
$T = \frac{1}{60}$

$C \approx 126.53 \mu F$

b) $V_r \approx \dfrac{T V_m}{\frac{T}{2} + 2 C R_L}$ (1)*

$T = \frac{1}{60}$
$V_m = 6.4\sqrt{2} - 2V_f$
$R_L = 2.2k\Omega$
$C = 126.53\mu F$

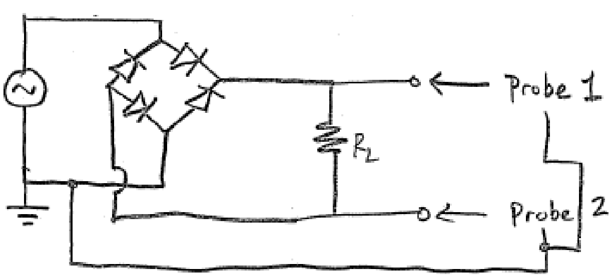
$V_r \approx .22566\ V$

c) $R_L \to \infty$
$V_r = 0$ for both half wave and full wave rectifiers.

$V_r \approx \dfrac{T V_m}{\frac{T}{2} + 2C(\infty)} = \dfrac{C}{\infty} = 0$

d) From equation (1)* above, a larger value of capacitance will result in a smaller ripple, so picking a larger value capacitor than what was calculated above will result in a smaller ripple, and ensure specifications will be satisfied.

3.

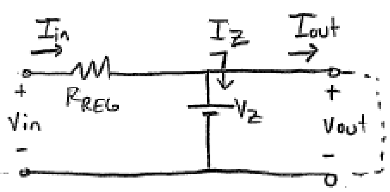


- Probe grounds are connected to function generator ground.
- Use MATH function on OSC to find Probe 1 - Probe 2 for output.

4. $P_Z = \dfrac{V_Z V_{in} - V_Z^2}{R_{Reg}}$

$V_Z = 5.1V$
$P_Z = 15mW$
$V_{in} = 6.4\sqrt{2}$

$R_{REG} = 1343.33\ \Omega$



$V_Z I_Z = P_Z$

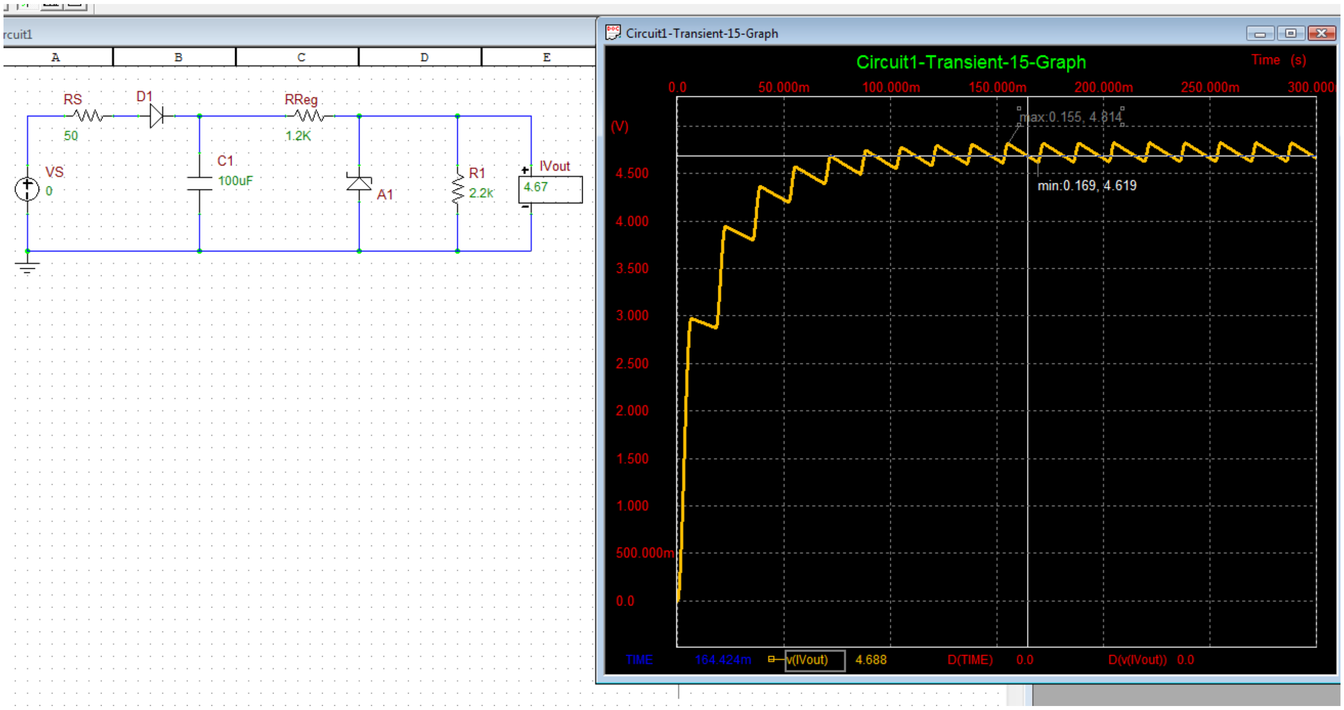
$\therefore\ I_Z = \dfrac{P_Z}{V_Z} = 2.941mA$ at maximum

If R_{REG} is the only load ($R_L \approx 0$) then $I_{in} = \dfrac{V_{in}}{R_{REG}}$

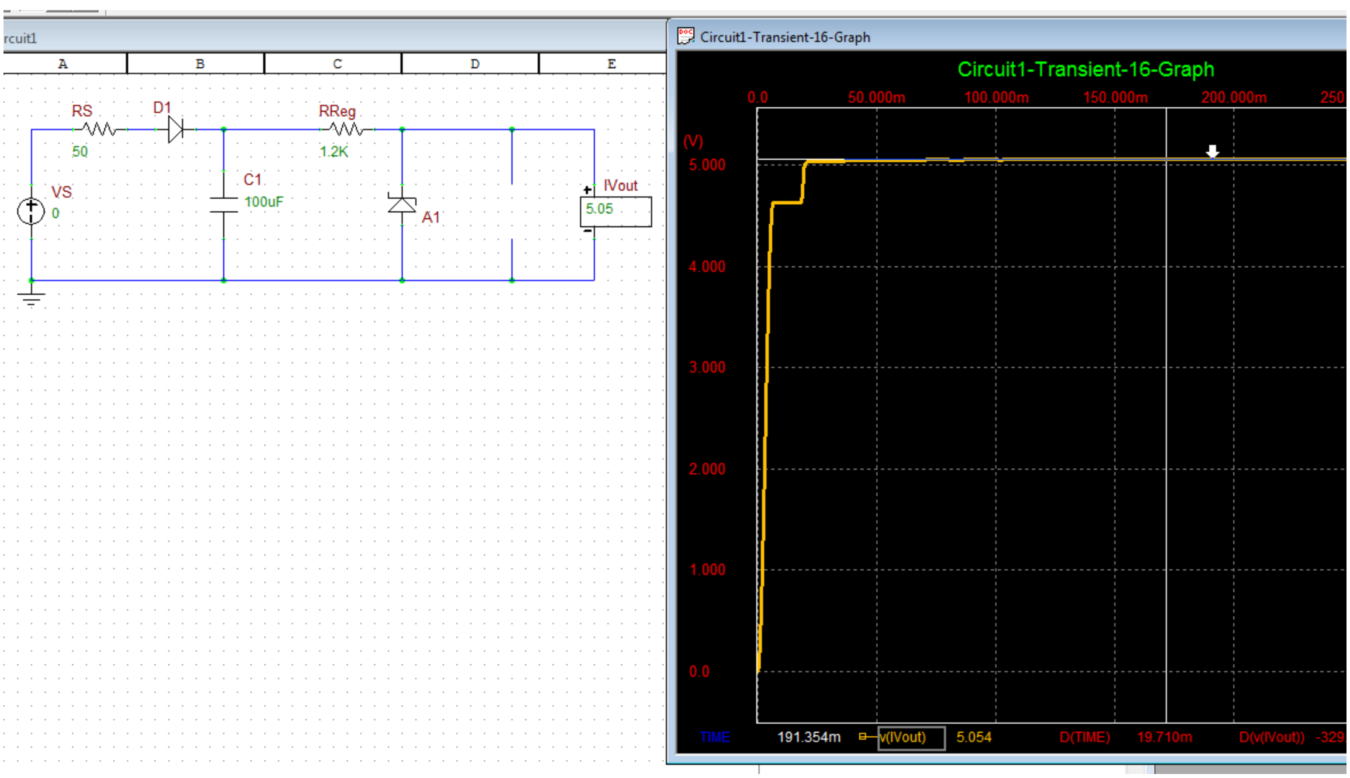
$\dfrac{V_{in}}{R_{REG}} - I_Z = I_{out_{max}}$

$I_{out_{max}} = 3.797mA$

5.

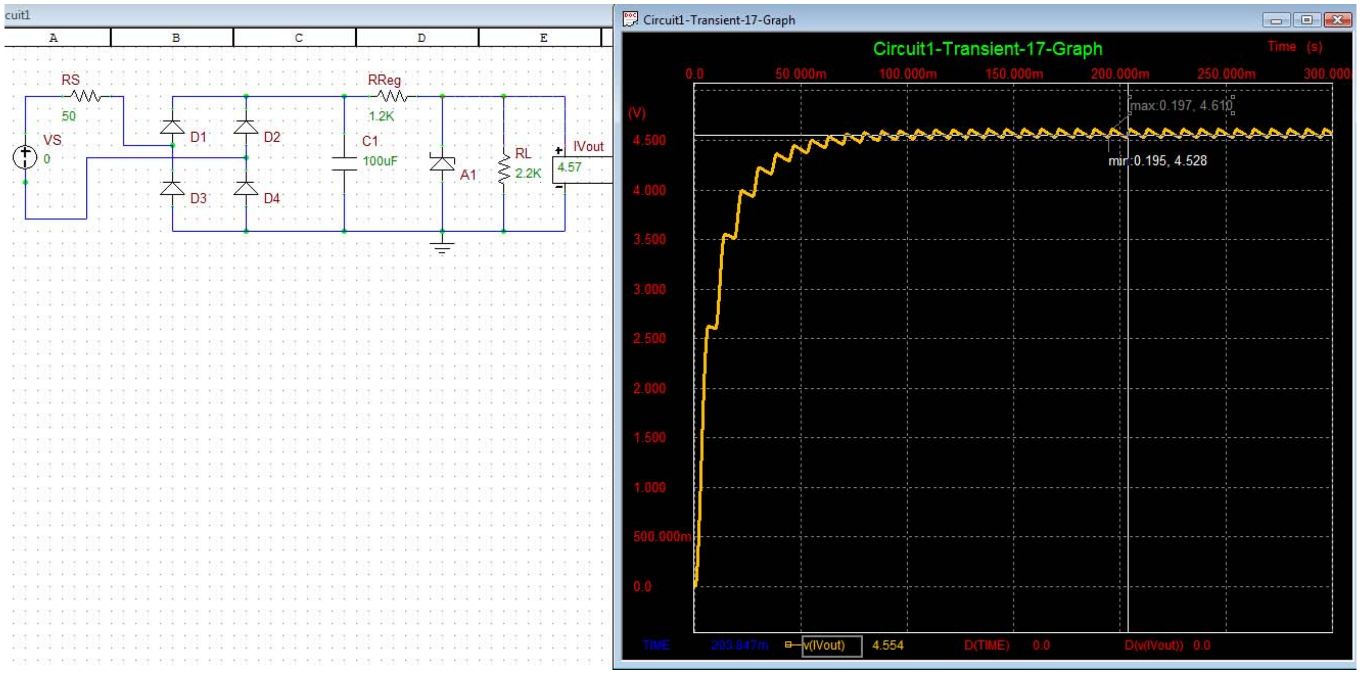


Ripple for the half wave rectifier can be seen from the above circuit (where the part values were chosen to fit the nearest part available in the parts kit) to be approximately .2V. The output voltage can be seen to be approximately 4.7V on average.

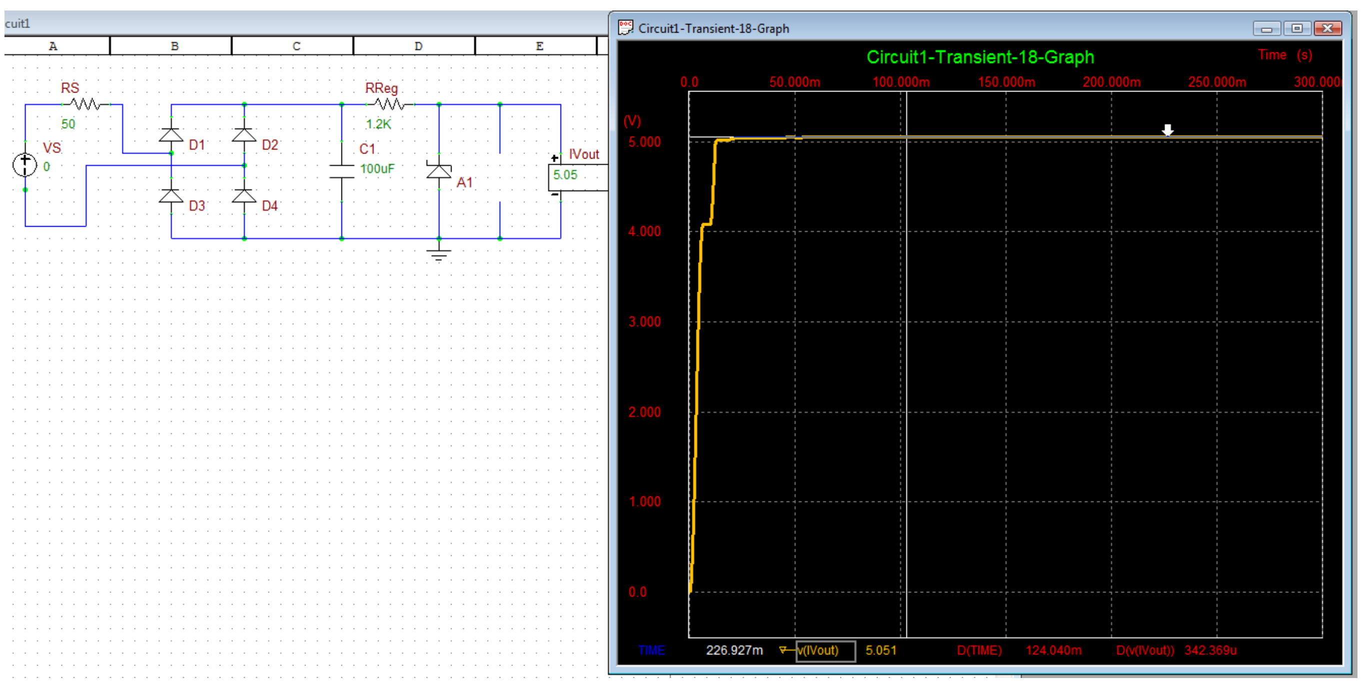


In the no load condition, the output voltage is approximate 5V.

Therefore, regulation = $(V_{NoLoad} - V_{FullLoad})/V_{FullLoad}$ * 100% = 7.53%



Ripple for the full wave rectifier can be seen from the above circuit to be about .1V. The average output is 4.57V.



With no load, the output is 5.051V. Therefore the regulation percentage is 9.76%.