Name: ____________________________

ECET 242 – Electronic Circuits

Lab 4
Regulated Power Supplies

Objective: Students successfully completing this lab exercise will accomplish the following objectives:

1. Learn to perform voltage regulation and voltage ripple test of an AC power adapter.
2. Construct a regulated power supply and study the operation of the various stages of AC to DC conversion.

Lab Report: A formal lab report will be required based on your combined results from labs 2, 3 and 4. Retain you results from this lab exercise and combine them with results from the previous labs. This lab will be due 1 weeks after the lab exercise is conducted.

Equipment:
Oscilloscope
1N4004 diodes (2)
1N4734A zener diode (1)
Various Resistors
100μF electrolytic capacitor (1)
Connecting leads
Digital multimeter (DMM)
CADET II lab trainer breadboard and supply
AC Power Adapter
Electrical tape
Jumper wires

Procedure 1: AC Power Adapter Measurements

1. Select an AC power adapter and identify the DC output ratings on the label of the device. Record the values for your adapter below.

Table 1: AC Power Adapter DC Ratings

Description	Symbol	Value
Rated output DC voltage	V_{DC}	
Rated output DC current	I_{DC}	

Complete each of the following calculations. Indicate the units of all calculated values.

a) Calculate the actual power (P_{DC}) at rated voltage and current.

$P_{DC} = V_{DC}I_{DC} =$ ____________

b) Calculate the minimum power rating of the load resistance for safe operation.

$P_{Rating} \geq 1.2\,(P_{DC}) =$ ____________

Calculate the number of ¼ W resistors required to meet or exceed the minimum power rating.

$N = \lceil P_{Rating} / ¼\,W \rceil =$ ____________ (where $\lceil \blacksquare \rceil$ is the ceiling operator which rounds to the next largest integer).

c) Calculate the total resistance required to obtain the rated output DC current.

$R_{Total} = V_{DC} / I_{DC} =$ ____________

d) If N ¼ W resistors are connected in parallel to achieve the total resistance, R_{Total}, what will the resistance of each resistor be?

Total parallel resistance = $R_{Total} = R_{Each} / N$. R_{Each} = ____________

e) Check the list of available resistances in Table 4 on the last page of this handout. Which available resistance is next highest to the calculated value of R_{Each}? If the calculated value is in between two available resistances, then choose the larger of the two.

$R_{Available}$ = ____________

f) Repeat steps (c) through (f) for a ½ W resistor. Record your results in Table 2 below.

Table 2: AC Adapter Load Test Calculations

Description	Symbol	¼ W Resistors	½ W Resistors
Number of parallel resistors needed to generate rated power	N		
Calculated resistance of each resistor	R_{Each}		
Available resistor value	$R_{Available}$		

2. Have the lab instructor verify your calculated resistor values in the table above. Then, obtain the appropriate resistors from the laboratory storage room.

3. Examine the cylindrical power adapter plug. The positive (+) terminal is the conductor on the interior of the cylinder. The negative (-) terminal is the conductor on the outside of the cylinder. Identify each of these. Insert a red wire into the cylinder so as to make contact with the positive terminal. Tightly wrap a green wire around the negative terminal. Tightly wrap both wires with electrical tape to secure the contacts.

4. Connect the adapter wires to a DC voltmeter. Apply power by plugging the adapter into an outlet on the lab bench. Record the DC voltage of the adapter.

$V_{DC\ (no\ load)}$ = ____________

5. Connect N resistors in parallel on a breadboard; each having a value of $R_{Available}$. Measure the resistance of the parallel combination.

$R_{Total\ (measured)}$ = ____________

6. Disconnect the adapter from bench power. Connect the red adapter wire to the input of an ammeter. Connect the output of the ammeter to the parallel resistor combination. Connect the green wire to the other side of the parallel resistor combination. *Have the instructor inspect your circuit.*

7. Connect a voltmeter to measure adapter voltage.

8. Measure the DC voltage and current. If the measured value of current is greater than the rated current, ***quickly*** turn off the power and remove one of the resistors. If the measured value of current is significantly less than the rated value, add an additional parallel resistor. After making any such minor adjustments, record the measured full-load DC voltage and current.

$V_{DC\ (full\ load)}$ = ____________ $I_{DC\ (full\ load)}$ = ____________

Calculate the percent voltage regulation of the power adapter.

%Voltage Regulation = ($V_{DC\ (no\ load)}$ – $V_{DC\ (full\ load)}$ / $V_{DC\ (no\ load)}$) x 100% = ____________ %

9. Using the oscilloscope, connect the CH1 probe to the positive side of the parallel resistors. Set the probe to x1. Set the three-way CH1 control switch to AC. Adjust the CH1 VOLTS/DIV knob to measure the peak-to-peak voltage. The peak-to-peak voltage in a regulator circuit is actually the ripple voltage. Record the measured ripple voltage.

   V_{RPP} = ____________

10. Below, sketch several cycles of the ripple voltage waveform. Include a copy of your sketch in your report. Label the horizontal and vertical axes and indicate the scale of each. Include a title that indicates the type of waveform.

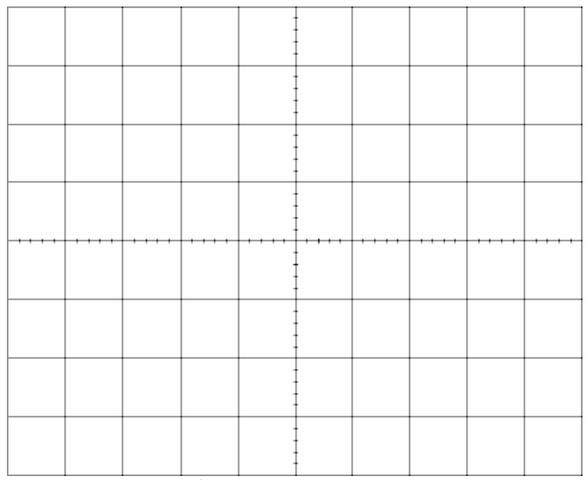

Figure 1: AC Power Adapter Ripple Voltage.

SCALES: Vertical ___________ V/Div, Horizontal ___________ s/Div

   Set the three-way CH1 control switch to GND and adjust the ground level to the center horizontal axis. Then, set the switch to DC and record the peak voltage.

   $V_{L\ (peak)}$ = ____________

   Calculate the percent ripple of the power adapter.

   %Ripple = (V_{RPP} / $V_{L\ (peak)}$) x 100% = ____________ %

Procedure 2: Regulated Power Supply

11. Turn on the oscilloscope. Follow the basic setup for display and measurement of time varying signals in Lab 2. Set the probe to x1. Set the three-way CH1 control switch to AC.

12. Use the 12.6 V transformer secondary winding terminals (red and blue) of the Cadet II lab trainer as the power source to the circuit below. Connect the yellow terminal to the ground terminal of the trainer.

    Construct the power supply circuit of a full-wave rectifier, capacitor filter and voltage regulating zener diode as shown in Figure 2.

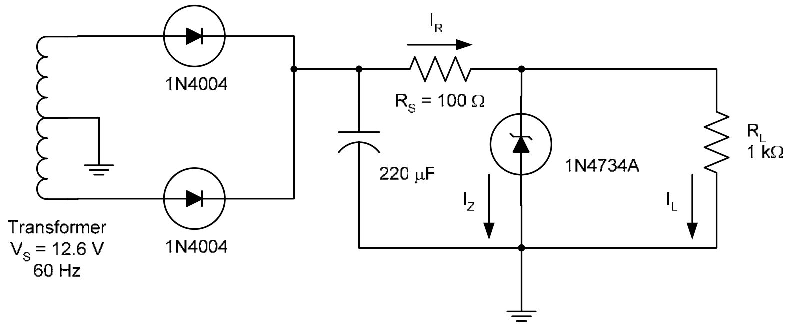

Figure 2: Filtered, Regulated Power Supply

13. Remove the load resistor (R_L). Using the DMM, measure the DC voltage across the capacitor and the DC voltage across the zener diode. Using the oscilloscope, measure the peak-to-peak ripple voltage across the capacitor and the peak to peak ripple across the zener diode. Record all four measurements in Table 3 below.

14. Repeat step 13 for RL = 1 kΩ, 470 Ω and $R_{L\ (min)}$ where $R_{L\ (min)}$ is the value calculated in the prelab exercise (use the next highest value available). Record all measurements in Table 3.

15. Use Ohm's Law to calculate the DC current in the load resistor (I_L) for all values of R_L. Show calculations on a separate sheet. Record your results in Table 3. Note that I_L is zero when R_L is removed.

16. Use Ohm's Law to calculate the DC current I_R in the surge protection resistor (R_S) for all values of R_L. Show calculations on a separate sheet. Record your results in Table 3.

17. Use Kirchhoff's Current law to calculate the DC current (I_Z) in the zener diode for all values of R_L. Show calculations on a separate sheet. Record your results in Table 3.

18. The 1N4734A zener diode has a max reverse DC current (I_{ZM}) as you noted in the prelab exercise. If the current in the zener diode exceeds I_{ZM}, the zener diode will be damaged. Based on the calculations of I_Z in the previous step, did you damage the zener diode in this experiment?

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Table 3: Measured and Calculated Results

Load Resistance	**Measured DC Voltage**		**Measured Ripple Voltage**		**Calculated % Ripple**		**Calculated DC Current (MA)**		
	V_C	V_Z	$V_{RPP(C)}$	$V_{RPP(Out)}$	$\%_{VRPP(C)}$	$\%V_{RPP(Out)}$	I_R	I_Z	I_L
R_L removed									
1 kΩ									
470 Ω									
$R_{L\ (min)}$									

Table 4: Available ¼ W Resistors

Ω	kΩ		MΩ
9.1 Ω	1 kΩ	33 kΩ	1 MΩ
10 Ω	1.21 kΩ	39 kΩ	1.1 MΩ
15 Ω	1.5 kΩ	47 kΩ	1.2 MΩ
18 Ω	1.82 kΩ	51 kΩ	1.3 MΩ
22 Ω	2 kΩ	56 kΩ	1.5 MΩ
24 Ω	2.2 kΩ	68 kΩ	1.6 MΩ
27 Ω	2.74 kΩ	75 kΩ	2 MΩ
31.6 Ω	3 kΩ	82 kΩ	2.2 MΩ
33 Ω	3.16 kΩ	91 kΩ	2.4 MΩ
39 Ω	3.3 kΩ	100 kΩ	2.4 MΩ
43 Ω	3.6 kΩ	120 kΩ	2.7 MΩ
47 Ω	3.74 kΩ	130 kΩ	3.3 MΩ
56 Ω	3.9 kΩ	150 kΩ	3.5 MΩ
60 Ω	4.7 kΩ	180 kΩ	4.3 MΩ
68 Ω	4.75 kΩ	200 kΩ	4.7 MΩ
75 Ω	4.99 kΩ	220 kΩ	8.2 MΩ
91 Ω	5.1 kΩ	240 kΩ	9.1 MΩ
100 Ω	5.6 kΩ	240 kΩ	10 MΩ
130 Ω	6.8 kΩ	270 kΩ	12 MΩ
150 Ω	8.2 kΩ	300 kΩ	16 MΩ
180 Ω	9.1 kΩ	330 kΩ	20 MΩ
220 Ω	10 kΩ	360 kΩ	36 MΩ
240 Ω	11 kΩ	470 kΩ	47 MΩ
300 Ω	13 kΩ	510 kΩ	
330 Ω	15 kΩ	560 kΩ	
390 Ω	20 kΩ	680 kΩ	
470 Ω	22 kΩ	750 kΩ	
510 Ω	27 kΩ	820 kΩ	
560 Ω	30 kΩ		
620 Ω			
680 Ω			
768 Ω			
820 Ω			
910 Ω			