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Date: November 19, 2019
Professor Steven Gillette

Abstract
In this lab, I began the construction of the MagLev project starting with the power supply. The lab required placing and soldering components as well as observing and measuring the AC source, filtered and regulated outputs.

Learning Objectives

- Use precision measurement tools to analyze an electronic circuit
- Visualize and measure ripple voltage in a DC power supply output.
- Compare unfiltered, filtered and filtered + regulated power supplies

Notes:
1. Took all voltage measurements relative to ground (unless otherwise stated)
2. Recorded relevant measurements and calculation results in data tables
3. Recorded all measured values on the circuit schematics
4. Used all available precision in calculations, rounded off answers to 3 significant figures
5. ***Measured and captured peak-to-peak ripple voltages using scope channel AC coupling.***
6. ***Measured and captured RMS and mean voltages using a DMM.***

Materials

Quantity	Description
1	MagLev Power supply parts kit
1	120/12V power supply
1	10kΩ resistor
1	Soldering station
1	DMM
1	DO-scope

Procedure – Setup

1. Used a DMM to m***easure and record*** the RMS output of the 120/12V “wall wart” power supply.

   $\underline{13.8V_{RMS}}$

2. ***Calculated and recorded*** the peak voltage using the Peak Voltage formula.

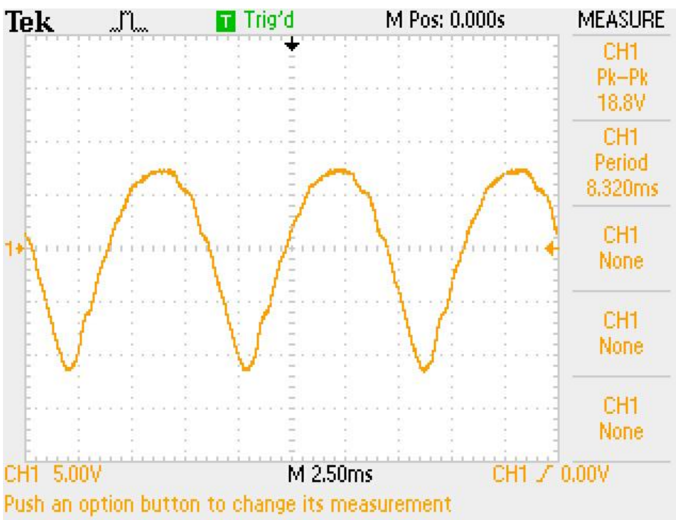
$$V_p = V_{RMS} * \sqrt{2} = 13.8 * 1.414 = \underline{19.5V_p}$$

3. ***Measured and recorded*** the peak to peak voltage using the DO-scope.

$\underline{V_{p\text{-}p} = 40V}$

Procedure – Unfiltered Bridge Rectifier

4. Soldered only the AC PWR connector and the bridge rectifier module onto the MagLev circuit board. Made sure that the writing on the bridge rectifier faces the center of the board.
5. Temporarily installed a 10kΩ resistor in the position designated for capacitor C1. ***Did not solder***.
6. Attached the DO-scope probe ground to the resistor lead in the hole marked GND. Attached the DO-scope probe to the resistor lead in the hole marked +. Set the scope to DC Coupling.
7. Plugged in the AC power supply and ***captured*** the output waveform of the unfiltered bridge rectifier. Used the scope MEASURE menu to display waveform peak to peak amplitude and period.



Procedure – Filtered Bridge Rectifier

8. Unplugged the power supply and soldered in the following components. Observed component polarity as work proceeded. All parts (except Q1) sit flush with the board.
    a. C1, C2, C3
    b. CON1 (installed so the white "wall" faces the center of the board
    c. Q1 (installed 1/8" to 1/4" above the board)

d. R1, R2 (470Ω)

e. ZD1 (the black stripe on the diode aligned with the stripe of the board silk screen)

9. Used the DMM diode check function to ***measure and record*** V_F (forward voltage drop) of the LED.

V_F = 2.54V

10. Soldered in the white LED to one of the riser boards. Observed LED polarity (the flat on the LED corresponds with the silk screen flat.

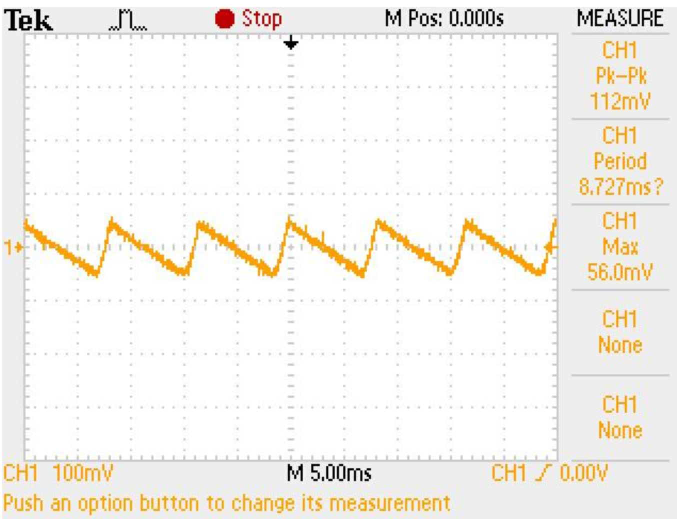
11. Installed (but did not solder) the LED riser board into CON1, lined up with the four pins. The LED points towards the center of the board.

12. Plugged in the power supply. The LED turned on. Left the board powered up for the following measurements.

13. Used a DMM to ***measure and record*** the DC voltage across C1.

17.38V

14. Used a DO scope to ***capture*** the ripple voltage across C1. Used the scope MEASURE menu to display waveform peak to peak amplitude and period.



15. Used a DMM to ***measure and record*** the voltage drop across R2, the LED current limiting resistor.

6.02V

16. ***Calculated and recorded*** the current flowing through R2 in milli-Amps.

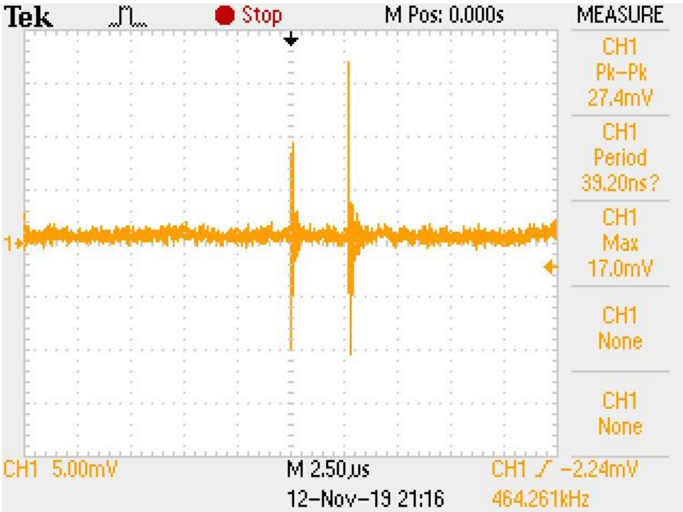
$$I = \frac{E}{E} = \frac{6.02}{470} = .013A = 13mA$$

Procedure – Filtered + Regulated Bridge Rectifier

17. Used a DMM to ***measure and record*** the DC voltage output of the Q1 emitter lead. ***Used extreme caution*** to avoid shorting transistor leads together with the DMM probe. Used the C1 lead marked GND for the DMM black lead and the transistor emitter for the DMM red lead.

9.01V

18. Set the DO-scope probe attenuation to 1X. Selected the appropriate scope channel and pressed the CH Menu button. Configured the scope channel attenuation to match the new probe setting. Set the scope channel to AC Coupling.
19. ***Measured, captured and recorded*** the V_{PP} ripple voltage at the Q1 emitter lead. ***Used extreme caution*** to avoid shorting transistor leads together with the scope probe. Used the C1 lead marked GND for the scope probe ground clip with the Pomona clip attached to the emitter.



Formulas

Voltage

$$V_P = V_{RMS} \times \sqrt{2}$$

$$V_{RMS} = \frac{V_P}{\sqrt{2}}$$

$$V_{RMS} = V_P \times 0.707$$

Where;
V_{RMS} = effective voltage
V_P = peak voltage

Frequency

$$f = \frac{1}{p}$$

Where;
f = frequency (Hertz)
p = period (seconds)

Ripple Voltage Change

$$\%Change = \frac{V_{P-P(final)} - V_{P-P(initial)}}{V_{P-P(initial)}} \times 100\%$$

Where;
% Change = percent ripple voltage change
$V_{P-P(final)}$ = filtered, regulated ripple voltage
$V_{P-P(initial)}$ = unfiltered, unregulated ripple voltage

Data Results

	Unfiltered	Filtered	Filtered + Regulated
V_{P-P}	$18.8V_{p-p}$	112mV	0mV/noise

Critical Thinking

1. Search the Internet for a data sheet for zener diode 1N5240B. Include a copy of one relevant page showing the reverse breakdown voltage for this diode. (Attach the relevant data sheet page to your report)

Please see final page of report. Reverse breakdown voltage appears to be V_R, 8V at 3μA.

2. Compare in table format the V_{PP} ripple voltages measured in this lab including unfiltered, filtered, and filtered plus regulated.

In the data results section above, the unfiltered voltage had the highest voltage. The filtered showed the unregulated ripple voltage. The regulation gave no indication of ripple on my oscilloscope, while other students showed a very clean signal with a very slight ripple voltage. Clearly, filtered and regulated components gives a very clean DC voltage.

Appendix A – Lab Notes

SIERRA COLLEGE	MECH 10 - Lab 19 MagLev Power Supply	Mechatronics *Real Skills Real Jobs*
Name Cayce Beames		11/12/19

Learning Objectives

- Use precision measurement tools to analyze an electronic circuit
- Visualize and measure ripple voltage in a DC power supply output.
- Compare unfiltered, filtered and filtered + regulated power supplies

Notes:

1. Take all voltage measurements relative to ground (unless otherwise stated)
2. Record relevant measurements and calculation results in data tables
3. Record all measured values on the circuit schematics
4. Use all available precision in calculations, round off answers to 3 significant figures
5. ***Measure and capture peak-to-peak ripple voltages using scope channel AC coupling.***
6. ***Measure and capture RMS and mean voltages using a DMM.***

Materials

Quantity	**Description**
1	MagLev Power supply parts kit
1	120/12V power supply 13.77
1	10kΩ resistor
1	Soldering station
1	DMM
1	DO-scope

Procedure – Setup

1. Use a DMM to m***easure and record*** the RMS output of the 120/12V "wall wart" power supply. 13.77V rms
2. ***Calculate and record*** the peak voltage using the Peak Voltage formula. 19.47Vp
3. ***Measure and record*** the peak to peak voltage using the DO-scope. 40.4Vp-p

Procedure – Unfiltered Bridge Rectifier

4. Solder only the AC PWR connector and the bridge rectifier module onto the MagLev circuit board. Make sure that the writing on the bridge rectifier faces the center of the board.
5. Temporarily install a 10kΩ resistor in the position designated for capacitor C1. ***Do not solder.***
6. Attach the DO-scope probe ground to the resistor lead in the hole marked GND. Attach the DO-scope probe to the resistor lead in the hole marked +. Set the scope to DC Coupling.

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7. Plug in the AC power supply and ***capture*** the output waveform of the unfiltered bridge rectifier. Use the scope MEASURE menu to display waveform peak to peak amplitude and period. 18.8Vp-p 8.320ms

Procedure – Filtered Bridge Rectifier

8. Unplug the power supply and solder in the following components. Be sure to observe component polarity as work proceeds. All parts (except Q1) should sit flush with the board.

   a. C1, C2, C3

   b. CON1 (install so the white "wall" faces the center of the board

   c. Q1 (install 1/8" to 1/4" above the board)

   d. R1, R2 (470Ω)

   e. ZD1 (the black stripe on the diode aligns with the stripe of the board silk screen)

9. Use the DMM diode check function to ***measure and record*** V_F (forward voltage drop) of the LED. 2.54V

10. Solder in the white LED to one of the riser boards. Observe LED polarity (the flat on the LED corresponds with the silk screen flat.

11. Install (but do not solder) the LED riser board into CON1, lining up with the four pins. The LED should point towards the center of the board.

12. Plug in the power supply. The LED should turn on. Leave the board powered up for the following measurements.

13. Use a DMM to ***measure and record*** the DC voltage across C1. 17.33V

14. Use a DO scope to ***capture*** the ripple voltage across C1. Use the scope MEASURE menu to display waveform peak to peak amplitude and period. 112mV 8.727ms

15. Use a DMM to ***measure and record*** the voltage drop across R2, the LED current limiting resistor. 6.02V

16. ***Calculate and record*** the current flowing through R2 in milli-Amps. $I = \frac{E}{R} = \frac{6.02}{470} = .013A = 13mA$

Procedure – Filtered + Regulated Bridge Rectifier

17. Use a DMM to ***measure and record*** the DC voltage output of the Q1 emitter lead. 9.06V ***Use extreme caution*** to avoid shorting transistor leads together with the DMM probe. Use the C1 lead marked GND for the DMM black lead and the transistor emitter for the DMM red lead.

18. Set the DO-scope probe attenuation to 1X. Select the appropriate scope channel and press the CH Menu button. Configure the scope channel attenuation to match the new probe setting. Set the scope channel to AC Coupling.

19. ***Measure, capture and record*** the V_{PP} ripple voltage at the Q1 emitter lead. ***Use extreme caution*** to avoid shorting transistor leads together with the scope probe. Use the C1 lead marked GND for the scope probe ground clip with the Pomona clip attached to the emitter. 27.4mV 39.2ns noise

Formulas

Voltage

$$V_P = V_{RMS} \times \sqrt{2} \qquad V_{RMS} = \frac{V_P}{\sqrt{2}} \qquad V_{RMS} = V_P \times 0.707$$

Where;
V_{RMS} = effective voltage
V_P = peak voltage

Frequency

$$f = \frac{1}{p}$$

Where;
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p = period (seconds)

Ripple Voltage Change

$$\%Change = \frac{V_{P-P(final)} - V_{P-P(initial)}}{V_{P-P(initial)}} \times 100\%$$

Where;
% Change = percent ripple voltage change
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Data Results

	Unfiltred	Filtered	Filtered + Regulated
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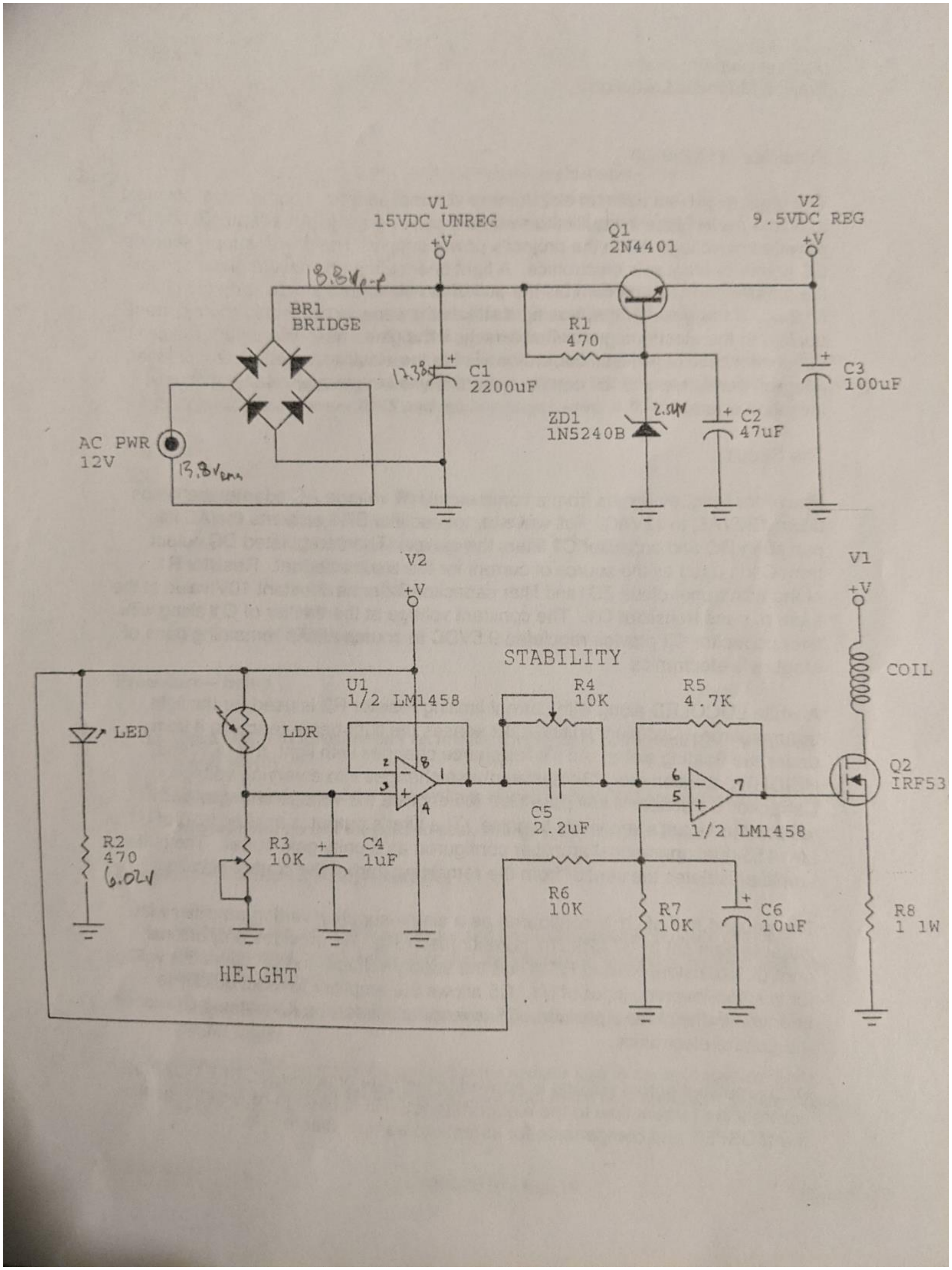
Critical Thinking

1. Search the Internet for a data sheet for zener diode 1N5240B. Include a copy of one relevant page showing the reverse breakdown voltage for this diode. (Attach the relevant data sheet page to your report)
2. Compare in table format the V_{PP} ripple voltages measured in this lab including unfiltered, filtered, and filtered plus regulated.


V1
15VDC UNREG
V2
9.5VDC REG
Q1
2N4401
+V
18.8Vp-p
BR1
BRIDGE
R1
470
C1
2200uF
C3
100uF
ZD1
1N5240B
C2
47uF
AC PWR
12V
13.8Vrms
V2
+V
V1
STABILITY
COIL
U1
1/2 LM1458
R4
10K
R5
4.7K
LED
LDR
Q2
IRF53
C5
2.2uF
1/2 LM1458
R2
470
6.02V
R3
10K
C4
1uF
R6
10K
R7
10K
C6
10uF
R8
1 1W
HEIGHT

FAIRCHILD
SEMICONDUCTOR®

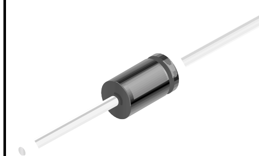
Zeners
1N5221B - 1N5279B

Absolute Maximum Ratings * T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
P_D	Power Dissipation Derate above 50°C	500 4.0	mW mW°C
T_{STG}	Storage Temperature Range	-65 to +200	°C
T_J	Maximum Junction Operating Temperature	+200	°C
	Lead Temperature (1/16” from case for 10 seconds)	+230	°C

* These ratings are limiting values above which the serviceability of the diode may be impaired.
** Non-recurrent square wave PW = 8.3ms, Ta = 50 degrees C.

Tolerance = 5%



DO-35 Glass case
COLOR BAND DENOTES CATHODE

Electrical Characteristics T_A=25°C unless otherwise noted

Device	V_Z (V) @ I_Z (Note 1)			Z_Z (Ω) @ I_Z (mA)		Z_{ZK} (Ω) @ I_{ZK} (mA)		I_R (μA) @ V_R (V)		T_C (%/°C)
	Min.	Typ.	Max.							
1N5221B	2.28	2.4	2.52	30	20	1,200	0.25	100	1.0	-0.085
1N5222B	2.375	2.5	2.625	30	20	1,250	0.25	100	1.0	-0.085
1N5223B	2.565	2.7	2.835	30	20	1,300	0.25	75	1.0	-0.080
1N5224B	2.66	2.8	2.94	30	20	1,400	0.25	75	1.0	-0.080
1N5225B	2.85	3	3.15	29	20	1,600	0.25	50	1.0	-0.075
1N5226B	3.135	3.3	3.465	28	20	1,600	0.25	25	1.0	-0.07
1N5227B	3.42	3.6	3.78	24	20	1,700	0.25	15	1.0	-0.065
1N5228B	3.705	3.9	4.095	23	20	1,900	0.25	10	1.0	-0.06
1N5229B	4.085	4.3	4.515	22	20	2,000	0.25	5.0	1.0	+/-0.055
1N5230B	4.465	4.7	4.935	19	20	1,900	0.25	2.0	1.0	+/-0.03
1N5231B	4.845	5.1	5.355	17	20	1,600	0.25	5.0	2.0	+/-0.03
1N5232B	5.32	5.6	5.88	11	20	1,600	0.25	5.0	3.0	0.038
1N5233B	5.7	6	6.3	7.0	20	1,600	0.25	5.0	3.5	0.038
1N5234B	5.89	6.2	6.51	7.0	20	1,000	0.25	5.0	4.0	0.045
1N5235B	6.46	6.8	7.14	5.0	20	750	0.25	3.0	5.0	0.05
1N5236B	7.125	7.5	7.875	6.0	20	500	0.25	3.0	6.0	0.058
1N5237B	7.79	8.2	8.61	8.0	20	500	0.25	3.0	6.5	0.062
1N5238B	8.265	8.7	9.135	8.0	20	600	0.25	3.0	6.5	0.065
1N5239B	8.645	9.1	9.555	10	20	600	0.25	3.0	7.0	0.068
1N5240B	9.5	10	10.5	17	20	600	0.25	3.0	8.0	0.075
1N5241B	10.45	11	11.55	22	20	600	0.25	2.0	8.4	0.076
1N5242B	11.4	12	12.6	30	20	600	0.25	0.1	9.1	0.077
1N5243B	12.35	13	13.65	13	9.5	600	0.25	0.1	9.9	0.079
1N5244B	13.3	14	14.7	15	9.0	600	0.25	0.1	10	0.080
1N5245B	14.25	15	15.75	16	8.5	600	0.25	0.1	11	0.082
1N5246B	15.2	16	16.8	17	7.8	600	0.25	0.1	12	0.083
1N5247B	16.15	17	17.85	19	7.4	600	0.25	0.1	13	0.084
1N5248B	17.1	18	18.9	21	7.0	600	0.25	0.1	14	0.085
1N5247B	18.05	19	19.95	23	6.6	600	0.25	0.1	14	0.085
1N5250B	19	20	21	25	6.2	600	0.25	0.1	15	0.086

Grading Criteria

		Points Possible	Points Earned
Documentation	Abstract, introduction, experiment, data results, conclusions, attachments, clarity, spelling, grammar	**10**	
Setup	Power supply voltages measured and calculated	**5**	
Unfiltered	Waveform captured	**5**	
Filtered	LED V_F, C1 DC voltage, V_{PP}, V_{R2}, I_{R2}, Q1 V_{DC}, V_{PP}, ripple waveform captured	**10**	
Filtered + Regulated	V_{DC}, $V_{p\text{-}p}$, ripple waveform captured	**10**	
Conclusions	Questions answered completely & accurately.	**10**	
On-time submittal	Lab report is submitted in accordance with the assignment due date as posted on Canvas	**5**	
	Total	**55**	

Lab Report Format

Abstract - a summary and high-level overview of the lab and its results
Introduction - State the objectives of the laboratory and list the equipment required
Experiment - Describe the procedure used to carry out the lab
Data Results - list data taken in table or graphical format where appropriate
Conclusion - State the conclusions drawn and lessons learned from the laboratory activities. Answer any questions found within the lab procedure.
Attachments – grading criteria, verification signatures, circuit diagrams, lab procedures & notes