Australian National University

ENGN1218 Introduction to Electronics

HLAB5 Manual and Report:

Smart Phone Battery Charger Circuit Implementation

Week: 10

Lab Duration: 3 hours

Due Date: The measurements are to be completed during lab time. The lab report is due Monday, 10am in Week 12. Late submission is accepted with 5% penalty only if submitted within 24 hours of due date.

Submission: All students will complete an individual or group lab report and upload a PDF report in wattle.

Total Marks: 25

Bonus Mark: Bonus Mark: +1 bonus mark for completing the additional task. See last pages of this document for details.

Contribution to Final Assessment: 6%

Attendance: To pass this course, students must attend and complete at least 6 out of 8 Labs, including HLab5.

Pre-Lab Reading: The following resources will help you successfully complete the lab.

- How to study for HLab5 web page in wattle
- Week 10 Zoom Masterclass.
- T6 V10-V14 echo360 video lectures
- Weekly problems in weeks 8 and 9
- Appendices in HLab02 (soldering)
- How to use vero board when soldering document
- Video lecture in echo360: HLab4-5 How_to_characterise_the diode_and_zener_diode
- Appendices in this lab manual

Pre-Lab Tasks:

- Before completing the lab, study the **Pre-Lab Reading** and read this entire lab manual carefully. Lab time is precious. Do not waste it reading the background material. If you do not do this minimum preparation, you may not be able to complete all the tasks in the lab time, resulting in loss of marks.
- Complete the theoretical calculations in **Table 1** before completing the lab.

Post-Lab Tasks:

- Simulate the circuits in **Figure 1** and **Figure 2** in PSPICE/LTSPICE and complete the results in **Table 1**. Pspice/LTspice does not have 78L12 part name so simulation results of **Figure 3** are not required.
- Compare theoretical analysis, simulation and actual measurements in **Table 1** and submit a report before the due date. Refer to the template report in wattle.
- Note: Do not perform the post-lab tasks during the lab time. You can complete these task, after the lab at your own convenience.

Lab Instructions:

- Students will perform this individually.
- Students should attempt the sections marked with TinkerCAD accordingly
- Utilise the lab recording to gain context of this lab in practice, as it contains some key practical procedures. **It is recommended to follow along with the in person lab while watching, and fill in appropriate components of this manual.**
- A formal report should be prepared and submitted in Wattle. Thus it would be a good idea to take some photos of the assembled circuit for inclusion in the report. Only one lab report is required for a group. Only one group member needs to upload the report using the link provided in wattle.

Learning Objectives:

After completing this lab, students will be able to:

1. Implement and solder a bridge rectifier circuit on a proto-board, demonstrating its performance.
2. Understand the effect of adding components such as capacitors and regulators.
3. Appreciate the difference between the values obtained from theoretical calculations, simulation, and measurements.
4. Learn how to remove, replace, or add components on the soldered circuit.
5. Measure various (dc and ac) voltages in the soldered circuit using appropriate lab instruments.

Lab Tasks

The results for this lab are to be tabulated in **Table 1** of the Lab Report section of this manual. You will need to recreate this table in your lab report.

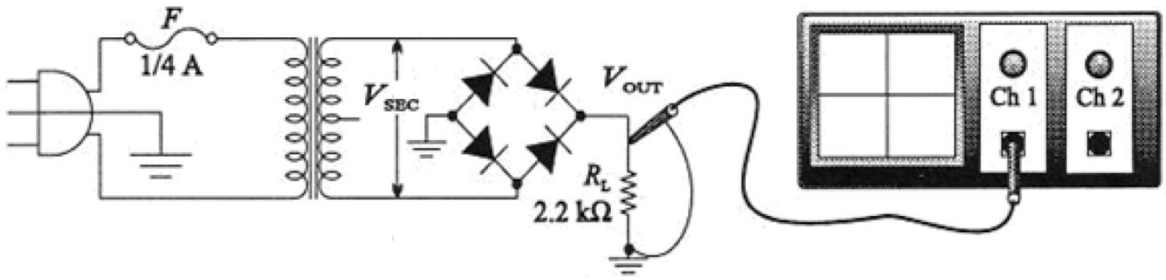

Figure 1: Diode bridge rectifier circuit.

For this lab, you require the following components:

1. Two 2.2 $k\Omega$ resistors.
2. One 12V (rms) AC transformer with fused line cord.
3. Four diodes 1N4004.
4. One 100 μF capacitor.
5. One 0.01 μF capacitor.
6. One 78L12 regulator.
7. One proto-board.
8. One LED (light emitting diode).

1. Full-Wave Rectifier Output

Consider the circuit shown in the **Figure 1**. Results for this circuit are to be tabulated in **Table 1**.

1. Using the breadboard in TinkerCAD, construct the full-wave bridge rectifier by laying out four diodes and a load resistor, as shown in **Figure 1**. The ground symbol is not necessarily connected to Earth – the two ground points indicated here should be connected together.
2. The output of the transformer in this lab is called the secondary terminal (our model has two outputs with nominal 12V (rms)) and will be used as input to the rectifier circuit. The

primary terminal is connected to 240V (rms) with a fuse. We will use the TinkerCAD function generator to model this.

3. Measure the peak voltage $V_{sec(p)}$ from the function generator output using the oscilloscope in TinkerCAD and the actual value of the load resistor R_L using the ohmmeter. Record your results in **Table 2**. You will need to recreate this table in your lab report. Note that the measurement of the output of the function generator should be done so before connecting to the circuit.

4. Check your circuit carefully before switching on the power. In a practical context, short-circuit checking functionality in a multi-meter can be useful to check the connections and any accidental short circuits. You can check for any short circuits using a multi-meter.

5. Measure and record the rectifier output peak voltage $V_{out(p)}$ using the oscilloscope in **Table 1**. This measured value can be used to calculate the measured $V_{out(DC)}$. **Tip:** This is just a measurement across the resistor, ensuring the two grounds are connected.

   Note: In practice, the oscilloscope should not be used to view both the secondary voltage V_{sec} and the output voltage V_{out} in the **Figure 1** at the same time. The reason is that the ground terminals of the probes are internally connected together.

6. Now consider the full-wave rectifier circuit with capacitor as shown in the **Figure 2**.

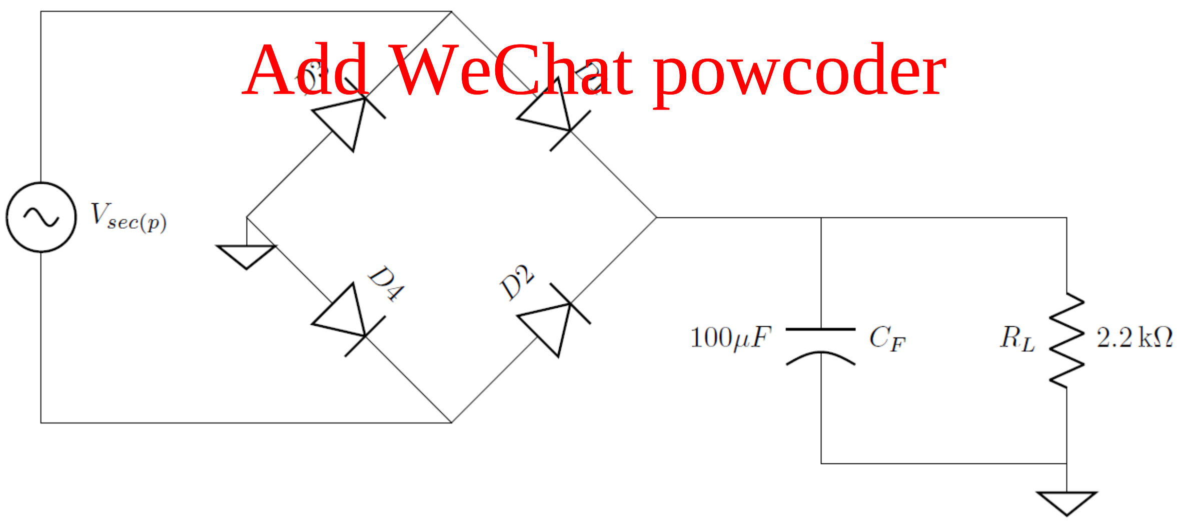

Figure 2: Diode bridge rectifier circuit with smoothing capacitor.

7. Connect the 100 μF (electrolytic, polarised) capacitor in parallel with the load resistor as shown in **Figure 2**. Make sure the electrolytic capacitor polarity is correct. Measure $V_{out(p)}$, $V_{r(pp)}$ and the ripple frequency using the oscilloscope. Record the values in **Table 1**. Use measured $V_{out(p)}$ to calculate measured $V_{out(DC)}$. You can take a screenshot of the oscilloscope for inclusion in your report. Also be mindful of report length constraints.

8. Now consider the full-wave rectifier circuit with capacitor and regulator as shown in the **Figure 3**. Unfortunately, the 78L12 is not available in TinkerCAD. Please utilise the lab recordings to finalise the lab tasks. Instructions have been retained as though you were attending the practical lab.

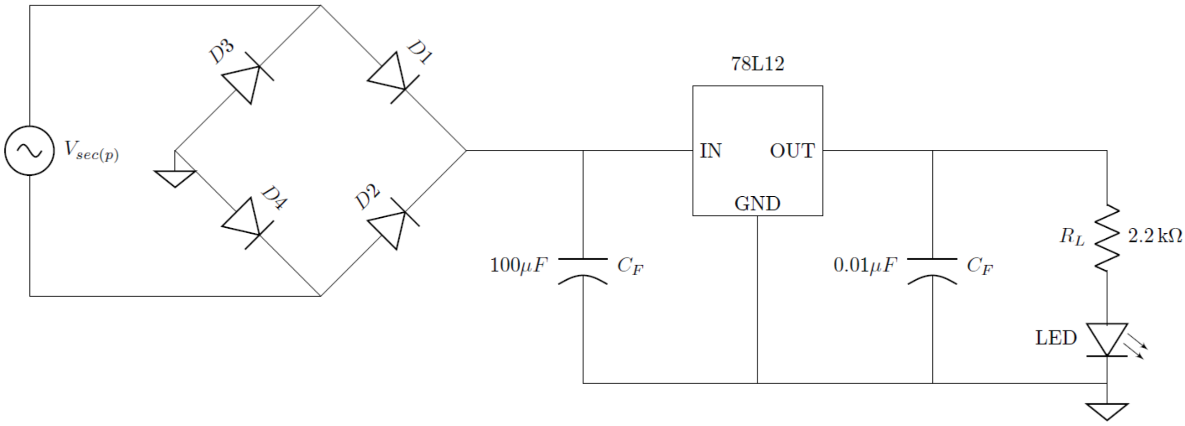

Figure 3: Diode bridge rectifier with smoothing capacitor and zener regulator.

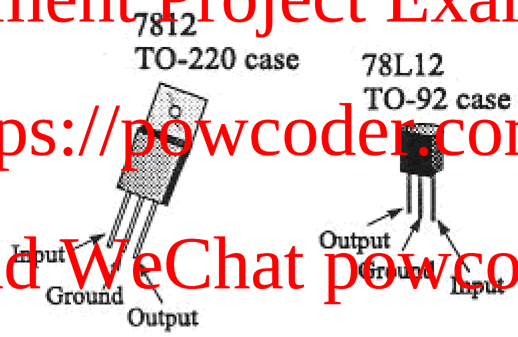

Figure 4: Zener Regulator pin diagram.

9. You can construct the circuit in **Figure 3** from the already soldered circuit for **Figure 2**. For this purpose, disconnect (or cut off) the load resistor R_L from the soldered circuit for **Figure 2**, and then add the *78L12* regulator with an additional 0.01 μF capacitor, which is required for the regulator to operate properly. In the output load side, connect a 2.2 $k\Omega$ resistor in series with a LED to indicate the presence of power.

10. Connect and solder a 78*L*12 regulator to provide +12V regulated output voltage as shown in **Figure 3**. The 78*L*12 regulator (shown in **Figure 4**) is a three terminal component. The letter “L” in the name 78*L*12 means small power option which can deliver over 100 *mA* and “12” denotes a 12V output. If more output current is required such as 1.0 *A* then you would need to use 7812 regulator.

11. Measure and record the output voltage $V_{out(DC)}$ in **Table 1** (measure across both R_L and LED diode). You can take a picture of the oscilloscope for inclusion in your report. Also be mindful of report length constraints.

12. Measure the voltage drop across the resistor using voltmeter and use ohm's law to calculate the measured current $I_{out(DC)}$. Is this current within the outage range of the zener regulator. Briefly discuss in your report.

13. Is your measured $V_{out(DC)}$ within 10% of predicted 12V DC output? Discuss in your report.

14. Show your working circuit to your tutor (LED should be turning ON) for recording attendance. You can take a picture of the oscilloscope for inclusion in your report. Also be mindful of report length constraints.

15. Turn off the power and clean up the table.

16. Congratulations!! You have successfully built the diode bridge rectifier with smoothing capacitor and zener regulator, which is the main part of the everyday smartphone battery charger.

Appendices: Theoretical Calculations

1. Bridge Rectifier without Capacitor

The analysis steps for the circuit without capacitor are:

Step 1. Find the peak input voltage

$V_{in(p)} = V_{\sec\,(p)}$ (Use the measured value in **Table 2** as the theoretical input value)

Step 2. Find the peak output voltage

$$V_{o(p)} = \left(V_{in(p)} - 1.4\right)V$$

Step 3. Find the average load voltage

$$V_{o(DC)} = \frac{2V_{o(p)}}{\pi}$$

2. Bridge Rectifier with Capacitor

The analysis steps for the circuit with capacitor are:

Step 1. Find the peak input voltage

$V_{in(p)} = V_{\sec\,(p)}$ (Use the measured value in **Table 2** as the theoretical input value)

Step 2. Find the peak output voltage

$$V_{o(p)} = \left(V_{in(p)} - 1.4\right)V$$

Step 3. Find the peak-to-peak ripple voltage

$$V_{r(pp)} = \frac{V_{o(DC)}}{2fR_LC} \approx \frac{V_{o(p)}}{2fR_LC}V$$

Note: The assumption $V_{o(p)} \approx V_{o(DC)}$ can be made in analysis, assuming the rectifier circuit given is properly designed.

Step 4. Find the average load voltage

$$V_{o(DC)} = V_{o(p)} - \frac{1}{2}V_{r(pp)}$$

Step 5. Find the average load current

$$I_{o(DC)} = \frac{V_{o(p)}}{R_L}$$

Step 6. Find the ripple factor and express it as a percentage

$$r = \frac{V_{r(pp)}}{V_{o(DC)}} \times 100\%$$

3. Bridge Rectifier with Capacitor and Zener Regulator

$V_{o(DC)}$ = 12 V (because of the zener regulator)

For Use in ENGN1218 HLab5 Report

Please see the HLab5 report template, which is separately provided. The Tables below are to be included in the HLab5 report.

Lab Report

The results for this lab are to be tabulated in **Table 1**. You will need to scan or take a photo and include this part in your report.

Table 1: Results for HLab5. The values for the cells highlighted with blue colour are not required.

		$V_{out(p)}$	$V_{out(DC)}$	$V_{r(pp)}$	Ripple f
Without capacitor	Theoretical				
	Simulation				
	TinkerCAD				
With capacitor	Theoretical				
	Simulation				
	TinkerCAD				
With capacitor and Zener regulator	Theoretical				
	Measured (recording)				

Table 2: Measurements for the full-wave rectifier.

Vsec(p)	R_L

Bonus Mark

Note: You will need to recreate Table below in your report to get the bonus mark. Also include the explanation why you choose the IC diode bridge.

In this lab, we used four 1N4004 diodes to make a diode bridge. Diode bridges are also available as a single integrated circuit.

Research the website https://au.element14.com/ and find an Integrated circuit diode bridge component which has similar electrical properties (repetitive reverse voltage, forward current and forward voltage). Complete the following table:

Table 3: Bonus mark

Property	**1N4004**	**Part name of IC diode bridge =**
Manufacturer		
Price (1+ or 5+)		
Repetitive Reverse Voltage Vrrm Max		
Forward Current If(AV)		
Forward Voltage VF max		

Using 1-2 sentences, please justify why you choose this IC diode bridge.

Uni ID: ____________________

Date: ____________________