

ECE 3254
Zener Diode Circuits and Applications
Laboratory #6
PRELAB

Name:

Partners:

Bench:

Read over the entire Lab 5. Show all work (equations, calculations, values, etc).

1. For the circuit shown in Figure 6-1, sketch $V_i(t)$ and $V_o(t)$ on the same graph as voltage vs. time. Use $V_i(t) = \mathbf{a\ 5\ ms\ ramp}$ from -10V to +10 V. Diodes D_1 and D_2 have a forward voltage drop of 0.6V, $R_s = 470\Omega$, $R_L = 1k\Omega$, and the Bias voltage = 4.1V. **Clearly** identify the output clipping voltages. Below, calculate and **clearly** identify the input voltage points where output clipping begins. Enter the clipped voltages corresponding and input voltages in Part I-4 on the data sheet. (40 points)
NOTE: This input voltage is a RAMP, not a sine wave like the example in the textbook!
2. Explain the difference between the operating characteristics of a regular diode and a Zener diode. Use drawings if helpful. (30 points)
3. What is the maximum regulator current that can be safely passed through a 10V 1W Zener diode? Enter this information below and in Part II-5 the data sheet. (15 points)
4. What signal is available at the sync output on the function generator? Why will you use this? (hint: see lab pages 2 and 3) (15 points)

OBJECTIVES:

To observe the characteristics of Zener diodes and Zener diode circuits.

EXERCISES:

This laboratory is broken into two parts:

Part I: Zener Diodes and Diode Clipper Circuits

Part II: Zener Diode Shunt Voltage Regulator

PART I: ZENER DIODES AND DIODE CLIPPERS

When forward biased, a Zener diode is identical to a regular diode. When reverse biased, the Zener diode can be modeled as a regular diode connected backwards with a bias supply in series. The circuit of Figure 5-1 is the equivalent model for the Zener diode circuit of Figure 5-2.

1. Construct the clipper circuit in Figure 6-1 using $D1=D2=1N4001$ or $1N4003$, $R_S = 470\Omega$, $R_L = 1k\Omega$, and DC Bias voltage = 4.1V

For $V_i(t)$, use the RAMP waveform on your function generator and adjust it to produce a $-10V$ to $+10V$ rise over 5 ms. NOTE: The function generator menu may not accept a typed freq below 1000 Hz; if not, use the down arrow button to set the frequency. Record your function generator settings on the data sheet.

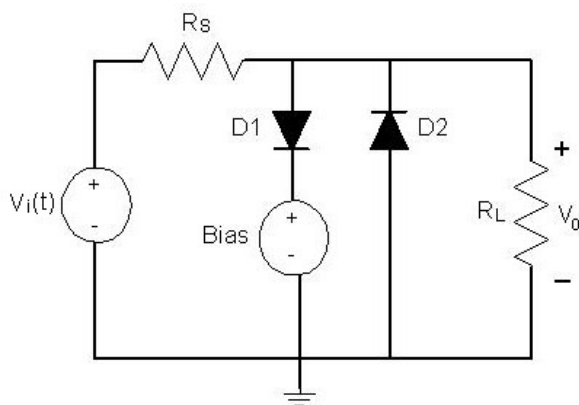


Figure 6-1 Diode Clipper

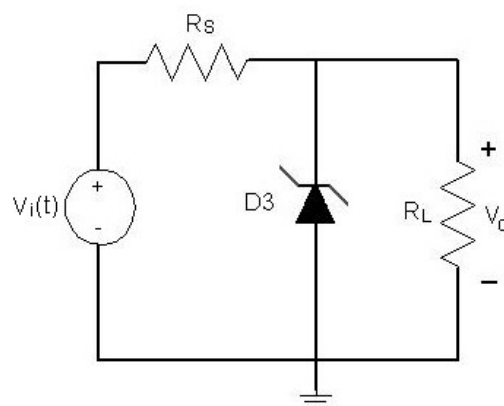


Figure 6-2 Zener Diode Clipper

2. The sync connector of the function generator produces a pulse that corresponds to the beginning of the waveform sent to the output connector. This pulse can be fed to the scope's external trigger so that the scope will always begin the trace when the generator waveform begins. We will use this feature to align and overlay waveforms from the circuits of Figures 6-1 and 6-2.

Connect $V_i(t)$ to scope CH 1 and $V_o(t)$ to scope CH 2. Use a BNC cable to connect the function generator Sync output to the scope External Trigger input. **Set the scope trigger to external** (use the trigger Edge button). Set the horizontal sweep to 1ms/div.

Capture and save the waveforms for $V_i(t)$ and $V_o(t)$. _____ .txt

Use the oscilloscope or buffer cursors to determine output clipping voltages and $\pm V_i$ where the output waveform begins to clip. Record these measurements on the data sheet.

3. Replace D_1 , D_2 , and the bias supply with $D_3 = 1N4732A$ 4.7V, 1W Zener (the circuit shown in Figure 6-2).

Capture and save the waveforms for $V_i(t)$ and $V_o(t)$. _____ .txt

Use the oscilloscope or buffer cursors to determine output clipping voltages and $\pm V_i$ where the output waveform begins to clip. Record these measurements on the data sheet.

4. Overlay the waveforms from Fig 6-1 with the waveforms from Fig 6-2 and save the overlay. _____ .txt

Save the overlay as a jpeg file. Use the red cursor to locate the upper break voltage (at the knee) of V_o and use the blue cursor to locate the lower break voltage (at the knee) of V_o .

***Print jpeg.** Title the print and label the input waveform and both output waveforms. Clearly identify the two circuit waveforms and identify the range of the input voltage waveform where the **output is not clipped**. Write your name(s) on the print and attach it to your data sheet.

On the data sheet, compare your data and overlay with the expected clipping levels from the prelab.

PART II: ZENER DIODE VOLTAGE REGULATOR

The Zener diode can maintain a reasonably flat reverse voltage over a range of diode currents. When the diode is used in as a shunt regulator in Figure 6-3, excess current not drawn by the load is passed through the diode, providing a constant voltage to the load resistor.

1. Obtain a 1N4740 10V, 1W Zener diode from your instructor and use the curve tracer to print the reverse characteristics of the Zener diode. **Print the trace.** Refer to the curve tracer operations manual page 3-15. Insert the diode backwards into the curve tracer and use the following settings:

Function =	Acquisition
Type =	diode
V_a max =	20 Volts
I_a max =	50mA
R_{load} =	10 ohms
P_{max} =	2 Watts

2. Construct the circuit given in Figure 6-3, using the DC power supply for the voltage source, a 1N4740 for the Zener diode, and 100Ω for R_s . For R_L , use the Clarostat 240-C Power Resistor Decade Box. NOTE: *Do not use the Heathkit 1N-3117 Decade Resistance; it can not safely dissipate enough power.*

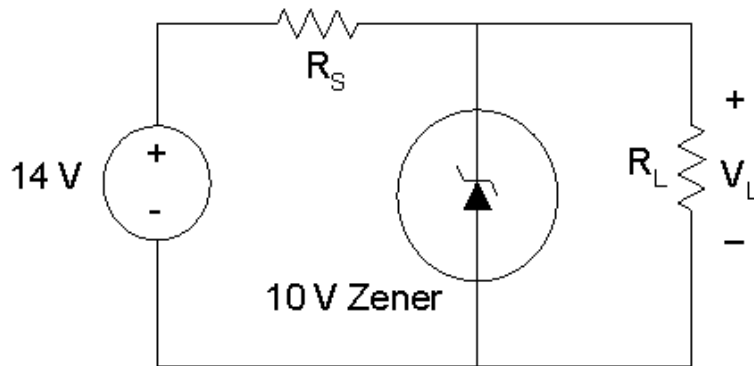


Figure 6-3 Voltage Regulator Using a Zener Diode

3. Measure V_L for each value of R_L . Using these voltage measurements, calculate the currents through the load resistor, the source resistor, and the diode. Using $V_D (=V_L)$ and I_D , calculate the power dissipated in the diode. Note: $i_L=(V_L/R_L)$, $i_s=(V_i-V_L)/R_s$, $i_D = i_s-i_L$. Record this information on the data sheet.
4. ***On the curve tracer plot**, show the operating point (i_D , V_D) of the diode for each value of R_L . Clearly label the load points for each value of R_L on your diode plot, write your name(s) on the plot, and attach the print to your data sheet.

* **Estimate** (by interpolating your results or determining a range) **the minimum load resistance and maximum load current for which your circuit would remain regulated**. Record these values on the data sheet.
5. With $R_L = \infty$, place your fingers on the Zener diode and notice how the diode voltage changes with the temperature. Record the maximum (warm) and minimum (cool) diode Zener voltages. Your fingers will cool the diode. Record your measurements on the data sheet.
6. Assume your Zener diode has an ideal 10V reverse breakdown. Calculate the maximum load current (not diode current) that can be drawn before the output voltage drops below 10 volts. (see the prelab notes for equations). Show your equation(s), values used, calculation performed, and result on the data sheet.
7. Assume your Zener diode has an ideal 10V reverse breakdown.
***Calculate the range of load resistance over which the output voltage remains regulated at 10 volts** (i.e. the maximum and the minimum load resistance for a 10V output)? Show your equation(s), values used, calculation performed, and result on the data sheet. (see the prelab notes for equations)
8. (5 points) Shut down Windows, return cables to racks, return parts to correct drawer bins, return adapters to container, turn off bench power, clear bench, and place seat under bench.

Names:

by first name: _____
 1st alphabetically – wiring 2nd alphabetically – Labview 3rd alphabetically – data sheet

PART I: ZENER DIODES AND DIODE CLIPPERS

1. Amplitude = _____ V_{pp} Offset = _____ V Frequency _____ Hz

2. V_o negative clip voltage _____ Corresponding V_i _____

V_o positive clip voltage _____ Corresponding V_i _____

3. V_o negative clip voltage _____ Corresponding V_i _____

V_o positive clip voltage _____ Corresponding V_i _____

4. *Expected values from prelab:*

V_o negative clip voltage _____ V_i when clip begins _____

V_o positive clip voltage _____ V_i when clip begins _____

Look at the data from 3 and the overlay you just printed. How do the clipping waveforms and voltages of the Zener clipper compare to the clipping waveforms and voltages of two diode/bias supply clipper, and how do the waveforms compare to the expected clipping levels?

PART II: ZENER DIODE VOLTAGE REGULATOR

3.	R _L	V _L (V)	i _L (mA)	i _s (mA)	i _D (mA)	P _D (W)
	100Ω	_____	_____	_____	_____	_____
	200Ω	_____	_____	_____	_____	_____
	250Ω	_____	_____	_____	_____	_____
	350Ω	_____	_____	_____	_____	_____
	450Ω	_____	_____	_____	_____	_____
	750Ω	_____	_____	_____	_____	_____
	1050Ω	_____	_____	_____	_____	_____
	4750Ω	_____	_____	_____	_____	_____
	∞Ω	_____	_____	_____	_____	_____

ECE 3254 Lab 5 Data Sheet

PART II: ZENER DIODE VOLTAGE REGULATOR (cont)

4. $R_{Lmin} \approx$ _____ $I_{Lmax} \approx$ _____

5. Measured (warm) max $V_Z =$ _____ % error = _____ (expected $V_Z = 10V$)

Measured (cool) min $V_Z =$ _____ % error = _____ (expected $V_Z = 10V$)

From prelab: Maximum reverse diode current for 1W at 10V = _____

Was your diode near this current rating? _____

What would you expect V_Z to do if you ran the diode close to the current rating? Why?

6. $I_{Lmax} =$ _____ Show equation(s) used, values used, etc, below.

7. For regulation, _____ $\leq RL \leq$ _____ Show work below.