EXPERIMENT 6: *THE ZENER DIODE AND REGULATION*

Equipment List

- P_3 Full Wave Bridge OR 4x 1N4004 Diodes.
- OS BK 2120B Dual Channel Oscilloscope
- 100 μF Electrolytic capacitor
- I Watt 8.2V Zener Diode
- R_5 Cenco 89 Ω, 2.2 A Rheostat
- R_1 Leeds & Northrup #4754 AC-DC Decade Resistor
- Center Tap Transformer Box

Introduction

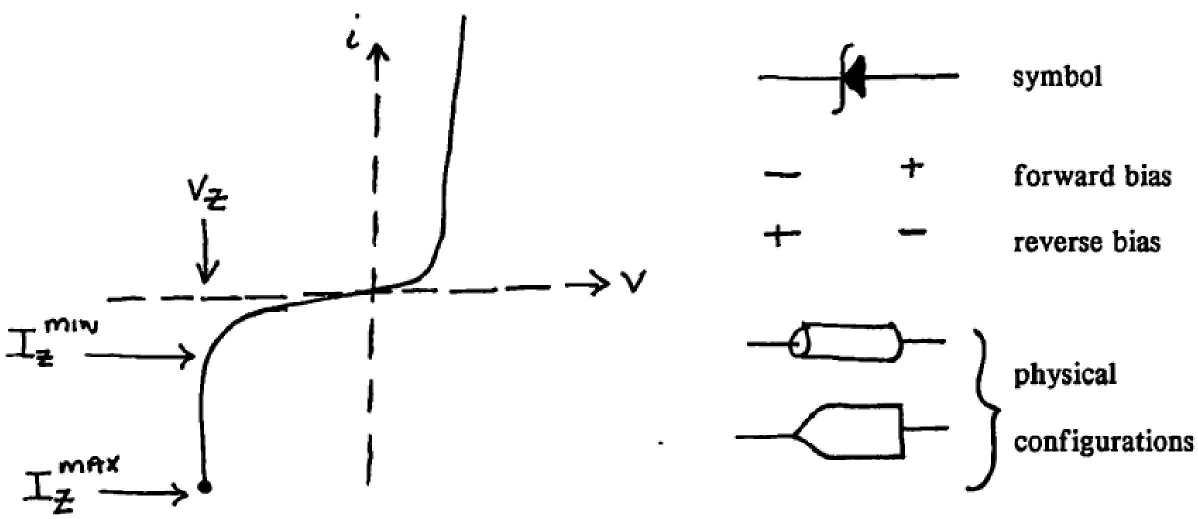

Figure 6.1 Zener Characteristic and Symbol

The forward characteristic of a zener diode is like that of a normal diode. In the reverse direction the characteristic is again normal; i.e., near zero current for any applied reverse bias, <u>until</u> a negative voltage limit, $-V_2$, is reached. At this point the diode breaks down and passes as much current as is presented to the zener diode at a near constant voltage. The breakdown is non-destructive so long as a specified maximum power loss, $P_z = V_z\, I_z^{max}$, is not exceeded.

Note that the physical description of the zener can be confusing. Some zeners look like bullets while others look just like ordinary diodes. The moral of this story is that you should never use anything unless you are sure of what it is. Electronics frequently come in a very small variety of packages and unless you know which package is which, you may send everything up in smoke.

In the Diode Lab we used a capacitor across the load to filter out much of the AC component from a full wave rectified signal. For long time constants this method for producing a DC source is quite effective;

however, the capacitive fitter provides poor regulation for varying loads; i.e., the DC voltage output shifts with a change in the load resistance. We could make use of a zener diode circuit to provide excellent voltage regulation within certain current limits. Or we could use a voltage regulator like the LM317.

$$V_{out} = 1.25V(1 + \frac{R_2}{R_1}) \quad (1)$$

Part I: Zener Characteristics

a) Construct the following circuit.

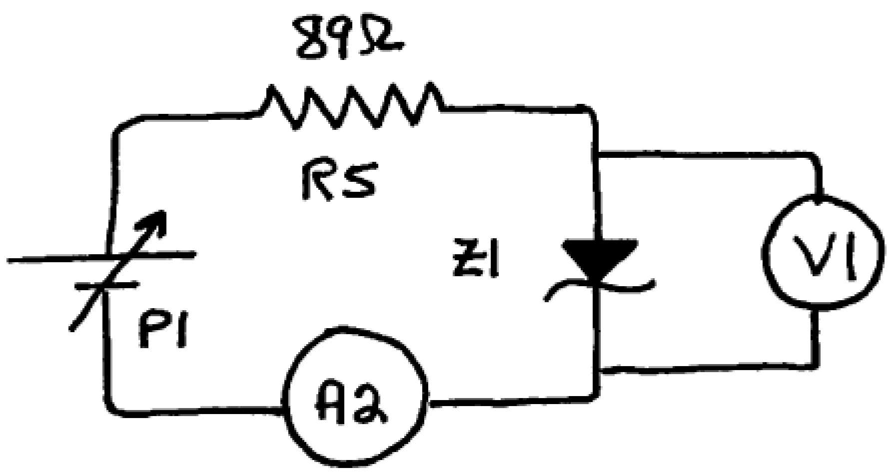

Figure 6.2 Zener Characteristics Measurement

b) Take several readings of voltage versus current to determine the forward characteristic. Do not exceed 100 mA. Do not peg the meters.
c) Reverse the diode and determine the reverse characteristic using the same meters and observing the same precautions.
d) Plot your results.
e) Estimate V_z from the plot.
f) These zeners are rated for 1 Watt. What is the maximum current you can pass through the diode, I_z^{max}?
g) Adjust the current to this value. Note the current slowly drops. Why? Well, when a device is rated at a certain power, this means it will operate without destroying itself at this power level. Where does the power go? It heats the device up, until there is equilibrium between heat generated in the device and heat lost by conduction through the leads and convection through the air. Since solid state devices are generally temperature dependent, we expect the characteristic to change slightly as it heats up.

h) Dump the heat from the zener. Use your fingers as a heat "sink" by squeezing the zener diode between two fingers (don't touch the leads, just the case). This should arrest the drift and perhaps reverse the trend.

i) Estimate I_z^{min}, from your graph. It is the point where the characteristic begins to drop sharply.

Part II: LM317 voltage regulator

The zener diode has a fixed voltage regulation set point, V_z. Replacing a LM317 voltage regulator gives more flexibility in selecting the output voltage.

Construct the circuit in Fig. 6.3 in the middle of your breadboard.

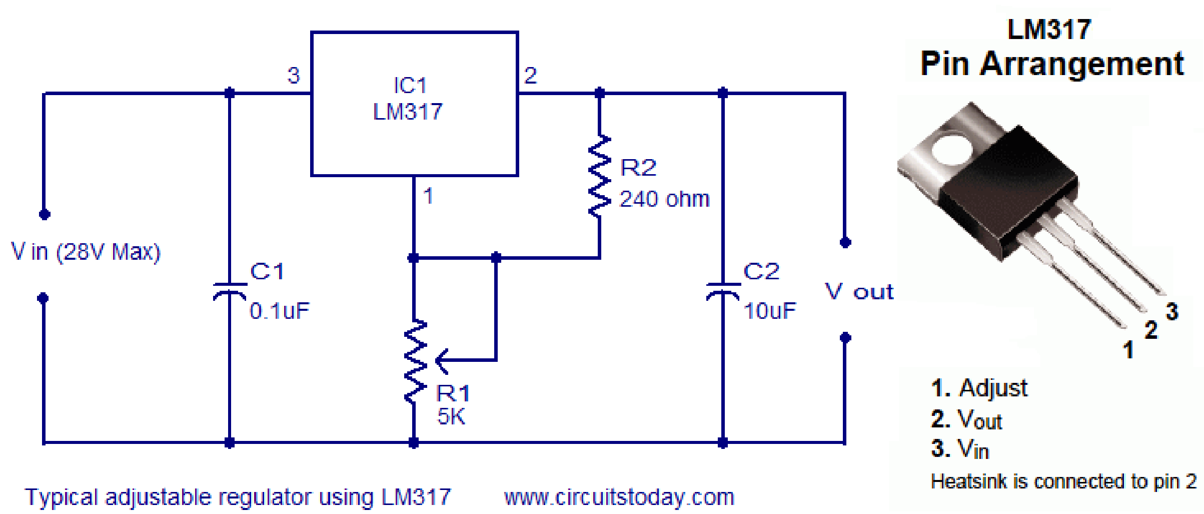

Figure 6.3: A typical LM317 Circuit. The caps are to smooth out fluctuations at the input and the output.

Notice that the values of R_1 and R_2 are ridiculous, Use R_1=240Ω and calculate the proper value of R_2 based on Equation 1 to make V_{out}=8.2V as it would be with the zener diode.

Power your circuit using the the full bridge rectifier from last week, see Fig. 4.

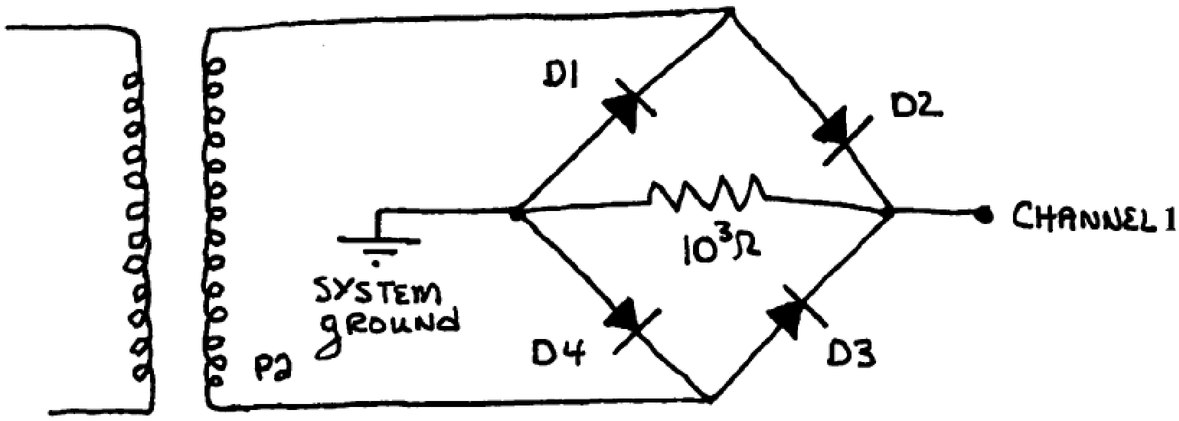

Figure 6.4: The full bridge rectifier, you will place the voltage regulator circuit between the bridge and the 1kΩ load.

Now use this circuit to condition the power leaving the bridge rectifier before it is used by the 1kΩ load.

a) Describe how the behavior of V_{Load} with the LM317 in control differs from what you found using without a voltage regulator. In particular measure the amplitude of the ripple voltage across the load. Compare this to the ripple voltage amplitude across the load with a 10μF capacitor in parallel with the load instead of regulation (careful about polarity).
b) Find the range of resistance values R_{Load} may have with constant ripple.
c) Check the validity of Eq. 1 by varying R_2 from 240Ω to the maximum possible with your input voltage.

Name:_____________________________________

Part I:

V(reverse)

V(forward)

I_z^{max}

I_z^{min}

Staple your part 1 graph to this sheet.

PartII:

Rectified voltage ripple w/ cap.

V_{pp}^{Ripple}

Rectified voltage ripple w/ LM317 voltage regulation.

V_{pp}^{Ripple}

Range of allowable R_{loads}

Slope and intercept of fit from V_{load} vs R_2

Slope	$Slope_{accepted}$
Intercept	$Intercept_{accepted}$

What is the percent error in the slope and intercept?

Staple your part 2 graph to this sheet.