Zener Voltage Regulator

Materials:

- 2 Series Mixed Series Oscilloscope (MSO)
- Arbitrary/Function Generator (AFG): AFG1000
- Digital Multimeter (DMM): DMM6500
- Direct current (DC) power supply: 2230 High Power Programmable Power Supply
- Resistors (2)
- Zener diode (1)
- Breadboard
- Jumper wires

Procedure:

Task 1: Calculating Line and Load Regulation of the Voltage Regulator Circuit
R_S = 200 Ω R_L = 100 Ω, 1 kΩ, 2 kΩ, 5 kΩ, 10 kΩ, 100 kΩ Zener Diode PN: 1N4727A

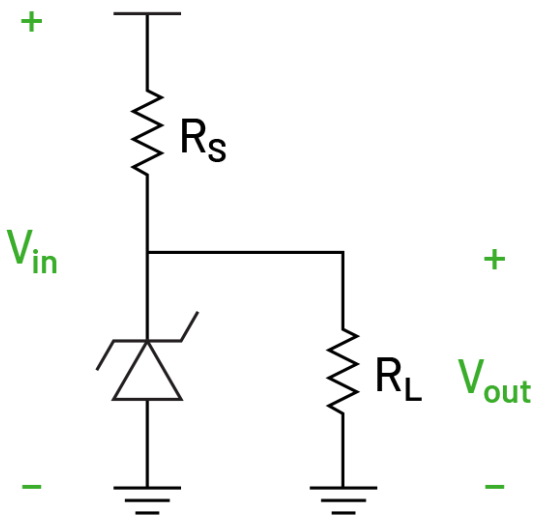

Figure 1. Zener voltage regulator circuit diagram.

1. Build the Zener voltage regulator circuit in Figure 1. using the corresponding resistor values. The source resistor (R_S) is a current limiting resistor to protect the Zener diode when there is no load attached to the circuit. To measure line regulation the load resistance needs to be infinite. Leave R_L open (no resistor connection for R_L). Make sure to have the diode in the correction orientation. Write down the listed Zener voltage of the diode from the diode datasheet. Use the DC power supply as the input source (V_{in}) and the DMM to measure the output across Zener diode (V_{out}).

2. Sweep the input voltage from 2 V to 8 V with 1 V intervals. Record the voltage across the Zener diode (V_{out}) in Table 1. For each interval. Analyze the trend of voltages across the diode. What happens when the input voltage is less than the Zener voltage?

Input Voltage (V_{in})	Diode Voltage (V_{out})
2 V	
3 V	
4 V	
5 V	
6 V	
7 V	
8 V	

Table 1. Measured diode voltage with no load resistance.

3. The line regulation of the regulator can be calculated using this formula:

$$Line\ Regulation: \quad \frac{\Delta V_{out}}{\Delta V_{in}}$$

Use the formula to calculate the line regulation of the regulator circuit. Calculate the line regulation with the input voltage values larger than the Zener voltage of the diode and record.

4. To calculate the load regulation of the circuit, vary R_L using the resistor values listed above Figure 1. Set the input voltage (V_{in}) to be 6 V. Record the voltage and current across the load resistor and record the measurements in Table 2.

Load Resistor (R_L)	Load Voltage (V_L)	Load Current (I_L)
100 Ω		
1 kΩ		
2 kΩ		
5 kΩ		
10 kΩ		
100 kΩ		

Table 2. Measured diode voltage and current with varied load resistance.

5. The load regulation of the regulator can be calculated using this formula:

$$Load\ Regulation: \quad \frac{\Delta V_{out}}{\Delta I_L}$$

Use the formula to calculate the load regulation of the regulator circuit based on the measurements collected in Table 2. What is the best resistance value to use with this regulator circuit?

Task 2**:** Testing the Regulator with a Sinusoidal Input

1. Use the same regulator circuit in Figure 1 with a suitable load resistor determined by the load regulation experiment in Task 1. Connect the AFG to the input of the circuit (V_{in}). Connect the channel 1 probe of the 2 Series MSO to the input and the channel 2 probe to the load resistor (V_{out}).

2. Configure the AFG to output a 60 Hz sine wave with an amplitude of 2 Vpp and a 4 V offset. This input should input from 3 V to 5 V. Observe the input and output waveforms on the 2 Series. If the channel 1 waveform is vertically offset from the channel 2 waveform, add a 4 V offset to channel 1 by tapping the icon on the bottom left-hand corner of the screen. Compare the input and output waveforms. What is the variation of the output waveform? Is this waveform a suitable DC signal?

3. Repeat step 2 with a 60 Hz sine wave with an amplitude of 1 Vpp and an offset of 4.5 V. Apply the 4.5 V offset to channel 1 on the oscilloscope. Which input waveform either from step 2 or 3 outputs the best DC signal for this regulator circuit?

Instructor's Notes:

Input Voltage (V_{in})	Diode Voltage (V_{out})
2 V	1.854 V
3 V	2.53 V
4 V	2.92 V
5 V	3.164 V
6 V	3.33 V
7 V	3.45 V
8 V	3.53 V

Table 1. Measured diode voltage with no load resistance.

Load Resistor (R_L)	Load Voltage (V_L)	Load Current ($I_{L)}$
100 Ω	1.94 V	19.4 mA
1 kΩ	3.23 V	3.23 mA
2 kΩ	3.27 V	1.64 mA
5 kΩ	3.3 V	0.66 mA
10 kΩ	3.31 V	0.331 mA
100 kΩ	3.32 V	0.0332 mA

Table 2. Measured diode voltage and current with varied load resistance.