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Electronic Circuits Laboratory

ELEC 375

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Experiment # 3

Diode Applications

Voltage regulator and Rectifiers

Objectives

1. To construct half-and full-wave rectifiers.
2. To investigate the use of capacitor filters to reduce ripple.
3. To demonstrate how loading of power supplies affects ripple.
4. To demonstrate the use of RC-π filters to reduce ripple.

Theory

The Zener diode is used in reverse biased as a simple voltage Regulator.

Half wave and full wave rectifier circuits causes AC input voltage to be converted into a pulsed waveform having an average, or, DC, voltage output. A filter that consists of an R-C circuit smooths out the pulsating output voltage of the rectifier.

Prelab

In the prelab part, the students are supposed to simulate the experiments of procedures before the lab and record their notice accordingly.

Equipments

1. 1N4004 (ECG116) silicon diode or the equivalent
2. 1N4736 silicon 6.8V Zener diode or the equivalent
3. DC power supplies (±15V and 6.8V with isolated ground and current-sinking capability)
4. Analog signal generator (5-10Vp-p sine wave at 1kHz)
5. Resistors
6. Capacitors
7. Dual-trace oscilloscope

Procedures

Procedure I: Zener Diode as voltage regulator

1. Wire the circuit shown in Figure 1 , where DC source V_S is set according to the values in Table 1.

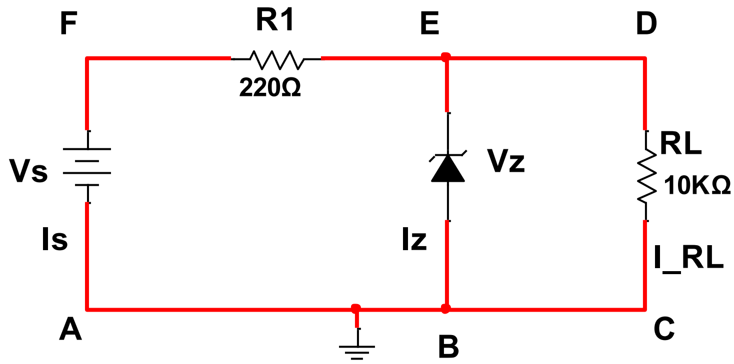

Figure 1 Zener Diode Voltage regulator Circuit

2. For each Vs value in Table 1, measure the load voltage V_{RL} across R_L with Zener diode removed.
3. Insert the Zener diode (Vz = 6.8 V) and measure V_{RL}, I_Z, and I_{RL} for each value of V_S in Table 1.
4. For each value of V_s in Table 1, calculate the power dissipated in the Zener diode. Does any value exceed the rated dissipation of the diode?

$$Power\ dissipated\ in\ Zener\ diode = V_z * I_z$$

Table 1

V_S	V_{RL} (volts) With diode ON	V_{RL} (volts) With diode OFF	I_Z	$I_{\_RL}$	Power dissipated in Zener
8V					
10V					
11V					
12V					

5. For the same circuit, set V_S=12V, then replace the load resistor with any other available five resistors and fill in the following table. Recommended to use (100Ω, 200 Ω, 500 Ω, 2 KΩ, and 10 KΩ), then measure and fill in the following table.

Table 2 Variable Load resistance for Voltage regulator

R_L	V_{RL} (volts)	I_RL (Amp)	Regulation %= $\frac{V_{RLnoload}-V_{RLload}}{V_{RL\_load}}$
100Ω			
500Ω			
2 KΩ			
10 KΩ			
30 KΩ			

$$\boldsymbol{Voltage\ regulation}\ \% = \frac{(V_{RL_{Noload}} - V_{RL_{load}})}{V_{RL_{load}}} * \mathbf{100\%} \quad ;\boldsymbol{where}\ V_{RL_{Noload}} = volateg\ accross\ the\ Zener\ diode\ when\ we\ remove\ R_L$$

Procedure II: Half wave Rectifiers

1. Connect the following circuit in figure 2, and show on the oscilloscope V1 and Vo and record the AC and DC (Ripple) components of Vo.

2. To investigate the effect of the load resistance and the capacitor on the % ripple: (without 4.7 and POT)

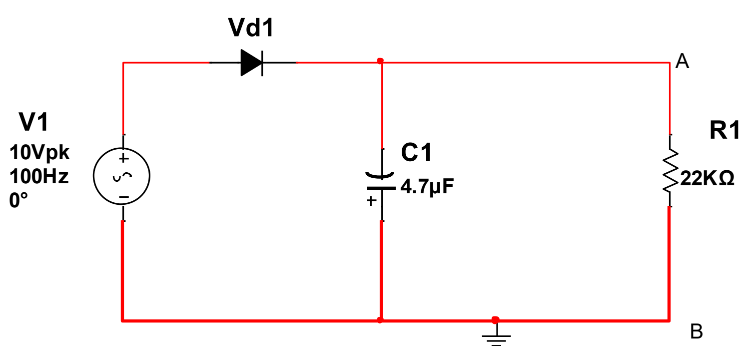

Figure 2: Zener Diode Voltage regulator Circuit

a) Fix the input voltage at a peak of 10V (with the capacitor is Disconnected) Measure and sketch output voltage wave form for R_{Load} = 470 Ω, 22 KΩ.

b) Now connect the capacitor (4.7 µF), and then using the oscilloscope to measure and sketch the DC mean value of the output, and the ripple (AC distortion). (Set the oscilloscope to DC coupling)

c) Explain the results.

d) Repeat step ***b*** for R_L =22KΩ and capacitor = 220µF).

e) Comment on your results and observations.

f) Insert a Zener diode in parallel to R_L and change the input Peak to (5V, 10V), (R_L =22KΩ and capacitor = 47µF)

g) Discuss the effect of the Zener.

Procedure III: Full wave Rectifiers (Simulation only)

Connect the following circuit in figure 3:

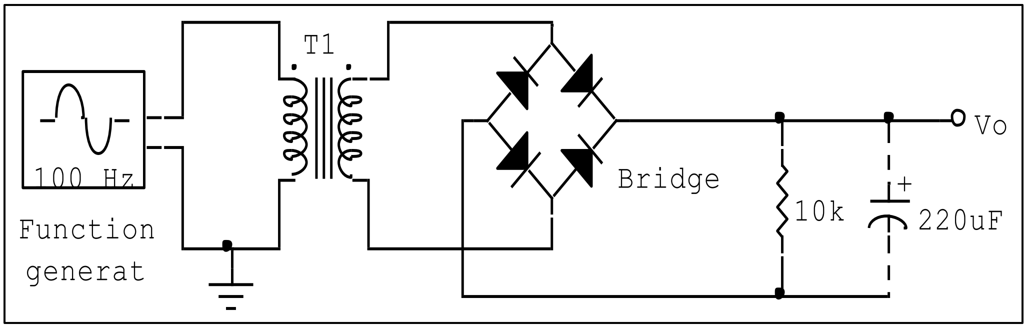

Figure 3: Full wave circuit

1. With the capacitor is disconnected; Change the input voltage until the output peak is 10V.
2. Measure and sketch the output voltage wave form.
3. Connect the capacitor to obtain a dc voltage from this circuit.
4. (Note the difference between the ac and dc coupling of the oscilloscope).
5. Measure and sketch the output voltage wave form (dc and ac components).
6. Calculate the % ripple using the measured data. $(Ripple = \frac{V_{rms}}{V_{average}} * 100\%\ ;where\ V_{rms} \approx \frac{V_{pp}}{2\sqrt{3}}\ , and\ V_{average} is\ the\ DC\ component)$.
7. Replace the capacitor by 47μF the repeat parts 5 and 6.
8. Now, connect the following circuit in figure 4.

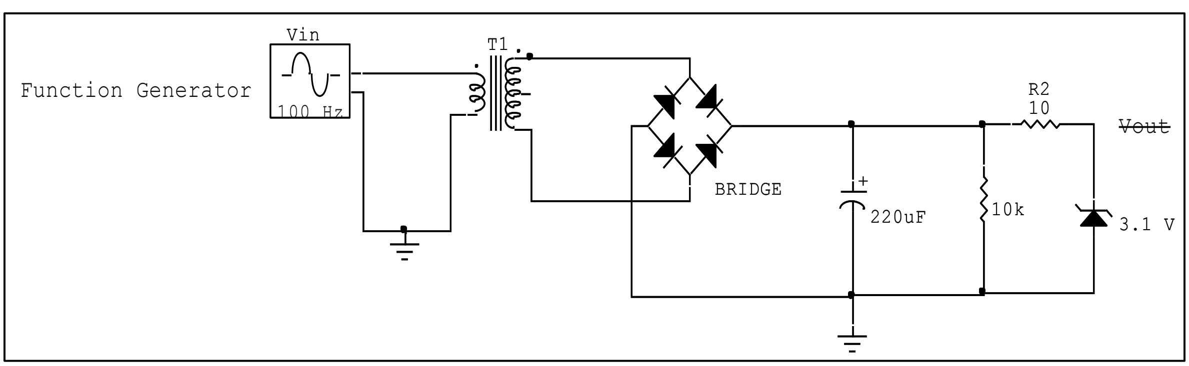

Figure4: Regulated Full wave circuit

a) Measure the ripple and the dc value of the output. For output peak is 5V and 10V
b) Discuss the results.

Note :(Calculating the value of the capacitor)
If the ripple is a small percentage of the total output voltage, then the voltage across the capacitor decays almost linearly. For a full-wave rectifier, the next input voltage peak occurs one half-period (T/2, where T is the period) the time derivative of the output voltage over the half-cycle can therefore be approximated as:

$$\frac{dv_o}{dt} \approx -\frac{v_{\max} - v_{\min}}{0.5T},$$

$$i_c = C\frac{dv_o}{dt} \approx -C\frac{v_{\max} - v_{\min}}{0.5T} = \quad \Rightarrow i_c = \frac{v_o}{R_L} \approx -C\frac{v_{\max} - v_{\min}}{0.5T}$$

$$\frac{\Delta v_r}{v_{o,avg}} = \frac{0.5T}{R_L C} \quad \boxed{\Rightarrow C = \frac{0.5T}{R_L}\frac{1}{\left(\Delta v_r / v_{o,avg}\right)} = \frac{1}{2fR_L}\frac{1}{\left(\Delta v_r / v_{o,avg}\right)}}$$

For example: If the percentage ripple is 5%, then $\Delta v_r / v_{o,avg} = 0.05$).