Introduction

Be sure to print a copy of Experiment #6 and bring it with you to lab. There will not be any experiment copies available in the lab. Also bring graph paper (cm x cm is best).

Preliminary Report Requirements

You should do the following in preparation for the experiment.

1. Assume the following circuit values:
   (a) $V_s = 10 \sin(\omega t)$, where $\omega = 120\pi$ (except circuit of Figure 2)
   (b) $C = 10\mu F$,
   (c) $R_L = 27k\Omega$,
   (d) $R_x = 1k\Omega$ (or greater)
   (e) $V_{on}$ (forward) = 0.6V
   (f) $V_z$ (reverse) = $-5.8V$ (Or, use what you found for the zener breakdown value for the zener diode in your kit.
   (g) $R_s = 50\Omega$ (Function generator internal resistance.)

2. Analyze the circuits in the Figures 1 to 5.

3. Sketch the expected graphs of $V_s(t)$, $V_d(t)$, and $V_L(t)$.

4. Find the peak value and the average DC value of the load voltage $V_L$.

5. For the DC Power Supply circuit in Figure 2, find the ripple voltage $V_r$ and average DC value of $V_L$ with
   (a) $\omega = 120\pi$ and
   (b) $\omega = 1200\pi$

6. For the Zener Regulator circuit in Figure 3, calculate the minimum value allowable for $R_L$ and still have good voltage regulation. Diode is “just ON reverse” at the voltage $V_Z$.

7. Be sure to complete the above before the lab session.

Note that in every case you must first find the range of values of $V_S$ that keep the diode(s) OFF. (i.e. What range of $V_s$ guarantees $V_d < V_{on}$?) Then, assume that range, use the open circuit model for diode, and, do circuit analysis. Next, assume $V_s$ takes on the remaining range of values; therefore, the diode must be ON. Replace the diode with the required ON model and do circuit analysis.

Purpose

The circuits in this experiment represent some of the most common and practical uses of diodes. Every electrical engineer should be familiar with the operation and analysis of these circuits. The fundamental concepts of these circuits are covered at length in your text and will not be reviewed here.
Parts

- 1 - 1N4004 (or 1N4006) diode
- 1 - 1N4375 zener diode
- 1 - 10µF capacitor
- assorted resistors

Procedure

Note that the data from this experiment are the sketches of the voltages that are taken right off the scope.

1. Set \( V_s(t) = 10 \sin(120\pi t) = 7.07 \text{V RMS} \). Do this by measuring \( V_g \) without anything connected to the function generator.

2. Construct the circuits and measure (i.e. sketch) the graphs of \( V_s(t) \), \( V_g(t) \), and \( V_L(t) \). Compare the sketches to your predictions of your preliminary work. If they are extremely different, your circuit may not be setup correctly.

3. For each circuit, use the DMM as a DC voltmeter and measure the DC value of \( V_L \). Compare this to your calculated values.

4. For the DC Power Supply circuit in Figure 2, be sure to measure \( V_r \) and the DC value of \( V_L \) at frequencies 60Hz and 600Hz and compare the values to your preliminary calculations.

5. For the Zener Regulator circuit, try attaching smaller and smaller values of \( R_L \) until you find the minimum \( R_L \) allowable and still have good regulation. Compare to your calculated minimum value.

6. **Answer the following sets of questions for all circuits**: What happens when you remove \( R_L \) and just leave an open circuit. Does the circuit performance improve? For the doubler circuit try different values of \( R_x \) and observe the effect on \( V_L \). What value of \( R_x \) drives \( V_L \) to a maximum value?

Report

For your written report:

1. Include preliminary calculations and sketches.

2. Include your data, i.e. the sketches of voltages from the scope.

3. Explain the discrepancies between calculated and actual experimental values. Example: Why is \( V_g \) so distorted when the circuits are attached to the function generator?

4. Any conclusions about the performance of the circuits and the questions that you have answered.
Figure 1: **Half-Wave Rectifier** This circuit clips off the negative peaks of the pure AC sine wave. The result is a voltage with a positive average value. So, we have converted AC to DC.

Figure 2: **The DC Power Supply** This circuit is the half-wave rectifier with a filter capacitor. The capacitor “holds up” the voltage so that the average DC value of the output voltage $V_L$ is almost the same magnitude as the magnitude of the input AC sine wave!

Figure 3: **The Zener Voltage Regulator** Note the addition of resistor $R_x$ to the circuit. Without resistor $R_x$ the output voltage cannot be pure DC which is our goal. We also require that $\frac{R}{R_L+R_x}(V_{g,\text{max}} - V_{d,\text{on}}) > |V_Z|$ to have pure DC output. Therefore, we need to have $R_L >> R_X$. The Zener Diode removes the ripple voltage that “rides on the DC value” of the power supply circuit above. We lose some magnitude but we gain a pure DC output as long as $R_L$ is not too small.
Figure 4: The Voltage Doubler In this circuit, we get the AC sine wave input to “ride on a DC” value equal to the magnitude of the sine wave input. The result is a “peak output voltage” that is twice the magnitude of the AC input peak. Note that the capacitor charges when the diode turns on and (if $R_L$ is sufficiently large) does not discharge much. That’s our free ride, the charge on the capacitor. This circuit is also called a “diode clamper.”

Figure 5: Voltage Doubled DC Supply Here we first double the input voltage with a voltage doubler circuit. Next, we connect that output to the input of a half-wave rectifier with filter capacitor. The resulting final output voltage is a DC voltage (almost) twice the value of the magnitude of the input AC sine wave! And they say you can’t get something for nothing ...