

NORTHWESTERN UNIVERSITY TECHNOLOGICAL INSTITUTE

ECE-270

Experiment #4

X-Y DISPLAY TECHNIQUES: DIODE CHARACTERISTICS PRELAB

Use your textbook and/or the library to answer the following questions about diodes.

1. What defines a "non-linear device"? Cite two examples.
2. Sketch the $i-v$ characteristic of a junction diode showing the forward-bias region and the reverse bias region.
3. What is the non-simplified (not what is given in part 5.) mathematical model of a pn junction diode at room temperature (excluding the breakdown region)?
4. Show the appropriate circuit model of a pn junction with negligible reverse current and a forward voltage drop of 0.6V? Label the conventional + and - ends of the model.
5. Given the simplified mathematical model $I = I_S e^{40V}$. Sketch I vs V . Take the logarithm of each side and sketch $\ln(I/I_S)$ vs V assuming $I_S = 10^{-6}$ A.
6. Sketch the expected output voltage from Figure 3. Let the source $V_S = 19.25V$ peak-to-peak and 60Hz. Let the diode's cut-in voltage be 0.7V (assume the avalanche voltage is large). Label peak voltages and important fine marks. How will adding the capacitor across R_L affect V_O ?

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INTRODUCTION

In experiment #1 we used the oscilloscope to display Lissajous patterns by replacing the 5B10N Time Base Amplifier with the 5A23N (or 5A15N) Amplifier. In this way we created an X vs Y display.

In the first part of this experiment we will utilize this X-Y display configuration for the oscilloscope to view the I vs V characteristics of a semiconductor diode. We will then return the oscilloscope to its original configuration for the rest of the experiment.

PROCEDURE

1. X-Y Display

Turn off the oscilloscope and remove the 5B10N Time Base Amplifier and replace it with the 5A23N (or 5A15N) Amplifier. Since the oscilloscopes do not have the capability of measuring current directly, we must measure the voltage across a known resistance and calculate the current by $I = V/R$.

The circuit shown in Figure 1 can be used to display the I-V characteristics of some device D.

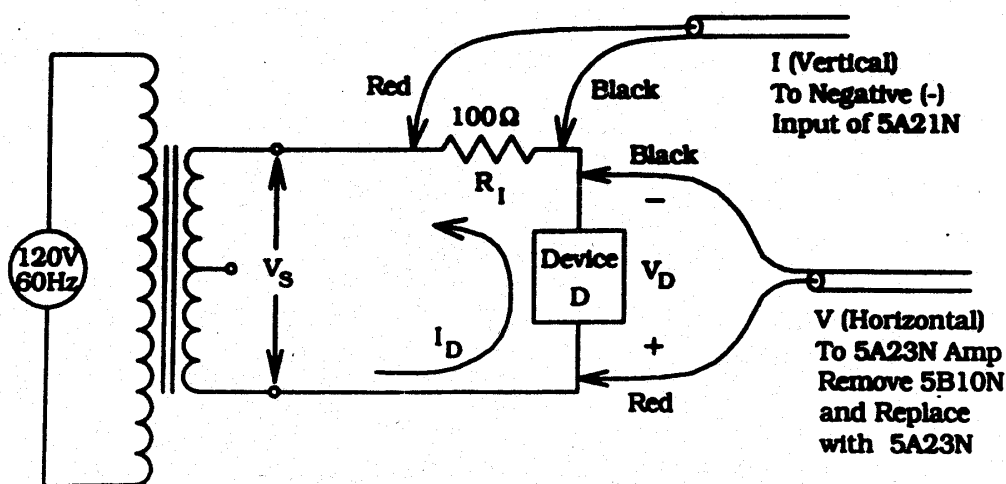


Figure 1

The current through R (the 100Ω resistor) is $I = V/100\Omega$ which is equal to I_D . Therefore, to view the display as I_D vs V_D the Y axis (Vertical axis) multiplier must be divided by 100Ω . This division converts the reading from VOLTS/DIV to a reading of AMPS/DIV. This is a simple scaling, so the scope display can be viewed as shown in Figure 2.

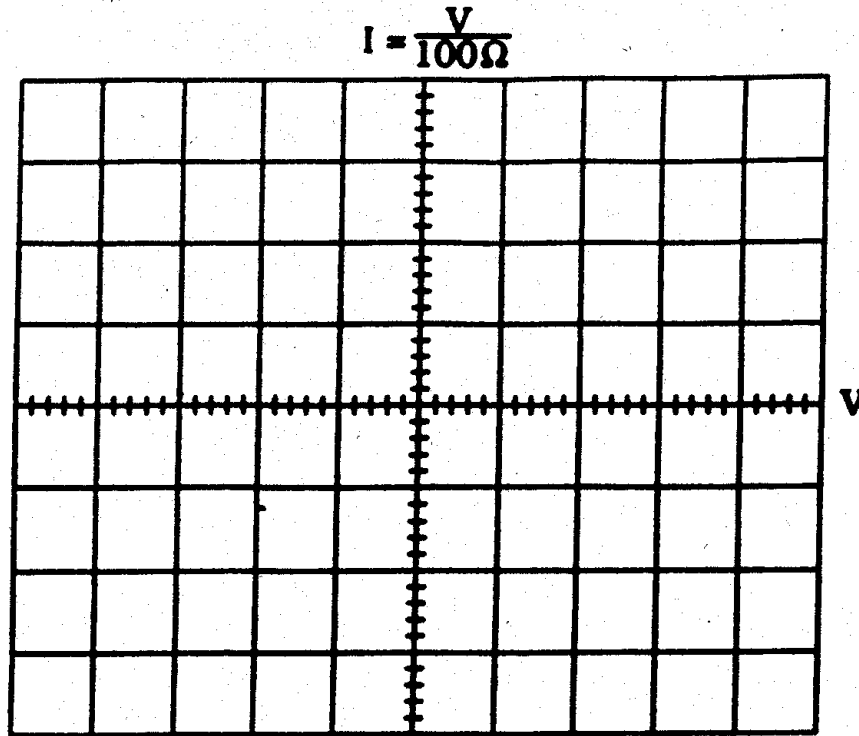


Figure 2

- Set the horizontal sensitivity to 0.5 VOLTS/DIV. For a vertical scale of 10 mA/DIV, what vertical sensitivity should be used? Before taking measurements, ground both inputs and center the dot appearing on the scope display. Also, leave the AC button out. Using a resistor for device D in figure 1, sketch the I-V characteristics for device D = 100Ω , 200Ω , and 400Ω . Calculate the slope of the each curve and compare to the expected value.
- Substitute a zener diode as device D and sketch the I-V characteristic. Determine the breakdown voltage.
- Substitute an ordinary diode as device D. Sketch the I-V characteristic and determine the forward conduction or cut-in voltage.
- Connect a 200Ω resistor in parallel with the ordinary diode and use this combination as device D. Sketch the I-V characteristics and explain the results.

2. Diode Circuits

Before starting this section, turn off the oscilloscope and reinstall the 5B10N Time Base Amplifier and the 5A23N (or 5A15N) Amplifier to their original positions.

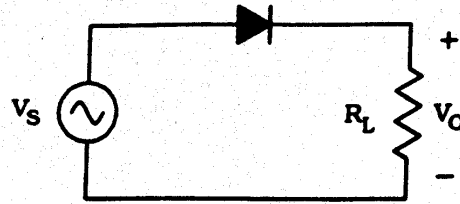


Figure 3

- Connect the ordinary diode in series with a $1\text{k}\Omega$ resistor and obtain a source voltage from the output of the transformer as shown in Figure 3. Sketch the output V_o and source V_s voltages. Explain the operation of this "half-wave" rectifier.
- Connect a $1\mu\text{F}$ capacitor in parallel with R_L and sketch the output V_o waveform. Identify and measure the ripple voltage.
- Change R_L to a $10\text{k}\Omega$ resistor and repeat part b) above. Explain the difference in term of the time constant $\tau = R_L C$.
- Change C to a $10\mu\text{F}$ capacitor and measure the ripple voltage.

3. Non-Linear Applications

a) Clipper

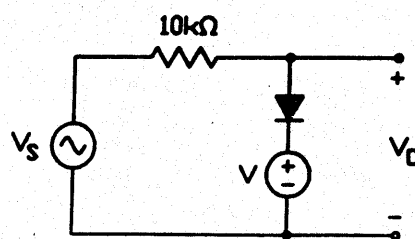


Figure 4

Construct the circuit shown in Figure 4. Use the output of the transformer for V_s and the output from the dc power supply for V (set to 2.0 Volts). Make sure the AC button on the oscilloscope is out and sketch V_o . Explain why the output waveform looks as it does

b) Clamper

Construct the circuit shown in Figure 5. Sketch V_o and V_s . Explain the operation of this circuit.

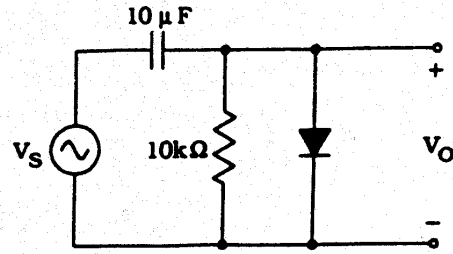


Figure 5

c) **Voltage Regulator**

For the circuit in Figure 6 use the dc power supply and vary V_1 from 0 to 12 volts. Plot V_L as a function of V_1 and explain the results.

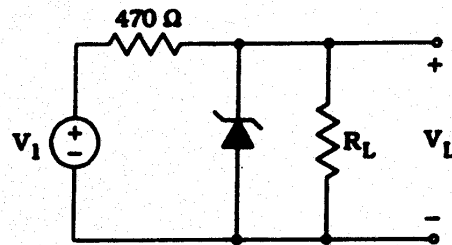


Figure 6

With $V_1 = 15V$, let $R_L = 1k\Omega, 820\Omega, 560\Omega, 330\Omega$, and 100Ω . For each value of resistance record the value of V_L and plot V_L as a function of R_L . What conclusion can you draw?

d) **Full Wave Rectifier**

Assemble the circuit in Figure 7. Sketch V_S and V_L and explain the operation of this circuit. Place a $10\mu F$ capacitor across R_L , and repeat. Measure the ripple voltage and compare to 2 d). Observe the average value and the ripple voltage in each case. Place a 5-10 Henry inductor in series with the parallel combination of R_L and C and repeat. What type of a converter is this circuit?

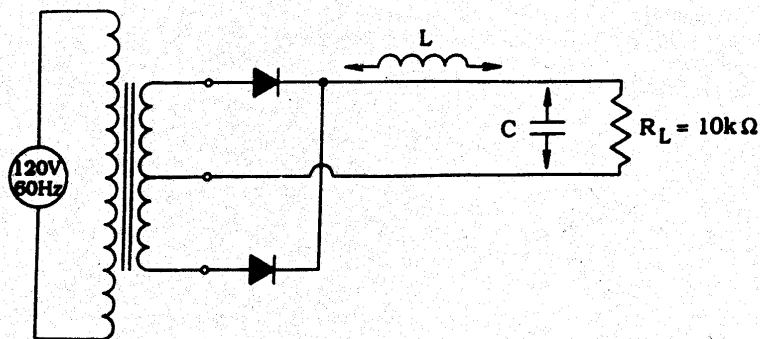


Figure 7