Laboratory Goals

- Familiarize students with oscilloscope phase shift measurements
- Locate the cutoff frequency (f_c) for the RC, low-pass filter circuit
- Visualize zener diode characteristics using the oscilloscope

Pre-lab / lab reading

- *Student Reference Manual for Electronic Instrumentation Laboratories* by Stanley Wolf and Richard Smith, Copyright 1990.
- *Agilent 54621A Oscilloscope User's Guide* published by Agilent Technologies, Copyright 2000. (Copies of this reference book are available in the lab, or at the website)

Equipment needed

- Lab notebook, pen
- Agilent 54621A Digital Oscilloscope
- Agilent 33120A Function Generator/Arbitrary Waveform Generator
- 2 oscilloscope probes (already attached to the oscilloscope)
- 1 BNC/EZ Hook test lead

Parts needed

- Circuit breadboard
- Capacitor, mylar film, .1uF, 100V
- Resistor, 110 Ohm, ¼ Watt
- Zener diode, 1N4730, 3.9VDC

Lab safety concerns

- Make sure before you apply power to a circuit, all connections are correct, and no shorted wires exist.
- Do not short the function generator signal and ground connections together
- Do not touch the circuit wiring while power is applied to it

1. Pre-Lab Activities

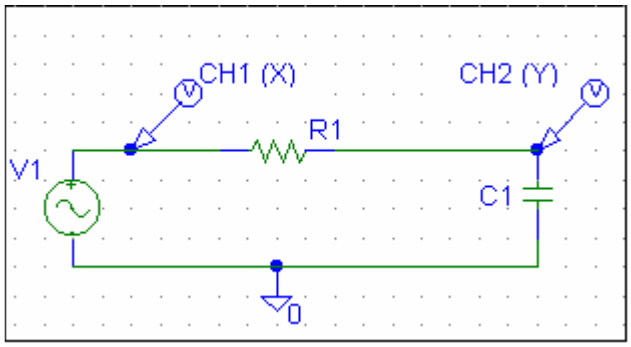
- Create a table in your lab notebook similar to the one shown below:

Input Frequency	10kHz	12kHz	f_c	20kHz
Calculated phase shift (degrees)				
Measured phase shift (x-y mode)				
Measured phase shift (x/t mode)				

- Calculate the cut off frequency f_c.
- Calculate and record the phase shift at the frequencies listed in the table

2. RC Circuit Construction and X-Y Phase Shift Measurement

- Measure the value of your resistor and capacitor, and recalculate the phase shift in the above table
- Construct the RC circuit shown below (Note that the **CH 1** and **CH 2** oscilloscope probe test points are shown)



- Adjust the signal generator to output a 1Vpp sine wave at 10kHz
- Connect the BNC end of the BNC/EZ Hook test lead to the function generator **OUTPUT**

- Clip the red and black EZ Hook ends to the circuit input and ground connections respectively

- Clip the **CH 1** oscilloscope probe and ground clip to the circuit input and ground connections respectively *(This is the test point for the input waveform)*
- Clip the **CH 2** oscilloscope probe and ground clip to the circuit output and ground connections respectively *(This is the test point for the output waveform, which is phase-shifted from the input waveform)*

- Refer to the *Agilent 54621A Oscilloscope User's Guide,* pages 5-12 ~ 5-15 for phase shift measurement using the X-Y mode. (You may have to increase the frequency to see the lissajous pattern as X-Y Mode in low frequency yields a line that does not facilitate measurement.)

- Calculate the degrees of phase shift using the formula sin (A/B)
- Record the result in your table
- Repeat the measurement for generator frequencies of 12kHz, f_c, and 20kHz

3. X/T Phase Shift Measurement

- Return the function generator output frequency to 10kHz
- Return to the **Main** mode of the oscilloscope (i.e., quit the X-Y mode):
  - Press the **Main/Delayed** button
  - Press the **Main** softkey

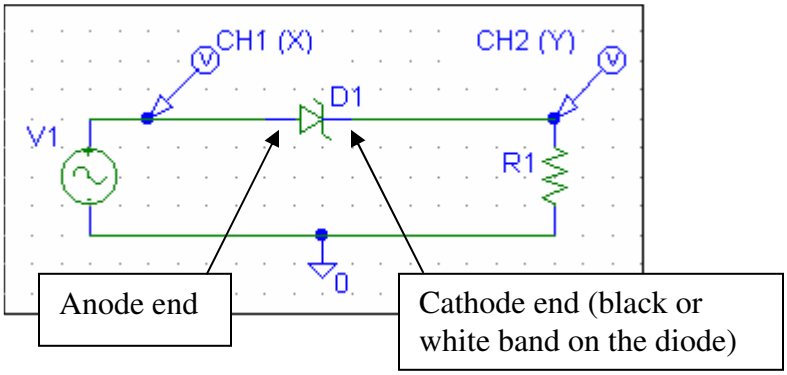
- Press the **Auto-Scale** button
- Press the **Quick Meas** button
- Verify that the selected **Source** is **CH 1**; if not press the **Source** softkey twice
- Press the → softkey to find the **Phase 1→2** option (in measurement menu 5 of 5)
- Press the **Phase 1→2** softkey to make an automatic phase measurement between **CH 1** (input) and **CH 2** (output) signals
- Record the indicated phase shift value in your table
- Repeat the measurement for generator frequencies of 12kHz, f_c, and 20kHz (note that you need only change the input frequency, and record the phase shift value shown)
- Unclip the connectors from the circuit, and disassemble the RC circuit

4. Using the Oscilloscope to Visualize Zener Diode Characteristics

This oscilloscope setup allows you to see how a zener diode behaves as the input voltage varies sinusoidally.

In the X-Y mode, the I-V characteristics of the zener diode are shown on the oscilloscope. The x-axis represents the applied input voltage, and the y-axis represents the current through the resistor. Ask you T.A. to further describe the zener diode, and the curve you see on the oscilloscope.

- Construct the zener diode circuit shown below (note that the black or white banded end of the diode must connect to resistor **R1**)



- Adjust the signal generator to output an 11Vpp sine wave with a frequency of 100Hz
- Clip the red and black EZ Hooks to the anode end of the diode and circuit ground connections respectively

- Clip the **CH 1** oscilloscope probe and ground clip to the anode end of the diode and circuit ground respectively
- Clip the **CH 2** oscilloscope probe and ground clip to the cathode (i.e., the black-banded) end of the diode and circuit ground respectively

- Enable the X-Y mode of the oscilloscope:
  - Press the **Auto-scale** button
  - Press the **Main/Delayed** button
  - Press the **XY** softkey

- Use the **CH1** and **CH2** vertical position knobs to move the waveform to the middle of the screen (notice the **CH 1** and **CH 2** values show 0 volts when each channel is exactly centered on the screen)
- Adjust **CH 1** vertical axis so that the waveform is as large as possible

- Create a diskette copy of the oscilloscope screen using the **Quick Print** option

- Experiment with the circuit by reducing the input voltage. What happens to the waveform as you do this?

- Vary the frequency from 100Hz to 15kHz and look at the effect on the I-V characteristics. Note your observation in your report and provide your best explanation of the observed behavior

- Unclip all connections to the circuit, then turn off the equipment

Before leaving the lab, take a few minutes to make sure all equipment and test leads are returned to your cabinet, and that you have cleaned up your work space.

4. Analysis

Write a brief summary report for labs (3a) and (3b). Be sure to also include the following topics:

For 2a:
Based on your observations, does the AC voltage divider circuit behave the same as a DC voltage divider circuit?

What other features of the oscilloscope and function generator did you investigate? Explain what they are, and how they might be used for your circuits.

For 2b:
Compare the measured and calculated phase shift values. Do the values generally agree? Explain possible reasons for any differences in the data.

Insert the waveform of the zener diode that you copied to a diskette. Label the points on the waveform where the diode begins to conduct current in the forward and reverse directions.

For both parts:
Explain any difficulties you had with these labs. (Please include any suggestions to improve them).