ECE 3254 Laboratory **Name** ________________________
Resistors, Oscilloscope, Function Generator, Measurements **Date:** ________________
Laboratory #2 Fall 2009 **Bench:** __________
PRELAB (100 points total)

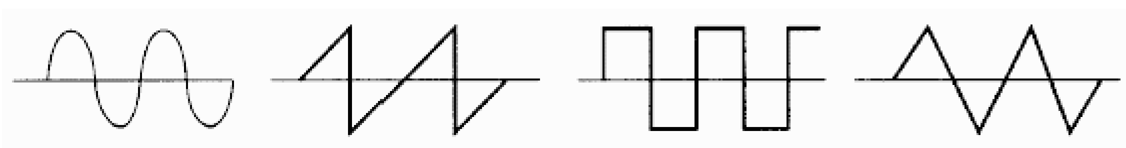
Prelab assignment (to be completed before coming to Lab 2):

1. Read over the material in the Lab 1 handout and Prelab 1 notes. Also see the XYZ's of Oscilloscopes, particularly pages (numbers at bottom of pages) 5-10, 12, 18-20, 23-35, and 48-50.

2. Complete the Voltage divider simulation from Lab 1, and print the schematics with bias simulation results, and the transient analysis. (Lab 1 Part III-9) (10 points)

3. What is the first thing you should do after the Oscilloscope has been turned ON? (see prelab notes) (5 points)

4. <u>Identify the waveform</u> types below, and <u>identify the period T</u> for each: (see XYZ pages 6,7, 9) (15 points)



5. Briefly, how does a digital oscilloscope captures and displays the input waveform? (see prelab notes and XYZ page 12) (10 points)

6. What does the vertical control of a scope do? (see prelab notes and XYZ page 18) (5 points)

7. What does AC input coupling do? How does it affect an AC waveform with a DC offset? (see prelab notes and XYZ page 19) (10 points)

8. For what are the horizontal display controls used? (see prelab notes and XYZ page 21) (5 points)

9. What does the oscilloscope trigger do for the display (think about how the waveform display would appear without the trigger)? (see prelab notes and XYZ page 28-31) (5 points)

10. How does the trigger accomplish this (what does the trigger determine / actually do)? (see prelab notes, XYZ page 28-31) (5 points)

11. The voltage of a sine wave plus a DC offset can be mathematically expressed as $v(t) = A + B\sin(\omega t)$ Show a derivation of the equation for the RMS value (V_{RMS}) of this voltage in terms of A and B. The period of $\sin(\omega t)$ is T seconds. Show the solution here and **enter the equation on Part III question 3 of the data sheet for use during lab.** (15 points – equations and work must be shown for credit)

12. Calculate V_{RMS} for a 4kHz $4V_{pp}$ sine wave with a 1V DC offset. Include the answer on Part III question 3 of the data sheet. (5 points) (show equation used and work for credit)

13. For a $4V_{PP}$ 1Khz square wave with a 2V DC offset, calculate the RMS value. Show your equations, work, and values used. Include the answer on Part III question 4 of the data sheet. (10 points)

ECE 3254
Oscilloscope, Function Generator, AC and DC measurements, Resistors, Tolerance
Laboratory #2
Last Revised: 09-08-2009

Record all measurements and calculations on the data sheet.
Always include the units for each measurement and calculation!

We will use the Agilent 33120A Function Generator, Agilent 34401A DMM, Fluke Model 45 DMM, and Agilent 33120A Oscilloscope to measure AC and DC voltages, and DC resistance.

Part I: Introduction to the Oscilloscope

1. Set up the oscilloscope for measurement - With the power "ON", initialize the Scope by pressing "save/recall" then press the soft key "default setup". **The factory default settings MUST always be loaded** after you have powered up the scope, or any time the scope measurements are incorrect. NOTE: cycling the power DOES NOT load the factory settings.

2. Connect a BNC cable to the Channel 1 input. Connect a BNC-Minigrabber adapter to the free end of the BNC cable, and then clip the red end of the Minigrabber to the "Probe Comp" output on the lower right side of the front panel. This "Probe Comp" output is a square wave signal to check the scope probe and vertical display settings.

3. Press the AUTOSCALE key on the front panel.

   a. Use the vertical control to reduce the waveform to about one division high on the display. Use your eye to measure the voltages and period. Calculate the frequency (f = 1/T). Pay attention to where the 0V ground indicator is. Record your measurements on the data sheet.

   b. Press the QUICK MEASURE button and toggle the softkeys to measure the waveform voltages (maximum, minimum, average, and peak-to-peak), period (T), and frequency (f). Record your measurements on the data sheet.

   c. Adjust the vertical and horizontal scale controls to make the displayed waveform as large as possible - with only <u>one complete</u> waveform displayed (and clear of the top or bottom of the display). Use your eye to measure the voltages and period. Calculate the frequency (f = 1/T). Pay attention to where the 0V ground indicator is. Record your measurements on the data sheet.

   d. Press the QUICK MEASURE button, toggle the softkeys to measure the waveform, and record your measurements on the data sheet.

4. Change the input coupling to AC (Press CH 1 key, then toggle the coupling softkey to AC), use the vertical position control to re-center the display (adjust the trigger level if the display is unstable), and use QUICK MEASURE to measure the waveform again. Record your results on the data sheet.

5. Use Labview to set the Function Generator to create a $2V_{pp}$ @ 1 kHz sin wave WITH no DC offset, and connect this signal to the CH 1 Scope input (see figure 2-1 on page 5 for the Function Generator output jack location). Record your generator settings on the data sheet.

6. Autoscale the oscilloscope, verify that the scope input coupling is set to DC, and adjust the vertical and horizontal scale controls to make the displayed waveform as large as possible (and clear of the top or bottom of the display).

a. Measure this waveform with your eye and record your measurements on the data sheet.
b. Measure this waveform with Quick Measure and record your measurements on the data sheet.

7. Use Labview to change the function generator signal frequency to 10 kHz and adjust the scope for maximum accuracy.

a. Measure this waveform with your eye and record your measurements on the data sheet.
b. Measure this waveform with Quick Measure and record your measurements on the data sheet.

Part II: Waveform Generation - AC with a DC offset

1. The waveform equation for a sinusoid with a DC offset is $v(t) = A + B\sin(\omega t)$, where A is the DC offset voltage, B is the sin wave amplitude = $V_{pp}/2$, and the period of $\sin(\omega t)$ is T seconds ($\omega=2\pi f$, $f=1/T$, where f is the frequency in Hz). Use Labview and the function generator to produce $V(t) = 3\sin(2\pi 2000t) + 3$ V for your instructor. On the data sheet, record Labview's generator settings used to produce this waveform.

2. Adjust the scope for maximum accuracy and measure the waveform. Record the measurements on the data sheet.

3. Display this waveform on the oscilloscope with DC input coupling and use Labview to capture and save the waveform (Labview Oscilloscope Control page > "Acquire Waveform" Click "OK" > "Save to Buffer" Click "Save > enter a filename > Click "Done" to return to the main menu.
File name:________________________

Insert a USB Flash Drive (Memory stick) or floppy disk into the computer and verify that the computer recognizes the drive. Go to the Labview "Buffer" > click drop-down box for file > Save selected Waveforms > save as "jpeg" > Set the **red cursor at V_{max}**, and the **blue cursor at V_{min}** , change the text "cursor 0" to Vmax, change the text "cursor 1" to Vmin > Save > Browse to your USB or floppy drive > enter a filename (with a .jpg extension) > OK.

Note: save as "jpeg" may bring up a distorted view of the waveform because the buffer display is in log scale. To fix this: change the x-scale to linear, click the magnifying glass icon and then click the bottom left graphic to center the waveform.

***Print one copy of jpeg file for your lab report.** Use a pen or pencil to clearly identify and label the important signal parameters (maximum voltage, minimum voltage, and period) on the print. Write all partners' names on the print, title the print, and staple the print to one lab report. *You only need one print for each team.*

Part III: RMS Measurements for AC waveforms with a DC offset voltage

1. Use Labview to set the Agilent 33120A function generator to produce a 1 kHz 4Vpp sine wave with a 0V DC (remember that the function generator voltage setting generates a peak-to-peak voltage). Connect the output of the Agilent 33120A to the scope and observe the waveform. Use DC input coupling and autoscale the scope. Next, adjust the scope's vertical scale to 2V/division. <u>Set the trigger mode to AUTO (not autolevel!) and set the trigger coupling to DC.</u>

a. Use the Function Gen front panel controls to vary the DC offset between -1.6V and +1.6V in 0.1V steps. On the data sheet, **describe what happens to the scope signal** as the DC offset is varied **and explain why the display changes.** (Remember V(t) = A + Bsinωt. What is not changing, what is changing, and how does that interact with the trigger?)

b. Increase the waveform's DC offset until the display becomes unstable. **Without using Autoscale or changing the vertical sensitivity, offset, or input coupling,** how can the scope display be stabilized?

2. The Agilent 34401A multimeter, the Fluke 45 multimeter, and the Agilent 54622A oscilloscope can be used to measure the RMS value of sinusoidal AC waveforms.

   Use the function generator to produce a 4 Vpp (peak-to-peak) 1 kHz sine wave with a 0V DC offset. On the data sheet, record the AC V_{RMS} measured by the Agilent 34401A meter, by the Fluke 45 meter and by "Quick Measure" on the oscilloscope with DC input coupling (adjust the scope for maximum measurement accuracy).

3. The Agilent 54622A oscilloscope can be also used to measure the true RMS value of an AC waveform with a DC offset. The waveform equation is $v(t) = A + B\sin(\omega t)$, where A is the DC offset voltage, B is equal to V_p (peak voltage), and the period of sin(ωt) is T seconds ($\omega=2\pi f$ and $f=1/T$, where f is the frequency in Hz). Add a 1V DC offset to the 4 Vpp (peak-to-peak) waveform of Step 2, then measure and record the AC RMS and DC voltages using the Agilent meter, the Fluke meter, and the "Quick Meas" setting on the oscilloscope. The voltmeters use an AC-coupled input when measuring AC Volts, which means that the DC component is blocked and is not included in the measurement. For the meters, calculate the true RMS from the AC and DC measurements.

4. Change the function generator output to a 4Vpp square wave with 2V DC offset, and re-measure the RMS voltage with the scope and meters.

5. **Before you leave:** Shut down Windows, return cables to racks, return parts to correct drawer bins, return adapters to container, turn off bench power, clear bench, and place seat under bench. **(Counts as 5 points of the Lab grade)**

Fig 2-1

Function Generator Output is the bottom BNC jack

ECE 3254 Lab 2 Data Sheet **Date______________** **Bench_________**
(100 points total)
Names: ________________________ ______________________ ______________________
by first name: 1st alphabetically – wiring 2nd alphabetically – Labview 3rd alphabetically – data sheet

Part I: Introduction to the Oscilloscope

3. a. **Waveform measured by eye with waveform small display size.**

Waveform type observed: ________________

Horizontal scale = _____________**s/div** Waveform horizontal divisions = ____________

T = _______________**s** f = 1/T = ____________**Hz**

Vertical scale = _____________**V/div** Waveform vertical divisions = _____________

V_{max} = ___________**V** V_{min} = __________**V** V_{pp} = ___________**V_{pp}** V_{avg} = ___________**V**

b. **Waveform measured by Quick Measure with small display size** (include units!)**.**

T = _________________ f = ______________

V_{max} = _____________ V_{min} = ____________ V_{pp} = _____________ V_{avg} = ____________

c. **Waveform measured by eye with waveform large display size.** (include units)

Horizontal scale = _____________**s/div** Waveform horizontal divisions = ____________

T = _________________ f = 1/T = _______________

Vertical scale = _____________**V/div** Waveform vertical divisions = ____________

V_{max} = _____________ V_{min} = ____________ V_{pp} = ____________ V_{avg} = ____________

d. **Waveform measured by Quick Measure with large size.** (include units)

T = _______________ f = ____________

V_{max} = _____________ V_{min} = ____________ V_{pp} = _____________ V_{avg} = ____________

Compare the measurements for part a, b, c, and d. If the calibrator waveform is a 5Vpp 1200 Hz square wave, **which measurement set is more accurate**? Why?

What does this tell you about how to set the oscilloscope for best measurement accuracy?

4. Waveform type observed: ________________ T = _______________ f = _____________

V_{max} = _____________ V_{min} = _____________ V_{pp} = ______________ V_{avg} = _____________

How did the display and measurements change the when you switched to AC coupling, and what was responsible for these changes? (Hint: see prelab notes about input coupling)?

5. Generator setting: Waveform type = ____________ Amplitude = __________ Freq = _________

6. a. **Waveform measured by eye .**

Horizontal scale = _________________ Waveform horizontal divisions = __________

T = _______________ f = 1/T = ______________

Vertical scale = ________________ Waveform vertical divisions = __________

V_{max} = _____________ V_{min} = ____________ V_{pp} = ____________ V_{avg} = _____________

b. **Waveform measured by Quick Measure.** T = _______________ f = ____________

V_{max} = ____________ V_{min} = ____________ V_{pp} = _____________ V_{avg} = ____________

7. a. **Waveform measured by eye.** Horizontal scale = ___________ Vertical scale = ___________

T = _______________ f = 1/T = ____________

V_{max} = ____________ V_{min} = ____________ V_{pp} = _____________ V_{avg} = ____________

b. **Waveform measured by Quick Measure.** T = _______________ f = ____________

V_{max} = ____________ V_{min} = ____________ V_{pp} = _____________ V_{avg} = ____________

Looking at your results for parts 3, 4, 5, 6, and 7, Which do you think is more accurate, eyes or quick measure? (NOTE: See page 3 of the prelab notes!)

Part II: Waveform Generation - AC with a DC offset

1. Frequency = ______________ , A = _____________, B = _____________,

   Amplitude = ______________V_{pp} Off Set = ________________ Wave Type = ________________

2. Frequency = ______________ , Vpp = ______________ , Vavg = ________________

   Are the measurements a reasonable match the function generator settings?

Part III: RMS Measurements for AC waveforms with a DC offset voltage

1.a. With DC input coupling, what happens to the scope display when the waveform DC offset is changed?? Explain why the display changes.

1.b. How can you stabilize the scope waveform display? ________________________________

2. Agilent meter V_{RMS} = ______________ Fluke V_{RMS} =_____________

   Quick Measure V_{RMS} = _______________

3. ***From Prelab question 11***, the true RMS equation for a sine wave with a DC offset is:

   V_{RMS} =

   From Prelab question 12, V_{rms}=_______________ (1kHz sin wave, 4V_{pp}, 1V DC offset)

   Measured Agilent meter AC V_{RMS} = ___________, V_{DC} = ___________

   Measured Fluke meter AC V_{RMS} = ____________, V_{DC} = ____________

   Measured by the scope: True V_{RMS} = ____________ V_{DC} = ____________

   What should the measured DC voltage have been? ______________
   How do the meter DC measurements compare to the actual DC offset voltage?

   How can you use the Fluke meter to obtain a true RMS measurement?

   From Fluke measurements, true RMS for this signal = _______________

How can you use the Agilent meter to obtain a true sine wave RMS measurement with a DC offset?

What kind of scope input coupling should you use to measure true RMS?_____________ Why?

Compare the RMS value measured by the Fluke meter and the scope "quick measure" with the theoretical RMS value for this waveform (Show % Error calculation). Is this error reasonable?

Why can't the DC offset measurement simply be added to the AC RMS measurement to obtain a true RMS value? (Hint: Explain using the RMS formula.)

4. ***From Prelab question 11***, the true square wave V_{RMS} = ____________

Measured Agilent meter AC V_{RMS} = __________, V_{DC} = __________, True RMS = __________

Measured Fluke meter AC V_{RMS} = ___________, V_{DC} = ___________, True RMS = __________

Measured by the scope: True V_{RMS} = ___________ V_{DC} = __________

How do these measurements compare to the expected value?

Based on all of your measurements, which instruments can be used to accurately measure true RMS for **sine waves** with DC offsets?

Based on all of your measurements, which instruments can be used to accurately measure true RMS for **square waves** with DC offsets?

5. **Before you leave:** Shut down Windows, return cables to racks, return parts to correct drawer bins, return adapters to container, turn off bench power, clear bench, and place seat under bench. **(Counts as 5 points of the Lab grade)**