1: Safety and Equipment Familiarization Laboratory

ECE 3200 Electronics II
updated 7 February 2020

References


Objectives

1. To learn how to work safely in the laboratory.
2. To learn how to compensate a 10x oscilloscope probe
3. Explore the operation and limitations of various pieces of laboratory equipment.

Pre-Laboratory Assignment

1. Read and study section 1.1 of the lab manual which addresses laboratory safety issues.
2. Read *XYZs of Oscilloscopes* (reference 1 above). Complete the “Written Exercises” Parts IA, IB, IIA, and IIB at the end of that document and turn it in at the beginning of your lab session.

THERE WILL BE A QUIZ ON THE PRE-LABORATORY MATERIAL.

Procedures

Oscilloscope Probe Compensation

1. Calibrate the 10x oscilloscope probes per instructions from your lab instructor, Sketch the shape of an undercompensated, overcompensated, and properly compensated oscilloscope. The first step in using an oscilloscope is to insure that the probes are properly compensated.

Use and Limitations of the Oscilloscope, DMM, and Function Generator

2. Identify the oscilloscope and function generator. You should have your own digital multimeter (DMM). Turn them “on”.
3. Setup the oscilloscope to simultaneously display two signals $v_1(t)$ and $v_2(t)$ against time where $v_1(t)$ is a 1kHz 0-5V 50% duty cycle square wave compensation signal available from your
oscilloscope (from the terminal labelled “Demo 2” on the front panel) and \( v_2(t) = 2V + \sin(2\pi1000\,t) \). Display \( v_1(t) \) on channel 1 and \( v_2(t) \) on channel 2.

Use the oscilloscope to set both the DC and AC components of \( v_2(t) \).

4. Check the DC and AC components of \( v_2(t) \) with your DMM. Remember that the DMM in “AC” mode measures the root-mean-square (RMS) component of the time-varying portion of the waveform. Are the DMM measurements accurate? Why or why not? Do you need to check your DMM specifications?

5. Position the 0V level of both channels to the vertical center line of the screen. Set both vertical amplifiers in the “DC” coupling mode. Set the “TRIGGER” coupling to “DC” and trigger mode to “AUTO”.

6. Set the trigger controls to “trigger” the scope trace when \( v_2(t) = 2.5V \) and \( \frac{dv_2}{dt} < 0 \) (that is, where the slope is decreasing, indicated by a downward facing arrow on the scope menu). Use the oscilloscope to measure the frequency of \( v_1(t) \) and \( v_2(t) \). You may set the trigger source to channel 2 in order to stabilize the waveform on this channel.

Can stationary displays of both \( v_1(t) \) and \( v_2(t) \) be obtained by using the trigger controls? Why or why not? Can you obtain a stationary display of both \( v_1(t) \) and \( v_2(t) \) by adjusting the frequency of \( v_2(t) \)? Explain.

7. Place the scope in CH 2 only mode and re-establish the trigger conditions of procedure 5. Readjust \( v_2(t) \) to \( 2V + \sin(2\pi1000\,t) \).

a. Set the input coupling for CH 2 to “AC” and describe the resulting change in the DISPLAYED signal.

What is the reason for this change?

What voltage is DISPLAYED by the scope under these conditions? Write an expression for it in standard trigonometric form.

How is it different from the ACTUAL signal being provided by the waveform generator? Which is more correct? Why? Could you use the DMM to help answer these questions?

b. Change the frequency of \( v_2(t) \) to about 100Hz. Use a trigger level of about 0.0V and “AUTO” triggering. Slowly reduce the FREQUENCY of \( v_2(t) \) until its DISPLAYED amplitude is approximately 0.71V.

Measure this frequency (the approximate lower -3dB frequency of the scope vertical amplifier).
c. Change the input coupling for CH 2 to “DC”. Set \( v_2(t) \) to a 1kHz square wave that varies between ±1V. Adjust the oscilloscope controls for a stable display. Slowly reduce the frequency of the square wave to around 100Hz. Now set the input coupling to “AC” and repeat. Document and explain the differences between the observed signals.

8. Using the oscilloscope and several fixed resistors (perhaps a resistor substitution box):
   
a. experimentally determine the output resistance (\( R_{out} \)) of the function generator when it is set to give an open circuit output of \( 5V \cdot \sin(2\pi 50,000 t) \); and

   b. examine the effect of frequency on \( R_{out} \).

MEASUREMENT OF CAPACITANCE

9. Use your oscilloscope to measure the capacitance of the capacitor provided by your lab instructor. Compare to the value measured by your DMM, if it is able to measure capacitance. Which measurement is more accurate? How do you know?

EXERCISES (to be done individually)

1. Describe and discuss the concept of oscilloscope “triggering” and how it is implemented in modern oscilloscopes (i.e. how the oscilloscope WORKS internally, and not simply how to use the scope). Develop your description around a block diagram of the oscilloscope. Include “typical” internal oscilloscope signal waveforms. Work a description of the function of the oscilloscope “trigger” controls into your discussion. The use of one or more references, either those cited above or some found on your own, should be useful here. Be sure to properly cite sources of your information, figures, etc. Do not plagiarize!

2. Using precise engineering terminology and with the aid of schematic diagram(s), describe, discuss, and explain the effect that the vertical amplifier COUPLING has on the performance of the oscilloscope. When is it appropriate to use AC coupling or DC coupling? Under what conditions might AC coupling introduce errors into a measurement? Under what conditions might DC coupling introduce errors into a measurement?

3. Contrast and compare the AUTO with the NORM triggering mode.

4.
   
a. Define, discuss, and explain the differences between precision, accuracy, resolution, sensitivity, and range as they pertain to measurements or measuring instruments. Consult reference 2 or another suitable source.

   b. Give numerical examples of each, i.e. for each one give a hypothetical set of data and/or measurements taken by (or given for) a hypothetical instrument and show what analysis/interpretation must be done on the data/measurements to obtain the particular parameter. Then, give the resulting numerical value for that parameter.

Credits, Copyright, and Use

Refer to front matter available at http://homepages.wmich.edu/~miller/ECE3200.html for material credits, further copyright information, and use guidelines.