PHY 132 – Summer 2008
LAB 1: Oscilloscope[1]

Introduction

In this introductory lab, we consider AC signals, and use of the oscilloscope. This material is out of sequence with PHY131, but the concepts are not difficult. Students are encouraged to read appropriate sections of the PHY131 textbook. There will be no report associated with this lab.

The oscilloscope (scope) is an indispensable tool for measuring electrical signals. It gives a display of voltage (vertical) vs. time (horizontal). These scales are accurately calibrated, so you can obtain numbers from the display. There are a zillion knobs, most of which we can ignore for now. You do need to understand the following:

1. Gain and position of Y and X axes. These are marked as volts/division and sec/division. 1 division is a 1 cm box on the screen. A value is determined from the display as volts = (# divisions) * (volts/division). You can generally read this to 0.1 division. Take care that the CAL knobs are clicked into the calibrated position.
2. Input coupling: A/C or D/C or GND. D/C feeds the signal directly into the scope. A/C feeds only the A/C part after stripping the average (D/C) value. GND shorts the input providing an accurate zero reference, for positioning the display.
3. Focus/Intensity: adjust these to get a clear sharp line, but don't burn the screen.

Theory:

AC signals frequently take the form of a sine wave, which we write as

$$v(t)=V_0\sin(\omega t) + V_{DC} \qquad \text{eq. 1}$$

This has amplitude V_0, and angular frequency defined as

$$\omega = 2\pi/T = 2\pi f \qquad \text{eq. 2}$$

[1] Adapted by R. J. Jacob from P. Bennett, PHY-132 Lab Manual© (ASU)

where T is the period (sec) and "f" is the frequency, in cycles per second or Hertz (Hz). It is possible also to have a DC offset V_{DC}.

RMS

Amplitude is frequently specified in terms of peak-to-peak (V_{pp}=2V_0) or "root-mean-square" (RMS). The latter is defined as $F_{rms} = \sqrt{\frac{\int_0^T f^2(t)dt}{T}}$. For a sine wave, this gives V_{rms} = $V_0/\sqrt{2}$). For a triangle wave, this gives V_{rms} = $V_0/\sqrt{3}$. You should be able to derive these two results.

<u>Part 1: D/C signals</u>

1. Measure the voltage from a standard D-size battery using both the scope and the DMM as shown in the circuit of Fig. 1. If you don't have a trace on your scope, some of the zillion knobs are probably set wrong. Ask for help. Be sure the scope vertical CAL and zero are both properly set. How good are your data? Reverse the battery to get an independent second reading for each instrument, which you can use to establish "errors".
2. Does unplugging either meter (DMM or scope) affect the reading of the other?
3. Slow down the sweep speed to 0.5 sec/div and describe the effect.

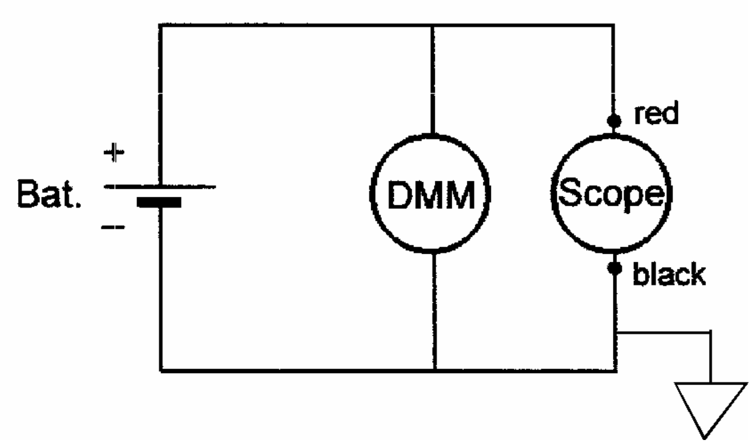

Fig. 1

Part 2: A/C signals

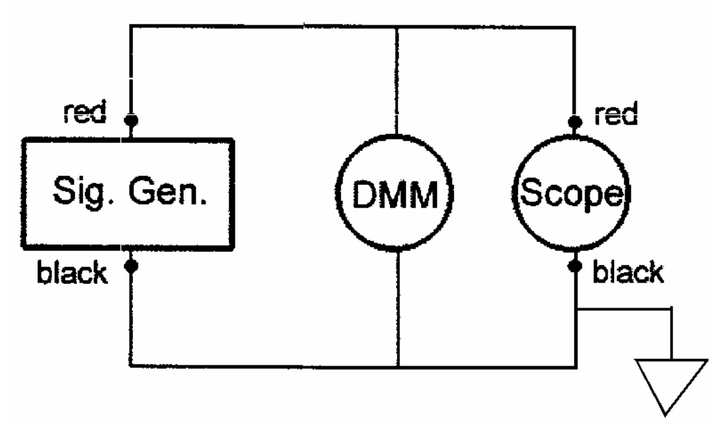

Fig. 2

1. Replace the battery with the signal generator as in the circuit of Fig. 2. Set the signal generator for a 1000Hz sine wave about $1V_{rms}$ on the DMM (AC)
2. Trigger: The display shows a recurring snapshot of an infinite wave-train. The image will stand still (retrace) provided it starts at the same point (voltage level) each time. This level is defined by the LEVEL control. Note that SLOPE must also be specified, since a sine wave crosses any level twice within its period, once rising and once falling. Adjust the trigger level and slope and explain the effect on the display.
3. DC offset: Pull out the OFFSET knob on the signal generator and watch the scope as you turn it. Be sure the scope is on DC coupling. Adjust the DC offset so the average ("center") of the sine wave is about 1.0 volts. Switch the DMM to DC, and compare its reading with the scope. Switch the scope to AC coupling and explain the result.
4. RMS: Set the sig. gen. DC offset accurately to zero, watching the DMM (DC). Change the DMM to AC, then determine the peak-to-peak voltage from your scope trace and compare with the reading from the DMM.
5. Repeat for a triangle wave.

Part 3: Frequency

1) Continue with the circuit shown in fig. 2. Adjust the SEC/DIV control to display one complete period of the measured waveform, making sure that the variable SEC/DIV control is in CAL detent.
2) Measure the period T of the wave, which is the time between two consecutive maxima (or alternate zero crossings). The frequency is given by f (Hz) = 1/T(sec). Compare with the signal generator setting.