Lab 2: AC circuits and the oscilloscope (version 1.4)

WARNING: Use electrical test equipment with care! Always double-check connections before applying power. Look for short circuits, which can quickly destroy expensive equipment.

Summary
Use of signal generator and oscilloscope to investigate current, voltage, and power dissipation in simple non-reactive circuits.

Learning Outcomes
- Understand functionality of oscilloscope including Triggering; V/div, T/div; GND, etc.
- Build circuit with resistors driven by AC voltages, and use oscilloscope for time-dependent analysis.
- Investigate instantaneous and average power dissipation at any resistive element.

Equipment needed:
DC Power Supply
Digital oscilloscope
Function generator
Circuit breadboard and components/cables/probes.

The digital oscilloscope
An oscilloscope is an instrument that graphically displays electrical signals at a given point in time (determined by the trigger) and shows the time dependence of these signals.

AC signals and probes
When you are looking for a periodic waveform, it can be re-sized on the horizontal axis (Sec/Div) and vertical axis (Volt/Div). Oscilloscope probes are test devices that allow for precise measurements of electrical signals. They have selectable attenuation that reduce the measured signal levels by factors of 10x, 100x, etc. The scope probe can also diminish the distortion associated to making a measurement, which is often important at high frequencies.

Experiment/procedure

The Voltage Divider
Construct the voltage divider circuit shown in the figure. Choose R1 and R2 with about the same values (in the range of a few kΩ is good). Check the resistor values with the multimeter before inserting them into the breadboard. Calculate the expected voltage and current through resistors and the output voltage (voltage across R2). Use Vin=5Vdc.

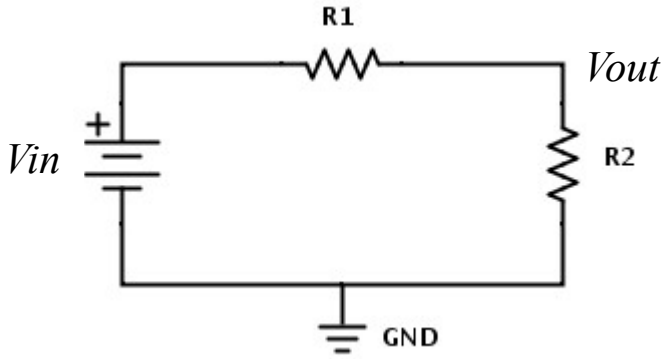

Figure 1

The oscilloscope can perform many of the functions that the digital multimeter DMM can do, such as a DC voltmeter. Connect BNC* probes to the oscilloscope to monitor the input Vin and output $Vout$, and characterize the voltage divider. (Remember scope channel should be set for DC coupling, why?). Change the coupling to AC and then to Ground and explain what is observed for all 3 cases.

Note*: BNC coaxial cables inner conductor is positive and outer shield is ground. Probes' lead colors are red for positive black for negative/GND.

The Function Generator

The signal/function generator can produce a wide variety of periodic waveforms that can be displayed and analyzed on the oscilloscope. Waveforms include sine waves, square waves, triangular waves, pules, etc., with controllable *frequency*, *amplitude*, and *offset*. Other parameters can be set depending on the generator used.

Test the signal generator by connecting it directly to the oscilloscope with a BNC cable. Set the function generator to produce a sine wave with frequency 455 kHz and amplitude of 1.2Vpp (peak-to-peak). Verify the output by observing the waveform on the scope. Now add a 500 mV (0.5 V) positive DC offset voltage to the sinusoidal waveform. As a first step, use trigger AUTO on the oscilloscope. Then use Trigger NORMAL and use the reference (trigger out or sync out depending on the generator) signal from the function generator connected to the other/second channel in the oscilloscope. Normal trigger requires specification of the trigger source: Ch1, Ch 2, Ext. etc. Practice changing V/div, Time/div, ground position, and trigger options. Also try different frequencies, amplitudes, offsets, and waveforms.

Use the scope to observe DC and AC components of the waveform by using different coupling options on the scope. The ability to view and isolate components of a time-varying waveform is one of the advantages of an oscilloscope compared to a multimeter. (*Note: AC coupling removes any DC offset from the displayed signal. DC coupling displays the AC signal together with its DC offset.*)

AC signal measurement with a simple circuit

Use the circuit built in Fig. 1 as an AC circuit. Replace the DC voltage supply by the function/waveform generator for AC signals.

Measure the amplitude, frequency, and offset at the input and output of the circuit (voltage divider) with respect to ground, and measure their relative phase. Use two channels of the oscilloscope to simultaneously observe/display the input in CH1 and the output in CH 2. Trigger NORMAL in CH1. Compare your results with the results from DC.

- Calculate the maximum instantaneous power dissipated in each resistor.
- Calculate the time average power dissipated in each resistor.
- Use the multimeter to measure the RMS voltage at the input and output. Is it what you expect? Explain your answer (why (not)?).

In your lab notebook

- Report all your studies and observations on the use of the function generator and the scope.
- Report the study of the dependence of the output Vout with respect to the input Vin.
- Include the calculations of the instantaneous and average powers of the resistors.
- Results and discussion of the measurements with the multimeter and the comparison with the oscilloscope.