# *Basic Measurements II*

## *Physics 251*

## *Fall 2022*

The purpose of this lab is to introduce the oscilloscope (Rigol DS1054) and the function generator (25 MHz, Rigol DG1022), and how to properly calibrate and use a scope probe without frying the oscilloscope :-).

## *AC Measurements with the oscilloscope*

By far, the most versatile piece of equipment you have available is the oscilloscope. If you have never used a scope before, the large number of controls can be confusing. To figure out how to use the scope, the best thing to do is to use a trial and error approach and ask plenty of questions. You can get some help from Appendix A of your book, and the manufacturers instruction book might be useful, but your best bet is to try.

### *Calibrating the probes*

After you figure out how to turn the scope on, the next step is to get a straight horizontal line across the center of the screen when nothing is connected to any of the inputs. This should happen automatically after the scope goes through its setup procedure. Once the scope is started up, go to pages 6 and 7 and perform the calibration procedure as indicated. If your scope is new, it is a good idea to install the color rings to aid in identifying which channel corresponds to which probe. Calibrate each of the two probes that came with your scope.

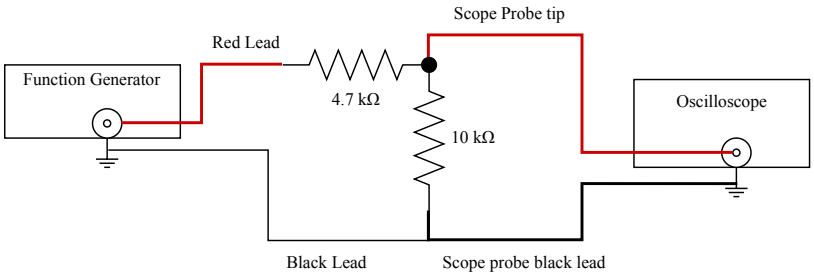


Figure 1: How to connect the function generator to the oscilloscope. It is **extremely important** that the black scope probe clip be connected as shown.

### *Adjusting the function generator*

Next, identify the function generator and turn it on. This is less complicated to use, but will probably take time to get used to. Figure out how to set it for a sine wave output with a frequency of 5 kHz and maximum amplitude (20 Volts peak to peak for the Rigol DG1022).

Now you are ready to display the function generator output on the scope. Because of the way you will often make measurements later in the course, use the circuit in Figure 1 rather than connecting the scope directly to the generator. Put the resistors in the protoboard and connect from the generator to the resistors with a BNC to alligator cable. Connect from the resistor to the scope with a scope probe. It is almost always best to use a scope probe when making measurements with a scope. Set the scope probe on 10x. This reduces the voltage by a factor of 10, but provides better isolation between the scope and the circuit under test. Find some settings that give a nice sine wave on the scope screen. Use the scope to measure the peak to peak voltage of the signal. Measure the period of the signal and convert it to frequency. The frequency is 1/period. (Record!) Next, figure out how to adjust the voltage output of the generator to its minimum value (which should be less than 100 mv) and measure the peak to peak value. The function generator is supposed to produce signals with frequencies up to 25 MHZ. Using a voltage of 1 or 2 $V_{pp}$, verify that this is the case with your scope. Look at the square and triangle signals produced by the function generator.

## *DC measurements with the oscilloscope*

The scope can be used for DC measurements. Although it is often not the best instrument for this kind of measurement, it is sometimes a convenient choice. Near the scope inputs are three position switches labeled AC, Gnd, DC. To make DC measurements, the switch must be in the DC position. Connect your scope probe to the variable voltage supply. Be sure to observe grounding conventions. The clip on your scope probe must connected to the power supply ground (The clip must **NOT** be connected to the power supply output). Vary the voltage throughout its range and observe the scope display.

## *A low pass filter*

Connect the circuit shown. Set the function generator for max output and for as low a frequency as you can conveniently view on the scope. Measure the output voltage as a function of frequency up to the maximum of the generator. Hint: start by increasing the frequency by factors of 10. Then fill in where there seems to be something happening. Make a log-log plot of your results as follows: Plot dB as $20 \log \frac{V_{out}}{V_{in}}$ on the $y$-axis and $\log f$ on the $x$. Label the frequency axis in Hz, i.e. $log100$ is 2. Label that point on the axis as 100, not 2. (This circuit is a low pass filter. High frequencies are attenuated compared to low frequencies. A good plot will show frequencies from 1kHz to 1 MHz; more points is better—when I did this, I sampled 35 different frequencies! Python and Julia are your friends for data analysis and plotting.)

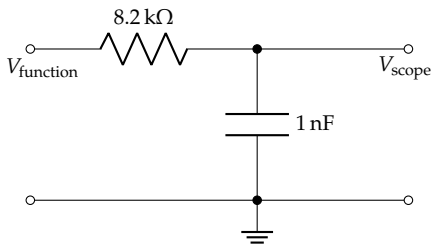

Figure 2: A Low pass filter.