Basic Measurements II

Physics 251

Spring 2025

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 according to the instructions attached to the end of this report.

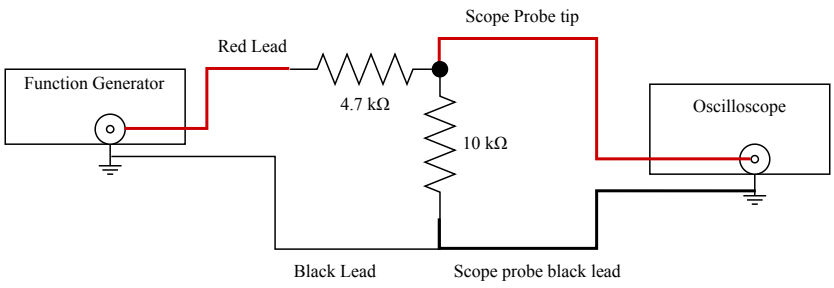


Figure 1: How to connect the function generator to the oscilloscope. It is **extremely important** that the black scope probe clip be connected as shown.

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.

In practice, you'll find that the Rigol scope will save you a lot of work, because you can have it measure things like the peak to peak voltage, as well as the frequency and period of a signal. These items can be accessed at the left side of the screen and use of the Menu button at the upper left.

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. On your Rigol scope, if you push (for example) CH1, you will see on the right side of the display at the top a "Coupling" menu item. Push the button to the right and then you can select DC in order to make DC measurements. Connect your scope probe to the variable voltage supply. Be sure to observe grounding conventions. The grounding clip on your scope probe must connected to the power supply ground (The ground 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 10 Hz to 10 MHz; more points is better—when I did this, I sampled 35 different frequencies! Julia or gnuplot are your friends for data analysis and plotting.)

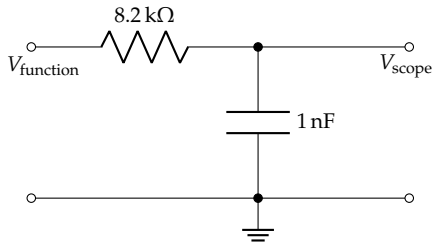


Figure 2: A Low pass filter.

Function Inspection

1. Press **Storage** → **Default** to restore the oscilloscope to its default configuratiuon.
2. Connect the earth alligator clip of the probe to the "Ground Terminal" as shown in the figure below.
3. Use the probe to connect the input terminal of CH1 of the oscilloscope and the "Compensation Signal Output Terminal" of the probe.

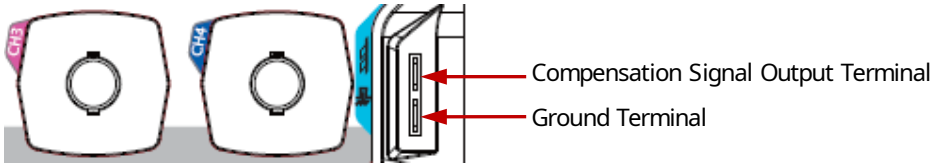


Figure 1-7 To Use the Compensation Signal

4. Press **AUTO**.
5. Observe the waveform on the display. In normal condition, the square waveform as shown in the figure below should be displayed.

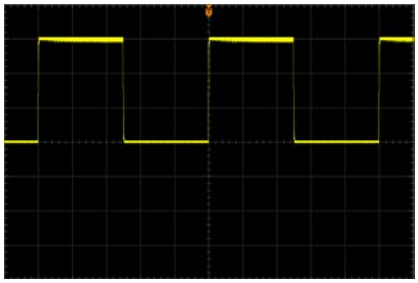


Figure 1-8 Square Waveform

6. Use the same method to test the other channels. If the square waveforms actually shown do not match that in the figure above, please perform "**Probe Compensation**".

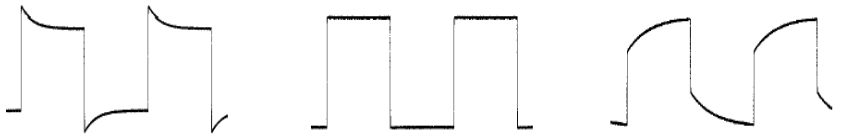
WARNING
To avoid electric shock when using the probe, please make sure that the insulated wire of the probe is in good condition and do not touch the metallic part of the probe when the probe is connected to high voltage source.

Tip
The signal output from the probe compensation connector can only be used for probe compensation adjustment and can not be used for calibration.

Probe Compensation

When the probes are used for the first time, you should compensate the probes to make them match the input channels of the oscilloscope. Non-compensated or poorly compensated probes may cause measurement inaccuracy or error. The probe compensation procedures are as follows.

1. Perform steps 1, 2, 3 and 4 of "**Function Inspection**".
2. Check the displayed waveforms and compare them with the following figures.



Over compensated Perfectly compensated Under compensated

Figure 1-9 Probe Compensation

3. Use a nonmetallic driver to adjust the low-frequency compensation adjustment hole on the probe until the displayed waveform is as the "Perfectly compensated" in the figure above.