

Oscilloscope, Function Generator, and Voltage Division

1. Introduction

In this lab the student will learn to use the oscilloscope and function generator. The student will also verify the concept of voltage division through measurements.

2. Background

This lab presents the basic controls of the oscilloscope and the function generator. Since the primary goal is orientation with the settings of each device that will be used throughout the semester, the following describes the features and options that are most important to know. *Please read them thoroughly—when you feel comfortable with them, obtain your lab instructor's signature after you explain them to him/her.*

2.1. Oscilloscope

General Comments for the Oscilloscope:

- Tan buttons bring up different menus with options.
- Pressing the “auto” button will *usually* capture a clean visual for a periodic waveform.
- Run/stop is self explanatory.
- Divisions on the oscilloscope (x and y axes) are dotted lines.

Channels:

- There are two (2) input channels—Channel 1 (Yellow) & Channel 2 (Blue).
- There is also a Math channel (Red) that allows arithmetic between references (White) and/or channels. References are previously saved signals.
- The “off” key turns each channel off when that specific channel is selected.

Vertical Scaling:

- The larger knob controls the Volts/div (assuming voltages are being measured) and is displayed in the lower left.
- The smaller knob controls the offset (from the x-axis) of the signal. In the vertical scaling menu, this is specified as the “position”.
- The probe setup option of the vertical scaling menu allows you to select voltage vs. current measurement and allows scaling. **Make sure the probe is set to 1x.**
- The vertical scaling menu also contains the coupling and impedance options—you should choose the type of signal for coupling and always have $1\text{M}\Omega$ selected unless otherwise stated.

Horizontal Scaling:

- If the signal is shifted, the “delay” light will be lit—“auto” capturing a waveform often does this to line up a jump in the signal with the origin.
- The larger knob controls the time/div (the seconds per division are shown next to the ‘M’). The smaller knob controls the time shift.

Measurements:

- Auto measurements can be selected using the “measurement” menu.
- Specific measurements can also be taken with the cursors (press the corresponding tan button).
- You must select the horizontal or vertical cursor bars—there are two for each.
- Movement of the bars is done through the measurement knob while “select” toggles between the two cursors for a given orientation.
- The change between the two cursors and value for the cursor that is currently selected are displayed.

Display Menu:

- The display can be one or two dimensional. Turn XY off to display the input waveform(s) with respect to time.
- The grid lines can also be turned off if desired.
- **Important:** To capture screen shots, you can either save them directly to a floppy disk by pressing the print button (looks like a printer) or you can open up a web browser on any of the computers *on that side of the lab* and type in the oscilloscope’s IP address.

2.2. Function GeneratorGeneral Comments for the Function Generator:

- You should always use the “output” terminal, not the “sync”.
- Pressing the blue keypad first will allow you to access options specified in blue colors above the corresponding keypads.
- If the oscilloscope does not show the correct waveform when the function generation is directly connected as an input, check the Output Terminal Option under the System Menu—it should be set to High Z (impedance) usually.

Characteristics Settings:

- The type of waveform can be selected from the top row of keypads.
- The characteristics can be selected from the lower row of keypads.
- You can adjust the settings in two ways—via the gray dial or manually by first pressing the “Enter Number”, then entering the digits (in green above the corresponding keypads), and lastly selecting the appropriate units which are also in green above the arrow keypads (e.g. kHz).
- V_{PP} refers to the peak-to-peak voltage, i.e. the difference between the maximum and minimum voltage values of the waveform.
- V_{RMS} refers to the root-mean-square voltage, which will be discussed later.
- The duty cycle (% of the time spent at the high voltage) can be set via the blue key option—this applies only to square waves.

3. Experimental Procedure

3.1. Equipment

- Tektronix TDS 3012B Digital Phosphor Oscilloscope
- Agilent E3631A DC Power Supply
- Agilent 33120A Waveform Generator
- (2) 10 k Ω Resistors, (1) 5 k Ω Resistor

3.2. Function Verification with the Oscilloscope

Connect the function generator output directly to one of the inputs of the oscilloscope. Select a 10 Hz square wave as output on the function generator with a 2 Volt Peak-to-Peak amplitude and a 60% duty cycle. Use your cursors to display the period and peak-to-peak voltage on the oscilloscope. **Save a screenshot (a picture, e.g. jpg is recommended) showing these measurements and include it in your lab write-up.**

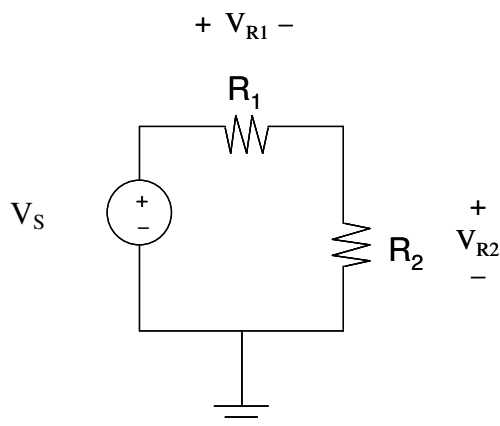


Figure 1: Voltage Division Circuit

3.3. Verification of Voltage Division with a DC Voltage Source

A circuit that will be used to verify voltage division is shown in Figure 1. Turn on the DC power supply and measure the output with the Digital MultiMeter (DMM). Adjust the output until the DMM reads 5 Volts—this will correspond to V_S in Figure 1. Select 10 k Ω resistors for R_1 and R_2 and measure them each using the DMM. **Record these values in Tables 1 and 2.** Use the equation for voltage division to calculate the theoretical voltages across the two resistors and **record these values in Table 1.** Next use the DMM to measure the actual voltages across R_1 and R_2 and **record these values in Table 2.** Replace R_2 with a 5 k Ω resistor, repeat the process and **record your values in the bottom row of Tables 1 and 2.**

3.4. Voltage Division with a Waveform Voltage Source

Set the function generator to output a 20 Hz sine wave with a 10 Volt Peak-to-Peak amplitude. Verify these characteristics on the oscilloscope. Using the same resistor

values as before, replace the DC power supply with the function generator in Figure 1 (V_S). Use a set of clamps to measure the V_S waveform on Channel 1 of the oscilloscope. Use another set of clamps to measure the V_{R2} voltage waveform on Channel 2. In addition to these two channels, use the math function to display the V_{R1} voltage waveform in red (Hint: use KVL to figure out what V_{R1} is equal to in terms of the other voltages shown in Figure 1). For each of the two same resistor combinations, measure the frequency and peak-to-peak amplitudes of each waveform, display them on the oscilloscope, and take a screenshot of them. **Include these screenshots in your lab write-up and record the measurements in Table 3.**

4. Conclusions

This concludes Lab 2. If time permits, you are encouraged to explore other settings on the oscilloscope and function generator. Please return all components to their appropriate places.

This week you are not required to complete a full report. Instead, you will be writing a memo. The memo must include:

- The recipient (i.e. TA) and his/her general company (University) information
- The writer (you) and your general company (University) information
- The date
- The purpose of writing the memo (i.e. conveying your lab results)
- A *brief* discussion of your results in a clear manner
- Greeting and conclusion

The memo should also include the following as attachment and refer to them in the body of the memo:

- The Data Entry and Lab Instructor Signature Page with all recorded numbers.
- Any snapshots, circuit diagrams, and/or calculations requested in the procedure.

Lastly, answer the following questions in your memo—make sure to **numerically justify your answers where possible**.

1. Explain any functions of the oscilloscope that were found easy or difficult.
2. Explain whether the voltage division equation was verified by your results. Did the equation hold true with a DC voltage source? With a waveform voltage source? What are some reasons for any differences between the theoretical and measured values?
3. How do the equations for voltage division and current division differ?
4. Why is it useful to know the voltage division equation when we already have the other equations necessary to determine each of the voltages? (i.e. Ohm's law, Kirchoff's Voltage Law, and the fact that elements in series have the same current)

Data Entry and Lab Instructor Signature Page

Attach this page to your lab write-up.

Lab Signature for Section 2 & 3.2 – Student Demonstrates Controls _____

Table 1: Theoretical Calculations (DC Voltage Source)

V_S (Volts)	R_1 (k Ω)	R_2 (k Ω)	V_{R1} (Volts)	V_{R2} (Volts)
5.00				
5.00				

Table 2: Measured Values (DC Voltage Source)

V_S (Volts)	R_1 (k Ω)	R_2 (k Ω)	V_{R1} (Volts)	V_{R2} (Volts)
5.00				
5.00				

Table 3: Measured Values (Waveform Voltage Source)

V_S (V _{PP})	R_1 (k Ω)	R_2 (k Ω)	V_{R1} (V _{PP})	V_{R2} (V _{PP})
10.00				
10.00				

Lab Signature for Section 3.3 & 3.4 – Student Explains Voltage Division _____