INTRODUCTION TO ARBITRARY/FUNCTION GENERATOR

BEFORE YOU BEGIN

PREREQUISITE LABS

- Introduction to MATLAB
- Introduction to Oscilloscope

EXPECTED KNOWLEDGE

- Ohm's law & Kirchhoff's laws
- Operation of the TDS3034B Digital Phosphor Oscilloscope

EQUIPMENT

- AFG3000 Series Arbitrary/Function Generator
- TDS3034B Digital Phosphor Oscilloscope

MATERIALS

- Resistor Color Guide
- Complete set of resistors in ECE Toolkit
- Complete set of capacitors in ECE Toolkit
- Solderless Breadboard
- BNC to BNC cables
- BNC to Banana cables
- BNC to Alligator cables
- BNC T connectors
- BNC 50Ω Load

OBJECTIVES

After completing this lab you should know how to:

- Use an AFG3000 Series Arbitrary/Function Generator to create typical waveforms, such as triangle and square waves, adjust the frequency and amplitude of the waveforms, and give the waveforms a DC offset.

INTRODUCTION

This lab will introduce you to the AFG3000 Series Arbitrary/Function Generator that you will be using throughout the student laboratories and during your career as an engineer.

PRELAB

CIRCUITS

Build the circuit shown in Figure 1. Note that you will need to use your resistor color guide to identify the 1 kΩ resistors. You will learn more about resistors and how to read their color codes in the following lab.
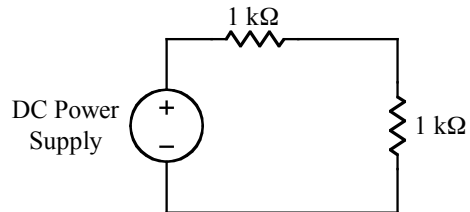

Figure 1. Circuit used in Lab Exercise 2.

FLOATING TERMINALS VERSUS GROUNDED TERMINALS

A terminal is said to be connected to earth ground when it is actually connected to the physical ground via a water pipe, metal rod, or some other type of conductor. The round prong of electrical outlets is connected to earth ground. Some of the terminals on the test equipment that you will be using are also connected to earth ground. This is important to know because this limits how you can interconnect the equipment.

OHM'S LAW

The relationship between the voltage and current is

$$v = iR$$

where v is the voltage in volts, i is the current in amperes, and R is the resistance in ohms. This equation, called Ohm's Law, precisely describes the relationship between the voltage drop across a resistor and the current flowing through a resistor. As shown in Figure 2, the voltage drop across the resistor increases as the current increases.
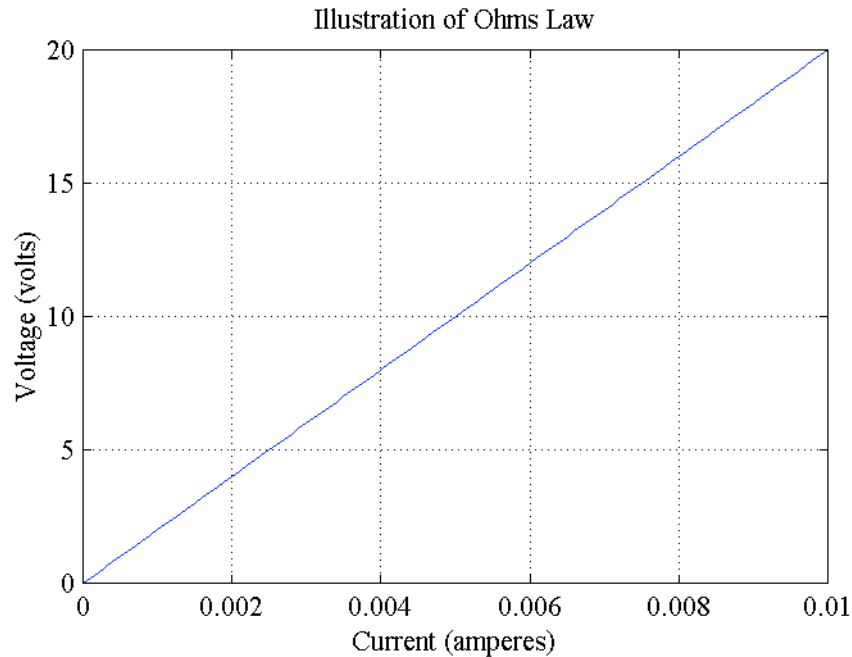
Illustration of Ohms Law

Figure 2. Plot of Ohm's Law, $v = iR$

Answer Question 1.

ALTERNATING VOLTAGE AND CURRENT

Relationship between Frequency and Period

The relationship between the frequency and period of a sinusoidal waveform is:

$$f = 1/T$$

where f is the frequency in Hertz and T is the period in seconds.

Answer Question 2.

Root Mean Square

An important measure of the amplitude of a sinusoidal voltage (and current) is its root mean square (rms) value. The rms value is defined as the square root of the mean value of the squared function,

$$V_{rms} = V_M / \sqrt{2}$$

where V_M is the amplitude of the sinusoidal source.

Since $V_M = V_{p-p}/2$,

$$V_{rms} = V_{p-p} / 2\sqrt{2}$$

where $V_{p\text{-}p}$ is the peak-to-peak ($2V_M$) value of the sinusoidal source.

Answer Question 3.

DC Offset

Recall from algebra that the graph of

$$v = f(x) + k$$

where k is a constant, is the graph of

$$v = f(x)$$

translated *k* units vertically.

A "DC offset" is simply a constant voltage that is added to an AC source. The term "DC" stands for direct current and describes a current (or voltage) that does not vary over time. Although the phrase "direct current" is misleading when used to describe a constant voltage, this phrase is widely used among engineers.

MATLAB

Use MATLAB to plot a sinusoidal voltage source with amplitude of 2 V and frequency of 3 Hz from 0 to 2 seconds. On the same graph plot the rms value. Also, on the same graph, plot the sinusoidal with an offset of 1.5V. Add text to each plot, labeling what it is. For assistance, use the MATLAB **help** command. Your plot should look like the plot in Figure 3.
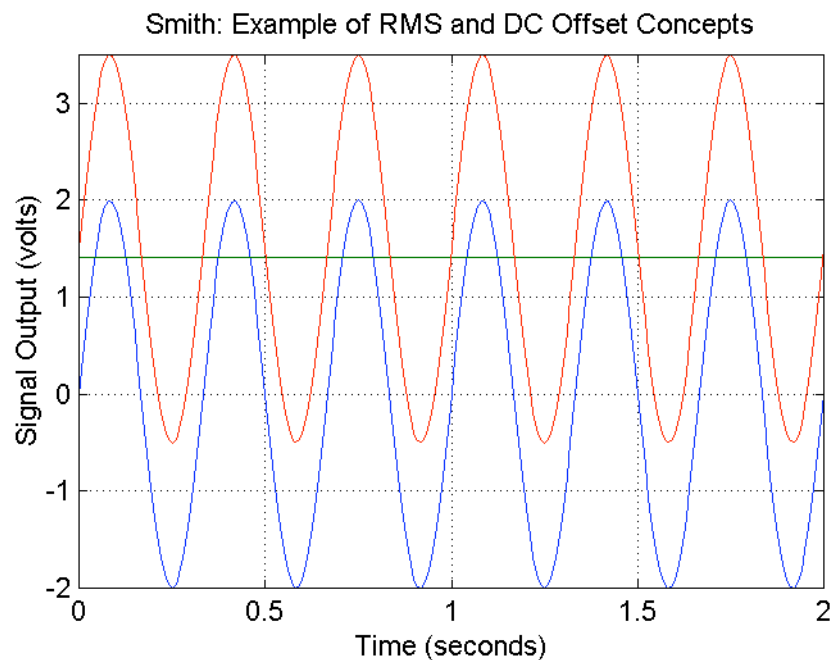

Figure 3. Example of DC Offset and RMS.

Answer Question 4.

AFG3000 SERIES ARBITRARY/FUNCTION GENERATOR

The AFG3000 Series arbitrary/function generator is used to supply sinusoidal (AC) voltage and current. The controls of the instrument are shown in Figure 4. The function generator has 2 different outputs: Output Channel 1 and Channel 2.
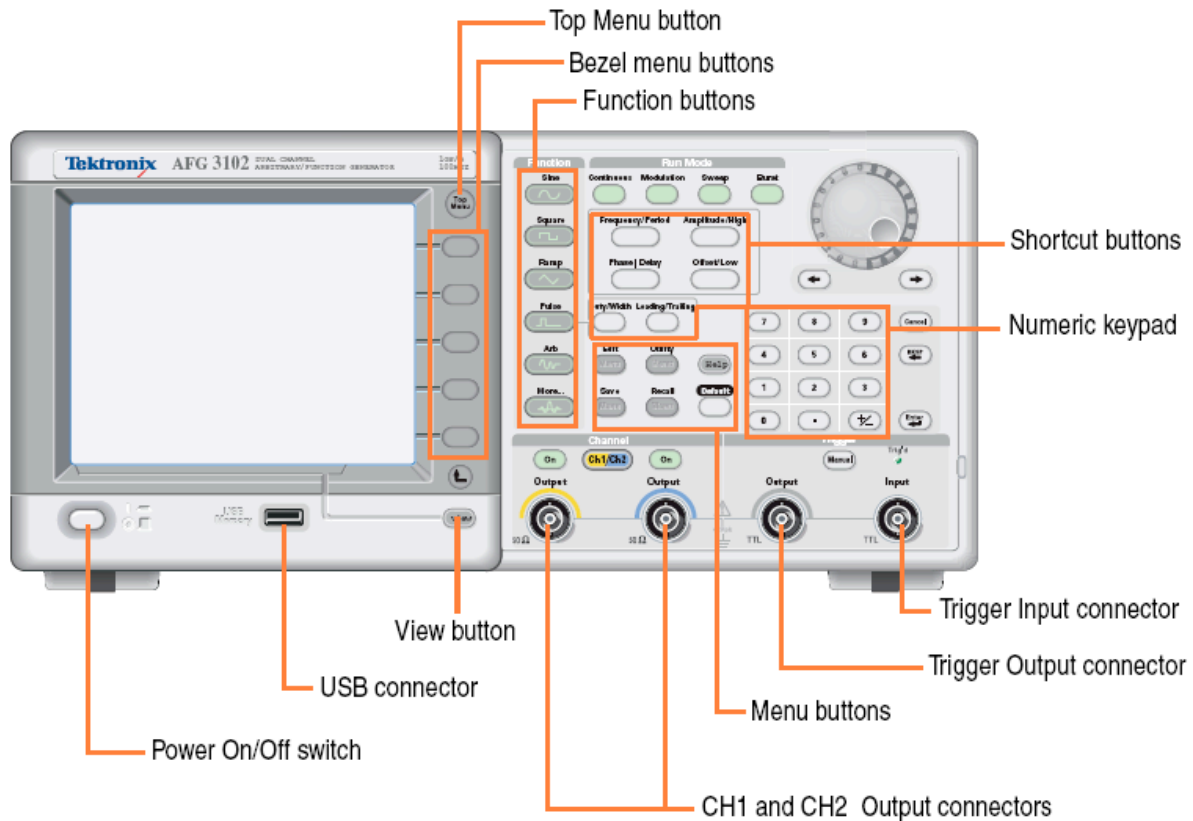

Figure 4. The AFG3000 Series Arbitrary/Function Generator

TYPICAL WAVEFORMS

Along with the familiar sine waveform, you will be working with other types of waveforms. The most common are square, triangle, and ramp (sawtooth) waves, as are seen in Figure 5. The function generator can also simulate noise (Figure 5) and various other waveforms.
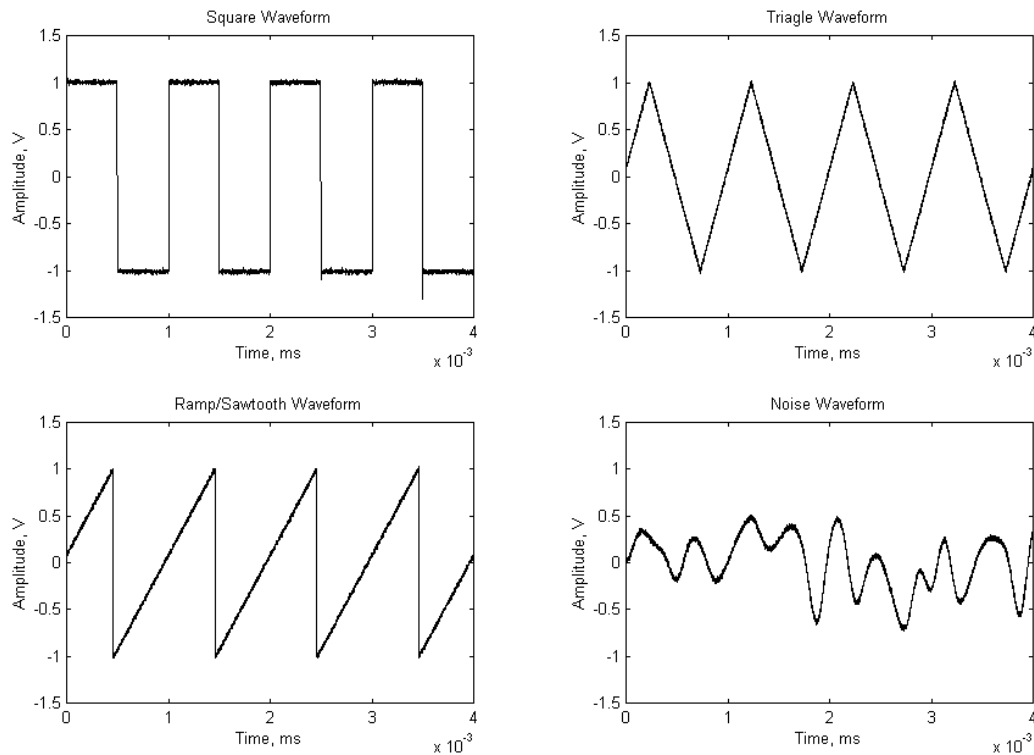
Figure 5. Various Waveforms Generated with Arbitrary/Function Generator.

When the function generator powers up, both channels default to a sine wave with amplitude of 1 V_{P-P} and a frequency of 1 MHz.

Answer Question 5.

Use the oscilloscope to measure the output voltage of the function generator.

1. Connect a BNC T connector to the output of Channel 1.
2. Connect a 50 Ω load to one end of the BNC T connector. The amplitude value displayed is the value of the signal when the output is terminated with a 50 Ω load. Without the load, the output would be twice the value displayed.
3. Connect a BNC to alligator cable to the other end of the BNC T connector.
4. Set the oscilloscope to measure AC voltage.
5. Press the Channel 1 Output On button.

Answer Question 6.

ADJUSTING THE FUNCTION GENERATOR SETTINGS

It is very rare that you will want to use the initial values of the function generator. All of the default settings can be manually set to any value within the limits of the equipment. You do not need to concern yourself with the limitations because all lab settings (after this lab) will be within the operating limits of all the lab equipment. All adjustments are made with the buttons on the control panel.

Adjusting Frequency

The following steps outline the procedure for adjusting the frequency:

1. Press CH1/CH2 to toggle between channels.
2. Press shortcut button Frequency.
3. Use the numerical keypad to enter desired value.
4. Press appropriate units bezel menu key.

Answer Question 6.

Adjusting the Period

Answer Questions 7 and 8.

Adjusting Amplitude

The following steps outline how to adjust the amplitude:

1. Press CH1/CH2 to toggle between channels.
2. Press shortcut button Amplitude.
3. Use the numerical keypad to enter desired value.
4. Press appropriate units bezel menu key.

Answer Questions 9 and 10.

Adding a DC Offset

A DC offset is a DC voltage an that is added to an AC source. This has the same effect as adding a constant value to the AC source. Remember from the prelab exercise that $1 + \sin(t)$ raises the sine function a unit of 1 on the ordinate (y-axis).

The following steps outline how to add a DC offset to a waveform:

1. Press CH1/CH2 to toggle between channels.
2. Press shortcut button Offset.
3. Use the numerical keypad to enter desired value.
4. Press appropriate units bezel menu key.

Answer Question 11.

Turn off power to all equipment and disconnect all circuits before leaving the lab.