Introduction to Lab Instruments and Components

Objective

This experiment will provide exposure to the various test equipment to be used in subsequent experiments. A primary purpose of this lab course is for you to master the use of electronic test equipment.

Apparatus Required

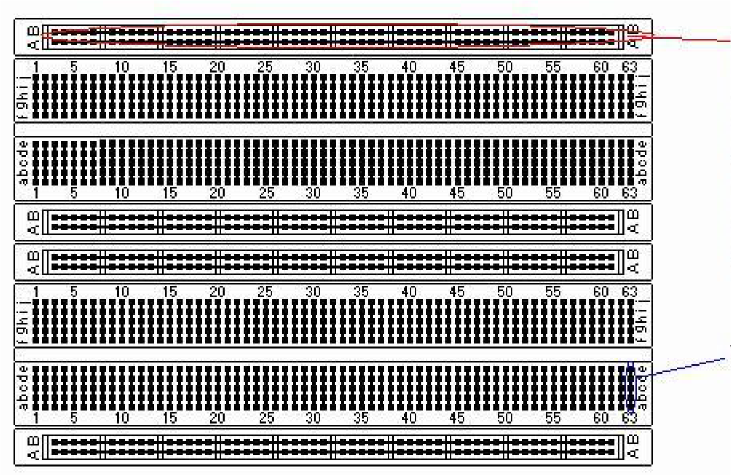
Sr. no	Apparatus	Range	Quantity
1	Power Supply	Standard	1
2	Function Generator	Standard	1
3	Oscilloscope	Standard	1
4	Breadboard	Standard	1
5	Resistors	5.1kΩ, 3.1kΩ	2
6	Wires	Standard	As Required

Procedure

BREADBOARD BASICS

Breadboards (aka. Solderless board, Prototype board) are simply a set of pre-wired interconnected strips that are accessible through periodically spaced hole in the board. Looking at Figure 1. You can identify which holes form an interconnected strip by the black lines connecting them. By plugging the lead of a component into a hole you will be connected to all the other components in that strip without permanently connecting them. This allows you to build, alter, and test your prototype circuits quickly. There are two basic types of strips. The first type is called connection strip, they typically take up most of the board and are connected horizontally. Each hole can be uniquely identified using the labels "a-j' column labels and '1- 63' row labels.

NOTE: 'a-e' connection strips are not connected to the 'f-i' connection strips. The second type is called bus strip. ALL the holes in a bus strip are connected vertically. Bus strips are typically labeled 'A' or 'B' and are marked by a red or blue line along their length.



- This is an example of a Bus. A Bus is often used as way of delivering a common voltage to the entire system. In this case, breadboard. You may use a bus to make a common ground for the circuit you will build in this class.
- This is common strip

Figure 1: Breadboard

Recognition of Basic Components

Here we are going to get acquainted to some of the basic components used in circuits such as the resistors. We will learn how to read the values using the codes as well as how to measure them using the ohmmeter.

Resistors

You will be given some resistors, use the instruments to find their values and fill out the Table 1-1.

	Measured
Resistor 1	
Resistor 2	
Resistor 3	

Table 1-1: Comparison between nominal and measured values.

Recognition of Basic Equipment

Before proceeding with the lab, please familiarize yourself with setting up the bench equipment. Refer to Section 3 for details.

OSCILLOSCOPE

Figure shows the digital storage oscilloscope.

Features

Intensity Control

Rotate clockwise to increase the display intensity; counterclockwise to decrease. You can vary the intensity control to bring out signal detail, much like an analog oscilloscope. Digital channel waveform intensity is not adjustable.

Figure 2: Oscilloscope

Auto-scale Key

When you press the Auto scale key the oscilloscope will quickly determine which channels have activity, and it will turn these channels on and scale them to display the input signals.

Vertical Position Control

Use this knob to change the channel's vertical position on the display. There is one Vertical Position control for each channel.

Channel On/Off Key

Use this key to switch the channel on or off, or to access the channel's menu in the soft-keys. There is one Channel On/Off key for each channel.

Vertical Sensitivity

Use this knob to change the vertical sensitivity (gain) of the channel.

Auto-Probe Interface

When you connect a probe to the oscilloscope, the Auto Probe Interface attempts to determine the type of probe and set its parameters in the Probe menu accordingly.

Horizontal Delay Control

When the oscilloscope is running, this control lets you set the acquisition window relative to the trigger point. When the oscilloscope is stopped, you can turn this knob to pan through the data horizontally.

This lets you see the captured waveform before the trigger (turn the knob clockwise) or after the trigger (turn the knob counterclockwise).

Horizontal Sweep Speed Control

Turn this knob to adjust the sweep speed. This will change the time per horizontal division on the display. When adjusted after the waveform has been acquired and the oscilloscope is stopped, this has the effect of stretching out or squeezing the waveform horizontally.

Measure Keys

Press the Cursors key to switch on cursors that you can use for making measurements. Press the Quick Measure key to access a set of predefined measurements

Measurements using Oscilloscope

The oscilloscope is primarily a voltage-measuring device. Once you have measured the voltage, other quantities are just a calculation away. For example, Ohm's law states that voltage between two points in a circuit equals the current times the resistance. From any two of these quantities you can calculate the third. Another handy formula is the power law: the power of a DC signal equals the voltage times the current. Calculations are more complicated for AC signals, but the point here is that measuring the voltage is the first step towards calculating other quantities.

Ohm's Law:

$$\text{Voltage} = \text{CurrenttimesResistance}$$

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

Power Law:

$$\text{Power} = \text{VoltagetimesCurrent}$$

Following figure shows the voltage of one peak - V[p] - and the peak-to-peak voltage - V [p-p] -, which is usually twice V[p]. Use the RMS (root-mean-square) voltage – V [RMS] - to calculate the power of an AC signal.

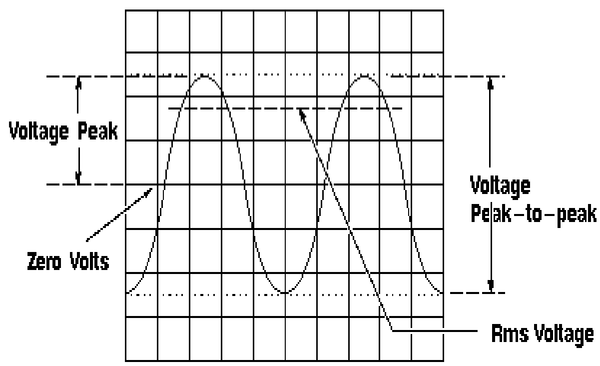


Figure 3: Voltage Peak and Peak-to-peak Voltage

Steps to Measure Voltage

1. Each probe has an alligator clip for connecting the scope to ground. Connect one of these clips to your circuit's ground.
    - It's not necessary to connect the clip on the other probe.
2. Connect a probe to a point in your circuit that has a voltage you want to measure.
3. If there's another voltage you'd like to measure, connect the other probe to this second point.
4. Each square on the screen's grid is one centimeter. Above, you set the VOLT/DIV knobs to 1 V. This means that each centimeter represents 1 volt, and each smaller division represents 0.2 volts.
5. If the voltage you're measuring is greater than 8 volts, the trace will go off the screen. If this happens, set the VOLT/DIV knob to a larger voltage.
6. An alternative to having the zero points for both traces on the bottom line of the grid, is to have one zero point on the center grid line, and the other on the bottom line. If the voltages you're working with go negative as well as positive, you'll probably want to have one zero point on the line 2 centimeters down from the top and the other on the line 2 centimeters up from the bottom.

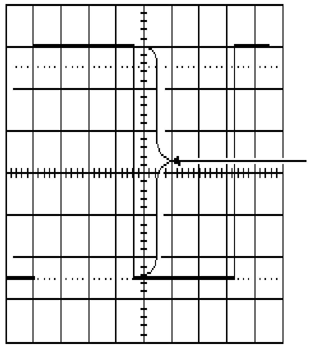


Figure 4: Measure Voltage on the Center Vertical Graticule Line

Frequency Measurement

Frequency can be measured on an oscilloscope by investigating the frequency spectrum of a signal on the screen and making a small calculation. Frequency is defined as the several times a cycle of an observed wave takes up in a second. The maximum frequency of a scope can measure may vary but it always in the 100's of MHz range. To check the performance of response of signals in a circuit, scope measures the rise and fall time of the wave.

Method to Measure Frequency

1. Increase the vertical sensitivity to get the clear picture of the wave on the screen without chopping any of its amplitude off.
2. Now adjust the sweep rate in such a way that screen displays a more than one but less than two complete cycles of the wave.
3. Now count the horizontal number of divisions of one complete cycle on the graticule from start to end.
4. Now take horizontal sweep rate and multiply it with the number of units that you counted for a cycle. It will give you the period of the wave. The period is the number of seconds each repeating waveform takes. With the help of period, you can simply calculate the frequency in cycles per second (Hertz).

Method to Measure Current

Attach a probe with the register to an electrical circuit. Make sure that resistor's power rating should be equal or greater than the power output of the system.

Now take the value of resistance and plug into Ohm's Law to calculate the current.

According to Ohm's Law,

$$Current = \frac{voltage}{resistance}$$

Signal Generator

The signal generator is used to generate signals for your circuits. You will need to know how to set the function generator to get sine, square, triangle or ramp signals. In addition, you will have to set up the frequency, the amplitude, offset voltage and the duty cycle.

The default settings for this instrument are a sinewave of 1 kHz, with an amplitude of 100 mV and a DC offset of 0.0 V.

Figure 5: Signal Generator

The signal generator is very easy to use since each function has a specific button. If you want to select a waveform, just look for the button with the desired waveform such as a sine wave, a square wave, triangle wave, or ramp wave. Then, just press its button. All that you have to do now is set the parameters for the waveform. To set the frequency, amplitude, offset or the duty cycle you need to do the following:

1. Press the appropriate gray buttons beneath the display screen (Freq/Period, Ampl/Hi Level, Offset/Lo Level, or Duty Cycle).
2. You may enter the value one of two ways.
    a. Turn the knob and the highlighted digit will change. You may select a different digit by using the **<** or the **>** buttons.
    b. You can also key in the digit by using number buttons.
3. Press "Output" button on the bottom right of the front panel (right next to Sync cable) and make sure the light is "on".

SIGNAL GENERATOR AND OSCILLOSCOPE

1. Use the signal generator and the oscilloscope to perform the following tasks.
2. Build circuit 'A' shown below in Figure 6.
3. Set the signal generator to generate a sinusoidal signal with a frequency of 100 Hz and peak-to-peak voltage of 5V.
4. Set up one probe across input signal, and another across R1 and R2 alternatively.
5. Measure and draw all the voltages and time related parameters on the graphs below.

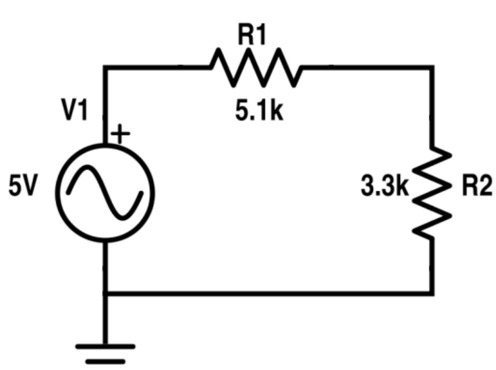


Figure 6: Circuit 'A'

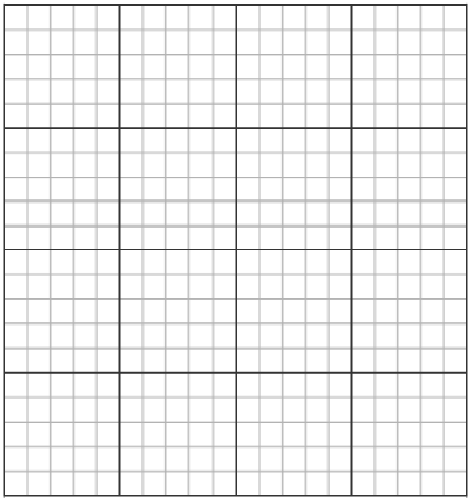


Figure 7: Input Voltage Signal

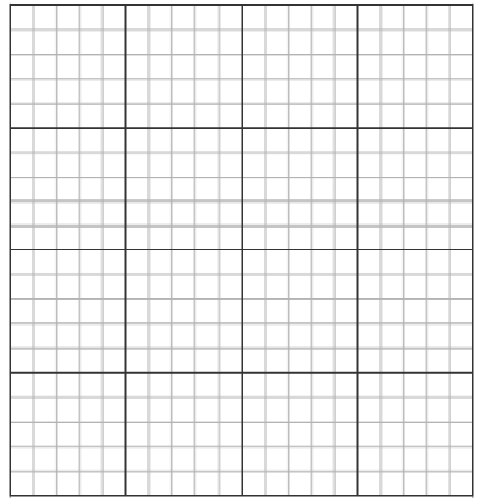


Figure 8: Voltage Signal across R1

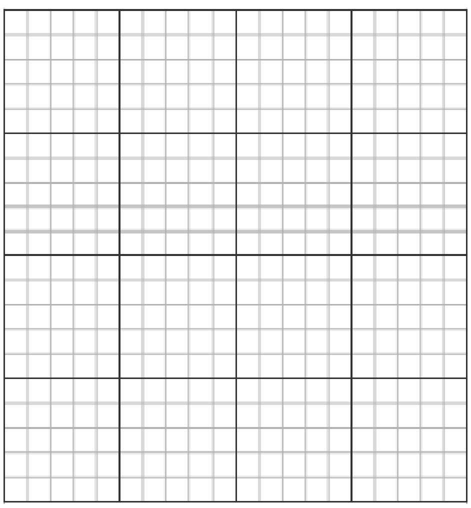


Figure 9: Voltage Signal across R2

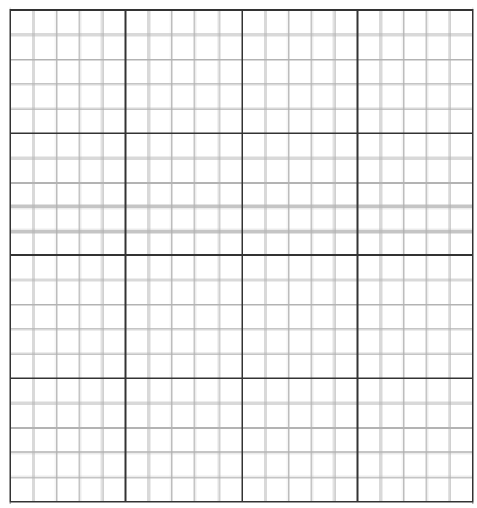


Figure 10: Draw 7V Sinusoidal Signal

Post Lab Questions

1. Define Ohm's law.

2. What is resistor?

3. How resistor works?

4. What is your inference from the input and output waveforms on oscilloscope?

5. Show calculations of 7V input signal (Figure 10) from signal generator.
    a. Voltage calculations (Following volt/dev and number of boxes of oscilloscope)
    b. Frequency/Period calculations (Following Steps in frequency measurements section)
    c. Current calculation (Ohm Law)