

PHYSICS 536
First Laboratory: Introduction to Instruments

The purpose of the first lab session is to learn to use the equipment that will be needed for future experiments. Most of your time will be spent with the oscilloscope. If you do not have time to work with the power supply and the multimeters, you should do those sections of this introductory in the second lab session before you start Experiment 1. A written report is not required for this lab.

A. Oscilloscope and Signal Generator.

You will learn to use the scope by doing the exercises in a Tektronix manual, "The XYZ's of using a Scope". You should study pages 1 through 29 in the manual before coming to lab. Do not study the exercises because they are much easier to understand when you have the scope before you. The exercises in the manual are written specifically for an older model Tektronix scope. The principles given in the "XYZ" manual are still applicable to newer scopes.

Changes to XYZ Exercise Instructions

1. In Exercise 2, delete step 5.
2. Add at the beginning of Exercise 3: Connect a scope probe to channel 1 and connect the probe tip to the probe adjustment signal on the front of the scope. The ground lead of the probe need not be connected. The signal is a square wave that will be used to demonstrate the scope controls. The correct "compensated" waveform is shown in Figure 23 (page 23). If the signal looks like the under compensated or overcompensated illustration in Figure 23, adjust the screwdriver control in the box where the probe cable connects to the scope. (If your probe cable does not have a box, ask your instructor to show you the adjustment). Follow the steps in Exercise 3 to observe the signal.
3. Error in Exercise 4, step 4: The horizontal sweep is calibrated when the control is full clockwise.

Begin XYZ Exercises

4. Do exercises 1 through 8 in the Tektronix manual. (The procedures covered in exercises 9-11 are not used in our laboratory).

The Krohn-Hite signal generator will be used to demonstrate that two signals can be observed on the scope at the same time. The frequency is selected by the row of push buttons on the left and the large knob is the middle. The amplitude is adjusted by the push buttons on the right and the small knob. A switch selects sine or square wave output. The "1 volt" output is a sine wave with amplitude of 1 volt RMS. (See the General Lab Instructions for more details).

Scope Settings:

- Both input channels on DC
- Vertical mode set to alternate between the two traces
- Both vertical gain controls on 2V/DIV
- Horizontal mode on NO DLY (No Delay)
- Horizontal sweep on 50 psec/div.
- Use automatic triggering
- Tripper source on internal

Signal generator settings

- Frequency: 10KHz (dial on 10, multiplier on x1k)
- Amplitude: press the 1V button, small knob on 10
- Switch set for square-wave output

1. Connect the “1 volt” signal and the output signal to scope channels 1 and 2, respectively. Adjust the vertical position control as needed. You should see a sine wave on channel 1 and a square wave on channel 2. You are triggering from channel 1 i.e. the scope always looks at input 1 to decide when to start the sweep, but it takes turns showing the signals on channels 1 and 2. Adjust the trigger level and slope controls to see their effects on the display. Notice that the square wave goes down when the sine wave goes up, i.e. these two signals are 180 degrees out of phase in the generator.
2. Change the trigger selection to channel 2. Change the trigger slope from positive to negative and you should see that you are triggering from channel 2. Leave the trigger slope on positive.
3. Change the trigger selector to vertical mode. Now both waves start as they go positive (or negative if you select negative slope). In this mode the trigger is taken from the channel that is being displayed, instead of only ch 1 or ch 2. Switch between the three trigger modes (ch 1, ch 2 and vertical mode) until you understand the difference.

B. Battery Operated multi-meter (Read GI-2)

You will have a digital meter that is battery operated. These devices are called multimeters because they can measure voltage (V), current (I), or resistance. In the AC mode, the meters respond only to changes in I or V. The meter records the average I or V in the DC mode.

1. Analog Meter. The polarity of the meter can be revised for DC measurements. When +DC is selected, the “plus” input should be positive relative to the common input. The “plus” input should be negative relative to common when – DC is selected. Be sure that the meter is on an appropriate scale before it is connected to a source of voltage or current. Excess voltage or current can damage the meter. The meter must be adjusted before resistance measurements are made. Connect the input

probes together. Adjust the “zero ohm” control until the moving pointer is at zero (extreme right end of the top scale). This adjustment must be repeated when you change resistance scales (ie, R x 1, R x 100, and R x 10,000). The resistance scale is very nonlinear because the current flowing through the meter is inversely proportional to the resistance being measured. An unused meter should not be left in the resistance mode. The internal batteries will discharge if the probe ends touch accidentally.

Connect the meter to a 200Ω resistor and observe the response on the R x 1 and R x 100 scales. (A resistor color code is posted in the lab). You will notice that the zero adjustment is different for the two scales. The zero adjustment is not as important when the pointer is near the left end of the scale.

2. Digital Meter: The seven modes of this meter are selected by the rotating switch; AC volts, DC volts, small DC volts, resistance, diode check, AC current, and DC current. The range of the meter automatically adjusts to the size of the signal (called autoranging). For example, in the DC voltage mode it will select a full-scale range of 3.2V, 32V, 320V or 750V, as required. This is very convenient, but can be slightly confusing. If the voltage you are observing changes from 3.1V to 3.3V, the display will change from 3.100 (3.2V range). The display will show OL (overload) when the meter is not on the proper range, and then quickly change to the correct range. The display is in millivolts in the 300mV mode. The meter displays the polarity of the red terminal relative to the common terminal. You can experiment with the meter using a voltage from the DC power supply. Please turn the meter off when it is not in use for long periods. If you leave the meter on for more than an hour, it will turn itself off. You can turn it back on by moving the rotary switch.

The insulating hoods on the scope probe prevent unwanted contacts when the meter is connected to a circuit. The hoods can be folded back to expose more of the “alligator” clips. The hood and clip can be removed to expose a sharp probe. (The probe is threaded. Turn the clip counter-clockwise). **Do not** force these probes into the sockets on the plug-in circuit board. The contacts will be damaged. A long-term contact to a socket should be made by attaching the clip to a short, bare wire.

3. AC Operated Digital Multimeter

The digital multimeter has buttons to select on/ off, voltage (V), current (A), Resistance (Ω), and the meter range. The voltage ranges are in volts, the current in milliamps (10-3 amps), and the resistance in kilohms (K) or megohms (M). The meter indicates polarity automatically. If the HI input is more negative than the LO input, a negative sign appears on the left side of the display.

Connect the meter to a 200Ω resistor. Select the 2K resistance scale by pressing the ohm button on the left-end range button. Compare the reading on different scales.

4. Power Supply

The power supply contains several separate voltage sources. Each source provides an electrical potential between a pair of terminals, which are labeled for polarity. There is no internal connection between the two voltage sources or ground; hence there is no potential between either terminal and any third reference.

Each source can be adjusted between 0 and 30 volts, although normal operations should be less than 25V. The sources will supply up to 200 mA of current. When an attempt is made to draw more than 200 mA of current, the voltage from the source is reduced to protect the instrument from damage.

One meter is used to monitor four functions, V_1 , V_2 , A_1 (current in amps), and A_2 . Two buttons select the four functions.

- a. Set the power supply meter for voltage sources (V_1). Adjust the V_1 control to see the voltage change. Set $V_1 = 10V$. Push the left button to select the current range. The current is zero because there is no connection to the source output terminal pair. Insert the ends of the 200Ω resistor into the open holes in the terminals. The current should jump up to 50 mA. ($I = V/R = 10V/200 = 0.05A$). Switch the meter back to V_1 and observe that the voltage is consistent when the resistor is added or removed. The voltage should not be affected by any current under 200 mA.
- b. Make a direct connection between the two terminals of V_1 . (The terminal covers can be screwed counter clockwise to expose metal at the base. Then the resistor lead can be used to connect between the terminals). When the connection is made, the voltage will drop to zero and the current will go to approximately 300 mA. The current meter will go off scale, but there is no damage. Make and break the connection several times to see these effects.

A multimeter can be used to see these effects and make an additional point. The multimeter acts like a large resistance in the voltage mode and a very small resistance in the current mode. Therefore the multimeter draws little current in the voltage mode and acts like a direct connection in the current mode.

- c. Set the meter for DC volts and connect it to the power supply terminals for V_1 . Adjust V_1 to approximately 8V. Switch the supply meter to current and notice that the external multimeter draws approximately zero current when it is in the voltage mode. Change the supply meter back to the voltage scale. Disconnect one lead of the multimeter from the supply to protect the meter when the mode is changed. Switch the multimeter to DC current range that can handle several hundred mA. Reconnect the lead. You should notice that that supply voltage drops to zero, like step 2, and the current flowing through the multimeter is between 200 and 300 mA. The maximum current from the supply is limited internally. You should observe that the maximum current does not change when the supply voltage control is varied.

5. Circuit Box

After reading the general lab instructions examine the box with plug-in sockets. Be sure you understand how the sockets are connected.

Familiarize yourself with the laboratory instruments before you try to make measurements with them. Time spend now will save time and improve quality later. Ask your instructor about anything that you do not understand.

GENERAL LABORATORY RULES

1. When you finish an experiment, put all components and equipment in their proper places. The wires you have used are to be kept in the table drawers. You should memorize the resistor color code. Notice that the rolls of hook-up wire are arranged according to the resistor color code to help you out.
2. Turn off the equipment before you leave. In addition, the analog multimeters should be left in the off position (or on a voltage scale if the meter has not off position). If you leave a multimeter on a resistance measuring scale with the probes touching, the meter batteries will soon run down.
3. If you have not finished with an experiment make arrangements with your lab instructor to leave your assembled circuit in a safe place.
4. Take care not to blow transistors, diodes, or integrated circuits by turning off your power supply before making circuit changes. Also, you should be sure that your power supply is set to the values given in the experiment instructions before you turn it on; if you are in doubt, turn the voltage knobs to zero (all the way counterclockwise) before you turn the power supply on.
5. Throw away any obviously bad resistors. If you suspect a diode or transistor to be bad, check it by using the simple conductance tests with the analog multimeter (diode; GI- 9.2, BJT: GI-10.2; JFET: GI-10.3). If, after performing the conductance

tests, you believe a diode or transistor to be bad, put it in the small cardboard box labeled "Bad diodes, transistors and chips". Someone will double-check it later. Suspected chips are to be placed in the small cardboard box too.