Lab #0 Introduction to Test and Measurement Equipment

Objective: To familiarize the student with basic equipment used throughout this course.

- Tektronix DMM4040 (6-1/2 Digital Precision Multimeter).
- Tektronix AFG3021B Single Channel Function Generator.
- Tektronix MSO2014 Mixed Signal Oscilloscope.
- BK precision Triple Output Digital Power Supply 1652

Experiment:

1. Generate a sine waveform on Tektronix AFG3021B Single Channel Function Generator.

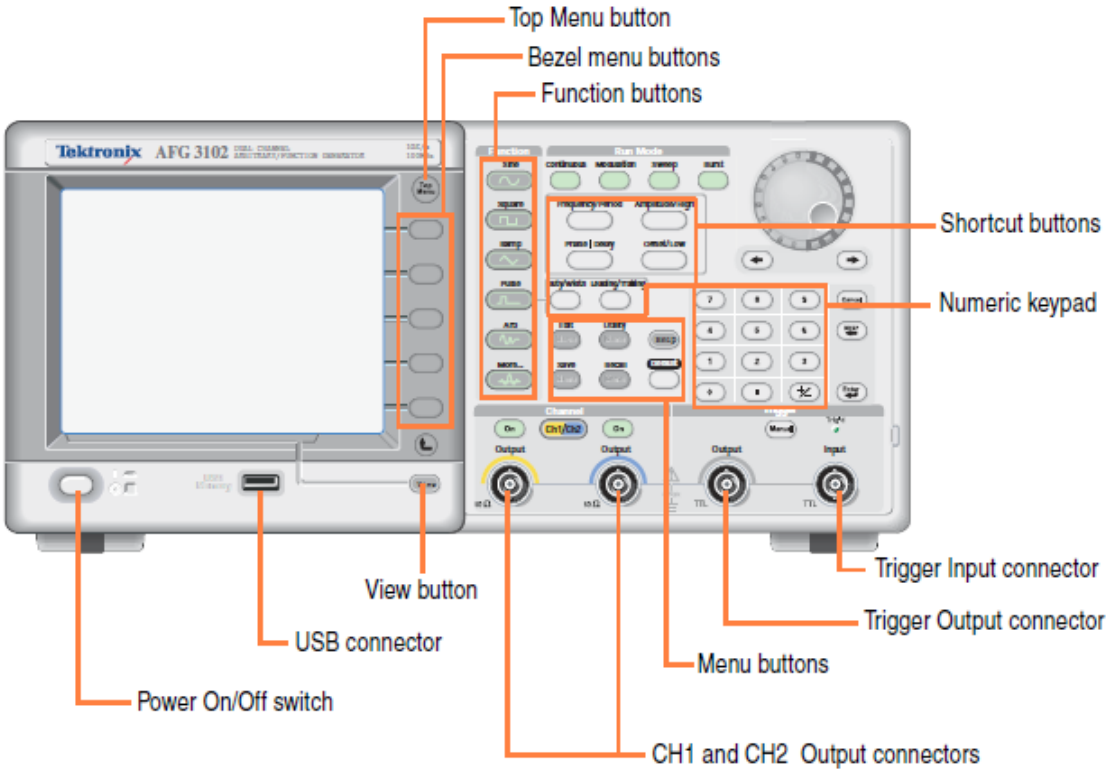


Figure 1. Tektronix AFG3021B Single Channel Function Generator.

Following the steps below to set the function generator to "sine wave", the frequency to 2.0 kHz and the amplitude to 1V.

- Turn on the function generator
- Connect a BNC cable (with red and black clips) from the CH1 Output (50Ω) of the function generator.
- Push the front-panel **Sine** button, and then push the **Continuous** button to select a waveform. (Note: you can also generate other waveforms such as square waveform, triangle waveform on CH1 Output).
- Push the front-panel **Channel Output On button** to enable the output.

- Push the front-panel **Frequency/Period** shortcut button. Keep in mind that this is a toggle button switching between frequency input and period input. To change the frequency value, use the keypad to enter 2 and then push the Bezel menu button (as labeled in Figure 1) to select kHz.
- Push the front-panel **Amplitude/High** shortcut button. Set the Amplitude to 1 V.

2. Display the sine waveform on the oscilloscope.

Figure 2. Tektronix MSO2014 Mixed Signal Oscilloscope

Before you turn on your oscilloscope, plug in a USB in the oscilloscope USB port. We will save oscilloscope images on the USB. When the lab is done, first turn off the oscilloscope and then unplug your USB.

Turn on oscilloscope and press **Default Setup** to restore the default setup. Always do this in the beginning of each lab. There are four color-coded channels, always use the matching color-coded oscilloscope probe for each channel. In this lab, we only need channel 1 (yellow).

Get the oscilloscope probe from the wall and set the probe compensation setting to (x10). This is to make sure that the probe setting matches with the default setting of each oscilloscope channel.

Connect the oscilloscope probe to the function generator BNC cable output (50Ω). Pull back to connect the robe tip (see Figure 3) to positive (red) of the functional generator alligator clip and connection the ground clip to negative (black) alligator clip.

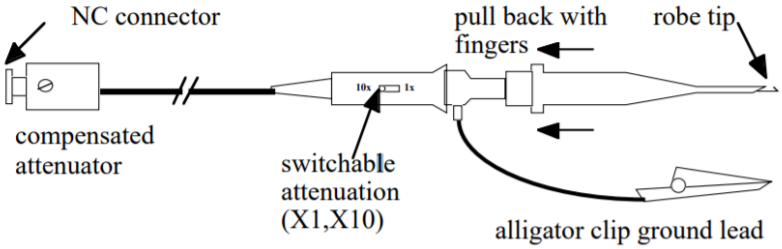


Figure 3. Oscilloscope Probe

The easiest way to get a good display of the input waveform automatically is to press **Autoset** (see Figure 4). To remove a side-bezel menu, push **Menu Off** button.

Figure 4. Tektronix MSO2014 Autoset

In addition, you can manually adjust the vertical scale and position, and the horizontal scale and position to get the desired waveform displayed. As we can see in Figure 5, there are three rows of knobs and buttons, labeled as **Position**, **Menu**, and **Scale**, for vertical controls. Vertical position knobs allow you to change the vertical position of each channel. Channel menu buttons (1, 2, 3, or 4) allow you to display the input waveform, set channel parameters, insert a label, and check probe settings (x10). You can also push the channel menu button twice to remove the corresponding waveform from the display. Finally, the verical scale knobs allow you to change the vertical scale of the display of each channel.

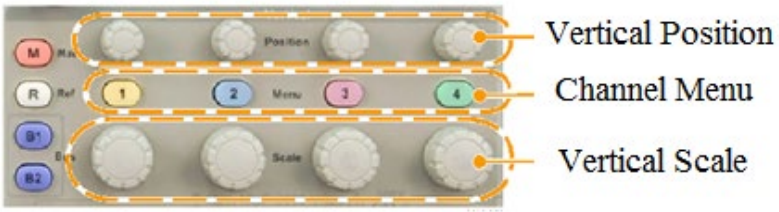


Figure 5. Four Oscilloscope Input Channels

Figure 6 shows Horizontal Scale and Position knobs. Unlike vertical scale and knob controls individual channel, horizontal scale and position knob control all four channels.

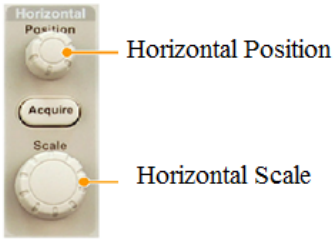


Figure 6. Horizontal Scale and Position Knobs

Adjust the vertical scale such that your sinusoid waveform is displayed at maximum height. Also adjust the horizontal scale such that there are only 2 full periods of the waveform displayed.

3. Cursor measurements

We can roughly estimate the peak-to-peak amplitude and the period of the waveform based on the vertical scale and the horizonal scale. For example, a square waveform is shown in Figure 7. The vertical scale is 2.00V/div, the amplitude is about 2.5 divisions, which is 5V; the time scale is 400us/div, one period is about 2.6 divisions, which is 1.04ms.

Figure 7. Vertical Scale and Horizontal Scale Readings

However, to measure the peak-to-peak amplitude and the period more precisely, we need to use cursors.

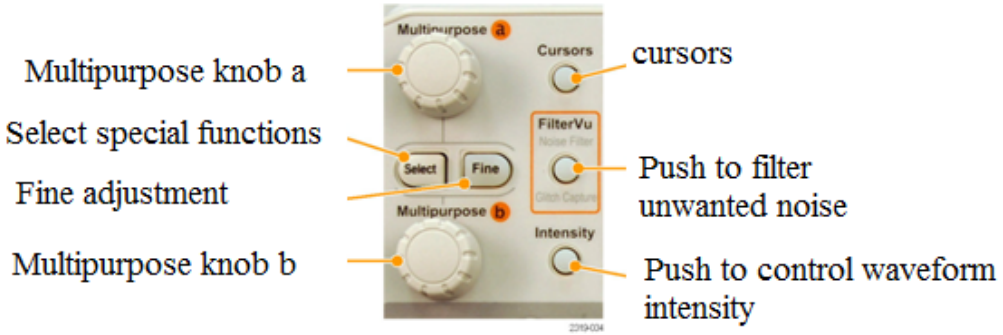


Figure 8. Cursor Buttons and Knobs

Push **Cursors** (as shown in Figure 8) once to activate the two vertical cursors. Push it again to turn on the two vertical and two horizontal cursors. The vertical cursors can be used to measure the period of a waveform or time delay between two waveforms. The horizontal cursors can be used to measure the peak-to-peak amplitude of a waveform.

You can push **Select** to make either the vertical cursors or the horizontal cursors active. When the cursors are active, you can turn the multipurpose knobs **a** and **b** to control their positions. You can use **Fine** button to toggle between making coarse and fine adjustments. To remove a side-bezel menu, push **Menu Off** button.

The cursor measures are displayed on the upper right corner. The first column shows the value (time) of two vertical cursors, and their difference. The second column shows the value (voltage) of two horizontal cursors, and their difference.

Place your two vertical cursors to the start and the end of one period of the waveform. The time difference of two cursors is your period cursor measurement. Place your two horizontal cursors to the lowest point and the highest point of the waveform. The voltage difference of two cursors is the peak-to-peak cursor measurement.

Next, we are going to label the waveform and save the image of your waveform together with your cursor measurements.

4. Label and save the waveform.
We want to add a label on the waveform shown on the display for easy identification. To label a channel, push the channel menu input button Channel 1 (see Figure 9 below).

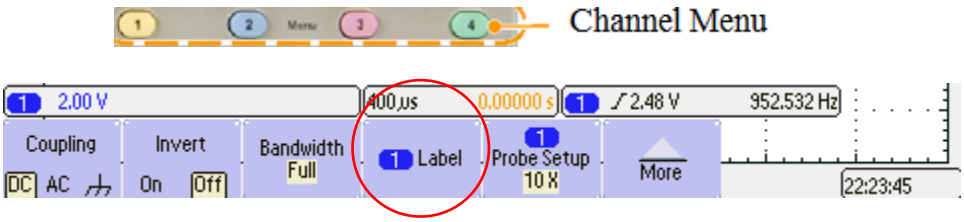
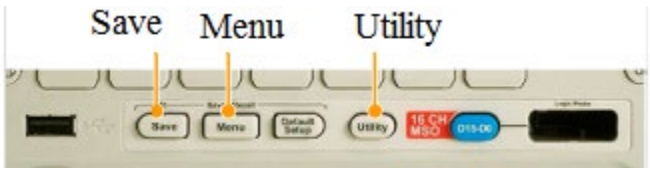


Figure 9. Label Waveform

To create a label, we first press the lower-bezel button under **Label**. Then we turn the multipurpose knob a (See Figure 8) to scroll the list to find each letter and then push **Enter Character** (left corner) to add. Please use your first name to label the waveform. Push **Menu Off** to remove all the menus when it is done.

To save the oscilloscope display to a USB drive, first make sure all the menus are off so they are not blocking your waveform and measurements, then you simply press **Save** button (only if you start from Default Setup in the beginning of the lab).



If the default setting has been changed and you are unable the save the image of your waveform, you can check the settings following the steps below. Otherwise, you can move to Step 5.

To check the settings, push **Menu** and then push **Save Screen Image** from the lower-bezel menu. From the side-bezel menu, push **File Format** repeatedly to select a format you desire (default is .png format). Push **Ink Saver** to turn the **Ink Saver** mode on. Once everything is set correctly, you can push **OK Save Screen Image** to write the image to USB. Once you set everything properly, you do not need to go through this process next time during the same lab session, you can save the display to a USB drive by pressing the **Save** button.

5. Built-in measurements
   There are many built-in measurements available in the oscilloscope. We will use built-in measurements to measure the period, frequency, and the peak-to-peak amplitude.

   To start, press **Measure** and then push **Add Measurement** (see Figure 10).

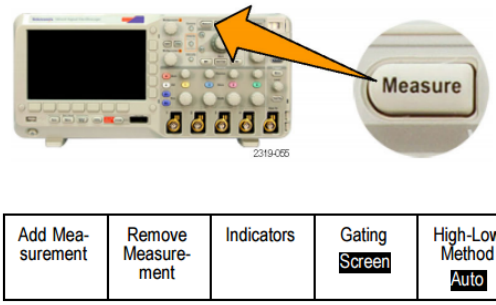


Figure 10. Measure Button and Bottom Menu

   Turn multipurpose knob **a** to select the specific measurement. If needed, then turn multipurpose knob **b** to select the channel to measure on. Then push **OK Add Measurement**. Please add three measurements (amplitude, period and frequency) of your waveform and save the image (press **Save** button). Note that the amplitude measurement is for peak-to-peak measurement, so it doubles the amplitude you set on the functional generator.

   You can only display up to 4 built-in measurements. To remove a measurement, push **Remove Measurement** and select the one you want to remove, or Remove All. Then push **Menu Off** to remove all the side menus.

6. Connect the TTL output of the functional generator to the oscilloscope and observe the waveform. What is the shape of the waveform?

   Now use the TTL output of the functional generator instead. First, set the amplitude to 1V, 2V, and 3V and observe the waveform on the oscilloscope. Does the waveform change as you change the TTL output amplitude? Then, set the frequency to 1Khz, 2Khz, and 5Khz and observe the waveform on the oscilloscope. Save the display of the TTL output at 5Khz with built-in amplitude and frequency measurements (no cursor measurements needed).

7. Tektronix DMM4040 and BK Precision Triple output DC Supply.
   The BK Precision Triple output DC Supply provides two adjustable supplies with a 0-24 volts DC output and one with a fixed 5-volt DC output.

   The fixed 5V supply has a current output of 0-4 Amps, allowing it to handle extensive digital logic circuitry. The two 0-24 volts supplies can be operated independently or in one of two modes. In the series mode, the “A” and “B” supplies are connected in series, allowing a single output of 0-48V at up to 0.5 Amps. In the parallel mode, the two supplies are connected in parallel, allowing a single 0-24V output at up to 1 Amp.

   Generate a 15V supply at A and a 12V supply at B, test each using DMM.

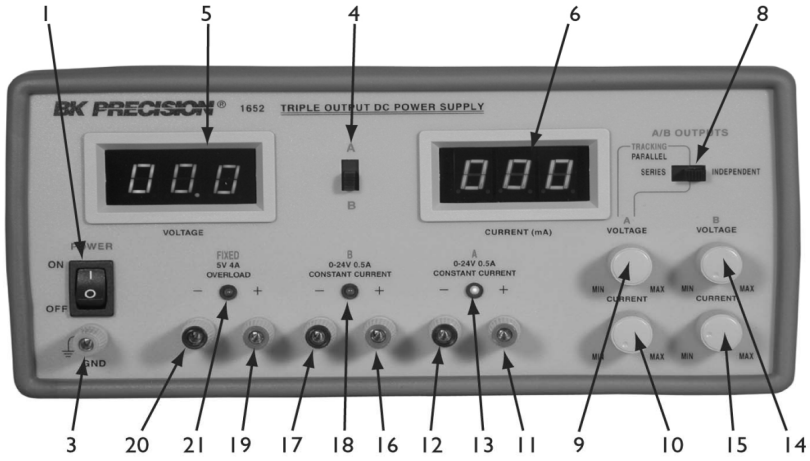


Figure 11. BK precision Triple Output Digital Power Supply 1652

1. POWER Switch. Turns power on and off.
3. GND Terminal (Green). Earth and Chassis Ground.
4. A/B Metering Switch. Selects Voltage & Current metering for the **“A”** or **“B”**.
5. Voltage Meter. Indicates voltage on the “A” or “B” supply.
6. Current Meter. Indicates current on the "A" or "B" supply.
8. Mode Switch: Three Position switch that selects INDEPENDENT mode, PARALLEL mode, or SERIES mode of the “A” and “B”. Set the switch to the right position, so the “A” and “B” power supplies are completely independent.
9 & 14. VOLTAGE Control. Adjusts the output voltage of the “A” or “B” supply.
10 & 15. CURRENT Control. Adjusts current limit in constant voltage mode.
11. “+” Terminal (Red). Positive polarity output terminal
12. “-” Terminal (Black). Negative polarity output terminal.
13 & 18. CONSTANT CURRENT Indicator. Red LED lights when supply is in the Constant Current mode. When the LED is off, the supply is in the Constant Voltage mode.
21. OVERLOAD Indicator. Lights when load on FIXED 5 Volt supply becomes too large.

Post-lab analysis:

1. No formal lab report is required for this lab. However, each student needs to submit the following printouts with clear annotations and explanations:
   a. Image(s) of the waveform with measurements obtained in Step 3 to 5. Make sure your printout(s) has the following information:
      -- two complete periods of sine waveform at maximum height
      -- cursor measurements: peak-to-peak amplitude, period
      -- built-in measurements: amplitude, period, and frequency
      -- label: your first name
      Note: you can use one or multiple images as long as all four information mentioned above are included.

   b. Image of the TTL output at 5Khz obtained in Step 6
   c. Nothing needs to submitted for Step 7

2. Record the peak-to-peak amplitudes and the period of the waveform obtained using cursors in Step 3 and the results obtained using built-in measurements in Step 5. Compare each to the real value.

	Real value	Cursor measurement in Step 3	Built-in measurement in Step 5	% error between cursor meas. and real value	% error between built-in meas. and real value
Peak-to-peak amplitude	2V				
Period	500μs				

3. What are the differences between the TTL output and regular function generator CH1 output (50Ω)? What is the use of TTL output?