# EE 2101 - EXPERIMENT 2
# BASIC OSCILLOSCOPE OPERATIONS

## EQUIPMENT USED

Oscilloscope:

DC Power Supply:

Signal Generators:

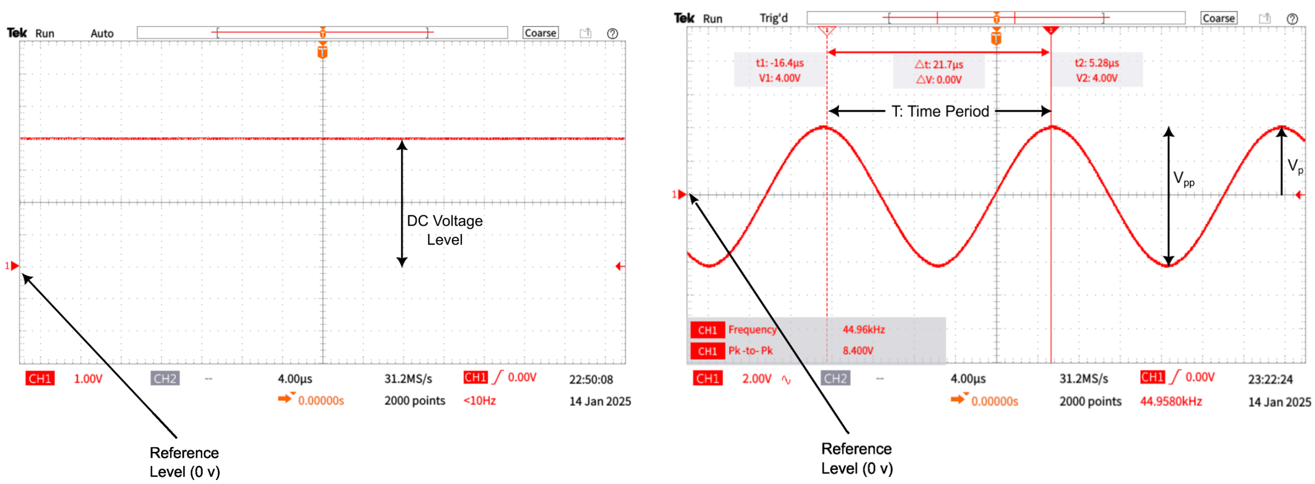
Cables Used:

## INTRODUCTION

The oscilloscope is the most versatile and most important tool in this lab and is probably the best tool an electrical engineer uses. This outline guides you through the basic operations of a specific oscilloscope, a Tektronix TBS1072C, 2 channel, dual time base scope with a DC-70 MHz vertical-amplifier bandwidth. Almost any modern scope will have the same control functions, and a good understanding of this scope will give you confidence in the use of any scope.

**Introduction to signal types**:

**DC (Direct Current) signal**: A voltage level that remains constant with respect to time is called DC signal. To describe a DC signal, only the voltage level needs to be known, as shown in the Figure.1a.




(a) (b)

Figure 1: Singals as viewed on oscilloscope. Figure.1a demonstrates DC signal as observed on an oscilloscope. Figure.1b demonstrates AC signal as observed on an oscilloscope. AC signal needs to described by time period and $V_{pp}$ while DC signal is described by its voltage level.

**AC (Alternating Current) signal**: If the voltage level varies with time, then the signal is called an AC signal as shown in the Figure.1b. To describe a sine wave, some characteristics of a sine wave need to be known or measured. When you see a sine wave you are seeing a varying voltage with respect to time in a cyclic fashion as shown in the figure. One complete cycle which is one positive half cycle and one negative half cycle constitutes one complete cycle of the waveform. The time taken for this signal is called the period (T) of this waveform and is measured in seconds. The number of times one cycle of the waveform repeats in one second is called the frequency of the waveform and is measured in cycles per second or Hz (Hertz). If the signal repeats itself then it is a periodic waveform otherwise it is aperiodic in nature. This describes the basic timing characteristic of the waveform. There are other timing measurements that can be done and you will be introduced to them as and when they are required for any particular experiment. The other major characteristic of a periodic waveform is the voltage level or the amplitude. There are various ways to define this characteristic. The figure shows two such definitions. The peak value of the voltage ($V_p$), and the peak-to-peak value of the voltage ($V_{pp}$). In addition, it is possible to characterize voltage levels in terms of the average and RMS value. These later definitions will be described in subsequent exercises. Peak, peak-to-peak, average and RMS values can also be applied to periodic signals that are not sinusoid, such as square and triangle waves. Again these periodic non-sinusoid signals will be discussed in subsequent exercise.

### The Oscilloscope

Now you are ready to look at using the most important tool in this lab, the oscilloscope. The oscilloscope sitting in front of you has the following main sections.

- The Display
- The Vertical (Analog) Section
- The Horizontal Section
- The Trigger Section
- The Measurement section (Cursor, Measure)
- Storage Section (Save/Recall)

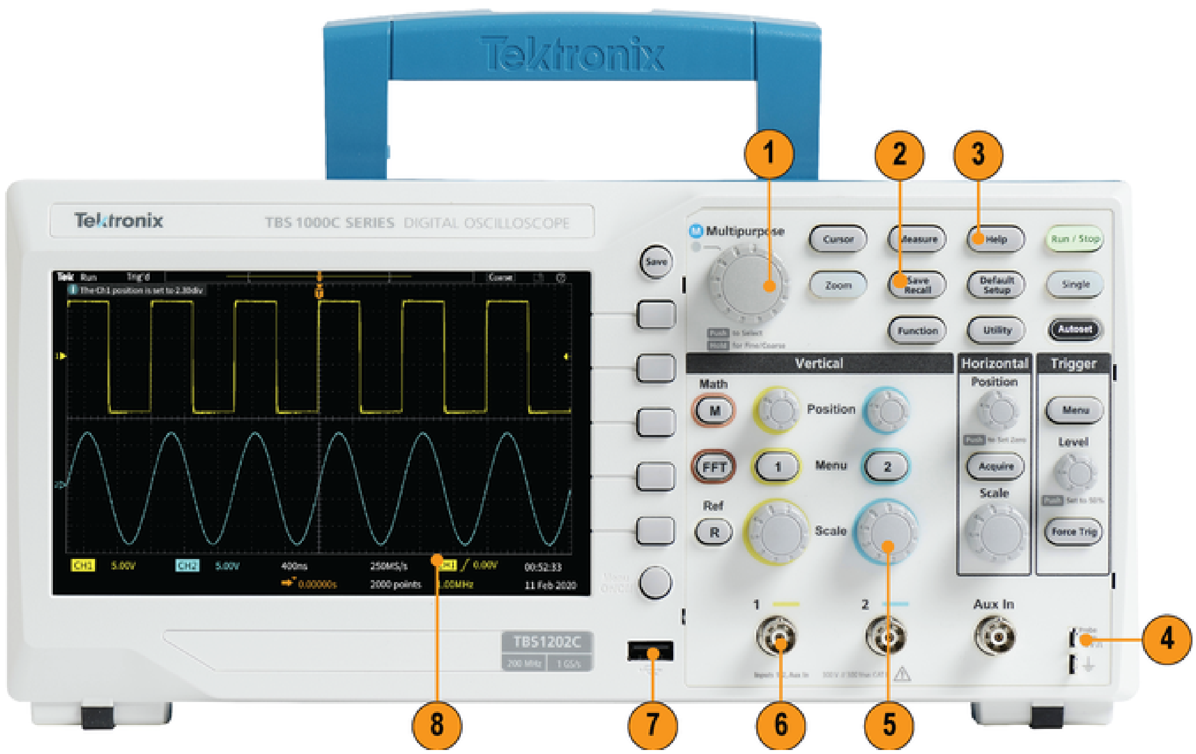



Figure 2: Tektronix TBS 1000C Oscilloscope and useful keys.(Figure Reference: Tektronix TBS1000C User Manual.)

The following are some important controls on the oscilloscope, as shown in the Figure.2.

1. Multipurpose knob for waveform navigation, zoom, and cursors
2. Save Recall (to save screen images, and waveforms)
3. Help

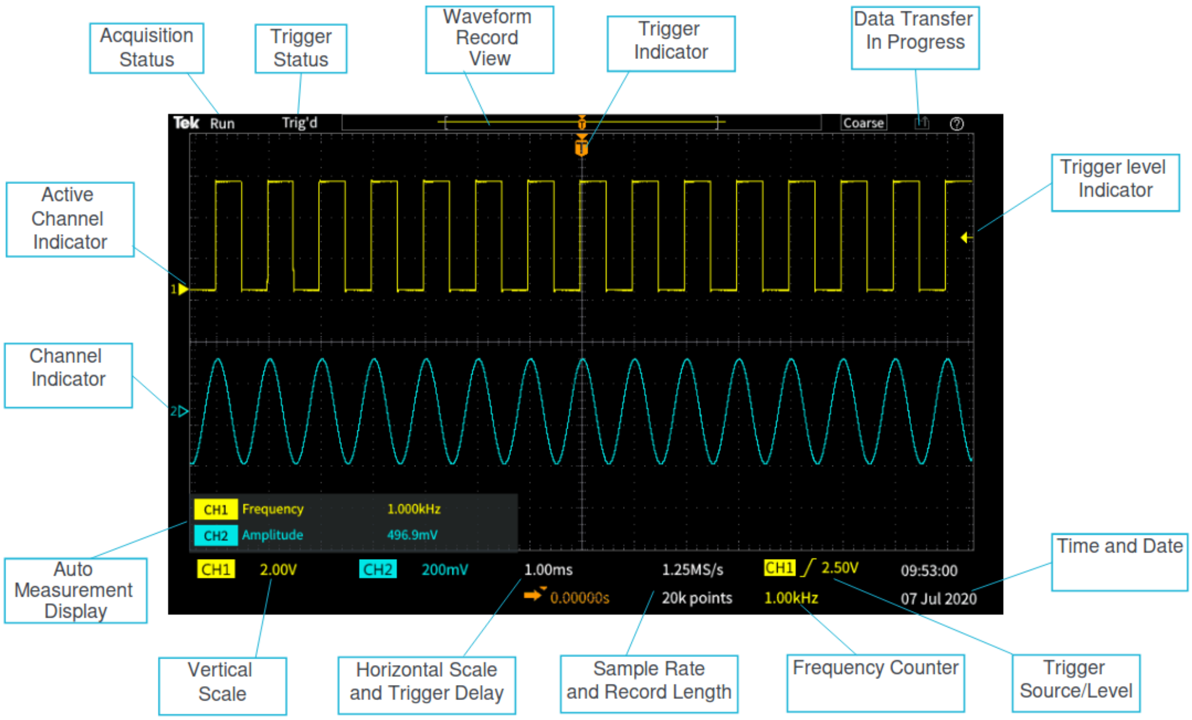



Figure 3: Information on oscilloscope display. (Figure Reference: TBS1000C Demonstration Guide, 26 JUNE 2020 - VERSION 1.0.)

4. Probe Compensation
5. Dedicated control knobs per channel
6. BNC probe interface
7. USB Host port for save/recall
8. Display

**Saving an image or waveform**:

While doing the experiments and learning to use the oscilloscope, you will be required to record all observed data and waveforms. This oscilloscope has built in features to store the current screen in a few formats. This part is explained to you first so that you don't need to draw the waveforms that you observe. Store them in a USB storage drive and attach them later to your final draft of the write up.

After stabilizing the waveform and obtaining all the required measurements pertaining to the waveform, perform the following steps to save the waveform. This is the simplest way of saving waveforms for future reference.

- Press the **Save/Recall** key to display the Save/Recall menu. You will find a menu pop-up (called the soft menu) on the right side of the screen. Each displayed icon on the menu has a push button key associated with it located below the screen. These push buttons are called soft keys.
- Press the **Action** key to select type of data to save; Image, Setup, or Waveform (can also choose to recall data).
- Press the **Save** As soft key to display the file formats menu. The oscilloscope allows you to store the screen images in PNG, JPG, and BMP, and data into a ISF (Tektronix Instrument Data File) or CSV (Comma Separated Variable) file suitable for spread sheet analysis.

- When saving a display image, you can choose to have the background be white by pressing **Settings ->** **InkSaver** On.

### OSCILLOSCOPE OPERATION I: LOOKING AT THE "VERTICAL SECTION"

This oscilloscope supports two inputs. Therefore, you can observe two external signals simultaneously. There are some internally generated signals that can be observed along with the two applied signals, but they will be discussed later. The vertical section has the following controls and buttons associated with it:

- Each channel has an input to which the signal is applied, a volts/div knob (in the Vertical section marked Scale) that helps in enlarging or shrinking the vertical size of the oscilloscope pattern (trace) and a position control knob (Position) for positioning of the waveform on the screen. These are mainly to assist in viewing the waveform under observation.
- There is a channel key (named '1' and '2') which pops up the soft menu for the respective channel.
- There is a math key, when pushed opens up a soft menu that allows the user to perform mathematical operations with the signal on either, or in some cases both, input channels.

**Part#1: Experiments with the DC signal**

When you first switch on the oscilloscope, it is advisable to use the default factory settings. To return oscilloscope to factory default settings press **Default Setup** key. To return oscilloscope to settings present before **Default Setup** was pressed, use **Undo Default Setup** soft key. After you have gained some experience and confidence, you can use your own personal settings.

Connect a 5V DC signal from the DC power supply to the Channel#1 of the oscilloscope. One rule to stabilize waveform quickly is to use **Autoset** feature of the oscilloscope. Press the **Autoset** button located on the front panel of the oscilloscope. You will notice that the oscilloscope automatically makes some adjustments and stabilizes the waveform. *Note: the oscilloscope may auto scale to the AC noise present on the signal, not the DC component.*

1. What is the location of the ground level and the level of the signal? (You may use Figure.1a and Figure.3 for reference.)

2. Turn the volts/div (**Scale**) knob clock wise and anti-clockwise in steps. You should notice the volts/div changing at the bottom left hand corner of the screen, indicated by *Vertical Scale* in Figure.3, and numbers will change in a 1:2:5 sequence (e.g. 0.1, 0.2, 0.5, 1, 2 5 etc.). What happens when the volts/div **Scale** knob is turned? Was there a shift in the position of the ground level?

3. What is the effect of turning the position knob for Channel#1? (Note your observation with reference to ground level)

4. Manually calculate the voltage level by counting the number of the divisions and multiplying it by the volts/div. Try this at different volts/div settings.

volts/div: ______ , #Divisions: ______ , voltage level: ______
volts/div: ______ , #Divisions: ______ , voltage level: ______
volts/div: ______ , #Divisions: ______ , voltage level: ______

Explain which of the volts/div setting gives the most accurate answer?

**Part#2: Channel Operations**

Pressing the Channel button ('1' or '2') push button brings up the soft menu for the corresponding channel, as shown in the Figure below.

Signal Coupling: This oscilloscope supports 2 types of signal coupling. Pressing the **-more- Page 1 of 2**, then the **Coupling** soft key, allows you to choose the signal coupling. DC coupling allows a complete transfer of the signal arriving at the oscilloscope inputs. It has all the components, DC and AC. Choosing AC coupling, inserts a capacitor in series with the signal there by allowing pure AC signal to pass through to the input circuits.

Bandwidth Limit: The **Bandwidth** soft key allows you to clean your signal. If you have a very fuzzy waveform, which is basically a clean signal with high frequency noise over it, this feature inserts a filter removing all the high frequency noise. Mainly used for improving signal quality for accurate measurements.

Inversion: The **Invert** soft key is used to provide a 180 degree phase shift, negate it, to the signal. It is useful for doing many mathematical operations.

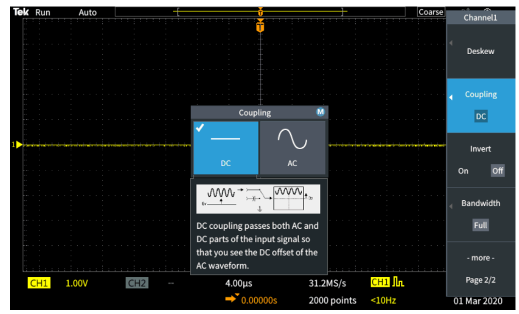



Figure 4: Channel soft menu

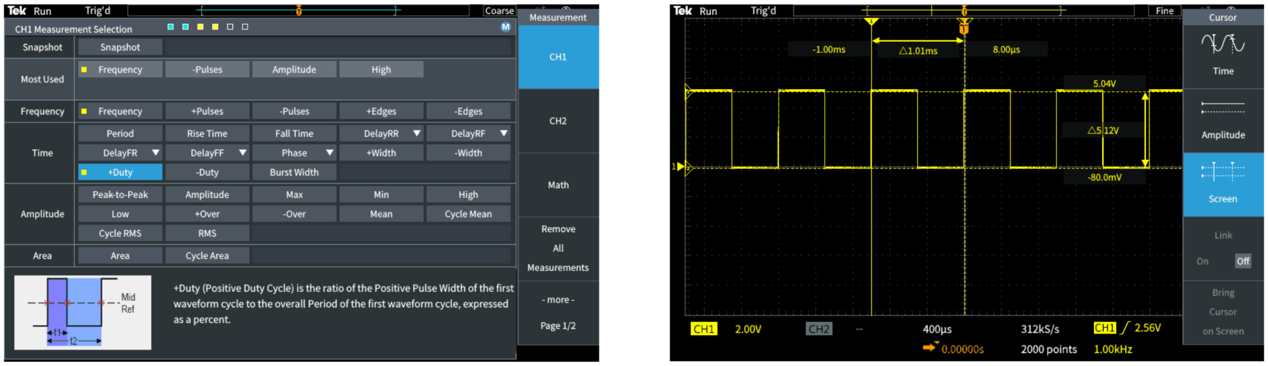
5. What happens to DC level when the coupling is changed from DC coupling to AC coupling?

6. To understand how **Bandwidth** limit works reduce the volts/div using **Scale** until the noise in the signal is observable, the position of the signal may need to be adjusted. What happens to noise in the DC level when the **Bandwidth** is selected?

7. Change the volts/div to to 5V and reposition the ground level to the center of the screen. What happens when the **Invert** is selected?

**Part#3: Vertical Parameter Measurements**

Quick Measurements (QM): This oscilloscope has built in capabilities that allow the user to take simple measurements quickly. This is introduced in this section so you can perform some more experiments with the vertical section. To use this feature, press the **Measure** key located on the front panel. This brings up a soft key menu on the right side of the screen. There, the source can be selected by pressing the soft key adjacent. The measurement type can be selected by rotating the **Multipurpose** knob and pressing on the desired measurement. The measurement choices can be removed by pressing the **Remove All Measurements** soft key. The selected measurements are displayed in *Auto Measurement Display* region as shown in Figure.3.




(a) (b)

Figure 5: Measuring signal parameters using oscilloscope. Figure.5a shows the soft menu when **Measure** key is pressed. Figure.5b shows the soft menu when **Cursor** key is pressed.

Measurement using Cursors: The cursor feature allows the user to make custom voltage or time measurements. To use cursor, once you have obtained a stable display, press the **Cursors** key. This brings up a soft key menu as shown in Figure.5b. The measurements can be made as following.

- Press the **Cursor** key which will bring up a soft key menu on the right side of the screen. You can choose the type of measurement as **Time**, **Amplitude**, or **Screen** (both).
- You can also choose to **Link** the cursors where they both move (On) with rotation of the **Multipurpose** knob or control them individually (Off).
- Time cursors are vertical dashed lines that adjust horizontally and normally indicate time relative to the trigger point. Amplitude cursors are horizontal dashed lines that adjust vertically and normally indicate voltage. It can change while using math operations.
  - The active cursor will be solid, and the inactive cursor will be dashed. The difference between the cursor values is also shown as a $\Delta$ or $\Delta V$, depending on the cursor type.
  - Select **Amplitude** and **Link** (on) to adjust the cursors together by turning the **Multipurpose** knob. The $\Delta T$ value will not change since the cursors adjust together.
  - Select **Time** and **Link** (on) to adjust the cursors together by turning the **Multipurpose** knob. The $\Delta V$ value will not change since the cursors adjust together.

8. Record the measurements: Using **Measure** function Max; Using the **Cursor** function determine the Max value.

   Measure_Max: , Cursor_Max:

**Part#4: Sinusoid with DC offset**

Connect a 100 mVpp 1 kHz Sine wave from the signal generator to Channel#1. Press **Autoset** to stabilize the signal. Use the position knob to bring the ground level of the waveform to the center of the screen.

9. Observe the effect of AC vs DC signal coupling on the waveform. Note your observations on the effects of changing the signal coupling.

10. Increase and decrease the volts/div setting. Note the effect of increasing and decreasing the volts/div on the waveform.

11. Measure the peak-peak voltage, maximum and minimum voltage using both the **Measure** as well as cursors. Measure the average value of waveform. The average value of the waveform can be computed as following, $Average = (Waveform\_Max + Waveform\_Min)/2$. Store screen images of the **Measure** Peak-to-Peak and **Cursor** Peak-to-Peak measurements only.

    Meas_Max: , Meas_Min: , Meas_PP: , Meas_AVG:
    Cursor_Max: , Cursor_Min: , Cursor_PP: , Cursor_AVG:

12. Measure the RMS value of the waveform using quick measurement and a digital multimeter (DMM).

    Meas_RMS: , DMM_RMS:
    Introduce some DC offset (e.g.: 20mV), which can be done by pressing the DC Offset button and adjusting the corresponding knob on the signal generator.

13. Observe and note the effect of AC and DC signal coupling on the sine wave.

14. With the DC offset still on, measure the average value using cursors and using the formula **(Positive peak voltage + Negative peak value)/2**. Measure the average value using **Measure** key and compare it with the calculate value.

    Meas_AVG: , Cursor_AVG:

## OSCILLOSCOPE OPERATION II: LOOKING AT THE "HORIZONTAL SECTION"

### Part#5: Experiments with the horizontal section

The horizontal section provides the timing control on the waveform that is being observed. It has the following controls and buttons associated with it.

- A secs/div knob marked **Scale**, in the Horizontal control menu, that helps in modifying the horizontal scale, which is displayed at *Horizontal Scale and Trigger Delay* as shown in Figure.3.
- A horizontal position control knob marked **Position** for positioning of the waveform on the screen.

These are mainly to assist the viewer in ease of viewing the waveform under observation and making time measurements.

15. Turn the Horizontal **Scale** knob clock wise and anti-clockwise. You should notice the secs/div changing on the screen. It will light up, when you adjust this setting. The secs/div knob changes in a 1:2:5 sequence (e.g. 0.1, 0.2, 0.5, 1, 2 5 etc). What happens when turning the secs/div knob?

16. Measure the period of the waveform by measuring the number of horizontal divisions and multiplying it by the secs/div.

    secs/div: ______ , #Divisions: ______ , time period: ______

    secs/div: ______ , #Divisions: ______ , time period: ______

    secs/div: ______ , #Divisions: ______ , time period: ______

    Verify your results by finding the period of the signal, the period is the reciprocal of the frequency.

17. Measure the period of the signal using the **Cursors** and the **Measure** feature. Save your waveforms for both the measurements.

    Cursor_Period: ______ , Meas_Period: ______