B2
Use of the Oscilloscope

DEARBORN | SCIENCE LEARNING CENTER

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Objectives

In this module, you will learn how to use an oscilloscope to:

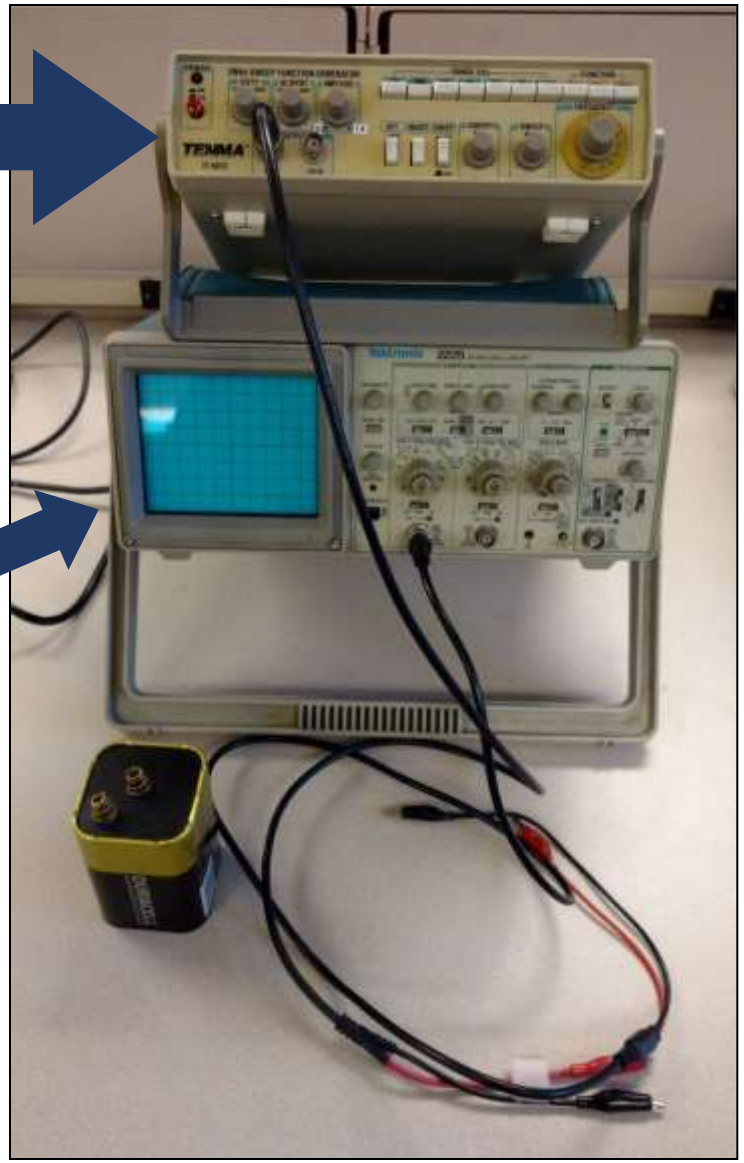
- measure the voltage of direct current (D.C.) signals that don't change over time
- measure the voltage and period of alternating current (A.C.) signals that change over time

Introduction to the Oscilloscope

Equipment

Before you begin, make sure that you have the following equipment:

- a function generator
- an oscilloscope
- a 6-volt battery
- two cables



General Oscilloscope Features

- The oscilloscopes you use in Phys 151 (above), Phys 126 (next slide), and the SLC all have similar controls.

Example Oscilloscope Features

Control Panel

Phys 126
Oscilloscopes

Input Channel Selector

Control Panel

Input Channel Selector

SLC Oscilloscope Features

Control Panel

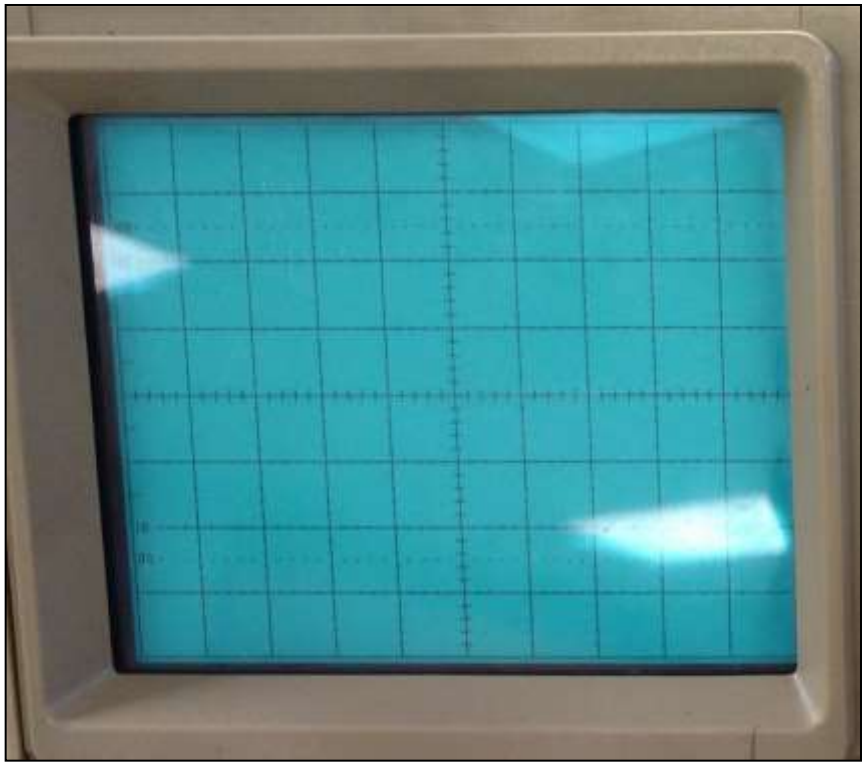
Input Channel Selector

This is the oscilloscope you will be using for the SLC module.

Oscilloscope Screen

Notice that the screen has horizontal and vertical **divisions**.

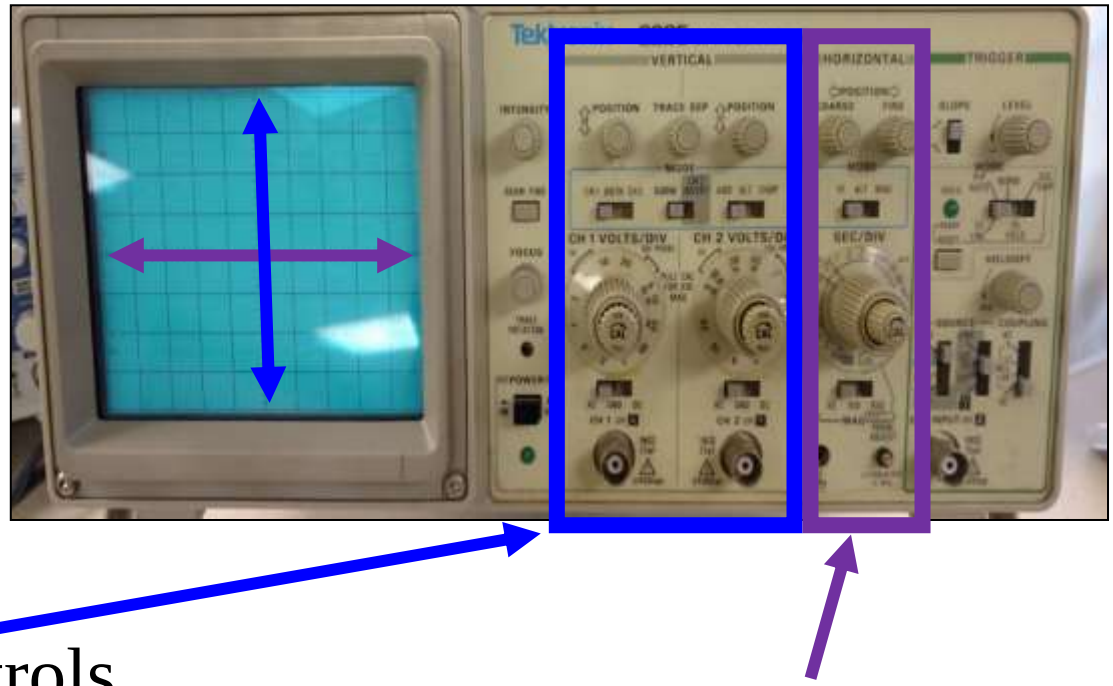
- Each major division measures 1 centimeter.
- The minor divisions (0.2 cm) are marked along the center lines.



Control Panel

The **vertical** axis represents **voltage**

The **horizontal** axis represents **time**



The vertical controls allow you to move or zoom in and out on the voltage axis.

The horizontal controls allow you to move or zoom in and out on the time axis.

Connect Cable

The cable should be plugged in to either channel 1 or channel 2.

- The cable has a rotating locking mechanism.
- The opening must be lined up with the metal pin.

Cable Locking Mechanism

Once inserted, the locking mechanism should be turned to lock the cable in place.

Unsecured (twist to lock)

Secured

Disconnect Cable Leads

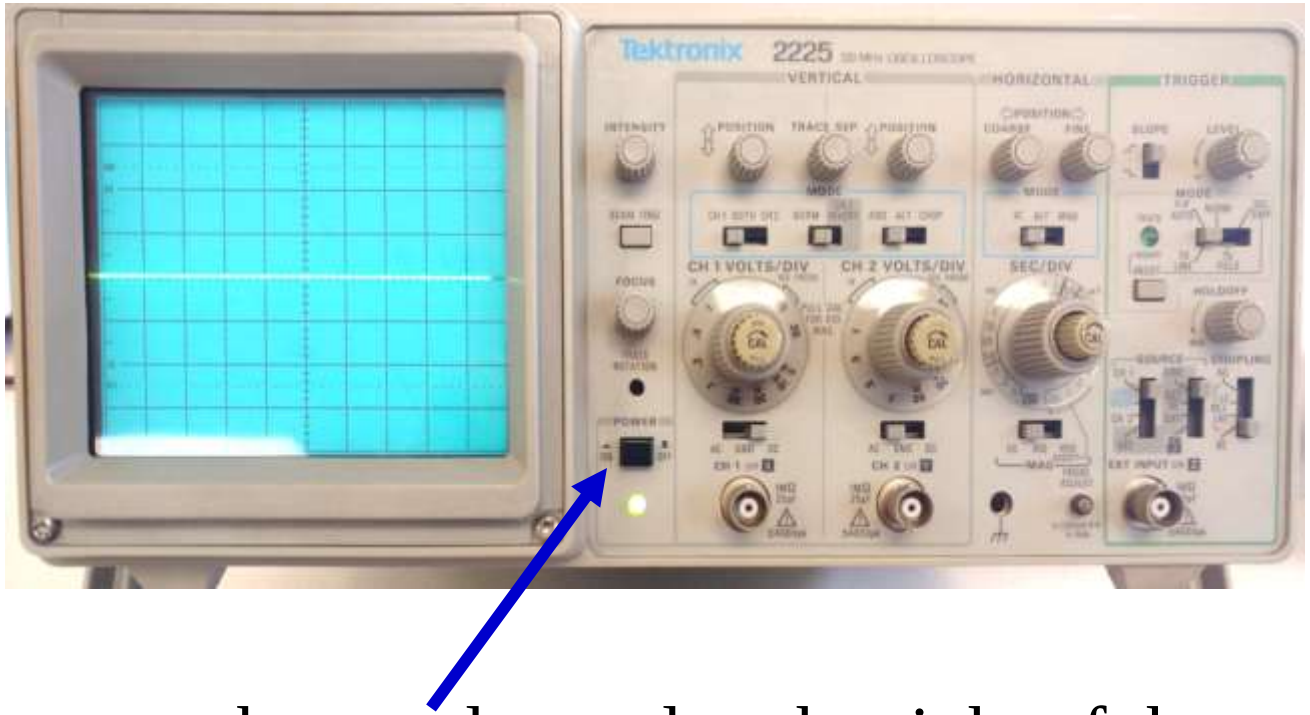
The other end of the cable has 2 leads with alligator clips.

- These clips should not be connected to anything at this point. (If they are, disconnect them.)

Input Channel Selection

- The oscilloscope is capable of measuring signals from two different sources.
- The CH1-BOTH-CH2 switch is used to choose between the sources.
    - For this module, set the switch to the channel your cable is plugged into. (CH1 or CH2)

Turning the Oscilloscope ON



- Push power button, located to the right of the screen, to the ON position.

Horizontal Axis

- Find the “SEC/DIV” knob.
- Turn the outer dial to set the horizontal axis scale.

Adjust the Horizontal Axis

- If the screen displays dots or flashing lines, adjust the knob until a stable line is displayed.

Vertical and Horizontal Position

- Move the line to the center of your screen using the **vertical** and **horizontal** position knobs.

Intensity and Focus Dials

The **intensity** dial controls the **brightness** of the line.

The **focus** dial controls the **sharpness** of the line.

- Adjust these settings if necessary

Summary: Oscilloscope Setup

To get started, follow these steps:

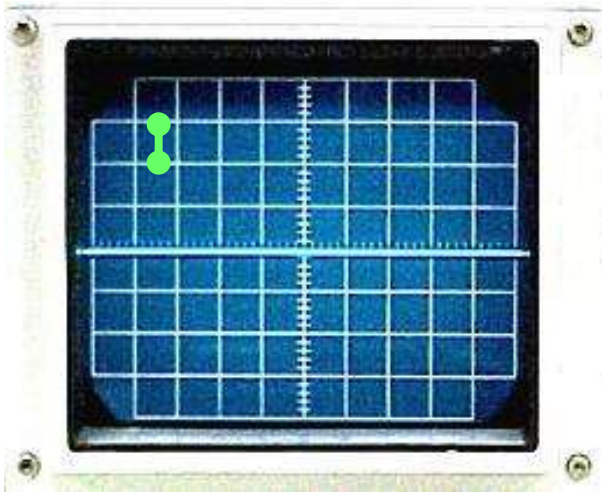
- Connect cable to input. Leads should be free.
- Select either channel 1 or 2.
- Turn power ON and wait for dot or line to appear.
- Set sec/div knob so that the line on the screen is clear and steady.
- Adjust horizontal and vertical position knobs to make sure that the line is fully visible.
- Adjust intensity and focus as needed.

Measuring Direct Current (D.C.) Signals

DC Measurement Setup

- Switch the A.C.-GND-D.C. switch to the D.C. position.
- Make sure the calibration (CAL) knob at the center of the volts/div dial is turned all the way **clockwise (right)** and **pushed in**.
- Make sure your line is still centered on the screen

Adjust Vertical Axis



We will be using the **1X setting** for this module. You would use the "10X probe" setting only if you were also using a separate 10X probe.

http://www.saelig.com/product/PSA001.htm

The volts/div dial tells you how many volts are represented by each centimeter vertically on the screen.

- Turn the outer dial to set the vertical axis to 2 volts/division. (Note that 2 is within the 1X bracket.)

Connect Cables

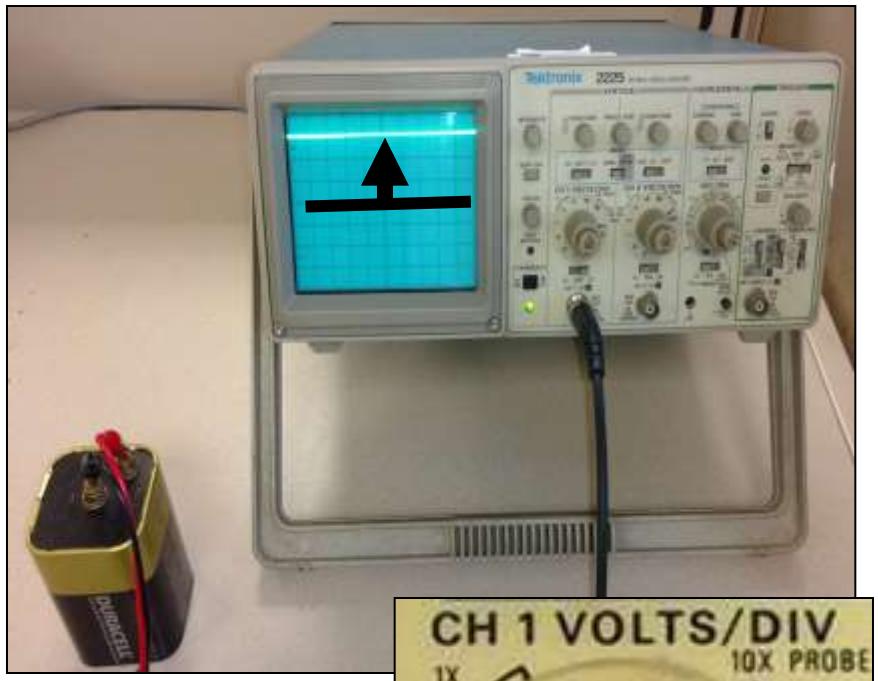
- Now take the cable connected to the input and connect the **black** lead to the **negative** terminal of the 6 volt battery.
- Take the **red** lead and touch it momentarily to the **positive** terminal of the battery.

The line on the oscilloscope should shift upwards.

Measuring DC Voltage

The amount that the line jumps up tells us the voltage of the battery.

- Attach the red lead to the positive terminal of the battery and calculate the battery's voltage.
  - The line should have shifted up about **3 divisions**:

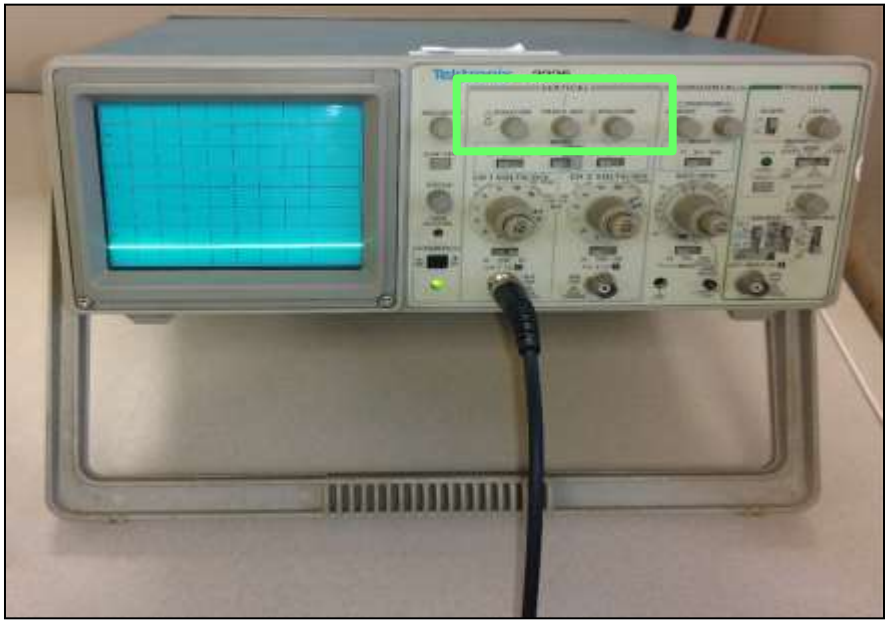


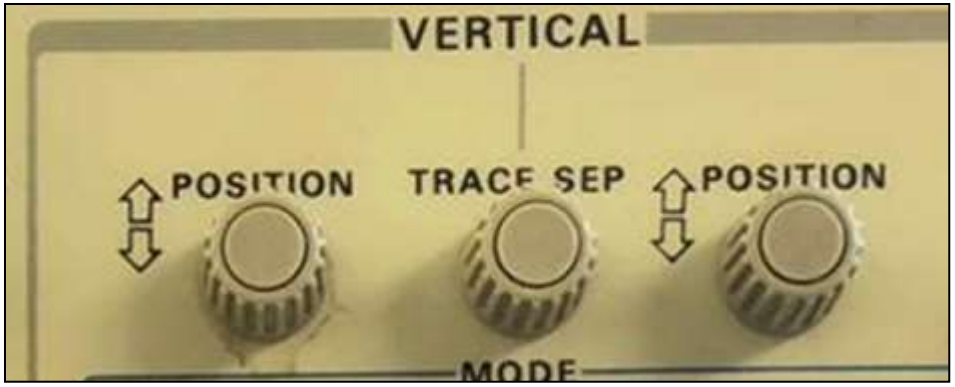
$$2\ \frac{\text{Volts}}{\text{Division}} \cdot \mathbf{3\ Divisions} = 6\ \text{Volts}$$

DC Voltage with New Settings

We can make the same measurement using different settings:

- Disconnect the red lead.
- Use the vertical position dial to move your baseline to a line near the bottom of the screen.



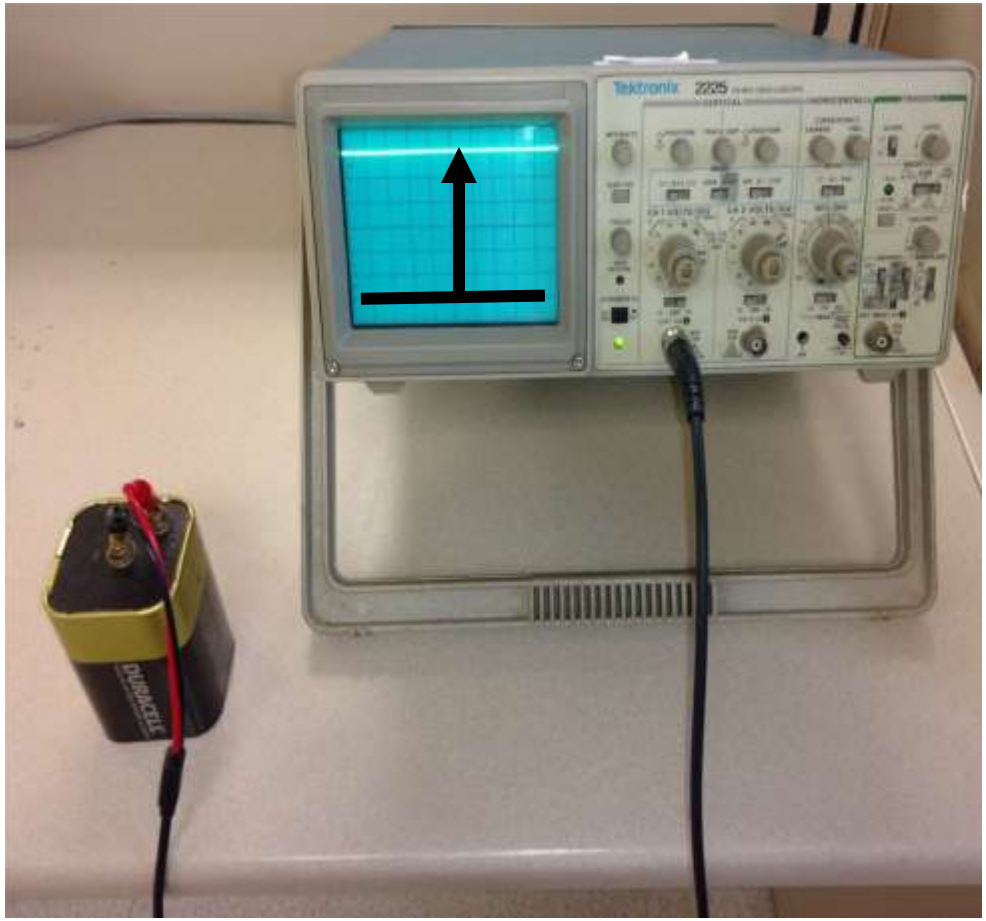


Changing DC Voltage Settings

- Adjust the vertical scale to 1 Volt/Div.
- Fasten the red lead to the positive terminal.
  - The line on the oscilloscope should now deflect about **6 divisions**.

$$1\ \frac{\text{Volt}}{\text{Div}} \cdot \mathbf{6\ Div} = 6\ \text{Volts}$$

Changing the volts/div dial does not change the voltage, it just adjusts the scale of the vertical axis.



- Disconnect the battery.

Summary: Measuring DC Voltage

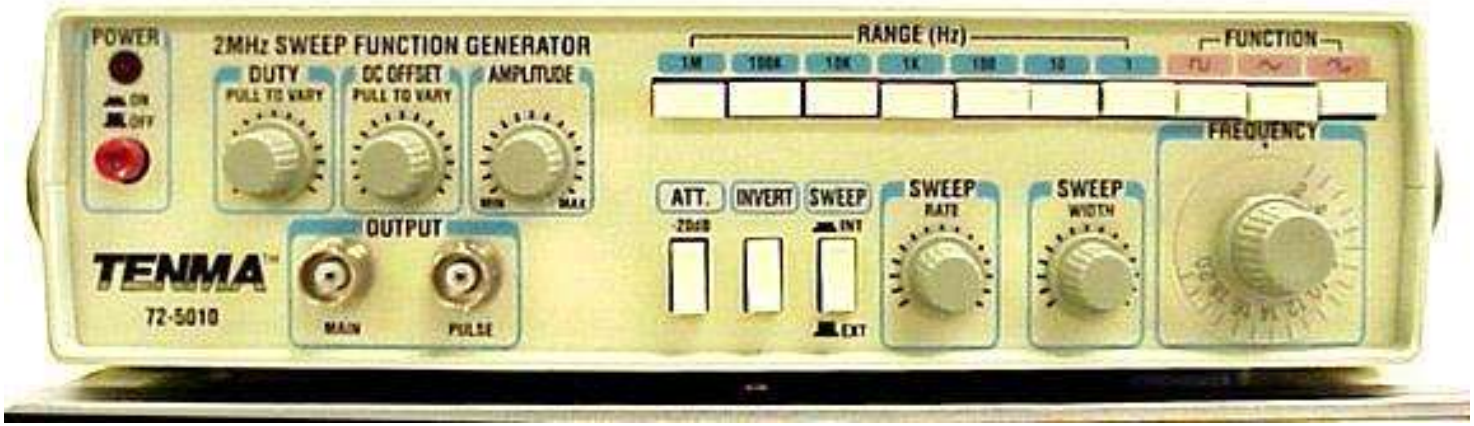
To measure a DC voltage, follow these steps:

- Switch the A.C.-GND-D.C. switch to the D.C. position.
- With the battery disconnected, use the vertical position dial to align your baseline with a line on the screen.
- Adjust the vertical axis scale so you can see how far your line deflects when you connect the leads
- Measure the deflection and calculate the voltage.

Introduction to the Function Generator

Function Generator

A function generator produces a voltage that changes over time.

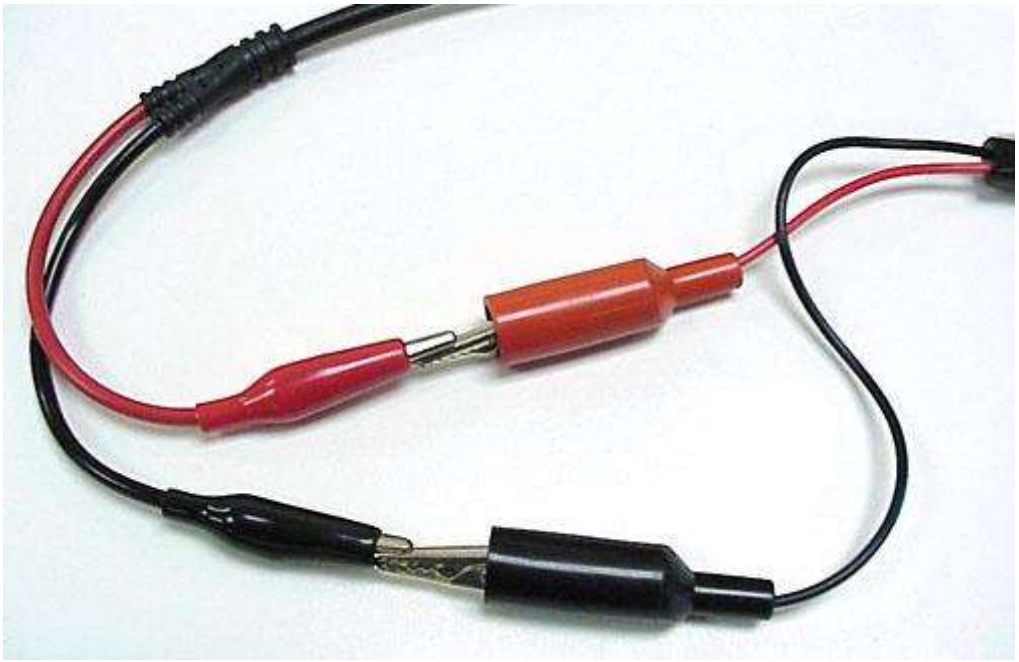


Function Generator Setup

- Turn on the Function Generator.
- Be sure that all the dials are turned completely clockwise and pushed in, and all rectangular buttons are in their outward position.
- There should also be a set of leads connected to the Main Output.

Connecting the Function Generator to the Oscilloscope

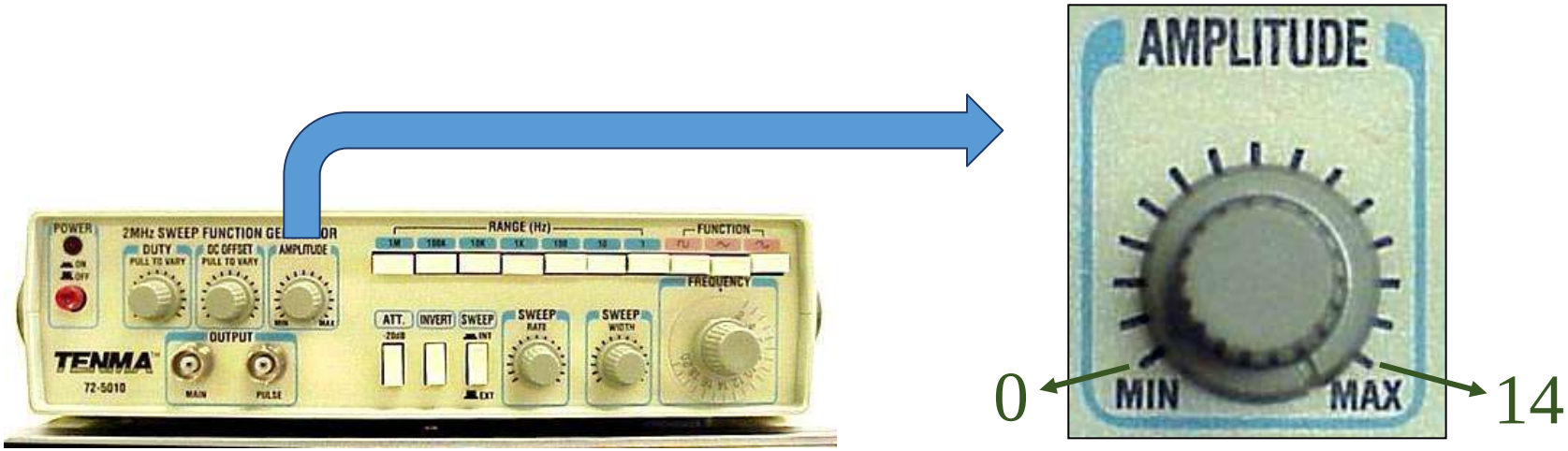
- Connect the black alligator clip from the function generator to that of the oscilloscope.
- Do the same with the red ones.



Amplitude Dial

This amplitude dial is used to adjust the peak to peak voltage of the AC waveform.

- Set the amplitude to max by turning the dial completely clockwise.

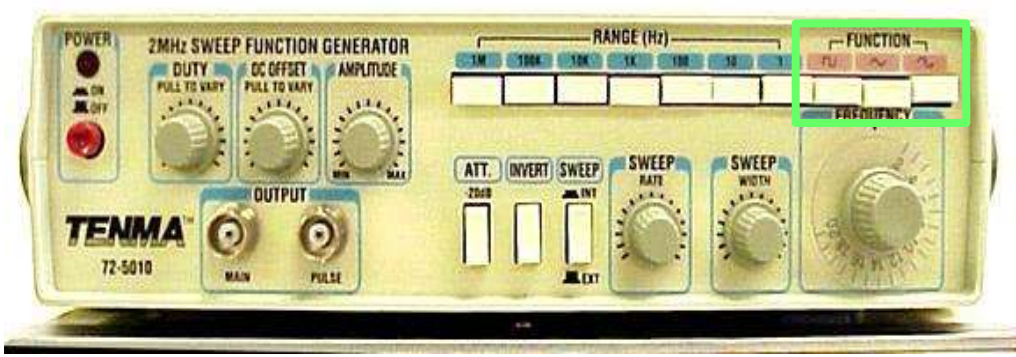


Function Buttons

These function buttons are located in the upper right corner of the function generator.

Selecting a button sets the type of voltage change over time as a square, triangular or sine wave.

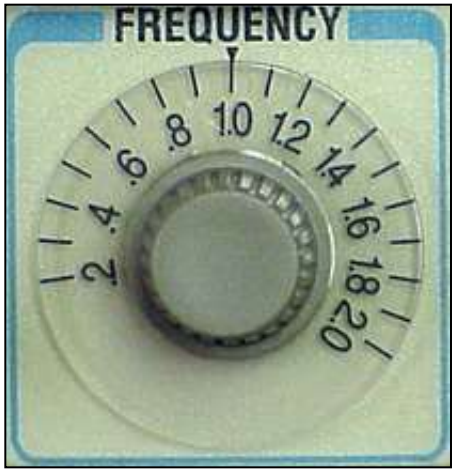
- Press the button for the sine wave.



Setting the Frequency

The frequency dial and range buttons are used together to set the frequency of the waveform.

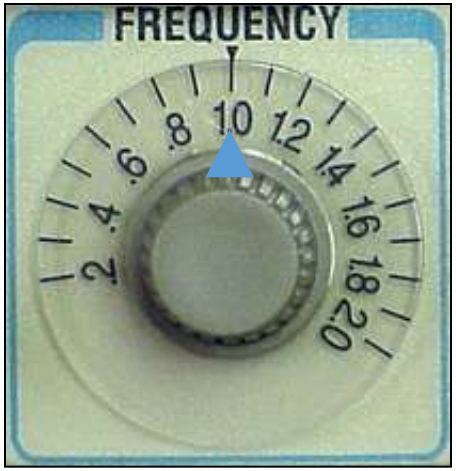
Pressing a range button will **multiply** the value of the frequency dial by that chosen range value.



Frequency Example #1

Here, the frequency dial is set to **1.0** and the range multiplier button is set at **10K (Hz)**

The output frequency is **1.0 x 10KHz = 10,000 Hz**



(10,000 cycles/sec)

Frequency Example #2

Now, the frequency dial is set to **0.8** and the range multiplier button is set at **1K (Hz)**

The resulting output frequency is **0.8 x 1KHz = 800 Hz**

(800 cycles/sec)

Summary: Function Generator

- Turn on the function generator by pressing the power button.
- Turn all dials completely clockwise and ensure all buttons are in the outward position.
- Press the function button of the desired wave function—i.e., triangle, square, or sine wave.
- Set the frequency dial **and** the range button of the function generator to achieve the desired frequency.
- Connect the leads of the function generator's output to the leads of the oscilloscope's input; red lead to red lead and black lead to black lead.

Measuring Time Varying Alternating Current (A.C.) Signals

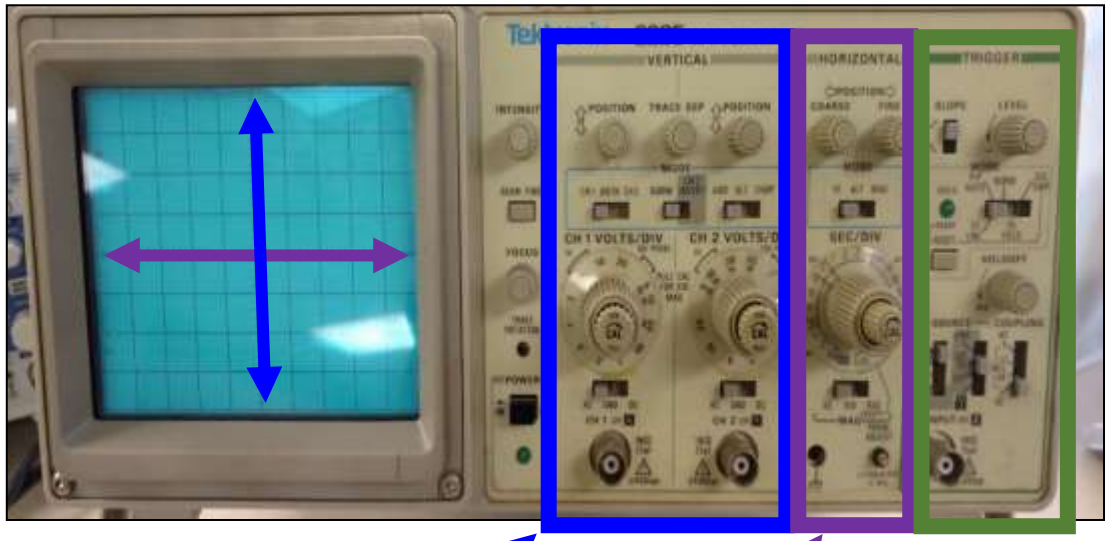
Control Panel Revisited

We use the oscilloscope to view the signal that the function generator creates.

The **vertical** axis represents **voltage**

The **horizontal** axis represents **time**

Triggering is used to stabilize the waveform



Vertical controls

Horizontal controls

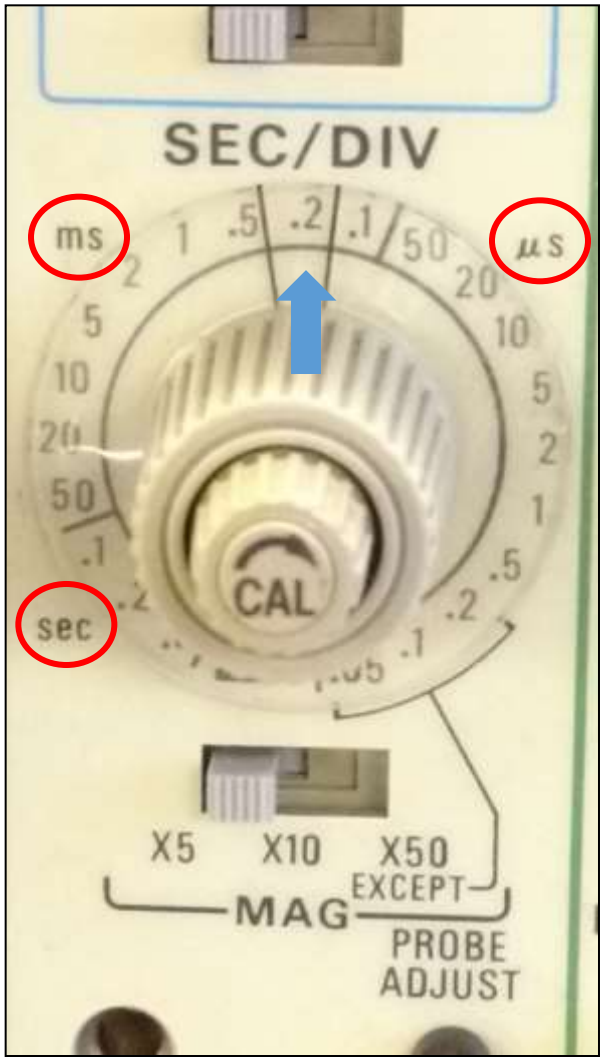
Trigger controls

AC Measurement Setup: Vertical

- Change the AC-GND-DC switch to A.C.
  - Make sure the inner calibration dial is pushed in and turned all the way clockwise.
- Adjust the vertical position if necessary

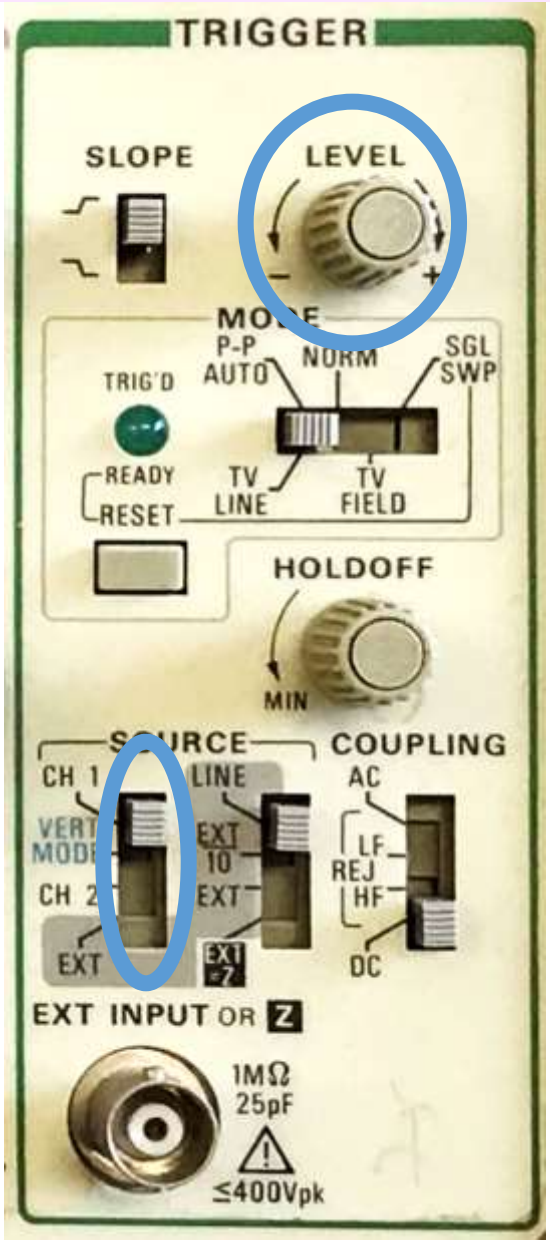
AC Measurement Setup: Horizontal

- Be sure to distinguish between ms (milliseconds) and μs (microseconds) and sec, units are important!
- The inner calibration (CAL) dial should be turned fully clockwise.
- Adjust the horizontal position if necessary.

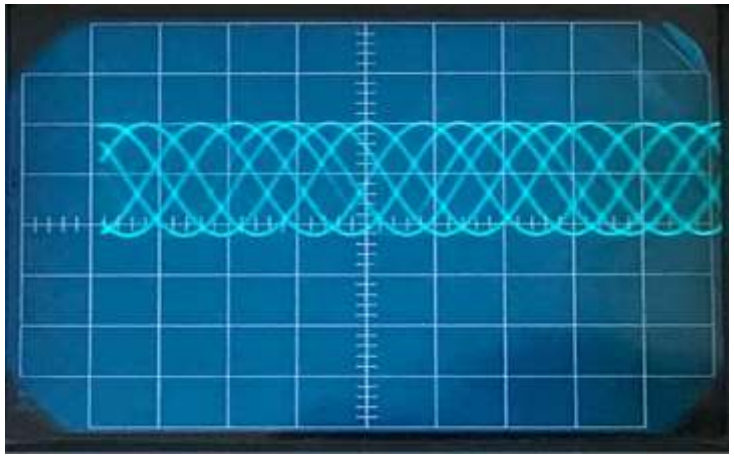


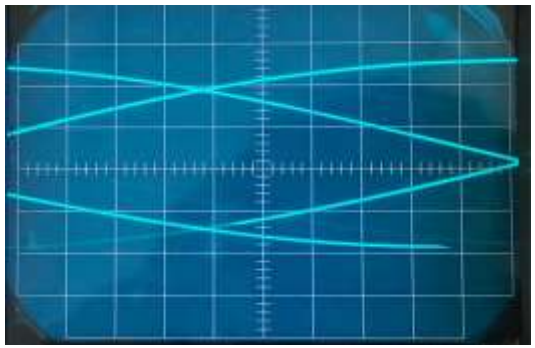
Trigger Adjustment

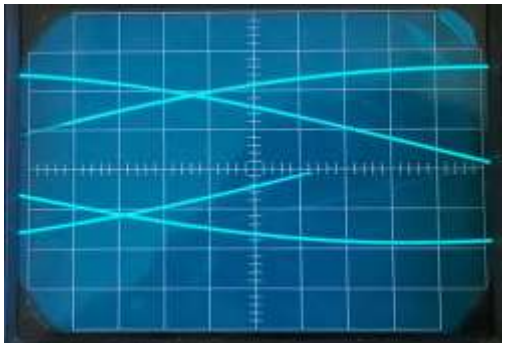
- Make sure the source channel is set to the channel being used. Leave the rest of the switches as they are pictured here.
- Use the trigger level dial to stabilize the waveform if necessary. (See images on next page.)



Unstable waveform examples

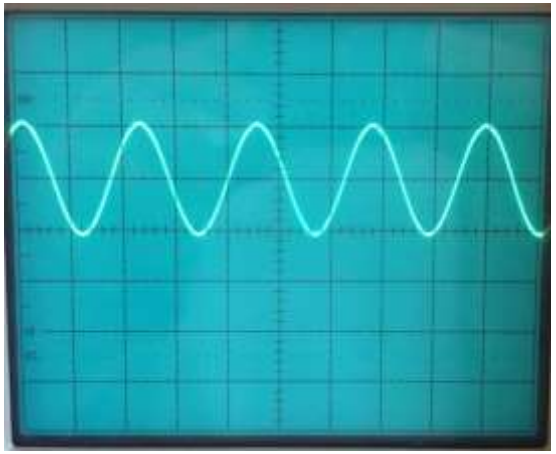






Problem: Overlapping or moving sine waves

- If your waveform looks like it is **overlapping** or **moving**, you'll need to adjust the **trigger level** dial.
- You want your waveform to look like the stable sine wave at right.



Stable Signal

Setting the Input Signal

Before measuring the voltage and period, set the **function generator** to:

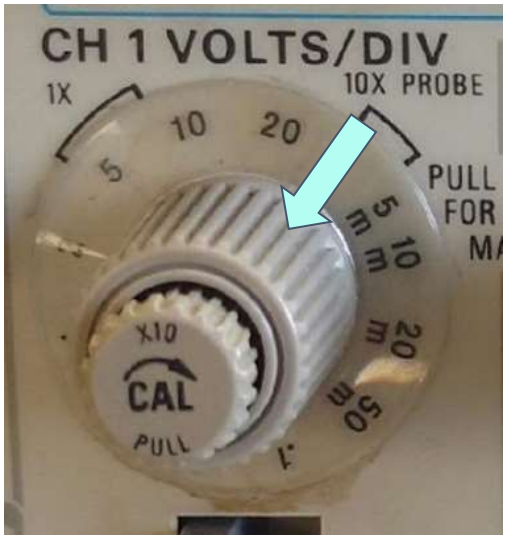
- Amplitude 7
- Frequency 800 Hz

Changing Oscilloscope Settings

Remember that the **function generator produces** the signal.

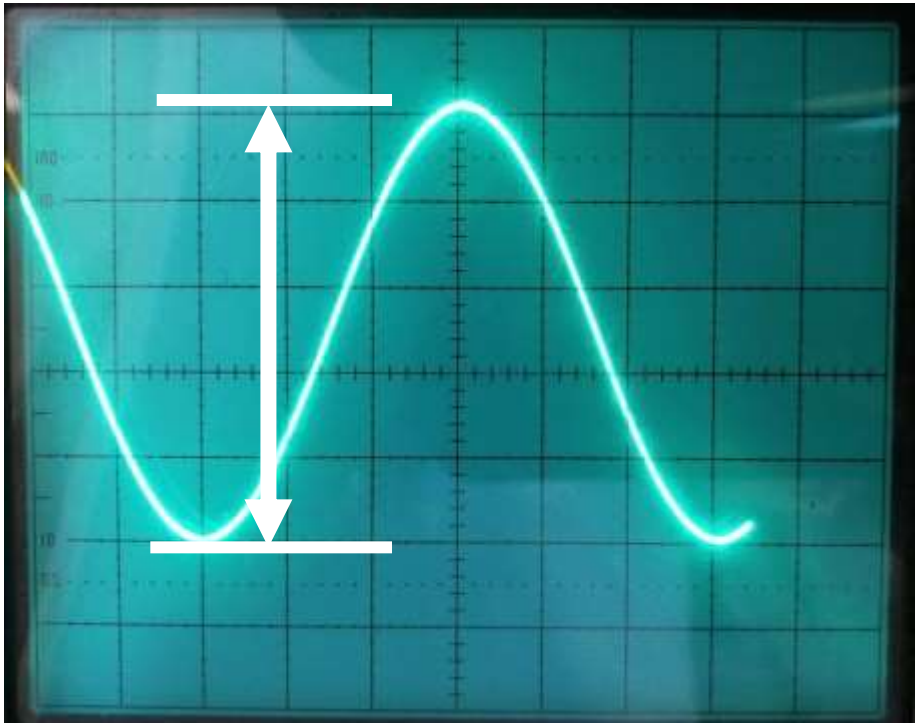
The **oscilloscope** just **measures** it.

- Turn the large VOLTS/DIV and SEC/DIV knobs until you clearly see 1-2 cycles of the wave within the screen.
- You will need to do this each time you adjust the frequency or amplitude



Measuring Voltage

- Position and scale the wave so it is visible and the bottom of the wave is lined up with one of the division markings.
- Count the number of vertical divisions from the bottom of the wave to the top.
- Calculate the peak-to-peak voltage as shown:

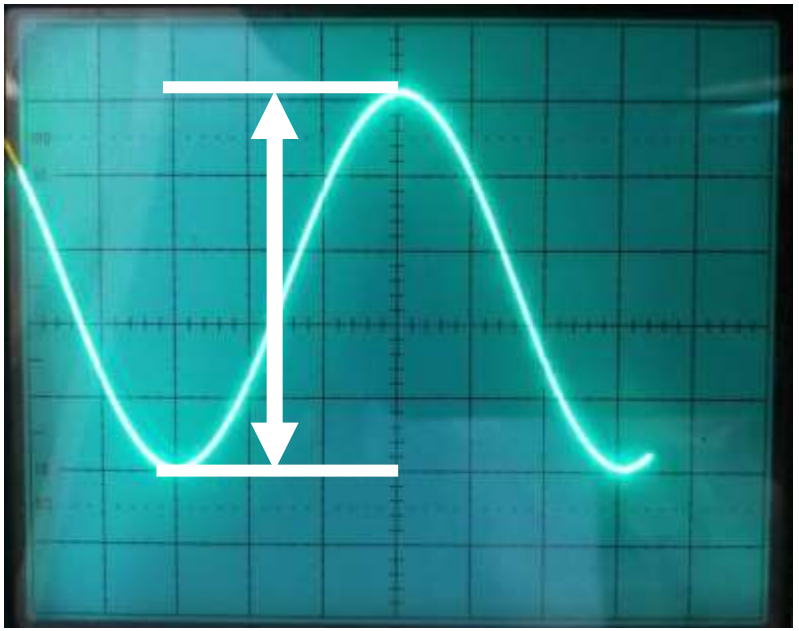


$$\frac{volts}{div}\ setting \times number\ of\ divisions = voltage$$

Measuring Voltage Example

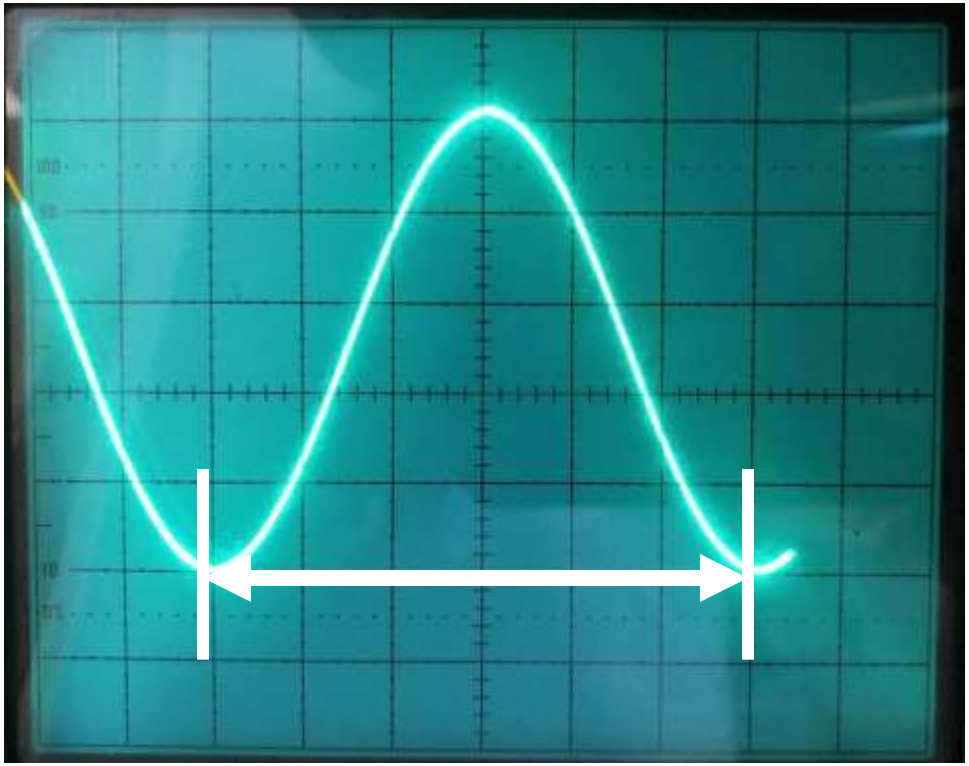
- In this situation, the setting was 2 volts per division.
- The number of divisions is 5.2 (each small dash is 0.2)

$$2\ \frac{\text{Volts}}{\text{Division}} \cdot 5.2\ \text{Divisions} = 10.4\ \text{V}$$



Measuring Period

- Position the sine wave so one peak or trough lines up with a division along the x-axis.
- Count the number of horizontal divisions for one full cycle.
- Calculate the period as shown:

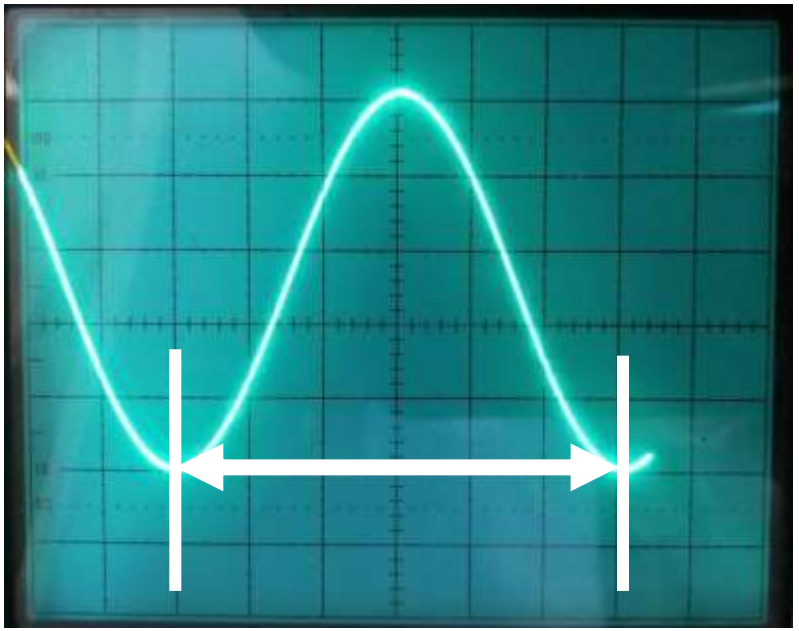


$$\frac{\text{seconds}}{\text{Division}} setting \cdot number\ of\ divisions = period$$

Measuring Period Example

- In this situation, the setting was 0.2 ms per division.
- The number of divisions is 6.

$$0.2\ \frac{\text{ms}}{\text{Division}} \cdot 6\ \text{Divisions} = 1.2ms$$



Changing Function Generator Settings

If we change the settings on the **function generator**, our measured values should change.

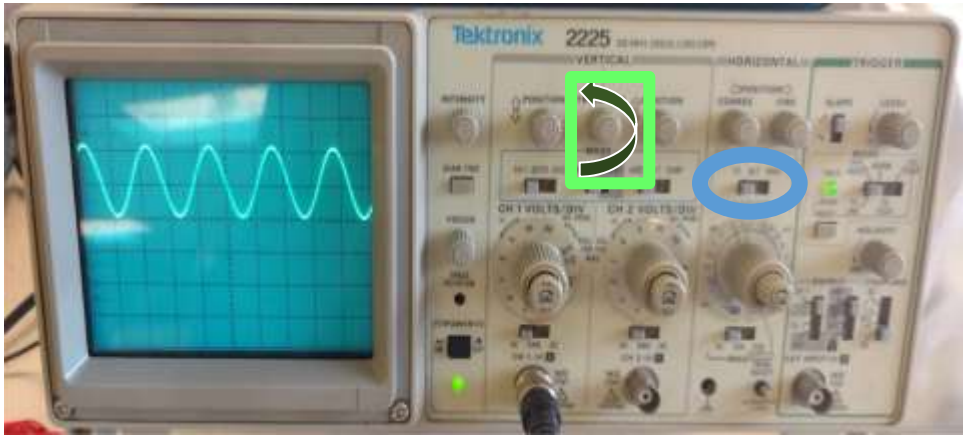
- Try it! Change the amplitude dial on the function generator.
  - Notice that the voltage reading on the oscilloscope changes.
- Dial in a different frequency on the function generator.
  - Notice that the period reading on the oscilloscope changes.

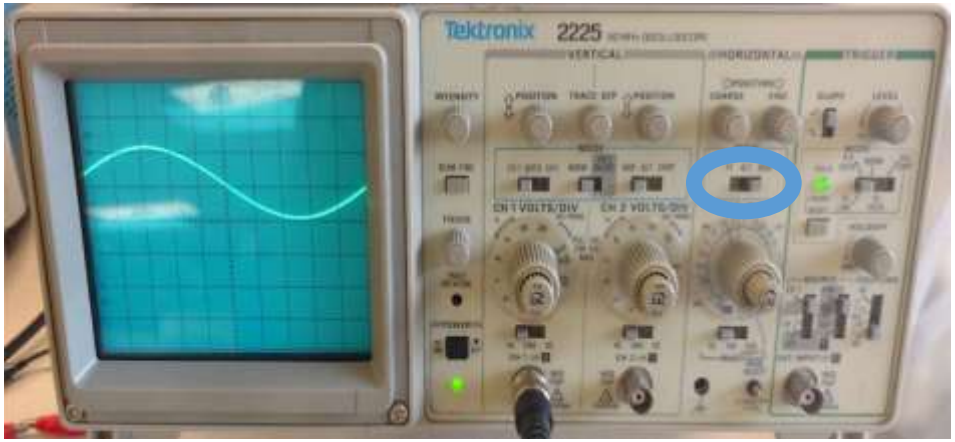
Additional Features: Attenuation

- The attenuation button on the function generator is used to output small voltages.
- Press the ATT button on the function generator to the IN position and observe the voltage on the oscilloscope.
- Adjust the vertical and horizontal axis scales on the oscilloscope if needed to properly observe the signal.
- Make sure to press the ATT button back to the OUTWARD position before continuing.

Additional Features: Magnification

- Flip the Mode switch from "X1" to "MAG"
- Make sure the Trace Sep knob is turned all the way counterclockwise
- Notice that this setting magnifies the horizontal axis. We can use it to zoom in on part of the wave.
- Flip the Mode switch back to "X1" before continuing.





Summary: Measuring AC Signals

- Flip the AC-GND-DC switch to AC.
- Set the VOLTS/DIV and SEC/DIV dials to reasonable settings. The inner CAL dials should be fully clockwise.
- If necessary, adjust the trigger level knob until you get a steady picture.
- Make sure you can see 1−2 full cycles of the sine wave.
- Adjust the intensity and focus to get a good sharp line.
- Measure the peak-to-peak voltage by counting vertical divisions, and multiplying by your Volts/Div setting.
- Measure the period by counting horizontal divisions, and multiplying by your Sec/Div setting (with proper units).

Practice Problem #1

Set amplitude to 7.

Set frequency to 1000 Hz.

- Find the peak to peak voltage.
- Find the period for one cycle.

Answer to #1

- Peak to peak voltage ~ 11 - 13 volts
- Time or period = 0.98 ms

Note: Each function generator outputs a slightly different voltage.

Practice Problem #2

Set amplitude to maximum (14).

Set frequency to 1300 Hz.

- Find the peak to peak voltage.
- Find the period for one cycle.

Answer to #2

- Peak to peak voltage ~ 22 - 26 volts
- Time or period = 0.78 ms

Note: Each function generator outputs a slightly different voltage.

You have now completed the Oscilloscope Module.

Obtain a Post Test and make measurements using the assigned Function Generator settings.