Experiment 4

The Oscilloscope

Preparation

Prepare for this week's quiz by reviewing previous work and by reading about oscilloscopes in your textbook. Review the properties of waves.

Principles

The oscilloscope uses a cathode ray tube, or CRT. In the CRT an electron gun shoots a stream of electrons toward a fluorescent screen which emits light at the points struck by the electrons. As it moves along the tube, the beam of electrons passes between two pairs of deflection plates. The beam will change direction, either horizontally or vertically, in response to an electrical signal applied to the plates. If only one signal is entered, it is applied to the y-axis deflection plates while an internally generated signal sweeps the beam across the screen horizontally. The y-axis then displays the voltage of the input signal as a function of time which is displayed on the x-axis. The oscilloscope is then a form of voltmeter.

In this exercise you will use a signal generator to produce AC signals. These waves will vary sinusoidally. They will have two important properties, the **amplitude** and the **frequency**. Remember that you can write the equation for a sine wave as:

$$y = A \sin \omega t$$

where A is the **amplitude** (remember sine varies between ± 1), t is **time** and ω is the **angular frequency** or $2\pi f$. The **frequency**, f, is the inverse of the **period**, T.

The frequency of your signal is displayed on your signal generator. You will use the oscilloscope to measure the amplitude (voltage) of these signals and also to find the period of the signals. The **period** is t**he amount of time it takes for the signal to repeat itself**. An example is shown in Figure 1. Here L is the number of divisions along the x-axis that the waveform covers. To find the period (T) of the signal, multiply the number of divisions by the time setting on the scope:

$$T = L \times \text{sweep setting}$$

The period can them be used to find the frequency using the equation:

$$f = \frac{1}{T}$$

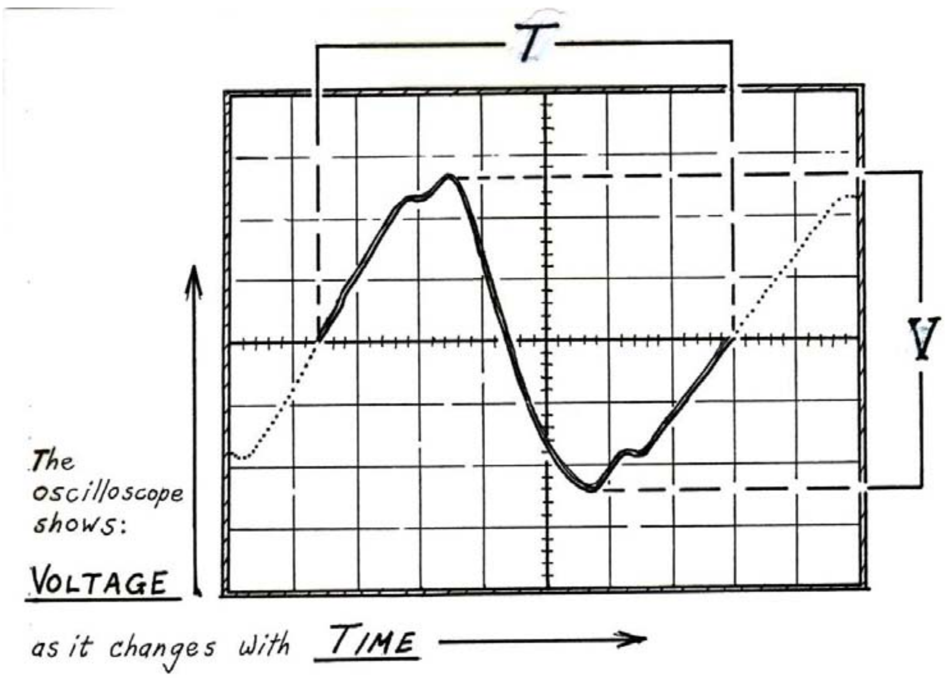
Note that the period is measured in seconds and the frequency has units of **1/second**, also known as **Hertz (Hz)**.

The voltage from the top to the bottom of the wave is called the **peak-to-peak voltage** *(V_{pp})* and is found by multiplying the height (H) of the wave by the voltage setting on the 'scope. See Figure 1.

$$V_{pp} = H \times \text{voltage setting}$$

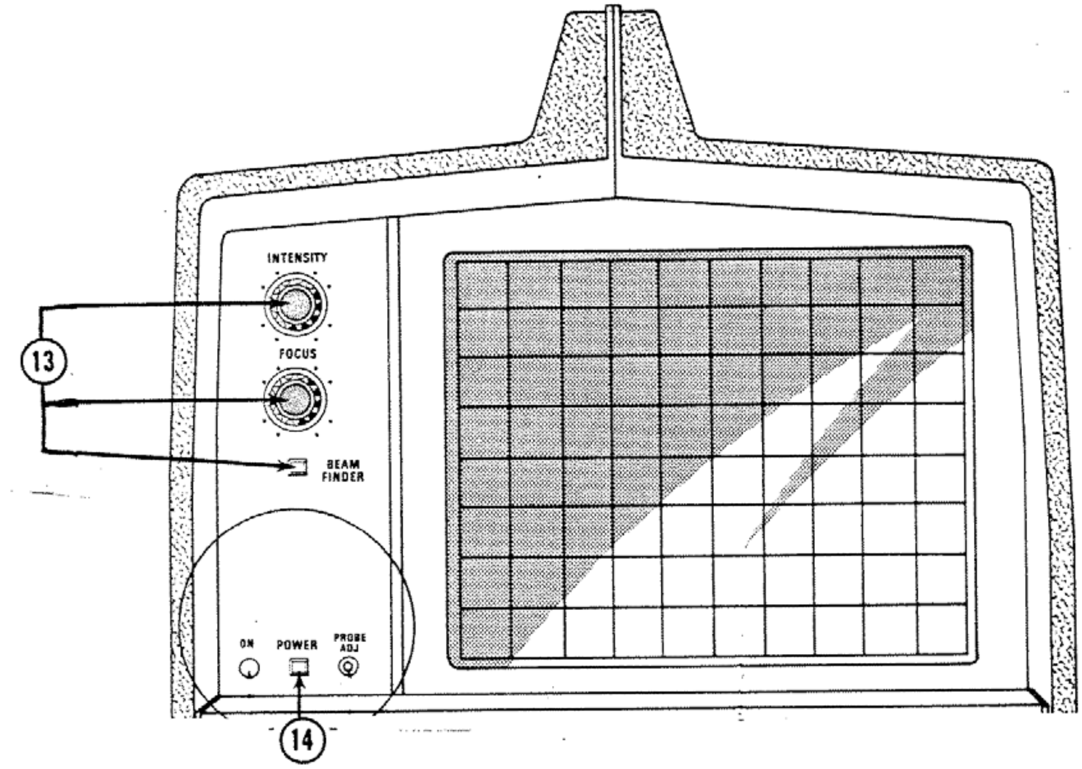
A "division" is one of the blocks on the grid that is approximately 1 cm square.

It is very important for you to remember that the signal originates from the signal generator and is displayed by the oscilloscope. The ‘scope can be adjusted to change the display of the signal, but the signal itself will be unchanged.

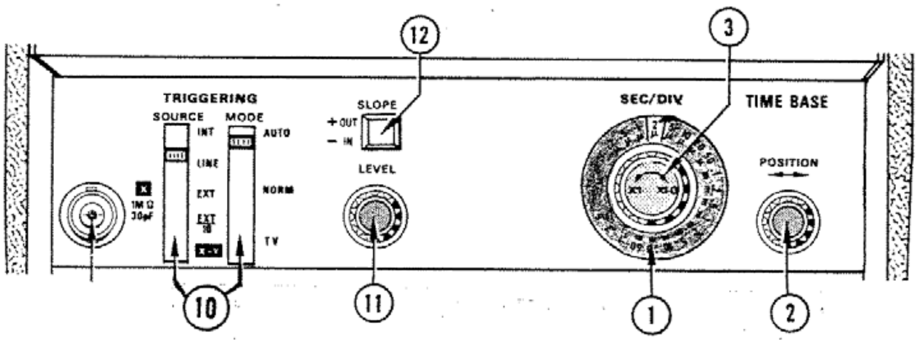


Equipment

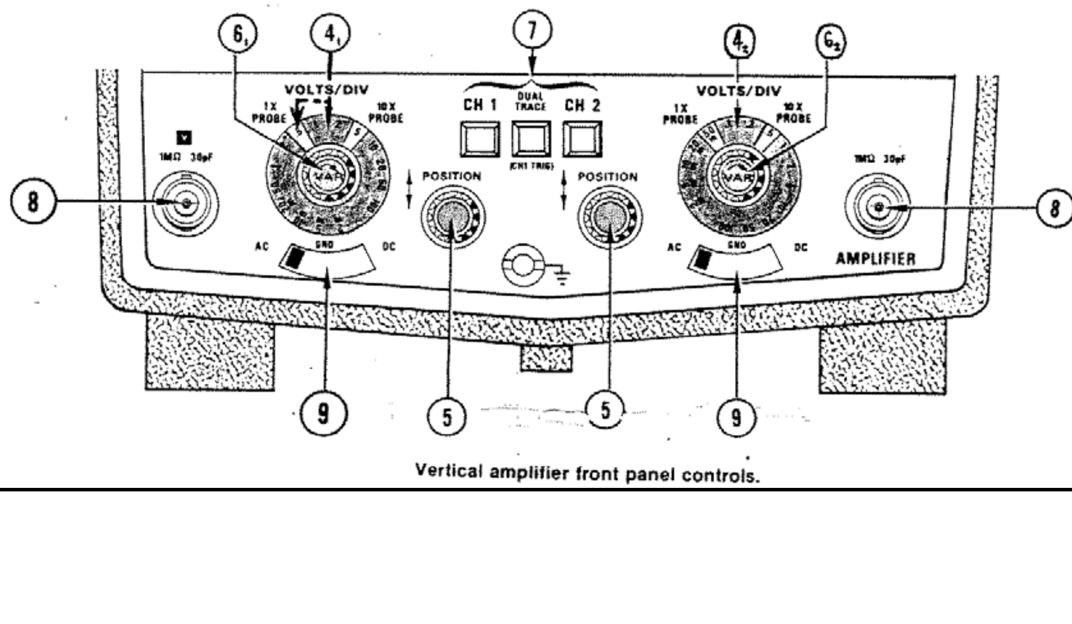
1 *signal generator with power cord*
1 *oscilloscope*
2 *3' banana wires, one red, one black*
2 *2' banana wires, one red, one black*
2 *ground isolators (three to two prong adapters)*
3 *BNC connectors*



Display front panel controls and connectors.



Time base front panel controls and connectors.



Vertical amplifier front panel controls.

Setting up the 'Scope

The equipment that you use in this experiment may vary from that shown in the pictures. Your lab instructor will show you how each piece of equipment works. Read the directions carefully before you begin and have the instructor check your set up before you plug anything in. Use ground isolators (three to two prong adapters) on the 'scope and signal generator plugs. Do not unplug a piece of equipment before you have turned it off, and make sure the equipment is turned off before you plug it in.

Connect the three prong adapter to the oscilloscope plug and plug it in. Use Figure 3 and the following directions to set up the 'scope.

1. **Power**. Remember; do not use the wall plug as an on/off switch.

2. **Intensity**. Adjust the brightness of the trace until you can just see all the details of the waveform. If the trace is too bright you will not get the best data, your eyes will get very tired, and you could damage the scope.

3. **Focus**. Rotate this button until the trace is sharp.

4. **Beam finder**. If you do not find a trace, push this button. The screen will display what quadrant the trace is in. You can then use the horizontal (#10) and vertical controls (#15) to move the trace to the middle of the screen.

5. **Triggering source and mode**. You will use the 'scope to observe signals that repeat frequently. The scope must start the sweep at the same point on the waveform every time in order to produce a stable image on the screen. This function is called "triggering". Put the source switch on "internal". This lets the scope decide when to trigger. Set the mode switch to "auto".

6. **Slope**. Usually the signal voltage will equal the triggering voltage twice, once going up and once coming down. This button enables you to select which voltage the scope will trigger on. Don't worry about this button.

7. **Level**. This sets an internal voltage which is compared to the voltage of the input signal. When the input signal voltage equals the trigger voltage, the scope will trigger. If you get an image that seems to be a superposition of many waves, turn the level knob back and forth slowly until you get a stable image.

8. **Sweep calibration**. This enables you to change the horizontal scale. Unless this knob is turned all the way clockwise, the scope is not calibrated and your data will be worthless. Turn this knob clockwise until it clicks and check it frequently as you take data.

9. **Sweep**. This determines the horizontal scale for the display. The scale is read in the upper white window. Its units are seconds/division.

10. **Horizontal position**. This enables you to move the signal back and forth along the X-axis. This determines, in effect, the value the signal will have at the origin.

11. **Channel select**. Most oscilloscopes are dual trace. This means that they can display two signals at once, which is why there are two signal ports and two sensitivity controls. You will use only one channel for this experiment, so push the button for channel 1.

12. **Signal ports**. There is one signal port for each channel. A BNC (banana to coaxial) connector is used to connect banana wires to the signal port.

13. **Sensitivity calibration**. This knob is used to change the vertical scale. If it is not turned all the way clockwise, the scope will be uncalibrated and your data will be worthless. Check this knob frequently as you take data.

14. **Sensitivity**. This determines the vertical scale. It is read in the left hand white window. The units are volts/division.

15. **Vertical position**. This knob controls the vertical position of the trace. You will find it very convenient when you are setting or reading voltages.

16. **AC/DC select**. When this is set to "AC" the DC part of the signal is filtered out by a capacitor placed in series between the signal input and the scope. When the selector is set to "ground", the beam will move to zero volts. When the selector is set to "DC", the entire signal will be displayed on the scope. Always keep the switch on DC, even if you are looking at an AC signal.

You should follow these procedures every time you use an oscilloscope. You can now perform the experiment.

Procedure

1. Connect the signal generator to the 'scope, red to red, and black to black. Have the lab instructor check the circuit **before** you turn the power on.

2. Set the sensitivity of the scope to 1 volt/div. Set the signal generator to sine wave output. Adjust the signal generator output to 5 volts. (The height of the signal will be 5 divisions.) Change the scope sensitivity to 5 volts/div. Note that the display is only about one division high and that the product of the height and the volt/div setting is still 5 volts. Set the sensitivity back to 1 volt/div.

3. Adjust the frequency of the signal generator output so that the frequency counter reads about 1.8 kHz. Adjust the sweep setting until you get about two complete waveforms on the screen. Record the frequency, the sweep setting, and the number of divisions it takes for one period of the wave.

4. Change the sweep setting so that you have twenty repetitions of the wave on the screen. Record the sweep setting and the number of divisions it takes for twenty waves.

5. Change the frequency of the signal to 24 kHz. Repeat steps 3 and 4.

6. Change the signal generator to square-wave output. Repeat steps 3, 4, and 5.

7. Turn everything off, disconnect the equipment and put it away.

Analysis

1. Calculate the period of each of the waves you measured.

2. Find the frequency of each wave.

3. Find the percent error between each calculated and measured frequency. The frequency you measured with the frequency counter is the accepted value.