Beginner Oscilloscope Tutorial
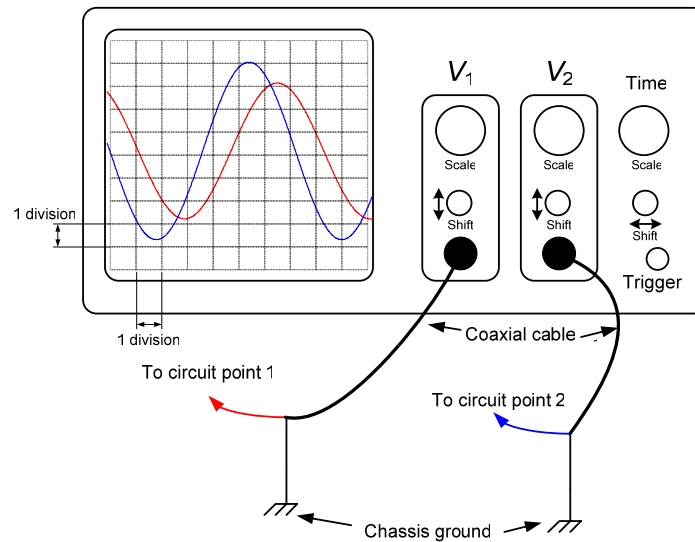

Figure 1. Oscilloscope essentials.

What does an oscilloscope do?

- Displays a plot of voltage v. time. Most oscilloscopes display two voltage waveforms at a time.

What is it useful for?

- Observing the shape of voltage waveforms, *especially periodic waveforms*.

What are the basic controls?

- **Voltage scaling**—controls the vertical display scale for each channel, typically 0.01 to 5 V/div (volts per major vertical division, as shown in Figure 1).
- **Voltage shifting**—continuous control of the vertical origins.
- **Time scaling**—controls the horizontal display scale, typically from 10^{-6} to 1 sec/div (time per major horizontal division).
- **Time shifting**—continuous control of the horizontal position of the waveform.
- **Trigger** (don't worry too much about this yet)—provides a way to control when $t = 0$, that is, what part of the waveform is at the left edge of the display. This might be a threshold voltage level or slope. The oscilloscope will wait until the moment the threshold is crossed to begin the next display. This is important for stabilizing the display of periodic waveforms.

Why does the oscilloscope on my bench look so complicated?

- Modern oscilloscopes perform many functions automatically, so the controls and display can be confusing. Along with measuring times and voltages accurately, oscilloscopes can also perform mathematical functions such as adding, subtracting, and multiplying waveforms.

Where should I start?

- Identify the knobs shown in the figure above on your oscilloscope. Connect a simple waveform from a function generator (amplitude ~1V, f ~100 Hz) into channel 1 and try to control its display. It should fill most of the display vertically; you should be able to show a fraction of a period or many periods at one time. If you can't see it at all, you may need to refer to information for your specific instrument to turn on the display of voltage channel 1.

Beginner Oscilloscope Tutorial (cont'd)

Once you've learned the basic oscilloscope controls, here are a few other things that you should know about. On older analog scopes, these are mostly controlled by a dedicated switch for each function. On digital scopes, there may be a pushbutton, but you may have to locate the options in a menu.

Coupling mode—ac, dc, or ground

- Each channel will generally have three modes:
    - **dc coupling** means that the signal is displayed without modification.
    - **ac coupling** is used to eliminate the dc offset of a signal so it will be centered around 0V. The oscilloscope applies a low-pass filter to the input.
    - **ground** (or **off**) mode means that the 0-V level is displayed for that channel (flat line). The voltage (vertical) shift knob can then be used to set the vertical origin.

Math operations

- Most oscilloscopes can perform at least two mathematical operations on the waveforms:
    - **Invert** one or both channels (multiply by –1)
    - **Add** the channels together or **subtract** one from the other. The subtraction operation is often more important, since the ground lead of each channel has to be connected to a common circuit node. Then the voltage across a circuit element not connected to that point can be found from the difference between the two channels (see Figure 2). The subtraction operation may be available as a combination of **invert** and **add**.
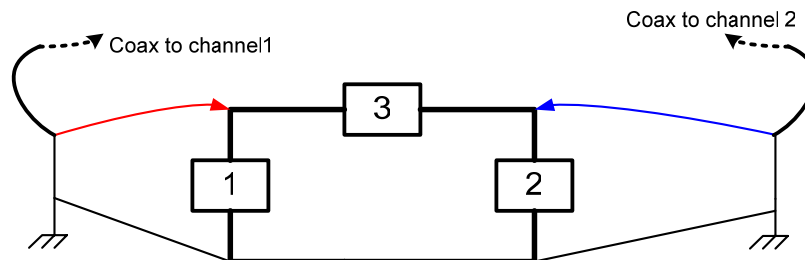- Digital scopes may be capable of many other mathematical operations.

Figure 2. In order to measure the voltage across element 3, we need the difference between channels 1 and 2.

Channel 1 v. Channel 2 display (*xy* or A-B mode)

- Sometimes you don't need to see each waveform as it changes with time, but you want to know how two voltages change with repect to each other. In this mode, one channel is plotted horizontally and the other vertically, and the shape is traced as time evolves.
- This can be very helpful for finding the phase difference between to sinusoidal signals, where *xy* mode will display an ellipse ("Lissajous figure").
- The trigger settings have no effect in *xy* mode.

Autoset (or, "Why didn't you tell me about that sooner?")

- Rather than manually setting the scales for your display, an autoset button may be able to find the amplitude and frequency of your waveform and do most of the work for you. Then you can make adjustments if you want. Not all oscilloscopes have this function.