Operating the Oscilloscope

Setting Up

This section briefly describes how to set up and start using an oscilloscope – specifically, how to ground the oscilloscope, set the controls in standard positions, and compensate the probe.

Proper grounding is an important step when setting up to take measurements or work on a circuit. Proper grounding of the oscilloscope protects you from a hazardous shock and grounding yourself protects your circuits from damage.

Ground the Oscilloscope

To ground the oscilloscope means to connect it to an electrically neutral reference point, such as earth ground. Ground your oscilloscope by plugging its three-pronged power cord into an outlet grounded to earth ground.

Grounding the oscilloscope is necessary for safety. If a high voltage contacts the case of an ungrounded oscilloscope – any part of the case, including knobs that appear insulated – it can give you a shock. However, with a properly grounded oscilloscope, the current travels through the grounding path to earth ground rather than through you to earth ground.

Grounding is also necessary for taking accurate measurements with your oscilloscope. The oscilloscope needs to share the same ground as any circuits you are testing.

Some oscilloscopes do not require separate connection to earth ground. These oscilloscopes have insulated cases and controls, which keeps any possible shock hazard away from the user.

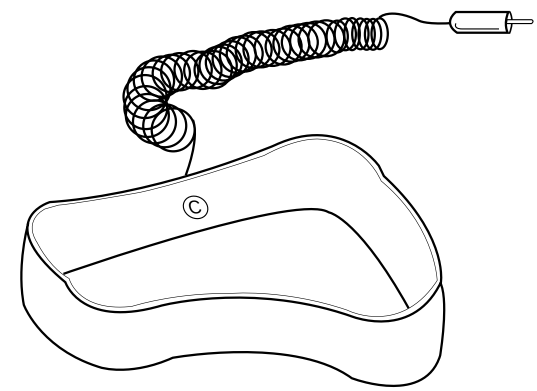

Figure 64. *Typical wrist-type grounding strap.*

Ground Yourself

If you are working with integrated circuits (ICs), you also need to ground yourself. Integrated circuits have tiny conduction paths that can be damaged by static electricity that builds up on your body. You can ruin an expensive IC simply by walking across a carpet or taking off a sweater and then touching the leads of the IC. To solve this problem, wear a grounding strap, as shows in Figure 64. This strap safely sends static charges on your body to earth ground.

Setting the Controls

After plugging in the oscilloscope, take a look at the front panel. As described previously, the front panel is typically divided into three main sections labeled vertical, horizontal, and trigger. Your oscilloscope may have other sections, depending on the model and type – analog or digital.

Notice the input connectors on your oscilloscope – this is where you attach the probes. Most oscilloscopes have at least two input channels and each channel can display a waveform on the screen. Multiple channels are useful for comparing waveforms.

Some oscilloscopes have AUTOSET and/or DEFAULT buttons that can set up the controls in one step to accommodate a signal. If your oscilloscope does not have this capability, it is helpful to set the controls to standard positions before taking measurements.

General instructions to set up the oscilloscope in standard positions are as follows:

- Set the oscilloscope to display channel 1
- Set the vertical volts/division scale and position controls to mid–range positions
- Turn off the variable volts/division
- Turn off all magnification settings
- Set the channel 1 input coupling to DC
- Set the trigger mode to auto
- Set the trigger source to channel 1
- Turn trigger holdoff to minimum or off
- Set the intensity control to a nominal viewing level, if available
- Adjust the focus control for a sharp display, if available
- Set the horizontal time/division and position controls to mid-range positions

Refer to the manual that accompanied your oscilloscope for more detailed instructions. The Systems and Controls of the Oscilloscope section of this primer describes oscilloscope controls in more detail.

Using Probes

Now you are ready to connect a probe to your oscilloscope. A probe, if well-matched to the oscilloscope, will enable you to access all of the power and performance in the oscilloscope and will ensure the integrity of the signal you are measuring.

Please refer to The Complete Measurement System under the Systems and Controls of the Oscilloscope section, or the Tektronix' *ABCs of Probes*, for additional information.

Connecting the Ground Clip

Measuring a signal requires two connections: the probe tip connection and the ground connection. Probes come with an alligator–clip attachment for grounding the probe to the circuit under test. In practice, you attach the grounding clip to a known ground in the circuit, such as the metal chassis of a stereo you are repairing, and touch the probe tip to a test point in the circuit.

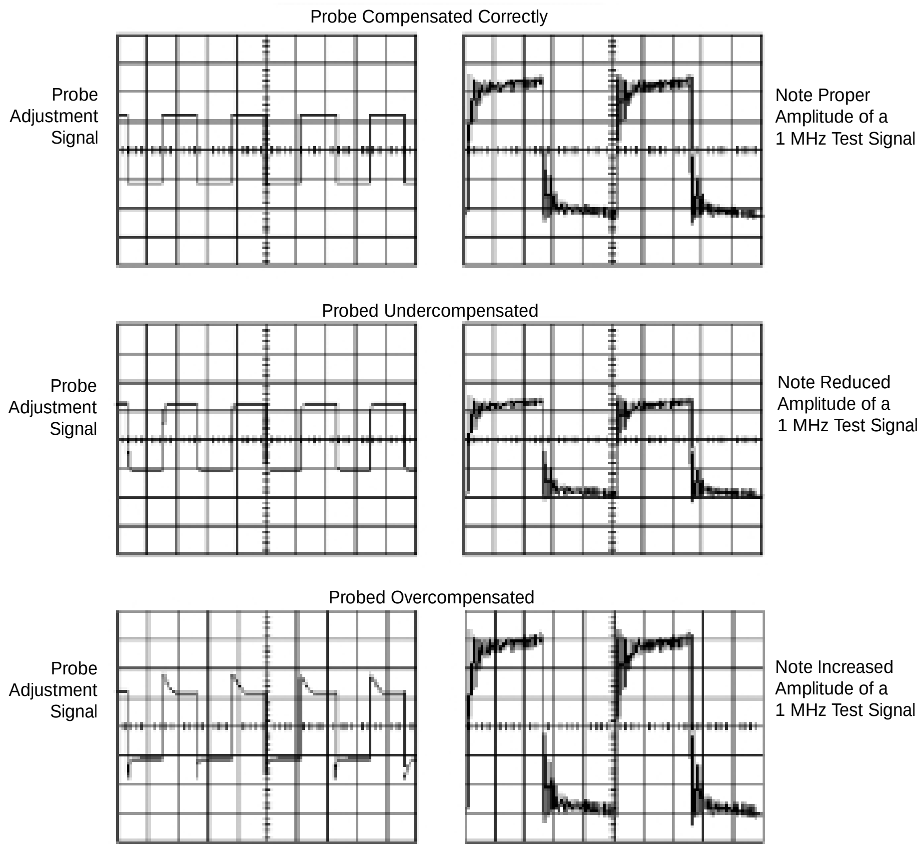

Figure 65. *The effects of improper probe compensation.*

Compensating the Probe

Passive attenuation voltage probes must be compensated to the oscilloscope. Before using a passive probe, you need to compensate it – to balance its electrical properties to a particular oscilloscope. You should get into the habit of compensating the probe every time you set up your oscilloscope. A poorly adjusted probe can make your measurements less accurate. Figure 65 illustrates the effects on a 1 MHz test signal when using a probe that is not properly compensated.

Most oscilloscopes have a square wave reference signal available at a terminal on the front panel used to compensate the probe. General instructions to compensate the probe are as follows:

- Attach the probe to a vertical channel
- Connect the probe tip to the probe compensation, i.e. square wave reference signal
- Attach the ground clip of the probe to ground
- View the square wave reference signal
- Make the proper adjustments on the probe so that the corners of the square wave are square

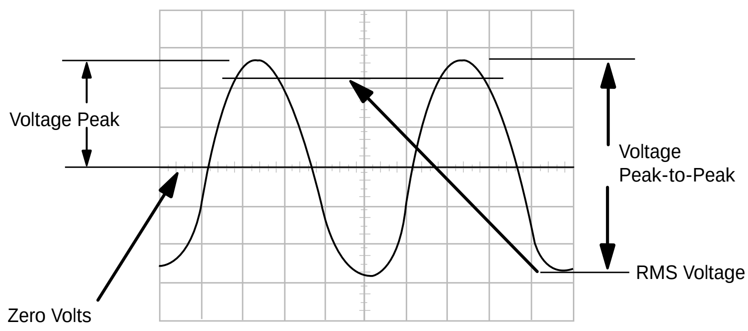

Figure 66. *Voltage peak (V_p) and peak-to-peak voltage (V_{p-p}).*

When you compensate the probe, always attach any accessory tips you will use and connect the probe to the vertical channel you plan to use. This will ensure that the oscilloscope has the same electrical properties as it does when you take measurements.

Oscilloscope Measurement Techniques

This section reviews basic measurement techniques. The two most basic measurements you can make are voltage and time measurements. Just about every other measurement is based on one of these two fundamental techniques.

This section discusses methods for taking measurements visually with the oscilloscope screen. This is a common technique with analog instruments, and also may be useful for "at-a-glance" interpretation of DSO and DPO displays.

Note that most digital oscilloscopes include automated measurement tools. Knowing how to make measurements manually as described here will help you understand and check the automatic measurements of DSOs and DPOs. Automated measurements are explained later in this section.

Voltage Measurements

Voltage is the amount of electric potential, expressed in volts, between two points in a circuit. Usually one of these points is ground (zero volts) but not always. Voltages can also be measured from peak-to-peak – from the maximum point of a signal to its minimum point. You must be careful to specify which voltage you mean.

The oscilloscope is primarily a voltage-measuring device. Once you have measured the voltage, other quantities are just a calculation away. For example, Ohm's law states that voltage between two points in a circuit equals the current times the resistance. From any two of these quantities you can calculate the third using the following formula:

Voltage = Current * Resistance

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

Power Law: Power = Voltage * Current

Another handy formula is the power law: the power of a DC signal equals the voltage times the current. Calculations are more complicated for AC signals, but the point here is that measuring the voltage is the first step toward calculating other quantities. Figure 70 shows the voltage of one peak (V_p) and the peak-to-peak voltage (V_{p-p}).