Lab 1

The Oscilloscope

Objective

This exercise is of a particularly practical nature, namely, introducing the use of the oscilloscope. The various input scaling, coupling, and triggering settings are examined along with a few specialty features.

Theory Overview

The oscilloscope (or simply scope, for short) is arguably the single most useful piece of test equipment in an electronics laboratory. The primary purpose of the oscilloscope is to plot a voltage versus time, although it can also be used to plot one voltage versus another voltage, and in some cases, to plot voltage versus frequency. Oscilloscopes are capable of measuring both AC and DC waveforms, and unlike typical DMMs, can measure AC waveforms of very high frequency (typically 100 MHz or more versus an upper limit of around 1 kHz for a general purpose DMM). It is also worth noting that a DMM will measure the RMS value of an AC sinusoidal voltage, not its peak value.

While the modern digital oscilloscope on the surface appears much like its analog ancestors, the internal circuitry is far more complicated and the instrument affords much greater flexibility in measurement. At a minimum, modern oscilloscopes offer two input measurement channels although four and eight channel instruments are increasing in popularity.

Unlike handheld DMMs, most oscilloscopes measure voltages with respect to ground, that is, the inputs are not floating and thus the black, or ground, lead is always connected to the circuit ground or common node. This is an extremely important point as failure to remember this may lead to the inadvertent short circuiting of components during measurement. The standard accepted method of measuring a nonground referenced potential is to use two probes, one tied to each node of interest, and then setting the oscilloscope to subtract the two channels rather than display each separately. Note that this technique is not required if the oscilloscope has floating inputs (for example, in a handheld oscilloscope). Further, while it is possible to measure non-ground referenced signals by floating the oscilloscope itself through defeating the ground pin on the power cord, this is a safety violation and should not be done.

Equipment

1. DC Power Supply
2. AC Function Generator
3. Digital Multimeter
4. Oscilloscope

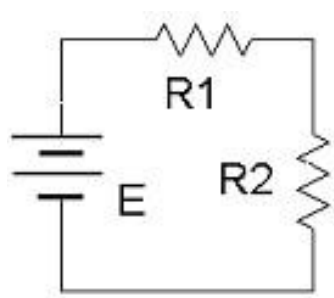

Figure 1

Components

1. 10 kΩ actual:__________________
2. 33 kΩ actual:__________________

Procedure

1. Find the following elements on your oscilloscope:

- Channel-1 and Channel-2 BNC input connectors.
- Trigger BNC input connector.

- Channel-1 and Channel-2 select buttons.
- Horizontal Sensitivity (or Scale) and Position knobs.
- Vertical Sensitivity (or Scale) and Position knobs.
- Trigger Level knob.

2. Note that the main display is similar to a sheet of graph paper. Each square will have an appropriate scaling factor or weighting, for example, 1 volt per division vertically or 2 milliseconds per division horizontally. Waveform voltages and timings may be determined directly from the display by using these scales.
3. Select the channel-1 and 2 buttons. There should now be two horizontal lines on the display. They may be moved via the Position knob.
4. One of the more important fundamental settings on an oscilloscope is the Input Coupling. This is controlled via one of the bottom row buttons. There are three choices: Ground removes the input thus showing a zero reference, AC allows only AC signals through thus blocking DC, and DC allows all signals through (it does not prevent AC).
5. Set the channel-1 Vertical Scale to 5 volts per division. Set the channel-2 Scale to 2 volts per division. Set the Time (Horizontal) Scale to 1 millisecond per division. Finally, set the input coupling to Ground for both input channels and align the two lines to the center line of the display via the Vertical Position knob.
6. Build the circuit shown in the figure using E=10V, R1=10kΩ and R2= 33kΩ. Connect a probe from the channel-1 input to the power supply (tip to plus, black clip to ground). Connect a second probe from channel-2 to R2 (again, tip to the high side of the resistor and the black clip to ground).
7. Switch both inputs to DC coupling. The two lines should have deflected upward. Channel-1 should be raised two divisions (2 divisions at 5 volts per division yields the 10 volt source). Using this method, determine the voltage across R2 (remember, input-2 should have been set for 2 volts per division). Calculate the expected voltage across R2 using measured resistor values and compare the two in Table 1. Note that it is not possible to achieve extremely high precision using this method (e.g., four or more digits). Indeed, a DMM is often more useful for direct measurement of DC potentials. Double check the results using a DMM and the final column of Table 1.
8. Select AC Coupling for the two inputs. The flat DC lines should drop back to zero. This is because AC Coupling blocks DC. This will be useful for measuring the AC component of a combined AC/DC signal, such as might be seen in an audio amplifier. Set the input coupling for both channels back to DC.
9. Replace the DC power supply with the function generator. Set the function generator for a 1 volt peak sine wave at 1 kHz and apply it to the resistor network. The display should now show two small sine waves. Adjust the Vertical Scale settings for the two inputs so that the waves take up the majority of the display. If the display is very blurry with the sine waves appearing to jump about side to side, the Trigger Level may need to be adjusted. Also, adjust the Time Scale so that only one or two cycles of the wave may be seen. Using the Scale settings, determine the two voltages (following the method of step 7) as well as the waveform's period and compare them to the values expected via theory, recording the results in Tables 2 and 3. Also crosscheck the results using a DMM to measure the RMS voltages.

10. To find the voltage across R1, the channel-2 voltage (VR2) may be subtracted from channel-1 (E source).
11. One of the more useful aspects of the oscilloscope is the ability to show the actual wave shape. This may be used, for example, as a means of determining distortion in an amplifier. Change the wave shape on the function generator to a square wave, triangle, or other shape and note how the oscilloscope responds. Note that the oscilloscope will also show a DC component, if any, as the AC signal being offset or “riding on the DC”. Adjust the function generator to add a DC offset to the signal and note how the oscilloscope display shifts. Return the function generator back to a sine wave and remove any DC offset.

Data Tables

DC

For R1:

	Scale (V/Div)	# Of Divisions	Voltage Peak-Peak	Voltage RMS
Oscilloscope				
Theoretical				

For R2:

	Scale (V/Div)	# Of Divisions	Voltage Peak-Peak	Voltage RMS
Oscilloscope				
Theoretical				

AC

For R1:

	Scale (V/Div)	# Of Divisions	Voltage Peak-Peak	Voltage RMS
Oscilloscope				
Theoretical				

For R2:

	Scale (V/Div)	# Of Divisions	Voltage Peak-Peak	Voltage RMS
Oscilloscope				
Theoretical				

For Frequency and Time Period:

	Scale (S/Div)	# Of Divisions	Time Period	Frequency
Oscilloscope				