Introduction to Oscilloscopes Worksheet

This worksheet explains how to use an oscilloscope to make basic measurements of waveforms. Read through each section and follow the directions.

1. **The GFG-8219A Function Generator**

The function generator is used to generate test signals when testing circuits. It can generate sine, square, and triangle waves, as well as some other signals. Connect the Output connector on the function generator to the Channel 1 input on the oscilloscope with a BNC-to-BNC cable. Below is a description of some of the function generator controls.

- 1M, 100k, 10k, 1k, 100, 10, 1 – sets the frequency range
- triangle, square, sine – select the shape of the waveform
- 1/0 – Power button
- Frequency - sets the frequency of the signal. The knob is pushed in for fixed frequency signals (the usual case), and pulled out for frequency swept signals.
- Offset – when this knob is in the pushed in position, no D.C. offset is added to the signal (the usual case). When in the pulled out position, this knob adds a D.C. offset to the signal.
- AMPL – sets the amplitude of the signal. When in the pushed in position, the function generator can generate fairly large amplitude signals (the usual case). When in the pulled out position, the function generator is limited to smaller amplitudes.

Initial setup:

- Turn the function generator on
- Make sure that the Frequency, Offset, and AMPL knobs are all in the pushed in position
- Push the 10k button to select the 10 kHz range
- Push the button with the sine wave to select the sine wave shape
- Turn the Frequency knob until the frequency in the display is 10 kHz
- Turn the AMPL knob to about half way between the minimum and maximum
- Use a BNC-to-BNC cable to connect the Output connecter on the function generator to Channel 1 on the oscilloscope.

2. Lab Kit Function Generator

To view a waveform on an oscilloscope, there first must be a waveform. Function generators output different waveforms. The function generator in your lab kit can output sine, triangle, and square waves. The frequencies and amplitudes of these waveforms can be adjusted. The Hz/kHz slider switch adjusts the frequency range. The 1/10/100 switch and the 1.0/0.1 slider switch work together to adjust the frequency. The settings are multiplied together to form the value in either the Hz or kHz range to output. For example, if the 1/10/100 switch is in the 100 position, the 1.0/0.1 slider switch in the 1.0 position, and the Hz/kHz switch in the Hz position, the function generator should output a waveform with a 100 Hz frequency. The amplitude slider switch adjusts the peak-to-peak voltage of the waveform. Configure the switches as indicated below to output a 10 kHz sine wave.

- ☐ Hz/kHz switch: kHz position
- ☐ 1/10/100 multiplier switch: 10 position
- ☐ 1.0/0.1 multiplier slider switch: Top most position (1.0)
- ☐ Amplitude slider switch: Top most position (Full amplitude)
- ☐ Sine/Triangle/Square wave switch: Sine wave position

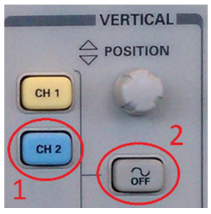
To view a waveform on an oscilloscope, a probe must connect the oscilloscope to the source of the waveform. Remember, the black, dangling lead of an oscilloscope is connected directly to earth ground. NEVER connect this lead to anything but ground. Connecting the ground lead to a voltage will short the voltage to ground.

- ☐ Connect a probe to Channel 1 of the Oscilloscope
- ☐ Connect the ground lead to the ground of your tool kit
- ☐ Connect the tip of the probe to the function generator

3. Adjust the Basic Oscilloscope Settings

Oscilloscopes have many settings. This section will guide you to set up the oscilloscope to measure the 10 kHz sine wave.

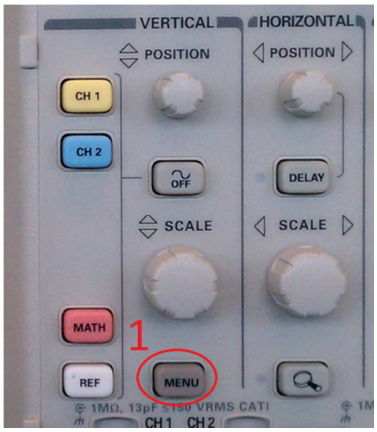
- ☐ For this tutorial, only one channel of the oscilloscope needs to be displayed. If Channel 2 is displayed, turn the channel off by pressing the “CH 2” button, then pressing the “OFF” button.

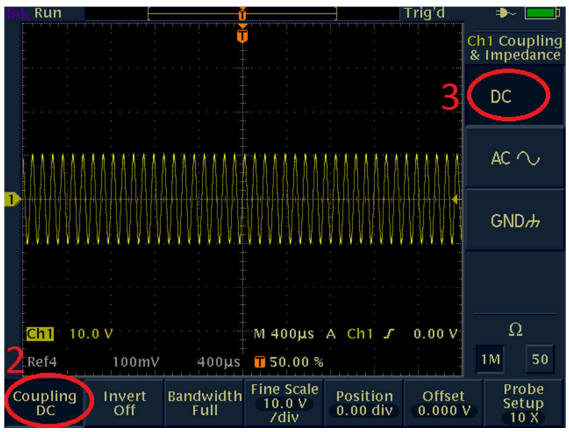


- The vertical position knob allows vertical shifting of the waveform on the screen. Adjust the vertical position of Channel 1 so that the waveform is in the middle of the screen

- Like the vertical position knob, the horizontal position knob allows shifting of the waveform on the screen. Adjust the horizontal position knob so that the starting position of the waveform is in the middle of the screen.

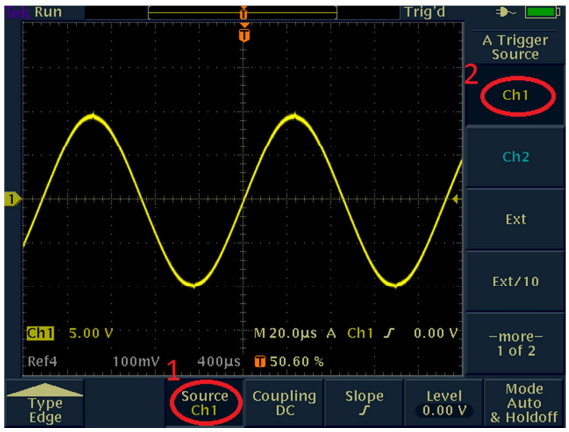
- Oscilloscopes channels can be set to show either the AC or DC (with AC) components of a waveform. This setting is called coupling. If set to AC, a coupling capacitor is internally inserted in series with the waveform path. This capacitor allows the AC component to pass, but blocks all DC. If set to DC, all DC (and AC riding on DC) is passed to the internal analyzing circuits of an oscilloscope. Generally, it is a good idea to leave oscilloscope channels on the DC setting since both AC and DC can be viewed with this setting. Set Channel 1 to DC coupling.





- The vertical scale knob adjusts the volts per division setting of the vertical axis. Set the vertical scale of Channel 1 to 5V per division. Note that the vertical scale is shown on the bottom of the screen.

On the function generator, adjust the amplitude control so that the signal on the oscilloscope covers about four vertical divisions (that is 20 V peak-to-peak) as shown in the figure below.



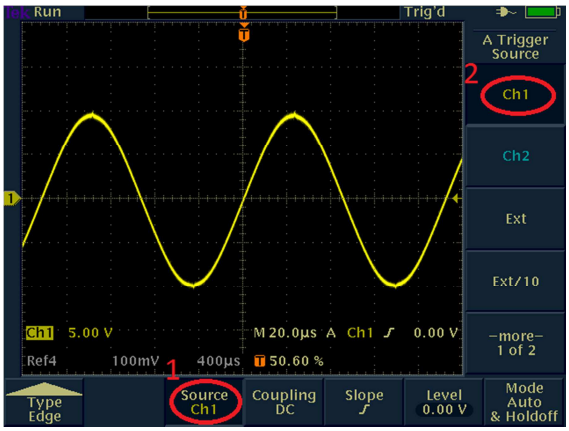
- The horizontal scale knob adjusts the seconds per division setting of the horizontal axis. Set the horizontal scale to 20µs per division. Note that the horizontal scale is shown on the bottom of the screen.

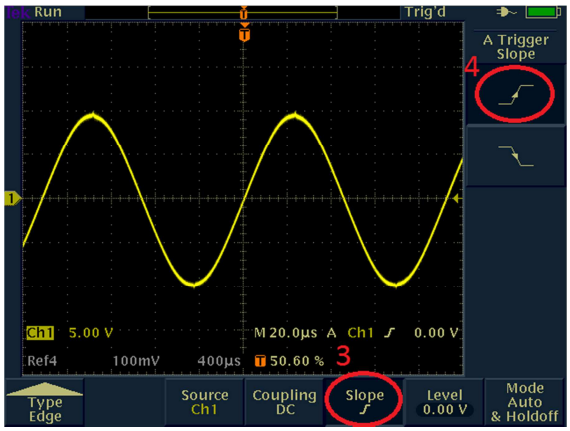
4. Triggering

If the signal appears to drift horizontally across the screen or if it has multiple traces, the triggering level may need to be adjusted. The triggering system of an oscilloscope causes the oscilloscope to wait to start drawing a trace until the input voltage crosses a certain voltage level, which is called the trigger level. If the trigger level is set to a voltage somewhere between the maximum and minimum input voltage, the oscilloscope will draw each trace exactly on top of the previous trace, and the signal will appear to be stationary on the screen. If the trigger level is set too high or too low, then the input signal never crosses the trigger level, and the signal may appear to drift across the screen or may even fill in the screen. Follow the steps below to demonstrate the effect of the trigger settings.

- Press the Trigger Menu button

- For the ‘Source’ option, select channel 1. For the ‘Slope’ option, select the rising edge. This forces the oscilloscope to trigger off of channel 1 on the rising or positive slope of a waveform.





- The trigger level knob adjusts the voltage necessary to trigger the oscilloscope. If set at 0V, a waveform rising from a negative voltage to a positive voltage will trigger the oscilloscope. If set at 5V, a rising voltage from below 5V to greater than 5V will trigger the oscilloscope. Likewise, if set to 15V, a voltage increasing from less than 15V to more than 15V will trigger the oscilloscope. The oscilloscope that you are using probably has its trigger level set to 0V already. Use the trigger level knob to set the triggering level to 0V if it is not there already.

- Adjust the trigger level to 5V. Notice how the triggered waveform aligns with the 0 position of the horizontal position control.

- Adjust the trigger level to 15V. How does the waveform behave? Is the waveform triggering the oscilloscope anymore?

- Adjust the trigger level back to 0V.

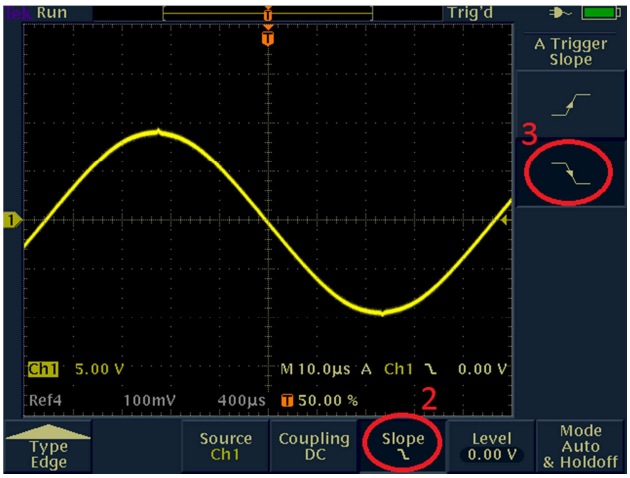
As you can see, setting the trigger level is important in order to get a stable view of a signal.

5. Making Measurements

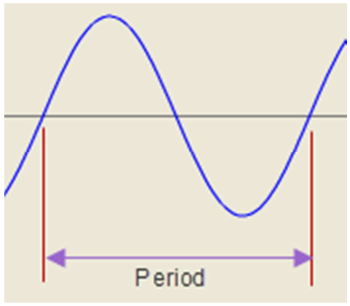
Finally, you are ready to measure the 10 kHz waveform. Follow the steps below to measure both frequency and amplitude.

- When making frequency measurements, it is best to adjust the waveform so that one cycle takes up as much of the screen as possible. Adjust the horizontal scale from 20 µs/ division to 10 µs/ division.

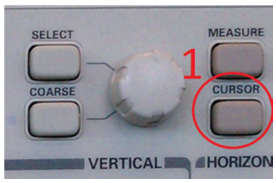
- Go back to the Trigger menu (press the ‘Menu’ button in the triggering section), and change the triggering slope to a falling edge. This way a sine wave and not a cosine wave is displayed.



- The period of a waveform is how long it takes one cycle to complete. With a sine wave, it is easiest to measure the period using the x-intercepts. Estimate the number of horizontal divisions in one cycle by counting the number of divisions between the first and last x-intercepts. Multiply this value by 10 µs (your current s/division horizontal setting). This value is your period. From the period, calculate the frequency (f = 1/T). Is your calculated frequency close to the ideal 10 kHz frequency?

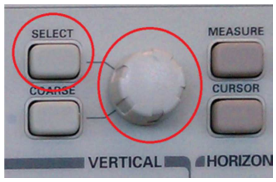


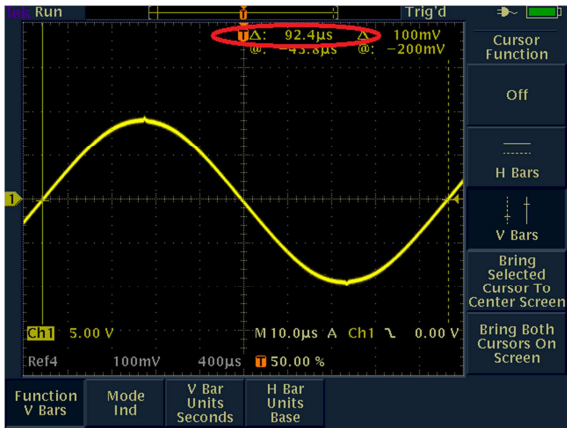
- Most oscilloscopes allow more detailed measurements using cursors. Press ‘Cursor’ button. Select “Function’, then ‘V Bars’.



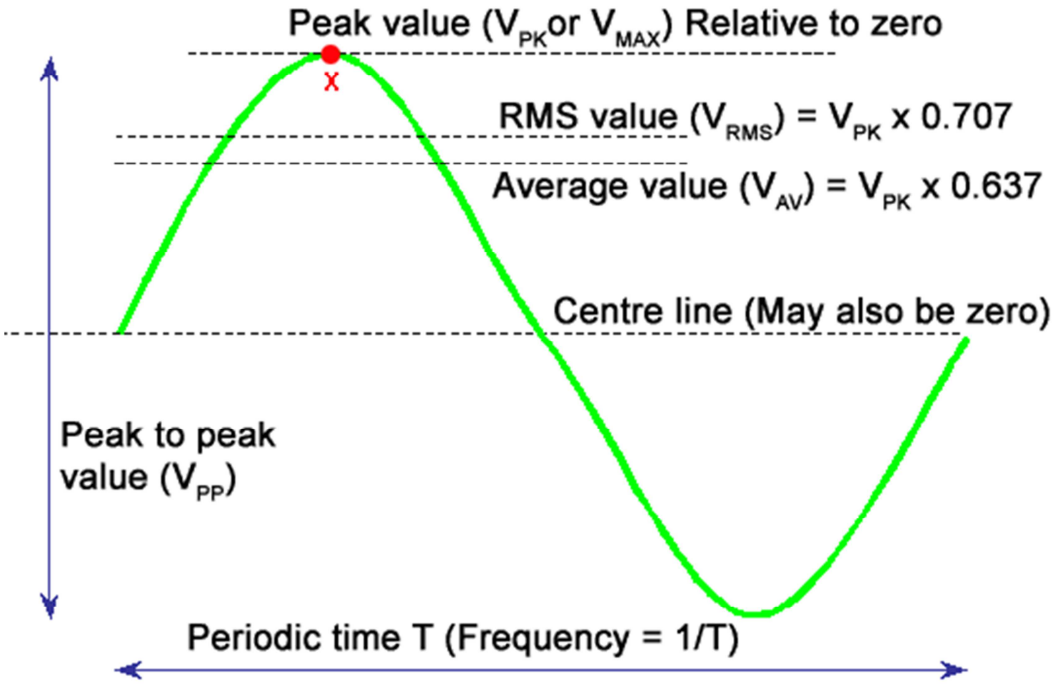
- Use the ‘Select’ button to switch between the two cursors. Adjust the cursors using the positioning knob so that the cursors are at the first and last x-intercepts. Read the delta between the two waveforms (this

is displayed on the screen). This is your period. Calculate the frequency (f = 1/T). How does it compare to the ideal 10 kHz frequency?

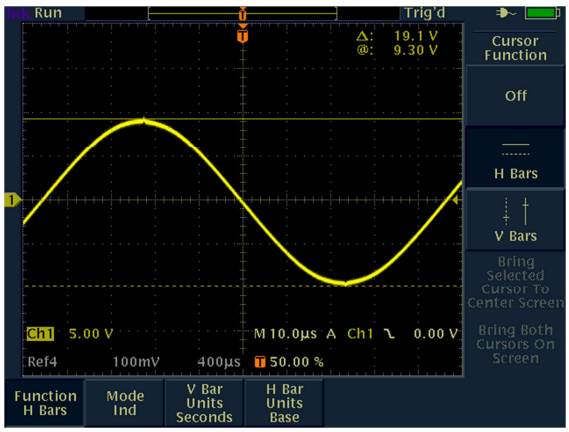




- Now it's time to measure amplitude. Let's measure the peak-to-peak voltage value of the waveform. Estimate the number of vertical divisions that the waveform occupies. Multiply this value by 5V (your current V/division setting). Your answer is the peak-to-peak value of the waveform.



- Again, we can use cursors to obtain a more accurate measurement. Select the 'Cursor' menu, the 'Function' option, and 'H Bars'. Use the 'Select' button and the position control knob to adjust the cursors to the highest and lowest points of the waveform. The delta between the cursors is displayed on the screen. This is the peak-to-peak value of the waveform.



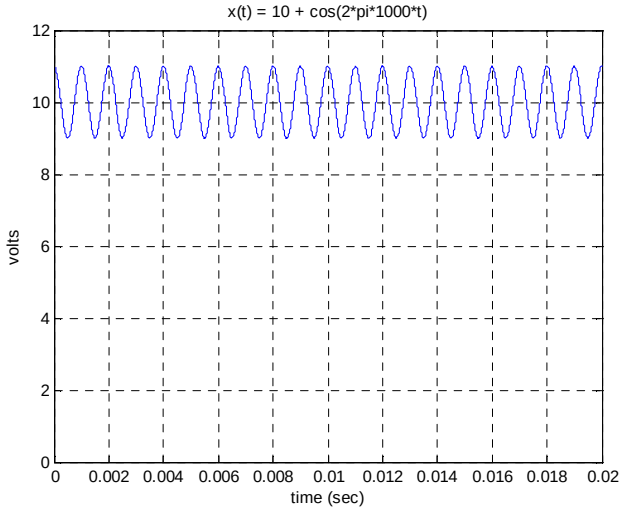
6. Square Wave

Congrats on measuring your first sine wave! Now that you know how to control an oscilloscope, practice a little more by measuring a 2V peak-to-peak 100 Hz square wave. Here are the basic steps:

- Set the function generator to output a 100 Hz square wave.
- If necessary, adjust the triggering controls.
- Adjust the horizontal and vertical controls so just one cycle of the waveform is displayed.
- Use the cursors to measure both frequency and amplitude of the square wave.

7. DC and AC Coupling

In this section, we will demonstrate the difference between DC coupling (the usual setting) and AC coupling. Sometimes we are interested in examining a small AC signal that has a large DC offset such as the one shown below. If we try to zoom in on the signal to get a close look at the AC part, the signal will go off the screen because of the large DC offset. AC coupling allows us to block the D.C. part of the signal so we can examine only the AC signal of interest.



First make sure that the oscilloscope is set to DC coupling. Also, make sure that the AMPL knob on the function generator is pushed in. Adjust the function generator to produce a 2V peak-to-peak sine wave with a frequency of 1 kHz. Next, pull out the Offset knob on the function generator, and adjust the Offset knob to add a 10V DC offset (that is the signal should have a maximum of 9V and a minimum of 11V as shown above). Sketch the shape of the signal showing the minimum voltage, maximum voltage, and period. Zoom in further (that is rotate the vertical scale knob clockwise) to see how the signal goes off the top of the screen.

Now switch the oscilloscope to A.C. coupling and sketch the display. What effect does the A.C. coupling setting have on the oscilloscope display? Now try zooming in to make the signal bigger. Does it go off the screen?

8. Two Channels

Now let's display two signals on the oscilloscope at the same time. This feature is often used to compare the timing of two signals. Connect the Output connector of the function generator to Channel 1 of the oscilloscope. On the function generator, find the output labeled TTL/CMOS Output (it is on the front on some models, and on the back on others). Connect the TTL/CMOS Output to Channel 2 of the oscilloscope. Turn on the oscilloscope's display for Channel 2 by clicking the CH 2 button. When you adjust the vertical position knob on the oscilloscope, it will adjust the trace for either Channel 1 or 2 depending on whether you pressed the CH 1 or CH 2 button most recently.

Adjust the oscilloscope so that Channel 1 is above Channel 2. Adjust the function generator to produce a 5V peak-to-peak sine wave with a 10 kHz frequency. Sketch the two signals and show how they line up in time.

9. Conclusion

Write a couple of paragraphs to summarize the following items:

1. What was the objective of this experiment and was the objective achieved?
2. What is the purpose of the function generator and the oscilloscope?
3. What is the difference between DC and AC coupling on the oscilloscope?
4. Other comments relevant to this experiment.