# Oscilloscopes and Function Generators Worksheet

## Objective

The focus of this worksheet is to introduce Oscilloscopes and Function Generators as powerful test equipment which help in testing designs under test (DUT).

## Oscilloscopes

### Discussion Overview

In electrical engineering, once a circuit is built, testing the design involves various voltage and current measurements to make sure they match predicted or intended values. Some voltages and currents in a circuit do not change appreciably over time. An example of this is the voltage at a power supply such as a battery. For most parts, as the circuit operates, the voltage across a battery does not change much over time. These kinds of “static” measurements are easily made using a multimeter.

Circuits with voltages and currents that do not change with time, however, are not very terribly interesting. Most circuits that do something interesting have values that change, at times quite rapidly, with time. For such circuits, an oscilloscope is the test equipment of choice. Using an oscilloscope, one can capture the time varying voltage at a node (with respect to ground) as a “real time” waveform. One can observe and measure the change in the voltage over time and determine how fast the voltage is changing.

In the next sections, we will go through step by step procedure on how to properly configure an oscilloscope and make meaningful measurements.

### Procedures

For all the steps below, refer to Figure 1 for the location of configuration knobs, buttons or soft-keys and Figure 2 for the indicators on the Readout Display. Please spend a few moments familiarizing yourself with the configuration/functional groups in Figure 1 and on your oscilloscope.

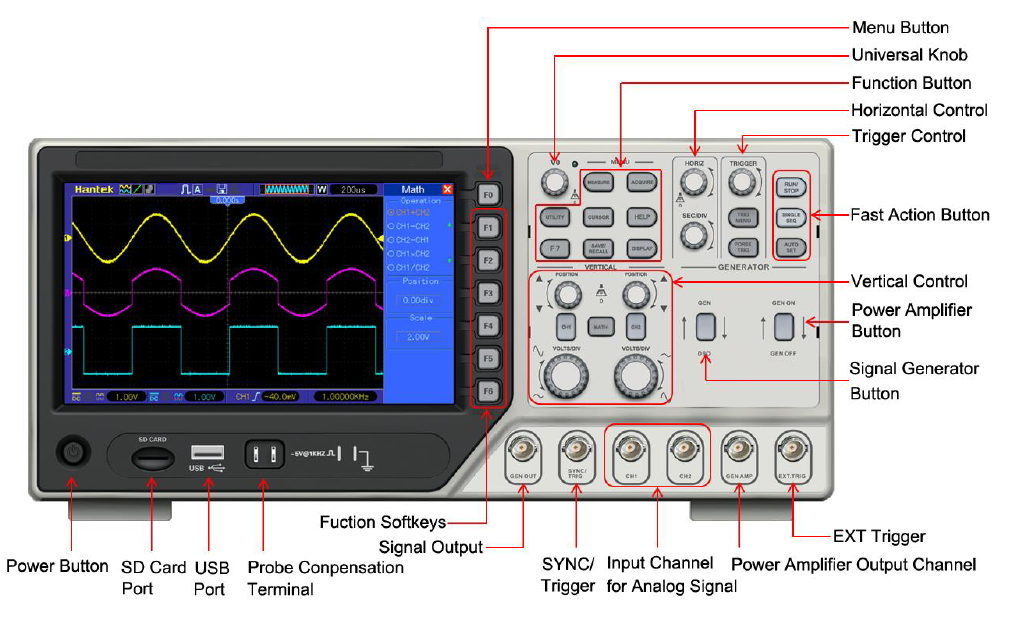


Figure 1 - Hantek DSO4102C Oscilloscope

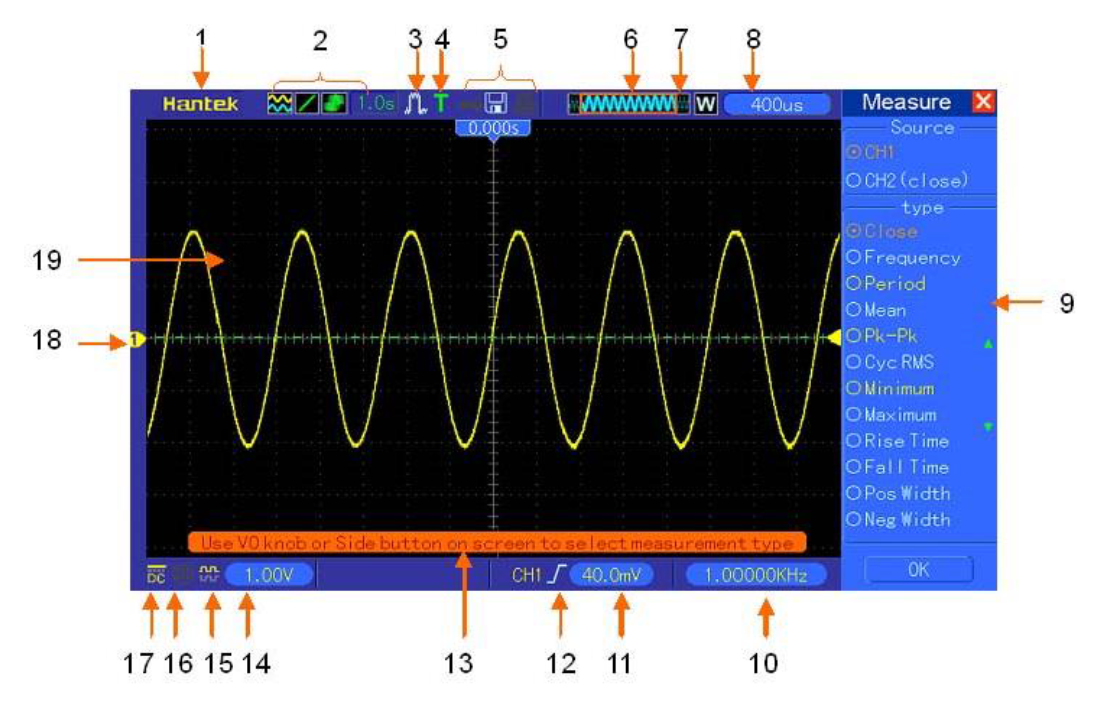
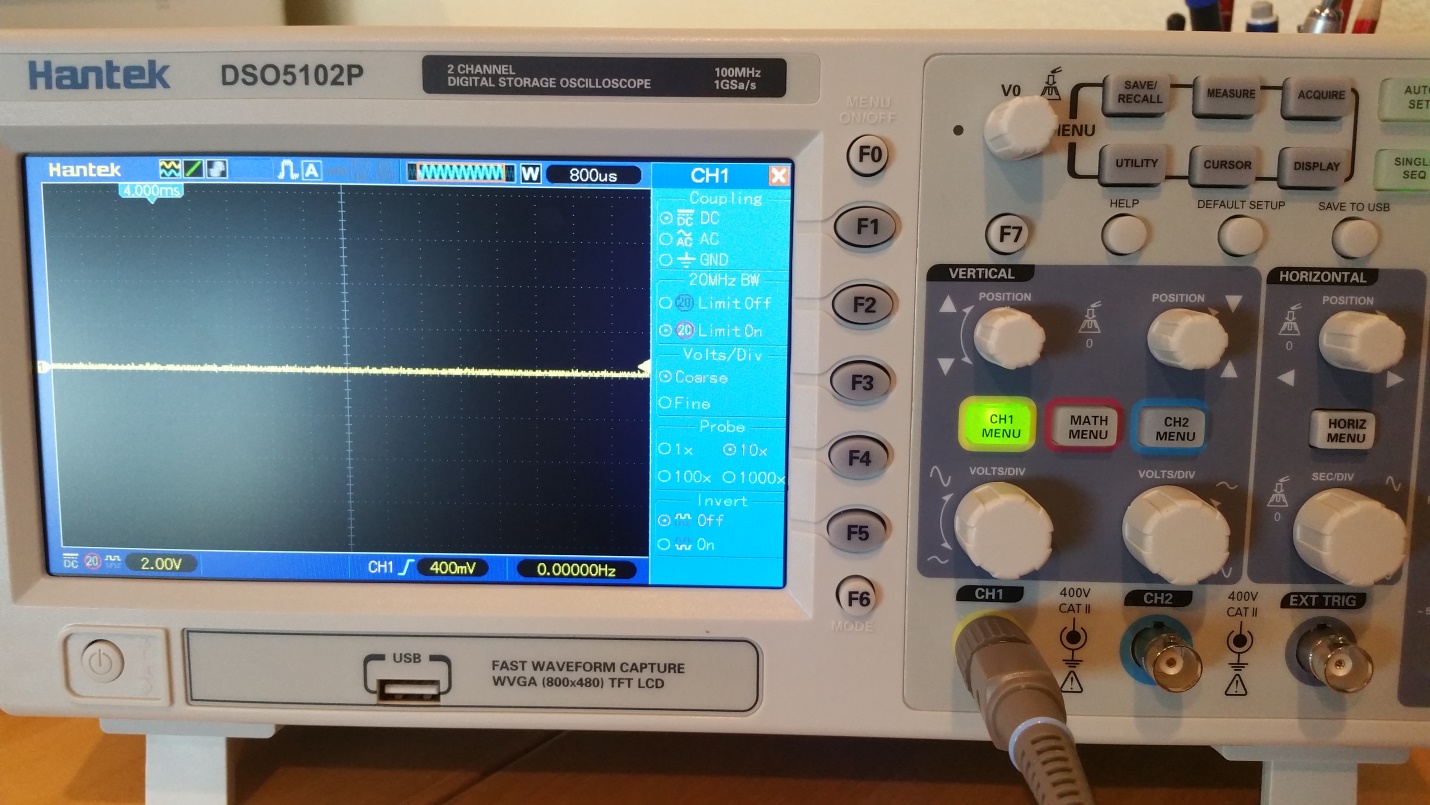


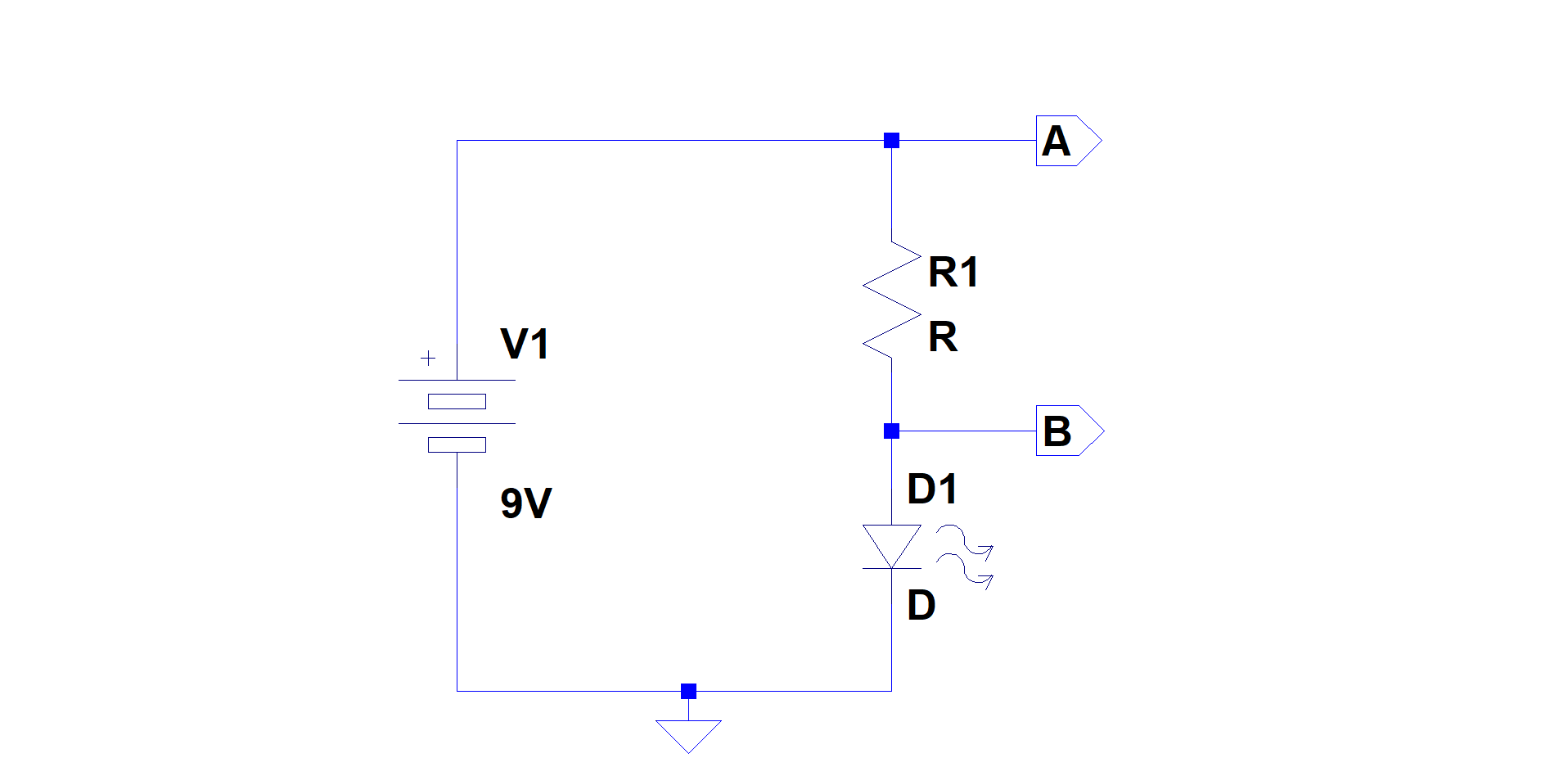
Figure 2 - Oscilloscope's Readout Display

Basic Setup

1. Connect your oscilloscope to the wall power and turn it on by pressing the power button.
2. Connect one probe to the channel 1 analog input by inserting and then twisting the probe’s BNC connector onto “CH1” BNC connector on the scope in the “Input Channel for Analog Signal” group shown in Figure 1.
3. On the probe head, check to see that the sliding switch for the “compensating network” is set to “X10”.
4. On the scope, to the right of the display next to the “Function Soft-keys”, check to see that the “Probe” setting next to “F4” is set to “10X” as well.
   1. When these two settings match, the reading on the scope corresponds to the actual voltage measurement in the circuit. (e.g. a 5V reading on the scope corresponds to a 5V measurement in the circuit.)
   2. If these settings don’t match, you will have to apply the correct scaling factor to get the correct measurement.



1. Once the oscilloscope has gone through self-configuration, enable channel one only by pressing the “CH1” button in the “Vertical Control” group.
   1. Make sure that only “CH1” button is lit up. If “CH2” is lit up, turn it off by pressing it once.
   2. The buttons in the “Generator” group should also be turned off.
2. Next, move the ground location of the waveform by adjusting the CH1 “Position” knob in the “Vertical Control” group. The “ground” location of the waveform is indicated by a small triangle to the left of the display with the channel number inside of the triangle.
   1. Note that the color of the waveform (e.g. yellow) matches the color of the channel button. Any setting associated with a particular channel will have its color matched with the waveform.
   2. Place the “ground” location to the center of the vertical axis by pressing the CH1’s “Position” knob.
3. Configure the vertical axis by adjusting the “VOLTS/DIV” knob in the vertical control group.
   1. Note that the value in sub-window 14 (refer to Figure 2) changes as the “VOLTS/DIV” knob is adjusted.
   2. The value read here corresponds to the number of volts per major divisions on the screen. So, for example, for a setting of 2.00VOLTS/DIV, the entire screen can display a signal that has an amplitude of 16V (for the 8 total major divisions on the screen).
4. Construct a simple LED circuit with a current limiting resistor that allows a maximum of 6mA of current through the LED when connected to a 9V battery.



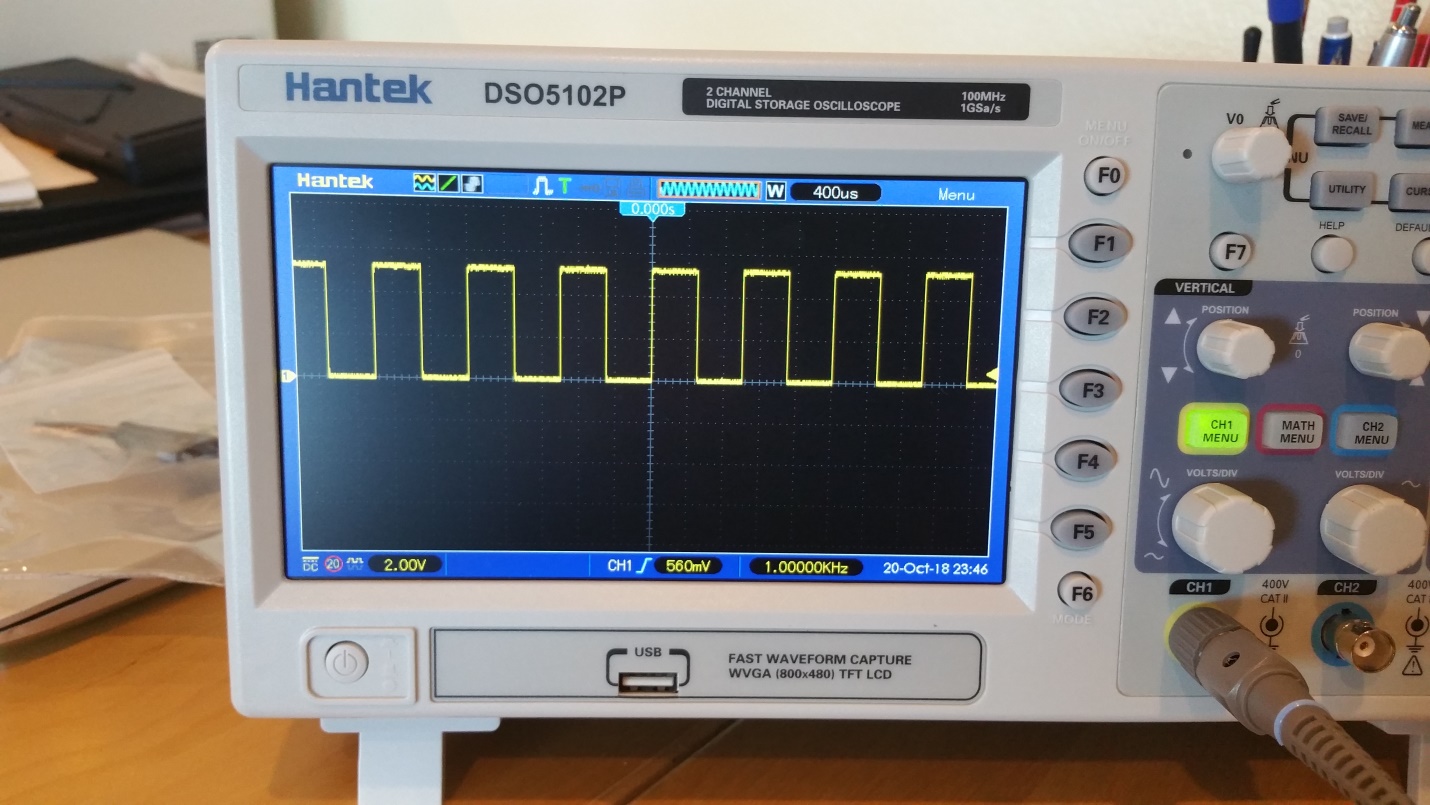
1. Connect your probe’s ground clip to GND (negative terminal of the battery.
2. Connect your probe to node A. Record the voltage measurement below  
     
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3. Connect your probe to node B. Record the voltage measurement below  
     
    \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Testing the Probe and Time Settings

Oscilloscopes normally provide a simple “Probe Compensation Terminal” (see Figure 1) which provides a test signal. For today’s project, we will use this terminal to simply display a “time varying” signal on the probe.

The “Compensation Terminal” outputs a square wave with an amplitude of ~5V and a frequency of 1KHz. Once properly configured and connected, you should see a 1 KHz square wave on the Readout Display.

1. Make sure the vertical configuration is set to 2.00V/Div.
2. Set the horizontal axis by adjusting the “SEC/DIV” knob in the “Horizontal Control” group.
   1. The time per major division setting on the horizontal axis is displayed in window 8 (see Figure 1).
   2. Set the time per division to 400s.
3. Connect the ground clip of the probe to the ground terminal of the “Compensation Terminal”.
4. Connect the probe tip to the signal terminal of the Compensation terminal. You should see a waveform similar to the one below on your Readout Display.



1. Adjust the horizontal trigger position by turning the “Position” knob in the “Horizontal Control”.
   1. Observe how the waveform “moves” as the “Position” knob is adjusted.
   2. Place the horizontal trigger position back at zero by pressing the “Position” knob.
2. Determine the signal’s amplitude from the displayed waveform and record it below.  
     
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3. Determine the signal’s period from the displayed waveform and record it below.  
     
    \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Determine the frequency from the measured period above and record it below  
     
    \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Press the “MEASURE” button in the “Function Button” group.
   1. On the right hand side of the Readout Display, you can see various measurements for the signal
   2. Read and record frequency, period and peak to peak (Pk-Pk) amplitude below  
        
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       \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
        
       \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   3. How do these values compare to the ones you measured in steps 6-7? How are they different and why?

## Function Generators

### Discussion Overview

Function generators are used in electrical engineering to create a certain periodic signal that can be used to “excite” a circuit in order to observe and test the behavior of the circuit.