Oscilloscope Measurements

1 Introduction

The principal use of an oscilloscope is to produce a graph of a signal voltage vs. time. In the older analog scope, the graph is produced with an electron beam striking a fluorescent screen. The beam is swept, horizontally, across the screen, and the amplified signal made to produce a vertical deflection.

In this laboratory, we will use a digital oscilloscope. In this device, the signal is sampled and digitized, and the results displayed on an LCD. Because a large number of measurements are made of the signal, this type of scope is capable of making many real-time measurements of waveforms. In addition, the entire digitized waveform may be transferred into a computer, for further analysis. Instead of making a "sweep" the scope will "acquire" data. This write-up will describe general features of oscilloscopes, and some specific features of the Tektronix TDS 1012.

Here is a view of the front of the scope:

![Figure 1: The front of the Tektronix TDS 1012b Digital Oscilloscope.](image)

2 Automatic Setting

One of the nicest features of a digital scope is its use of its computational capabilities to search for signals and automatically make the settings necessary to display the signals. For the Tektronix TDS 1012, for example, just connect a signal to one of the inputs and press the Autoset button! The scope will find the signal for you. However, you will undoubtedly want to learn more about the specific settings you can make, in order have the scope do just what you want.
3 Triggering

An oscilloscope requires a trigger, to initiate a sweep of the beam across the screen. The same is true for a digital scope’s acquisition cycle. The trigger can be produced by a different selectable sources. The selections may be viewed from the Trigger Menu, and/or the Ch 1 or Ch 2 Menus.

- **Internal** A signal on one of the input channels.
- **External** A signal on the external trigger input. Not necessarily one of the input signals being looked at.
- **Line** The trigger is at 60 Hz, in phase with the local AC line voltage.

When input or external trigger signals are used to produce the trigger, the “Trigger Level” knob controls the voltage threshold which the signal must cross in order to make a trigger.

3.1 Internal

3.1.1 Normal

This uses the signal itself to initiate a sweep or acquisition. Normal triggering repeats as fast as possible.

3.1.2 Auto

No signal is required. An internal clock starts sweeps.

3.1.3 Single

Just one sweep is made, until reactivitated.

4 Signal Inputs

4.1 Input Impedance

An oscilloscope displays a voltage signal. Its input impedance (mainly resistive) is generally in excess of $10^6 \ \Omega$, just like a voltmeter. (A scope, at its simplest, is an expensive voltmeter! You can even use it to measure a constant (DC) voltage.)

4.2 Coupling

It is sometimes desirable to “subtract off” a constant voltage which a time-varying signal is “sitting on.” To do this, a large capacitor is inserted in series with the signal. That way, the DC component is blocked, and only the time-varying component gets through. This capability is built into most scopes: it is referred to as AC Coupling. Not including the series capacitor is called DC Coupling. You can also select “GND”, which will connect the input to ground, giving a display which corresponds to 0 volts input.
4.3 Vertical Gain
The oscilloscope can display signals as small as a few mVolts to several Volts. To accommodate such a large dynamic range, the input signal is amplified by different amounts. The result is the setting “Volts/Div”, the number of volts corresponding to 1 division, vertically, on the display. This can be controlled with the “Volts/Div” knob. The setting normally is displayed on the screen.

4.4 Channels
This and many scopes can simultaneously display two independent signals. You activate the display of a specific channel \( J \) by pressing the button \( \text{Ch J Menu} \). Successive presses will also remove the display. The Channel Menu displays and permits changes of the coupling, the vertical gain resolution, the bandwidth limit, and the probe attenuation. CAUTION: Make sure the “probe attenuation” is always set to “1X”. Otherwise the scope’s voltage readings may be incorrect.

4.5 Input Averages
The TDS 210 digitizes samples with an accuracy of 8 bits. To increase the accuracy when there are many of the same waveforms, the scope will take an average of several (4 to 128) sweeps. This will increase the “sharpness” of the observed traces. This selection is made in the \( \text{Acquire} \) Menu.

5 Other Features

5.1 Measurements
The \( \text{Measure} \) Menu provides selection of measurements, for either channel of: Mean (average), RMS value, period, frequency, and peak-to-peak value.

5.2 Saving Waveforms
It is possible to store several different waveforms, and to recall them to compare with a current one. This is done under the \( \text{Save/Recall} \) Menu.

6 Reading out to a computer
The digital scope at each workstation is connected to the workstation computer, and readout is controlled with the program \( \text{Open Choice Desktop} \). Click on the icon to bring it up. To read out a waveform, do the following:

1. Select (click on) \( \text{Waveform Data Capture} \).
2. Select \( \text{Instrument} \).
(a) Select **USB0 :: :: :: INSTR**.
(b) Click **OK**.

3. Select channels if necessary.

4. Click on **Get Data**.

5. Click on **Copy to Clipboard**.

6. Paste into a spreadsheet.