Introduction to the Oscilloscope

An oscilloscope is a fancy voltmeter that visualizes changes in voltage over time. Fig. 1 shows the front view of the oscilloscope TEKTRONIX TDS1002. Besides the display, the electronics of an oscilloscope can be divided into 3 major units:

1. amplifier (VERTICAL)
2. time base (HORIZONTAL)
3. trigger unit (TRIGGER)

The time base determines the temporal resolution of the input signal. The amplifier determines amplitude scale of the signal. The trigger unit is used to choose the event that starts the recording of the signal. Mostly, this is an edge (low-high or high-low) of the sampled waveform, but one can also trigger on more sophisticated events like pulses of a pre-defined duration, a number of edges with a given time, etc.

The display (Fig. 2) is covered by a graticule, the distance between two adjacent lines is called a division. With the SEC/DIV and VOLTS/DIV knob the corresponding time (horizontal) and voltage (vertical) scaling of both these axes can be adjusted. All of these settings as well as the functions that are assigned to the programmable buttons on the right side of the screen are displayed on the screen.
Setting the horizontal axis

Here, the time window display for the voltage waveform (Fig. 3) is determined. The setting is changed with the SEC/DIV dial; settings range from 5 ns per division (turning the dial clockwise) to 50 s per division (turning it counter-clockwise). The chosen value is displayed on the screen (Part C of Fig. 2). With the POSITION dial, the waveform can be shifted horizontally. If we expect to observe a signal with a frequency \( f \), the time scale should be chosen to be close to \( \frac{1}{(n \times f)} \), where \( n \) is the number of divisions that one period of the signal is supposed to occupy.

Example: To display a 250 Hz signal in 9 divisions (almost filling the whole screen), we calculate the setting as \( \frac{1}{(9 \times 250 \text{ Hz})} = 440 \mu\text{s/div} \). The available settings are 250 \( \mu\text{s} \) and 500 \( \mu\text{s} \) per division. Starting with the larger value will result in one cycle occupying \( \frac{4 \text{ ms}}{0.5 \text{ ms/div}} = 8 \text{ div} \).

Setting the vertical axis
To see a signal on the screen, we connect signal leads to one of the amplifier channels. The appropriate channel has to be displayed, which can be toggled by pressing the CH1 MENU or CH2 MENU button in the VERTICAL section of the front panel (Fig. 4). On the screen (Part A and B of Fig. 2), you see which channels are active and the voltage setting for either of them. This setting can be changed by turning the VOLTS/DIV dial. Values ranging from 2 mV/DIV (fully clockwise) to 5 V/DIV (fully counterclockwise) are available.

The voltage offset (i.e. the vertical position of the waveform with the respect to the middle line) can be adjusted by rotating the POSITION dial. Also, if CH1 MENU or CH2 MENU is pressed, a menu is displayed on the right side of the screen that determines several features of the respective vertical amplifier. When measuring signal amplitudes, the value read from the screen must be multiplied with the setting displayed on the screen.

Example: A 3.2 division amplitude on the screen would represent 6.4 V at a setting of 2.00 V/div but only 320 mV at 100 mV/div.

Synchronizing the display

**Figure 4:** Vertical settings
To obtain a stable display of a periodic signal, the sweep must begin at the same point in each signal cycle. There are TRIGGER controls at the right side of the front panel (Fig. 5) that select how this is done. By pressing the button TRIG MENU you enter the trigger menu, displayed on the right side of the screen. Use the settings: Type: Edge, Slope: Rising, Mode: Auto, Coupling: DC. Source can be set to CH1 or CH2, according to where the signal is connected. The latter setting as well as trigger level (voltage) and type are displayed on the screen (Part D of Fig. 2). With the knob TRIGGER LEVEL, the voltage at which the display of the waveform starts is adjusted. The trigger level is displayed as a small horizontal arrow in the rightmost division on the screen. This level should be kept as near to the center position as possible, but adjusted slightly to obtain a stationary display. You may have to readjust the Trigger Level when the amplification is changed or when the signal significantly changes shape.