Introduction to the Oscilloscope

Figure 1: Front view of the oscilloscope TDS1002

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 at which speed the input signal is detected (sampled). The amplifier prepares and samples the input signal at the rate given by the time base. The trigger unit is used to choose the event at which the amplifier starts to record 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 (pulses of a pre-defined duration, a number of edges within 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.

Figure 2: Screenshot
Setting the horizontal axis

With this part (Fig. 3), one determines the time window for which the voltage waveform is displayed. 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 $1/(n \times f)$, 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 $1/(9 \times 250Hz) = 440 \mu s/\text{div}$. The available settings are 250 $\mu s$ and 500 $\mu s$ per division. Starting with the larger value will result in one cycle occupying $(4 \text{ ms})/(0.5 \text{ ms/\text{div}}) = 8 \text{ div}$.

Figure 3:
Horizontal settings

Setting the vertical axis

To get a signal onto the screen, we have to connect the leads to one of the amplifier channels. The leads usually have an outer shield, which is grounded and has black insulation. This wire must be connected to the GROUND side of the signal source. 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 what is the voltage setting for either of them. This setting can be changed by turning the VOLTS/DIV dial, values reaching from 2 mV/DIV (fully clockwise) to 5 V/DIV (fully counter-clockwise) 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 are pressed, a menu is displayed on the right side of the screen, that determines several features of the respective vertical amplifier. Settings should be: Coupling: AC, BW Limit: Off, Volts/Div: Coarse, Probe: 1x, Invert: Off. 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

In order to obtain a stable display of a periodic signal, the sweep must begin at the same point in each signal cycle. There are a set of TRIGGER controls at the right side of the front panel (Fig. 5) that select how this is to be accomplished. 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 in order to obtain a stationary display. You may have to readjust the Trigger Level when the amplification is changed or when the signal significantly changes.

**Figure 5:** Trigger settings
Working with the INSTEK Signal Generator

Figure 6: Front Panel of the Signal Generator

Don’t be confused by the large number of buttons on the front panel, you will only use a few of them. The output voltage of the waveform generator is connected to the circuit with a BNC-adapter at outlet E. For the experiments, waveform, frequency, and voltage have to be adjusted.

Choosing the waveform

With the "WAVE”-button (item A in Fig. 6), one can toggle between triangular, rectangular, and sine wave as an output. The choice is displayed directly below this button.

Setting the frequency

The output frequency of the generator can be set in two ways:

- Direct input via the keypad (item B of Fig. 6), type the number and enter the value by pressing the appropriate unit (Hz, kHz, or MHz).

- If a value is already entered and displayed, each single digit can be changed separately. With the two keys (item D of Fig. 6), the active digit is selected, it is blinking a few seconds after the selection. Then, with knob C, the digit can be changed, wait at least one second, until the change becomes active at the output.

Setting the amplitude

The output voltage is continuously variable with knob F.