Wrocław University of Science and Technology

ELECTRIONIC MEASUREMENTS
LABORATORY REPORT

Chair of Electronic and Photonic Metrology
ELECTRIONIC MEASUREMENTS LABORATORY

Theme of class: OSCILLOSCOPE

Group no: 1

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1 Introduction

The goal of the laboratory was to learn how to use an oscilloscope and a signal generator. We configured the signal, observed various signal shapes and measured signal parameters such as frequency, magnitude, phase shift, period, and average value.

Theory

An oscilloscope, formerly known as an oscillograph, is an instrument that graphically displays electrical signals and shows how those signals change over time.

There are two types of oscilloscopes: analog and digital. An analog oscilloscope captures and displays the voltage waveform in its original form, while a digital oscilloscope uses an analog-to-digital converter to capture and store information digitally. Nowadays most engineers use digital oscilloscopes for designing and debugging digital circuits.

A brief history

The oscilloscope was invented by a French physicist André Blondel in 1893. His device was able to register the values of electrical quantities such as alternative current intensity. An ink pendulum attached to a coil recorded the information on a moving paper tape. The first oscilloscopes had a very small bandwidth, between 10 and 19 kHz.

How does an oscilloscope work?

To fully understand experiments with an oscilloscope, we have to know how it works.

First of all, an oscilloscope is a combination of various components. But, there are four that are the most important among all. These are:

- CRT
  - The cathode ray tube is used to display a graph of the voltage or current at a given point in time. The voltage is applied to the cathode, and the ammeter measures the current. The electrons are then accelerated towards the anode, and the voltage controls the beam's intensity. This creates a beam of electrons that scans the screen from left to right, and the beam's intensity is proportional to the current.
- Vertical control
  - Vertical control adjusts the voltage displayed on the screen. The height of the waveforms determines this voltage on the screen. The higher the waveforms, the higher the voltage. The vertical control allows you to adjust the voltage to match the waveforms on the screen.
- Horizontal control
  - Horizontal control allows the oscilloscope to display a single horizontal line on the screen. It can be used to adjust the timebase, which is the time it takes for the oscilloscope to draw a single horizontal line on the screen. This is measured in milliseconds (ms) and can be adjusted by turning the horizontal control knob.
- Triggering control

– Triggering controls the timing of the waveform display. The waveforms are displayed in the time domain, so triggering is used to control the start and stop times of the waveforms. Triggering is also used to control the acquisition of data.

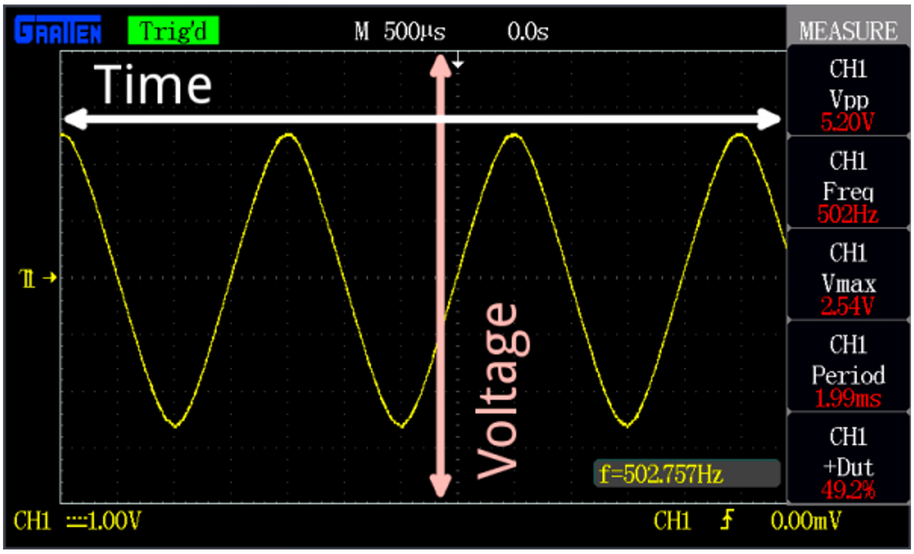

Figure 1: Scaled signal in time and amplitude

Digital oscilloscopes work by sampling voltage at a fixed rate and displaying the voltage waveforms on a digital screen. The voltage waveforms are displayed as a series of dots representing the voltage amplitude at a specific point in time. The oscilloscope samples the voltage waveforms at a fixed rate and calculates the average voltage between the samples. This process is repeated for every sample, and the resulting waveform is displayed on the oscilloscope's screen. So This is ....

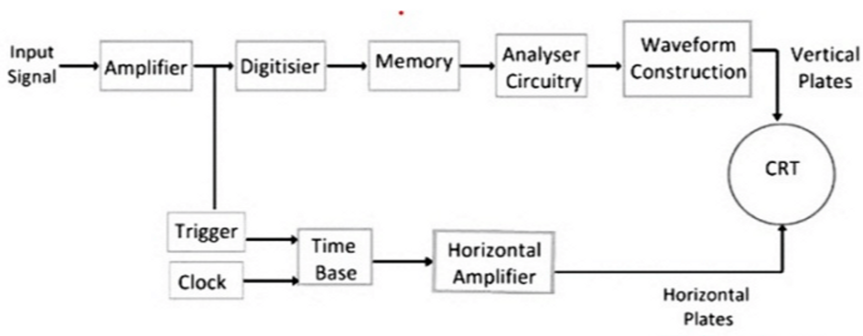

Figure 2: Schematic example

2 Experiment

2.1 Setup

2.2 Measurement methods

First, we explored different ways of obtaining the parameters' values. We configured the signal generator to $f = 864\,\mathrm{Hz}$, $U_{pp} = 2.6\,\mathrm{V}$ and connected it to the first oscilloscope channel.

Direct

To obtain parameters' values using the direct method, one must read the peak-to-peak distance from the oscilloscope's display and multiply it by the setting of the vertical sensitivity knob. The picture may be shifted to facilitate reading.

The vertical sensitivity knob was set to $0.5\,\mathrm{V}$. Table 1 shows the parameters' values.

$Y[div]$	C_y[V]	f[Hz]	V_{pp}[V]	V_m[V]	V_0[V]	T[µs]
5.1	0.5	864	2.55	1.275	0.3	1157

Table 1: Direct method (Y – peak-to-peak distance, C_y – sensitivity, f – frequency, V_{pp} – peak-to-peak value, V_m – magnitude, V_0 – average (DC) value, T – period)

V_{pp}, V_m and T calculations are shown in Equations 1, 2, 3.

$$V_{pp} = Y \cdot C_y = 5.1 \cdot 0.5\,\mathrm{V} = 2.55\,\mathrm{V} \tag{1}$$

$$V_m = \frac{V_{pp}}{2} = \frac{2.55\,\mathrm{V}}{2} = 1.275\,\mathrm{V} \tag{2}$$

$$T = \frac{1}{f} = \frac{1}{864\,\mathrm{Hz}} = 0.001\,157\,407\,407\,\mathrm{s} = 1157\,\mathrm{\mu s} \tag{3}$$

Cursors

In the cursors method, the measurement is performed indirectly via two pairs of horizontal and vertical cursors. The distance between a pair of cursors is displayed on the screen. Therefore, e.g. signal peak-to-peak value may be measured by aligning horizontal cursors with its opposite peaks.

The cursors were positioned at $1.64\,\mathrm{V}$ and $-0.96\,\mathrm{V}$. Table 2 shows the parameters' values.

V_a[V]	V_b[V]	f[Hz]	V_{pp}[V]	V_m[V]	V_0[V]	T[µs]
1.64	-0.96	864	2.6	1.3	0.3	1157

Table 2: Direct method (V_b – 1st cursor, V_b – 2nd cursor, f – frequency, V_{pp} – peak-to-peak voltage, V_m – magnitude, V_0 – average (DC) voltage, T – period)

V_m and T calculations are shown in Equations 4, 5.

$$V_m = \frac{V_{pp}}{2} = \frac{2.6\,\mathrm{V}}{2} = 1.3\,\mathrm{V} \tag{4}$$

$$T = \frac{1}{f} = \frac{1}{864\,\text{Hz}} = 0.001\,157\,407\,407\,\text{s} = 1157\,\mu\text{s} \tag{5}$$

Measure

In the measure method, a "measure" button is pressed on the oscilloscope to obtain the results. The peak-to-peak value is then read directly from the display.

Table 3 shows the parameters' values.

f[Hz]	V_{pp}[V]	V_m[V]	V_0[V]	T[µs]
864	2.6	1.3	0.3	1157

Table 3: Direct method (f – frequency, V_{pp} – peak-to-peak voltage, V_m – magnitude, V_0 – average (DC) voltage, T – period)

V_m and T calculations are shown in Equations 6, 7.

$$V_m = \frac{V_{pp}}{2} = \frac{2.6\,\text{V}}{2} = 1.3\,\text{V} \tag{6}$$

$$T = \frac{1}{f} = \frac{1}{864\,\text{Hz}} = 0.001\,157\,407\,407\,\text{s} = 1157\,\mu\text{s} \tag{7}$$

2.3 Triggering

In this part of the experiment we observed what happens to displayed signals when different trigger sources are used. We generated two signals and connected them to Channels 1 and 2.

- CH1
  - $V_0 = 0\,\text{V}$
  - $V_{pp} = 2.3\,\text{V}$
  - $f = 864\,\text{Hz}$ or $f = 1\,\text{kHz}$
- CH2
  - $V_0 = 0\,\text{V}$
  - $V_{pp} = 2\,\text{V}$
  - $f = 4\,\text{kHz}$

Next, different frequency and trigger combinations were tried. Table 4 shows the collected data.

f_1[kHz]	f_2[kHz]	Trigger source	Graph
0.864	4	CH1	Unstable
1	4	CH1	Stable
1	4	CH2	Unstable
0.864	4	CH2	Unstable

Table 4: Frequency and trigger combinations

2.4 Oscilloscope functions

In the last part of the experiment we investigated two functions offered by the device: Math and Acquire.

The Math function facilitates performing operations such as signal addition, subtraction, multiplication, etc.

The Acquire function is used to control how the waveform is generated by varying the sample rate of the ADC (analog-to-digital) converter, and offers various acquisition modes. During the laboratory we used the Averaging Acquisition Mode - it averaged out the noise in the taken samples and displayed the underlying signal.

3 Conclusions

3.1 Measurement methods

All methods returned similar results. The direct method proved to be the least precise, which shouldn't come as a surprise as it involves the most amount of human work.

3.2 Triggering

Most combinations proved to be unstable, and the non-triggering wave appeared to be moving. This was a result of the trigger happening at the wrong time - we could only see a part of the wave that was getting re-drawn at certain intervals.

The combination $f_1 = 1\,\mathrm{kHz}$, $f_2 = 4\,\mathrm{kHz}$, Trigger source = CH1 was stable because:

- the first period was a multiplication of the second, so the drawing was always triggered at the beginning of each wave;
- the triggering wave had a bigger period, so by the time the trigger was released, the second wave was done getting drawn.

3.3 Oscilloscope functions

The Averaging Acquisition Mode is useful when we want to see the underlaying wave. It's worth noting, however, that this mode will remove any random noise, hence it should not be used when accurate reading is necessary.