

# Wrocław University of Science and Technology

## ELECTRONIC MEASUREMENTS LABORATORY REPORT

Chair of Electronic and Photonic Metrology  
ELECTRONIC MEASUREMENTS LABORATORY

Theme of class: DC CURRENT MEASUREMENT

Group no: 1

Students:

1. Paulina Nowak 251002
2. Ivan Melnyk 275510
3. Stanislav Kustov 275512

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Lab assistant: mgr inż. Krzysztof Adamczyk

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## 1 Introduction

In the last laboratory we were learning about DC voltage measurement with an analogue and digital multimeter. We explored their parameters and calculated measurement errors and found out their sources.

### First Experiment

In the first experiment we connected voltmeter parallel to the circuit which consists of power source and resistor. From the lecture we know that proper way to measure voltage is to connect voltmeter with infinite internal resistance, so current does not flow through, but in real world meter is not ideal and it's changes the measured value. During this experiment we observe the influence of internal voltmeter resistance on the accuracy of measurement.

### Second Experiment

In the second experiment we are using two voltmeters power supply and voltage divider. We learned how voltage dividers work and how load on output changes output voltage. We will consider 4 different configurations: 2 with internal resistance of 1 k Ohm and two with 1 M Ohm using different k coefficients.

## 2 Experiment

### 2.1 Setup

During the laboratory we used the SDG1025 signal generator and a "SDS1052DL+" oscilloscope.

Detailed explanation of how we used it

SDG1025 signal generator

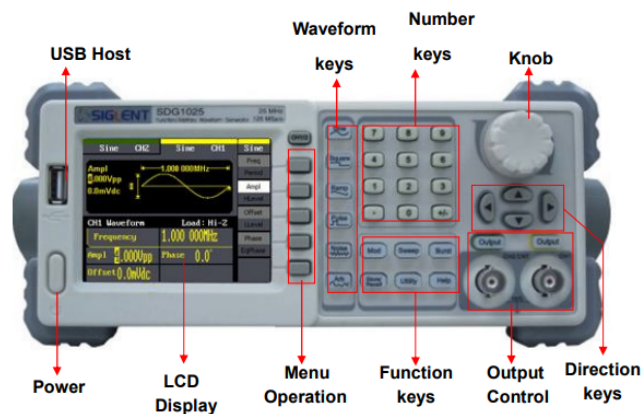


Figure 1: SDG1025

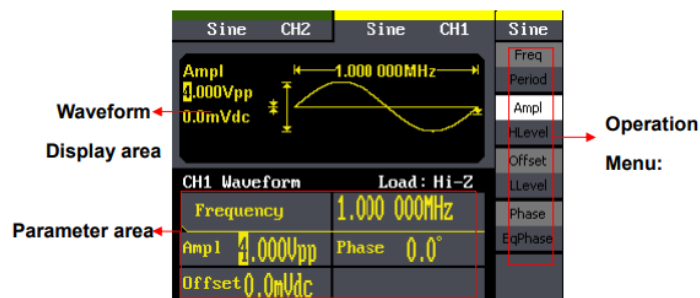


Figure 2: SDG1025 interface

- To set a waveform we used buttons with a waveform icon that are on **"waveform keys"** panel.
- With "Sine" button waveform window will display sine waveform.
- By setting frequency/period, amplitude/high level, offset/low level, sine signal with different parameters can be generated.
- To set freq and another parameters we used **Number keys**, all parameters displayed in **"Parameter Area"**

- We used two buttons on the right side of the operation panel, which are used to activate or deactivate the output signal.
- There are three sets of buttons on the operation panel, which are direction button, the knob and the keypad.
- The up and down keys were used to shift parameters and the left and right keys were used to shift digits.
- Keypad was used to directly set the parameters value.
- Knob was used to change a signal digit value whose range is 0 9



Function menu	Setting	Explanations
Freq/ Period		Set the signal frequency or period; The current parameter will be switched at a second press.
Ampl/ HLevel		Set the signal amplitude or high level; The current parameter will be switched at a second press.
Offset/ LLevel		Set the signal offset or low level; The current parameter will be switched at a second press.
Phase/ EqPhase		Set the phase of the signal; The current parameter will be switched at a second press.

Figure 3: Setting sign signals

- To Set the Output Frequency/Period we used "Sine" and "Freq" buttons. The frequency shown on the screen when the instrument is powered is the default value or the set value beforehand. When setting the function, if the current value is valid for the new waveform, it will be used sequentially. Also we used direction button to select the digit you want to edit and direction button to select the digit you want to edit. - We applied the same for the rest of the parameters using "Ampl", "Offset" and "Phase" buttons.

## ”SDS1052DL+” oscilloscope

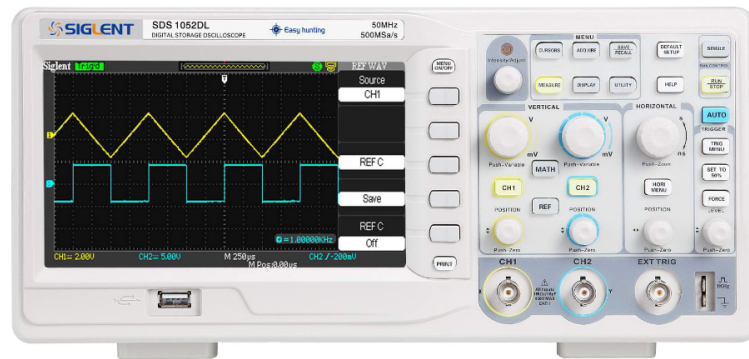


Figure 4: Schematic example

### Menu and Control Button

- It would be better to start from channel buttons. We used them to turn that channel ON or OFF and open the channel menu for that channel. Also we can use the channel menu to set up a channel. When the channel is on, the channel button is lit.
- RUN/STOP: Continuously acquires waveforms or stops the acquisition.
- SET TO 50%: We used it to stabilize a waveform quickly. The oscilloscope can set the trigger level to be halfway between the minimum and maximum voltage level automatically.
- MATH: It used to display the Math menu. We can use the ”**MATH**” menu to use the oscilloscopes Math functions.
- ”HORI MENU”: We used it to display the Horizontal menu. We can use the Horizontal menu to display the waveform and zoom in a segment of a waveform.
- MEASURE: Used to display a menu of measurement parameters.
- AUTO: Very useful button. Automatically sets the oscilloscope controls to produce a usable display of the input signals.
- SINGLE: Acquire a single waveform and then stops.
- Channel Connector (CH1, CH2): Input connectors for waveforms display.
- The horizontal position control establishes the time between the trigger position and the screen center. We can adjust the horizontal ”POSITION” knob control to view waveform data before the trigger, after the trigger, or some of each. When we change the horizontal position of a waveform, we are changing the time between the trigger and the center of the display actually

### Universal Knob

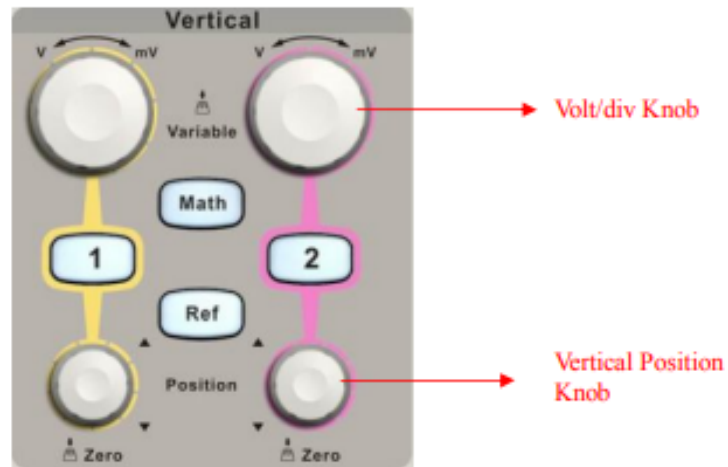


Figure 5: Universal knob

This is a very useful knob. We used the Universal knob with many functions, such as adjusting the holdoff time, moving cursors, setting the pulse width, adjusting the upper and lower frequency limit, adjust X and Y masks when using the pass/fail function etc. We can also turn the “Universal” knob to adjust the storage position of setups, waveforms, pictures when saving/recalling and to select menu options.

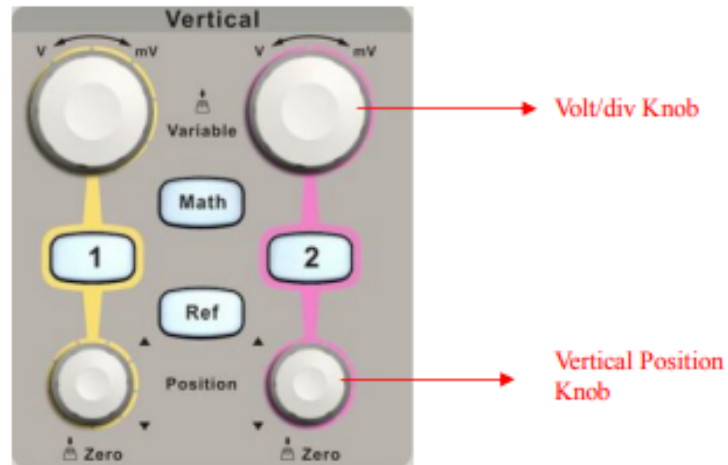
### Vertical System

We used vertical control for displaying waveform, rectify scale and position.



### Horizontal System

As shown on the picture below, there are one button and two knobs in the HORIZONTAL area. We used the horizontal controls to change the horizontal scale and position of waveforms. The horizontal position readout shows the time represented by the center of the screen, using the time of the trigger as zero. Changing the horizontal scale causes the waveform to expand or contract around the screen center.



## 2.2 Measurement methods

First, we explored different ways of obtaining the parameters' values. We configured the signal generator to  $f = 864 \text{ Hz}$ ,  $V_{pp} = 2.6 \text{ V}$  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 sensitivity knob. The picture may be shifted with knobs to facilitate reading.

The vertical sensitivity knob was set to 0.5 V. Table 1 shows the parameters' values.

$Y[div]$	$C_y[V]$	$f[Hz]$	$V_{pp}[V]$	$V_m[V]$	$V_0[V]$	$T[\mu s]$
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 voltage,  $V_m$  – magnitude,  $V_0$  – average (DC) voltage,  $T$  – period)

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

$$V_{pp} = Y \cdot C_y = 5.1 \cdot 0.5 \text{ V} = 2.55 \text{ V} \quad (1)$$

$$V_m = \frac{V_{pp}}{2} = \frac{2.55 \text{ V}}{2} = 1.275 \text{ V} \quad (2)$$

$$T = \frac{1}{f} = \frac{1}{864 \text{ Hz}} = 0.001 \, 157 \, 407 \, 407 \text{ s} = 1157 \, \mu\text{s} \quad (3)$$

**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 voltage may be measured by aligning horizontal cursors with its opposite peaks.

The cursors were positioned at 1.64 V and  $-0.96$  V. Table 2 shows the parameters' values.

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

Table 2: Direct method ( $V_b$  – 1st cursor,  $V_a$  – 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.

$$V_m = \frac{V_{pp}}{2} = \frac{2.6 \text{ V}}{2} = 1.3 \text{ V} \quad (4)$$

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

**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.

$f[\text{Hz}]$	$V_{pp}[\text{V}]$	$V_m[\text{V}]$	$V_0[\text{V}]$	$T[\mu\text{s}]$
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.

$$V_m = \frac{V_{pp}}{2} = \frac{2.6 \text{ V}}{2} = 1.3 \text{ V} \quad (6)$$

$$T = \frac{1}{f} = \frac{1}{864 \text{ Hz}} = 0.001157407407 \text{ s} = 1157 \mu\text{s} \quad (7)$$

### 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.

$f_1[\text{kHz}]$	$f_2[\text{kHz}]$	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 Measurements**

At this laboratory we learned that measuring devices are not ideal and have own resistance which shouldn't come as a surprise and we have to take this fact into account while making measurements.

### **3.2 First Experiment**

### **3.3 Second Experiment**