Digital Oscilloscope used for engineering measurements

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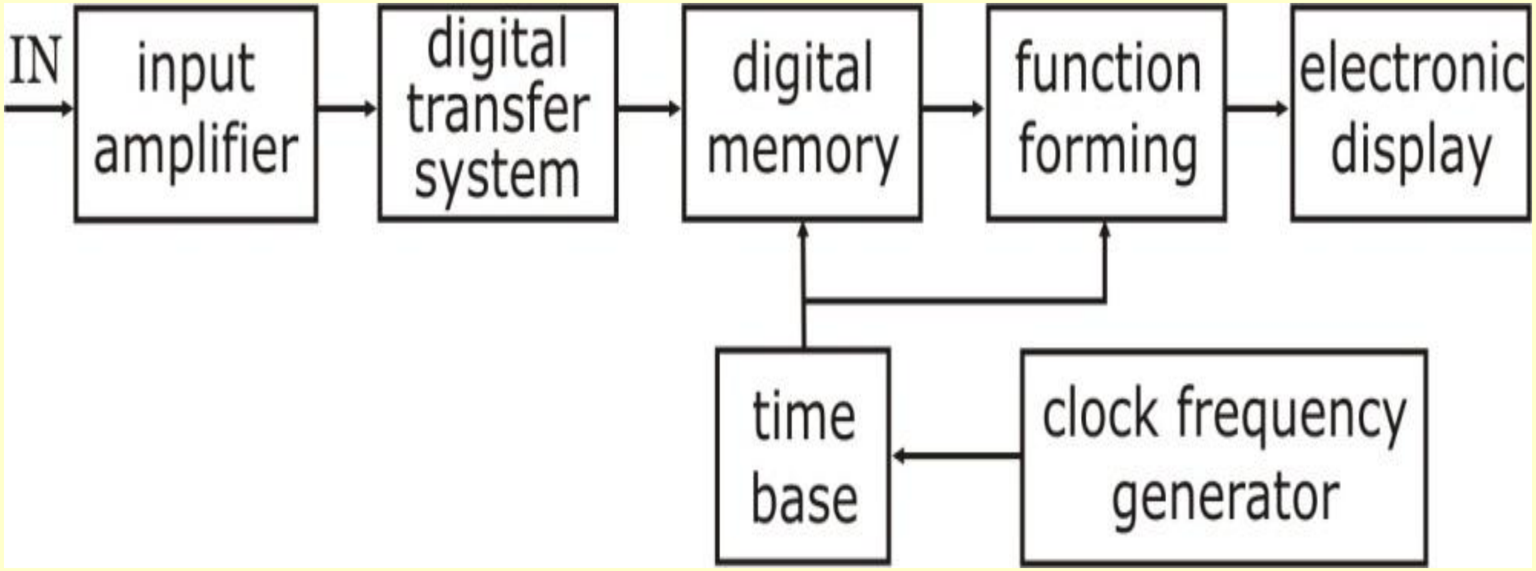
An oscilloscope

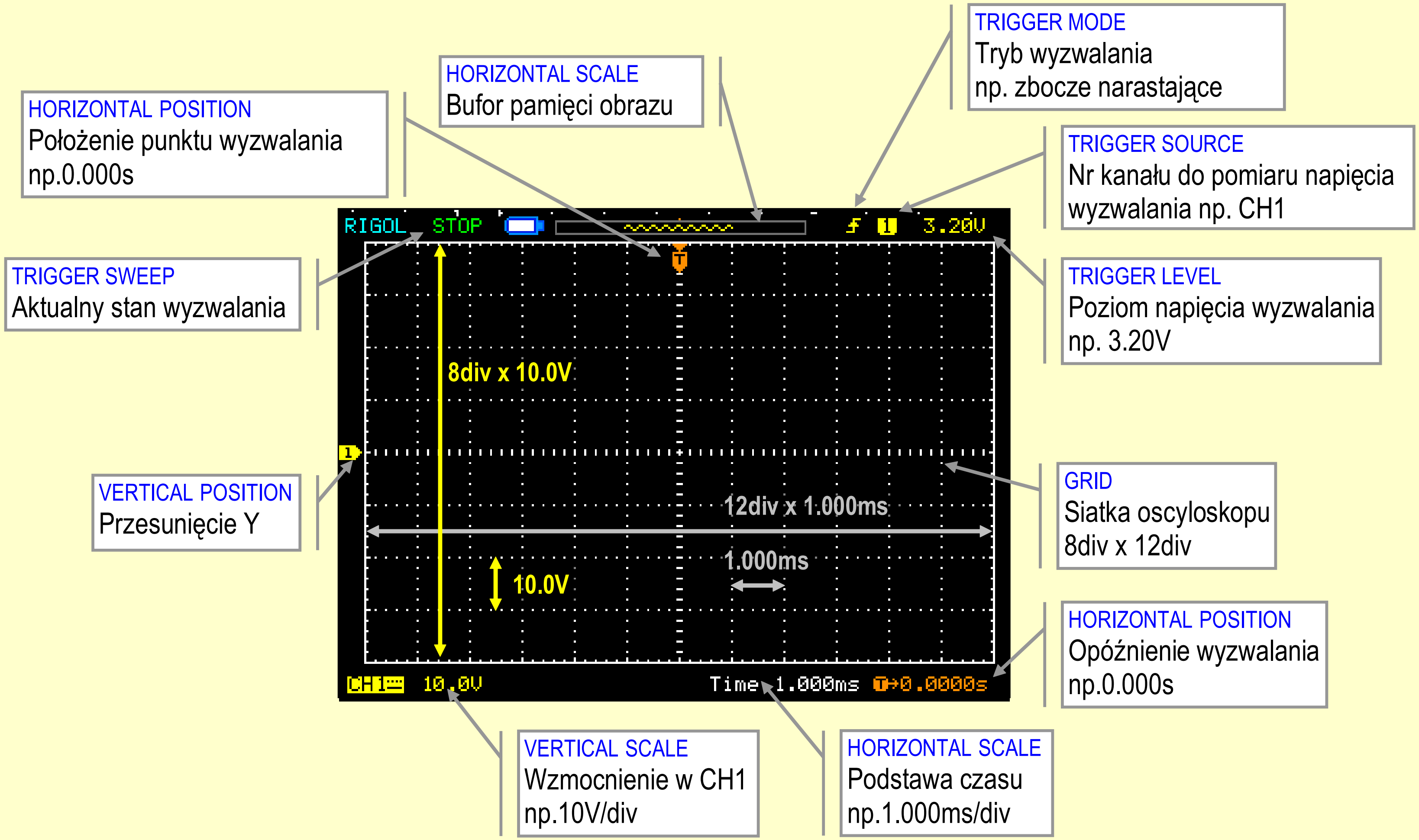
- An oscilloscope (referred to as a scope for short) is a universal measuring instrument capable of measuring a variety of rapidly changing electrical signals.. The oscilloscope displays graphs of voltage against time. Nowadays, oscilloscope is one of the most versatile and widely used electronic instruments for measurement and diagnostic purposes. It is used to diagnose electronic systems and characterize parameters of electrical signals. The digital oscilloscope offers a recording of sampled signals, mathematical operation on signals and the Fourier analysis. Most oscilloscopes can be operated by computers via USB interface. Sampled signals and their parameters can be recorded and saved in the form of files. Image from oscilloscope screen can be transferred to computer for further analysis.

The block diagram of digital oscilloscope

- The block diagram of a digital oscilloscope is shown in figure below. The analogue signal passes through an instrumental amplifier to digital transfer system, in which signal is sampled and quantised, and transformed into digital form. The frequency of sampling depends on the range of the time base, which is synchronised by the clock.



View of a typical oscilloscope display window with grid and settings of controls



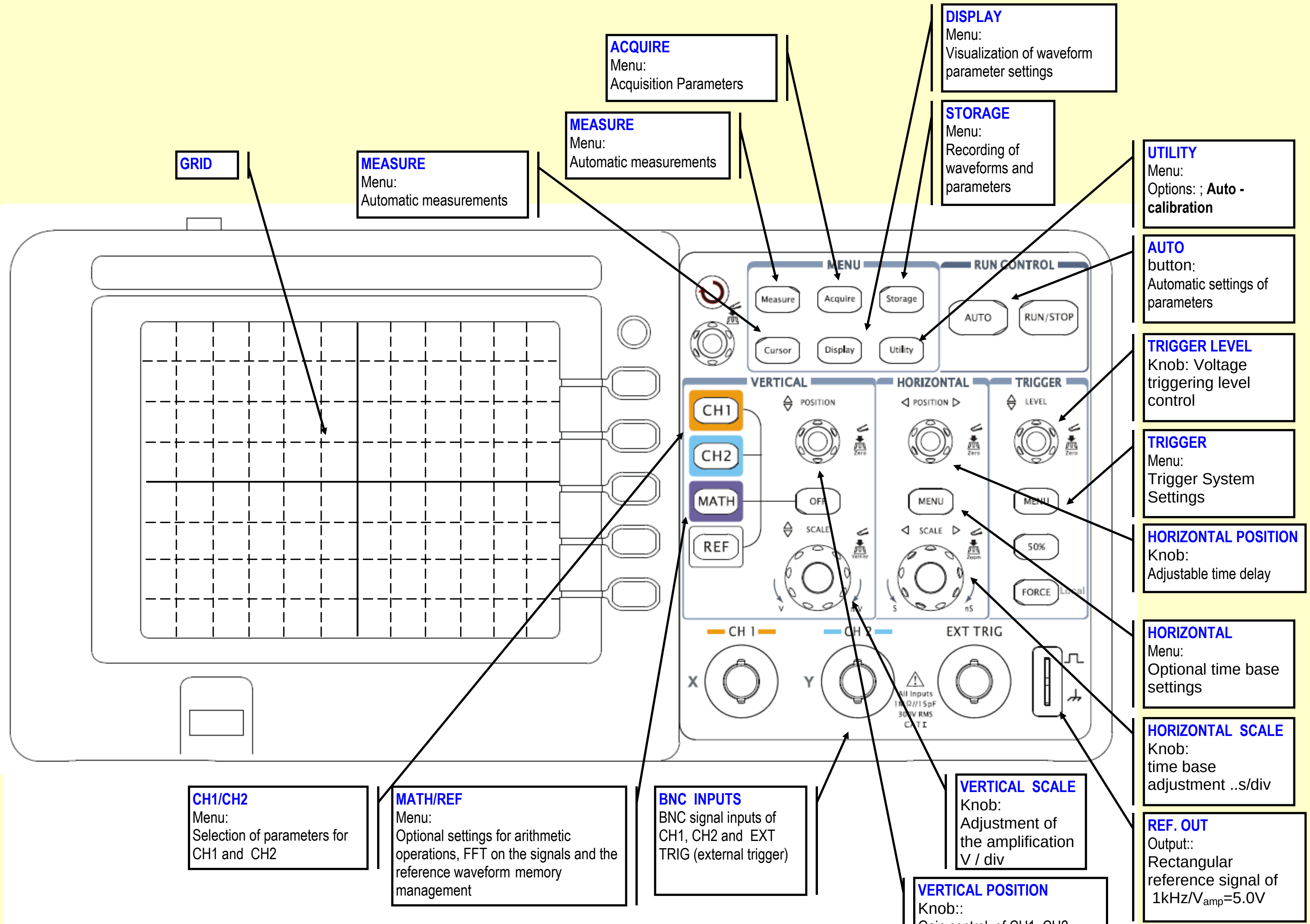
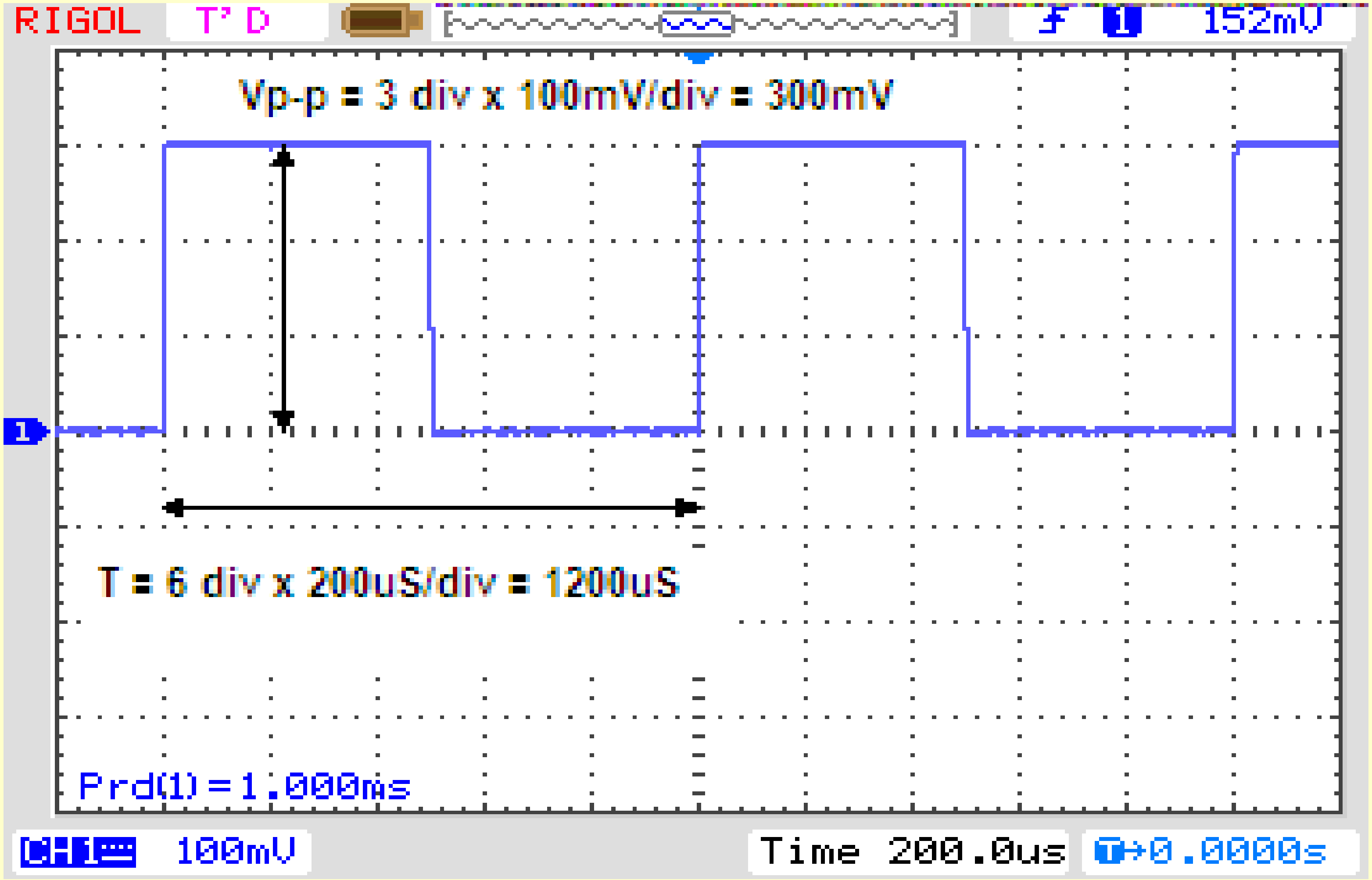
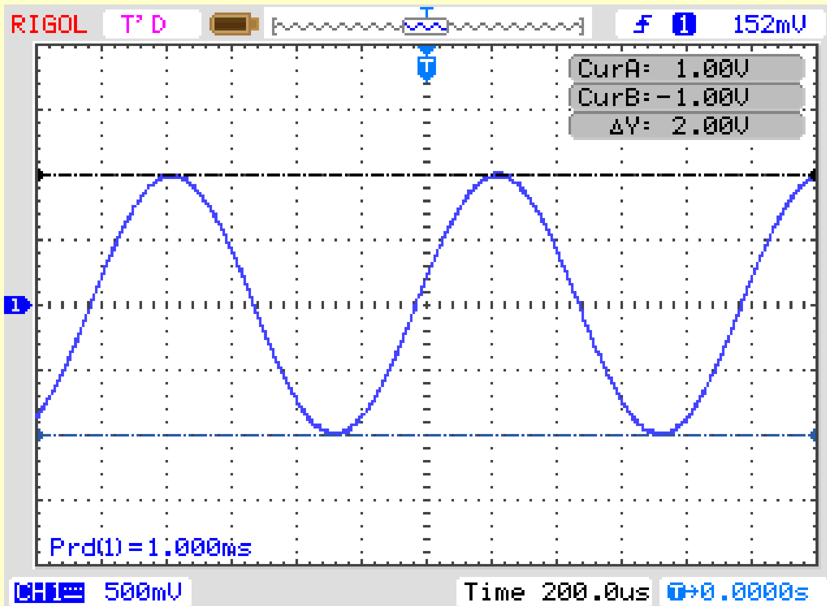


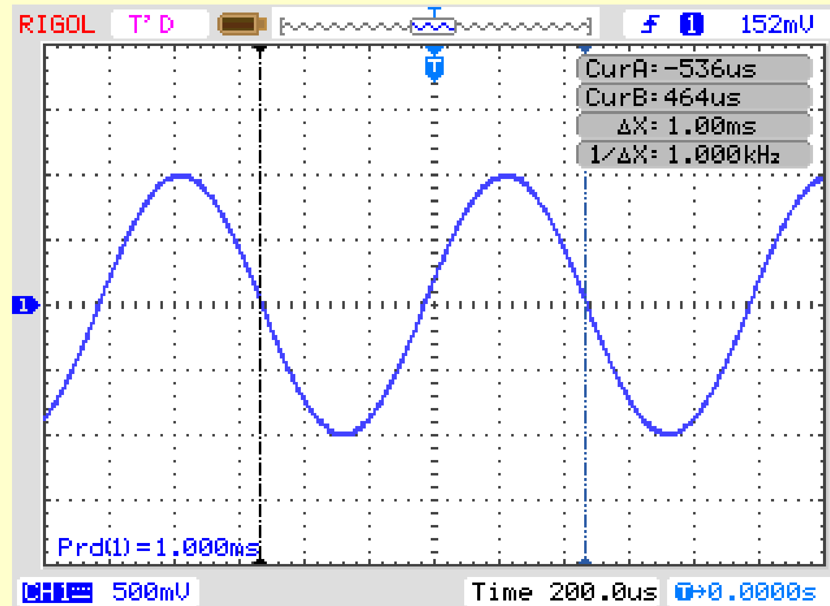
Fig 2. Control panel of Digital oscilloscope

direct reading from oscilloscope grid



peak-to-peak voltage measurement





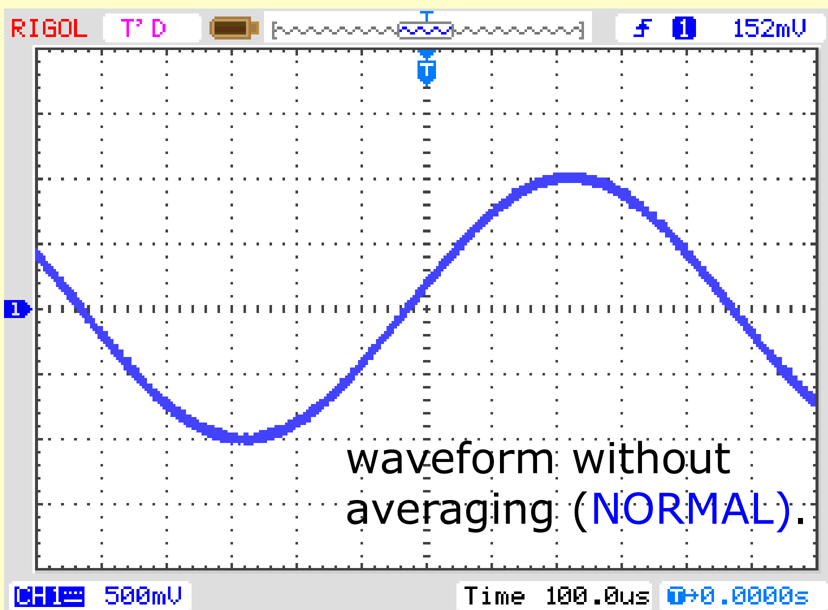
Example of peak-to-peak voltage measurement V_{p-p} using OY CURSOR; b) T – period of waveform measurement be using OX CURSOR

automatic measurement function

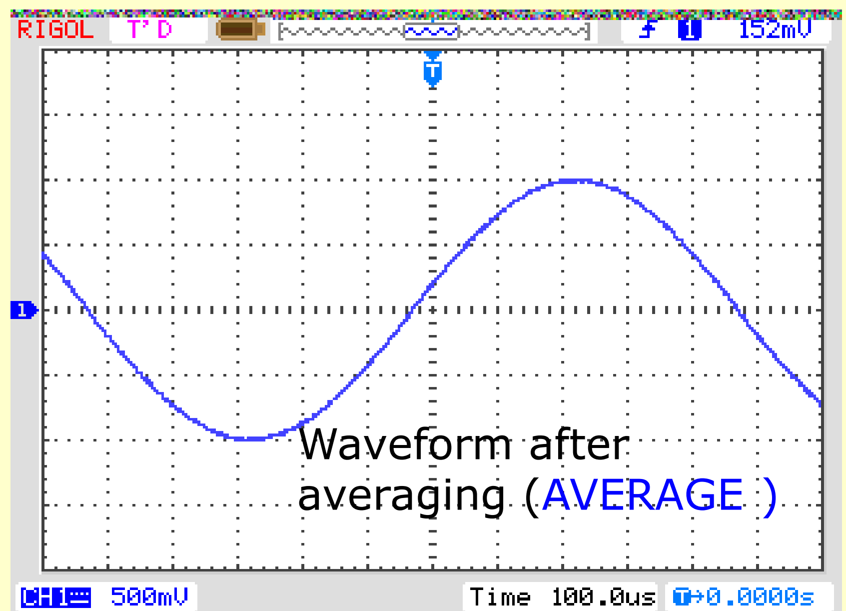
The third method is to use automatic measurement function. To activate of automatic measurement mode use button from menu MEASURE. Amplitude (V_{AMP}), peak-to-peak (V_{P-P}), Maximum value (V_{MAX}), minimum value (V_{MIN}), average (V_{AVG}), RMS value (V_{RMS}), period (T_P), frequency (f), raising time (t_R), falling time (t_F), pulse width in low state (t_L), pulse width in high state (t_H), duty cycle (C_D), time delay (t_D), are displayed.

averaging function

The averaging function is used to reduce noise or unwanted disturbances influencing measured waveform.
Averaging is done over the required number of samples the choice of which is availed from: ACQUIRE/ACQUISITION->AVERAGE.

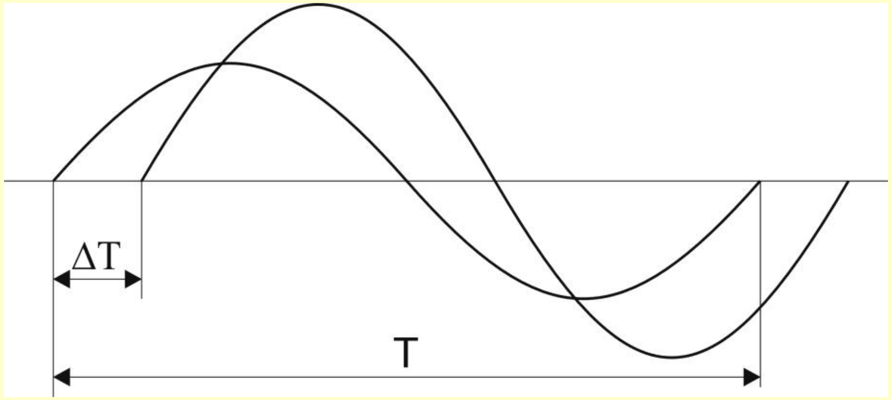


waveform without averaging (NORMAL).



Waveform after averaging (AVERAGE)

Phase Shift measurement - direct method



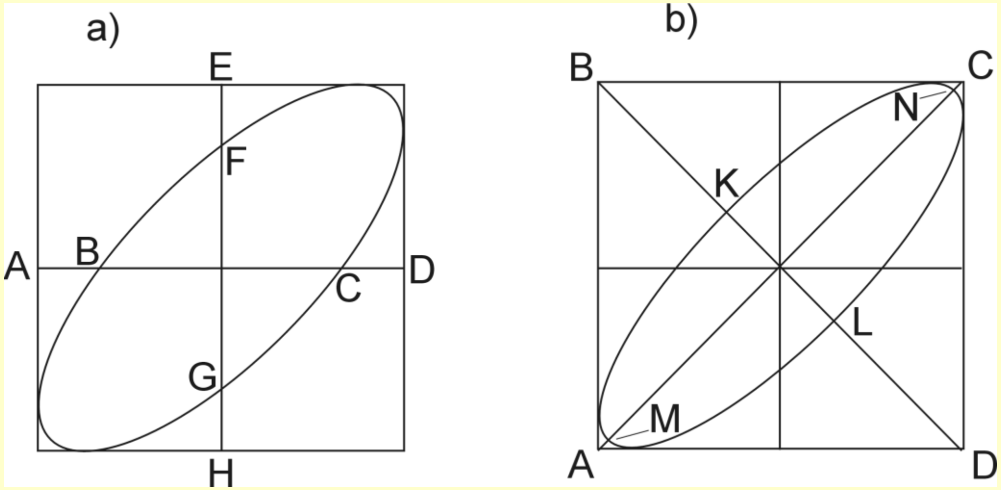
$$\varphi = 2\pi \frac{\Delta T}{T}$$

ΔT- time difference between to moments when
two waveforms are crossing 0X axis,
T- period – time of one waveform period
of the signal under test.

1st direct method (method based on shift transformation in time interval)
2nd Lissajous patterns method based on ellipse shape
3rd Compensation method,

Phase Shift measurement –Lissajous

for larger shift $\varphi > \frac{\pi}{3}.$ $\sin\varphi = \frac{FG}{EH}.$ $\sin\varphi = \frac{BC}{AD}.$

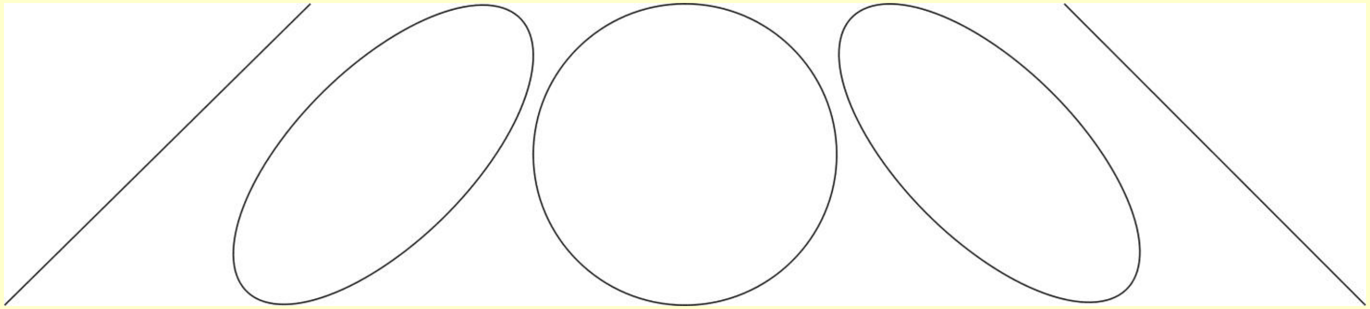


$$\varphi = \arcsin\frac{FG}{EH} = \arcsin\frac{BC}{AD}$$

$$tg\,\frac{\varphi}{2} = \frac{KL}{MN} \qquad \varphi = 2\cdot arctg\,\frac{KL}{MN}$$

very small

$$\varphi = \arcsin\frac{KL}{AD}\frac{MN}{CD}$$



0°, 360° **45°, 315°** **90°, 270°** **135°, 225°** **80°**

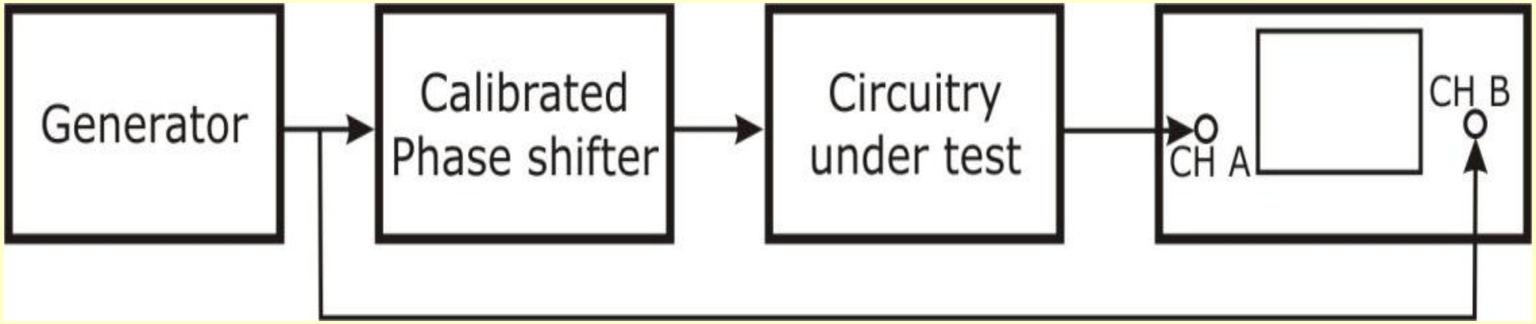
Phase Shift measurement –Lissajous

$$\delta\varphi = \left| \frac{FG \cdot \delta FG}{EH \sqrt{1 - \left(\frac{FG}{EH}\right)^2} \arcsin \frac{FG}{EH}} \right| + \left| - \frac{FG \cdot \delta EH}{EH \sqrt{1 - \left(\frac{FG}{EH}\right)^2} \arcsin \frac{FG}{EH}} \right|$$

A condition that must be fulfilled in the method of the ellipse is equal amplitudes along the two axes, namely AB = AD. Both presented methods for determining the phase angle involving ellipse are rather of low accuracy: t
he result is expected to be within a few %. Error is caused by:

•Not accurate measurement of separation between points on the ellipse,
•The finite thickness of the line representing ellipses on the screen,
•uncompensated parasitic phase shifts,
•inaccurate setting of equality of both amplitudes.

Phase Shift measurement – compensation method



The method is based on compensation of phase shift between two harmonic signals using calibrated phase shifter to archive 0 shift or complement to 2π.

Oscilloscope is used as compensation indicator.
The compensation phase α is read on the scale of phase shifter.
If straight line is inclined to the right then compensation is , $\phi=-\alpha$
if inclined to the left then compensation is $\phi = \pi-\alpha$

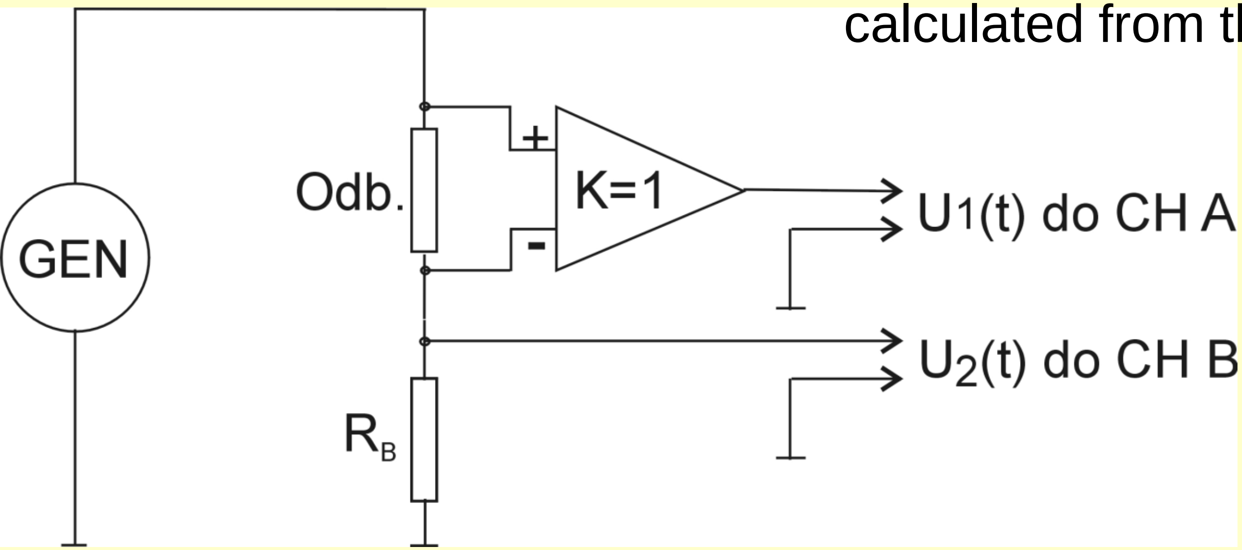
Electrical power measurement

$$P = \frac{1}{T}\int_0^T u(t)\cdot i(t)dt$$

There are several methods of the electrical active power measurement of small values (mW) for a wide frequency range, limited by he bandwidth of used oscilloscope.

These methods are primarily based on semi bridge method using an additional resistor or capacitor.

In such cases, the power output is calculated from the surface of the ellipse.



EXPERIMENT TASK 1

Setting up oscilloscope,

auto calibration

oscilloscope testing

by reference signals

EXPERIMENT TASK 1

Setting up oscilloscope, auto calibration

oscilloscope testing by reference signals

Table 1. Reference signal measured by oscilloscope: (rectangular pulse train signal).
V_{AMP}-amplitude, V_{P-P} – peak to peak, f – frequency,
T – period, C_D – duty factor

V_{AMP}	V_{P-P}	f	T	C_D
V	V	Hz	ms	%

EXPERIMENT TASK 2

Electrical signal parameter measurements

Table 2,3,4. Measurements of parameters of the signal No 1,2,3

signal No 1- Sin, 2 - Triangular , 3 - Rectangular					
Data acquisition mode	Type of measurement	V_{AMP}	V_{P-P}	f	T
-	-	V	V	Hz	ms
NORMAL	direct				
NORMAL	automatic				
AVERAGE 256	direct				
AVERAGE 256	automatic				

EXPERIMENT TASK 3

Phase shift measurement

Table 5. Parameters of tested signals

Parameter	Signal 1	Signal 2
Frequency [Hz]		
Level of the signal [dB]		
Phase of the signal from channel 1 φ_{01}[°]		
Phase of the signal from channel 2 φ_{02}[°]		
Phase shift between signals from channel 1 and 2 $\varphi = \varphi_{01} - \varphi_{02}$ [°]		

EXPERIMENT TASK 3

Phase shift measurement – direct method

Table 6. Phase shift measurement results and calculations

Signal 1				Signal 2			
ΔT	T	φ		ΔT	T	φ	
s	s	rad	deg	s	s	rad	deg

$$\varphi(\mathrm{deg}) = \frac{\Delta T}{T} \cdot 360 \quad and \quad \varphi(rad) = \frac{\Delta T}{T} \cdot 2\pi$$

EXPERIMENT TASK 3

Phase shift measurement – utilizing Lissajous patterns

Table 7. Phase shift measurement results and calculations

1st set of Signals 1 and 2						2nd set of Signals 1 and 2					
Fig. 8a, Eqn. (8)			Fig. 8b, Eqn. . (12)			Fig. 8a, Eqn. (6)			Fig. 8b, Eqn (12)		
FG	EH	φ	KL	MN	φ	FG	EH	φ	KL	MN	φ
div	div	deg	div	div	deg	div	div	deg	div	div	deg

$$\varphi = \arcsin\frac{FG}{EH} = \arcsin\frac{BC}{AD}$$

EXPERIMENT TASK 4

Recording and processing of data using oscilloscope communication interfaces

By using the oscilloscope STORAGE, record the data set using the oscilloscope function STORAGE/CSV file. Saving data in a file with the extension *. CSV (Comma Separated Values English) you can edit it in a spreadsheet. Please use the drawing function graphs in a spreadsheet illustrating the stored process. You must configure the settings of the chart (the number of horizontal lines and vertical grid, scale, axis) in a way which would make it possible to comply to the grid scale of the oscilloscope window. In order to compare, record a screenshot using the oscilloscope STORAGE/BITMAP