NORTH SOUTH UNIVERSITY

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Department of Mathematics & Physics

Introduction to Laboratory Equipment Manual

PHY-108L

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Breadboard

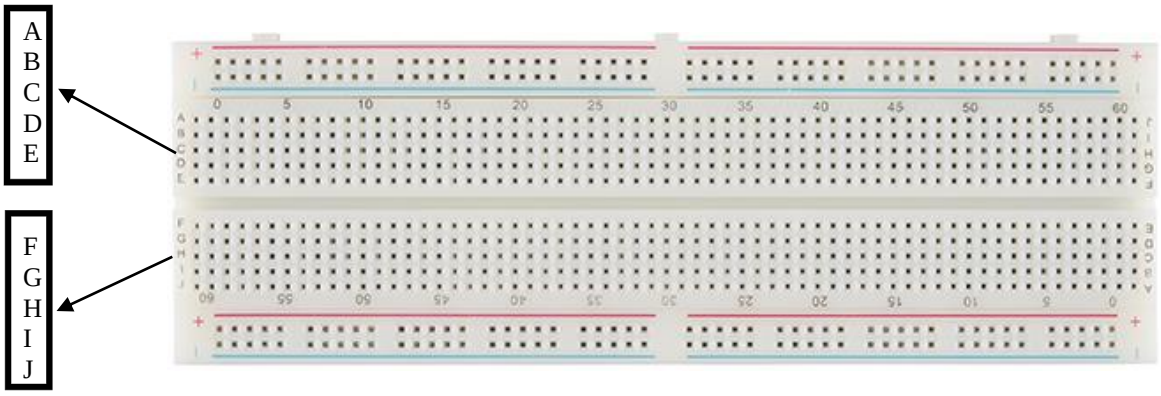


Figure 1: Breadboard (Top View)

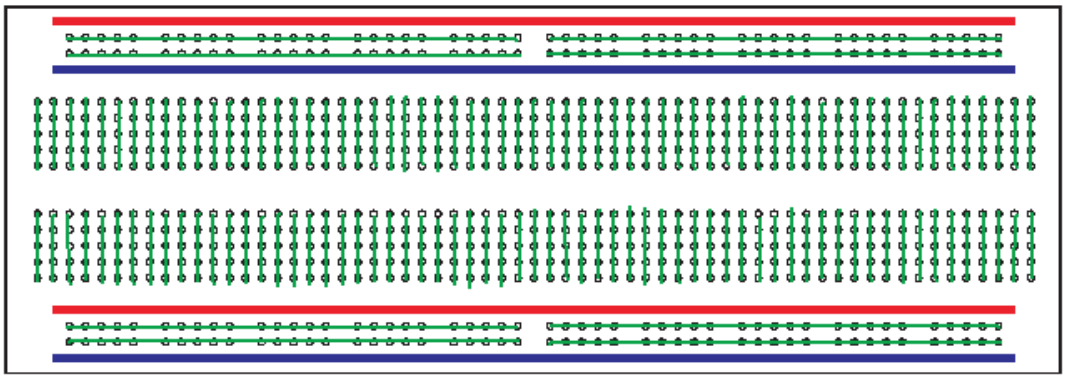


Figure 2: Breadboard (Internal connections)

A breadboard is a rectangular plastic board with a bunch of tiny holes called nodes in it. These nodes let you easily insert electronic components to build an electronic circuit. Pictures of breadboard are given above.

The green lines marked on Figure 2 show the internal connections of a breadboard. As shown in Figure 2, the nodes “A B C D E” and “F G H I J” are connected vertically. On the other hand, “+” and “-” are connected horizontally. A detailed visual picture is given below for your better understanding.

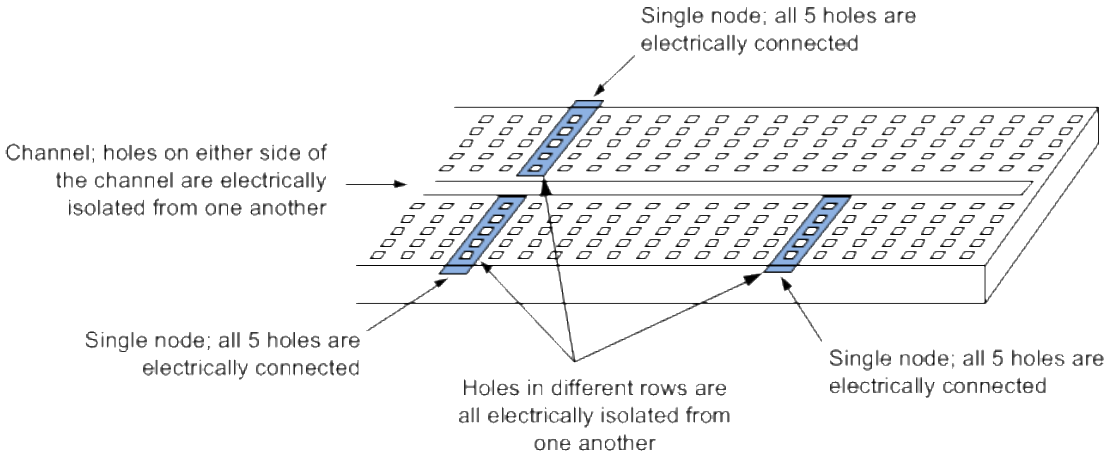


Figure 3: Detailed visualisation of a breadboard

The common components that we are going to use in the breadboard are as follows:

- **Resistor:** A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element.

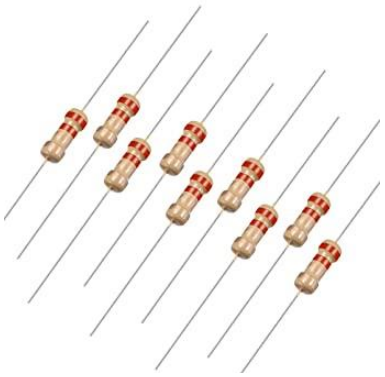


Figure 4: Resistors

- **Capacitor:** A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals.

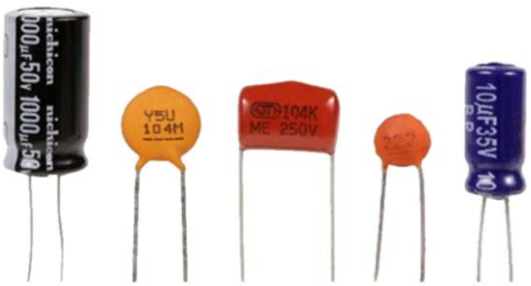


Figure 5: Capacitors

- **Inductor:** An inductor, also called a coil, choke, or reactor, is a passive two-terminal electrical component that stores energy in a magnetic field when electric current flows through it.

Figure 6: Inductors

Now, as you see in the above diagrams, most of the commonly used components have two legs. In Figure 3, observe the blue shaded rows, each of these rows depicts one single node that consist of 5 holes (A B C D E/ F G H I J), and each hole are internally connected. Now look at figure 3, there is a long break labelled as “channel”, this channel separates the two nodes “A B C D E” & “F G H I J”.

Now, let’s move on to how to connect these components in the right manner. The rule for connecting the components correctly is to avoid short connections. But how? To avoid short circuits, you must not connect the two legs of the same component in the holes from the same single node (A B C D E). For example, take a resistor, either insert one leg in any hole from the first node (A/B/C/D/E) and the other leg into any hole from a single node as mentioned in Figure 3 after the break (“F/G/H/I/J”) or insert one leg in any hole from the first single node (A/B/C/D/E) and the other leg into any hole from any other single node below/above.

A brief on parallel and series connections of different components (resistors / capacitors / inductors) is given below.

Series Connection on a breadboard:

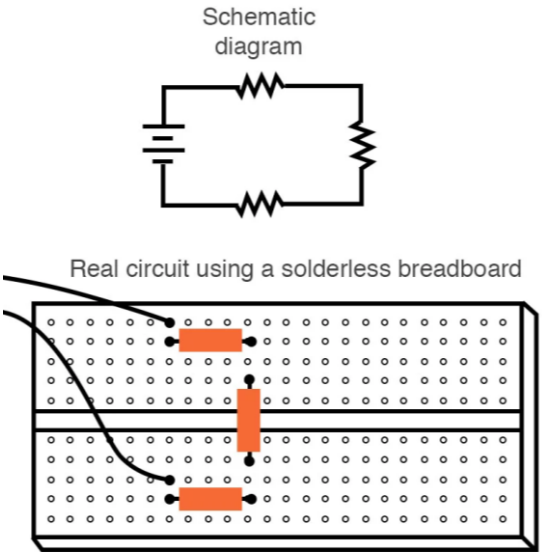


Figure 7: Method 1 for series connection on a breadboard

As you can be seen in the above Figure 7, for a series connection, you must connet one leg of a component to another leg of another component and so on. Another way of series connection is shown below. Note that the connections in Figure 8 are same as the ones in Figure 7, just the placement is different.

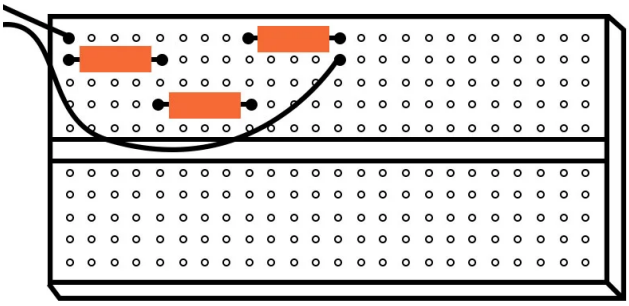


Figure 8: Method 2 for series connection on a breadboard

Parallel Connection on a breadboard:

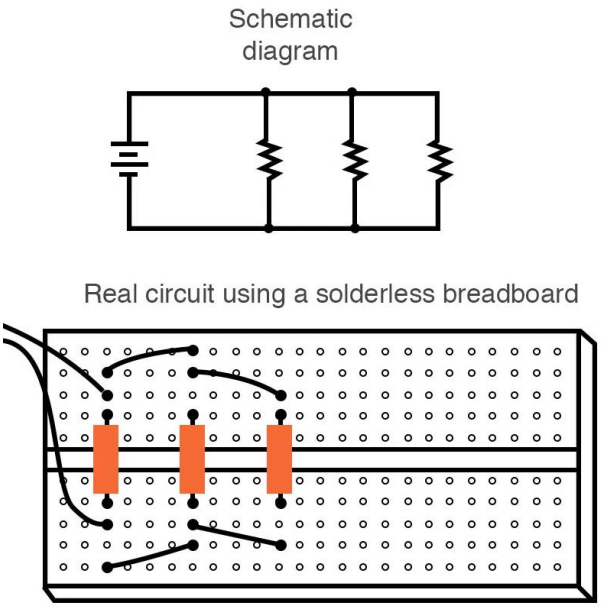


Figure 9: Method 1 for parallel connection on a breadboard

As you can be seen in above Figure 9, for a parallel connection, you must connect the legs of the components in the same node and the corresponding legs must be in another node. Note that the connections in Figure 9 are the same as the ones in Figure 10, just the placement is different.

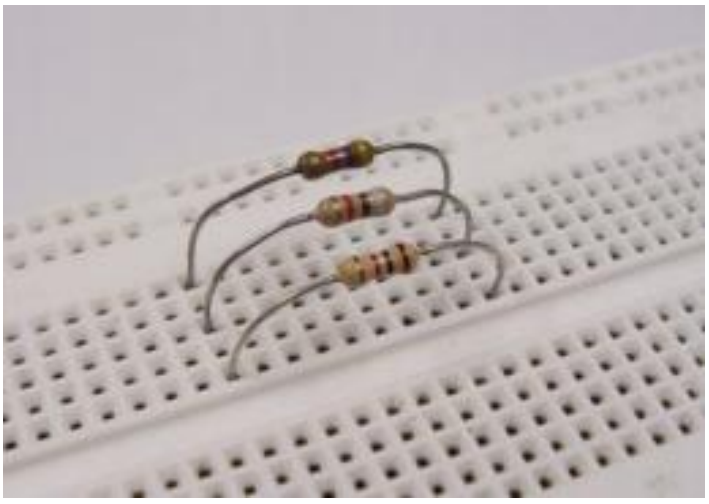


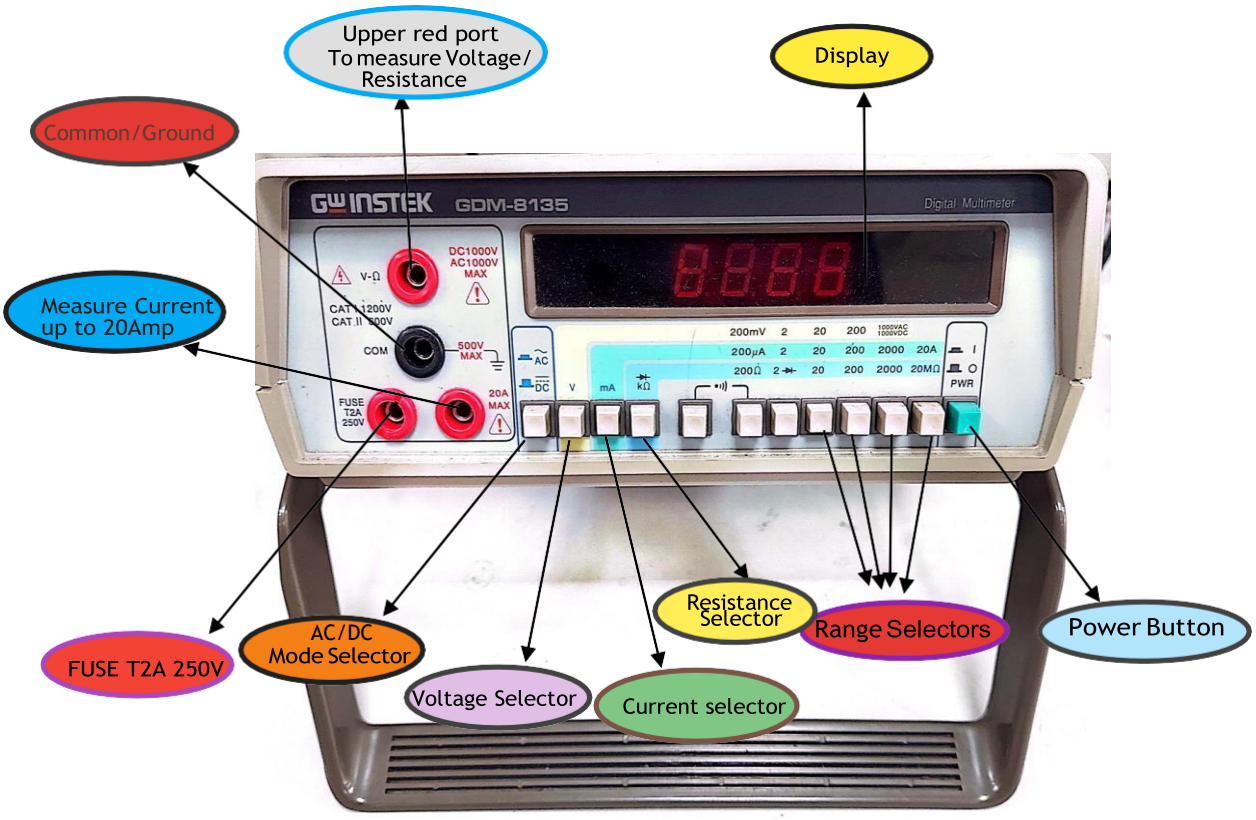
Figure 10: Method 2 for a parallel connection on a breadboard

Digital Multimeter (DMM)

A DMM is mainly used to measure current, voltage, resistance, capacitance and so on. In our lab, there are two different types of DMMs with similar functionalities and some common features such as a power button, a display, set of probes, and input jacks. The pictures of the two types are given below along with their detailed functionalities.

Figure 1: Type 1 DMM; Model: GOM-8135

Figure 2: Type 2 DMM; Model: SDM3045X



1) **Power button** – To turn on/off the DMM

2) **Range Selectors** – These buttons allow us to set the range of values. For example, If our reading is within 20 (V/mA/□), we will press the button which is labelled 20 and if our reding is 180 we will press 200.

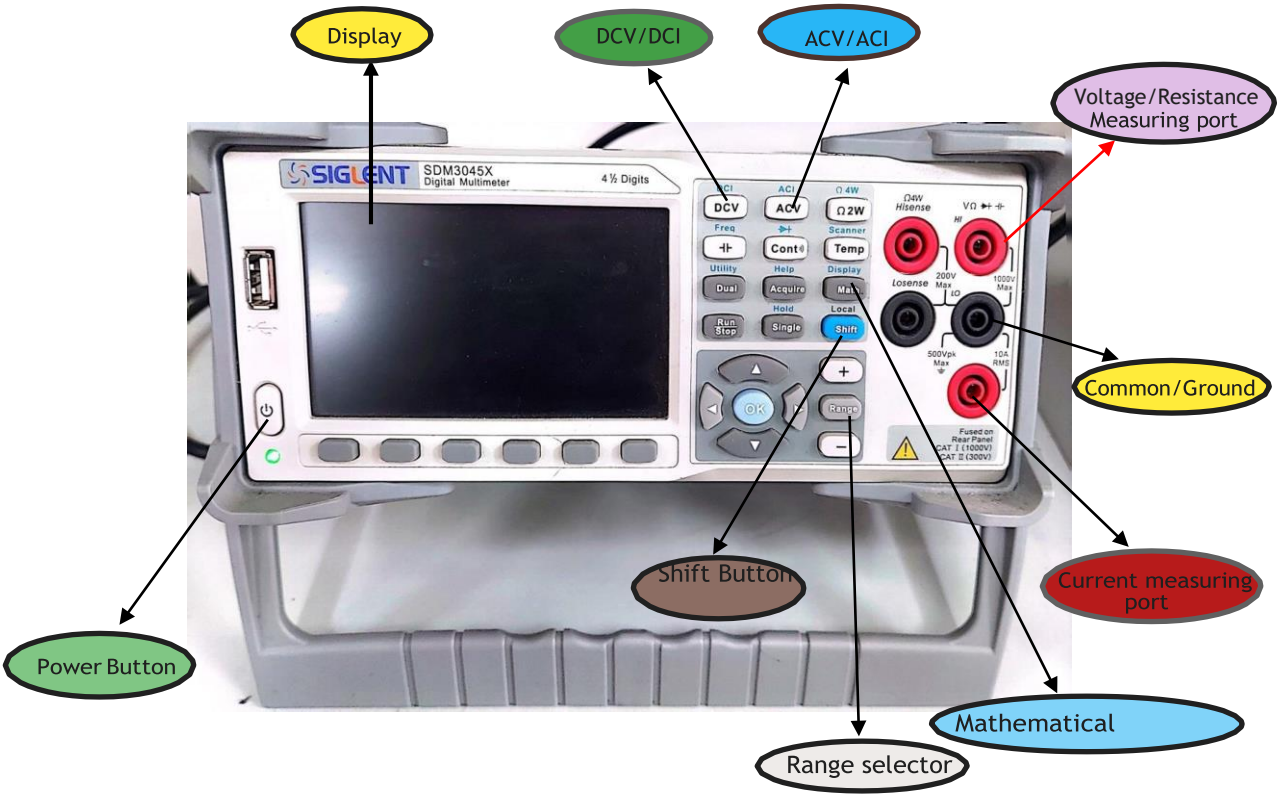
3) **Unit buttons** – We need to select the unit for which we are taking the reading.
   To measure voltage- press V
   To measure current- press mA
   To measure resistance - press kΩ

4) **Mode selector** – For DC mode, the button will be as it is. For AC, the button will have to be pressed inward.

5) **Upper red port (labelled as V −Ω)** – to measure voltage and resistance, connect the red jack here.

6) **Bottom-left red port (labelled as FUSE T2A 250V) –** to measure current, connect the red jack here.

7) **Black port (labelled ad COM)** – It is also known as common/ground. Always connect the black jack to measure any value,



1) **Power button** – To turn on/off the DMM

2) **Voltage/Resistance Measuring port (labelled as V-Ω)** – to measure voltage and resistance, connect the red jack here.

3) **Current Measuring port (labelled as 10A RMS)** – to measure current, connect the red jack here.

4) **Common/Ground port** – It is also known as common/ground. Always connect the black jack to measure any value.

5) **Range selector** – This button is usually set as Auto. However, if you need to set the range manually, you can do that with this button.

6) **DCV** – used to measure DC Voltage.

7) **DCI** -In order to measure DC Current (DCI), press shift then press DCV.

8) **ACV** - used to measure AC Voltage. But to measure AC Current (ACI), press shift then press ACV.

9) **Run/Stop** – Use to run or stop the reading.

10) **Shift Button –** To change the operational mode like DC to AC and vice versa.

DC Power Supply

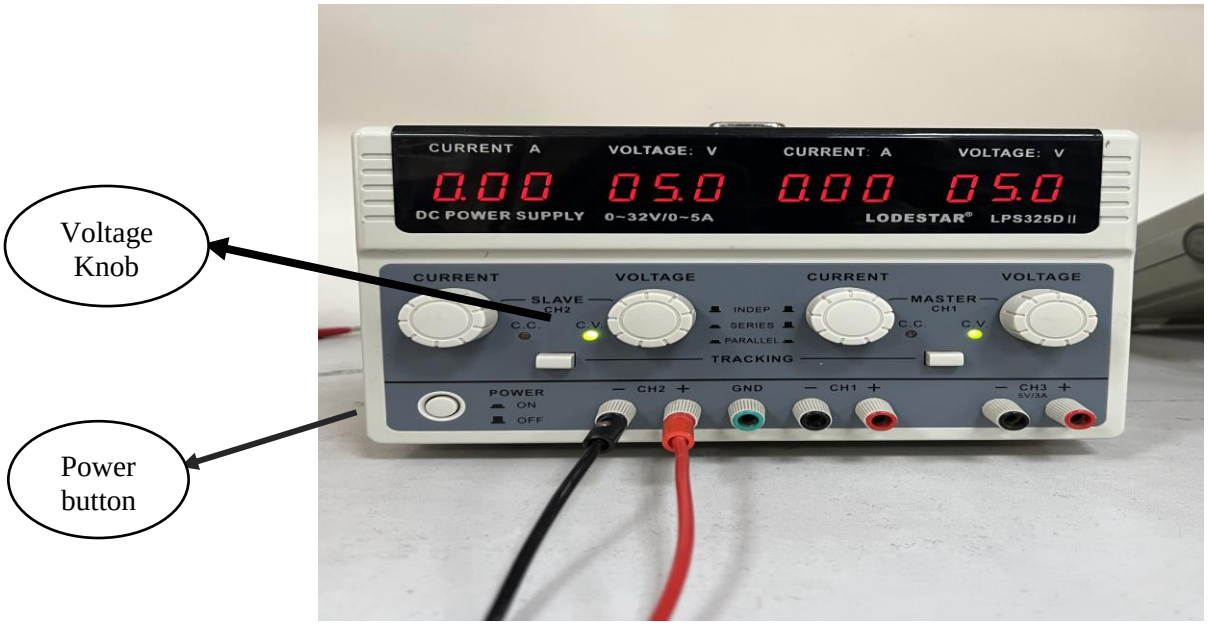


Figure 1: DC Power Supply (Model 1: LPS325D)

Figure 2: DC Power Supply (Model 2: LP3003D

A DC power supply provides direct current (DC) voltage to power a device under test such as a circuit board/breadboard or electronic product. As of now, two models of DC power supply are available in your physics laboratory shown above.

Model 1 (LPS325D):

- This model comprises a power button, two sets of positive and negative terminals, a ground terminal and fixed 5V supply (at the right-most corner), two sets of voltage and current knobs.
- The red and black wires are connected in the positive and negative terminal respectively as shown in the picture above. You can connect the wires on either set of terminals (right or left).
- If you need only 5V in any experiment, you may connect the wires in the fixed 5V terminal on the rightmost corner of the supply.
- The voltage knobs are the only knobs that you will need to use in your experiments. As you turn the knobs clockwise, the voltage increases.
- As you can see in the display of the DC power supply, the current is always set to 0. You can do this by turning the current knob to its absolute anti-clockwise position.

Model 2 (LP3003D):

- a power button, a set of positive and negative terminals, a ground terminal, two current knobs ("fine" & "coarse"), and two voltage knobs ("fine" & "coarse").
- Unlike model 1, this DC power supply does not have a 5V fixed supply.
- The red and black wires are connected in the positive and negative terminal respectively as shown in the picture above.
- The voltage knobs are the only knobs that you will need to use in your experiments.
- As can be seen in the diagram(left), there are two voltage knobs, fine and coarse. The fine voltage knob allows you to make very small changes to the voltage, in other words, you can say it is less sensitive to any movement you make to the knob.
- On the other hand, the coarse voltage knob allows you to make larger changes to the voltage, in others words, it is more sensitive.
- As you can see in the display of the DC power supply, the current is always set to 0. You can do this by turning the current knob to its absolute anti-clockwise position.

<u>Note:</u> Before connecting the DC power supply to your circuit, make sure the current is

Function Generator

A function generator is usually used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine wave, square wave, triangular wave, and sawtooth shapes. There are two types of function generators available in the physics lab. Such as GFG-8250A and SDG-810. These function generators can provide versatile waveforms of high efficiency and convenient operation. Familiarize yourselves with these functions thoroughly through Operation Manual.

GFG-8250A (SAC512):

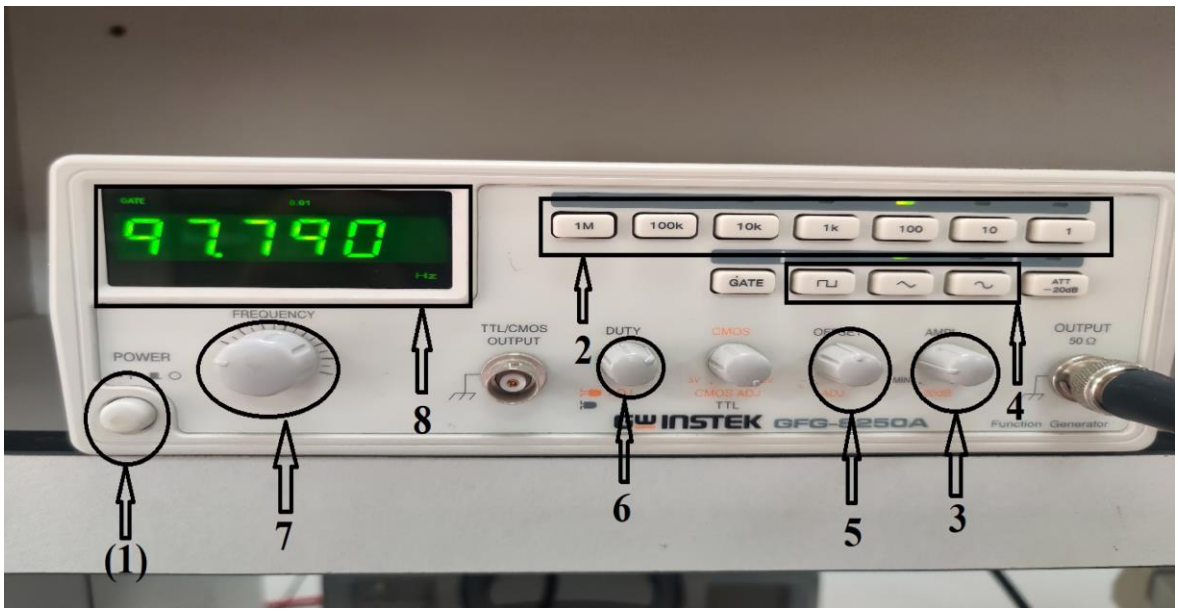


Figure 1: Function Generator (GFG-8250A)

GFG-8250A function generator can generate signals in the frequency range 0.5Hz to 5MHz. Let's have look at its functions.

1. **Power Switch:** The power switch is used for turning on and turning off the device.

2. **Frequency Range Selector:** To select the required frequency range by pressing the relevant push button on the panel as shown in Table 1.

3. **Amplitude Control:** Turn clockwise for increasing amplitude and anticlockwise for decreasing amplitude.

Table-1 (for GFG-8250A)

Push Button	1M	100k	10k	1k	100	10	1
Frequency Range	500kHz | 5MHz	50kHz | 500kHz	5kHz | 50kHz	500Hz | 5kHz	50Hz | 500Hz	5Hz | 50Hz	0.5Hz | 5Hz

4. **Function Selector:** Press one of the three push buttons to select the desired output waveform.

5. **DC Offset Control:** Pull out the knob to select any DC level of the waveform between ±10V, turn clockwise to set a positive DC level waveform, and invert for a negative DC level waveform.

6. **Duty Cycle Adjustment:** Pull out and rotate the knob to adjust the duty cycle of the waveform.

7. **Frequency Adjustment:** Turn clockwise the knob for MAX frequency and invert for MIN frequency.

8. **Display:** Shows the frequency.

SDG810 (SAC514):

The Siglent SDG810 is a 1-channel Function/Waveform Generator that provides high-quality signals up to 5 MHz. The **SDG810** function generators have a sophisticated and easy-to-use interface. All functions and parameters are easy to locate thanks to the graphical interface. Let's have a look at its functions:

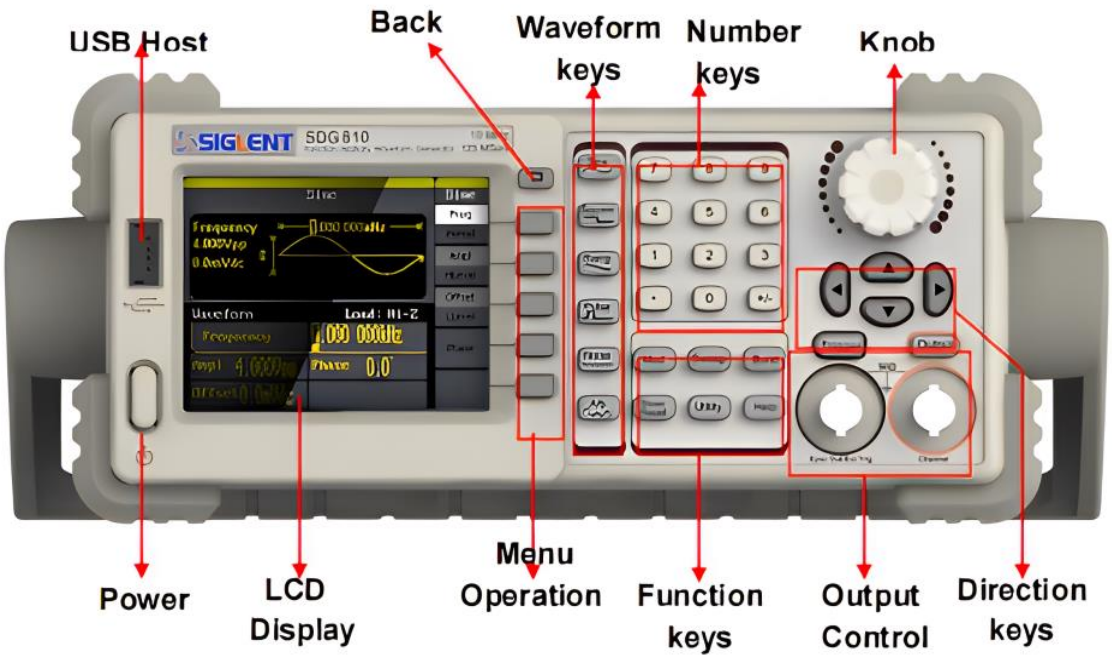


Figure 2: Function Generator (SDG810)

1. Power Switch: The power switch is used for turning on and turning off the device.

2. **Waveform Keys:** On the operation panel, there is a set of buttons with a waveform icon. See Figure 1. Press "Sine" to get the Sine wave and press the Square, Ramp, Noise, Arb button for respective signals.

Figure 3- Waveform Selection Buttons

3. **Output Control:** As is shown in Figure 2, there are two buttons on the right side of the operation panel, which are used to output/trigger control. Press Output button, activate or deactivate the output signal. **You will not get the signal without pressing output button.**

Figure 4: Output Control

4. Number Keys and Direction Keys:

a. The up and down keys are used to shift parameters and the left and right keys are used to shift digits.

b. Keypad is used to directly set the value of the parameter.

c. Knob is used to change a signal digit value whose range is 0~9.

Figure 5: Number Keys and Direction Keys

5. LCD Display:

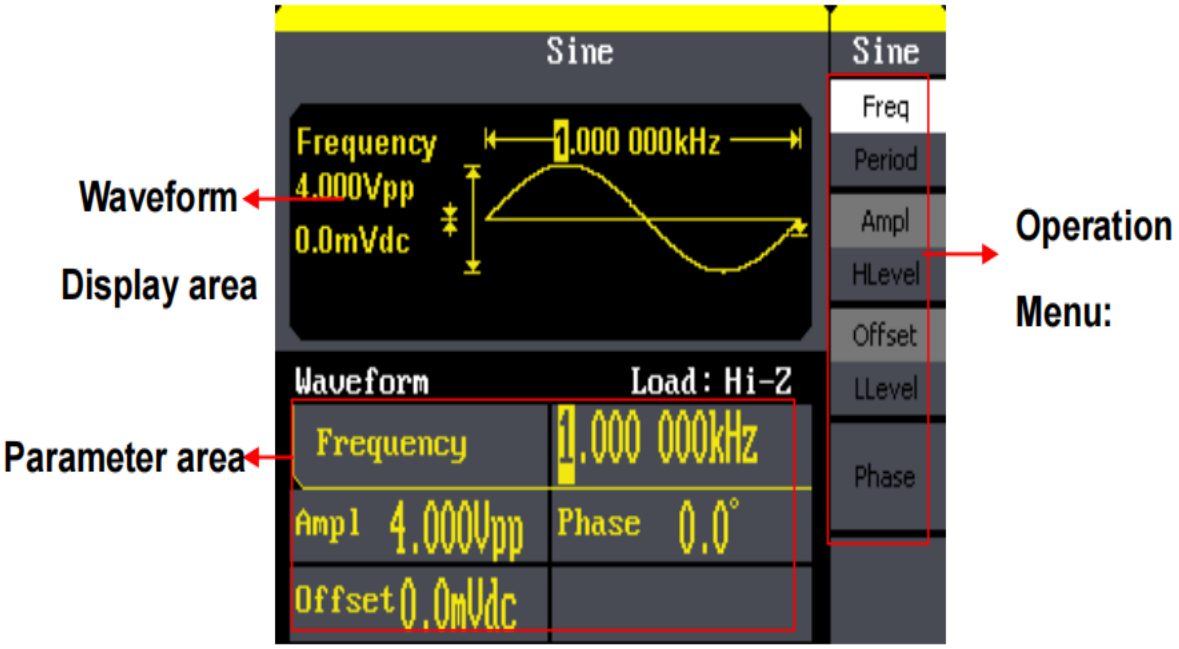
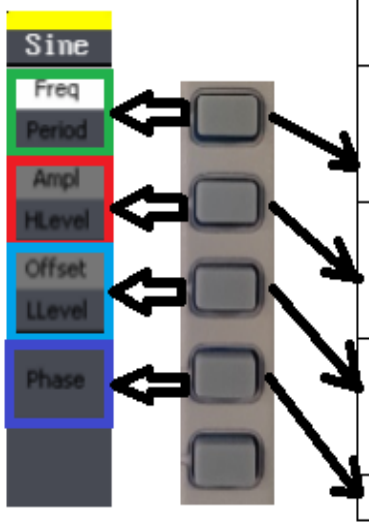


Figure 6- Display Interface (Sine Wave is the default display signal)

6. **Menu Operation:** Menu explanation is given in the following figure 7.



Function menu	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	Set the phase of the signal;

Figure 7: Menu operation

Oscilloscope

Purpose

This manual will familiarize you with the introduction of digital oscilloscopes. You will explore two different oscilloscopes that are used in our lab.

- Digital Oscilloscope (SIGLEND SDS1052DL+/50MHz)
- Digital Oscilloscope (GW instek GDS1102B/100MHz)

The Oscilloscope

An oscilloscope is an instrument that used to measure the potential difference (voltage) across a component as a function of time. The display of the oscilloscope is a two-dimensional graph. Voltage is displayed on the y-axis, while time is displayed on the x-axis.

Oscilloscopes are used to record data from electrical sensors, visualize waveforms generated by instruments and troubleshoot and fix electronic devices. In troubleshooting devices, it is typically important to understand the concurrent behavior of multiple devices at the same time, and so modern oscilloscopes are capable of displaying and storing information for two or more signals (called *channels*) at the same time. The input connectors (CH-1 and CH-2) are BNC (Bayonet Neill-Concelman) connectors.

Several settings adjustments are necessary for correct measurements of a waveform:

- Adjusting the POSITION of the waveform (left, right, up, down) is useful for centering or otherwise aligning waveforms. This is very important when comparing two waveforms, as all measurements require that the waveforms are aligned correctly.
- It is important that the full signal is visible and takes up the correct portion of the screen to maximize the precision of the measurements. This can be adjusted with the voltage (VERTICAL) SCALE settings which is voltage/div and time (HORIZONTAL) SCALE settings which is time/div.

Note: Changing the scale or position of the waveform does not affect the voltage or time of the signal measurements; it only changes its display.

- The TRIGGER LEVEL is the minimum voltage at which the oscilloscope interprets the measurement as a signal as opposed to noise. If the value is too high or too low, the signal will never cross the trigger threshold and no waveform will be displayed. If it is too close to zero, the oscilloscope might trigger noise, and you could miss the important part of the signal. Remember that the wires in your circuit behave like antennae – you can pick up everything from radio signals to the electric lights in the room!

- If you are unable to display a waveform, make sure that the cable is plugged into the correct channel and that the appropriate channel button is pressed. Pressing on the AUTO button under RUN CONTROL will typically get a useful measurement of the waveform, but it may not be ideal for your purposes. (It just brings you close!). And then you can adjust the time and voltage/div according to your requirements.
- With a digital oscilloscope, many measurements can be done automatically. Pushing the Measure button will show you the list of possible measurements. The cursor for selecting a measurement can be controlled using the button at the left of the menu panel.

Digital Oscilloscope (SIGLEND SDS1052DL+/50MHz)

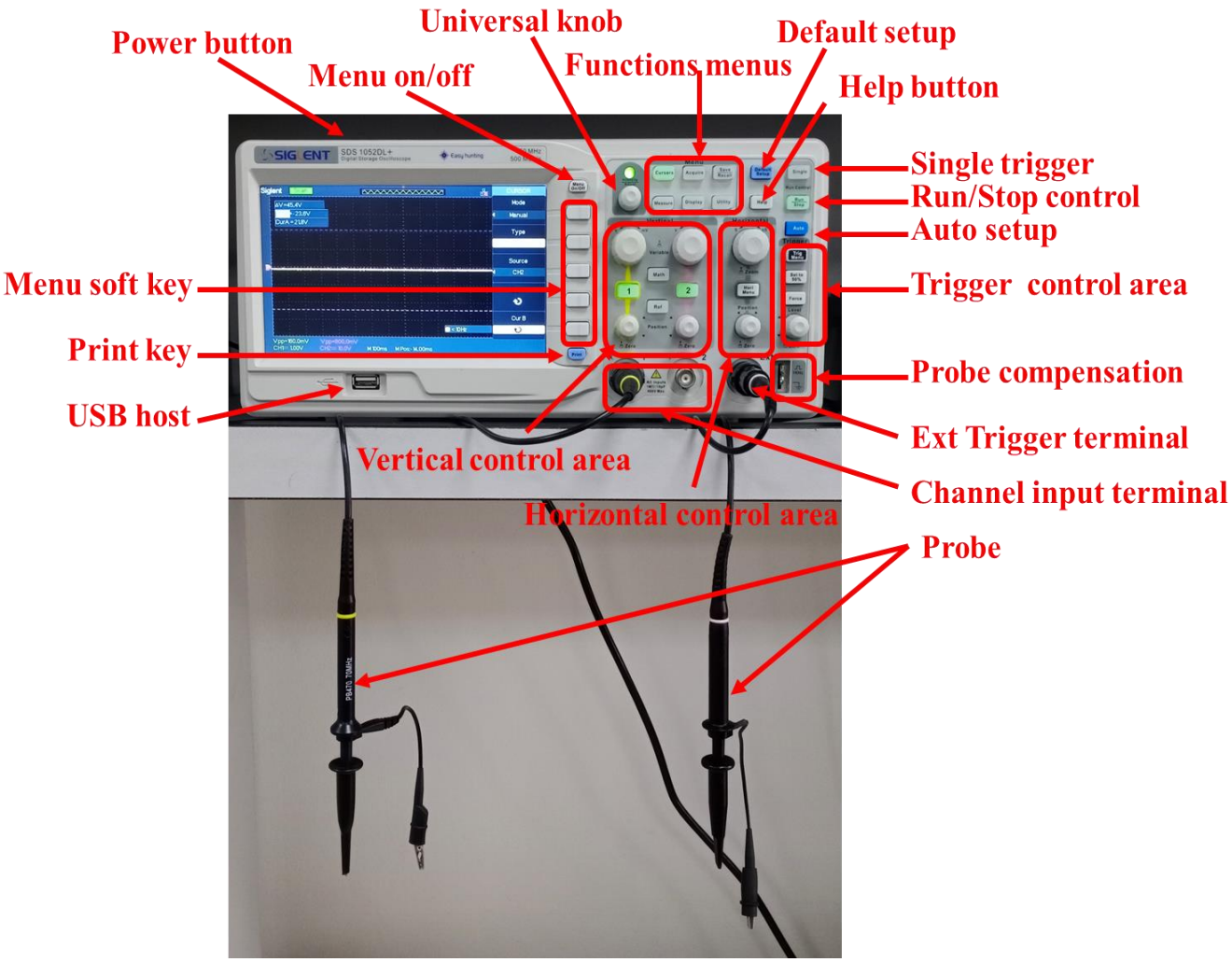


Figure 1: SIGLEND SDS1052DL+ digital oscilloscope.

Menu and Control Button

Showing as the following picture:

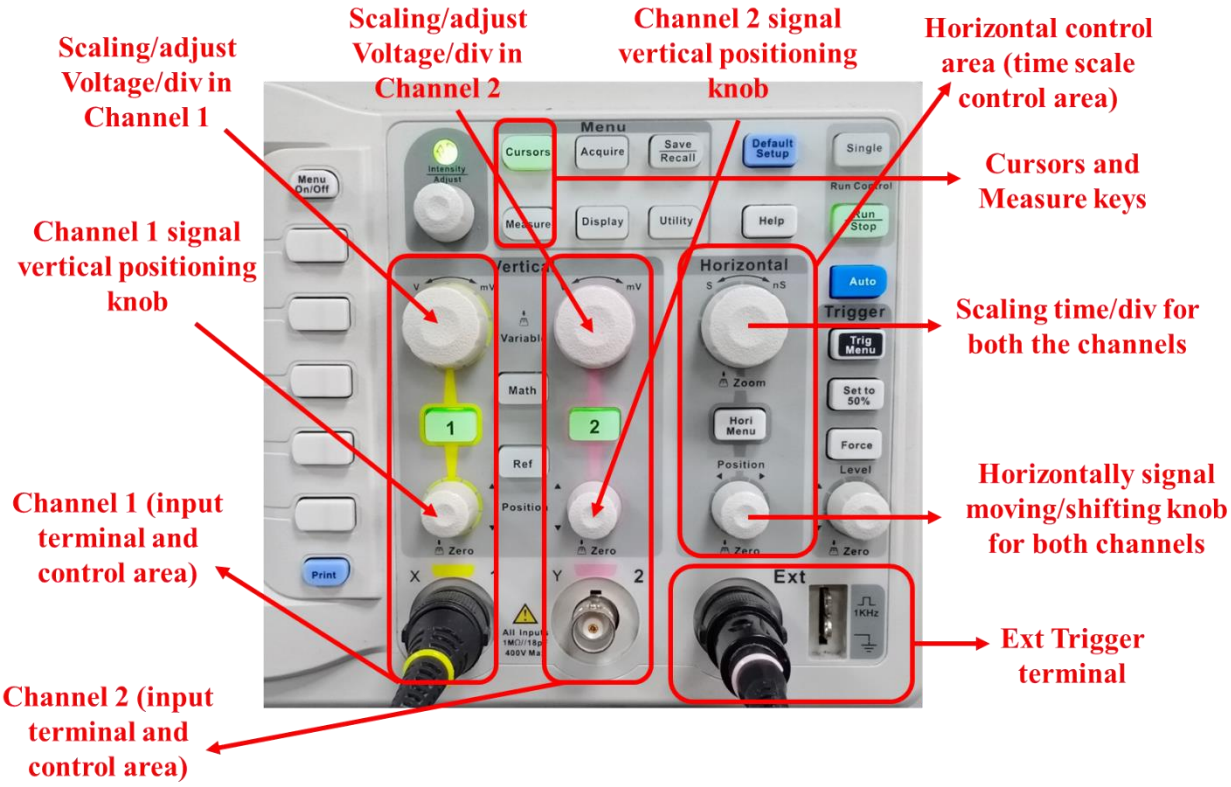


Figure 2. Menu and control button of SIGLEND SDS1052DL+ digital oscilloscope.

■ **Channel buttons (1, 2):** Press a channel button to turn that channel ON or OFF and open the channel menu for that channel. You can use the channel menu to set up a channel. When the channel is on, the channel button is lit.

■ **MATH:** Press to display the Math menu. You can use the MATH menu to use the oscilloscopes Math functions.

■ **REF:** Press to display the Ref Wave menu. This menu can save and recall four or two reference waveforms in internal memory.

■ **HORI MENU:** Press to display the Horizontal menu. You can use the Horizontal menu to display the waveform and zoom in on a segment of a waveform.

■ **TRIG MENU:** Press to display the Trigger menu. You can use the Trigger menu to set the trigger type (Edge. Pulse, Video, Slope, Alternative) and trigger settings.

■ **SET TO 50%:** Press to stabilize a waveform quickly. The oscilloscope can set the trigger level to be halfway between the minimum and maximum voltage level automatically. This is useful when you connect a signal to the EXT TRIG connector and set the trigger source to Ext or Ext/5.

■ **FORCE:** Use the FORCE button to complete the current waveform acquisition whether the oscilloscope detects a trigger or not. This is useful for Single acquisitions and Normal trigger mode.

■ **SAVE/RECALL:** Press to display the Save/Recall menu. You can use the Save/Recall menu to save and recall up to 20 oscilloscope setups or waveforms in internal memory (up to 20 waveforms) or on a USB memory device (limited by the memory capacity of the USB device). You can also use it to recall the default factory settings, save waveform data as a comma-delimited file (.CSV), and save or print the displayed waveform image.

■ **ACQUIRE:** Press to display Acquire menu. You can use the Acquire menu to set the acquisition Sampling Mode (Sampling, Peak Detect, Average).

■ **MEASURE:** Press to display a menu of measurement parameters.

Example: V_{max}, V_{min}, V_{amp}, V_{p-p}, Mean, V_{rms}

■ **CURSORS:** Press the Cursor Menu. Vertical Position controls adjust cursor position while displaying the Cursor Menu and the cursors are activated. Cursors remain displayed (unless the "Type" option is set to "Off") after leaving the Cursor Menu but are not adjustable.

■ **DISPLAY:** Press to open the Display menu. You can use the Display menu to set grid and waveform display styles, and persistence.

■ **UTILITY:** Press to open the Utility menu. You can use the Utility menu to configure oscilloscope features, such as sound, language, counter, etc. You can also view system status and update software.

■ **DEFAULT SETUP:** Press to reset the oscilloscope's settings to the default factory configuration.

■ **HELP:** Enter the online help system.

■ **AUTO:** Automatically sets the oscilloscope controls to produce a usable display of the input signals.

■ **RUN/STOP:** Continuously acquires waveforms or stops the acquisition. Note: If waveform acquisition is stopped (using the RUN/STOP or SINGLE button), the SEC/DIV control expands or compresses the waveform.

■ **SINGLE:** Acquire a single waveform and then stops.

Connector

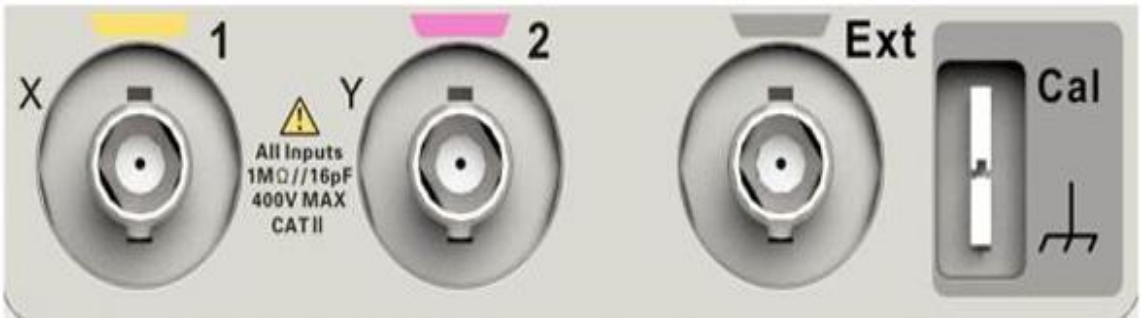
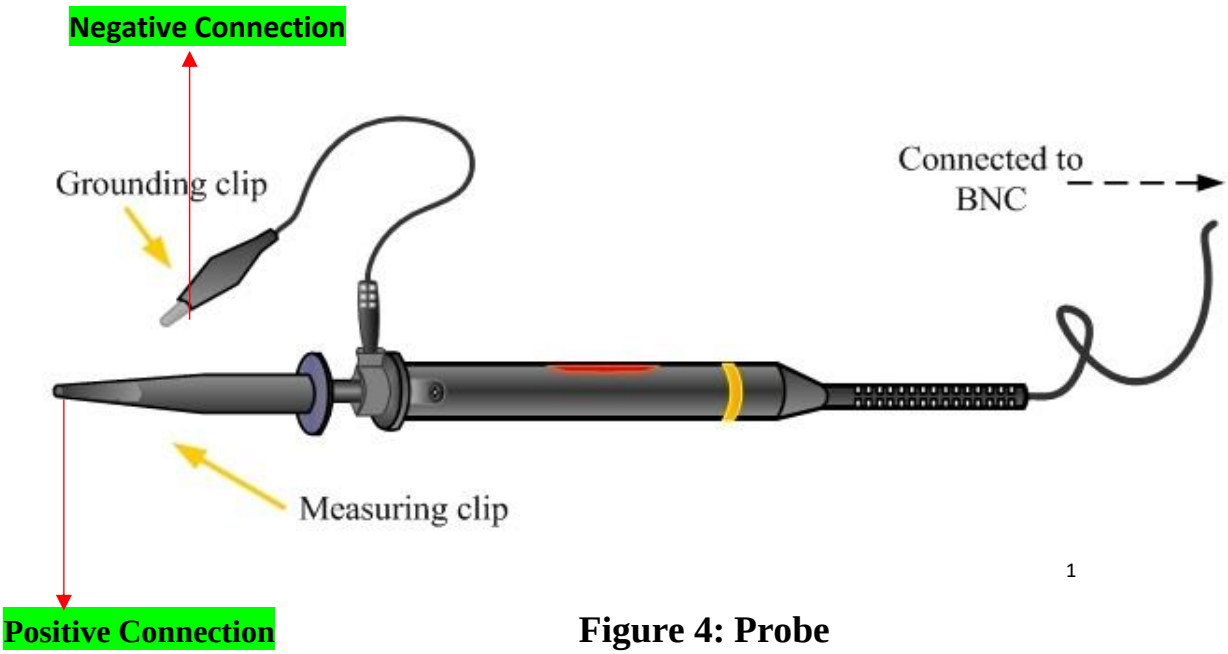


Figure 3: connector of SIGLEND SDS1052DL+ digital oscilloscope.

■ **Channel Connector (CH1, CH2):** Input connectors for waveforms display.

■ **EXT TRIG:** Input connector for an external trigger source. Use the Trigger Menu to select the "Ext" or "Ext/5" trigger source.

■ **Probe Component:** Voltage probe compensation output and ground. Use to electrically match the probe to the oscilloscope input circuit.



[1]

Figure 4: Probe

***Note:** If you connect a voltage source to a ground terminal, you may damage the oscilloscope or the circuit under test. To avoid this, do not connect a voltage source to any ground terminals.*

[1]

Auto Measurement

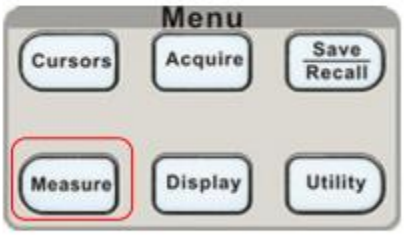


Figure 5: Measure Button

When you take automatic measurements, the oscilloscope does all the calculations for you. Because the measurements use the waveform record points, they are more accurate than the graticule or cursor measurements. Press the **'MEASURE'** for the Automatic Test. There are three auto measurement types: Voltage, Time, and Delay.

Table 1: Auto measure function menu 1:

Option	Instruction
Voltage	Press this button to enter the **Voltage** measure menu.
Time	Press this button to enter the **Time** measure menu.
Delay	Press this button to enter the **Delay** measure menu.
All Mea	Press this button to enter the **All Measurement** menu.
Clear Measure	Press this button to **clear** all the measurements that you chose.

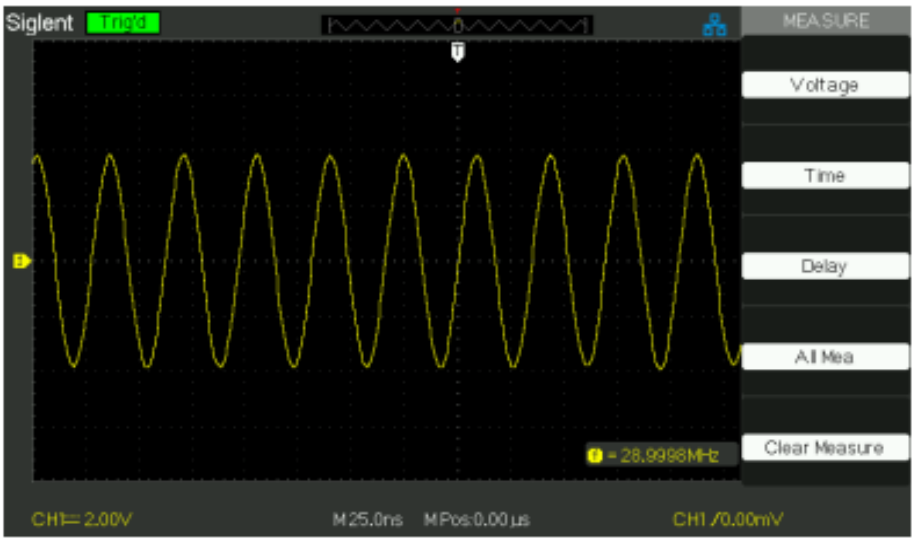


Figure 6: Auto measurement function

Table 2: Auto measure function 2-Voltage measure menu:

Option	Setting	Instruction
Source	CH1, CH2	Select input signal source for Voltage measure.
Type	Vmax, Vmin, Vp-p, Vamp, Vtop, Vbase, Cycle Mean, Mean, Cycle Vrms, Vrms, ROVShoot, FOVShoot, RPREShoot, FPREShoot	Press the "Type" button or turn the "Universal" knob to select the Voltage measure parameter
Add	Example: Vp-p	Choose the measurement, after pressing the button, the measurement value will be shown in the lower left of the screen
Return		Return to the first page of the auto measurement menu.

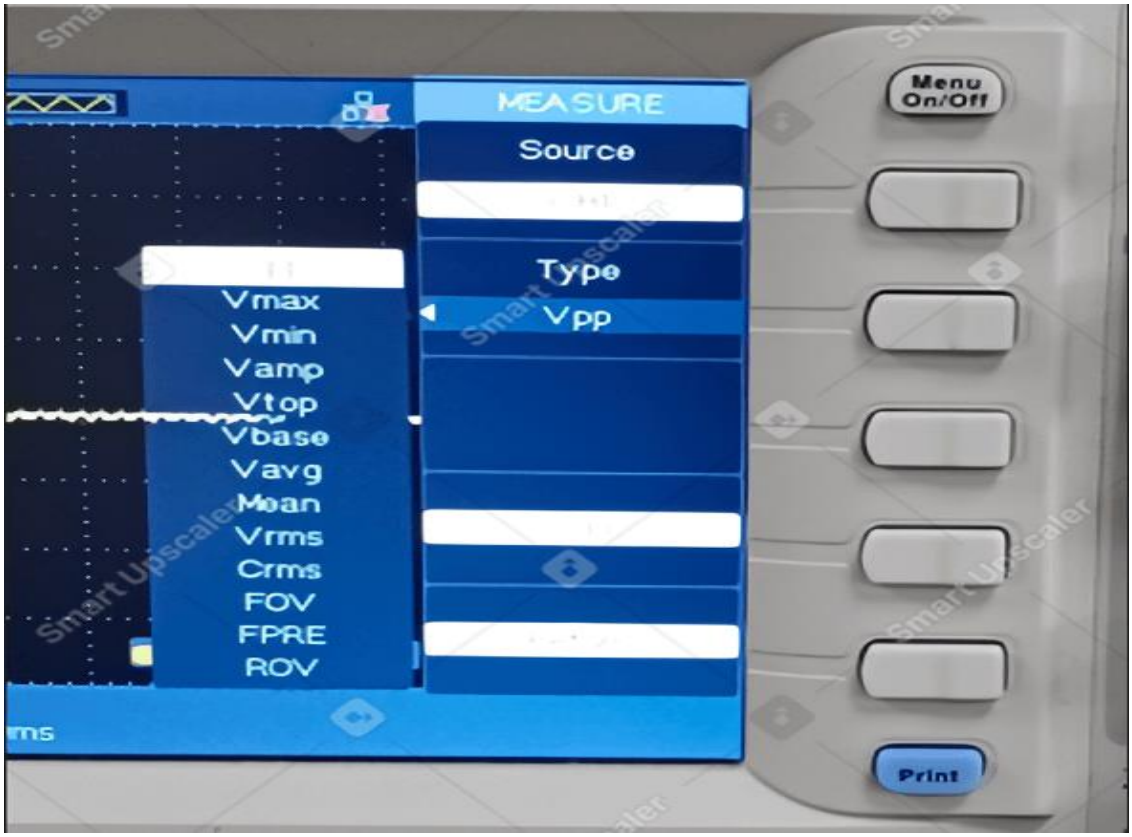


Figure 7: Auto measure function 2-Voltage measure menu

Table 3: Auto measure function3-Time measure menu:

Option	Setting	Instruction
Source	CH1, CH2	Select input signal source for Time measure.
Type	Rise Time, Fall Time, Freq, Period, BWidth, +Width -Width, +Duty、-Duty.	Press the "Type" button or turn the "Universal" knob to select the Time measure parameter
Add	Example: Freq, Time Period.	Choose the measurement, after pressing the button, the measurement value will be shown in the lower left of the screen
Return		Return to the first page of the auto measurement menu.

Default Setup

The oscilloscope is set up for normal operation when it is shipped from the factory. This is the default setup. To recall this setup, press the DEFAULT SETUP button. For the options, buttons, and controls that change settings when you press the DEFAULT SETUP button, refer to Appendix B.

The DEFAULT SETUP button does not reset the following settings:

- Language option
- Saved reference waveform files
- Saved setup files
- Display contrast
- Calibration data

Digital Oscilloscope (GW instek GDS1102B/100MHz)

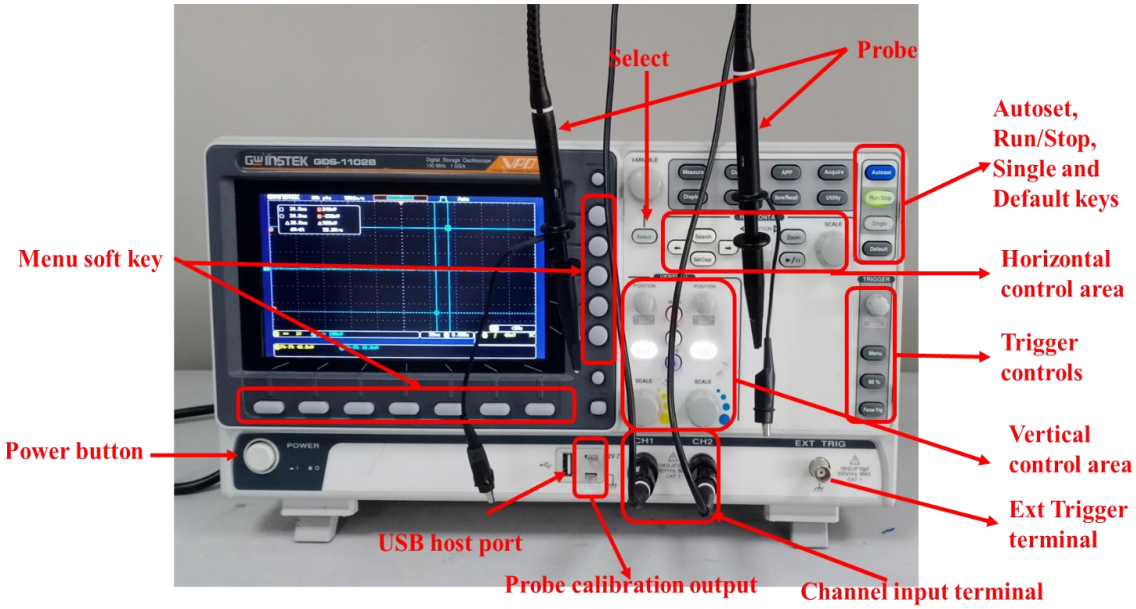


Figure 8: GW instek GDS1102B digital oscilloscope.

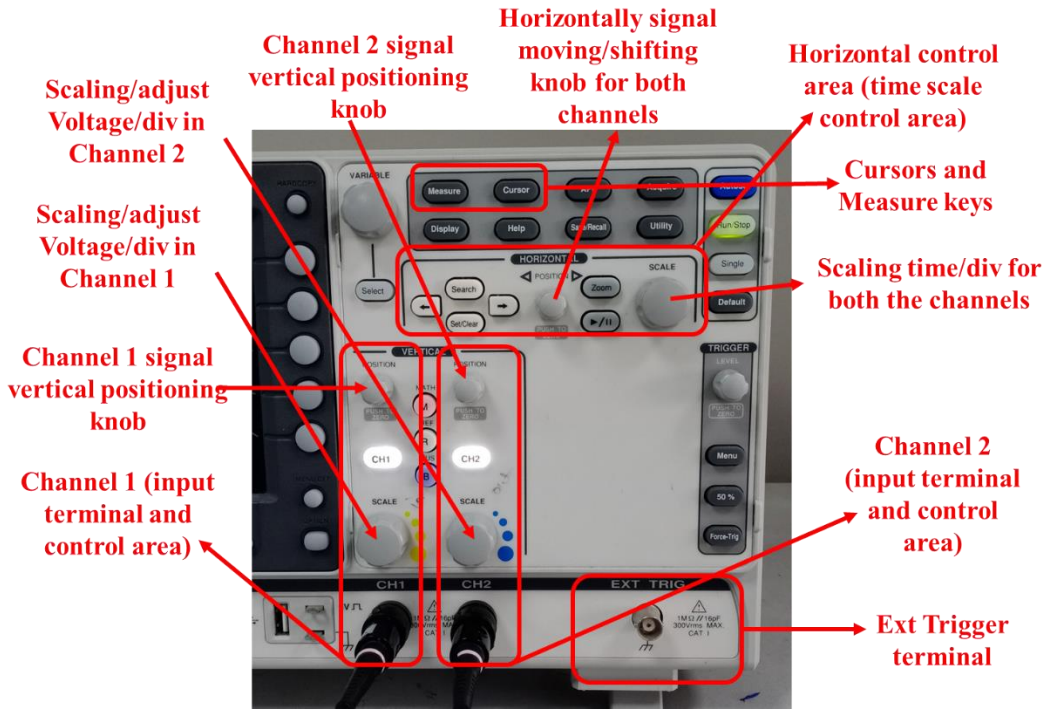


Figure 9: Menu and control button of GW instek GDS1102B digital oscilloscope.

So, in this part, we will have a look at the Cursor and Measure functions for the below-displayed Oscilloscope.

Procedures to use **cursor function** for the **GWINSTEK GDS-1102B** model Digital **Oscilloscope**:

Step-1: Carefully look at the yellow-colored box below in figure-10 and match it with your machine. You'll find a set of keys with 'Measure', 'Cursor', 'App', 'Acquire', 'Display', 'Help', 'Save/Recall', and 'Utility'.

Step-2: You can measure waveform data using cursors. Cursors are horizontal and vertical markers that indicate X-axis values (usually time) and Y-axis values (usually voltage) on a selected waveform source. When you press the Cursors key, it will illuminate, and the cursors will turn on. To turn cursors off, press this key again until it is not illuminated. See the no. 2 circled key namely 'Cursor' in the yellow box below in Figure-10.

This oscilloscope will have vertical and horizontal cursors for both channel 1 and channel 2.

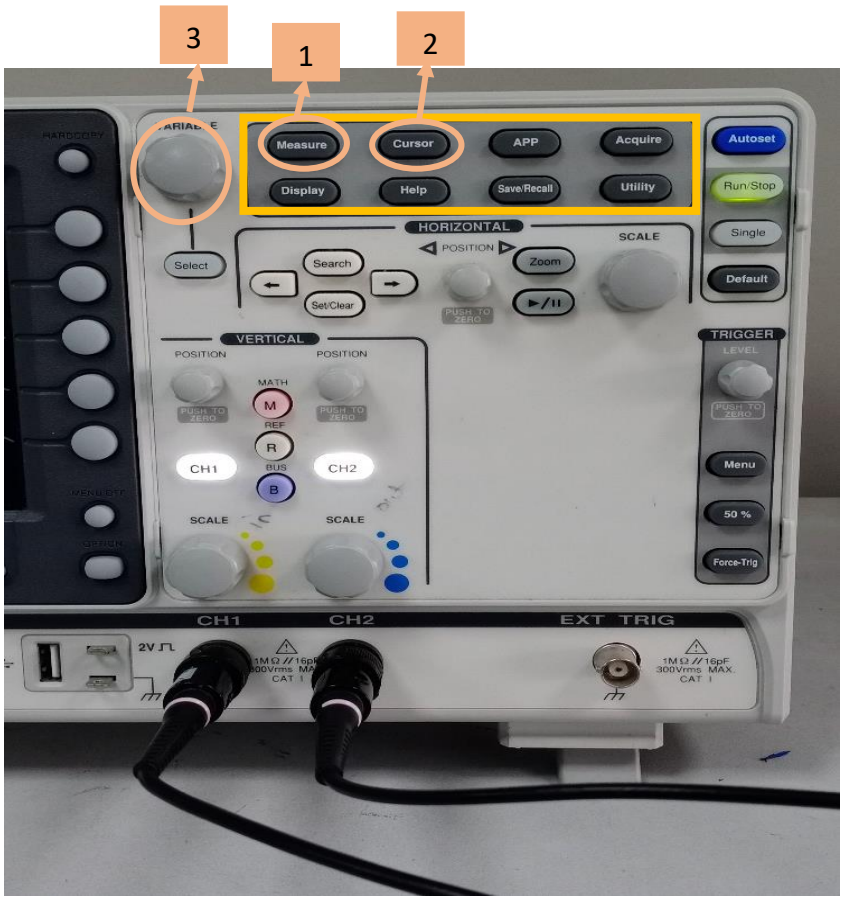


Figure 10: Measure and Cursor functionalities for GWINSTEK GDS-1102B model Digital Oscilloscope.

Step-3: After pressing on the cursor key, it will appear with two cursors as displayed in figure-11.

Step-4: You'll see a row of boxes beneath the edge of the display for:

H Cursor – Horizontal Cursor,
V Cursor – Vertical Cursor,
H Unit– Horizontal Axis Unit for the Plot in the display,
V Unit – Vertical Axis Unit for the Graph in the display.

Step-5: Now, when you select H Cursor by pressing the respective button just below the boxes, cursors in the display will work for horizontal mapping on the signal. It means that cursors can move across the x-axis over the signal.

Step-6: After fixing your horizontal axis coordinates through H Cursors, we need to go to the respective output coordinates on the signal to get the desired output value. For this, we will select V Cursor which will employ the cursors to move across the y-axis over the signal.

******* You will move the cursors to the desired coordinates using the variable knob as mentioned as no. 3 circles in Figure-10.

(Each cursor has three functions to do. You can select one cursor only when another will appear with a dashed line. You can select the second one by pressing twice on the particular cursor option, the selected one will appear with a blue-colored solid line. You can move both of the cursors by pressing thrice over the particular cursor, both will appear as blue-colored solid lines.)

Figure 11: Horizontal (H) Cursor and Vertical (V) Cursor

Procedures to use **Measurement function** for the **GWINSTEK GDS-1102B** model Digital **Oscilloscope**:

Step-1: By selecting the track menu you have to setup cursor A/cursor B for channel 1 / channel 2, you may use the measure function to find out the necessary parameters' output values. You will use the 'Measure' button (as shown in no 2 circled in Figure-10) to activate the measurement functions in the display which in turn will appear with the below-shown display.

Figure 12: Measurement function

Step-2: Following Figure-12, we can add/remove measurements on the display for the signals. However, for instance, it needs to get the peak-peak voltage value for the input/output signal you performed. You'll use the 'Add Measurement" button following the respective button below.

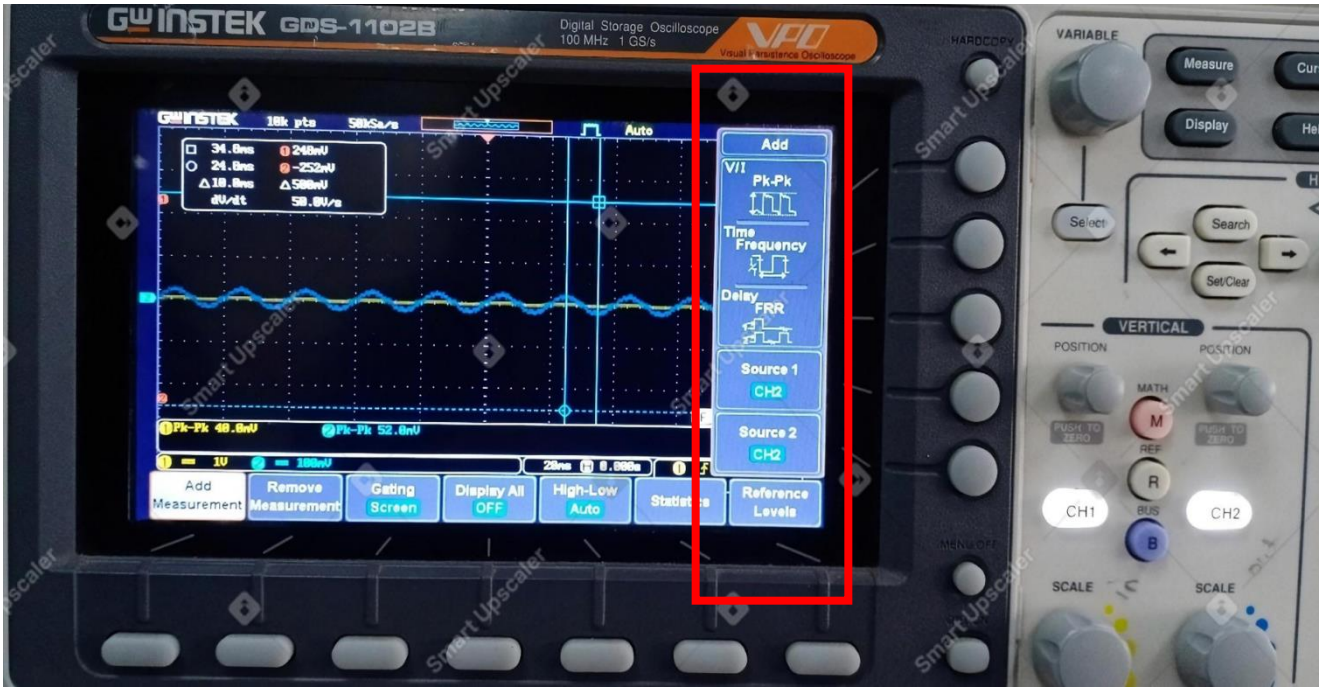


Figure 13: Parameter bases and Source options

Step-3: After selecting 'Add Measurement" the display appears as shown in Figure-13 with parameter bases and source options in the red marked section, try and match with your device!

Step-4: First one for voltage and current measurement. You'll be able to get the respective voltage and current values by selecting the V/I Pk-Pk menu along with the Period, Frequency, and so on.

Step-5: Must select the source for the desired signal values in the oscilloscope display you want to get using measurement functions.