Student ID:	21201820	Lab Section:	05
Name:	Siffat Ara Fasha	Lab Group:	12

Experiment No. 4

Study of I-V Characteristics of Linear Circuits

Objective

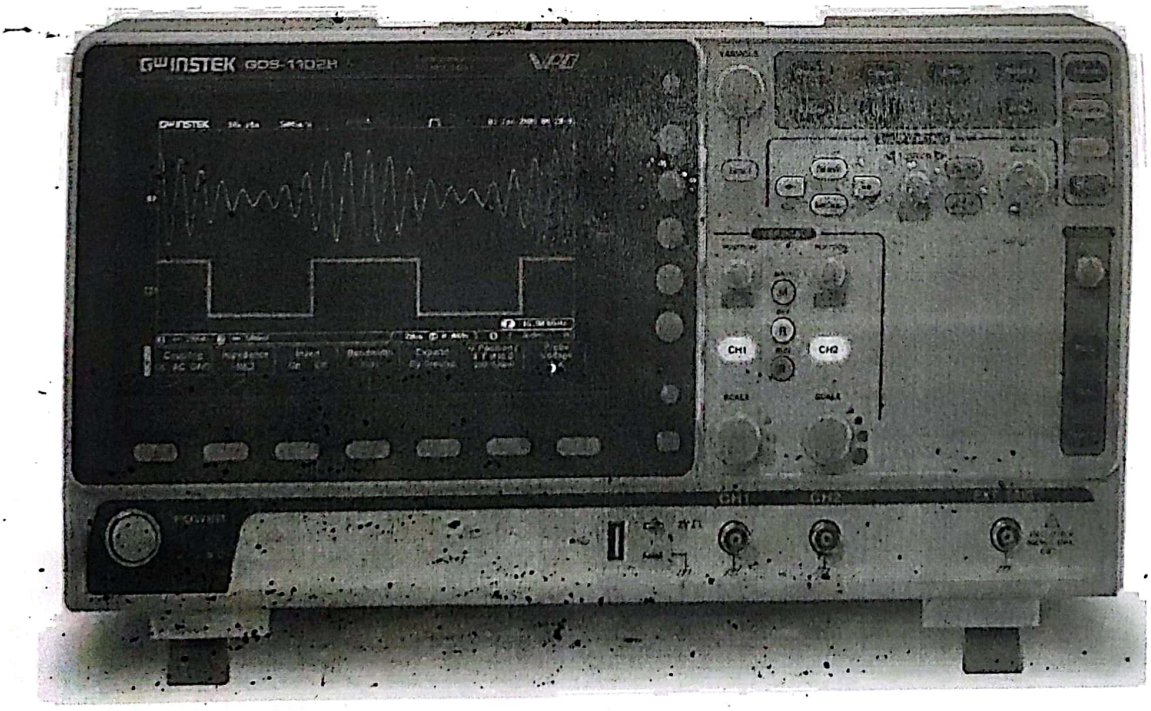
The aim of this experiment is to acquaint students with the concept of I-V characteristics. They will find I-V characteristics of some linear components and some circuits consisting linear combinations of them.

Part 2: By Using Oscilloscope

Theory

Oscilloscope

Oscilloscope is a device that can measure a sequence of voltages over time and can display that information by plotting them on a screen. In fact, oscilloscopes available at our labs are dual channel (**CH1** and **CH2**), meaning, they can simultaneously show voltage vs time graph across two separate set of nodes.



An oscilloscope

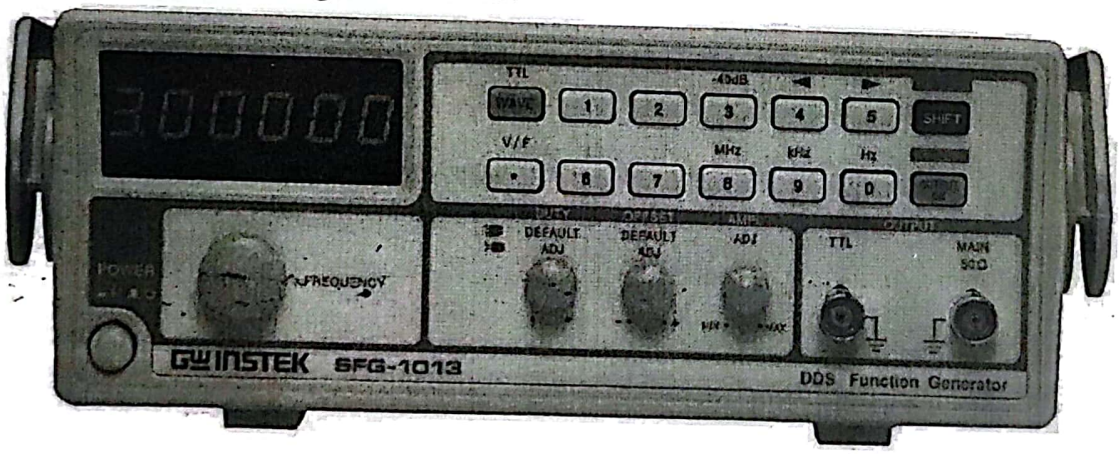
In the default mode, an oscilloscope can show 2 separate graphs (yellow and blue) where the common x-axis for both of the graphs is **time** and y-axis for the **yellow** graph is the voltage measured at **CH1** and the **blue** graph is the voltage measured at **CH2**.

However, there is another mode called the **"XY" mode** where we can plot voltage from **CH1** on the x-axis vs voltage from **CH2** on the y-axis. This is exactly how we can plot I-V characteristics on an oscilloscope. If we connect the voltage, V across the two terminals to **CH1** and the measure the current I on **CH2**, we could plot the I-V characteristics. However, oscilloscopes can only measure voltages. This can easily be done using a 1 kΩ resistor since the voltage (in volts) across a 1 kΩ resistor is equivalent to the current (in milliApmeres) through that resistor.

There is another hurdle to overcome regarding the negative terminals of the two oscilloscope channels. Although they seem separate, in actuality, the two negative terminals are internally shorted. Hence, we need to connect only one of the negative terminals. But this is a challenge since we may want the inverted voltages. This can be easily done through the GUI by pressing the channel buttons. For example, if we want to invert **CH1**, it can be done by press the glowing **CH1** button and then turning **On** "**Invert**" mode (detailed procedures are discussed later).

Function Generator

Function generator is a device that can generate various shapes of electrical waveforms. We can produce signals of different frequencies, amplitudes, and wave shapes, such as sine waves, square waves, triangular waves etc.



A Function Generator

In the previous part, we collected data using a multimeter and the supply voltage was changed with a knob on the DC power supply. However, an oscilloscope samples thousands to millions of data point per second. So, manually adjusting the supply voltage is not possible. However, for that, we may use a function generator that creates a 1 kHz signal of the maximum amplitude (10 V) as the supply voltage V_S.

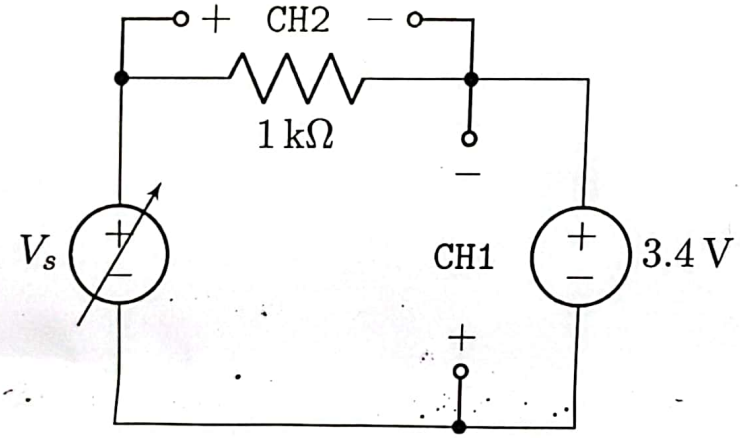
Signature of Lab Faculty: Tawfiqur Date: 30.3.24

Apparatus

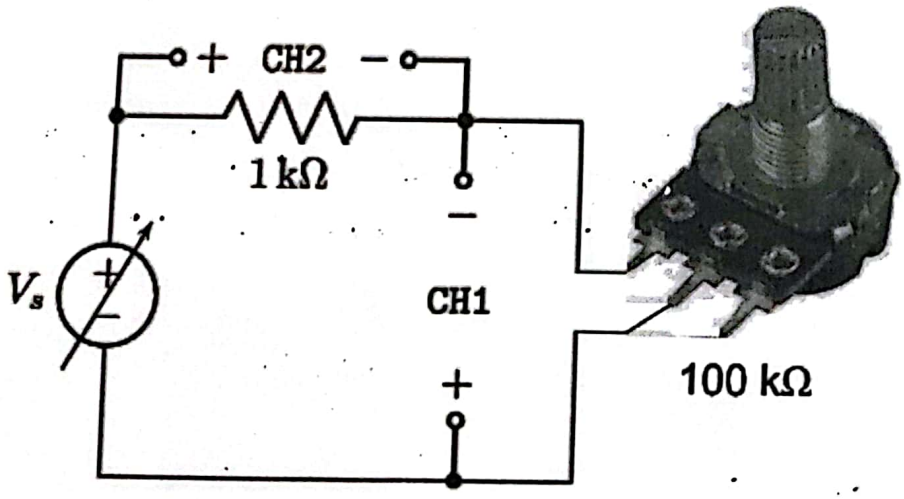
- Oscilloscope
- Function Generator
- DC power supply
- A 100 kΩ potentiometer
- Light Dependent Resistors (LDRs)
- Breadboard
- Jumper wires

Procedures

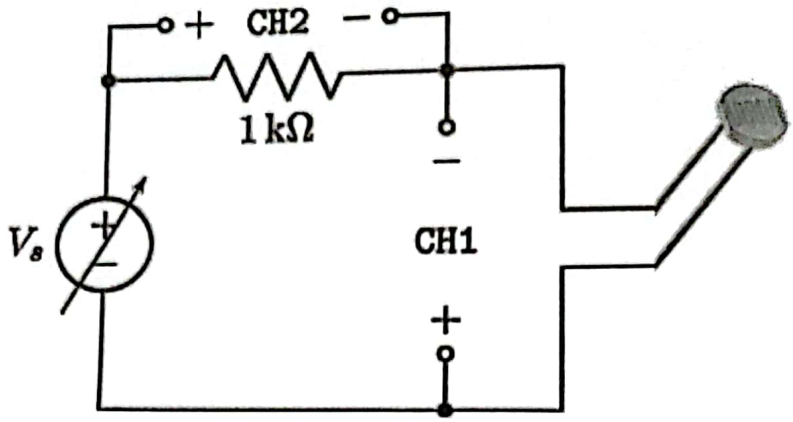
- Construct the following circuits on a breadboard. Try to minimize the number of jumper wires in your circuit:



Circuit 4 (DC Voltage Source)

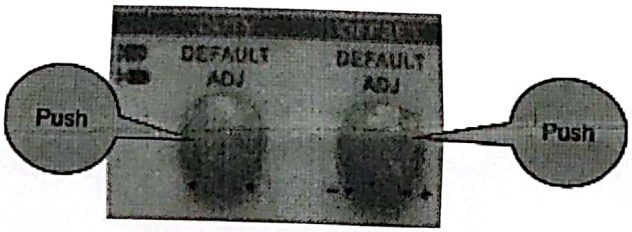


Circuit 5 (Potentiometer)

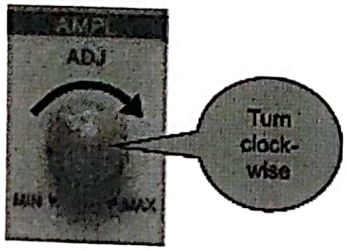


Circuit 6 (LDR)

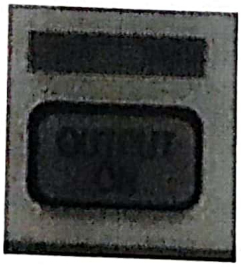
- Setup the **function generator**:
  - Connect the positive and negative terminals of the function generator according to the positives and negatives of the supply voltage V_s.
  - Make sure the **DUTY** and **OFFSET** adjustment knobs are **pushed in** **(default mode).**



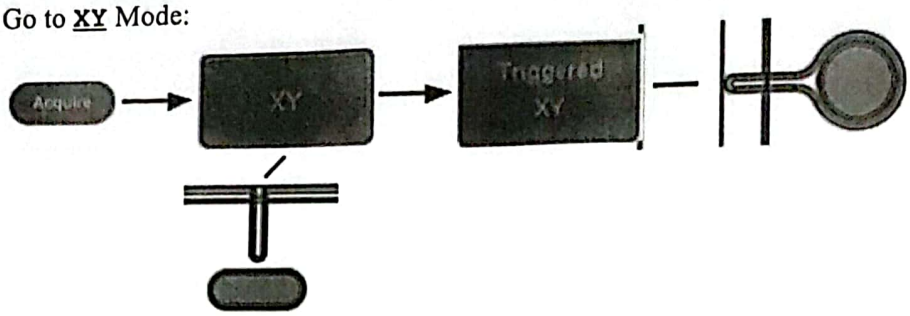
- Set the **AMPL** (amplitude) adjustment knob to the **MAX** position.



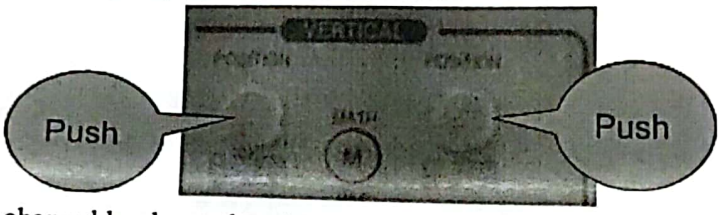
- Turn on the **output**.



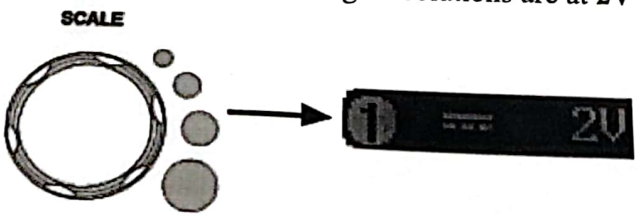
➢ Go to **XY** Mode:



➢ Set position to origin by **pushing** the **position knobs** on each channel.



➢ Turn both channel knobs so that the voltage resolutions are at **2V per division.**



Questions

6.

(a) In normal mode of operation, an oscilloscope always plots -

☑ voltage as a function of time ☐ current as a function of time

(b) In X-Y mode of operation, an oscilloscope plots Channel-1 along the -

☑ y-axis ☐ x-axis

(c) Is there any way to observe the one you haven't selected in (a)?

Yes 1 kΩ Resistor can be used. Since the voltage across a 1 kΩ Resistor is equivalent to the current through the resistor or we can use a current probe which converts the current to a voltage signal that can be displayed on the oscilloscope. Then we can observe current waveform as a function of time.

7. Put a checkmark beside the correct answers:

a. The I-V characteristics of the following circuits were **straight lines** -

☑ Circuit 4 ☐ Circuit 5 ☐ Circuit 6

b. The I-V characteristics of the following circuits went **through origin** -

☐ Circuit 4 ☑ Circuit 5 ☑ Circuit 6

c. The following circuits were **equivalent to a resistor** -

☐ Circuit 4 ☐ Circuit 5 ☑ Circuit 6

d. When the LDR was completely **in darkness**, the I-V characteristic line was -

☐ y-axis ☑ x-axis ☐ parallel to x-axis but shifted upwards

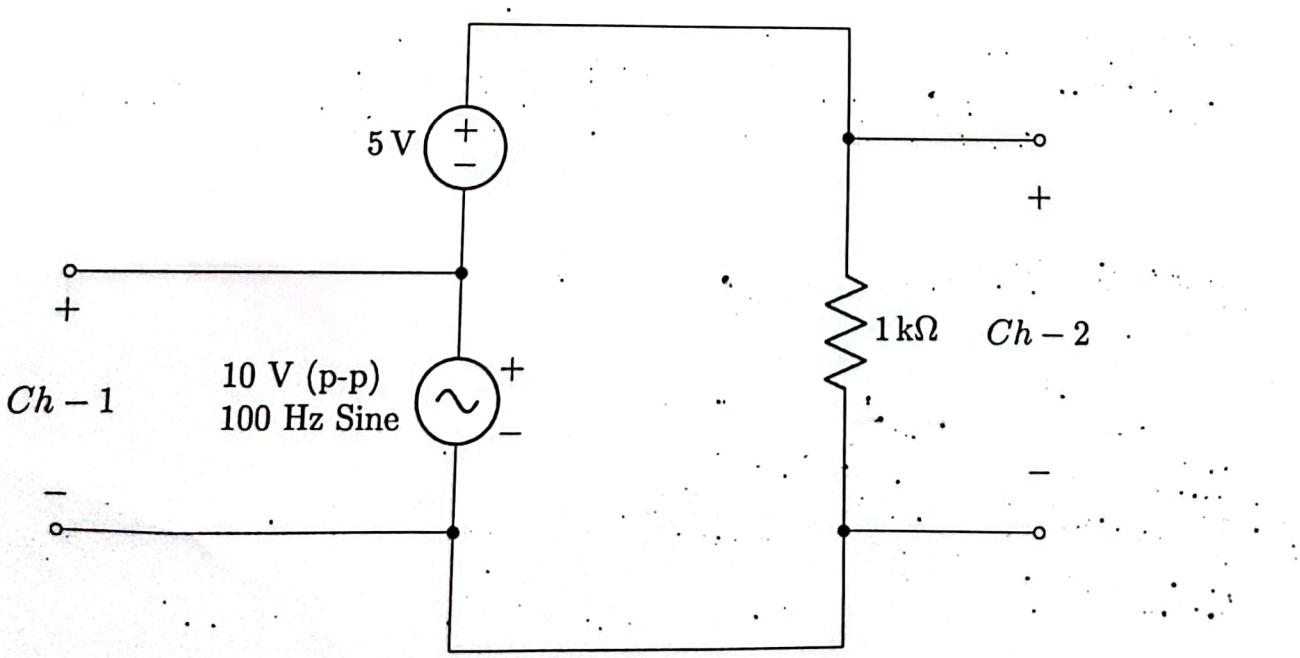
e. When the LDR was completely **in darkness**, it was equivalent to -

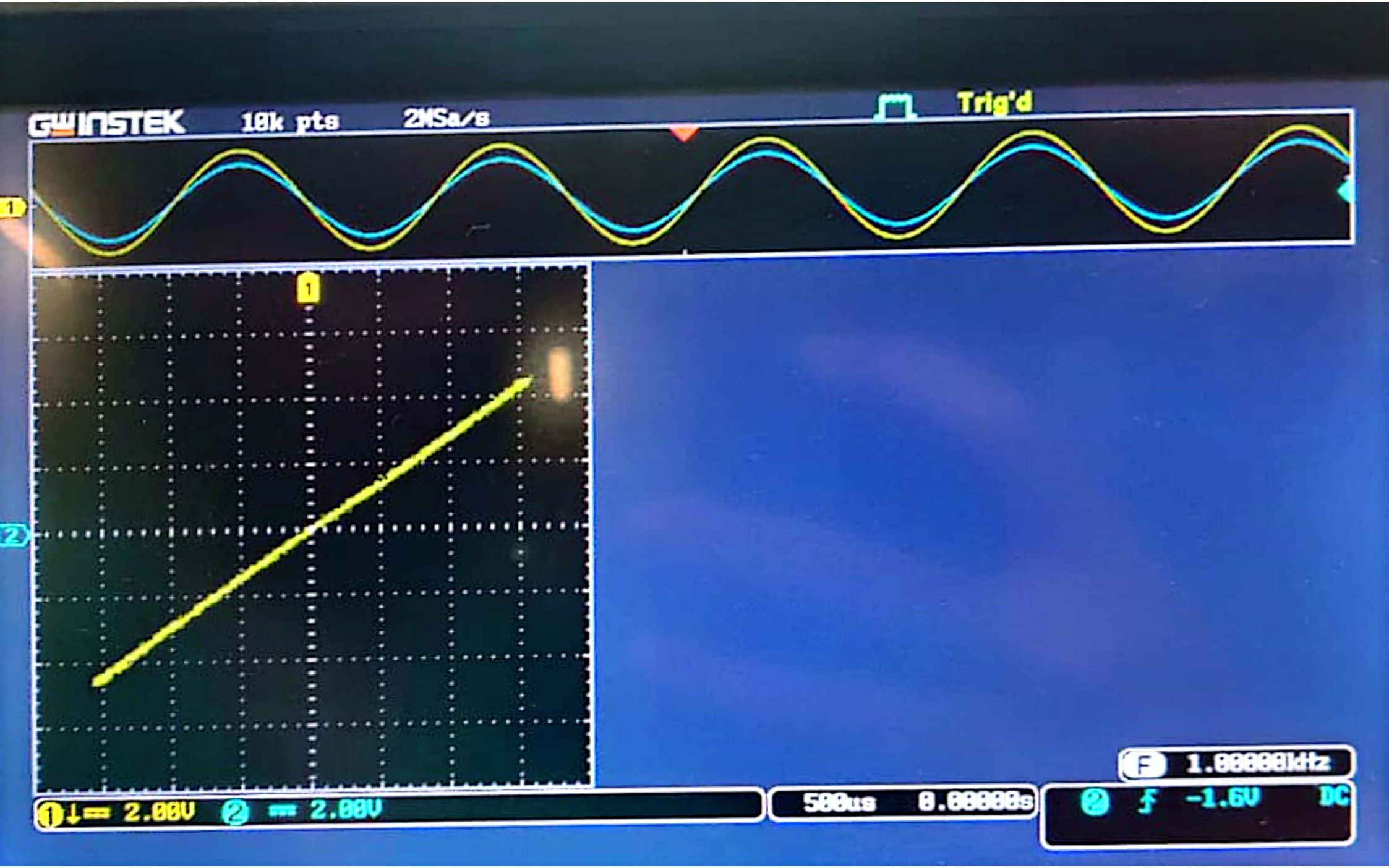
☐ short circuit ☑ open-circuit ☐ 1 kΩ resistor ☐ 0A current source

8. Why was it necessary to invert Channel-2 of the Oscilloscope in order to visualize the *I vs. V* plot of **Circuit 4, 5,** and **6**?

The 2 negative terminals of the 2 oscilloscope are internally shorted. so we need to connect only one of the negative terminal when the current flows through the resistor, the voltage across the resistor may have inverted, compared to the voltage source. Inverted changes the plotted I-V graph. Shows the correct polarity and direction of the current flowing through resistor.

9. Draw the waveforms that should be observed in Channel-1 and Channel-2 of an oscilloscope when both the channels are ON and are connected in a setup shown below. Draw both the plots in the same template given below. Mark the waveforms according to their visualizing channel.




GW INSTEK
10k pts
2MSa/s
Trig'd
1
2
1
1↓ 2.00V
2 2.00V
500us
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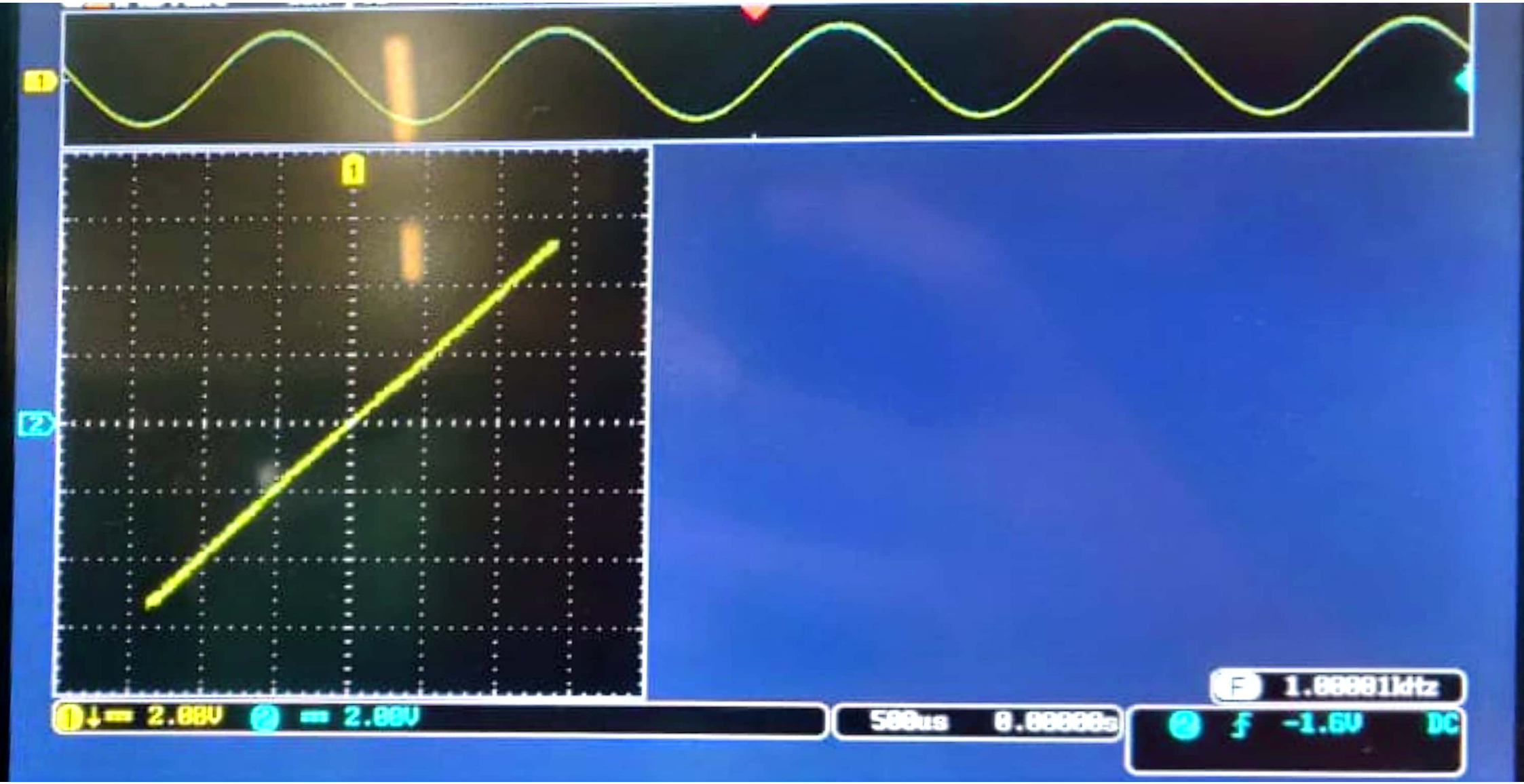
2 -1.6V
DC




GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
GW INSTEK
10k pts
2MSa/s
Trig'd
2.00V
2.00V
500us
-1.6V
DC
POWER