BASIC ELECTRONICS LAB
EC29201
LAB REPORT
BATCH 5

Experiment No. : 2 (Ohm's Law and RC Circuits(Filters and rectifiers))

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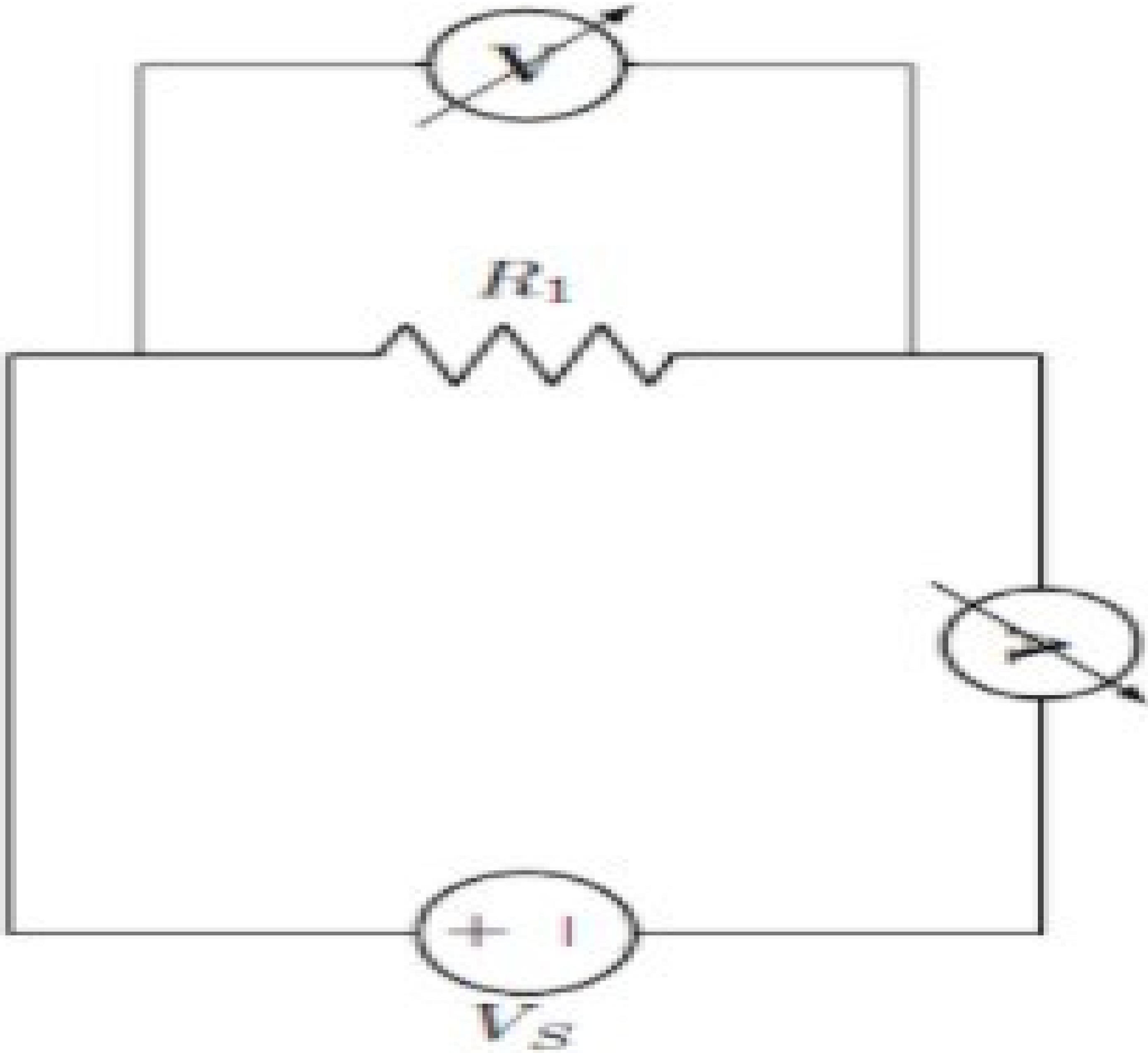
Part-1

AIM : To Verify Ohm's Laws in Resistors,Series Combinations,Parallel Combinations and explain working principle of Non Ohmic Devices

Ohm’s Law (Circuit Diagram):



Ohm’s Law (theory):

.Ohm’s law states that the current flowing in a resistor is directly proportional to the applied potential difference and inversely proportional to the resistance in the circuit

If I is the current flowing through a conducting wire and V is the potential difference across the ends of the conducting wire, then according to Ohm’s law (At constant temperature):

=>$I \propto V$

Such a conductor is characterized by its ‘Resistance’ – R measured in Ohms.

$V=I*R$ where V is voltage in volts, I is current in amperes and R is resistance in ohms

Ohm’s Law (simulated data):

INSTRUCTION

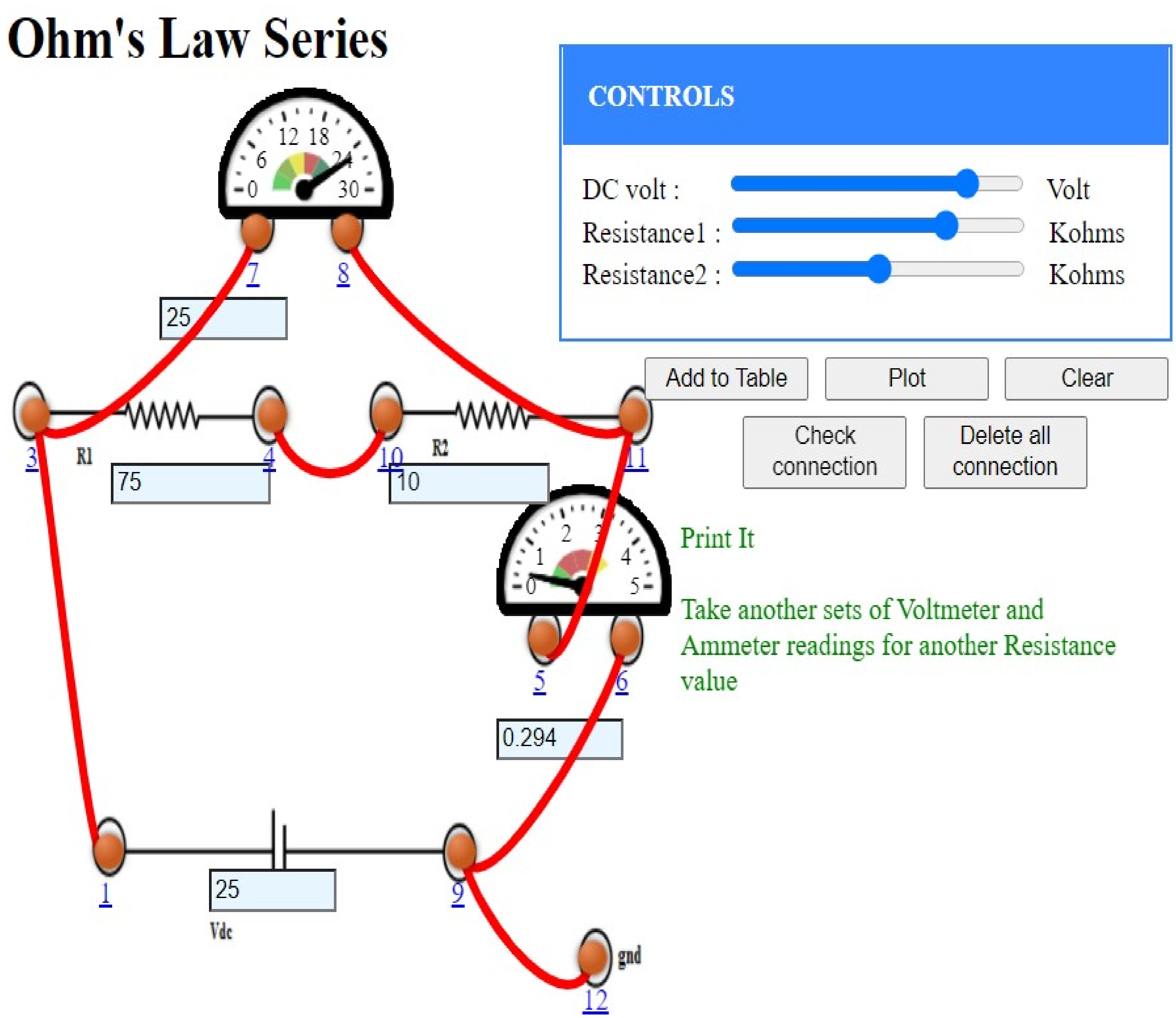
EXPERIMENTAL TABLE

Resistance(R_1): 75 KΩ

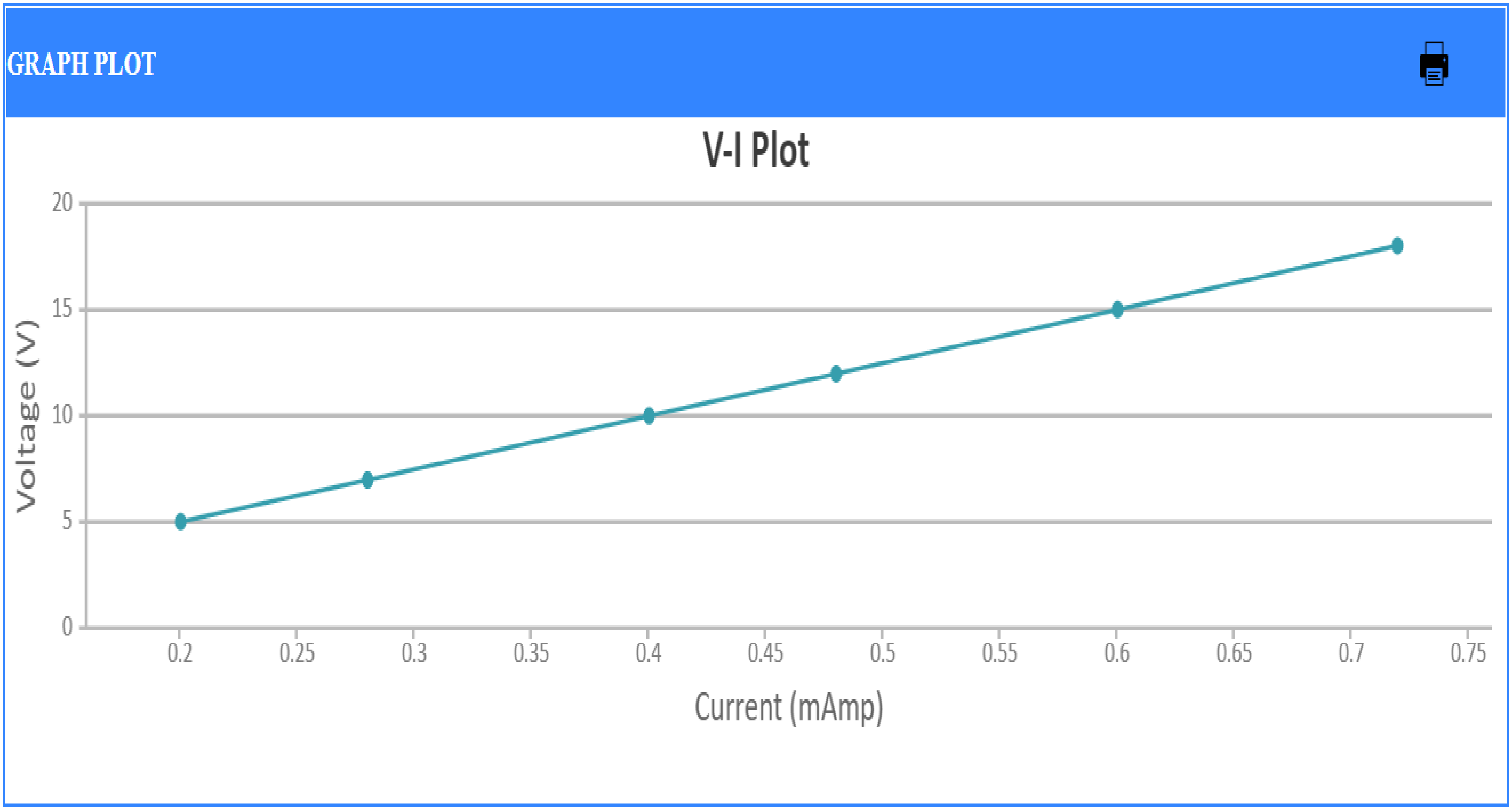
Resistance(R_2): 10 KΩ

Resistance(R_{eq}): 85 KΩ

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	5	0.0588
2	10	0.118
3	12	0.141
4	15	0.176
5	20	0.235
6	25	0.294



Ohm’s Law (Graph):



Ohm’s Law for Resistance in series (Circuit Diagram):

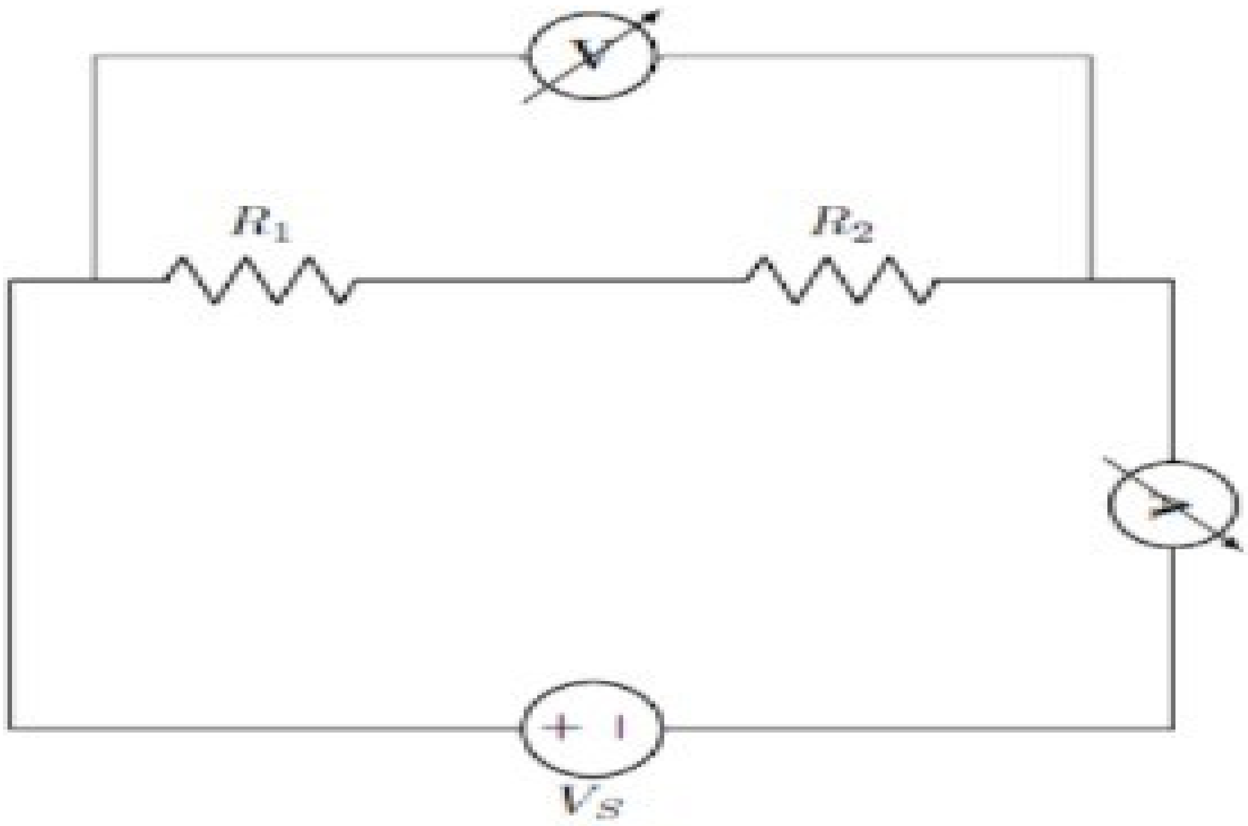


Figure 3: Series resistors

Ohm’s Law for Resistance in Series(Theory)

According to Ohm’s law, $V=I*R$, and in series connection of resistances same current flows to each resistor R_1 and R_2, So the voltage drop across R_1 is $V_1=I*R_1$ and across R_2 is $V_2=I*R_2$

If we substitute the values for individual voltages, we get:
$V_T=I_T*(R_1+R_2)$

This gives the equivalent resistance as
$R_{eq}=R_1 + R_2$

$I_T = V_T / R_{eq}$

Ohm’s Law for Resistances in Series (Simulated Data)

INSTRUCTION

EXPERIMENTAL TABLE

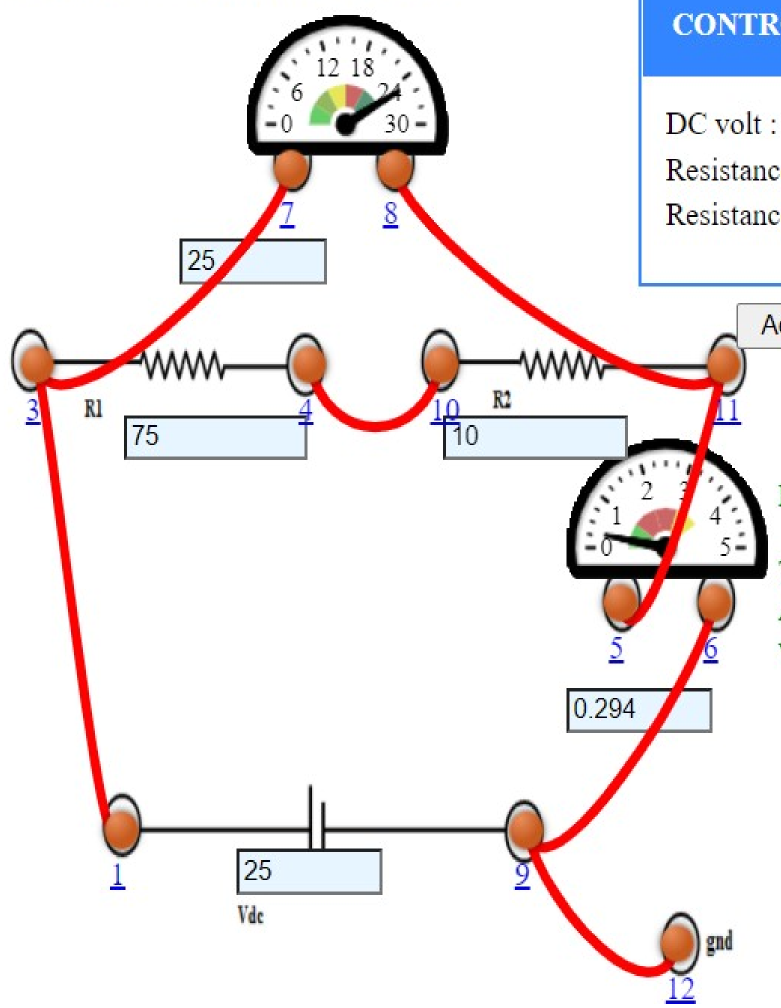
Resistance(R_1): 75 KΩ

Resistance(R_2): 10 KΩ

Resistance(R_{eq}): 85 KΩ

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	5	0.0588
2	10	0.118
3	12	0.141
4	15	0.176
5	20	0.235
6	25	0.294

Ohm's Law Series



CONTROLS

DC volt : Volt

Resistance1 : Kohms

Resistance2 : Kohms

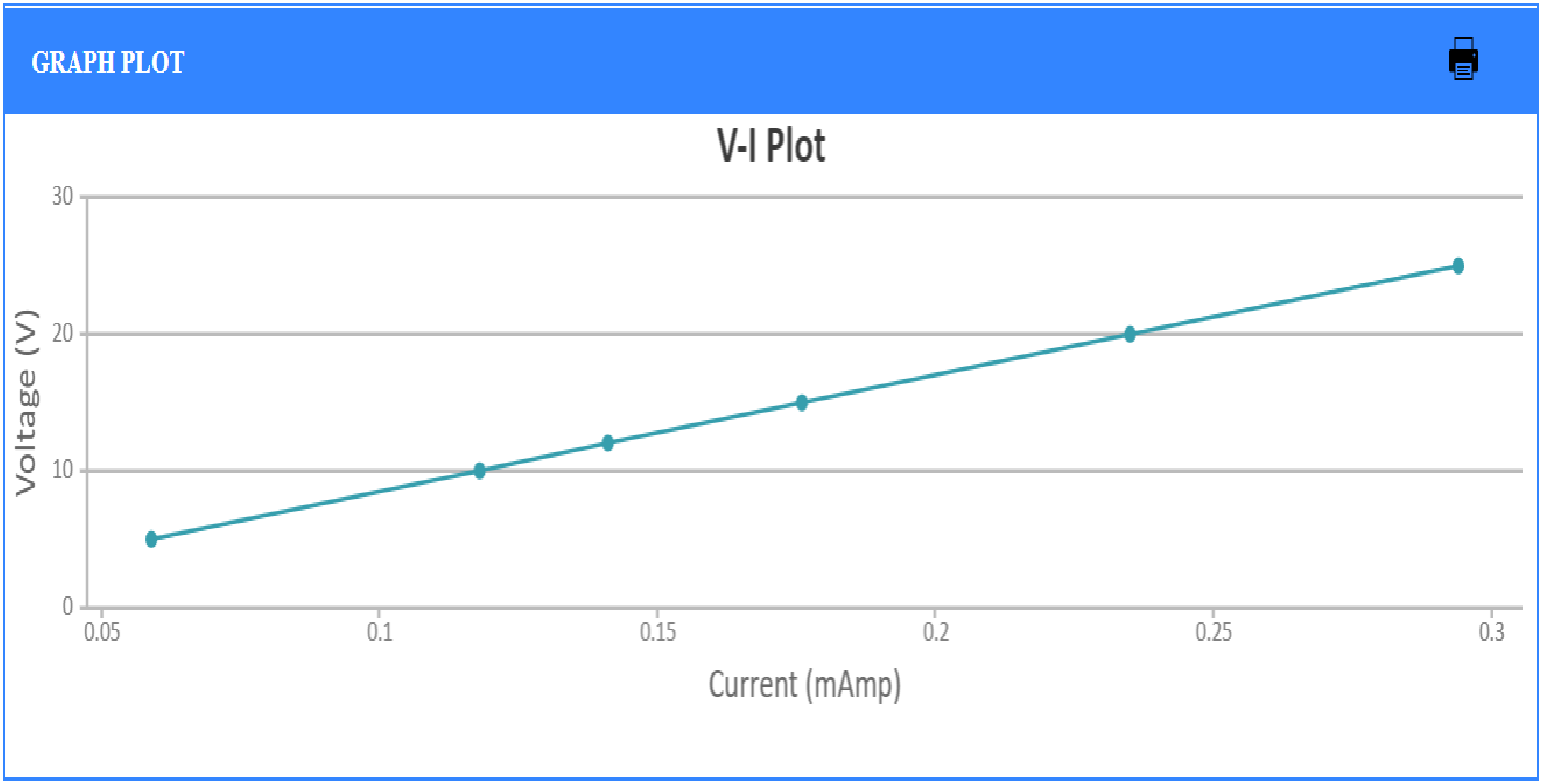
Add to Table | Plot | Clear

Check connection | Delete all connection

Print It

Take another sets of Voltmeter and Ammeter readings for another Resistance value

Ohm’s Law for Resistances in series(Graph)



Ohm’s Law for Resistance in Parallel(Circuit Diagram) :

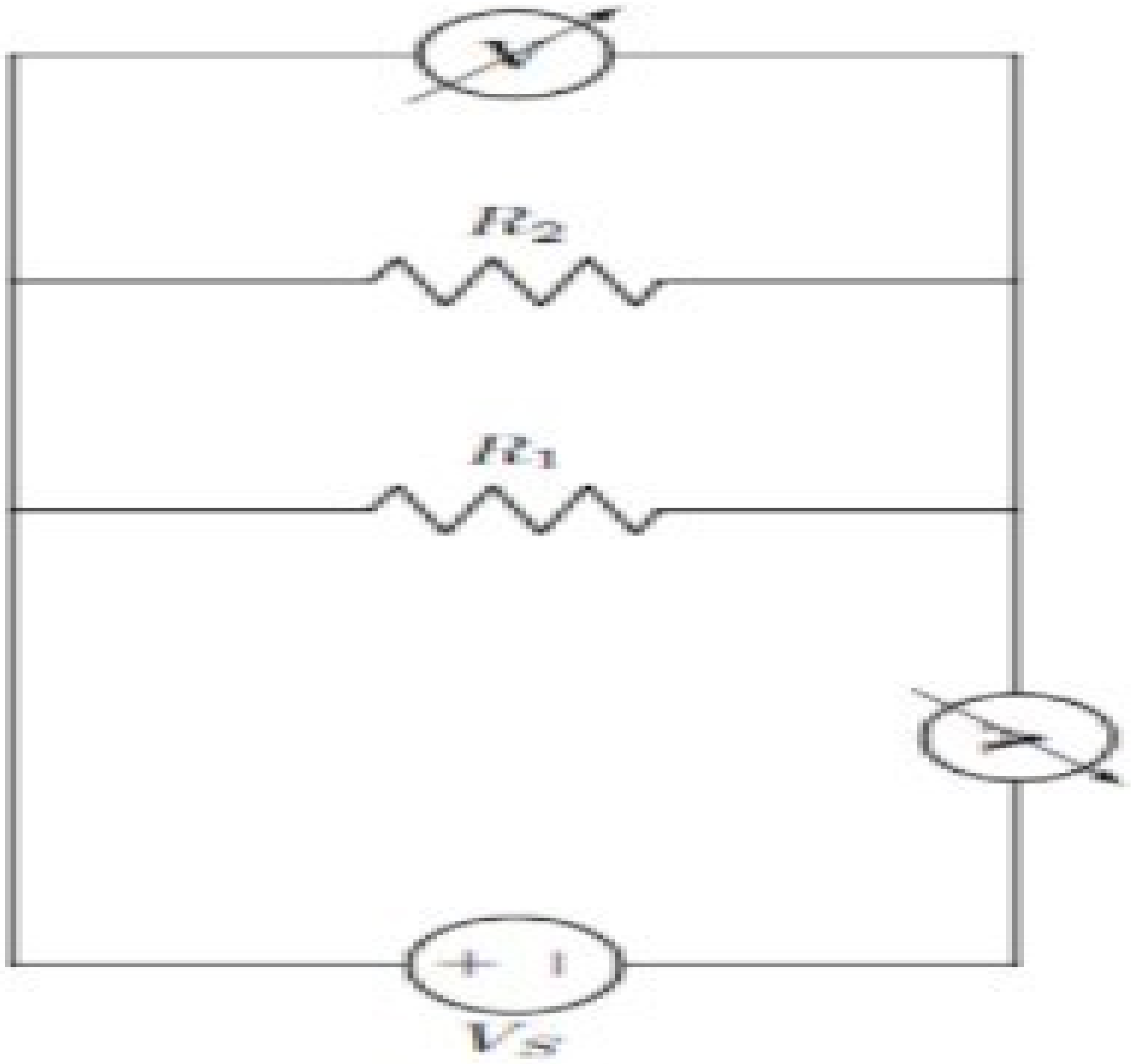


Figure 4: Parallel resistors

Ohm’s Law for Resistance in Parallel (Theory)

Ohm’s Law for Resistors in Parallel:

According to Ohm’s law, V=I*R and in parallel connection of resistances same drop of voltage is there across each resistor. Let I_1 and I_2 currents flows from R_1 and R_2 respectively. So the voltage drop across R_1 is $V= I_1 * R_1$ and across R_2 is $V=I_2 * R_2$

$VT= I_1 * R_1$ or $I_2 * R_2$

And $I_T = I_1 + I_2$

$V_T / R_{eq} = V / R_1 + V / R_2$ $R_{eq} = (R_1 R_2)/(R_1 + R_2)$

$I_T = V_T / R_{eq}$,Therefore

$Req=(R_1 * R_2)/(R_1+R_2)$

Ohm’s Law for Resistances in Parallel (Simulated Data):

INSTRUCTION

EXPERIMENTAL TABLE

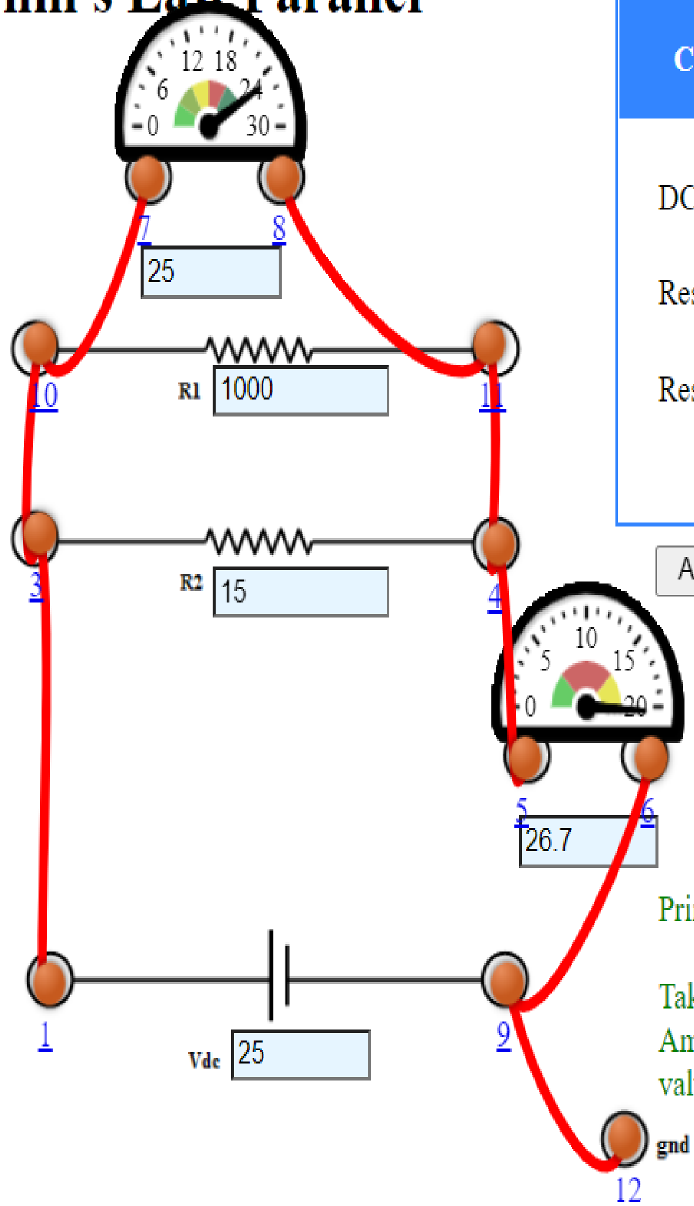
Resistance(R_1): 1000 Ω

Resistance(R_2): 15 KΩ

Resistance(R_{eq}): 0.149977 Ω

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	5	5.33
2	10	10.7
3	12	12.8
4	15	16.0
5	20	21.3
6	25	26.7

Ohm's Law Parallel



CONTROLS

DC volt : Volt

Resistance1 : Ohms

Resistance2 : Kohms

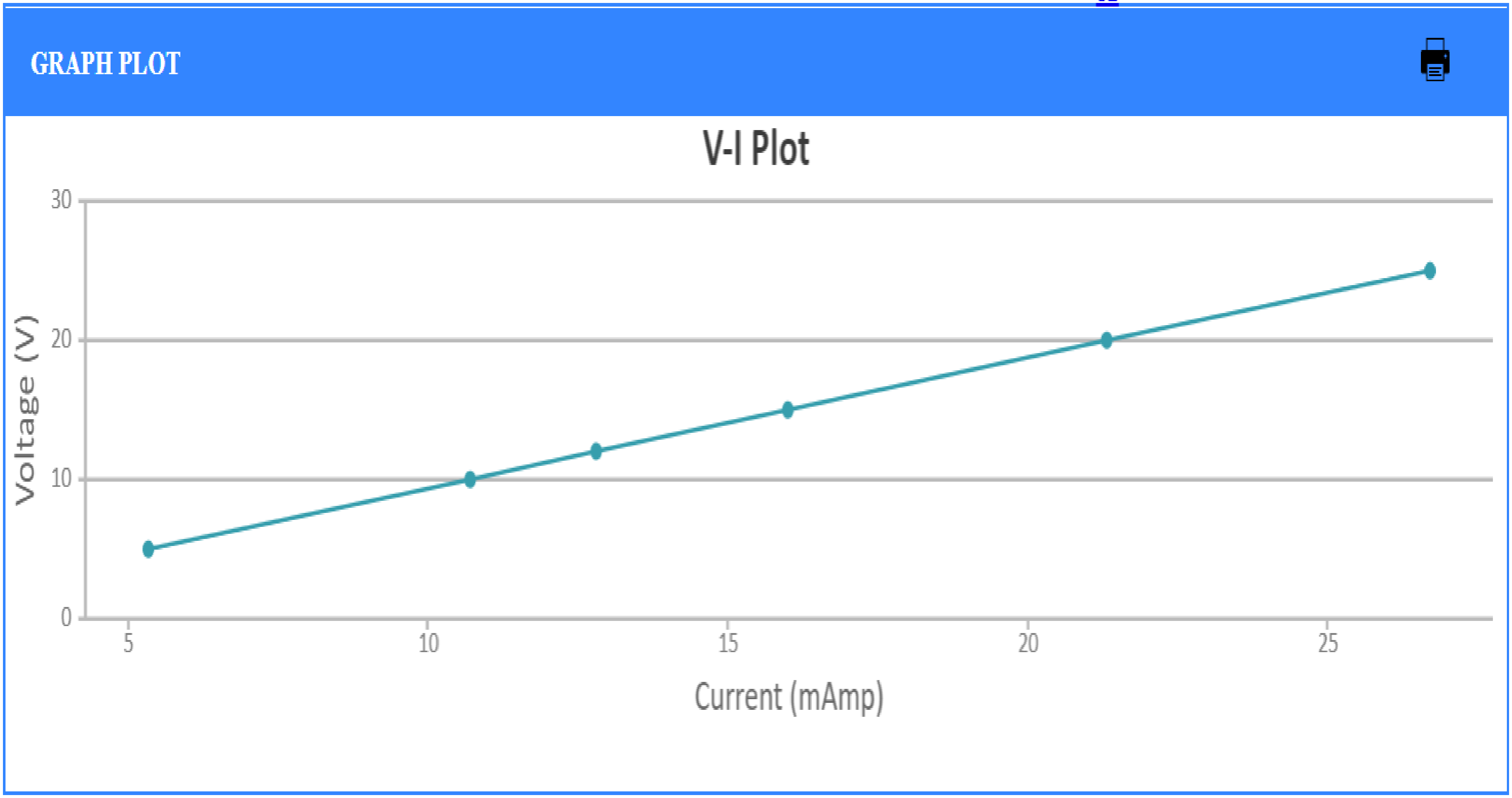
Add to Table | Plot | Clear

Check connection | Delete all connection

Print It

Take another sets of Voltmeter and Ammeter readings for another Resistance value

Ohm’s Law for Resistances in Parallel (Graph)



Non Ohmic Devices(Circuit diagram)

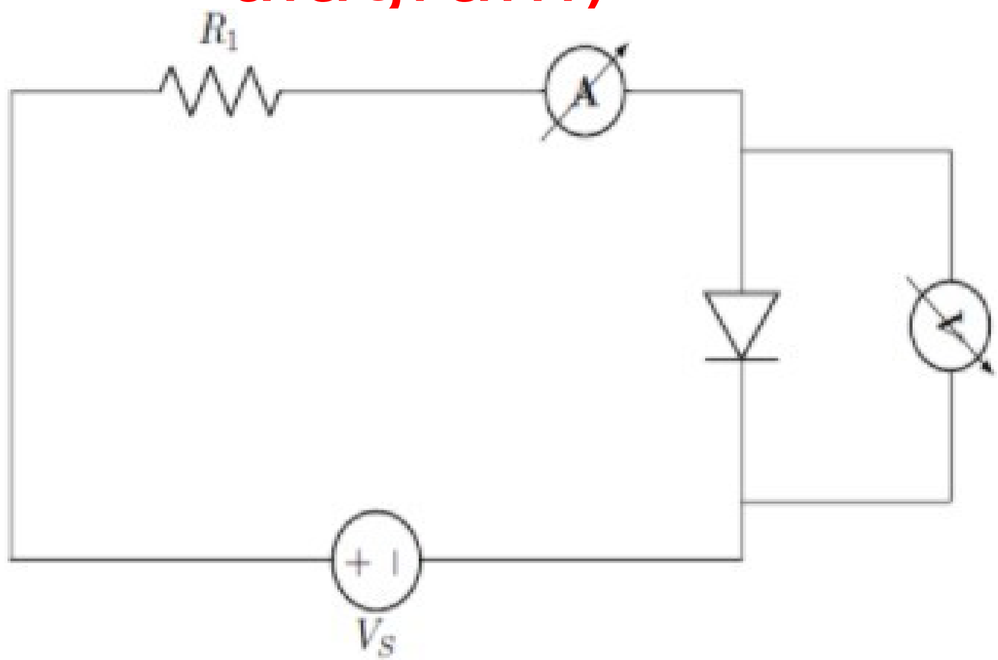


Figure 5: Non Ohmic Device

Working principle of Non Ohmic Device

A Non ohmic device is a device that does not obey Ohm's Law. Such devices do not have a constant resistance and the resistance is constantly changing also known as dynamic resistance. The value of resistance depends temperature and many other factors.Examples of such devices are tungsten filament (bulb), diode,thermistor etc.

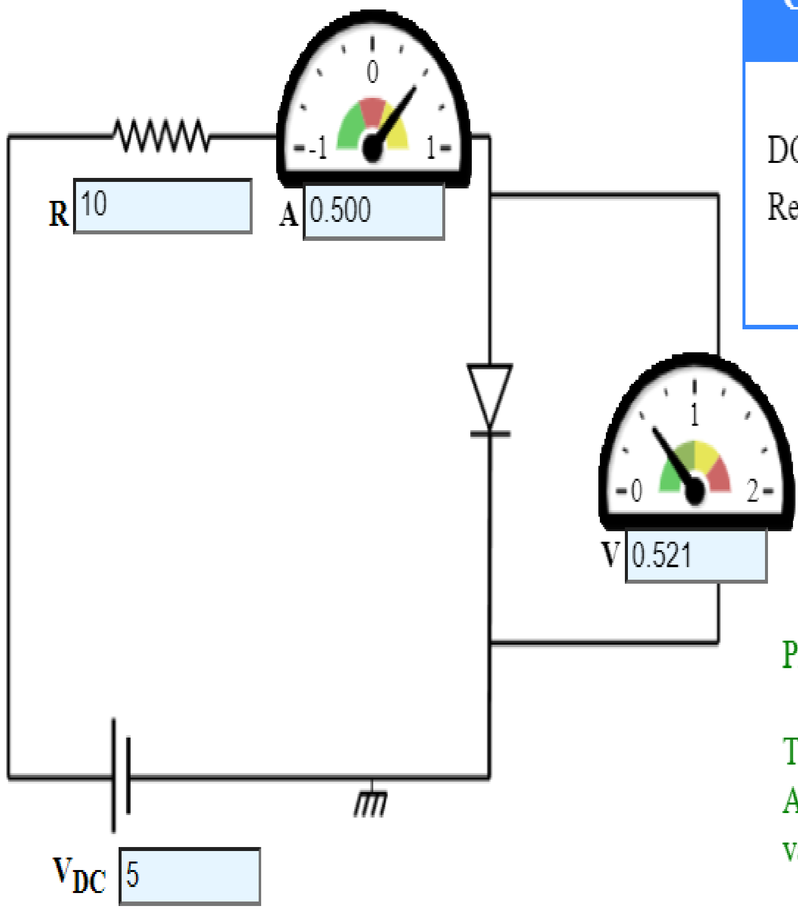
Non Ohmic Devices (simulated data):

INSTRUCTION

EXPERIMENTAL TABLE

Serial No.	Voltage(Volt)	Current (mAmp)	Resistance (KOhm)
1	0.461	0.0500	100
2	0.468	0.0667	75
3	0.478	0.0980	51
4	0.498	0.208	24
5	0.521	0.500	10

Non Ohmic Device



CONTROLS

DC volt : Volt

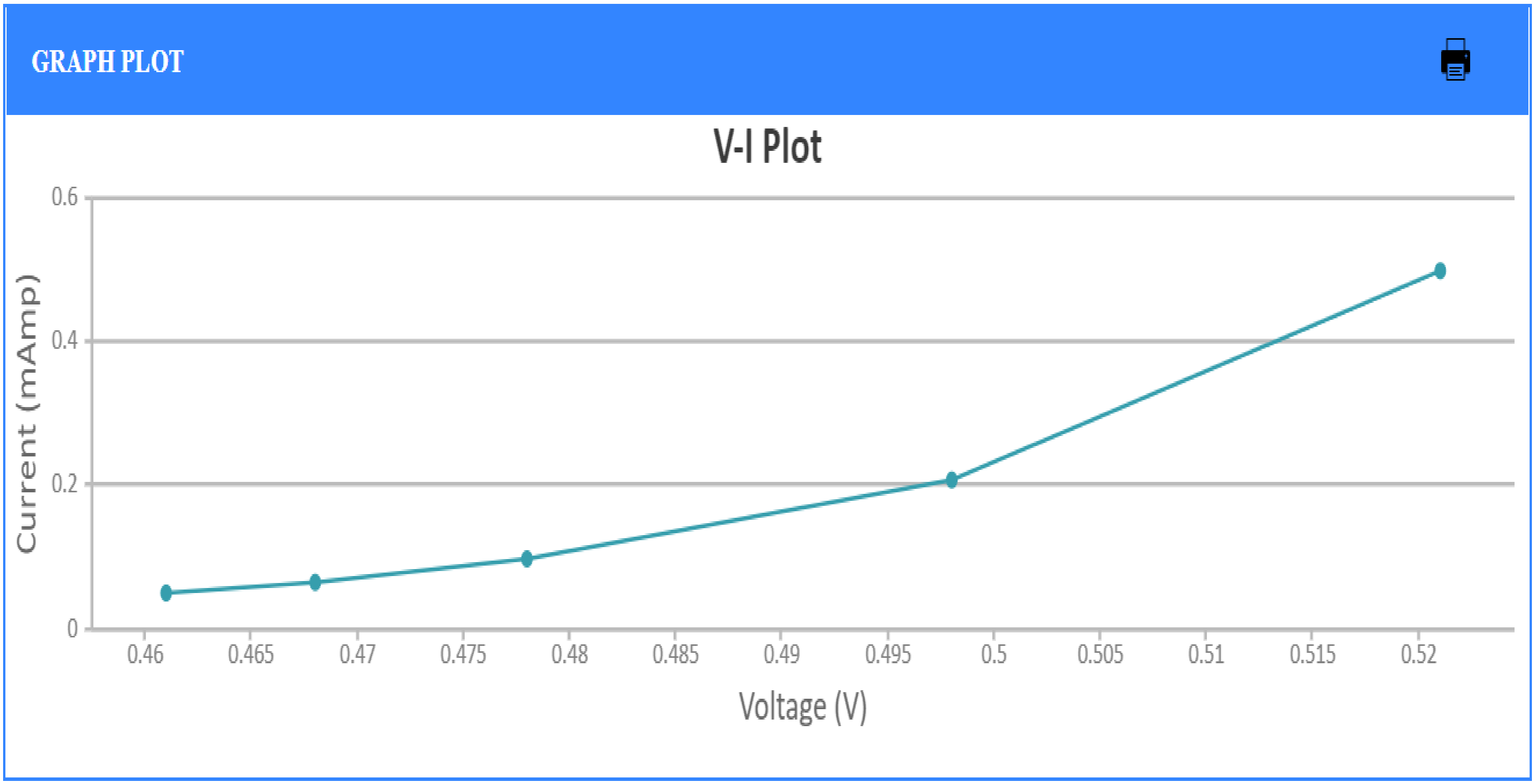
Resistance : Kohms

Add to Table | Plot | Clear

Print It

Take another sets of Voltmeter and Ammeter readings for another Resistance value

Non Ohmic Resistors (Graph):



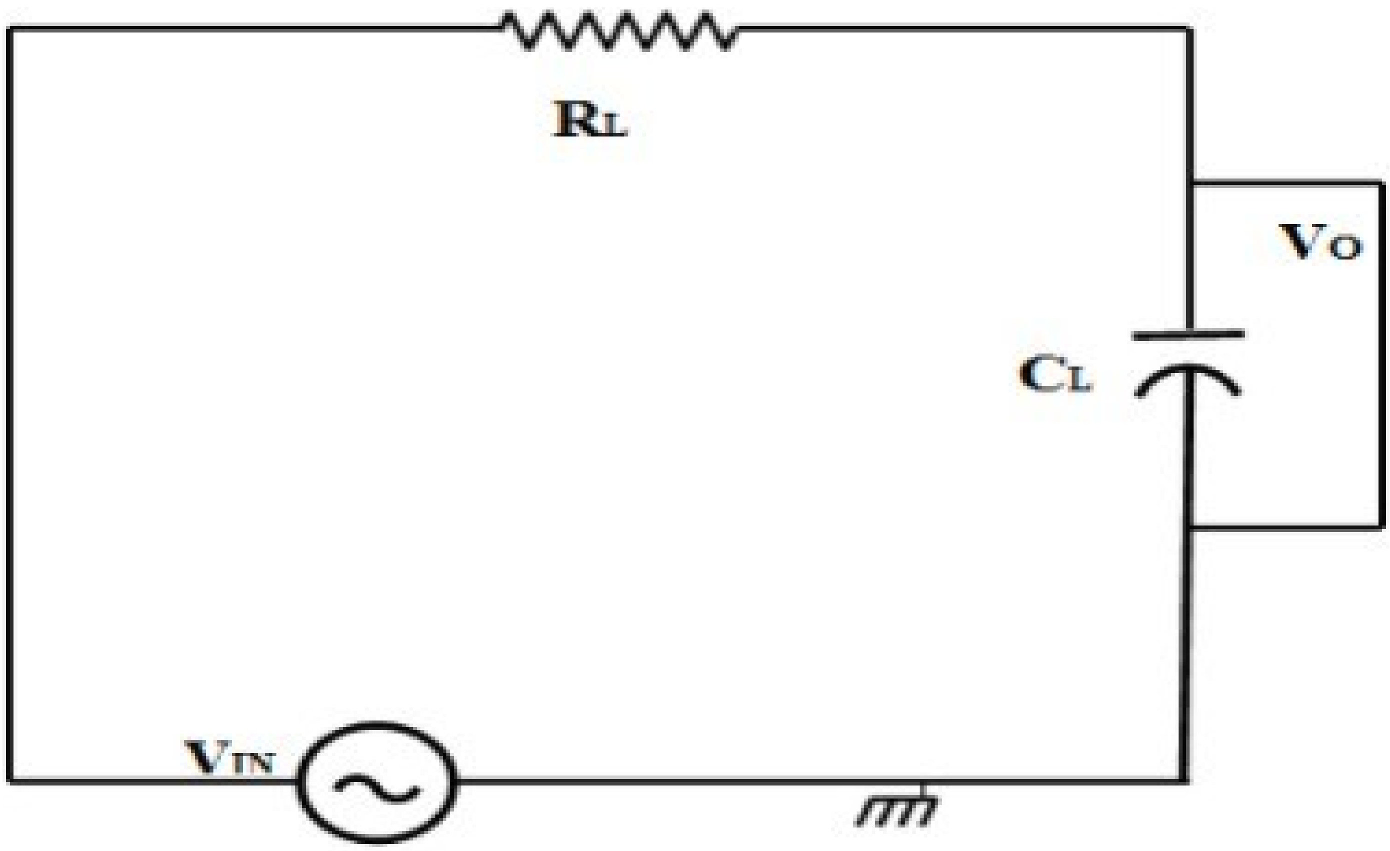
Summary And Observations:

- In this experiment, we verified Ohm's law for a single Resistor.
- We also found the R_{eq} for series combination of resistances using Ohm's Law and verified the formula for equivalent resistance for two resistors in series.
- We also found the R_{eq} for parallel combination of resistances using Ohm's Law and verified the formula for equivalent resistance for two resistors in parallel
- We also verified the working principle of a non ohmic device using simulations and proved that they do not follow ohm's law.
- Also the ammeter and voltmeter used will also have some resistance.

Part -2

AIM: To explain RC Voltage Dividers, working of a RC Circuit as a Low Pass Filter and also working of a RC Circuit as a High Pass Filter

Circuit Diagram for RC Low Pass Filters



Working principle of a low pass filter

- Filters : A filter is a circuit capable of passing (or amplifying) certain frequencies while removing other frequencies. Thus, a filter can extract the required frequencies from signals and remove the undesirable or irrelevant frequencies.
- Low Pass Filters : This type of filters allows only the frequency lower than the cut off frequency(f_c), starting from zero. This is made by connecting a resistor in series with a capacitor and output voltage is measured across the capacitor.
- Cut-Off Frequency: The frequency at which the amplitude of the signal is decreased by 3 decibels is knwons as the cut off frequency(f_c). At this value power reduces by 50 percent.(or output voltage is half the input voltage).
  , so this is the reason for selecting 3 decibels as reference.Formula
  ($f_c = 1/2 \times \pi \times R_L \times C_L$)
- $$X_C = \frac{1}{2\pi f C}$$ a:(C:Capacitance,f:Frequency)
- Low-Pass Filter Phase Shift:Phase = -arctan($2\pi \times f \times R \times C)$
- V_{out} :Voltage difference across the capacitor.

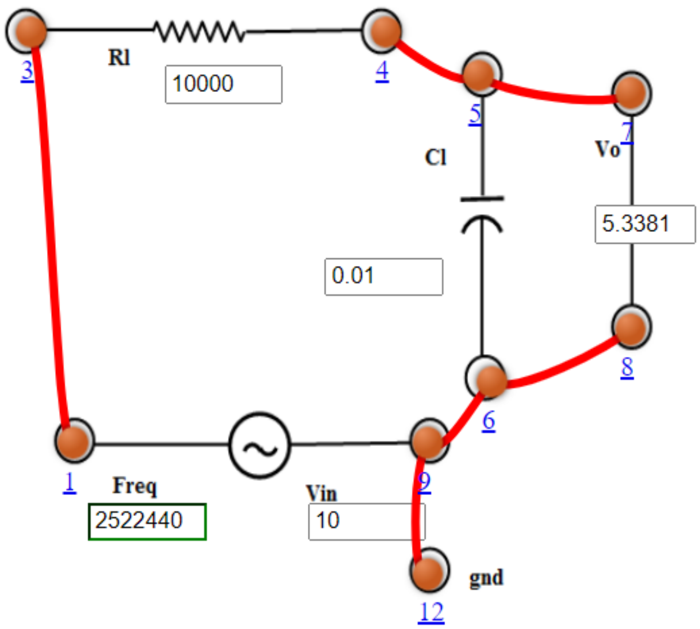
$$V_{OUT} = V_{IN}\left(\frac{X_C}{\sqrt{R_1^2 + X_C^2}}\right)$$

Here as we decrease the frequency , the capacitive reactance increases as it is inversely proportional to the frequency and thus transferring the whole input voltage as output, and at higher frequencies the voltage is very less and it disallows the higher frequency, therefore at low frequency Vin=Vout and making the circuit as a **Low pass filter.**

Simulated Data for RC Low Pass Filter:

V_{in}=10 V
R_L=10kOhm
C=0.01nF

INSTRUCTION



Phase of 1st order low pass filter

CONTROLS

Load Resistance (R_L) : Ω
Load Capacitor(C_L) : nf
Input Voltage (V_{in}) : V
Frequency (Freq) : Hz

Add to Table | Phase Response | Clear

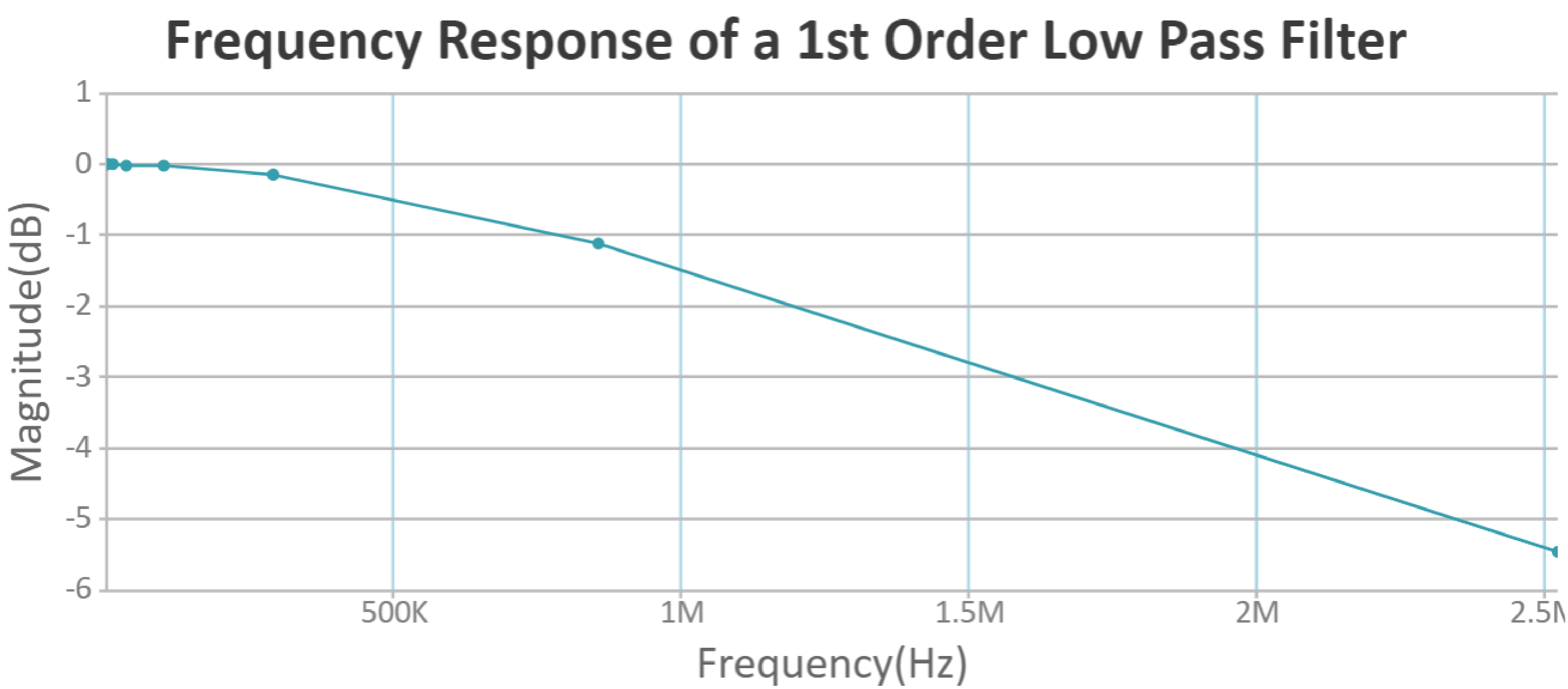
Check connection | Delete all connection

EXPERIMENTAL TABLE

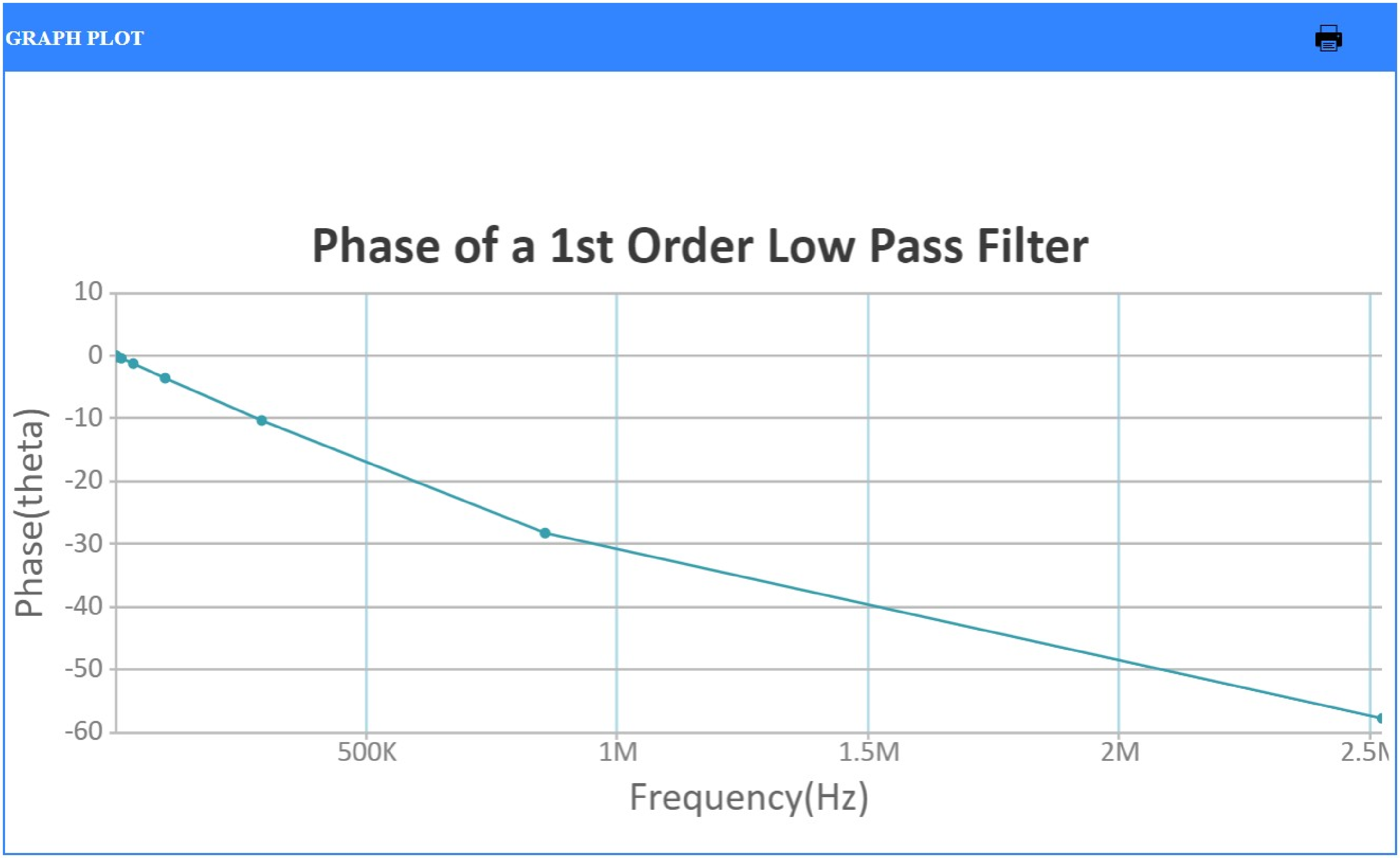
Serial No.	Frequency(Hz)	Magnitude(dB)	Phase(theta)	Output Voltage(V)
1	50	-4.33854e-9	-0.00181185	10.000
2	149	-3.7787200000000004e-8	-0.00534715	10.000
3	438	-3.29112e-7	-0.0157806	10.000
4	3818	-0.0000249656	-0.137443	10.000
5	11267	-0.000217436	-0.405616	9.9997
6	33252	-0.001893432	-1.19691	9.9978
7	98134	-0.01646342	-3.52837	9.9811
8	289614	-0.1413372	-10.3134	9.8386
9	854713	-1.099534	-28.2394	8.8110
10	2522440	-5.45226	-57.7660	5.3381

Graph for RC Low Pass Filter(Frequency Response)

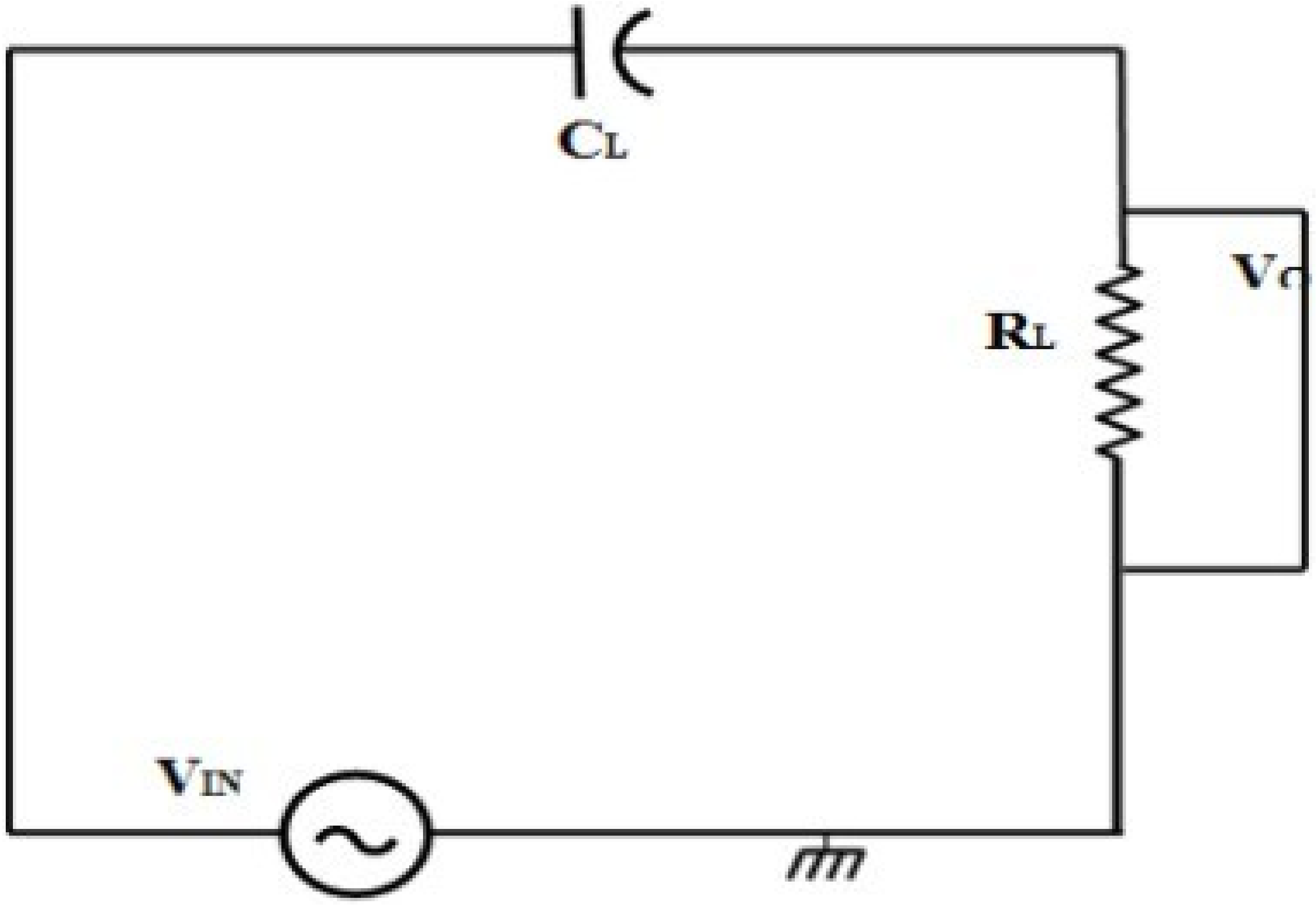
GRAPH PLOT



Graph for RC low pass filter(Phase response)



Circuit Diagram for RC High Pass Filter



Working principle of high pass filter

- Filters : A filter is a circuit capable of passing (or amplifying) certain frequencies while removing other frequencies. Thus, a filter can extract the required frequencies from signals and remove the undesirable or irrelevant frequencies.
- High Pass Filters : This type of filters allows only the frequency higher than the cut off frequency(f_c). This is made by connecting a resistor in series with a capacitor and output voltage is obtained across the resistor.
- Cut-Off Frequency: The frequency at which the amplitude of the signal is decreased by 3 decibels is knwons as the cut off frequency(f_c). At this value power is ½ of input power. , so this is the reason for selecting 3 decibels as reference.Formula
  $f_c = 1/2 \times \pi \times R_L \times C_L$
- Capacitive Reactance:(C:Capacitance,f:Frequency)

$$X_C = \frac{1}{2\pi f C}$$

- High Pass Filter Phase Shift: Phase = $\pi/2 - \arctan(2 \times \pi \times f \times R \times C)$
- V_{out} :Voltage difference across the resistor.

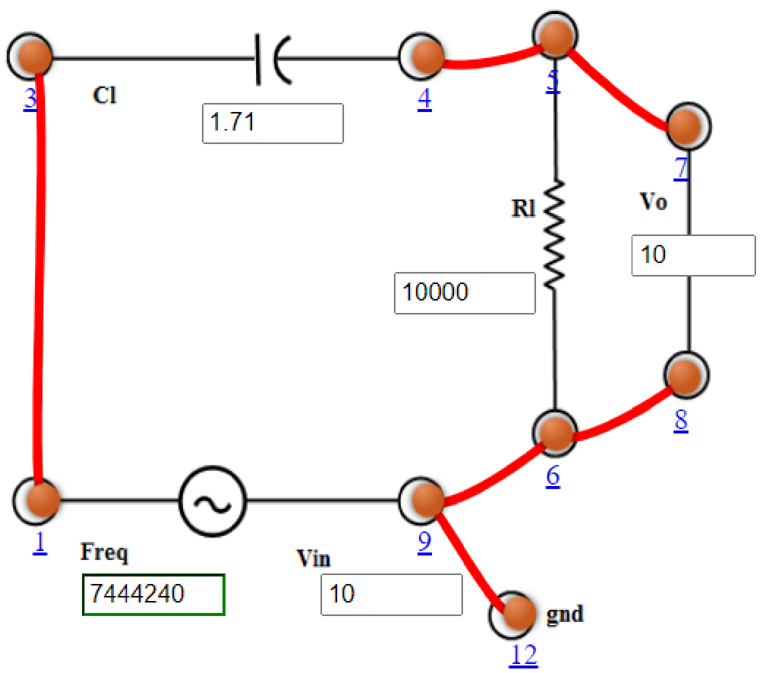
$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{R}{\sqrt{R^2 + Xc^2}}$$

Here as we increase the frequency,the capacitive reactance decreases as it is inversely proportional to the frequency and thus almost all the input voltage drops in the resistance ,therefore at higher frequency Vin=Vout making the circuit as a **high pass filter.**

Simulated Data for RC high Pass Filter:

V_{in}=10 V
R_L=10kOhm
C=1.71nF

INSTRUCTION



Phase of 1st order low pass filter

CONTROLS

Load Resistance (R_L) : Ω
Load Capacitor(C_L) : nf
Input Voltage (V_{in}) : V
Frequency (Freq) : Hz

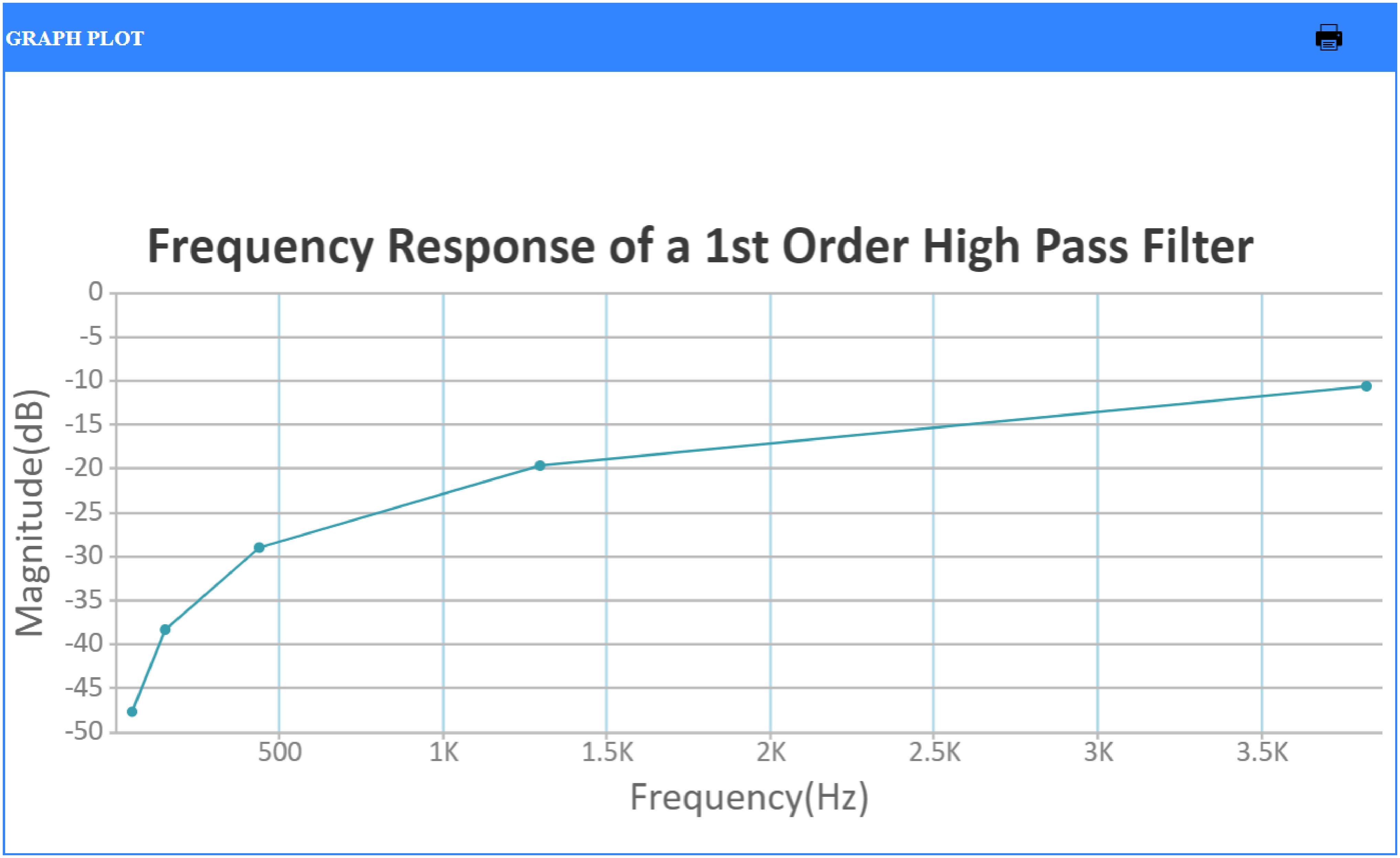
Add to Table | Phase Response | Clear

Check connection | Delete all connection

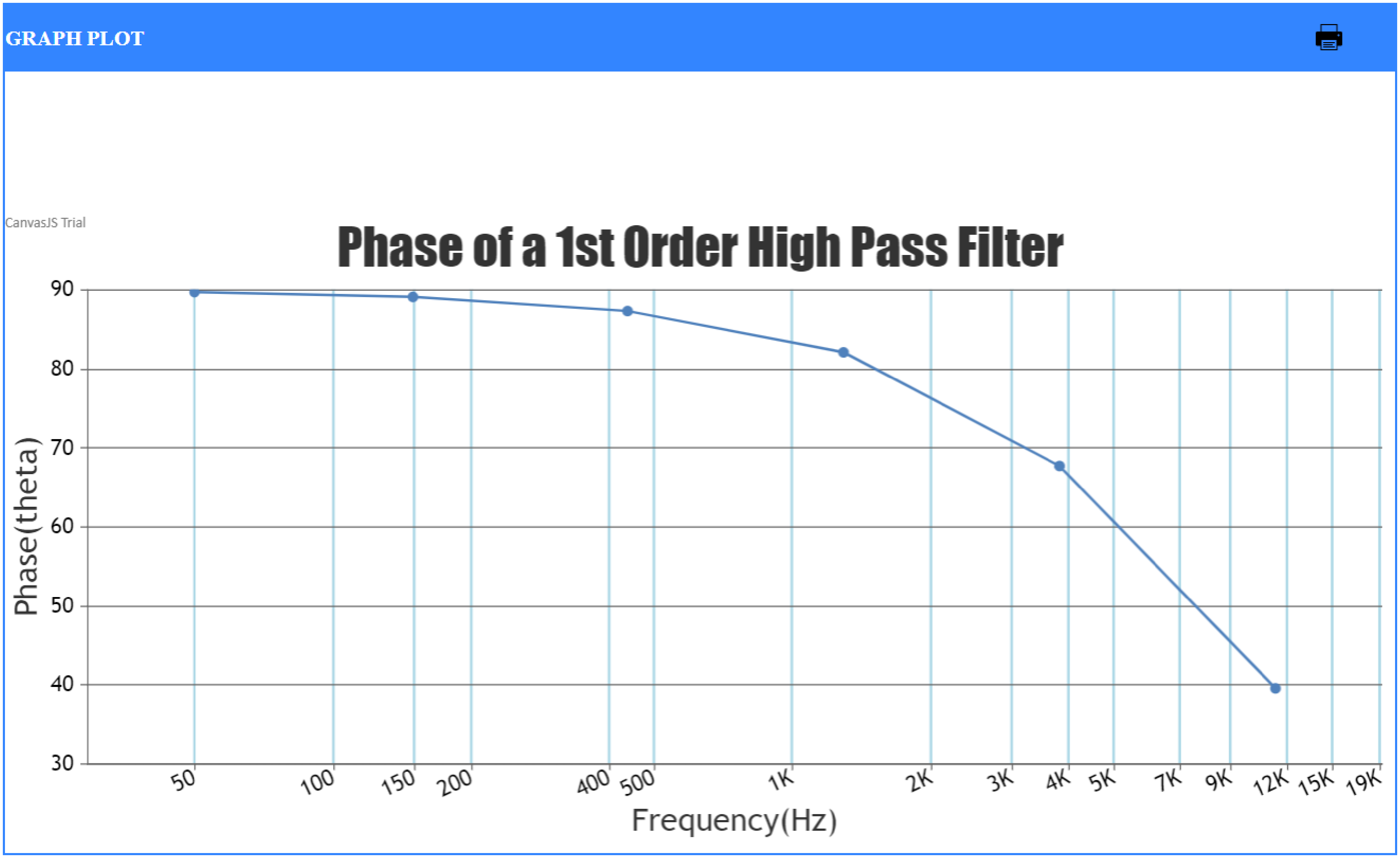
EXPERIMENTAL TABLE

Serial No.	Frequency(Hz)	Magnitude(dB)	Phase(theta)	Output Voltage(V
1	50	-45.3446	89.7358	0.054047
2	438	-26.554000000000002	87.3492	0.47021
3	1294	-17.2275	82.1325	1.3760
4	3818	-8.41926	67.7411	3.7935
5	11267	-2.26096	39.5926	7.7082
6	98134	-0.03893	5.42336	9.9553
7	289614	-0.00448756	1.84254	9.9948
8	854713	-0.000515474	0.624525	9.9994
9	2522440	-0.0000591872	0.211624	9.9999
10	7444240	-0.0000067956600000001	0.0717078	10.000

Frequency response graph for RC high Pass Filter



Phase response graph for RC high Pass Filter



Summary

- In this experiment,we learnt what is an electrical filter and how does it works.
- Secondly,we saw the construction and working of the Low Pass Filter and how it disallows the higher frequencies
- Next ,we saw the construction and working of the High Pass Filter and how it allows higher frequencies only.

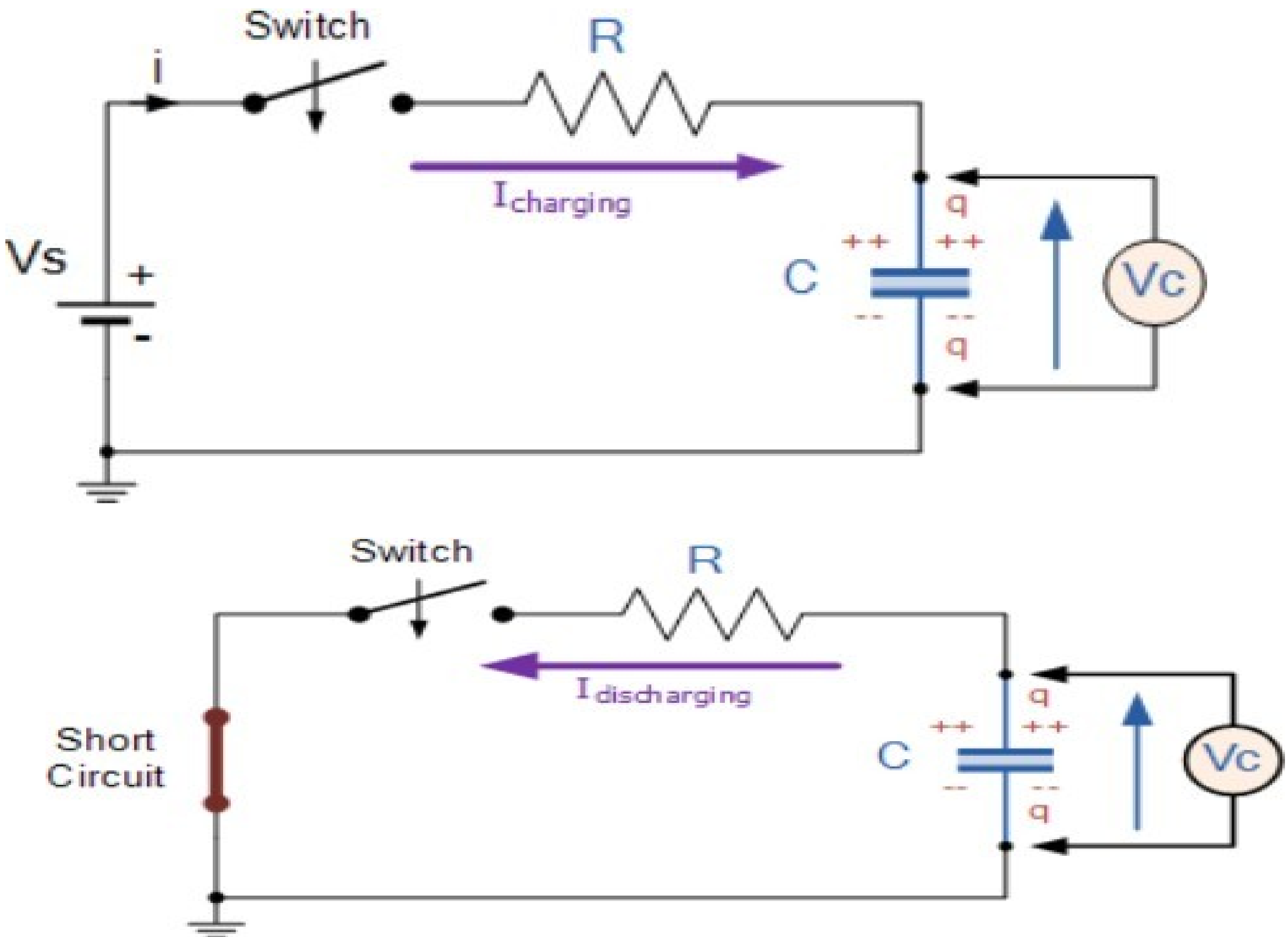
Observations

1.The plot for frequency response and phase response is better depicted in the vlab simulation where the circuit is pre drawn.
2.In practical the output frequency response is not a square wave but a curve.

Part -3

AIM: To study the working of an RC circuit as a differentiator and integrator and thereby study the output response to a square wave input.

Circuit Diagram for RC Circuits charging and discharging



Charging and Discharging of capacitor(Theory)

- Charging Of Capacitor
- In the first circuit ,a battery is supplying energy to the capacitor in the form of charge carried in the form of current from the battery.
- Kirchoff's Equation for charging the capaci $V_s - R \times i(t) - V_c(t) = 0$
- Using this formula ,we can find the potential difference across the capacitor as (keeping i(t)=dq/dt and Vc(t) as q/C,where q is charge on capacitor and C is capacitance of the capacitor) :

$$V_C = V_S\,(1 - e^{(-t/RC)})$$

- Here as we can see from the equation, Voltage increases ,and thus charge increases, with time (t) making it a charging circuit.
- Here R× C is the time constant for the circuit.
- In 1 time constant = R C , the capacitor charges 63% of the maximum charge that can come in this circuit.

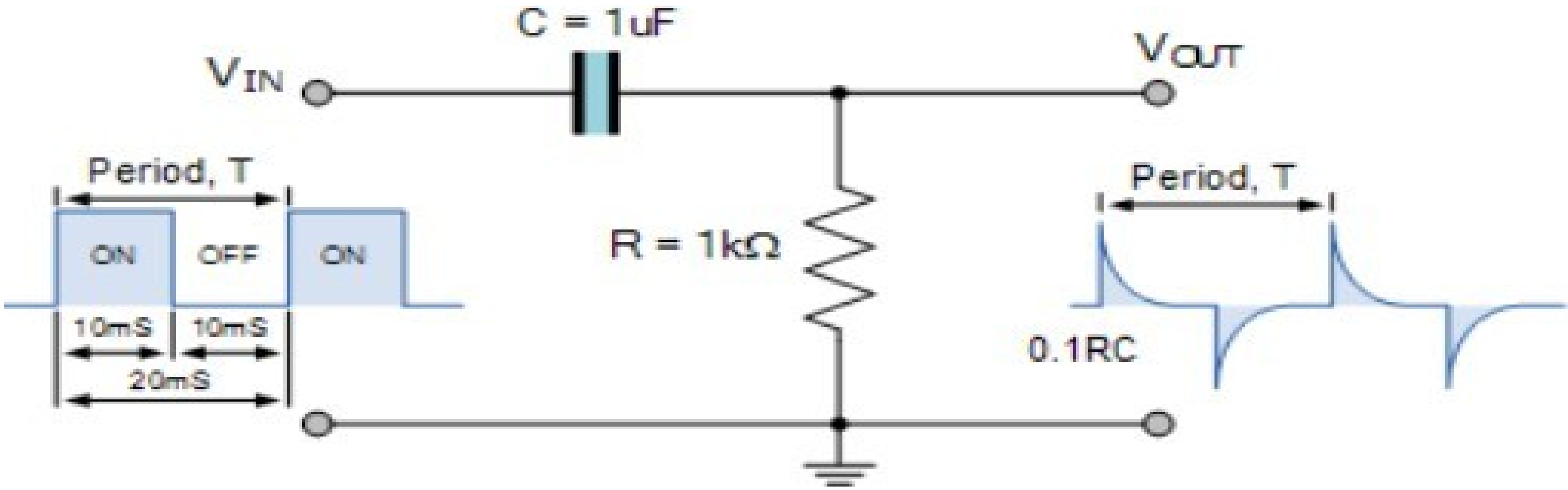
- Discharging of Capacitor
- In the second circuit ,capacitor is supplying energy to the resistor in the form of current and heat energy is produced, thus discharging the capacitor.
- Kirchoff's Equation for discharging the capacitor: ×

$V_c(t)=i(t)$ R

- Using this formula ,we can find the potential difference across the capacitor as (keeping i(t)=dq/dt and Vc(t) as q/C,where q is charge on capacitor and C is capacitance of the capacitor) :

- Here as we can see from the equation, Voltage decreases ,and thus charge decrea $V_C = V_S \times e^{-t/RC}$ e (t) making it a discharging circuit.
- Here also R $\times$ C is the time constant for the circuit.
- In 1 time constant = R C , the capacitor charges 63% of the charge it had at starting.

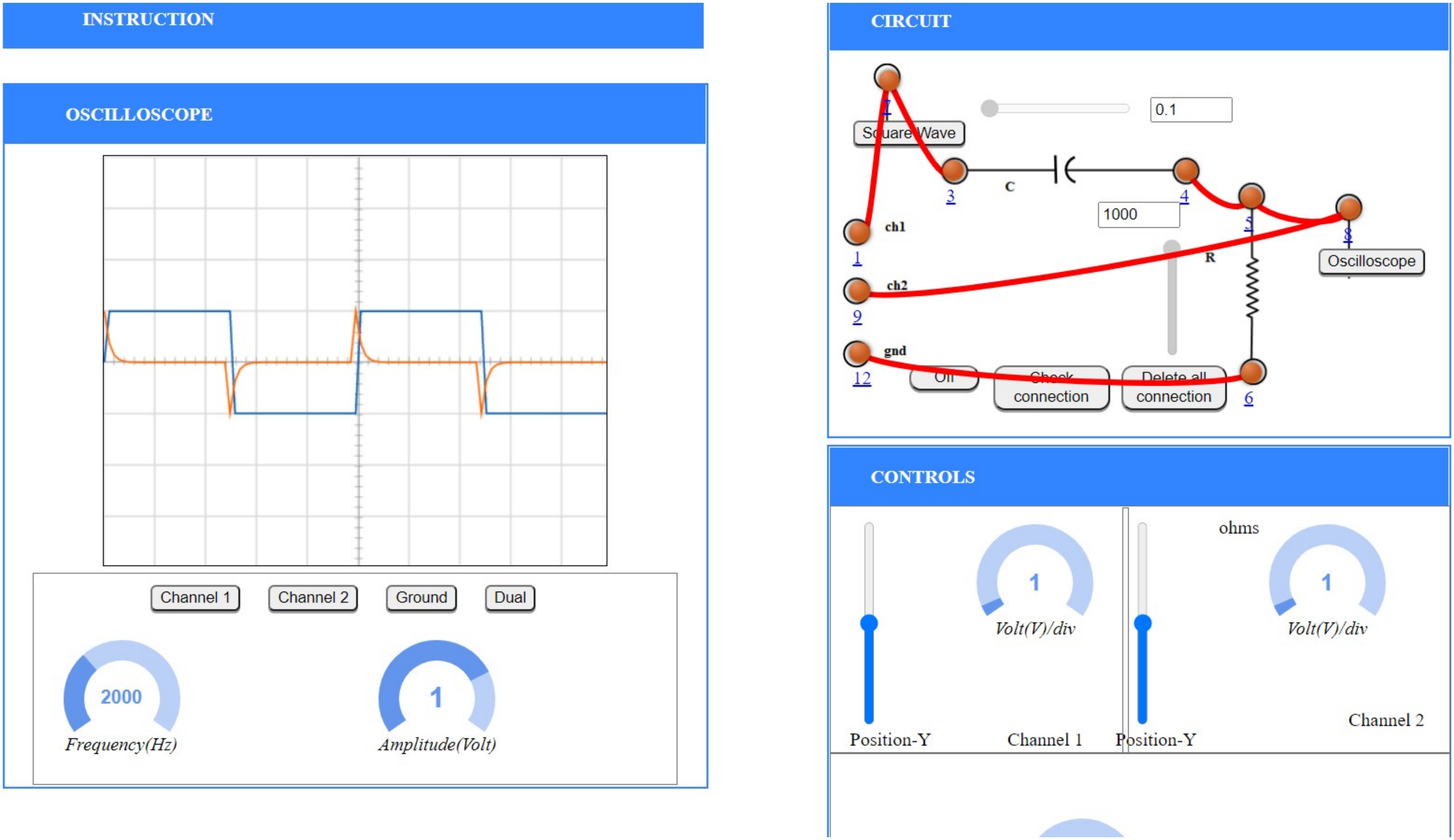
Circuit Diagram for RC Circuits as differentiator



Working principle of RC differentiator circuits

- The Differentiator circuit converts or 'differentiates' a square wave input signal into high frequency spikes at its output.
- As shown in the circuit ,a capacitor and a resistor is joined in series and a voltmeter is attached to the ends of the resistor.
- In an RC circuit if we take the voltage drop across R, and if we keep RC time constant as very short compared to the time period of the input waveform we will be differentiating the square wave.
- RC<<Time period of input waveform.

Oscilloscope simulations for RC differentiator circuit

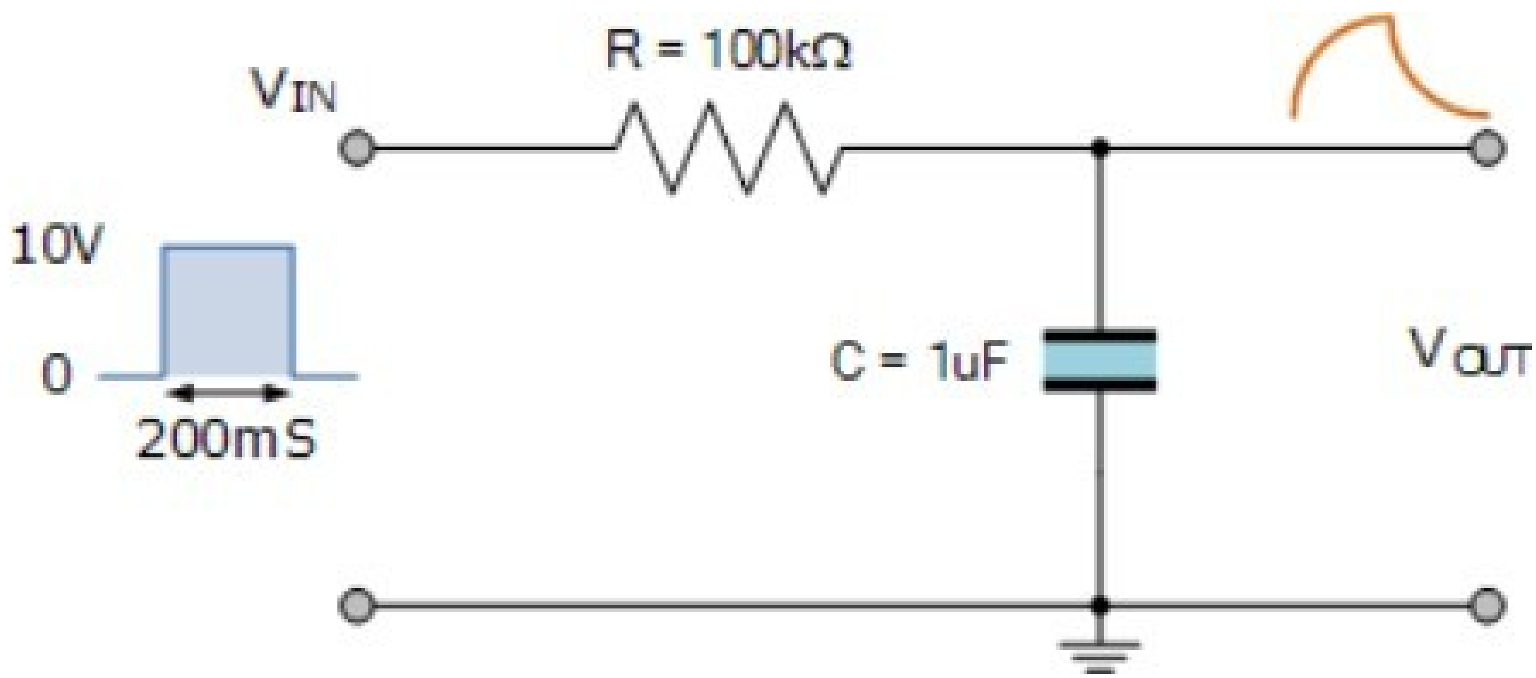


Oscilloscope simulations for RC differentiator circuit

Oscilloscope simulations for RC differentiator circuit

Oscilloscope simulations for RC differentiator circuit

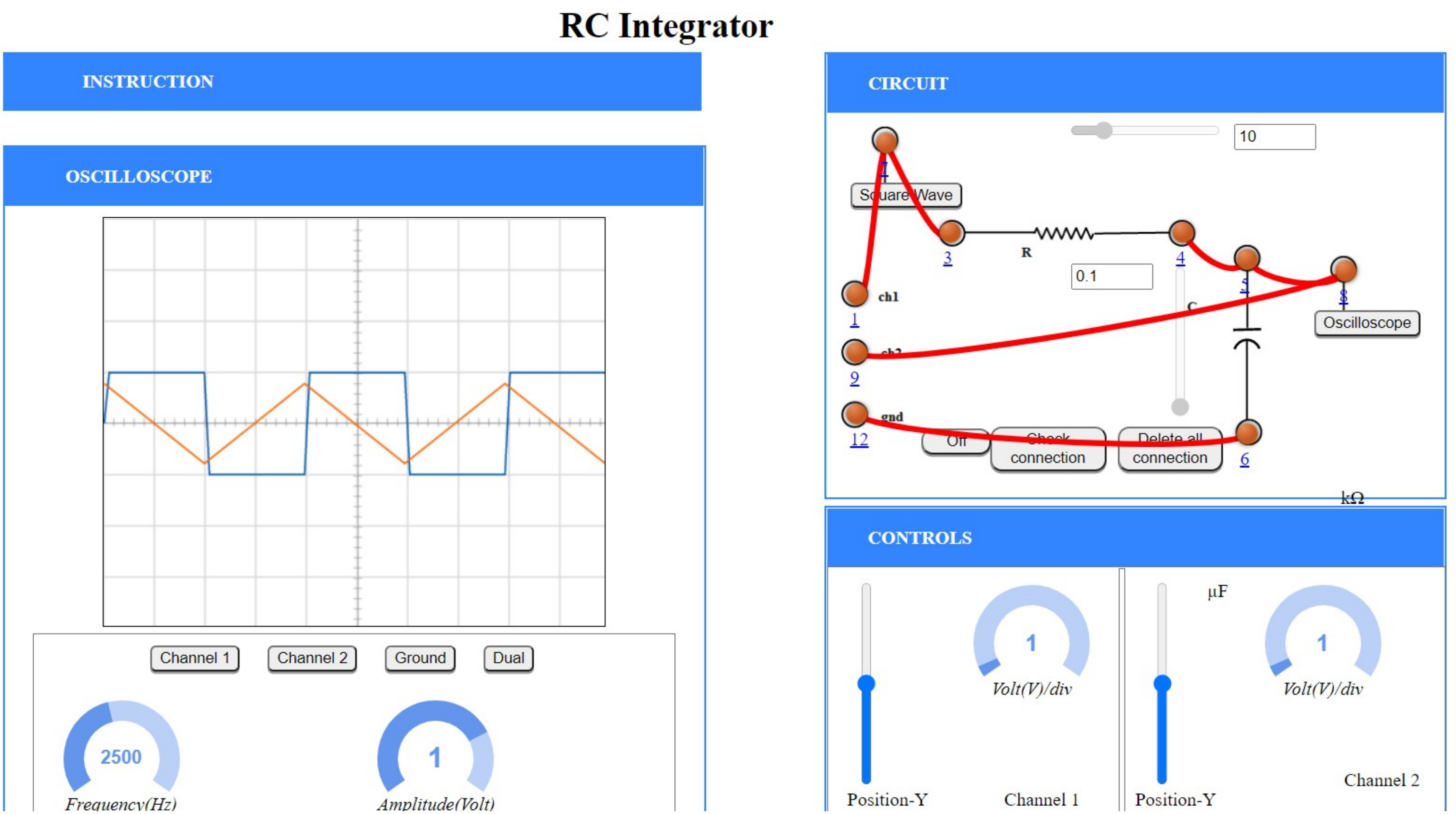
Circuit Diagram for RC Circuits as integrator



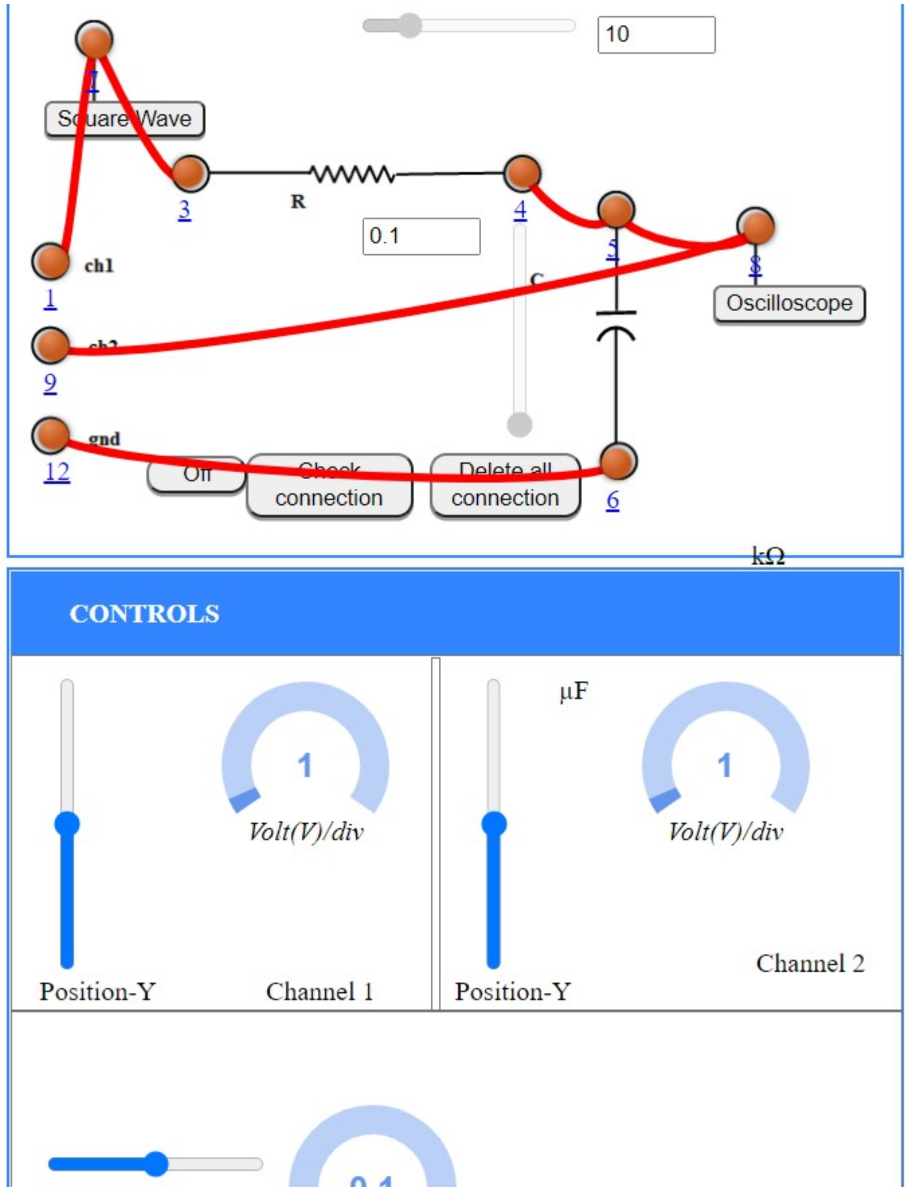
Working principle of RC integrator circuits

- The Integrator circuit converts or ‘integrates' a square wave input signal into triangular waveforms at its output.
- As shown in the circuit above ,a capacitor and a resistor is joined in series and a voltmeter is attached to the ends of the capacitor.
- So, we put a resistor such that we can control the current and ideally try to have dV_{out}/dt to be a constant. Since the current does not change much during the initial part of the charging and discharging of the capacitor , the value of RC must be chosen such that it is large compared to the time period of the square wave.
- RC>>Time period of square wave.

Oscilloscope simulations for RC integrator circuit



Oscilloscope simulations for RC integrator circuit



Oscilloscope simulations for RC integrator circuit

Oscilloscope simulations for RC integrator circuit

Summary

- In this experiment,we learnt the principle behind charging and discharging of a RC Circuit.
- We also saw the construction and working of the RC Differentiator circuits which differentiates a square wave and converts into spikes.
- Next ,we saw the construction and working of the RC Integrator which integrates the square wave to a triangular waveform.

Observations

1.The frequency of output signal was not changing according to input frequency in RC differentiator circuit.(A glitch in vlab)
2.The square wave input is not ideal in practical experiment.