

Title: Verification of V-I and I-V characteristics of a diode.

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COURSE: ANALOG ELECTRONICS CIRCUIT LAB (Day 4).

ASSIGNMENT-4

(Experiment No.: 04)

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Objective: To verify the V-I and I-V characteristics of a diode.

Theoretical Background: A diode is a semiconductor device that allows current to flow in one direction only. It is represented by the symbol shown below.

The ideal diode equation is given by:

$$I = I_s \left(e^{\frac{V}{nV_T}} - 1 \right)$$

Experiment No. 4

Date : 27.08.2021

Title :- Realization of V-I and I-V converter using the operational amplifier.

Aim :- The aim of this experiment is to find out the characteristics of op-amp while as voltage to current converter and as an current (I) to voltage (V) converter. Also observe the calculated values to the observed values from the circuit.

Apparatus Required :-

- (i) AC power source
- (ii) Ground.
- (iii) op-amp (3 channel)
- (iv) resistors.
- (v) probes (voltmeter and ammeter)
- (vi) connecting wires.

Theory :- Voltage and current are the basic quantities. They can be converted into one another depending on the environment. Voltage to current converter and current to voltage converter are the two circuits that help in such conversion.

■ Voltage to current converter :- A V-I converter is an electronic circuit that takes current as the input and produces the voltage as output. An op-amp based voltage to current converter produces an output current when a voltage is applied in the non inverting terminal.

The nodal equation at the inverting input terminal's node-

$$\frac{V_i}{R_L} - I_o = 0 \Rightarrow I_o = \frac{V_i}{R_L}.$$

We can rewrite the above equation as: $\frac{I_o}{V_i} = \frac{1}{R_L}$

The above equation represents the ratio of the output current I_o and the input voltage V_i & it is equal to the reciprocal of the resistance R_L . The ratio of the output current I_o and the input voltage (V_o) is called Transconductance.

■ Current to Voltage converter: A current to voltage converter produces an output voltage when current is applied at the inverting end of the op-amp.

The nodal equation at the inverting terminal would be,

$$-I_i + \frac{0 - V_o}{R_f} = 0$$

$$\Rightarrow -\frac{V_o}{R_f} = I_i$$

$$\Rightarrow V_o = -I_i R_f$$

Thus the output voltage, V_o of current to voltage converter is the inverted (negative) product of the feedback resistance, R_f and input current, I_i . Now, we can write the above expression as,

$$\frac{V_o}{I_i} = -R_f$$

This ratio of the output voltage and input current is called Transresistance. So, the gain of the current to voltage converter is transresistance and it is equal to the feedback resistance (R_f).

3.

Procedure :- The procedure of this experiment is as follows -

(i) Open any of your internet browser and go to Multisim Live simulator, click on the new circuit and create a new circuit area for these two circuits.

(ii) Drag and drop all the required items and place them according to the circuit diagram. Once the components are placed, connect the apparatus using the connecting wires.

(iii) After making the connection of this circuit, simulate the circuit and observe the values. Go to the grapher section for the V-I and I-V graph for both the circuits.

(iv) From this, provide the observation and conclusion for this experiment.

Calculation :- For V-I converter, the nodal equation at the inverting output will be,

$$\frac{V_i}{R_L} = I_o \Rightarrow I_o = \frac{V_i}{R_L}$$

where, I_o = Output current

V_i = Input Voltage

R_L = Load Resistance

And for I-V converter, the nodal equation at the non-inverting terminal will be,

$$-I_i + \frac{0 - V_o}{R_f} = 0$$

$$\Rightarrow -I_i - \frac{V_o}{R_f} = 0$$

$$\Rightarrow -I_i = \frac{V_o}{R_f}$$

$$\Rightarrow V_o = -I_i R_f$$

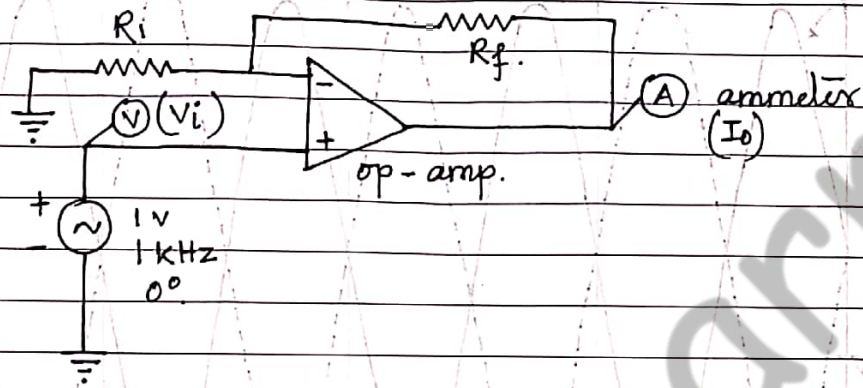
where, V_o = Output voltage

I_i = Input voltage

R_f = feedback resistance

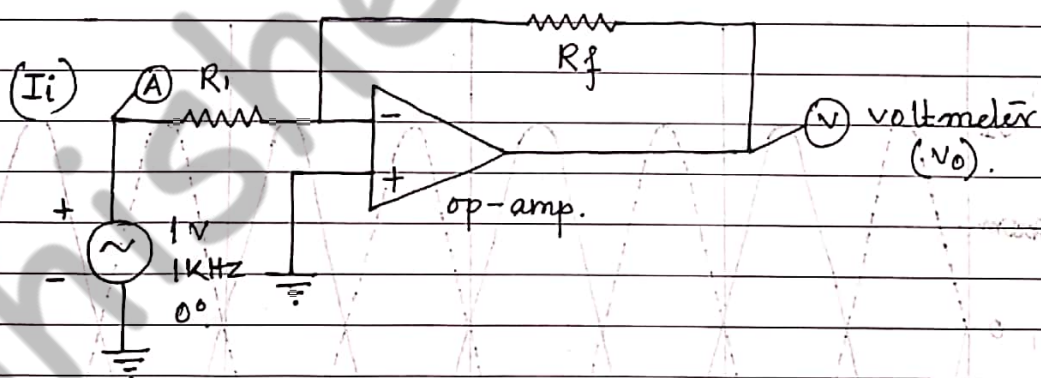
Circuit Diagram :-

① V-I (voltage to current) converter using Op-Amp :-



Here in this circuit we are using AC voltage source of 1V and 2V. And for each voltage, there are 3 different resistances used here. they are, 1k Ω , 5k Ω and 10k Ω . Based on these 6 cases we are going to create the table and compare the actual and the calculated values.

② I-V (current to voltage) converter using Op-Amp :-



Like wise the V-I converter, here also we are going to use two different amount of power sources 1V and 2V and for each case we'll be using 3 different R_f values i.e. 1k Ω , 5k Ω and 10k Ω . Similarly, based on the 6 cases, we have created a table which consists the observed and the calculated values for comparison.

Graph :-

① V-I (Voltage to current) converter circuit :-

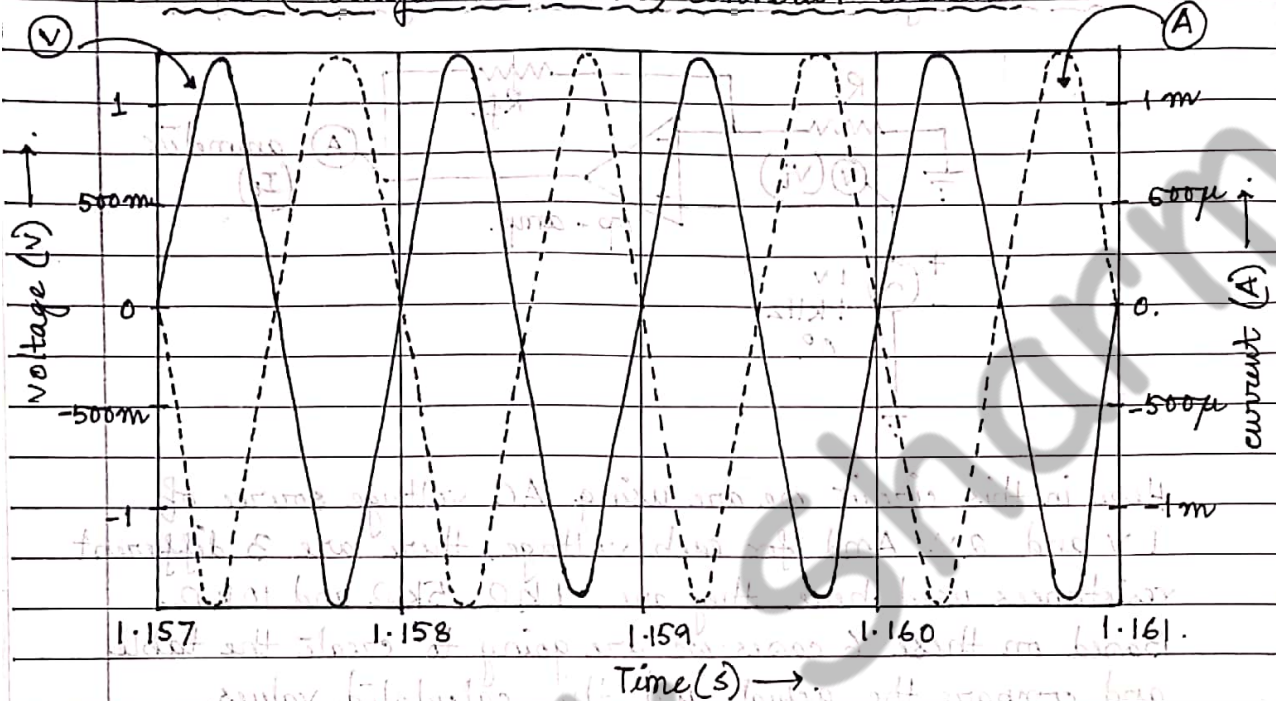


Fig : V-I v/s T graph of V-I converter circuit

② I-V (Current to voltage) converter circuit :-

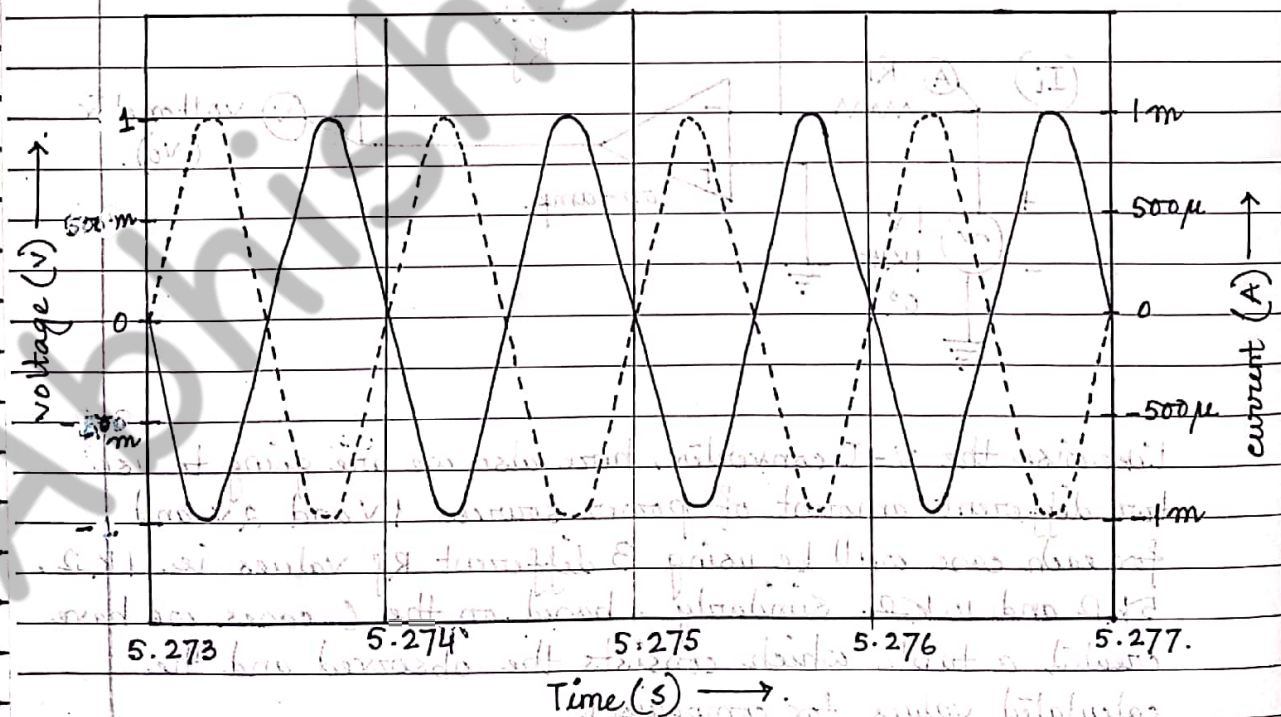


Fig : I-V v/s T graph for I-V converter circuit

Observation Table :-

① V-I converter using Op-Amp :-

$$I_o = \frac{V_i}{R_L}$$

Input Voltage (V_i)	Resistance (R_L)	Output A (calculated) $I_o(c)$	Output A (obs.) $I_o(obs)$
AC power source voltage <u>1 V.</u>	$1 k\Omega$	$I_{oc} = \frac{998.49 \text{ mV}}{1 k\Omega}$ $= 998.49 \mu A$	998.48 μA
	$5 k\Omega$	$I_{oc} = \frac{998.49 \text{ mV}}{5 k\Omega}$ $= 199.698 \mu A$	199.70 μA
	$10 k\Omega$	$I_{oc} = \frac{998.49 \text{ mV}}{10 k\Omega}$ $= 99.85 \mu A$	99.848 μA
	$1 k\Omega$	$I_{oc} = \frac{1.9970 \text{ V}}{1 k\Omega}$ $= 1.9970 \text{ mA}$	1.9970 mA
<u>2 V.</u>	$5 k\Omega$	$I_{oc} = \frac{1.9970 \text{ V}}{5 k\Omega}$ $= 399.4 \mu A$	399.39 μA
	$10 k\Omega$	$I_{oc} = \frac{1.9970 \text{ V}}{10 k\Omega}$ $= 199.70 \mu A$	199.70 μA
	$1 k\Omega$	$I_{oc} = \frac{1.9970 \text{ V}}{1 k\Omega}$ $= 1.9970 \text{ mA}$	1.9970 mA

② I-V converter using Op-Amp :-

$$V_o = -I_i R_f$$

Power source voltage	Resistance (R_L) (Ω)	Output V (calculated) (V_{oc}) V	Output V (obs.) ($V_{o obs}$) V
AC power source voltage <u>1 V</u>	$1 k\Omega$	$V_{oc} = -(-998.48 \mu A \times 1 k\Omega)$ $= (+)998.48 \text{ mV}$	(+)998.48 mV
	$5 k\Omega$	$V_{oc} = -(-199.70 \mu A \times 5 k\Omega)$ $= 998.5 \text{ mV}$	998.48 mV

