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THIRD YEAR

SECTION - 'I'

ROLL NO. : 01

ENROLLMENT NO. : 12019009001127.

ANALOG ELECTRONICS CIRCUIT LAB (Day 4).

ASSIGNMENT-4.

(Experiment No. : 04)

Date :- 20. 08. 2021

University of Enggineering & Management, Kolkata.

Experiment No. 4
Date : 20.08.2021.

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_1. 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 its transresistance and it is equal to the feedback resistance (R_f).

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.

$$\frac{V_i}{R_L} = I_0. \Rightarrow I_0 = \frac{V_i}{R_L}.$$

where, I_0 = 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.

$$-I_i + \frac{0-V_0}{R_f} = 0.$$

$$\Rightarrow -I_i - \frac{V_0}{R_f} = 0.$$

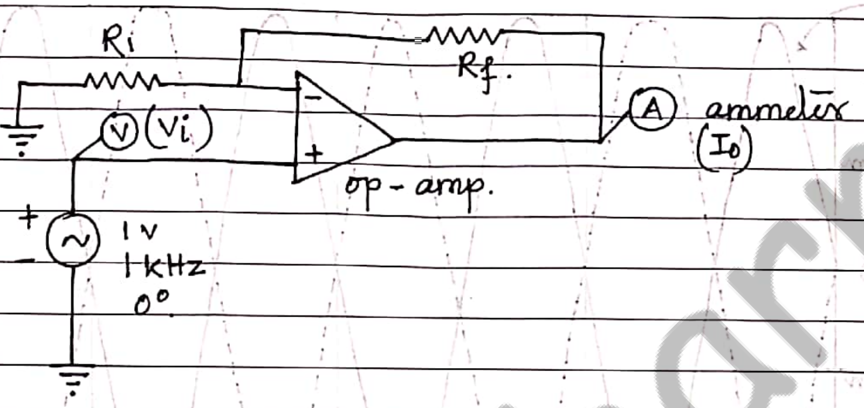
$$\Rightarrow -I_i = \frac{V_0}{R_f}$$

$$\Rightarrow V_0 = -I_i R_f$$

where, V_0 = Output voltage
I_i = Input voltage
R_f = feedback resistance

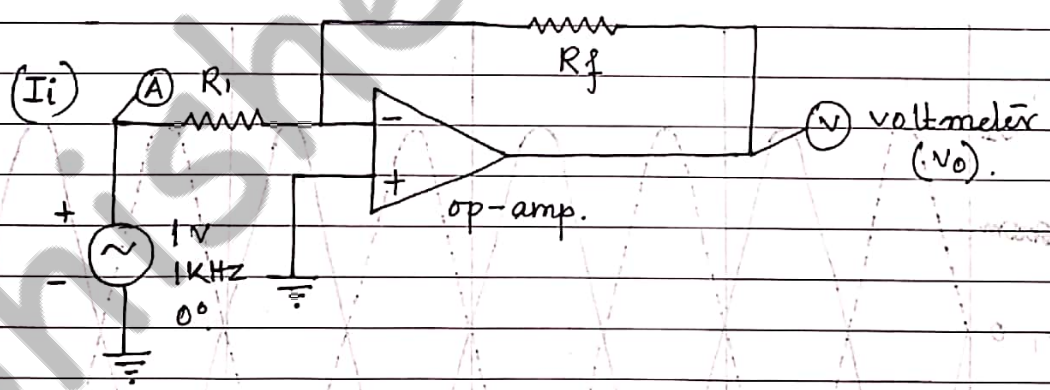
Circuit Diagram :-

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



Here in this circuit we are using AC voltage source of 1 V and 2 V. And for each voltage, there are 3 different resistances used here. they are, 1 kΩ, 5 kΩ and 10 kΩ. 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 :-



Likewise the V-I converter, here also we are going to use two different amount of power sources 1 V and 2 V and for each case we'll be using 3 different Rf values ie. 1 kΩ, 5 kΩ and 10 kΩ. 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 :-

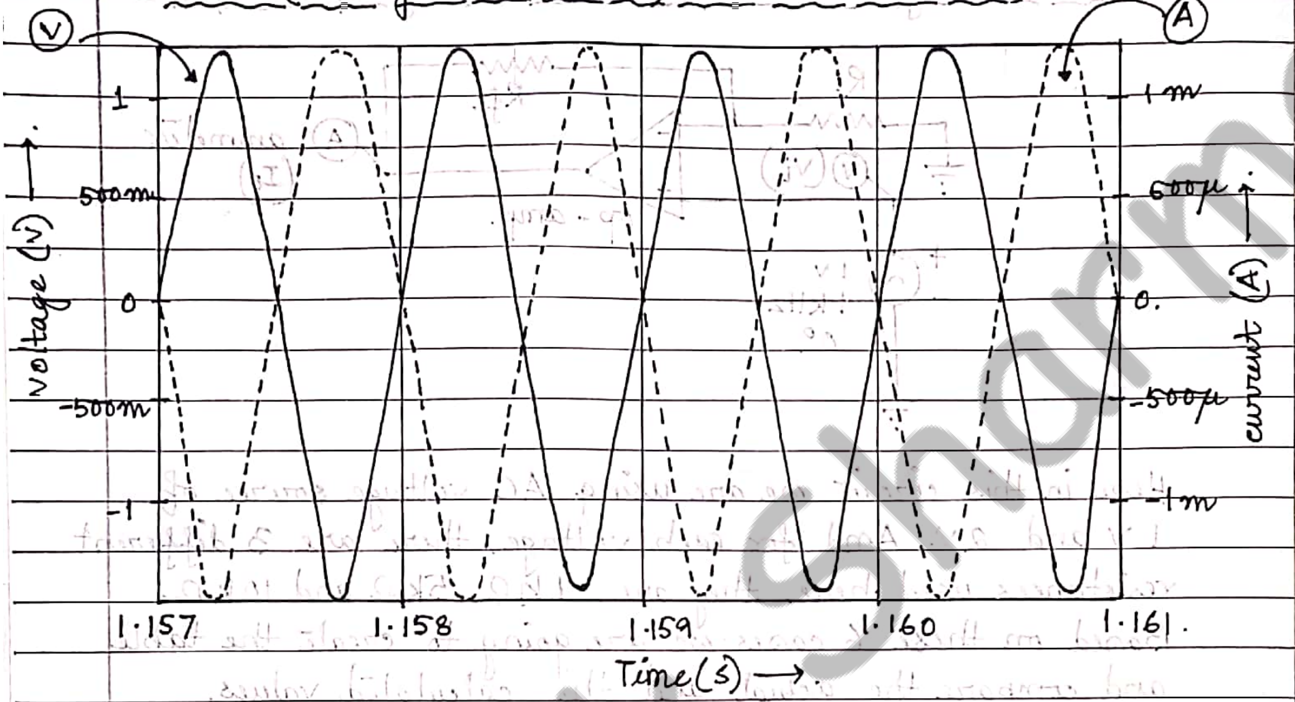


Fig : V-I v/s T graph of V-I converter circuit

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

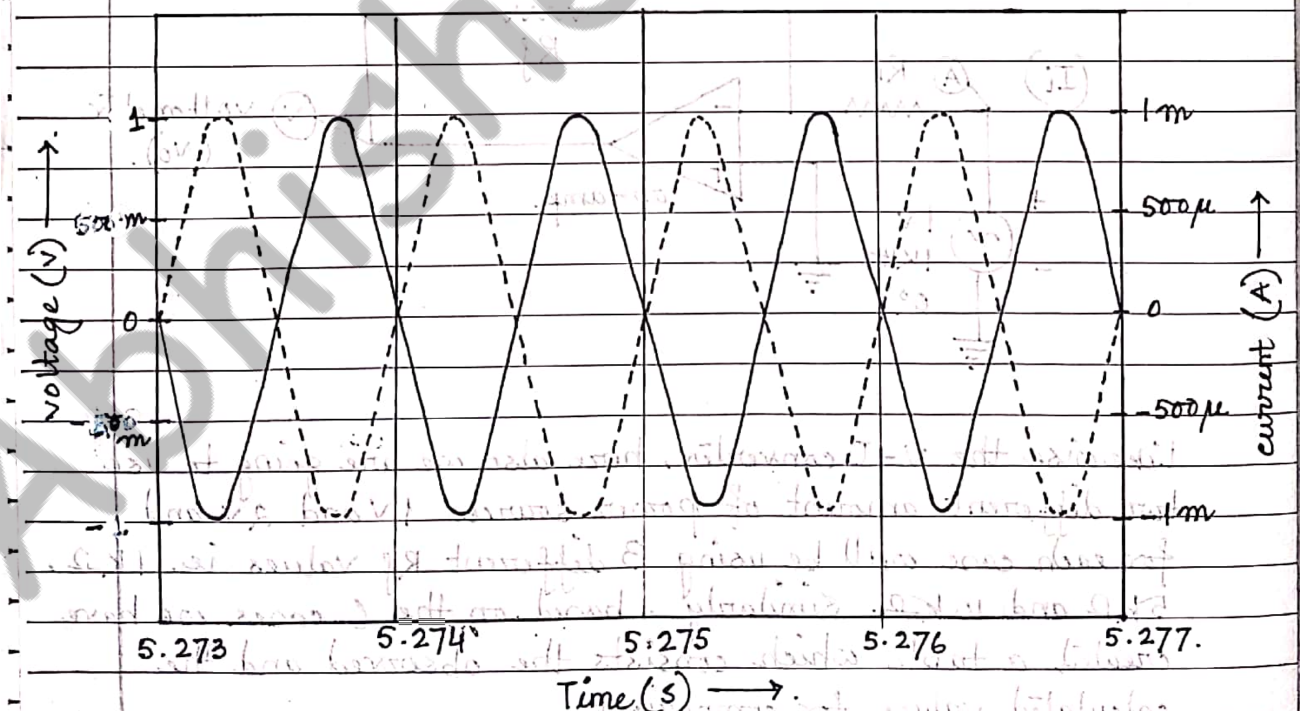


Fig : I-V v/s T graph for I-V converter circuit

Observation Table :-

① V-I converter using Op-Amp :-

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

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

② I-V converter using Op-Amp :-

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

Power source voltage	Resistance (R_L)(Ω)	Output V (calculated) (V_{oc}) V	Output V (obs.) ($V_{o\,obs}$) V.
AC power source voltage 1V	1 kΩ	V_{oc} = −(−998.48 μA × 1 kΩ) = (+)998.48 mV	(+)998.48 mV.
	5 kΩ.	V_{oc} = −(−199.70 μA. × 5 kΩ) = 998.5 mV	998.48 mV.

	10 kΩ	$V_{oc} = -(-99.848\ \mu A \times 10\ k\Omega) = 998.48\ mV$	998.48 mV.
	1 kΩ	$V_{oc} = -(-1.9970\ mA \times 1\ k\Omega) = 1.9970\ V$	1.9970 V.
AC power source voltage $\boxed{2\ V}$	5 kΩ	$V_{oc} = -(-399.39\ \mu A \times 5k\Omega) = 1.99695\ V$	1.9970 V
	10 kΩ	$V_{oc} = -(-199.70\ \mu A \times 10\ k\Omega) = 1.9970\ V$	1.9970 V.

Conclusion :-

From the above observation of the parameters collected from the simulator which were simulating the two circuits V-I and I-V converter using op-amp, we have concluded that both of them were successfully built on the multisim and simulated perfectly. All the observed and calculated results shows us the efficiency of implementation. Hence, we can conclude that, we have deployed the circuits with no tolerance.
