Experiment 4

Objective: To realize instrumentation and transconductance amplifiers.

Equipment Required: Breadboard, Regulated Power Supply, Function Generator, and CRO.

Components Required:

For Instrumentation Amplifier - OP-AMP 741 IC (3), Resistances: 10 kΩ (7), 5.1 kΩ, 20 kΩ, and connecting wires.

For Transconductance Amplifier - OP-AMP 741 IC (1), Resistances: 10 kΩ (4), 100 Ω, 220 Ω, 330 Ω, 470 Ω, 510 Ω, and connecting wires.

- **Instrumentation Amplifier**

An instrumentation amplifier shown in Fig. 1 is a differential amplifier that has been outfitted with input buffer amplifiers (which eliminate the need for input impedance matching and thus make the amplifier particularly suitable for use in measurement and test equipment). Additional characteristics include very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedances. Instrumentation amplifiers are used where great accuracy and stability of the circuit both short and long-term are required. This is a special amplifier used to measure small electrical signals from sensors and amplifies them.

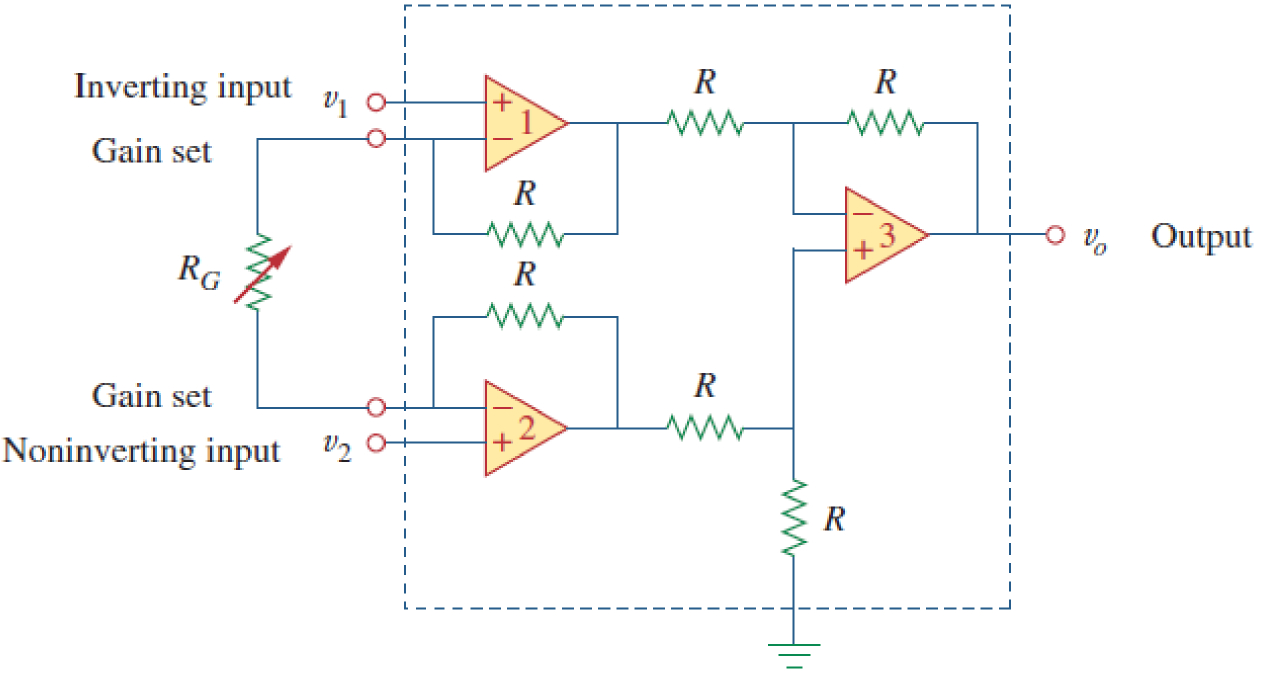

Figure 1: Instrumentation Amplifier

R = 10 kΩ and R_G = 5 kΩ, 10 kΩ, and 20 kΩ

$$v_o = \left(1 + \frac{2R}{R_G}\right)(v_2 - v_1)$$

Procedure (Instrumentation Amplifier):

1. Hook up the circuit as shown in Fig. 1 on breadboard.
2. Measure input and output voltages on CRO for different set of sinusoidal input voltages and R_G.
3. Tabulate the measurements.

S. No	V_1	V_2	R_G	V_{out} (V)
1	0 V	0 V	5 kΩ	
2	1 V (peak)	0 V	5 kΩ	
3	0 V	1 V (peak)	5 kΩ	
4	1 V (peak)	1 V (peak)	5 kΩ	
5	0 V	0 V	10 kΩ	
6	1 V (peak)	0 V	10 kΩ	
7	0 V	1 V (peak)	10 kΩ	
8	1 V (peak)	1 V (peak)	10 kΩ	
9	0 V	0 V	20 kΩ	
10	1 V (peak)	0 V	20 kΩ	
11	0 V	1 V (peak)	20 kΩ	
12	1 V (peak)	1 V (peak)	20 kΩ	

- **Transconductance Amplifier**

A transconductance amplifier gives an output current proportional to input voltage. The basic circuit of transconductance amplifier consists of op-amp with load connected between the non-inverting terminal and ground. If $R_2/R_1 = R_4/R_3$ is satisfied the circuit generates an output current $| i_L | = |V_1/R_3|$, irrespective of value of load resistance R_L. The gain of transconductance amplifier is given by $G_m = i_L/V_1 = 1/R_3$. Of course the circuit can work only if op-amp operates within its output voltage and currents limits, and hence there is an upper limit both for i_L and R_L.

The term transconductance is made up of two terms 'trans' and 'conductance. The term 'trans' stands for transfer, which is used to define relation between input and output. 'Conductance' is the ratio of current to voltage. This amplifier is also called as voltage to current amplifier.

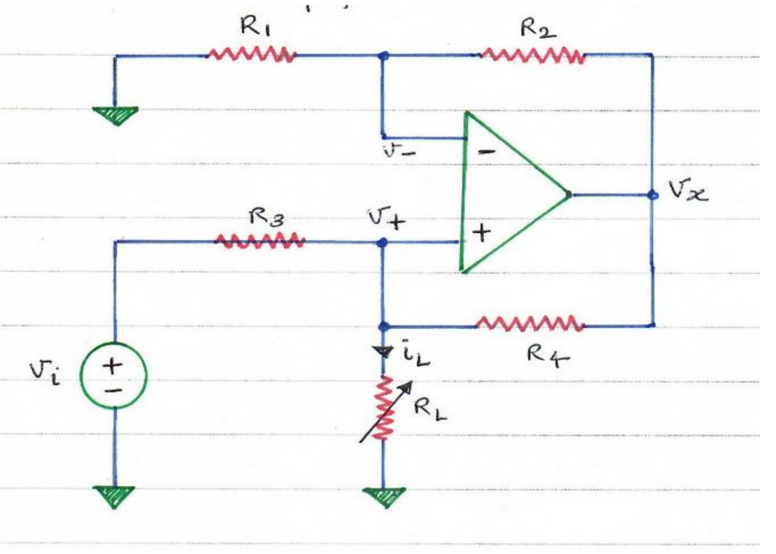

Figure 2: Transconductance Amplifier

R1 = R2 = R3 = R4 = 10 kΩ = R and R_L = 100 Ω, 220 Ω, 330 Ω, 470 Ω, 510 Ω

$$i_L = \frac{v_1}{R}, G_m = \frac{i_L}{v_i} = \frac{1}{R}, v_L = R_L i_L$$

Procedure (Transconductance Amplifier):

1. Hook up the circuit as shown in Fig. 2 on breadboard.
2. Measure input and load voltage (voltage across R_L) on CRO for different load resistances (R_L) given in the table keeping input voltage fixed at sinusoidal voltage of 0.2 V (peak).
3. Tabulate the measurements.
4. Calculate $i_L = v_L/R_L$

S. No	V_1	R_L	v_L (mV)	i_L (μA)
1	0.2 V (peak)	100 Ω		
2	0.2 V (peak)	220 Ω		
3	0.2 V (peak)	330 Ω		
4	0.2 V (peak)	470 Ω		
5	0.2 V (peak)	510 Ω		

Precautions to be taken:
1. Ensure that all the discrete components are working properly.
2. Make sure that all the connections in the circuit are correct before giving supply to circuit.
3. Remove the supply before changing any connections in circuit.
4. Check the amplitude of the supply signal before applying it to the circuit.
5. Ensure that the op-amp(s) does not saturate.