

Experiment 03: Study of Operational Amplifiers

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1 Aim

- Study of op-Amp as inverting and non-inverting amplifiers.
- Study of application of op-Amp as adder and subtractor.

2 Theory

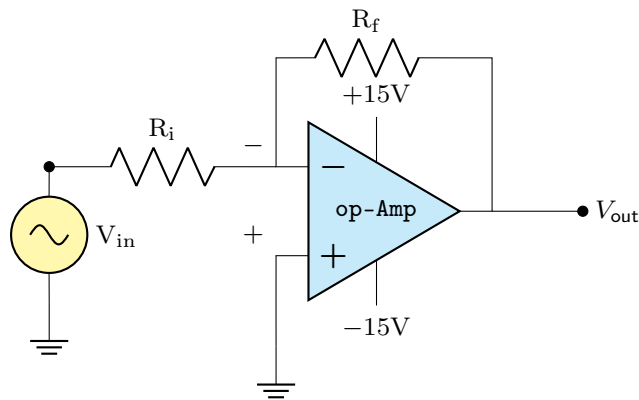


Figure 1: Circuit diagram for an inverting op-Amp

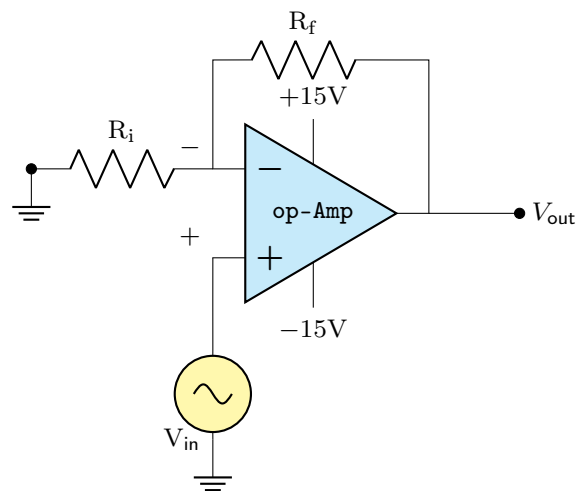
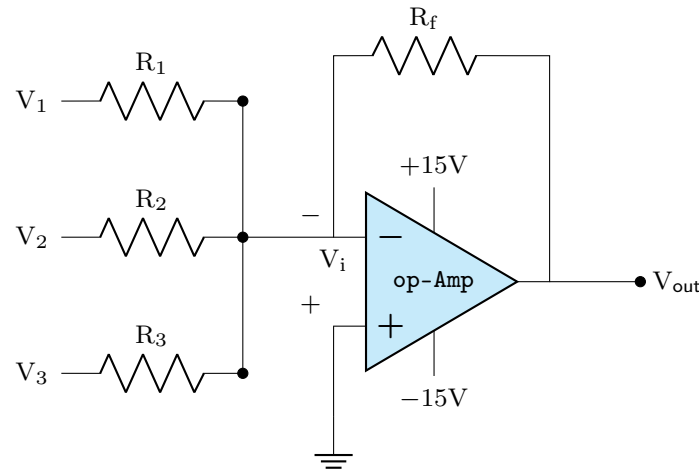


Figure 2: Circuit diagram for a non-inverting op-Amp

op-Amp as Adder:**Figure 3:** Circuit for op-Amp as an adder

For the circuit shown above, the current through op-Amp is negligible, hence the total current through the three resistors R_1 , R_2 , R_3 goes through R_f . Applying Kirchoff's current law at the junction, we get:

$$\frac{V_{out} - V_i}{R_f} = \frac{V_i - V_1}{R_1} + \frac{V_i - V_2}{R_2} + \frac{V_i - V_3}{R_3}$$

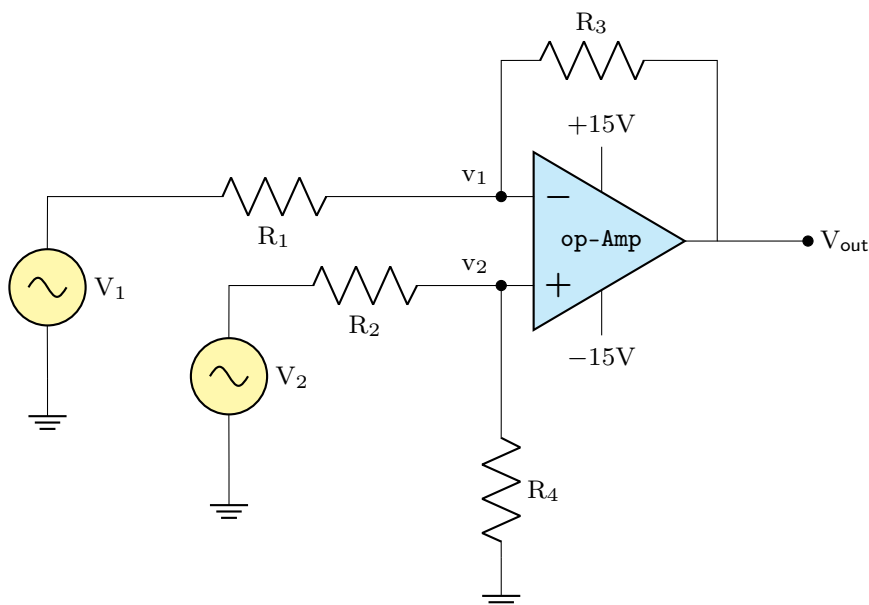
From the virtual ground condition, $V_i \approx 0$, hence:

$$V_{out} = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right)$$

If we take $R_f = R_1 = R_2 = R_3$, then:

$$V_{out} = -(V_1 + V_2 + V_3)$$

Hence, the circuit acts as an adder, that is, it adds the individual input voltages.

op-Amp as Subtractor:**Figure 4:** Circuit diagram for op-Amp as a subtractor

For the circuit shown above, the current through op-Amp is negligible. Thus, using Kirchoff's current law at the junctions, we get:

$$\frac{V_1 - v_1}{R_1} = \frac{v_1 - V_{\text{out}}}{R_3} = \frac{V_1 - V_{\text{out}}}{R_1 + R_3} \implies v_1 = \frac{R_3}{R_1 + R_3}(V_1 - V_{\text{out}}) + V_{\text{out}}$$

$$\frac{V_2 - v_2}{R_2} = \frac{v_2 - 0}{R_4} = \frac{V_2}{R_2 + R_4} \implies v_2 = \frac{R_4}{R_2 + R_4}V_2$$

From the virtual ground condition, $v_1 \approx v_2$, hence:

$$\frac{R_3}{R_1 + R_3}V_1 + \frac{R_1}{R_1 + R_3}V_{\text{out}} = \frac{R_4}{R_2 + R_4}V_2 \implies V_{\text{out}} = \frac{R_4(R_1 + R_3)}{(R_4 + R_2)R_1}V_1 - \frac{R_3}{R_1}V_2$$

If we take $R_1 = R_2 = R_3 = R_4$, then:

$$\boxed{V_{\text{out}} = -(V_2 - V_1)}$$

Hence, the circuit acts as a subtractor, that is, it subtracts the individual input voltages.

3 Data and Calculation

4 Sources of Error

5 Discussion and Conclusion