Group No:

Experiment-03

Study of Op-Amp: Non-Inverting Amplifier, Inverting Amplifier, Inverting Summing Amplifier

CSE251 - Electronic Devices and Circuits Lab

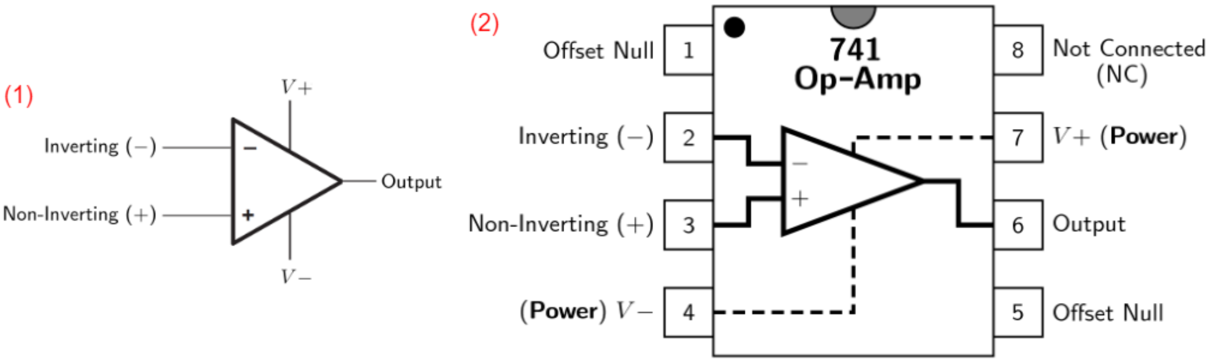
Objective

1. To investigate the use of Operational Amplifier (Op-Amp) as Non-Inverting Amplifier, Inverting Amplifier and Inverting Summing Amplifier

Equipment

1. Op-Amp (uA741)
2. Resistance ($1k\Omega, 2.7k\Omega, 10k\Omega$)
3. DC Power Supply
4. Function Generator
5. Trainer Board
6. Digital Multimeter
7. Breadboard, Chords and Wires

Background Theory

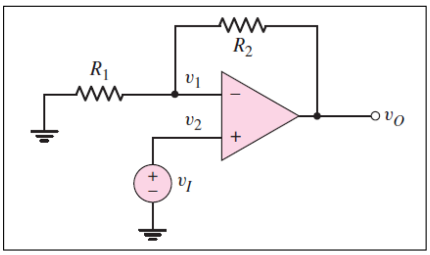


(1) Op-Amp Simplified Circuit Symbol (2) Op-Amp IC Pin Diagram

Non-Inverting Amplifier

The amplifier circuit of an op-amp that does not invert the input voltage at the output is called the non-inverting amplifier. This circuit amplifies the input voltage, v_I according to the gain which can be controlled by the resistances R_1 and R_2. The following equation shows the relation between the input and output of a non-inverting amplifier:

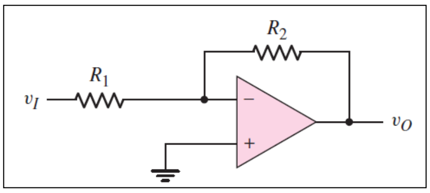
$$v_O = (1 + \frac{R_2}{R_1}) \times v_I; \texttt{ where, gain = } (1 + \frac{R_2}{R_1})$$



Non-inverting Amplifier

Inverting Amplifier

Inverting amplifier configuration of an op-amp is one of the most widely used op-amp circuits. It amplifies the input voltage, v_I according to the gain which can be controlled by the resistances R_1 and R_2. The input voltage gets inverted at the output, hence the name inverting amplifier. The following equation shows the relation between the input and output of an inverting amplifier:

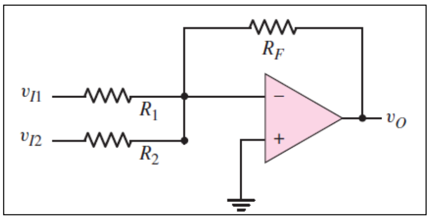


Inverting Amplifier

$$v_O = -(\frac{R_2}{R_1}) \times v_I; \texttt{ where, gain = } -\frac{R_2}{R_1}$$

Inverting Summing Amplifier

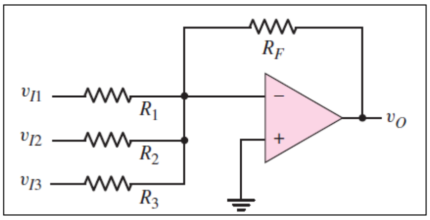
The figure shows the circuit configuration of an op-amp known as inverting summing amplifier that does the job of weighted summation. The input voltages are added according to their weight and gets inverted at the output. The weight of each input voltage during the summing operation can be controlled by the resistances R_1, R_2 and R_F. The following equation shows the relation between input and output of the circuit:



Inverting Summing Amplifier

$$v_O = -(\tfrac{R_F}{R_1} \times v_{I1} + \tfrac{R_F}{R_2} \times v_{I2}); \quad \texttt{where, gain for } v_{I1} \texttt{ = } -\tfrac{R_F}{R_1}\texttt{, gain for } v_{I2} \texttt{ = } -\tfrac{R_F}{R_2}$$

The inverting summing amplifier circuit has 2 inputs which can be extended to as many inputs as we want and the equation will change accordingly. Let's say, we need to add another input, v_{I3}. The equation will become:

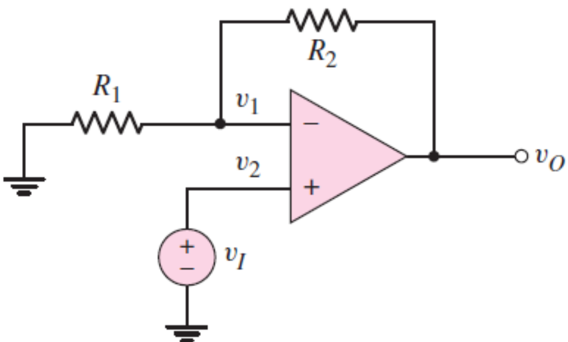


3-input Inverting Summing Amplifier

$$v_O = -(\tfrac{R_F}{R_1} \times v_{I1} + \tfrac{R_F}{R_2} \times v_{I2} + \tfrac{R_F}{R_3} \times v_{I3})$$

`where, gain for` v_{I1} `=` $-\frac{R_F}{R_1}$`, gain for` v_{I2} `=` $-\frac{R_F}{R_2}$
`gain for` v_{I3} `=` $-\frac{R_F}{R_3}$

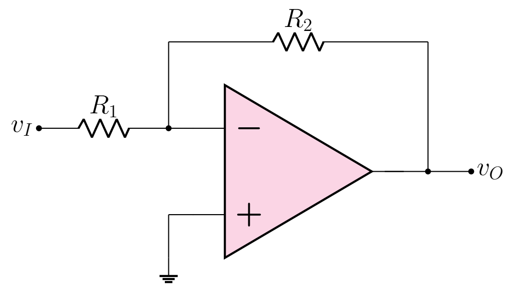
Task-01: Non-Inverting Amplifier



Procedure

1. Construct the circuit with $v_I = 2$ V (p-p), 1 kHz sine wave. Use $R_1 = 1$ kΩ, $R_2 = 2.7$ kΩ. Use the supply voltages, $V_S^+ = +8V$ and $V_S^- = -8V$ and **use these supply voltages for the next tasks**.
2. Connect the CH1 and CH2 of the Oscilloscope to v_I and v_O respectively. Use the ***Scale*** knob to make sure that the scales of CH1 and CH2 are the same. Observe the input and output waveform and capture them using a camera.
3. Use the ***Measure*** button to get necessary data for the 'Data Sheet' attached at the end of the lab sheet. Capture the measurements of CH1 and CH2 using a camera.

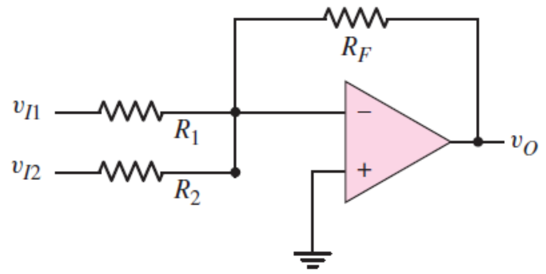
Task-02: Inverting Amplifier



Procedure

1. Construct the circuit with $v_I = 2$ V (p-p), 1 kHz sine wave. Use $R_1 = 1$ kΩ, $R_2 = 2.7$ kΩ.
2. Connect the CH1 and CH2 of the Oscilloscope to v_I and v_O respectively. Use the ***Scale*** knob to make sure that the scales of CH1 and CH2 are the same. Observe the input and output waveform and capture them using a camera.
3. Use the ***Measure*** button to get necessary data for the 'Data Sheet'. Capture the measurements of CH1 and CH2 using a camera.

Task-03: Inverting Summing Amplifier



Procedure

1. Construct the circuit using the CH1 and CH2 of the DC Power Supply for $v_{I1} = 1$ V and $v_{I2} = 2$ V respectively.
2. Use $R_1 = 10$ kΩ, $R_2 = 10$ kΩ and $R_F = 10$ kΩ.
3. Use the digital multimeter to measure the output voltage v_O to get necessary data for the 'Data Sheet'.

Task-04: Report

1. Cover page [include course code, course title, name, student ID, group, semester, date of performance, date of submission]
2. Attach the signed Data Sheet.
3. Attach the captured photos of all the waveforms and measurements you have observed in the Oscilloscope. Each photo should contain necessary description.
4. Answer the questions of the Test Your Understanding section.
5. Add a brief Discussion at the end of the report. For the Discussion part of the lab report, you should include the answers of the following questions in your own words:
   - What did you learn from this experiment?
   - What challenges did you face and how did you overcome the challenges? (if any)
   - What mistakes did you make and how did you correct the mistakes? (if any)
   - How will this experiment help you in future experiments of this course?

Data Sheet

for Task-01:

Value of R_1 using multimeter =
Value of R_2 using multimeter =
Input Amplitude from Oscilloscope (use the **Measure** button), $v_I = \frac{Pk-Pk}{2} =$
Output Amplitude from Oscilloscope (use the **Measure** button), $v_O = \frac{Pk-Pk}{2} =$
Output Amplitude from equation, $v_O = (1 + \frac{R_2}{R_1}) \times v_I =$

for Task-02:

Value of R_1 using multimeter =
Value of R_2 using multimeter =
Input Amplitude from Oscilloscope (use the **Measure** button), $v_I = \frac{Pk-Pk}{2} =$
Output Amplitude from Oscilloscope (use the **Measure** button), $v_O = \frac{Pk-Pk}{2} =$
Output Amplitude from equation, $v_O = -(\frac{R_2}{R_1}) \times v_I =$

for Task-03:

Value of R_1 using multimeter =
Value of R_2 using multimeter =
Value of R_F using multimeter =
from multimeter, $v_{I1} =$
from multimeter, $v_{I2} =$
Output Amplitude from multimeter, $v_O =$
Output Amplitude from equation, $v_O = -(\frac{R_F}{R_1} \times v_{I1} + \frac{R_F}{R_2} \times v_{I2}) =$

`Signature of the lab faculty`

Test Your Understanding

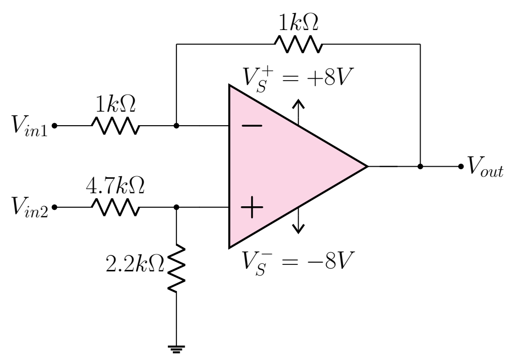
Answer the following questions:

1. You are given an inverting amplifier with $v_I = 4$ V (p-p) sine wave, $R_1 = 1\ k\Omega$, $R_2 = 2.2\ k\Omega$. Draw the waveform of v_I and v_O in the same graph with proper labels.
   Answer:

2. You are given a non-inverting amplifier with $v_I = 4$ V (p-p) sine wave, $R_1 = 1\ k\Omega$, $R_2 = 2.2\ k\Omega$. Draw the waveform of v_I and v_O in the same graph with proper labels.
Answer:

3. Deduce the value of V_{out} from the circuit below.

*[**Hints**: Consider the current towards the inverting and non-inverting terminals of Op-Amp is zero, and the voltage of the inverting terminal equals the voltage of the non-inverting terminal]*



Answer: