

# SNS COLLEGE OF TECHNOLOGY



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COIMBATORE-641 035, TAMIL NADU

## DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

**Course Name: 23ECT203 LINEAR INTEGRATED CIRCUITS**

**II YEAR/VI SEMESTER**

**UNIT II –APPLICATIONS OF OPERATIONAL AMPLIFIERS**

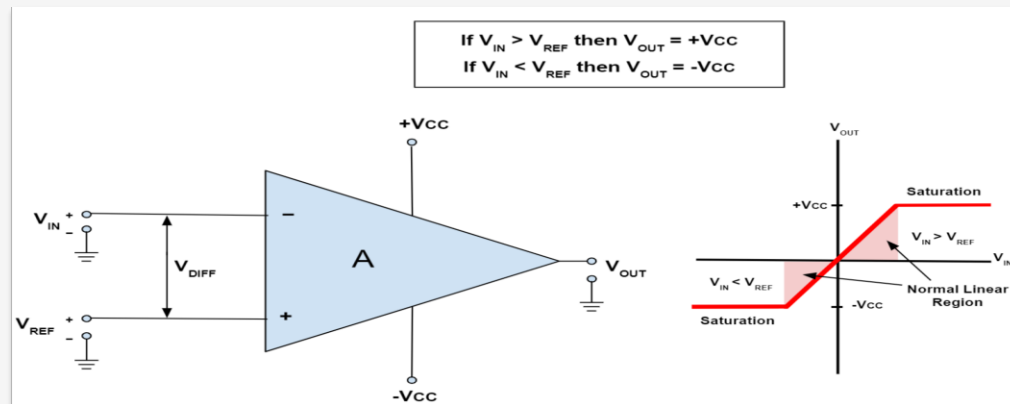
**Topic : Inverting and Non-inverting Amplifiers**



# Empathy: Understanding Problem



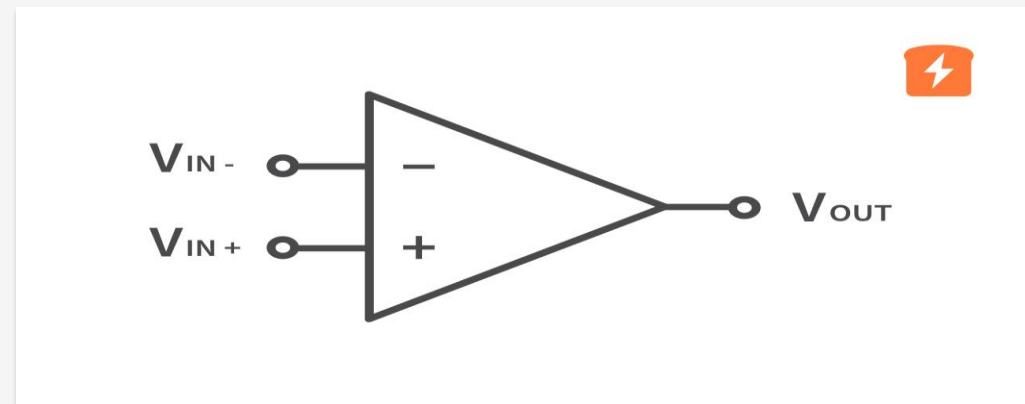
## Real-World Problems



- 📶 **Signal processing** requires precise amplification
- 🔌 Electronic devices need **stable voltage levels**
- 🔊 Sensor outputs require **signal conditioning**
- 🔊 Audio systems need **impedance matching**



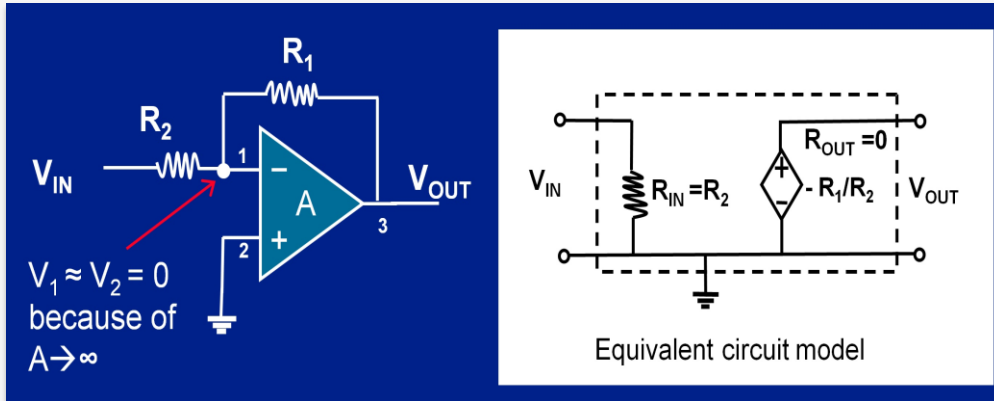
## Impact if Not Solved



- ⚠️ **Signal distortion** and data corruption
- 🔋 **Inefficient power usage** and reduced battery life
- 🔊 Poor audio quality in communication systems
- ❓ **Device malfunction** in critical applications

# Define: Identifying Solution Requirements

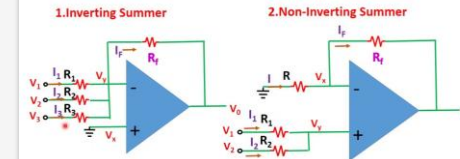
## Limitations of Existing Methods



- ⊖ **Discrete components** - larger footprint
- ⊖ **Fixed gain** - limited flexibility
- ⊖ **Poor stability** - temperature dependent
- ⊖ **Alignment issues** - input/output mismatch
- ⊖ **Component tolerance** - affects accuracy

## Technology Gaps

### Summing Amplifier

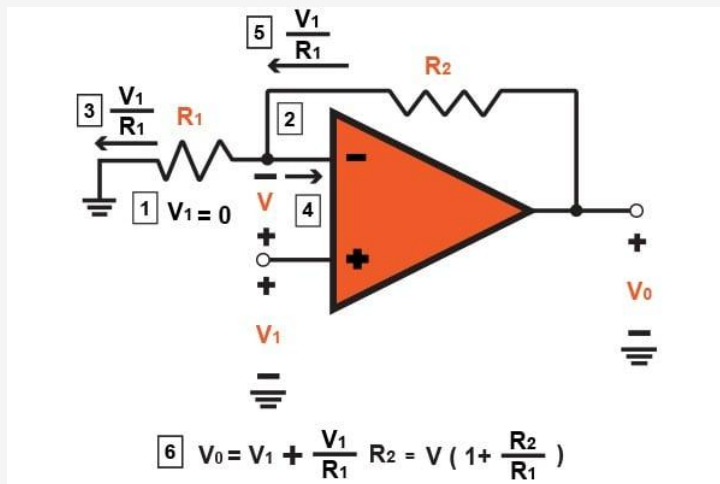


- ↗ **Precision** - accurate signal amplification
- ↗ **Integration** - compact, multifunctional circuits
- ↗ **Adaptability** - configurable gain settings
- ↗ **Alignment** - phase and impedance matching



## Ideate: Non-Inverting Amplifier

### Circuit Configuration



$$\text{Gain (A}_v\text{)} = 1 + R_f/R_1$$



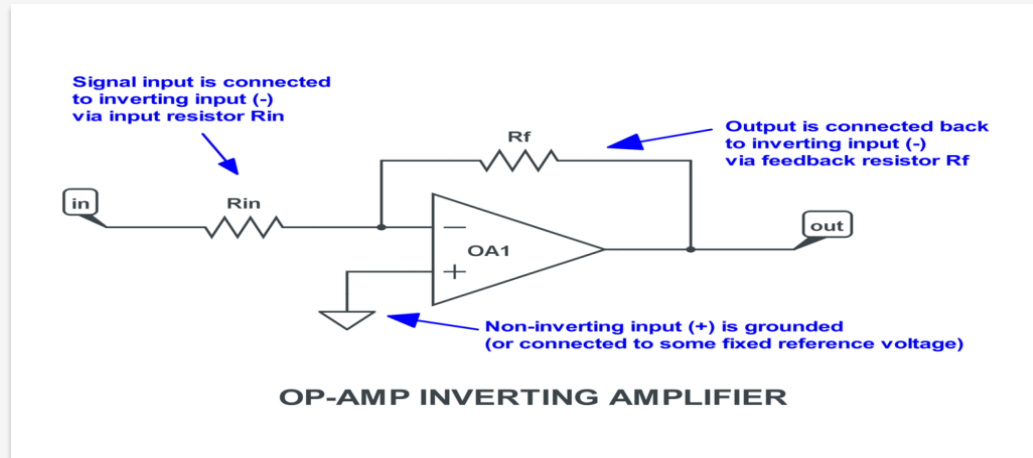
### Key Characteristics

- ▶ **High input impedance**  $\approx \infty$
- ▶ **Low output impedance**  $\approx 0\Omega$
- ▶ **Wide bandwidth** compared to inverting
- ▶ **Better isolation** from source



# Comparison: Inverting vs Non-Inverting Amplifiers

## - Inverting Amplifier

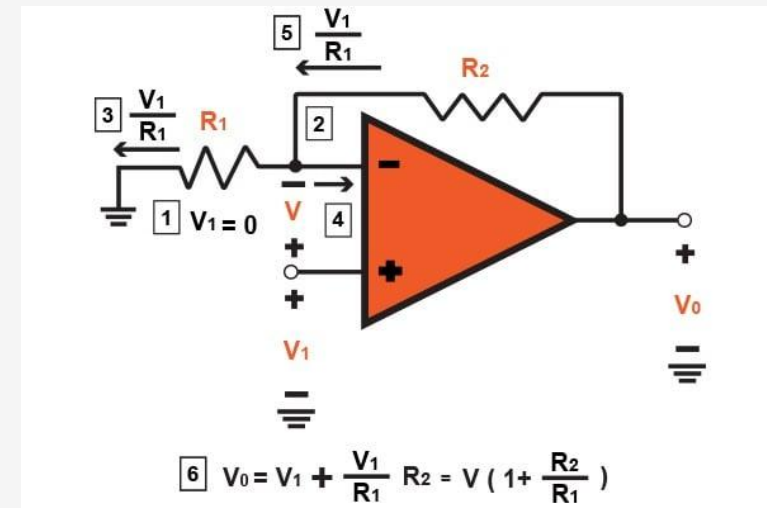


Input to inverting terminal

180° phase shift

Gain =  $-R_f/R_{in}$

## + Non-Inverting Amplifier



Input to non-inverting terminal

In-phase output

Gain =  $1 + R_f/R_1$



## Student Activity: Five Minutes



### Activity Instructions

- 1 Form groups of **3-4 students**
- 2 Each group selects one **real-world application** from:
  - 3 Audio systems, sensor interfaces, medical devices, or instrumentation
  - 4 Identify whether it uses **inverting or non-inverting** amplifier
  - 5 Justify your choice with **technical reasoning** based on:
    - 6 Input impedance requirements
    - Phase relationship needs
    - Gain and bandwidth considerations



### Expected Outcome

- ✓ Identify **key differences** between amplifier types
- ✓ Apply theoretical knowledge to **practical scenarios**
- ✓ Develop **critical thinking** skills
- ✓ Understand **selection criteria** for different applications

### Group Discussion



### Topic Focus

- **Input impedance** differences ( $\infty$  vs  $R_{in}$ )
- **Phase relationship** between input and output
- **Gain characteristics** and limitations
- **Application-specific** design considerations



# Assessment Questions



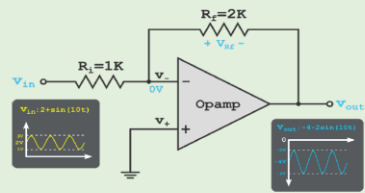
## GATE Style Question

### Example 7

Figure 1.3.12 demonstrates an inverting amplifier with a voltage gain of -2. The input side is fed with a mixed signal containing both DC and AC portion, expressed as:

$$v_{in} = 2 + \sin(10t)$$

The expression of the output voltage can be derived by applying the gain equation.



$$A_v = -\frac{R_f}{R_i} = -2$$

$$v_{out} = -2v_{in}$$

$$v_{out} = -2[2 + \sin(10t)]$$

$$= -4 - 2\sin(10t)$$

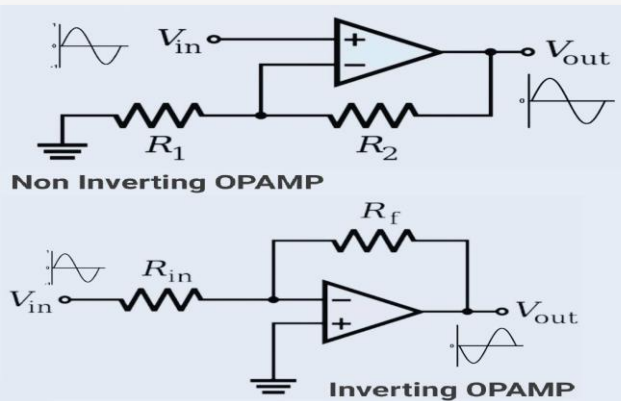
Figure 1.3.12: A mixed signal being amplified by an inverting amplifier with a gain of -2

**Calculate voltage gain of inverting amplifier with  $R_f=10k\Omega$  and  $R_{in}=1k\Omega$**

**Answer:  $A_v = -R_f/R_{in} = -10$**



## Industry Oriented Question



**Which amplifier type is preferred for sensor signal conditioning in medical devices?**

**Answer: Non-inverting amplifier due to high input impedance**

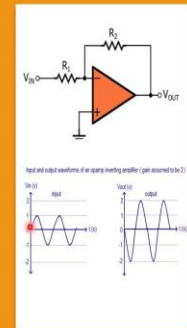


## Conceptual Question

### Inverting Amplifier

- Inverting amplifier is one in which the output is exactly 180° out of phase with respect to input (i.e. if you apply a positive voltage, output will be negative).
- Output is an inverted (in terms of phase) amplified version of input.
- The output voltage,  $V_{out} = -AV_{in}$

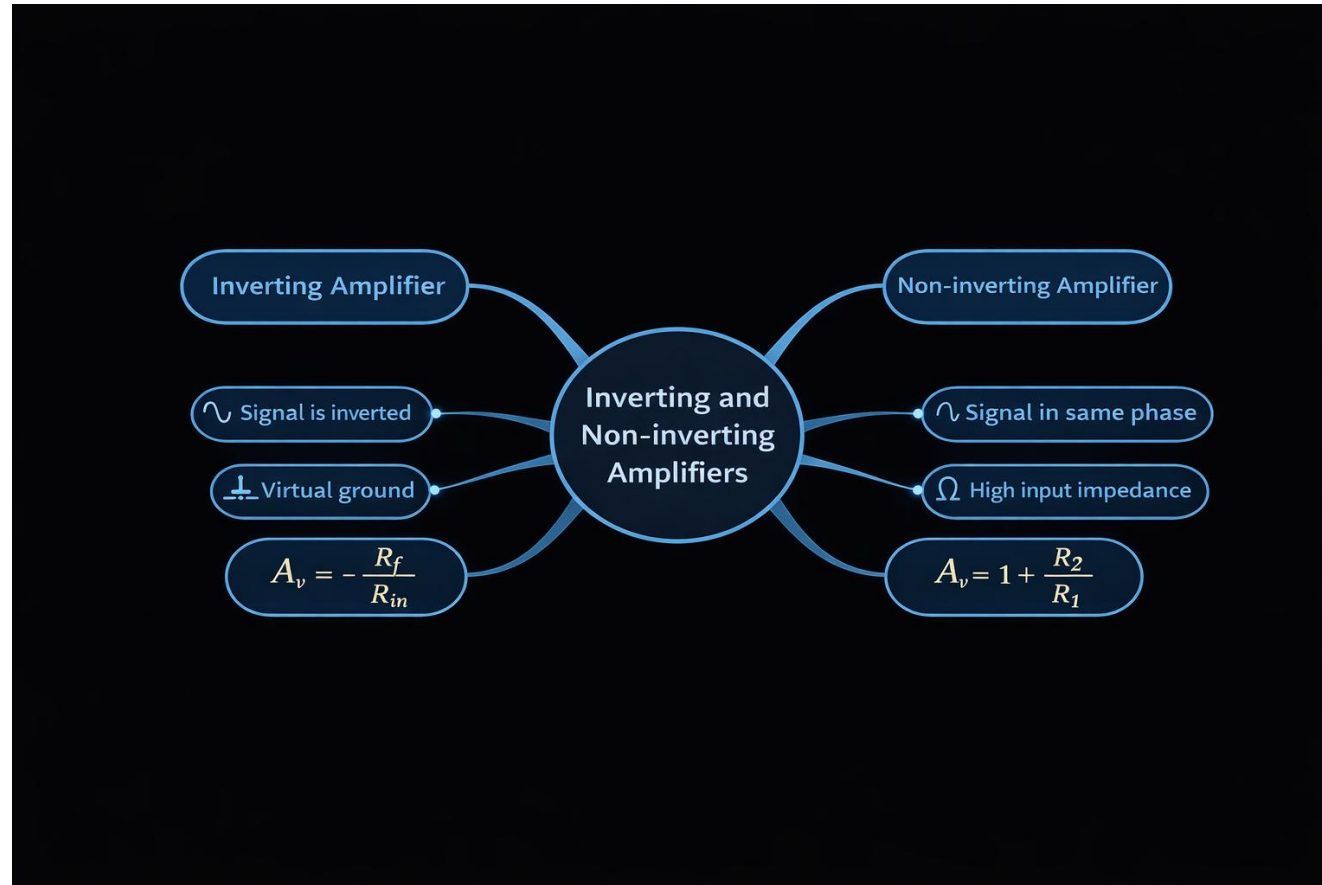
Where gain,  $A = -\frac{R_2}{R_1}$



**Why is output of a non-inverting amplifier in-phase with input?**

**Answer: Input applied to non-inverting terminal maintains same polarity**

# Summary : Mind Map





## Textbook 1

### **Linear Integrated Circuits**

**D. Roy Choudhry, Shail Jain**

New Age International Pvt. Ltd.

Fifth Edition, 2018



## Textbook 2

### **Design with Operational Amplifiers**

**Sergio Franco**

Tata Mc Graw-Hill

Fourth Edition, 2014

# Thank You