

SNS COLLEGE OF TECHNOLOGY



(An Autonomous Institution)

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COIMBATORE-641 035, TAMIL NADU

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Course Name: 23ECT203 LINEAR INTEGRATED CIRCUITS

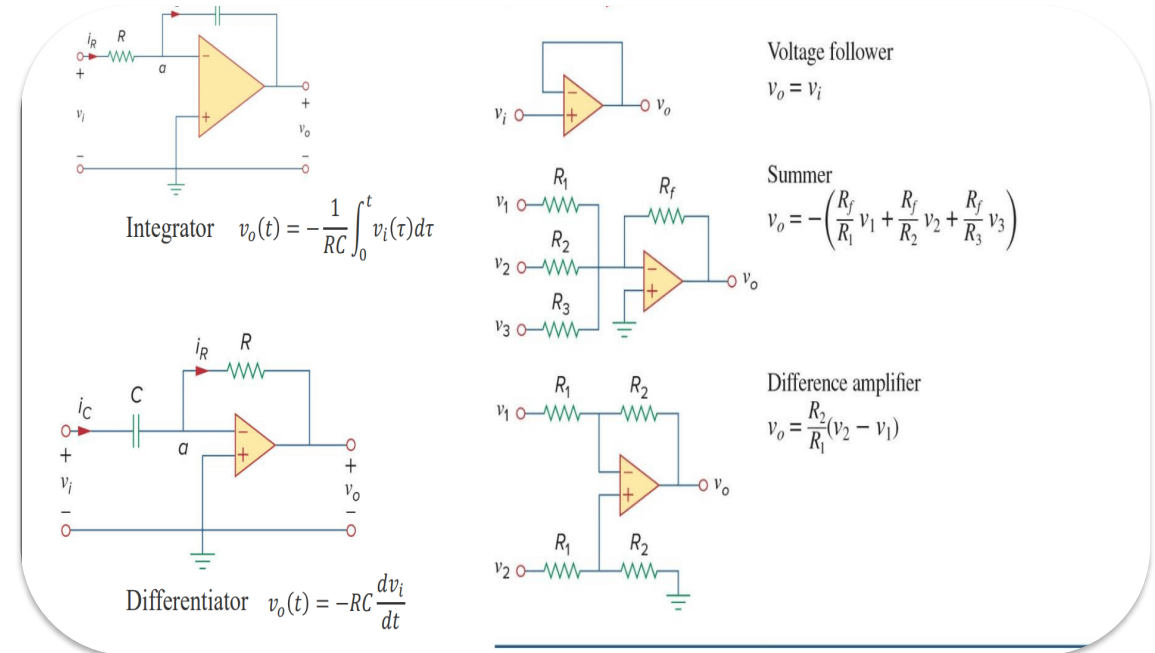
II YEAR/VI SEMESTER

UNIT II –APPLICATIONS OF OPERATIONAL AMPLIFIERS





Topic :Basic applications of op-amp

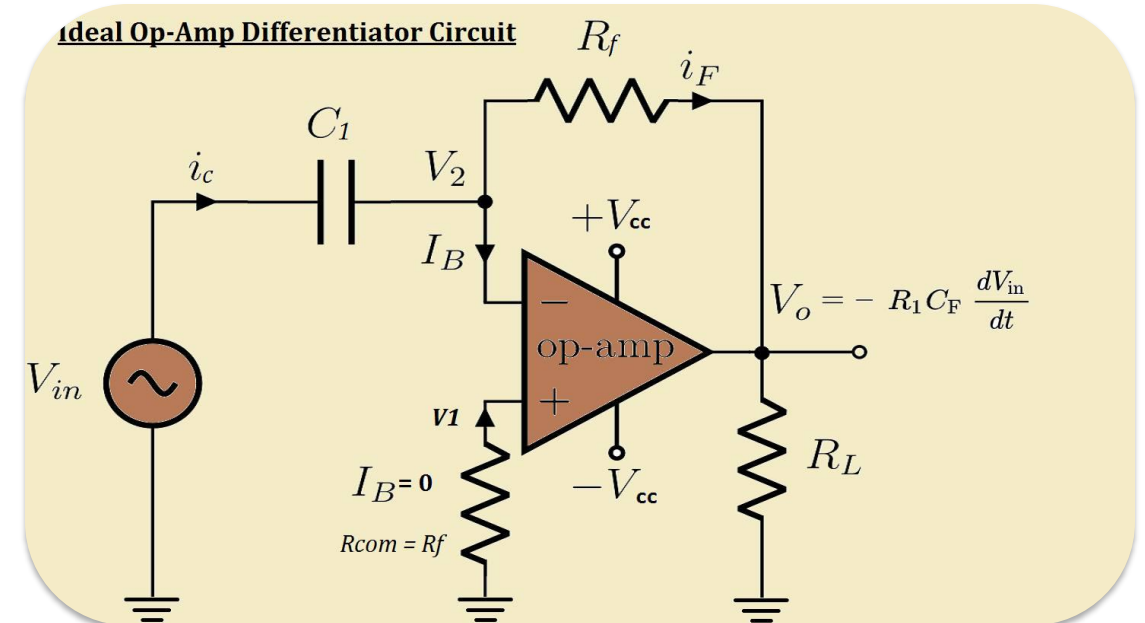
Introduction to Op-Amp Applications

- 💡 **What are op-amp applications?** Configurations that utilize operational amplifiers to perform specific signal processing tasks
- ⚙️ **Why important?** Foundation of analog circuit design, enabling amplification, filtering, and signal conditioning
- 🔧 **Versatility** Same component can perform many functions by changing external components
- 📈 **Role in signal processing** Amplification, filtering, integration, differentiation, comparison, and more








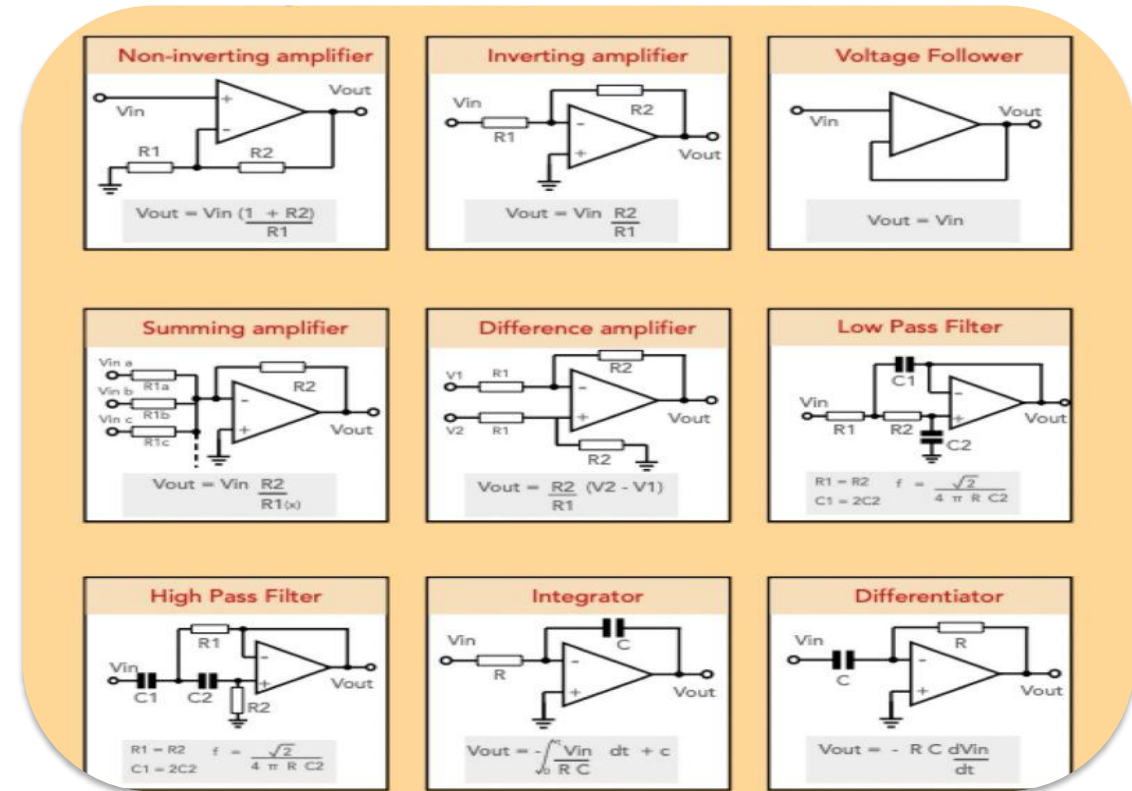
Stage 1: Empathize

- 
Understanding Challenges in learning op-amp applications
- 
Circuit Configurations Differentiating between inverting, non-inverting, and specialized configurations
- 
Feedback Mechanisms Analyzing positive and negative feedback effects on circuit behavior
- 
Mathematical Concepts Applying transfer functions and frequency response analysis to practical circuits



Stage 2: Define

- 
Learning Goals Master circuit analysis, understand feedback principles, apply mathematical concepts
- 
Amplification Inverting, non-inverting, differential, and instrumentation amplifiers
- 
Signal Conversion V/I converters, I/V converters, voltage followers
- 
Filtering Low-pass, high-pass, band-pass Butterworth filters
- 
Signal Conditioning Comparators, Schmitt triggers, rectifiers, differentiators, integrators



Stage 3: Ideate

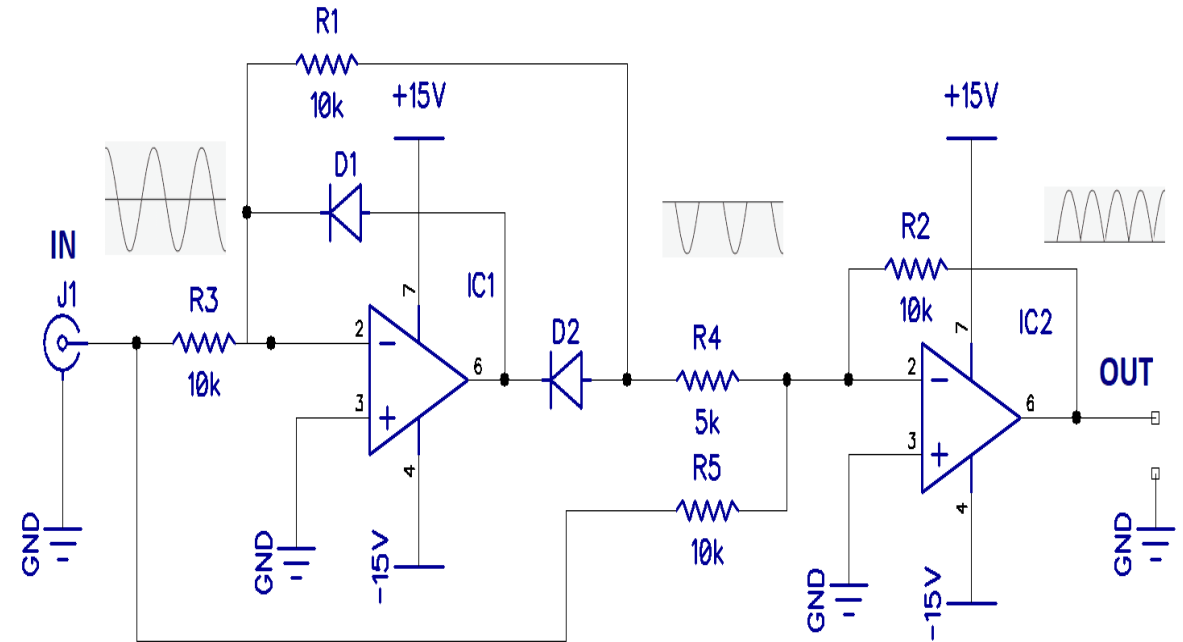
- **Circuit Analysis** Apply Kirchhoff's laws, nodal analysis, and superposition principle

- **Simulation Tools** Use SPICE, Multisim, or Proteus to verify theoretical calculations

- **Practical Applications** Identify real-world uses for each configuration

- ➔ **Transfer Functions** Derive mathematical relationships between inputs and outputs

- **Component Selection** Choose appropriate resistor/capacitor values for desired performance



Stage 4: Prototype

↘ Inverting Amplifier

Output is inverted and amplified

$$V_{out} = - (R_f/R_{in}) \times V_{in}$$

↗ Non-Inverting Amplifier

Output is in phase and amplified

$$V_{out} = (1 + R_f/R_{in}) \times V_{in}$$

+ Summing Amplifier

Multiple inputs summed together

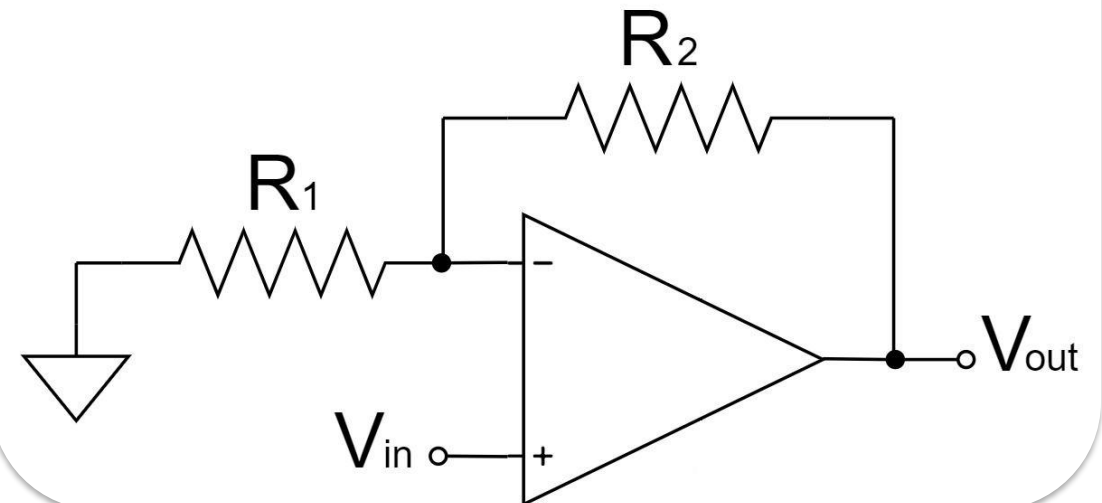
$$V_{out} = -R_f \times (V_1/R_1 + V_2/R_2 + \dots)$$

↔ Differential Amplifier


Amplifies difference between inputs


$$V_{out} = (R_f/R_{in}) \times (V_2 - V_1)$$


Non-Inverting Amplifier Circuit



Stage 5: Test

- 
Theoretical Analysis Apply transfer functions and nodal analysis to predict circuit behavior

- 
Simulation Tools Use SPICE, Multisim, or Proteus to verify theoretical calculations

- 
Practical Testing Build circuits on breadboard and measure with oscilloscope, multimeter

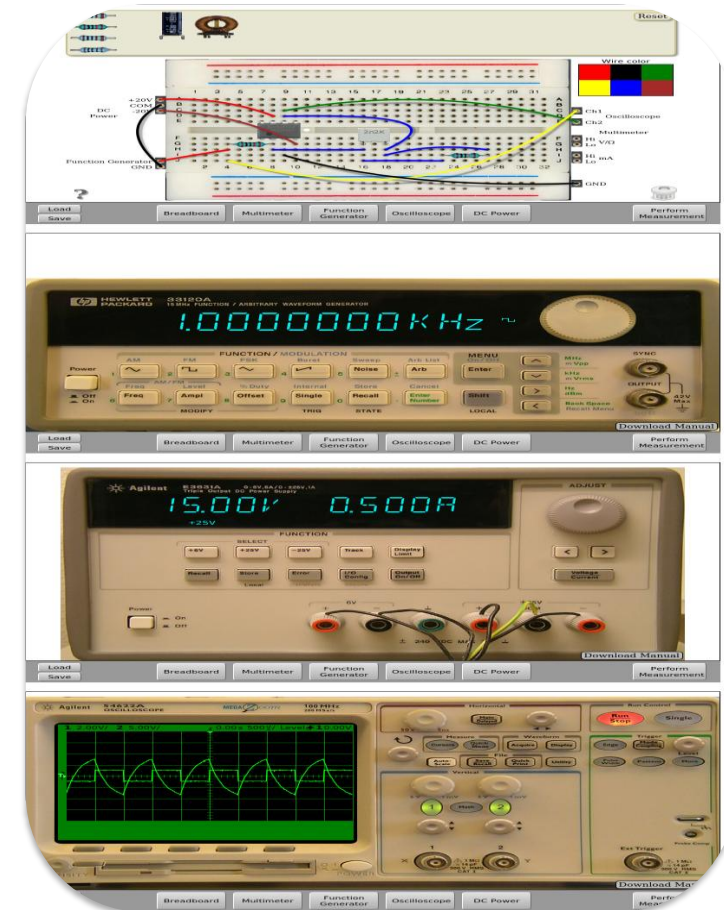
Testing Methods Comparison

Calculation

- Quick, ideal results
- Ignores component tolerances
- Limited frequency response

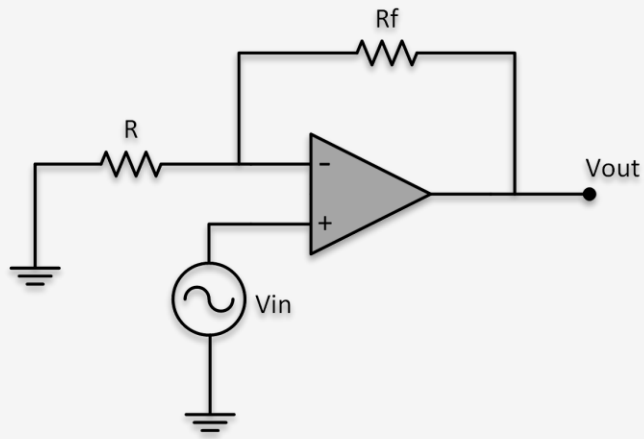
Simulation

- Includes component models
- Shows frequency behavior
- Faster than physical testing



Inverting and Non-inverting Amplifiers

↘ Inverting Amplifier

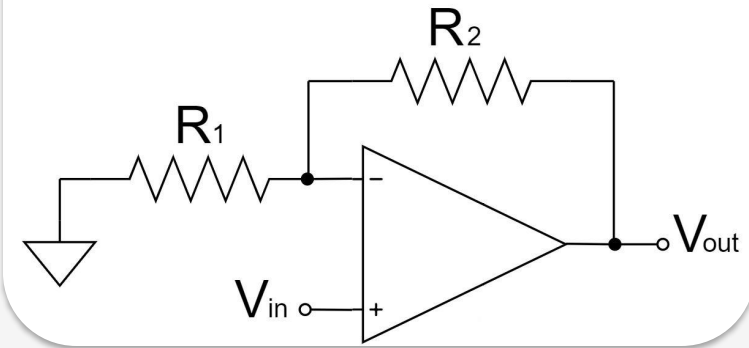


$$V_{out} = - (R_f/R_{in}) \times V_{in}$$

- ✓ Output is 180° out of phase with input
- ✓ Input impedance $\approx R_{in}$
- ✓ Virtual ground at inverting input

↗ Non-Inverting Amplifier

Non-Inverting Amplifier Circuit

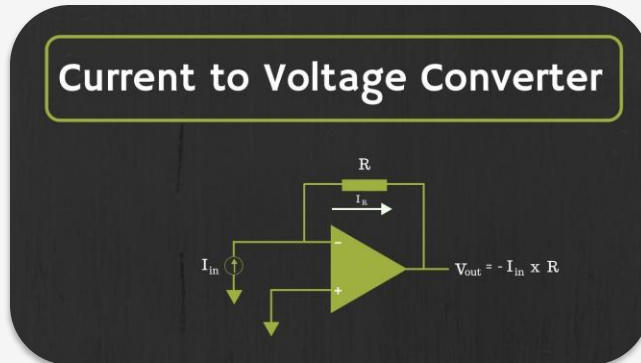


$$V_{out} = (1 + R_f/R_1) \times V_{in}$$

- ✓ Output is in phase with input
- ✓ High input impedance
- ✓ Minimum gain = 1 (voltage follower)

V/I & I/V converters and Voltage Follower

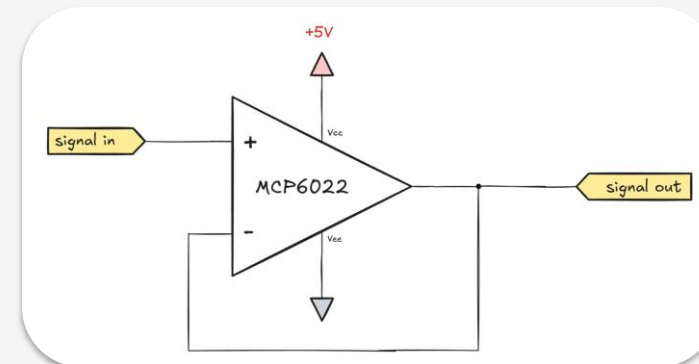
↔ Voltage-to-Current Converter



$$I_{out} = V_{in} / R$$

- ✓ Output current proportional to input voltage
- ✓ Used in current transmission systems

↔ Voltage Follower

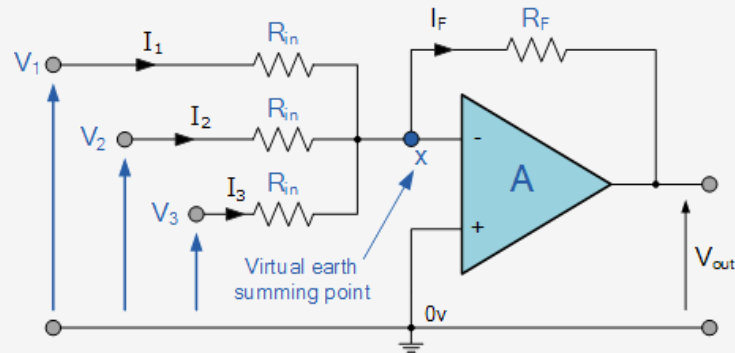


$$V_{out} = V_{in}$$

- ✓ Unity gain (Gain = 1)
- ✓ High input impedance, low output impedance
- ✓ Buffer/isolator between circuit stages
- ✓ Prevents loading of source circuit
- ✓ Applications: impedance matching, signal isolation

Summer and Subtractor

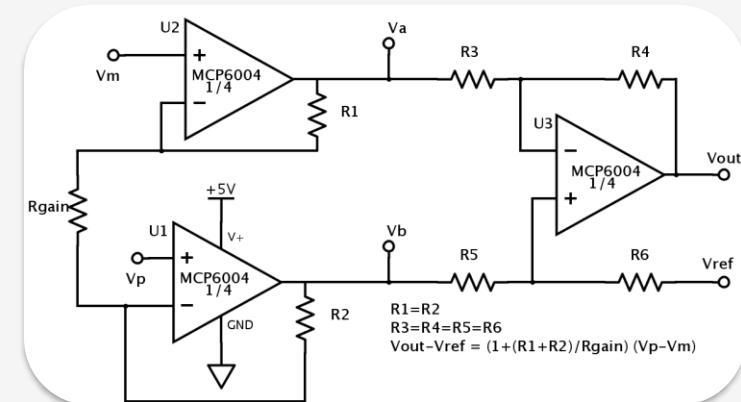
+ Summing Amplifier



$$V_{out} = -R_f \times (V_1/R_1 + V_2/R_2 + \dots + V_n/R_n)$$

- ✓ Multiple inputs summed together
- ✓ Output is inverted sum of inputs
- ✓ Each input can have different weight
- ✓ Used in audio mixing, DAC

- Differential Amplifier



$$V_{out} = (R_f/R_1) \times (V_2 - V_1)$$

- ✓ Amplifies difference between inputs
- ✓ Rejects common-mode signals
- ✓ High CMRR (Common-Mode Rejection Ratio)
- ✓ Used in instrumentation, noise rejection

Activity Brainstorm Blitz

Topic: Basic Applications of OP-AMP

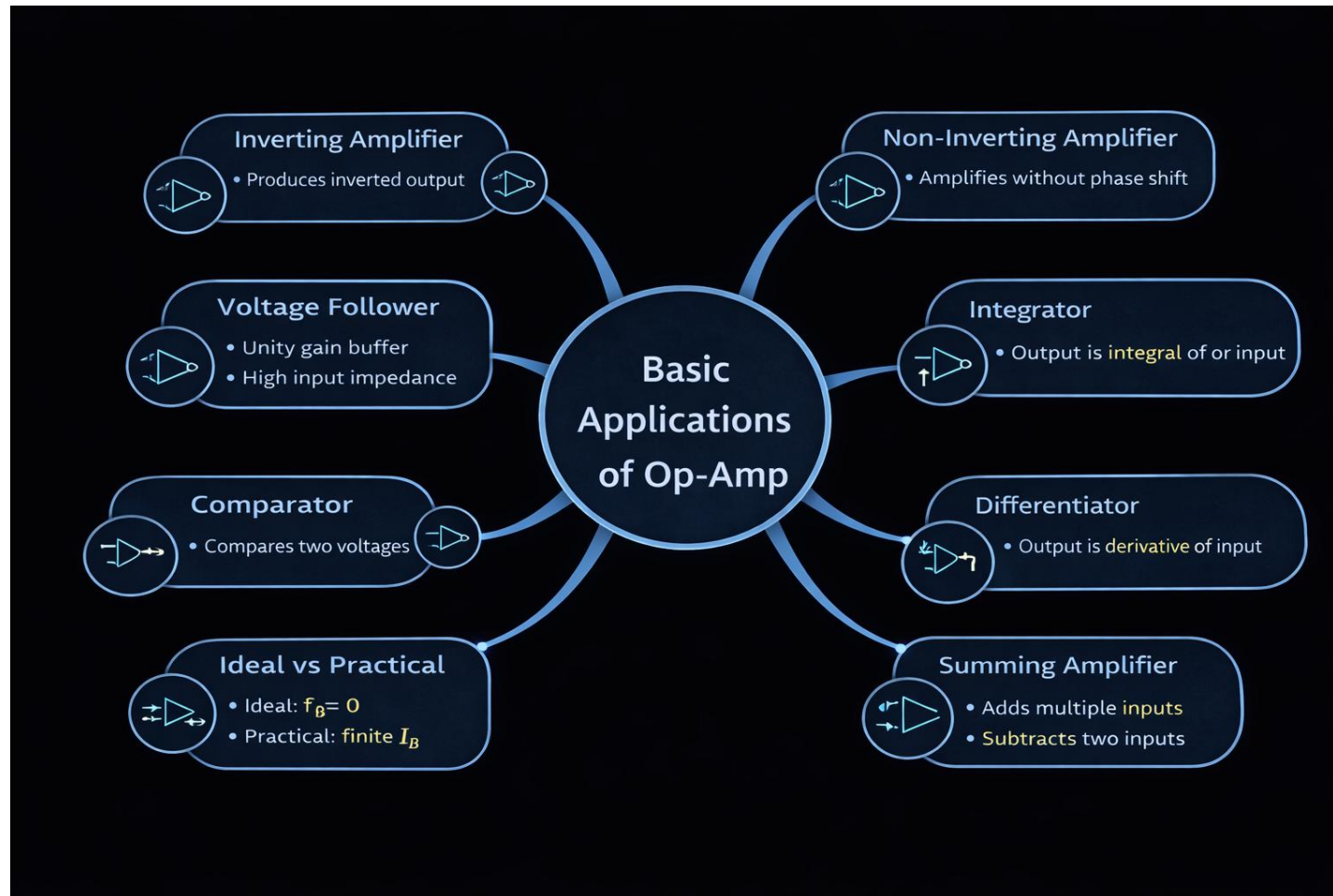
Instructions

- 1 •Students work **individually (2 min)** → **pairs/groups (5 min)** → **class share (3 min)**
 - Whiteboard / chart paper / digital board

Question:

- 2
 - Where do we use **amplification** in daily life?
 - How can an OP-AMP be used to **increase signal strength**?
 - What happens when we **add or subtract signals** using an OP-AMP?
 - How can OP-AMPs help in **comparison or decision making**?
 - What role do OP-AMPs play in **signal conditioning**?

Summary: Mind map



Assessment

🔍 Exam-Oriented Questions

- 🕒 Derive the transfer function for an inverting amplifier with input resistance R_1 and feedback resistance R_f
- 🕒 Explain the principle of operation of a Schmitt trigger and its advantage over a simple comparator
- 🕒 Design a summing amplifier to implement $V_{out} = -(2V_1 + 3V_2 + 4V_3)$
- 🕒 Compare the frequency response characteristics of integrator and differentiator circuits
- 🕒 Draw a voltage-to-current converter circuit and derive the expression for output current



References

Textbooks

- **D. Roy Choudhry, Shail Jain**, "Linear Integrated Circuits", New Age International Pvt. Ltd., Fifth edition 2018. **(Unit II, Sections 2.1-2.7)**
- **Sergio Franco**, "Design with Operational Amplifiers and Analog Integrated Circuits", Fourth Edition, Tata Mc Graw-Hill, 2014. **(Chapter 3-5)**
- **Ramakant A. Gayakwad**, "OP-AMP and Linear ICs", 4th Edition, Prentice Hall/Pearson Education, 2001. **(Chapters 4-7)**

Online Resources

- 🌐 **NPTEL**, Linear Integrated Circuits - https://onlinecourses.nptel.ac.in/noc24_ee73/preview
- 🌐 **Texas Instruments**, "Op-amp Basics: Introduction to the Operational Amplifier", Technical Document - <https://www.ti.com/lit/an/sboa091a/sboa091a.pdf>
- 🌐 **Analog Devices**, "Op Amp Applications Handbook", Chapter 1-4 - <https://www.analog.com/en/education/education-library/op-amp-applications-handbook.html>

Thank You!