Module II: Operational Amplifier and Its Applications

Basic Electronics Engineering – *3rd Semester UG Engineering (AICTE Curriculum)*

Section 1: Introduction to Operational Amplifiers

- An **operational amplifier (Op-Amp)** is a high-gain, DC-coupled voltage amplifier with differential inputs and usually a single-ended output.
- Widely used in signal conditioning, filtering, and mathematical operations.

1.1 Op-Amp IC 741

- A classic general-purpose op-amp used in analog circuits.
- Features: High gain (~100,000), dual polarity supply, and low offset voltage.

Section 2: Op-Amp Input Modes and Parameters

2.1 Input Modes

- **Differential Mode**: Inputs are different voltages.
- **Common Mode**: Inputs are the same voltage.

2.2 Parameters

- **Input Offset Voltage**
- **Input Bias Current**
- **Slew Rate**: Maximum rate of change of output voltage
- **CMRR (Common Mode Rejection Ratio)**

- **PSRR (Power Supply Rejection Ratio)**

Section 3: Open Loop Configuration

- Very high gain (~10^5–10^6)
- **No feedback** applied
- Not practical for linear applications due to instability
- Used in **comparators**

Section 4: Negative Feedback in Op-Amps

- Feedback stabilizes gain and improves bandwidth
- Lowers distortion and input/output impedance
- Enables **linear applications** like amplifiers

Section 5: Op-Amp Applications

5.1 Inverting Amplifier

- Input applied through resistor to inverting input
- Output is 180° out of phase
- Gain: Av=−RfRinA_v = -\frac{R_f}{R_{in}}

5.2 Non-Inverting Amplifier

- Input applied to non-inverting terminal
- Output in phase with input

- Gain: $Av=1+\frac{R_f}{R_1}$

5.3 Summing Amplifier

- Adds multiple input signals
- Weighted summation using resistor network

5.4 Difference Amplifier

- Outputs the difference of two input voltages
- Used in signal subtraction and noise reduction

5.5 Unity Gain Buffer

- Also called **voltage follower**
- Gain = 1; high input impedance, low output impedance

5.6 Comparator

- Compares input with reference
- Output is either HIGH or LOW depending on input polarity

5.7 Integrator

- Performs mathematical integration of input
- Output: $Vout(t)=-\frac{1}{RC} \int V_{in}(t)dt$

5.8 Differentiator

- Performs differentiation of input
- Output: $Vout(t)=-RC\frac{dV_{in}(t)}{dt}$