Chapter - 14

Operation Amplifier

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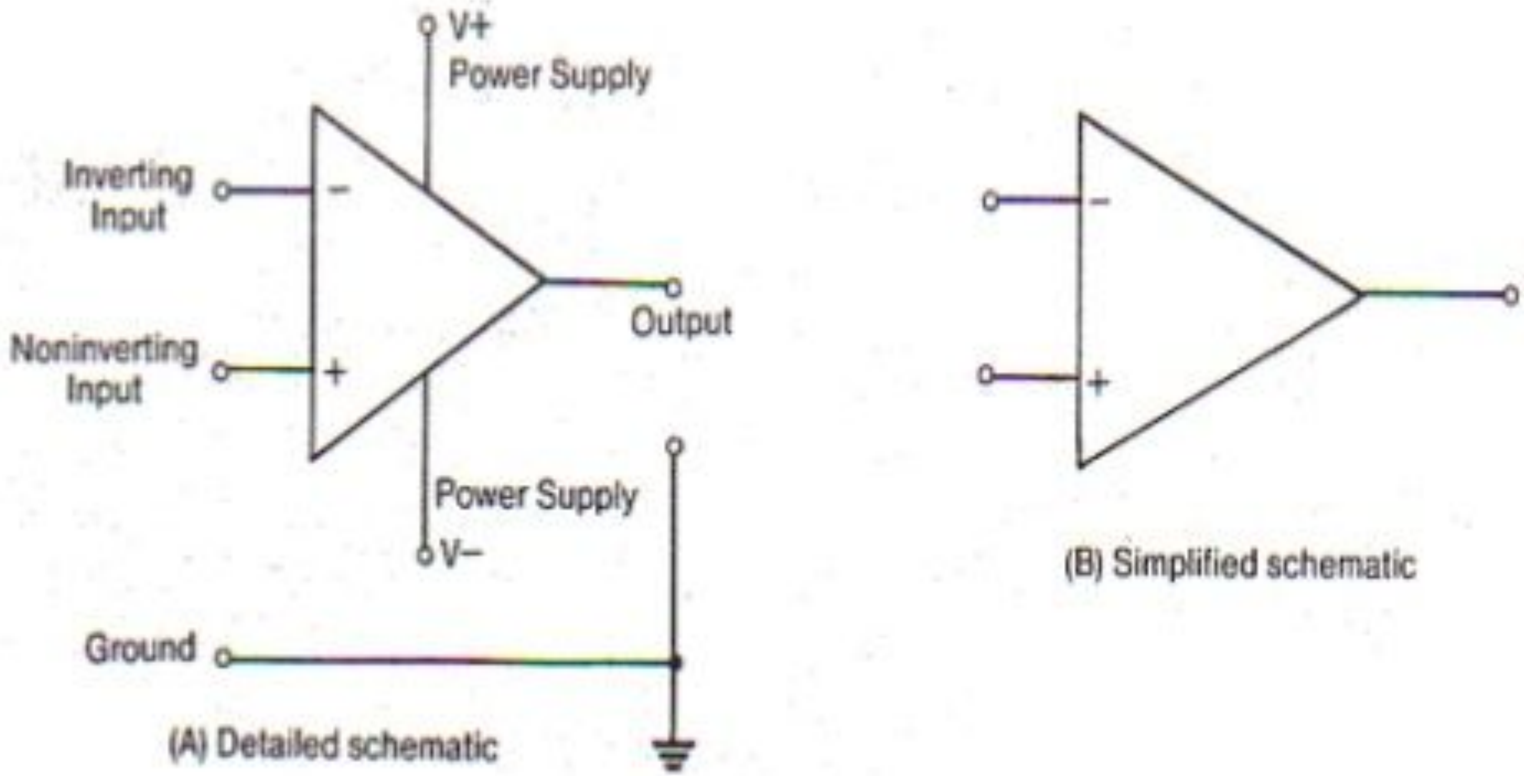
✓An operational amplifier (op-amp) is a DC-coupled high- gain electronic voltage amplifier

✓ Direct- coupled high gain amplifier usually consisting of one or more differential amplifiers

✓Designed for computing mathematical functions such as addition, subtraction ,multiplication, integration & differentiation

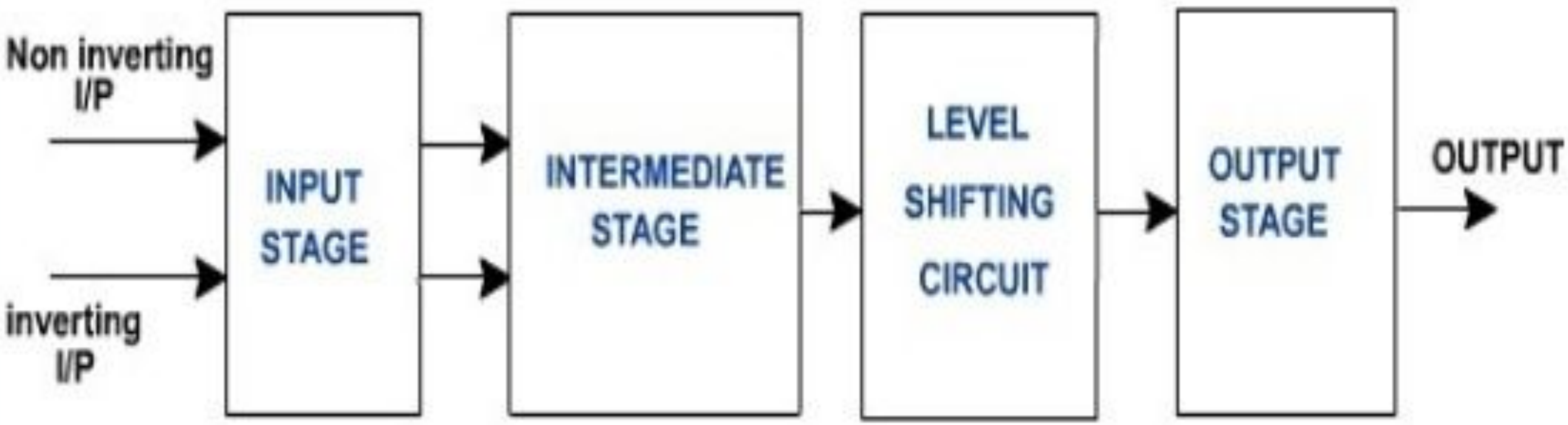
SYMBOL



(A) Detailed schematic

(B) Simplified schematic

BLOCK DIAGRAM

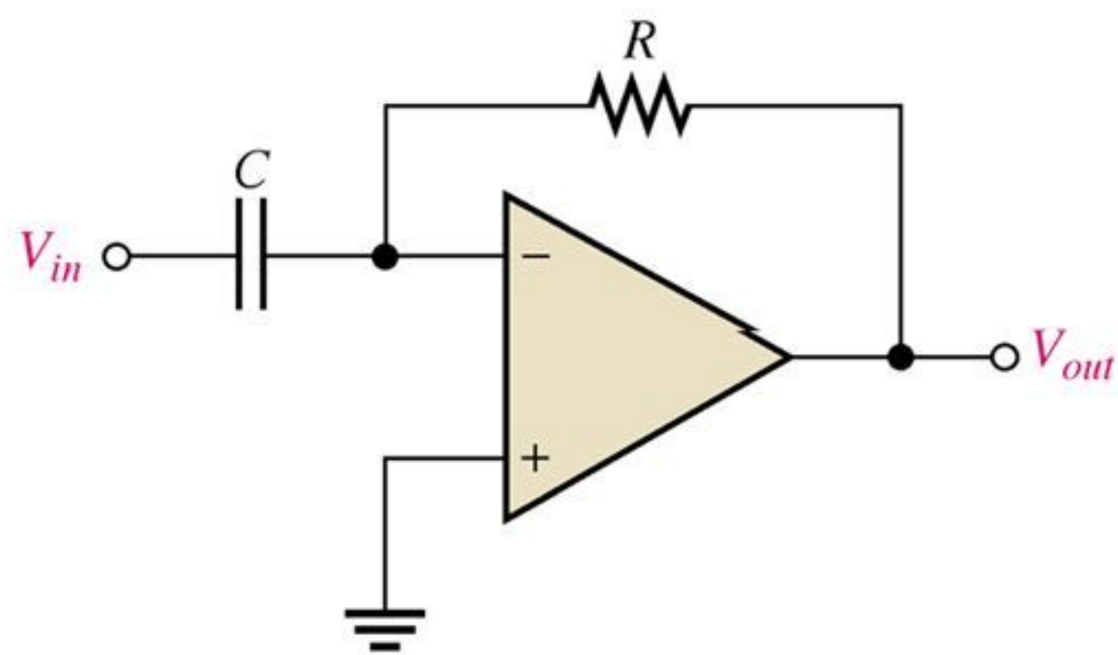


Characteristics of Ideal Op-Amp:

- Infinite input impedence (about 2 Mohm)
- Low output impedence (about 200 ohm)
- Very large voltage gain at low frequency.
- Infinite bandwidth.
- No slew rate- No delay between changes in i/p and changes in o/p.

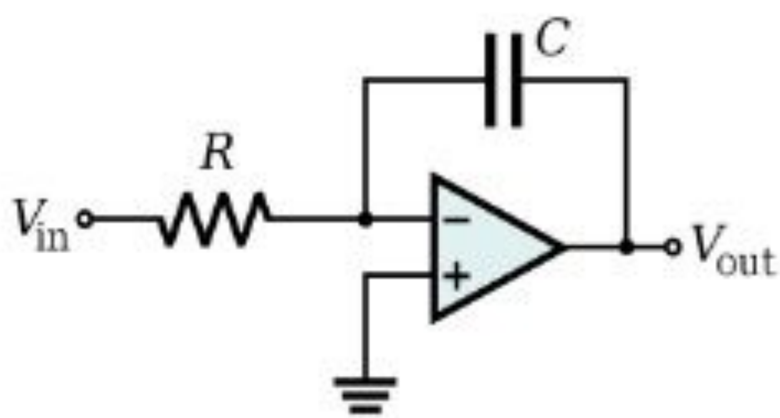
The Op-Amp Differentiator

- An ideal differentiator is shown in figure.
- The capacitor is now input element.
- A differentiator produces an output that is proportional to the rate of change of input voltage



Op-Amp Integrator:-

- If feedback component used is a capacitor ,the resulting connection is called integrator.
- The circuit diagram of ideal op-amp integrator

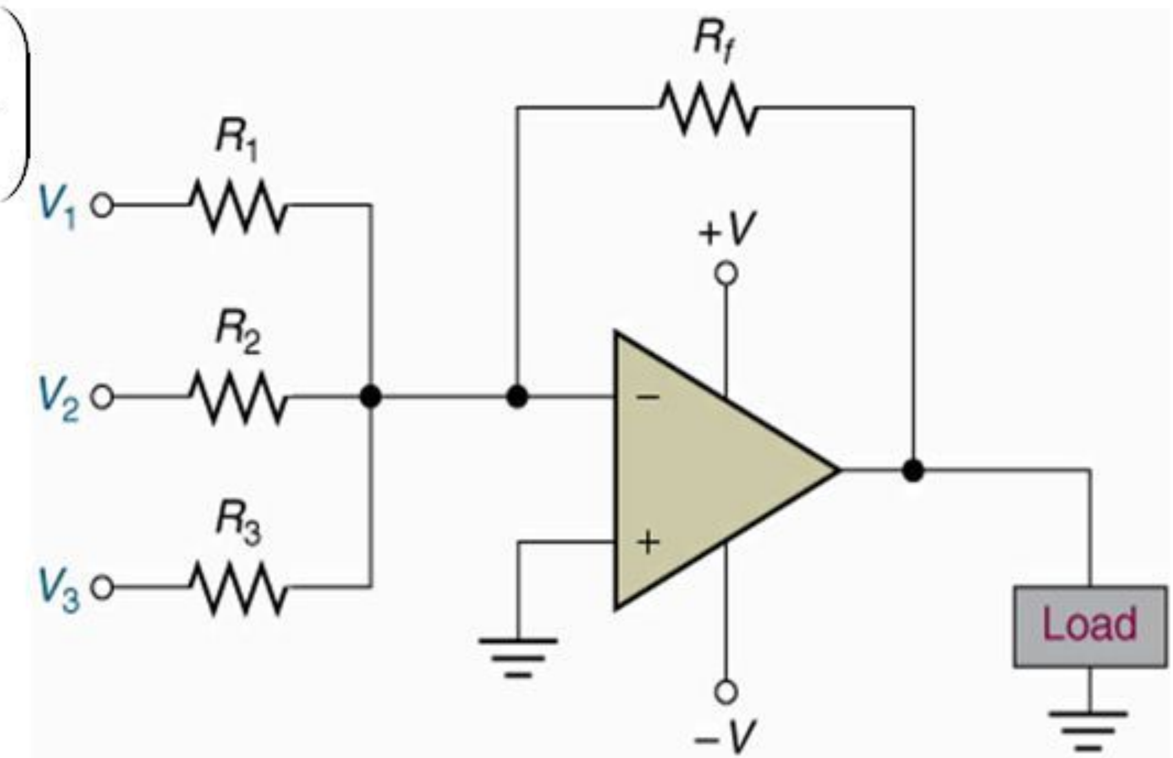


$$V_{out} = -\frac{1}{R_{in}C}\int_0^t V_{in}\,dt = -\int_0^t V_{in}\frac{dt}{R_{in}.C}$$

Summing Amplifiers

- Summing amplifier – An op-amp circuit that produces an output proportional to the sum of its input voltages.

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



Inverting amplifier

- Uses negative feedback to invert and amplify a voltage (multiplies by a negative constant)

$$V_{\mathrm{out}} = -\frac{R_{\mathrm{f}}}{R_{\mathrm{in}}} V_{\mathrm{in}}$$

Non-inverting amplifier

- Amplifies a voltage (multiplies by a constant greater than 1)

$$V_{\text{out}} = V_{\text{in}} \left(1 + \frac{R_2}{R_1}\right)$$

Feedback:

Definition

Feedback is defined as the process in which a part of output signal (voltage or current) is returned back to the input.
The amplifier that operates on the principle of feedback is known as feedback amplifier.

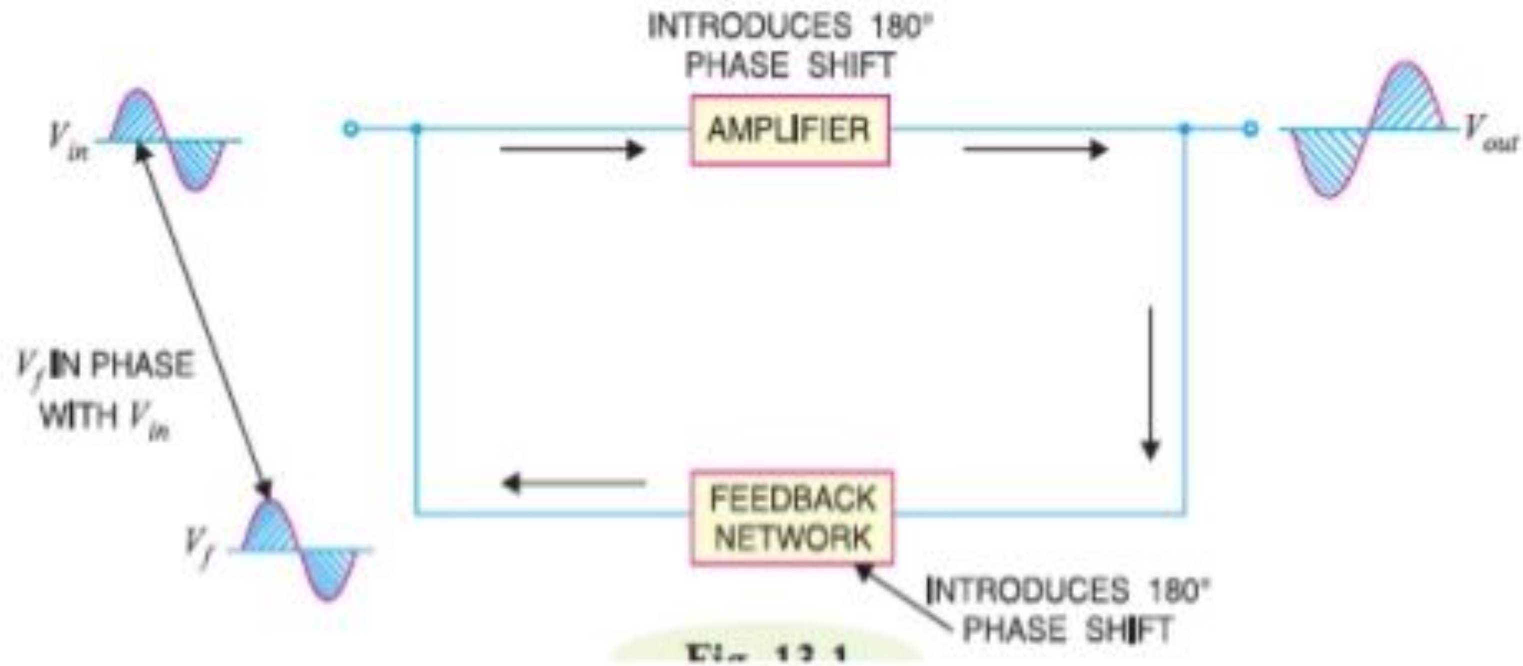
Types of feedback

1. Positive feedback
2. Negative feedback.

- If the original input signal and the feedback signal are in phase, the feedback is called as positive feedback.
- However if these two signals are out of phase then the feedback is called as negative feedback.

Positive feedback

- When the feedback energy (voltage or current) is in phase with the input signal and thus aids it, it is called positive feedback. This is illustrated in Fig.1. Both amplifier and feedback network introduce a phase shift of 180°. The result is a 360° phase shift around the loop, causing the feedback voltage V_f to be in phase with the input signal V_{in}.

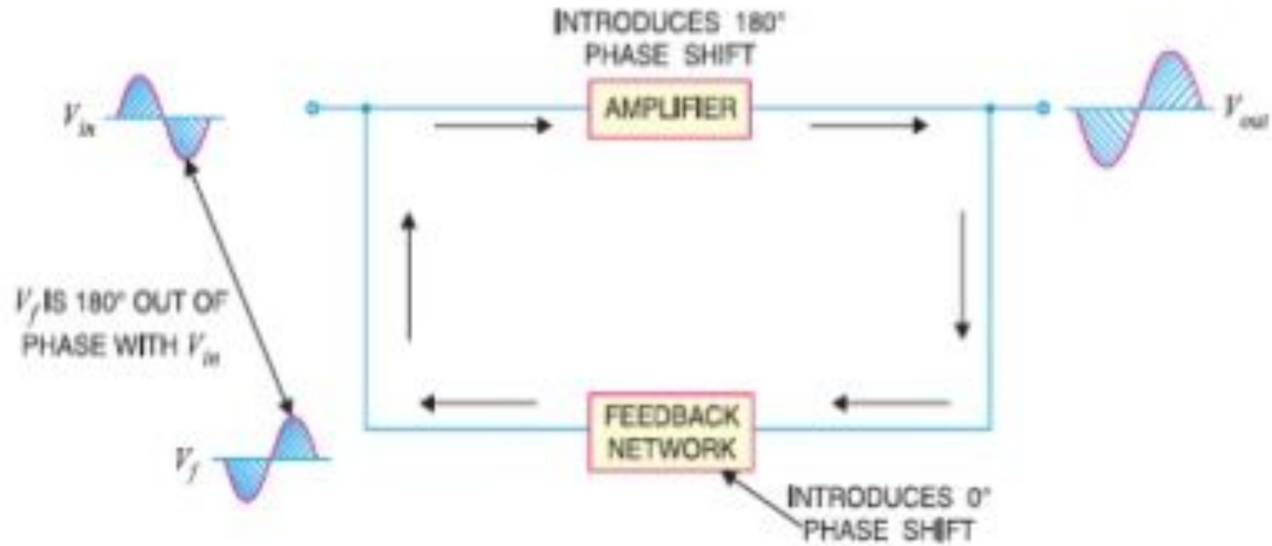


Positive feedback

- The positive feedback increases the gain of the amplifier. However, it has the disadvantages of increased distortion and instability.
- Therefore, positive feedback is seldom employed in amplifiers.
- One important use of positive feedback is in oscillators.

Negative feedback

- When the feedback energy (voltage or current) is out of phase with the input signal and thus opposes it, it is called negative feedback. This is illustrated in Fig.2.
- As you can see, the amplifier introduces a phase shift of 180° into the circuit while the feedback network is so designed that it introduces no phase shift (i.e., 0° phase shift). The result is that the feedback voltage V_f is 180° out of phase with the input signal V_{in}.



Negative feedback

- Negative feedback reduces the gain of the amplifier. However, the advantages of negative feedback are: reduction in distortion, stability in gain, increased bandwidth and improved input and output impedances.
- It is due to these advantages that negative feedback is frequently employed in amplifiers.

Common Mode Rejection Ratio (CMRR)

It is defined as the ratio of differential voltage gain A_d to the common mode voltage gain A_{cm}

$$CMRR = \frac{A_d}{A_{cm}}$$

- 20 dB for 741 IC

Supply Voltage Rejection Ratio (SVRR)

It is defined as the ratio of change in input offset voltage to the corresponding change in supply voltage.

$$SVRR = \frac{\Delta V_{io}}{\Delta V}$$

- 150 ụV/V for 741 IC

Slew Rate (SR)

It is defined as the maximum rate of change of output voltage .

$$SR = \frac{\Delta Vo}{\Delta t}$$

- 0.5 V/ụs for 741 IC