IRE 105 ELECTRONICS DEVICES AND APPLICATIONS

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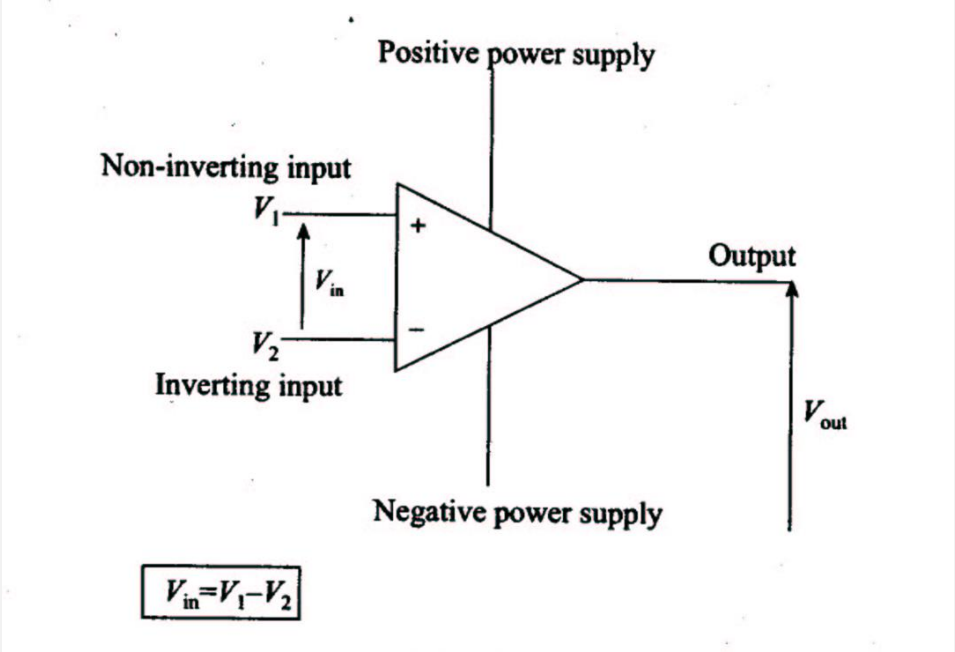
OPAMP

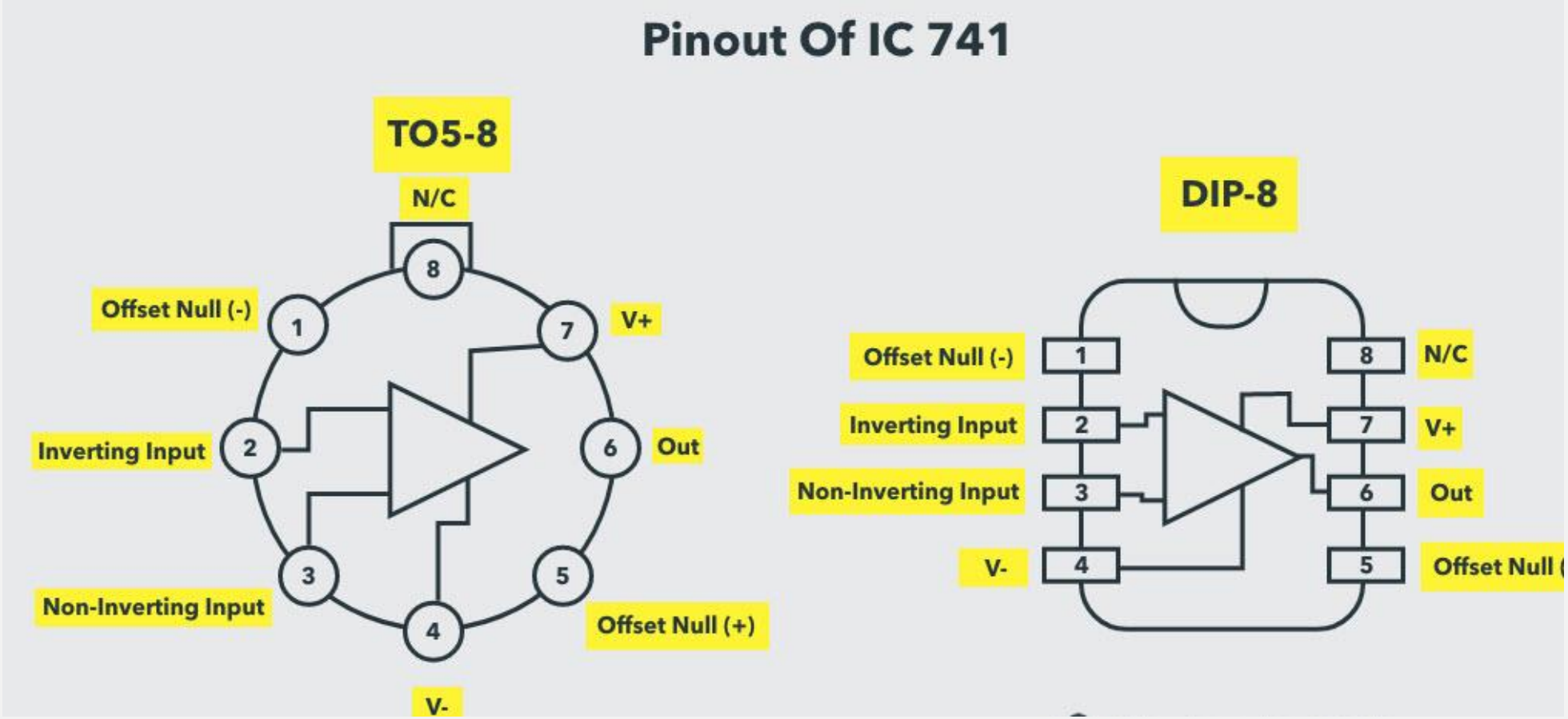
- OPAMP (Operational Amplifier) is an integrated circuit (IC) that operates as voltage amplifier.
- OPAMP is designed to be used with components like capacitors and resistors, between its in/out terminals.
- Op-Amp IC 741 or **LM741** is one of the most used operational amplifier integrated circuits.
- This small chip mainly performs mathematical operations like addition, subtraction, multiplication, division, differentiation, integration, etc. in various circuits.



- 741 requires plus and minus 15V
- Others may require only positive or both positive and negative voltages
- Output voltage is limited to

$$-V_{CC} < V_{OUT} < +V_{CC}$$

OPAMP PINS


Pinout Of IC 741
TO5-8
N/C
8
Offset Null (-)
1
7
V+
Inverting Input
2
6
Out
3
5
Non-Inverting Input
4
Offset Null (+)
V-
DIP-8
Offset Null (-)
1
8
N/C
Inverting Input
2
7
V+
Non-Inverting Input
3
6
Out
V-
4
5
Offset Null (

OPAMP PINS

- **Pin4 & Pin7 (Power Supply):** Pin7 is the positive voltage supply terminal and Pin4 is the negative voltage supply terminal. The 741 IC draws in power for its operation from these pins. The voltage between these two pins can be anywhere between 5V and 18V.
- **Pin6 (Output):** This is the output pin of IC 741. The voltage at this pin depends on the signals at the input pins and the feedback mechanism used. If the output is said to be high, it means that voltage at the output is equal to positive supply voltage. Similarly, if the output is said to be low, it means that voltage at the output is equal to negative supply voltage.
- **Pin2 & Pin3 (Input):** These are input pins for the IC. Pin2 is the inverting input and Pin3 is the non-inverting input. If the voltage at Pin2 is greater than the voltage at Pin3, i.e., the voltage at inverting input is higher, the output signal stays low. Similarly, if the voltage at Pin3 is greater than the voltage at Pin2, i.e., the voltage at non-inverting input is high, the output goes high.
- **Pin1 & Pin5 (Offset Null):** Because of high gain provided by 741 Op-Amp, even slight differences in voltages at the inverting and non-inverting inputs, caused due to irregularities in manufacturing process or external disturbances, can influence the output. To nullify this effect, an offset voltage can be applied at pin1 and pin5, and is usually done using a potentiometer.
- **Pin8 (N/C):** This pin is not connected to any circuit inside 741 IC. It’s just a dummy lead used to fill the void space in standard 8 pin packages.

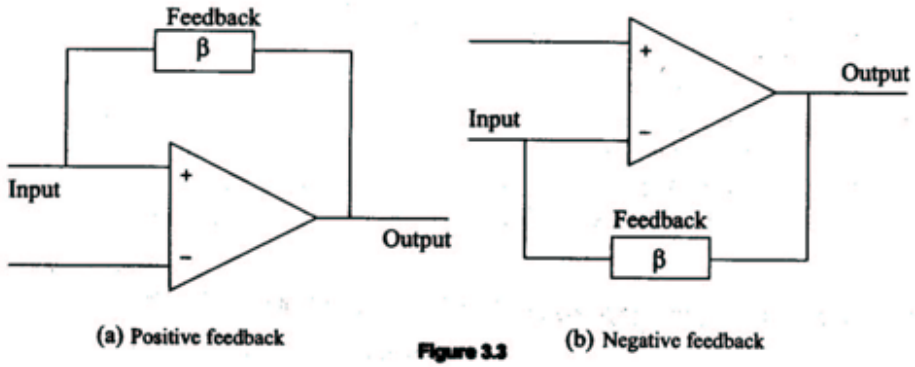
WHY OPAMP IS CALLED SO?

OPAMP is an electronic unit that acts as a voltage controlled voltage source. It can be used to make a current controlled current source. An OPAMP has the ability to sum, subtract, multiply, amplify, integrate, differentiate, and compare signals. The ability of OPAMP to perform these mathematical terms is the reason of its being called operational amplifier.

IDEAL OPAMP CHARACTERISTICS

- Gain is infinite $A = \frac{V_{OUT}}{V_+ - V_-} = \frac{V_{OUT}}{V_{IN}} \to \infty$
- Input resistance is infinite $R_{IN} \to \infty$
- Output resistance is zero $R_{OUT} = 0$
- Input voltage is zero $V_{IN} = 0$
- Input current is zero $I_+ = 0$ $I_- = 0$

POSITIVE AND NEGATIVE FEEDBACK



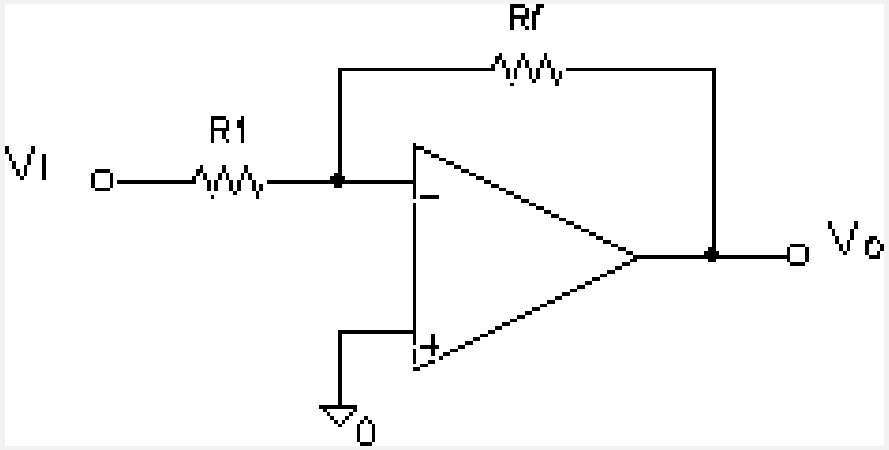
- Connecting the output to the positive input is positive feedback
- Connecting the output to the negative input is negative feedback

Why do we use feedback in amps?

Negative feedback reduces gain of the amplifier. It also reduce distortion, noise and instability. This feedback increases bandwidth and improves input and output impedances. Due to these advantages, the negative feedback is frequently used in amplifiers.

OP-AMP CONFIGURATIONS

- Inverting Op-Amp

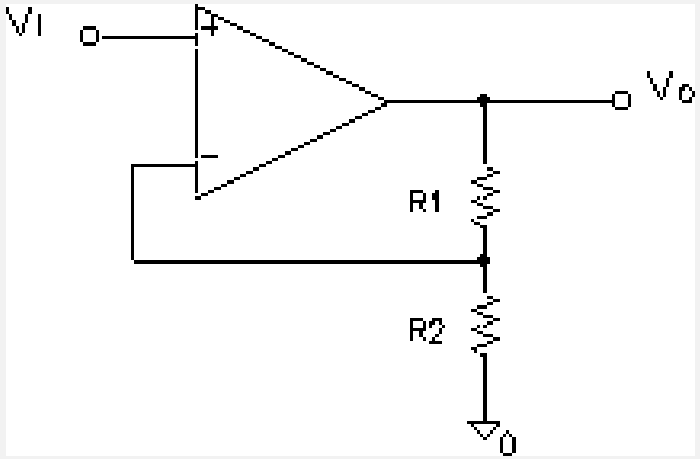


OP-AMP CONFIGURATIONS (CONTD.)

- Why the minus sign for the current through R_f?
  - The convention for Ohm's Law is that the current flows from the high voltage to the low voltage for a resistor
  - Here the current flows from the low voltage (ground) to the high voltage (V_O)

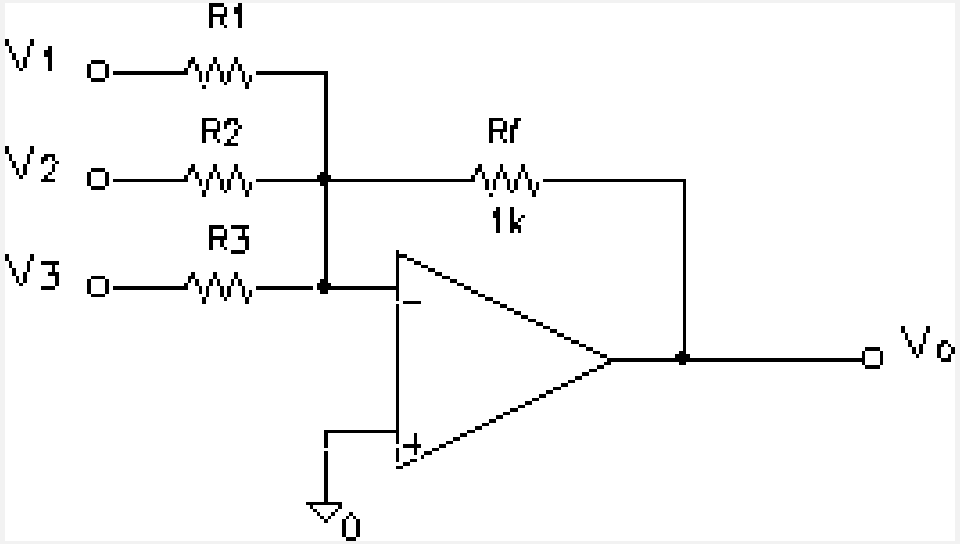
OP-AMP CONFIGURATIONS (CONTD.)

- Non-Inverting Amplifier



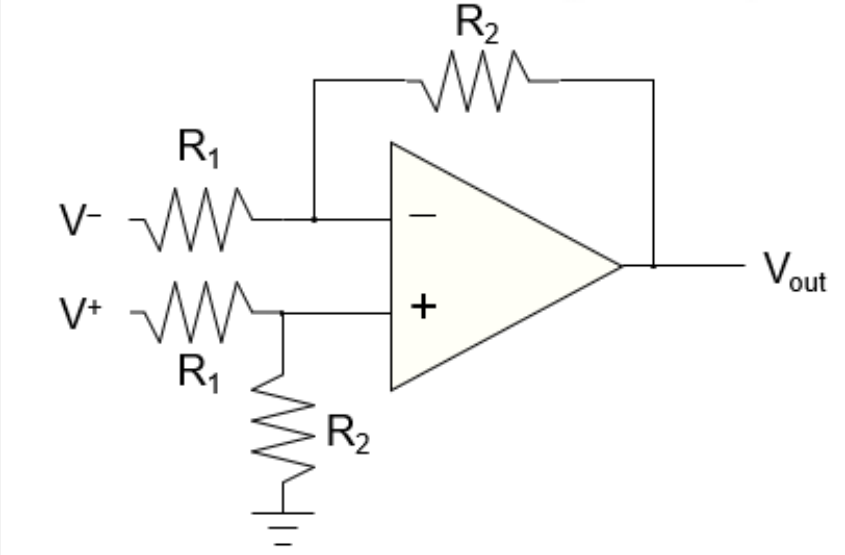
OP-AMP CONFIGURATIONS (CONTD.)

- Inverting Summing Amplifier



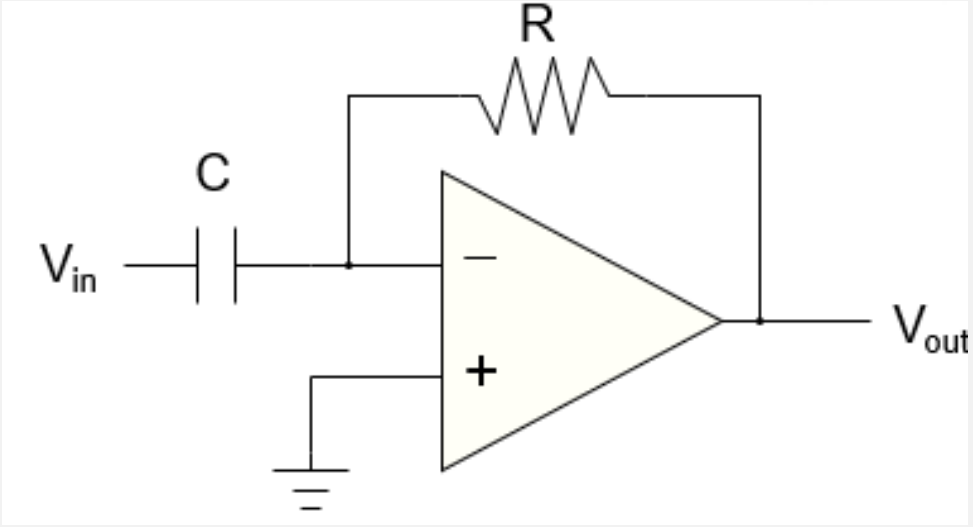
OP-AMP CONFIGURATIONS (CONTD.)

- Subtracting Amplifier



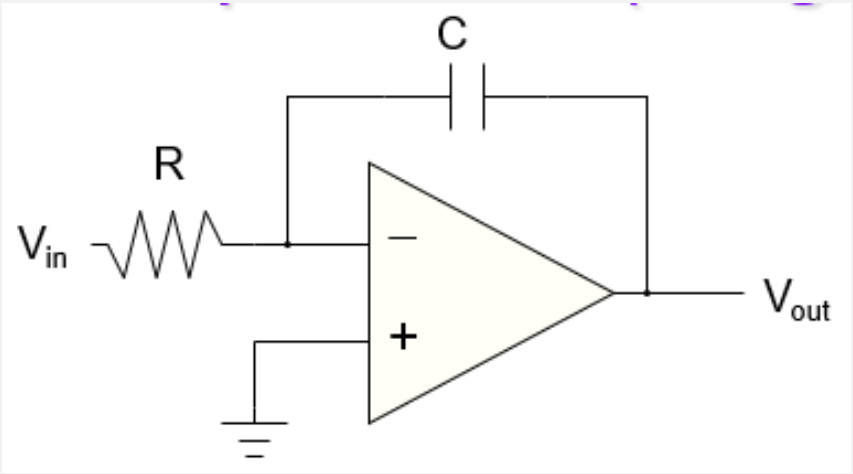
OP-AMP CONFIGURATIONS (CONTD.)

- Differentiator



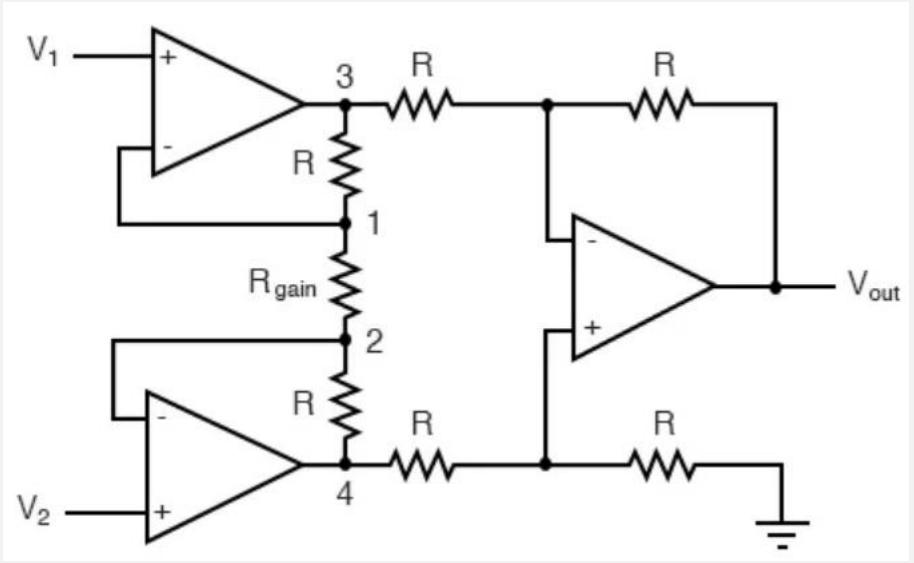
OP-AMP CONFIGURATIONS (CONTD.)

- Integrator



INSTRUMENTATION AMPLIFIER

- An instrumentation amplifier is used to amplify very low-level signals, rejecting noise and interference signals.



APPLICATIONS OF INSTRUMENTATION AMPLIFIER

- The applications of the instrumentation amplifier include the following.
- These amplifiers mainly involve where the accuracy of high differential gain is required, strength must be preserved in noisy surroundings, as well as where huge common-mode signals are there. Some of the applications are
- Instrumentation amplifiers are used in data acquisition from small o/p transducers like thermocouples, strain gauges, measurements of Wheatstone bridge, etc.
- These amplifiers are used in navigation, medical, radar, etc.
- These amplifiers are used to enhance the S/N ratio (signal to noise) in audio applications like audio signals with low amplitude.
- These amplifiers are used for imaging as well as video data acquisition in the conditioning of high-speed signal.
- These amplifiers are used in RF cable systems for amplification of the high-frequency signal.

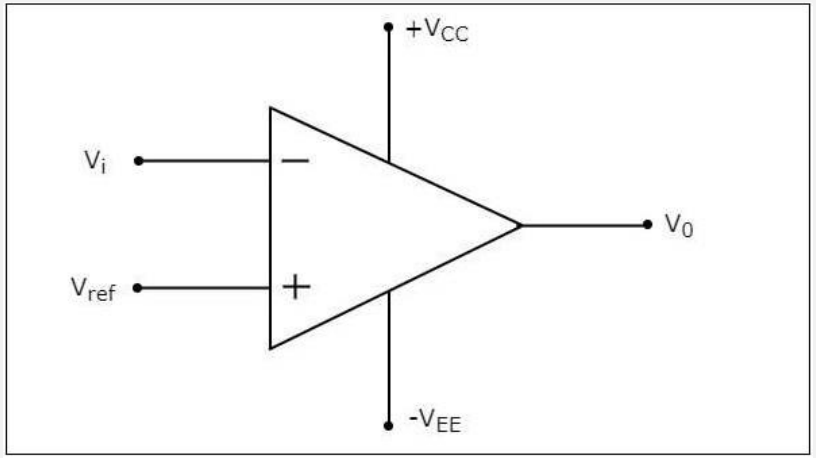
OPAMP COMPARATOR

- A **comparator** is an electronic circuit, which compares the two inputs that are applied to it and produces an output. The output value of the compar
- An op-amp consists of two input terminals and hence an op-amp based comparator compares the two inputs that are applied to it and produces the result of comparison as the output. This chapter discusses about **op-amp based comparators**. comparator indicates which of the inputs is greater or lesser.
- Comparators are of two types : **Inverting** and **Non-inverting**.

INVERTING COMPARATOR

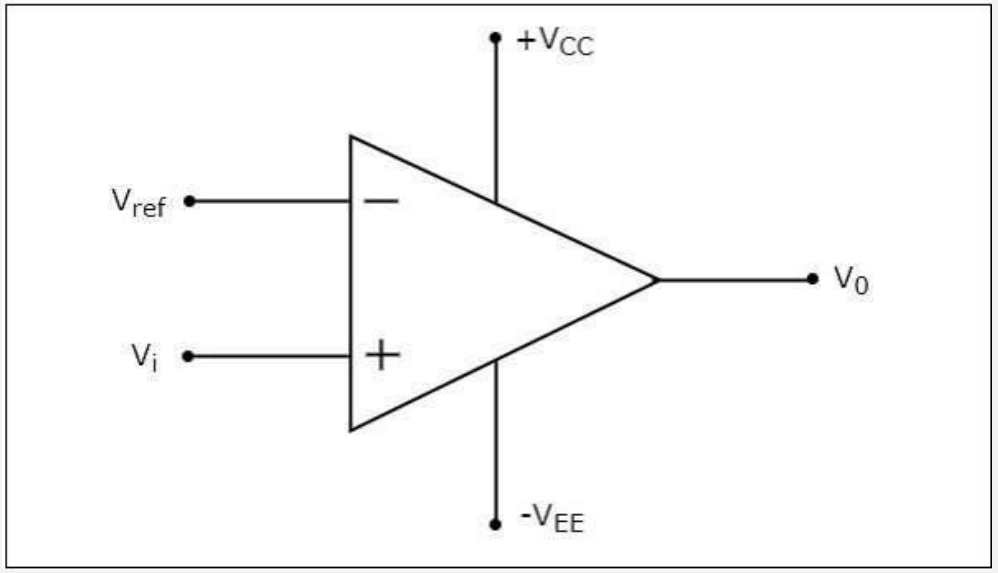
- An **inverting comparator** is an op-amp based comparator for which a reference voltage is applied to its non-inverting terminal and the input voltage is applied to its inverting terminal. This comparator is called as **inverting** comparator because the input voltage, which has to be compared is applied to the inverting terminal of op-amp.

The operation of an inverting comparator is very simple. It produces one of the two values, +Vsat
and −Vsat
at the output based on the values of its input voltage Vi and the reference voltage Vref



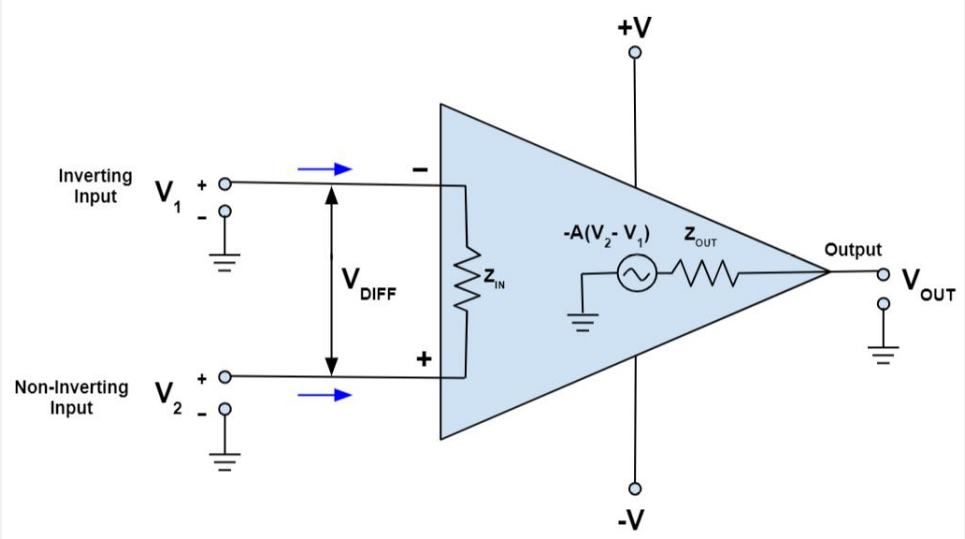
NON-INVERTING COMPARATOR

- A non-inverting comparator is an op-amp based comparator for which a reference voltage is applied to its inverting terminal and the input voltage is applied to its non-inverting terminal. This op-amp based comparator is called as **non-inverting** comparator because the input voltage, which has to be compared is applied to the non-inverting terminal of the op-amp.



GOLDEN RULE OF OPAMP

- No current flows into the +/− inputs of the op amp.
- In a circuit with negative feedback, the output of the op amp will try to adjust its output so that the voltage difference between the + and − inputs is zero (V+ = V−).



VOLTAGE TO CURRENT CONVERTER USING OP-AMP

- If the output/load current, I_L is directly proportional to the input voltage, it is called voltage to current converter.
- Floating load: floating between inverting terminal and the output terminal which means it is not directly grounded that is why it is called floating load
- Inverting voltage to current converter and non-inverting voltage to current converter.

OPAMP APPLICATION

- Op-amps are widely used for various applications. It is no exaggeration to say that op-amps are found in almost all electrical appliances. For example, op-amps amplify analog signals from various sensors in IoT-connected home appliances and measuring instruments.