Operational Amplifiers

What is an Op-Amp

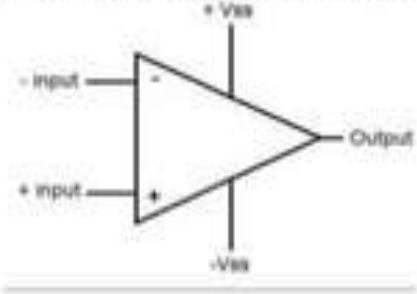
- Low cost integrating circuit consisting of:
  - Transistors
  - Resistors
  - Capacitors
- Able to amplify a signal due to an external power supply
- Name derives from its use to perform operations on a signal.

WHAT IS OP-AMP?

✓ *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*

✓ *Output stage is generally a push-pull or push-pull complementary-symmetry pair.*



✓ *Op amps are differential amplifiers, and their output voltage is proportional to the difference of the two input voltages. The op amp's schematic symbol is shown in the above figure*

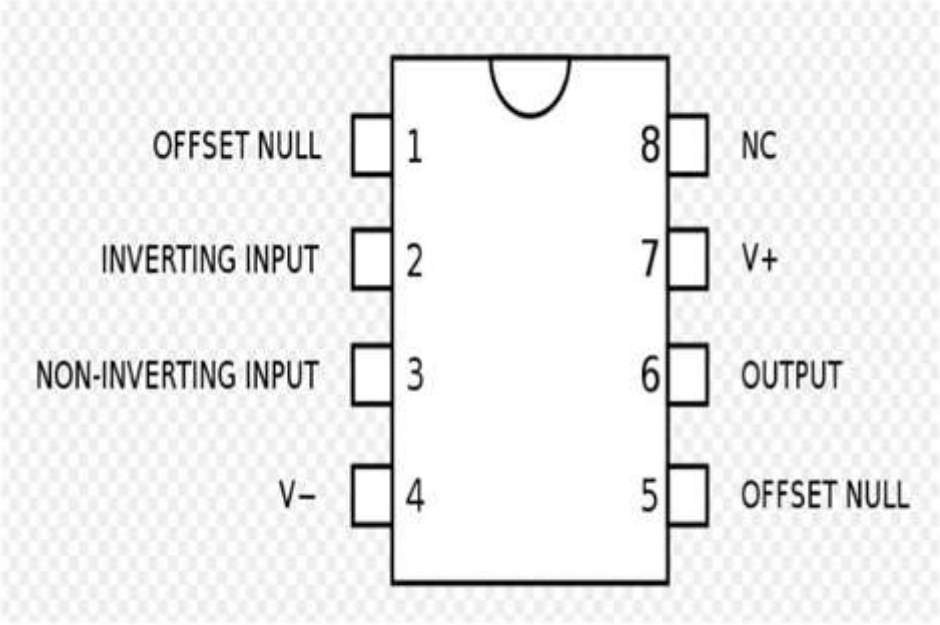
✓ *The two input terminals, called the inverting and non-inverting, are labeled with - and +, respectively.*

- When an op-amp is configured in *any* negative-feedback arrangement, it will obey the following two rules:
  - The inputs to the op-amp draw or source no current (true whether negative feedback or not)
  - The op-amp output will do whatever it can (within its limitations) to make the voltage difference between the two inputs zero

Applications of Op-Amps

- Simple Amplifiers
- Summers
- Comparators
- Integrators
- Differentiators
- Analog to Digital Converters

What do they really look like?



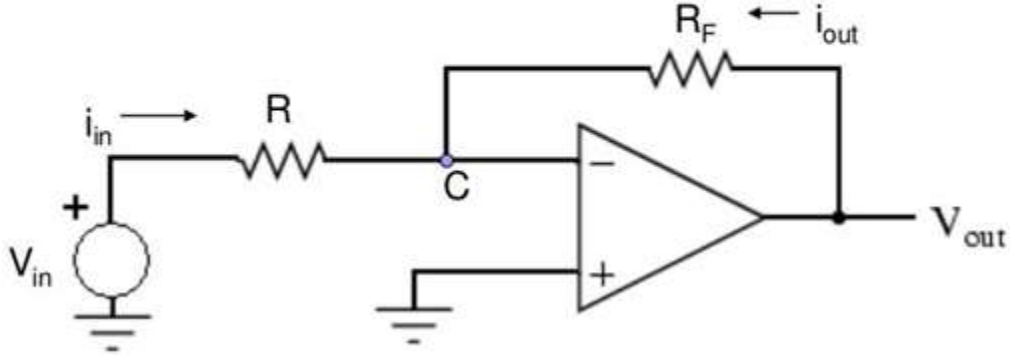
CHARACTERISTICS OF IDEAL OP-AMP

- Infinite input impedance(about 2Mohm)
- Low output impedance(about 200 ohm)
- Very large voltage gain at low frequency
- Thus,small changes in voltages can be amplified byusing an op-amp
- Infinte bandwidth(all frequencies are amplified by same factor

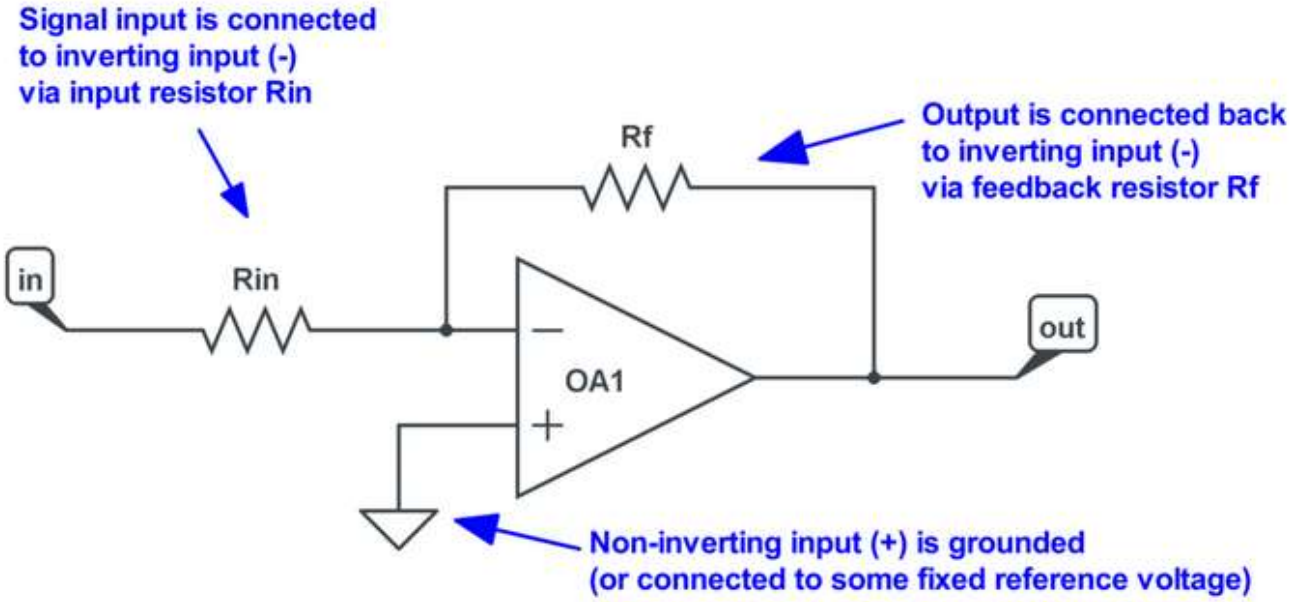
❑Infinite Common-mode rejection ratio

❑Infinite Power supply rejection ratio.

Inverting Amplifier

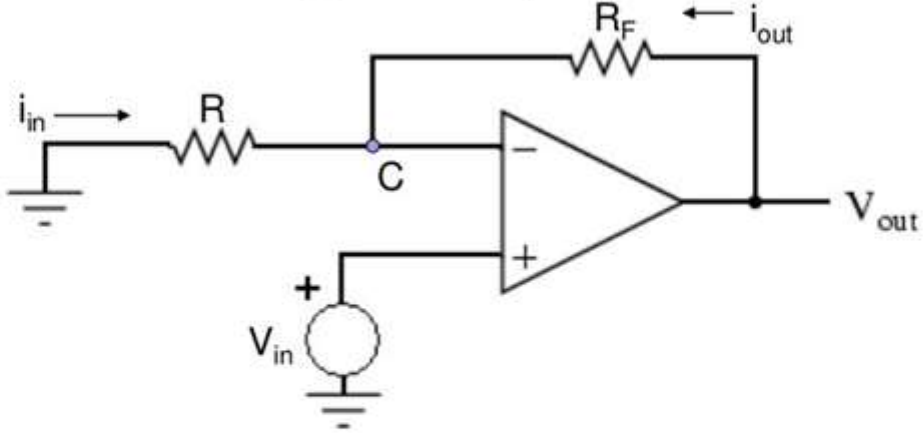


$$\frac{V_{out}}{V_{in}} = -\frac{R_F}{R}$$

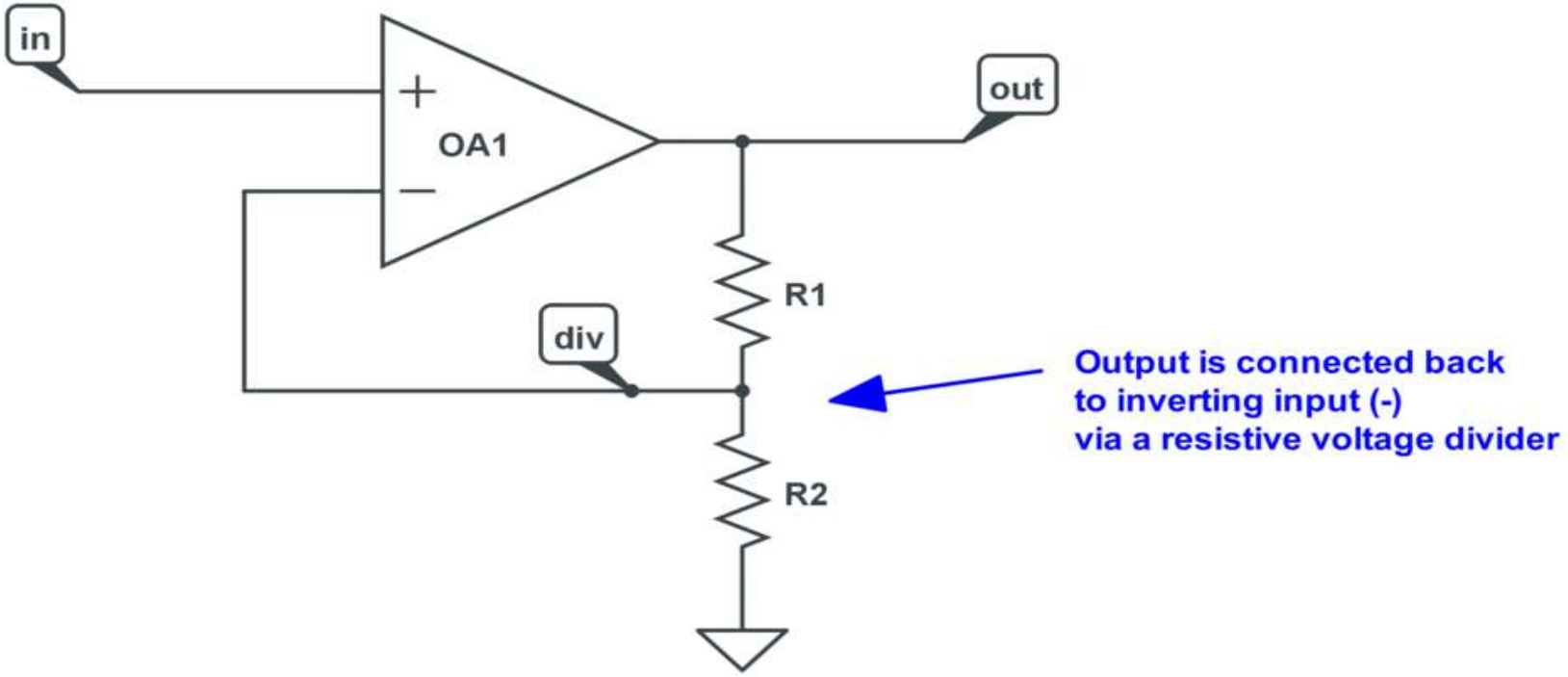


OP-AMP INVERTING AMPLIFIER

Non-Inverting Amplifier



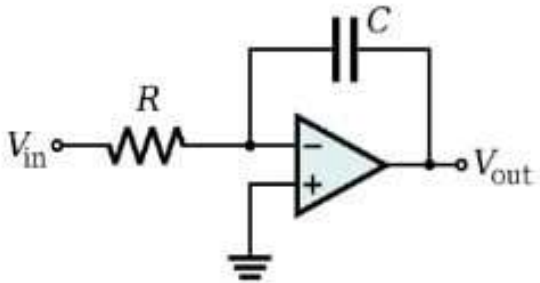
$$\frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R}$$



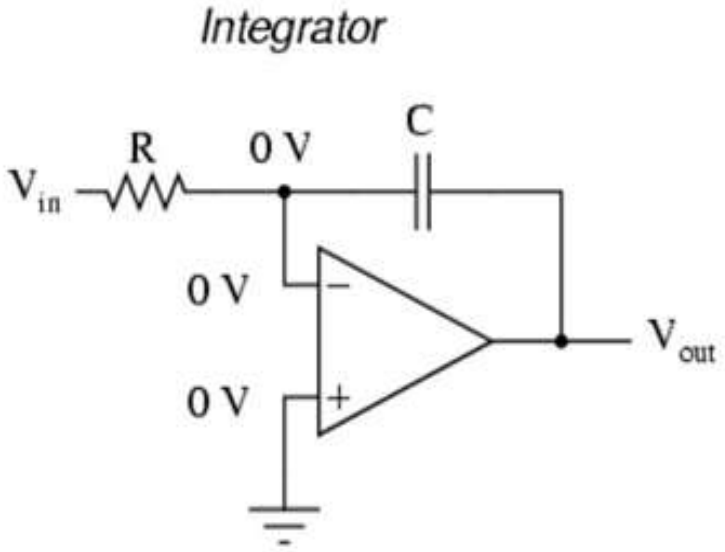
OP-AMP NON-INVERTING AMPLIFIER

Op-Amp Integrator:-

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



Integrating Circuit



- Replace feedback resistor of inverting op-amp with capacitor
- A constant input signal generates a certain rate of change in output voltage
- Smoothes signals over time

$$\frac{dv_{out}}{dt} = -\frac{V_{in}}{RC}$$

or

$$V_{out} = \int_0^t -\frac{V_{in}}{RC}\,dt + c$$

Where,

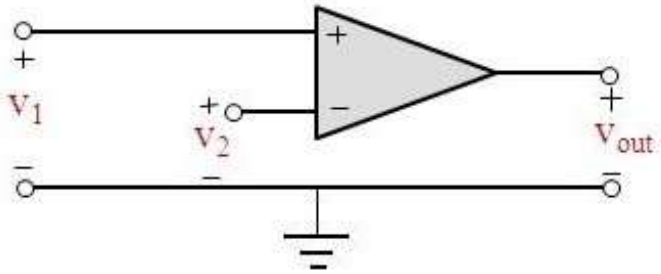
c = Output voltage at start time (t=0)

❖What is a Differential Amplifier ?

Some Definitions and Symbols

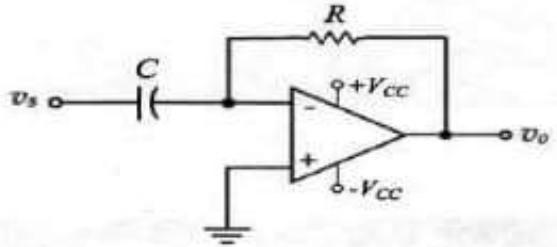
- **Differential Amplifier:** A differential amplifier is an amplifier that amplifies the difference between two voltages and rejects the average or common mode value of the two voltages.

Symbol for a Differential Amplifier



Differentiator Op-Amp:-

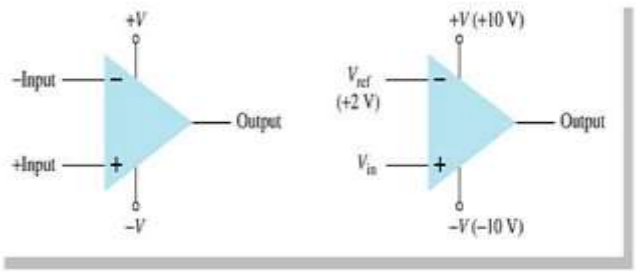
- The op-amp circuits that contain capacitor is the differentiating amplifier .

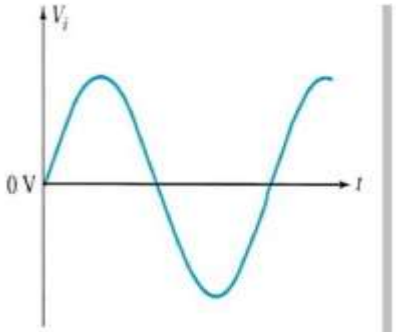


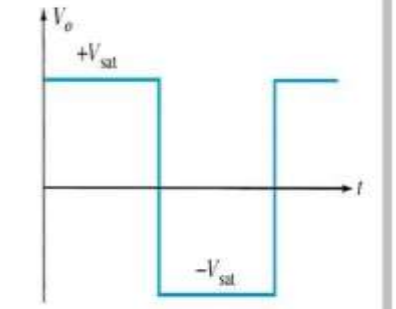
$$\frac{-v_o}{R} = C\frac{dv_s}{dt}$$

$$v_o = -RC\frac{dv_s}{dt}$$

Comparator Circuit







The operation is a basic comparison. The output swings between its maximum and minimum voltage, depending upon whether one input (V_{in}) is greater or less than the other (V_{ref}).

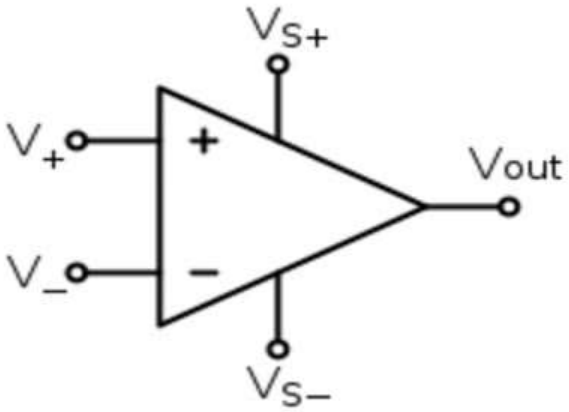
The output is always a square wave where:

- The maximum high output voltage is $+V_{SAT}$.
- The minimum low output voltage is $-V_{SAT}$.

OP-Amp

Common Mode Rejection Ratio

CMRR



Should have High Differential Voltage gain(A_{DM})

Very Low Common mode Voltage gain (A_{CM})

The Ratio of "A_{DM} / A_{CM} = CMRR"

$$CMRR = \frac{A_{DM}}{A_{CM}}$$

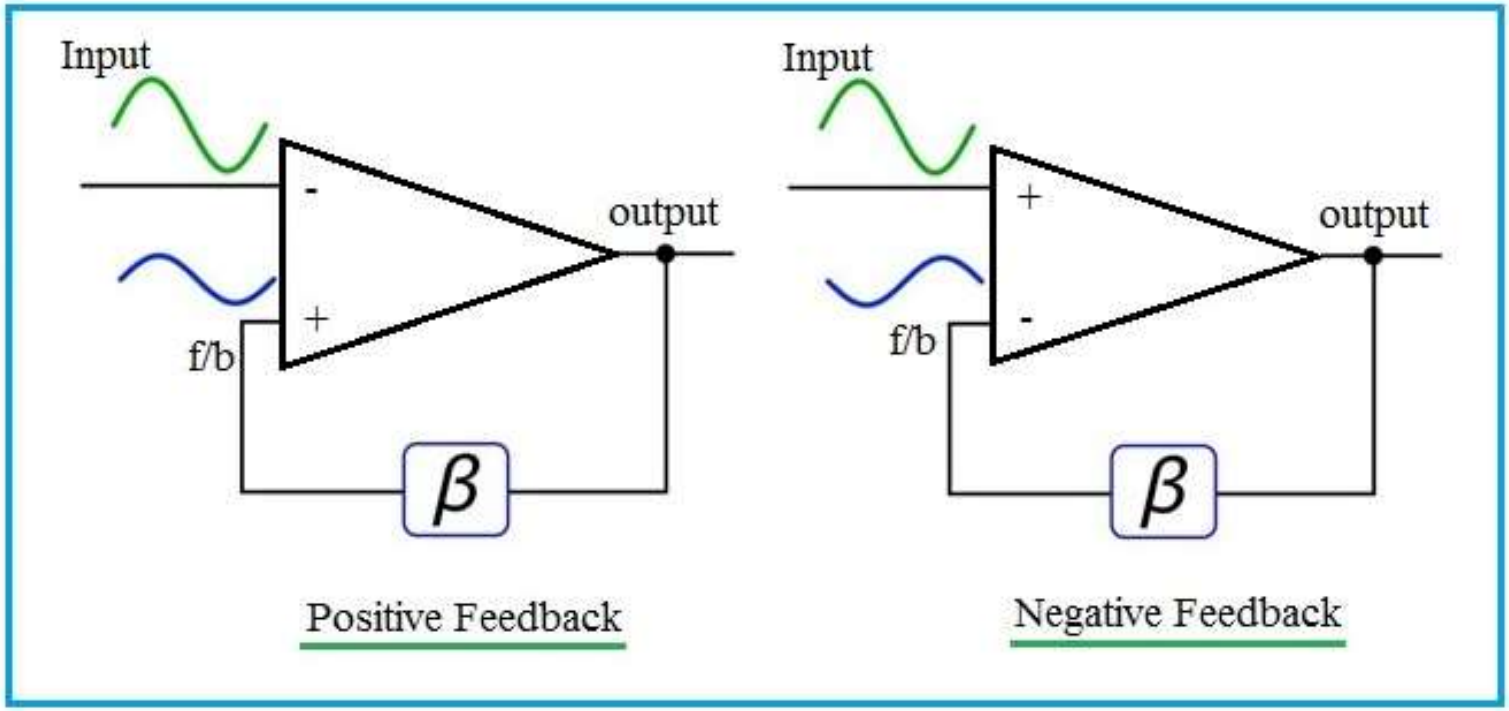
$$CMRR_{dB} = 20 \log_{10} \frac{A_{DM}}{A_{CM}}$$

$$= 20 \log_{10} CMRR$$

Feedback

In electronics, feedback is defined as the process of returning a portion of a signal output from a circuit or device to its input.

Positive feedback is a process in which the results of an activity induce more of the same action to happen in a feedback loop. The initial action is amplified as a result of this. Negative feedback, on the other hand, occurs when the end effects of an activity prevent that action from continuing to occur.


Input
-
+
output
f/b
β
Positive Feedback
Input
+
-
output
f/b
β
Negative Feedback

In op-amps the term virtual ground means that the voltage at that particular node is almost equal to ground voltage (0V). It is not physically connected to ground. This concept is very useful in analysis of opamp circuits and it will make a lot of calculations very simple.