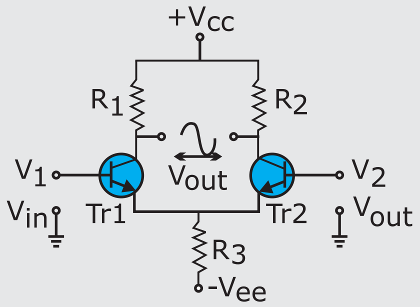
Operational Amplifier

Differential Amplifier

Generalized form of a differential amplifier with two inputs V_1 & V_2. The two identical transistors TR_1 and TR_2 are both biased at the same operating point with their emitters connected together and returned to the common point, $-V_{EE}$ by way of resistor R_E



Differential mode input: Here two different input signals are connected as V_1 and V_2. The output (V_0) is taken across only one transistor T_1. This type of circuit is called differential input, single ended output mode. The output voltage of the circuit is given by:

$$V_0 = A(V_1 = V_2)$$

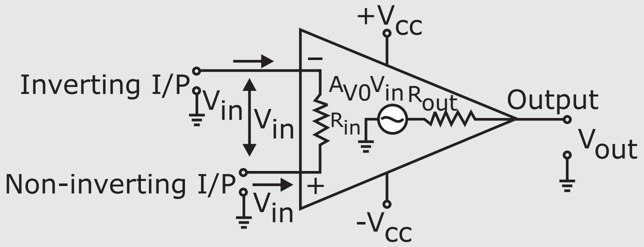
If $V_1 = V_2$ in magnitude, but opposite in signs, then we get:

$$V_0 = A[V_1 = V_2] = 2AV_1$$

Common mode input: If two input signal are applied at two inputs such that $V_1 = V_2$ both in magnitudes and polarity, then $V_0 = A(V_1 = V_2) = A(V_1 = V_2) = 0$

Operational Amplifier

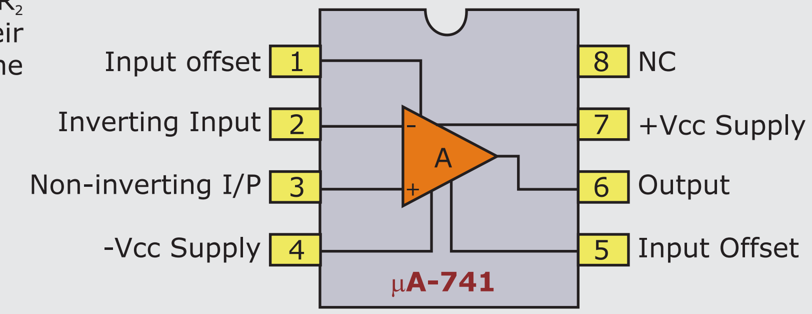
An operational amplifier (OPAMP) is an electronic circuit, which uses differential amplifier inside it. It is a high gain directly coupled amplifier. The operational amplifier is used for different mathematical operations like addition subtraction, integration, differentiation and A/D conversion, comparison etc.



Characteristics of Ideal Operational Amplifier:

* Its open loop gain infinite i.e. When feedback is not used its gain is infinite.
* Its input resistance is infinite i.e. It does not absorb any current from the input signal.
* So, its bias current s is zero.
* Its CMRR is infinite.
* Its input-offset voltage is zero.
* Its offset current is zero i.e. The difference between bias current s is zero.
* It can amplify any signal having any frequency between bias currents is zero.
* It can amplify any signal having any frequency i.e. From DC (zero frequency) to AC (infinite frequency).
* Its propagation delay is zero.

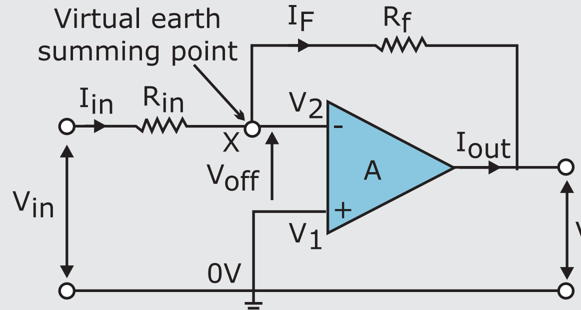
μA-741 Operational Amplifier



Basically a three-terminal device which consists of two high impedance inputs, one is called the Inverting Input, marked with a negative or "minus" sign (-) and another is called the Non-Inpverting Input, marked with a positive or "plus" sing (+).

Inverting Amplifier

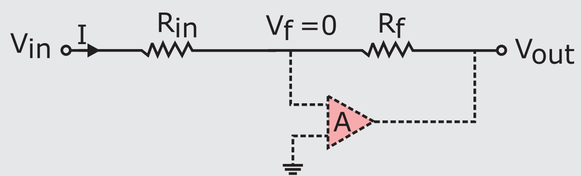
In inverting mode the input is applied to the inverting terminal of OPAMP.



Important Rules

* No current flows into the input terminals
* The differential input voltage is zero as $V_1 = V_2 = 0$ (Virtual Earth)

Calculation of Closed Loop Gain



$$i = \frac{V_{in} - V_{out}}{R_{in} + R_f} \quad \text{Therefore, } i = \frac{V_{in} - V_2}{R_{in}} = \frac{V_2 - V_{out}}{R_f}$$

$$i = \frac{V_{in}}{R_{in}} \frac{V_2}{R_{in}} = \frac{V_2}{R_f} - \frac{V_{out}}{R_f} \text{ so, } \frac{V_{in}}{R_{in}} = V_2\left[\frac{1}{R_{in}} + \frac{1}{R_f}\right] - \frac{V_{out}}{R_f}$$

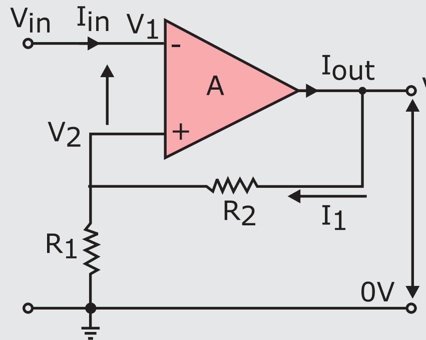
$$\text{and as } i = \frac{V_{in} - 0}{R_{in}} = \frac{0 - V_{out}}{R_f} \quad \frac{R_f}{R_{in}} = \frac{0 - V_{out}}{V_{in} - 0}$$

the closed Loop Gain (Av) is given as, $\frac{V_{out}}{V_{in}} = \frac{R_f}{R_{in}}$

$$V_{out} = \frac{R_f}{R_{in}} \times V_{in}$$

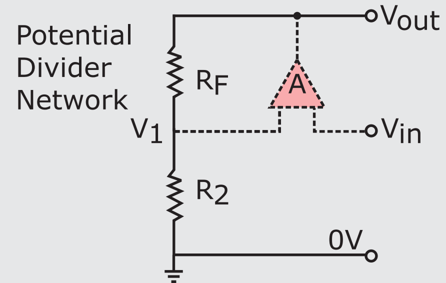
The negative sign in the equation indicates an inversion of the output signal with respect to the input as it is 180° out or phase. This is due to the feedback being negative in value.

Non-Inverting Amplifier



The input voltage signal, (V_{in}) is applied directly to the non inverting (+) input terminal.

Calculation of Closed Loop Gain



$$V_1 = \frac{R_2}{R_2 + R_F} \times V_{out}$$

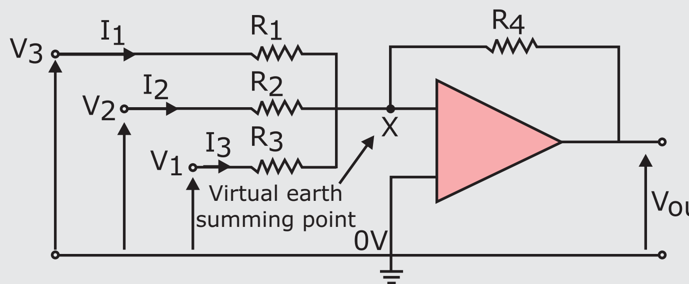
Ideal Summing Point $V_1 = V_{in}$

Voltage Gain, A_V is equal to $\frac{V_{out}}{V_{in}}$

Then, $A_V = \frac{V_{out}}{V_{in}} = \frac{R_2 + R_F}{R_2}$

Transpose to give, $A_V = \frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_2}$

Summing Amplifier



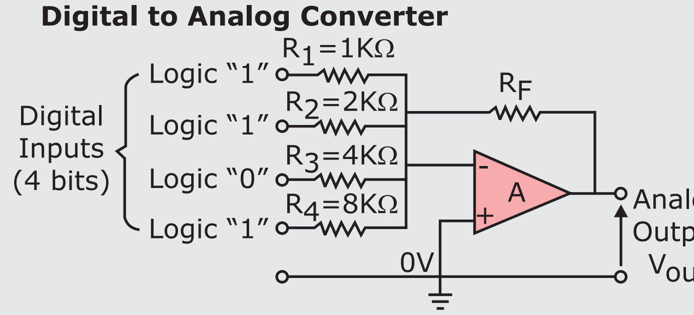
$$I_F = I_1 + I_2 + I_3 = -\left[\frac{V_1}{R_{in}} + \frac{V_2}{R_{in}} + \frac{V_3}{R_{in}}\right]$$

Inverting Equation: $V_{out} = -\frac{R_F}{R_{in}} \times V_{in}$

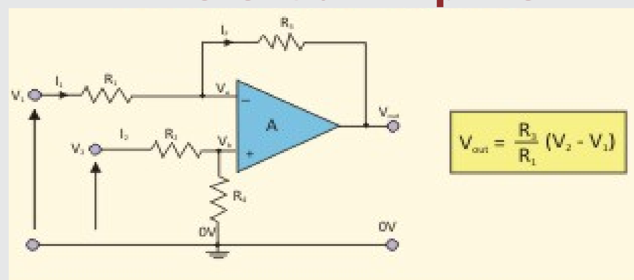
Then, $-V_{out} = \left[\frac{R_F}{R_{in}}V_1 + \frac{R_F}{R_{in}}V_2 + \frac{R_F}{R_{in}}V_3\right]$

Summing Amplifier Application

Digital to Analog Converter

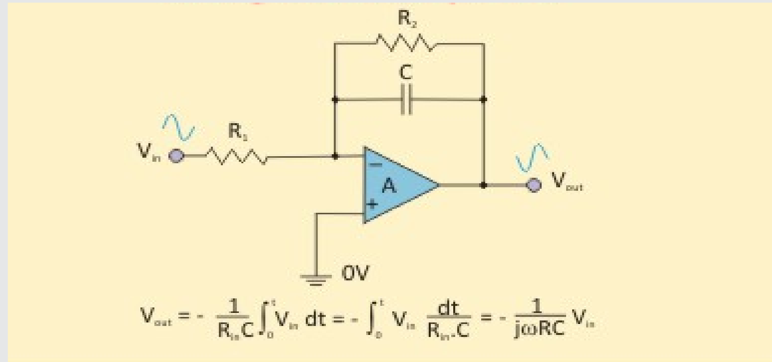


Differential Amplifier



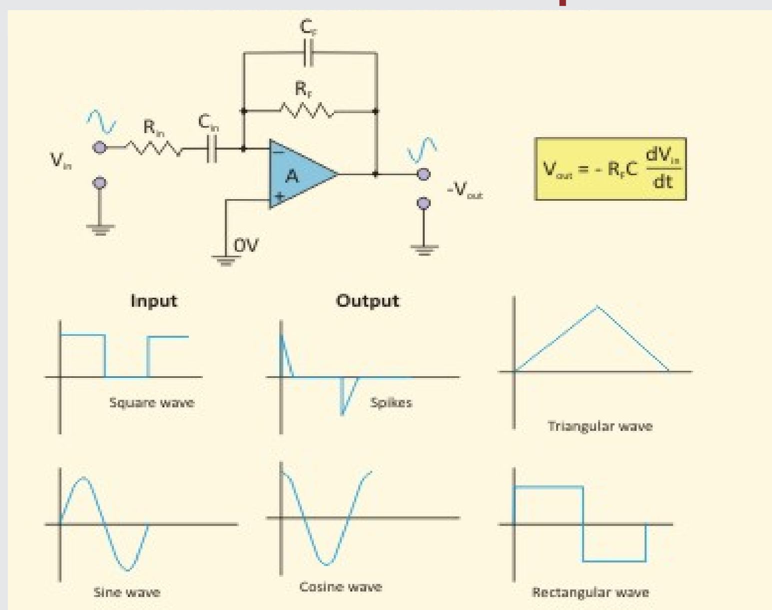
$$V_{out} = \frac{R_3}{R_1}(V_2 - V_1)$$

Integrator Amplifier



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

Differentiator Amplifier



$$V_{out} = -R_f C \frac{dV_{in}}{dt}$$


36197
Operational Amplifier Trainer


36245
Study of OP-AMP Comparator


36246
OP-AMP Mathematical Operations


36247
Op-Amp Applications


36276
Study of Schmitt's Trigger Circuit


36302
Class a, b, c & ab Amplifier


36328
Op-Amp Applications Trainer


36331
AC/DC Sources Experimental Trainer

IT-2013, Ramchandrapura Indl. Area, Sitapura Extension, Jaipur-302022, India. Ph: +91-9829132777; +91-9413330765; Email: info@tesca.in; Web: www.tesca.in