UNIT - 4 (Part - 1) ①

Operational Amplifiers

Introduction to op-Amp:- -ve feedback amp

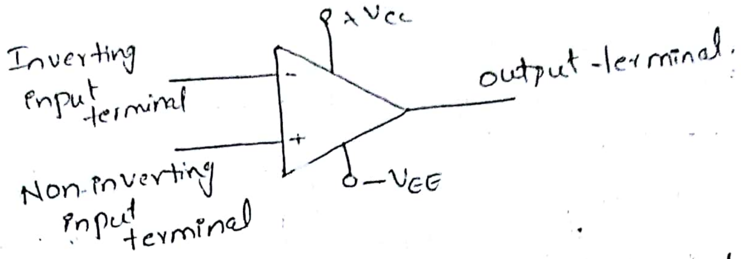
Operational Amplifier is a 2 input Voltage controlled device whose output voltage is proportional to the difference between the 2 input voltages. operational Amplifier is most commonly referred as "op-Amp". It is basically a direct coupled high gain Amplifier. It has high input impedance and Low output impedance (less than 100Ω) and has capability of amplifying signals having frequency range from 0 Hz to 1MHz. i.e op-Amp is used to amplify DC as well as AC signals.

These are originally used in Analog Computers to perform mathematical operations such as addition, subtraction, Integration and differentiation etc. It can also be used in other applications such as active filters, oscillators, comparators, regulators etc. Pulse generators, square wave, triangular wave generators, A-D & D-A converters, V-I & I-V converters.

A negative voltage shunt feedback is normally employed to the amplifier to control the over all characteristics of the op-amp.

- low cost
- small size
- h reliability
- op stability
- value of offset V and I

circuit symbol of op-amp:-



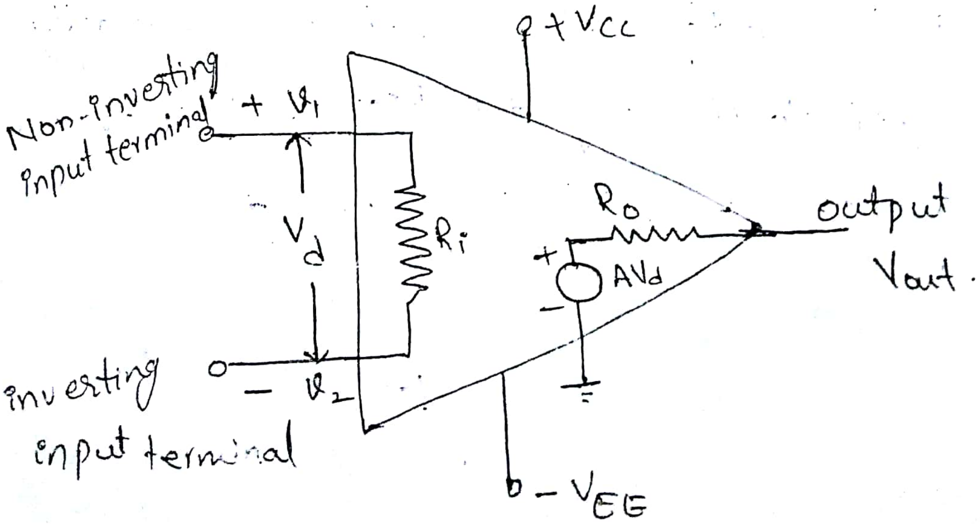
1) There are 2 power supplies +Vcc and negative voltage -VEE whose values ranges from ±5V to ±22V.

2) There are 2 input terminals indicated with " + & -" i.e Non-inverting input terminal (+ve) and Inverting input terminal (-ve) respectively.

If any input is given to inverting terminal, a negative o/p is obtained and if input is given to Non-inverting terminal, a +ve o/p is obtained.

3) It has one output terminal.

Equivalent circuit of an OP-AMP:-



The output section consists of a voltage controlled source in series with the output resistance R_o.

From figure it is clear that R_i is the Thevenin equivalent resistance seen at the i/p terminal. The differential input voltage V_d is given by

$$V_d = v_1 - v_2$$

where v_1 = voltage given to non-inverting terminal
v_2 = " " " inverting terminal.

The output voltage is

$$V_{out} = AV_d$$

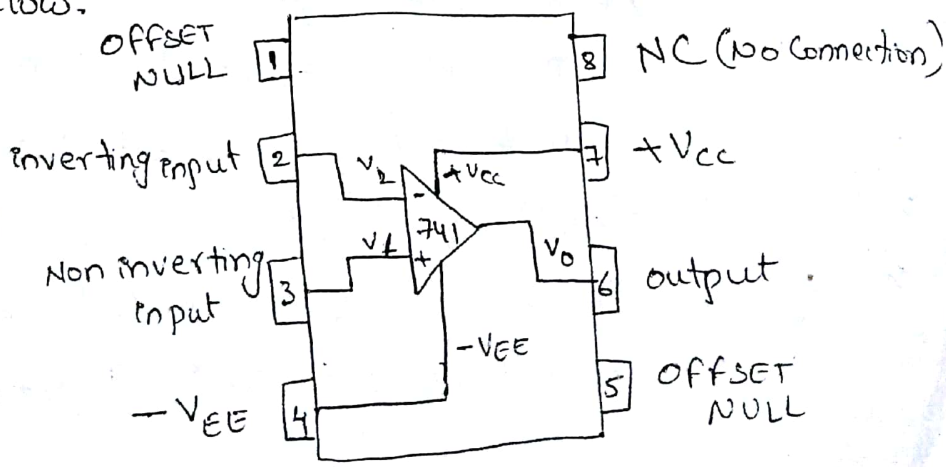
$$V_{out} = A(v_1 - v_2)$$

where 'A' is the open-loop ~~ga~~ voltage gain i.e gain without any feed back from output to input.

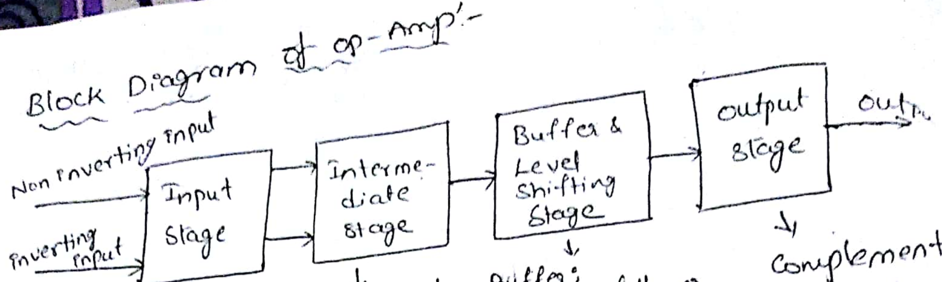
~~Pin Config:~~

Pin configuration of an op-Amp:-

The general IC ~~#~~ representation of op-amp is IC 741. The pin configuration of IC 741 is as shown below.



Block Diagram of op-Amp:-



- Input Stage → Dual input Balanced o/p differential amplifier
- Intermediate stage → Dual input unbalanced o/p differential Amplifier
- Buffer & Level Shifting Stage → Buffer: Emitter follower with high i/p impedance & Level shifters are clamping circuits
- Output stage → Complementary-symmetry push-pull amplifier (class AB) to prevent distortions.

o/p is taken b/w collectors of a emitter biased ckt so that o/p remains balanced. DC voltage at quiescent conditions = 0 so balanced o/p

Input Stage:-

The op-Amp overall characteristics are determined by the designing of input stage. It should provide high i/p impedance, High CMRR, Low o/p impedance and should have direct coupled 2 differential input terminals. These are all satisfied using differential amplifier. usually "Dual-input Balanced output" differential is used in input stage.

Intermediate Stage:-

This stage is used to provide additional voltage gain to achieve overall large gain. So cascaded (multistage) Amplifiers are used. usually there will be one or 2 intermediate stages with "Dual-input unbalanced output" Differential Amplifier.

- o/p is measured at the collector of only one of the two LTs w.r.t gnd (single ended)

In quiescent condition some dc voltage exists, there is no collector vltg to balance or nullify this o/p dc vltg so unbalanced

Buffer and Level Shifter stage :-

Buffer is usually Emitter - follower with high input impedance, Low o/p impedance and unity gain to prevent loading. Level shifting network is used to bring the DC output voltage to zero (ground) voltage when no signal at input is applied. This occurs because of intermediate stage and output stage. Level shifting circuits are basically clamping circuits.

Output Stage :- The requirements of output stage are

1) output impedance must be Low
2) Large o/p D.C voltage swing.
3) High current Sourcing & sinking capability.
4) Low power dissipation.

All the above Requirements are fullfilled by Placing a push-pull Amplifier operated in class AB mode to prevent distortions in the Output.

Ideal op-Amp :-

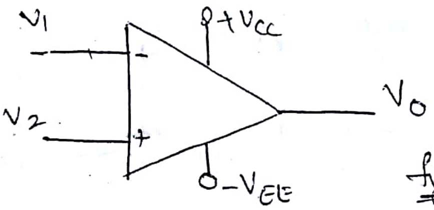


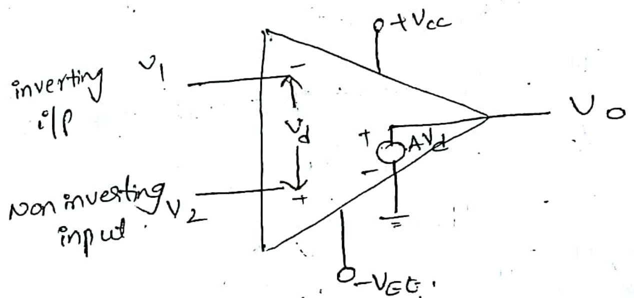
fig :- Ideal op-Amp.

An Amplifier with infinite open loop gain, infinite i/p resistance and zero o/p resistance is called as an ideal op-Amp.

The characteristics of Ideal Op-Amp are the fo.

1) Infinite voltage gain
2) Infinite input impedance
3) Zero output impedance
4) Infinite open Loop Band width.
5) Zero offset voltage & current.

Equivalent circuit of Ideal op-amp:-



Concept of virtual Ground:-

For this consider an ideal op-amp with infinite gain. Let the input voltage be V_i and the output voltage V_o as shown in figure above.

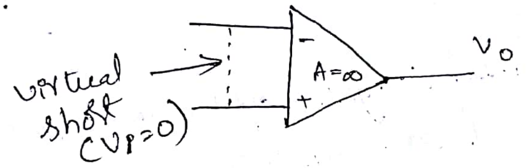
We know that the gain of an op-amp is given by $A = \frac{V_o}{V_i}$.

$\because A = \infty$ for ideal op-amp we have

$V_i = \frac{V_o}{\infty} = 0$ i.e input voltage is zero.

It happens only under short circuit condition. In op-amps there exists no real short circuit across input terminals.

Therefore, we conclude that the input terminals of the op-amp are virtually shorted together. i.e If one of the input terminals is grounded, the virtual short becomes a virtual ground.



$V_o = A v_{in}$

$\therefore v_{in} = \frac{V_o}{A}$

$v_{in} = 0$

$v_1 - v_2 = 0$

$\Rightarrow v_1 = v_2$

characteristics of op-Amps:-

The characteristics of an op-amp can be determined by considering the equivalent circuit of an op-amp as shown below.

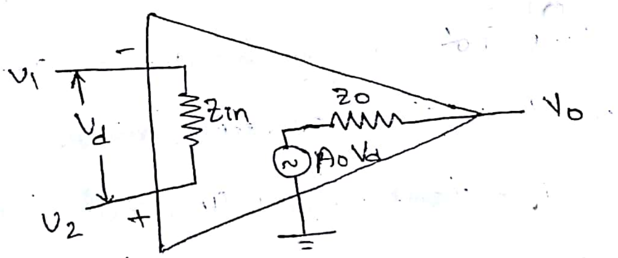


fig:- Equivalent circuit of practical op-amp.

1) Open Loop Gain, Ao:-

let V_1 be the input given to inverting terminal and V_2 is input given to non-inverting terminal. The difference between these two voltages is called as differential voltage, V_d i.e

$$V_d = V_2 - V_1$$

When no feed back is there from output to...
the op-amp is said to be in open loop condition.
Generally, most op-amps have a negative feedback from o/p to the inverting input terminal. Then the op-amp is said to be in ~~open loop~~ closed loop condition.

The open loop voltage gain of the op-amp is represented as A_0 and is defined as ratio of output voltage to the differential input voltage.

$$A_0 = \frac{V_o}{V_d} = \frac{V_o}{V_1 - V_2}$$

open loop gain of ideal op-Amp = infinity
Practical op-Amp is 200,000

2) Input Impedance, (Zin) :- It is the equivalent resistance that is measured at the +ve terminal & -ve input terminal with respect to ground.

It is also defined as ratio of change in input voltage to the change in input current measured at either of the input terminals with respect to ground.

Zin for Ideal op-Amp is ∞
Practical op-Amp is $2M\Omega$

Infinite i/p resistance means current equal to zero

3) output Impedance :- (Zo)

It is the equivalent resistance that is measured at the o/p terminal w.r.t ground. (OR)

It is the ratio of change in output voltage to the change in output current.

Zo for ideal op-amp is '0'

practical op-amp is 75Ω

4) Unit-gain Band width :- (GB).

For ideal op-amp it is ∞ for closed loop.

It is the Bandwidth of the amplifier when the gain is unity. For practical op-amp its value is 1MHz.

The product of Gain and Band width is called as Gain Band width product. when it is calculated for unit gain, it is called as unit gain Band width.

5) input offset voltage (V_{io}) :-

For an ideal op-amp when the inverting & non-inverting input terminal are grounded & supplied with equal voltages. The output voltage is equal to zero

But practically, a small voltage is required to make output zero. This voltage which is required to make the output zero is called input offset voltage.

For ideal op-amp it is zero (0)

practically it is ±15mV.

3) output Impedance :- (Zo)

It is the equivalent resistance that is measured at the o/p terminal w.r.t ground (8)

" It is the ratio of change in output voltage to the change in output current.

Zo for ideal op-amp is 'O'

practical op-amp is 75Ω

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For ideal op-amp it is zero (0)

practically it is ± 15mv.

a) Slew Rate :- SR.
It is defined as the maximum rate of change of its o/p voltage w.r.t to time.

$$S_R = \left[\frac{dV_o}{dt}\right]_{max}$$

units :- v/μs

For ideal op-amp it is ∞
Practically it is 0.5 v/μs.

CMRR :- Common Mode Rejection Ratio :-

The ability of op-amp to amplify the differential input signal & reject the common mode signal is measured by CMRR.

It is defined as ratio of the differential gain to the common mode gain

$$CMRR = \left|\frac{A_d}{A_c}\right|$$

For ideal op-amp CMRR is ∞, so that amplifier is free from undesired common mode signals such as pick ups, thermal noise etc

Input offset current :-

It is difference between the two input currents. The 741 has an input offset of 20nA. Smaller the input offset current, the better is the op-amp's performance.

Input Bias current : IC 741 has 80nA.

It is the average of currents that flow into two inputs.

For ideal op-amp input bias current is 0

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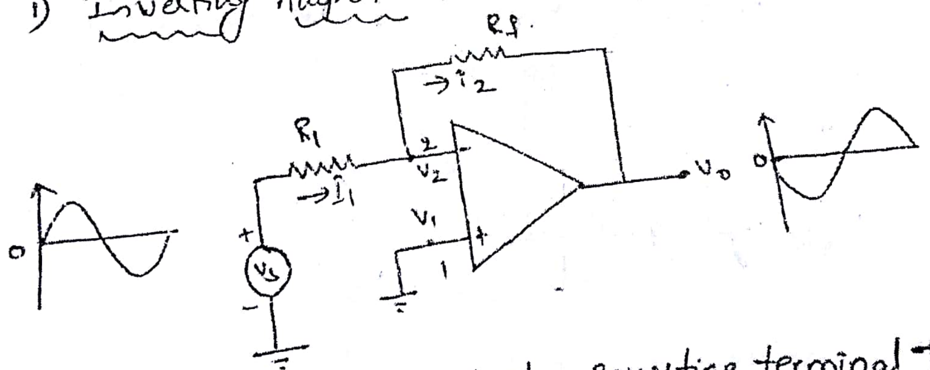
Applications of op-amp:-

The op-amps are developed for analog computer to perform the mathematical operations such as addition, subtraction, multiplication etc. Some of the applications of operation amplifier in IC format are as follows.

1) Inverting Amplifier
2) Non-inverting amplifier
3) Summing Amplifier
4) Difference Amplifier
5) Differentiator
6) Integrator &
7) Instrumentation Amplifier.

1) Inverting Amplifier:-



The input is given to the inverting terminal through a resistor, R_1. and the non-inverting terminal is grounded. R_f is feed back resistor. when an input voltage signal "V_s" is applied to inverting input terminal, an input current starts flowing input terminal into op-amp. As the input impedance of op-amp is infinity, I_1 current will not flow into the amplifier, rather it flows through the output loop & feedback loop to the output.

The voltage gain, $A_v = \frac{V_o}{V_s}$

applying KCL at node 2, we have

$$\frac{V_s - V_2}{R_1} = \frac{V_2 - V_o}{R_f} \rightarrow ①$$

But from the concept of virtual ground, voltage at node 2 $V_2 = 0$. Substituting this in eq ① we get.

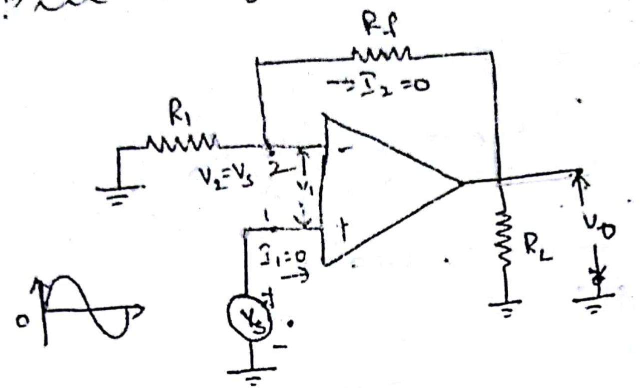
$$\frac{V_s - 0}{R_1} = \frac{0 - V_o}{R_f} \Rightarrow \frac{V_s}{R_1} = \frac{-V_o}{R_f}$$

$$\Rightarrow V_s R_f = -V_o R_1$$

$$A_v = \frac{V_o}{V_s} = \frac{-R_f}{R_1}$$

∴ voltage gain $\boxed{A_v = \frac{-R_f}{R_1}}$

⇒ Non-inverting Amplifier :-



$$\frac{0 - V_s}{R_1} = \frac{V_s - V_0}{R_f}$$

$$\frac{-V_s}{R_1} = \frac{V_s - V_0}{R_f}$$

$$\frac{V_s}{V_s - V_0} = -\frac{R_1}{R_f}$$

$$\frac{V_s - V_0}{V_s} = -\frac{R_f}{R_1}$$

$$1 - \frac{V_0}{V_s} = -\frac{R_f}{R_1}$$

$$\boxed{\frac{V_0}{V_s} = 1 + \frac{R_f}{R_1}}$$

Here, the input is given to the non-inverting terminal and the inverting terminal is grounded. From the concept of virtual ground, at node 2, V_2 and input signal voltage V_s are equal i.e $V_2 = V_s$. When V_s is applied at non-inverting terminal, the current I_1 flows into op-amp and I_2 flows through feedback loop (R_f)

Applying voltage division rule, we get

$$V_2 = V_s = \frac{V_0 R_1}{R_1 + R_f}$$

$$\frac{V_s}{V_0} = \frac{R_1}{R_1 + R_f} \Rightarrow \frac{V_0}{V_s} = \frac{R_1 + R_f}{R_1}$$

$$\Rightarrow \frac{V_0}{V_s} = 1 + \frac{R_f}{R_1}$$

∴ voltage gain, $\boxed{A_V = \frac{V_0}{V_s} = 1 + \frac{R_f}{R_1}}$

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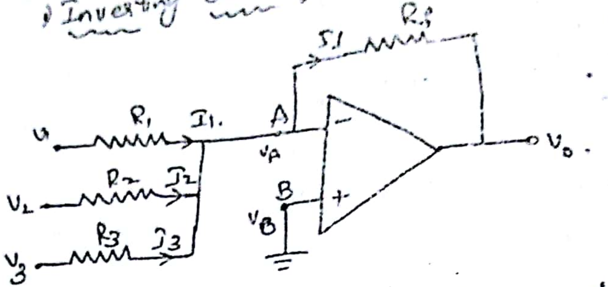
3) Summer:-

i) Inverting Summing Amplifier:-



In this, all the inputs are given to the inverting terminal of the op-amp. and the non-inverting terminal is grounded.

From concept of virtual ground, as node B is grounded, the node A is also at virtual ground potential. $\therefore V_A = V_B = 0$.

Apply KCL at node A, we get.

$$I_1 + I_2 + I_3 = I_f$$

$$\frac{V_1 - V_A}{R_1} + \frac{V_2 - V_A}{R_2} + \frac{V_3 - V_A}{R_3} = \frac{V_A - V_0}{R_f}$$

as $V_A = 0$, we get.

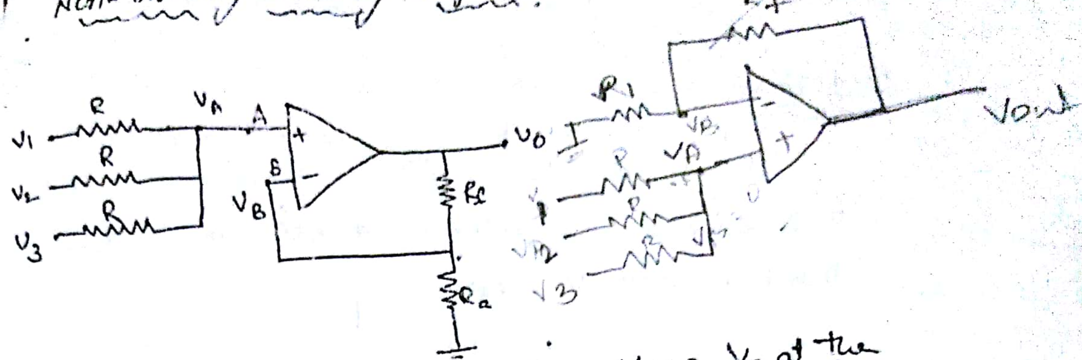
$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = \frac{-V_0}{R_f}.$$

$$V_0 = -R_f\left[\frac{V_2}{R_2} + \frac{V_1}{R_1} + \frac{V_3}{R_3}\right]$$

If $R_1 = R_2 = R_3 = R_f = R$, then

$$\boxed{V_0 = -[V_1 + V_2 + V_3]}$$

Non-inverting Summing Amplifier :-



Using ~~Superposition~~ theorem, the voltage V_A at the non-inverting ~~terminal~~ is

$$V_A = \frac{R/2}{R+R/2} \cdot V_1 + \frac{R/2}{R+R/2} \cdot V_2 + \frac{R/2}{R+R/2} \cdot V_3$$

$$V_A = \frac{V_1 + V_2 + V_3}{3}$$

$$V_{out} = V_o = \left[1 + \frac{R_f}{R_1}\right]\left[\frac{V_1+V_2+V_3}{3}\right]$$

If we assume the gain of the circuit $\left\{1+\frac{R_f}{R_1}\right\}$ is made equal to no. of inputs then the o/p voltage will become equal to the sum of all the input voltages.

$$\boxed{V_o = V_1 + V_2 + V_3}$$

let $V_A = V_B = V$

$$\frac{V_1 - V}{R} + \frac{V_2 - V}{R} + \frac{V_3 - V}{R} = 0$$

$$\frac{-3V}{R} = \frac{-(V_1 + V_2 + V_3)}{R}$$

$$\boxed{V = V_1 + V_2 + V_3 / 3}$$

$$\therefore V_o = \left(1 + \frac{R_f}{R_1}\right) V_B = K \cdot (V_1 + V_2 + V_3)$$

$$\frac{-V_B}{R_1} = \frac{V_B - V_o}{R_f}$$

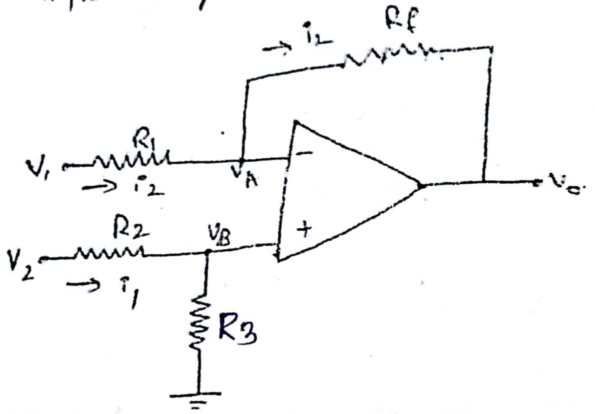
$$\frac{-V_o}{R_f} = -\frac{V_B}{R_1} - \frac{V_B}{R_f}$$

$$\frac{V_o}{R_f} = V_B\left(\frac{1}{R_1} + \frac{1}{R_f}\right)$$

$$\frac{V_o}{R_f} = \frac{V_B (R_f + R_1)}{R_1 R_f}$$

Difference (Subtractor) Amplifier :-

The difference amplifier gives output that is proportional to difference between the two input voltages V_1 & V_2.



Here, input is applied to both inverting and non-inverting terminals.

According to virtual ground concept, the node A voltage, V_A and node B voltage V_B are equal.

i.e $V_A = V_B$

Apply KCL at node B, we get

$$\frac{V_2 - V_B}{R_2} = \frac{V_B - 0}{R_3} \Rightarrow \frac{V_2}{R_2} - \frac{V_B}{R_2} = \frac{V_B}{R_3}$$

$$\frac{V_2}{R_2} = \frac{V_B}{R_3} + \frac{V_B}{R_2} = V_B\left(\frac{1}{R_3} + \frac{1}{R_2}\right)$$

$$V_B = \frac{V_2}{R_2\left[\frac{1}{R_3} + 1/R_2\right]} = \frac{V_2}{1 + R_2/R_3}$$

Now again apply KCL at node 2, we have

$$\frac{V_1 - V_A}{R_1} = \frac{V_A - V_0}{R_f}$$

$$\frac{V_1}{R_1} = \frac{V_A}{R_f} - \frac{V_0}{R_f} + \frac{V_A}{R_1}$$

$$\frac{V_1}{R_1} = V_A\left[\frac{1}{R_f} + \frac{1}{R_1}\right] - \frac{V_0}{R_f}$$

$$V_1 = V_A\left[\frac{R_1}{R_f} + 1\right] - V_0\frac{R_1}{R_f}$$

$\because V_A = V_B$ we have $V_A = V_B = \frac{V_2}{1 + R_2/R_3}$

$$V_1 = \left[\frac{V_2}{1 + R_2/R_3}\right]\left[1 + \frac{R_1}{R_f}\right] - V_0\frac{R_1}{R_f}.$$

Assume, $R_1 = R_2 = R_3 = R_f = R$, then we get,

$$V_1 = \left(\frac{V_2}{2}\right)(2) - V_0$$

$$\boxed{V_0 = V_2 - V_1}$$

If $\frac{R_1}{R_f} = \frac{R_2}{R_3}$ we get

$$V_1 = \frac{V_2}{\left(1 + \frac{R_1}{R_f}\right)} \cdot \left(1 + \frac{R_1}{R_f}\right) - V_0\frac{R_1}{R_f}$$

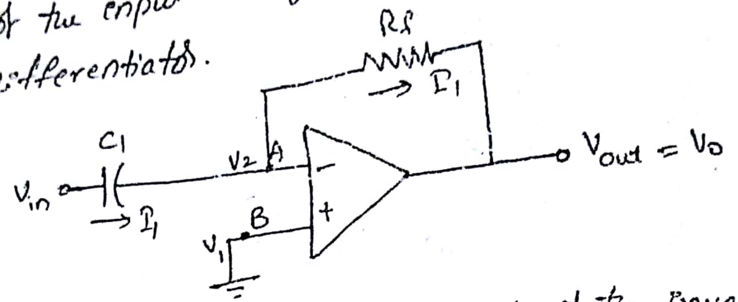
$$V_1 = V_2 - V_0\frac{R_1}{R_f}$$

$$V_0\frac{R_1}{R_f} = V_2 - V_1$$

$$\therefore V_0 = \frac{R_f}{R_1}(V_2 - V_1) = K(V_2 - V_1)$$

Differentiator:- (Imp).

The circuit which produces the differentiation of the input voltage at its output is called differentiator.



An input voltage V_{in} is applied at the inverting terminal of the op-amp.

The potential of node A is same as node B due to virtual ground concept, hence $V_1 = V_2 = 0$.

∵ Input current inside op-amp is zero, entire current I_1 flows through the resistance, R_f.

From input side of differentiator, we have

Let i be the rate of change of charge i.e, dq/dt

⇒ Charge $q = CV$

$$I_1 = C_1 \frac{d}{dt}(V_{in} - V_2) = C_1 \frac{d}{dt}(V_{in}) \rightarrow ①$$

$i = \frac{dq}{dt} = \frac{d}{dt} C_1 V_{in}$

$= C_1 \frac{d}{dt}(V_1 - V_2)$

At the output side, we have

$$I_1 = \frac{V_2 - V_0}{R_f} = \frac{-V_0}{R_f} \rightarrow ②$$

(−ve Sign indicates 180° phase shift b/w i/p & o/p)

Equating ① & ②

$$C_1 \frac{d}{dt} V_{in} = \frac{-V_0}{R_f}$$

$$V_o = -C_1 R_f \frac{dV_{in}}{dt}.$$

Limitations of Ideal Differentiator:-

1) The gain increases as frequency increases. So at some high frequency, the differentiator may become unstable and break into the oscillations.

2) The input impedance decreases as frequency increases. which makes circuit very much sensitive to the noise.

These limitations can be overcome by using a differentiator circuit is called practical differentiator circuit.

Guidelines to Design Practical Differentiator:-

1) choose f_a as the highest frequency of the input signal.

2) choose C_1 to be less than 1μF and calculate the value of R_f.

3) choose f_b as I/P 10 times f_a O/P which ensures that $f_a < f_b$.

4) Finally, calculate the values of R_1 & C_f from the expression $R_1 C_1 = R_f C_f$.

5) The R_{comp} can be selected as $R_1 \| R_f$ but practically it is almost equal to R_L.

Cosine wave - Sine

Δ wave - ⊓⊔⊓

rarely used in analog computers coz it tends to amplify noise

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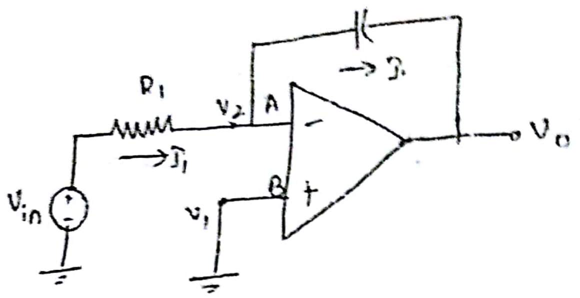
5) Integrator (Ideal)

The integrator circuit can be obtained by exchanging the position of R & C in the basic differentiator circuit.



The input voltage Vin is applied to the negative input terminal through resistor R_1. Current through capacitor, C_f is given by,

$$I = C_f \cdot \frac{d}{dt}(V_2 - V_o)$$

apply KCL at node A,

$$\frac{V_{in} - V_2}{R_1} = C_f \cdot \frac{d}{dt}(V_2 - V_o)$$

$V_1 = V_2 = 0$ from virtual ground concept.

$$\therefore \frac{V_{in}}{R_1} = C_f \cdot \frac{d}{dt} \cdot (-V_o) = C_f \cdot \frac{d}{dt}(-V_o)$$

$$\frac{dV_o}{dt} = \frac{-V_{in}}{R_1 C_f}$$

applying integration on both sides,

$$\int d\frac{V_o}{dt} = \frac{-1}{R_1 C_f}\int_0^t V_{in}(t)$$

we get

$$\boxed{V_o = -\frac{1}{R_1 C_f}\int_0^t V_{in}(t)\,dt}$$

sin will give cos
⊓⊔ step — Δ wave
— ramp or linearly changing v/s

used in filters, analog computers
ramp or sweep generators

Limitations of an Ideal integrator:-

1) output wave form may be distorted due to an error voltage.

2) Band width of ideal integrator is very small.

To overcome these limitations practical integrator is designed.

6) Instrumentation Amplifier:-

Measurement control of physical quantities is required in large no. of industrial and consumer applications. Some of the examples are measurement and control of temperature, humidity, water flow etc. These are in general measured using Transducers. The o/p of transducer has to be amplified in order to drive the indicator & display system. This function is done by an Instrumentation Amplifier.

one form of energy → Transducer → Another form of energy

Mobile phone that converts sound into electrical energy

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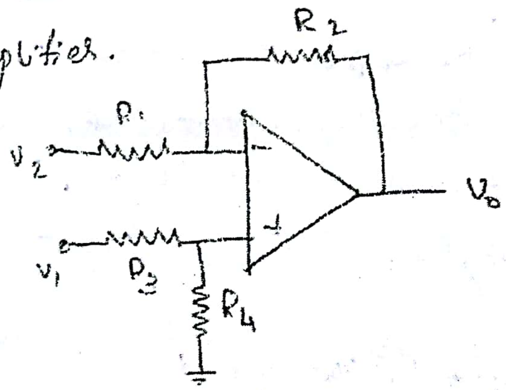
The main features of an Instrumentation Amplifier are

1) High gain accuracy
2) High CMRR
3) Low o/p impedance
4) Low D.C offset.
5) High gain stability with low temperature co-efficient.

The below fig shows the circuit of a basic difference amplifier.



$$V_o = \frac{R_2}{R_1}(V_1 - V_2)$$

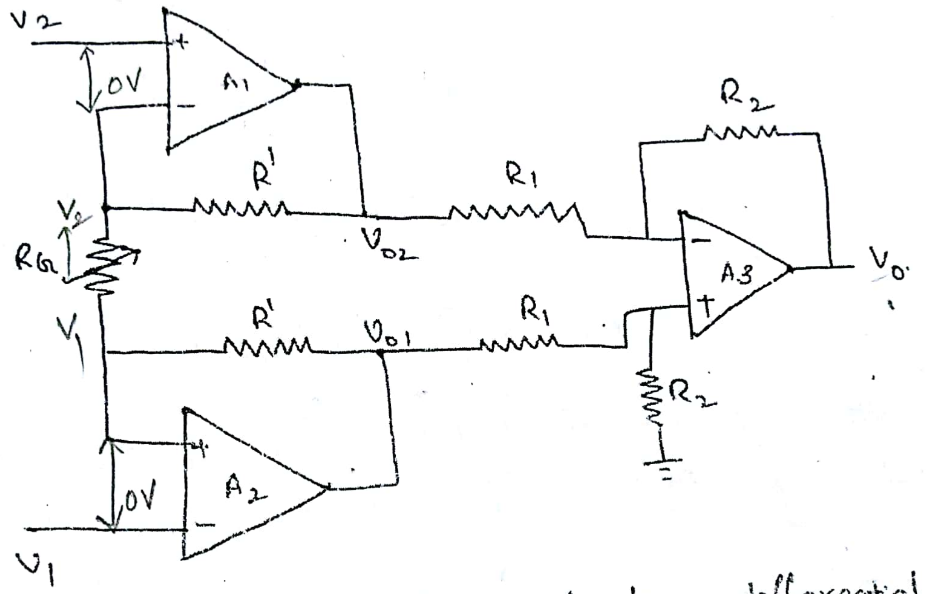
If $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

$$V_0 = \frac{R_2}{R_1}(V_1 - V_2)$$

One of the most commonly used Instrumentation amplifier circuit is the 3 op-amp instrumentation amplifier.

A non-inverting amplifier is added to each of the basic differential amplifier inputs in the circuit. This circuit provides high input resistance for accurate measurement of signals from Transducers.

The circuit diagram of 3 op-amp Instrumentation amplifier is as follows.



The op-amps A_1 and A_2 have differential input voltage as zero. when $V_1 = V_2$ i.e, under common mode condition, the voltage across R_G is zero. Hence no current flows through R_G and R'. Thus the non inverting amplifier A_1 acts as a voltage follower, so its output $V_{02} = V_2$. Similarly, the op-amp A_2 acts as a voltage follower and has the output $V_{01} = V_1$.

when $V_1 \neq V_2$ current flows through the resistors R_G, R' and $(V_{02} - V_{01}) > (V_2 - V_1)$

Thus, The circuit has differential gain and CMRR more when compared to signal op-amp circuit.

The output voltage V_o of the instrumentation amplifier can be calculated as follows.

voltage at +ve input terminal of op-amp A_3

$$V_o = -\frac{R_2}{R_1} V_{o2} + \left(1 + \frac{R_2}{R_1}\right)\left(\frac{V_{o1} R_2}{R_1 + R_2}\right)$$

$$= \frac{R_2}{R_1}(V_{o1} - V_{o2}). \rightarrow (1)$$

As no current flows into the op-amp, the current flowing in R_G in up direction is $I = \frac{V_{o1} - V_{o2}}{R_G}$

This current passes through R'.

$$V_{o1} = R'I + V_1 = \frac{R'}{R_G}(V_1 - V_2) + V_1$$

$||^{ly}$

$$V_{o2} = -R'I + V_2 = -\frac{R'}{R_G}(V_1 - V_2) + V_2$$

Substituting these in eq (1) we get.

$$V_o = \frac{R_2}{R_1}\left[\left(\frac{R'}{R_G}(V_1 - V_2) + V_1\right) - \left(-\frac{R'}{R_G}(V_1 - V_2) + V_2\right)\right]$$

$$= \frac{R_2}{R_1}\left[\frac{R'}{R_G}(V_1 - V_2) + V_1 + \frac{R'}{R_G}(V_1 - V_2) - V_2\right]$$

$$= \frac{R_2}{R_1}\left[\frac{2R'}{R_G}(V_1 - V_2) + (V_1 - V_2)\right]$$

$$= \frac{R_2}{R_1}\left[1 + \frac{2R'}{R_G}\right](V_1 - V_2)$$

This is overall gain of the circuit.

(13)

The difference gain of this instrumentation amplifier can be varied by replacing the resistor R_G with a potentiometer. The value of R_G should never be made to zero as this produces gain infinity. Hence to avoid this, in practical circuit a fixed resistance in series with potentiometer is used in place of R.

Applications of Instrumentation Amplifier:-

Instrumentation amplifier along with the transducers bridge is used in many practical applications like

1) Temperature indicator,
2) Temperature controller,
3) Light intensity meter etc.

Instrumentation Amplifier: Instrumentation amplifiers are used in measuring and controlling of the physical quantities in the industrial processes for measurement and control of temperature, humidity, and light intensity. Normally a transducer which converts one form of energy into another is used to sense and deliver the required information in the form of an electric quantity such as voltage, current or resistance. The signal is sent to the preamplifier stage for initial amplification and after further amplification and processing, may be passed to the output stages such as meters, oscilloscopes, charts, magnetic recorders.

The major function of an instrumentation amplifier is precise amplification of low level output signal of the transducer, and

The instrumentation amplifier is widely used in applications where low noise, low thermal and time drifts, high input impedance and accurate closed loop gains are required.