Chapter.4 Electrical Signal Processing and Transmission

4.1

Basic Op-Amp Characteristics

Operational

They were first developed to do mathematical operations and at that time we didn't have digital Computers they used this for analog Computers for analog mathematical operations i.e. addition, Subtraction, integⁿ, differentiation etc. These operations were solved in hardware at that time.

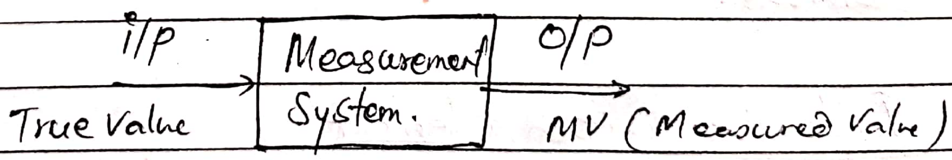
SP → Cha 4-7 out of 7 Chapters.

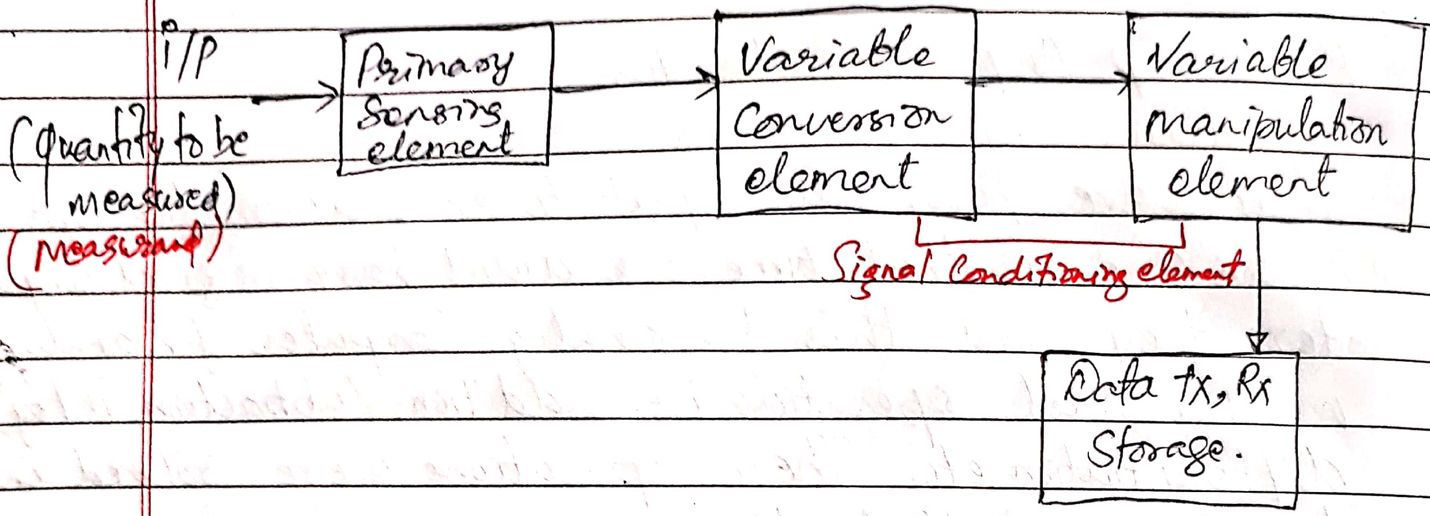
'AK Shawney' A course in electrical measure and instrumentation.

* 125 → Practical → 25.
↘ Theory (100) → 20
↘ 80

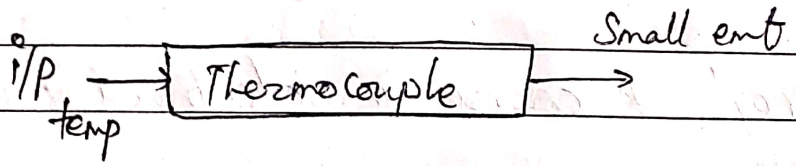
* Theory + Numerical.

Instrumentation System is the means to Carry out the measurement of process and operation of determining the value of variable or defined quantity order measurement





Functional element of instrumentation System.



1. Primary Sensing element → Transducer.
2. Variable Conversion element →

ADC, DAC, dc to ac, ac to dc.

3. Variable manipulation element →
   → amplifiers

Certain operations are performed on the Signal (Signal Conversion & Variable manipulation) ⇒ Signal Conditioning elements.

4. Data transmission element

Simply Shaft or telemetry or etc.

Signal Conditioner
The Signal Conditioner puts the output from the Sensor into a Suitable Condition for processing So that it Can be displayed. In case of thermocouple, Signal Conditioner may be an amplifier.

Signal processor
The output from a Signal Conditioner is generally either a dc voltage, dc Current or variable frequency ac voltage.
It is taken out by the Signal processor and then filtered from, Subtracted, added, multipled, divided Subtracted, differentiated, integrated or Compared so as to bring out the desired data.
Example:
analog to digital Conv. & filter.

Signal Conditioner is one of the Components of instrumentation/measurement System. It takes the output of Sensor and make it into suitable Condition So that the Signal Can be processed by rest of the System:-
Op-amp

Chapter 4

Electrical Signal processing and transmission

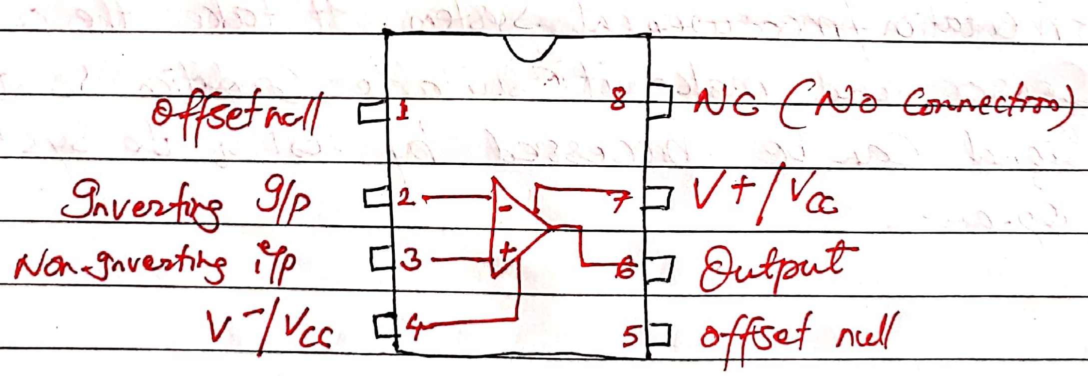
4.1 Basic op-amp Chac.

→ Op-amp has high input impedance and low o/p impedance and capable to amplify the ac or dc signal having frequency of 0 hertz dc to 1 MHz ac.

→ An op-amp was designed to perform mathematical operations such as summation, subtraction, multiplications, differentiations & integrations etc. It can be used for sign changing, scale changing, phase shifting voltage regulation, oscillator ckt and active filters and to construct sample and hold ckt.

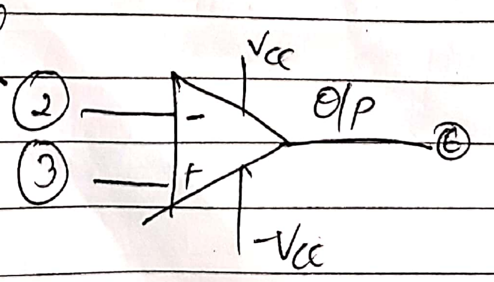
→ Op-Amp pin Configuration:

ⓐ DIL package



Top view of IC 741 opamp

Ckt Symbol



Ideal chac. of op-amp

(a) Open-Loop Voltage gain (A_{OL}) is infinite.
(b) The input impedance Z_i is infinite.
(c) The output impedance Z_0 is zero.

(d) Common mode rejection ratio (CMRR) is infinite.

(e) Bandwidth is infinite.
(f) The two i/p terminals are virtually short ckted.

$$V_d = V_{INV} - V_{N\text{-}INV} \simeq 0$$

$$\cancel{V_2 - V_3}. \quad V_3 - V_2$$

Practical Chac.

$$Z_0 = 100\Omega \text{ (below)}$$
$$Z_i \simeq 100k\Omega \text{ to } M\Omega$$

$$A_{OL} = \frac{V_0}{V_d} = 1,00,000 \quad \text{If, } V_0 = 15V,$$

$$V_d = 150\mu V$$

$$V_0 = A_{OL}(V_+ - V_0)$$
$$= A_V \cdot V_d$$

$$A_{OL} = \infty$$

$$V_0 = A \cdot V_d$$

$$\text{or, } V_d = \frac{V_0}{A_{OL}} = \frac{\,\cdot\,}{\infty}$$

$$= 0$$

[illegible]

1. Its open loop gain is infinite. When the op-amp is operated without any connection between the outputs and any of the inputs (i.e. w/o feedback), it is said to be open loop condition.

2. Its input resistance (i.e. the resistance measured between inverting and non-inverting terminals), R_{in} is infinite. It means the input current (current from the source) is zero and it doesn't load the source. It also means that an ideal op-amp is a voltage controlled device.

3. Its output resistance R_{out} is zero i.e. the output voltage V_{out} doesnot depend on the load resistance connected in between the output terminals. i.e. output voltage V_{out} is independent of the current drawn by the load. The output can drive infinite no. of other devices.

4. Because of the infinite voltage gain, the voltage between the inverting and non-inverting terminals of the input i.e. differential input voltage $V_d = V_2 - V_1$ is essentially zero for infinite output voltage. This implies that V_1 and V_2 track each other i.e. a virtual short circuit exists between two input terminals but with no current flowing between the two terminals as R_{in} is infinite.

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5. Infinite frequency bandwidth:
It has flat frequency response from dc to infinity that any frequency signal from zero to infinity Hz can be amplified without alternuation.

6. Drift of characteristics with temperature is NIL.

7. CMRR is ∞, that the amplifier is free from noise.

8. Slew rate is ∞, so that the output voltage changes occurs simultaneously with input voltage change.

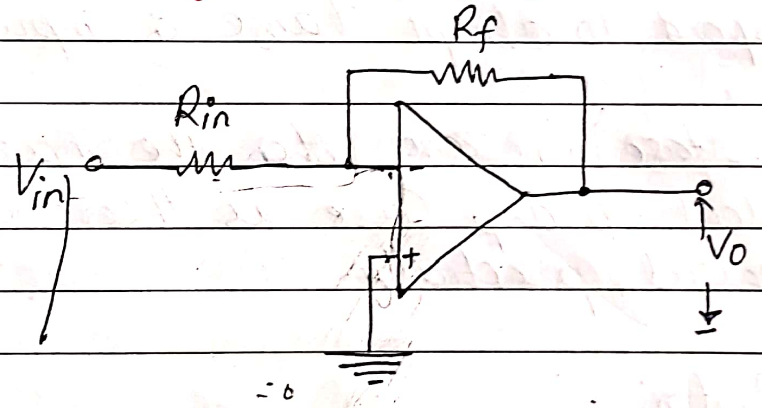
Slew Rate: Maximum Rate at which amplifier can respond to abrupt change of input level.

9. The output voltage is zero when the input voltage is 0. The ideal op-amp case is theoretical and cannot be realised practically.

Signal Amplification:
Normally, the output of the transducer in electrical form is very weak and low level. To drive the other stages of instrumentation system, the direct output of transducer is not able. Hence, the strength of the weak signal needs to be increased. This boosting function is done by signal amplifier. In instrumentation system, op-amp based amplifiers are used. Some of the important amplifiers constructed out of op-amps are:

1. Buffer Amplifier.
2. Inverting Amplifier.
3. Non-Inverting amplifier.
4. Summing Amplifier.
5. Difference Amplifier.
6. Differentiator.
7. Integrator
8. Logarithmic Amplifier
9. Antilog Amplifier.
10. Instrumentation amplifier
11. Differential Amplifier.

1. Buffer Amplifier/Isolation Amplifier/Voltage Follower



Single Signal amplify.

fig(1)

Here, $V_o = -\frac{R_f}{R_{in}} \cdot V_{in}$

When $R_f = R_{in}$

$$\boxed{V_o = -V_{in}}$$

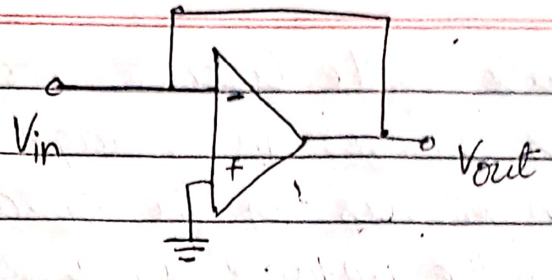


Fig (ii) Sign Changer.

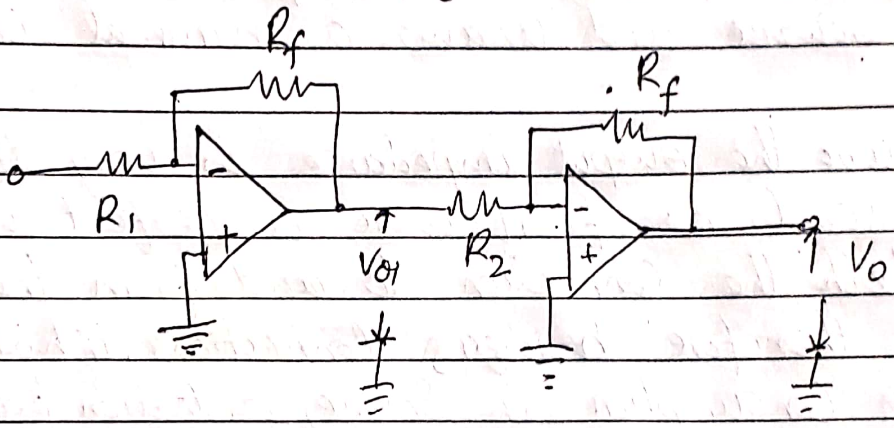


Fig (iii)

The buffer amplifier is a unity gain amplifier also known as voltage follower. The buffer amplifier is essentially an impedance transformer which Converts voltage at high impedance to voltage at low impedance.

From figure (iii), $V_{O1} = -\frac{R_f}{R_1} \cdot V_{in}$ — (I)

$V_o = -\frac{R_f}{R_2} \cdot V_{O1}$ — (II)

From (I) & (II),

$$V_o = \left(-\frac{R_f}{R_2}\right) \cdot \left(-\frac{R_f}{R_1}\right) \cdot V_{in}$$

When, $R_f = R_2 = R_1$;

$$\boxed{V_o = V_{in}}$$

This amplifier is called as isolation amplifier.

feedback ↳ (-ve)

oscillator ↳ (+ve)

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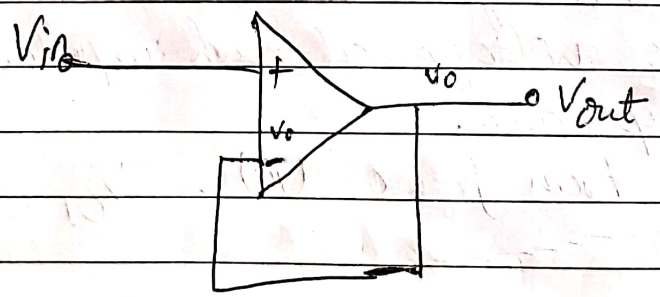
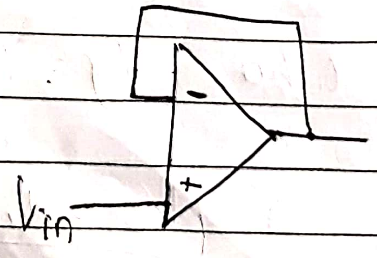
The importance of the circuit doesnot come from any ~~branches~~ Changes in voltage, but from the input & output impedances of the op-amp. The input impedance of the op-amp is very high, meaning that the input of the op-amp doesnot load down the Source and draws a minimal current from it.

Because the output impedance is very low; it drives the load as if it were a perfect voltage source. So both the connection to and from the buffer are therefore bridging connections, which reduce power consumption in source, distortion from overloading crosstail & other electromagnetic interference.

This is suitable for avoiding attenuation in the wire connection in the ckt.



(iv) Op-amp buffer



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2. Inverting Amplifier.

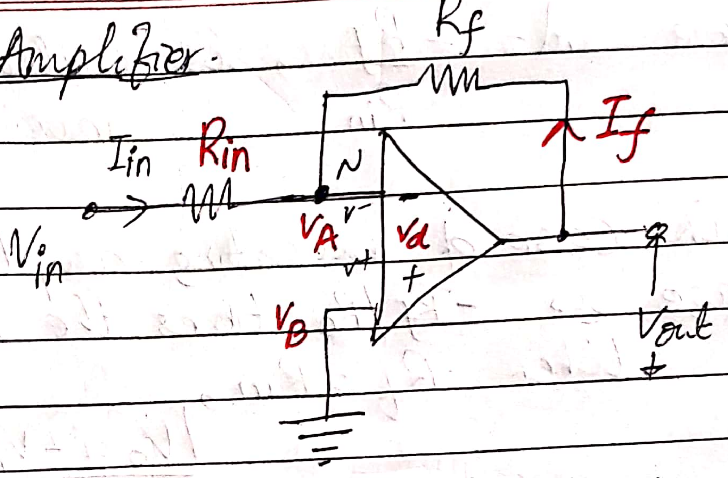

Fig: Inverting mode of op-amp

Figure above shows the inverting configuration of op-amp.

From circuit, $V_d = V_a - V_b$

$V_d = V_a - V_b = 0$

$\therefore V_a = V_b$.

Now, $V_b = 0$ [$\because V_b$ is grounded]

$\therefore V_a = 0$

Now using KCL at node N;

$I_{in} + I_f = 0 \Rightarrow I_{in} = -I_f$ — ①

Now, $I_{in} = \dfrac{V_{in} - V_A}{R_{in}} = \dfrac{V_{in}}{R_{in}}$ — ②

$I_f = \dfrac{V_0 - V_A}{R_f} = \dfrac{V_0}{R_f}$ — ③ $\{V_A = 0\}$

from eqn ①, ② & ③,

$$\frac{V_{in}}{R_{in}} = -\frac{V_0}{R_f}$$

or, $\boxed{V_0 = \left(-\dfrac{R_f}{R_{in}}\right) \cdot V_{in}}$ — ④

Where $A = -\frac{R_f}{R_{in}}$, is called closed loop gain of inverting amplifier.

So in case of inverting amplifier, the output voltage is $-R_f/R_o$ times the input voltage.

When $R_f = R_{in}$, $\boxed{V_o = -V_{in}}$

3. Non-Inverting mode of op-amp

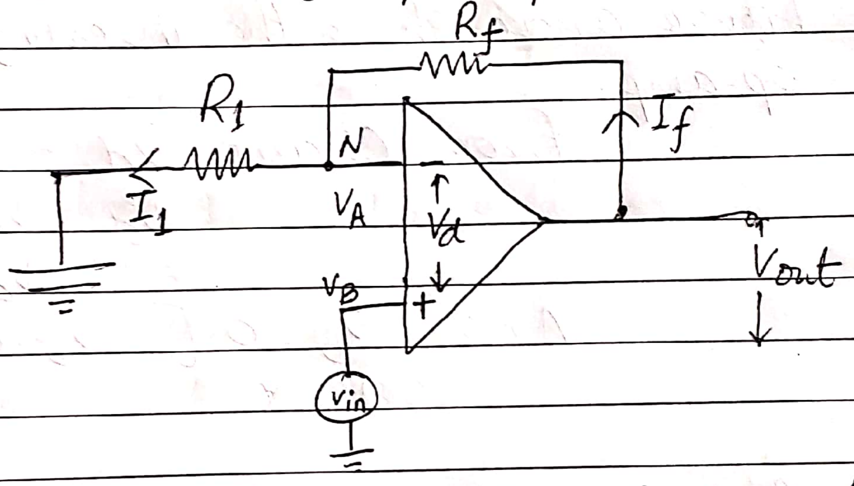

Figure: Non-Inverting amplifier Configuration

From circuit diagram,

$$V_d = V_B - V_A = 0$$

$$V_B = V_A = V_{in} \quad \text{— (1)}$$

Using KCL at Node N;

$$I_f = I_1 \quad \text{— (2)}$$

$$I_f = \frac{V_o - V_A}{R_f} = \frac{V_o - V_{in}}{R_f} \quad \text{— (3)}$$

$$I_1 = \frac{V_A - 0}{R_1} = \frac{V_{in}}{R_1} \quad \text{— (4)}$$

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from above equations,

$$\frac{V_o - V_{in}}{R_f} = \frac{V_{in}}{R_1}.$$

$$\frac{V_o}{R_f} = \frac{V_{in}}{R_f} + \frac{V_{in}}{R_1}$$

or, $$\frac{V_o}{R_f} = V_{in}\left(\frac{1}{R_f} + \frac{1}{R_1}\right) \Rightarrow V_o = \left(1 + \frac{R_f}{R_1}\right) V_{in} \quad \text{--- (5)}$$

i.e. $\boxed{V_o = A V_{in}}$

Where,

$A = 1 + \frac{R_f}{R_1}$ is the closed loop gain of non-inverting amplifier.

4. Summing Amplifier: (Adder)

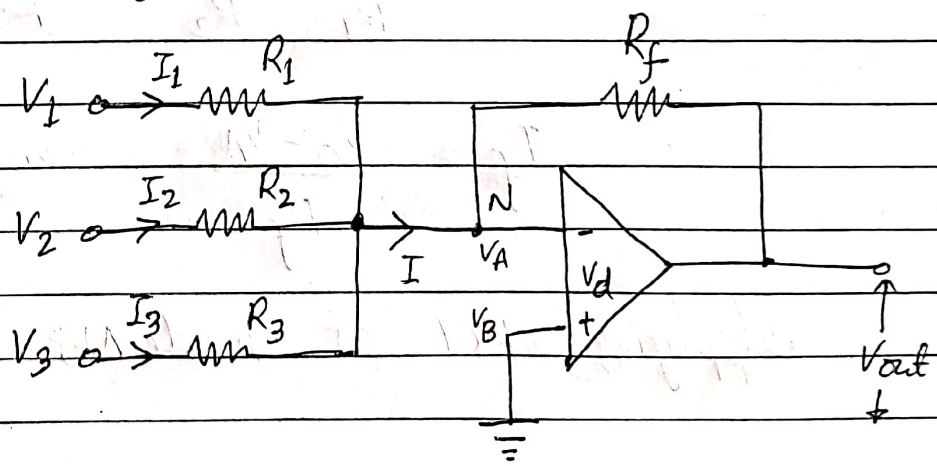

Figure: Operational Amplifier as Adder

Circuits above performs the addition of signals with amplification if desired.

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From the circuit diagram; $V_d = 0$

i.e. $V_A = V_B$

V_B is grounded, $V_B = 0 = V_A$.

Now, $I_1 = \frac{V_1 - V_A}{R_1} = V_1/R_1$.

$I_2 = \frac{V_2 - V_A}{R_2} = V_2/R_2$

$I_3 = \frac{V_3 - V_A}{R_3} = V_3/R_3$

Now, $I = I_1 + I_2 + I_3$

$$I = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \quad \text{--- (1)}$$

$$I_f = \frac{V_0 - V_A}{R_f} = V_0/R_f \quad \text{--- (2)}$$

Applying KCL at node N;

$I_f + I = 0$

$I_f = -I$ --- (3)

From eq^n (1), (2) & (3)

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

$$V_O = -\frac{R_f}{R_1} V_1 - \frac{R_f}{R_2} V_2 - \frac{R_f}{R_3} V_3$$

When, $R_f = R_1 = R_2 = R_3$;

$$\boxed{V_O = -(V_1 + V_2 + V_3)}$$

Hence output Signal is the addition of input Signals.

When, $R_1 = R_2 = R_3 = R$;

$$V_O = -\frac{R_f}{R}(V_1 + V_2 + V_3)$$

$$\boxed{V_O = -A(V_1 + V_2 + V_3)}$$

Where $A = \frac{R_f}{R}$ is gain of Summing amplifier

5. ## Difference Amplifier (Subtractor)

The circuit performs the subtraction of one signal from another.

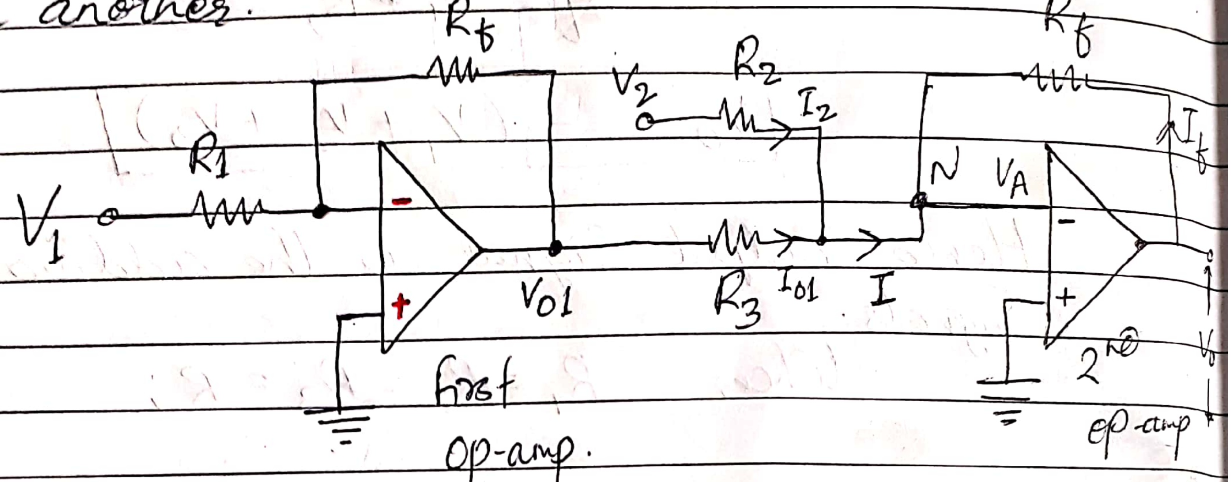

Figure: Operational Amplifier as a Subtractor.

first $\quad V_{01} = -\frac{R_f}{R_1} \cdot V_1 \quad$ — (1)

$$I_2 = \frac{V_2 - V_A}{R_2} \quad \text{— (2)}$$

$$I_{01} = \frac{V_{01} - V_A}{R_3} \quad \text{— (3)}$$

2^{nd}

Grounded, $V_A = V_B = 0$ — (4)

$$I_f = \frac{V_0 - V_A}{R_f} \quad \text{— (5)}$$

At Node N, $\quad I + I_f = 0$

$$I = -I_f \quad \text{— (6)}$$

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Also, $I = I_{01} + I_2$ — (7)

From above equations, (2) (3) (4) (5)

$$I_2 = \frac{V_2}{R_2}, \quad I_{01} = \frac{V_{01}}{R_3}, \quad I_f = \frac{V_0}{R_f}$$

Using (7),

$$I = I_{01} + I_2 = \frac{V_{01}}{R_3} + \frac{V_2}{R_2}$$

$$I = -\frac{R_f}{R_1} \cdot \frac{1}{R_3} \cdot V_1 + \frac{V_2}{R_2} \quad \text{— (8)}$$

Using $I = -I_f$

$$-\frac{V_0}{R_f} = -\frac{R_f}{R_1} \cdot \frac{1}{R_3} V_1 + \frac{V_2}{R_2}$$

$$V_0 = \frac{R_f}{R_1} \cdot \frac{R_f}{R_3} V_1 - \frac{R_f}{R_2} \cdot V_2 \quad \text{— (9)}$$

If $R_f = R_1 = R_2 = R_3$,

Then Circuit acts as pure ~~recl~~ Subtractor.

$$\boxed{V_0 = V_1 - V_2} \quad \text{— (10)}$$

Alternatively, superposition theorem can be used to obtain the output.

{(By V_{01} + V_2 effect)}

OP-Amp as Subtractor

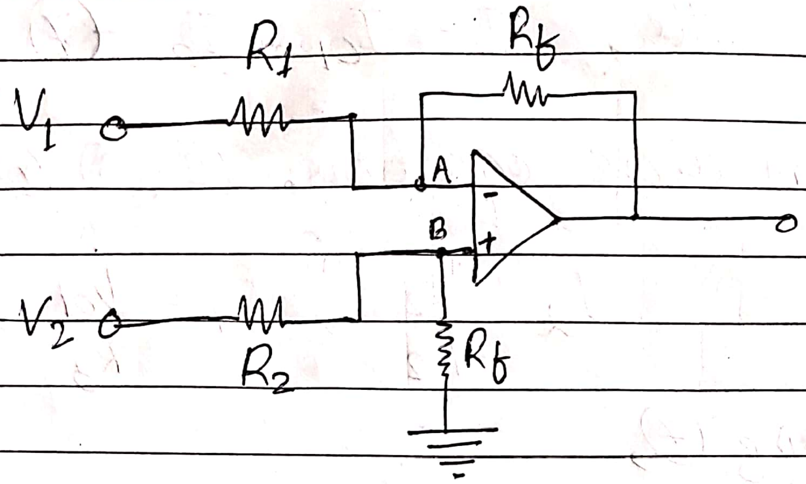


Fig :- Subtractor using Single op-amp

Superposition theorem,

Considering V_1 only,

$$\text{Output, } V_{O1} = -\frac{R_f}{R_1} \cdot V_1 \quad \text{—(1)}$$

Considering V_2 only,

$$\text{Output, } V_{O2} = \left(1 + \frac{R_f}{R_1}\right) V_B \quad \text{—(2)}$$

$$V_B = V_2 - \left(\frac{R_2}{R_2 + R_f}\right) \cdot V_2$$

$$= \frac{V_2 R_2 + V_2 R_f - V_2 R_2}{(R_2 + R_f)}$$

$$V_B = \frac{R_f}{R_2 + R_f} \cdot V_2 \quad \text{—(3)}$$

From (2) and (3),

$$V_{O2} = \left(1 + \frac{R_f}{R_1}\right) \cdot \left(\frac{R_f}{R_2 + R_f}\right) \cdot V_2 \quad -(4)$$

The output V_o is sum of V_{O1} & V_{O2}

or, $$V_o = -\frac{R_f}{R_1} \cdot V_1 + \left(1 + \frac{R_f}{R_1}\right)\left(\frac{R_f}{R_2 + R_f}\right) V_2$$

$$V_o = -\frac{R_f}{R_1} V_1 + \left(\frac{R_1 + R_f}{R_1}\right) \cdot \left(\frac{R_f}{R_2 + R_f}\right) V_2$$

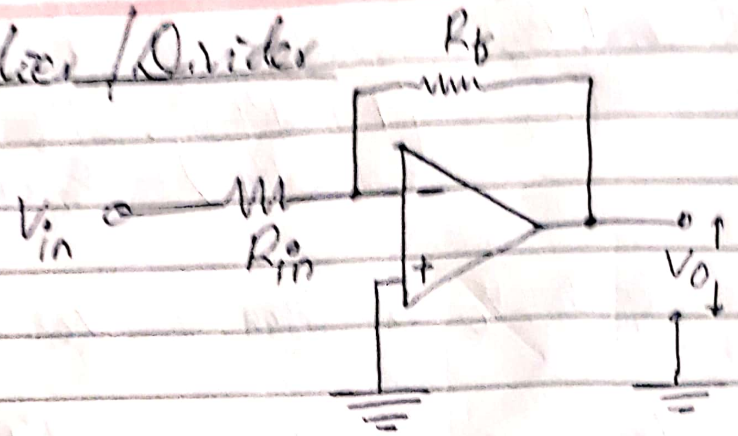
If, $R_1 = R_2 = R$; then;

$$V_o = -\frac{R_f}{R_1} V_1 + \frac{R_f}{R_1} V_2$$

$$\boxed{V_o = \frac{R_f}{R_1} (V_2 - V_1)} \quad -(5)$$

When $R_f = R_1$; $\boxed{V_o = V_2 - V_1}$

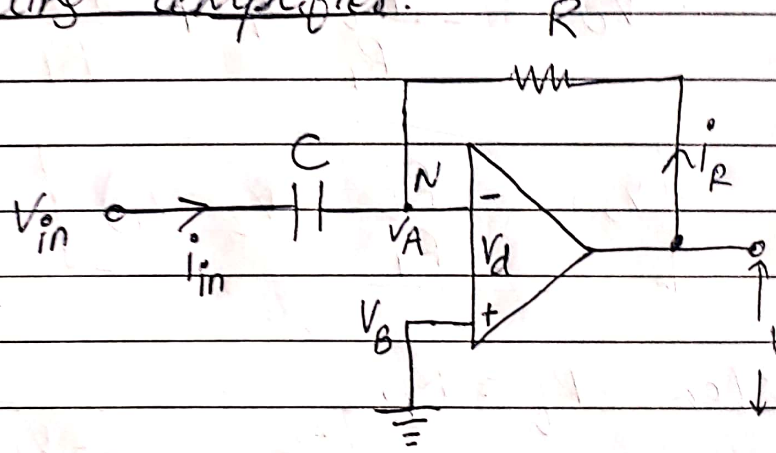
Multiplier / Divider



$$V_o = -\frac{R_f}{R_{in}} V_{in}$$

Case(i) $R_f > R_{in}$ → Multiplier
$R_f < R_{in}$ → Divider

6. Differentiating amplifier:



(Produces voltage output which is directly prop. to the rate of change of input voltage)

From fig: $V_A = V_B = 0$ — ①

$$i_{in} = C\frac{dV_c}{dt} = C\frac{d(V_{in} - V_A)}{dt}$$

$$\therefore i_{in} = C\frac{dV_{in}}{dt} \quad —②$$

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$$i_R = \frac{V_0 - V_A}{R} = \frac{V_0}{R} \quad \text{—③}$$

Using KCL at Node N;

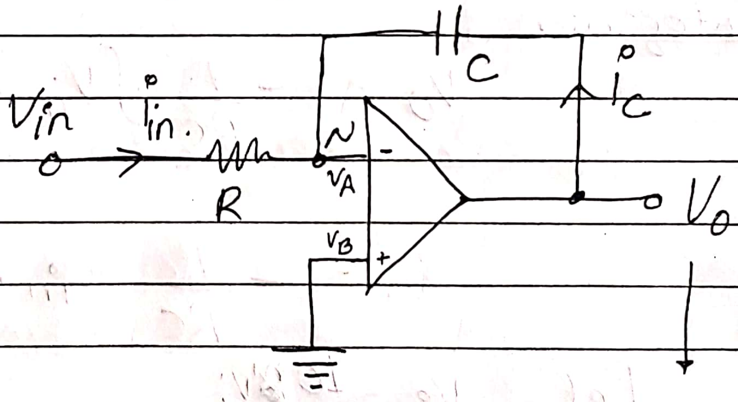
$$i_{in} + i_R = 0 \Rightarrow i_{in} = -i_R$$

or, $$C\frac{dV_{in}}{dt} = -\frac{V_0}{R}$$

or, $$\boxed{V_0 = -RC\frac{dV_{in}}{dt}}$$

⑦ Integrating amplifier

→(Change position of Capacitor and resistance)



$$V_A = V_B = 0 \quad \text{—①}$$

$$i_{in} = \frac{V_{in} - 0}{R} \quad \text{—②}$$

$$i_c = C\frac{d(V_0 - 0)}{dt}$$

$$i_c = C\frac{dV_0}{dt} \quad \text{—③}$$

Applying KCL at Node N.

$$i_{in} = -i_c$$

or, $$\frac{V_{in}}{R} = -C\frac{dV_0}{dt}$$

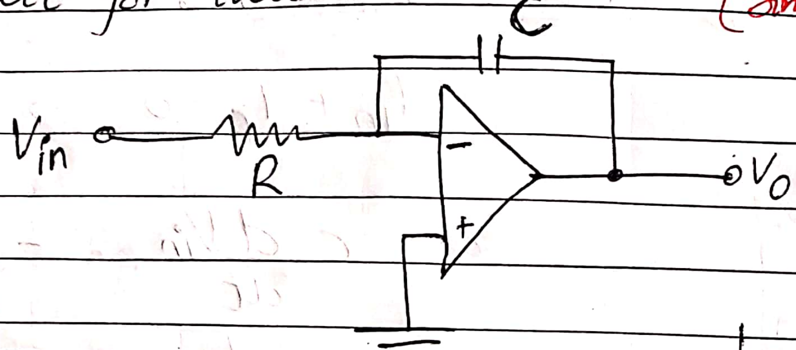
$$\boxed{V_0 = -\frac{1}{RC}\int V_{in}\,dt}$$

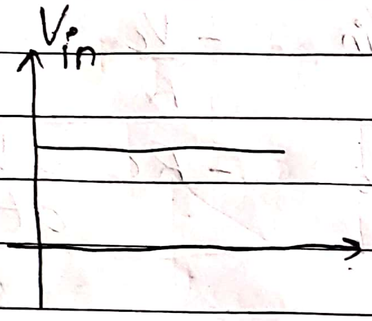
$R = M\Omega$

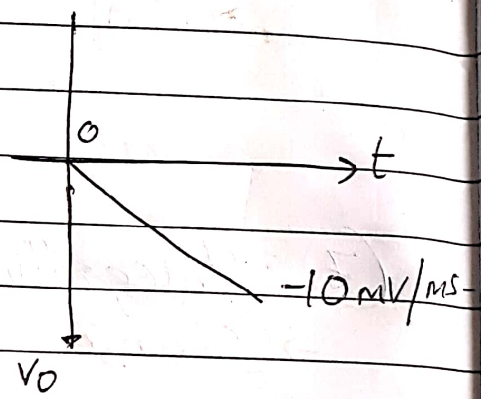
$C = \mu F$

Numerical

An op-amp is used as an integrator to produce a ramp signal of -10 mV/ms. Design a circuit for this {Sim. to 2074 Bhadra}







Integrator,

$$V_o = -\frac{1}{RC}\int V_{in}.dt$$

$$= -\frac{1}{RC} V_{in}.t$$

Let, $V_{in} = 10\,mV$;

Then, $V_o = -\frac{10}{RC} * t$ (mV)

$$\Rightarrow \frac{V_o}{t} = -\frac{10}{RC} \text{ mV/s}$$

5V/ms

$V_o = \frac{-5}{RC}.t$

~~RC=10^-3~~

$\frac{V_o}{t} = \frac{-5}{RC}$ v/s. By design considerations, $V_o/t = -10$ mV/ms

$\boxed{RC = 10^{-3}}$

When, RC = range of 10^{-3}

Using $R = 1k\Omega$, $C = 1\mu f$

then $RC = 1ms$

Hence ramp generator requires a Constant voltage of 10 mV and resistance, $R = 1 k\Omega$ & $C = 1 \mu F$ in feedback.

Instrumentation Amplifier

An instrumentation amplifier is a specific combination of dc-op amps wired up with feedback and needs a very little design effort from the user.
The output signal provided by the transducer is very weak i.e. low level, so needs to be amplified before further processing and this is normally done with instrumentation amplifier.

Important features (Why needed?)

1. Selectable gain with high gain accuracy and gain linearity.
2. Differential input capability with high CMRR, even with source having unbalanced high output impedance.
3. High gain stability with low temp^r coefficients.
4. Low offset and drift errors ref. to input.
5. Low output impedance.

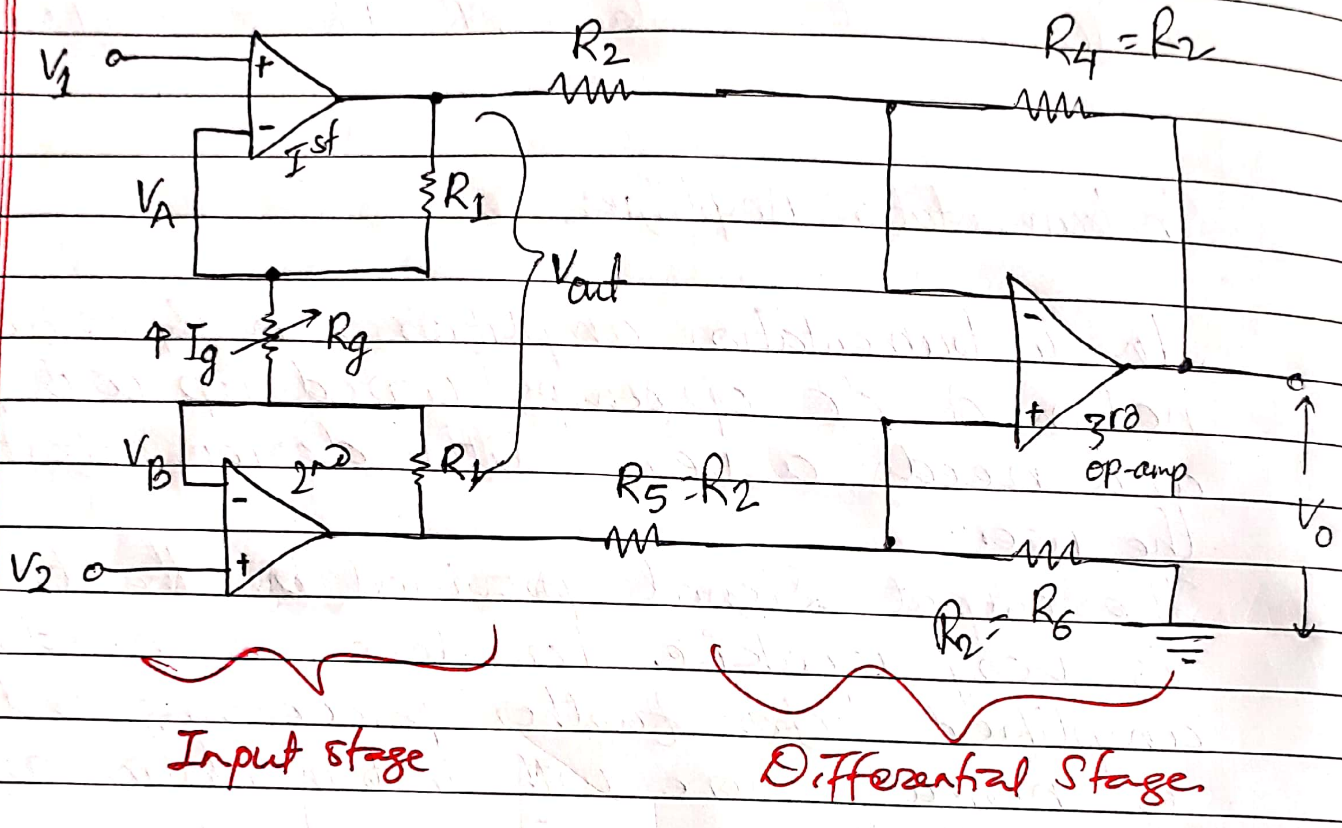


Fig: Instrumentation Amplifier.

(i) Input stage with double op-amps.
(ii) Differential Stage with third op-amps.

The input stage offers a very high input impedance to both the input signals and allows to set the gain with the single resistor. The second stage is a unity gain differential amplifier with the output, negative feedback and ground connections brought out.

The output of input stage op-amps are connected together through a string of resistors. The resistors R_1 are internal to the integrated ckt while R_g is gain setting resistor which can be internally or externally connected.

Now, voltage across R_g may be expressed as:

$$V_{Rg} = I_g R_g \quad \text{--- (1)}$$

The voltage across at node A is given by;

$$V_d = V_1 - V_A$$

$$\text{or,} \quad -V_A = V_d - V_1$$

For ideal concept,

$$V_d = 0$$

$$V_A = V_1 \quad \text{--- (2)}$$

Slly,

$$V_B = V_2 \quad \text{--- (3)}$$

$$V_{Rg} = V_B - V_A = I_g R_g = V_2 - V_1$$

$$\boxed{I_g = \frac{V_2 - V_1}{R_g}} \quad \text{--- (4)}$$

But the output voltage is the summation of all the drops in the series network of output formed by $R_1 - R_g - R_1$ arrangement so,

$$V_{out} = I_g (R_1 + R_g + R_1)$$

$$\therefore V_{out} = I_g (2R_1 + R_g) \quad \text{--- (5)}$$

Hence, $$V_{out} = \frac{V_2 - V_1}{R_g} (2R_1 + R_g)$$

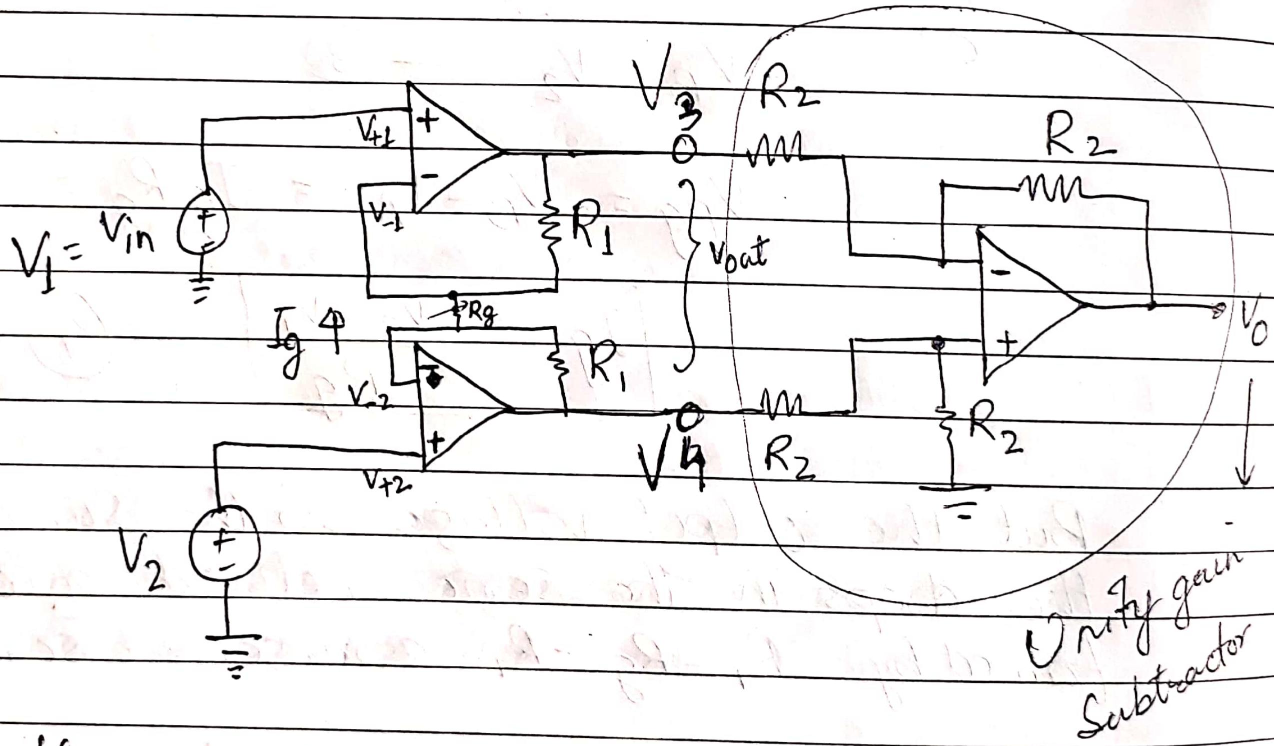
$$V_{out} = (V_2 - V_1)\left(\frac{2R_1}{R_g} + 1\right)$$

This is the output provided by the input stage of instrumentation amplifier.

The 2nd stage of the instrumentation amplifier is a unity gain differential amplifier. Hence the output of 3rd op-amp will be:-

$$\boxed{V_0 = (V_2 - V_1)\left(\frac{2R_1}{R_g} + 1\right)} \quad -8$$

Alternative way (Easier Shortcut Approach)



Here, $V_{+1} = V_1$

For ideal case,

$$V_{+1} = V_{-1} = V_1$$

Similarly,

$$V_{+2} = V_{-2} = V_2$$

From the assumption of the current flow dir^n,

$$I_g = \frac{V_{-2} - V_{-1}}{R_g}$$

$$\boxed{I_g = \frac{V_2 - V_1}{R_g}} \quad — (1)$$

The output voltage V_{out} is

$$V_{out} = V_{34} = V_4 - V_3$$

$$= I_g (R_1 + R_g + R_1) \quad — (2)$$

Substituting (1) in (2)

$$V_{out} = V_4 - V_3 = \frac{V_2 - V_1}{R_g} (R_g + 2R_1)$$

$$V_{out} = (V_2 - V_1) \left\{ 1 + \frac{2R_1}{R_g} \right\}$$

This is output provided by the input stage of instrumentation amplifier.

The second stage is unity again difference amplifier,

$$V_0 = V_4 - V_3 = (V_2 - V_1) \left(1 + \frac{2R_1}{R_g} \right)$$

or,

$$\frac{V_0}{(V_2 - V_1)} = \left(1 + \frac{2R_1}{R_g} \right)$$

which is gain of Inst. op-amp

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Elimination of Common mode Signal

Suppose, $V_3 = x + V_{cm}$, volts

$V_4 = y + V_{cm}$, volts

Where x & y are output voltages at 3 & 4
V_{cm} = common mode signal.

$$V_0 = V_4 - V_3 = y + \cancel{V_{cm}} - x - \cancel{V_{cm}}$$

$$= y - x \quad \text{--- (1)}$$

Equation (1) shows beside the property of high CMRR of op-amp, the unity gain differential amplifier also removes the noise.

Assignment -2

1. List out the ideal characteristics of op-amp.
2. Design an integrator circuit with output ramp voltage of - 15 V/ms.
3. Describe Instrumentation Amplifier with its salient features. appl^ns.
4. Derive the expression for gain and list out applications of op-amp under following configuration.
   * Inverting
   * Non-Inverting
   * Summer
   * Subtractor / Differential
   * Integrator
   * Differentiator

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Network Isolation

Isolation indicates the electrical isolation and is provided by the transformer or by the isolation amplifier. The isolation amplifier may be constructed

→ Transformer in Electrical Machines $\{N_2 = N_1\}$
→ Isolation Amplifier
→ Optocoupler / LDR used ckts. LED

Wave Shaping

- Electronic circuit used to create or modify specified time varying electrical voltage or current waveform using combination of active and passive elements known as wave shaping.

- Most wave shaping ckts are used to generate periodic waveform such as square waveform, sine wave & rectified sine wave, triangular wave.

- May be linear or non-linear.

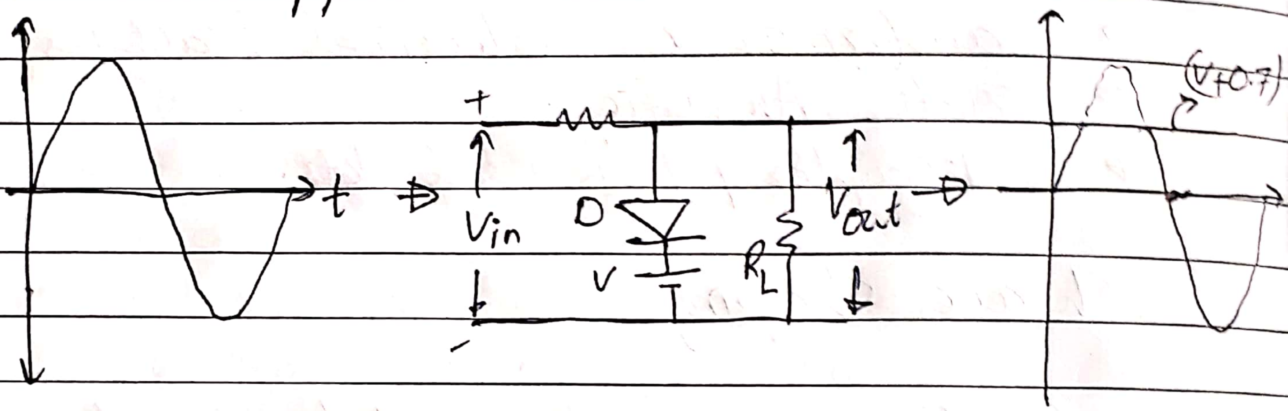
- Linear wave shaping involves the passage of signal through linear system such as resistors which donot change the waveform of the input signals when it is transmitted through them

- Non-Linear waveshaping involves passage of

Signals through non-linear system such as diode, transistors etc as they alter the waveform of the input signals when it is transmitted through them.

Example.

Clipper Ckt.

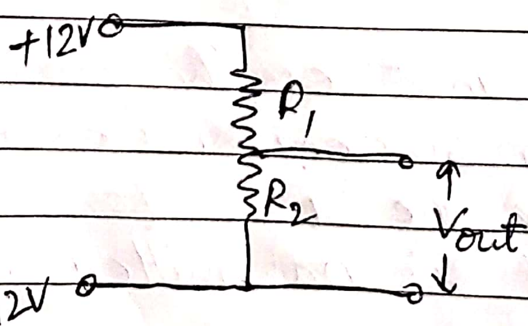


Signal Attenuation:-

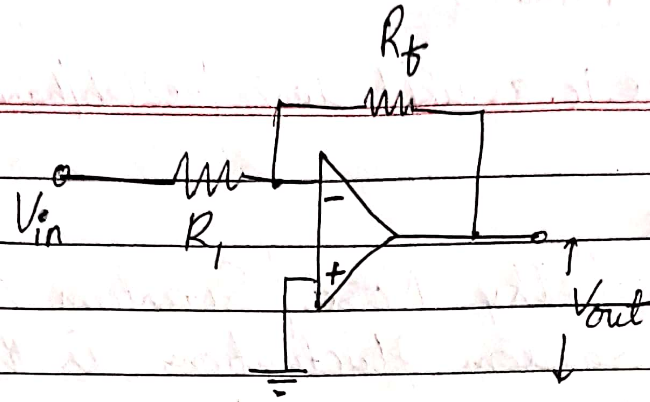
→ Attenuation refers to a waveform in signal strength commonly occuring while transmitting analog or digital signal over a certain distance.

→ Reverse process of signal amplification.

Example:



$$A = \frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_2} < 1$$



$$A = \frac{V_{out}}{V_{in}} = \frac{-R_f}{R_{in}}$$

If $R_f < R_{in}$
attenuation achieved

<u>But;</u>
Use of op-amp as signal attenuator is more expensive than using a potentiometer.
(But op-amp has advantage of small size & low power consumption).

Effect of Noise, Analog Filtering, Digital Filtering

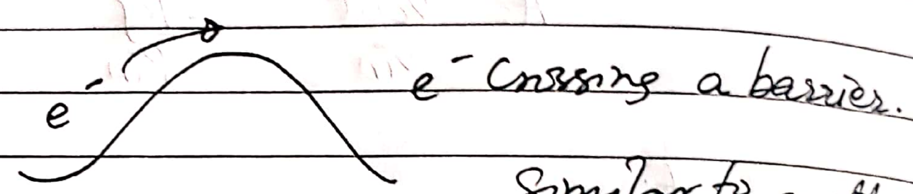
- Noise is any kind of unwanted signal (pure random signal) that is not related to the input.
- It interferes the original signal and misleads the information carried by the signal.
- In case of amplifier circuits, the noise signal will also gets amplified along with the amplifier along with the input signal and will appear at the output which is undesirable

Different types of Noise are
→ Thermal Noise, Shot Noise
→ Flicker Noise, partition noise, Burst Noise, Avalanche Noise.
→ Gas noise etc.

Texas Instruments

https://intranet.ee.ic.ac.uk/t.clarke/ee2lab/handouts/A/noise-3.pdf

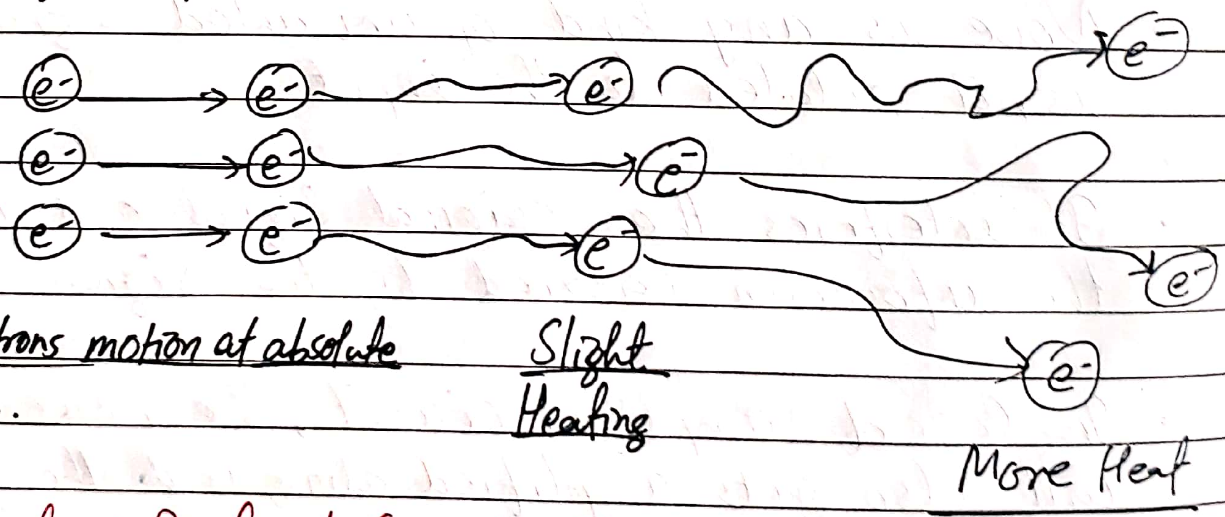
1. Shot Noise
→ is for schottky Noise / Quantum Noise.
→ Caused by random fluctuations in the motion of charge carriers in the conductor/current



Similar to earthquake

→ depends on current flow.

2. Thermal Noise.
→ Referred as Johnson Noise after its discoverer.
→ Generated by thermal agitations of electrons in a conductor.
Simply put, as a conductor is heated, it will be noisy
→ Only stops at absolute zero.



→ Independent of Current flow.

3. Flicker Noise. (Associated with DC Current)
also known as 1/f Noise, is a signal noise.

4. Burst Noise: Popcorn Noise (imperfections in semi-conductor material and heavy ion implants)

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5. Avalanche Noise is created.
→ When pn junction is operated in reverse break-down mode.

Analog filtering

Filters are frequency selective network which passes the signal of desired frequency and blocks rest of the signals.
On the basis of components used,

ⓐ Active filters

ⓑ Passive filters (Contains passive elements, don't contain active components such as transistors, Battery)

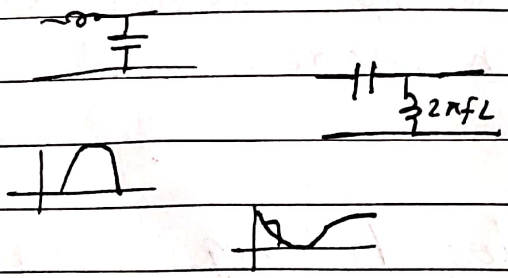
optional

Active filters	Passive filters
→ Active filters have a power gain.	Consumes the energy of signal, but no power gain is available.
→ Requires external power supply.	Operate only on signal i/p.
→ Active filters have frequency limitations due to active elements.	→ No freq. limitations.
	BETTER STABILITY & Can withstand large currents.
EXP.	CHEAPER

(Relatively)

Based on the ~~components used~~ frequency response, the filters Can be

1. Low-pass filter
2. High-pass filter
3. Band-pass filter
4. Band stop filter



Digital Filtering

Digital Filters are formed by Connection of the memory along with the multiplexer. There are two classes of the digital filters depending upon the impulse response. They are: (For Mathematical Operations)

ⓐ Finite Impulse Response Filter (FIR)

→ response become exactly zero at $t > T$,

$T \rightarrow$ finite 'T'

ⓑ Infinite Impulse Response Filter (IIR)

→ Impulse response which does not become exactly zero past a Certain point, but Continues indefinitely.

Optical Communication, Fibre optics, Electro-optic, Conversion devices

Fibre optic Communication is a method of transmitting the information from one place to another by sending the pulse of light through an optical fiber. The light from an electromagnetic carrier wave that is modulated to Carry information.

General Block digram →

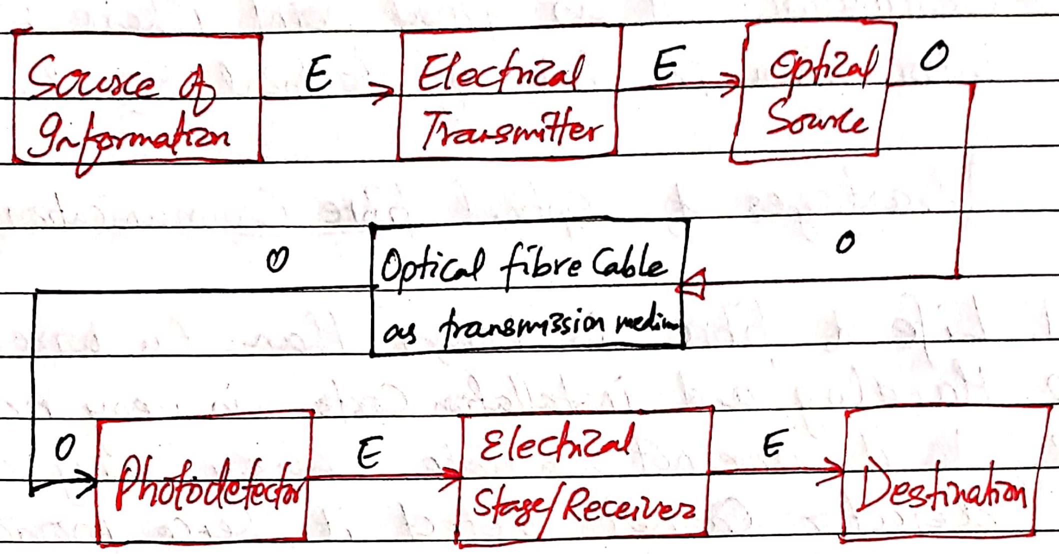


fig-: Optical fibre Communication.

1. Information Source:
   It provides an electrical signal to the transmitter comprising an electrical stage.

2. Electrical Transmitter: It drives an optical source to give modulation of light wave carrier.

3. Optical Source: It provides the electrical-optical conversion. It may be a semiconductor laser or an LED.

4. Optical Cable: It serves as transmission medium.

5. Photodetector/optical detector: It is responsible for the optical to electrical conversion of data & hence the demodulation of optical carrier Eg. Photodiode, phototransistors

6. Electrical Receiver: It is used for electrical interfacing at the receiver end of the optical link and to perform signal processing electrically.

7) Destination: It is final point where we receive the information in form of electrical Signal.

Advantages of Optical fibre Communication:

1. Life of fibre is Longer than Cu wire.
2. Handling and installation Costs is very nominal.
3. As it doesnot radiate energy, any antenna or the detector Cannot detect it, hence providing Signal Security.
4. Total electrical isolation in txn medium.
5. Immense Bandwidth to utilize.
6. Very low txn. losses
7. Small Size & light weight
8. Immunity to interference & Crosstalk.
9. very low power Consumption etc.

Disadvantages of optical fibre Communication:

1. Manpower - Skilled.
2. Costly if under utilized ⇒ Starting Costs are high.
3. Jointing & Splicing of fibre → time Consuming.
4. Precise & Costlier equipments required.

Application

→ Telecommunication → Space application → Broadband appl^n
→ Computer Application → Medical → Military

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Electro-optic Conversion Devices

The devices which convert electrical energy into photonic energy are called the electro-optic conversion devices.

LASER, LED, photo emissive cells.

Other devices which convert light energy into electrical energy are called opto-electric devices.

LDR, Solar cells, photo diodes etc.

Past Questions (IOE Exam) [12 Marks, 10 Marks]

1. Why is Signal Conditioning done in instrumentation System? Derive the expression for closed loop gain of op-amp in inverting mode. Also explain ideal char. of op-amp.

2. Design an integrator Ckt to produce ramp voltage of -20V/ms

3. Block diagram of optical fibre communication & adv.

4. Derive voltage gain of 3-op-amp Instrumentation amplifiers. Adv. of optical fibre Commn.