9:00Am to 6pm

ANALOG CIRCUITS → Gain vs. a factor.

Circuit's
- → Energy processing (Generators, motors) → electrical to mechanical; mechanical to electricals
- → Signal processing ⇒ 1. Manipulation of information
  - Nowadays we are using
  - 2. Storage → Digital (Hard-disk)

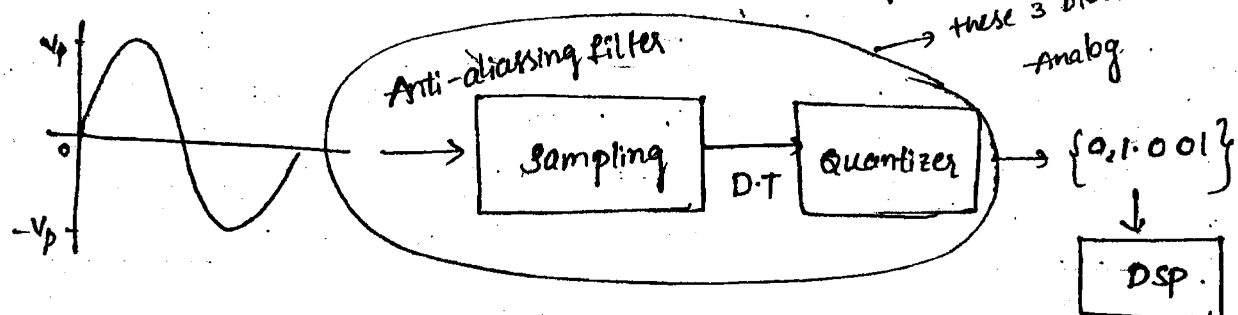
(Manipulation, communication)

Signal processing can be done in → Analog / → Digital } difference is (1) Noise immunity (2) programmable) (3) storage (4) scalability

VLSI – CHEAP. ↓ will do several copies of it by cascading.

All Naturally occuring signals are Analog.

these 3 blocks are Analog



It is given to ADC/DAC → Interfacing devices

Real signal → Time limited → Infinite Band limited

Digital Circuits:- Logic-gate is the building block's ↓ dont know wt is inside.

Analog circuits:- op-amp is the building block.

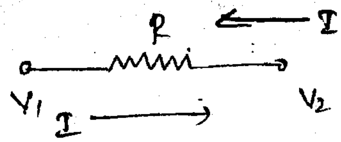
Designing & using op-amp, both are different

1. op-amp as a building block (Ideal op-amp)
2. Inside op-amp (100 – 50 Transistor (Tx))

Biode → BJT → Amplifier's | using TX

Real op-amp ← we will set inside op-amp

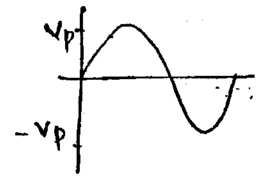
* Ohm's law →

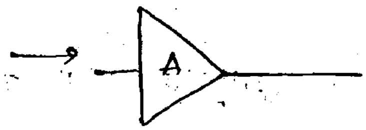


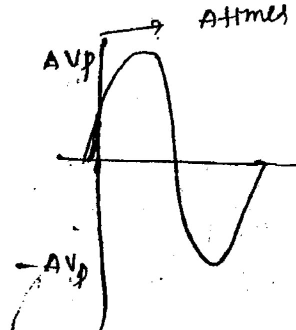
$I = \frac{V_2 - V_1}{R}$

$I = \frac{V_1 - V_2}{R}$

* KCl →

→ 

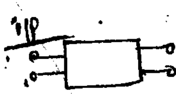
→ 



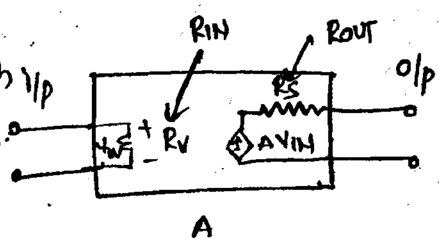
A times of i/p (AVp) & Vp -

Voltage Amplifier:-

$V_o = AV_I$ → linear | inside the op-amp (transistor, diode) all are non-linear.

→ Opamp is a two terminal device 

=& voltmeter · high i/p
shunt resistance — ∞
series resistance — 0 less



voltage Amplifier (i/p → V, o/p → V)

$V_o = AV_{IN}$ ↑ High

VIN — voltage measured by volt meter at the i/p
Rv — Resistance measured by the volt meter

→ The i/p port of the V-amplifier is measuring the applied i/p voltage ⇒ i/p port of the V-amplifier is like a voltmeter.

- Here i/p voltage controlling the o/p voltage.

→ The o/p port is the like a VCVS.

c.s.o

at i/p side we have only 1 resistor → $R_{IN} = R_V$ (large) → because it is in ||lel (i.e Ideal voltmeter has ∞ Resistance)

→ here also only one 1 resistor $R_{OUT} = R_S$ (small) → because it is series with voltage. i.e In Ideal VS Resistance value is 0)

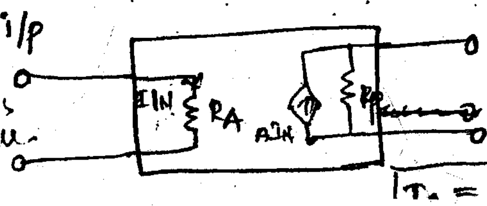
Current Amplifier:-

every ammeter having resistance.

→ The i/p to the current Amplifier is (i/p) → current
o/p → current

For ammeter
shunt resis = 0 less
series resis = high ∞

- the i/p current controlling the o/p current
→ Ideally ammeter include zero resistance.



Condition.

$I_o = A I_{in}$

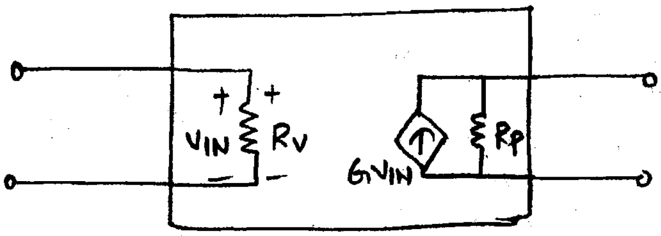
Here o/p current depends on the i/p current

$R_{IN} = R_A$ (small)

$R_{OUT} = R_p$ (large)

3. Transconductance amplifier:— (VCCS) → Here o/p is current so it is current source.

i/p	o/p
→ V	V
→ I	I
→ V	I ✓
→ I	V



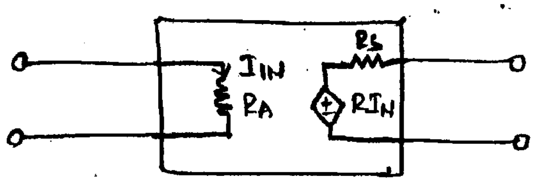
$I_o = G V_{IN}$

$R_{IN} = R_V$ (large)

$R_{OUT} = R_p$ (large)

Rp

4. Trans resistance amplifier:— (CCVS) → Here o/p is voltage so it's voltage source



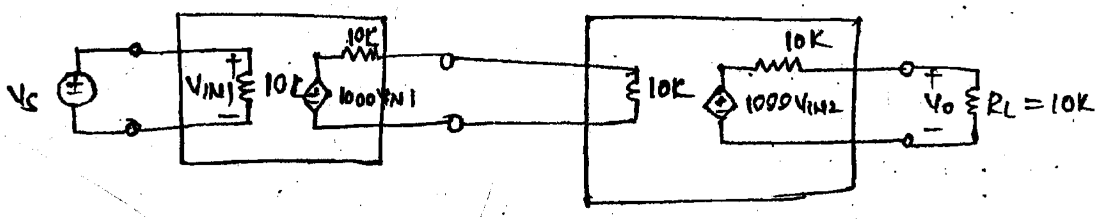
$V_o = R I_N$

$R_{IN} = R_A$ (small)

$R_{OUT} = R_S$ (small)

* 2 Identical voltage amplifier's each with gain = 1000, $R_{IN} = 10k$, $R_{OUT} = 10k$ are connected in cascade. Find the over all voltage gain if $R_L = 10K$.

Sol:



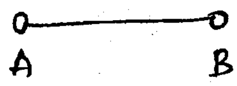
Find $\frac{V_o}{V_s}$

$V_{IN1} = V_s$

$V_{IN2} = \frac{1000 V_{IN1}}{2} = 500 V_s$

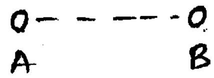
$V_o = 1000 V_{IN2} = 500 \times 500 V_s$

$\boxed{\frac{V_o}{V_s} = 500 \times 500 = 250k}$

→ 

'Real short'

$V_A = V_B$ (physically shorted)

→ 

$V_A = V_B$ (virtual short) ⟹ The i/p terminals are virtually shorted.

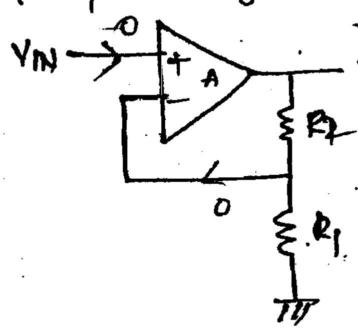
⇒ o/p connected to -ve input terminal ⟹ op-amp is in negative f/b.

(Ideal op-amp) + (Neg f/b) ⟹ virtual -short ($V_+ = V_-$)

*** o/p (V_0) is connected to -ve terminal.

1 -ve feedback op-amp stability:-

+ve f/b:- o/p(V_0) is connected to +ve terminal.



V_0 ↑↓

V_0 ↑ses for unknown reason.

suppose (V_0↑) → (V_-↑) → (V_D↓) → (V_0↓)

$V_+ = V_{IN}$

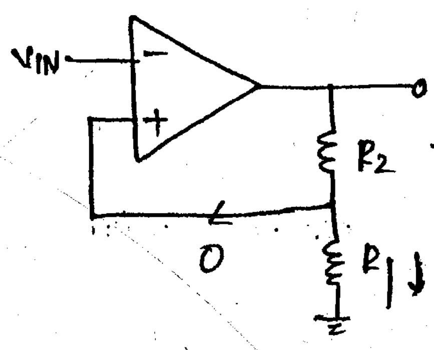
$V_- = \frac{V_0 \cdot R_1}{R_1 + R_2}$

↓ $V_D = V_+ - V_-$ ↑

V_0↓ $= A V_D$ ↓

In neg f/b ⟹ V_0 → finite + stable.

1 +ve feed back op-amp stability:-



V_0 ↑ --- $+\infty$ (V_0↑) (V_+↑) (V_D↑) (V_0↑)

$V_- = V_{IN}$

$V_+ = V_0 \frac{R_1}{R_1 + R_2}$

↓ --- $(-\infty)$

$V_0 = A V_D$

In pos f/b ⟹ $V_0 = \pm\infty$

(Checking virtual-short condition) for Ideal op-amp in neg f/b:-

$V_0 \longrightarrow F$.   F - finite

$A \longrightarrow I$ I - Infinite

$$V_D = \frac{V_0}{A} = \frac{F}{I} = 0$$

we know that

$V_D = V_+ - V_-$ $V_+ - V_- = 0$

$$\boxed{V_+ = V_-} \leftarrow \text{virtual short}$$

$V_0 = A V_D$

$$\lim_{x \to 0} \sin x \cdot 1/x \Rightarrow 0 \cdot \infty = 1$$

($\sin x$ ↓ small, $1/x$ ↓ large)

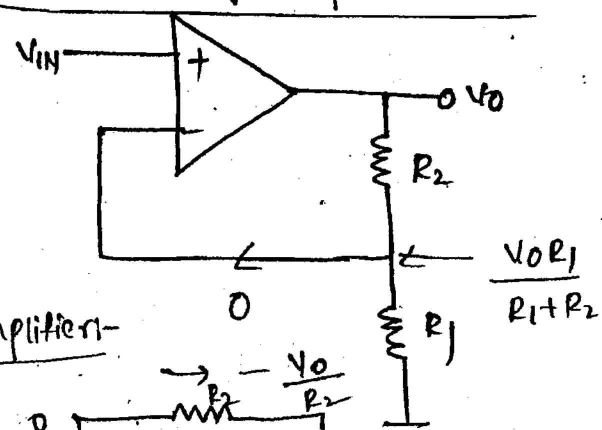
For Ideal op-amp in +ve f/b:-

$V_0 \longrightarrow I$

$A \longrightarrow I$ $V_+ \neq V_-$

$$V_D = \frac{V_0}{A} = \frac{I}{I} \neq 0$$

Non-Inverting amplifier:-



$V_+ = V_-$

$$V_{IN} = \frac{V_0 R_1}{R_1 + R_2}.$$

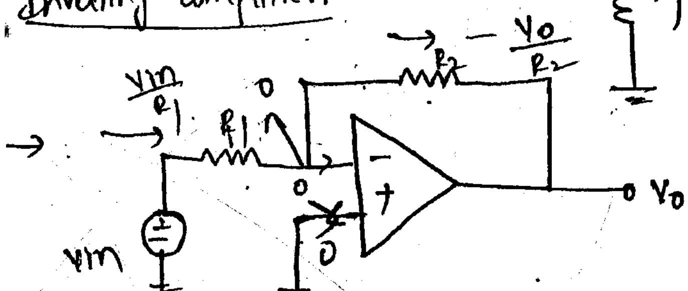
$$\boxed{\frac{V_0}{V_{IN}} = 1 + \frac{R_1}{R_2}} \rightarrow +ve$$

$V_0 = (+ve\ number) V_{IN}$

Non-inverting op-amp

V_0 & V_{IN} have the same sign (same phase)

Inverting amplifier:-



$$\frac{V_{IN}}{R_1} = -\frac{V_0}{R_2}$$

$$\boxed{\frac{V_0}{V_{IN}} = -\frac{R_2}{R_1}} \text{ -ve, } 180°$$

$$\boxed{V_0 = \left(-\frac{R_2}{R_1}\right) V_{IN}}$$

V_0 & V_{IN} are 180° out