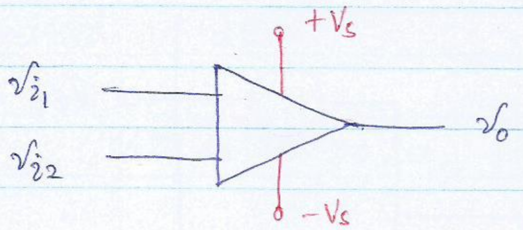
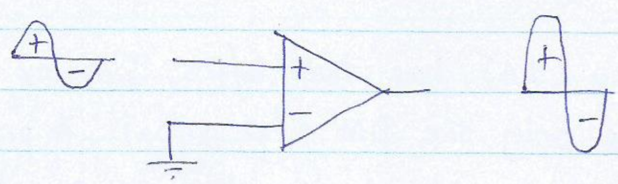
No: Date: 04/08/2017

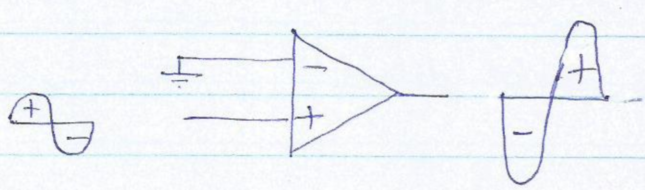


CCt symbol of VFOA

I/P 1 – Non Inverting i/p
I/P 2 – Inverting i/p

OA Can be powered by → Dual DC supply $(+V_s, -V_s)$ – Dual Supply OAs (Common VFOA Type)
→ Single DC supply (V_s) – Single Supply OAs. (Some are compatible with logic ccts.)



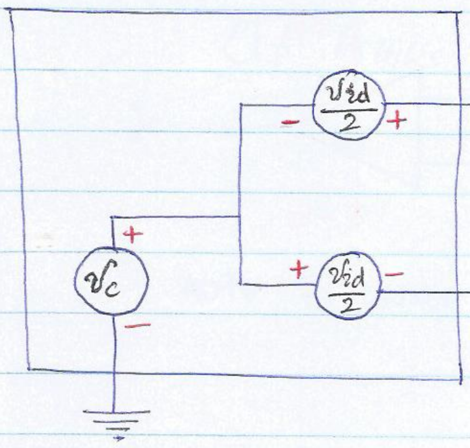


With OAs two types of i/p Signals are associated with,

* Differential Signals, v_{id} (Differential mode signals)
* Common Signals, v_{ic} (Common mode signals)

I/Ps 1 and 2 are above the common (gnd) potential.

They are represented by the following model.



$v_{i1} = v_c + \frac{v_{id}}{2}$

$v_{i2} = v_c - \frac{v_{id}}{2}$

$v_{i1} - v_{i2} = v_{id}$ $\qquad$ $\frac{v_{i1} + v_{i2}}{2} = v_c$

Usually,

- Common Signal, v_c is unwanted
- Diff. mode signal is the wanted signal.

A Differential Amp (DA) has two i/ps. Similar to OA. An Ideal DA amplifies only the DM i/p signal. A practical DA amplifies more than DM signal and less the CM signal.

Two types of Gains can be defined.

Differential Gain, (DM Gain) $\qquad A_d = \frac{v_o}{v_{id}} = \frac{v_o}{v_{i1} - v_{i2}}$

Common mode Gain, $\qquad A_c = \frac{v_o}{v_c} = \frac{v_o}{\left(\frac{v_{i1} + v_{i2}}{2}\right)}$

Common Rejection Ratio (CMRR) $= \left|\frac{A_d}{A_c}\right|$

CMRR is specified in dB

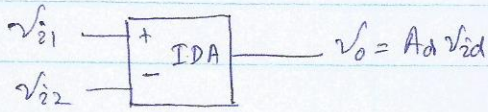
$$CMRR_{dB} = 20 \log_{10} \left| \frac{A_d}{A_c} \right|$$

For an IDA

A_d – Finite

$A_c = 0$

$\therefore$ CMRR $= \infty$

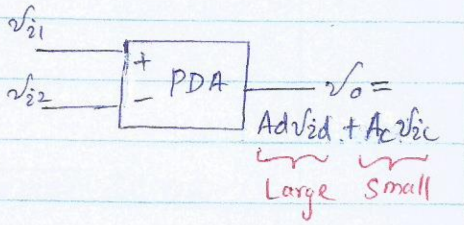


For a practical DA

A_d – Finite (High)

$A_c \neq 0$ (Low)

$\therefore$ CMRR $\neq \infty$ (high)



Ex: $A_d = 1000$

CMRR $= 80$ dB

$\therefore A_c = ?$

$$\left| \frac{A_d}{A_c} \right| = 10^4 \Rightarrow A_c = \frac{A_d}{10^4} = \frac{1}{10} = \underline{\underline{0.1}}$$

OA also has,

high DM Gain, A_d

low CM Gain, A_c

$$v_o = A_d v_{id} + A_c v_{ic} = A_d \left[v_{id} + \frac{v_{ic}}{CMRR} \right]$$

For general purpose IC OA (Ex: 741, TL082, ...) A_d is of the oder of 10^5 (100 dB)

CMRR can be > 80 dB

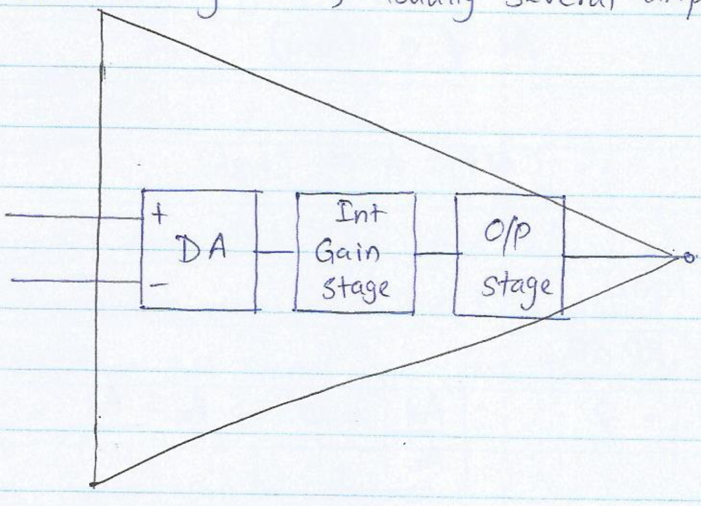
$\therefore\ v_o \simeq A_d v_{id}$

- OAs are manufactured using different technologies,

Ex: BJTs – Bipolar OAs (Ex: 741)
BIFET – BiFET OAs (Ex. TL082)
(FET + BJT)
CMOS – CMOS OAs
⋮ ⋮

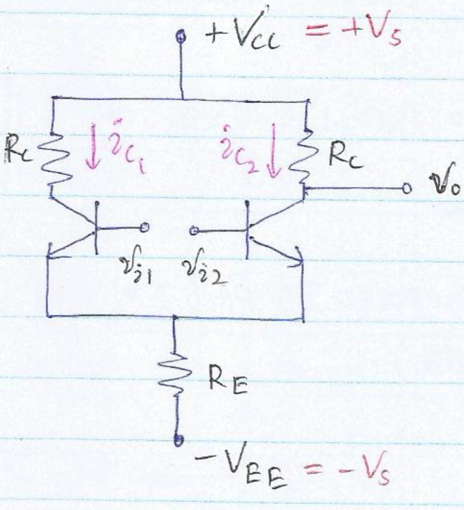
Internal Architecture of OA

To achieve high A_d, usually several amplifying stages are used.

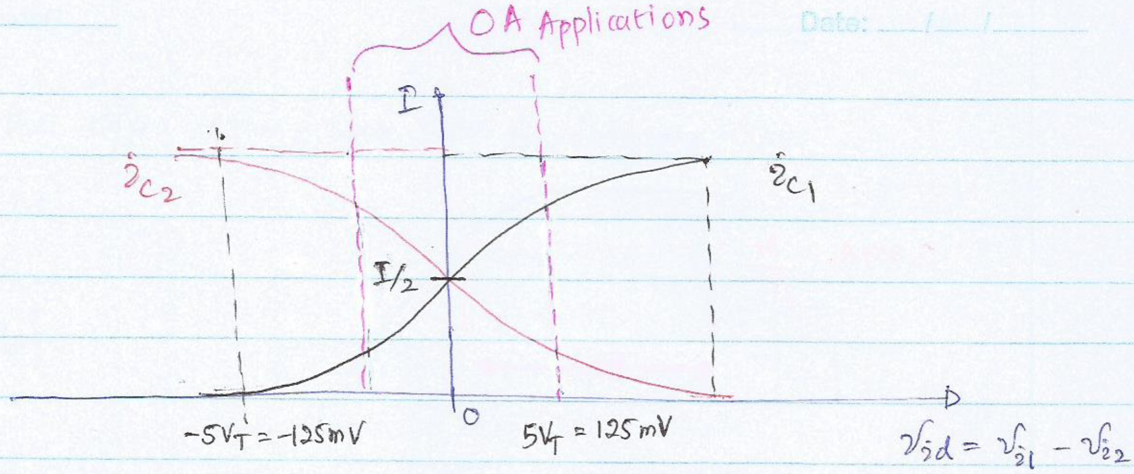


Basic BJT DA

(Differential pair
or
Emitter Coupled Pair)



→ Basis for high speed logic family ECL



OA Can be used,

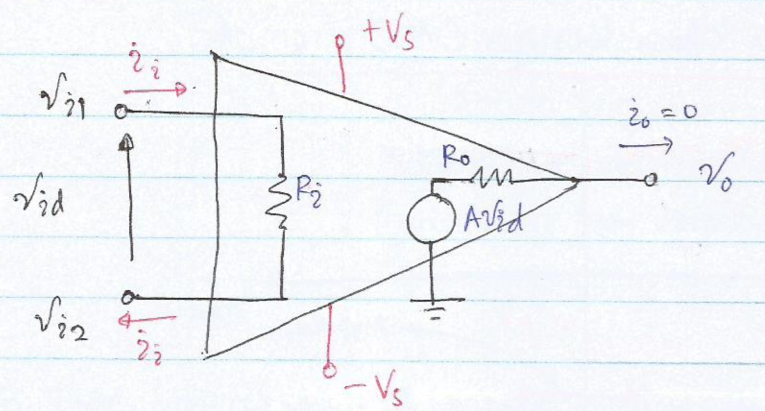
- Open-Loop Configuration
  Limited Applications

- Closed-Loop Configuration (with feedback)
  Many Applications

Important Electrical Parameters of a general purpose IC OA

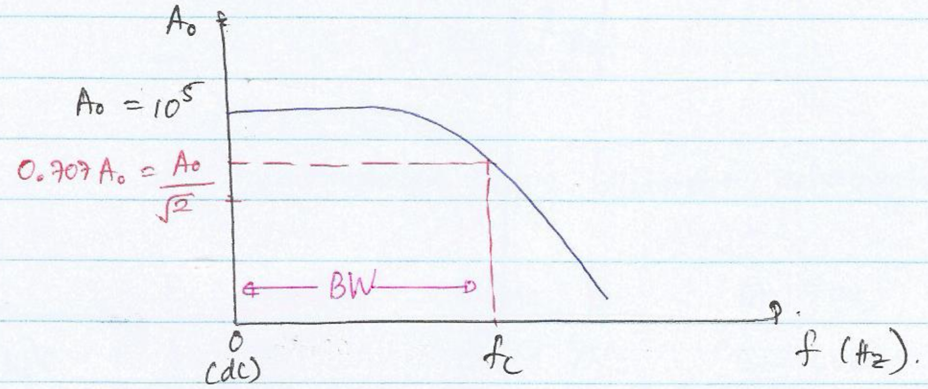
Basic parameters

- Open Loop gain, $A = A_d = \frac{v_o}{v_{id}} = \frac{v_o}{v_{i1} - v_{i2}}$ $= 100\text{ dB}$ $\cong 10^5\ (2\times10^5)$.
- I/P Impedance, R_i – $1M\Omega\ (2M\Omega)$
- O/P Impedance, R_o – 100Ω (   )
- Bandwith, BW – $1MHz\ (1.5\ MHz)$



$$R_i = \frac{v_{id}}{i_i} = \frac{v_{i1} - v_{i2}}{i_i}$$

$$R_o = \frac{v_o|_{oc}}{i_o|_{sc}}$$



Ideal OA

A hypothetical Concept, but important to simplify cct. analysis.

For an IOA,

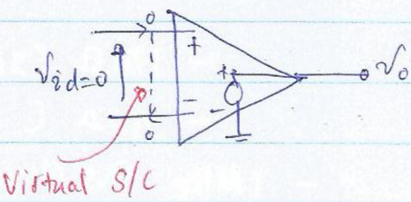
$A = \infty$ $\quad (\therefore CMRR = \infty) \Rightarrow v_{id} = 0$

$v_{i1} = v_{i2}$

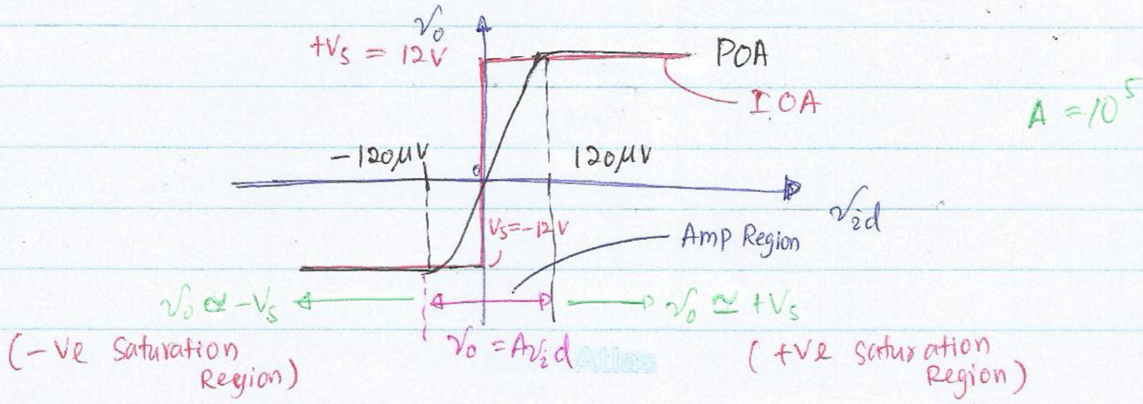
$R_i = \infty$ $\quad (i_i = 0)$

$R_o = 0$

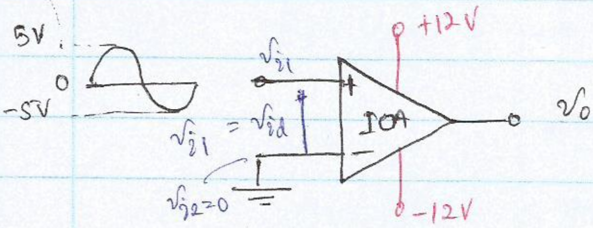
$BW = \infty$

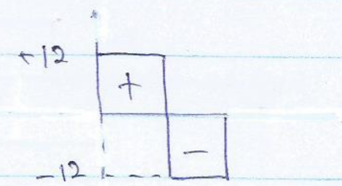


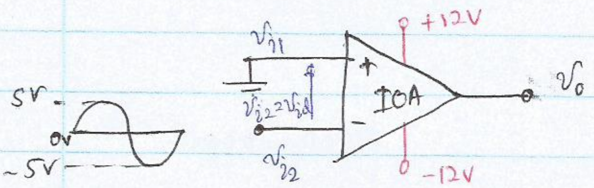
Voltage Transfer Characteristics (VTC) of an OA

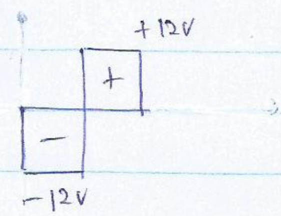


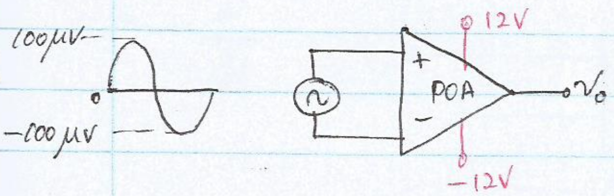
Q1 Sketch the o/p Voltage wave form for following ccts.

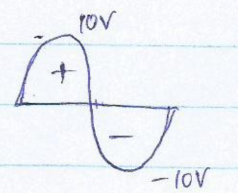








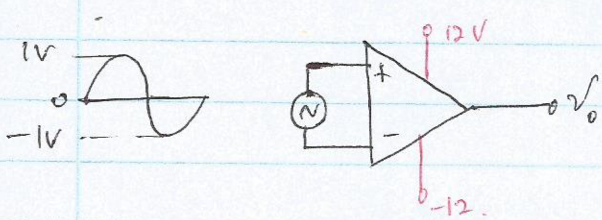


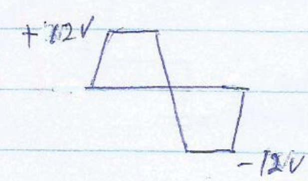


$V_o = A v_{id}$

$= 10^5 \times 100 \times 10^{-6}$

$= 10$





Practical OP Amp CCts.

OP Amp based Amplifiers.

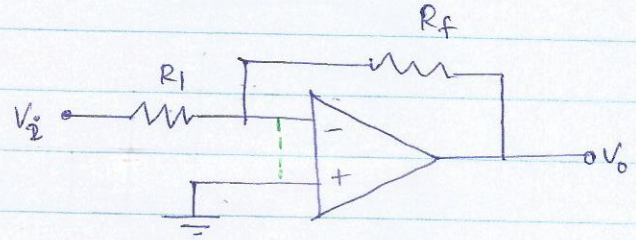
- Inverting Amplifiers (-ve gain)
- Non inverting Amplifiers. (+ve gain.
- Summing Amplifiers (OP Amp adder or Analogue Adder)
- Buffer Amplifiers (unity +ve gain amp)

Unless otherwise mentioned, we may assume an IOA.

← In these applications OA is used in closed-loop Configuration. (Negative Feedback)

Part of the o/p is fed back to the i/p and added (-)vely.

Inverting Amp-



$$\frac{V_i}{R_1} + \frac{V_o}{R_f} = 0$$

∴ Closed loop.

Voltage gain,

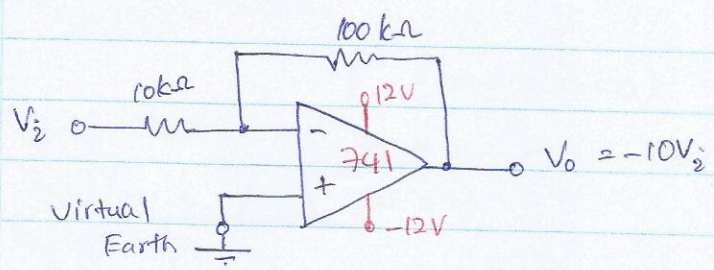
$$\frac{V_o}{V_i} = \frac{-R_f}{R_1}$$

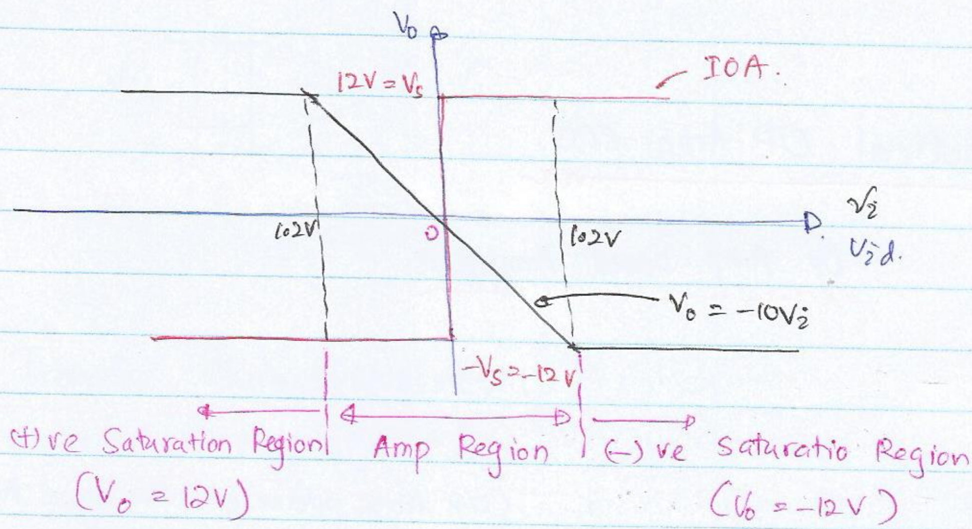
• Open loop

Voltage gain,

$$\frac{V_o}{V_{id}} = \infty$$

ex.





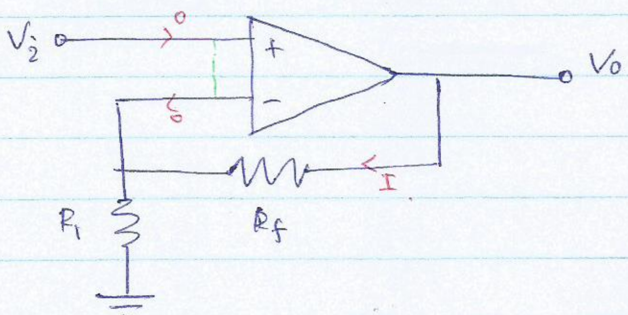
Q2 Sketch the output voltage wave for,

(i) $V_i(t) = 0.5 \sin \omega t$ volts — $V_p = 0.5 < 1.2V$ (o/p not clipped)

$V_o(t) = -5 \sin \omega t$
$= 5 \sin(\omega t + 180^\circ)$

(ii) $V_i(t) = 2 \sin \omega t$ Volts — $V_p = 2V > 1.2V$ (o/p is clipped)

Non Inverting Amp



$$I = \frac{V_o - V_i}{R_f} = \frac{V_i}{R_1}$$

∴ Close Loop Gain,

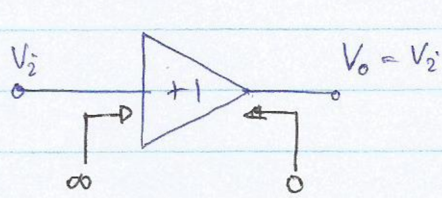
$$\frac{V_o}{V_i} = 1 + \frac{R_f}{R_1} \geq 1$$

Buffer Amp has,

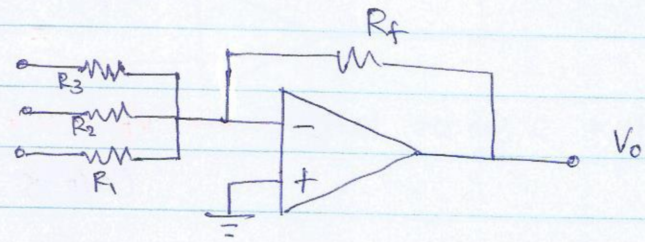
$A_v = \frac{V_o}{V_i} + 1$

$R_i = \infty$

$R_o = 0$



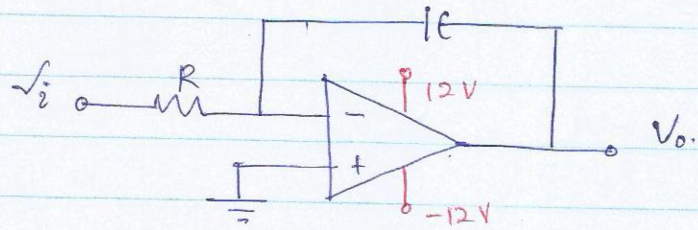
Summing Amplifier



$$V_o = -\left(\frac{R_f}{R_1}v_{i1} + \frac{R_f}{R_2}v_{i2} + \frac{R_f}{R_3}v_{i3}\right)$$

$$V_o = -\left(A_1 v_{i1} + A_2 v_{i2} + A_3 v_{i3}\right)$$

Integrator



$$V_o(t) = \frac{-1}{RC}\int V_1(t)\,dt$$

RC = Integrating time constant (s)

(R: Ω, C: F)

No : ____________ Date: ___/___/______

Q3 sketch the o/p waveform from $t=0$ on wards for,

(a) $V_i = 1V$

(b) $V_i = -1V$

(c) for a squre wave i/p

Assume $R = 1M\Omega$, $F = 1\mu F$ } $RC = 1s$