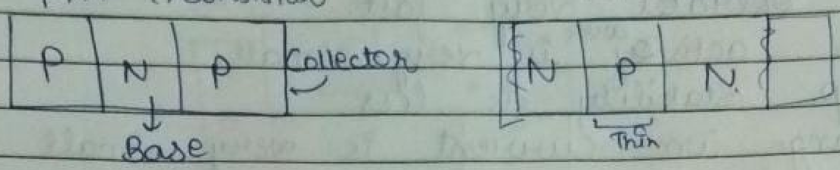
UNIT - 6

Transistors.

PNP transistor NPN transistor.



A semiconductor device consisting of two p-n junctions formed by sandwitching either p-type or n-type semiconductor between a pair of opposite types is known as transistor

It is of two types

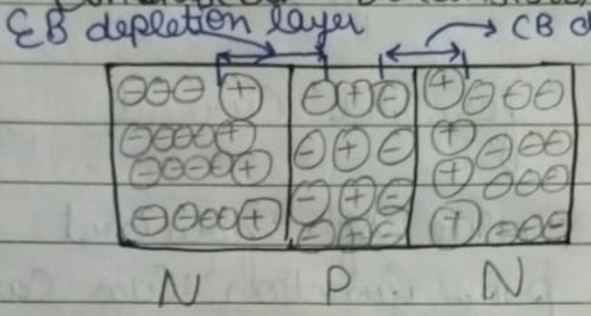
(i) PNP transistor
(ii) NPN transistor

It has 3 terminal

(i.) Emittor
It emitts majority charge carriers and its area.

Base is lightly dopped.
Collector moderately dopped and larger size

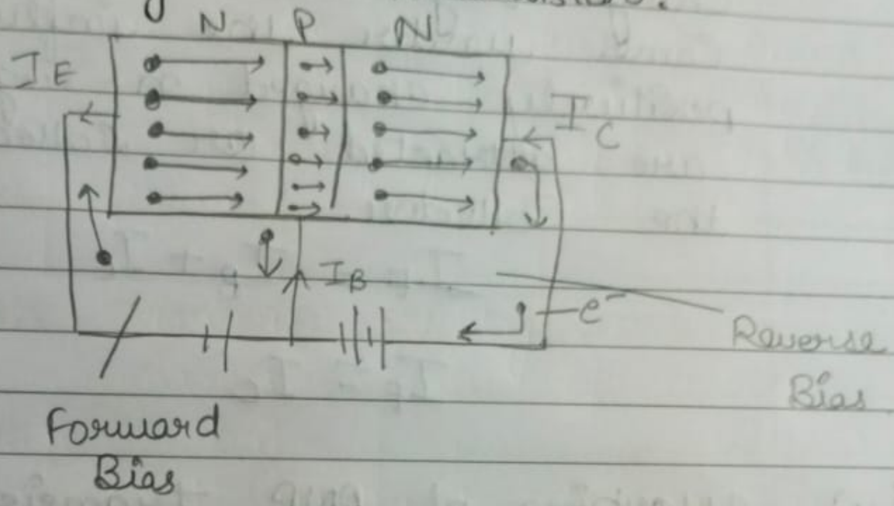
Unbiased Transistor



The more heavily doped a region is the greater is the Concentration of ions near the junction. This means that the depletion layer panitrates slightly into the emitter region (heavily doped) but lightly into the base (lightly doped Therefore the depletion layer formed at the emittea junction is smaller.

However at the Collector junction the depletion layer penetrates deep into the base (lightly doped) and a quiet deep into the Collector (Moderatly doped) therefore the depletion layer formed at the collector junction is larger comparitively

working NPN transistor.



As the emitter based junction is forward bias a large number of electrons in the emitter are pushed towards the base this consetutes the emitter current I_E when these electrons enter the P-Type material they tend to combine with the holes. Since the base is lightly doped and very thin only a few electrons combined with the holes to consetute base current I_E.

__/__/____

The remaining electrons diffuse accross the thin base region and reach the Collector space charge layer. These electrons then Come under the influence of positively charged n-region and are attracted or collected by the Collector.

$$I_E = I_B + I_C$$

$$I_E \simeq I_C$$

H/W Working of PNP transistor.

Ques imp for exam $\boxed{\text{2 marks}}$

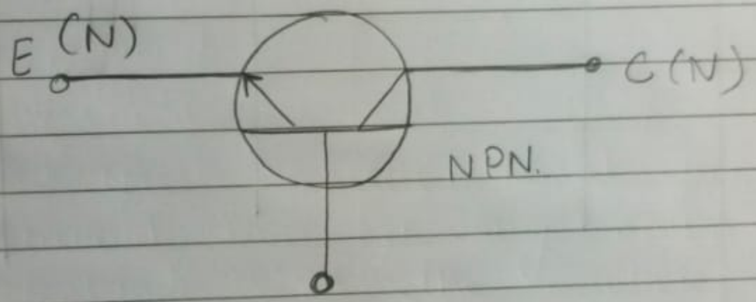
Is it possible for two discreate diode connected back to back can act as a transistor?

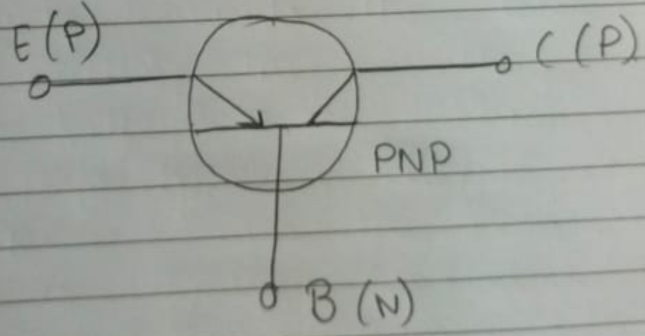
NO, bcoz transistor doped

Diff. operating Conditions of transistor.

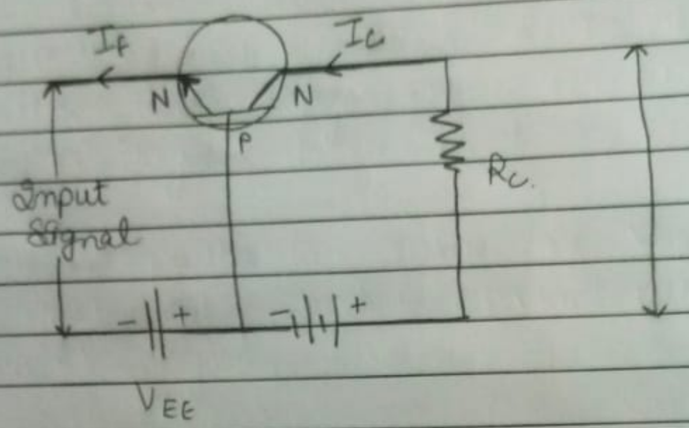
Condition	Emitter $J x^n$	Collector $J x^n$	Region of operatn
FR	F.B	R.B	Active
F.F	FB	FB	Saturation
RR	RB	RB	Cut-off
RF	RB	FB	inverted.

Draw Symbols of Transistor.





Common Base Configuration of Transistor



* Current Amplification factor denoted by α.

$$\alpha = \frac{I_C}{I_E} \quad \begin{matrix} \leftarrow \text{Output} \\ \leftarrow \text{Input} \end{matrix}$$

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

$$I_E = I_C + I_B$$

$$\Delta I_E = \Delta I_C + \Delta I_B$$

$$\frac{\Delta I_E}{\Delta I_E} = \frac{\Delta I_C}{\Delta I_E} + \frac{\Delta I_B}{\Delta I_E}$$

$$1 = \alpha + \frac{\Delta I_B}{\Delta I_E}$$

$$\boxed{\alpha = 1 - \frac{\Delta I_B}{\Delta I_E}}$$

value of α is always less than 1.

2. Collector Current.

~~a larg~~ The total Collector current Consist of

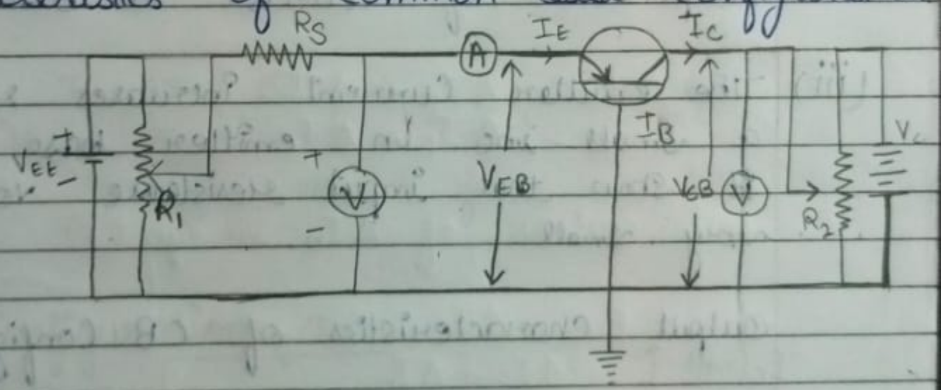
(i) ~~a~~ large porcentage of Emitter Current that reaches the Collector terminal.

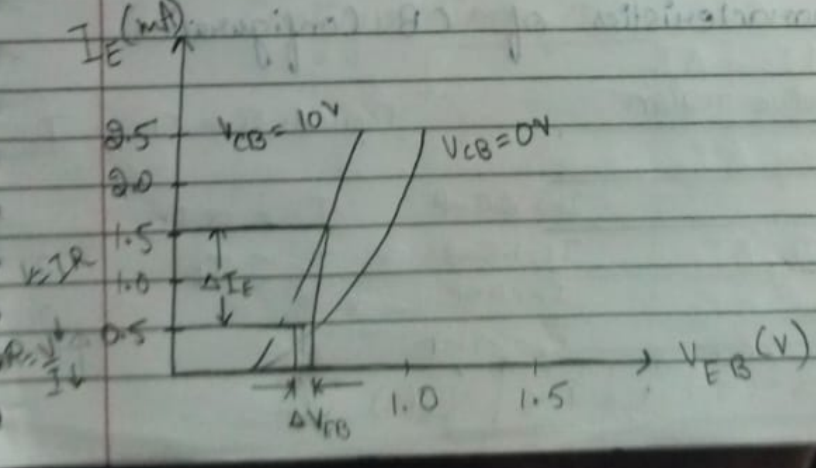
$$I_C = \alpha I_E$$

(ii) The leakage current due to the movement of minority Carrier. This Current is Calculated when Emitter Circuit is open.

$$I_C = \alpha I_E + I_{CBO}$$ open

Input Characteristics of Common base Configuration





Input Char

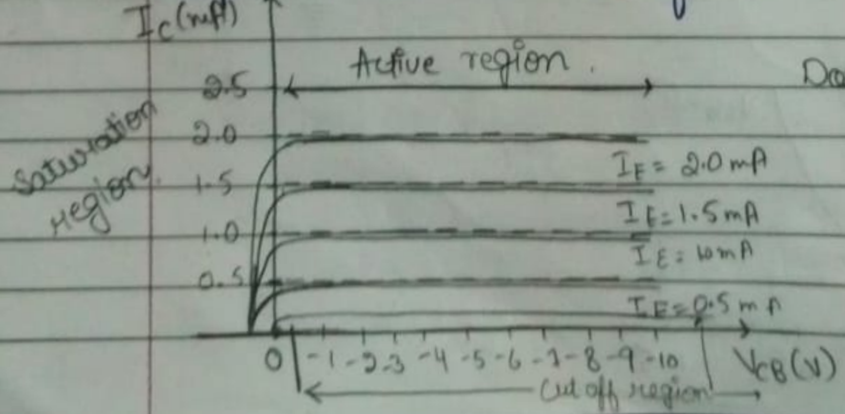
In common base configuration the curve plotted b/w emitter current and emitter base voltage at constant collector base voltage is called Input Characteristic Curve.

(i) For a particular value of V_{CB} the curve is just like diode characteristic in the forward region.

(ii) When V_{CB} is increased the value of I_E increase slightly for the given value of V_{EE} hence the junction becomes a better diode.
It also reveals that emitter current and hence the collector current is almost independent of collector to base voltage.

(iii) The emitter current increases rapidly with a small inc in emitter base voltage. It show that input resistance voltage is very small

Output characteristics of CB Configuration



Dotted line show I_C

$I_C = \alpha I_E$

$I_C \simeq I_E$

In Common Base Confi. the curve plotted b/w Collector current and Collector based voltage and Constant emitter current is called output Char.

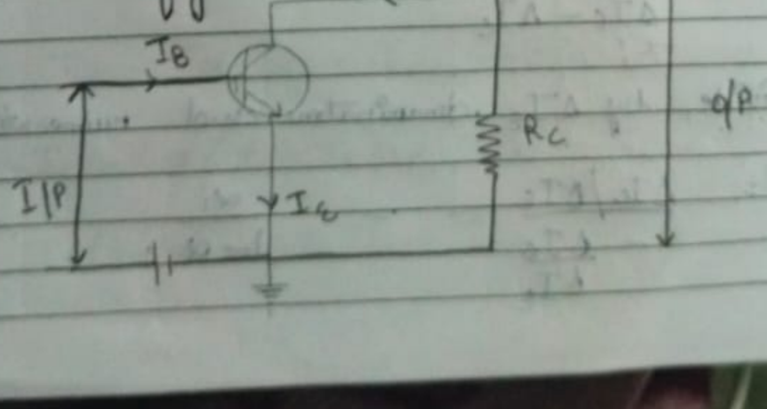
(i) In the active region where collector based junction is reverse biased. Collector current is almost equal to emitter current.

(ii) In the active region the curves are almost flat a very large chang V_{CB} produces only a tiny change in I_E, it means the Circuit have very high output r.

(iii) when base voltage becomes +ve i.e C.b.j is forward biases current decreases abruptedly This is called Saturation current. In this region, I_C doesn't depend much on I_C.

(iv) when I_E ~~is~~ $= 0$, $I_C \neq 0$ although its value is very small. Infact this is a reverse leakage current flows in the collector circuit

CE Configuration.



Characteristics

CE

Current & Amplication factor = β

i_C = output current

i

Current Amp. factor β is defined as ratio of change in Collector current to the change in base current

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

we also know,

$$\Delta I_E = \Delta I_B + \Delta I_C$$
$$\Delta I_B = \Delta I_E - \Delta I_C$$

put values of ΔI_B in eqn (1.)

$$\beta = \frac{\Delta I_C}{\Delta I_E - \Delta I_C}$$

Divide by ΔI_E denominator and numerator.

$$\beta = \frac{\Delta I_C / \Delta I_E}{1 - \frac{\Delta I_C}{\Delta I_E}} = \frac{\alpha}{1-\alpha}$$

Date
Page

$$\boxed{\beta = \frac{\alpha}{1-\alpha}}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

$$\beta+1 = \frac{\alpha}{1-\alpha}+1 = \frac{\alpha+1-\alpha}{1-\alpha}$$

$$\boxed{\beta+1 = \frac{1}{1-\alpha}}$$

$$1-\alpha = \frac{1}{\beta+1}$$

$$1-\frac{1}{\beta+1} = \alpha$$

$$\alpha = 1-\frac{1}{\beta+1} = \frac{\beta+1-1}{\beta+1}$$

$$\alpha = \frac{\beta}{\beta+1}$$

Collector Current.

$$I_E = I_C + I_B \text{ —(i.)}$$

$$I_C = \alpha I_E + I_{CBO} \text{ —(ii.)}$$

$$I_C = \alpha(I_C + I_B) + I_{CBO}$$

$$I_C(1-\alpha) = \alpha I_B + I_{CBO}$$

$$I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO} \quad \text{--- (iii)}$$

In CE Configuration, if base circuit is open $I_B = 0$

$$I_{CEO} = \frac{1}{1-\alpha} I_{CBO}$$

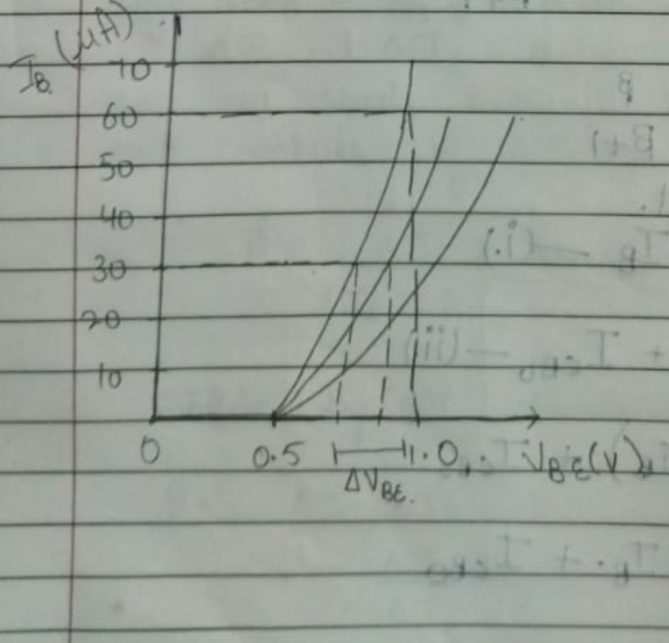
Put in eq^n (iii)

$$\boxed{I_C = \frac{\alpha}{1-\alpha} I_B + I_{CEO}}$$

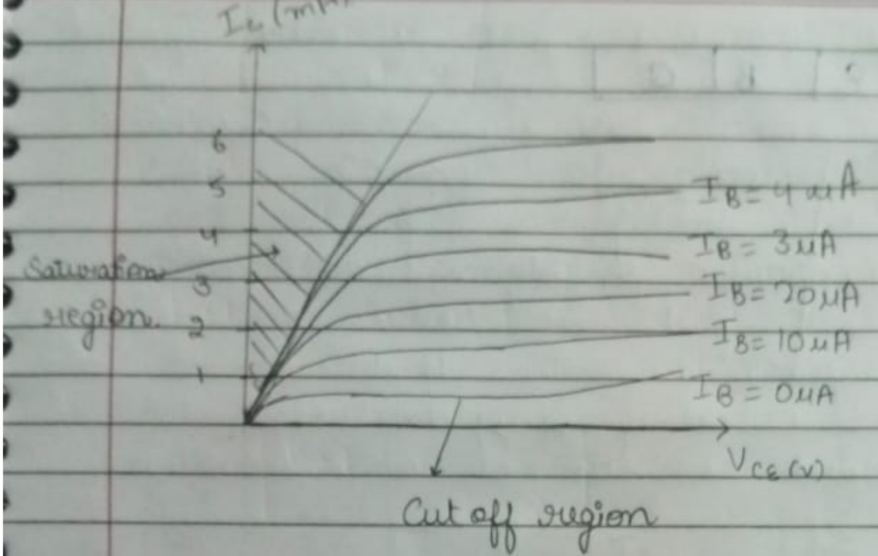
$$I_C = \beta I_B + I_{CEO}$$

Characteristics of Common Emitter Configuration

I/P characteristics of CE.



Date
Page



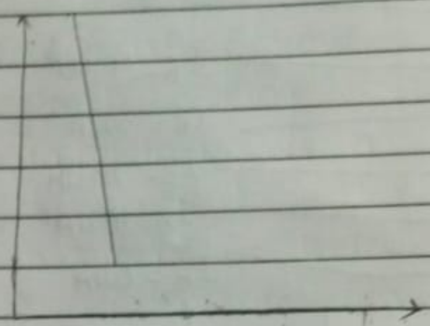
The curves are similar to those obtained for common base Configuration. The only difference is that in this case I_B increases less rapidey with increase V_{BE}. Hence the Input resistance of Common Emitter Configuration is Comparitevly higher than C.B Configuration.

In active region I_C increase slightly and V_{CB} increases. The slope of curve is little bit more of output chardcteristic of C.B Configuration. Hence, output resistance of their Confi. is less as Compared to C.B Configuration.

Common Collector Configuration
Circuit diagram
Derivation for gamma
Collector current
Input & output characters

RB↑↑ | B | C | E |
I_B ↓↓

$V_{EB}\uparrow\uparrow$ | E | B | C |

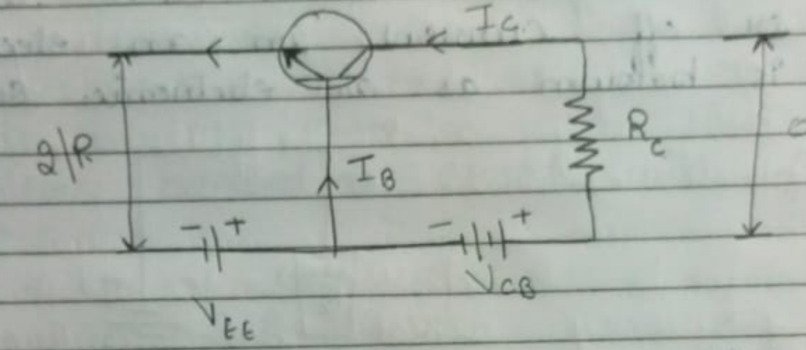


- On the basis of input resist.
- " " " output "
- Current gain
- voltage gain

Application

Transistor as an amplifier

A transistor is a device which raises the strength of weak signal. Thus act as an amplifier. The basic transistor amplifier circuit is shown in fig below.



$V = IR$

$\frac{V}{R} = I$

when a weak signal is applied at the input.
Causes an appriciable change in emitter current (change of 0.1V in signal voltage causes the change of 1mA in the the emitter current) as the input ckt has very low resistance. This causes, almost the same change in collector ckt due to transistor

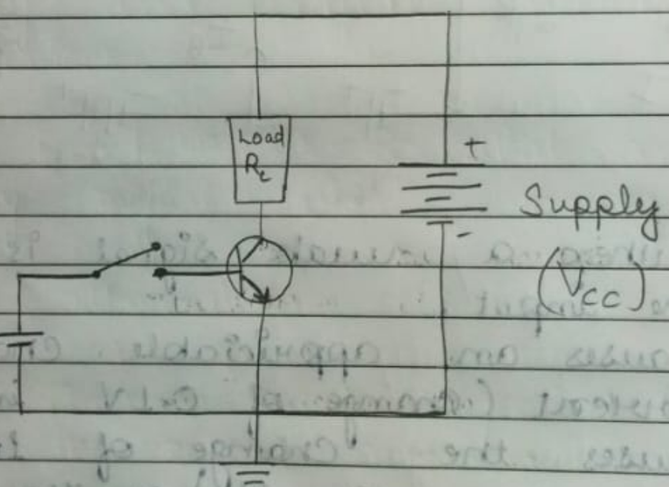
In collector ckt a load resistor of high value say 10KΩ. when C.C flows through such a high resistance. It produces a large voltage drop across. Circuit.

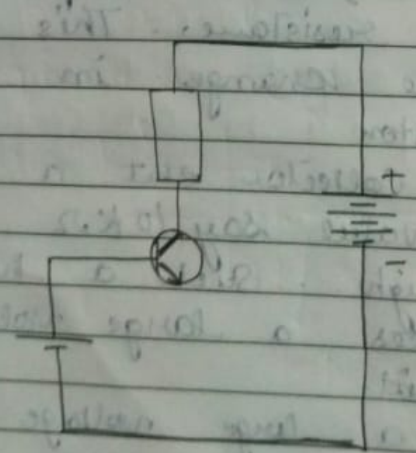
It produces a large voltage drop Vo is equal to

Thus a weak signal of 0.1V applied at the input Ckt. Appear at in the amplifier ~~The I/P~~ Ckt appear 10V in the Collector Ckt.

Transistor as a Switch.

An electronic device that turns on or off current in an electronic ckt is known as an electronic switch.





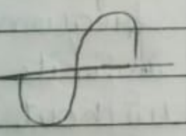
Date
Page

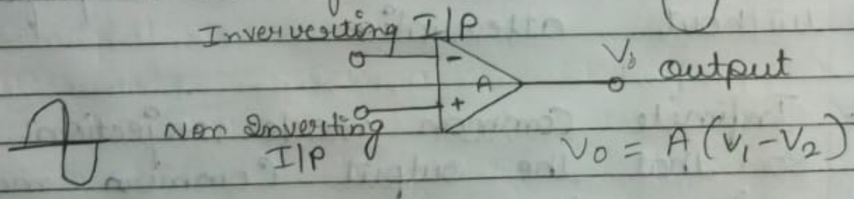
When the switch as is open the transistor is in cut of state and no current flows in the collector Ckt. Thus the transistor behave as open switch for the collector Ckt

When the switch as is closed the base emitter junction is forward bias and the transistor comes into conducting stage or state. At this state current flows in the collector Ckt. Thus the transistor behaved as closed switch for the C.C.

Operational Amplifier.

Schematic Symbol.

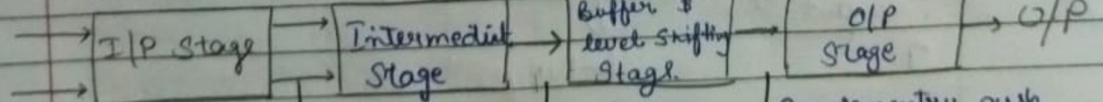




$V_0 = A(V_1 - V_2)$

A.
Large signal voltage gain
B.

Block diagram representation of



Dual I/P balanced O/P → Reject Noice → High I/P Impedence → High voltage gain	Dual I/P unbalanced O/P → Provide very↑ voltage gain	Emitter follower. → ↑I/P R (↓I) reduces loading → Low O/P R → Set DC level to zero	Complementary push pull amp. → Dec O/P Impedence → Raise current supply to O/P → Increase O/P voltage swing.

FREEMIND

Date

Page

The Ideal op-amp.

an Ideal op-amp would a exhibit with the following characteristic

1. [(A) infinite voltage gain]

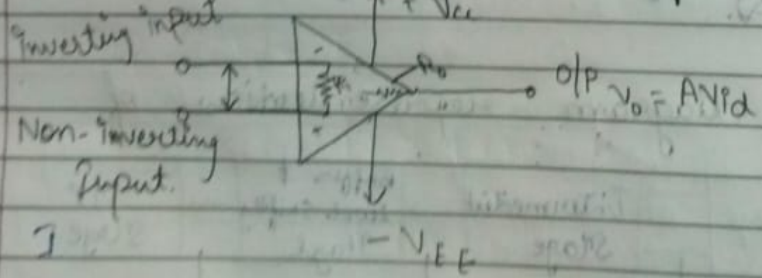
2. Infinite input resistance so that any signal source can drive it and there is no loading of preceding state

0 output resistance so that output can dry and infinite number of other devices.

4. Infinite Band-width. So that any frequency signal from zero to infinite hertz can be amplified without attenuation.

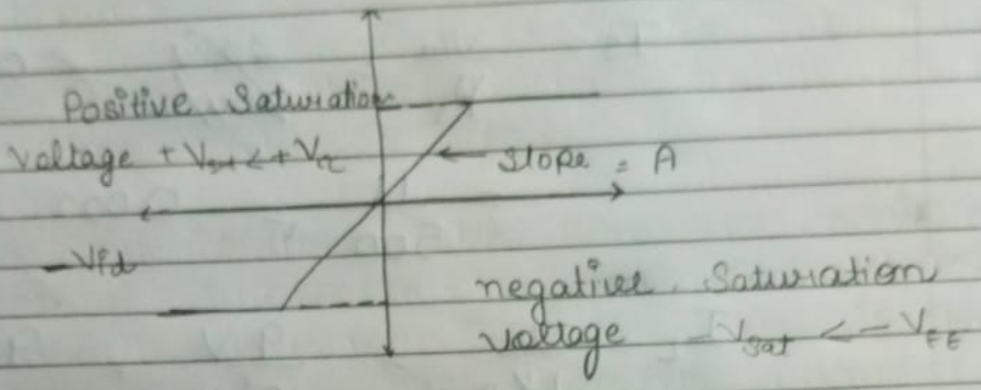
4. Infinite Common mode rejection Ratio. So that the output Common mode noise voltage is zero.

Equivalent Crt of an op-amp.



I

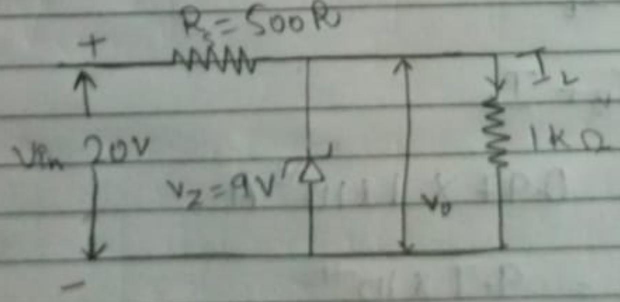
Ideal voltage transfer curve.



output voltage is directly proportional to the input difference until it reaches the saturation voltages and there after the output voltage Remain Constant as shown in figure.

Ques For Ckt shown in the figure below.

(i) output voltage
(ii) voltage drop across the series resistance.
(iii) Current through zener diode.



(i) $V_0 = V_Z = 9V$

(ii) $V_s = V_{in} - V_Z$
$= 20 - 9$
$= 11V.$

(iii.) Istly you must know I_S

$$I_S = \frac{V_{in}}{R_s} = \frac{\cancel{20}\,V}{\cancel{500}\,\Omega} \neq \cancel{0.04}$$

$$= \frac{11}{500} = 0.022.$$

$$I_L = \frac{V_0}{1K\Omega} = \frac{9\,V}{10^3\,V} = 9\times10^{-3}\,A$$

$$I_Z = I_S - I_L$$

$$= 0.022 - 0.009$$
$$= 0.013\,A.$$

Ques. In a Common base Configuration the Current amplification factor is 0.97 If the emitter Current is 1mA. Determine the base.

$\alpha = 0.97$

$I_c = \alpha I_E$

$I_E = I_B + I_c$

$I_c = 0.97 \times 1\times10^{-3}\,A$

$I_c = 9.7\times10^{-4}$

$I_E = I_B + I_c$

$1\times10^{-3}A = I_B + 9.7\times10^{-4}$

$10^{-3}A - 0.97\times10^{-3} = I_B$

$I_B = 0.03\ mA.$

In a Common Base Connection emitter Current is 1mA. If Collector Current is open. 20mA. when the emitter Ckt current when Determine the total collector current. $\alpha = 0.95$ and also find the base current.

$I_C = \alpha I_E + I_{CBO}$

$\alpha = 0.95$

$I_E = 1\ mA$ milli

$I_{CBO} = 20\ \cancel{micro}\ m\ A$

$I_C = 0.95 \times 1\,mA + 20 \times mA$

$= 20.95\ mA$