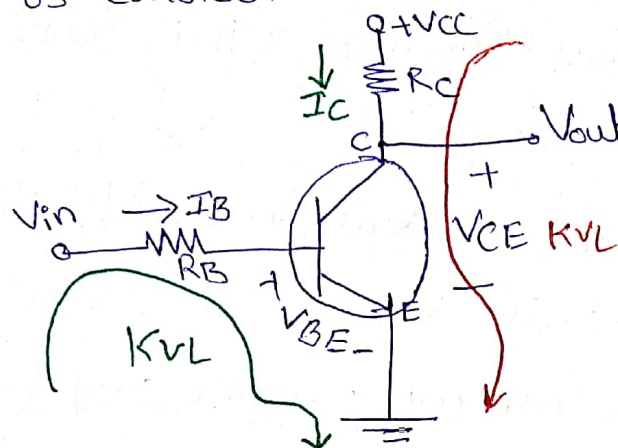


* BJT as a Switch and Amplifier:

(17)

Let us consider a BJT in common emitter configuration



Apply KVL in o/p side

$$-V_{CC} + I_C R_C + V_{CE} = 0$$

$$V_{CE} = V_{CC} - I_C R_C$$

$$\underline{V_{out} = V_{CE} = V_{CC} - I_C R_C}$$

case(1): Let $V_{in} = 0$; base voltage remains zero and transistor will remain 'OFF'. $\rightarrow$ conduction is not possible, $I_B = 0$
 $I_C = 0$

$$\therefore \boxed{V_{out} = V_{CC}}$$

case(2): Let $V_{in} > 0$; for small values of V_{in} transistor will not begin conduction, because to begin conduction V_{BE} should exceed $V_{BE \text{ cut-in}}$ (around 0.6 volts)

$$\therefore T \rightarrow \text{OFF}, I_B = I_C = 0 \quad \boxed{V_{out} = V_{CC}}$$

case(3): Let V_{in} increased sufficiently, then V_{BE} can exceed $V_{BE \text{ cut-in}}$, and transistor begins conduction

I_B & I_C starts flowing
Apply KVL in input side

$$-V_{in} + I_B R_B + V_{BE} = 0$$

$$I_B R_B = V_{in} - V_{BE}$$

$$I_B = \frac{V_{in} - V_{BE}}{R_B}$$

(R_B Limits I_B)

$$\underline{I_C = \beta I_B}$$

where ' β ' is a large number, $\therefore$ a small base current is enough to get large I_C . $\underline{V_{out} = V_{CC} - I_C R_C}$

→ If V_{in} is continuously increased, I_B & I_C will increase, (18)
where as V_{out} will decrease.

→ This decrease in V_{out} continues till it reaches minimum value ' V_{CEsat} '.

case (4):- Let $V_{in} \uparrow$, further, as V_{out} (or) V_{CE} has already reached minimum value V_{CEsat} , it can not decrease any further, $\therefore I_C$ can not increase any further (or) I_C gets saturated,

$$I_{Csat} = \frac{V_{CC} - V_{CEsat}}{R_C}$$

but base current $I_B = \frac{V_{in} - V_{BE}}{R_B}$ will continue to increase as V_{in} increases.

This condition in which $I_B \uparrow$, but I_C remains constant is called "saturation". in this saturation transistor does not obey $I_C = \beta I_B$ Relation so $I_C < \beta I_B$

' β ' of a transistor in saturation is called "forced β "

$$\beta_{forced} = \frac{I_{C(sat)}}{I_B} \quad ***$$

If $V_{in} \uparrow$, $I_B \uparrow$, $\beta_{forced} \downarrow$

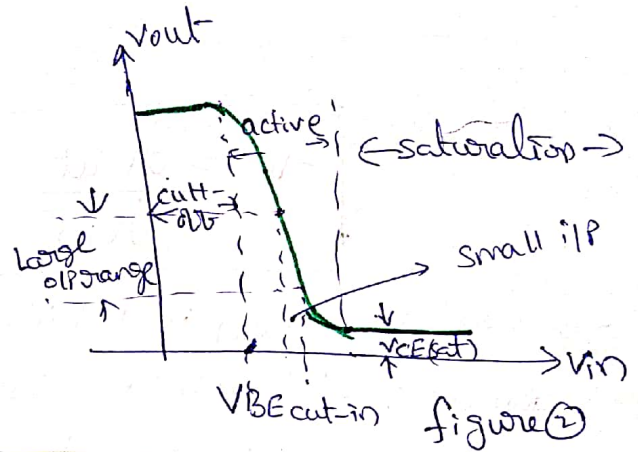
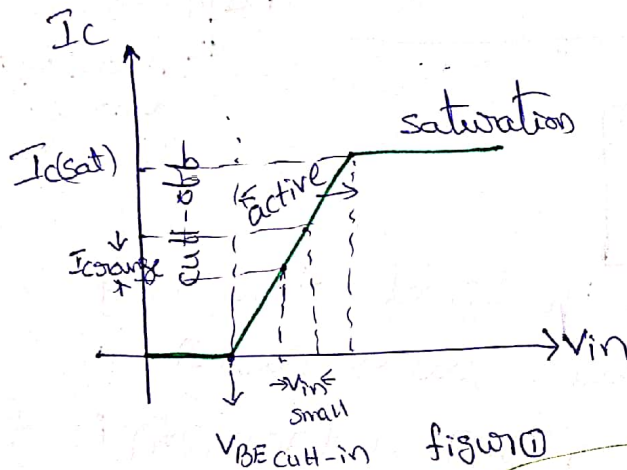
"Decrease in ' β ' implies that, the amplification ability of transistor becomes smaller in saturation."

over drive:- is the ratio of normal β and forced β . (19)

$$\text{over drive} = \frac{\beta}{\beta_{\text{forced}}}$$

"over drive is a measure of how deeper, the transistor is pushed into saturation".

→ Large over drive indicates 'deep saturation'.



cut-off:- $I_c = 0$ & $V_{out} = V_{CC} \rightarrow$ OFF Switch (open ckt)

saturation:- $I_c = I_{c(sat)}$, & $V_{CE} = V_{CE(sat)} \approx 0 \rightarrow$ ON switch (short ckt)

Active region:- Region of the graph, where I_c & V_{out} will actively change with V_{in} .

→ when a transistor is operated in active region, a small change in i/p is enough to produce a large change in o/p, current and voltage; Hence transistor can act as a "Amplifier".

we have to observe above two figures

→ The slope of I_c vs V_{in} plot in active region is called "Trans conductance" of the BJT.

Small Signal Transconductance = $g_m = \frac{\Delta I_C}{\Delta V_{in}}$ figure ①

$$g_m = \frac{dI_C}{dV_{in}}$$

$\Delta V_{in} \rightarrow 0$
 $\downarrow$
 V_{in} changes by small amount

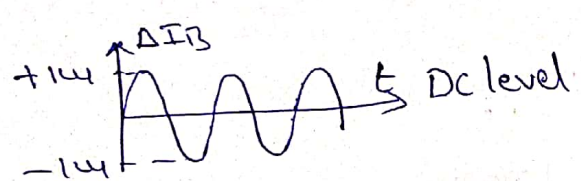
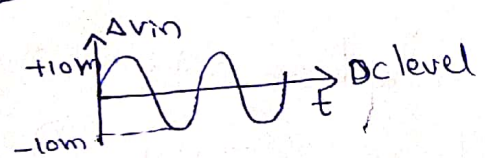
Small signal voltage gain = $A_v = \frac{\Delta V_{out}}{\Delta V_{in}}$ figure ②

$$A_v = \frac{dV_{out}}{dV_{in}}$$

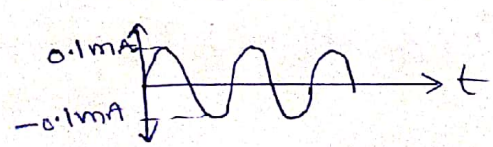
$\Delta V_{in} \rightarrow 0$
 $\downarrow$
 changes by small amount.

- An amplifier in which i/p signal changes by small amount is called "small signal amplifier".
- In a small signal amplifier, a transistor is forced to operate in active region, so that I_C v/s V_{in} (fig ①) and V_{out} v/s V_{in} (fig ②) plots become linear, and thus o/p current & voltage will be a replica of i/p then o/p is undistorted.

EX:- $\Delta V_{in} = \pm 10mV$

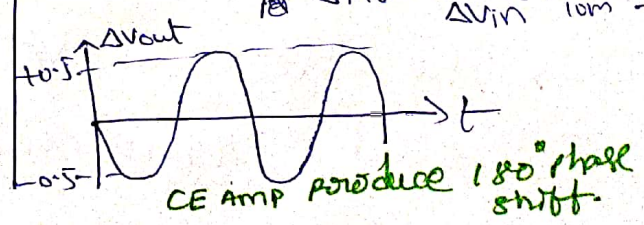


$\Delta I_C = \beta \cdot \Delta I_B ; \beta = 100$
 $\Delta I_C = (100)(\pm 1\mu A) = \pm 0.1mA$



$V_{out} = V_{CC} - I_C R_C$
 $\Delta V_{out} = 0 - (\Delta I_C R_C) \quad (\because \Delta V_{CC} = 0)$
 $= -\Delta I_C R_C$
 $= -(\pm 0.1m) \times 5K$
 (as $R_C = 5K\Omega$)

$\Delta V_{out} = \pm 0.5V$
 $\Delta A_v = \frac{\Delta V_{out}}{\Delta V_{in}} = \frac{0.5-50}{10m}$



⊗ Transistor as a Inverter:-

(21)

→ Inverter means invert the signals, when we apply any signal input to the inverter, the inverter will invert the signal and reverse at the output.

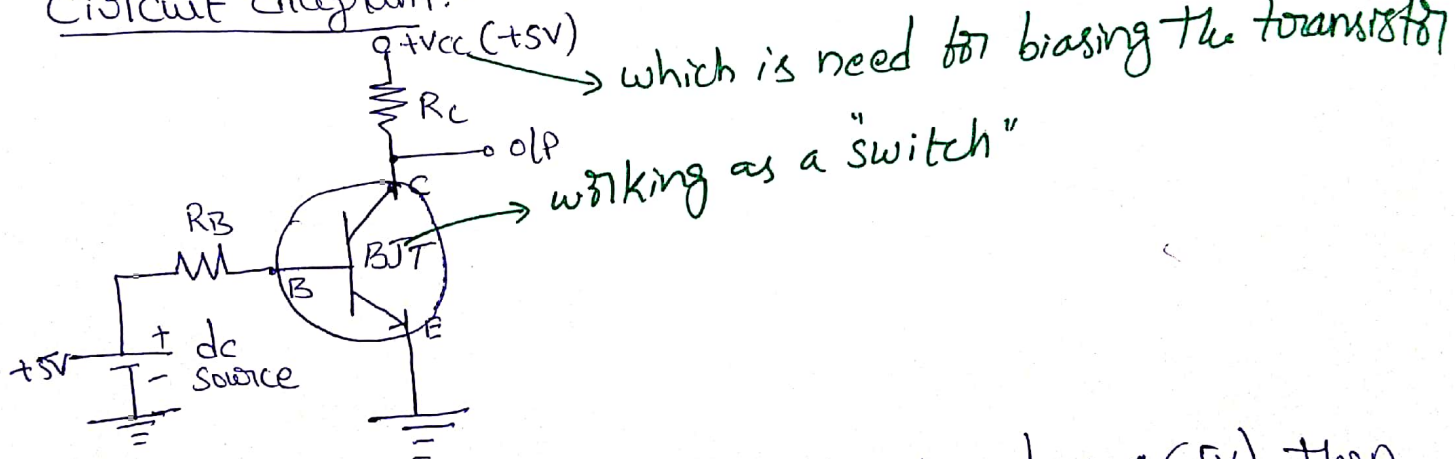
EX:-  NOT gate logic

Function of Inverter:-

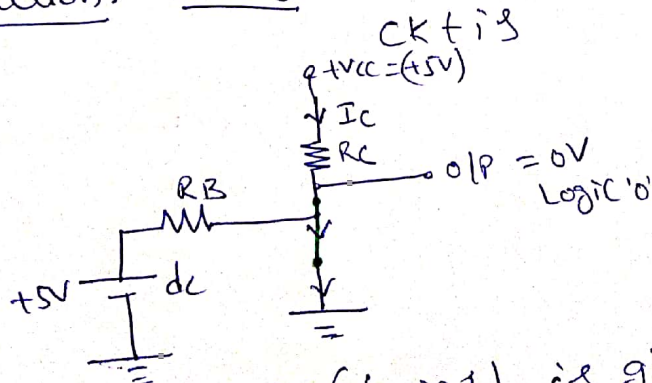
when

$i/p = 0$ then $o/p = 1$ [Here logic 0 = 0V
 $i/p = 1$ then $o/p = 0$ logic 1 = 5V]

Circuit diagram:-

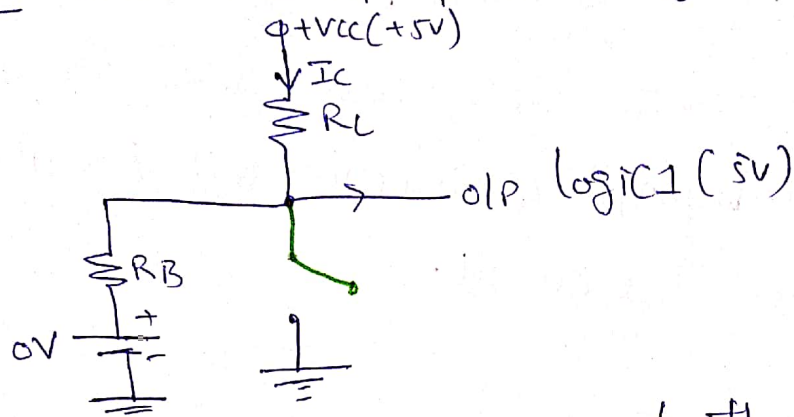


operation:- case (i): when we apply input is logic 1 (5V) then



Here i/p is 5V (logic 1) is given to the base terminal then BJT will act as a closed switch then direction of all the currents grounded through R_C , then output we will get logic '0' (0V).

case ②: when we apply i/p is logic '0' (0V) then ckt is (22)



Here i/p is 0V (logic 0) is given to the base terminal then BJT will act as open switch then all the current set at the o/p, so o/p is logic 1 (+5V).

