Biasing:

Setting the value of V_{GS} (or V_{BE}) for the given circuit is called biasing.

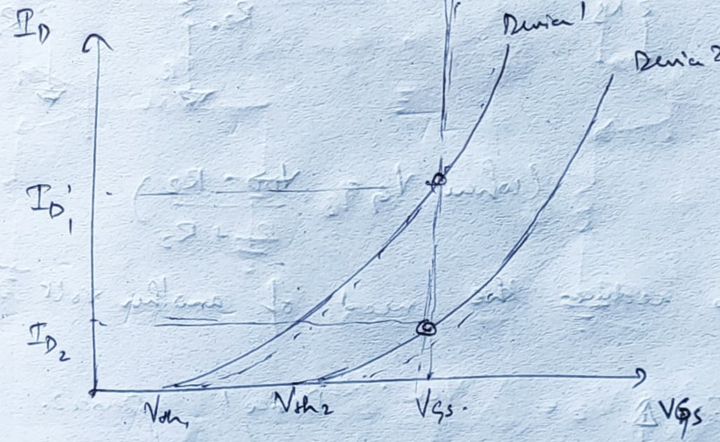
Generally, the properties of two transistors (even from the same manufacturer) can vary significantly. Hence, it is recommended to bias the transistor in such a way that it can be used for other transistors as well.

MOSFET:

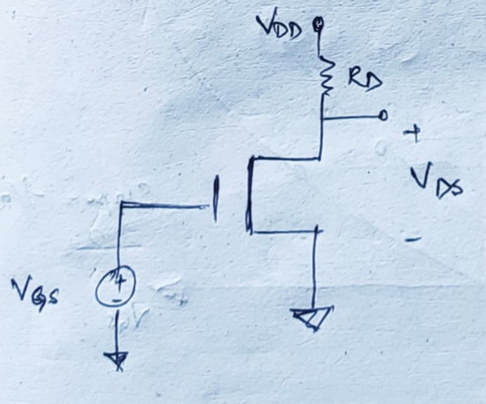
(*). Fixing V_{GS} (not good at all).

$$I_{D} = \frac{1}{2} K_n (V_{GS} - V_{th})^2 \Rightarrow g_m = K_n (V_{GS} - V_{th}) = \frac{I_D}{(V_{GS} - V_{th})}$$

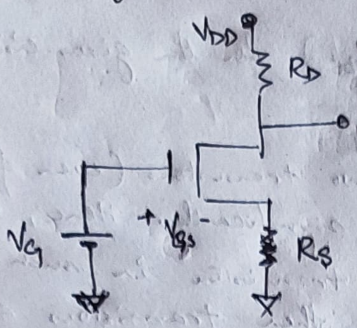
Since V_{th} varies with transistors, the gain we get for different transistors. Hence, it is not recommended.



Ckt:



(*) Fixing V_G and connecting a source resistance



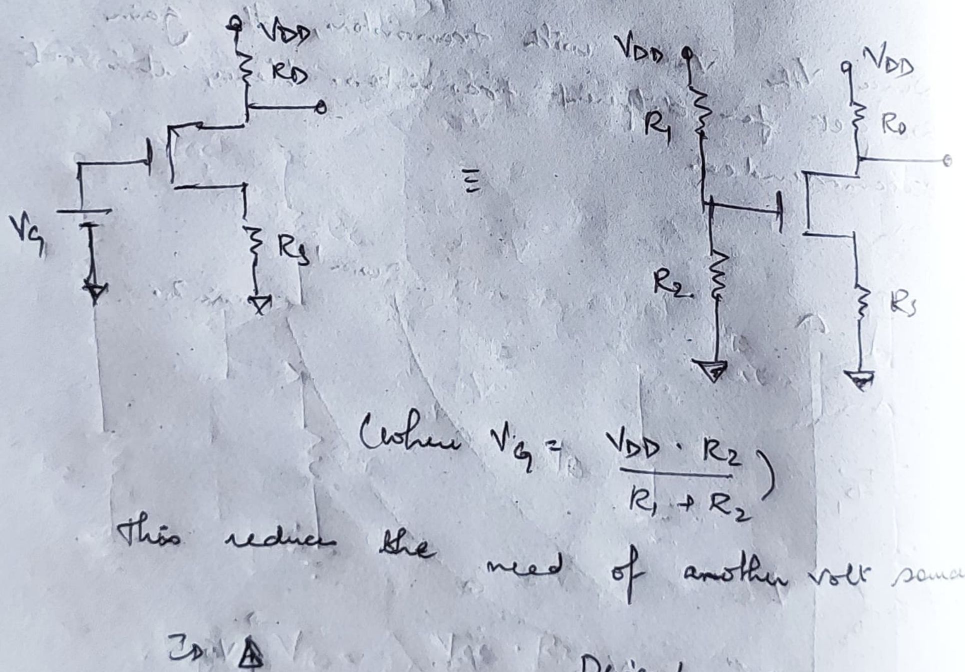
$V_G = V_{GS} + R_S I_D$

If $V_G >> V_{GS}$:

V_G and R_S will mostly determine I_D.

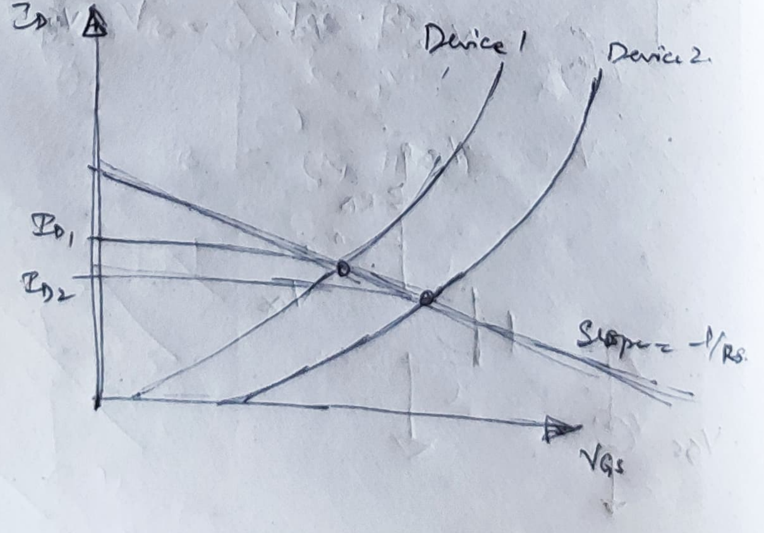
For a not so significant difference b/w V_G and V_{GS} the resistance R_S provides a -ve feedback which prevents change in I_D.

PS! ckt can be redrawn as.

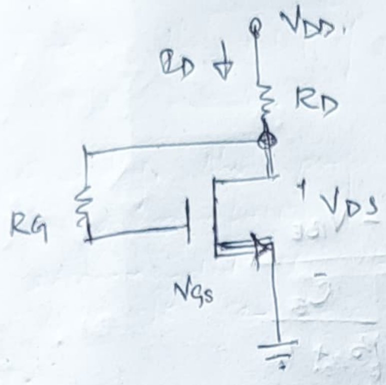


(where $V_G = \frac{V_{DD} \cdot R_2}{R_1 + R_2}$)

this reduces the need of another volt source



(*). Using drain-to-gate feedback



A large R_G is used to bias the gate.

Since R_G is large, no current i_G will pass, causing $\boxed{i_G = 0}$.

$$V_{GS} = V_{DS} = V_{DD} - R_D I_D$$

or. $V_{DD} = V_{GS} + R_D + I_D$.

This is similar to the previous case.

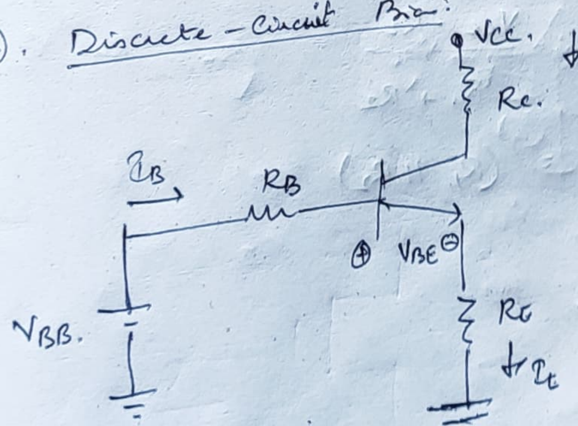
BJT:

Bad biasing schemes:

- Keeping V_{BE} constant.
- Fixing i_B

Reason: Same as fixing V_{GS} of MOSFET.
(diff properties, diff amplification).

(*). Discrete-Circuit Bias:



$$V_{BB} = V_{BE} + I_B \cdot R_B + I_E R_E.$$

$$\left[\because I_B = \frac{I_E}{\beta+1} \right]$$

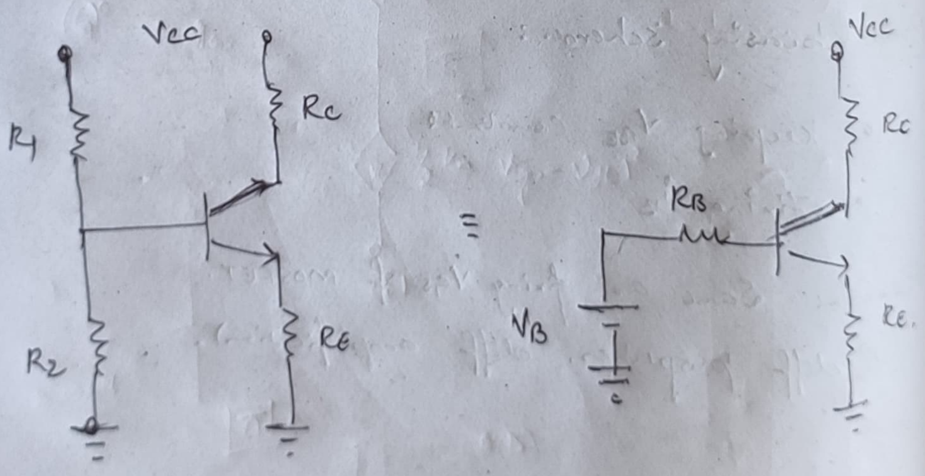
$$\Rightarrow I_E = \frac{V_{BB} - V_{BE}}{R_E + \frac{R_B}{\beta+1}}$$

Since β and V_{BE} change with devices, for somewhat fixed I_E,

$$V_{BB} >> V_{BE}$$

$$R_E >> \frac{R_B}{\beta+1}.$$

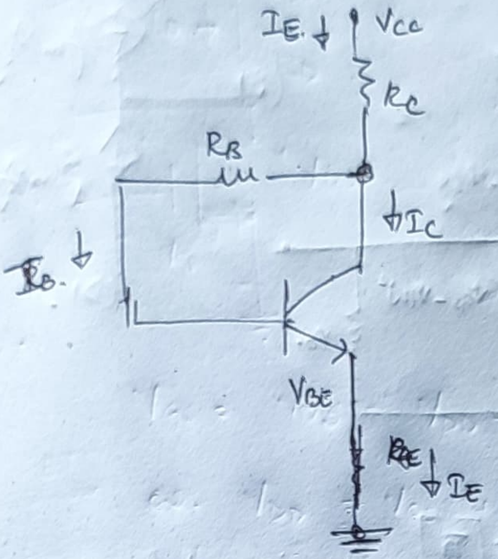
Circuit can be redrawn as:



where $V_B = \frac{V_{cc} \cdot R_2}{R_1 + R_2}$

$$R_B = (R_1 \parallel R_2)$$

(*). Using Collector to Base feedback resistor:



$$V_{CC} = I_E \cdot R_C + R_B \cdot I_B + V_{BE}$$

$$\Rightarrow \quad I_E = \frac{V_{CC} - V_{BE}}{R_E + \frac{R_B}{\beta + 1}}$$

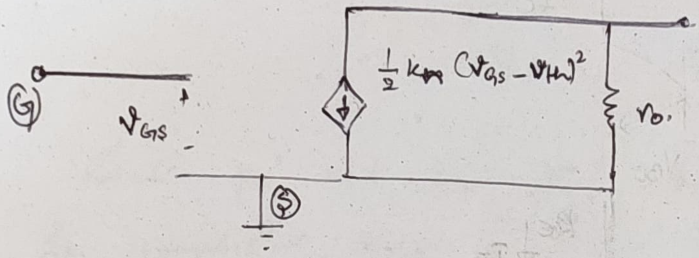
Similar to previous case.

Amplifier Models: (Recap)

N MOS

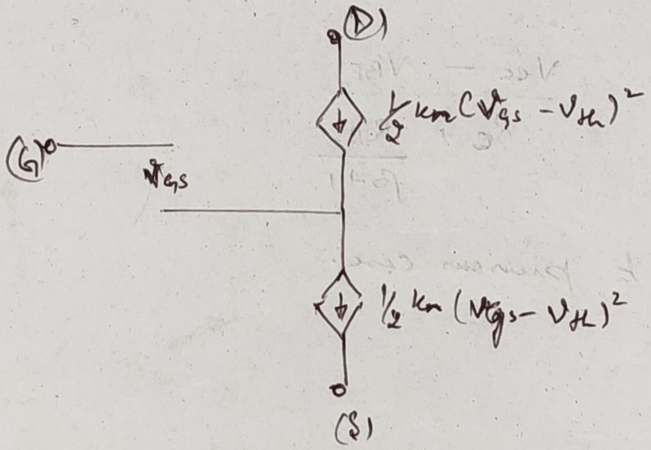
Large Amplifier (Normal):

π.



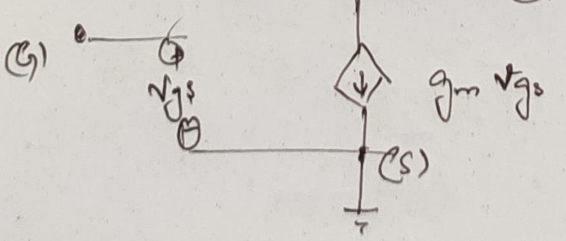
T.

(ro will be ignored for the moment)



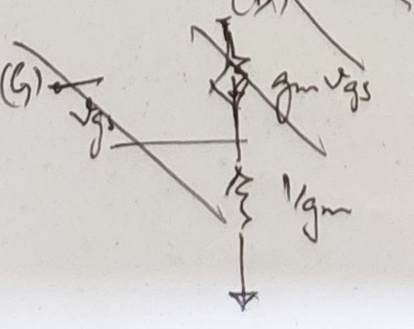
Small:

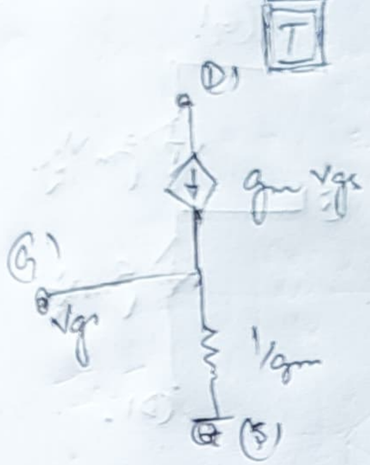
$\boxed{\pi}$



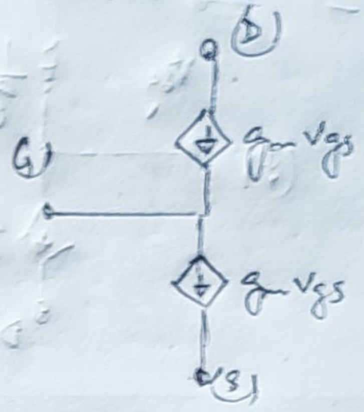
$g_m = k_n \cdot (v_{GS} - v_{th})$

$\boxed{T}$



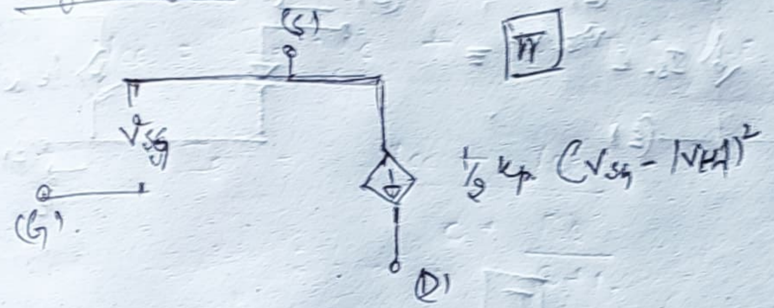


or

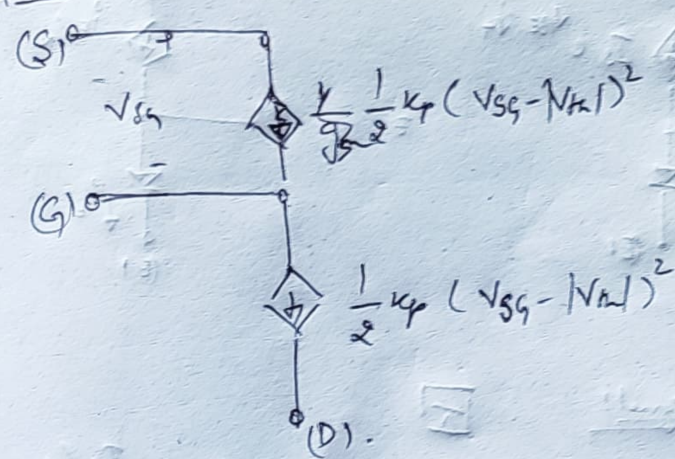


PMOS

Large signal:

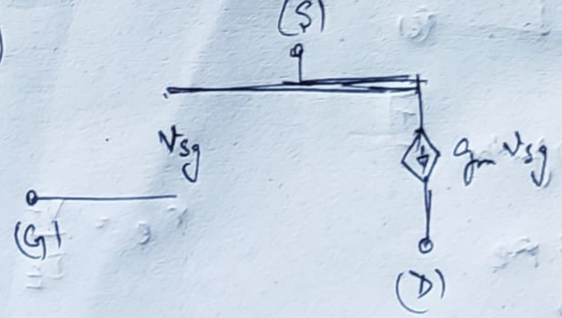


or $\boxed{T}$

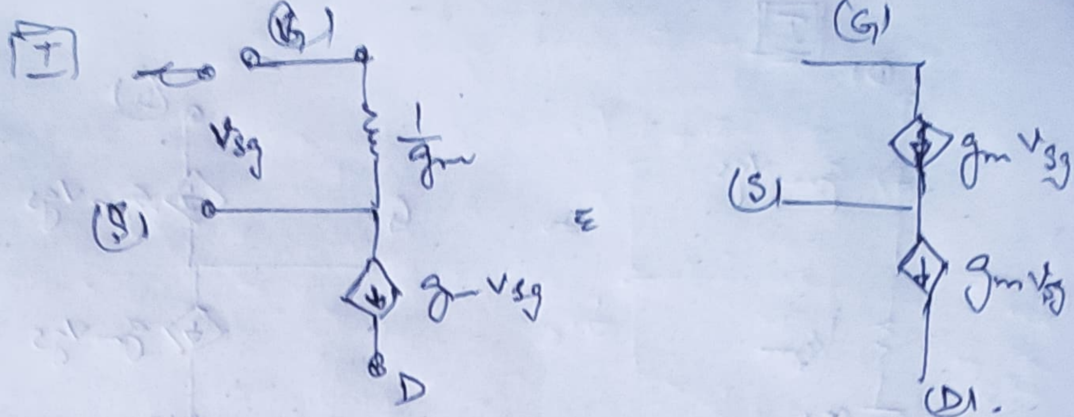


Small Scale:

$\boxed{\pi}$

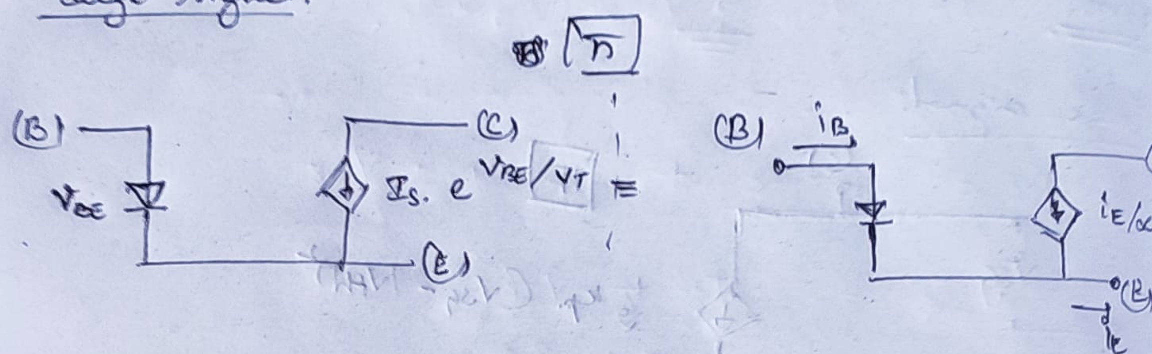


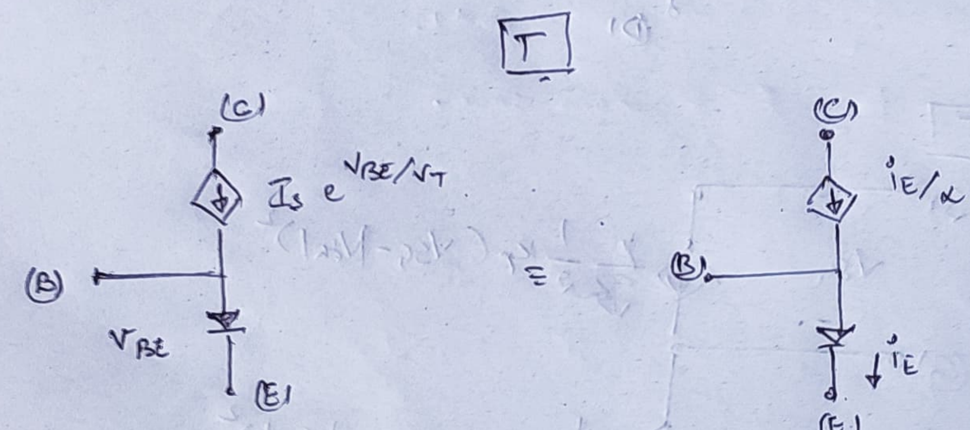
$(g_m = k_p(v_{sg} - |V_{tp}|)$



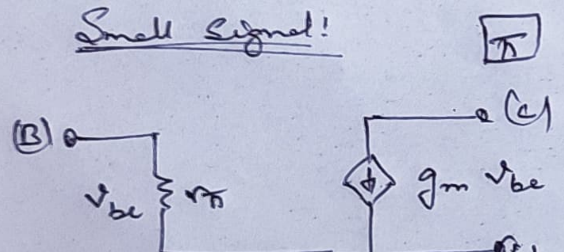
npn BJT:

large signal:



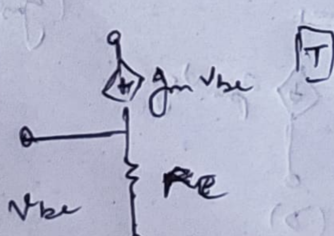


Small signal:



$g_m = I_S/V_T$

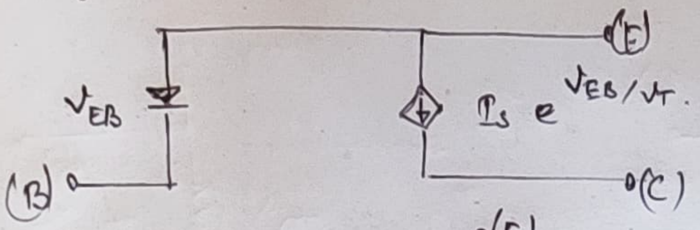
$r_\pi = V_T/I_B$



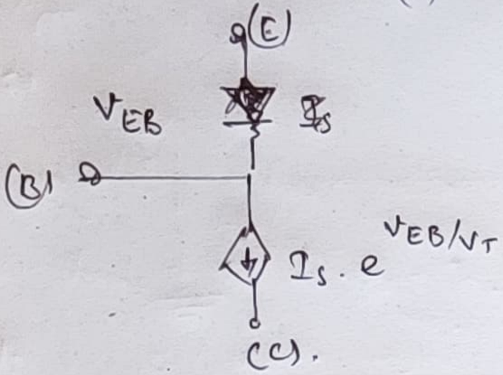
$r_e = \frac{V_T}{I_E}$

pnp BJT:

Large signal:

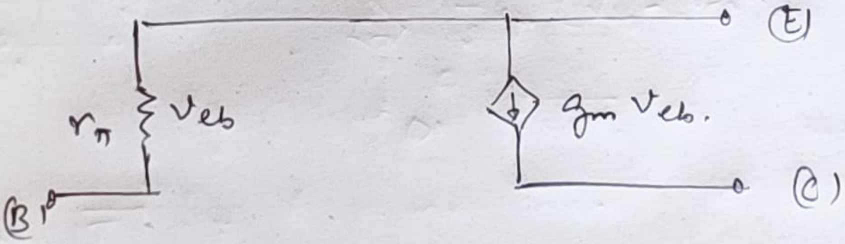


$\boxed{\pi}$

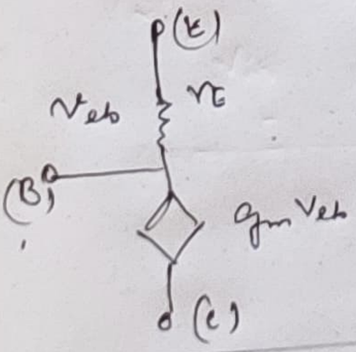


$\boxed{T}$

Small Scale:



$\boxed{\pi}$



$\boxed{T}$

Discrete Circuit Amplifier:

(will learn in week 6).

BJT:

→ Common Emitter
→ Common Base
→ Common Collector

MOS:

→ Common Source
→ Common Gate
→ Common Drain