CMR INSTITUTE OF TECHNOLOGY

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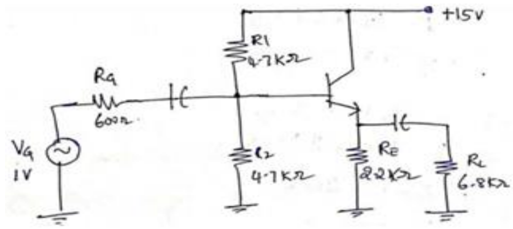
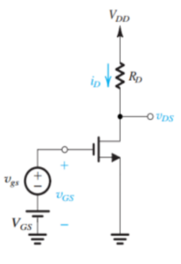
Internal Assesment Test - I

Sub:	Electronic Principles and Circuits						Code:	BEC303	
Date:	07/11/2024	Duration:	90 mins	Max Marks:	50	Sem:	3rd	Branch:	ECE
Answer Any FIVE FULL Questions									

		Marks	OBE CO	OBE RBT
1.	(a) Discuss Two transistor models of Transistor. (b) Explain BJT AC model of Voltage Divider Biased Amplifier.	[4+6]	CO1	L2
2.	(a) Define (i) AC Beta (ii) AC Resistance of the emitter diode. (b) The collector voltage at emitter biased amplifier is inverted with respect to input. Justify the statement with the help of circuit diagram.	[4+6]	CO1	L2
3.	With neat circuit diagram, develop an expression for voltage gain, input impedance and output impedance for common gate amplifier.	[10]	CO1	L2
4.	a) Explain the working of an inverting op-amp with the help of diagram and derive its voltage gain. (b) Explain the concept of virtual ground in OPAMP.	[6+4]	CO3	L2

5.	(a) With circuit diagram, explain the source follower and derive its voltage gain. (b) With neat circuit diagrams, explain biasing of MOSFET by fixing the gate voltage.	[5+5]	CO2	L2
6.	For the circuit shown in Fig 1, determine the voltage gain and ac load voltage if $\beta = 150$.  Fig 1	[10]	CO1	L3
7.	For an amplifier in fig 2, let $V_{DD} = 5V$, $R_D = 10K$, $V_t = 1V$, $k_n' = 20\mu A/V^2$, $W/L = 20$, $V_{GS} = 2V$, $\lambda = 0$. (a) Find the dc current I_D and dc voltage V_{DS} (b) Find g_m (c) Find the voltage gain (d) If $v_{gs} = 0.2 \sin\omega t$ volts find v_{ds} assuming that the small signal approximation holds. What are the minimum and maximum values of v_{DS}.  Fig 2	[10]	CO2	L3

CI ***CCI*** ***HOD***

SOLUTIONS OF IAT - I

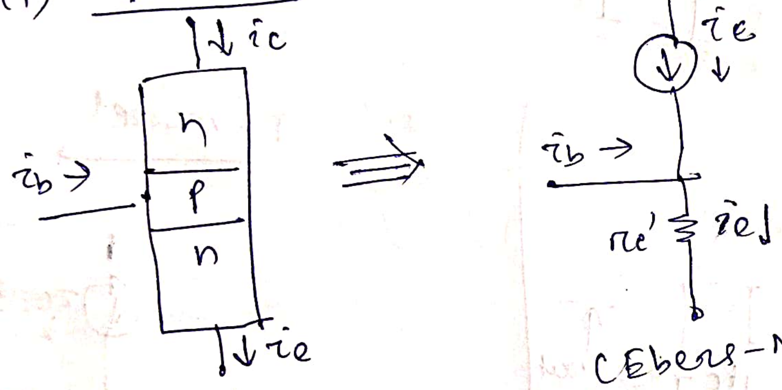
Sub : EPC

Sem : 3rd (ECE)

1. (a) Discuss Two transistor model of Transistor.

We need to study the model of the transistor amplifier to analyze the ac operation of transistor amplifier.

(i) T-model :-



(Ebers-Moll model)

→ collector diode acts as a current source

→ emitter diode acts as ac resistance re'.

Input impedance :-

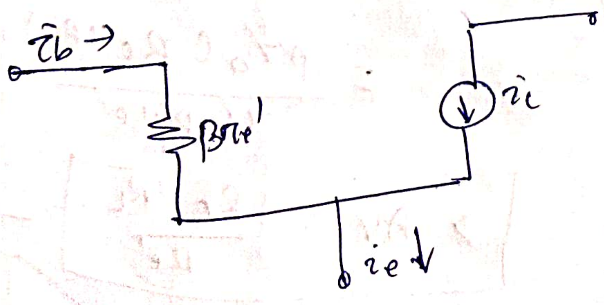
$$Z_{in(base)} = \frac{v_{be}}{i_b}$$

$$Z_{in(base)} = \frac{i_e r_e'}{i_b}$$

since $i_e \approx i_c$

$$Z_{in(base)} = \beta r_e'$$

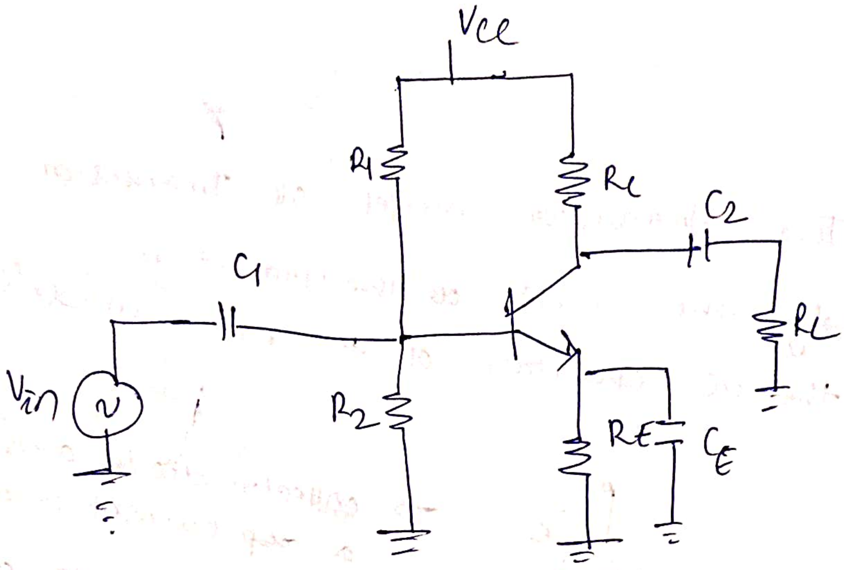
(ii) π-model :-



→ an i/p impedance of βre' will load the ac voltage source driving the base.

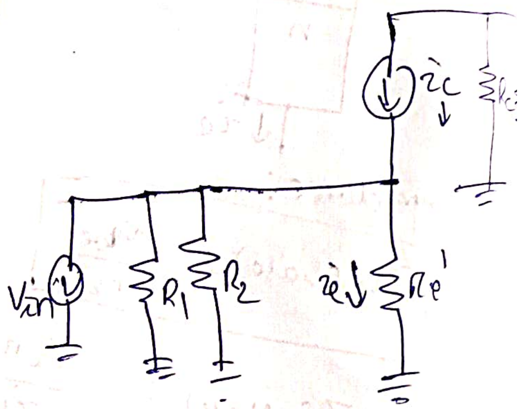
$$Z_{in} = \beta r_e'$$

(b) Explain BJT Ac model of VDB Amplifier



π-model

T-model



→ The voltage gain is given as

$$A_V = \frac{V_{out}}{V_{in}} \quad \text{——— (1)}$$

$$V_{out} = i_c (R_C \| R_L)$$

$$V_{in} = i_b \beta r_e'$$

$$\Rightarrow A_V = \frac{i_c (R_C \| R_L)}{i_b \beta r_e'}$$

$$= \frac{\beta i_b (R_C \| R_L)}{i_b \beta r_e'}$$

$$\boxed{\Rightarrow A_V = \frac{R_C \| R_L}{r_e'}} \quad \text{—— (2)}$$

Total collector resistance

$R_C \| R_L = r_c$ = ac collector resistance

Putting this in eq(2)

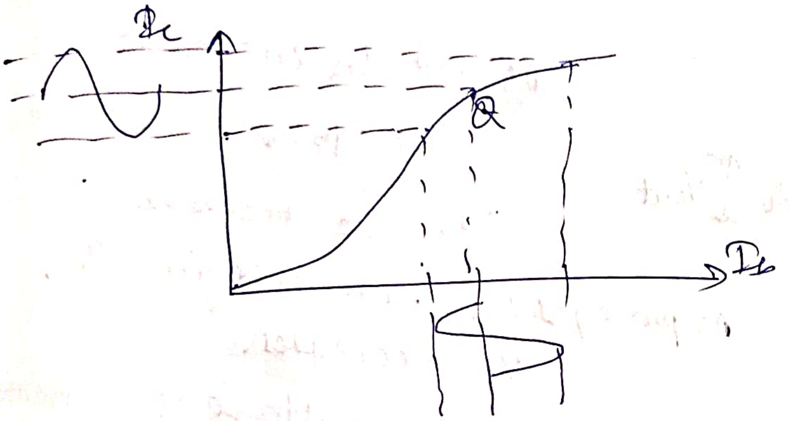
$$\boxed{A_V = \frac{r_c}{r_e'}}$$

② (a) Define (a) AC Beta (b) AC resistance of emitter diode.

(a) AC Beta :

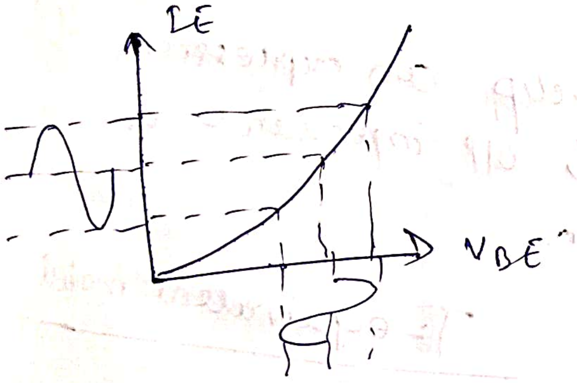
ac current gain $(\beta) = \frac{i_c}{i_b}$ → ac collector current, → ac base current.

β is listed as h_{fe}.



(b) AC resistance of emitter diode :

→ when a small ac voltage is applied at the emitter diode, it produces an ac current as shown in the fig.



→ Total current = dc component + ac component

$\Rightarrow I_E = I_{EQ} + i_e$

Similarly, $V_{BE} = V_{BEQ} + v_{be}$

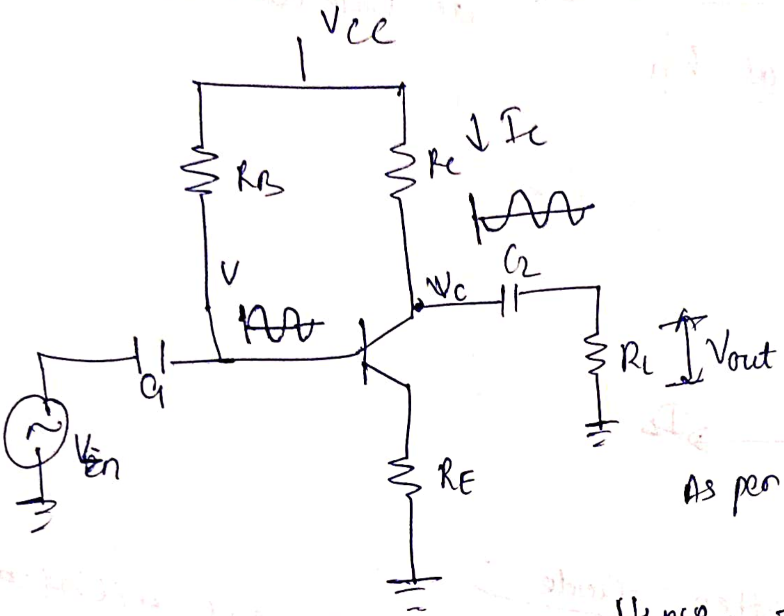
The ac emitter resistance is found to be,

$$r_e' = \frac{v_{be}}{i_e}$$

Using solid state physics and calculus, the ac emitter resistance can be derived as,

$$r_e' = \frac{25\,mV}{I_E}$$

(b) The collector voltage at the emitter based amplifier is inverted with respect to the input. Justify.



We have,

$V_C = V_{CC} - I_C R_C$ — (1)

As i/p I_B increases

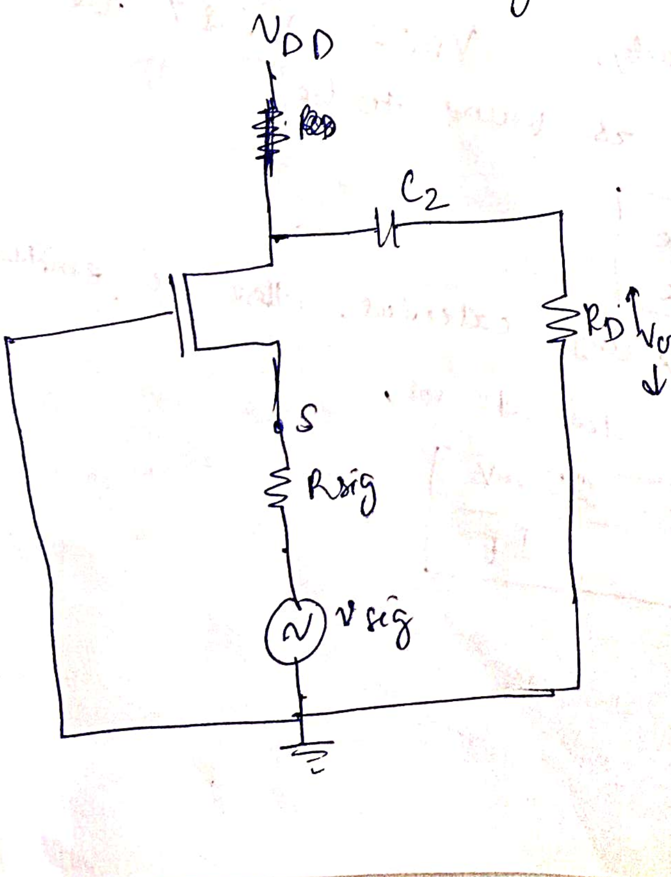
$I_C = \beta I_B$

So, I_C increases

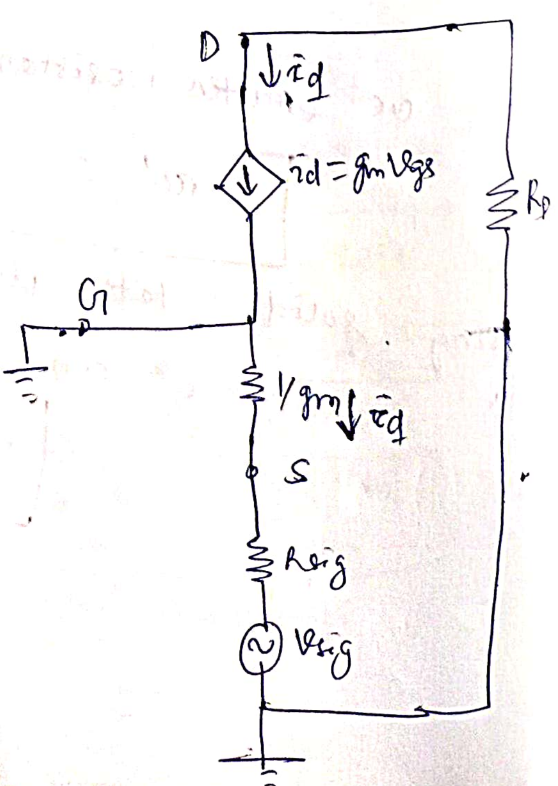
As per eq (1), with rise in I_C, V_C decreases.

Hence, the collector voltage is inverted with respect to the i/p.

(3) With neat diagram, develop an expression for voltage gain, i/p impedance, o/p impedance of common gate amplifier.



T-equivalent model



Here,

→ $R_{in} = 1/g_m$

→ $R_{out} = R_D$

→ $V_{in} = -i_d(1/g_m)$

$V_{out} = -i_d R_D$

⇒ Voltage gain (Av) $= \frac{V_{out}}{V_{in}} = \frac{-i_d R_D}{-i_d(1/g_m)}$

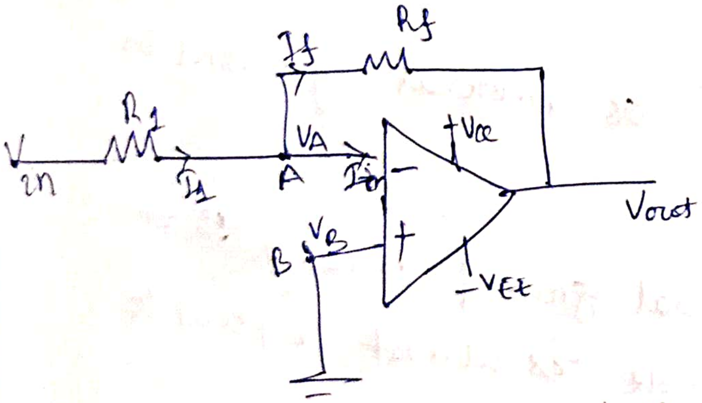
$\Rightarrow \boxed{A_V = g_m R_D}$

→ Overall voltage gain

$(G_V) = \frac{R_{in} \cdot A_V}{R_{in} + R_{sig}}$

$\therefore G_V = \frac{(1/g_m) \cdot A_V}{(1/g_m) + R_{sig}} = \frac{A_V}{1 + g_m R_{sig}} = \frac{g_m R_D}{1 + g_m R_{sig}}$

(4) (a) Derive the voltage gain of inverting OPAmp.



→ Inverting amplifier gives a phase shift of 180° between i/p and o/p signal.

→ Then i/p voltage is connected to the inverting terminal and the non-inverting terminal is grounded.

→ As per the virtual ground concept,

$V_A - V_B = 0$

As, $V_B = 0$ ⇒ $V_A = 0\,V$.

Applying KCL at point A,

$I_1 = I_{in} + I_f$

Due to OPAMP high impendance, $I_{in} \simeq 0$, so

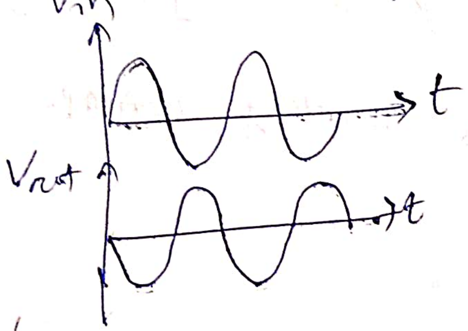
$I_1 = I_f$

$$\Rightarrow \frac{V_{in} - V_A}{R_1} = \frac{V_A - V_{out}}{R_f}$$

Putting $V_A = 0V$.

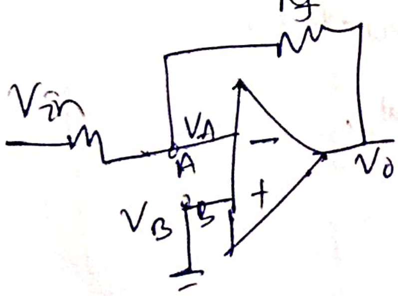
$$\Rightarrow \frac{V_{in}}{R_1} = -\frac{V_{out}}{R_f} \Rightarrow \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_1}$$

$$\Rightarrow \boxed{A_V = -\frac{R_f}{R_1}}$$



(b) Explain the concept of virtual ground in OPAMP.

In OPAMP, the term virtual ground means that voltage at a particular node is almost equal to the ground voltage (0V.).



As point B is grounded $\Rightarrow V_B = 0V$.

As in OPAMP, $V_A - V_B = 0$

$\Rightarrow V_A = V_B = 0V$.

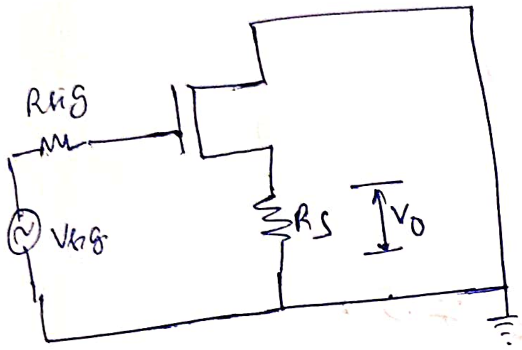
Even if point A is not physically connected to ground, but still voltage at point A (V_A) is 0V.

So, point A is said to be at virtual ground.

(5) With circuit diagram, explain the source follower and derive its voltage gain.

Source follower is the common Drain (CD) configuration of MOSFET.

T-equivalent model



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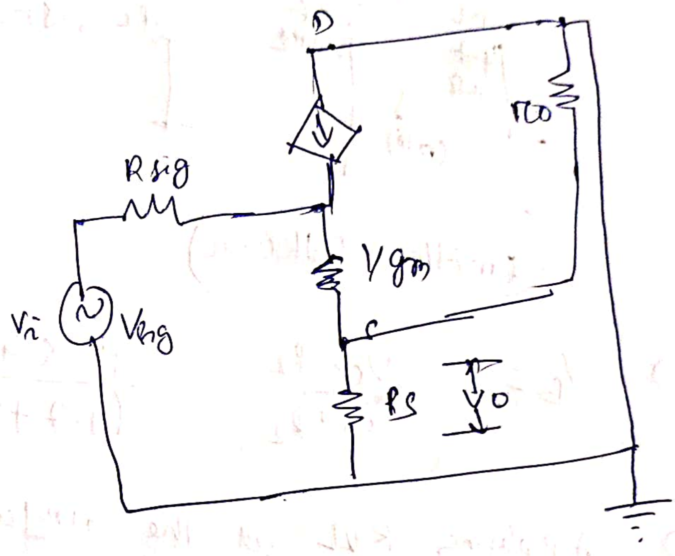
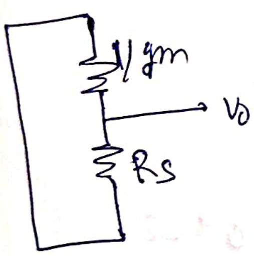


→ $R_{in} = R_{sig} = \infty$



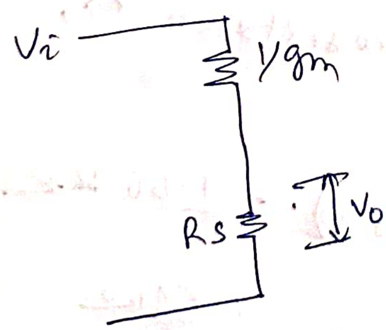
$\therefore R_o = \frac{1}{g_m} \| R_s$

As $R_s >> 1/g_m$

$\Rightarrow$ $R_o = 1/g_m$

Applying voltage-divider rule,

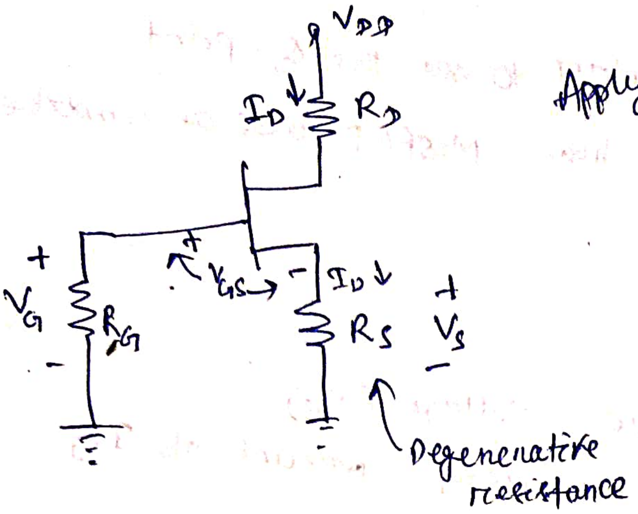
→



$$V_o = \frac{R_s \cdot V_i}{1/g_m + R_s}$$

$$\Rightarrow \frac{V_o}{V_i} = A_v = \frac{R_s}{1/g_m + R_s} = \frac{g_m R_s}{1 + g_m R_s}$$

5(b) Biasing by fixing V_G and connecting a resistance in the source.



Applying KVL,

$V_G - V_{GS} - I_D R_S = 0$

$\Rightarrow V_G = V_{GS} + I_D R_S$ —— (1)

Here, if V_G is fixed / constant, and if I_D varies due to change in temp.,

then V_{GS} should ↓ to maintain V_G = constant.

Single polarity supply:-

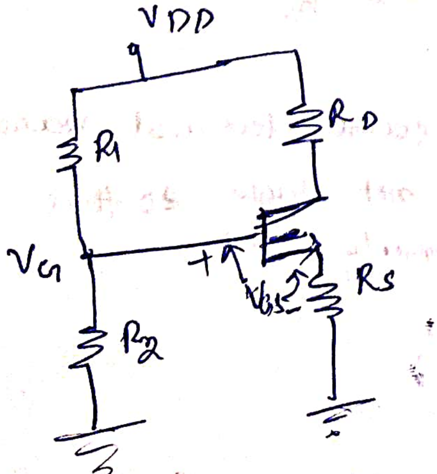
→ V_{GS} decreases
→ i/p decrease
→ I_D decrease.

R_S provide -ve feedback, and it is called as degenerative resistance.

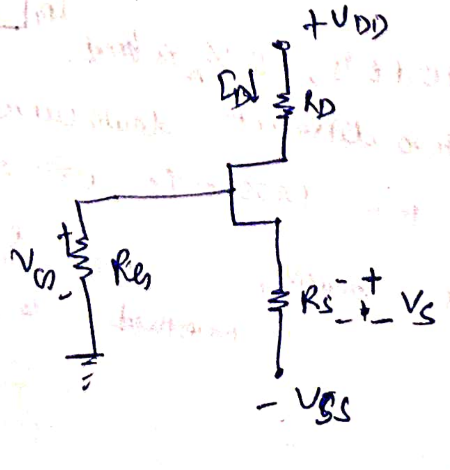
(i) If $V_G >> V_{GS}$ - drop V_{GS} is negligible.
so I_D can be maintain constant.
In eq(1), V_{GS} neglected

$I_D = V_G / R_S$

(ii) If V_G is not greater than V_{GS}
→ drop of V_{GS} can not be neglected.
- R_S provide -ve feedback.
which will ⇒ stabilize the value of I_D.



(a) single supply source.

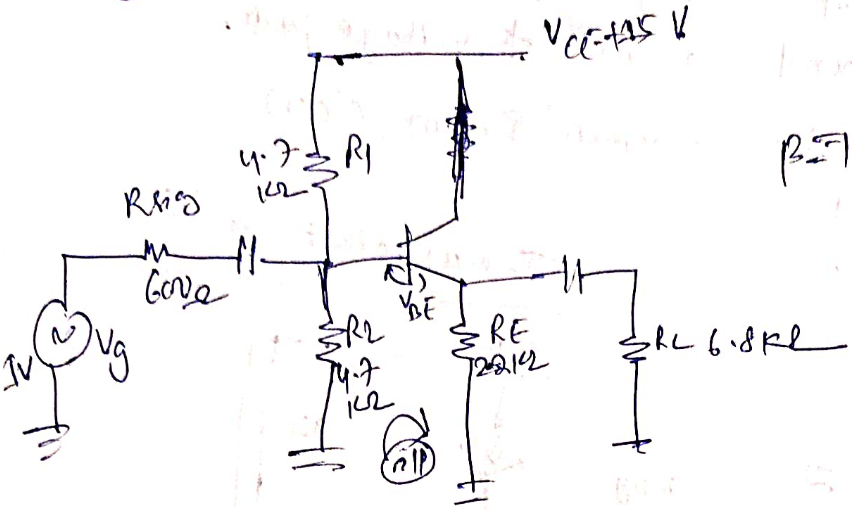


+ve power supply is connected to drain and -ve power supply is connected to source. to obtain a fixed V_G.

(b) dual power supply.

(6)

Find voltage gain and ac load voltage?



β = 150

(Emitter follower)

→ $V_B = \frac{V_{CC} R_2}{R_1 + R_2} = \frac{15 \times 4.7}{(4.7+4.7)} = 7.5$ V.

→ Applying KVL at the i/p loop

$V_B - V_{BE} - I_E R_E = 0$

$\Rightarrow 7.5 - 0.7 = I_E (2.2\ k\Omega)$

$\therefore I_E = 3.09$ mA.

→ ac emitter resistance, $r_e' = \frac{25\ mV}{I_E}$

$\Rightarrow r_e' = \frac{25\ mV}{3.09\ mA} = 8.09\ \Omega$.

→ The external ac emitter resistance is,

$r_e = R_E \| R_L$
$= (2.2\ k\Omega) \| (6.8\ k\Omega) = 1.66\ k\Omega$

→ voltage gain $(A_V) = \frac{r_e}{r_e + r_e'} = \frac{1.66\ k\Omega}{1.66\ k\Omega + 8.09\ \Omega}$

$= 0.995$

⇒ The input impendance of the base is

$$Z_{in}(base) = \beta(R_e + r_e')$$
$$= 150\,(1.66\,k\Omega + 8.09\,\Omega) = 250\,k\Omega.$$

→ $$Z_{in}(stage) = R_1 \,||\, R_2 \,||\, \beta(R_e + r_e')$$
$$= (4.7\,k\Omega) \,||\, (4.7\,k\Omega) \,||\, 150\,(1.66\,k\Omega + 8.09\,\Omega)$$
$$= 2.35\,k\Omega.$$

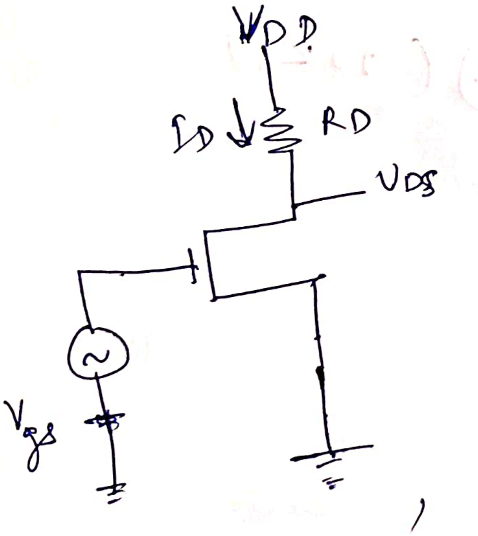
→ Applying voltage divider rule, the ac i/p voltage

$$V_{in} = \frac{Z_{in}(stage) \times V_{in}}{R_{sig} + Z_{in}(stage)}$$
$$= \frac{(2.35\,k\Omega) \times (1\,V)}{(600\,\Omega) + (2.35\,k\Omega)} = 0.797\,V.$$

→ We have

$$A_v = \frac{V_{out}}{V_{in}}$$
$$\Rightarrow V_{out} = A_v \cdot V_{in} = (0.995)(0.797)$$
$$= 0.793\,V.$$

(7)



Given $V_{DD} = 5V$.
$R_D = 10\,k\Omega$
$V_t = 1V$.
$K_n' = 20\,\mu A/V^2$.
$\frac{W}{L} = 20$, $V_{gs} = 2V$, $\lambda = 0$

(a) Find dc current I_D, dc voltage V_{DS}.
(b) Find g_m
(c) Find voltage gain (A_v).

(a) we have,

$$I_D = \frac{1}{2} k_n' \frac{W}{L} (V_{GS} - V_t)^2$$

$$\Rightarrow I_D = \frac{1}{2}(20)(20)(2-1)^2$$

$$\Rightarrow I_D = 200\ \mu A.$$

Applying KVL at the o/p side,

$$V_{DD} - I_D R_D - V_{DS} = 0$$

$$\Rightarrow V_{DS} = V_{DD} - I_D R_D$$

$$= 5\ V. - (200\ \mu A)(10\ k\Omega)$$

$$= 3V.$$

(b) we have,

$$g_m = k_n' \frac{W}{L} (V_{GS} - V_{t0})$$

$$= (20)(20)(2-1)$$

$$= 400\ \mu A/V. = 0.4\ mA/V.$$

(c) Voltage gain

$$A_V = -g_m R_D$$

$$= (-0.4\ mA/V.)(10\ k\Omega)$$

$$= 4$$

(d) $V_{ds\ max} = 0.8\ V$

$V_{ds\ min} = -0.8\ V$