CMR
INSTITUTE OF
TECHNOLOGY

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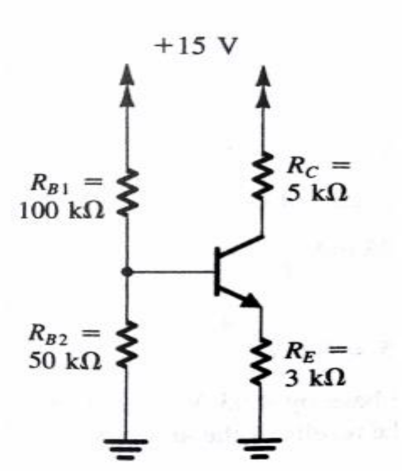
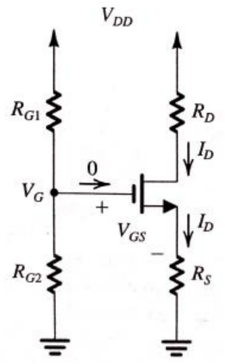
Internal Assesment Test - I

Sub:	Analog Circuits							Code:	18EC42
Date:	19/ 05 / 2021	Duration:	90 mins	Max Marks:	50	Sem:	4th	Branch:	ECE
Answer Any FIVE FULL Questions									

		Marks	OBE	
			CO	RBT
1.	With the help of necessary circuit diagrams and design equations, explain the classical discrete biasing (voltage divider biasing) of BJT. How does R_E provide a negative feedback action to stabilise the bias current.	[10]	CO1	L2
2.	a)Why biasing a MOSFET amplifier circuit by fixing V_{GS} is not considered as a good technique?	[04]	CO1	L2
	b)With the help of necessary circuit diagrams and design equations, explain MOSFET biasing circuit by Fixing V_G and connecting a resistance in the source.	[06]	CO1	L2
3.	Calculate Thevenin equivalent voltage and resistance and hence draw the equivalent circuit. Find I_C,I_B,I_E , V_B, V_C . Assume β=100, V_{BE} =0.7V 	[10]	CO1	L3
4.	With the small signal equivalent model of MOSFET, derive an expression for the voltage gain and transconductance, g_m of MOSFET.	[10]	CO2	L2
5.	Considering the conceptual circuit of Common Emitter BJT Amplifier, derive the following parameters; g_m, r_e, $r_π$ and A_v. Draw the hybrid π model.	[10]	CO2	L2
6.	Design a MOS Amplifier (by fixing gate voltage), for the circuit below, given the specifications: I_D =0.5mA, Vt=1V, K_n'W/L=1mA/V^2,V_{DD}=15V. Calculate the percentage change in the value of I_D obtained when the MOSFET is replaced with another unit having Vt=1.5V. Consider λ = 0. 	[10]	CO2	L3

7.	Define the following characteristic parameters of Amplifiers using necessary circuit diagram. A_v , A_{vo} , $G_{v,}$ G_{vo}, G_m, R_i, R_{in} and R_{out}	[10]	CO2	L2
8.	With a neat circuit diagram and ac equivalent circuit, derive the expressions for Voltage gains A_v , A_{vo} , $G_{v,}$ and Output resistance R_{out} for a Common source amplifier without source resistance.	[10]	CO2	L3

IAT-1 (19/05/2021)

Analog Circuits Scheme

4th Sem

Q-1 Diagram Voltage divider- 2 Marks

Explanation-6 Marks

Explanation of RE stabilization-2 marks

Q-2(a)Expalanation-4 Marks

Q2(b) Circuit Diagram-2 Marks

Explanation- 4 Marks

Q-3 Rth-1 marks

Vth-1 marks

Equivalent circuit -3 Mark

Ic, Ib, IE, VB, VC----- 5 marks (Each carries 1 mark)

Q-4 Small signal model-2 marks

Voltage gain-4 Marks

Transconductance-4 marks

Q-5 Circuit diagram-1 Marks

Gm, re, rpi, Av---8 Marks

Hybrid pi mosel-1 marks

Q-6 RD, RS, RG1,RG2---8 Marks

% change in ID= 2 marks

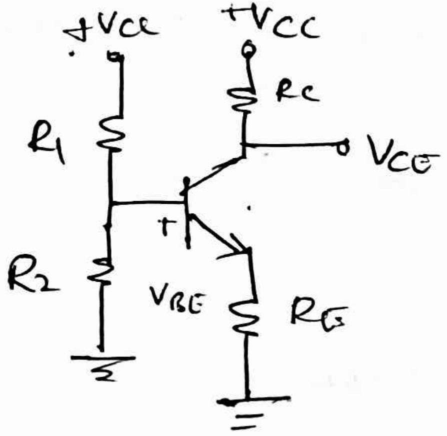
Q-7 Diagram -2 marks

Each parameter- 1 mark each (8x1= 8 marks)

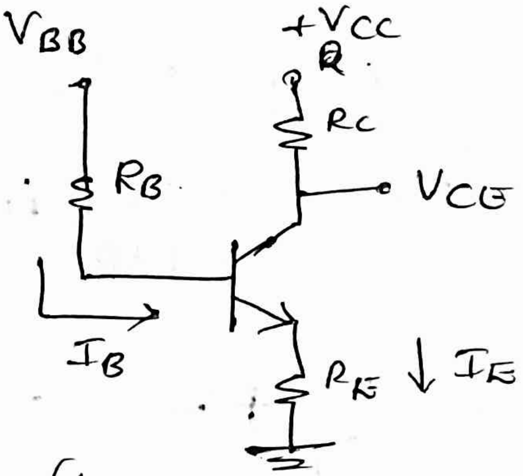
Q-8 Circuit-2 marks

Each parameter - 2 mark each (4x2=8 marks)

1)



(a)



(b)

Fig (a) shows arrangement used for classical transistor amplifier biasing.

→ A fraction of Vce is applied at base by using voltage divider ~~at~~ R_1 & R_2

$$1+\beta$$

putting I_B from eqn 4 into ③ we have

$$V_{BB} = \frac{I_E}{(1+\beta)} R_B + V_{BE} + I_E R_E$$

$$I_E\left(\frac{R_B}{1+\beta} + R_E\right) = V_{BB} - V_{BE}$$

$$\Rightarrow \boxed{I_E = \frac{V_{BB} - V_{BE}}{R_E + \frac{R_B}{1+\beta}}} \longrightarrow ⑤$$

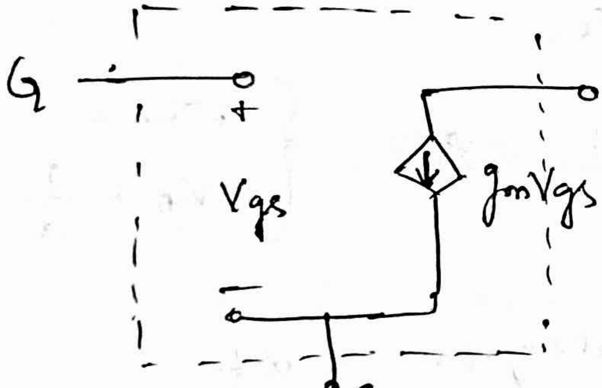
NOTE :- In order to make I_E insensitive

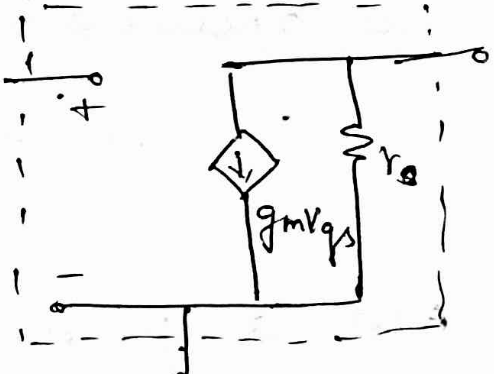
→ If R_B is small, base voltage is determined by voltage divider R_1 & R_2 & it remains constant.

→ So ↑se in V_E result in decrease in V_{BE}.

→ This in turn reduce collector and emitter current..

4) Small signal equivalent of MOSFET





(i) Replace MOSFET by equivalent circuit as the

(ii) Ideal const, dc vtg sources are replaced by short circuit

(iii) Constant dc current if present are replaced by an open circuit.

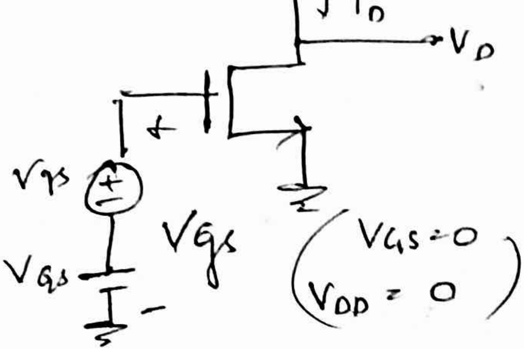
⇒ Fig (a) circuit has prob, that drain current in sat// is independent of drain vtg

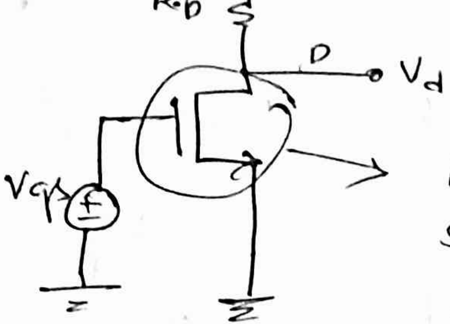
→ But drain current ~~is~~ depends on V_{DS} which is modeled by r. r_o

$$r_o = \frac{|V_A|}{I_D} \longrightarrow 1$$

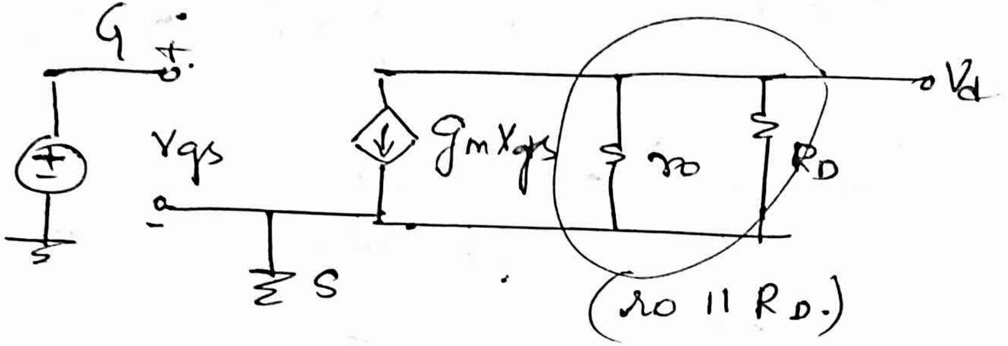
where $V_A = \frac{1}{\lambda}$

For a given technology





Replace by small signal model.



Resultant circuit

Voltage gain (A_V) = $\frac{V_d}{V_{gs}}$

$g_m \propto k_n'$, $g_m \propto \frac{W}{L}$, $g_m \propto V_{ov}$ & $(V_{GS}-V_t)$

→ Gm increased by large W & small L

→ gm ↑sed by increasing V_{GS}

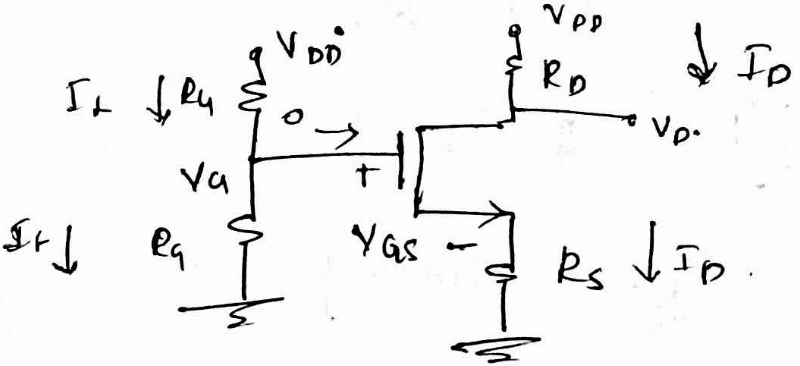
We have, $I_D = \frac{1}{2} K_n' \frac{W}{L}(V_{GS}-V_t)^2$

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

$$\Rightarrow \boxed{V_{GS}-V_t = \sqrt{\frac{2 I_D L}{K' W}}}$$

But sub, values,

Gm



$$\left[\begin{array}{l} I_D R_D = \frac{V_{DD}}{3} = \frac{15}{3} = 5V \\ V_D = 15 - 5 = 10V \end{array} \right.$$

$$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{15-10}{0.5 \times 10^{-3}} = \underline{\underline{10\,k\Omega}}$$

By thumb rule

$$R_S = \frac{V_S}{I_D} = \frac{5}{0.5 \times 10^{-3}} = \underline{\underline{10\,k\Omega}} \qquad \left[V_S = \frac{V_{DD}}{3} = 5V \right]$$

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

$$^{-3}\left(\qquad \right)^2$$

$\boxed{8R_{G2} = 7R_{G1}}$ | $\boxed{R_{G1} = \frac{8}{7} R_{G2}}$

Let $\boxed{R_{G2} = 7M\Omega}$ | $\boxed{R_{G1} = 8M\Omega}$

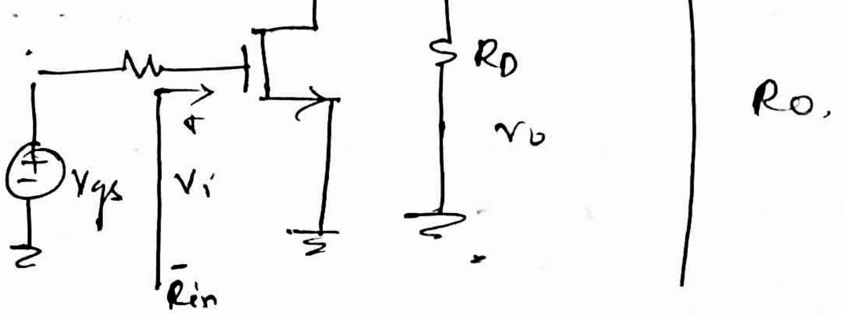
% change in I_D = ? $V_t = 1.5$ & $1\ mA/V^2$

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

$$I_D = \frac{1}{2}\times 10^{-3} \times (V_{GS} - 1.5)^2$$

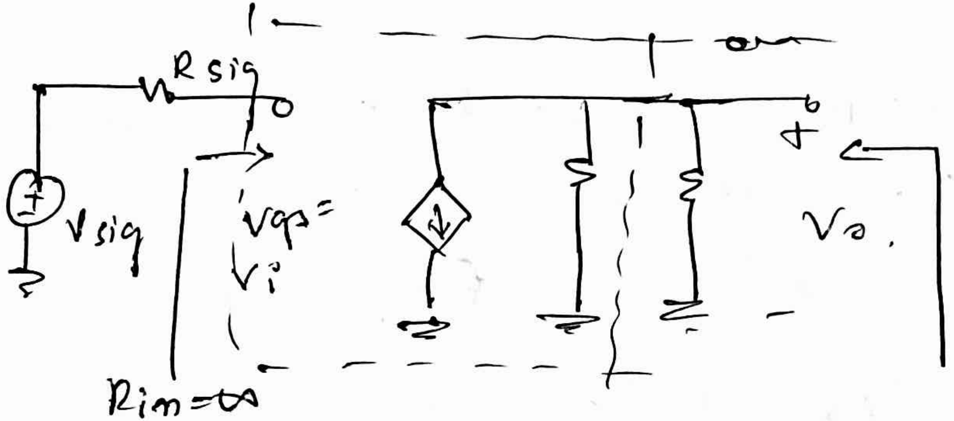
$$2I_D = (7 - 10 I_D - 1.5)^2 = (5.5 - 10 I_D)^2$$

$$2I_D = \frac{(11 - 20 I_D)^2}{4}$$



as Fig(a).

CS fed with Vsg



$R_D \parallel r_o = R_p$

Fig(b): CS amplifier with MOSFET replaced by Hybrid π model

$$\boxed{A_{vo} = \frac{v_o}{v_i} = -g_m\,(R_D \| r_o)} \longrightarrow ③$$

→ R_D is usually much lower than r_o & effect of reducing $|A_{vo}|$ is slight. Thus

→ $$\boxed{A_{vo} \simeq -g_m R_D} \longrightarrow ④$$

R_o :— O/p resistance R_o seen back into o/p terminal with $v_i = 0$.

$v_{gs} = 0$ & thus $g_m v_{gs} = 0$

Thus, $$\boxed{R_o = R_D \| r_o} \longrightarrow 5$$

$$\boxed{R_o = R_D} \longrightarrow ⑥$$

(R_D smaller than r_o)

→ If a load resistance R_L is connected to the o/p terminal of amplifier. so R_L will be placed.

$$\boxed{A_V = -g_m(R_D \| R_L \| r_o)} \rightarrow ⑧$$

→ As $v_i = v_{sig}$, Overall voltage gain

$$G_v = \frac{v_o}{v_{sig}} = \frac{v_o}{v_i} = -g_m(R_D \| R_L \| r_o)$$

$$\boxed{G_v = -g_m(R_D \| R_L \| r_o)} \rightarrow ⑨$$

R_1+R_2

$$V_B = V_{CC} \times \frac{R_{B2}}{R_{B1}+R_{B2}} = 15 \times \frac{50\times10^3}{(100+50)10^3}$$

$$\boxed{V_B = 5V}$$

WKT, $R_B = R_{B1} \parallel R_{B2} \Rightarrow \frac{100\times50\times10^6}{(100+50)10^3} = \underline{\underline{33.33\,k\Omega}}$

By KVL, $I_E = \frac{V_{BB}-V_{BE}}{R_E + \left(\frac{R_B}{\beta+1}\right)}$

Substg,

$$I_E = \frac{5-0.7}{}$$

$= 1.29 \times 10$

$$V_{cc} = I_C R_C + V_{CE} + I_E R_E$$

$$V_{cc} = I_{cc} R_c + V_c$$

$$V_c = V_{cc} - I_c R_c$$

$$= 15 - 1.29 \times 5$$

$$\underline{\underline{V_c = 8.55V}}$$

$$\boxed{V_{BB} = V_B = 5V}$$

$$I_B = \frac{I_E}{\beta + 1}$$

$$I_B = \frac{1.29 \times 10^{-3}}{100 + 1} = \underline{\underline{0.012\ mA}}$$