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"Analog Electronics"   IIOT - B2

"Assignment - III"

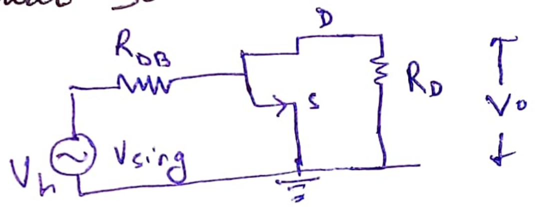
Q MOSFET Amplifier Configuration

① Common Source   (ii) Common Base   (iii) Common Drain

Soln

(I) Common Source.

① Without Source Resistance



(i) Input resistance (R_{in})

$$R = \frac{V}{i \to 0}$$

$$R_{in} = R_{sing} = \infty$$

(ii) Output Resistance (R_{out})

$$R_{out} = r_o \| R_D$$

$$r_o \gg R_D$$

$$R_{out} = \frac{r_o R_D}{R_D + r_o} = \frac{r_o R_D}{r_o}$$

$$R_{out} = R_D$$

(iii) Voltage gain (A_v)

$$A_v = \frac{V_o}{V_{in}} = \frac{i_v (r_o \| R_D)}{V_{in}}$$

$$A_v = -g_m (r_o \| R_D) \quad \text{where } g_m = \frac{i_o}{V_{in}}$$

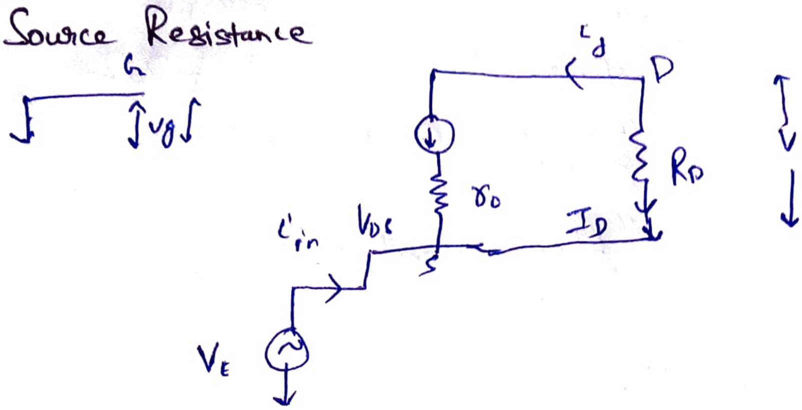
transconductance

Overall gain: G_v

$$G_v = \frac{V_o}{V_{sip}} = \frac{-i_a (r_o \| R_D)}{V_{gs}}$$

Total gain transcond. = $G_v = -g_m (r_o \| R_D)$

(II) With Source Resistance



(i) Input Resistance

$$\frac{V_{in}}{i_{in}} = R_{in}$$

$$i_{in} + i_d = 0$$

$$\Rightarrow i_{in} = -i_d = -g_m V_{gs}$$

$$V_{gs} = -V_i$$

$$\Rightarrow V_{in} = r_o(g_m V_{gs} + i_{in})$$

$$V_{in} = r_o g_m(-V_{in}) + r_o i_{in}$$

$$\frac{V_{in}}{i_{in}} = \frac{r_o}{1+g_m r_o} = \left(\frac{1}{g_m} \| r_o\right)$$

(ii) Output Resistance

$$R_{out} = \left.\frac{V_{in}}{i_{in}}\right|_{V_{in}=0}$$

$$R_{out} = (r_o \| R_D)$$

$$R_{out} = R_D$$

(iii) Voltage Gain

$$V_{gs} = -V_i$$

$$V_o = (i_d - g_m V_{gs})\, r_o + V_i$$

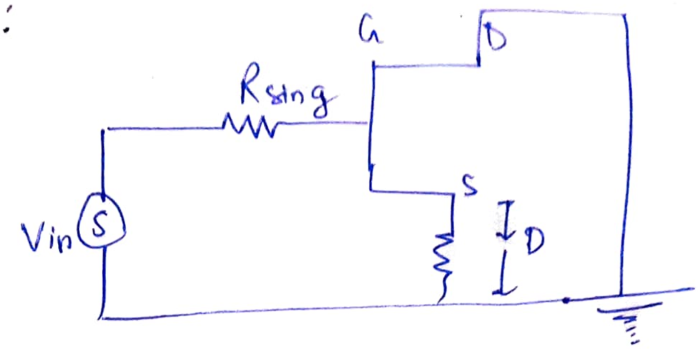
$$V_o = r_o i_d - g_m r_o V_i + V_i$$

$$V_o = -i_d R_D$$

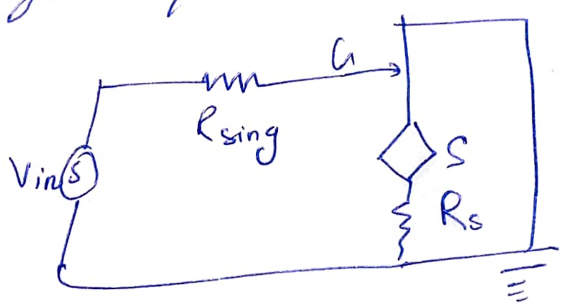
$$V_o = -\frac{r_o}{R_D} = V_o + (1+g_m r_o)V_i$$

$$\Rightarrow \boxed{A_v \cdot \frac{V_o}{V_i} = \frac{1+g_m r_o}{1+r_o/R_D}}$$

(B) Common Drain:



→ Small signal Equivalent Circuit Diagram



(i) Input Resistance (R_{in})

$$R_{in} = R_{sing} = \infty$$

(ii) Output Resistance (R_{out})

$$R_{out} = \frac{1}{g_m} \parallel R_s$$

as $R_s >> g_m \Rightarrow R_s \simeq \frac{1}{g_m}$

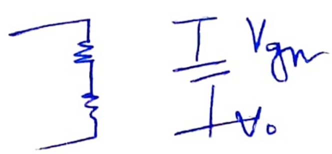
(iii) Voltage Gain (A_v)

Using Voltage divider formula

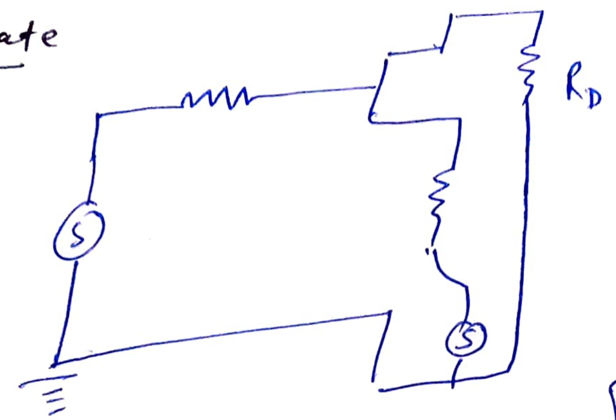
$$V_s = \frac{R_s}{R_s + 1/g_m} \cdot V_{in}$$

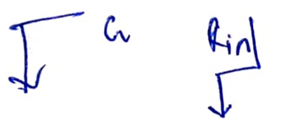
$$A_v = \frac{\frac{R_s}{R_s + 1/g_m} \cdot V_{in}}{V_{in}}$$

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



3. Common Gate





(i) Input Resistance

$$\frac{V_{in}}{i_{in}} = R_{in}$$

$$i_n + i_d = 0$$

$$i_{in} = -i_d = -I_m V_{gs}$$

$$V_{gs} = -V_i$$

$$V_{in} = r_o (g_m V_{gs}) + i_{in}$$

$$V_{in} = r_o g_m (-V_{in}) + r\, i_{in}$$

$$\frac{V_{in}}{i_{in}} = \frac{-r_o}{1+g_m r_o} = \left(\frac{1}{g_m} \| r_o\right)$$

(ii) Output Resistance

$$R_{out} = \frac{V_o}{i_{in}}\Big|_{V_{in}=0}$$

$$R_{out} = (r_o \| R_o)$$

$$R_{out} = R_D$$

(iii) Voltage Gain

$$V_{gs} = -V_i$$

$$V_D = (-i_d - g_m r_o V_i) + V_i$$

$$V_o = -i_a R_D$$

$$-\frac{r_o}{R_D} V_o = V_D + (1+g_m r_o) V_i$$

$$\boxed{A_v = \frac{V_o}{V_i} = \frac{1+g_m r_o}{1+r_o/R_D}}$$