

UNIT :- 05

FET. AMPLIFIER

* SMALL SIGNAL MODEL *

Drain Resistance (r_d) :- It is the ratio of drain to source voltage and drain current.

$$r_d = \frac{\Delta V_{DS}}{\Delta I_D}$$

Transconductance (or) Mutual conductance (g_m) :- It is the ratio of drain current to the gate to source voltage.

$$g_m = \frac{\Delta I_D}{\Delta V_{GS}}$$

Amplification Factor (M) :- It is the ratio of drain to source voltage to the gate to source voltage.

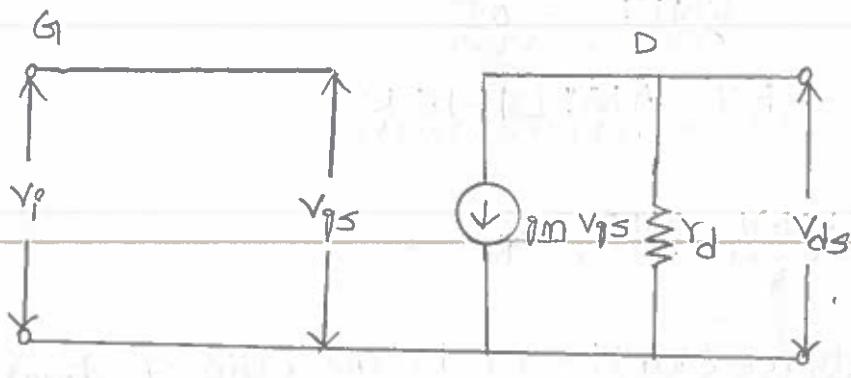
$$M = \frac{\Delta V_{DS}}{\Delta V_{GS}}$$

Relation between r_d , g_m , M is

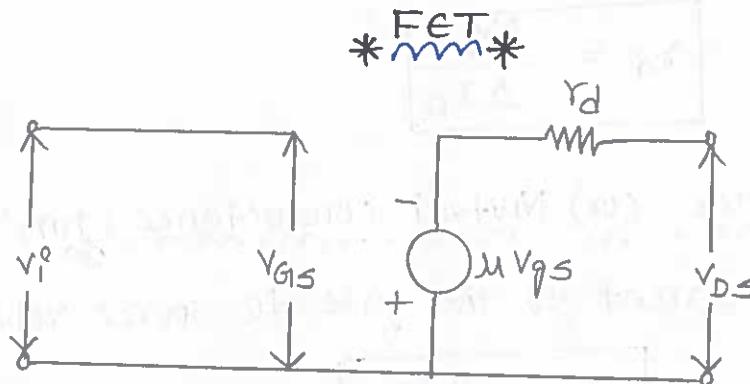
$$M = g_m \cdot r_d$$

$$M = \frac{\Delta I_D}{\Delta V_{GS}} \cdot \frac{\Delta V_{DS}}{\Delta I_D}$$

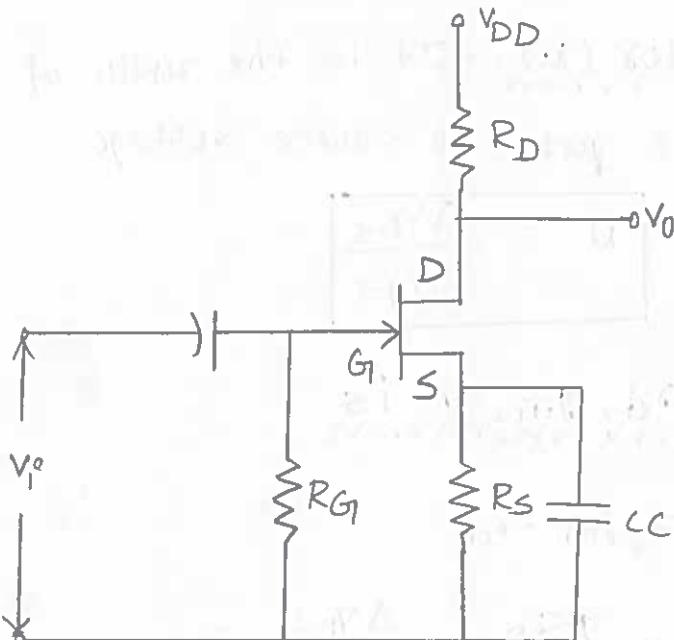
$$M = \frac{\Delta V_{DS}}{\Delta V_{GS}}$$



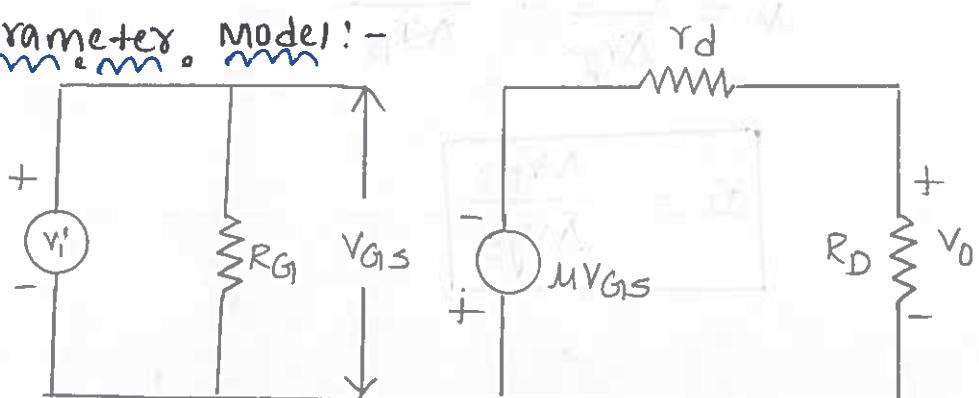
* Modified H-parameter model (or) small signal model for *



Common Source FET Amplifier:-



H-parameter Model:-



Voltage Gain (AV) :-

$$AV = \frac{V_o}{V_i}$$

$$V_o = \frac{\mu V_{GS} \times R_D}{R_D + r_d} = \frac{\mu V_{GS} R_D}{R_D + r_d}$$

From input circuit $V_{GS} = V_i$

$$V_o = \frac{\mu V_i R_D}{R_D + r_d}$$

$$\frac{V_o}{V_i} = \frac{\mu R_D}{R_D + r_d}$$

$$AV = \boxed{\frac{\mu R_D}{R_D + r_d}}$$

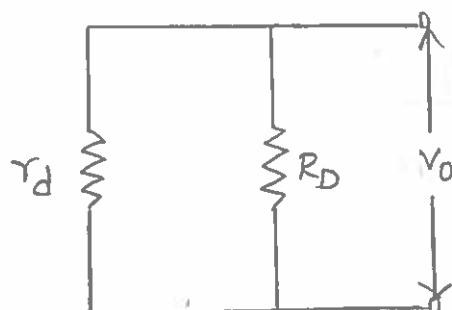
Input impedance (R_i) :-

$$R_i = R_G$$

Output Impedance (Z_o) :-

$$V_i = 0$$

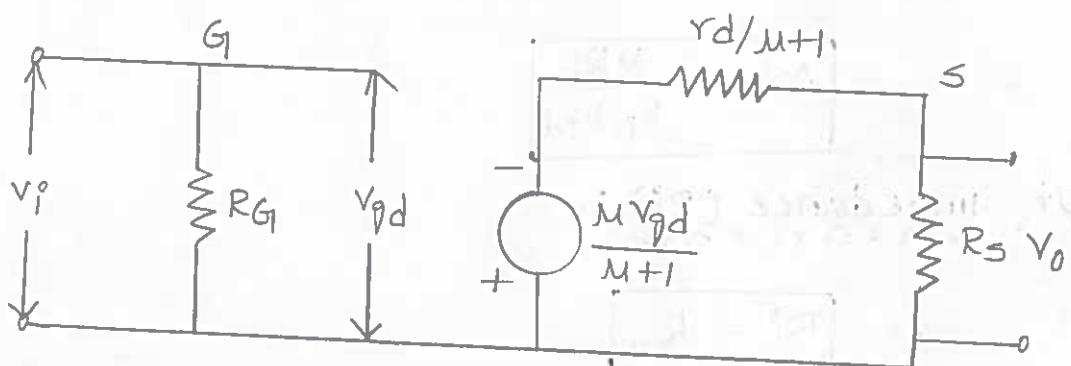
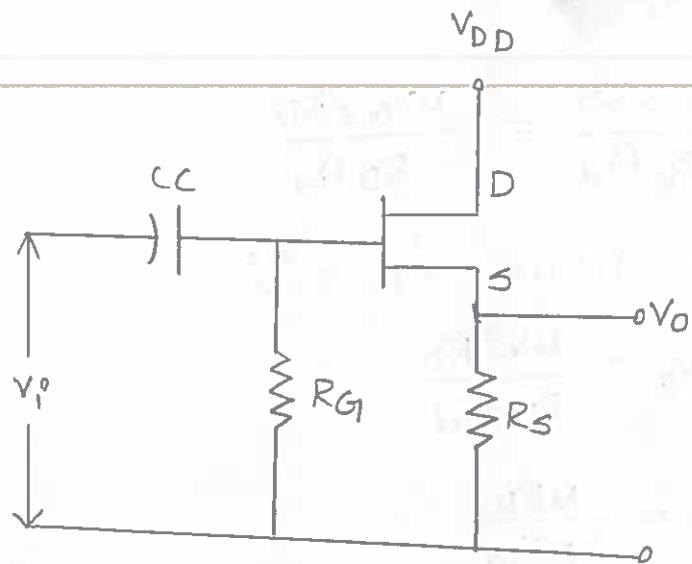
$$V_{GS} = 0$$



$$Z_o = r_d // R_D$$

$$Z_o = \boxed{\frac{r_d R_D}{r_d + R_D}}$$

Common Drain FET Amplifier:-



Voltage Gain (AV) :-

$$AV = \frac{V_O}{V_I}$$

$$V_O = \frac{\mu V_Q d}{\mu + 1} \cdot R_S$$

$$\frac{R_S + r_d}{r_d / (\mu + 1)}$$

$$V_O = \frac{\frac{\mu V_Q d}{\mu + 1} R_S}{\frac{R_S(\mu + 1) + r_d}{\mu + 1}}$$

$$V_o = \frac{\mu V_{gd} R_s}{R_s(\mu + 1) + r_d}$$

$$V_i^e = V_{gd}$$

$$AV = \frac{\mu R_s}{R_s(\mu + 1) + r_d}$$

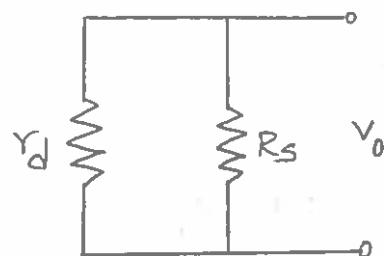
INPUT Resistance (R_i^e):-

$$R_i^e = R_g$$

Output Resistance (R_o):-

$$V_i^e = 0$$

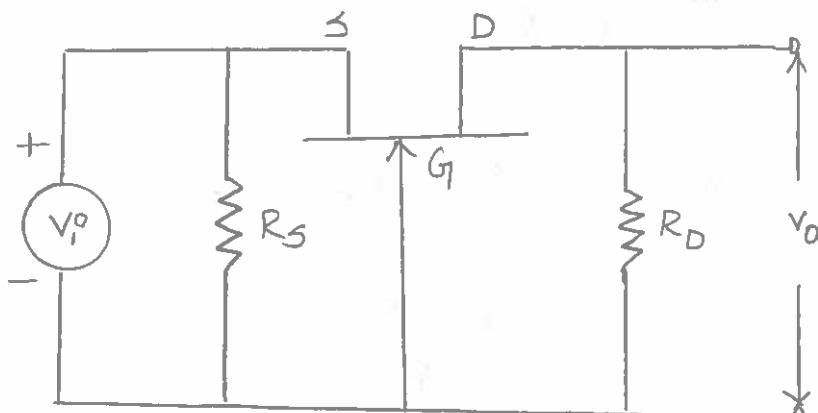
$$V_{gd} = 0$$

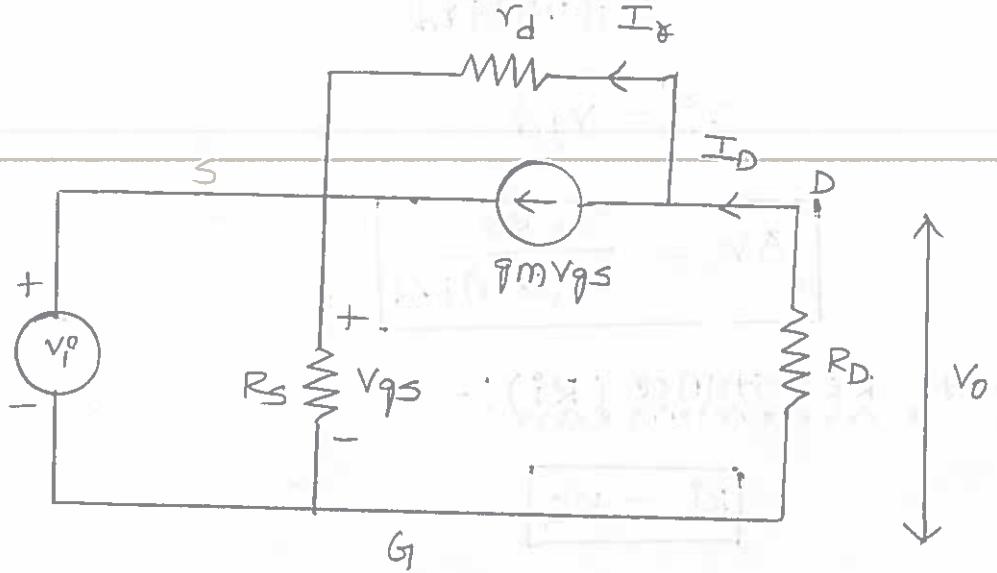


$$Z_o = R_s // r_d$$

$$Z_o = \frac{R_s r_d}{R_s + r_d}$$

common gate Amplifier:-





entering current

$$I_D = \eta m V_{qs} + I_r$$

$$I_r = I_D - \eta m V_{qs} \rightarrow ①$$

From equation ①

$$V_o = (I_D - \eta m V_{qs}) r_d + V_{qs}$$

$$V_i^o = V_{qs}$$

$$V_o = (I_D - \eta m V_i^o) r_d + V_i^o$$

$$I_D = \frac{V_o}{R_D}$$

$$V_o = \left(\frac{V_o}{R_D} - \eta m V_i^o \right) r_d + V_i^o$$

$$V_o - \frac{V_o}{R_D} r_d = (-\eta m r_d + 1) V_i^o$$

$$\frac{V_o}{V_i^o} = \frac{-\eta m r_d + 1}{1 - \frac{r_d}{R_D}}$$

INPUT resistance (R_i):-

$$R_i = R_s \parallel \frac{1}{g_m}$$

$$R_i = \frac{R_s \frac{1}{g_m}}{R_s + \frac{1}{g_m}}$$

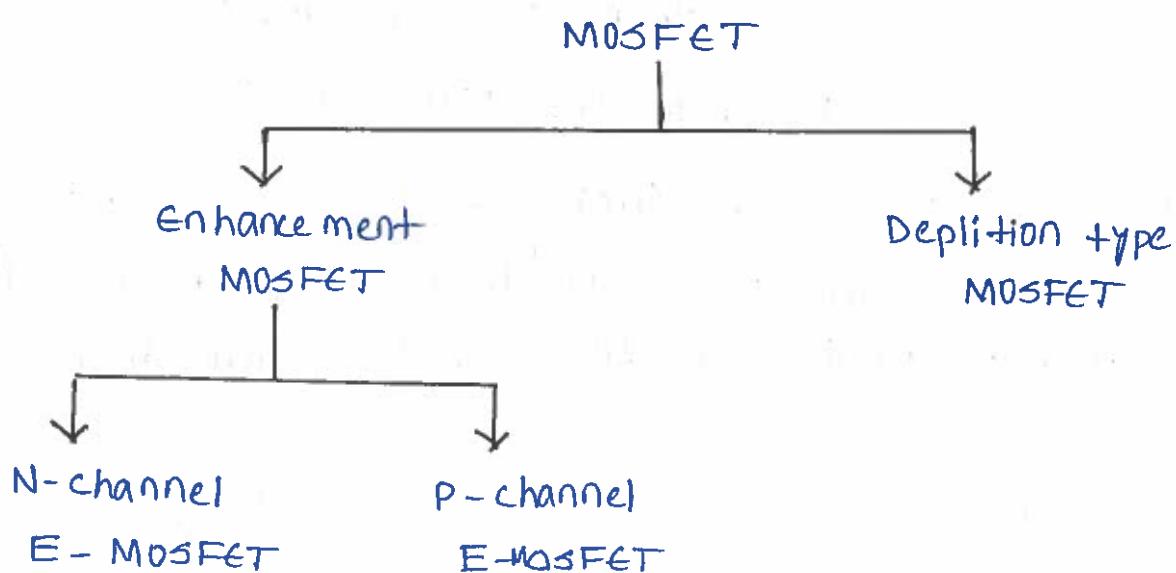
OUTPUT Resistance (R_o):-

$$R_o = r_d \parallel R_D$$

$$R_o = \frac{r_d R_D}{r_d + R_D}$$

* MOSFET characteristics in enhancement and depletion *

* mode *



MOSFET:-

There are two types of MOSFET

- * enhancement MOSFET
- * depletion type MOSFET

Depletion type MOSFET:-

N-channel depletion type MOSFET consist of p-type substrate which is lightly doped two n⁺ regions are added to the substrate which are highly doped. one n⁺ region act as a source and another n⁺ region act as a drain.

SiO₂ layer added on the top of substrate which act as a insulator on SiO₂ layer Aluminium layer is coated which act as a gate terminal. In depletion type MOSFET there is channel between two N⁺ regions.

V_{GS} voltage is applied between gate and source terminals and V_{DS} voltage is applied between drain and source terminals.

When V_{GS} = 0 and V_{DS} = 0 then no current produced in the MOSFET so I_D = 0.

When V_{GS} = 0, V_{DS} is increased from "0", then electrons move from source to drain through n-channel so, the current produce in the MOSFET from drain to source.

When V_{GS} = Negative voltage and V_{DS} is increased then due to the negative voltage at gate terminal holes are attracted towards n-channel and these are recombined with electrons present in the n-channel hence channel width increase and I_D current will decrease.

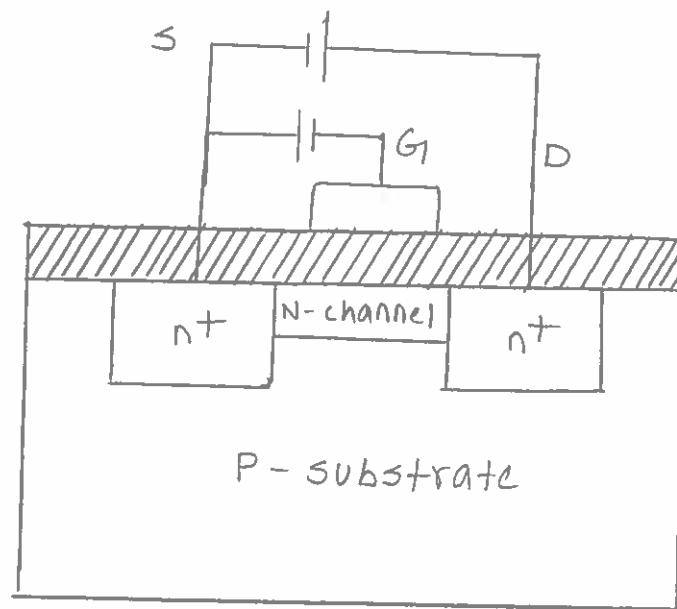
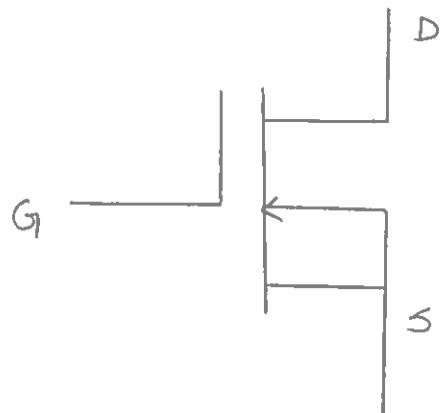
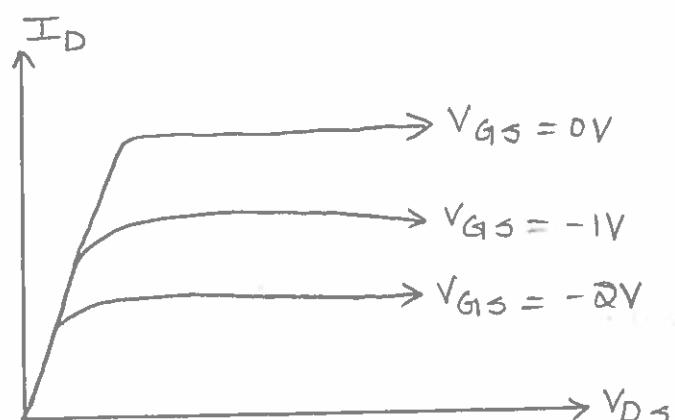


Fig:- Depletion type MOSFET

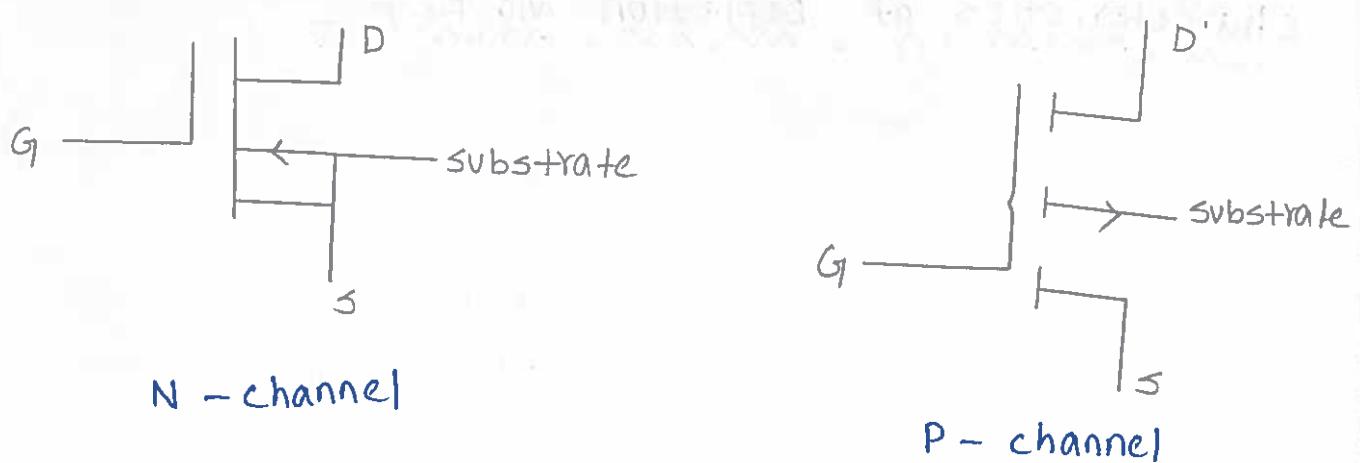
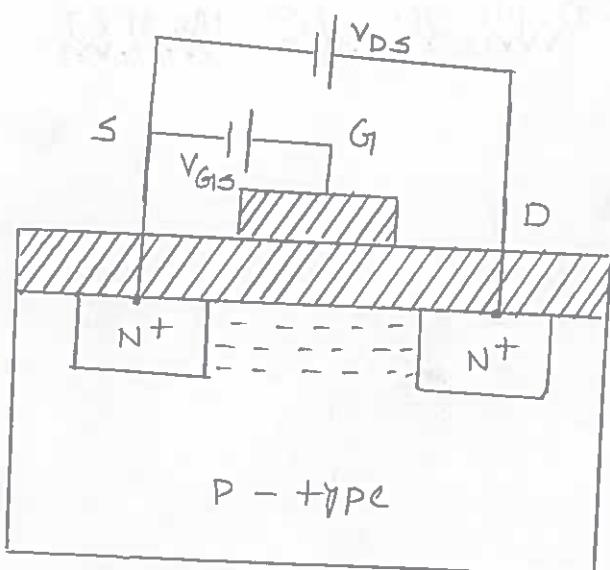
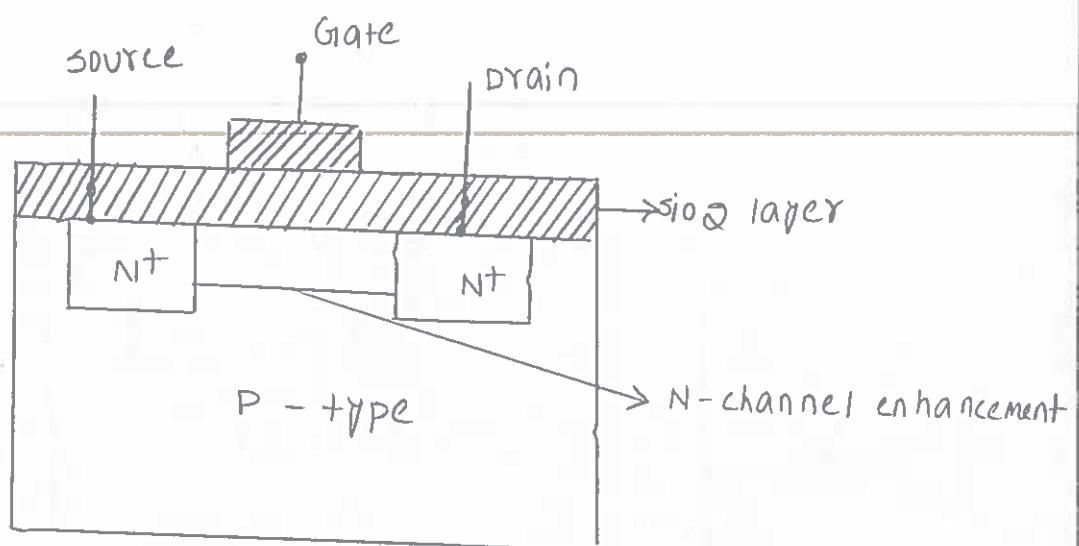


N-channel Depletion MOSFET SYMBOL

Characteristics of Depletion MOSFET:-



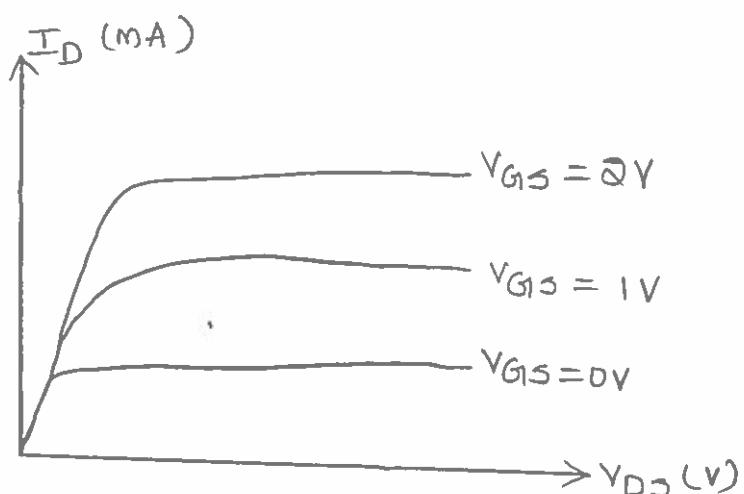
Enhancement MOSFET:-



In enhancement MOSFET there is no continuous channel in an MOSFET. this condition is represented by the broken line in the symbols.

TWO highly dopped N⁺ regions are diffused in a lightly doped substrate of P-type silicon substrate. one N⁺ region is called the source S and the other one is called the drain D. They are seperated by 1 mil (10^{-3}) inch . A thin insulating layer of SiO₂ is grown over the surface of the structure and holes are cut into the oxide layer, allowing contact with source and drain. Then a thin layer of metal aluminium is formed over the layer of SiO₂. This metal layer covers the entire channel region and it forms the Gate G.

Characteristics of enhancement MOSFET)-



and the *Thalassophyllum* *lanceolatum* (L.) Griseb. (1806) is
common with *Leptostomum* *virginianum*

The *Thalassophyllum* *lanceolatum* (L.) Griseb. (1806)
is a small greenish brown alga which grows on
the lower parts of marshy shores and the bases of
puffy grasses. It is found from N. A. to S. America
but is especially common in the warmer parts of
South America. It is a very delicate alga and
cannot stand exposure to bright sunlight.
It is also common in the cooler lands where

there is no bright sun.

There are two species of *Thalassophyllum* which
are easily distinguished by their color. One is
brownish green and the other is yellowish green.
The brownish green species is *Thalassophyllum*
lanceolatum (L.) Griseb. (1806) and the yellowish
green species is *Thalassophyllum* *virginianum* (L.)
Griseb. (1806). The *Thalassophyllum* *lanceolatum*
(L.) Griseb. (1806) is a small greenish brown alga
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