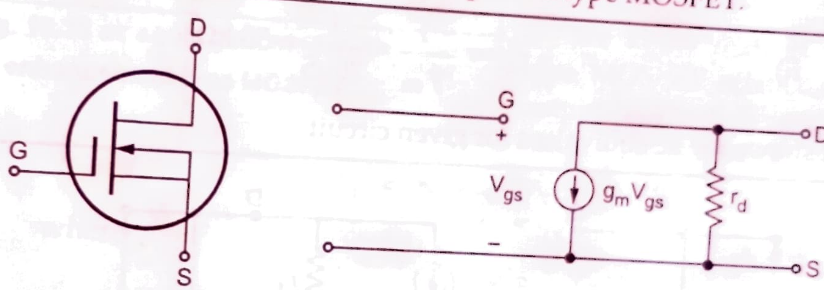
iii) A_v : From equation 10.80 we have

$$A_v = \frac{R_D(1+g_m r_d)}{r_d + R_D} = \frac{5.1\,K(1+2.8\,mS \times 50\,K)}{50\,K+5.1\,K}$$

$$= 13.05$$

10.7 Depletion - Type MOSFET Amplifier

Fig. 10.30 shows as equivalent model of depletion type MOSFET.



(a) Symbol (b) ac equivalent model

Fig. 10.30

This is exactly same as that of JFET. The only difference is that in depletion layer MOSFET. V_{GSQ} can be positive for n-channel MOSFET and negative for p-channel MOSFET.

Due to this in depletion MOSFET, g_m can be greater than g_{mo}. This is illustrated in the following example.

Ex. 10.7 : *For the circuit shown in Fig. 10.31 V_{GSQ} = 2V, with I_{DQ} = 5 mA and y_{os} = 20 mS. Calculate g_m, r_d, Z_i, Z_o and A_v.*

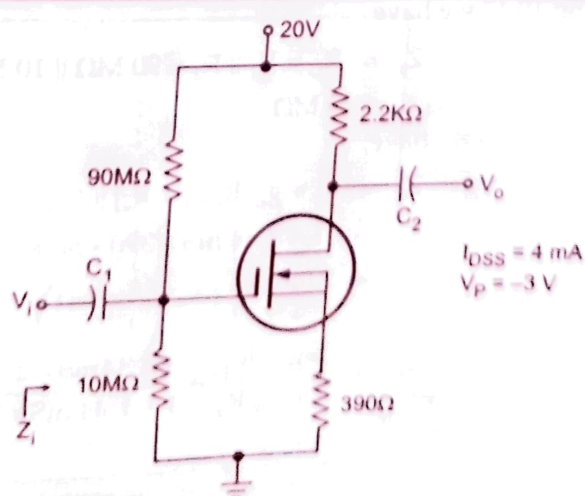


Fig. 10.31

Solution :

i)
$$g_{mo} = \frac{2I_{dSS}}{|V_P|} = \frac{2(4\ \text{mA})}{3\ \text{V}} = 2.67\ \text{mS}$$

$$g_m = g_{mo}\left(1 - \frac{V_{GSQ}}{V_P}\right) = 2.67\ \text{mS}\left(1 - \frac{2\text{V}}{-3\ \text{V}}\right)$$

$$= 4.44\ \text{mS}$$

We observed that, g_m is greater than g_{mo} if V_{GSQ} is positive in n-channel depletion type MOSFET.

ii)
$$r_d = \frac{1}{y_{os}} = \frac{1}{20\,\mu\text{S}} = 50\ \text{k}\Omega$$

Fig. 10.32 shows the ac equivalent for given circuit.

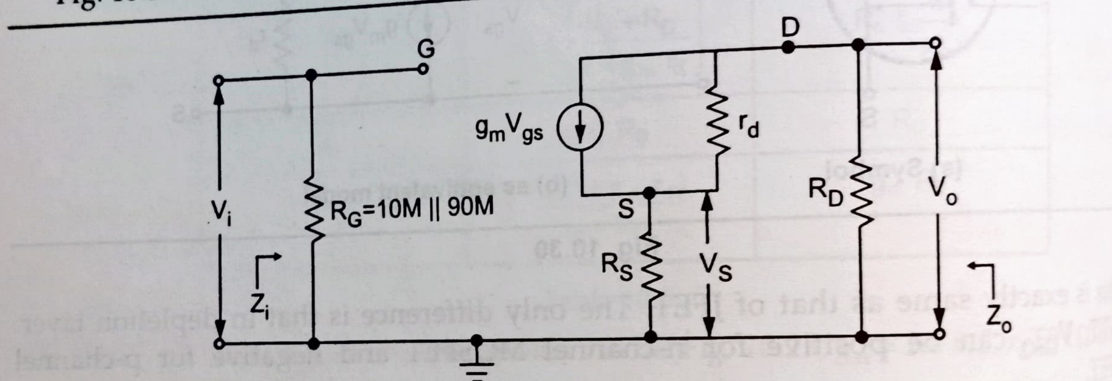


Fig. 10.32

This ac equivalent is exactly same as the circuit given in Fig. 10.18. Therefore formulae applicable for ac equivalent circuit given in the Fig. 10.18 are also applicable to the circuit given in Fig. 10.32.

iii) Z_i : From equation 10.42 we have

$$Z_i = R_G = R_1 \,||\, R_2 = 90\ \text{M}\Omega \,||\, 10\ \text{M}\Omega$$
$$= 9\ \text{M}\Omega$$

iv) Z_o : From equation 10.45 we have,

$$Z_o = [1 + g_m R_s r_d + R_s] \,||\, R_D$$
$$= [1 + 4.44\ \text{mS} \times 390 \times 50\ \text{K} + 390] \,||\, 2.2\ \text{K}$$
$$= 2146\ \Omega$$

v) A_v : From equation 10.48 we have

$$A_v = \frac{-g_m R_d}{1 + g_m R_s} = \frac{-4.44\text{mS} \times 2.2\text{K}}{1 + 4.44\ \text{mS} \times 390}$$
$$= 3.576$$

10.8 Enhancement-Type MOSFET Amplifier

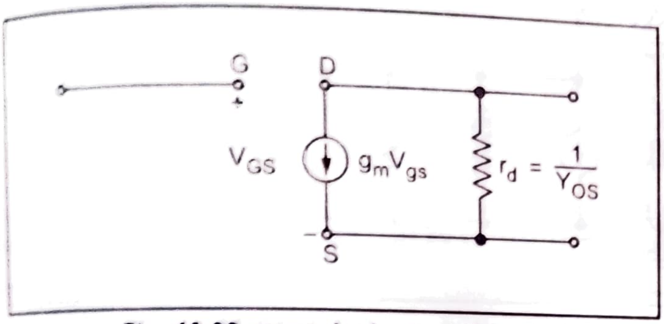


Fig. 10.33 ac equivalent model of enhancement type MOSFET

Fig. 10.33 shows ac equivalent model of enhancement type MOSFET. This is exactly same as that of JFET. The only difference is that in enhancement type MOSFET, V_{GSO} is positive for n channel MOSFET and negative for p-channel MOSFET.

We know that, in enhancement type MOSFET relationship between output current I_d and controlling voltage V_{GS} is given as,

$$I_d = K(V_{GS} - V_T)^2 \quad \text{... (10.82 a)}$$

where

$$K = \frac{I_d\,(ON)}{(V_{GS}(ON) - V_T)^2}$$

$$g_m = \frac{\Delta I_D}{\Delta V_{GS}} \quad \text{... (10.82 b)}$$

Thus, differentiating equation 10.82 with respect to V_{GS} we get the equation for g_m as follows,

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

$$= V_{GS}\,[K\,(V_{GS} - V_T)]^2$$

$$= 2K\,(V_{GS} - V_T) \quad \text{... (10.83)}$$

10.8.1 Enhancement Type MOSFET with Feedback Bias

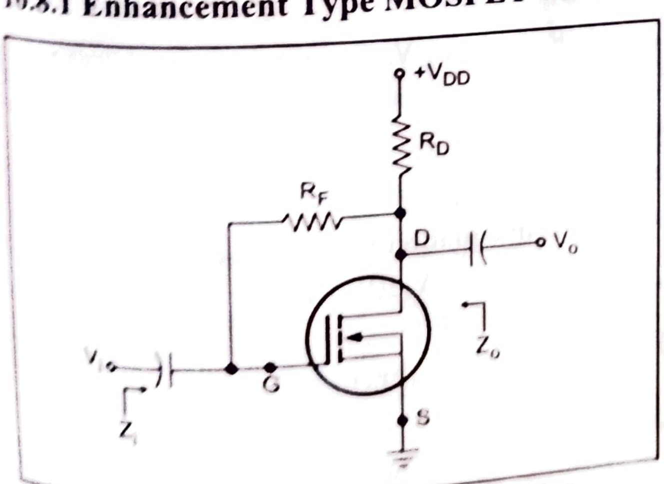


Fig. 10.34 Common source amplifier using enhancement type MOSFET

Fig. 10.34 shows common source amplifier using enhancement type MOSFET. In this circuit biasing is provided by feedback bias.

Replacing enhancement type MOSFET with its ac equivalent and capacitors and dc voltage source with short circuits, we get ac equivalent model shown in the Fig. 10.35.

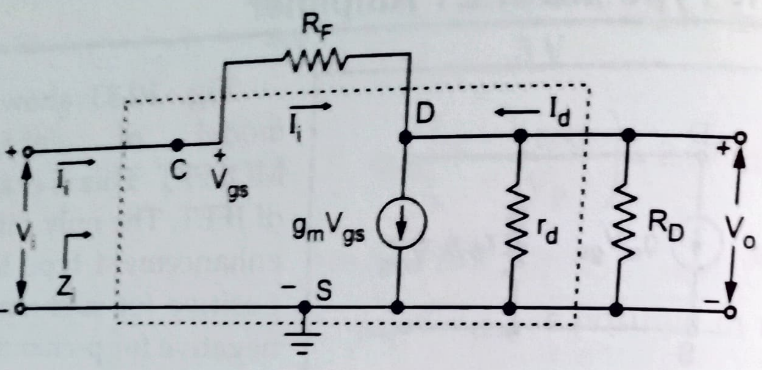


Fig. 10.35 ac equivalent circuit of circuit shows in Fig. 10.34

Input impedance Z_i : It is given as,

$$Z_i = \frac{V_i}{I_i}$$

Applying Kirchhoff's current law at node D we get,

$$I_i + I_d = g_m V_{gs} \quad \dots (10.84)$$

Looking at Fig. 10.35 we can write,

$$V_{gs} = V_i \quad \dots (10.85)$$

and

$$V_o = -I_d (R_D \| r_d) \quad \dots (10.86)$$

$\therefore$

$$I_d = \frac{-V_o}{R_D \| r_d} \quad \dots (10.87)$$

Substituting values of V_{gs} and I_d from equations 10.85 and 10.87 respectively in equation 10.84 we get,

$$I_i - \frac{V_o}{R_D \| r_d} = g_m V_i \quad \dots (10.88)$$

$\therefore$

$$V_o = I_i (R_D \| r_d) - g_m V_i (R_D \| r_d) \quad \dots (10.89)$$

Applying KVL to the outer loop of Fig. 10.35 we get,

$$I_i = \frac{V_i - V_o}{R_F} \quad \dots (10.90)$$

Substituting value of V_o from equation 10.89 in equation 10.90 we get,

$$I_i = \frac{V_i - (I_i - g_m V_i)(R_D \| r_d)}{R_F}$$

$\therefore$

$$I_i + \frac{I_i (R_D \| r_d)}{R_F} = \frac{V_i + g_m V_i (R_D \| r_d)}{R_F}$$

$\therefore$

$$\frac{I_i (R_F + R_D \| r_d)}{R_F} = \frac{V_i (1 + g_m (R_D \| r_d))}{R_F}$$