EMOSFET

the Enhancement MOSFETS, or E-MOSFETS, only conduct when a suitable gate-to-source positive voltage is applied, unlike Depletion type MOSFETs which conduct only when the gate voltage is zero.

However, due to the construction and physics of an enhancement type MOSFET, there is a minimum gate-to-source voltage, called the threshold voltage V_{Th} that must be applied to the gate before it starts to conduct, thus allowing the drain current to flow.

In other words, an E-MOSFET does not conduct until the gate-source voltage, V_{GS} is less than the threshold voltage, $V_{Th.}$.

- But as the forward bias at the gate increases, the drain current, I_D (or drain-source current, I_{DS}) will also increase, making the E-MOSFET ideal for use in MOSFET amplifier circuits.
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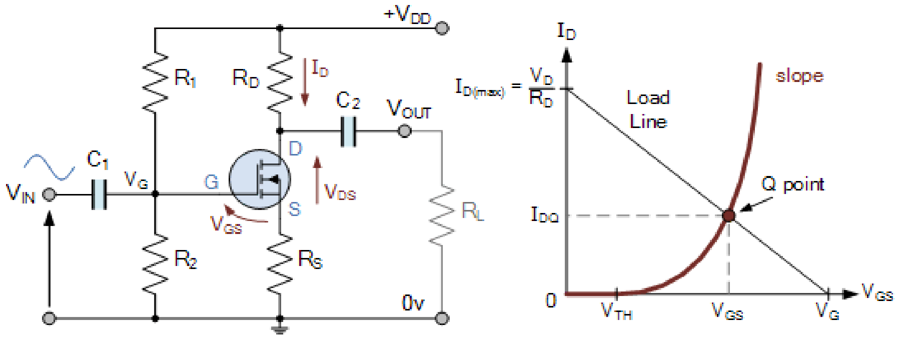


This simple enhancement-mode common source MOSFET amplifier configuration uses a single supply at the drain and generates the required gate voltage, VG using a resistor divider.

As we know that for a MOSFET, no current flows into the gate terminal, we can make the following basic assumptions about the MOSFET amplifiers DC operating conditions .

$$V_{DD} = I_D R_D + V_{DS} + I_D R_S$$

$$= I_D(R_D + R_S) + V_{DS}$$

$$\therefore\ R_D + R_S = \frac{V_{DD} - V_{DS}}{I_D}$$

$$R_D = \frac{V_{DD} - V_D}{I_D}$$

$$and \qquad R_S = \frac{V_S}{I_D}$$

and the MOSFET gate-to-source voltage, VGS is given as:

$$V_{GS} = V_G - I_S R_S$$

As we have already discussed, for proper operation of the mosfet, this gate-source voltage must be greater than the threshold voltage of the MOSFET, that is VGS > VTH.

Since IS = ID, the gate voltage, VG is therefore equal too:

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

$$\therefore\ V_G = V_{GS} + I_D R_S$$

$$Or\ \ V_G = V_{GS} + V_S$$

To set the MOSFET amplifier gate voltage to this value we select the values of the resistors, R1 and R2 within the voltage divider network to the required values.

Since, no current flows into the gate terminal of a MOSFET device so the formula for voltage division is given as:

$$V_G = V_{DD}\left(\frac{R_2}{R_1 + R_2}\right)$$

It can be noted that, this voltage divider equation only determines the ratio of the two bias resistors, R1 and R2 and not their actual values.

It is always desirable to make the values of these two resistors as large as possible to reduce their I2R power loss and increase the MOSFETs amplifiers input resistance.

MOSFET Amplifier Example No1

An common source mosfet amplifier is to be constructed using a n-channel eMOSFET which has a conduction parameter of $50mA/V^2$ and a threshold voltage of 2.0 volts. If the supply voltage is +15 volts and the load resistor is 470 Ohms, calculate the values of the resistors required to bias the MOSFET amplifier at $1/3(V_{DD})$. Draw the circuit diagram.

Values given: $V_{DD} = +15v$, $V_{TH} = +2.0v$, $k = 50mA/V^2$ and $R_D = 470\Omega$.

For an undistorted and symmetrical output waveform, set the DC biasing voltage of the drain terminal to half the supply voltage.

1. Drain Current, I_D

$$V_D = \frac{V_{DD}}{2} = \frac{15}{2} = 7.5v$$

$$I_D = \frac{V_D}{R_D} = \frac{7.5}{470} = 16mA$$

$$V_D = VR_D$$

2. Gate-source Voltage, V_{GS}

$$I_D = k(V_{GS} - V_{TH})^2$$

$$\therefore V_{GS} = \sqrt{\frac{I_D}{k}} + V_{TH} = \sqrt{\frac{0.016}{0.05}} + 2.0 = 2.6v$$

3. Gate Voltage, V_G

$$V_G = \frac{1}{3}V_{DD} = \frac{15}{3} = 5v$$

$$V_G = V_{GS} + V_S$$

$$\therefore V_S = V_G - V_{GS} = 5 - 2.6 = 2.4v$$

Thus applying KVL across the mosfet, the drain-source voltage, V_{DS} is given as:

$$V_{DD} = V_D + V_{DS} + V_S = 15v$$

$$\therefore V_{DS} = V_{DD} - V_D - V_S = 15 - 7.5 - 2.4 = 5.1v$$

$$V_D = VR_D$$

4. Source Resistance, R_S

$$R_S = \frac{V_S}{I_D} = \frac{2.4}{0.016} = 150\Omega$$

The ratio of the voltage divider resistors, R1 and R2 required to give $1/3V_{DD}$ is calculated as:

$$V_G = V_{DD}\left(\frac{R_2}{R_1 + R_2}\right) = 15\left(\frac{1}{3}\right)$$

If we choose: R1 = 200kΩ and R2 = 100kΩ this will satisfy the condition of: $V_G = 1/3V_{DD}$. Also this combination of bias resistors will give an input resistance to the mosfet amplifier of approximately 67kΩ

Example(1):-

For EMOSFET if I_D=10 mA when V_{GS}=8 V , V_{GSth}=2 V .Find I_D when V_{GS}=4 V ?

Solution:-

I_D=$K(V_{GS} - V_{GSth})^2$

$K = \frac{I_D}{(V_{GS} - V_{GSth})^2} = \frac{10\ mA}{(8V-2V)^2}$=$0.278 \times 10^{-3} A/V^2$

For V_{GS}=4 V

I_D= $0.278 \times 10^{-3} \times (4V - 2V)^2$=$1.11\ mA$

Example(2)

For the circuit shown in figure(2).If $V_{DD} = 16\ V, V_D = 12\ V$ and $V_{GS} = -2\ V$, Determine R_s . If R_1= 91 $K\boldsymbol{\Omega}$, R_2= 47 $K\boldsymbol{\Omega}$, R_D= 1.8 $K\boldsymbol{\Omega}$?

Solution:-

$V_G = \frac{V_{DD}R_2}{R_1+R_2}$=$\frac{12\ V\times 47K}{91\ K+47K}$=5.44 V

$$I_D = \frac{V_{DD} - V_D}{R_D}$$

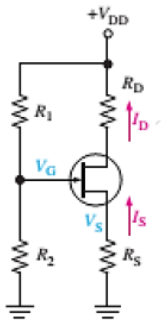
$I_D = \frac{16\ V-12\ V}{1.8\ K\boldsymbol{\Omega}}$= $2.22\ mA$

The equation of V_{GS} is then written and the known values substituted:

V_{GS}= V_G- V_S

$-2V = 5.44\ V - (2.22\ mA)R_S$

R_S=$\frac{7.44\ V}{2.22\ mA}$=3.35 $K\boldsymbol{\Omega}$



An n-channel JFET with voltage-divider bias (I_S=I_D).

Figure (2)

Example(3)

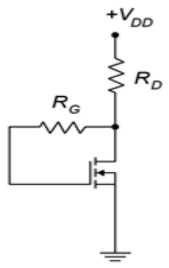
For circuit shown in figure(3) V_{GS}=6V, $I_D = 4mA$, V_{GSth}=3V, $V_{DS} = \frac{1}{2}$ V_{DD}. Determine V_{DD}, R_D?

Solution:-

V_{DS}= V_{GS}= $6V = \frac{1}{2} V_{DD}$

V_{DD} = $12V$

$R_D = \frac{V_{RD}}{I_D} = \frac{V_{DD}-V_{DS}}{I_D} = \frac{12V-6V}{4mA} = \frac{6V}{4mA} = 1.5K\boldsymbol{\Omega}$



Drain feedback bias prototype.

Figure (3)

Example(4)

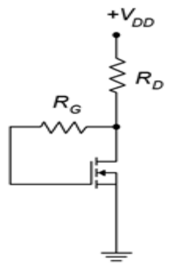
For the circuit shown in figure(4), if the R_G=10 $M\boldsymbol{\Omega}$, R_D=2 $K\boldsymbol{\Omega}$, V_{DD} = $12V$, I_D = 6 mA,$K = 0.24 \times 10^{-3}\ A/V^2$, V_{GS}= 6.4V , I_D= 2.75 mA, V_{GSth}= 3 V. Find g_m,A_V without r_d ?

Solution:-

$a - g_m = 2 \times K \times (V_{GS} - V_{GSth})$

$g_m = 2(0.24 \times 10^{-3}\ A/V^2)(6.4V\ - 3\ V) = 1.63\ mS$

b- $A_V = -\ g_m\ R_D = -3.26$



Drain feedback bias prototype.

Figure (4)