Electronic Devices

Final Term
Lecture - 08

Reference book:

Electronic Devices and Circuit Theory (Chapter-7)

Robert L. Boylestad and L. Nashelsky , (11th Edition)

E-MOSFET VOLTAGE-DIVIDER BIAS

- **E-MOSFETs** use the **same procedure** to **JFETs** and **D-MOSFETs.**

$$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$$

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

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

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

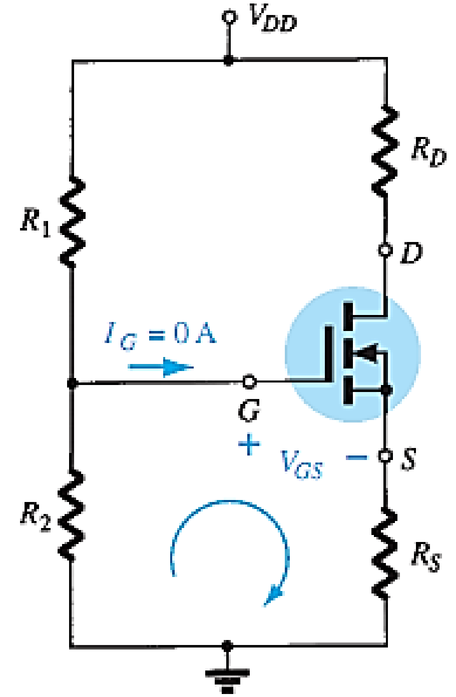


FIG. 7.43
Voltage-divider biasing arrangement for an n-channel enhancement MOSFET.

E-MOSFET VOLTAGE-DIVIDER BIAS

- **Graphical Approach:**
  - Calculate the value for

$$k = \frac{I_{D(on)}}{(V_{GS(on)} - V_{GS(Th)})^2}$$

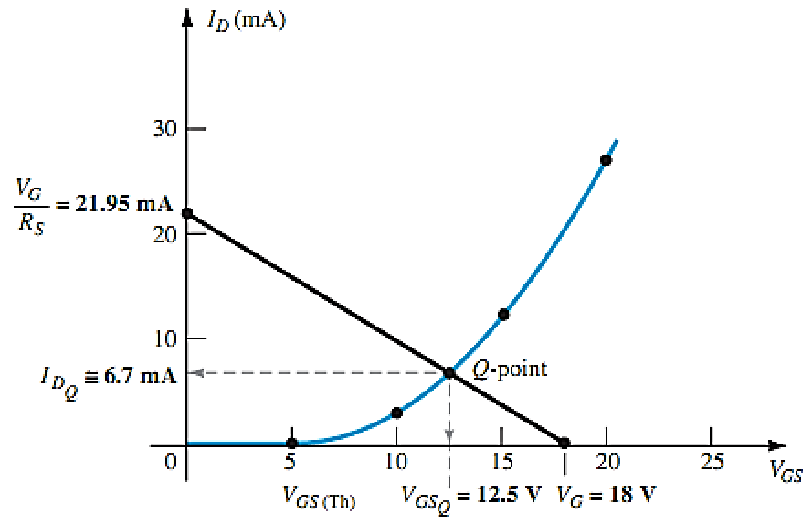
  - Plot V_{GS} *vs* I_D using

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

  - Plot for:
    - » $V_{GS} = V_G$ *at* $I_D = 0A$
    - » $V_{GS} = 0V$ *at* $I_D = V_G/R_S$

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

  - Identify the Q-point.



E-MOSFET VOLTAGE-DIVIDER BIAS EXAMPLE

- Determine I_D, V_{GS}, *and* V_{DS} for the following network:

$$V_G = \frac{R_2 V_{DD}}{R_1 + R_2} = \frac{(18\ \text{M}\Omega)(40\ \text{V})}{22\ \text{M}\Omega + 18\ \text{M}\Omega} = 18\ \text{V}$$

$$V_{GS} = V_G - I_D R_S = 18\ \text{V} - I_D(0.82\ \text{k}\Omega)$$

When $I_D = 0$ mA,

$$V_{GS} = 18\ \text{V} - (0\ \text{mA})(0.82\ \text{k}\Omega) = 18\ \text{V}$$

When $I_D = 0$ mA,

$$V_{GS} = 18\ \text{V} - (0\ \text{mA})(0.82\ \text{k}\Omega) = 18\ \text{V}$$

as appearing on Fig. 7.45. When $V_{GS} = 0$ V,

$$V_{GS} = 18\ \text{V} - I_D(0.82\ \text{k}\Omega)$$

$$0 = 18\ \text{V} - I_D(0.82\ \text{k}\Omega)$$

$$I_D = \frac{18\ \text{V}}{0.82\ \text{k}\Omega} = 21.95\ \text{mA}$$

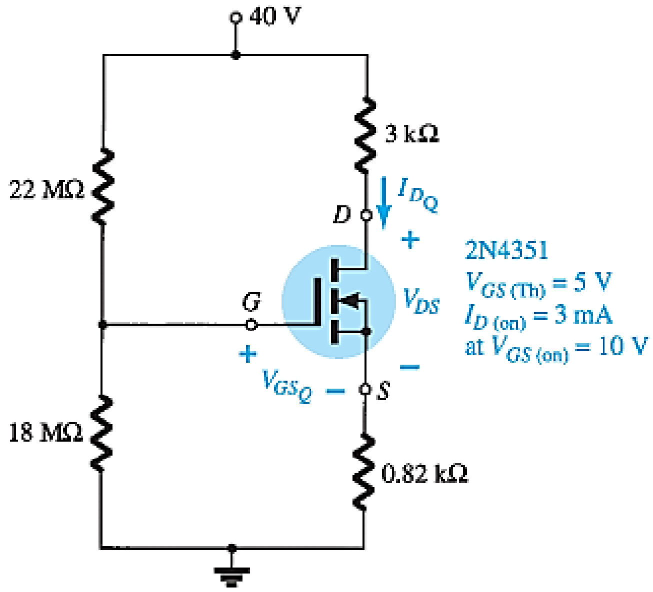


FIG. 7.44
Example 7.11.

E-MOSFET VOLTAGE-DIVIDER BIAS EXAMPLE

Device

$$V_{GS(\text{Th})} = 5\text{ V}, \qquad I_{D(\text{on})} = 3\text{ mA with } V_{GS(\text{on})} = 10\text{ V}$$

$$\text{Eq. (7.34):}\quad k = \frac{I_{D(\text{on})}}{(V_{GS(\text{on})} - V_{GS(\text{Th})})^2} = \frac{3\text{ mA}}{(10\text{ V} - 5\text{ V})^2} = 0.12 \times 10^{-3}\text{ A/V}^2$$

and

$$I_D = k(V_{GS} - V_{GS(\text{Th})})^2 = 0.12 \times 10^{-3}(V_{GS} - 5)^2$$

$$I_{D_Q} \cong \mathbf{6.7\text{ mA}}$$

$$V_{GS_Q} = \mathbf{12.5\text{ V}}$$

$$\begin{aligned} V_{DS} &= V_{DD} - I_D(R_S + R_D) \\ &= 40\text{ V} - (6.7\text{ mA})(0.82\text{ k}\Omega + 3.0\text{ k}\Omega) \\ &= 40\text{ V} - 25.6\text{ V} \\ &= \mathbf{14.4\text{ V}} \end{aligned}$$

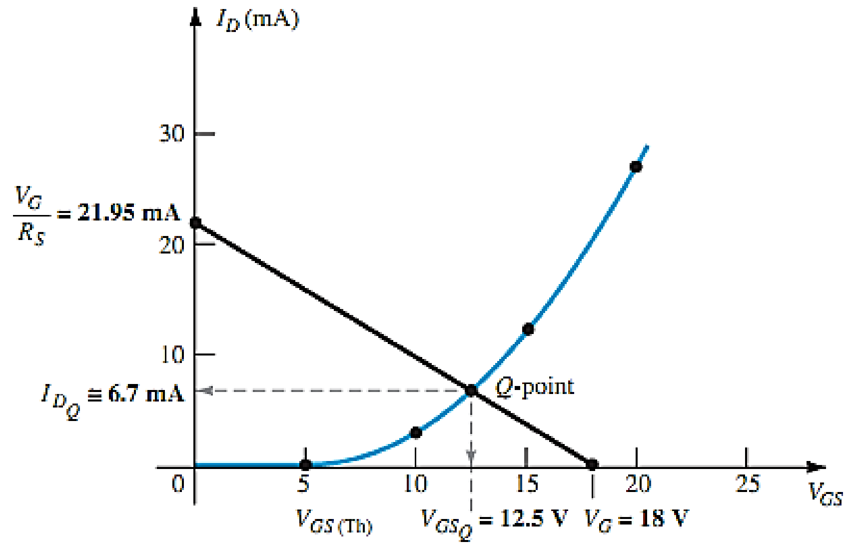


FIG. 7.45
Determining the Q-point for the network of Example 7.11.

E-MOSFET FEEDBACK BIAS

$$I_G \approx 0A$$

$$V_{RG} = 0V$$

$$V_{GS} = V_{DS}$$

$$V_{GS} = V_{DD} - I_D R_D$$

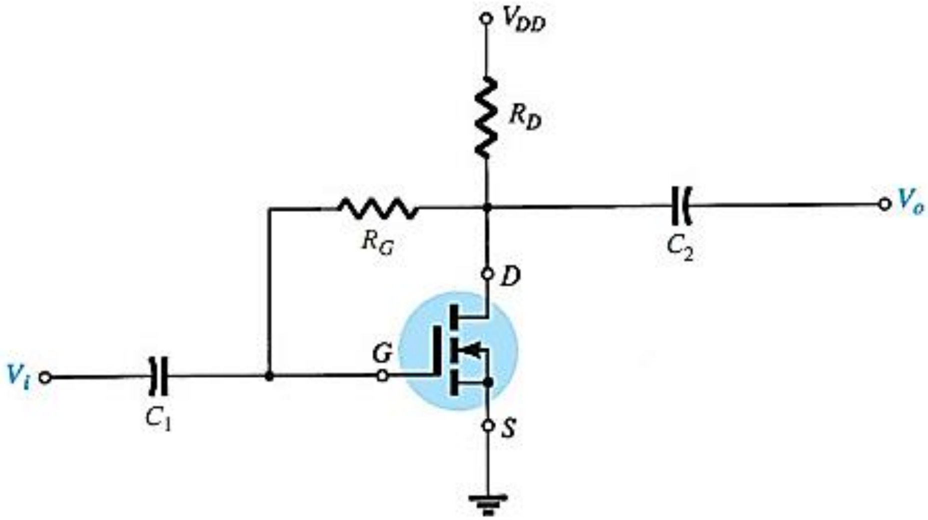


FIG. 7.37
Feedback biasing arrangement.

E-MOSFET FEEDBACK BIAS

- **Graphical Approach** (to find V_{GSQ} and I_{DQ}):
  - Calculate the value for

$$k = \frac{I_{D(on)}}{(V_{GS(on)} - V_{GS(Th)})^2}$$

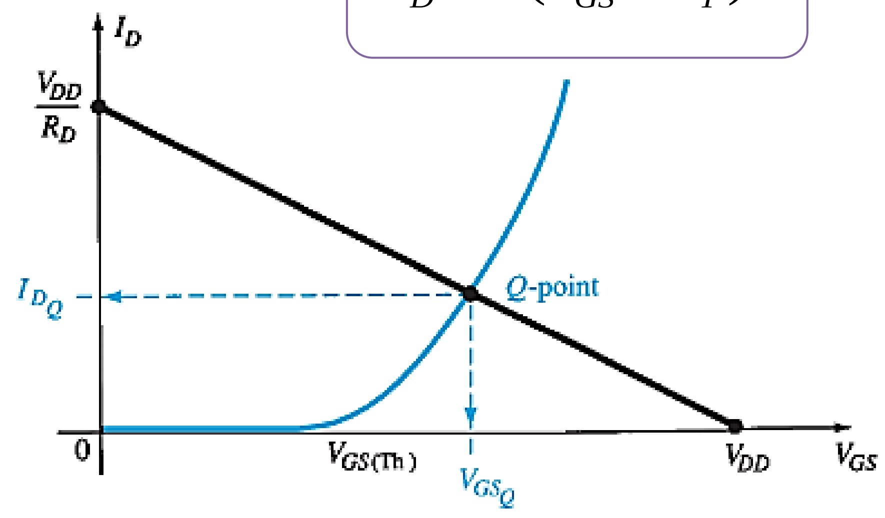
  - Plot $\boldsymbol{V_{GS}}$ ***vs*** $\boldsymbol{I_D}$ for the range of interest.

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

  - Plot :

$$V_{GS} = V_{DD} - I_D R_D$$

  - Identify the Q-point.



E-MOSFET FEEDBACK BIAS EXAMPLE

- ***Example 7.10:*** Determine I_{DQ} ***and*** V_{DSQ} for the following circuit:

$$k = \frac{I_{D(\text{on})}}{(V_{GS(\text{on})} - V_{GS(\text{Th})})^2}$$
$$= \frac{6\text{ mA}}{(8\text{ V} - 3\text{ V})^2} = \frac{6 \times 10^{-3}}{25}\text{ A/V}^2$$
$$= 0.24 \times 10^{-3}\text{ A/V}^2$$

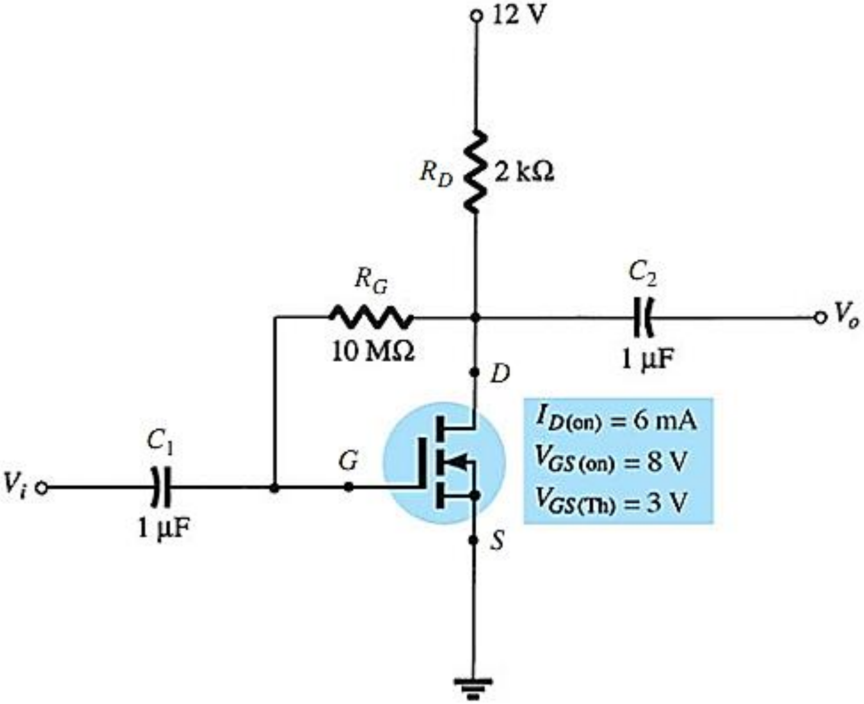


FIG. 7.40
Example 7.10.

E-MOSFET FEEDBACK BIAS EXAMPLE CONTD.

For $V_{GS} = 6\text{ V}$ (between 3 and 8 V):

$$I_D = 0.24 \times 10^{-3}(6\text{ V} - 3\text{ V})^2 = 0.24 \times 10^{-3}(9)$$
$$= 2.16\text{ mA}$$

as shown on Fig. 7.41. For $V_{GS} = 10\text{ V}$ (slightly greater than $V_{GS(\text{Th})}$),

$$I_D = 0.24 \times 10^{-3}(10\text{ V} - 3\text{ V})^2 = 0.24 \times 10^{-3}(49)$$
$$= 11.76\text{ mA}$$

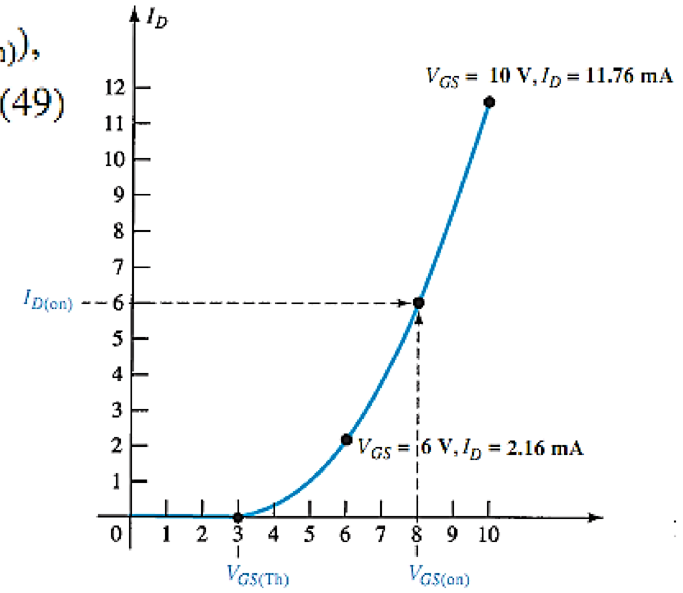


FIG. 7.41
Plotting the transfer curve for the MOSFET of Fig. 7.40.

For the Network Bias Line

$$V_{GS} = V_{DD} - I_D R_D$$
$$= 12\text{ V} - I_D(2\text{ k}\Omega)$$

Eq. (7.37): $V_{GS} = V_{DD} = 12\text{ V}\big|_{I_D = 0\text{ mA}}$

Eq. (7.38): $I_D = \dfrac{V_{DD}}{R_D} = \dfrac{12\text{ V}}{2\text{ k}\Omega} = 6\text{ mA}\big|_{V_{GS} = 0\text{ V}}$

E-MOSFET FEEDBACK BIAS EXAMPLE CONTD.

$$I_{D_Q} = 2.75\text{ mA}$$
$$V_{GS_Q} = 6.4\text{ V}$$
$$V_{DS_Q} = V_{GS_Q} = 6.4\text{ V}$$

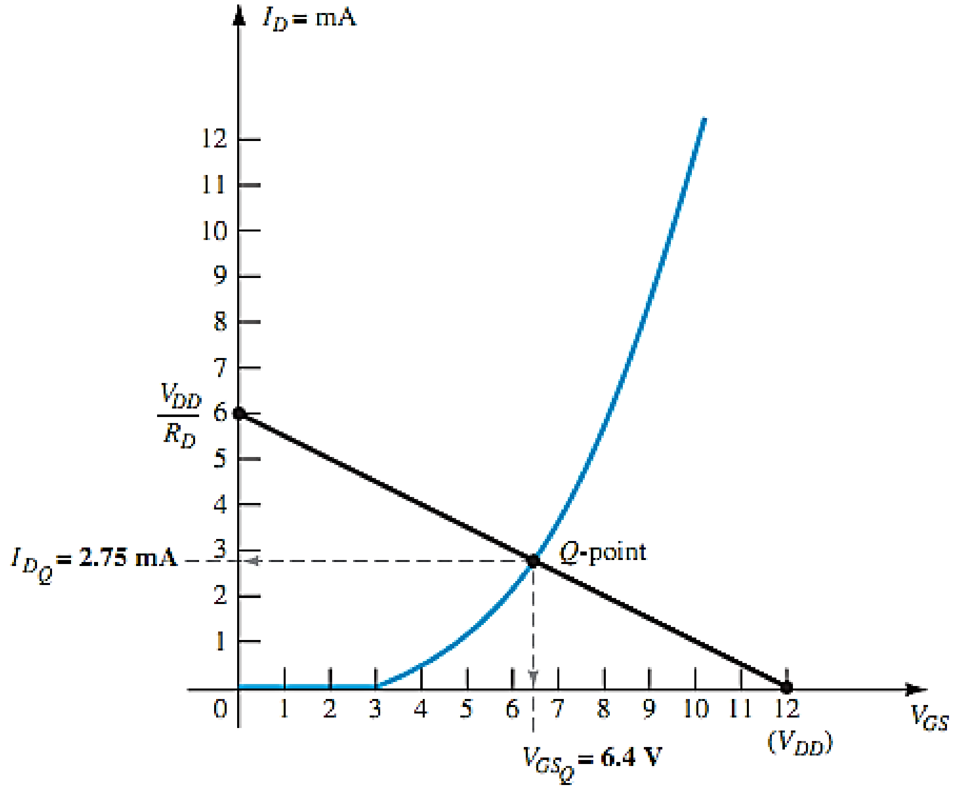


FIG. 7.42
Determining the Q-point for the network of Fig. 7.40.

p-CHANNEL FETs

- For **p-channel FETs** the **same** calculations and graphs are used, **except** that the **voltage polarities** and **current directions** are the **opposite**.

- The graphs will be mirrors of the n-channel graphs.

End of Lecture-8