Electronic Circuits

Prof. Nizamettin AYDIN

naydin@yildiz.edu.tr

http://www.yildiz.edu.tr/~naydin

Dr. Gökhan Bilgin

gokhanb@ce.yildiz.edu.tr

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Common FET Biasing Circuits

JFET Biasing Circuits

- Fixed – Bias
- Self-Bias
- Voltage-Divider Bias

D-Type MOSFET Biasing Circuits

- Self-Bias
- Voltage-Divider Bias

E-Type MOSFET Biasing Circuits

- Feedback Configuration
- Voltage-Divider Bias

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Basic Current Relationships

For all FETs:

$$I_G \cong 0A$$
$$I_D = I_S$$

For JFETS and D-Type MOSFETs:

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

For E-Type MOSFETs:

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

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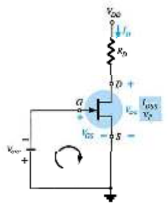
Fixed-Bias Configuration

$$V_{DS} = V_{DD} - I_D R_D$$
$$V_S = 0V$$
$$V_C = V_{DS}$$
$$V = V_{GS}$$
$$V_{GS} = -V_{GG}$$



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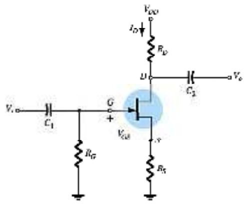
Self-Bias Configuration



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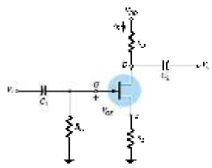
Self-Bias Calculations

For the indicated loop, $V_{GS} = -I_D R_S$

To solve this equation:

- **Select an $I_D < I_{DSS}$ and use the component value of R_S to calculate V_{GS}**
- **Plot the point identified by I_D and V_{GS}. Draw a line from the origin of the axis to this point.**
- **Plot the transfer curve using I_{DSS} and V_P ($V_P = V_{GSoff}$ in specification sheets) points such as $I_D = I_{DSS}/4$ and $I_D = I_{DS}$**

The Q-point is located where the first line intersects the transfer curve. Use the value of I_D at the Q-point (I_{DQ}) to solve for the other voltages:



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

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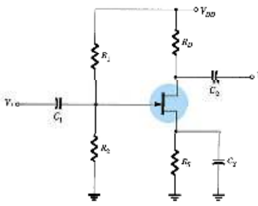
Voltage-Divider Bias

$I_G = 0$ A

I_D responds to changes in V_{GS}.



Voltage-Divider Bias Calculations

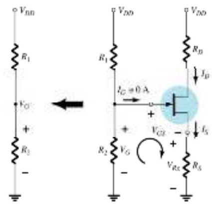
V_G is equal to the voltage across divider resistor R_2:

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

Using Kirchhoff's Law:

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

The Q point is established by plotting a line that intersects the transfer curve.



Voltage-Divider Q-point

Step 1

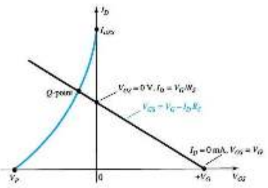
Plot the line by plotting two points:
- $V_{GS} = V_G$, $I_D = 0$ A
- $V_{GS} = 0$ V, $I_D = V_G / R_S$

Step 2

Plot the transfer curve by plotting I_{DSS}, V_P and the calculated values of I_D

Step 3

The Q-point is located where the line intersects the transfer curve



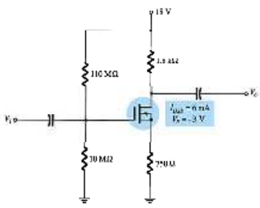
Voltage-Divider Bias Calculations

Using the value of I_D at the Q-point, solve for the other variables in the voltage-divider bias circuit:

$$V_{DS} = V_{DD} - I_D(R_D + R_S)$$
$$V_D = V_{DD} - I_D R_D$$
$$V_S = I_D R_S$$
$$I_{R1} = I_{R2} = \frac{V_{DD}}{R_1 + R_2}$$

D-Type MOSFET Bias Circuits

Depletion-type MOSFET bias circuits are similar to those used to bias JFETs. The only difference is that depletion-type MOSFETs can operate with positive values of V_{GS} and with I_D values that exceed I_{DSS}.



Self-Bias

Step 1

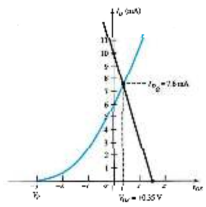
Plot line for
- $V_{GS} = V_G$, $I_D = 0$ A
- $I_D = V_G/R_S$, $V_{GS} = 0$ V

Step 2

Plot the transfer curve using I_{DSS}, V_P and calculated values of I_D

Step 3

The Q-point is located where the line intersects the transfer curve. Use the I_D at the Q-point to solve for the other variables in the voltage-divider bias circuit.



These are the same steps used to analyze JFET self-bias circuits.

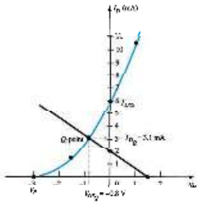
Voltage-Divider Bias

Step 1
Plot the line for
- $V_{GS} = V_G$, $I_D = 0$ A
- $I_D = V_G/R_S$, $V_{GS} = 0$ V

Step 2
Plot the transfer curve using I_{DSS}, V_P and calculated values of I_D.

Step 3
The Q-point is located where the line intersects the transfer curve is. Use the I_D at the Q-point to solve for the other variables in the voltage-divider bias circuit.

These are the same steps used to analyze JFET voltage-divider bias circuits.



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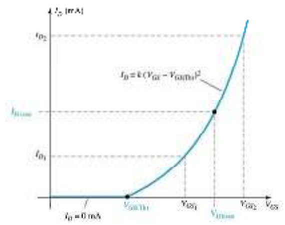
E-Type MOSFET Bias Circuits

The transfer characteristic for the e-type MOSFET is very different from that of a simple JFET or the d-type MOSFET.



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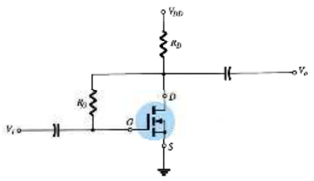
Feedback Bias Circuit

$I_G = 0$ A

$V_{RG} = 0$ V

$V_{DS} = V_{GS}$

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



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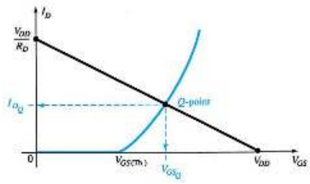
Feedback Bias Q-Point

Step 1
Plot the line using
- $V_{GS} = V_{DD}$, $I_D = 0$ A
- $I_D = V_{DD} / R_D$, $V_{GS} = 0$ V

Step 2
Using values from the specification sheet, plot the transfer curve with
- V_{GSTh} , $I_D = 0$ A
- $V_{GS(on)}$, $I_{D(on)}$

Step 3
The Q-point is located where the line and the transfer curve intersect

Step 4
Using the value of I_D at the Q-point, solve for the other variables in the bias circuit



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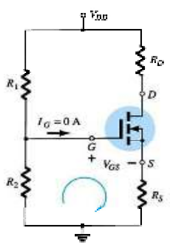
Voltage-Divider Biasing

Plot the line and the transfer curve to find the Q-point. Use these equations:

$$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$$
$$V_{GS} = V_G - I_D R_S$$
$$V_{DS} = V_{DD} - I_D (R_S + R_D)$$



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Voltage-Divider Bias Q-Point

Step 1
Plot the line using
- $V_{GS} = V_G = (R_2 V_{DD}) / (R_1 + R_2)$, $I_D = 0$ A
- $I_D = V_G/R_S$, $V_{GS} = 0$ V

Step 2
Using values from the specification sheet, plot the transfer curve with
- V_{GSTh}, $I_D = 0$ A
- $V_{GS(on)}$, $I_{D(on)}$

Step 3
The point where the line and the transfer curve intersect is the Q-point.

Step 4
Using the value of I_D at the Q-point, solve for the other circuit values.

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p-Channel FETs

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

The graphs are mirror images of the *n*-channel graphs.

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Applications

Voltage-controlled resistor
JFET voltmeter
Timer network
Fiber optic circuitry
MOSFET relay driver

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