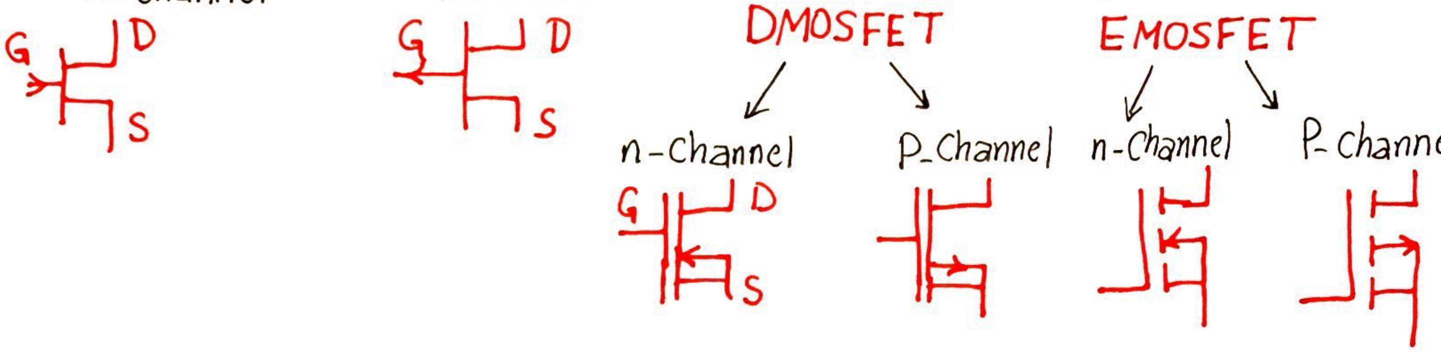
Electronics : ENEE 236 ⟹ L14 - JFET Baiasing

JFET → n-Channel, P-Channel

MOSFET → ~~n-Channel~~ DMOSFET, ~~P-Channel~~ EMOSFET

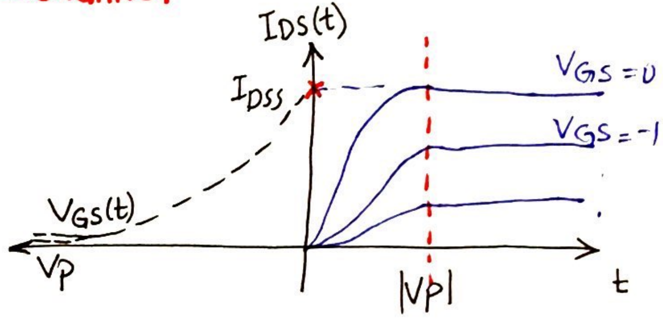
DMOSFET → n-Channel, P-Channel

EMOSFET → n-Channel, P-Channel



$V_P = \begin{cases} \text{negative value for n-channel} \\ \text{Positive value for P-channel} \end{cases}$

$$\left[I_{DS}(t) = I_{DSS}\left(1 - \frac{V_{GS}(t)}{V_P}\right)^2 \right]$$



In pinch off Region

$V_P < V_{GS} \leq 0$ "n-channel"

$|V_{DS}| > |V_P| - |V_{GS}|$ | "P-channel" $V_P < V_{GS} \leq 0$

Common JFET Biasing Circuit

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

Important

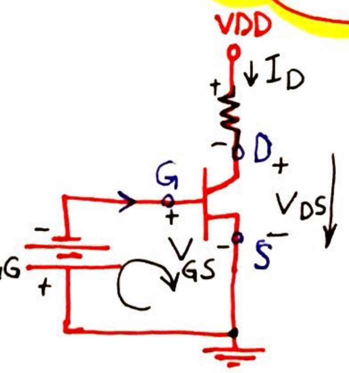
For All FETs:
$I_G \cong 0A$, $I_D = I_S = I_{DS}$

For All JFETs:
$I_{DS}(t) = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$

نفسها لل DMOS.

1 Fixed-Bias : I_{DSS} ✓, V_P ✓

V_{GS}? I_D? V_{DS}?



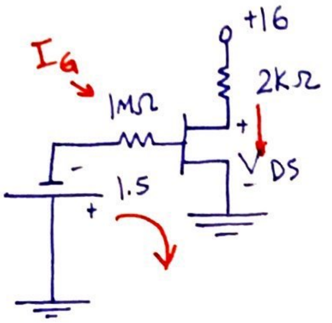
$V_{GG} + V_{GS} = 0 \Rightarrow V_{GS} = -V_{GG}$

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

$V_{DS} = V_D$

$V_{GS} = V_G$

$\boxed{0 = V_S}$ دائماً



Example

$I_{DSS} = 10\ mA$
$V_P = -4$

$V_{GS} = -1.5$ Volt

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 = 10\,mA\left(1 - \frac{-1.5}{-4}\right)^2$$

$$= 3.9\ mA$$

$$V_{DS} = 16 - I_D \cdot 2K = 8.2\ V$$

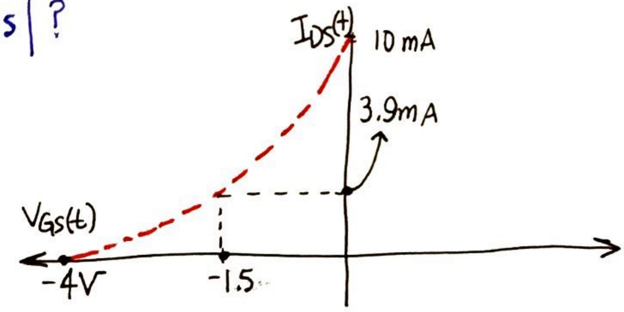
Check

$|V_{DS}| > |V_p| - |V_{GS}|$?

$8.2 > |4| - 1.5$

Graphical method

- $I_{DS} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$
- $V_{GS} = -1.5$ Fixd



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2 Self-Bias Configuration

$$0 + V_{GS} + I_D R_S = 0$$

(I_S)

$$V_{GS} = V_G - V_S = 0 - V_S = -V_S$$

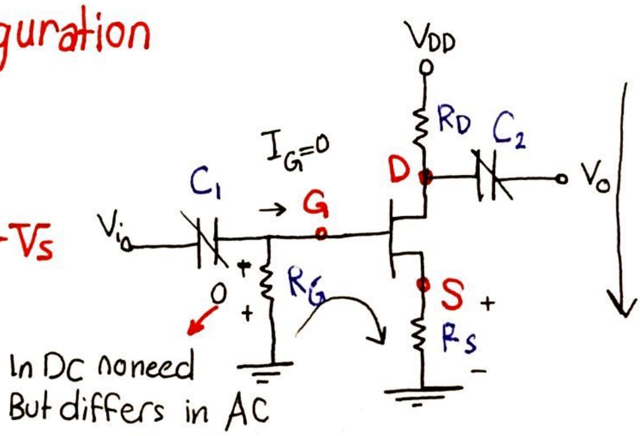
$$V_S = I_D R_S$$

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

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

$$V_{DS} = V_D - V_S$$

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



$V_{GS} = V_G - V_S$ ($V_G \to 0$)

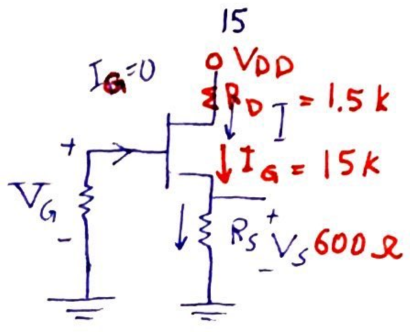
$V_{GS} = 0 - I_S R_S$

$V_{GS} = -I_S R_S$

$V_{GS} = -600\, I_S$ ($I_S \Leftrightarrow I_D$)

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

$= 10mA\left(1 - \frac{-600 I_D}{-4}\right)^2 \Rightarrow$ معادلة تربيعية $\frac{-b \mp \sqrt{b^2 - 4ac}}{2a}$



$I_{D1,2}$ → 14.77 mA $> I_{DSS}$
→ 3.0 mA $< I_{DSS}$ ✓ ، الحد

$15 - 1.5k\, I_D - V_{DS} - 0.6k\, I_D = 0$

$V_{DS} = 10.2V$

I_{DSS} : Is the Maximum value and it's 10 mA which mean that $14.77 > I_{DSS}$ the other solution is 3mA and it's $< I_{DSS}$ then it's accepted!

$V_{GS} = -600 \cdot 3mA$ (I_D نعتمد على)

$= -1800mV = -1.8V$

$|V_{DS}| > |V_P| - |V_{GS}|$

$10.2 > |4| - |1.8|$ ✓ "Cheaked"

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2 Graphical method : ⇒ Graph بنستخدم ال $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$ بدل ما نستخدم المعادلة

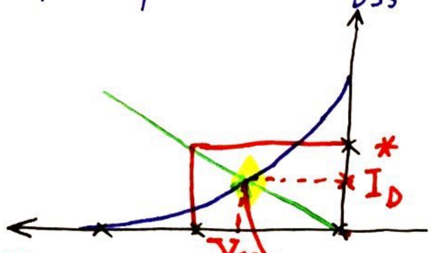
$V_{GS} = (-0.6K)\, I_{DS}$

لو حطينا $I_{DS} = 0 \Leftarrow V_{GS} = 0$ يعني

بتمر بال origin بتطلع *

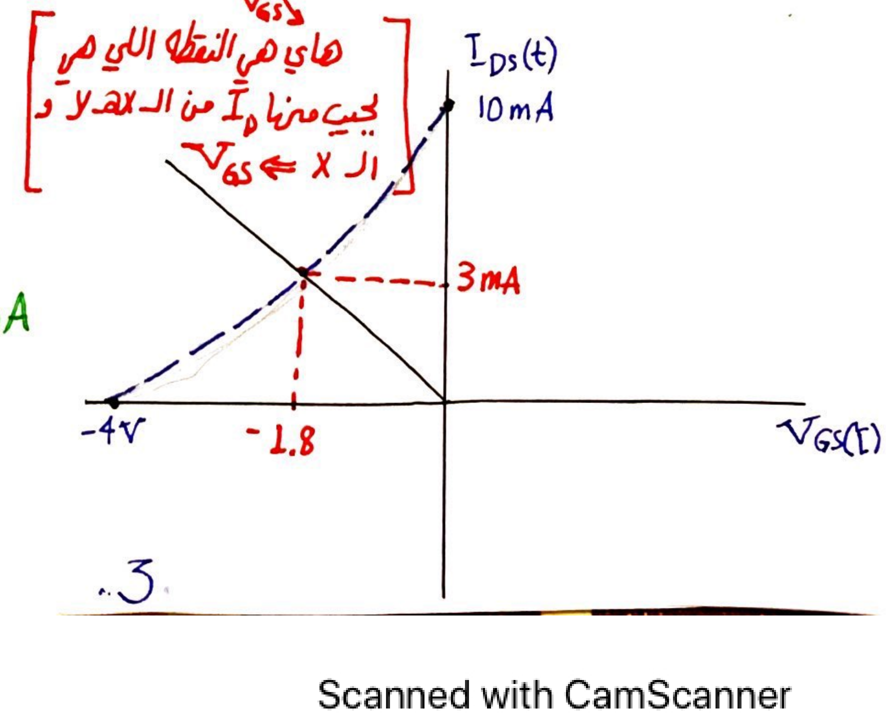
نعطاي قيمة ل I_{DS} مثلا 5

ولنفرض طلع $V_{GS} = -3$

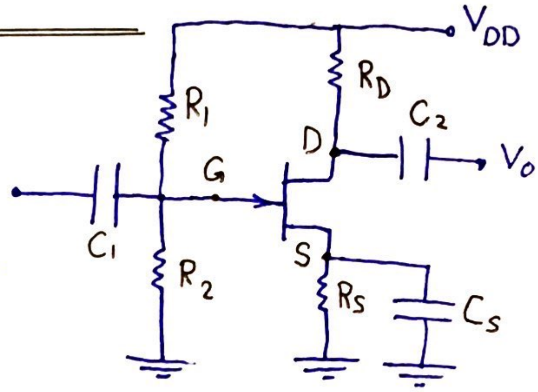


When $V_{GS} = 0 \rightarrow I_{DS} = 0$

When $V_{GS} = -3 \rightarrow I_{DS} = 5mA$



3 Voltage_Divider Bias



$I_G = 0mA$

I_D responds to changes in V_{GS}

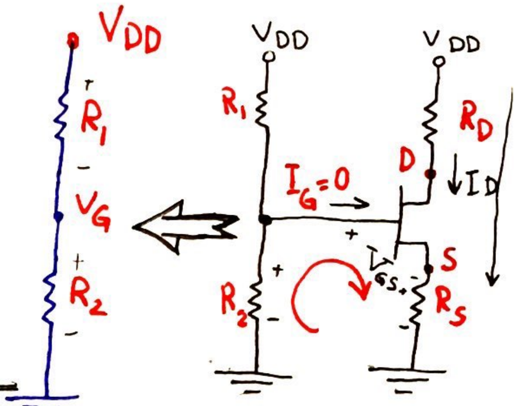
V_G is equal to the voltage across divider resistor R_2

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

$$V_S = I_D R_S$$

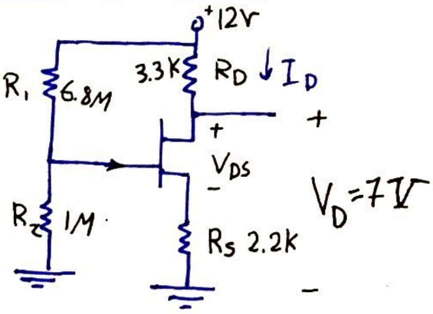
Using kirchhoff's law: $V_{GS} = V_G - I_D R_S$

$$V_{GS} = \frac{R_2}{R_1 + R_2} \cdot V_{DD} - I_D R_S$$



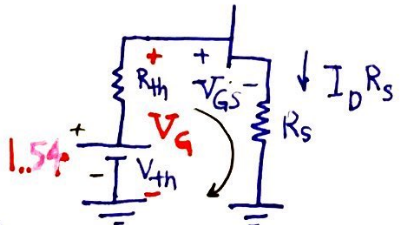
Example

I_D, V_{GS} ?



$$I_D = \frac{12-7}{3.3K} = \frac{5}{3.3k}$$

$= 1.52\,mA$



$$V_{th} = \frac{R_2}{R_1 + R_2} \cdot 12$$

$\Updownarrow$

$$V_G = \frac{1M}{7.8M} \cdot 12 = 1.54$$

KVL $\Rightarrow V_G - I_D R_S = V_{GS}$

$1.54 - (1.52m)(2.2k) = V_{GS} =$

$V_{GS} = 1.54 - 3.344 = -1.8\,V$

$$R_{th} = R_1 \,//\, R_2$$

$$V_{th} = \frac{R_2}{R_1 + R_2} \cdot V_G$$

طريقة الدكتور

$V_{th} = V_{GS} + I_D R_S$

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

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

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

أو

$$\left[\frac{V_{th} - V_{GS}}{R_S} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2\right]$$

"تكملة السؤال" الجواب

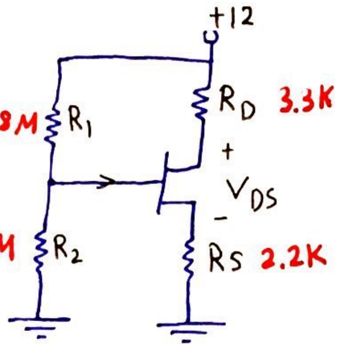
$V_S = I_D R_S = (1.52mA) * (2.2k) = 3.34V$

$$V_G = \frac{1M}{1M + 6M} \cdot 15 = 1.54V$$

هسا لو V_D مش معروفة عندي بضطر اعمل معادلة تربيعية

$$\left[V_{GS} = \frac{R_2}{R_1 + R_2} \cdot V_{DD} - I_D R_S\right]$$

Example_ V_D unknown



$$V_{GS} = \frac{R_2}{R_1+R_2} \cdot V_{DD} - I_D R_s$$

$$V_{GS} = 1.54 - I_D R_s$$

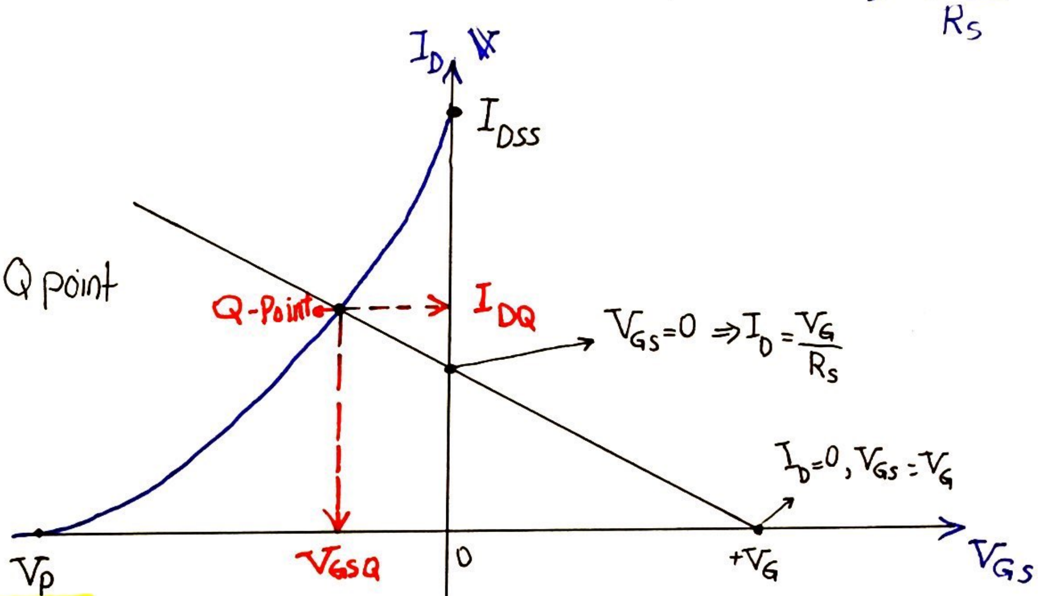
When $I_D = 0 \Rightarrow V_{GS} = 1.54$

When $V_{GS} = 0 \Rightarrow I_D = \frac{1.54}{R_s}$

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

$$= I_{DSS}\left(1 - \frac{1.54 - I_D R_s}{V_P}\right)^2$$

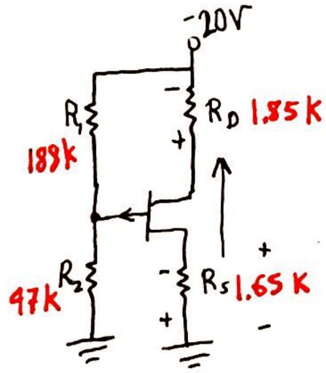
Voltage _Divider Q point



Example p_Channel

$V_P = 5\,V > 0$

$I_{DSS} = 18\,mA$



$$V_{GS} = V_G - V_S = \frac{R_2}{R_1+R_2} \cdot 20 + I_D R_s$$

مايش ماينسى

$$V_{GS} = -4 + I_D R_s$$

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

$$= I_{DSS}\left(1 - \frac{-4 + I_D R_s}{5}\right)^2$$

$$= 18mA\left(1 - \frac{-4 + I_D \times 1.65}{5}\right)^2$$

$I_{D1} = 4.7\,mA$ ✓ $< I_{DSS}$

$I_{D2} = 7.4\,mA$ ✓ $< I_{DSS}$

V_{GS} ما بتقرر الا لما اشوف فـ بشوف كل وحدة منهم تبعطيني كم؟

$V_{GS} = -4 + (4.7m)(1.65k) = 3.75\,V$

$V_{GS} = -4 + (7.4m)(1.65k) = 8.21\,V$

$V_P = 5$ لازم يكون اصغر

فـ I_{D1} ✓