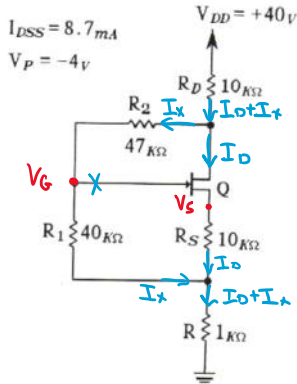


נתון המעגל הבא:

①



ציור: 1) את נקודת העבודה של ה-FET

$$V_{GS} = +V_{R1} - V_{RS} = 40I_x - 10I_D \leftarrow \text{סיוע מנק' G \delta}$$

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 8.7 \left(1 - \frac{40I_x - 10I_D}{-4}\right)^2$$

$$V_{DD} - 0 = 40V = (I_D + I_x)R_D + I_x R_2 + I_x R_1 + (I_x + I_D)R$$

$$40V = (I_D + I_x)(R_D + R) + I_x(R_2 + R_1) = (I_D + I_x)(10+1) + I_x(47+40)$$

$$40 = 11I_D + 11I_x + 87I_x = 11I_D + 98I_x$$

$$I_x = \frac{40 - 11I_D}{98}$$

$$I_D = 8.7 \left(1 - \frac{V_{GS}}{V_P}\right)^2 \xrightarrow{\text{solve}} I_{D1} = 1.518 \text{ mA}, I_{D2} = 1.296 \text{ mA}$$

$$V_{GS1} = 40 \left(\frac{40 - 11I_{D1}}{98}\right) - 10I_{D1} \xrightarrow{\text{CALC}} V_{GS1} = -5.669V > V_P(-4V) \quad \text{X סך-מאזן}$$

$$V_{GS2} = 40 \left(\frac{40 - 11I_{D2}}{98}\right) - 10I_{D2} \xrightarrow{\text{CALC}} V_{GS2} = -2.452V < V_P(-4V) \quad \text{✓ סך-מאזן}$$

$$I_x = \frac{40 - 11I_D}{98} = \frac{40 - 11 \cdot 1.296}{98} = 0.263 \text{ mA}$$

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

$$= 40 - (0.263 + 1.296) \cdot (10 + 1) - 1.296 \cdot 10 = 9.894V$$

$$I_D = 1.296 \text{ mA}, V_{GS} = -2.452V, V_{DS} = 9.894V$$

נתון המעגל הבא:

3

$$I_{DSS} = 7.2 \text{ mA}$$

$$V_P = +2.5 \text{ V}$$

$$V_{DD} = -24 \text{ V}$$

$$V_{GS} = I_D R_S = 1.2 I_D$$

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 7.2 \left(1 - \frac{1.2 I_D}{2.5}\right)^2 \xrightarrow{\text{Solve}} I_{D1} = 3.545 \text{ mA}, I_{D2} = 1.224 \text{ mA}$$

$$V_{GS1} = 1.2 I_{D1} = 1.2 \cdot 3.545 = 4.2 \text{ V} > |V_P| \quad \text{X פ'אן קס}$$

$$V_{GS2} = 1.2 I_{D2} = 1.2 \cdot 1.224 = 1.469 \text{ V} < |V_P| \quad \checkmark \text{ פ'אן קס}$$

$$V_{GS} = 1.469 \text{ V}, I_D = 1.224 \text{ mA}, V_{SD} = 13.351 \text{ V}$$

צ"ל: 1) את נקודת העבודה של ה-FET

$$V_{SD} = -24 \text{ V} = -I_D R_D - V_{SD} - I_D R_S$$

$$V_{SD} = 24 - I_D (R_D + R_S) = 24 - 1.224 (7.5 + 1.2) = 13.351 \text{ V}$$

נתון המעגל הבא:

4

$$I_{DSS} = 3.1 \text{ mA}$$

$$V_P = +1.5 \text{ V}$$

$$V_{DD} = -36 \text{ V}$$

$$V_{GS} = -3 + V_{RS} = -3 + I_D R_S = 3.9 I_D - 3$$

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 3.1 \left(1 - \frac{3.9 I_D - 3}{1.5}\right)^2 \xrightarrow{\text{Solve}} I_{D1} = 0.942 \text{ mA}, I_{D2} = 1.414 \text{ mA}$$

$$V_{GS1} = 3.9 I_{D1} - 3 = 3.9 \cdot 0.942 - 3 = 0.674 \text{ V} < |V_P| \quad \checkmark \text{ פ'אן קס}$$

$$V_{GS2} = 3.9 I_{D2} - 3 = 3.9 \cdot 1.414 - 3 = 2.5 \text{ V} > |V_P| \quad \text{X פ'אן קס}$$

$$V_{GS} = 0.674 \text{ V}, I_D = 0.942 \text{ mA}, V_{SD} = 21.196 \text{ V}$$

צ"ל: 1) את נקודת העבודה של ה-FET

$$V_{SD} = -36 \text{ V} = -I_D R_D - V_{SD} - I_D R_S + 3$$

$$V_{SD} = 36 - I_D (R_D + R_S) + 3 = 39 - 0.942 (15 + 3.9) = 21.196 \text{ V}$$

נתון המעגל הבא:

5

$$I_{DSS} = 12 \text{ mA}$$

$$V_P = -2 \text{ V}$$

$$V_{DD} = +24 \text{ V}$$

$$V_{GS} = -V_{R2} = -I_D R_2 = -2 I_D$$

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 12 \left(1 - \frac{-2 I_D}{-2}\right)^2 \xrightarrow{\text{Solve}} I_{D1} = 0.75 \text{ mA}, I_{D2} = 1.333 \text{ mA}$$

$$V_{GS1} = -2 I_{D1} = -2 \cdot 0.75 = -1.5 \text{ V} > V_P \quad \checkmark \text{ פ'אן קס}$$

$$V_{GS2} = -2 I_{D2} = -2 \cdot 1.333 = -2.666 \text{ V} < V_P \quad \text{X פ'אן קס}$$

$$I_D = 0.75 \text{ mA}, V_{GS} = -1.5 \text{ V}$$

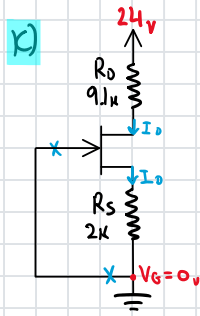
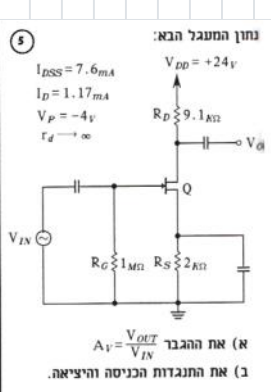
צ"ל: 1) את נקודת העבודה של ה-FET

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

$$V_{DS} = 24 - 0.75 \cdot 10 = 16.5 \text{ V} \rightarrow V_{DS} = 16.5 \text{ V}$$

עבודה FET (AC)

13:57 Monday, 1 January 2024



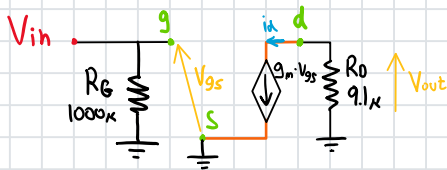
$$V_{GS} = -U_{RS} = -I_D R_S = -2 I_D$$

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 7.6 \left(1 - \frac{-2I_D}{-4}\right)^2 \xrightarrow{\text{solve}} I_{D1} = 3.322 \text{ mA}, I_{D2} = 1.204 \text{ mA}$$

$$V_{GS1} = -2 I_{D1} = -2 \cdot 3.322 = -6.644 \text{ V} < V_P (-4 \text{ V}) \quad \text{X לא אפשרי}$$

$$V_{GS2} = -2 I_{D2} = -2 \cdot 1.204 = -2.408 \text{ V} > V_P (-4 \text{ V}) \quad \checkmark \text{ אפשרי}$$

$$V_{GS} = -2.408 \text{ V}, I_D = 1.204 \text{ mA} \rightarrow g_m = \frac{2 I_{DSS}}{|V_P|} \left(1 - \frac{V_{GS}}{V_P}\right) = \frac{2 \cdot 7.6}{|-4|} \cdot \left(1 - \frac{-2.408}{-4}\right) = 1.512 \text{ mS}$$

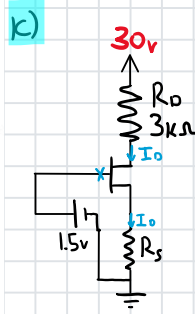
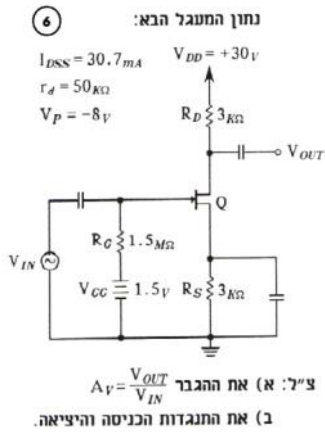


$$V_{out} = -U_{RD} = -i_d \cdot R_D = -g_m V_{GS} \cdot 9.1 = -1.512 \cdot 9.1 \cdot V_{GS} = -13.759 V_{GS}$$

$$V_{in} = V_{GS}$$

$$A_V = \frac{V_{out}}{V_{in}} = \frac{-13.759 V_{GS}}{V_{GS}} = -13.759$$

2) $R_{in} = R_G = 1 \text{ M}\Omega$, $R_{out} = R_D = 9.1 \text{ k}\Omega$



$$V_{GS} = 1.5 - R_S I_D = 1.5 - 3 I_D$$

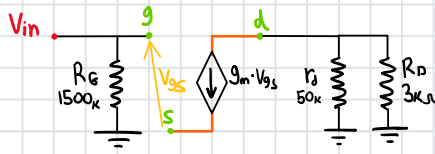
$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 30.7 \left(1 - \frac{1.5 - 3 I_D}{-8}\right)^2 \xrightarrow{\text{solve}} I_{D1} = 4.147 \text{ mA}, I_{D2} = 2.418 \text{ mA}$$

$$V_{GS1} = 1.5 - 3 I_{D1} = -10.9 \text{ V} < V_P \quad \text{X פ'אן קס}$$

$$V_{GS2} = 1.5 - 3 I_{D2} = -5.754 \text{ V} > V_P \quad \checkmark \text{ פ'אן קס}$$

$$V_{GS} = -5.754 \text{ V}$$

$$g_m = \frac{2 I_{DSS}}{|V_P|} \left(1 - \frac{V_{GS}}{V_P}\right) = \frac{2 \cdot 30.7}{8} \left(1 - \frac{-5.754}{-8}\right) = 2.155 \text{ V/V}$$

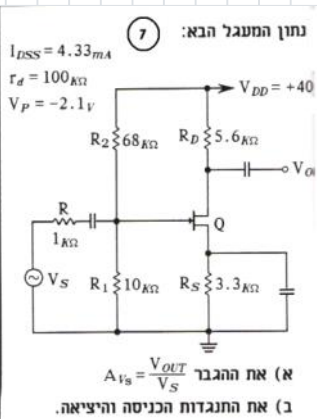


$$V_{out} = -R_D g_m V_{GS} = -3 \cdot 2.155 V_{GS} = -6.464 V_{GS}$$

$$V_{in} = V_{GS}$$

$$A_v = \frac{V_{out}}{V_{in}} = \frac{-6.464 V_{GS}}{V_{GS}} = -6.464$$

2) $R_{in} = R_G = 1.5 \text{ M}\Omega$, $R_{out} = R_D \parallel r_d = 3 \parallel 50 = \frac{3 \cdot 50}{3+50} = 2.83 \text{ k}\Omega$



$$I_{R1} = I_{R2} = \frac{V_G - 0}{R_1} = \frac{V_{DD} - V_G}{R_2} \Rightarrow \frac{V_G}{10} = \frac{40 - V_G}{68}$$

$$68 V_G = 400 - 10 V_G$$

$$V_G = \frac{400}{68+10} = 5.128 \text{ V}$$

$$V_{GS} = V_G - V_S = 5.128 - I_D R_S = 5.128 - 3.3 I_D$$

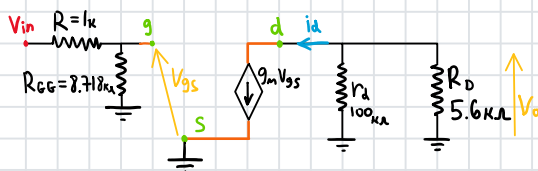
$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 4.33 \left(1 - \frac{5.128 - 3.3 I_D}{-2.1}\right)^2 \xrightarrow{\text{solve}} I_{D1} = 2.692 \text{ mA}, I_{D2} = 1.782 \text{ mA}$$

$$V_{GS1} = 5.128 - 3.3 I_{D1} = -3.7 \text{ V} < V_P \quad \text{X פ'אן קס}$$

$$V_{GS2} = 5.128 - 3.3 I_{D2} = -0.753 \text{ V} > V_P \quad \checkmark \text{ פ'אן קס}$$

$$V_{GS} = -0.753 \text{ V}$$

$$g_m = \frac{2 I_{DSS}}{|V_P|} \left(1 - \frac{V_{GS}}{V_P}\right) = \frac{2 \cdot 4.33}{2.1} \left(1 - \frac{-0.753}{-2.1}\right) = 2.645 \text{ ms} , R_{GG} = R_1 \parallel R_2 = \frac{10 \cdot 68}{10+68} = 8.718 \text{ k}\Omega$$



$$I_{R_D} = i_d \frac{r_d}{r_d + R_D} = 2.645 V_{GS} \cdot \frac{100}{100+5.6} = 2.504 V_{GS}$$

$$V_{out} = -I_{R_D} R_D = -2.504 V_{GS} \cdot 5.6 = -14.027 V_{GS}$$

$$V_{GS} = V_{in} \frac{R_{GG}}{R_{GG} + R} \rightarrow V_{in} = V_{GS} \frac{8.718+1}{8.718} = 1.115 V_{GS}$$

$$A_v = \frac{V_{out}}{V_{in}} = \frac{-14.027 V_{GS}}{1.115 V_{GS}} = -12.584$$

5) $R_{in} = R + R_{GG} = 9.718 \text{ k}\Omega$

$R_{out} = r_d \parallel R_D = 5.303 \text{ k}\Omega$