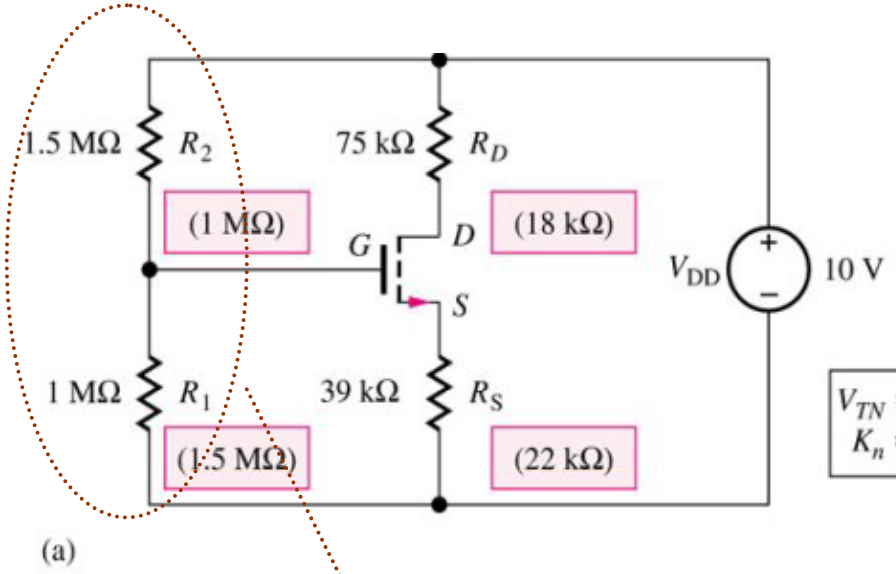
Example 1

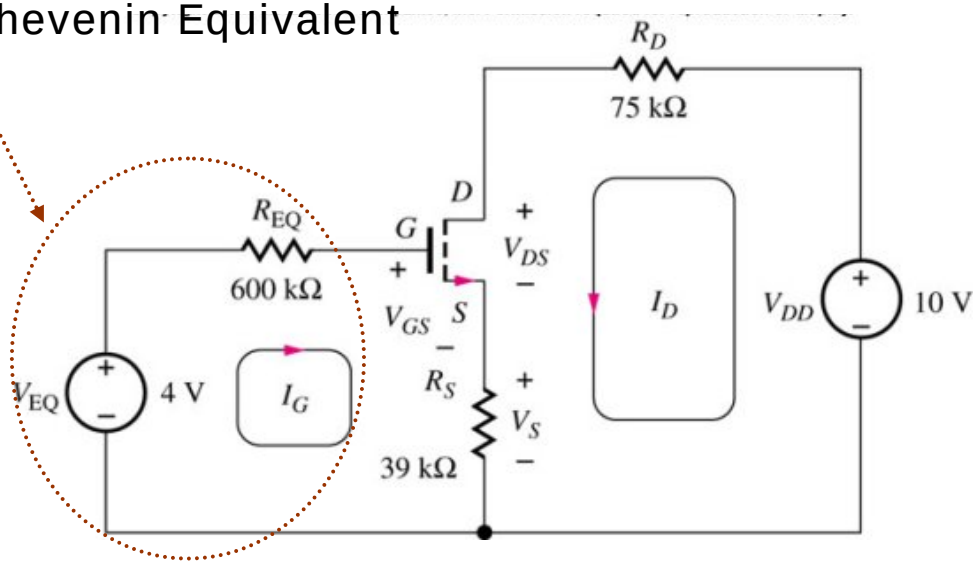


Problem: Find Q-pt (I_D, V_{DS})

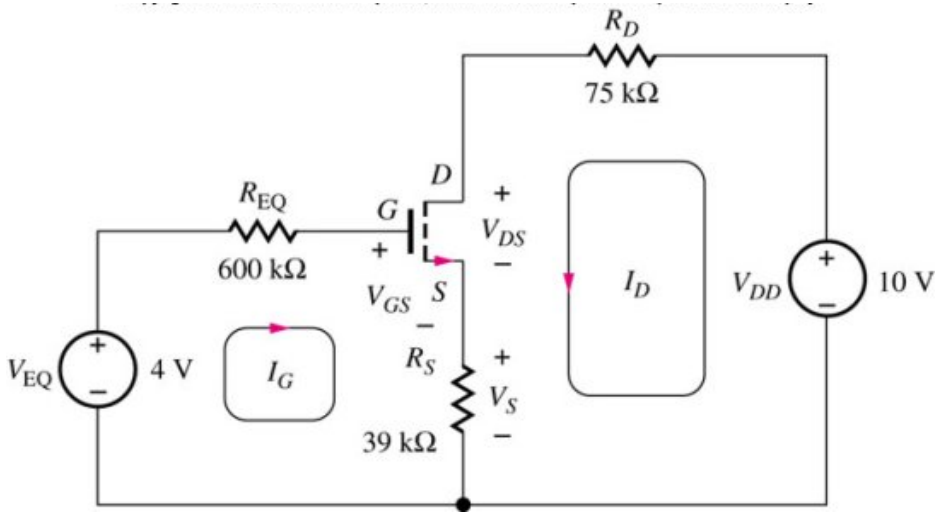
Assumption: Transistor is saturated.

Analysis: Simplify the circuit,

Thevenin Equivalent



Example 1



Since I_G=0, $\quad V_{EQ}=V_{GS}+I_D R_S$

$$V_{EQ}=V_{GS}+\frac{K_n R_S}{2}\left(V_{GS}-V_{TN}\right)^2$$

$$4=V_{GS}+\frac{\left(25\times10^{-6}\right)\left(3.9\times10^{4}\right)}{2}\left(V_{GS}-1\right)^2$$

$$V_{GS}{}^2+0.05V_{GS}-7.21=0$$

$$\therefore V_{GS}=-2.71\text{V},+2.66\text{V}$$

Since $V_{GS}<V_{TN}$ for V_{GS}= *-2.71 V* and MOSFET will be cut-off,

$\therefore V_{GS}=+2.66\text{V}$ and I_D= 34.4 μA

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

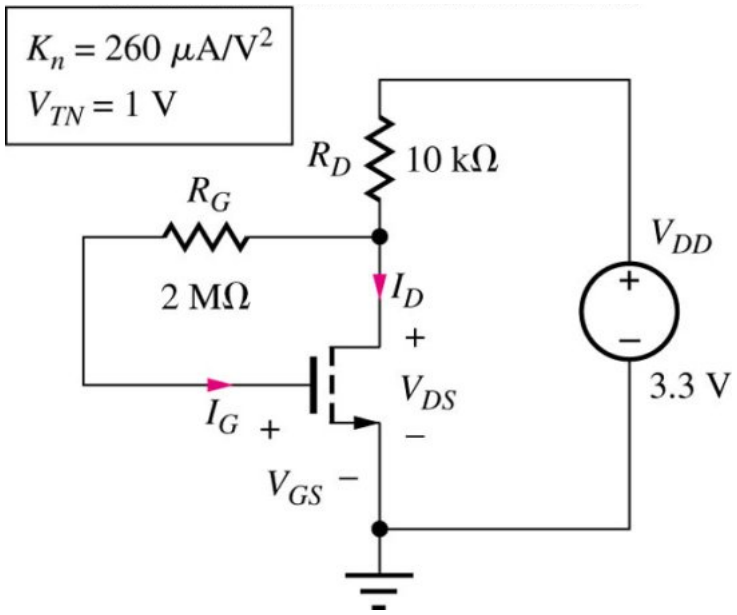
$$\therefore V_{DS}=6.08\text{V}$$

$V_{DS}>V_{GS}$-V_{TN}. Hence saturation region assumption is correct.

Q-pt: (34.4 μA, 6.08 V) with V_{GS}= 2.66 V

Note: body effect and channel length modulation effect have been neglected.

Example 2



Problem: Find Q-pt (I_D, V_{DS})

Assumption: Transistor is saturated (since $V_{DS} = V_{GS}$)

Analysis:

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

$$V_{GS} = V_{DD} - \frac{K_n R_D}{2}\left(V_{GS} - V_{TN}\right)^2$$

$$\therefore V_{GS} = 3.3 - \frac{\left(2.6\times10^{-4}\right)\left(10^4\right)}{2}\left(V_{GS} - 1\right)^2$$

$$\therefore V_{GS} = -0.769\text{V}, +2.00\text{V}$$

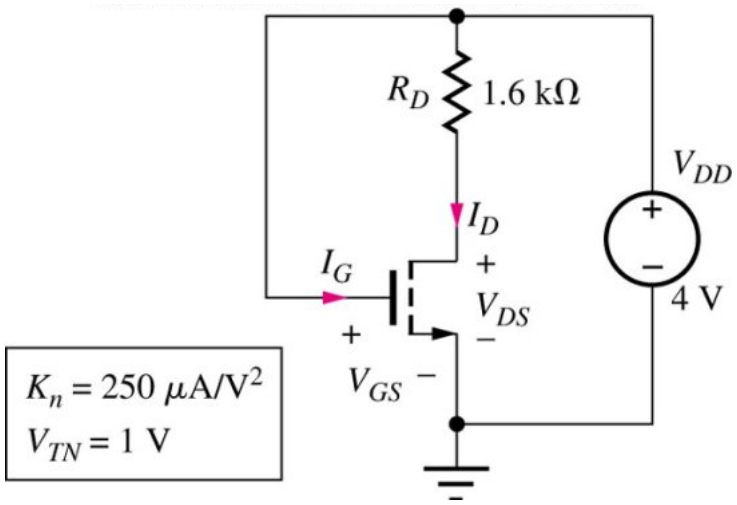
Since $V_{GS} < V_{TN}$ for $V_{GS} = -0.769$ V and MOSFET will be cut-off,

$V_{GS} = +2.00$V and $I_D = 130\ \mu$A

$V_{DS} > V_{GS} - V_{TN}$. Hence saturation region assumption is correct.

Q-pt: (130 μA, 2.00 V)

Example 3



Problem: Find Q-pt (I_D, V_{DS})

Assumption: transistor is saturated

Analysis:

$$V_{GS}=V_{DD}=4\text{ V}$$

$$I_D=\frac{250}{2}\frac{\mu A}{V^2}(4-1)^2=1.13\text{mA}$$

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

$$\therefore 4=1600I_D+V_{DS}$$

$$\therefore V_{DS}=2.19\text{V}$$

But $V_{DS}<V_{GS}-V_{TN}$. Hence, saturation region assumption is incorrect

Using triode region equation,

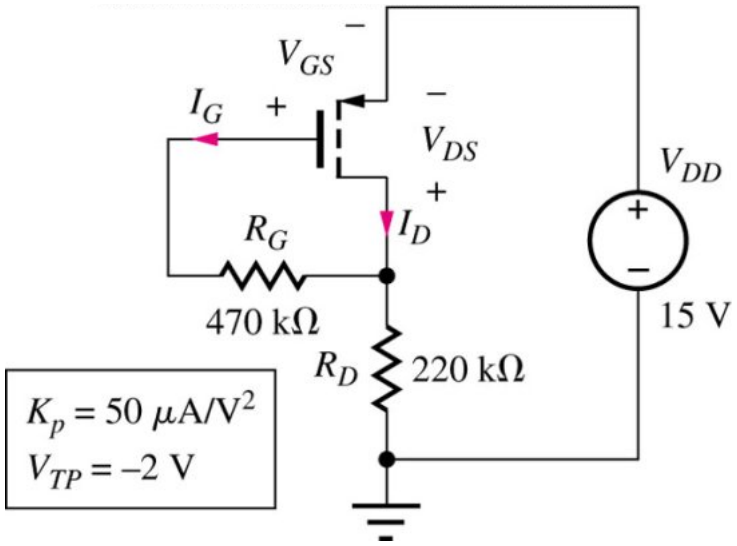
$$4-V_{DS}=1600(250)\frac{\mu A}{V^2}(4-1-\frac{V_{DS}}{2})V_{DS}$$

$$\therefore V_{DS}=2.3\text{V}\ \text{ and }\ I_D=1.06\text{ mA}$$

$V_{DS}<V_{GS}-V_{TN}$, transistor is in triode region

Q-pt:(1.06 mA, 2.3 V)

Example 4 (PMOS)



Problem: Find Q-pt (I_D, V_{DS})

Assumption: transistor is saturated (since $V_{DS} = V_{GS}$)

Analysis:

Since $I_G = 0$, $V_{GS} = V_{DS}$

Also $15\text{V} - (220\text{k}\Omega) I_D + V_{DS} = 0$

$$\therefore 15\text{V} - (220\text{k}\Omega)\frac{50}{2}\frac{\mu\text{A}}{\text{V}^2}\left(V_{GS} + 2\right)^2 + V_{GS} = 0$$

$$\therefore V_{GS} = -0.369\text{V}, -3.45\text{V}$$

Since V_{GS}= -0.369 V is less than V_{TP}= -2 V, V_{GS} = -3.45 V

I_D = 52.5 μA and V_{GS} = -3.45 V

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

Hence saturation assumption is correct.

Q-pt: (52.5 μA, -3.45 V)