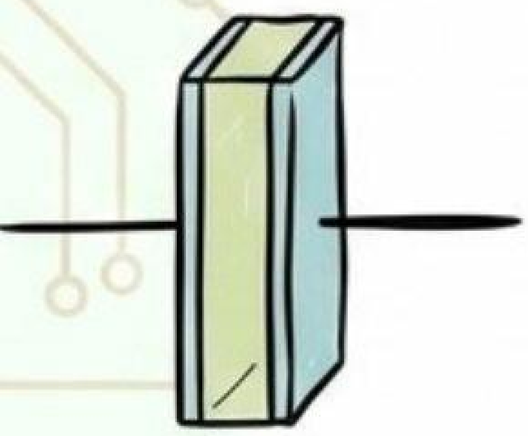
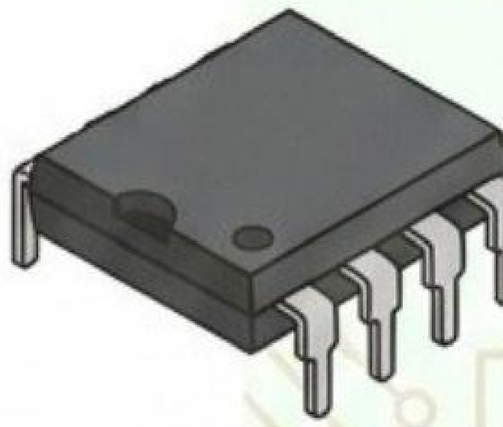
$$V = I * R$$



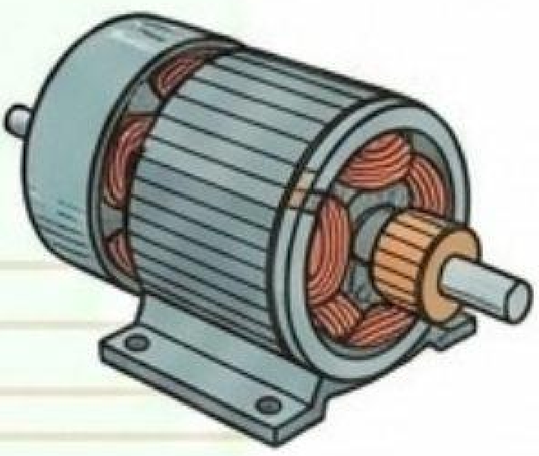
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** EE 312 **







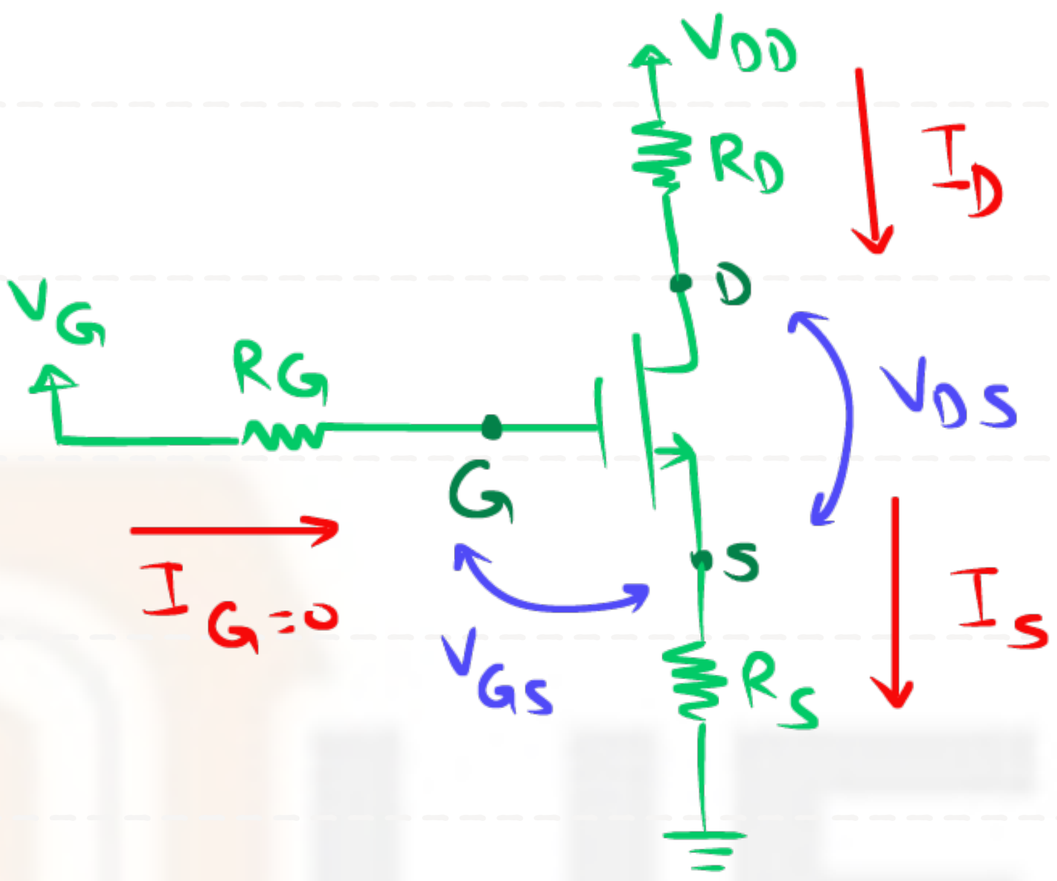


$$P = V * I * \cos(\varphi)$$

<< Chapter 1 -- Part B >>

MOSFET

- NMOS
- PMOS



G → Gate

D → Drain

S → source

$I_G = 0$ دائماً $\longrightarrow$ $I_D = I_S$

* V_{ov} (overdrive Voltage) :

$$V_{ov} = V_{GS} - V_t \longrightarrow V_{GS} = V_{ov} + V_t$$

V_t ↓

يعني Thermal voltage

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* Regions of MOSFET:

① cutoff ⟶ $I_D = 0$ ، $V_{GS} < V_t$

on { ② Triode ⟶ $V_{GS} > V_t$ ، $V_{DS} < V_{ov}$

③ saturation ⟶ $V_{GS} > V_t$ ، $V_{DS} > V_{ov}$

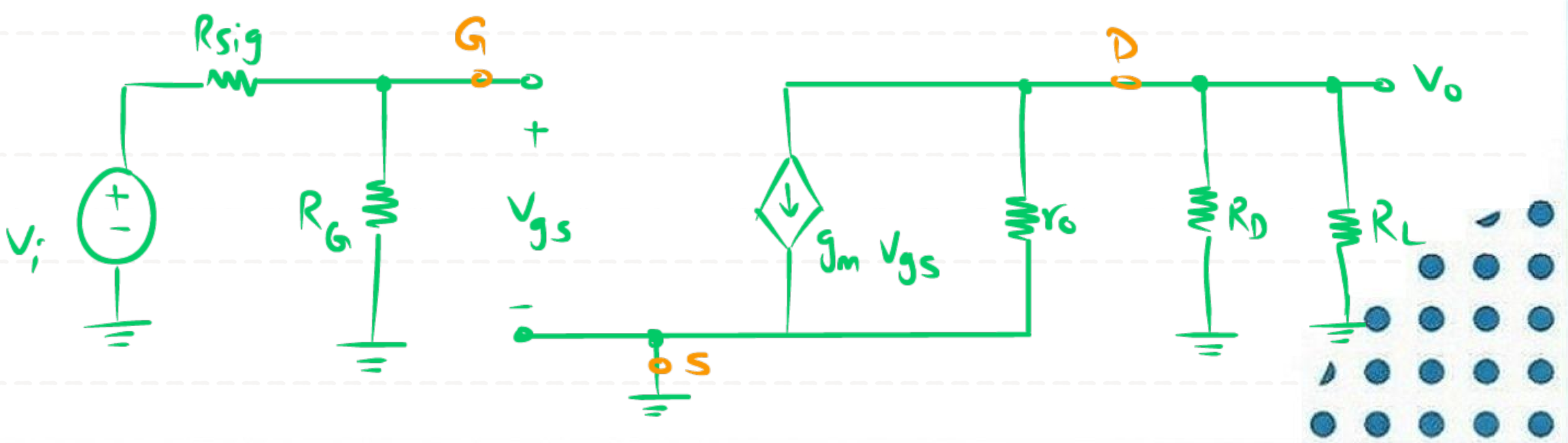
* Saturation current:

$$I_D = \frac{1}{2} k_n' \frac{W}{L} V_{ov}^2 = \frac{1}{2} k_n' \frac{W}{L} (V_{GS} - V_t)^2$$

$$k_n' = \mu_n C_{ox}$$

$$k_n = k_n' \frac{W}{L} = \mu_n C_{ox} \frac{W}{L}$$

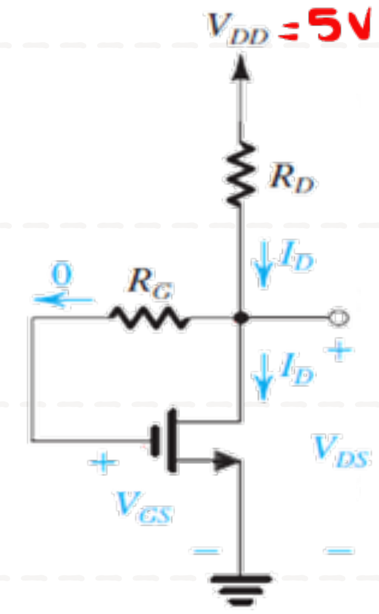
* Equivalent circuit:



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Sample Problem - 1

Design a given circuit with the following requirements to operate at a DC drain current of 0.5 mA. Let, V_{DD}=+5V, V_t=1 V, $k'n(W/L)$ =1mA/ V^2 and λ=0. Find the value of R , and V_{GS}.



$I_D = 0.5\ mA$, $V_{DD} = 5\ V$

$V_t = 1V$, $k_n' \frac{W}{L} = 1mA/V^2$

$V_D = V_G$, $V_S = 0$

$V_D = V_G = V_{GS} = V_{DS}$

Solution:

$$I_D = \frac{1}{2} k_n' \frac{W}{L} V_{ov}^2$$

$$0.5\ mA = \frac{1}{2} k_n' \frac{W}{L} V_{ov}^2$$

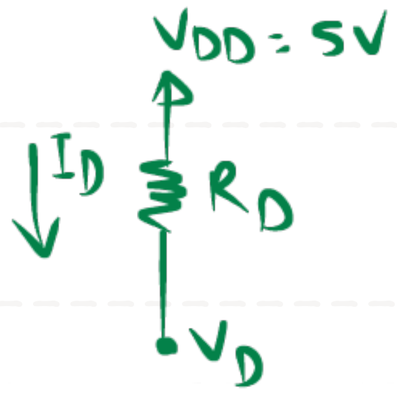
$$0.5mA = \frac{1}{2} \times 1mA \times V_{ov}^2 \longrightarrow V_{ov}^2 = \frac{0.5\ mA}{\frac{1}{2} \times 1mA} = 1\ V$$

$\therefore V_{ov} = 1V$

$\therefore V_{ov} = V_{GS} - V_t \longrightarrow V_{GS} = V_{ov} + V_t = 1 + 1$

$\therefore V_{GS} = 2\ V$

$\therefore R_D = \frac{\text{النهاية} - \text{البداية}}{I_D} = \frac{V_{DD} - V_D}{I_D}$

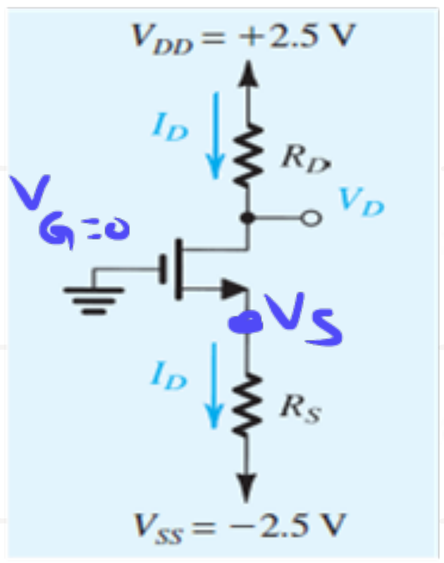


$\therefore R_D = \frac{5 - 2}{0.5} = 6\ k\Omega$

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Sample Problem-2

Determine the values of R_D and R_s so that the transistor operates at I_D=0.4 mA and V_D=+0.5V in the given circuit. The NMOS transistor has V_t=0.7V, $\mu_n C_{ox}$=100μA/V², L=1 μm and W=32μm. Neglect the channel length modulation effect (i.e assume that λ=0).

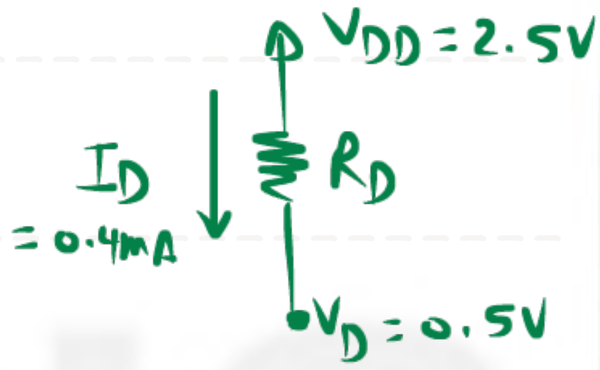


$I_D = 0.4\,mA$, $V_D = 0.5\,V$, $V_t = 0.7\,V$

$\mu_n C_{ox} = 100\,\mu A/V^2$, $L = 1\,\mu m$, $W = 32\,\mu m$

Solution:

$$\therefore R_D = \frac{V_{DD} - V_D}{I_D} = \frac{2.5 - 0.5}{0.4\,mA} = 5\,k\Omega$$



$$\therefore I_D = \frac{1}{2} k_n' \frac{W}{L} V_{OV}^2$$

$$0.4 \times 10^{-3} = \frac{1}{2} \times 100 \times 10^{-6} \times \frac{32}{1} \times V_{OV}^2$$

$$V_{OV}^2 = \frac{0.4 \times 10^{-3}}{\frac{1}{2} \times 100 \times 10^{-6} \times \frac{32}{1}} = 0.25\,V$$

$$\therefore V_{OV} = 0.5\,V$$

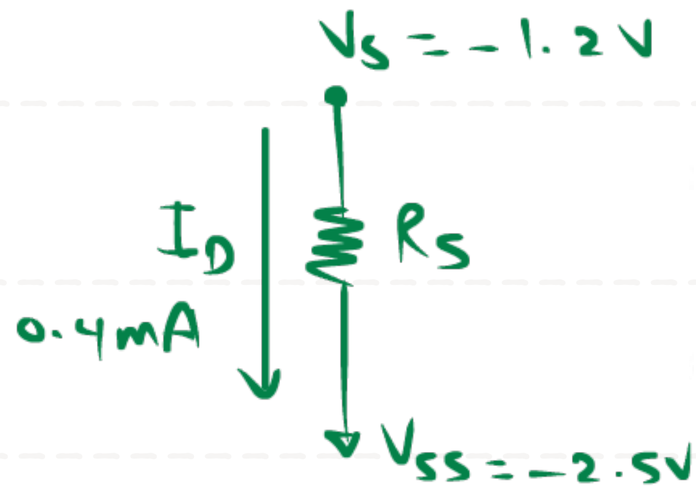
$$\therefore V_{GS} = V_{OV} + V_t = 0.5 + 0.7$$

$$\therefore V_{GS} = 1.2\,V$$

$$\therefore V_{GS} = V_G - V_S$$

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

$$\therefore V_S = -V_{GS} = -1.2\ V$$



$$\therefore R_S = \frac{V_S - V_{SS}}{I_D}$$

$$= \frac{-1.2 - (-2.5)}{0.4\ mA}$$

$$\therefore R_S = 3.25\ k\Omega$$

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Sample Problem-3

An n-channel MOSFET operating with V_{ov}=0.5V exhibits a linear resistance r_{DS} = 1kΩ when v_{DS} is very small. What is the value of the device transconductance parameter k_n? What is the value of the current I_D obtained when v_{DS} is increased to 0.5 V? and to 1V?

Solution:

$V_{ov} = 0.5\,V$, $r_{DS} = 1k\Omega$, $k_n = ??$

$I_D = ?? \longrightarrow V_{DS} = 0.5V$, $V_{DS} = 1V$

$\therefore g_{ds} = \frac{1}{r_{DS}} = \frac{1}{1k\Omega}$

$\therefore g_{ds} = k_n' \frac{W}{L} V_{ov} = k_n V_{ov}$

$\therefore k_n = \frac{g_{ds}}{V_{ov}} = \frac{1/1\times10^3}{0.5} = 2\,mA/V^2$

m → $\times 10^{-3}$
μ → $\times 10^{-6}$
k → $\times 10^{3}$
M → $\times 10^{6}$

$\therefore V_{DS} \geq V_{ov}$

$\therefore I_D = \frac{1}{2} k_n' \frac{W}{L} V_{ov}^2 = \frac{1}{2} \times 2 \times 10^{-3} \times 0.5^2$

$\therefore I_D = 0.00025\,A = 0.25\,mA$

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