EI-27003: Electronics Devices and Circuits
Lecture - 14

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LECTURE - 14

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Numerical

- Consider a process technology for which L_{min}=0.4um, t_{ox}=8nm, u_n=450cm²/v-s and V_t=0.7V.
- (a)Find C_{ox} and K_n
- (b)For a MOSFET with W/L=8um/0.8um, calculate the values of V_{GS} and V_{DSmin} needed to operate the transistor in the saturation region with dc current I_D=100uA.
- (c)For the device in (b), find the value of V_{GS} required to cause the device to operate as a1000ohm resistor for very small V_{DS}.

- Solution: (a)$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.45X10^{-11}}{8X10^{-9}}$=$4.32X10^{-3}$ F/m² = 4.32 fF/um²

K_n=$u_n C_{ox}$= 450 x 4.32 = 194uA/V²

- For MOS operation in saturation region:

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

Numerical

-
  - $100 = \frac{1}{2} X 194\, X \frac{8}{0.8} (V_{GS} - 0.7)^2$
    - $V_{GS} - 0.7$=0.32V
    - OR V_{GS}=1.02V
  - Hence V_{DSmin}=$V_{GS} - V_t$= 0.32V

- For MOSFET in triode region with V_{DS} very small

$$I_D = K_n \frac{W}{L} (V_{GS} - V_t) V_{DS}$$

From which the drain to source resistance r_{DS} can be written as:

$$r_{DS} = \left.\frac{V_{DS}}{I_D}\right\}\ \text{small VDS}$$

$$= 1/K_n \frac{W}{L} (V_{GS} - V_t)$$

$$1000 = \frac{1}{194\, X\, 10^{-6}\ X 10 (V_{GS} - 0.7)}$$

Numerical

- This give $V_{GS} - 0.7$=0.52V
- OR

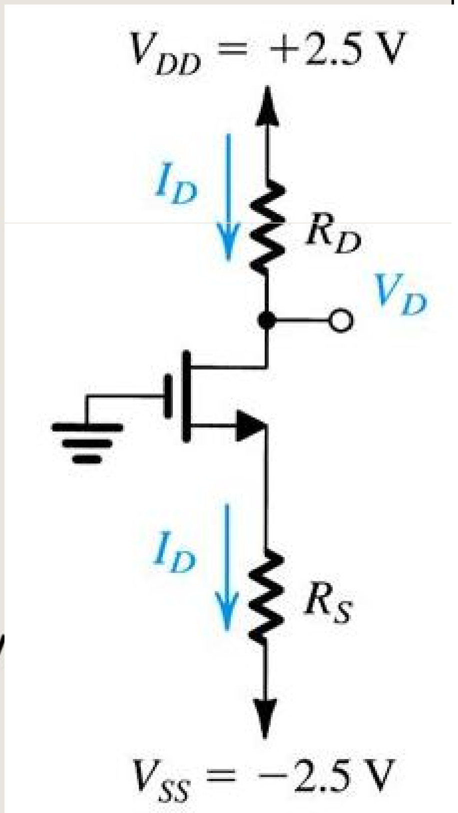
V_{GS}=1.22V

Numerical -2

- Design the circuit shown in fig, so that the transistor operates at I_D=0.4mA and V_D=+0.5V. The NMOS transistor has V_t=0.7V, u_nC_{ox}=100uA/V^2, L=1um and W=32um. Neglect the channel-length modulation effect.

Solution

- Since V_D=+0.5V, V_G=0V
- $V_{DS}<(V_{GS}-V_t)$ triode region & $V_{DS}>(V_{GS}-V_t)$ sat. region
- $V_D>V_G$, it means that NMOS is operating in saturation region. So use saturation equation to find V_{GS}.
- $I_D = \frac{1}{2} u_n C_{ox} \frac{W}{L} (V_{GS} - V_t)^2$
- $400 = \frac{1}{2} 100 \frac{32}{1} (V_{GS} - V_t)^2$
- Which results $(V_{GS} - V_t)$=0.5V OR V_{GS}=0.5 + 0.7=1.2V
- We know V_{GS}= $V_G - V_s$ i.e 1.2 = 0 – 1.2
- Hence V_S= -1.2V



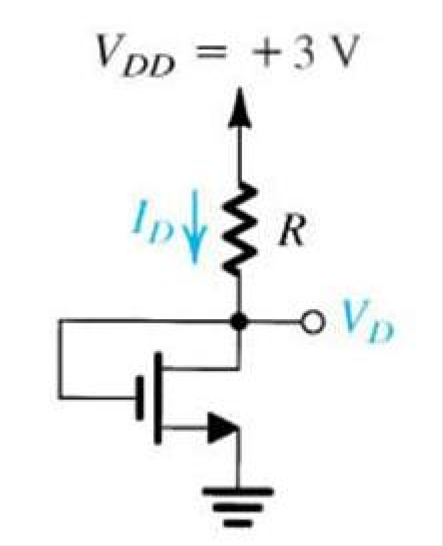
Numerical -2

- $$R_S = \frac{V_S - V_{SS}}{I_D} = \frac{-1.2-(-2.5)}{0.4} = 3.25\text{K}\Omega$$

Similarly $$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{2.5-0.5}{0.4} = 5\text{K}\Omega$$

Numerical -3

- Design the circuit shown in fig. to obtain a current I_D 0f 80uA. Find the value required for R and find dc voltage V_D. Let the NMOS transistor have V_t=0.6V, u_nC_{ox}=200uA/V^2, L=0.8um and W=4um. Neglect the channel length modulation effect.



- Solution:
- From Fig. Drain is connected to gate, hence V_D=V_G, hence NMOS is operating in Saturation region.

Numerical -3

- $I_D = \frac{1}{2} u_n C_{ox} \frac{W}{L} (V_{GS} - V_t)^2$

We can write : $(V_{GS} - V_t) = \sqrt{\frac{2I_D}{u_n C_{ox} \frac{W}{L}}}$

$(V_{GS} - V_t) = \sqrt{\frac{2X80}{200X\frac{4}{0.8}}}$ =0.4V

V_{GS}=0.4+0.6=1V

Since V_s=0V

Hence V_D=V_G=1V

Hence required value of R

$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{3-1}{0.08}$= 25KΩ

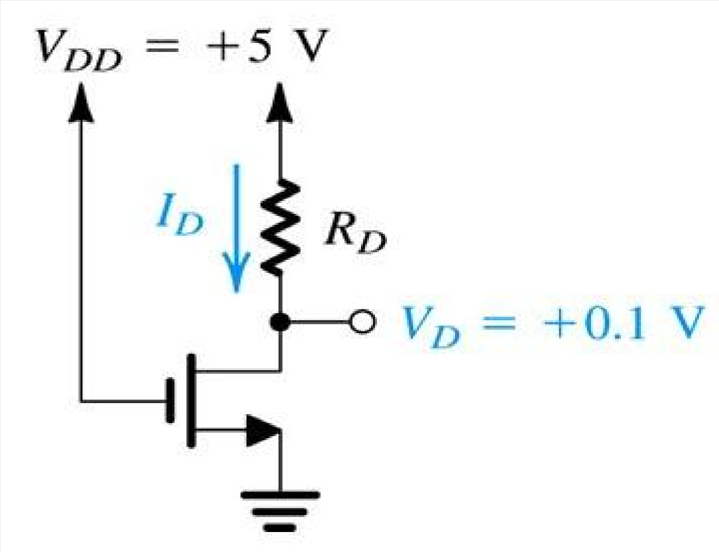
Numerical - HW

- Redesign the circuit in Numerical-3 to double the value of I_D without changing V_D. Give new values for W/L and R.

Answer: W/L=10 i.e. 8um/0.8um, R=12.5KΩ

- Design the circuit in fig to establish a drain voltage of 0.1V. What is the effective resistance between drain and source at this operating point?

  Assume V_t=1V and Kn(W/L)=1mA/V^2



Answer: R_D=12.4KΩ , r_{DS}=253Ω

Its Quiz Time

https://forms.gle/vgZLfLnRCvUJXSNMA