EE 362 Electronic, Magnetic, & Optical Properties of Materials
Quiz 9 (Spring 2024)

Name Key A

Instructions: Open book & notes. Place answers in indicated spaces. Show **all** work. Use 4-5 significant figures.

A silicon n-channel MOSFET is described by the following parameters: $t_{ox} = 36$ nm, $L = 3$ μm, $W = 27$ μm, and $\mu_n = 436$ cm^2/V-s. The source and body are grounded. Find the oxide capacitance C_{ox} (F/m^2). If the threshold voltage is $V_T = 0.76$ V and gate-source voltage is $V_{GS} = 1.5$ V, find the saturation drain-source voltage V_{DS}(sat). Then, determine the mode of operation and drain current I_D when $V_{DS} = 0.4$ V. Repeat for $V_{DS} = 2.4$ V.

(10.35) $C_{ox} = \frac{\epsilon_{ox}}{t_{ox}}$ From Table B.6, $\epsilon_{r,ox} = 3.9$

$= \frac{3.9(8.854187878 \times 10^{-12})}{36 \times 10^{-9}} = 9.592037 \times 10^{-4} \frac{F}{m^2}$

(10.43b) $V_{DS}(sat) = V_{GS} - V_T = 1.5 - 0.76 = 0.74 V$

For $V_{DS} = 0.4\,V < V_{DS}(sat) \Rightarrow$ Linear mode

(10.44a) $I_D = \frac{W \mu_n C_{ox}}{2L}\left[2(V_{GS} - V_T)V_{DS} - V_{DS}^2\right]$

$= \frac{27 \times 10^{-6}(436 \times 10^{-4})(9.592 \times 10^{-4})}{2(3 \times 10^{-6})}\left[2(0.74)0.4 - 0.4^2\right]$

$= 8.130057 \times 10^{-5}\,A = 81.3006\,\mu A$

For $V_{DS} = 2.4\,V > V_{DS}(sat) \Rightarrow$ Saturation mode

(10.45a) $I_D = \frac{W \mu_n C_{ox}}{2L}(V_{GS} - V_T)^2 = \frac{27(436 \times 10^{-4})9.592 \times 10^{-4}}{2(3)}(0.74)^2$

$= 1.03056 \times 10^{-4}\,A = 103.056\,\mu A$

$C_{ox} =$ 9.592×10^{-4} F/m^2 $V_{DS}(sat) =$ 0.74 V

V_{DS} = 0.4 V: Mode of operation is Linear and $I_D =$ 81.3006 μA

V_{DS} = 2.4 V: Mode of operation is Saturation and $I_D =$ 103.056 μA

EE 362 Electronic, Magnetic, & Optical Properties of Materials
Quiz 9 (Spring 2024)

Name Key B

Instructions: Open book & notes. Place answers in indicated spaces. Show **all** work. Use 4-5 significant figures.

A silicon n-channel MOSFET is described by the following parameters: $t_{ox} = 30$ nm, $L = 2$ μm, $W = 20$ μm, and $\mu_n = 456$ cm^2/V-s. The source and body are grounded. Find the oxide capacitance C_{ox} (F/m^2). If the threshold voltage is $V_T = 0.74$ V and the gate-source voltage is $V_{GS} = 1.8$ V, find the saturation drain-source voltage V_{DS}(sat). Then, determine the mode of operation and drain current I_D when $V_{DS} = 0.7$ V. Repeat for $V_{DS} = 2.8$ V.

Table B.6, $\epsilon_{r,ox} = 3.9$

(10.35) $C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = \frac{3.9(8.8541878\times10^{-12})}{30\times10^{-9}} = 1.151044\times10^{-3}\ \frac{F}{m^2}$

(10.436) $V_{DS}(sat) = V_{GS} - V_T = 1.8 - 0.74 = 1.06\ V$

For $V_{DS} = 0.7V < V_{DS}(sat) \Rightarrow$ Linear Mode

(10.44a) $I_D = \frac{W\mu_n C_{ox}}{2L}\left[2(V_{GS}-V_T)V_{DS} - V_{DS}^2\right]$

$I_D = \frac{20\times10^{-6}(456\times10^{-4})1.151\times10^{-3}}{2(2\times10^{-6})}\left[2(1.06)0.7 - 0.7^2\right]$

$I_D = 2.608635\times10^{-4}\ A = 260.8635\ \mu A$

For $V_{DS} = 2.8V > V_{DS}(sat) \Rightarrow$ Saturation Mode

(10.45a) $I_D = \frac{W\mu_n C_{ox}}{2L}(V_{GS}-V_T)^2$

$I_D = \frac{20(456\times10^{-4})1.151\times10^{-3}}{2(2)}(1.06)^2 = 2.948755\times10^{-4}\ A$

$= 294.8755\ \mu A$

$C_{ox} =$ $1.151\times10^{-3}\ F/m^2$ $V_{DS}(sat) =$ $1.06\ V$

$V_{DS} = 0.7$ V: Mode of operation is Linear and $I_D =$ $260.8635\ \mu A$

$V_{DS} = 2.8$ V: Mode of operation is Saturation and $I_D =$ $294.8755\ \mu A$