PROBLEM SET #6

Issued: Friday, October 4, 2019
Due: Friday, October 18, 2019, 12:00 noon via Gradescope.

1. Sedra & Smith, Problem 5.49
2. Sedra & Smith, Problem 5.50
3. The cross-section and top-view of an NMOS transistor are shown below. The length of the channel is $5\mu m$. The width of the channel changes linearly from $1\mu m$ at the source to $0.3\mu m$ at the drain. Derive the expression for the device current when operating in the saturation region as a function of $\mu_n$, $C_{ox}$, $V_{GS}$, $V_{DS}$ and $V_{th}$. Assume $\lambda=0$.

4. In the following circuit, find $V_G$ to set $V_D=8V$. Device parameters: $K'=100\mu A/V^2$, $V_T=0.7V$, $2\phi_F=0.6V$, $\gamma=0.75\sqrt{V}$.

\[ V_{DD} = 10V \]
\[ R_D = 1K \]
\[ V_D = \text{variable} \]
\[ V_G \]
\[ R_S = 1K \]
5. (a) Calculate the on-resistance for an NMOS transistor having $W/L = 100/1$ and operating with $V_{GS} = 5\, \text{V}$ and $V_{TN} = 0.75\, \text{V}$. (b) Repeat for a similar PMOS transistor with $V_{GS} = -5\, \text{V}$ and $V_{TP} = -0.75\, \text{V}$. (c) What $W/L$ is required for the PMOS transistor to have the same $R_{on}$ as the NMOS transistor in (a)?

6. What is the impedance between $V_1$ and $V_2$ under following conditions. Device parameters: $K' = 100\mu\text{A}/\text{V}^2$, $V_T = 0.7\, \text{V}$.
   (a) $V_1 = 0\, \text{V}$, $V_{C1} = 5\, \text{V}$, $V_{C2} = 0\, \text{V}$.
   (b) $V_1 = 2.5\, \text{V}$, $V_{C1} = 5\, \text{V}$, $V_{C2} = 1\, \text{V}$.
   (c) $V_1 = 2.5\, \text{V}$, $V_{C1} = 2.5\, \text{V}$, $V_{C2} = 5\, \text{V}$.

7. Indicate the region of operation for an npn transistor biased as follows:
   (a) $V_{BE} = -5.0\, \text{V}$, $V_{BC} = 0.7\, \text{V}$.
   (b) $V_{BE} = -5.0\, \text{V}$, $V_{BC} = -5.0\, \text{V}$.
   (c) $V_{BE} = 0.7\, \text{V}$, $V_{BC} = 0.7\, \text{V}$.
   (d) $V_{BE} = 0.7\, \text{V}$, $V_{BC} = -5.0\, \text{V}$.

8. Indicate the region of operation for a pnp transistor biased as follows:
   (a) $V_{EB} = 0.7\, \text{V}$, $V_{CB} = 0.7\, \text{V}$.
   (b) $V_{EB} = 0.7\, \text{V}$, $V_{CB} = -0.65$.
   (c) $V_{EB} = -0.65\, \text{V}$, $V_{CB} = 0.7\, \text{V}$.
   (d) $V_{EB} = -0.65\, \text{V}$, $V_{CB} = -0.65\, \text{V}$.

9. Sedra & Smith, Problem 6.28
10. Sedra & Smith, Problem 6.56
11. Find the transistor operating points, $V_C$, and $V_E$ in the following circuits. $\beta = 50$, $V_{BE} = 0.7\, \text{V}$.