ELE222E INTRODUCTION TO ELECTRONICS (21271)
Midterm Exam #1 ✎ 10 March 2004 ⌚ 10.00-12.00
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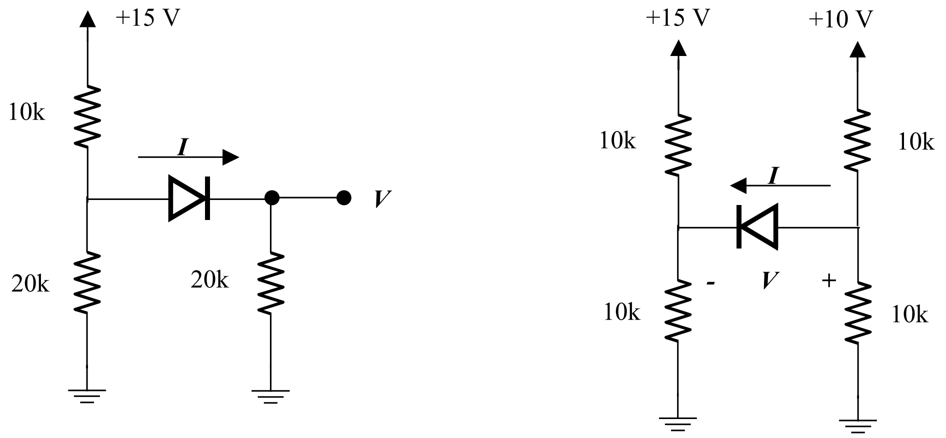
SOLUTIONS

1. Explain in a few sentences the physical events underlying the growth of depletion layer in a pn junction under open-circuit conditions? What happens to the depletion layer when the pn junction is biased? Explain the physical meaning of "potential barrier". (7 sentences maximum, 30 points)

THE ANSWERS ARE ALREADY AVAILABLE IN BOOKS.

2. Assuming the diodes shown below are all ideal, utilize Thévenin's Theorem to simplify the circuits and find the values of the labeled currents and voltages. (2x 20 points)



For the circuit on the left, $V_{anode} = \dfrac{20k}{20k + 10k} 15V = 10V$ and $R_{anode} = 10k \parallel 20k = 6k7$.

$V_{anode} > V = V_{cathode}$. , therefore 0,6 V may drop acress the diode and it is forward biased. That means the current that flows through can be calculated from $I = \dfrac{10V - 0{,}6V}{6k7 + 20k} = 0{,}35mA$. Thus, $V = I \cdot 20k = 7{,}04V$ which proves $V_{anode} > V = V_{cathode}$ and forward bias.

For the circuit on the right, $V_{cathode} = \dfrac{10k}{10k + 10k} 15V = 7{,}5V$ and $R_{cathode} = 10k \parallel 10k = 5k$ and $V_{anode} = \dfrac{10k}{10k + 10k} 10V = 5V$ and $R_{anode} = 10k \parallel 10k = 5k$. Since $V_{anode} < V_{cathode}$ the diode is reverse biased and no current flows through. $V = V_{anode} - V_{cathode} = -2{,}5$ V.

3. For the circuit shown below right,

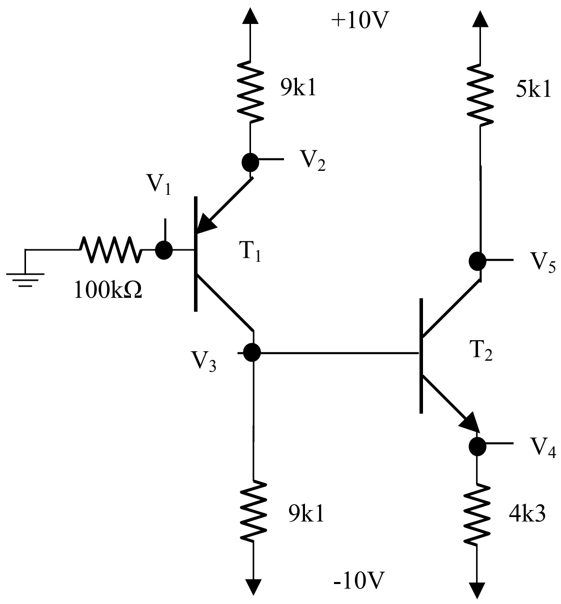
find the labeled node voltages for (3x 10 points)

a. β = ∞

b. β = 100

c. β = 10

Remember: |V_{BE}| = 0,6 V.



(a) $h_{FE} = \beta = \infty$

Automatically, V_1 = 0V and thus V_2 = 0.6 V. $I_{E1} = (V_{CC}-V_2)/9k1$ = 1,03 mA.

THUS I_{C1} = 1,03 mA.
$V_3 = -V_{EE} + I_{C1}*9k1$ = -0,6 V.
Therefore V_4 = -1,2 V.

$I_{E2} = (V_4-V_{EE})/4k3$ = 2,05 mA. THUS I_{C2} = 2,05 mA. $V_5 = V_{CC} - I_{C2}*5k1$ = -0,45 V. This last value makes sure that T_2 is still in the active region because CB junction is reverse biased.

(b) $h_{FE} = \beta = 100$

Direction 1: From ground over 100k to Vcc.

$I_{C1} = h_{FE} \cdot \dfrac{V_{CC} - (-V_{BE1})}{100k + h_{FE} 9k1}$ = 0,93 mA. $V_1 = I_{B1}*100k$ = 0,93 V and V_2 = 1,53 V.

Loop 2: From $-V_{EE}$ over C_1 to B_2 to E_2 to $-V_{EE}$.

$I_{C2} = h_{FE} \cdot \dfrac{9k1 * I_{C1} - V_{BE2}}{9k1 + (1 + h_{FE})4k3}$ = 1,77 mA. $V_3 = -V_{EE} + 9k1\,(I_{C1} - I_{B2})$ = -1,70 V.

Therefore V_4 = -2,30 V. $V_5 = V_{CC} - 5k1*I_{C2}$ = 0,95 V.

(c) $h_{FE} = \beta = 10$

Direction 1: From ground over 100k to Vcc.

$I_{C1} = h_{FE} \cdot \dfrac{V_{CC} - (-V_{BE1})}{100k + h_{FE} 9k1}$ = 0,49 mA. $V_1 = I_{B1}*100k$ = 4,92 V and V_2 = 5,52 V.

Loop 2: From $-V_{EE}$ over C_1 to B_2 to E_2 to $-V_{EE}$.

$I_{C2} = h_{FE} \cdot \dfrac{9k1 * I_{C1} - V_{BE2}}{9k1 + (1 + h_{FE})4k3}$ = 0,69 mA. $V_3 = -V_{EE} + 9k1\,(I_{C1} - I_{B2})$ = -6,15 V.

Therefore V_4 = -6,75 V. $V_5 = V_{CC} - 5k1*I_{C2}$ = 6,49 V.