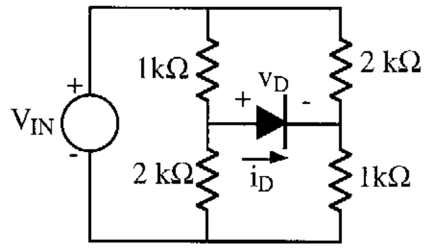
Homework Assignment No. 1 – Solutions

Problem 1



(a.) The first thing to do is to find Thevenin's equivalent circuit seen from the diode.

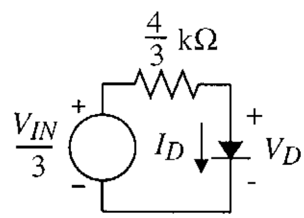
The Thevenin voltage is,

$$V_{TH} = V_{IN}\left(\frac{2}{3} - \frac{1}{3}\right) = \frac{V_{IN}}{3}$$

The Thevenin resistance is,

$$R_{TH} = 1\text{k}\Omega \| 2\text{k}\Omega + 1\text{k}\Omega \| 2\text{k}\Omega = \frac{4}{3}\ \text{k}\Omega$$

The equivalent circuit now becomes,



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Now, with V_{IN} = 10V, we know the diode is forward biased. Therefore, replacing it with a short-circuit gives,

$$V_D = \underline{\underline{0\text{V}}} \quad \text{and } I_D = \frac{10}{3}\text{x}\frac{3}{4\text{k}\Omega} = \underline{\underline{2.5\text{ mA}}}$$

(b.) With V_{IN} = -10V, we know the diode is reverse biased. Therefore replacing it with an open-circuit gives,

$$V_D = \underline{\underline{-3.33\text{V}}} \quad \text{and } I_D = \underline{\underline{0\text{ mA}}}$$

Problem 2

4.52

$$V_{GG} = \frac{100\text{k}\Omega}{100\text{k}\Omega + 220\text{k}\Omega} 12V = 3.75V$$

$$3.75 = V_{GS} + 24\text{x}10^3 I_{DS} = V_{GS} + 24\text{x}10^3 \frac{5}{1}\frac{25\text{x}10^{-6}}{2}(V_{GS} - 1)^2$$

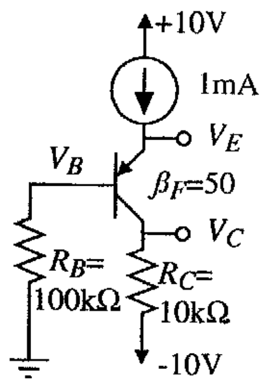
$$1.5V_{GS}^2 - 2V_{GS} - 2.25 = 0 \rightarrow V_{GS} = 2.061\text{V} \text{ and } I_{DS} = 70.36\mu\text{A}$$

$$V_{DS} = 12 - 36\text{x}10^3 I_{DS} = 9.467\text{V}$$

$$\text{Q-point: } (70.4\mu\text{A}, 9.47\text{V})$$

Problem 3

A pnp BJT circuit is shown. (a.) Find the dc values of I_E, I_C, I_B, V_E, V_C and V_B if $\beta = 50$ and $V_{EB}(\text{on}) = 0.65\text{V}$. (b.) For what value of R_C does the BJT become saturated? (Recall that saturation of a BJT corresponds to the BE and BC junctions forward biased.)



Solution

(a.) Note that $\boxed{I_E = 1\text{mA}}$ $\alpha_F = \dfrac{\beta_F}{1+\beta_F} = \dfrac{50}{51} = 0.98$

$\therefore I_C = \alpha_F I_E = 0.98 \cdot 1\text{mA} = 0.98\text{mA} \Rightarrow \boxed{I_C = 0.98\text{mA}}$

$$I_B = \frac{I_C}{\beta_F} = \frac{0.98\text{mA}}{50} = 19.6\mu\text{A} \Rightarrow \boxed{I_B = 19.6\mu\text{A}}$$

Now, $V_B = I_B \cdot 100\text{k}\Omega = 1.96\text{V} \Rightarrow \boxed{V_B = 1.96\text{V}}$

$V_E = V_B + V_{EB}(\text{on}) = 1.96\text{V} + 0.65\text{V} = 2.61\text{V} \Rightarrow \boxed{V_E = 2.61\text{V}}$

Finally, $V_C = -10\text{V} + I_C \cdot 10\text{k}\Omega = -10\text{V} + 0.98\text{mA}\cdot 10\text{k}\Omega = -0.2\text{V} \Rightarrow \boxed{V_C = -0.2\text{V} \approx 0\text{V}}$

(b.) Saturation occurs when $V_{BC} = 0$ of $V_B = V_C$. Therefore, $V_C = 1.96\text{V}$. The current through R_C is still 0.98mA, so solving for R_C gives,

$$R_C = \frac{V_C + 10\text{V}}{I_C} = \frac{11.96\text{V}}{0.98\text{mA}} = 12.20\text{k}\Omega \Rightarrow \boxed{R_C = 12.2\text{k}\Omega}$$

Problem 4

5.47

$$V_{BB} = 15\frac{120}{120+240} = 5.00\text{V} \text{ and } R_{BB} = 120\text{k}\Omega \| 240\text{k}\Omega = 80\text{k}\Omega$$

$$I_C = 100\frac{5.00 - 0.700}{80000 + 101(100000)} = 42.2\mu\text{A}.$$

$$V_{CE} = 15 - 42.2\text{x}10^{-6}(10^5) - \frac{101}{100}42.2\text{x}10^{-6}(1.5\text{x}10^5) = 4.39\text{V}$$

Q – point: (42.2 μA, 4.39 V))
