

Microelectronics Circuit Analysis and Design

Homework(3rd)

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1.45 The diode cut-in voltage is $V_\gamma = 0.7$ V for the circuits shown in Figure P1.45. Plot V_O and I_D versus I_I over the range $0 \leq I_I \leq 2$ mA for the circuit shown in (a) Figure P1.45(a), (b) Figure P1.45(b), and (c) Figure P1.45(c).

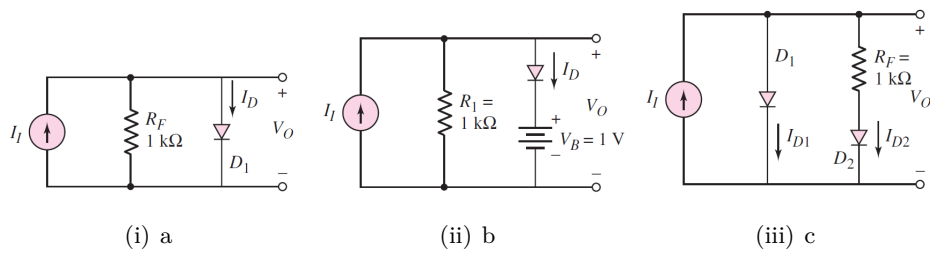


Figure 1: (a)

Solution:

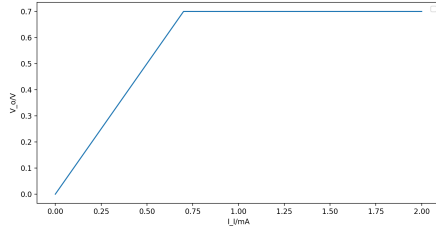
(a) KCL: $I_I = \frac{V_O}{R_F} + I_D$

When $V_O \geq V_\gamma = 0.7$ V, the diode is conducted, so R_F is shorted $\Rightarrow I_D = I_I - 0.7$, $V_O = 0.7$ V

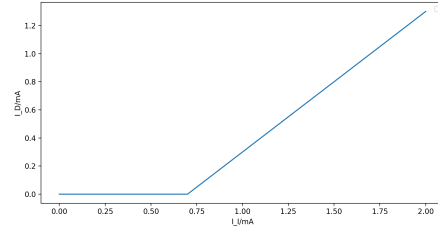
To satisfy the circumstance, we need $I_I \geq 0.7$ mA.

When $V_O \leq V_\gamma = 0.7$ V, the diode isn't conducted and can be regarded as open $\Rightarrow I_D = 0$, $V_O = I_I R_F$

To satisfy the circumstance, we need $I_I \leq 0.7$ mA.



(i) $V_O - I_I$



(ii) $I_D - I_I$

Figure 2: (a)

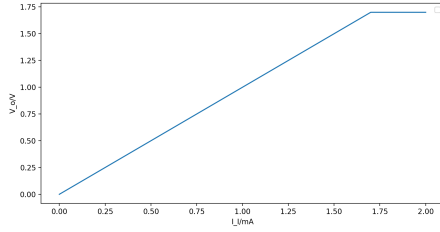
(b) KCL: $I_I = \frac{V_O}{R_F} + I_D$

When $V_O \geq V_\gamma + V_B = 1.7V$, the diode is conducted, so R_F is shorted $\Rightarrow I_D = I_I - 1.7, V_O = 1.7V$

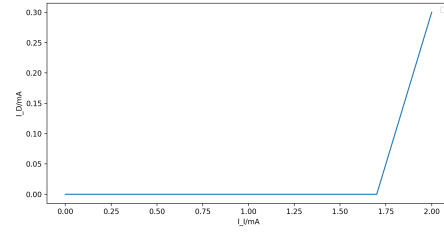
To satisfy the circumstance, we need $I_I \geq 1.7mA$.

When $V_O \leq V_\gamma + V_B = 1.7V$, the diode isn't conducted and can be regarded as open $\Rightarrow I_D = 0, V_O = I_I R_F$

To satisfy the circumstance, we need $I_I \leq 1.7mA$.



(i) $V_O - I_I$

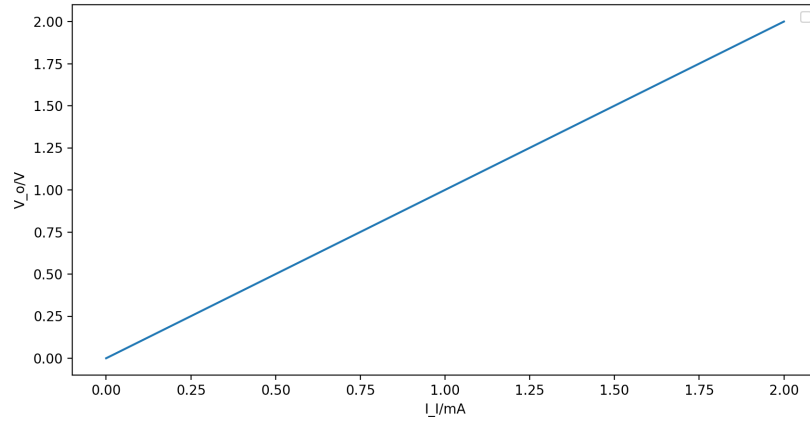


(ii) $I_D - I_I$

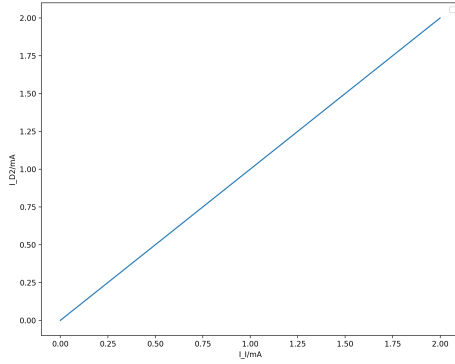
Figure 3: (b)

(c) We can know that D_1 will be conducted forever (ideal Current Source), and at this time D_2 and R_F will be shorted.

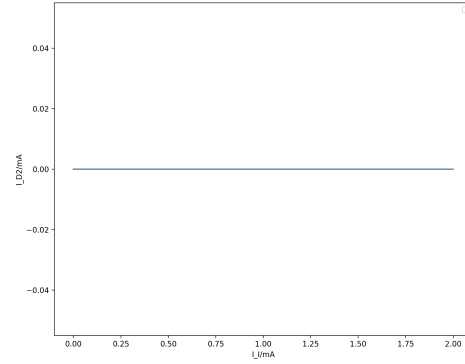
$\Rightarrow V_O = 0.7V, I_{D1} = I_I$ and $I_{D2} = 0$



(i) $V_O - I_I$



(ii) $I_{D1} - I_I$



(iii) $I_{D2} - I_I$

Figure 4: (a)

1.50 Assume each diode in the circuit shown in Figure P1.50 has a cut-in voltage of $V_\gamma = 0.65\text{V}$. (a) The input voltage is $V_I = 5\text{V}$. Determine the value of R_1 required such that I_{D1} is one-half the value of I_{D2} . What are the values of I_{D1} and I_{D2} ? (b) If $V_I = 8\text{V}$ and $R_1 = 2\text{k}\Omega$, determine I_{D1} and I_{D2} .

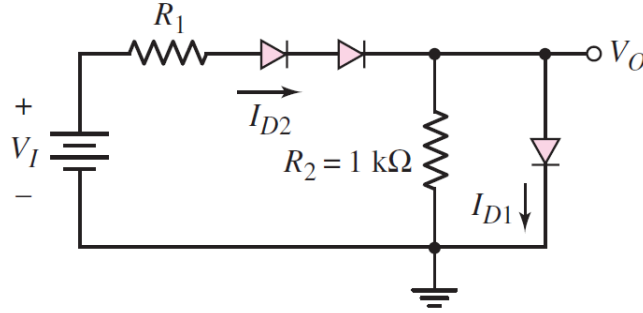


Figure 5: Problem 1.50

Solution:

(a) Actually, we can know that D_1 and D_2 are conducted, so we have equation:

$$\begin{cases} V_O = V_\gamma \\ I_{D1} = \frac{1}{2} I_{D2} \\ V_I - V_O = I_{D2} R_1 + 2V_\gamma \\ I_{D2} = \frac{V_O}{R_2} + I_{D1} \end{cases} \Rightarrow \begin{cases} R_1 = 1.56 k\Omega \\ I_{D2} = 1.3 \text{ mA} \\ I_{D1} = 1.95 \text{ mA} \end{cases}$$

(b) We assume D_1 and D_2 are conducted, so we have equation

$$\begin{cases} V_O = V_\gamma \\ V_I - V_O = I_{D2} R_1 + 2V_\gamma \\ I_{D2} = \frac{V_O}{R_2} + I_{D1} \end{cases} \Rightarrow \begin{cases} I_{D1} = 3.025 \text{ mA} \\ I_{D2} = 2.375 \text{ mA} \end{cases}$$

1.57 Consider the Zener diode circuit shown in Figure P1.57. The Zener breakdown voltage is $V_Z = 5.6 \text{ V}$ at $I_Z = 0.1 \text{ mA}$, and the incremental Zener resistance is $r_z = 10 \Omega$. (a) Determine V_O with no load ($R_L = \infty$). (b) Find the change in the output voltage if V_{PS} changes by $\pm 1 \text{ V}$. (c) Find V_O if $V_{PS} = 10 \text{ V}$ and $R_L = 2 k\Omega$.

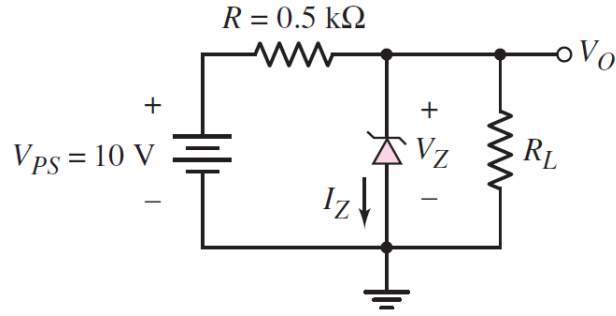


Figure 6: Problem 1.57

Solution:

(a) Because of KCL and information provided by problem:

$$\frac{V_{PS} - V_O}{R} = \frac{V_O - V_z}{r_z} \Rightarrow V_O = 5.686\text{V}$$

(b) When $V_{PS} = 9\text{V}$:

$$\frac{V_{PS} - V_O}{R} = \frac{V_O - V_z}{r_z} \Rightarrow V_{O1} = \frac{17}{3}\text{V}$$

When $V_{PS} = 11\text{V}$:

$$\begin{aligned} \frac{V_{PS} - V_O}{R} &= \frac{V_O - V_z}{r_z} \Rightarrow V_{O2} = \frac{97}{17}\text{V} \\ \Rightarrow \Delta V_O &= V_{O1} - V_{O2} = 0.0392\text{V} \end{aligned}$$

(c) Because of KCL and information provided by problem, we have equation:

$$\frac{V_{PS} - V_O}{R} = \frac{V_O - V_Z}{r_z} + \frac{V_O}{R_L} \Rightarrow V_O = 5.659\text{V}$$