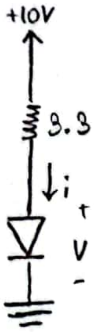
15212021104 - Doğukan Kıyıklık

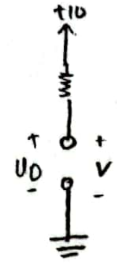
Q1) Find the values of I and V for the circuits, assuming that the diodes are ideal.

a)

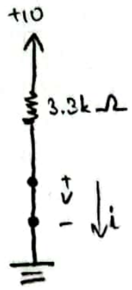


$\Rightarrow$

Assume diode is off state;



$i = 0$, $V_D = 10V$ } If diode is off, V_D must be negative. But, this condition is not satisfied. So, diode is <u>on</u> state



$\Rightarrow$ $i = V/R \Rightarrow \dfrac{10}{3.3\times10^3} = \boxed{3.03\,mA}$ Answer

Answer $\boxed{V = 10V}$

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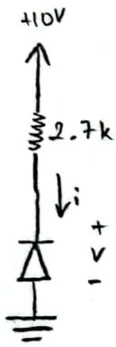
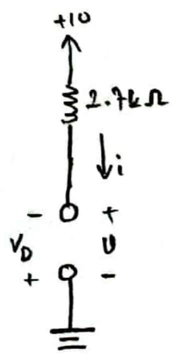
b)



$\Rightarrow$

Assume diode is off state;



$i = 0$, $V_D = -10V$ } If diode is off, $V_D < 0$. Condition satisfied

Answer

$\boxed{\begin{array}{l} i = 0\,A \\ V = 10V \end{array}}$

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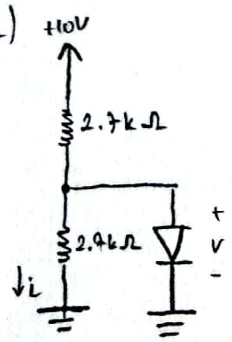
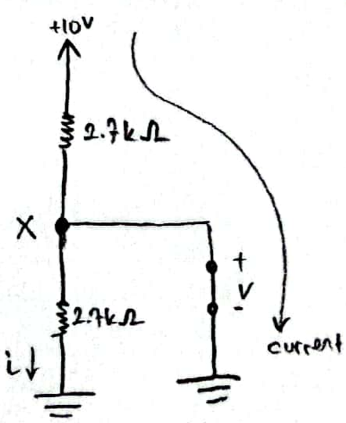
c)



$\Rightarrow$

Assume diode is on state



$V_x = 0$, so i must be equal to 0

$V = 0$

Answer

$\boxed{\begin{array}{l} i = 0 \\ V = 0 \end{array}}$

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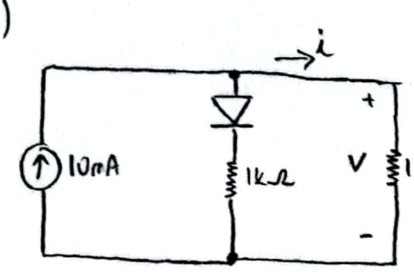
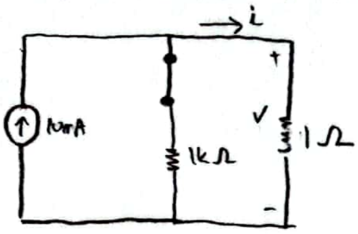
d)



Assume diode is on



$V_D = 0 \quad i > 0$; condition satisfied

$$R_{eq} \Rightarrow \frac{1}{\frac{1}{10^3} + 1} = 999\,m\Omega$$

Answer

$$V = 10 \times 10^{-3} \times 999 \times 10^{-3} = \boxed{9.99 \times 10^{-3}\,V}$$

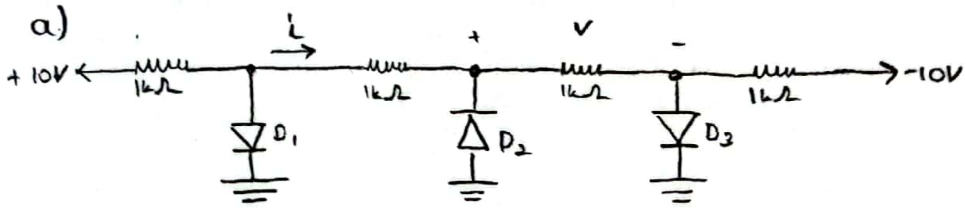
Answer

$$i = V/R \rightarrow \frac{9.99 \times 10^{-3}}{1} = \boxed{9.99\,mA}$$

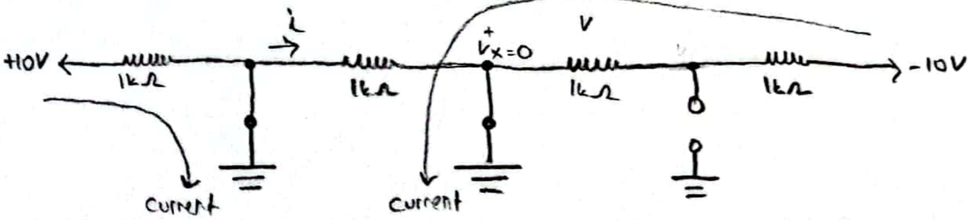
Q2)

Find the values of I and V for the circuits, assuming that diodes are ideal. For part(b), consider $V_{in} = 0, 2, 6$ and $10V$. Also, plot V versus V_{in} for V_{in} ranging from $-10V$ to $10V$

a)



Assume D_1 on, D_2 on, D_3 off



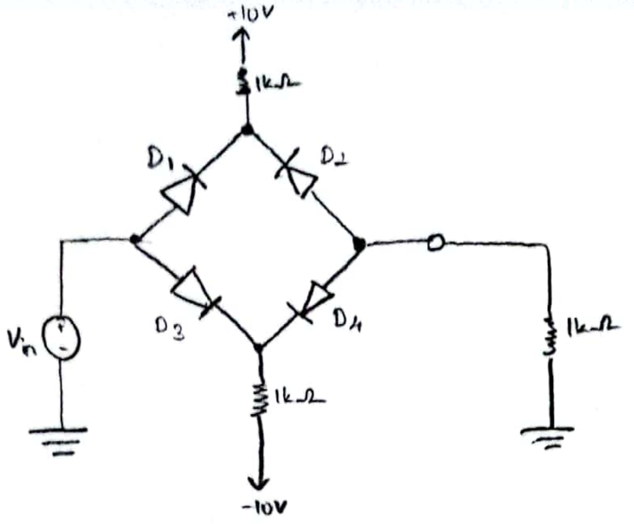
i must be equal to zero.

$$V = \frac{V_x - (-10V)}{2k\Omega} \times 1k\Omega \Rightarrow V = 5V$$

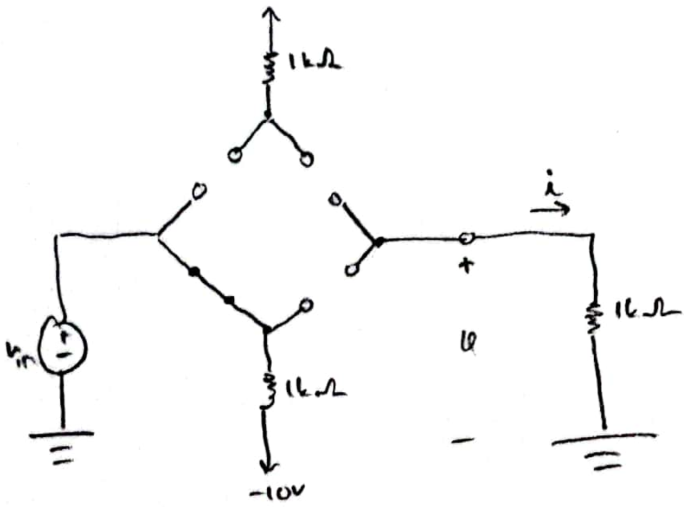
Answer

$$\left\{ \boxed{\begin{array}{l} i = 0 \\ V = 5V \end{array}} \right.$$

b)



$0 < V_{in} < 10$ iken, sadece D_3 on durumunda olur.



Bu yüzden $V_{in} = 0, 2, 4, 6, 8\,V$ değerleri için $i = 0$ $V = 0$ olur

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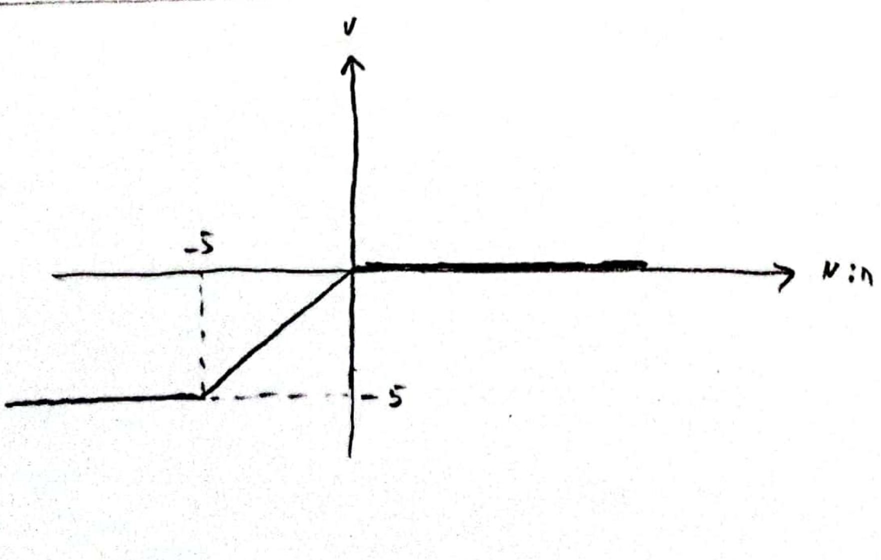
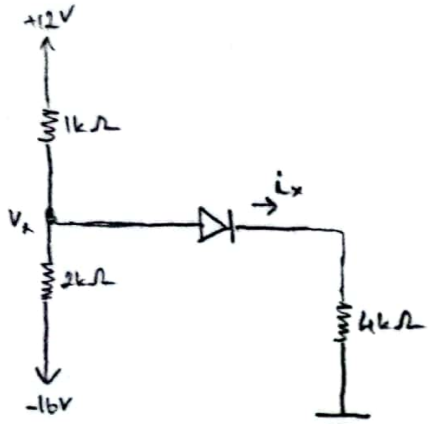


$V_{in} < 0$ iken D_3 ve D_4 on durumunda olur.

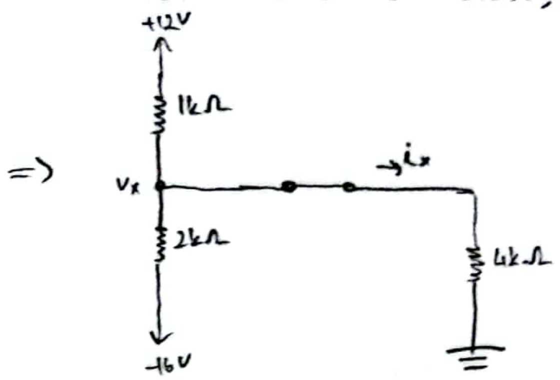
-5 değerinde iken D_3 ve D_4 tam iletken hale gelir ve devredeki akım bu noktada sabitlenir

Q3,

The diode is ideal. Determine the state of the diode and the values of V_x and i_x.



Assume diode on state;



$$\underset{(4)}{\frac{12-V_x}{10^3}} = \underset{(2)}{\frac{V_x+16}{2\times10^3}} + \frac{V_x}{4\times10^3} \Rightarrow 48-4V_x = 2V_x+32+V_x$$

$$16 = 7V_x \rightarrow \boxed{V_x = 2.28V}$$

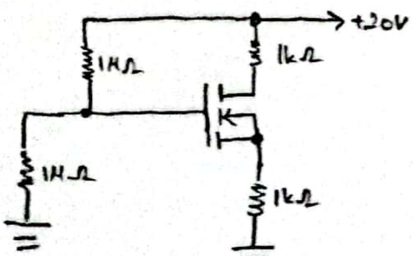
$$i_x = \frac{V_x}{4\times10^3} \Rightarrow \frac{2.28}{4\times10^3} = \boxed{0.57mA}$$

Answer

$i_x > 0$, so $\boxed{\text{diode is on, } V_x = 2.28V,\ i_x = 0.57mA}$

Q4,

Find the values of I_{DQ} for the circuit. Assume that $V_{to} = 4V$ and $K = 1mA/V^2$.
Repeat for $V_{to} = 2V$ and $K = 2mA/V^2$



For $V_{to} = 4V$ and $K = 1\times10^{-3}A$,

$$V_G = 20\times\frac{1M\Omega}{1M\Omega+1M\Omega} \Rightarrow 10V$$

At point Q $\Rightarrow V_G = V_{GSQ} + I_{DQ}\cdot10^3$

At saturation $\Rightarrow I_{DQ} = K(V_{GSQ}-V_{to})^2$

$$\Rightarrow 10 = V_{GSQ} + \cancel{10^3}\,\cancel{10^{-3}}(\overset{y}{V_{GSQ}}-4)^2 \Rightarrow y^2+16-8y+y=10 \rightarrow y^2-7y+6=0$$

$$(y-1)(y-6) \Rightarrow y = 1/6$$

$\boxed{V_{GSQ} = 1 \text{ or } 6}$ At saturation; $V_{GSQ} \geq V_{to}$

So $V_{GSQ} = 6$

$$I_{DQ} = 10^{-3}(6-4)^2 \Rightarrow \boxed{4mA}$$

Answer

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b) for $V_{to} = 2V$ and $K = 2mA/V^2$,

$$\left.\begin{aligned} V_{GS} &= 10V \\ V_G &= V_{GSQ} + I_{DQ} \cdot 10^3 \\ I_{DQ} &= K(V_{GSQ} - V_{to})^2 \end{aligned}\right\} \quad 10 = \underbrace{V_{GSQ}}_{y} + 2(V_{GSQ} - 2)^2 \Rightarrow 10 = y + 2y^2 - 8y + 8$$

$$\Rightarrow 2y^2 - 7y - 2 = 0 \qquad \Delta = 49 - 4.2.(-2) = 65$$

$$y_1 = \frac{7 + \sqrt{65}}{4} = 3.76$$

$$y_2 = \frac{7 - \sqrt{65}}{4} = -0.26$$

On saturation,

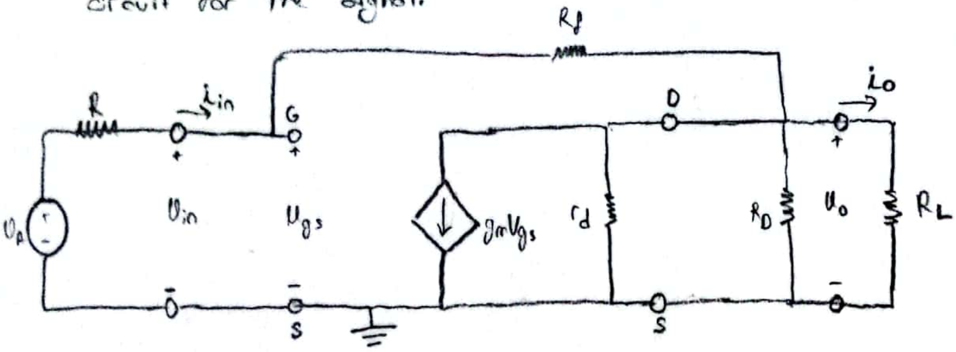
$V_{GSQ} > V_{to}$, so $V_{GSQ} = 3.76$

Answer

$$I_{DQ} = 2 \times 10^{-3} (3.76 - 2)^2 = \boxed{6.19mA}$$

Q5)

a) Draw the small-signal equivalent circuit, assuming that the capacitors are short circuit for the signal.



b) Assume that $r_d = \infty$, and derive expressions for the voltage gain, input resistance, output resistance.

$$\frac{V_{in}-V_o}{R_f} = g_m \overbrace{V_{gs}}^{V_{in}=V_{gs}} + \frac{V_o}{R_L'} \Rightarrow R_L' = \frac{1}{\cancel{\frac{1}{r_d}} + \frac{1}{R_d} + \cancel{\frac{R}{R_f}}} = \frac{1}{\frac{1}{R_d}+\frac{1}{R_L}}$$

$$V_{in}\left(\frac{1}{R_f} - g_m\right) = V_o\left(\frac{1}{R_f} + \frac{1}{\frac{1}{R_d}+\frac{1}{R_L}}\right)$$

$$\boxed{A_V = \frac{V_o}{V_{in}} \Rightarrow \frac{\frac{1}{R_f} - g_m}{\frac{1}{R_f} + \frac{1}{\frac{1}{R_d}+\frac{1}{R_L}}}}$$

Answer of voltage gain.

$$R_{in} = \frac{V_{in}}{i_{in}} \Rightarrow i_{in} = \frac{V_{in}-V_o}{R_f} \Rightarrow \boxed{R_{in} = \frac{V_{in}}{\frac{V_{in}-V_o}{R_f}}}$$

Answer of input resistance

$$\boxed{R_o = \frac{R_D R_L (R_f + R)}{(R_f + R)(R_L + R_D) + (1 + g_m R)(R_D R_L)}}$$

Answer

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c) Find I_{DQ} if $R = 100k\Omega$, $R_f = 100k\Omega$, $R_D = 3k\Omega$, $R_L = 10k\Omega$, $V_{DD} = 20V$, $V_{to} = 5V$, and $K = 1mA/V^2$. Determine the value of g_m at the Q point.

$$V_{GS} = V_{DA}$$

$$\frac{20 - V_D}{R_D} = I_D \, .$$

On saturation

$$I_D = \frac{K}{2} \cdot \left(V_{GS} - V_{to} \right)^2$$

$$\frac{20 - V_D}{3\times10^3} = \frac{10^{-3}}{2} \left(V_D - 5 \right)^2$$

$$40 - 2V_D = 3V_D^2 + 75 - 30V_D$$

$$\Rightarrow 3V_D^2 - 28V_D + 35 = 0 \longrightarrow V_D = 7.846$$

$$I_D = \frac{20 - 7.846}{3\times10^3} = \boxed{4.05mA} \text{ Answer}$$

$$g_m = \sqrt{2KI_D} = \sqrt{2\times10^{-3} \times 4.05\times10^{-3}} = 2.84 mA/V^2$$

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d) Evaluate the exp. found in part (b) by using the values given part (c)

$$A_V = \frac{\frac{1}{R_f} - g_m}{\frac{1}{R_f} + \frac{1}{\frac{1}{R_d} + \frac{1}{R_L}}} \Rightarrow \frac{\frac{1}{100\times10^3} - 2.84\times10^{-3}}{\frac{1}{100\times10^3} + \frac{1}{\frac{1}{3\times10^3} + \frac{1}{10\times10^3}}} \Rightarrow \frac{-2.83\times10^{-3}}{4.33\times10^{-4}}$$

$$\boxed{= -6.53} \text{ Answer}$$

$$R_{in} \Rightarrow \frac{3\times10^3 \times 10\times10^3 + 100\times10^3 \left(3\times10^3 + 10\times10^3 \right)}{\left(3\times10^3 \times 10\times10^3 \times 2.46\times10^{-3} + 3\times10^3 + 10\times10^3 \right)} = \boxed{13.51\times10^3\Omega} \text{ Answer}$$

$$R_{out} \Rightarrow \frac{3\times10^3 \times 10\times10^3 \left(100\times10^3 + 100\times10^3 \right)}{\left(100\times10^3 + 100\times10^3\right)\left(3\times10^3 + 10\times10^3\right) + \left(1 + 2.446\times100\right) 3\times10^3 \times 10\times10^3}$$

$$\boxed{= 537.2\Omega} \text{ Answer}$$

e) Find $V_o(t)$ if $V(t) = 0.2\sin(200\pi t)$

$$\frac{V_o(t)}{V_{in}(t)} = -0.761$$

$$V_o(t) = -0.761 \times 0.2$$

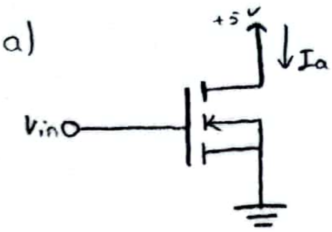
$$\boxed{V_o(t) = -0.152\sin(200\pi t)}$$

f) inverter. Çünkü output pozitiften $\rightarrow$ negatife değişiyor

Q6,

Find the currents and the region of operation for each of the enhancement transistors, for $V_{in} = 0$ and $V_{in} = 5V$. $|V_{to}| = 1V$ and $K = 0.2 mA/V^2$

a)



for $V_{in} = 0V$, $V_{to} = 1$

Answer

$V_{GS} = 0V$; $V_{GS} \leq V_{to}$ $\Rightarrow$ $\boxed{\text{Cutoff region} \quad I_a = 0}$

for $V_{in} = 5V$, $V_{to} = 1$ $V_{DS} = 5V$

$V_{GS} = 5V$; $V_{GS} > V_{to}$ and $V_{DS} \geq V_{GS} - V_{to}$

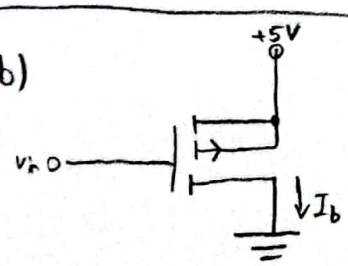
$5 \geq 4$ $\Rightarrow$ $\boxed{\text{saturation region}}$

$I_a = K(V_{GS} - V_{to})^2 = 0.2 \times 10^{-3} (4)^2 = \boxed{3.2 mA}$

$\boxed{\text{Saturation region, } I_a = 3.2mA}$

Answer

b)



for $V_{in} = 0V$, $V_{to} = -1$

Answer

$V_{GS} = -5V$; $V_{GS} \leq V_{to}$ $V_{DS} = -5V$ and $V_{DS} \leq V_{GS} - V_{to}$ $\Rightarrow$ $\boxed{\text{Saturation region}}$

$-5 \leq -4$

Answer

$I_b = K(V_{GS} - V_{to})^2 \Rightarrow 0.2 \times 10^{-3} (-4)^2 = \boxed{3.2mA}$

for $V_{in} = 5V$, $V_{to} = -1$

Answer Answer

$V_{GS} = 0V$; $V_{DS} = -5V$ $V_{GS} \geq V_{to}$ $\Rightarrow$ $\boxed{\text{cutoff region}}$ and $\boxed{I_b = 0}$