American University of Beirut

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

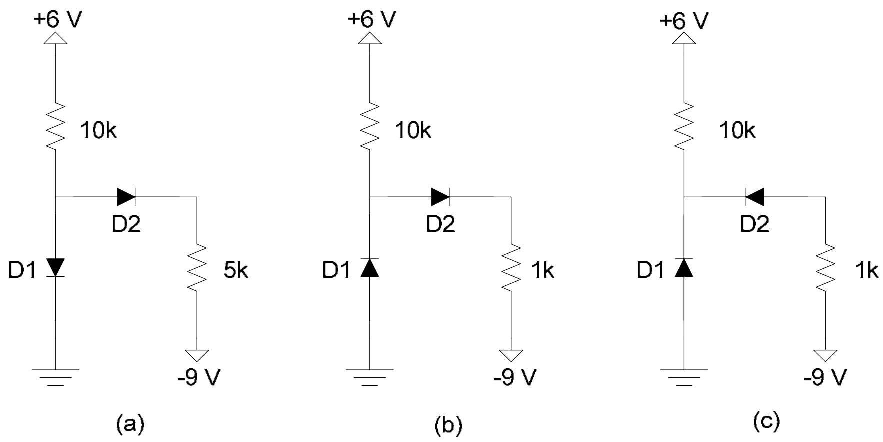
EECE 310 – Electronics Fall 2007 – 2008

Due Tuesday October 16, 2007

Homework 2

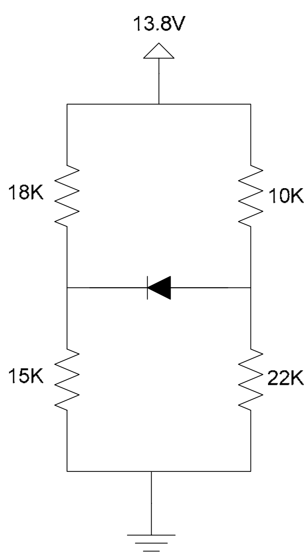
1. A junction diode operating at a temperature of 33 degrees C has $I_S = 10^{-15}$ A and n = 1.05. (a) What is the diode voltage if the diode current is 0.1 mA? (b) What will be the diode voltage if the current increases by a factor of 50?

2. Find the operating point (I_D, V_D) for the diodes in the circuits shown below. Assume that all the diodes are ideal.



3.

a. Assume that the diode in the circuit below is ideal. Find the operating point (i_D, v_D) of the diode. *Hint*: Use the Thévenin equivalent circuit.



b. Repeat part (a) for a real diode at a temperature of 27 degrees C with $n = 1$ and $I_S = 10^{-16}$ A, using:

i. Iterations with an initial guess for i_D equal to the value found in part (a)

ii. The graphical load line method.

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CAD Assignment 1

Use PSpice to analyze the circuit of Problem 3 in Homework 2. (Note: The PSpice tutorial from EECE 200 is available on Moodle.)

Start by placing 4 resistors with the values shown, and a 13.8V DC voltage source.

Make sure that your ground node(s) are named **0**.

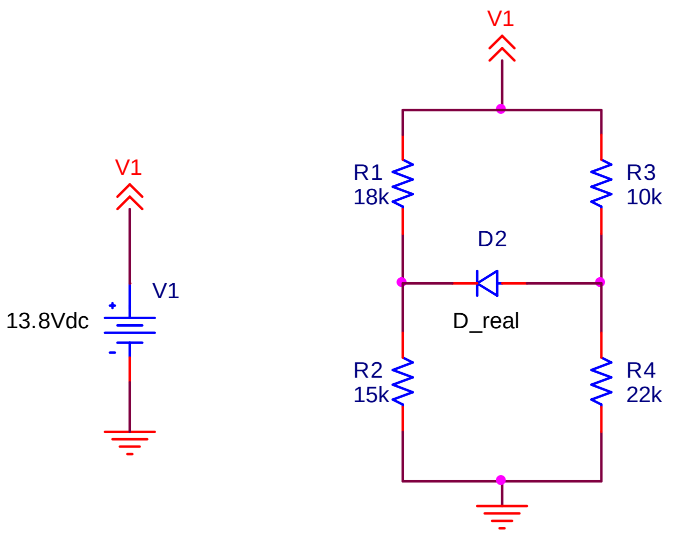
The diode part to use is Dbreak from the BREAKOUT library. After placing the diode, right-click on its symbol, then click on Edit Pspice Model. Replace the `.model` line in the Model Editor with the following line:

```
.model D_ideal D Is=1e-16 n=1e-6
```

The unusually small value of n (10^{-6}) in this model makes the diode behave like an ideal one.

Create a new simulation profile, (under the PSpice menu), and call it DC Analysis. What we are interested in for this circuit is an Analysis Type of “Bias Point”.

Simulate your circuit, and observe the node voltages and branch currents, by clicking on the “V” and “I” buttons on the Capture toolbar.



To simulate the circuit now with a real diode, right-click on the diode symbol, then click on Edit Pspice Model. Replace the `.model` line in the Model Editor with the following line:

```
.model D_real D Is=1e-16 n=1
```

This value of $n = 1$ makes the diode behave like a real one, with a value of $I_S = 10^{-16}$ A.

Simulate your circuit, and observe the node voltages and branch currents, by clicking on the “V” and “I” buttons on the Capture toolbar.

- Submit a printout of your Capture windows showing the values of currents and voltages for both cases (ideal diode and real diode).

- List the values of the diode voltage and current for the real diode case, as obtained from SPICE, and compare them with the values obtained in Problem 3, part (b-i).

Problem 1:

a) $V_T = \frac{kT}{q} = \frac{1.38\times10^{-23}\times(273+33)}{1.6\times10^{-19}} = 26.4\,mV$

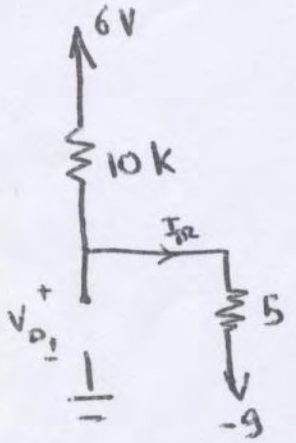
$V_D = n V_T \ln\left(\frac{I_D}{I_s}+1\right) = 1.05\,(26.4m)\,\ln\left(\frac{0.1\times10^{-3}}{10^{-15}}+1\right) = 0.702\,V.$

b) $I_D = 50\,(0.1) = 5\,mA$

$V_D = n V_T \ln\left(\frac{5\times10^{-3}}{10^{-15}}+1\right) = 0.81\,V$

Problem 2:

a) Assume D_1 off ; D_2 on. $\Rightarrow I_{D1} = 0A$; $V_{D2} = 0V$

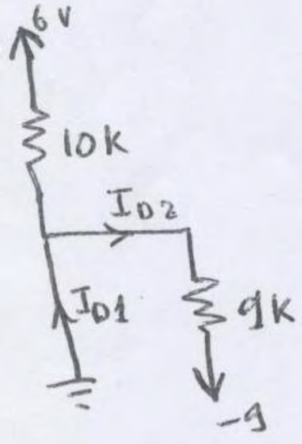


$I_{D2} = \frac{6-(-9)}{(10+5)k} = \frac{15}{15K} = 1mA > 0 \Rightarrow$ correct assum.

$V_{D_1} = 5 I_{D_2} - 9 = -4V < 0 \Rightarrow D_1$ off $\Rightarrow$ correct ass.

$\Rightarrow D_1\,(0, -4V)$; $D_2\,(1mA, 0V)$

b) Assume D_1 on and D_2 on $\Rightarrow V_{D_1} = 0V$; $V_{D_2} = 0V$

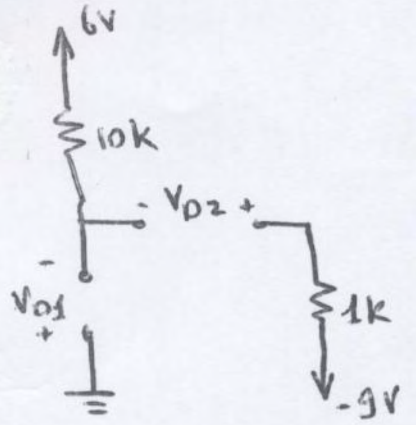


KVL: $\Rightarrow 1 I_{D2} - 9 = 0 \Rightarrow I_{D2} = 9\,mA. > 0 \Rightarrow D_2$ on

KCL: $\Rightarrow I_{D_1} + \frac{6}{10K} = I_{D_2} \Rightarrow I_{D_1} = 9 - 0.6 = 8.4\,mA > 0 \Rightarrow D_1$ on

$\Rightarrow D_1\,(8.4mA, 0V)$; $D_2\,(9mA, 0V)$

c) Assume D_1 off and D_2 off $\Rightarrow I_{D1} = 0\,mA$; $I_{D2} = 0\,mA$



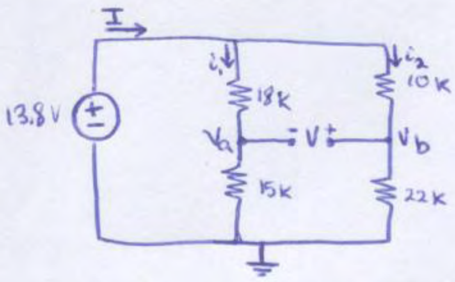
KVL $\Rightarrow$ $6 = 10k \times 0 - V_{D1} \Rightarrow V_{D1} = -6\,V < 0 \Rightarrow D_1$ off

KVL $\Rightarrow$ $6 = 10k \times 0 - V_{D2} + 1k \times 0 - 9 \Rightarrow V_{D2} = -15 < 0 \Rightarrow D_2$ off.

D_1 (0mA, -6V) : D_2(0mA, -15V)

Problem 3:

a) Finding V_{th}:



$$I = \frac{13.8}{(18+15) \parallel (10+22)} = \frac{13.8}{16.246} = 0.85\,mA$$

$$i_1 = \frac{16.246}{33} \times 0.85 = 0.418\,mA$$

$$i_2 = \frac{16.246}{32} \times 0.85 = 0.432\,mA$$

So $\left.\begin{array}{l} V_a = 15\,i_1 = 15 \times 0.418 = 6.27V \\ V_b = 22\,i_2 = 22 \times 0.432 = 9.504V \end{array}\right] \Rightarrow V_{th} = V_b - V_a = 3.204\,V$

$R_{th} = 18 \parallel 15 + 10 \parallel 22 = 8.\overline{18} + 6.875 = 15.055\,k\Omega \approx 15\,k\Omega$

So the equivalent circuit is:

D is ON since $i_D = \frac{3.204}{15} = 0.2135\,mA$

$V_D = 0V$

So the operating point of the diode is $(0.2135, 0)$

b) i-

$$V_T = \frac{kT}{q} = \frac{1.38 \times 10^{-23} \times (273+27)}{1.6 \times 10^{-19}} = 25.87 \text{ mV}$$

we know that: $v_D = nV_T \ln\left(\frac{i_D}{I_S} + 1\right)$

using KVL: $i_D = \frac{V_{th}}{R_{th}} - \frac{v_D}{R_{th}} = \frac{3.204}{15} - \frac{1 \times 25.87 \times 10^{-3}}{15} \times \ln\left(\frac{i_D}{10^{-13}} + 1\right)$

$$i_D = 0.213 - 1.718 \times 10^{-3} \ln\left(\frac{i_D}{10^{-13}} + 1\right)$$

initial guess: $i_D = \frac{3.204}{15} = 0.213 \text{ mA}$

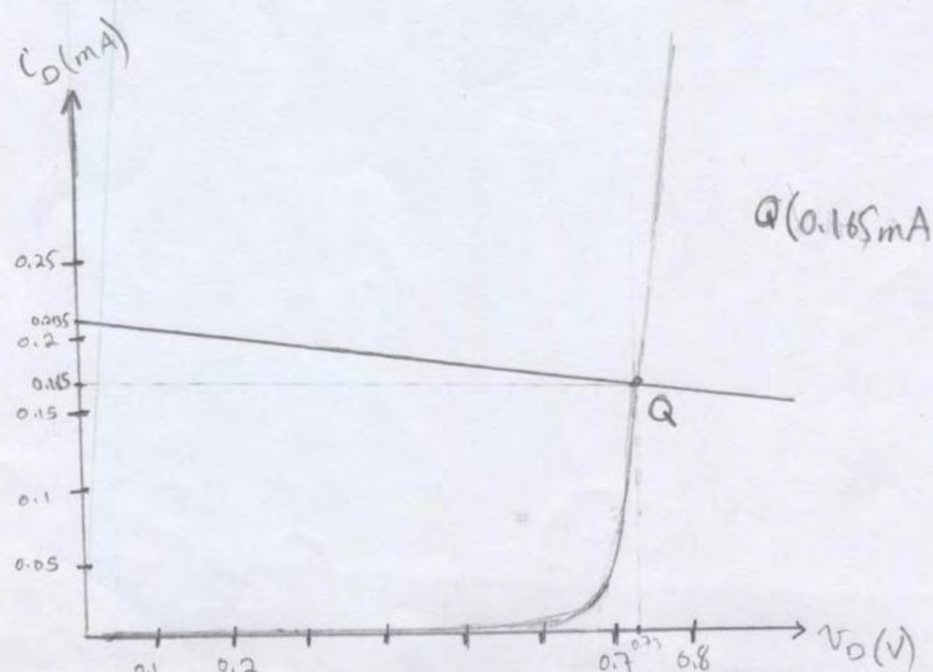
after 2 iterations: $i_D = 0.165 \text{ mA}$; $V_D = 0.727 \text{ V}$

ii) using graphical load line method:

Draw: $i_D = I_S\left(e^{\frac{v_D}{nV_T}} - 1\right)$ (in mA)

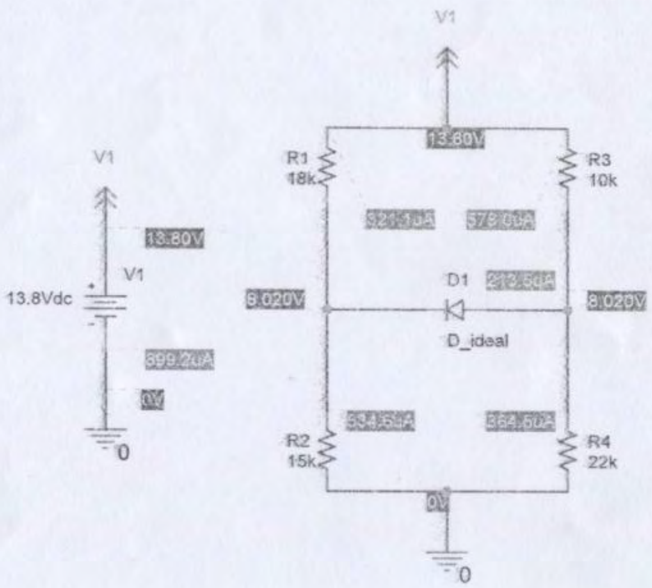
$$i_D = \frac{V_{th}}{R_{th}} - \frac{v_D}{R_{th}} = 0.213 - 66.4 \times 10^{-3}\, v_D$$

Intersection Point: Q (0.165mA; 0.728 V)



Q(0.165mA; 0.73V)

Ideal Diode



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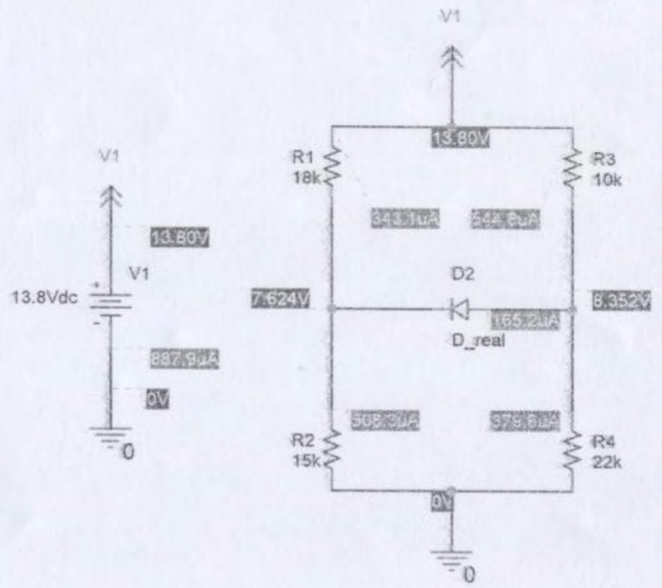
Real Diode

$i_D = 165.2\,\mu A$

$v_D = 8.352 - 7.624$

$= 0.728\,V$



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