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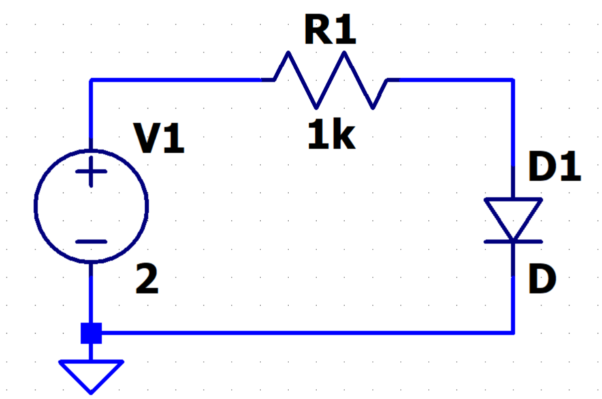
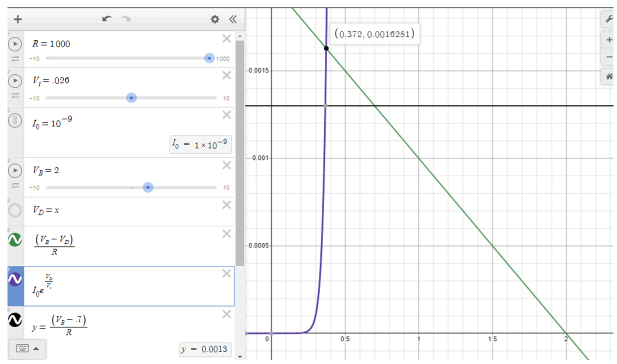
Intro to Electronics HW3

1) Consider a series circuit consulting of an ideal DC voltage source (2.0 V), a resistor (1.0 kΩ) and a silicon diode that is biased in the forward direction. A Si diode has a turn-on voltage of 0.7 V and a reverse saturation current of I0 = 1 nA.
    a) Sketch the electrical circuit. Make a quantitative plot of the diode forward characteristic and the load line. Determine the diode forward current from the plot.





Vbat-IR=Vdiode
I=(VBat-Vdiode)/R
I=(2-x)/1000

I=I0(e^Vd/Vt)
I=10^-9(e^Vd/.026)

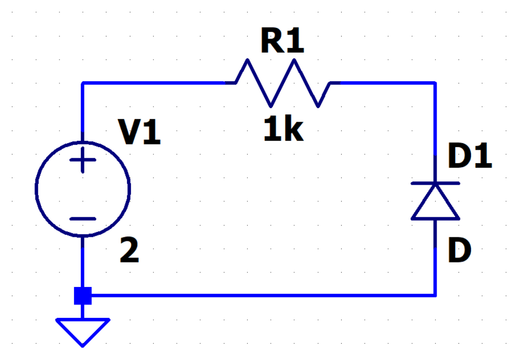
I=0.016A

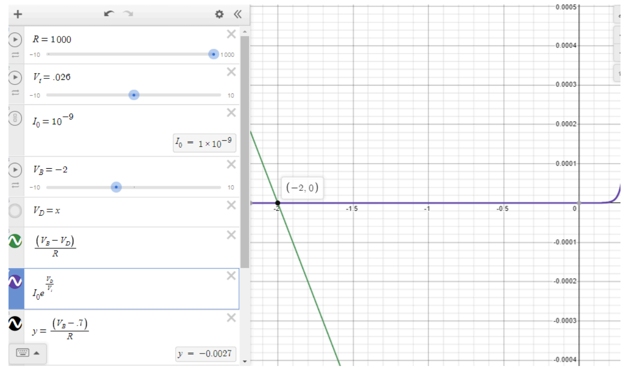
    b) Calculate the diode forward current without using the plot. Comment on the agreement / disagreement between graphical solution and analytical solution.

Vdiode~=.7
I=(VBat-Vdiode)/R
I=(2-.7)/1000
I=0.013A

It’s approximately equal. This works because Vdiode >> Vt

    c) Next consider that the polarity of the diode is reversed. Sketch the electrical circuit. Make a quantitative plot of the diode reverse characteristic and the load line. Determine the diode current from the plot.





Essentially 0A

d) What is the diode reverse current (without using the plot)? Comment on the agreement / disagreement between graphical solution and analytical solution.

Vdiode~=.7

I=(VBat-Vdiode)/R

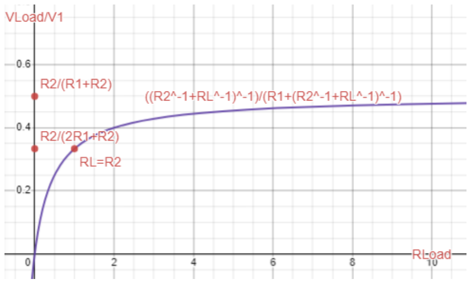
I=(-2-.7)/1000

I=-0.027A

This is incorrect because Vdiode >\> Vt

2) A voltage divider is intended to provide a stable voltage to a load. A Zener diode circuit is also intended to provide a stable voltage to a load. This problem compares the two methods.

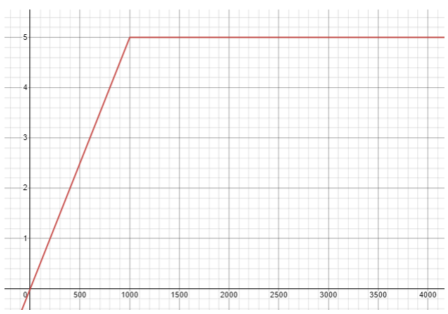
   a) The circuit below is a voltage divider that is connected to a load resistance (RLoad). Draw the right-hand-side (RHS) diagram and complete it.



   b) What do we learn from the diagram? Which condition must the load resistance satisfy, so that a voltage divider works as intended?

RL>>R2

   c) The circuit below is a Zener-diode-voltage-stabilization circuit that a load is connected to. Draw the RHS diagram and complete it.



   d) What do we learn from the diagram? Which condition must the load resistance satisfy, so that a voltage stabilization circuit provides a stable voltage?

RL>Vd*R1/(V1-Vd)
RL>5*1000/(10-5)=5000/5=1000

   e) Compare the two circuits above. Advantages? Disadvantages?

The Zener diode gives a constant voltage as long as RL is over a certain threshold, but will dump more current past the load to do so.

3) Consider the voltage-stabilization circuit below.

   a) Explain the purpose of the Zener diode.

A smoothing diode to maintain a more stable voltage. If the voltage goes too high, it will act as a smaller resistance and allow it to drop.

   b) What is the major disadvantage of the circuit?

The diode will waste power. It will waste less if it’s just to protect from higher voltages, but will waste more if the RMS of Vsource is greater than the zener diode voltage.

4) Consider the following diode circuit containing a silicon pn-junction diode with VAC = 10 mV, RAC = 100 Ω, VDC = 5 V, RDC = 100 Ω, and R = 1 kΩ. Assume that the capacitor C blocks all DC but lets pass all AC.
    a) Determine the steady-state voltage and current (DC values) of the diode (numerical values). The steady-state values may be called quiescent-point (Q-point) values.

V=5, R=1100, Vd=.7
V_R=5-.7=4.3
I=V_R/R=4.3/1100=3.909mA

    b) Draw an AC small-signal equivalent circuit of the diode circuit. Determine the Si-diode's differential resistance (numerical value).

Vmax=5.01, R=1100, Vd=.7
V_R=5.01-.7=4.31
Imax=V_R/R=4.31/1100=3.918mA
Vmin=4.99, R=1100, Vd=.7
V_R=4.99-.7=4.29
Imin=V_R/R=4.29/1100=3.900mA
Vdiff=0.02V, Idiff=0.01818mA
R=Vdiff/Idiff=1100.110011
rD=R-1100=0.11 ohms

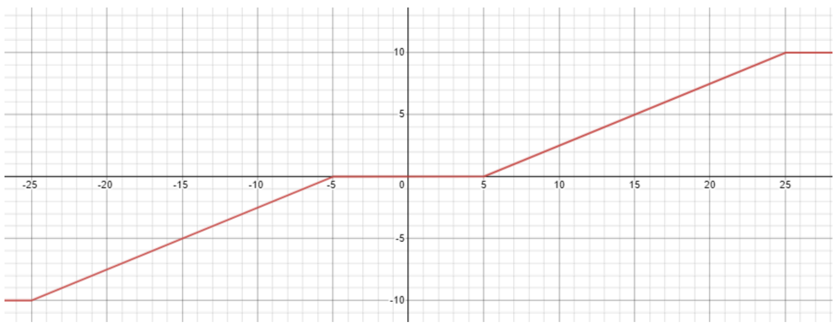
    c) Determine the AC voltage across and current through the diode (numerical values).

IAC=.00909mA, VAC=0.03020mV

5) Consider the following Si Zener-diode circuit. Assume that the Zener voltage of all four Zener diodes is VZener = 5 V. Assume that R1 = R2 = 1 kΩ.
   a) Define the diode threshold voltage (in your own words) and give its numerical value for the above circuit. Define the Zener voltage (in your own words) and give its numerical value for the above circuit.

The voltage required to make a significant current flow through a diode
The voltage a zener diode will maintain when more than that is applied, 5V.

   b) Draw the output-voltage-versus-input-voltage diagram of the circuit. Use the abscissa (horizontal axis) for the input voltage and the ordinate (vertical axis) for the output voltage. Mark all significant points of the diagram with numerical voltage values.



   c) Explain the diagram that you drew under the previous question.

The first two diodes block out anything less than 5, the resistors divide the remaining voltage in half, and the last two diodes cut off the voltage at 10.

   d) What is the output voltage for VIn = 10 V? What is the current value through R1?

V(R1+R2)=Vin-5=5V
Vdivider=5/2=2.5V
Vout=2.5V
5V/2kOhm=2.5mA

Vout=2.5V
I(R1)=2.5mA

   e) What is the output voltage for VIn = 30 V? What is the current value through R1?

V(R1+R2)=Vin-5=25V
Vdivider=25/2=12.5V
Vout=10V
V(R1)=25-10=15V
I=V/R=15/1k=15mA
I(R1)=15mA

Vout=10V
I(R1)=15mA