Lab #1: Introduction to Diodes

Objectives

1) Determine I-V characteristics of a silicon diode utilizing a Tektronics curve tracer.
2) Study DC load line analysis for a simple circuit.
3) Study the half-wave rectifier circuit, with and without a filter capacitor.
4) Study diode logic "AND" gate.

I-V Characteristic Curves

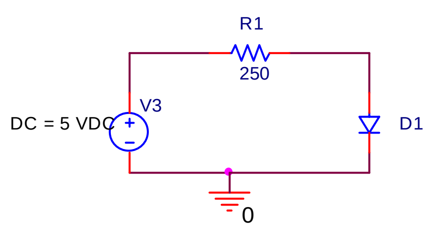
a) Obtain a 1N4001 Silicon diode and plot the forward bias I-V characteristic curve for this device. Your lab instructor will show you how to operate the curve tester.

b) Can you suggest a suitable circuit to obtain the I-V information in part a) if a curve tracer instrument is not available? What drawbacks, if any, would your method entail?

c) Are the plots as expected? If everything appears ok…. find the approximate Forward biased turn-on voltage, V_Y. Note: for a silicon diode V_Y should be approximately 0.7 V

DC Load Line Analysis

a) Consider the following circuit diagram:



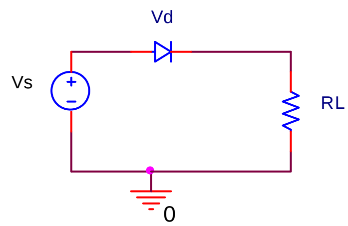
b) Based on the schematic in a) plot the DC load line on the I-V forward biased plot.

c) The intersection of the DC load line and the diode conductance plot represents the quiescent, or quiet, condition of the circuit. (Note that our textbook refers to this point as the operating point of the circuit. Both terms are widely used). The voltage and current values corresponding to this point are referenced as V_{DQ} and I_{DQ}. Carefully record these values.

d) Construct the circuit in a) and measure I_D and V_D using the digital multi-meter. Do these values agree with your expectations from part c)? If not…consult with your lab instructor for help.

<u>Half Wave Rectifier Circuit</u>

a) Consider the rectifier circuit shown below, where $V_S = 5 \sin 2\pi (1000)\ t$, $R_L = 1000\ \Omega$.



b) Assume an ideal diode and sketch the expected output voltage waveform across R_L.

c) Compute the expected average and rms voltage value of V_L.

d) A full-wave rectifier circuit will cause the signal frequency to double in value. Does the half-wave rectifier behave in a similar fashion? Explain.

e) Construct the circuit shown above.

f) Measure the output voltage, V_L, using oscilloscope. Compare the measured average and rms voltages to the expected values from part c).
Note: many newer digital scopes will display precise values for peak, average and rms voltage. Please use this feature if it is available.

g) Carefully sketch the output waveform. Is the waveform what you expected? Discuss.

<u>Half-Wave Rectifier Circuit with Capacitor Filter</u>

a) An unregulated DC power supply may be constructed by utilizing the half wave rectifier circuit above and placing a suitable capacitor in parallel with the load resistor, R_L. As discussed in class, a minor voltage fluctuation is often permissible in DC supplies. The idea here is to control the size of this variance, or ripple, by properly selecting the parallel capacitance value. The following equation, based on an analysis of the circuit time constant, will give a suitable capacitance value:

$$C = \frac{V_{max}}{\Delta V . f . R_L}$$

b) Show that the above equation is identical to equation 10.10 in your textbook:

$$C = \frac{I_L T}{V_r}$$

c) Using the following parameters, compute the proper capacitance value:

$V_{max} = V_S - 0.7$, $V_S = 5$ Vpeak, f = 100 Hz, $\Delta V = 5\%$ Vmax, $R_L = 1000\ \Omega$.

d) Modify the previous circuit by adding a filter capacitor of the proper value in parallel with R_L.
e) Using the oscilloscope, observe the output voltage present across R_L. Carefully sketch the waveform present. By carefully adjusting the vertical and horizontal scale controls on the oscilloscope it should be possible to detect the ripple effect. Note : if the scope is set AC probe coupling, the DC level will be removed and only the time varying ripple signals will remain. Ask your lab instructor for assistance if you have difficulty with this step.
f) Carefully measure the rms output voltage, and ripple voltage if possible. Are these Values what you expected? Explain any possible sources of error.

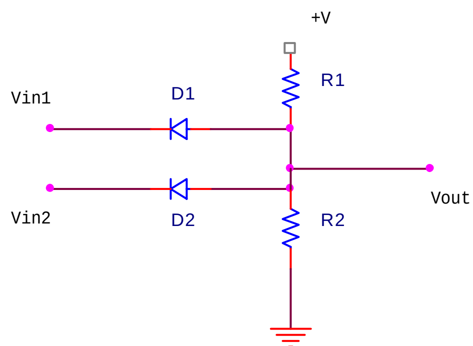
g) Discuss the effects of using filter capacitor across the load resistor. What would happen to the ripple voltage if the load resistance is increased or decreased? Do you think the effective DC voltage level would remain constant if R_L is changed?
h) Substitute a 1k Ω resistor for your R_L and repeat part f).

Diode Logic "AND" Gate

a) A logic "AND" gate might be characterized by the following "truth table":

V_1	V_2	V_{out}
0 (or "low" or "off")	0	off
0 (or "low" or "off")	1	off
1 (or "high" or "on")	0	off
1 (or "high" or "on")	1	on

b) A simple diode circuit that performs the "AND" function is shown in the following schematic:



c) Assuming an ideal diode is used, whenever *either* V_{in1} or V_{in2} are low enough to forward bias diodes D1 *or* D2 current will flow to ground through the input voltage sources. This will result in a very low V_{out}. This might be considered to be an "OFF" or "LOW" logic state. If both V_{in1} and V_{in2} are high enough to reverse bias pn junctions, then both diodes would act like open circuits and current (I) would flow to ground through the R1-R2 voltage divider. The output voltage would then be equal to [R2 / (R1 + R2)]* V. This might be considered to be an "on "or "high" logic state.

d) Can you suggest a circuit that performs an "OR" function as defined as below:

V_1	V_2	V_{out}
0	0	off
0	1	on
1	0	on
1	1	on

e) Construct the circuits in parts b) and d) above using +5V for "+V" and suitable values for R1 and R2. Verify the truth tables by recording the actual output voltage in each situation. If your "high" output voltage does not exactly equal to the expected high voltage and/or your "low" output voltage does not exactly equal 0 V, explain why.

Write Up

Complete your lab report, following the format outlined by your TA