The George Washington University
School of Engineering and Applied Science
Department of Electrical and Computer Engineering
ECE 20 - LAB

Experiment # 1
Solid State Diodes
Testing & Characterization

Components:

Kit Part #	***Spice Part Name***	***Part Description***	***Symbol Name*** ***(used in schematics throughout this lab manual)***
1N34A	*NONE*	Germanium Diode	D1
1N4002	D1N4002	Series Silicon Diode	D2
MV5753	*NONE*	Gallium Arsenide Phosphide (GaAsP) Light Emitting Diode (LED)	DS1
1N752A	D1N750	Zener Diode	VR1
Resistor	R	1 Ω Resistor	R1
Resistor	R	1 MΩ Resistor	R2
Capacitor	C	470 uF Capacitor	C1

Table 1.1

Objectives:

- To use an ohm meter to determine the forward and reverse resistance of different types of diodes.
- To use the Diode Test function of the Keithley Model 175.
- To obtain one diode i-v characteristic curve by using the information obtained from a test circuit.
- To obtain the i-v forward bias characteristic curves for several types of diodes by using the Tektronix Model 571.
- To obtain the i-v reverse bias characteristic curve for a Zener diode.
- To determine the value of the small signal resistance of one diode for different operating points and using three different techniques: graphically, analytically and by the application of a small signal.
- To interpret the results of static and dynamic diode tests.

Prelab: ***(Submit electronically prior to lab meeting,*** *also have a printed copy for yourself during lab)*

1. Read through lab, generate an equipment list.
2. Download and **Print** the specification sheet for the 4 diodes: 1N34A, 1N4002, MV5753, 1N752A *(see the lab website for links to spec sheet downloads)*

   a) From the spec sheet, populate the following table for each diode:

Diode:	V_F, I_F	V_R
1N34A		
1N4002		
MV5753		
1N752A		

Table 1.2 – Spec Sheet Values

3. Read "Tutorial #1 - *DC Sweep Simulation in SPICE*" on lab website, use it to plot the i-v characteristic curve for diodes: 1N4002, and 1N752A. Sweep the current from -1A to + 1A. label the end values for each curve. Notice the diodes have different part names in 'SPICE' as shown in Table 1.1 above.

4. Plot only the *forward* characteristic IV curve for the two diodes: 1N4002, and 1N752A, sweeping the current from 0A to 20mA. Do your graphs line up with the values you collected from the spec sheet in table 1.2?

5. Memorize the following in the event of a pre-lab quiz:
   a) The symbols for a Diode, LED, and Zener Diode (which terminal is anode/cathode)
   b) Be able to identify the 4 diodes in your kit on site
   c) The forward region i-v relationship equation (given later in this lab manual)
   d) Know the shape of a typical diode IV Curve
   e) Read the rest of the lab to have a general understanding of how we will use the data you've generated in this prelab.

<u>Lab</u>:

Part 1 - Data & Static Diode Tests:

a. Prepare a table with the four diodes in the left column, and the parameters you will record as titles in adjacent columns.
b. Set the Keithley Model 175 multimeter to read OHMs, and set it to auto range.
c. Connect the positive lead to the anode of the diode, and the negative lead to the cathode of the diode.
d. Measure and record the forward direction resistance (Rf) of D1, D2, VR1 and DS1. Then set the ohm meter to its highest scale, measure and record the reverse direction resistance (Rr) of D1, D2, VR1 and DS1. Place this data in your table.
e. Calculate the back to front ratio (Rr/Rf) for D1, D2, VR1 and DS1. Place this information in your table.
f. Set the Keithley Model 175 to perform a 'diode test' function (see section 2.7.11 of the Keithley Model 175 manual, it is on the lab website). Measure and record the forward and reverse bias voltage readings for D1, D2, VR1 and DS1. This information will complete your table.

Part 2 - Reverse Saturation Current:

Construct the circuit depicted in Fig # 1 on a breadboard using the following specifications:

Vd = -10 Vdc
R = R2 (see table 1.1)
D = D1 (see table 1.1)

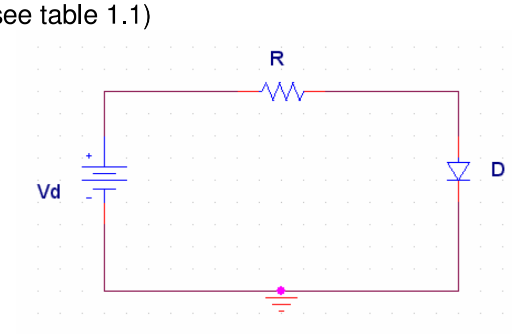

Fig # 1

a. Using the multimeter to measure current, find the reverse saturation current I_S of the diode. The multimeter must be connected in such a manner that its loading effect is reduced to a minimum.

b. Repeat this procedure for diode D2.

c. What is the value of I_S that SPICE uses to model this diode D2 (refer to your prelab)?

Part 3 - Forward I-V Characteristic

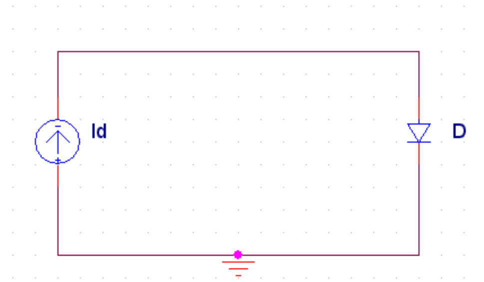

Fig # 2

a. Assemble the circuit shown in Fig # 2. The goal is to generate the IV-curve for the diode as you did in the prelab. You will need to use the "DC Power Supply" as a current source to do this, refer to *page 38 – Constant Current operation section of the Power Supply Manual*.

b. Using Diode D1, vary I_D from 0 to 20 mA DC in 2 mA steps, write down the voltage drop (V_D) across the diode for each value of I_D. Repeat this procedure for diodes D2, DS1, VR1.

c. With the help of speed-sheet software, plot the values obtained in part b), and those predicted by equation 1 (you should have 2 overlapping curves: expected & measured for each diode). Mark the point on the measured I-V curve that indicates the voltage drop across D2 when the forward current is equal to 10 mA DC, and again when the forward current is equal to 20mA DC.

d. In the forward region the i-v relationship is closely approximated by:

$$I_D = I_S\,[\exp(V_D / n\,V_T) - 1] \quad \textbf{\textit{equation 1}}$$

From the I-V curve, use the two points you've marked on the IV curve (Id=10mA, Vd) & (Id=20mA, Vd) to determine the values of **n** and $\mathbf{I_S}$. You will have 2 equations and 2 unknowns. Do this for diode.

e. Compare the value of I_S obtained in part 2a) to 2c) with the value you've calculated in 3d) for diodes D1 and D2.

Part 4 - Diode Parameters on the Curve Tracer

a. Use the Tektronix Model 571 Curve Tracer to obtain the i-v forward bias characteristic curves for D1, D2, VR1 and DS1, the GTA will show you how to test a diode using the curve tracer. Annotate the 10mA point on each curve (cut-in or cut-off point), and the point for which the voltage is equal to the value measured using the Keithley 175 diode test function.

b. Use the Tektronix Model 571 Curve Tracer to obtain the i-v reversed bias characteristic curves for D1, D2, VR1 and DS1. On the curve for VR1 find VZ when IZ is equal to 20 mA. Choose the appropriate range voltage and current range.

c. Compare the results generated by your test circuit to the results generated by the curve tracer for D2 and explain all differences!

d. Explain the methodology Keithley uses to perform the diode test. What are the nominal conditions for this test?

Part 5 - Small Signal Analysis (extra credit)

a. Compute rd analytically for I_D=6 mA, and for I_D=14 mA using rd=$d\,v_D/\,d\,i_D = (nV_T)/I_D$. You have already estimated the value of nV_T previously.

b. Compute the small signal resistance for D2 graphically for I_D=14 mA, and for I_D=6 mA using $r_d = d\,v_D/\,d\,i_D$ and Plot # 2.

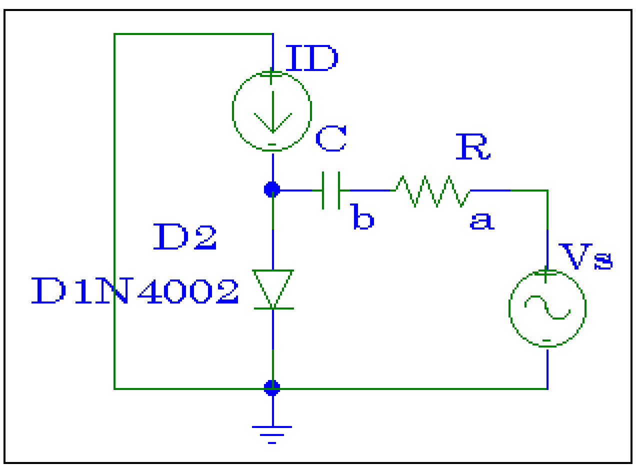

Fig # 3

Build the circuit shown in Fig # 3. R=R1 (1 W) and C=C1 (as large as possible)

c. Set I_D=14 mA, v_S=15 mV_{RMS}, (100kHz sinusoidal signal), and measure va (or vs) and vb (or vd). Compute the small signal resistance of the diode for this operating point: rd = vd / id.

d. Compare the values of rd obtained by the three different techniques.

Analysis to consider in Lab write-up:

In your prelab and in the lab, you have used 3 techniques to obtain the IV characteristic curves for the diodes: Spice based, Multimeter based, and Curve Tracer based. Compare and contrast the methods in your analysis; in addition compare the data you have collected to the data specifications from the manufacturer. If the data collected is not accurate, calculated percentages of error in each case.