Experiment D

Diodes

Before you start to perform an experiment you are obliged to have mastered the following theoretical subjects:

1. Intrinsic and doped semiconductors. [1], [2], [3].
2. p-n junction and metal-semiconductor (m-s) junction. [2], [3].
3. Zener breakdown. Avalanche breakdown. [1], [2], [3].

Purpose

The measurement of the current-voltage (I-V) characteristic of selected diodes is the purpose of experiment. The silicon diode and the Zener diode are investigated.

Experimental procedure

1. Connect the circuit according to the diagram presented in Fig. 1. Use the jumper to select the second diode (D_2). Connect the power supply to the circuit using three varicoloured wires (i.e. red: "plus", black: "minus" and blue: "zero"). WARNING: you have to set up the serial operating mode of the power supply and turn round the voltage adjustment knob to the extremely left position.
2. Select the optimal ranges of DMMs (Digital MultiMeter).
3. **Before you switch on the power supply ask the supervisor to approve the circuit configuration.**
4. Adjust the symmetrical voltage to ±25V. Notice the status of the power validity control LEDs (red: +25V; green: –25V).
5. Make the measurements of the current-voltage (I-V) characteristic of investigated diode. Characteristic chart has to be composed of at last 40 measurement points ($20 \div 25$ for the forward direction and $15 \div 20$ for the reverse direction). Fit the concentration of measurement points adequately to the rate of changes of the registered current through diode. Multirotational potentiometer P_1 guarantee the fine tuning of diode bias voltage. The extremely left position of P_1 potentiometer is related to the maximum reverse bias voltage (about: –9V). The extremely right position of P_1 potentiometer is related to the maximum forward bias voltage (value dependent on the selected diode). Start the measurements (both for reverse and forward directions) from 0V bias voltage adjusted by P_1 potentiometer. Make the measurements efficiently to prevent the diode overheating (in particular for the forward direction). NOTICE: voltage bias regulator with the build-in overload protection supports the current limit (75mA) to protect the diodes.
6. **Don't forget to select the proper ammeter range when you pass from the reverse direction to the forward direction. Switch off DMM before you change the ammeter range.**
7. Write down the obtained results in the data table

Symbol of diode	reverse direction			forward direction	
	Lp.	U	I	U	I
		[V]	[μA]/[mA]	[V]	[mA]
D_2	1.				
	2.				

8. Repeat listed above measurement procedure for Zener diode D_3.

Report elaboration

Report has to be composed of:

1. Front page (by using a pattern).
2. Description of experiment purposes.
3. Short introduction (basic definitions, formulas, description of used marks and symbols).
4. Schematic diagrams of tested circuits.
5. List of used instruments and devices (id/stock number, type, setting and range values).
6. Measuring results (including oscillograms and tables).
7. Plots, calculations, analysis, interpretation and sub-conclusions related to all required points of "Experimental procedure".
8. Remarks and final conclusions.

Use the obtained results to plot the current-voltage (I-V) characteristics of two investigated diodes. Show D_2 diode characteristic as two different graphs – for the forward and the reverse direction respectively. Draw D_3 Zener diode characteristic as the next chart with Zener voltage strongly marked (see Appendix A1).

Draw the additional characteristic chart in semi-logarithmic scale $\ln(I) \sim U$ for the forward direction of D_2 diode (see Eq. 2 below and section IV.3.3 in [6]). Follow the additional chart to derive the m parameter (use least square method for linear approximation – see section II.4 in [6]). Notice the examination of diode characteristic for the forward direction only, gives:

$$I = I_S \exp\left(\frac{eU}{mkT}\right). \tag{1}$$

You can rewrite the Eq. 1 as

$$\ln(I) = \frac{eU}{mkT} + \ln(I_S) \tag{2}$$

to simplify the examination of semi-logarithmic characteristic chart. If the investigated diodes were not overheated the temperature T in Eq. 2 is related to room temperature.

References

[1] F. Przezdziecki, A. Opolski, *Elektrotechnika i elektronika*, PWN, Warszawa, 1986.
[2] A. Rusek, *Podstawy elektroniki*, the first part, WSiP, Warszawa, 1979.
[3] K. Bracławski, A. Siennicki, *Elementy półprzewodnikowe*, WSiP, Warszawa, 1986.
[4] User manuals of the power supply and DMMs.
[5] Data sheets of tested diodes – at the web site of Electronics and Metrology Lab.
[6] B. Żółtowski, *Wprowadzenie do zajęć laboratoryjnych z fizyki*, Skrypt PŁ, Łódź, 2001 – (see also the home page at: www.if.p.lodz.pl).
[7] B. Żółtowski, *Laboratory data analysis*, Skrypt PŁ, Łódź, 2005 – (see also the home page at: www.if.p.lodz.pl).