

Exercise 332

Vacuum diode

By G. Derfel

1. Theory

1. Vacuum diode, its structure, principle of operation, characteristics and parameters. Thermionic emission. [1]
2. Principle of operation of oscilloscope. [1] or [2]

2. Devices

1. Vacuum diodes.
2. DC power supplies for anode voltage and for cathode heater with voltmeters and ammeters.
3. Generator.
4. Oscilloscope.

3. Method

The aim of experiment is to obtain the characteristics of diode, it means the anode current I_a as a function of anode voltage U_a . The experimental set is shown in fig.1.

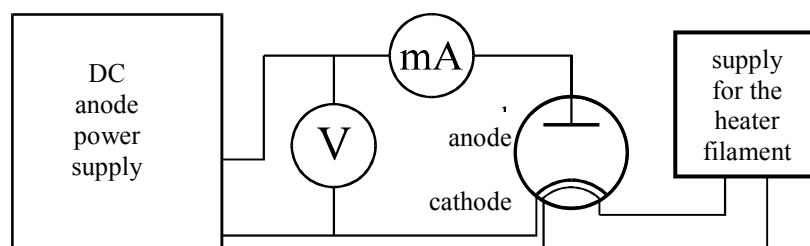


Fig. 1. Experimental setup for determination of diode characteristics. The voltmeter and ammeter shown in the figure are built in the anode power supply.

The differential internal resistance of the valve is given by the formula

$$R_w = \frac{\delta U_a}{\delta I_a}, \quad (1)$$

where δU_a denotes a voltage interval and δI_a denotes corresponding current interval read from the characteristic.

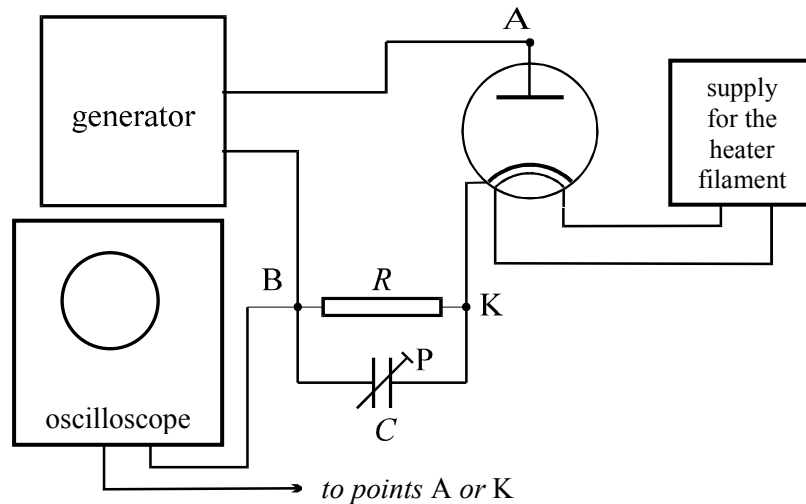


Fig. 2. Experimental setup for observation of rectification.

Rectification of the alternating voltage is demonstrated by means of the circuit shown in fig. 2. The ac voltage from generator is biased to the diode. The shape of the voltage before and after rectification is observed on the oscilloscope screen. The capacitances C which are connected parallel to the resistance R serve as a filter which smoothes the rectified voltage.

4. Course of experiment

Voltages are regulated by knobs on the DC power supplies. The voltages and currents are measured by meters built in these supplies and can be read from displays.

In the second part of exercise, the anode DC power supply is replaced by the AC generator. The frequency and amplitude of the bias voltage can be regulated. The key denoted by $\times 0,1$ should be pressed. The bias voltage as a function of time can be observed on the oscilloscope screen. In order to observe the bias AC voltage before rectification, the oscilloscope should be connected to points A and B. In order to observe the rectified voltage, the oscilloscope should be connected to the ends of the resistor R , i.e. to the points K and B. The switch P allows to add condensers $C_1 - C_6$ parallel to the resistor and to observe their influence on the rectification effect.

5. Experimental procedure

Part I. Determination of current- voltage characteristic of diode

1. Turn all the knobs on both DC power supplies to the left.
2. Build the circuit according to the scheme given in fig. 1.
3. After checking the circuit by the teacher switch on the supplies.
4. Set the heater voltage on $U_h = 4V$.
5. Vary the anode voltage U_a by 1V and read the anode current intensity I_a . **Attention!** Do not exceed maximum value of the current intensity given on the label at the experimental stage.
6. Repeat the measurements for the heater voltages 5 and 6V.
7. Note the results in the table:

		I_a [mA]		
U_h [V]		4V	5V	6V
U_a [V]				

7. Turn all the knobs on both DC power supplies to the left and switch the supplies off.

Part II. Observation of rectification effect

1. Set the circuit according to fig. 2.
2. After checking the circuit by the teacher switch on the generator and oscilloscope and switch on the heater supply. Set the heater voltage on 6V.
3. Choose the sinusoidal shape of the AC voltage yielded by the generator. Connect the oscilloscope to points A and B. Choose frequency and amplitude of the bias voltage. Copy the plot from the oscilloscope screen.
4. Connect the oscilloscope to points B and K. Observe the time dependence of voltage after rectification. Copy it from the screen.
5. Add the condensers $C_1 - C_6$ by means of the switch P and observe the effect of growing capacitance on the shape of rectified voltage. Copy the plots from the screen.
6. Vary the frequency and observe what is its influence on the shape of rectified voltage.

6. Preparation of the report

The report should contain:

1. Short description of the principle of the experiment including the explanation of the rectification by the diode.
2. Tables with results of measurements.
Plots of the anode characteristics of the diode $U_a(I_a)$ (on the common sheet for all the heater voltages). Add the experimental uncertainties to the experimental points on the plots.
4. Calculation of differential internal resistance R_w by use of eq. (1).
5. Copies of the plots taken from the oscilloscope screen together with suitable explanation.
6. Discussion of possible sources of experimental errors..

7. References

- [1] B. Jaworski, A. Dietlaf, L. Miłkowska, *Kurs fizyki*, t.2, PWN, Warszawa, 1984
- [2] J. Karniewicz, T. Sokołowski, *Podstawy fizyki laboratoryjnej*, skrypt PŁ, Łódź, 1996.