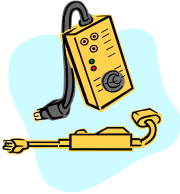# CIRCUITS WITH ZD AND LEDS

I. OBJECTIVES

a) The determination of the current-voltage characteristics for the rectifying diodes;
b) The determination of the function of Zener diodes in double voltage clamp circuits
c) The determination of the functioning of LEDs in logic level indicator circuits

II. COMPONENTS AND INSTRUMENTATION

For the experiments you will use Si diodes: rectifying diodes; two Zener diodes (DZ3V3 and DZ6V8), resistors with different values. The dc voltage is obtained from a double regulated power supply and the sinusoidal voltage (with variable amplitude and frequency) is obtained from a signal generator. To visualize the variable voltages and the diodes' characteristics you will use a dual channel oscilloscope. You will also use a multimeter to measure the dc voltages.

III. THEORETICAL ASPECTS

The Zener diode

The Zener Diode is a special semiconductor diode that is used in the breakdown region, this region being not destructive. The symbol and the current-voltage characteristic of the Zener diode are presented in Fig. 1.
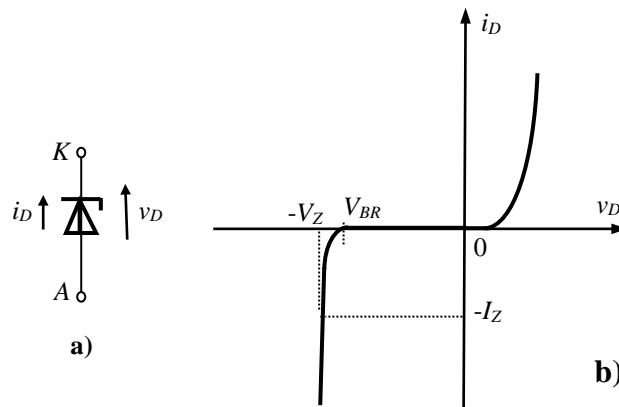

Fig. 1. The Zener Diode: a) symbol; b) i_D - v_D characteristic.

For the Zener diode (*ZD*) the data sheet is specifies the value of the Zener voltage V_Z at a nominal current I_Z that defines the nominal operating point in the breakdown region *(-V_Z ;-I_Z)*.

In order to make things easier, we choose to consider i_Z and v_Z as the reference directions for the current and voltage, in order to work with positive quantities, as they can be seen in Fig. 2. a). The $i_Z(v_Z)$ curve for common use of the *ZD* appears now in the Ist quadrant as it is presented in Fig. 2.b) for a real *ZD* (full lines) and for an ideal *ZD* (broken line). For an ideal *ZD* we remark that there is no

voltage change when the current through *ZD* changes. This property is called *voltage regulation*. For a real diode we have a certain change (very small) of the voltage with the current change (Fig. 3.).

In order for a *ZD* to operate in the regulation region we should know the range in which the current is supposed to lie. In general the data sheet specifies the current I_{Zmin} as a minimum current for that the *ZD* still works in the regulation region, the value of this current being equal with the knee current. The maximum value I_{Zmax} can be extracted from the maximum power rating P_{dmax} (also given in the data sheet).
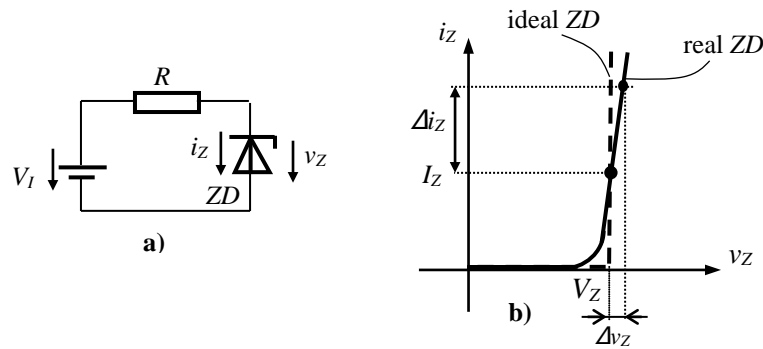
$$I_{Z\,max} = \frac{P_{d\,max}}{V_Z}$$

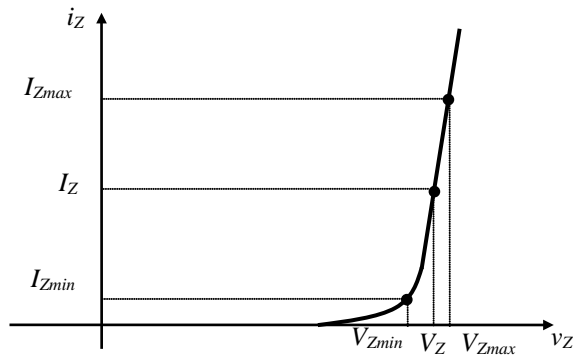Fig. 2. a) Reference directions of i_Z and v_Z; b) i_Z - v_Z curve

Fig. 3. The regulation region of *ZD*

IV. PREPARATION

1. P. ZENER DIODE

1.1. P. The iz(vz) characteristic on the oscilloscope
- How does $i_Z(v_Z)$ characteristic look like?

1.2. P. Asymmetrical double voltage clamp (limiter) with Zener diodes
- What is the value of the regulation voltage, V_Z, for DZ3V3 and DZ6V8?
- For the circuit in Fig. 5, deduce VTC $v_O(v_I)$ for v_I in [-10; 10] V. Specify the states (on/off/breakdown) for the two diodes on the plot.

2. P. Circuits with LEDs
- For the circuit in Fig. 6, what is the role of the diodes D1, D2? What is the role of the 3 LEDs, LED1, LED2, LED3?
- Fill in the electrical functioning table:

v_A [V]	v_B [V]	v_O [V]	D1	D2	LED1	LED2	LED3
0	0						
0	10						
10	0						
10	10						

- Assume the positive logical convention – high voltage level (10 V): "1" logic, low voltage level (0 V): "0". Fill in the truth table.

A	B	OUT
0	0	
0	1	
1	0	
1	1	

V. EXPLORATIONS AND RESULTS

1. ZENER DIODE

1.1. The $i_Z(v_Z)$ characteristic on the oscilloscope

Exploration

Build the circuit in Fig. 4.
- v_S – sinusoidal voltage with 10V amplitude and 100Hz frequency, obtained from the signal generator;
- Visualise the diode's characteristic on the oscilloscope (XY mode), by connecting the signal from point A to one channel, and the signal from point B to the other one.
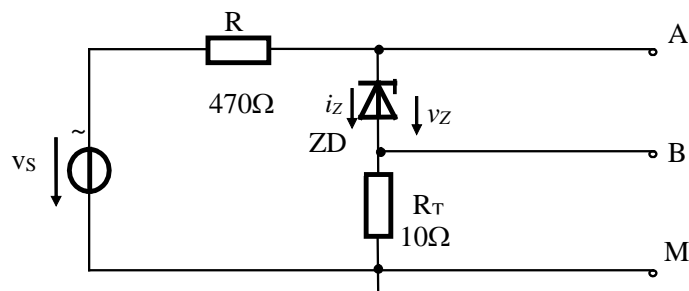

Fig. 4. Arrangement for displaying the $i_Z(v_Z)$ characteristic using an earthed source

Results

- Draw the obtained characteristic from the oscilloscope.
- In which quadrant is the regulation region of *ZD*?

1.2. P. Asymmetrical double voltage clamp (limiter) with Zener diodes

Exploration

Build the circuit in Fig. 5.

- v_I - sinusoidal voltage with 10V amplitude and 100Hz frequency, obtained from the signal generator;
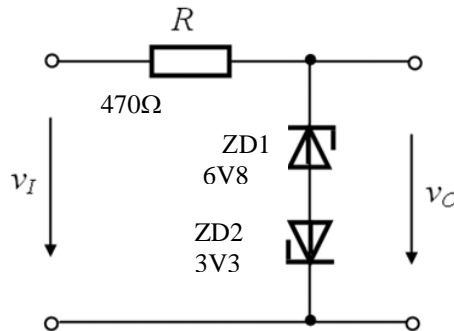- Visualize the input voltage and the output voltage on the oscilloscope, using the XY mode.

Fig. 5 Asymmetrical double voltage clamp (limiter) with Zener diodes

Results
- Draw VTC $v_O(v_I)$ from the oscilloscope.

2. Circuits with LEDs
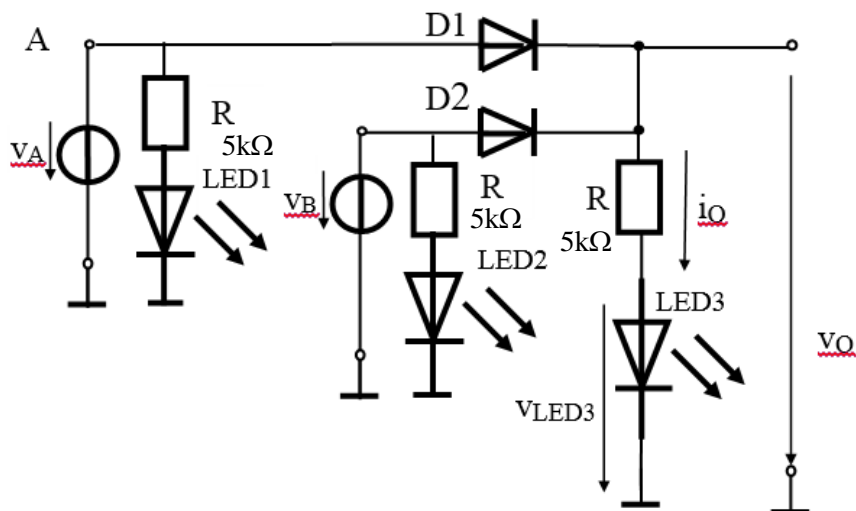
Exploration

Build the circuit in Fig. 6.

Fig. 6. Logic level indicator with diodes and LEDs

- v_A, v_B are dc voltages
- v_O is measured with the voltmeter.
- v_A, v_B will successively have all 4 combinations of values, according with the following table. Fill in the table with the measured values for v_O, v_{LED3} and the states of the 3 LEDs.

v_A [V]	v_B [V]	v_O [V]	v_{LED3} [V]	LED1	LED2	LED3
0	0					
0	10					
10	0					
10	10					

Results

- Measured values for v_O, v_{LED3} and the states of the 3 LEDs.
- For what values of v_O is LED3 on?
- What is the logic function of the circuit?
- What is the value of the maximum output current, $i_{O, max}$?

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1. Oltean, G., Electronic Devices, Editura U.T. Pres, Cluj-Napoca, ISBN 973-662-220-7, 2006
2. Sedra, A. S., Smith, K. C., Microelectronic Circuits, Fifth Edition, Oxford University Press, ISBN: 0-19-514252-7, 2004
3. http://www.bel.utcluj.ro/dce/didactic/ed/ed.htm