BRAC UNIVERSITY
ELECTRONIC DEVICE AND CIRCUITS I LAB
ECE202 / EEE206

Exp. 3: STUDY OF ZENER DIODE AND ITS APPLICATION IN VOLTAGE REGULATION

OBJECTIVE

To study the I-V characteristics of a zener diode and its application as a voltage regulator in a DC power supply and determine the line and load regulations.

COMPONENTS REQUIRED

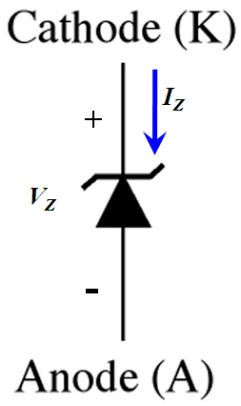
- Zener diode (5.1 volt)
- Resistance ($1\,k\Omega$, $0.5\,\Omega$, $1k\,\Omega$)
- POT $100\,k\,\Omega$ (voltage varies from 0-$100\,k\,\Omega$)

THEORY

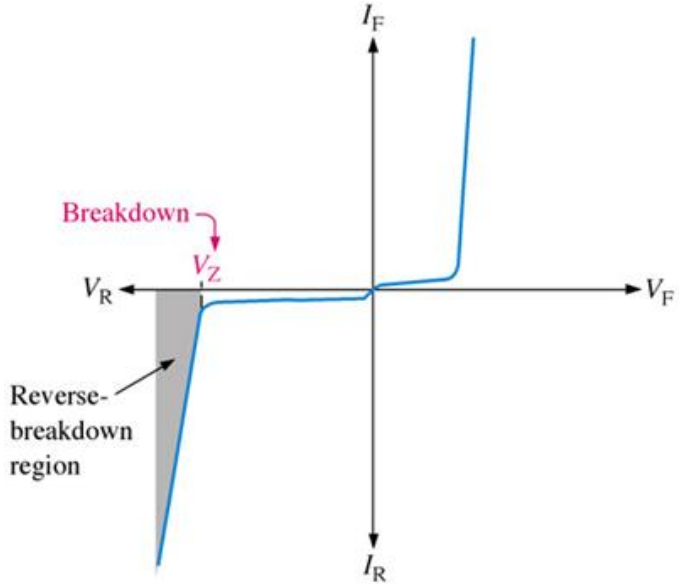
The diodes we have studied before do not operate in the breakdown region because this may damage them. A Zener diode is different it is a silicon diode that the manufacturer has optimized for operation in the breakdown region. It is used to build voltage regulator circuits that hold the load voltage almost constant despite large change in line voltage and load resistance. Figures below show the symbol of Zener diode and its operating region.

Vz = -Vd

Iz = -Id



Zener Diode Symbol



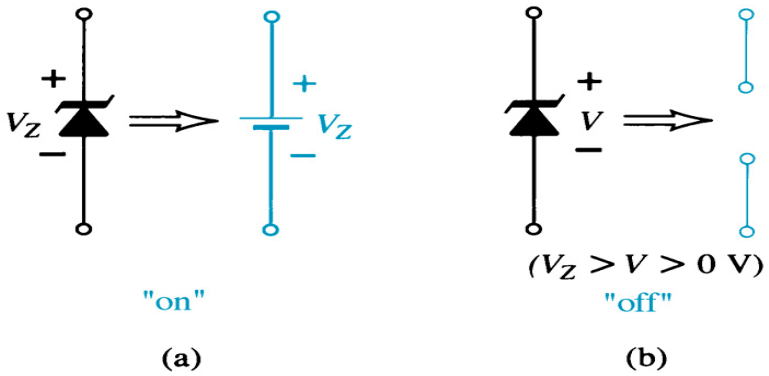
Normal operating region of a zener diode

The Zener diode may have a breakdown voltage from about 2 to 200 V. These diodes can operate in any of the three regions: forward, leakage and breakdown.

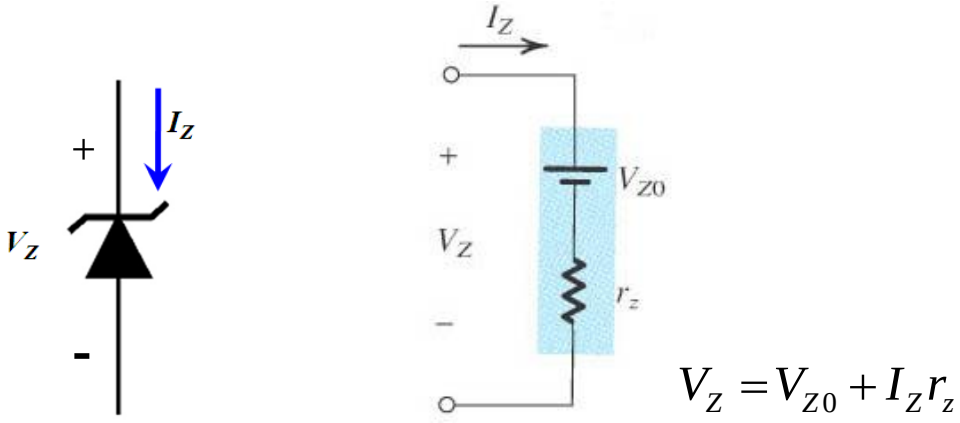
- In the forward region it works as an ordinary diode.
- In the leakage region (between zero and breakdown) it has only a small reverse saturation current.
- In the breakdown region it has a sharp knee, followed by an almost vertical increase in current without changing the voltage.
- The voltage is almost constant, approximately equal to Vz over most of the breakdown region.

***Model Approximations*:**

First approximation: When the voltage across the zener diode $V \geq V_Z$, the diode is ON, and it is represented by a battery with constant voltage of V_Z, otherwise the diode is OFF and it is represented by an open circuit.



Second approximation: The Zener diode is modeled with a battery of voltage V_{Z0} in series with resistance r_z, called the zener resistance, to account for the slight increase in the zener voltage V_Z with the zener current I_Z.



$$V_Z = V_{Z0} + I_Z r_z$$

- ⇨ V_z = V_z0 + I_z*r_z
- ⇨ -V_D = V_z0 – Id*r_z
- ⇨ V_D = -V_z0 + Id*r_z
- ⇨ X = -Vz0 + y*r_z

***Voltage Regulation*:**

Voltage regulation, a measure of performance of voltage regulator circuits, is classified as two types:

1. Line Regulation and
2. Load Regulation.

1. **Line Regulation**: line regulation is the variation in the output or the load voltage (V_L) for one volt variation in the input voltage (V_i), expressed mathematically as $\Delta V_L/\Delta V_i$ (mV/V).

2. **Load Regulation**: load regulation is the variation in the output or the load voltage (V_L) for one mA variation in the load current (I_L), expressed mathematically as $\Delta V_L/\Delta I_L$ (mV/mA).

EXPERIMENTAL WORK

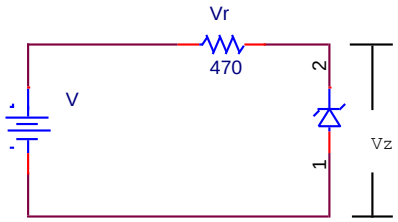


Fig 1: Circuit diagram 1

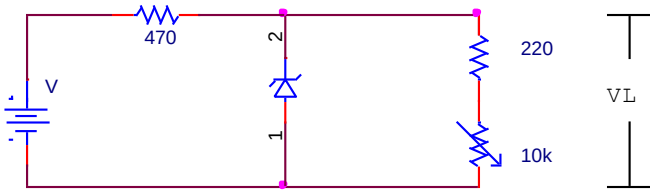


Fig 1: Circuit diagram 2

***Procedure*:**

- Connect the circuit as shown in the circuit diagram 1.
- Vary the supply voltage from 0 to 10 volt, in steps of 1 V and complete Table1. Try to take more readings with smaller voltage increments (0.1 or 0.2 V) near the breakdown region in order to accurately capture the transition.
- Connect the circuit as shown in the circuit diagram 2.
- Keep the 100k POT at maximum position and then power up the ckt. Apply 10 V DC at the input.
- Gradually decrease the POT resistance and complete Table 2.

- Replace load with 10 kΩ resistance, vary the supply voltage and take readings for Table 3.

Table 1			
V (V)	V_R (V)	V_Z (V)	$I_Z = \frac{V_R}{R_1}$ (mA)

Table 2		
V_{220} (V)	V_L (V)	$I_L = \frac{V_{220}}{R_{220}}$ (mA)

Table 3	
V (V)	V_L (V)

REPORT

- Plot the I-V characteristics (V_Z *vs.* I_Z) of the Zener diode. Estimate the Zener knee current and voltage (I_{ZK}, V_{ZK}) from the plot. Also calculate the voltage V_{Z0} and the zener resistance r_z using the data.
- Plot V_L *vs.* I_L for the data of Table 2. Determine the load regulation.
- Plot V_L vs. V for the data of Table 3. Determine the line regulation.
- Calculate the load and line regulation for the ckt 2 and compare with those obtained from experimental data.
- Tabulate your results as in Table 4. Comment on your results.

Table 4

V_{ZK} (V)	I_{ZK} (mA)	V_{Z0} (V)	r_z (ohm)	**Load regulation** (mV/mA)		**Line regulation** (mV/V)	
				From Experiment	**Theoretical Calculation**	**From Experiment**	**Theoretical Calculation**