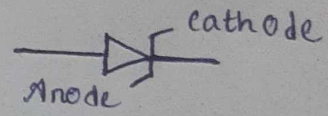
Assignment.

ALL ABOUT ZENER DIODES.

★ ZENER DIODES

- Zener diodes are sillion based semiconductor devices which allow current to flow bidrectionally either reverse or forward.
- It is comprised of heavily doped P-N silicon junction.
- It has a ~~He~~ set reverse breakdown voltage which when achieved; diode starts to conduct current in reverse direction.
- One of the main advantage of zener diode is that a varying range of voltages will still maintain a constant voltage drop across the diode. As a result, zenerdiodes can be used for voltage regulation purposes.
- It is denoted by the symbol →



★ ZENER DIODE SPECIFICATIONS.

(I) Zener voltage :- this relates to the reverse breakdown voltage.

(II) Zener resistance :- the resistance exhibited by the diode.

(III) Power rating :- the maximum power dissipation rating of the diode.

(IV) Voltage tolerance :- typically ± 5%.

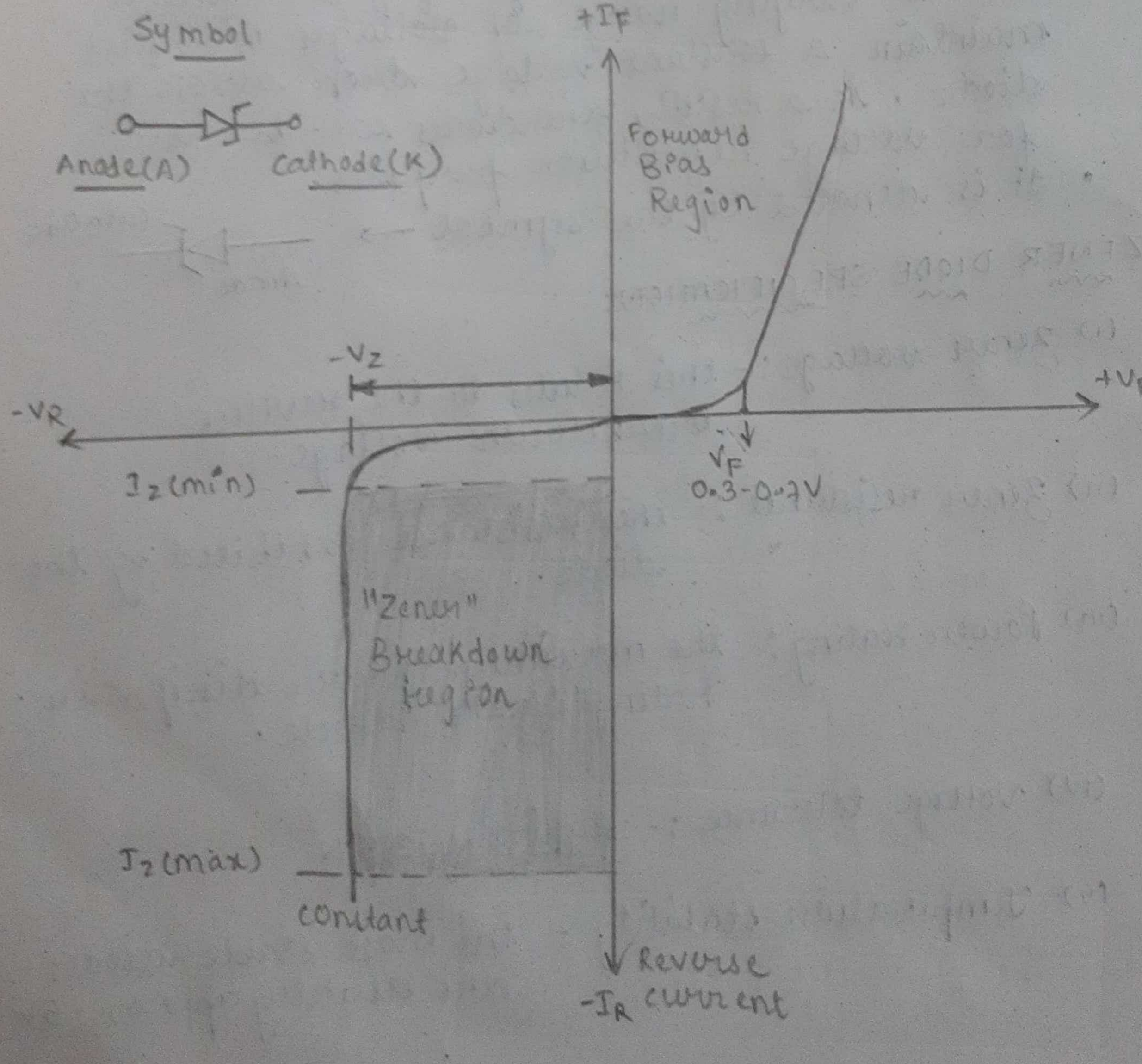
(V) Temperature stability :- the mast stable diodes are usually approx. 5V.

★ ZENER DIODE CHARACTERISTICS.

- Zener diodes operate similarly to conventional diodes when in the forward-bias mode. They have a bias turn on voltage of between 0.3-0.7V.

- In the reverse bias mode, when the voltage reaches the set breakdown voltage the reverse current characteristic changes abruptly to a comparitively high level and no matter how much is the applied voltage, the voltage drop across zener diode remains constant in the breakdown region.

- Characteristic sketch

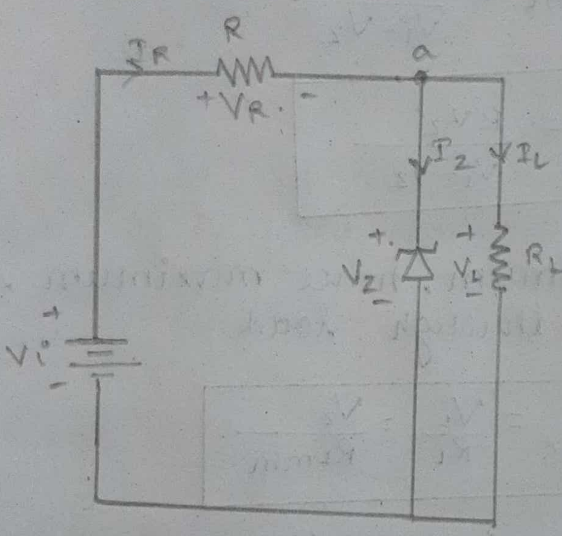


★ ZENER DIODE APPLICATIONS

(i) Voltage regulation (#)
(ii) Voltage reference
(iii) Surge suppression
(iv) Switching applications
(v) Clipper circuits.

- ZENER DIODE AS A VOLTAGE REGULATOR.

Basic configuration:



Case I: Both V_i and R_L Fixed.

∵ Diode is parallel to load.

∴ $V_Z = V_L$

On applying voltage divider rule, we have

$$\boxed{V_Z = V_L = \frac{R_L V_i}{R_L + R}}$$

On applying KCL at node a, we have

$$I_R = I_Z + I_L$$

$$\Rightarrow \boxed{I_Z = I_R - I_L}$$

$$\boxed{I_L = \frac{V_L}{R_L} \quad \text{and} \quad I_R = \frac{V_R}{R} = \frac{V_i - V_L}{R}}$$

$$\boxed{P_Z = V_Z I_Z}$$

Case 2: V_i is fixed and R_L is variable

We know, from voltage divider rule,

$$V_L = V_Z = \frac{R_L V_i}{R_L + R}$$

$$\Rightarrow \frac{R_L + R}{R_L} = \frac{V_i}{V_Z}$$

$$\Rightarrow 1 + \frac{R}{R_L} = \frac{V_i}{V_Z}.$$

$$\Rightarrow \frac{R}{R_L} = \frac{V_i}{V_Z} - 1 = \frac{V_i - V_Z}{V_Z}.$$

$$\Rightarrow R_L = \frac{R V_Z}{V_i - V_Z}$$

or,
$$\boxed{R_{L\,min} = \frac{R V_Z}{V_i - V_Z}}$$

$\because$ R_L is minimum, hence maximum current will flow through load.

$$\therefore \boxed{I_{L\,max} = \frac{V_L}{R_L} = \frac{V_Z}{R_{L\,min}}}$$

Once the diode is ON, voltage across R is fixed at,

$$V_R = V_i - V_Z$$

$$\therefore \boxed{I_R = \frac{V_R}{R} = \frac{V_i - V_Z}{R}}$$

And, zener current.

$$I_Z = I_R - I_L$$

$$\therefore \boxed{I_{L\,min} = I_R - I_Z}$$

$\because$ I_L is minimum, hence R_L is maximum.

$$\therefore \boxed{R_{L\,max} = \frac{V_L}{I_L} = \frac{V_Z}{I_{L\,min}} = \frac{V_Z}{I_R - I_Z}}$$

Case 3: R_L is fixed and V_i is variable

We know, from voltage divider rule.

$$V_L = V_Z = \frac{R_L V_i}{R_L + R}.$$

$$\Rightarrow \quad V_i = \frac{(R_L + R) V_Z}{R_L}$$

or, $$\boxed{V_{imin} = \frac{(R_L + R) V_Z}{R_L}}$$

The maximum value of V_i is limited by the maximum zener current $I_{ZM} = I_R - I_L$

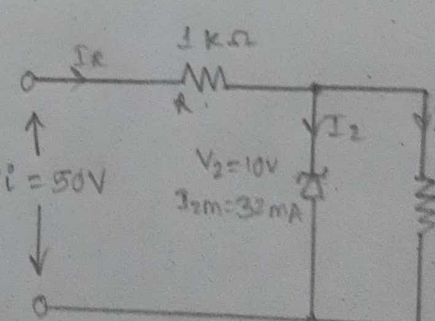
$$\boxed{I_{Rmax} = I_{ZM} + I_L}$$

$\because$ I_L is fixed at V_Z / R_L and I_{ZM} is the maximum value of I_Z, the maximum V_i is defined by.

$$\boxed{\begin{aligned} V_{imax} &= V_{Rmax} + V_Z. \\ V_{imax} &= I_{Rmax} R + V_Z \end{aligned}}$$

Question: Determine R_{Lmin} and R_{Lmax} for the given configuration.

Ans given: $V_i = 50V$, $V_Z = 10V$.
$I_{ZM} = 32mA$; $R = 1k\Omega$



$$R_{Lmin} = \frac{R V_Z}{V_i - V_Z} = \frac{1000 \times 10}{50 - 10} = \frac{1000 \times 10}{40} = \frac{1000}{4} = 250\Omega$$

$$I_R = \frac{V_R}{R} = \frac{V_i - V_Z}{R} = \frac{40}{1k\Omega} = 40mA.$$

$\therefore$ $I_{Lmin} = I_R - I_{ZM} = 40 - 32 = 8mA.$

$\therefore$ $R_{Lmax} = \frac{V_Z}{I_{Lmin}} = \frac{10V}{8mA} = 1.25k\Omega$ or 1250Ω

$\therefore$ $$\boxed{R_{Lmin} = 250\Omega,\ R_{Lmax} = 1.25k\Omega, \text{ or, } 250 \le R_L \le 1250}$$