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INSPIRING CREATIVE AND INNOVATIVE MINDS

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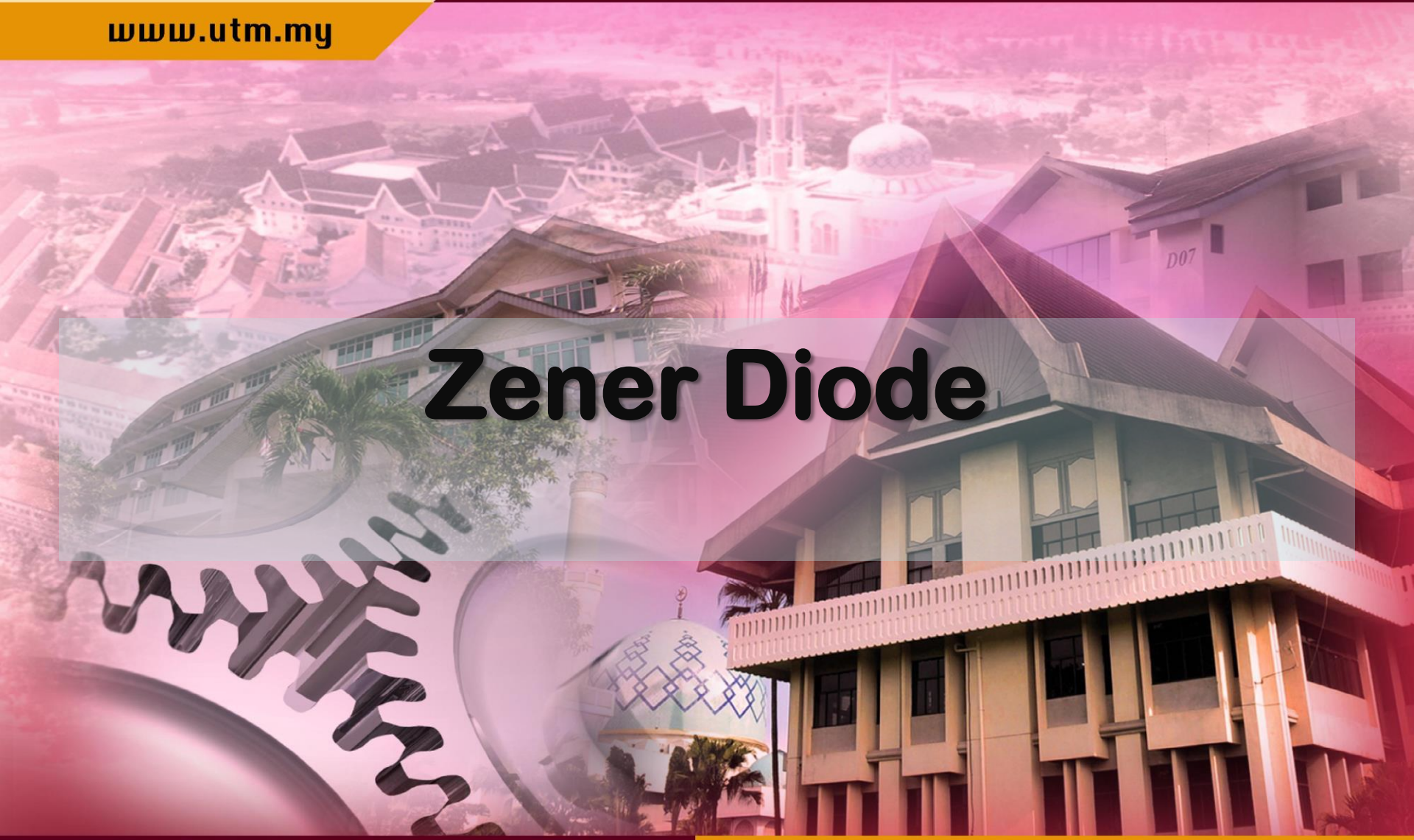
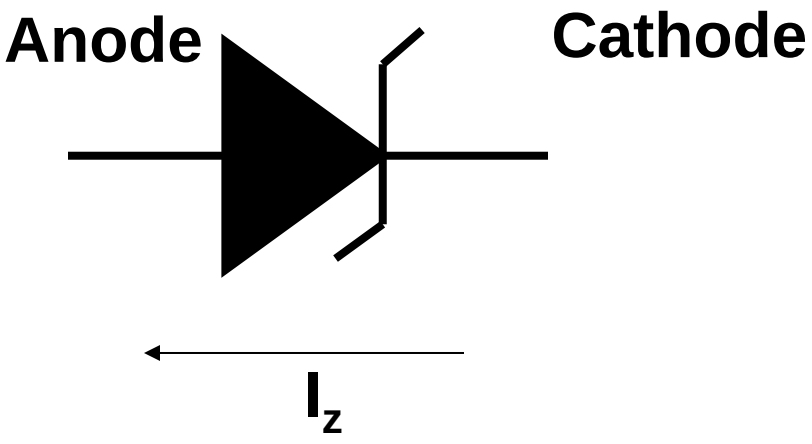


Zener Diode

Zener Diode

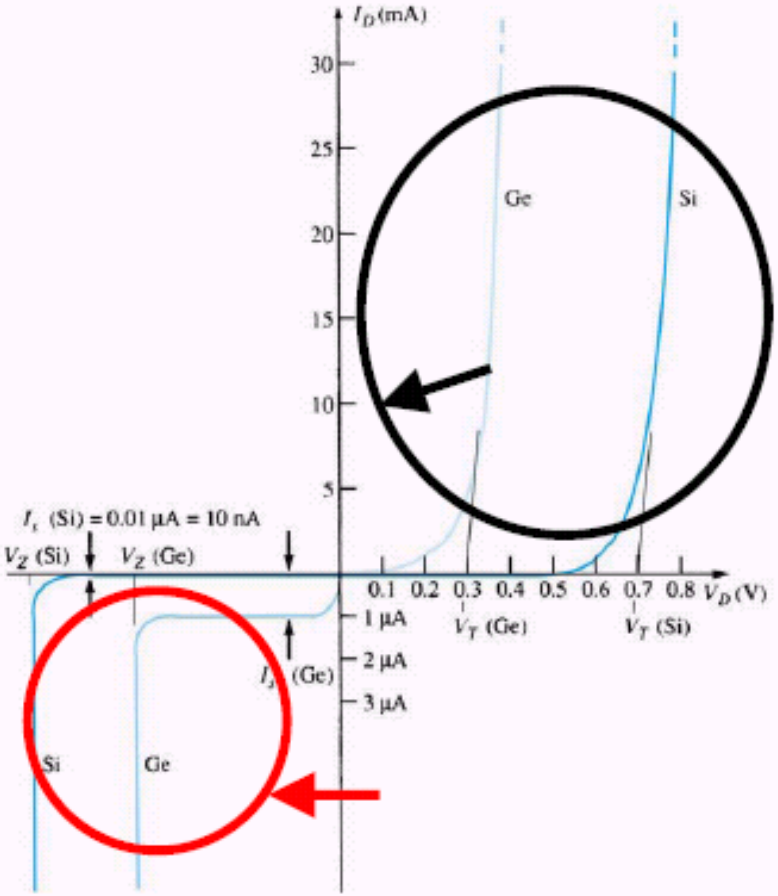


Symbol

Zener Diode

- Design to operate in reverse breakdown.
- Mainly use for voltage regulation and limiting application.
- In reverse bias, the zener diode is ‘on’ and the voltage across the zener diode is called Zener voltage, V_z
- In forward bias, zener diode act like the regular diode.
- Note that the direction of the current flow is different between zener and regular diode.

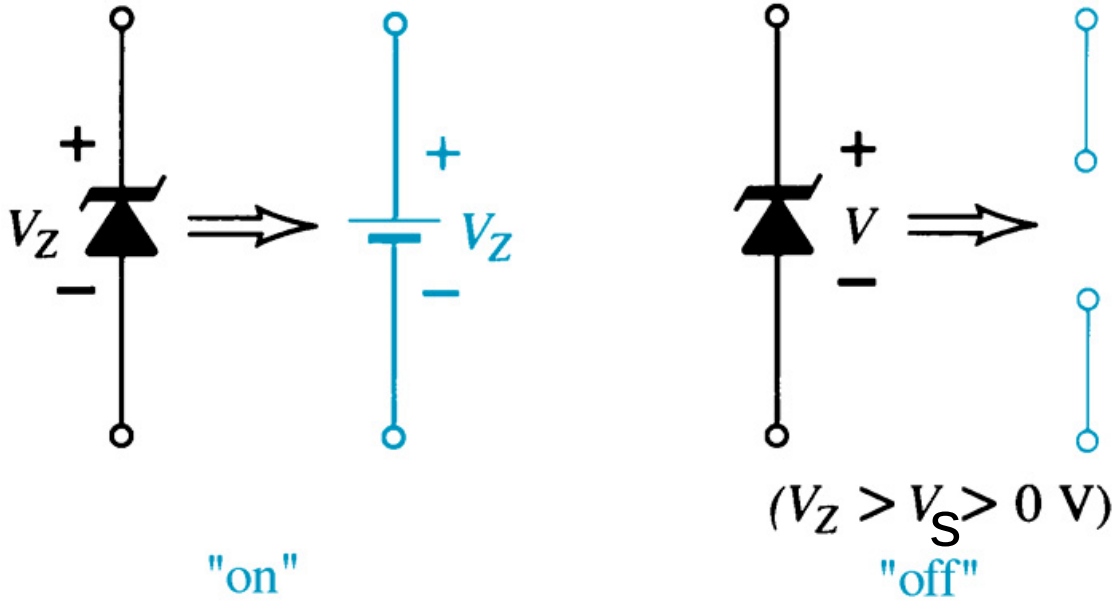
Zener Diode



Black circle → regular diode operating region

Red circle → zener diode operating region

Zener Diode



Vs > Vz

Zener Diode

- Three types of Zener analysis
  - Fixed V_S and R_L
  - Fixed V_S and variable R_L
  - Variable V_S and fixed R_L

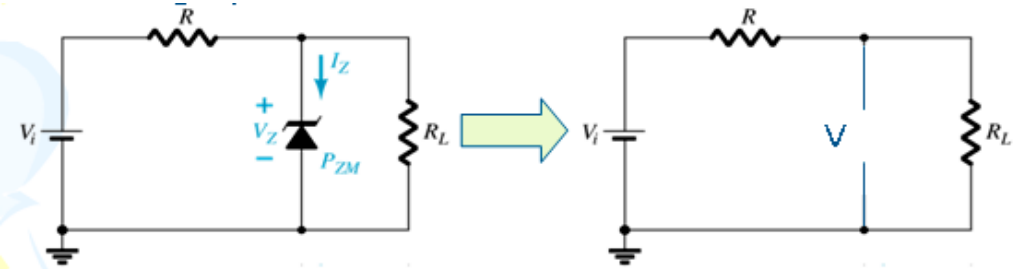
Zener Diode

- Fixed V_S and R_L

The applied dc voltage is fixed, as the load resistor.

The analysis :

1. **Determine the state of the Zener diode by removing it from the network and calculating the voltage across the resulting open circuit.**

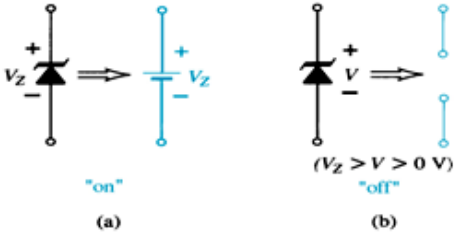


Calculate the V using voltage divider rule:

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

if $V \geq V_Z$, the Zener diode is on

if $V < V_Z$, the Zener diode is off



Zener Diode

2. **Substitute the appropriate equivalent circuit and solve for the desired unknowns.**

- For the on state diode, the voltages across parallel elements must be the same.

$$V_L = V_Z$$

The Zener diode current is determined by KCL:

$$I_Z = I_R - I_L$$

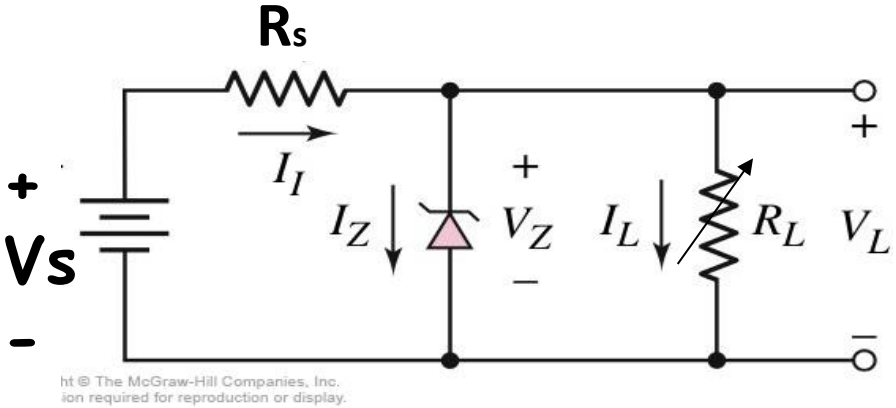
The power dissipated by the Zener diode is determined by:

$$P_Z = V_Z I_Z$$

- For the off state diode, the equivalent circuit is open-circuit.

Zener Diode

- Fixed V_S and Variable R_L



Step 1- get the R_{Lmin} so that zener is on.

$$V_L = \frac{R_L Vs}{R_S + R_L} \longrightarrow R_{L\min} = \frac{R_S V_Z}{V_S - V_Z}$$

- if $R_L \geq R_{Lmin}$, zener diode 'on', so that $V_L = V_Z$

Step 2: Calculate the I_Z using KCL: 2 condition

1. **If R_{Lmin}, then I_{Lmax} and I_{Zmin} because of constant I_1**
2. **If R_{Lmax}, then I_{Lmin} and I_{Zmax}**

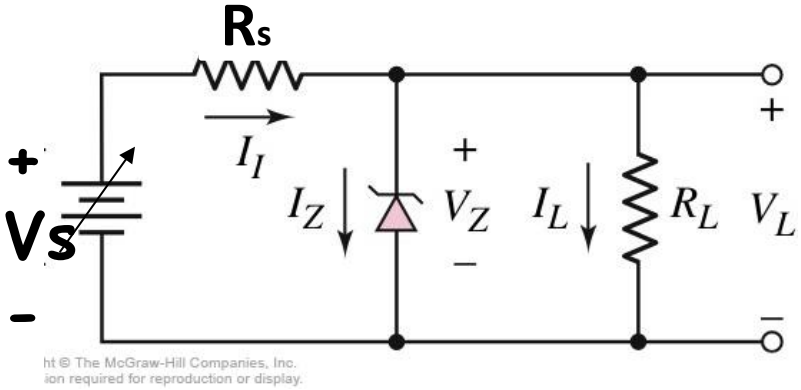
Zener Diode

$$I_{Z\,\min or \max} = I_{1\text{constant}} - I_{L\,\max or \min}$$; Izmax taken from data sheet
Izmin = 0, if not given

Where $I_1 = \dfrac{V_S - V_Z}{R_S}$ **and** $I_{L\max} = \dfrac{V_Z}{R_{L\min}}$ **or** $R_{L\max} = \dfrac{V_Z}{I_{L\min}}$

Zener Diode

- Variable V_S and fixed R_L



Step 1- get the V_{Smin} so that zener is on.

$$V_L = \frac{R_L Vs}{R_S + R_L} \longrightarrow V_{S\min} = \frac{(R_L + R_S)V_Z}{R_L}$$

if $V_S \geq V_{Smin}$, zener diode will 'on', so that $V_L = V_Z$

Step 2: Calculate the I_Z using KCL: 2 condition

1. **if V_{Smin} , then I_{1min} and I_{Zmin} because of constant I_L**
2. **if V_{Smax}, thenI_{1max} and I_{Zmax}**

Zener Diode

$$I_{Z\,\min or\,\max} = I_{1\min or\,\max} - I_{L\text{constant}}$$; Izmax= Pzmax/Vz

where $I_L = \frac{V_L}{R_L}$ and $I_{1\min} = \frac{V_{S\min} - V_Z}{R_S}$ or $V_{S\max} = I_{1\max} R_S + V_Z$