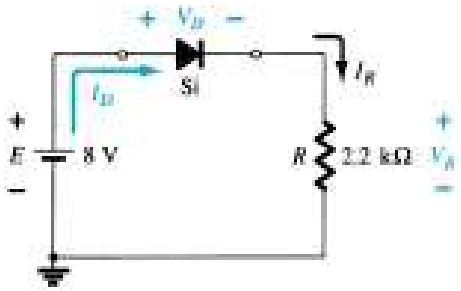
Diode Example

For the series diode configuration, determine V_D, V_R, *and* I_D.



1

- Since the applied voltage establishes a current in the clockwise direction to match the arrow of the symbol and the diode is in the "on" state,

VD = 0.7 V

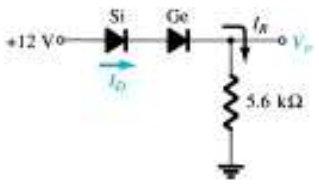
$$V_R = E - V_D = 8\text{ V} - 0.7\text{ V} = \mathbf{7.3\text{ V}}$$

$$I_D = I_R = \frac{V_R}{R} = \frac{7.3\text{ V}}{2.2\text{ k}\Omega} \cong \mathbf{3.32\text{ mA}}$$

2

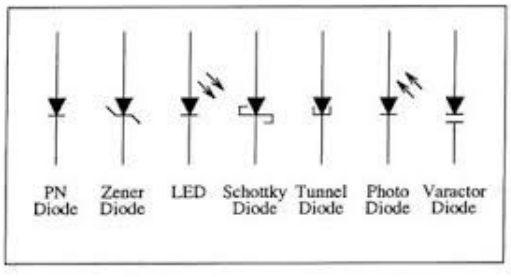
Homework

- Determine *Vo and I_D for the series circuit*



3

Other Types of Diodes



Diode Symbols

- **Zener**
- **LED**

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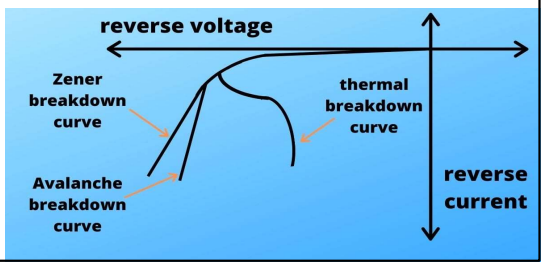
REVERSE BREAKDOWN

- Two types of reverse breakdown: ***avalanche breakdown & zener breakdown***
- i) **Avalanche breakdown**
- **ii) Zener breakdown**



Avalanche Breakdown

If we increase the reverse bias voltage of diode further then we reach a certain point after which the applied field is so strong that the thermally generated charge carriers gain sufficient energy. When the charges start to flow through the junction they simply hit the immobile ions and break the covalent bond due to their high energy. This broken covalent bond produces a new electron-hole pair. The new carriers again gain sufficient energy and produce a new electron-hole pair. This cumulative process is called Avalanche Breakdown.

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ZENER Breakdown

The Zener Breakdown is the **higher** version of Avalanche Breakdown.

- occurs at relatively low reverse voltage.
- a zener diode is heavily doped to reduce breakdown voltage.
- this causes very thin depletion region.
- as a result, intense electric field exists within the depletion region.
- Near zener breakdown voltage (Vz), the field have enough energy to pull electrons from their valence bands and create current.

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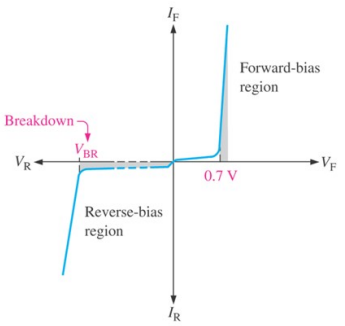
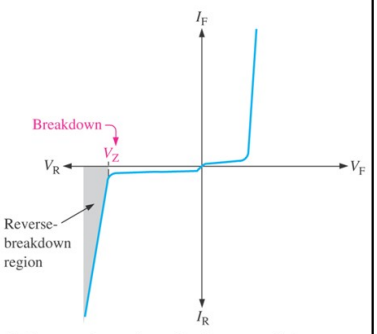
Operating Region

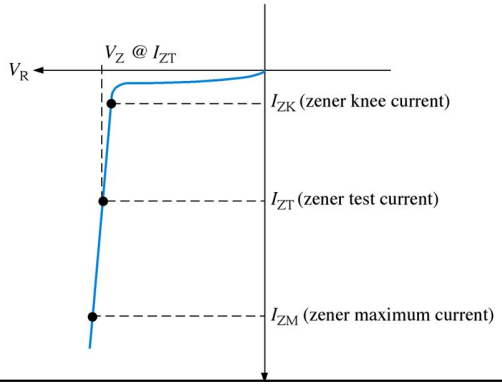


(a) The normal operating regions for a rectifier diode are shown as shaded areas.



(b) The normal operating region for a zener diode is shaded.

ZENER Diode Characteristic Curve



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Breakdown Characteristic

- The reverse voltage (V_R) is increased – the reverse current (I_R) remains extremely small up to the "knee" of the curve.
- Reverse current – called the zener current, I_Z.
- At that point, breakdown effect begin where zener impedance (Z_z) begin to decrease as I_Z increases rapidly.
- At the bottom of the knee- the zener breakdown voltage (V_Z) remains constant although it increase slightly as the zener current, I_Z increase.
- I_{ZK} – min. current required to maintain voltage regulation
- I_{ZM} – max. amount of current the diode can handle without being damage/destroyed
- I_{ZT} – the current level at which the V_Z rating of diode is measured (specified on a data sheet)
- **The zener diode maintains nearly constant voltage for value of reverse current rating from I_{ZK} to I_{ZM}**

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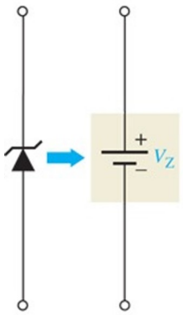
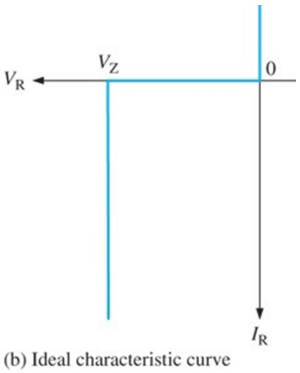
ZENER EQUIVALENT CIRCUIT (Ideal Model)

NO zener impedance ($Z_Z = 0$)



(a) Ideal model



(b) Ideal characteristic curve

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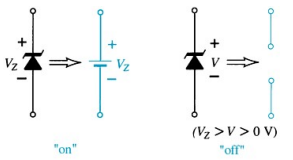
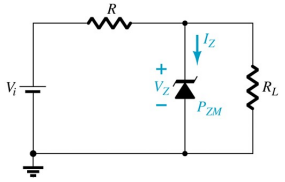
Zener Diodes

The Zener is a diode operated in reverse bias at the Zener Voltage (V_z).

- **When $V_i \geq V_Z$**
  - **The Zener is on**
  - **Voltage across the Zener is V_Z**
  - **Zener current: $I_Z = I_R - I_{RL}$**
  - **The Zener Power: $P_Z = V_Z I_Z$**
- **When $V_i < V_Z$**
  - **The Zener is off**
  - **The Zener acts as an open circuit**





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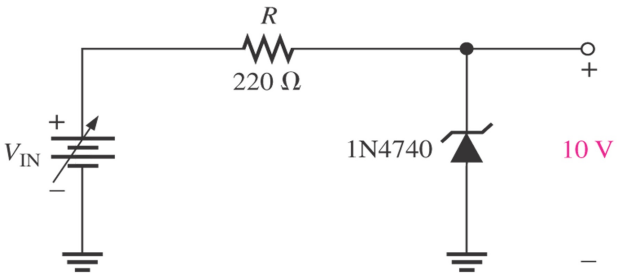
Voltage Regulation by Zener Diode



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The input voltage source (input voltage, Vi) has to be connected with the Zener diode in reverse biased condition.

Case:1
When the circuit is closed, there is a fixed output voltage across the load. This fixed voltage is maintained until the input voltage is same/greater than the Zener voltage.

Case:2
When the input voltage is same/greater than Zener voltage, the Zener diode reverse-biased characteristics start to reflect. At the Zener voltage current will flow through the Zener diode as well as resistance *R*. Thus, to maintain the output voltage drop across Rs will also increase.

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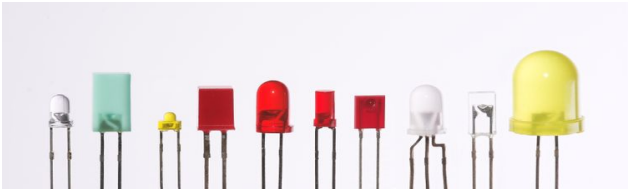
The Light-Emitting Diode (LED)



LED that are produced in an array of shapes and sizes.

LED characteristics:

- characteristic curves are very similar to those for p-n junction diodes
- higher forward voltage (V_F)
- lower reverse breakdown voltage (V_{BR}).

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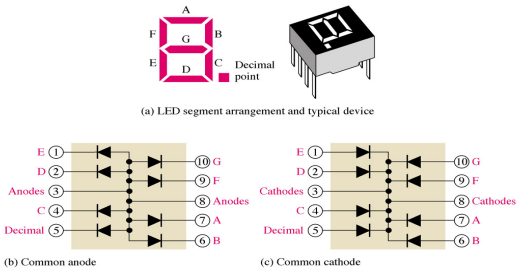
The Light-Emitting Diode (LED)

Application

The seven segment display is an example of LEDs use for display of decimal digits.



The 7-segment LED display.

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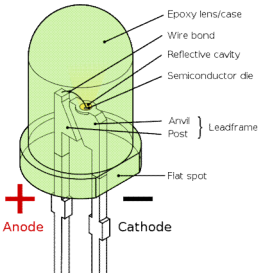
The Light-Emitting Diode (LED)

When a light-emitting diode is forward biased, electrons are able to recombine with holes within the device, releasing energy in the form of photons.

This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor.

Fabricating the *pn* junction using a semiconductor of the type known as direct-bandgap materials.



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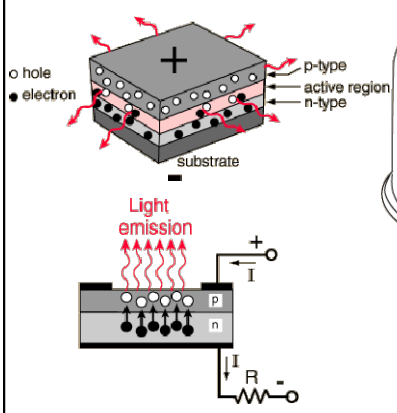
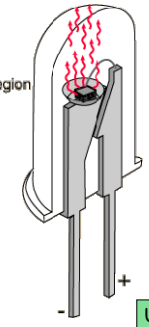
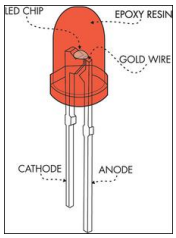
LED - Light Emitting Diodes







UV - AlGaN
Blue - GaN, InGaN
Red, green - GaP
Red, yellow - GaAsP
IR- GaAs

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