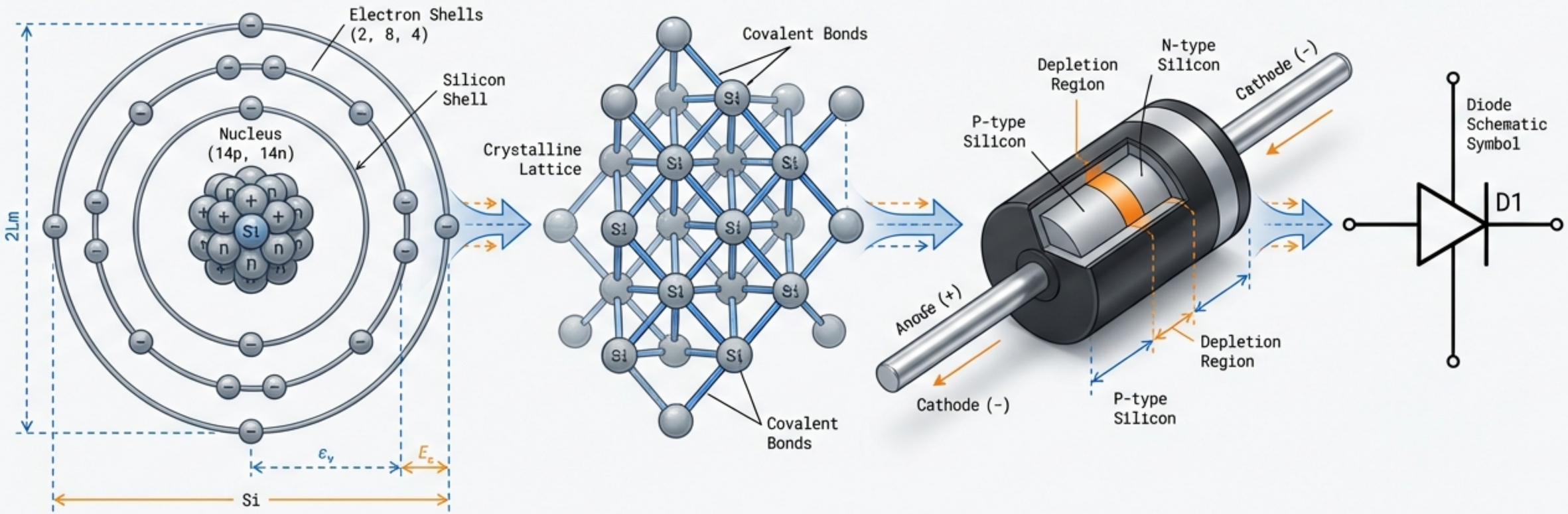
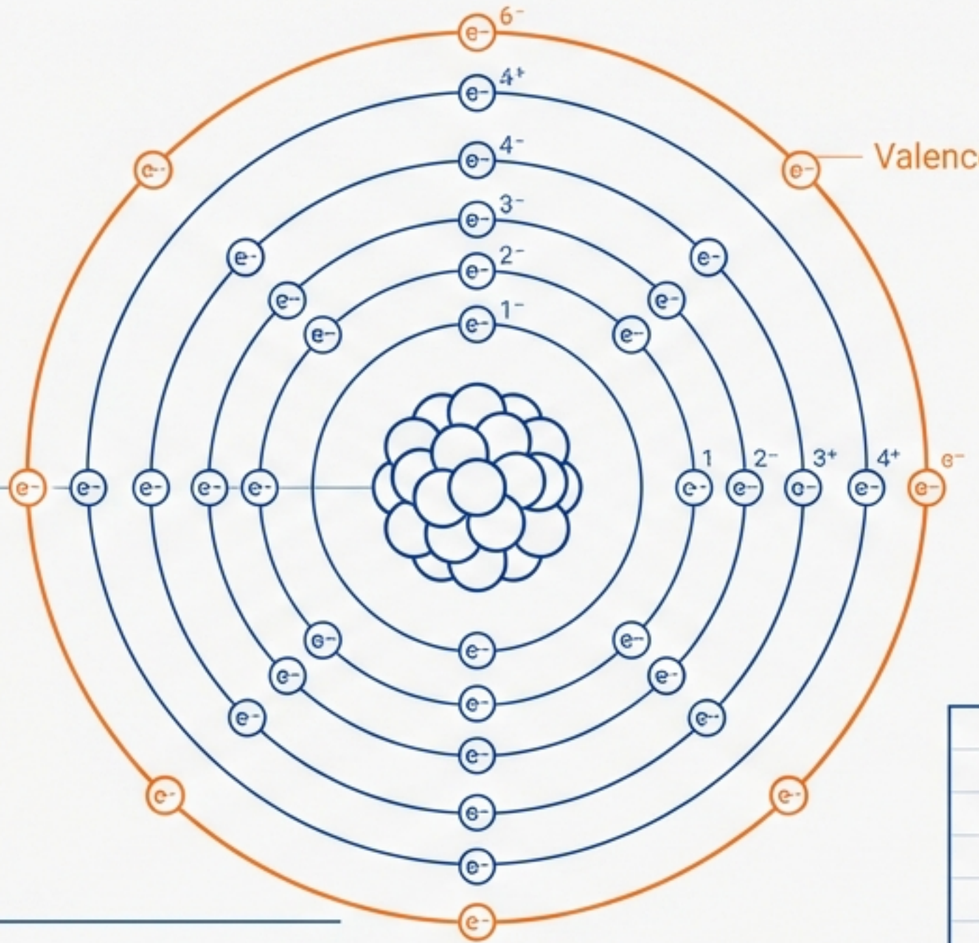
Unit 11: Semiconductors and Diodes

From Atomic Theory to Circuit Application

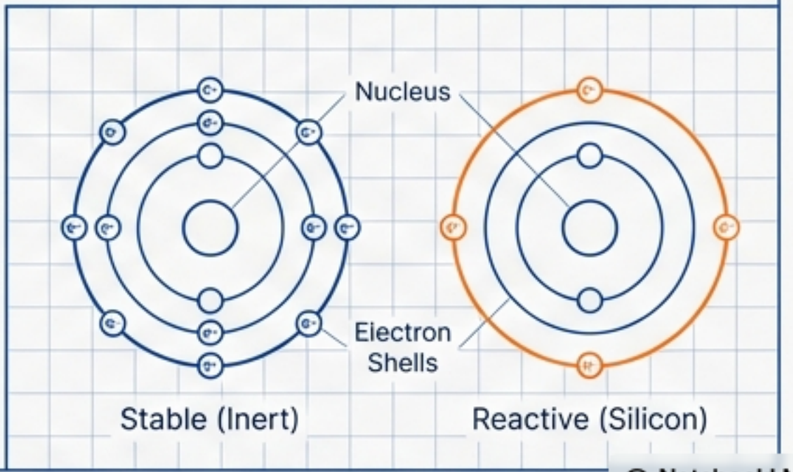


The Physics of Matter: Atomic Theory

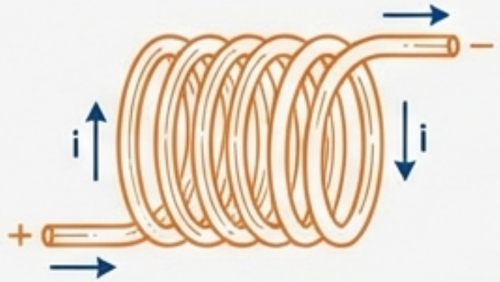
All electronics rely on manipulating subatomic particles. To understand the diode, we must first understand the atom's drive for stability.

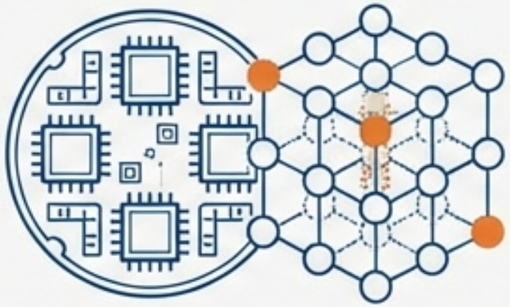


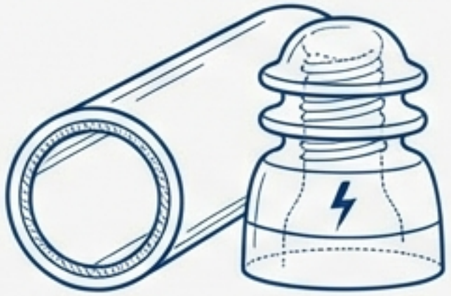
The Octet Rule: Atoms seek stability by attempting to fill their valence shell with exactly 8 electrons. This drive creates chemical bonding and electrical flow.



The Spectrum of Conductivity







Conductors

1–3 Valence Electrons.
Loosely held.
Examples: Copper, Gold, Aluminium

Semiconductors

Exactly 4 Valence Electrons.
Conductivity controlled by doping.
Examples: Silicon, Germanium

Insulators

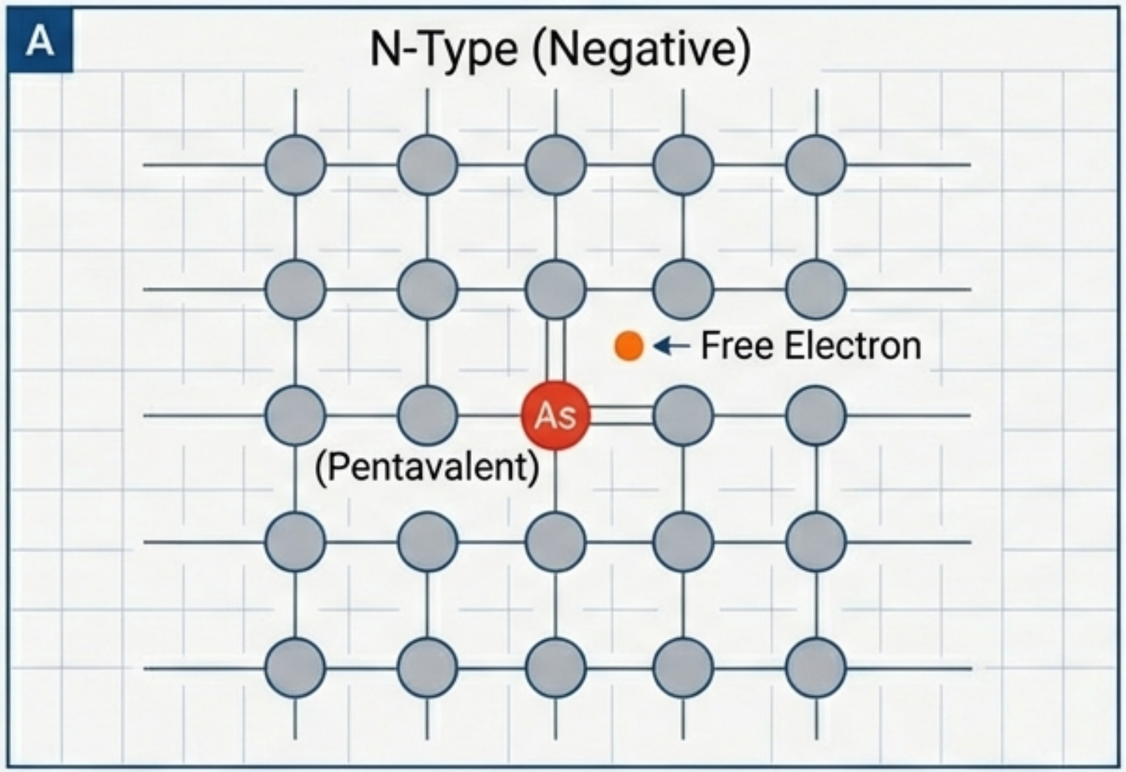
5–8 Valence Electrons.
Tightly held.
Examples: PVC, Glass, Rubber

Low (Left) ← Electrical Resistance → High (Right)

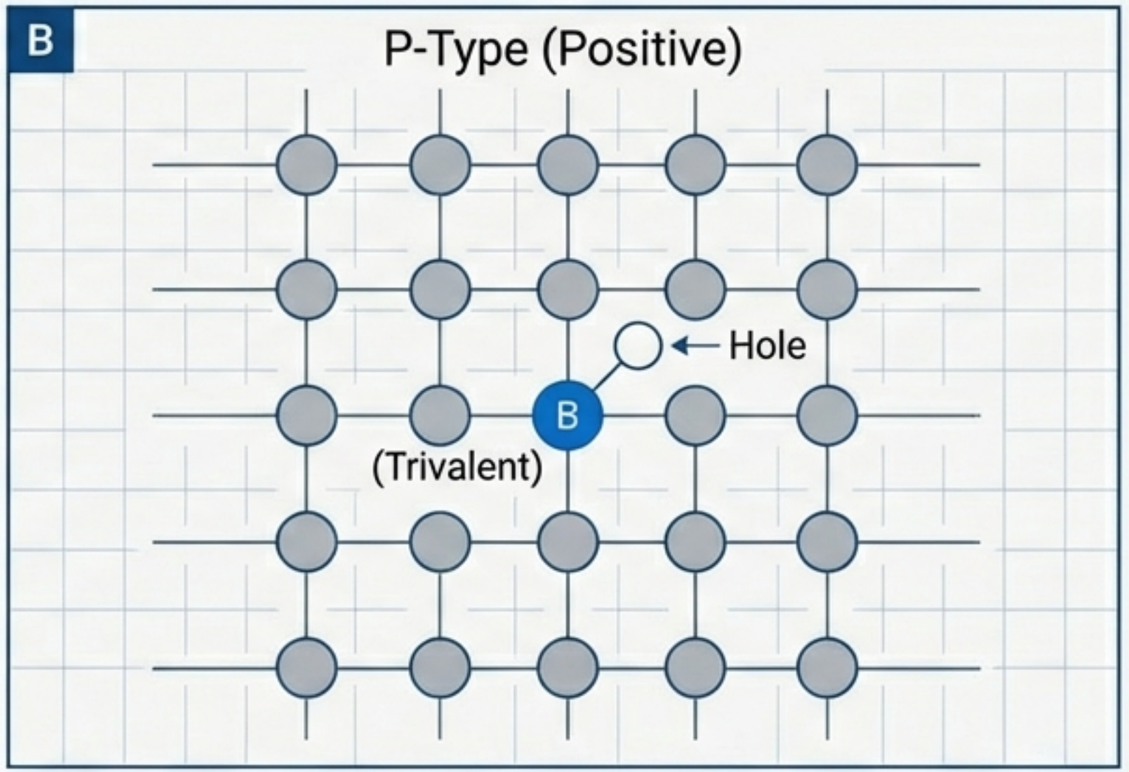
Engineering Conductivity: The Doping Process

Transforming intrinsic silicon into N-Type and P-Type materials.

Pure silicon acts as an insulator. By adding impurities (“Doping”), we introduce instability that creates charge carriers.

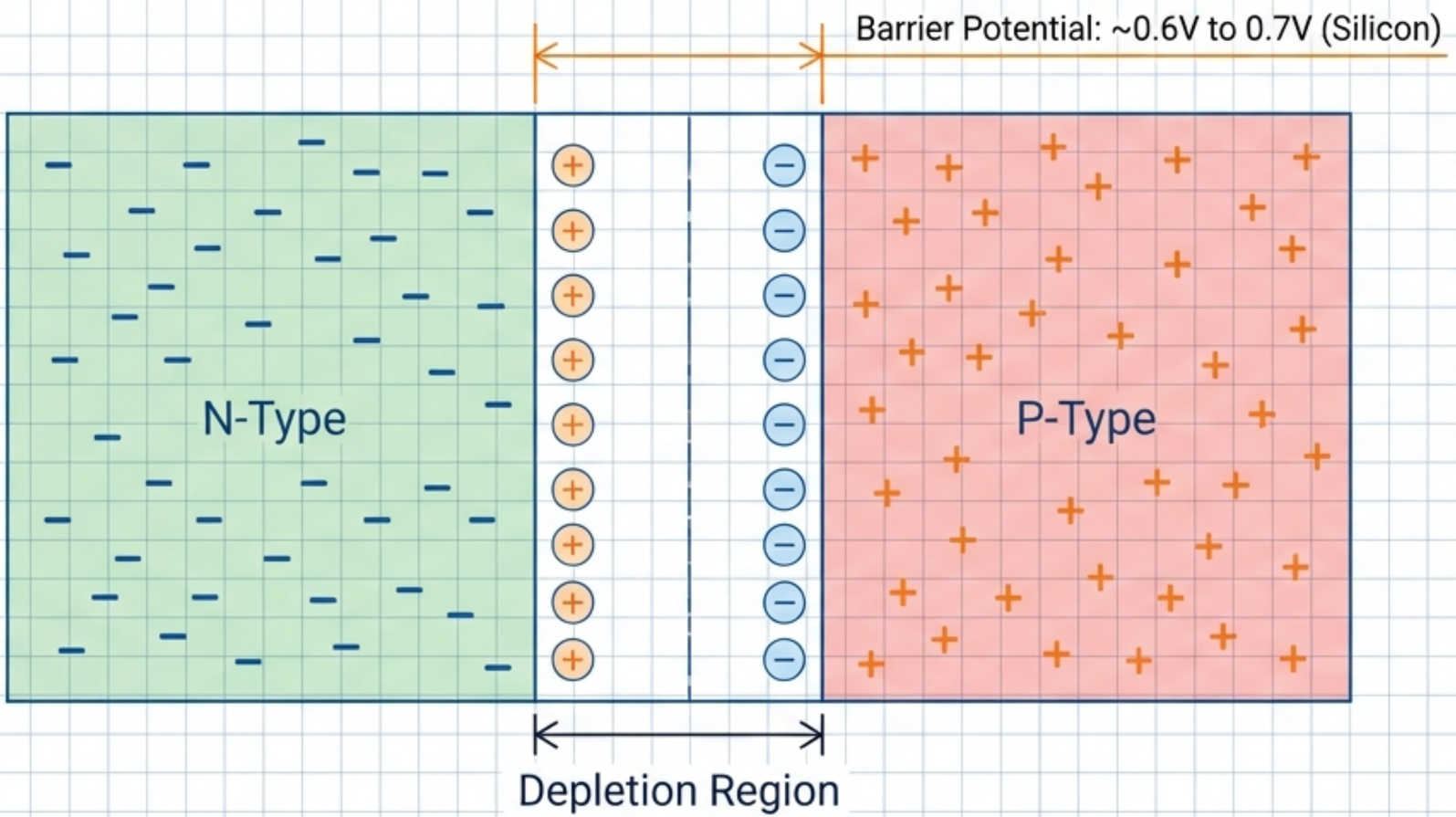


Pentavalent Impurity (5e). Result: Excess Electrons.



Trivalent Impurity (3e). Result: Excess Holes.

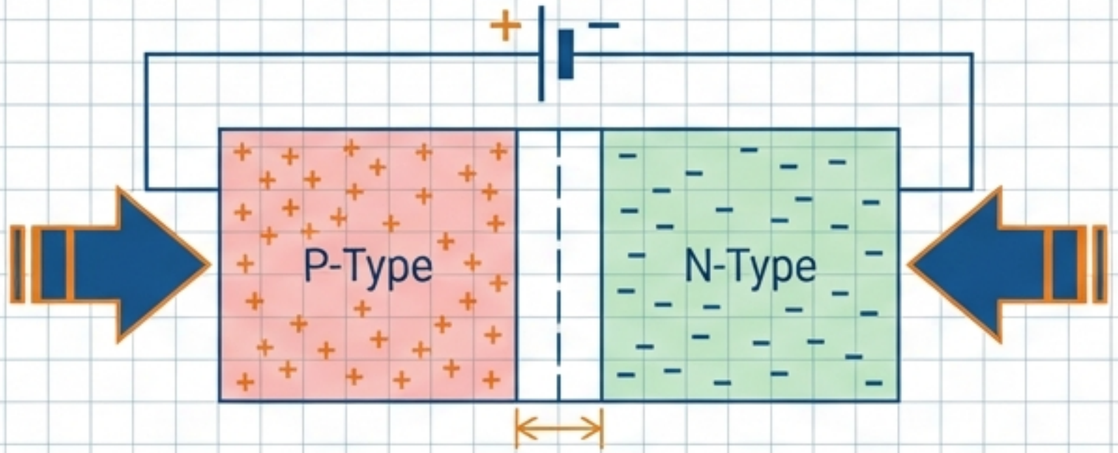
The PN Junction: Creating the Barrier



Process Description:

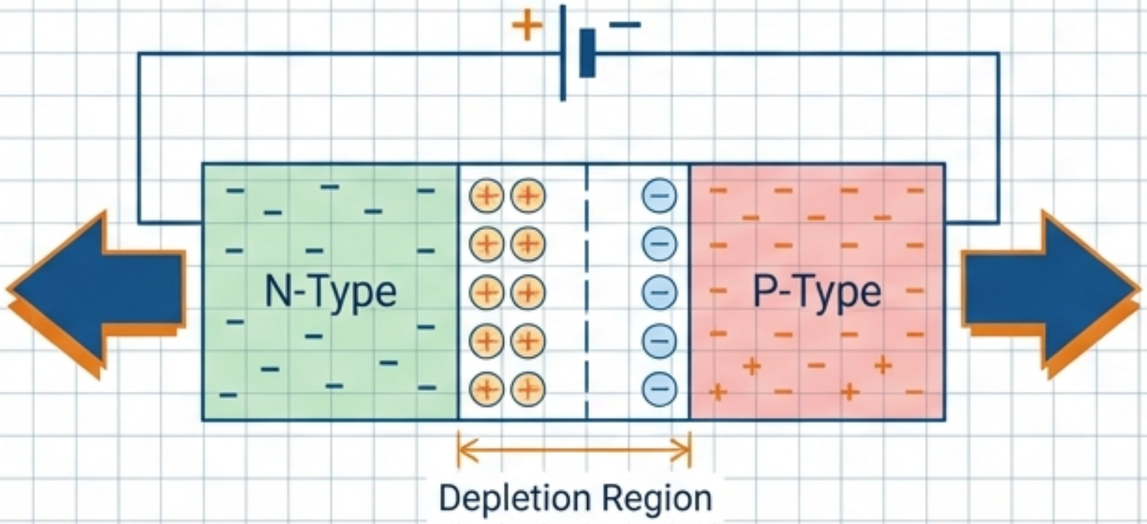
1. **Diffusion:** Electrons rush to fill holes.
2. **Recombination:** Charges cancel out.
3. **Isolation:** A wall of ions forms, blocking further flow.

Biasing the Diode (The Switch)



Forward Bias (Closed Switch)

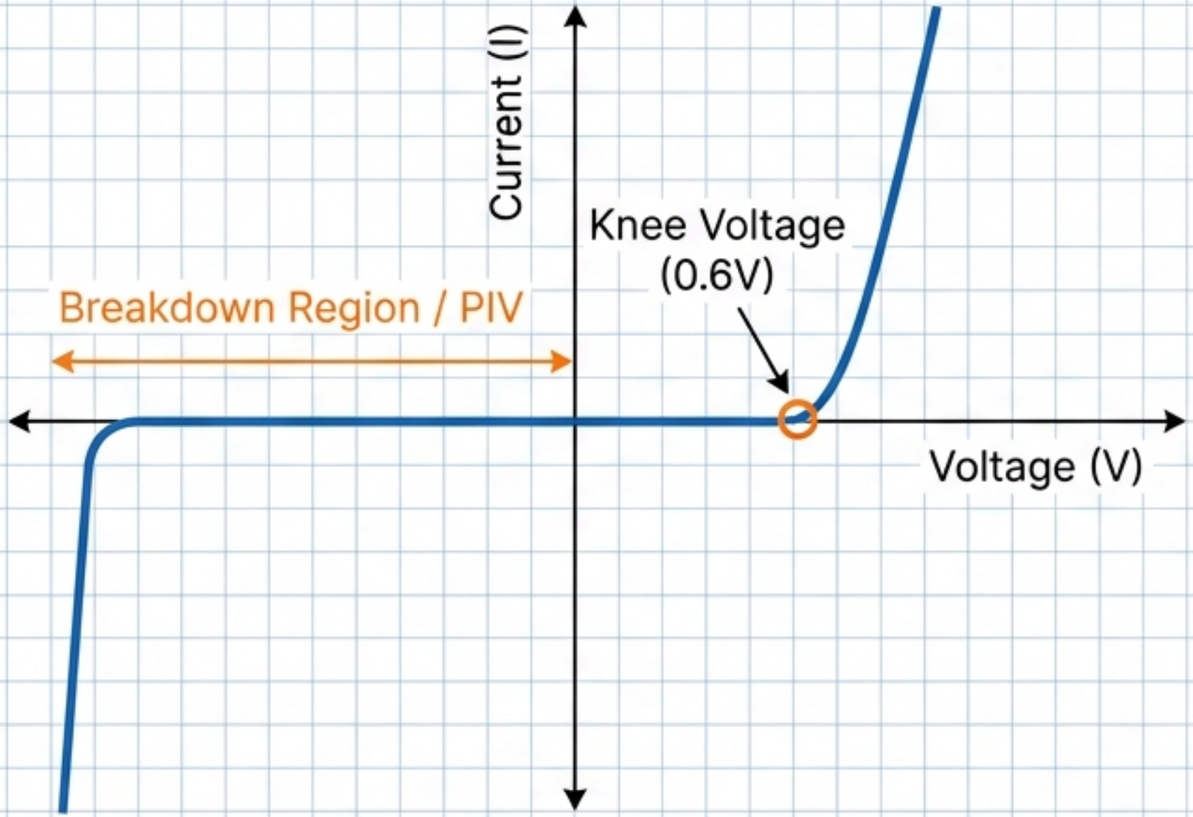
Current Flows. In Roboto Mono. Depletion region narrows.

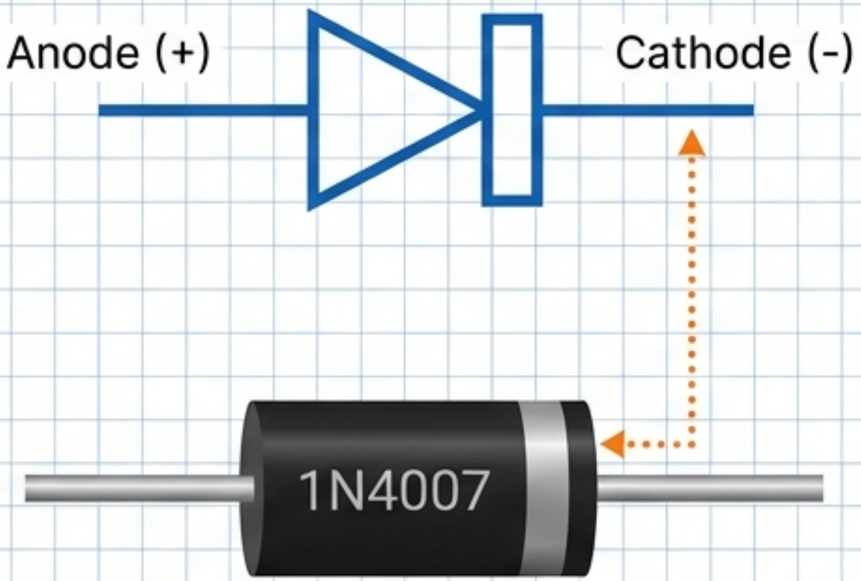


Reverse Bias (Open Switch)

Current Blocked. Roboto Mono. Depletion region widens.

Diode Characteristics and Symbols

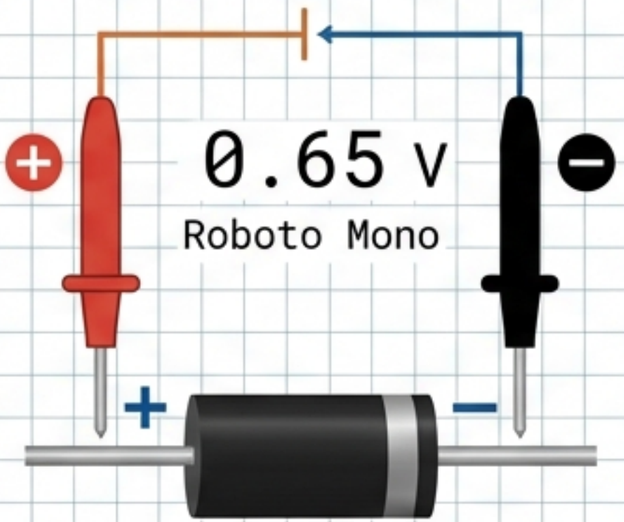




PIV (Peak Inverse Voltage): Max reverse voltage before failure.
If (Max Forward Current): Max current limit.

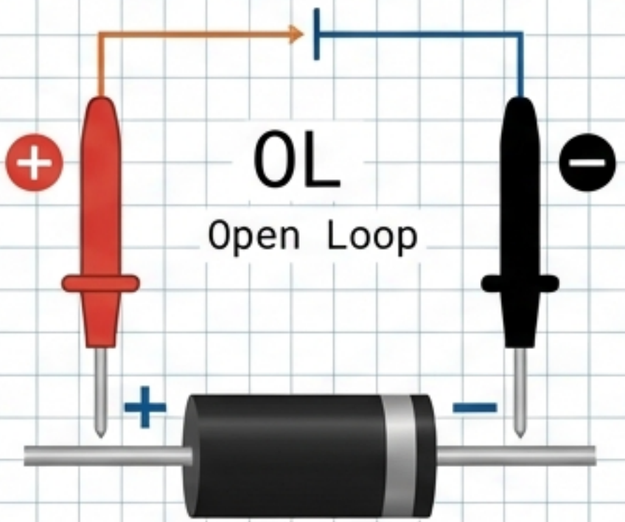
Testing Diodes with a Multimeter

Scenario A (Good Forward)



PASS: Forward Bias Drop

Scenario B (Good Reverse)

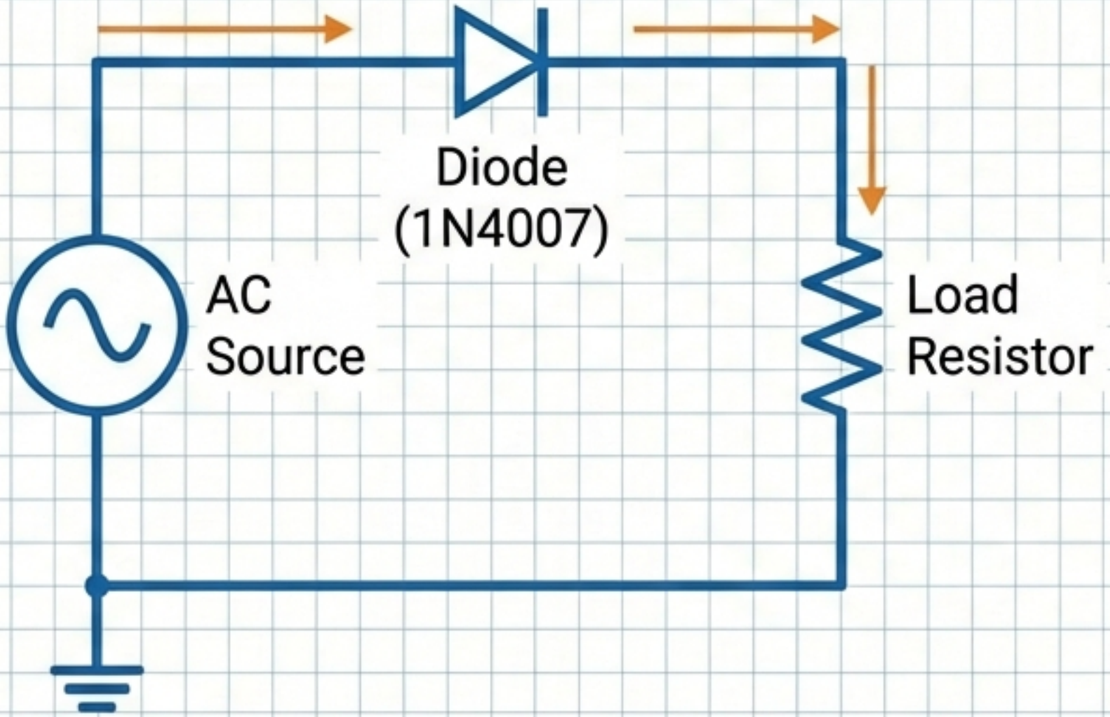


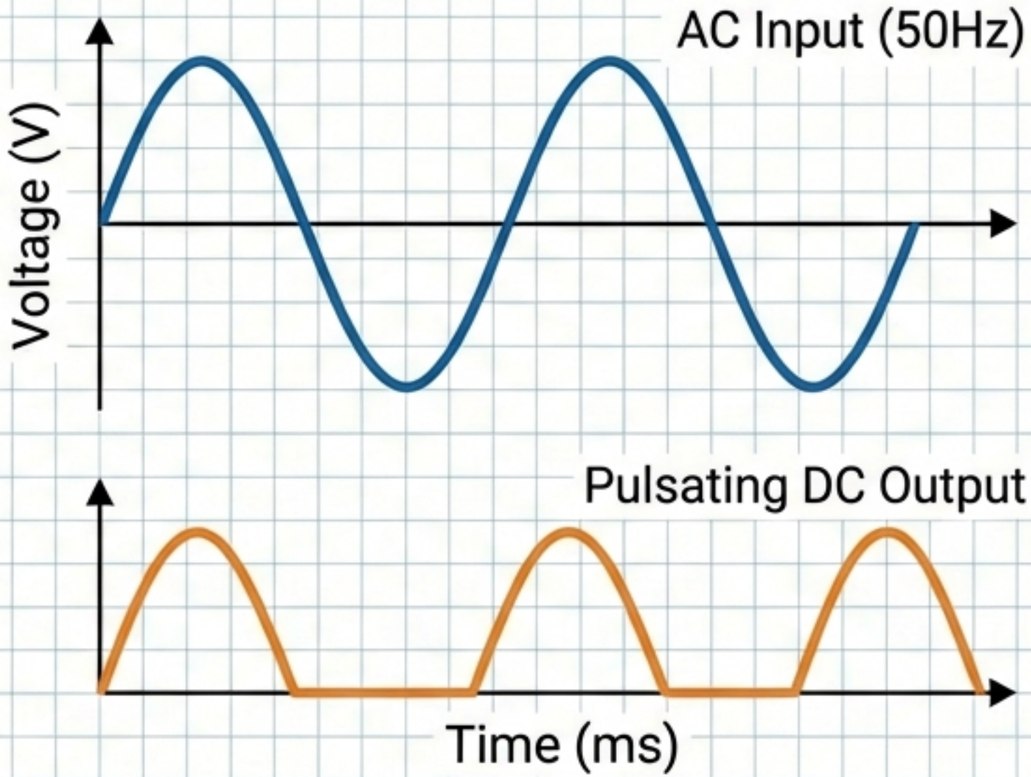
PASS: Blocking Current

Short Circuit	Reads 0V / Beep in both directions	FAIL
Open Circuit	Reads OL in both directions	FAIL

Half-Wave Rectification

Converting AC to DC (Low Efficiency)

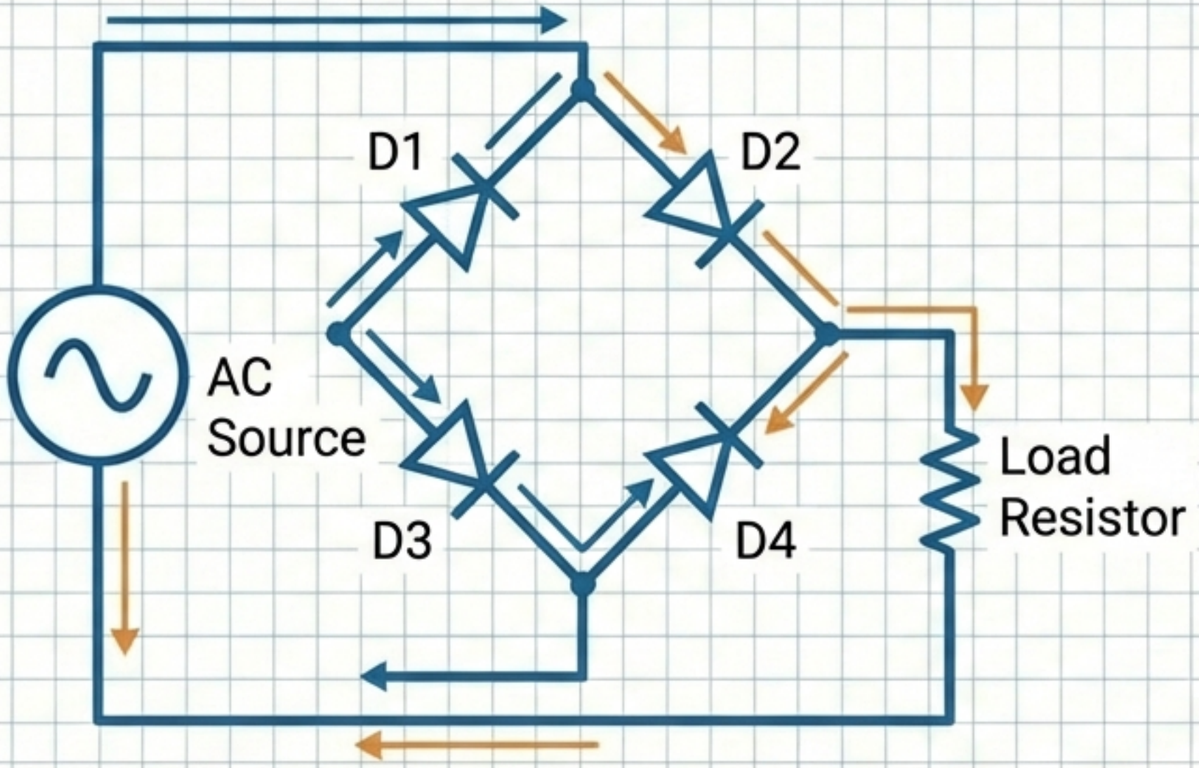


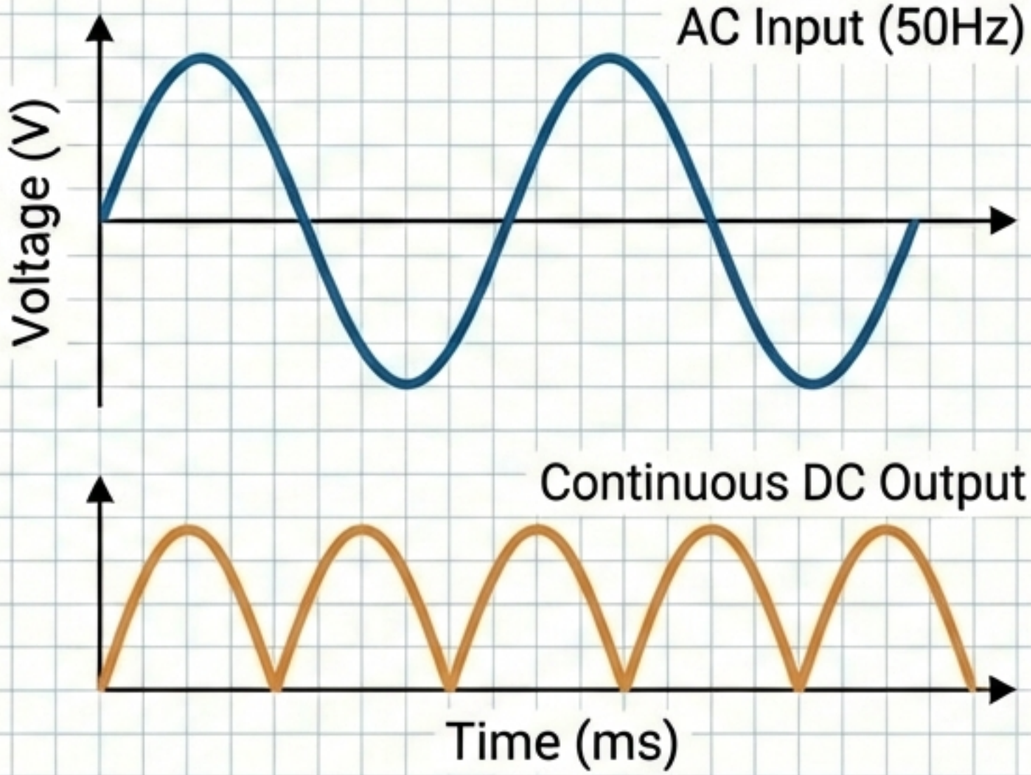


Efficiency: ~50% (Negative cycle is lost)
Ripple Frequency: 50Hz (Same as Input)

Full-Wave Bridge Rectification

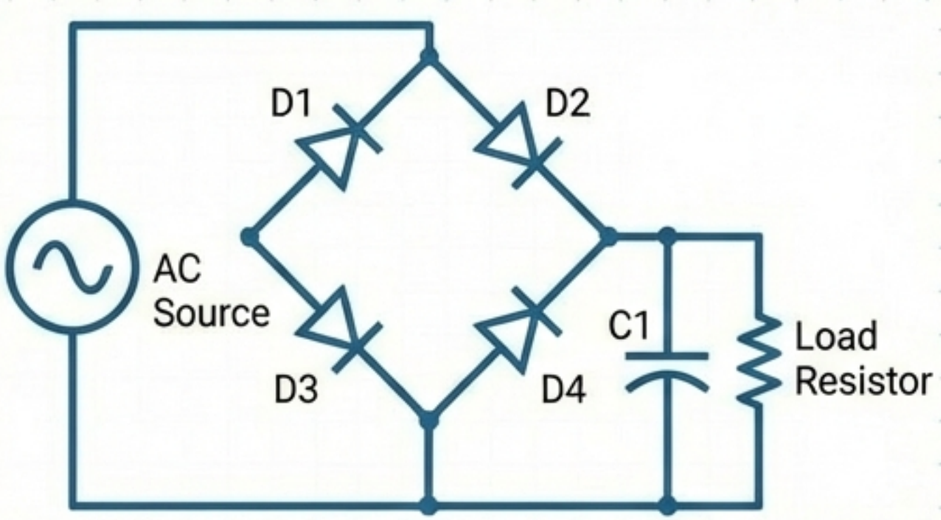
Converting AC to DC (High Efficiency)

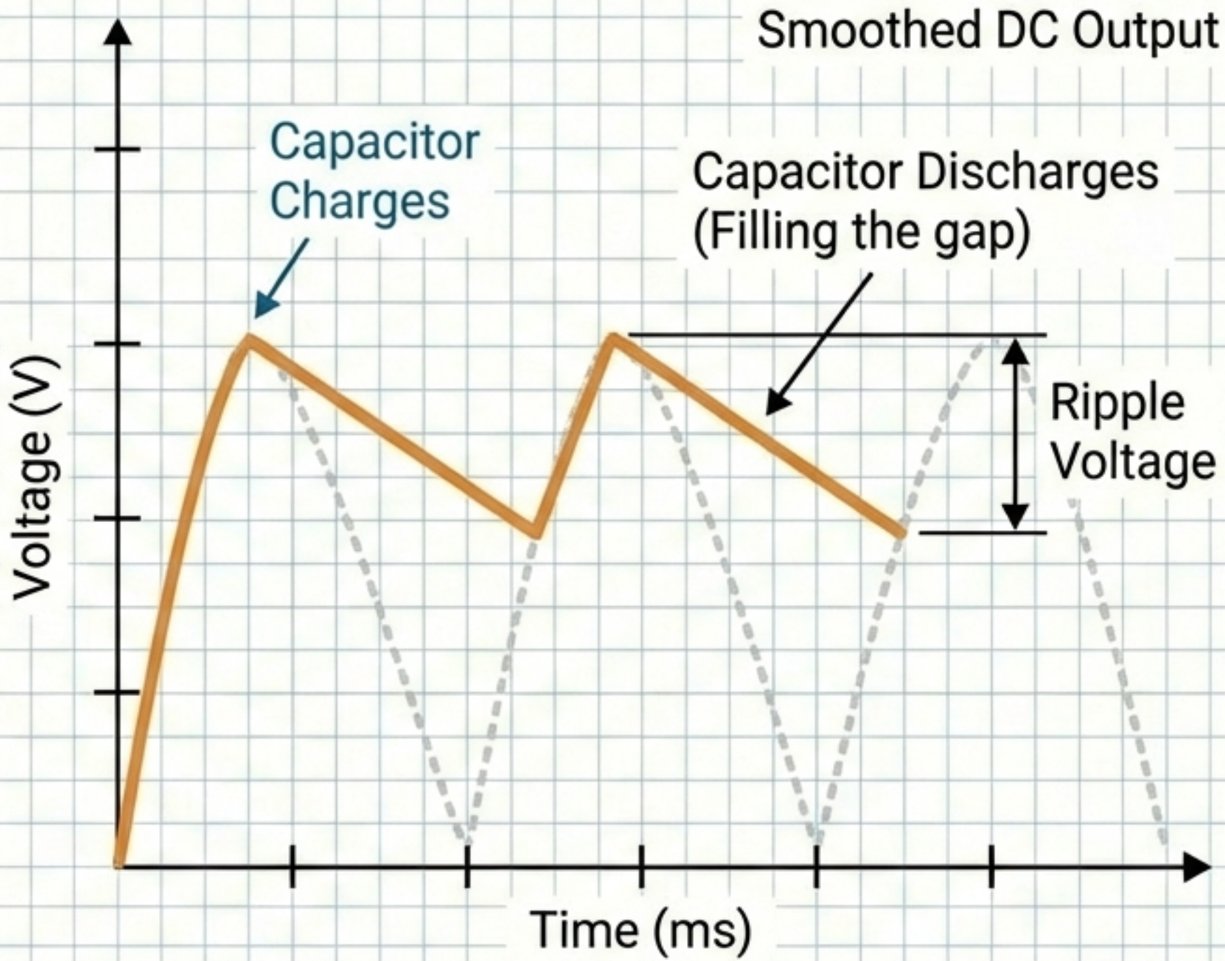




- Efficiency: 100% (Full cycle utilized)
- Ripple Frequency: 100Hz (Double the Input)

Smoothing the Output

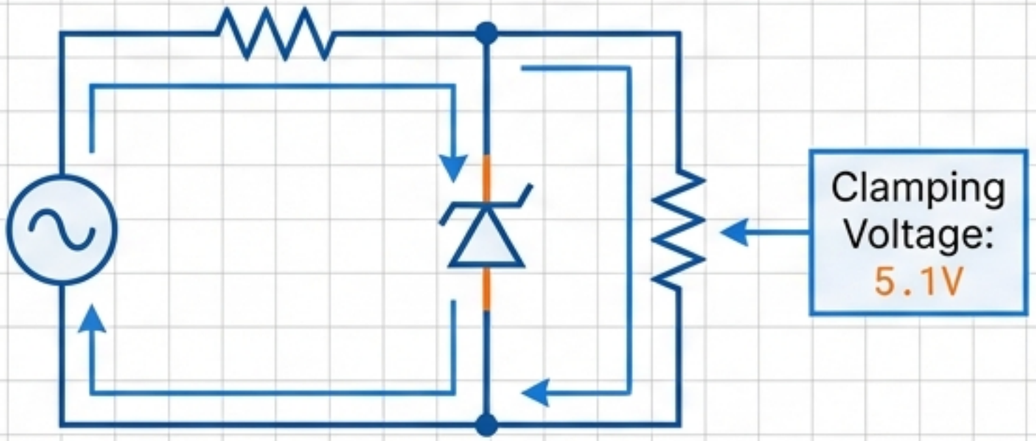




Special Purpose Diodes

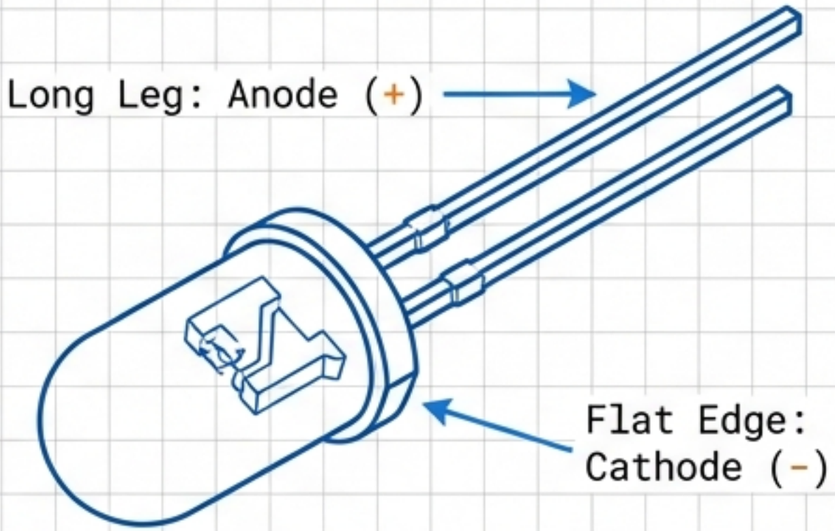
Zener Diode

Voltage Regulation (Stabilization)



Operates in reverse breakdown to maintain constant voltage across load.

LED (Light Emitting Diode)



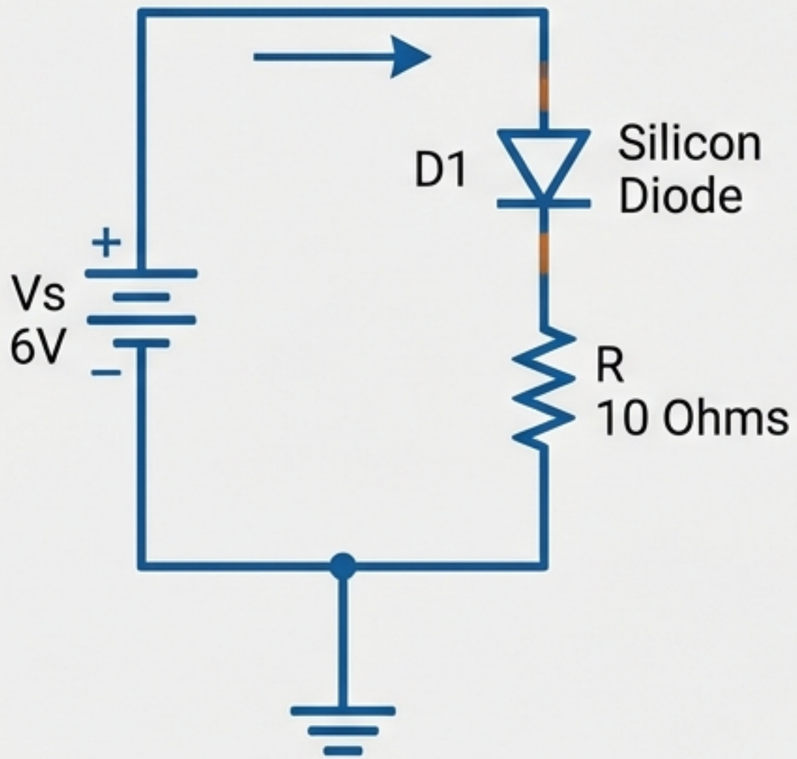
⚠ **WARNING:** Must use Series Resistor to limit current.

Emits light when forward-biased; current must be limited to prevent burnout.

Circuit Calculations: Ohm's Law

The Golden Rule: Subtract the Diode Drop (0.6V) First.

Worked Example 2



The Formula:

$$I = \frac{V_s - V_f}{R}$$

If Supply < 0.6V, Current = 0A.

The Substitution:

$$I = \frac{6V - 0.6V}{10\ Ohms}$$

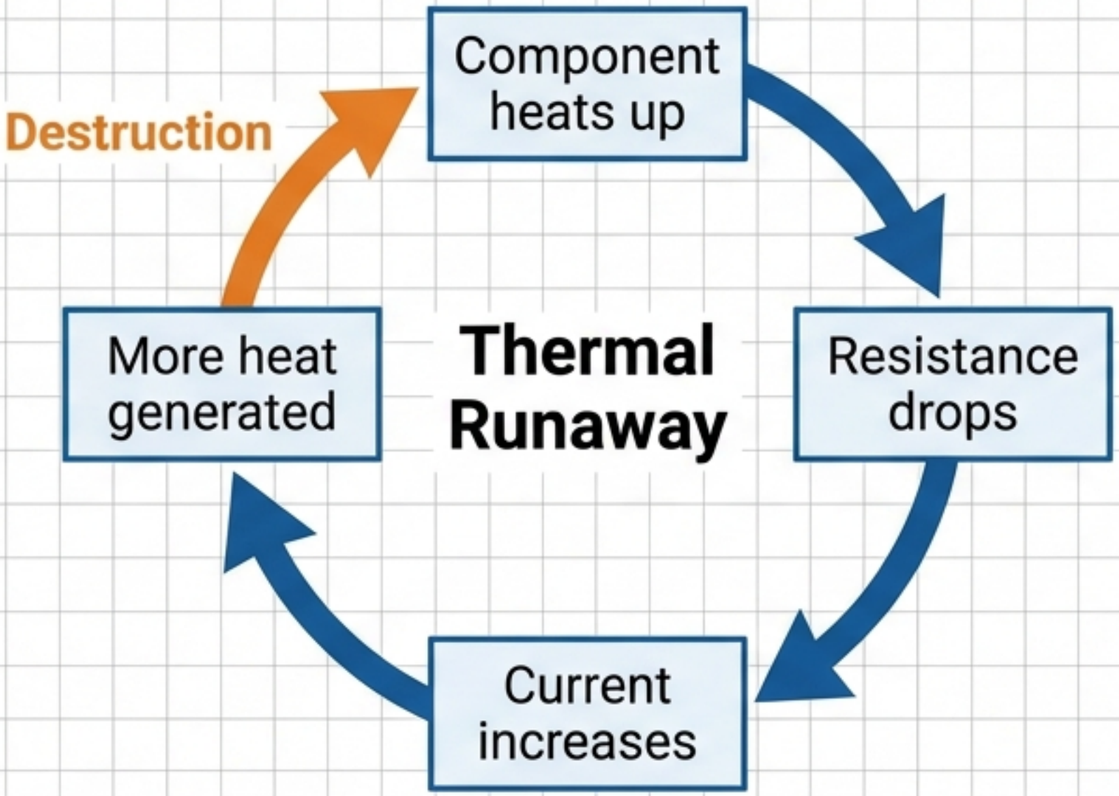
The Result:

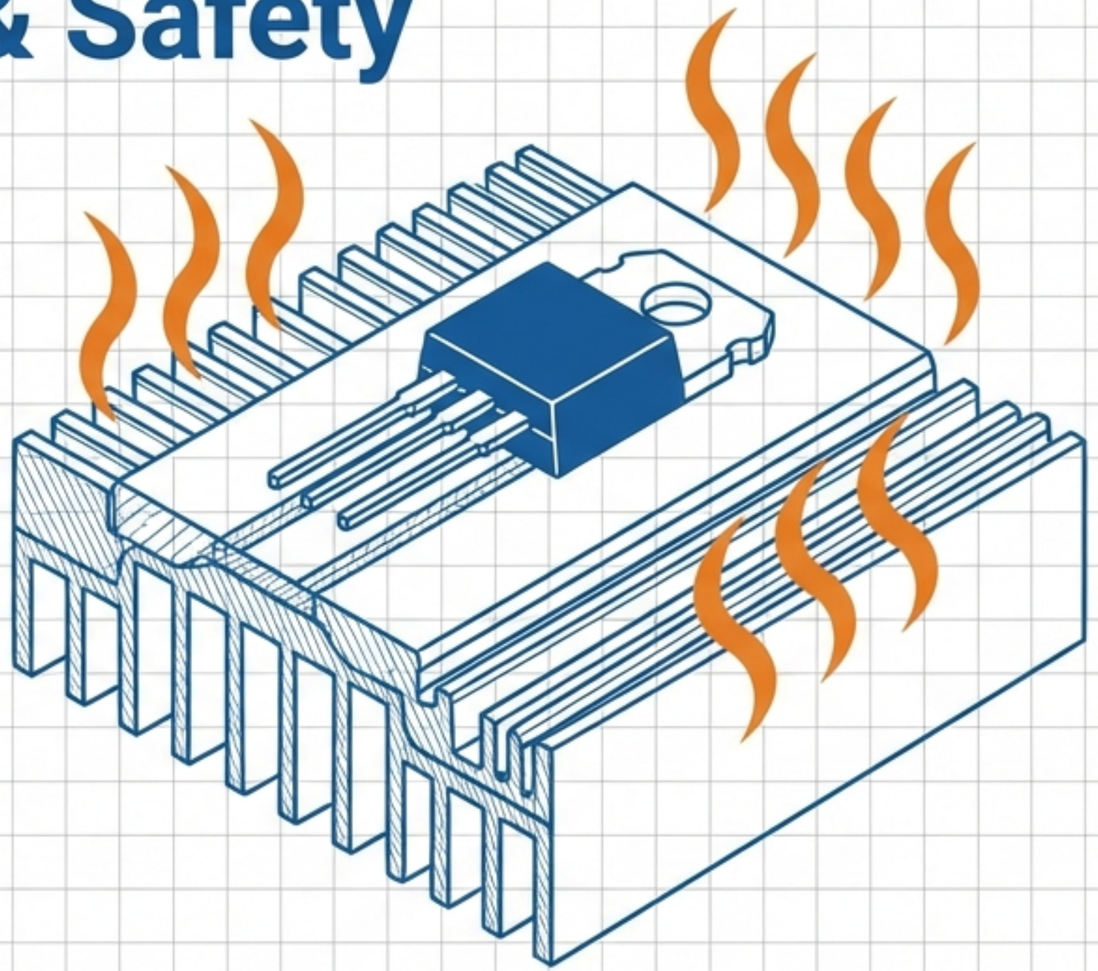
$$I = \frac{5.4V}{10\ Ohms} = 0.54\ A$$

Thermal Management & Safety

Power Loss (P)

= Voltage Drop (0.6V) × Current (I)





Use Heat Sinks and Thermal Paste to dissipate energy.

Unit 11 Essential Facts Cheat Sheet

MATERIALS

`Silicon (Si)` = 4 Valence Electrons.
N-Type = Pentavalent (Free Electrons).
P-Type = Trivalent (Holes).

THE BARRIER

Silicon Barrier Potential = **0.6V**.
Germanium = **0.3V**.
Must exceed this to conduct.

RECTIFIERS

Half-Wave = 50Hz Ripple (Low Eff).
Full-Wave = 100Hz Ripple (High Eff).

SAFETY

Always subtract 0.6V before calc.
Always use resistor with LED.
Zener used for Voltage Reg.

End of Unit 11.