PLTW Engineering

10-12/Diodes

May 7, 2020

10-12/DE

Lesson: **5/7/2020**

Students will be able to explain the properties and uses of diodes.

What is a diode?

A diode is an electrical device allowing current to move through it in one direction with far greater ease than in the other.

The most common kind of diode in modern circuit design is the semiconductor diode, although other diode technologies exist.

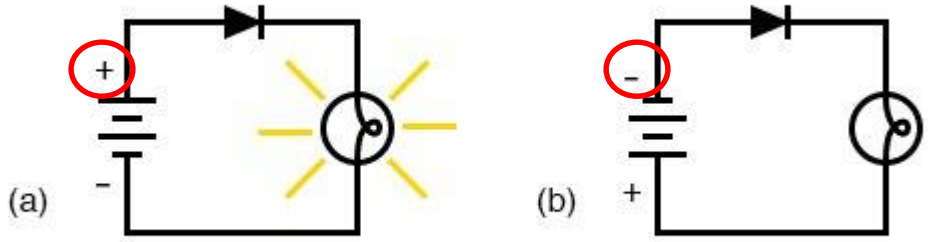
How a diode operates

When placed in a simple battery-lamp circuit, the diode will either allow or prevent current through the lamp, depending on the polarity of the applied voltage.

When the polarity of the battery is such that current is allowed to flow through the diode, the diode is said to be forward-biased. When the battery is “backward” and the diode blocks current, the diode is said to be reverse-biased. A diode may be thought of as like a switch: “closed” when forward-biased and “open” when reverse-biased.

How a diode operates

The direction of the diode symbol's arrowhead points at the direction of the current in conventional flow. This convention holds true for all semiconductors possessing arrowheads in their schematics. The opposite is true when electron flow is used, where the current direction is against the arrowhead.



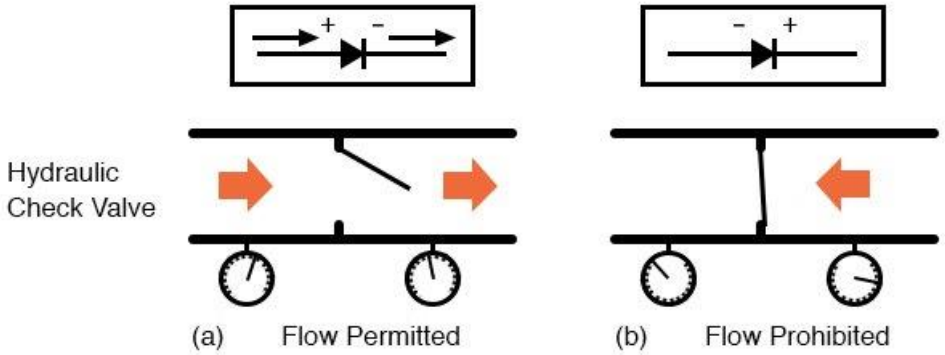
How a diode operates

The function of a diode is similar to the function of a hydraulic “check valve” in terms of allowing fluid to flow through it in only one direction.

Check valves are essentially pressure-operated devices: they open and allow flow if the pressure across them is of the correct “polarity” to open the gate. If the pressure is of the opposite “polarity,” the pressure difference across the check valve will close and hold the gate so that no flow occurs.

How a diode operates

Like check valves, diodes are essentially “pressure” operated (voltage-operated) devices. The essential difference between forward-bias and reverse-bias is the polarity of the voltage dropped across the diode.



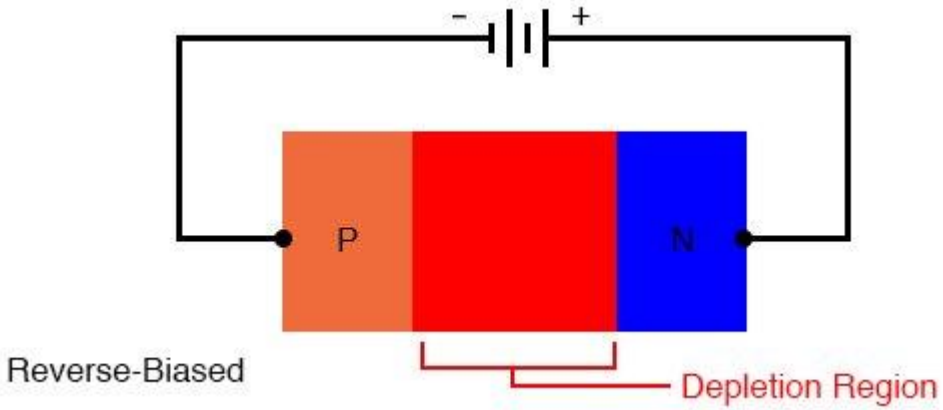
Forward vs Reverse bias diode

A forward-biased diode conducts current and drops a small voltage across it, leaving most of the battery voltage dropped across the lamp.

If the battery's polarity is reversed, the diode becomes reverse-biased, and drops all of the battery's voltage leaving none for the lamp.

Forward vs Reverse bias diode

If a reverse-biasing voltage is applied across the P-N junction, this depletion region expands, further resisting any current through it.



Forward vs Reverse bias diode

A reverse-biased diode prevents current from going through it, due to the expanded depletion region. In actuality, a very small amount of current can and does go through a reverse-biased diode, called the leakage current, but it can be ignored for most purposes.

The ability of a diode to withstand reverse-bias voltages is limited, as it is for any insulator. If the applied reverse-bias voltage becomes too great, the diode will experience a condition known as breakdown, which is usually destructive.

Diode equation

$$I_D = I_S(e^{qV_D / NkT} - 1)$$

Where,

I_D = Diode current in amps

I_S = Saturation current in amps (typically 1×10^{-12} amps)

e = Euler's constant (~ 2.718281828)

q = charge of election (1.6×10^{-19} coulombs)

V_D = Voltage applied across diode in volts

N = "Nonideality" or "Emission" coefficient (typically between 1 and 2)

k = Boltzmann's constant (1.38×10^{-23})

T = Junction Temperature in Kelvins

Quiz yourself

1. A diode is an electrical component that can be compared to which hydraulic component?
2. A forward based diode allows what to flow?
3. When a diode prohibits current flow, what type is it?
4. What is the voltage called when it is dropping across a conducting, forward-based diode?

5. What is term for the maximum reverse-bias voltage that a diode can withstand?

Helpful links

Youtube video about how diodes work

Tutorial about how to use the diode equations