

1. Describe the difference between n-type and p-type semiconductor materials

The primary difference lies in the types of majority charge carriers created through the doping process:

- n-type materials: These are created by adding impurities that result in an excess of conduction band electrons. Electrons are the majority carriers, and they are used when a negative charge flow is desired.
- p-type materials: These are created by adding impurities (like Boron) that lack one electron, creating "holes". It contains an excess of valence band holes, which act as the majority carriers to move and carry current.

2. Describe in your own words the conditions established by forward- and reverse-bias conditions on a p-n junction diode and how the resulting current is affected.

- Forward Bias: The positive side of the power source is connected to the p-type material and the negative is connected to the n-type material; the depletion region is reduced and the holes and electrons in the p-n junction are forced closer together towards the center of the diode. If the electrons cross the junction the diode allows the current to pass, for example a voltage of 0.7 volts in silicon-based diodes.
- Reverse Bias: The direction of the positive and negative connection from the power supply is opposite from that for forward bias. The positive connection is towards the n-type material and the negative connection is towards the p-type material. This increases the width of the depletion region and moves the electrons and holes away from the middle. The diode conducts electrons away from the center of the diode, and acts like an open switch, except for a tiny leakage current.

3. Describe in your own words the meaning of the ideal word as applied to a device or a system.

The ideal refers to a theoretical model used to simplify circuit analysis:

An ideal diode can thus be viewed as a perfect switch. When it is forward-biased, it behaves like a short-circuit, since there is no forward voltage drop (zero voltage), no internal resistance (zero resistance), and it can carry an unlimited amount of current. Reverse-biased, a diode is an open

circuit with infinite resistance. Real diodes, however, are not ideal components. They have a forward voltage drop and leakage currents in reverse bias.

4. Calculations

a. Determine the thermal voltage for a diode at a temperature of 25°C. According to the source, at a temperature of 25°C, the thermal voltage is constant at:

- $V_T \approx 26 \text{ mV}$

b. Find the diode current (I_D) if $I_S=40 \text{ nA}$, $n=2$, and $V_D=0.5 \text{ V}$

1. Formula:

$$I_D = I_s(e^{V_D/nV_T} - 1)$$

2. Exponent Calculation: $0.5 \text{ V} / (2 \times 0.026 \text{ V}) = 0.5 / 0.052 \approx 9.615$

3. Value of: $e^{9.615} \approx 14988.5$

4. Final current:

$$I_D = 40 \text{ nA} \times (14988.5 - 1) = 40 \text{ nA} \times 14987.5$$

$I_D \approx 599,500 \text{ nA}$ or 0.5995 mA (approximately 0.6 mA).