SEMICONDUCTOR ELECTRONICS

ZENER DIODE

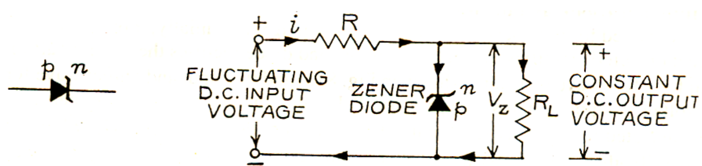
DIFFERENT TYPES OF JUNCTION DIODE

There are various types of junction diodes, each serving specific purposes. Among the notable types are the Zener diode, photodiode, light-emitting diode (LED), and solar cell.

Zener Diode:

A Zener diode functions as a voltage-regulating device, relying on the phenomenon of avalanche breakdown within a junction diode. As the reverse bias applied to a junction diode increases, there is a sudden surge in the reverse current when the reverse bias reaches a specific value known as the 'breakdown voltage' or 'Zener voltage.' In this region of the reverse characteristic curve, the voltage across the diode remains nearly constant over a significant range of currents. This property allows the Zener diode to stabilize voltage at a predetermined value.

The Zener diode can be tailored, through controlled doping, to stabilize voltage at any desired level between 4 and 100 volts. The symbol of a Zener diode is depicted in Fig. (a), and Fig. (b) Illustrates a straightforward circuit for stabilizing voltage across a load RL. The circuit comprises a series voltage-dropping resistance R and a Zener diode in parallel with the load RL. The Zener diode is chosen with a Zener voltage (VZ) equal to the desired voltage across the load.



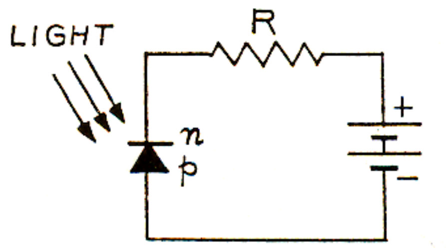
(a) (b)

In the presence of fluctuating DC input voltage, such as the DC output of a rectifier, any increase in input voltage leads to excess voltage being dropped across resistance R. Consequently, the input current (i) increases, and this increase is conducted by the Zener diode. As a result, the current through the load, and hence the voltage across it, remains constant at VZ. Conversely, a decrease in the input voltage causes a decrease in the input current, and the Zener diode adjusts the current through the load to maintain a constant voltage.

The circuit's functionality is contingent upon the input voltage not falling below VZ, as resistance R absorbs input voltage fluctuations to ensure a steady output voltage VZ.

Photodiode:

A photodiode is a semiconductor device designed as a reverse-biased p-n junction with photosensitive properties. This junction is encased in clear plastic, with the upper surface positioned to be exposed to light. In contrast, the remaining sides of the plastic housing are either painted black or enclosed within a metallic case. Notably, the entire photodiode unit is remarkably compact, typically around a size of 0.1 inches.

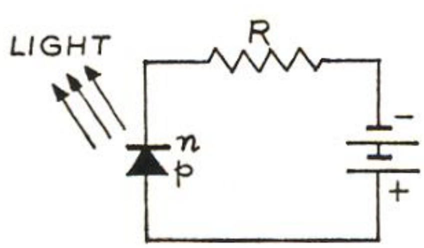


When the junction receives no incident light and is subjected to a reverse-bias of several tenths of a volt, a nearly constant small current in the microampere range, known as "dark" current, is generated. This dark current is a result of the reverse saturation current arising from thermally-generated minority carriers, where electrons are in the p-region and holes are in the n-region. However, when light of the appropriate frequency illuminates the junction, additional electron-hole pairs are formed near the junction due to the breaking of covalent bonds. These light-generated minority carriers traverse the reverse-biased junction, contributing to the reverse current caused by thermally-generated carriers. Consequently, the overall current in the circuit increases, typically by a fraction of a milliampere. This phenomenon, termed "photoconductive" current, exhibits an almost linear relationship with the incident light flux.

P-n photodiodes demonstrate the capability to operate at frequencies on the order of 1 MHz, making them suitable for applications such as high-speed reading of computer punched cards, light-detection systems, light-operated switches, and electronic counters.

Light-Emitting Diode (LED):

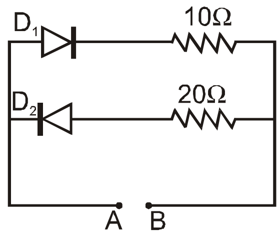
When a p-n junction diode undergoes forward-biasing, both electrons and holes migrate towards the junction. As they traverse the junction, electrons plunge into the holes, resulting in a process known as recombination. This recombination event leads to the release of energy at the junction, primarily attributed to the electrons descending from a higher energy level to a lower one. In the case of germanium (Ge) and silicon (Si) diodes, the energy liberated manifests as infra-red radiation. Conversely, if the diode is constructed from gallium arsenide or indium phosphide, the released energy takes the form of visible light. Such diodes are termed 'light-emitting diodes' (LEDs).



The advent of LEDs has led to their widespread adoption, supplanting incandescent lamps in numerous applications. This shift is owing to their advantages, including low power consumption, prolonged operational lifespan, and rapid on-off switching capabilities. LEDs find extensive use in modern electronic devices, particularly in sleek gadgets like calculators, showcasing their versatility and efficiency.

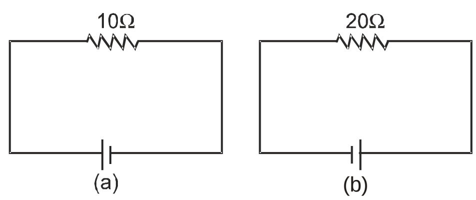
Example.

A 2V battery can be linked across points A and B, as depicted in the diagram. Assuming that each diode has zero resistance in forward bias and infinite resistance in reverse bias, determine the current delivered by the battery when the positive terminal is connected to (a) point A and (b) point B.



Solution.

(a) In the scenario where the positive terminal of the battery is linked to point A, diode D1 experiences forward bias, while D2 is subjected to reverse bias. The resistance of D1 is considered negligible, akin to a wire with zero resistance, while the resistance of D2 is infinite, treated as a broken circuit. The resulting equivalent circuit is illustrated in the figure. The current supplied by the battery can be calculated as 2 V divided by 10 Ω, yielding 0.2 A.



(b) Conversely, when the positive terminal of the battery connects to point B, D2 becomes forward-biased, and D1 is reverse-biased. The corresponding equivalent circuit is portrayed in figure (b). The current flowing through the battery is determined as 2 V divided by 20 Ω, resulting in a current of 0.1 A.