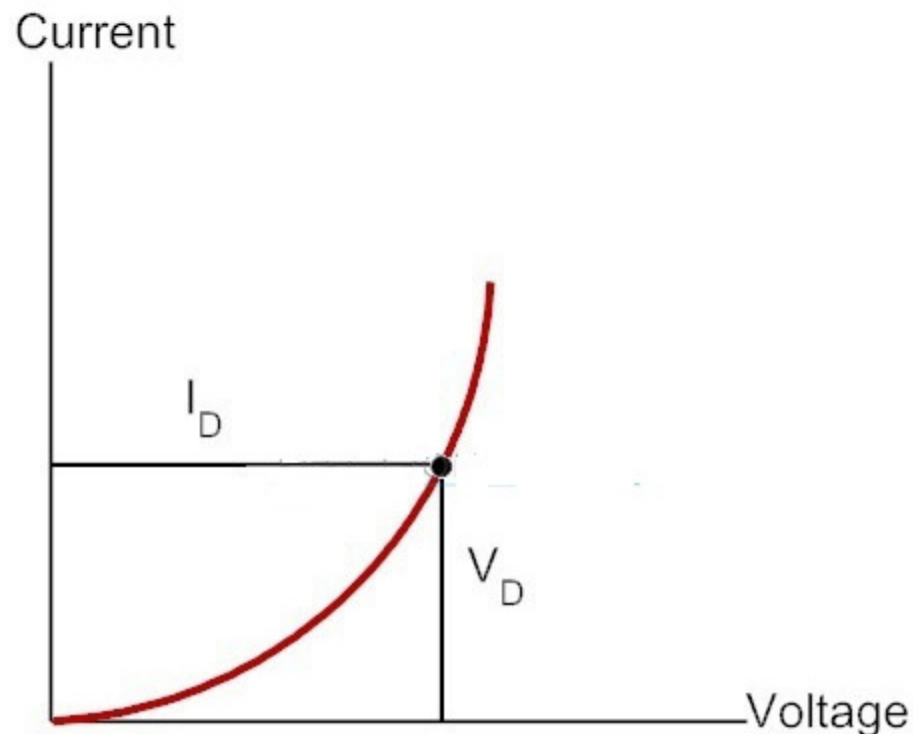


DC or Static Resistance

Static resistance or DC resistance of a PN junction diode defines the diode's resistive nature when a DC source is connected to it. If an external DC voltage is given to the circuit in which the semiconductor diode is a part of it, results in a Q-point or operating point on the PN junction diode characteristic curve that does not alter with time.

The static resistance at the knee of the curve and below of it will be much greater than the resistance values of the vertical rise section of the characteristic curve. Minimum is the current passing through a diode maximum is the level of DC resistance.

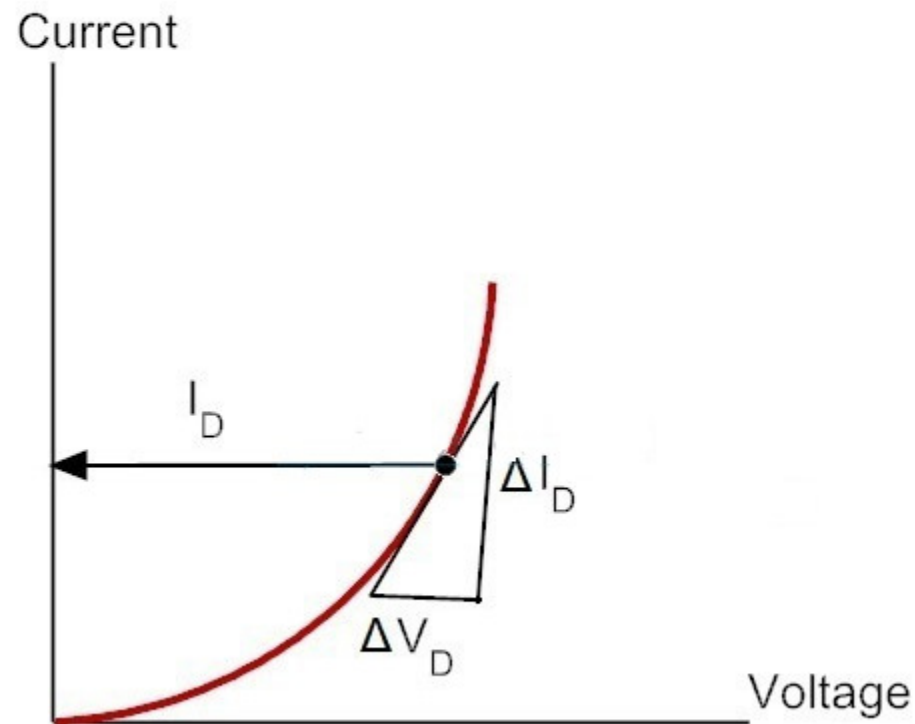
$$R_{DC} = V_{DC} / I_{DC}$$



AC or Dynamic Resistance

For small signal operation current flowing through a diode varies about some d.c operating current. The resistance offered by the diode to this varying component of current is called the dynamic resistance. It is given by the reciprocal of the slope of current-voltage characteristic at the operating point.

$$r_d = \Delta V_d / \Delta I_d$$



Assignment:

From Shockley Equation $I = I_0(\exp^{qV/nkT} - 1)$

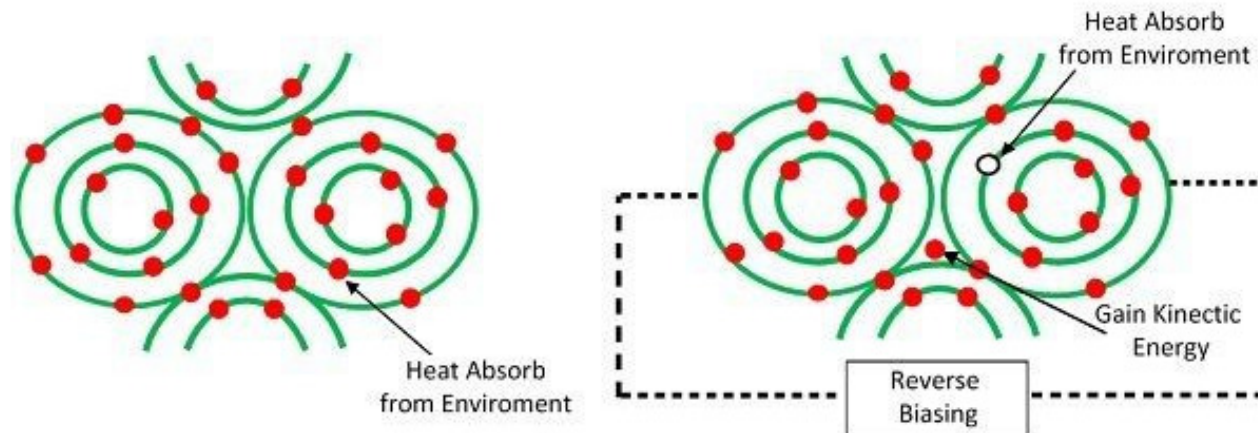
Prove Dynamic Resistance $r_d = 26n/I$

PN Junction Breakdown

An electrical breakdown of material such as the semiconductor can occur due to two different phenomena known as a) Avalanche Breakdown
b) Zener Breakdown

What is Avalanche Breakdown?

The charge carrier of the PN-junction diode absorbs heat from the environment at normal room temperature. When the reverse biased applied across the junction, the kinetic energy of the electrons increases and they starts moving at high velocity. While moving, they collide with the other atoms and creates the number of free electrons which causes the reverse saturation current. Because of this saturation current, the avalanche breakdown mechanism occurs in the diode.



Electron Absorb Heat From Charge Carrier

The Kinetic Energy of the electron increases

PN Junction Breakdown

An electrical breakdown of material such as the semiconductor can occur due to two different phenomena known as a) Avalanche Breakdown
b) Zener Breakdown

What is Zener Breakdown?

When the diode is reverse biased, the kinetic energy of the electrons increases and they move at a high velocity. The high-velocity electrons collide with other atoms and they break the covalent bonds and generate free electrons. These free electrons, in turn, give rise to a high value of reverse saturation current. This is known as Zener breakdown.

A P-N Junction is formed between

P-type Silicon doped with B with a doping density of 10^{18} cm^{-3} .

N-type Silicon doped with P with a doping density of 10^{15} cm^{-3}

What is the doping density of Zener diode?

Zener Diode

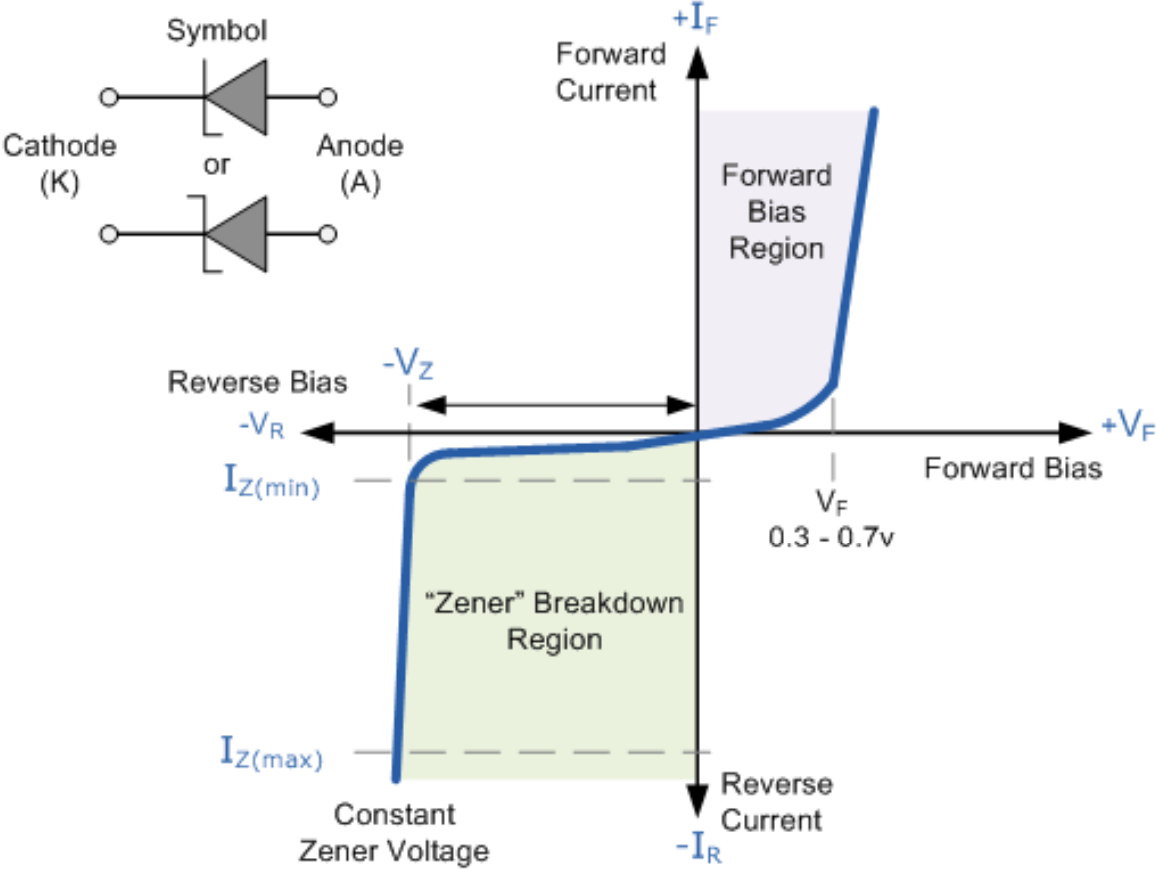
- The **Zener Diode** or “Breakdown Diode”, as they are sometimes referred too, are basically the same as the standard PN junction diode but they are specially designed to have a low and specified **Reverse Breakdown Voltage** which takes advantage of any reverse voltage applied to it.
- The **Zener diode** behaves just like a normal general-purpose diode consisting of a silicon PN junction and when biased in the forward direction, that is Anode positive with respect to its Cathode, it behaves just like a normal signal diode passing the rated current.
- However, unlike a conventional diode that blocks any flow of current through itself when reverse biased, that is the Cathode becomes more positive than the Anode, as soon as the reverse voltage reaches a pre-determined value, the zener diode begins to conduct in the reverse direction.

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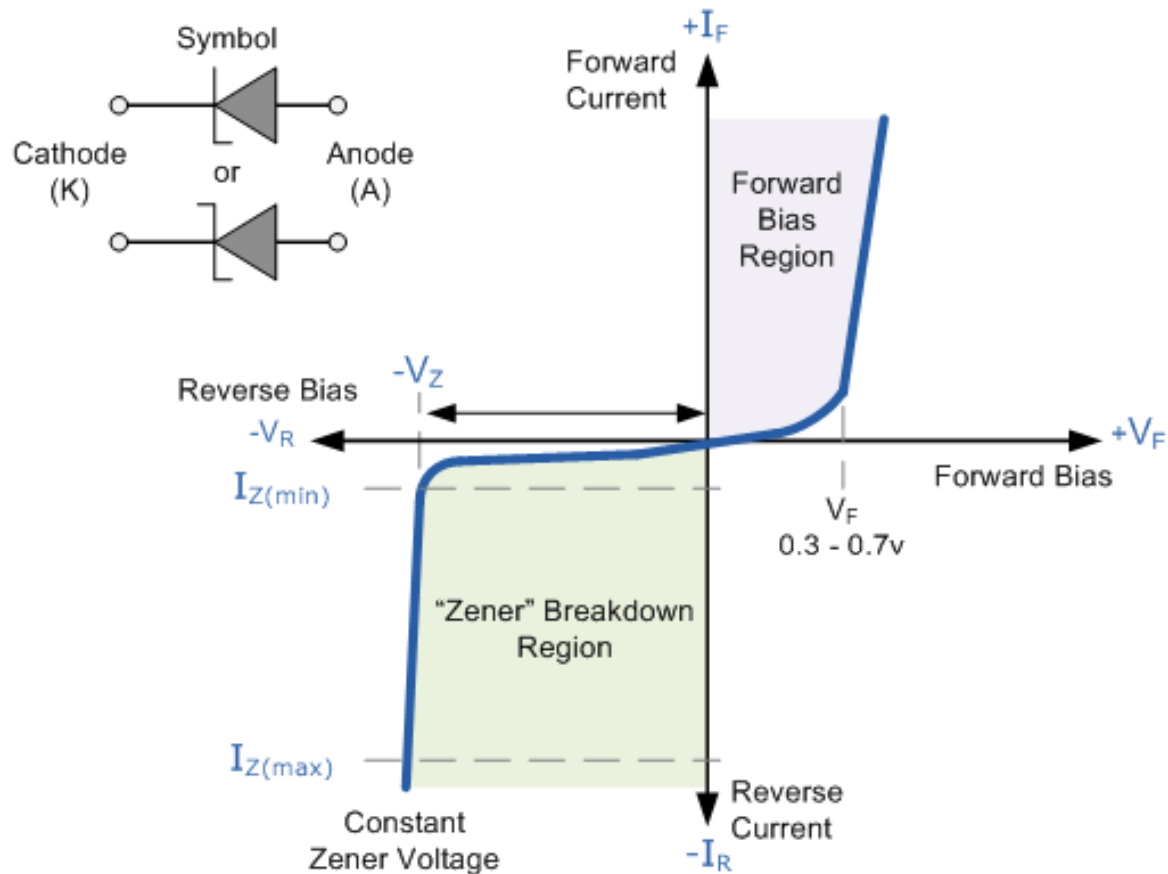
- This is because when the reverse voltage applied across the zener diode exceeds the rated voltage of the device a process called *Breakdown* occurs in the semiconductor depletion layer and a current starts to flow through the diode to limit this increase in voltage.

- The current now flowing through the zener diode increases dramatically to the maximum circuit value (which is usually limited by a series resistor) and once achieved, this reverse saturation current remains fairly constant over a wide range of reverse voltages. The voltage point at which the voltage across the zener diode becomes stable is called the “zener voltage”, (V_z) and for zener diodes this voltage can range from less than one volt to a few hundred volts.
- The point at which the zener voltage triggers the current to flow through the diode can be very accurately controlled (to less than 1% tolerance) in the doping stage of the diodes semiconductor construction giving the diode a specific *zener breakdown voltage*, (V_z) for example, 4.3V or 7.5V. This zener breakdown voltage on the I-V curve is almost a vertical straight line.

Zener Diode I-V Characteristics

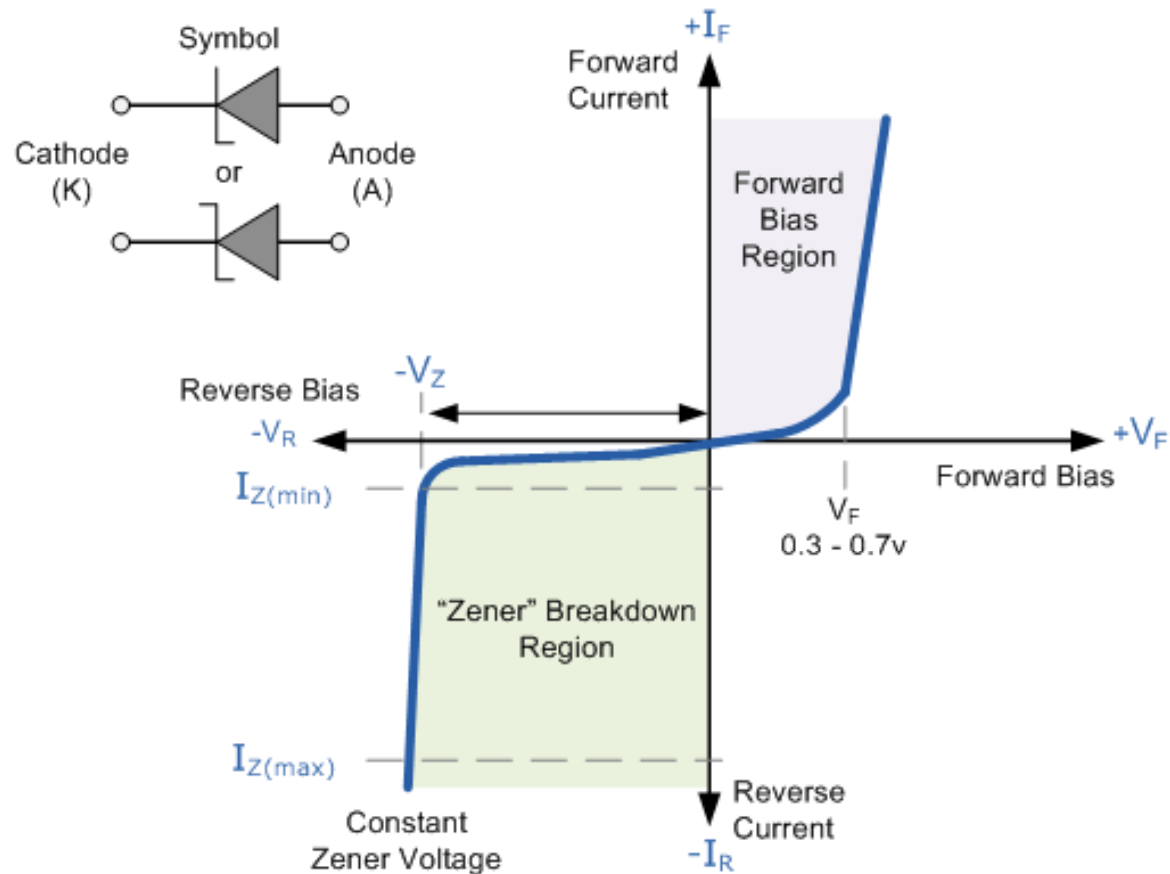


Zener Diode I-V Characteristics



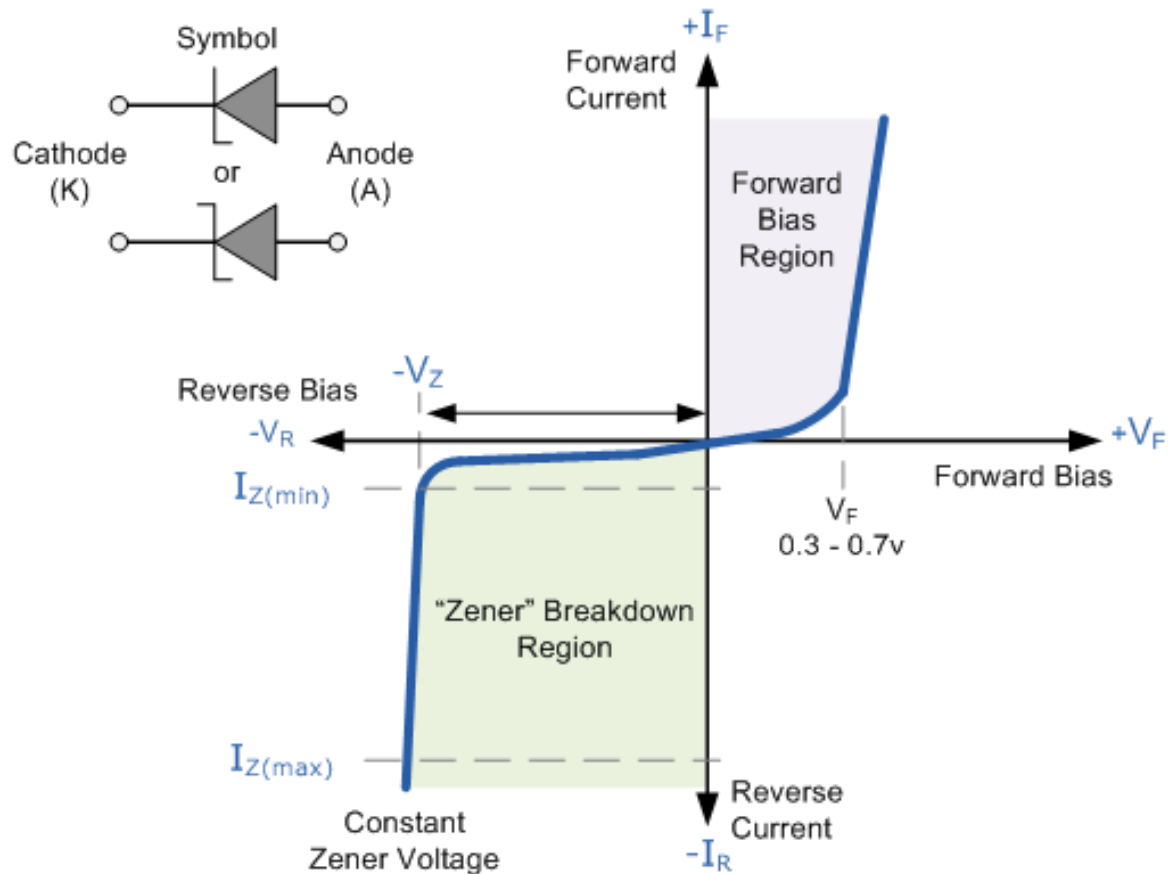
The **Zener Diode** is used in its “reverse bias” or reverse breakdown mode, i.e. the diode's anode connects to the negative supply. From the I-V characteristics curve above, we can see that the zener diode has a region in its reverse bias characteristics of almost a constant negative voltage regardless of the value of the current flowing through the diode.

Zener Diode I-V Characteristics



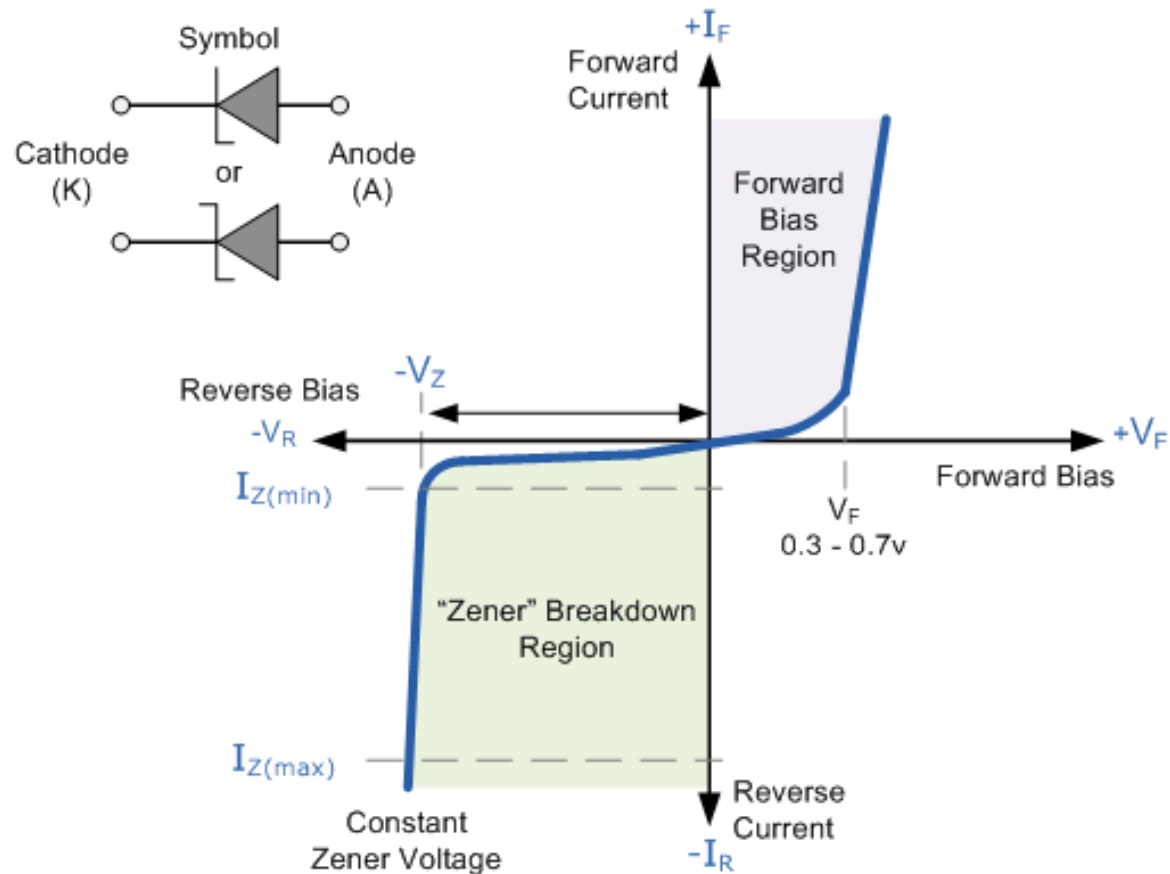
This voltage remains almost constant even with large changes in current providing the zener diodes current remains between the breakdown current $I_{Z(\min)}$ and its maximum current rating $I_{Z(\max)}$.

Zener Diode I-V Characteristics



This ability of the zener diode to control itself can be used to great effect to regulate or stabilize a voltage source against supply or load variations. The fact that the voltage across the diode in the breakdown region is almost constant turns out to be an important characteristic of the zener diode as it can be used in the simplest types of voltage regulator applications.

Zener Diode I-V Characteristics



The function of a voltage regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or variations in the load current. A zener diode will continue to regulate its voltage until the diodes holding current falls below the minimum $I_{Z(min)}$ value in the reverse breakdown region.