ZENER DIODE

A Zener diode is a type of diode that permits current not only in the forward direction like a normal diode, but also in the reverse direction if the voltage is lar ger than the breakdown voltage known as "Zener knee voltage" or "Zener voltage".

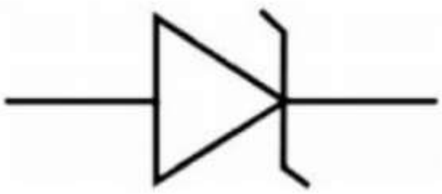

Figure 1.2.1 Diode Symbol

Diagram Source Brain Kart

However, the Zener Diode or "Breakdown Diode" as they are sometimes called, are basically the same as the standard PN junction diode but are specially designed to have a low pre-determined Reverse Breakdown Voltage that takes advantage of this high reverse voltage. The point at which a Zener diode breaks down or conducts is called the "Zener Voltage" (Vz).

The Zener diode is like a general-purpose signal diode consisting of a silicon PN junction. When biased in the forward direction it behaves just like a nor mal signal diode passing the rated current, but when a reverse voltage is applied to it the reverse saturation current remains fairly constant over a wide range of voltages. The reverse voltage increases until the diodes breakdown voltage V_B is reached at which point a process called Avalanche Breakdown occurs in the depletion lay er and the current flowing through the Zener diode increases dramatically to the maximum circuit value (which is usually limited by a series resistor). This breakdown voltage point is called the "Zener voltage" for Zener diodes.

Avalanche Breakdown:

There is a limit for the reverse voltage. Reverse voltage can increase until the diode break down voltage reaches. This point is called Avalanche Breakdown region. At this stage maximum current will flow through the Zener diode. This breakdown point is referred as “Zener voltage”.

The point at which current flows can be very accurately controlled (to less than 1% tolerance) in the doping stage of the diodes construction giving the diode a specific Zener breakdown voltage, (Vz) ranging from a few volts up to a few hundred volts. This Zener breakdown voltage on the I-V curve is almost a vertical straight line.

Zener diode characteristics

The Zener Diode is used in its "reverse bias" or reverse breakdown mode, i.e. the diodes 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 di ode and remains nearly constant even with large changes in current as long as the Zener diodes current remains between the breakdown current IZ(min) and the maximum current rating IZ(max).

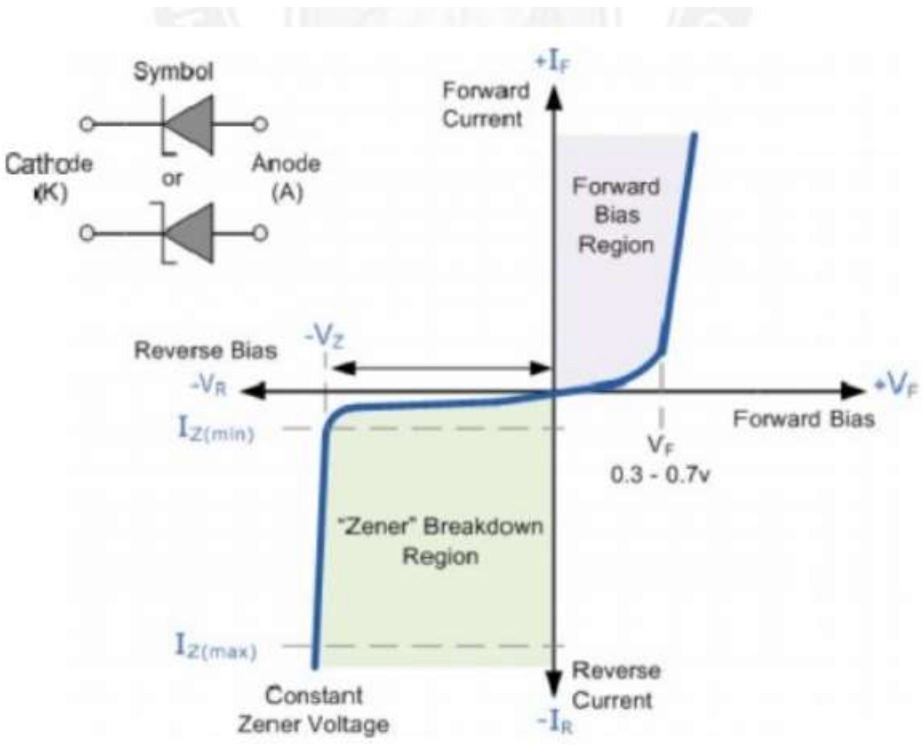

Figure 1.2.2 Zener diode characteristics

Diagram Source Brain Kart

The Zener Diode Regulator

Zener Diodes can be used to produce a stabilised voltage output with low ripple under varying load current conditions. By passing a small current through the diode from a voltage source, via a suitable current limiting resistor (R_S), the Zener diode will conduct sufficient current to maintain a voltage drop of Vout.

We remember from the previous tutorials that the DC output voltage from the half or full-wave rectifiers contains ripple superimposed onto the DC voltage and that as the load value changes to the average output voltage. By connecting a simple Zener stabiliser circuit as shown below across the output of the rectifier, a more stable output voltage can be produced.

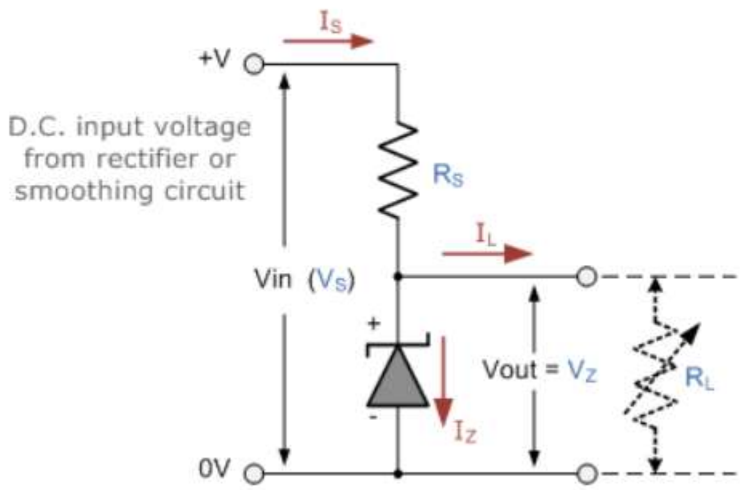

Figure 1.2.3 Zener Diode Regulator

Diagram Source Brain Kart

Resistor, R_S is connected in series with the Zener diode to limit the current flow through the diode with the voltage source, V_S being connected across the combination. The stabilised output voltage V_{out} is taken from across the Zener diode.

The Zener diode is connected with its cathode terminal connected to the positive rail of the DC supply so it is reverse biased and will be operating in its breakdown condition. Resistor R_S is selected so to limit the maximum current flowing in the circuit.

With no load connected to the circuit, the load current will be zero, ($I_L = 0$), and all the circuit current passes through the Zener diode which in turn dissipates its maximum power.

Also, a small value of the series resistor R_S will result in a greater diode current when the load resistance R_L is connected and large as this will increase the power dissipation requirement of the diode so care must be taken when selecting the appropriate value of series resistance so that the Zener's maximum power rating is not exceeded under this no-load or high-impedance condition.

The load is connected in parallel with the Zener diode, so the voltage across R_L is always the same as the Zener voltage, ($V_R = V_Z$).

There is a minimum Zener current for which the stabilisation of the voltage is effective and the Zener current must stay above this value operating under load within its breakdown region at all times. The upper limit of current is dependent upon the power rating of the device. The supply voltage V_S must be greater than V_Z.

One small problem with Zener diode stabiliser circuits is that the diode can sometimes generate electrical noise on top of the DC supply as it tries to stabilise the voltage. Normally this is not a problem for most applications but the addition of a large value decoupling capacitor across the Zener's output may be required to give additional smoothing.

Then to summarise a little. A Zener diode is always operated in its reverse biased condition. As such a simple voltage regulator circuit can be designed using a Zener diode to maintain a constant DC output voltage across the load in spite of variations in the input voltage or changes in the load current.

The Zener voltage regulator consists of a current limiting resistor R_S connected in series with the input voltage V_S with the Zener diode connected in parallel with the load R_L in this reverse biased condition. The stabilised output voltage is always selected to be the same as the breakdown voltage V_Z of the diode.