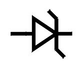
Unit 29 Zener Diodes



- A Zener diode conducts in reverse bias when the voltage is greater than the Zener voltage for the diode.

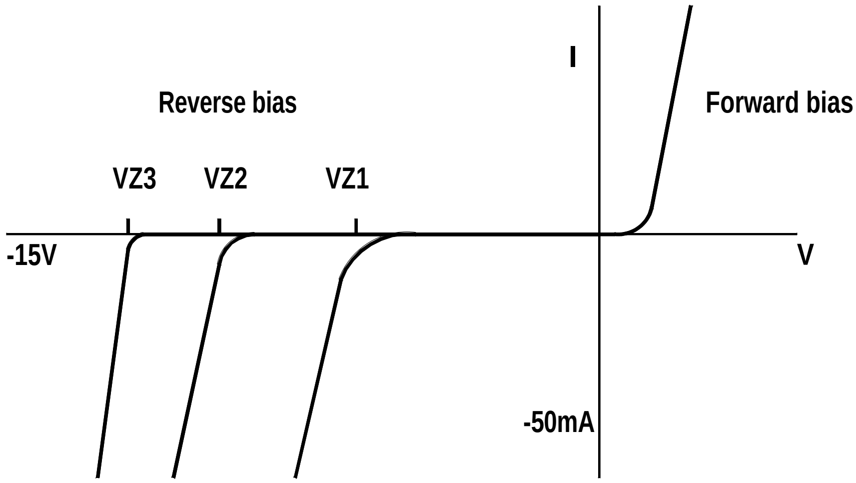
- Zener diodes are normally used in reverse bias.

- Increased doping concentrations in pn diodes reduce the reverse breakdown voltage.
- The avalanche effect dominates at large voltage.
- The Zener effect dominates at low voltages.
- Zener diode is the name for a diode which breaks down in reverse bias due to either mechanism.
- In a circuit the maximum temperature stability is obtained by using Zener diodes rated at about 6 volts.

Conduction at the peak inverse voltage (PIV)
1N4005 has a PIV of 600V
A limiting resistance prevents destruction of diode
Power = $V \times I$ gives heating
Limiting current allows recovery

Doping varies PIV from 1000V to 3V

Zener Diodes breakdown from 3 to 100V



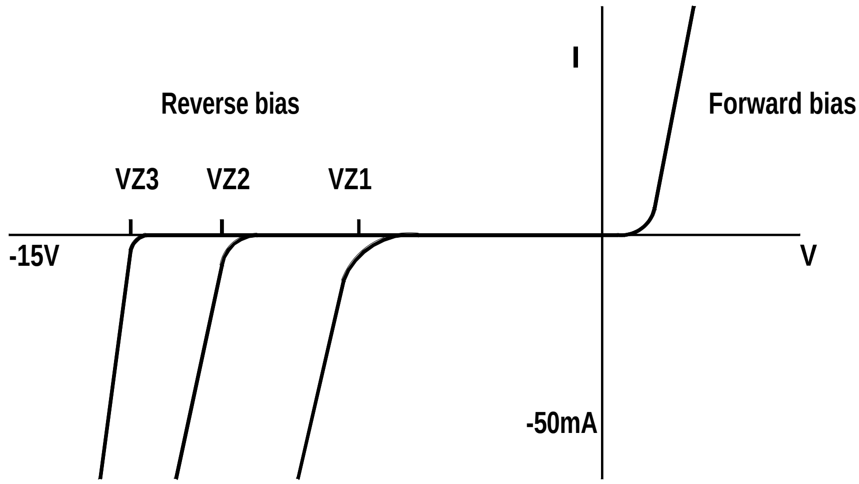
Zener diode characteristic curves

The Zener voltage is the reverse bias voltage at which the current increases rapidly for a very small change of the reverse voltage.

Two mechanisms are involved in the reverse breakdown in Zener diodes.

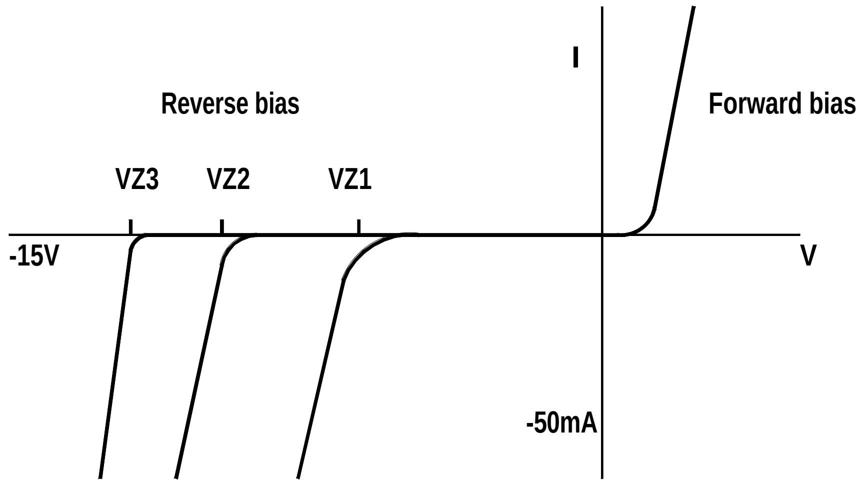
- For voltages greater than about 6 volts, the avalanche effect dominates.
  A minority carrier is accelerated across the reverse biased junction causes avalanching. Electron—hole pairs

- Below 6V, Zener effect dominates.
  Quantum mechanical tunneling of valence electrons to nearby sites in the conduction band on the other side of the junction.
  The junction must be very thin
  Implies high doping levels to keep the depletion layer thin when the reverse bias is applied.



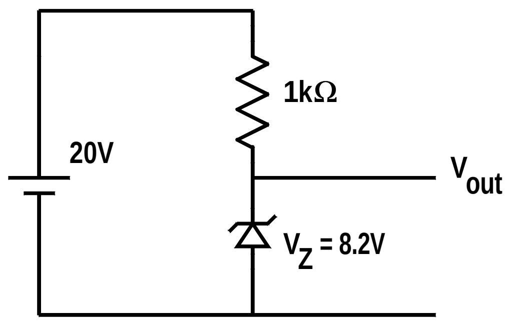
- The sharpness of onset of breakdown increases with increasing breakdown voltage.

- The slope of the I–V characteristic changes with breakdown voltage.



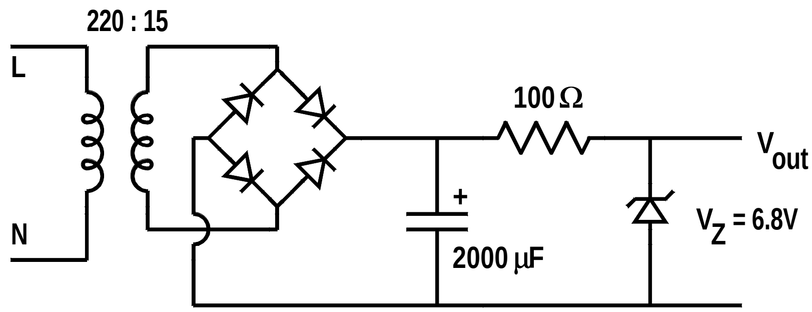
- The temperature coefficient of breakdown voltage is negative for Zener mechanism and positive for avalanche mechanism.

- Change over at about 6 volts Temperature coefficient is then nearly zero

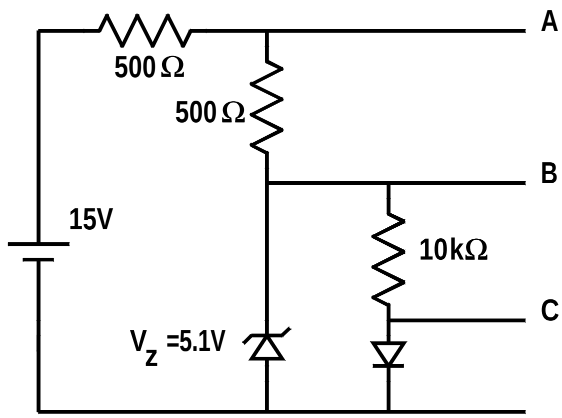


Zener diode voltage regulator
Max current with $V_{out} > 8.2V$

Diode is reverse biased
V_{out} will be 8.2V.
Current in $1k\Omega$ is $\frac{20-8.2}{1k\Omega} = 11.8mA$.
This 11.8mA also flows in the Zener diode.
Some current is diverted into external load
Output voltage is at 8.2V while some current flows in the reverse biased Zener diode.



19V across 200μF capacitor
Current in the 100Ω is $\frac{19-6.8}{100} = 0.12A$
Maximum regulated current available.
Mains voltage drop by 10% to 200V
gives 17V across the capacitor.
Worst case of 15.5 across the capacitor.
Current in 100Ω is $\frac{15.5-6.8}{100} = 0.09A$
More conservative estimate of max current



Calculate voltages at points A, B and C

Diode is forward biased, $V_C = 0.7V$
Zener diode is reverse biased, $V_B = 5.1V$
Two 500Ω form potential divider

$$I = \frac{15 - 5.1}{500 + 500} = 9.9mA$$

$$V_A = 9.9mA \times 500 + 5.1 = 10.05V$$