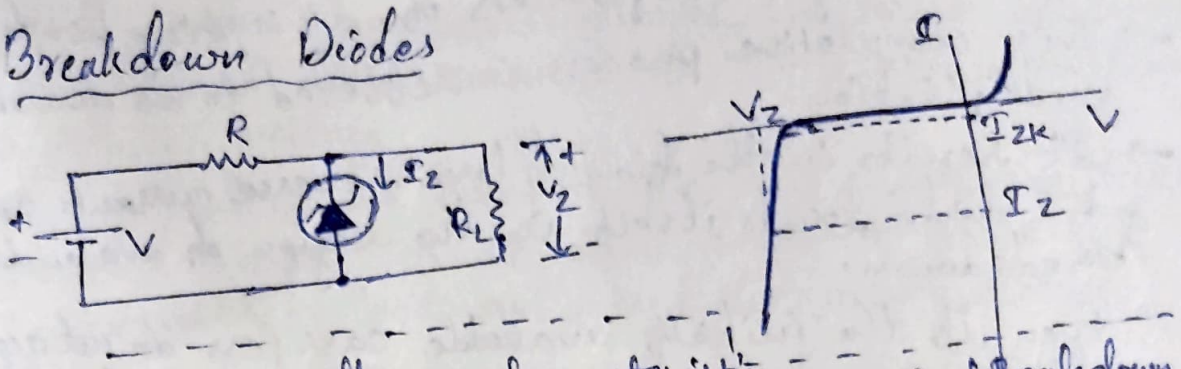
Breakdown Diodes



→ The reverse-voltage characteristic of a semiconductor diode, including the breakdown region is shown above.

→ Diodes which are designed with adequate power dissipation capabilities to operate in the breakdown region may be employed as voltage-reference or constant voltage devices.

→ Such diodes are known as avalanche breakdown or Zener diodes

→ The source V and resistor R are selected so that the diode is operating in breakdown region.

→ Diode voltage, which is also the voltage across the load R_L is V_Z and the diode current is I_Z.

→ Diode will now regulate the load voltage against variations in load current and against variations in supply voltage V because, in the breakdown region, large changes in diode current produce only small changes in diode voltage.

→ The diode will continue to regulate until the circuit operation requires the diode current to fall to I_{ZK}, in the neighborhood of the knee of the diode volt-ampere curve.

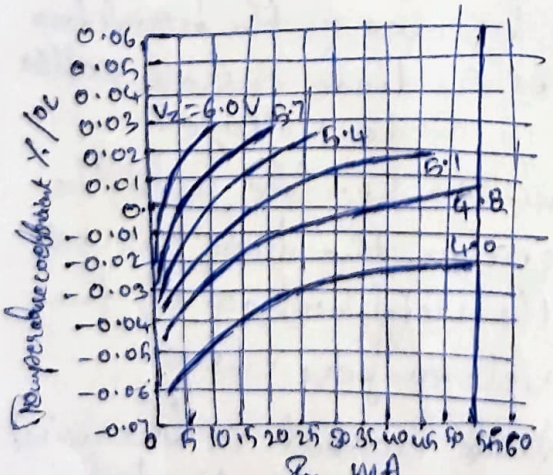
→ The upper limit of diode current is determined by the power-dissipation rating of the diode.

→ There are two mechanisms of diode breakdown for increasing reverse voltage.

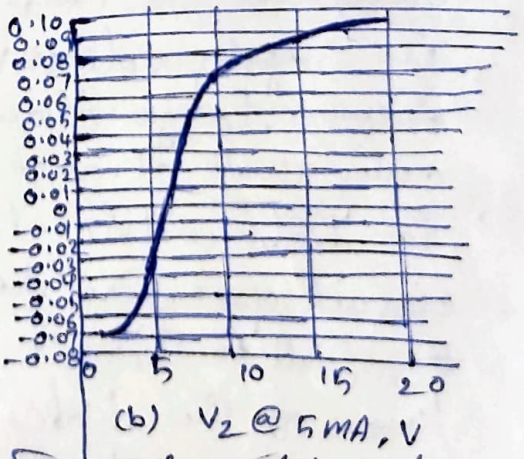
→ In one mechanism, the thermally generated electrons and holes acquire sufficient energy from the appli→

→ potential to produce new carriers by removing valence electrons from their bonds.
→ These new carriers, in turn, produce additional carriers again through the process of disrupting bonds.
→ This cumulative process is refered to as avalanche multiplication.
→ It results in the flow of large reverse currents and the diode looks itself in the region of avalanche breakdown.
→ Even if the initially available carriers do not acquire sufficient energy to disrupt bonds, it is possible to initiate breakdown through a direct rupture of bonds because of existence of strong electric field.
→ Under this circumstances the breakdown is refered to as zener breakdown.
→ This zener effect plays an important role only in diodes with breakdown voltages below about 6V.
→ The term 'zener' is commonly used for avalanche or breakdown diode even at higher voltages.
→ Silicon diodes operated in avalanche breakdown are available with maintaining voltages from several volts to several hundred volts and with power ratings up to 50W.

→ Temperature Characteristics



(a) as a function of operating voltage.



Temperature coefficients for a number of zener diodes having different operating voltages operating current (b) as function

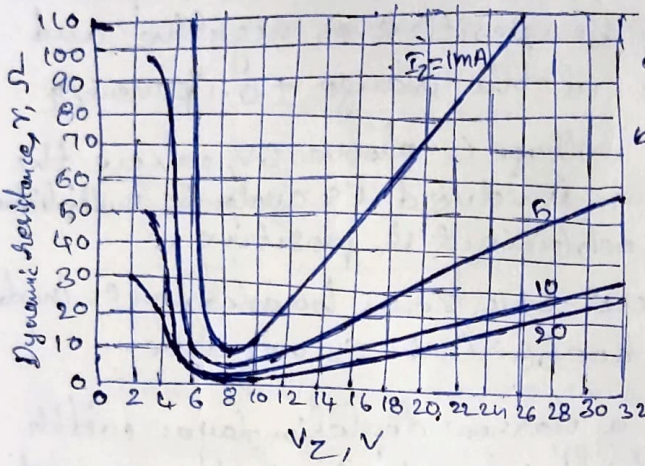
→ The temperature coefficient is given as percentage change reference voltage per centigrade change in diode temperature.

→ Therefore the value of avalanche voltage must increase with increased temperature.

→ Dynamic Resistance and [redacted]

→ For a Zener diode, if the reciprocal slope $\Delta V_Z / \Delta I_Z$, called dynamic resistance, is r, then a change ΔI_Z in the operating current of the diode produces a change $\Delta V_Z = r \Delta I_Z$ in the operating voltage.

→ Ideally, $r = 0$, corresponding to a volt-ampere curve which, in the breakdown region, is precisely vertical.



Dynamic resistance at a number of currents for Zener diodes of different operating voltages at 25°C

→ The broader minimum occurs in the range 6 to 10V, and at large V_Z and small I_Z, the dynamic resistance r may become quite large.

→ The capacitance across a breakdown diode is the transition capacitance and hence varies inversely as some power of voltage.

→ Since C_T is proportional to cross-sectional area of the diode, high-power avalanche diodes have very large capacitances

→ Values of C_T from 10 to 10,000 pF are common.

PN Junction as a Rectifier

→ One of the important applications of the diode is the rectifier circuits.

→ These circuits are used to convert the ac i/p of the normal available power supply into a dc o/p.

→ The dc source of power is an important requirement in almost all electronic systems like televisions, stereos and computers.

→ However, the o/p of a rectifier circuit always contains some ac components.