TRANSITION AND DIFFUSION CAPACITANCES:

1. Maximum Forward Current

The Maximum Forward Current (IF(max)) is as its name implies the maximum forward current allowed to flow through the device. When the diode is conducting in the forward bias condition, it has a very small "ON" resistance across the PN junction and therefore, power is dissipated across this junction (Ohm´s Law) in the form of heat.

Then, exceeding its (IF(max)) value will cause more heat to be generated across the junction and the diode will fail due to thermal overload, usually with destructive consequences. When operating diodes around their maximum current ratings it is always best to provide additional cooling to dissipate the heat produced by the diode.

For example, our small 1N4148 signal diode has a maximum current rating of about 150mA with a power dissipation of 500mW at 25oC. Then a resistor must be used in series with the diode to limit the forward current, (IF(max)) through it to below this value.

2. Peak Inverse Voltage

The Peak Inverse Voltage (PIV) or Maximum Reverse Voltage (VR(max)), is the maximum allowable Reverse operating voltage that can be applied across the diode without reverse breakdown and damage occurring to the device. This rating therefore, is usually less than the "avalanche breakdown" level on the reverse bias characteristic curve. Typical values of VR(max) range from a few volts to thousands of volts and must be considered when replacing a diode.

The peak inverse voltage is an important parameter and is mainly used for rectifying diodes in AC rectifier circuits with reference to the amplitude of the voltage were the sinusoidal waveform changes from a positive to a negative value on each and every cycle.

3. Forward Power Dissipation

Signal diodes have a Forward Power Dissipation, (PD(max)) rating. This rating is the maximum possible power dissipation of the diode when it is forward biased (conducting). When current flows through the signal diode the biasing of the PN junction is not perfect and offers some resistance to the flow of current resulting in power being dissipated (lost) in the diode in the form of heat.

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As small signal diodes are nonlinear devices the resistance of the PN junction is not constant, it is a dynamic property then we cannot use Ohms Law to define the power in terms of current and resistance or voltage and resistance as we can for resistors. Then to find the power that will be dissipated by the diode we must multiply the voltage drop across it times the current flowing through it: PD = VxI

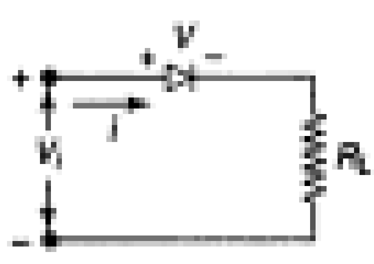
4. Maximum Operating Temperature

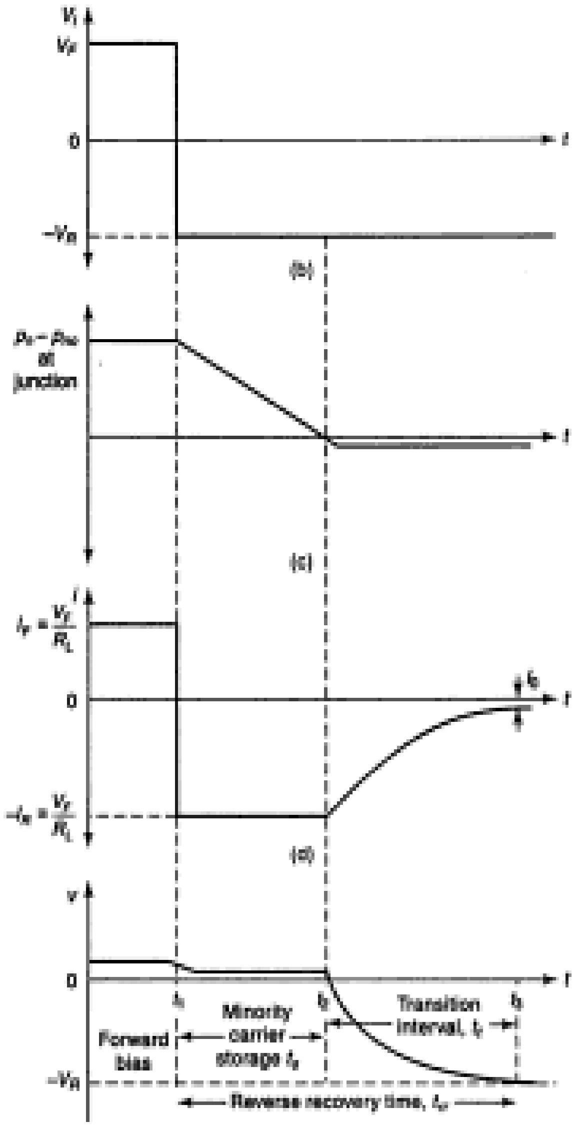
The Maximum Operating Temperature actually relates to the Junction Temperature (TJ) of the diode and is related to maximum power dissipation. It is the maximum temperature allowable before the structure of the diode deteriorates and is expressed in units of degrees centigrade per Watt, (oC/W). This value is linked closely to the maximum forward current of the device so that at this value the temperature of the junction is not exceeded. However, the maximum forward current will also depend upon the ambient temperature in which the device is operating so the maximum forward current is usually quoted for two or more ambient temperature values such as 25oC or 70oC.

SWITCHING CHARACTERISTICS

Diodes are often used in switching mode. When the applied bias voltage to the PN diode is suddenly reversed in opposite direction and it reaches a steady state at a interval of time that is called the **recovery time**. Forward recovery time is defined is the time required the forward voltage or current to reach a specified value after switching diode from its reverse to forward biased state.

When PN diode is forward biased the minority electrons concentration in P region is linear. If the junction is suddenly reversed at t1 then because of stored electronic charge, the reverse current I_R is initially of the same magnitude as forward current I_F.





The diode will continue to conduct until the injected or excess minority carrier density (p-po) or (n-no) has dropped to zero shown in fig. c.

In fig. b the applied voltage Vi = V_F for the time up to t1 is in the direction to forward bias the diode. The resistance R_L is large so that the drop across R_L is large when compared to the drop across diode. Then the current is I= V_F / R_L = I

At time t=t1 the input voltage is reversed to the value of $-V_R$ current does not become zero and the value is I= V_R / R_L = I_R shown in fig d..

During the time interval from t1 to t2 the injected minority carriers have remained stored and hence this interval is called the **storage time (t1).**

After the instant t=t2, the diode gradually recovers and ultimately reaches the steady state. The time interval between t2 and instant t3 when the diode has recovered nominally is called the **transition time t_t.**

The recovery said to have completed (i) when even the minority carriers remote from the junction have difference to the junction and crossed it. (ii) when the junction transition capacitance C across the reverse biased junction has got charged through the external resistor R_L to the voltage $-V_R$.

For commercial switching type diodes the reverse recovery time t_{rr} ranges from less than 1ns up to as high as 1us.

In order to minimize the effect of reverse current the time period of the operating frequency should be a minimum of approximately 10 times t_{rr}. For example if diode has t_{rr} of 2ns its operating frequency is

$$f_{max} = \frac{1}{T} = \frac{1}{10 \times t_{rr}} = \frac{1}{10 \times 2 \times 10^{-9}} = 50 \text{ MHz}$$

The reverse recovery time can be reduced b shortening the length of the P region in a PN junction diode.

The stored storage and switching time can be reduced by introduction of gold impurities into junction diode by diffusion. The gold dopant also called a **life time killer**, increases the recombination rate and removes the stored minority carriers.

This technique is used to produce diodes and other active devices for high speed applications.

APPLICATION OF PN DIODE

- Can be used as rectifier in DC Power Supplies.
- In Demodulation or Detector Circuits.
- In clamping networks used as DC Restorers
- In clipping circuits used for waveform generation.
- As switches in digital logic circuits.
- In demodulation circuits