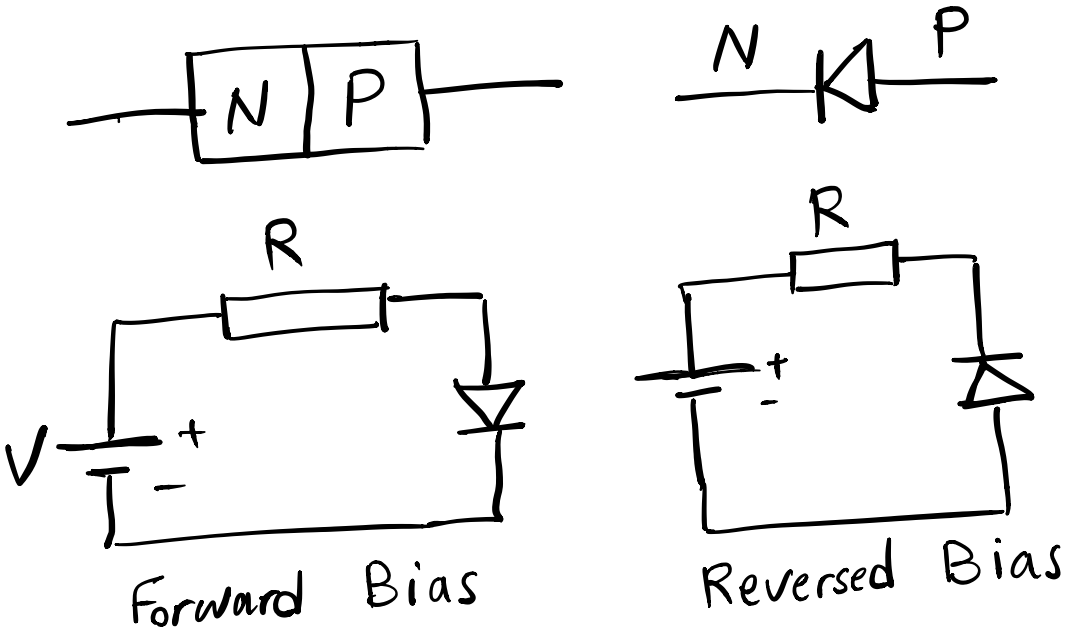
Diodes

Diodes are components that restrict the direction of flow of charge carries. A Diode allows an electric current to flow in one direction, but blocks it in the opposite direction. Thus, the diode can be thaught of as an electronic version of a check valve. Circuits that require current flow in only one direction typically include one or more diodes in the circuit design.

- Semiconductor Diodes

Most modern diodes are based on semiconductor P-N junctions.

In a P-N diode, conventional current can flow from the p-type side (the anode) to the N-type side (the cathode), but cannot flow in the opposite direction. Figure below shows the construction, symbol, forward and reverse connection.



Diodes allow electricity to flow in only one direction. The arrow of the circuit symbol shows the direction in which the current can flow.

Forward Voltage Drop

Electricity uses up a little energy pushing its way through the diode, rather like a person pushing through a door with a spring. This means that there is a small voltage across a conducting diode, it is called the forward voltage drop and is about 0.7V for normal diodes which are made from silicon.

Reverse voltage

when a reverse voltage is applied a perfect diode does not conduct, but all real diodes leak a very tiny current of a few μA or less. This can be ignored in most circuits it will be very small compared with the current flowing in the forward direction. However, all diodes have a maximum reverse voltage (usually 50 V or more) and if this is exceeded the diode will fail and pass a large current in the reverse direction, this is called beakdown.

- Diode characteristics

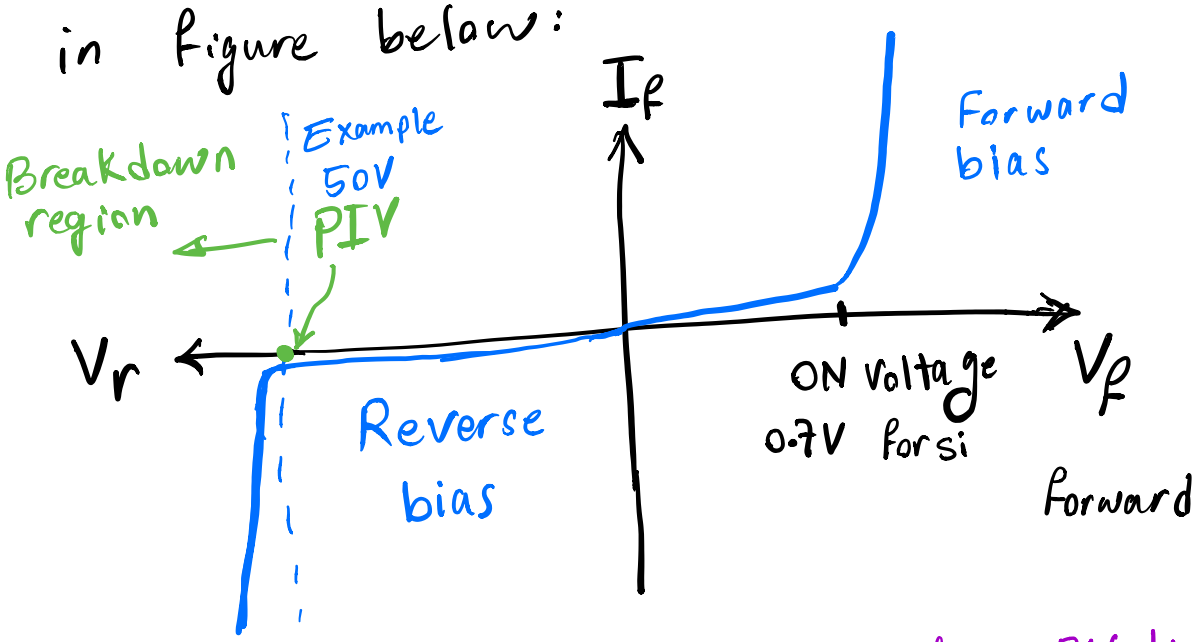
A diodés I-V characteristic can be approximated by two regions of operation. Below a certain difference in potential between the two leads, and the diode can be thought of as an open (non-conductive) circuit. As the potential difference is increased, at some stage the diode will become conductive, at which point it can be thought of as a connection with zero (or at least very low) resistance. In a normal silicon diode at rated

currents, the voltage drop across a a conducting diode is approximately 0.6 to 0.7 volts for silicon diode and 0.2 - 0.3 for Germanium diode.

Inside the diode the current experience some resistance, which is known as the internal or bulk resistance (R_B). It is typically consists of the N-type resistance plus the P-type material resistance. It has a typical value of 1 ohm.

$$r_B = r_N + r_P$$

Reffering to the I-V characteristics in figure below:



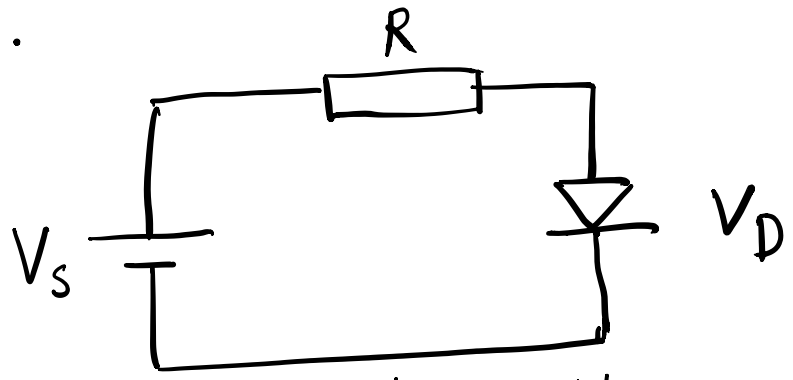
I-V characteristics of a PN diode

In the reverse bias region for a normal P-N diode the current through the device is very low (in the μA range) for all voltages up to a point called the peak-inverse-votage (PIV) Beyond this point a process called reverse breakdown occurs which causes

the device to be damaged with a large increase in current.

For special purpose diodes like the avalanche or zener diodes, the concept of PIV is not applicable since they have a deliberate Breakdown beyond a Known reverse current such that the revese voltage is "clamped" to a Known value (called the zener voltage or breakdown voltage). These devices however a maximum limit to to the current and power in the zener or avalanche region.

The diodes are normally cascaded in circuits with a current limiting resistor, this resistor is connected in series with the diode and it is used to control the maximum current that passes through the diode.



R: current limiting resistor

In the figure above the maximum current that pass through the diode can be defined by the following equation:

$$I = (V_S - V_D)/R$$

and the maximum power dissipation, can be defined by the maximum power that the diode can dissipate without degrading its performance or reducing its life:

$$P = V_D \times I$$

wher P is the power in the diode, I is the diode current and V_D is the voltage across the diode.

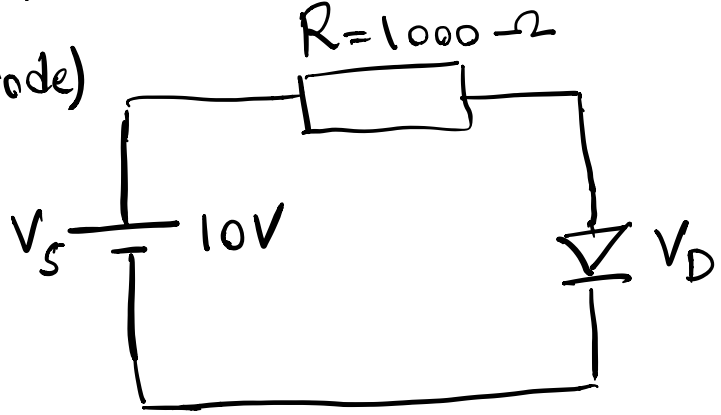
Example

A diode has $r_p = 0.13$ ohm and $r_N = 0.1\ \Omega$, what is its bulk resistance?

$$r_B = r_N + r_p = 0.13 + 0.1 = 0.23 \text{ ohms}$$

Example

For the circuit shown, Find the diode current.
(Assume silicon diode)



$$V_S = RI + V_D$$

$$I = (V_S - V_D)/R = \frac{10 - 0.7}{1000} = 9.3 \text{ mA}$$

Example

The voltage across a diode (For example diode 1N4001) is 0.93 V when the current is 1A, what is the power dissipated by the diode?

$$P = V_D \times I = 0.93 \times 1 = 0.93 \text{ watt}$$