Diodes

Introduction

A diode is made of a semi-conductor between a conductor and an insulator (conductor - semi-conductor - insulator). Resistivity increases when going from right to left and vice versa.

Doping

Doping is adding impurities to a material to change it's properties. When silicon is doped with boron, the positive charges of silicon are more than the negative charges (P-type). However when silicon is doped with phosphrous, the negative charges are more than the positive charges (N-type).

Diode (The non-linear element)

A diode is the combination of a P-type and an N-type with a depletion region in between.

Connecting the diode to a battery of voltage V_s able to break the depletion region leads to a current passing from the P-type side to the N-type side.

Diodes act like a closed switch when (Forward mode):

$$V_a > V_k V_{\text{ak}} > V_{\text{Do}}$$

(a $\rightarrow$ anode, k $\rightarrow$ cathode, $V_{\text{Do}} \rightarrow$ depletion breaking voltage)

and an open switch when (Reverse mode):

$$V_a < V_k V_{\text{ak}} < V_{\text{Do}}$$

Therefore the current passing through a diode:

$$I = I_s\left(e^{\frac{V}{\eta}V_T} - 1\right)$$

"η" is the ideality factor of the diode. "I_s" is the reverse saturation current passing through the diode in the reverse mode (Theoretically equals zero). "V_T" is the thermal voltage which is the voltage affected by heat.

$$V_T = \frac{\text{kT}}{q}$$

Where T is the temprature, k is the boltzman constant and q is the electron charge.

Diode (Electronic Valve) Models

1. Ideal model
2. Approximate model
3. Actual model

Ideal model

In an ideal model, in a forward connection the diode is replaced by a closed switch and by an open switch in a reverse connection.

Approximate model

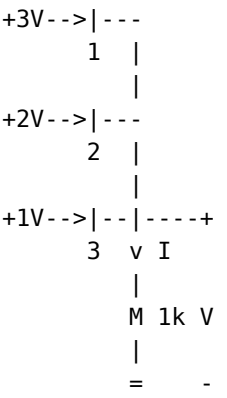
In an approximate model, in a forward connection the diode is replaced by a battery of voltage ranging between 0.3V and 0.7V and by an open switch in a reverse connection.

Actual model

In an actual model, in a forward connection the diode is replaced with a battery of voltage V_{Do} series with a resistance of r and by an open switch in a reverse connection.

Examples

1. Find V and I in the opposite circuit.



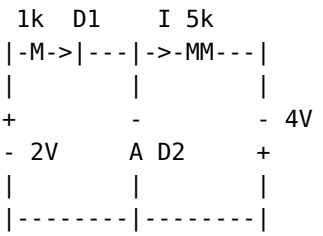
sol:

1. Assume that the diode with the most voltage is the 'on' diode.

$$\therefore V = 3V$$

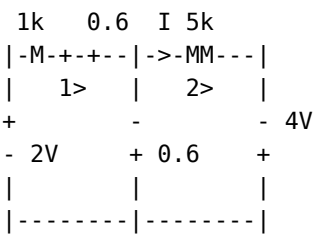
$$\therefore I = \frac{3}{1000}\ \text{mA}$$

2. Find "I" assuming an approximate model ($V_{\text{Do}} = 0.6V$)



sol:

1. Assume both diodes are on:



Using mesh analysis: mesh 1:

$$2 - 0.6 + 0.6 = I_1(1)$$

$$\therefore I = 2\text{mA}$$

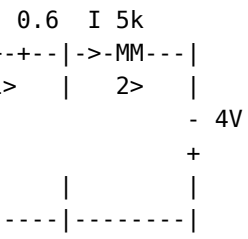
mesh 2:

$$-0.6 + 4 = I_2(5)$$

$$\therefore I_2 = 0.68\text{mA}$$

2. Using the directions of the currents obtained:

D_1 is on while D_2 is off.



Using KVL:

$$0 = 2 + I + 0.6 + 5I - 4$$

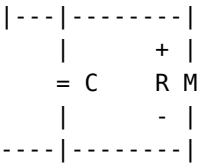
$$\therefore I =$$

Diode Applications

The Rectifier Circuit

The rectifier circuit converts the AC to a DC.

1. Half Wave Rectifier



2. Full Wave Rectifier

TODO

The DC from FWR > DC from HWR