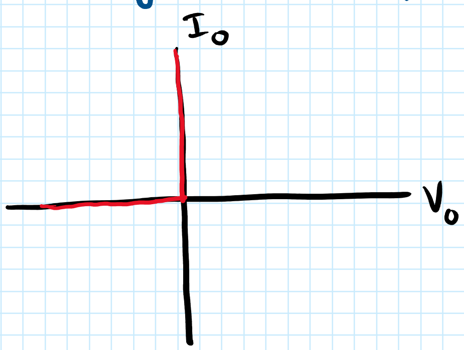
IDEAL & PRACTICAL DIODE

Ideal diode:

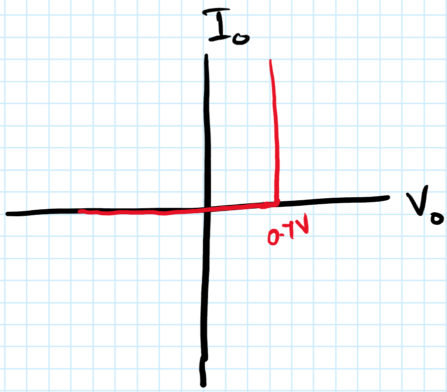
- When in forward bias, it offers no resistance and hence acts as a closed switch
- There is no cut in / knee voltage required
- When in reverse bias, it offers infinite resistance; hence acts as an open switch
- There is no reverse saturation (leakage) current

Practical diode:

- In forward bias, it starts conducting only after a certain knee voltage is supplied.
- In reverse bias, there is no current due to majority carriers
- There is a current from minority carriers that is ignored. Hence, practically acts as open switch



Ideal



Practical

TEMPERATURE EFFECTS ON V-I CHARACTERISTICS OF DIODE

Temperature ↑ ⟶ more e^- and hole pairs ⟶ Conductivity ↑, Current ↑

Under Forward Bias:

Barrier voltage: inversely dependent on temperature

- decreases by 2.5 mV / 1°C rise in temp. for Ge, Si

Knee voltage: inversely dependent on temperature

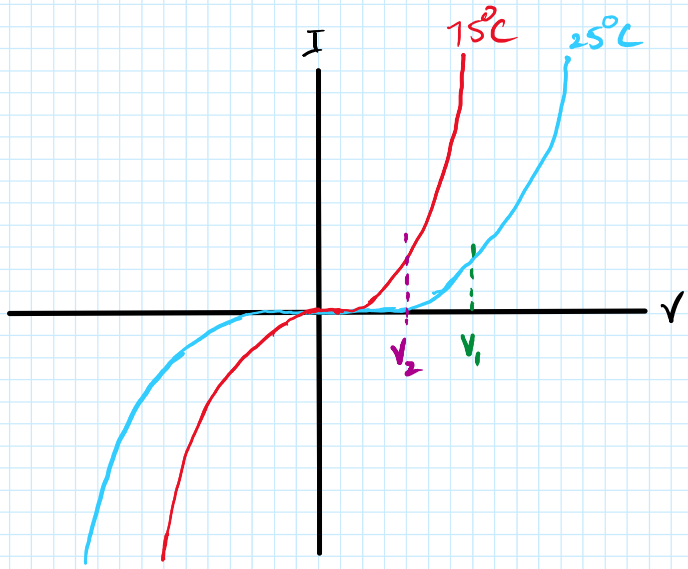
Under Reverse Bias:

Reverse saturation current: dependent on temperature

- as minority carriers increases with rise in temp., reverse saturation

- as minority carriers increases with rise in temp., reverse saturation current increases
- rise is 7% / 1°C rise in temp. for Ge, Si
- approximately doubles for every 10°C rise

Reverse breakdown voltage:



NUMERICALS

① Reverse saturation current of silicon diode at 20°C is 0.1 μA. Determine its value if the temperature is increased by 40°C.

Soln. Given $T = 20°C$, $I_s = 0.1\ \mu A$

w.k.t. I_s doubles for every 10°C increase.

Hence,

$T = 30°C$, $I_s = 0.2\ \mu A$

$T = 40°C$, $I_s = 0.4\ \mu A$

$T = 50°C$, $I_s = 0.8\ \mu A$

$T = 60°C$, $I_s = 1.6\ \mu A$

② Knee voltage of Si diode is 0.7 V and reverse saturation current is 20 nA at 25°C. Determine these values at 40°C.

Soln. Rate of decrease of knee voltage = 2.5 mV / 1°C

Decrease in knee voltage here = $(2.5)(40-25) = (2.5)(15) = 37.5\ mV = 0.0375\ V$

Knee voltage at 40°C = $0.7 - 0.0375 = 0.6625\ V$

For reverse saturation current,

$\uparrow 10^\circ C \longrightarrow$ doubles

$\Rightarrow$ Rate of increase $= 2^{\left(\frac{\Delta T}{10}\right)}$

$= 2^{\left(\frac{15}{10}\right)}$

$= 2.828$

Reverse saturation at $40^\circ = (2.828)(20 \times 10^{-9})$

$= \underline{\underline{5.656 \times 10^{-8}}}$

(3) Reverse saturation current of a Ge diode is 200 µA at room temperature 27°C. Calculate the current in forward biased condition if forward biased voltage is 0.2 V at room temp. If temp. is increased by 30°C, calculate reverse saturation current and forward current for same forward voltage at new temperature.

Soln:

$I_D = I_S\left[e^{\frac{qV_D}{nKT}} - 1\right]$

$I_D = 200 \times 10^{-6}\left[e^{\frac{q(0.2)}{(1)(k)(300)}} - 1\right]$

$= \underline{\underline{0.454 \text{ A}}}$

Now if temp is increased by 30°C:

$T_n = 27 + 30 + 273 = 330 \text{ K}$

$I_{S_1} = 200 \times 10^{-6}$

w.k.t. I_S doubles for every 10° jump.

$\Rightarrow I_{S_2} = 2^{\left(\frac{30}{10}\right)} \times 200 \times 10^{-6}$

$= \underline{\underline{1.6 \times 10^{-3}}}$

$I_{D_2} = I_{S_2}\left[e^{\frac{q(0.2)}{k(330)}} - 1\right]$

$= 1.6 \times 10^{-3}\left[e^{\frac{q(0.2)}{330\,K}} - 1\right]$

$= \underline{\underline{1.8 \text{ A}}}$