EECS 312 – Electronic Circuits I –Notes
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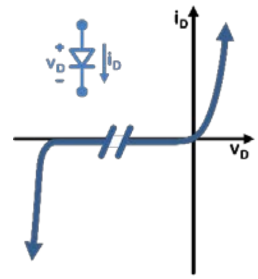
The Junction Diode and Models

Expanding on the non-ideal behavior of valves, actual diodes also differ from the ideal diodes.

1. There needs to be a small potential before the diode turns on.
2. It does not turn on instantaneously. There is a smooth increase.
3. The i-v plot never goes completely vertical.
4. There is a small leakage current in the for negative voltages.
5. The diode will breakdown at large negative voltages.



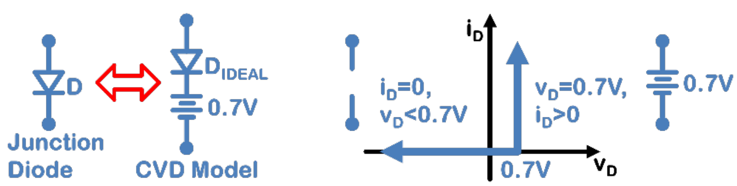
For many circuits, the voltages are never large (negative) enough to push the diode into breakdown and this region can be ignored. In doing so, the i-v relationship is described using an exponential function (derived from semiconductor physics):

$$i_D = I_S\left(e^{\frac{v_D}{nV_T}} - 1\right) \qquad \text{or} \qquad v_D = nV_T ln(i_D/I_S + 1)$$

Where i_D is the diode current, v_D is the diode voltage, I_S is a scaling or saturation current (typicall 1×10^{-8} to $1x10^{-15}$ A), V_T is the thermal voltage ($V_T = k{\cdot}T/q$, typically 0.025V), and n is a factor ranging between 1 & 2. The exponential model can be approximated for $v_D >> 0$ and $v_D << 0$.

FB approximation ($v_D >> 0$): $i_D = I_S e^{\frac{v_D}{nV_T}}$ or $v_D = nV_T ln(i_D/I_S)$
RB approximation ($v_D << 0$): $i_D = -I_S$

The exponential equation is convenient and can be used for both FB and RB, but it is difficult to use for solving circuits. As a result, we can use simplified models that account for just the positive potential need to turn the diode "on" to address difference #2. This model is referred to as the Constant Voltage Drop (CVD) model and typically uses 0.7V to model the turn on voltage. The figure below shows the junction diode modeled as an ideal diode in series with a 0.7V battery (the 0.7V CVD model).



This model is useful for quick analysis of circuit at DC with junction diodes. The process involves replacing each junction diode with the CVD model, and then using the 5-step process outlined previously. Additionally, a small series resistance can also be added to account for difference #3 above (the plot never goes completely vertical), although determining the resistance value is not always straight forward (see next notes page). This model is referred to as the piecewise linear (PWL) or battery plus resistance model.