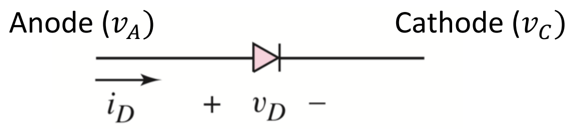
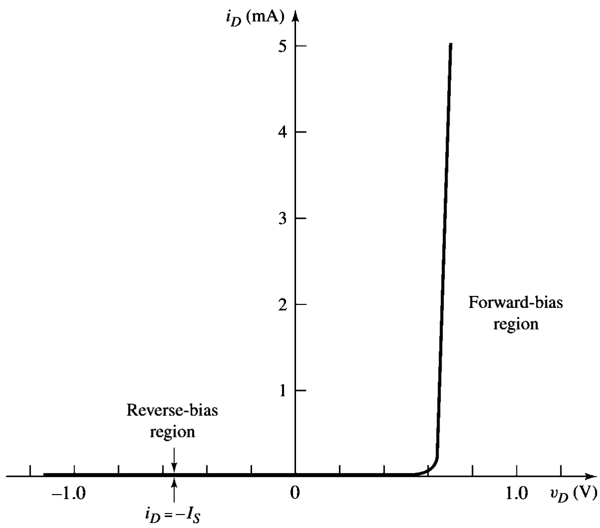
1. IV curve of a real diode



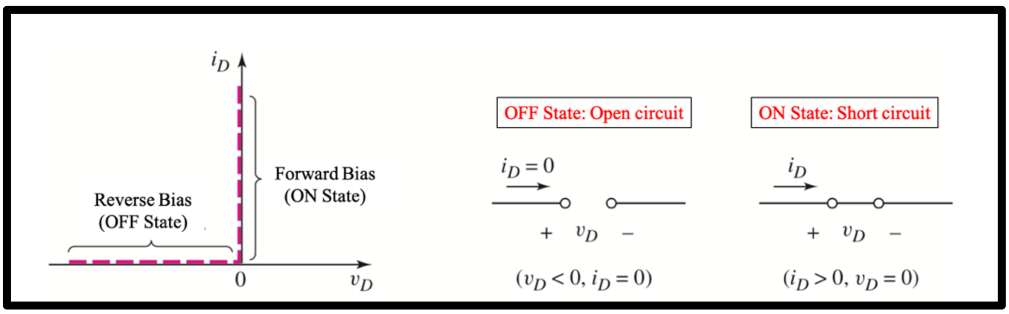
Forward Bias: $v_A > v_C$ [v_D positive]
Reverse Bias: $v_A \leq v_C$ [v_D negative]



Equation: $i_D = I_S\left(e^{\frac{v_D}{V_T}} - 1\right)$
where v_D $(= v_A - v_C)$ is the voltage across the diode, i_D is the current through the diode (from anode to cathode) and V_T, called the thermal voltage, is a temperature dependent constant. For temperature $T = 300K$, $V_T = 25\ mV$.

2. Diode models (for rapid analysis)

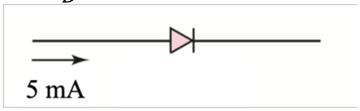
2.1. Ideal diode model



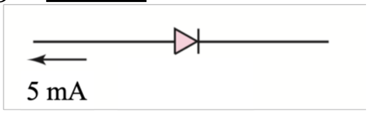
In this model, we say the diode is ON *if the current through the diode is positive* and replace it with a short circuit. Hence, the voltage across the diode is zero in this case. *If the voltage across the diode is negative* ($v_C \geq v_A$),

then we say the diode is OFF and replace it with an open circuit. Thus, in this case, the current through the diode is zero.
So, to check if a diode is ON, we need to check the current through it (if positive, then ON) and to check if a diode is OFF, we need to check the voltage across it (if negative, then OFF).

Remember 1:
We define the diode current i_D from anode to cathode. So,

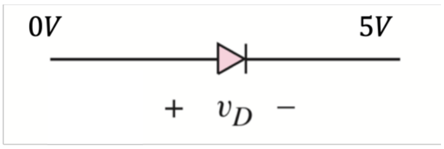


in this case the current i_D is *positive* and the diode is ON. And for this case



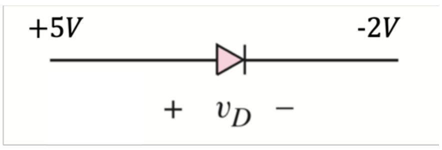
the current i_D is *negative* and the diode is **not** ON (in fact, this is not possible).

Remember 2:
We define the diode voltage v_D as the voltage of anode with respect to the voltage of cathode. For example:



$$\boxed{\begin{array}{l} v_A = 0V \\ v_C = 5V \\ v_D = v_A - v_C = 0 - 5 = -5V \end{array}}$$

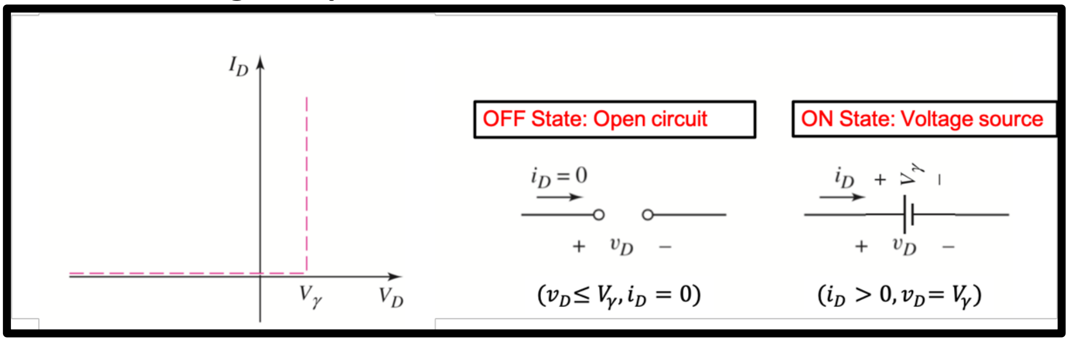
In this case, the voltage v_D across the diode is *negative* and the diode is OFF. Again



$$\boxed{\begin{array}{l} v_A = 5V \\ v_C = -2V \\ v_D = v_A - v_C = 5 - (-2) = 7V \end{array}}$$

in this case, the voltage v_D across the diode is *positive* and the diode is **not** OFF (in fact, this is not possible).

2.2. Constant voltage drop model



In this model, we say the diode is **ON** *if the current through the diode is positive* and replace it with a voltage source. Hence, the voltage across the diode is constant (V_γ) in this case. *If the voltage across the diode is less than or equals to* V_γ ($v_D \leq V_\gamma$), then we say the diode is **OFF** and replace it with an open circuit. Thus, in this case, the current through the diode is zero. Typical value of V_γ for silicon diode is $0.7V$. For ideal diode model, $V_\gamma = 0V$.

3. Method of assumed state [From Neaman]

Analyzing multi-diode circuits requires determining if the individual devices are ON or OFF. In many cases, the choice is not obvious, so we must initially guess the state of each device, then analyze the circuit to determine if we have a solution consistent with our initial guess. To do this, we can:

i. **Assume** the state of a diode. If a diode is assumed ON, the voltage across the diode is assumed to be V_γ(Voltage source or short circuit). If a diode is assumed to be OFF, the current through the diode is assumed to be zero (Open circuit).

ii. **Analyze** the "linear" circuit with the assumed diode states.

iii. **Evaluate** the resulting state of each diode.

If the initial assumption were that a diode is OFF and the analysis shows that $V_D \leq V_\gamma$, then the assumption is *correct*. If, however, the analysis actually shows that $V_D > V_\gamma$, then the initial assumption is *incorrect*.

Similarly, if the initial assumption were that a diode is ON and the analysis shows that $I_D > 0$, then the initial assumption is *correct*. If, however, the analysis shows that $I_D \leq 0$, then the initial assumption is *incorrect*.

iv. If ***any*** initial assumption is proven incorrect, then a new assumption must be made and the new "linear" circuit must be analyzed. Step iii must then be repeated.

4. Examples

Please go through the following examples for better understanding. See class notes for detailed solutions of some of these problems.

Sedra: Example 4.2, Exercise 4.4
Neaman: Example 2.9, 2.10, 2.11 Exercise 2.9, 2.10, 2.11