EE292: Fundamentals of ECE

Fall 2012

TTh 10:00-11:15 SEB 1242

Lecture 11

121002

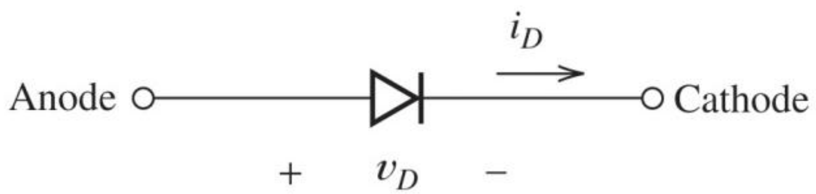
http://www.ee.unlv.edu/~b1morris/ee292/

Outline

- Review
- Diodes
- Lab Kits

Diode

- Two terminal device
  - Anode – positive polarity
  - Cathode – negative polarity

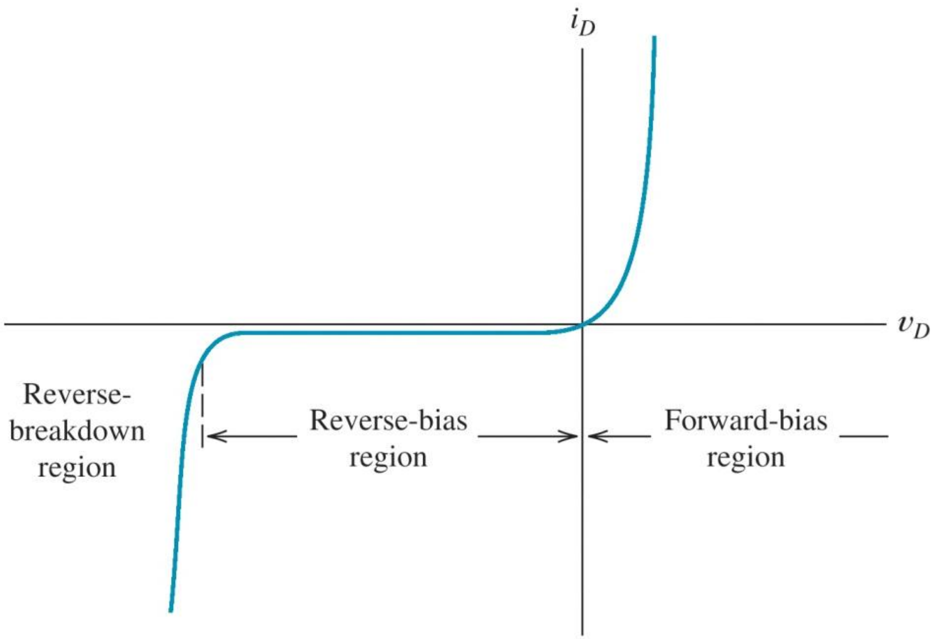


(a) Circuit symbol

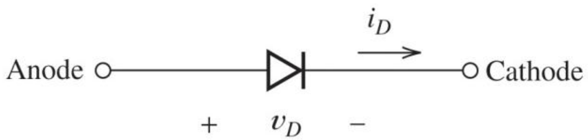
- Current flows from anode to cathode
  - This is the typical sign convention

Voltage/Current Characteristics

- Forward Bias
  - Positive voltage v_d causes large currents
  - Current flows easily through the device (from anode to cathode)
  - Arbitrarily large current has almost constant voltage (diode is "on")
- Reverse Bias
  - Negative voltage → no current
  - Open circuit (diode is "off")
- Reverse-Breakdown
  - Large negative voltage causes large negative currents
  - Similar operation as for forward bias



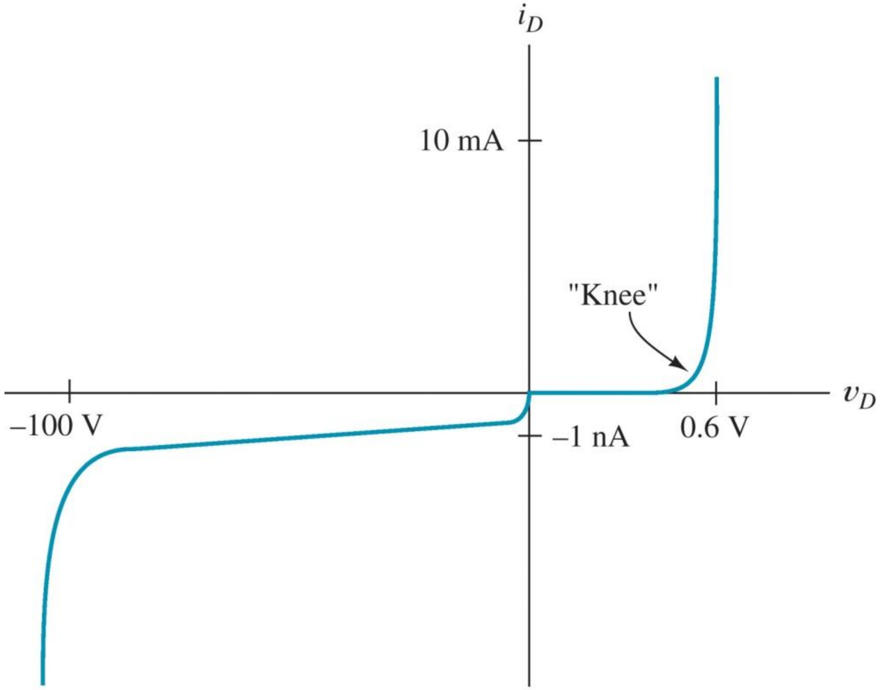
(b) Volt–ampere characteristic

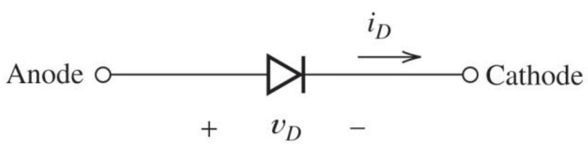


(a) Circuit symbol

Voltage/Current for Typical Diode

- Forward Bias
  - "Knee" indicates where current starts to flow
  - $v_{on} = 0.6$ or $0.7\ V$
  - Diode supports any current through it
- Reverse Bias
  - Very small currents → essentially no reverse current
- Reverse-Breakdown
  - $v_{on} = -100\ V$
  - Large reverse currents are possible



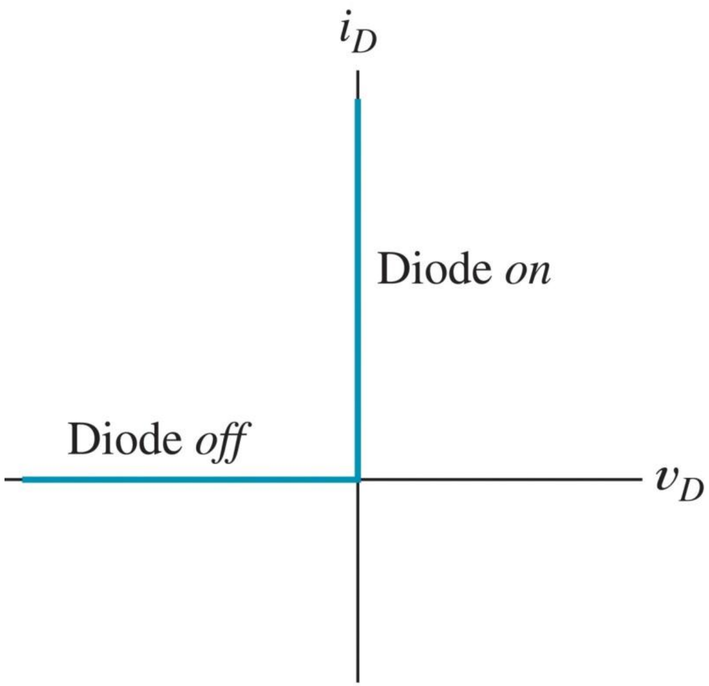


(a) Circuit symbol

Ideal Diode Model

- Two state model
- “On” State
  - Forward operation
  - Diode is a perfect conductor →short circuit
- “Off” State
  - Reverse biased
  - No current through diode → open circuit

- Useful for “quick and dirty” understanding of a complicated circuit
- Will improve this model to make it more realistic (offset model)



Circuit Analysis with Diodes

- Assume state {on, off} for each ideal diode and check if the initial guess was correct
  - $i_d > 0$ positive for "on" diode
  - $v_d < 0$ negative for "off" diode
    - These imply a correct guess
  - Otherwise adjust guess and try again

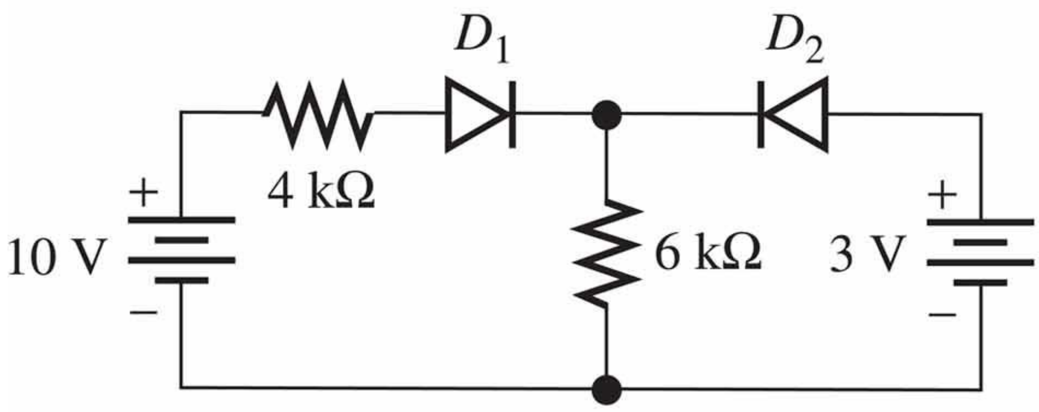
- Exhaustive search is daunting
  - 2^n different combinations for n diodes
- Will require experience to make correct guess

Steps for Circuit Analysis with Ideal Diode

1. Assume a state for each diode, either on (i.e., a short circuit) or off (i.e., an open circuit). For n diodes there are 2^n possible combinations of diode states
2. Analyze the circuit to determine the current through the diodes assumed to be on and the voltage across the diodes assumed to be off.
3. Check to see if the result is consistent with the assumed state for each diode. Current must flow in the forward direction for diodes assumed to be on. Furthermore, the voltage across the diodes assumed to be off must be positive at the cathode (i.e., reversed bias).
4. If the results are consistent with the assumed states, the analysis is finished. Otherwise, return to step 1 and choose a different combination of diode states.

Ideal Diode Example

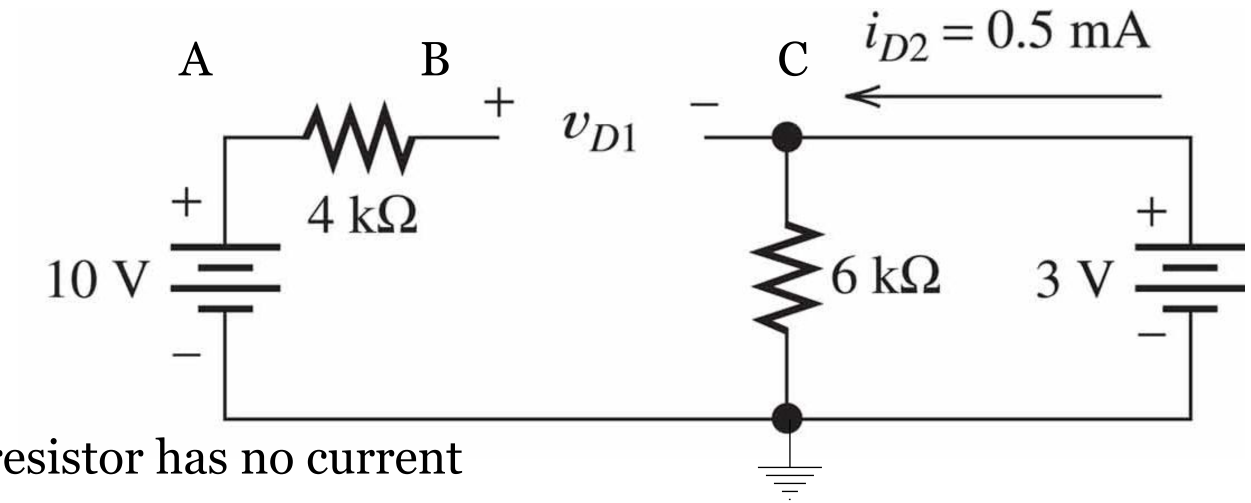
- Use the ideal-diode model to analyze the circuit. Start by assuming D_1 is off and D_2 is on.



(a) Circuit diagram

Ideal Diode Example

- D_1 is off → open circuit
- D_2 is on → short circuit



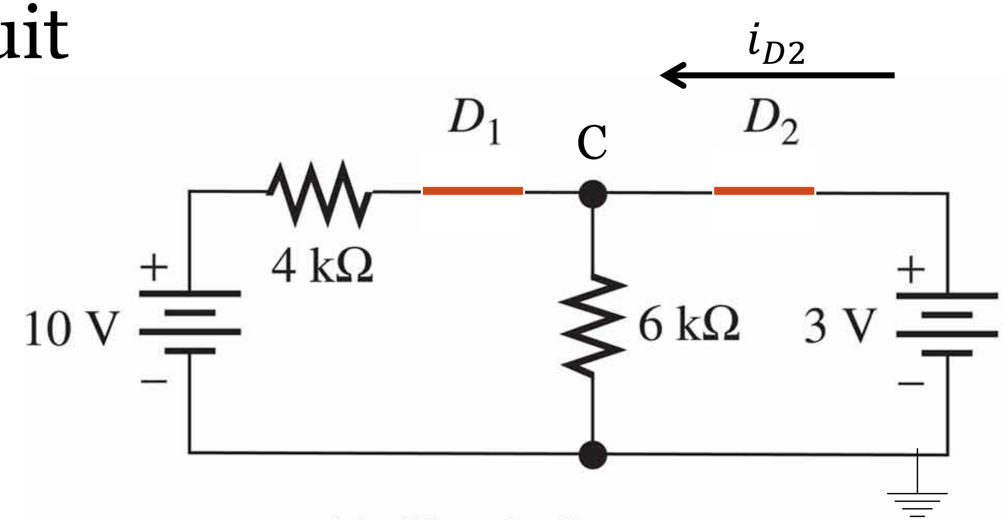
- $v_A = 10\ V$
- $v_B = 10\ V$
  - Disconnected resistor has no current
- $v_C = 3\ V$
  - Short circuit diode
  - $i_{D2} = \frac{V}{R} = \frac{3}{6} = 0.5\ A$
  - Consistent with on diode
- $v_{D1} = 7\ V$
  - Diode should be on → incorrect guess

Ideal Diode Example

- D_1 is on → short circuit
- D_2 is on → short circuit

- $v_C = 3\ V$

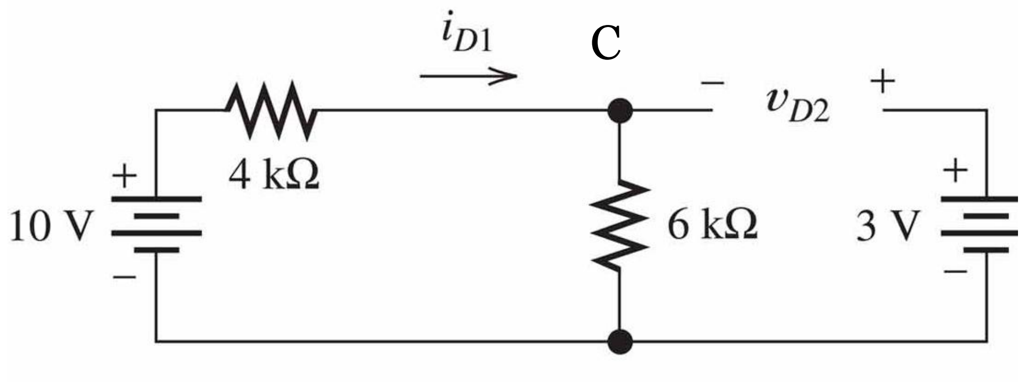
- KCL @ C
    - $\frac{3-10}{4} + \frac{3}{6} = i_{D2}$
    - $i_{D2} = -\frac{7}{4} + \frac{1}{2} = -\frac{5}{4} < 0$
    - Reverse bias current → incorrect operation for D_2



(a) Circuit diagram

Ideal Diode Example

- D_1 is on → short circuit
- D_2 is off → open circuit

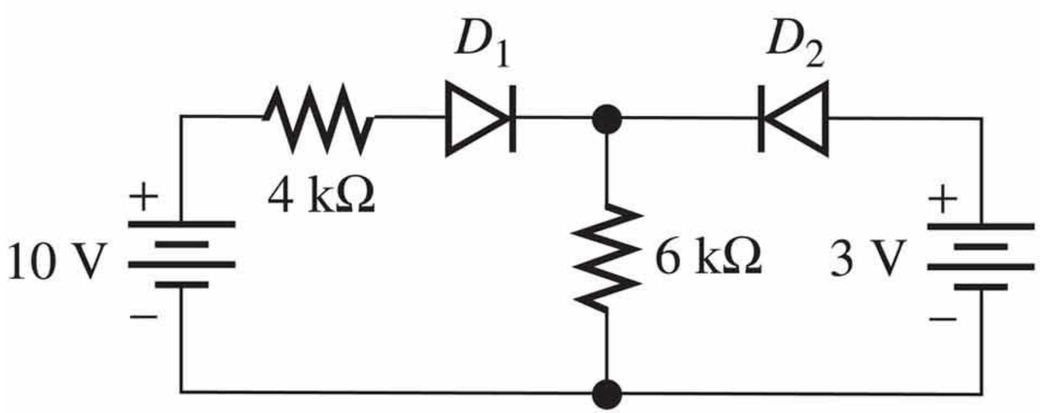


- Using voltage divider
  - $v_C = 10\left(\frac{6}{10}\right) = 6\ V$
  - $v_{D2} = 3 - v_c = 3 - 6 = -3\ V$
    - Reverse biased → "off" → correct operation
- D_1 current through series resistance
  - $i_{D1} = \frac{10}{(4+6)} = \frac{10}{10} = 1\ A > 0$
  - Current flow → forward bias → "on" → correct operation

Ideal Diode Example

- D_1 is off → open circuit
- D_2 is off → open circuit

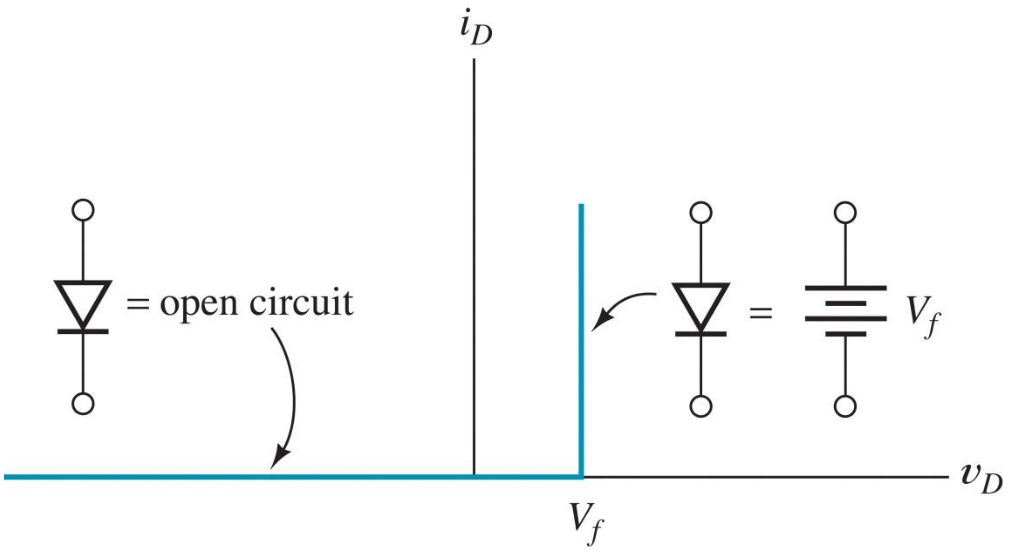
- Why doesn't this work?



(a) Circuit diagram

Offset Diode Model

- (Simple piecewise-linear diode equivalent circuit in book)
- Two state model
- “On” State
  - Forward operation
  - Diode has a fixed voltage across terminals
    - $v_f = v_{on} = 0.7\ V$
- “Off” State
  - Reverse biased
  - No current through diode → short circuit



- More realistic than the ideal model
- Circuit analysis works in the same way as for ideal case
  - Replace “on” diode with 0.7 V battery

Offset Diode Model Example

- Repeat previous example with offset model instead of ideal diode model