Lecture6: Diode (4)

Sung-Min Hong (smhong@gist.ac.kr)

Semiconductor Device Simulation Lab.
School of Electrical Engineering and Coumputer Science
Gwangju Institute of Science and Technology

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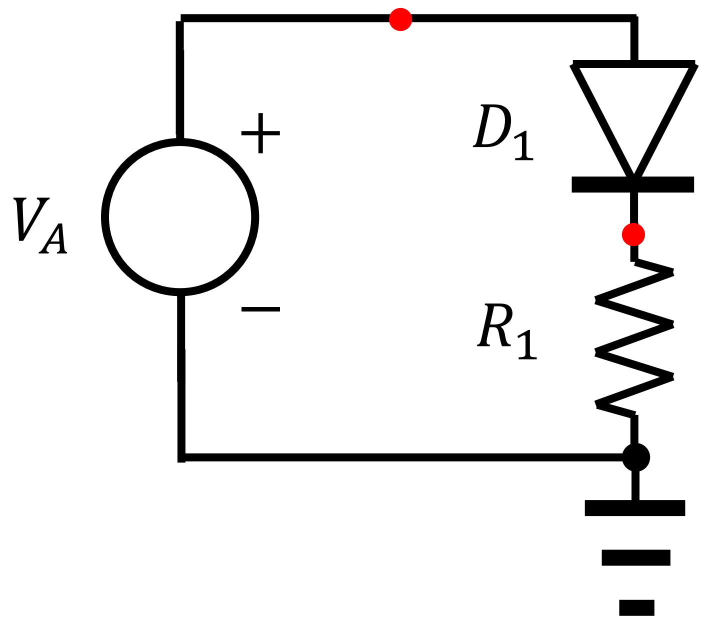
General solution (1)

- Analyze the following circuit. (A diode-resistor combination)
  - Calculation of node voltages and terminal currents



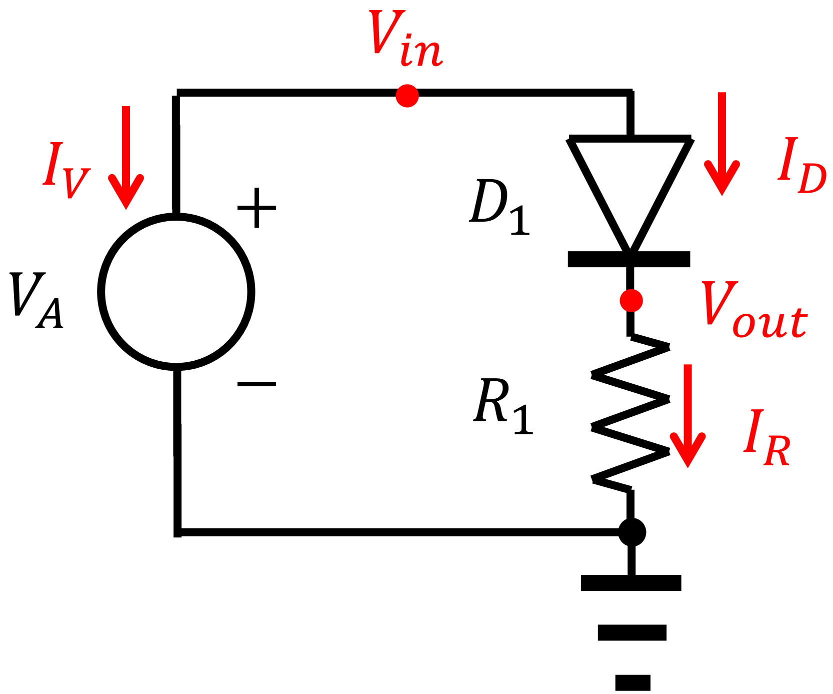
General solution (2)

- Identify the nodes and apply the KCL.
  - Two nodes (red dots) are found.

$$I_V + I_D = 0$$
$$-I_D + I_R = 0$$

  - Equations for terminal IVs

$$V_{in} = V_A$$
$$I_D = I_S\left(\exp\left(\frac{V_{in} - V_{out}}{V_T}\right) - 1\right)$$
$$I_R = \frac{V_{out}}{R_1}$$



General solution (3)

- Solve the set of equations.
  - After simple manipulation, it is easily found that

$$-I_S \left(\exp\left(\frac{V_A - V_{out}}{V_T} \right) - 1 \right) + \frac{V_{out}}{R_1} = 0$$

  - An nonlinear equation for V_{out} is obtained.
  - The solution, V_{out}, can be visualized by drawing the following two curves.

$$y = I_S \left(\exp\left(\frac{V_A - x}{V_T} \right) - 1 \right)$$

$$y = \frac{x}{R_1}$$

Graphical solution (1)

- Assume that V_A = 2 V, I_s = 0.5 fA, and R_1 = 270 Ω.
  - Draw two curves:

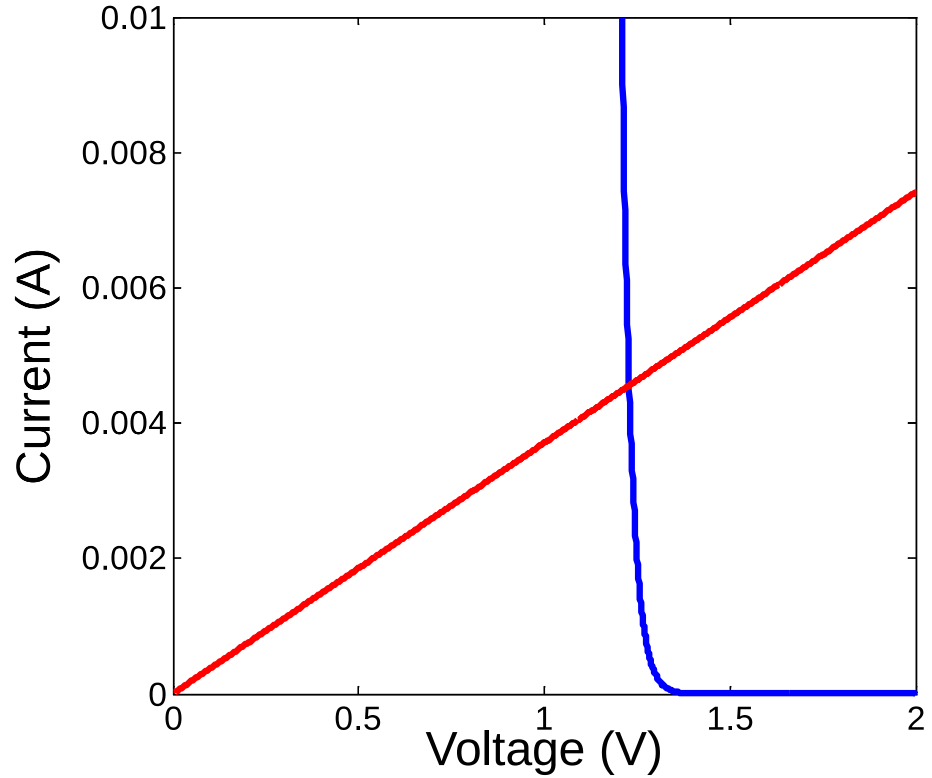
$$y = I_S\left(\exp\left(\frac{V_A - x}{V_T}\right) - 1\right)$$

$$y = \frac{x}{R_1}$$

  - The answer is

V_{out} = 1.2287 V.

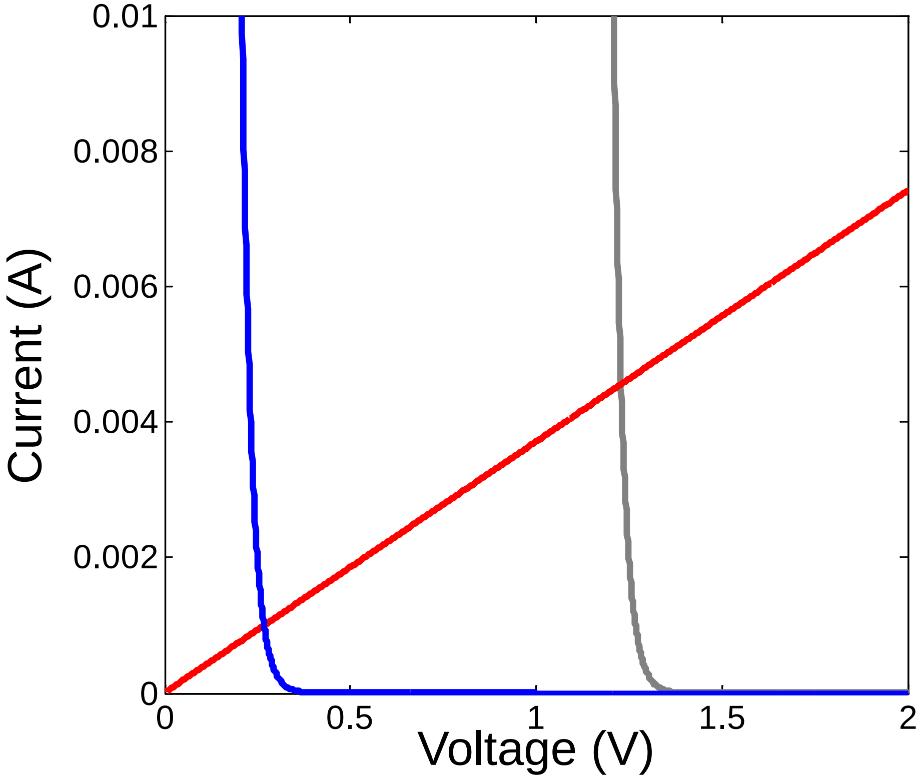
  - 0.77 V is applied to the diode.



Graphical solution (2)

- Reduce V_A to 1 V.
  - The answer is

  V_{out} = 0.2687 V.
  - 0.73 V is applied to the diode.



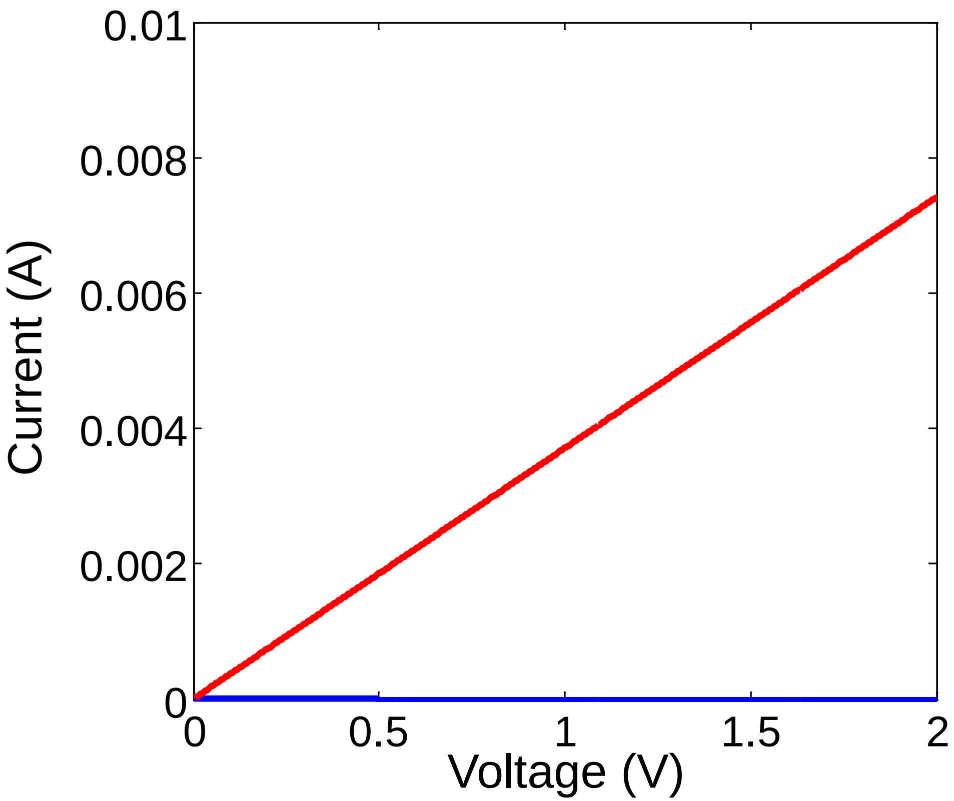
- Even smaller V_A?
  - For example, 0.5 V?

When V_A = 0.5 V

- The same scale as before.
  - ???

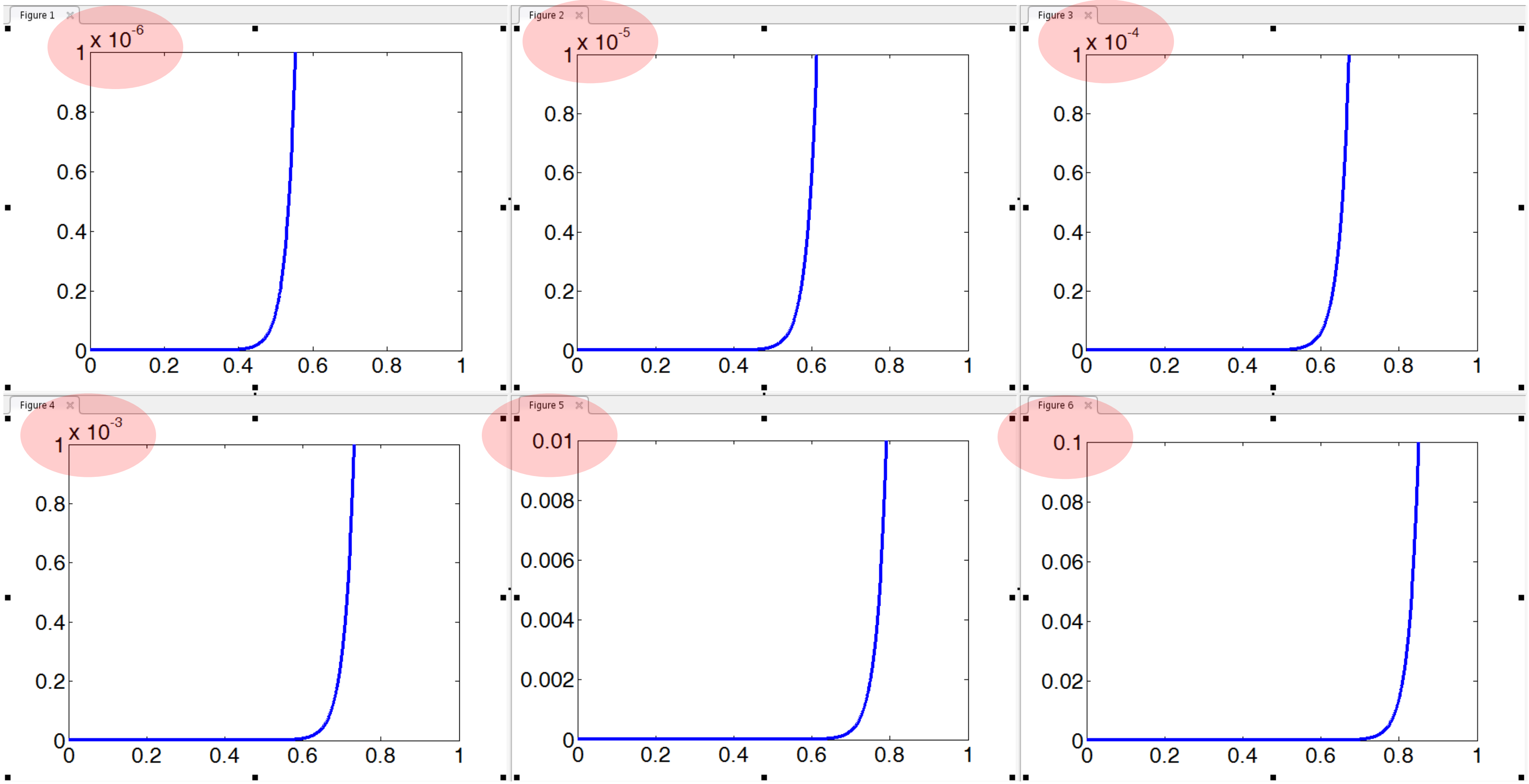
  - What is V_{out}?

- Not enough V_A
  - No current conduction



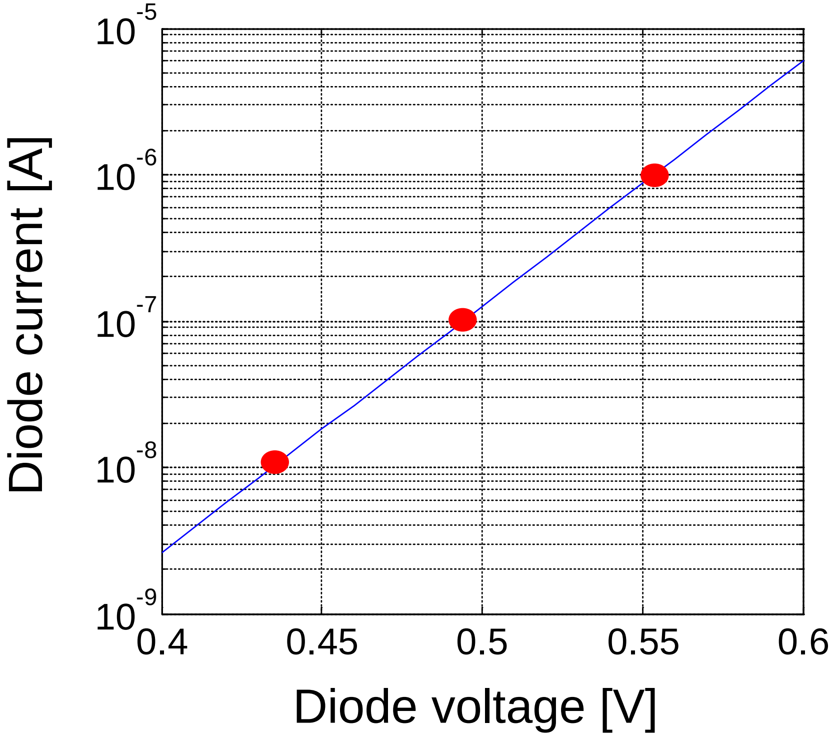
Dioide IV curves

- A diode with $I_S = 5 \times 10^{-16}$A (Only different y scales)



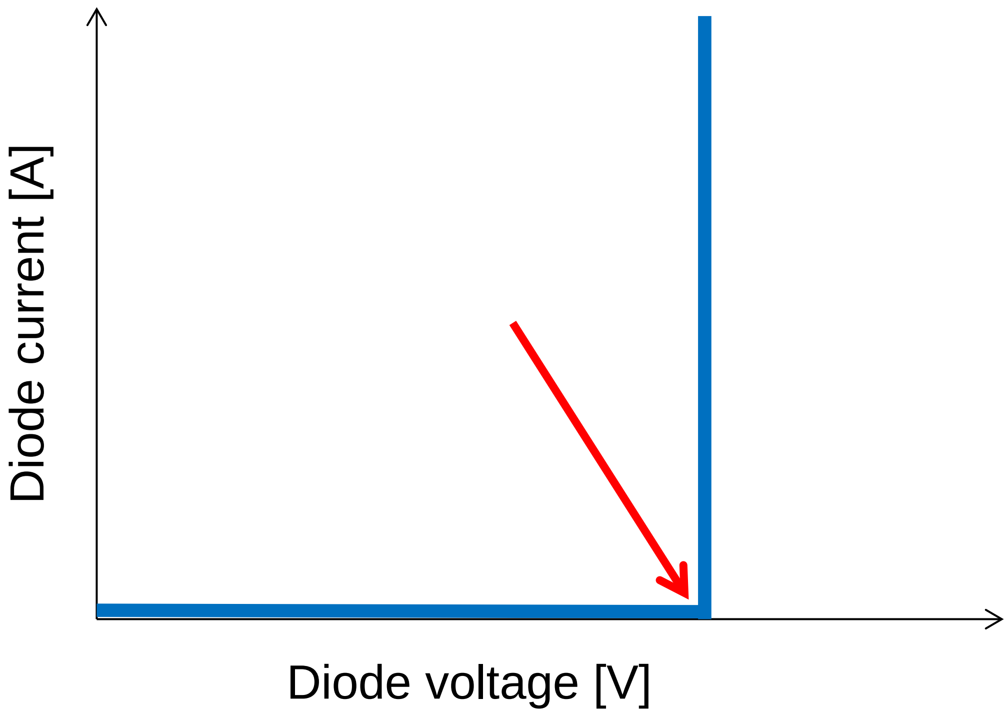
Important observation

- In order to obtain 10x large current,
  - We must apply only 60 mV additionally. (300K)



Diode model

- Two phases



Homework#3

- Due: 09:00, March 25
  - Submit your Homework answer sheet (hardcopy) directly to Mr. Suhyeong Cha, our TA.
  - His office: EECS building C-411
- Solve following problems of the 2018 mid-term exam.
  - P12
  - P13
  - P14
  - P15
- Solve following problems of the 2017 mid-term exam.
  - P17
  - P18
  - P19
  - P20