

dummy8

Student Group

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Table of Contents

| | |
|---|---|
| Exercise E1.1 Circuit with multiple diodes: which lamps light up? | 2 |
| Simulation: multiple diodes and lamps | 2 |
| Solution path | 2 |
| Result | 2 |
| Exercise E2.1 Circuit with multiple diodes II: current calculation | 3 |
| Simulation: two diodes and two resistors | 3 |
| Solution path | 3 |
| Result | 4 |
| Exercise E3.1 Circuit with multiple diodes III: switch-dependent currents | 4 |
| Simulation: switch-dependent diode circuit | 5 |
| Solution path: switch open | 5 |
| Result: switch open | 5 |
| Solution path: switch closed | 5 |
| Result: switch closed | 6 |

Exercise E1.1 Circuit with multiple diodes: which lamps light up?

The following simulation includes multiple diodes and several lamps. A lamp lights brightly when a voltage of approximately

$$U_{\text{lamp}} \geq 5 \text{ V}$$

drops across it.

Close the switch in the simulation.

- Which lamps light up brightly?
- Which lamps remain dark?
- Explain the result using the idea of diode bypass paths.

Simulation: multiple diodes and lamps

Result

Solution path

Number the lamps from left to right:

$$L_1, L_2, L_3, L_4, L_5.$$

After the switch is closed, check which diode paths become forward-biased.

A forward-biased diode behaves approximately like a low-voltage path. Therefore, if a diode is connected in parallel to a lamp or to a group of lamps, it can bypass this part of the circuit.

In this circuit:

- one diode bypasses the middle part of the lamp chain,
- another diode bypasses one of the inner lamps,
- therefore the voltage across the bypassed lamps is too small to make them light brightly.

The outer lamps are not bypassed in the same way. They receive a sufficiently large voltage.

Result

The lamps

$$\boxed{L_1 \text{ and } L_5}$$

light up brightly.

The lamps

$$\boxed{L_2, L_3, L_4}$$

remain dark or almost dark.

The reason is not that the lamps are broken, but that the conducting diodes create bypass paths with a much smaller voltage drop.

Exercise E2.1 Circuit with multiple diodes II: current calculation

The following simulation includes two diodes and two resistors.

Assume a simple constant-voltage diode model:

$$U_{\text{F}} = 0.6 \text{ V}$$

The source voltage is

$$U_0 = 4.0 \text{ V}$$

The resistors are

$$R_1 = 200 \text{ } \Omega, \quad R_2 = 100 \text{ } \Omega$$

Calculate the currents through

- I_{D_1} ,
- I_{R_1} ,
- I_{R_2} .

Simulation: two diodes and two resistors

Result

Solution path

Both diodes are forward-biased.

First consider the branch with (R_1) . There is one forward-biased diode in series with (R_1) , so the resistor voltage is

$$U_{R1} = U_0 - U_F = 4.0 \text{ V} - 0.6 \text{ V} = 3.4 \text{ V}.$$

Thus

$$I_{R1} = \frac{U_{R1}}{R_1} = \frac{3.4 \text{ V}}{200 \Omega} = 17 \text{ mA}.$$

Now consider the branch with (R_2) . Here the current path includes two forward-biased diode drops, so

$$U_{R2} = U_0 - 2U_F = 4.0 \text{ V} - 2 \cdot 0.6 \text{ V} = 2.8 \text{ V}.$$

Thus

$$I_{R2} = \frac{U_{R2}}{R_2} = \frac{2.8 \text{ V}}{100 \Omega} = 28 \text{ mA}.$$

The diode (D_1) carries the current feeding both branches:

$$I_{D1} = I_{R1} + I_{R2}.$$

Result

$$\boxed{I_{R1} = 17 \text{ mA}}$$

$$\boxed{I_{R2} = 28 \text{ mA}}$$

$$\boxed{I_{D1} = I_{R1} + I_{R2} = 45 \text{ mA}}$$

Exercise E3.1 Circuit with multiple diodes III: switch-dependent currents

The following simulation includes two diodes and a switch.

Assume a simple constant-voltage diode model:

$$U_F = 0.7 \text{ V}.$$

The source voltage is

$$U_0 = 5.0 \text{ V}.$$

The resistor is

$$\left[\begin{array}{l} R_1=1.0 \text{ k}\Omega. \end{array} \right]$$

Calculate the currents through

- I_{R_1} ,
- I_{D_1} ,
- I_{D_2} ,

depending on the switch state S .

Simulation: switch-dependent diode circuit

Result

Solution path: switch open

With the switch open, only D_1 is connected to the resistor path.

The node voltage is clamped to approximately one forward voltage:

$$U_{\text{node}} \approx U_{\text{F}} = 0.7 \text{ V}.$$

The resistor current is therefore

$$I_{R_1} = \frac{U_0 - U_{\text{F}}}{R_1} = \frac{5.0 \text{ V} - 0.7 \text{ V}}{1.0 \text{ k}\Omega} = 4.3 \text{ mA}.$$

Since only D_1 conducts,

$$I_{D_1} = I_{R_1}, \quad I_{D_2} = 0.$$

Result: switch open

$$\boxed{I_{R_1} = 4.3 \text{ mA}}$$

$$\boxed{I_{D_1} = 4.3 \text{ mA}}$$

$$\boxed{I_{D_2} = 0}$$

Solution path: switch closed

With the switch closed, D_1 and D_2 are connected in parallel.

The node voltage is still clamped to approximately

$$U_{\text{node}} \approx U_{\text{F}} = 0.7 \text{ V}.$$

Therefore the resistor current remains

$$I_{R1} = \frac{5.0\text{ V} - 0.7\text{ V}}{1.0\text{ k}\Omega} = 4.3\text{ mA}$$

This current now splits between (D_1) and (D_2) :

$$I_{D1} + I_{D2} = I_{R1}$$

With the simple constant-voltage diode model, the individual diode currents are not uniquely determined. The model only fixes the total current.

If both real diodes are assumed to be identical, the current approximately splits equally:

$$I_{D1} \approx I_{D2} \approx \frac{I_{R1}}{2}$$

Result: switch closed

The total current is

$$\boxed{I_{R1} = 4.3\text{ mA}}$$

and

$$\boxed{I_{D1} + I_{D2} = 4.3\text{ mA}}$$

With identical real diodes, approximately

$$\boxed{I_{D1} \approx I_{D2} \approx 2.15\text{ mA}}$$

This exercise shows a limitation of the constant-voltage diode model. For parallel diodes, the total current can be calculated, but the current sharing between idealized identical diodes is not uniquely determined.

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