Lab 1 - The Diode

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ECE 3110

September 24, 2024

1 Introduction

In this lab we build a simple circuit utilizing a diode and a resistor to measure and analyze the performance of the diode under different condiditions. Before we take measurements of the circuit, we solve for the voltages and current through the circuit in a few different ways and then compare our results. We will test our circuit with a few different voltages to see how the components respond.

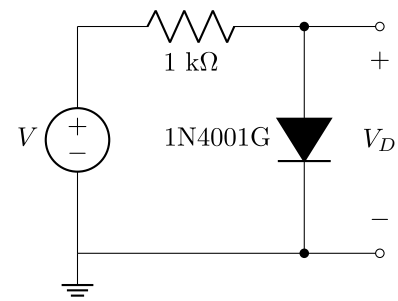

Figure 1: The circuit we used in the lab.

2 Theory

To analyze the circuit we will make use of three ways to model a diode, known as the *ideal model*, *constant drop model*, and the *exponential model*. For each model we will calculate the current through the circuit, and the voltages present around the resistor and the diode for 10 V, 1.2 V, and 0.75 V (a voltage where we found the current to drop off significantly).

2.1 Ideal Model

In the ideal model we assume that a diode is simply a short circuit when forward biased, which leaves us with a circuit as shown in Fig. 2.1.

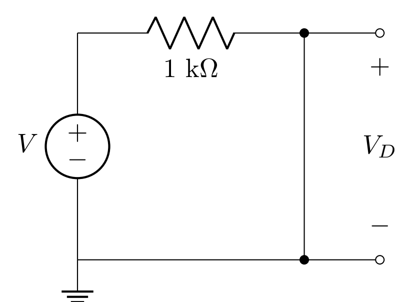

Figure 2: The circuit when using the ideal model.

Without a diode present, the current through the circuit is shown with $I = \frac{V}{R}$, and the voltage over the diode is always 0 V.

For 10 V: $I = \frac{10\ \text{V}}{1\ \text{k}\Omega} = 10$ mA
For 1.2 V: $I = \frac{1.2\ \text{V}}{1\ \text{k}\Omega} = 1.2$ mA
For 0.75 V: $I = \frac{0.75\ \text{V}}{1\ \text{k}\Omega} = 0.75$ mA

2.2 Constant Drop

The constant drop model for a diode suggests that a diode can be replaced by a voltage source equalling 0.7 V with the positive terminal aligned with the cathode of the diode. See Fig. 2.2

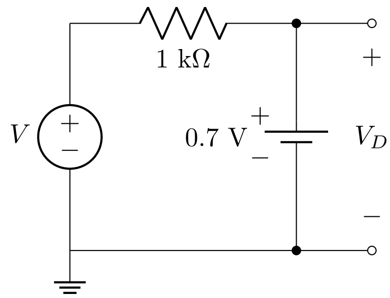

Figure 3: The circuit when usint the constant drop model.

With a supposed battery supplying voltage to the circuit, the resulting voltage over that resistor is then reduced to $V - 0.7$ V. This means that the current through the circuit is shown by $I = \frac{V - 0.7\ \text{V}}{R}$.

For 10 V: $I = \frac{9.3\ \text{V}}{1\ \text{k}\Omega} = 9.3$ mA
For 1.2 V: $I = \frac{0.6\ \text{V}}{1\ \text{k}\Omega} = 0.6$ mA
For 0.75 V: $I = \frac{0.15\ \text{V}}{1\ \text{k}\Omega} = 0.15$ mA

2.3 Exponential Model

When using the exponential model, we use Eq. 1 to show the relationship between the current and the voltage through a diode.

$$I = I_S e^{V/V_{TH}} \tag{1}$$

We are using a value of $V_{TH} = 25.9$ mV for the thermal voltage. I_S is calculated by using an operating point given from a datasheet in Eq. 1. Rearranging the equation yields the following:

$$I_S = \frac{I}{e^{V/V_{TH}}}$$

Plugging in our values we find:

$$I_S = \frac{1\ \text{A}}{e^{0.93\ \text{V}/25.9\ \text{mV}}} = 2.545 \times 10^{-16} \text{A}$$

Now, with a satisfactory I_S value we can use the iterative method to solve for the current and voltage in the diode.

Using the following two equations we can iterate on the values of I and V_D until we have sufficiently accurate values.

3 Graphical Analysis

4 Results

5 Conclusion

6 Extra Thoughts