Workshop Materials for

Workshop W27: Flexible resources for supporting student conceptual understanding of diode circuits in electronics courses

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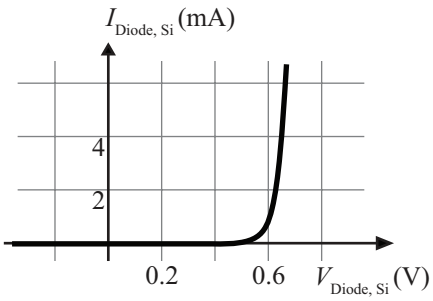
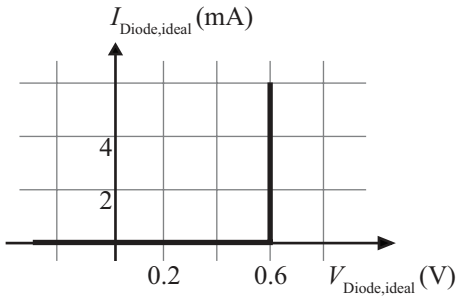
Ideal Diode Model

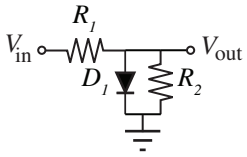
$$V_{Diode} = V_a - V_c$$





CURRENTS AND VOLTAGES IN DIODE CIRCUITS

For this tutorial, consider the circuit at right. Assume all components are ideal and that the diode has a turn on voltage of 0.6 V. Further assume that $R_1 = R_2$ and that no load is attached to the circuit.



I. Circuit behavior for positive input voltage

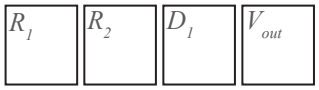
Suppose $V_{in} = +6.0$ V.

A. What is the voltage across the diode D_1? Explain.

B. What is the voltage across the resistor R_1? Explain.

C. What is V_{out}? Explain.

D. In the boxes at right, draw arrows to indicate the directions of the currents through resistors R_1 and R_2, diode D_1, and the circuit's output terminal (indicated by V_{out}). If there is no current through a given element or terminal, state so explicitly. Explain.



E. Is the absolute value of the current through R_1 *greater than, less than,* or *equal to* the absolute value of the current through R_2? If either current is equal to zero, state so explicitly. Explain how your answer is consistent with Ohm's law.

II. Circuit behavior for a negative input voltage

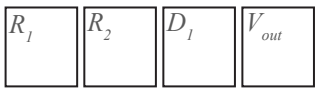
Suppose $V_{in} = -6.0$ V.

A. Consider the following statement made by a student:

"I think V_{out} is zero in this case. Current can't go through the diode because it is reverse-biased, so there can't be any voltage across it."

Do you *agree* or *disagree* with the student? Explain.

B. In the boxes at right, draw arrows to indicate the directions of the currents through resistors R_1 and R_2, diode D_1, and the circuit's output terminal (indicated by V_{out}). If there is no current through a given element or terminal, state so explicitly. Explain.



C. Is the absolute value of the current through R_1 in part II *greater than, less than,* or *equal to* the absolute value of the current through R_1 in in part I? Explain.

D. Is it possible for there to be a non-zero voltage across a diode through which there is no current? If so, under what conditions is it possible? Explain.

In the circuit at right, V_{in} = +10 V, R_1 = 19 kΩ, and R_2 = 1 kΩ. Assume the diode is ideal.

The current through the diode is:

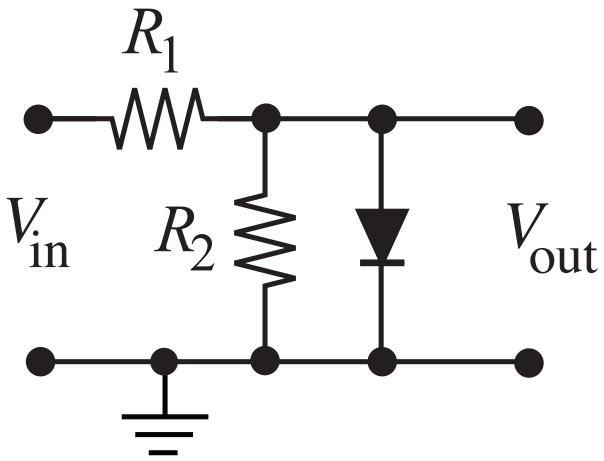
A) 0.00 mA

B) 0.25 mA

C) 0.50 mA

D) 0.53 mA

E) None of the above



1

In the circuit at right, V_{in} = +10 V, **R_1 = 9 kΩ,** and R_2 = 1 kΩ. Assume the diode is ideal.

The current through the diode is most nearly:

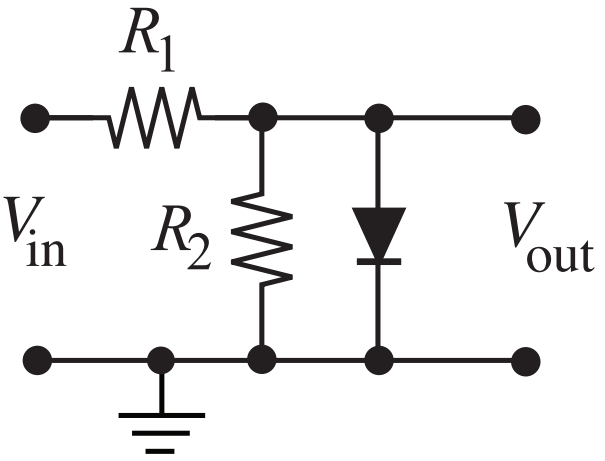
A) 0.00 mA

B) 0.44 mA

C) 0.60 mA

D) 1.04 mA

E) None of the above



2

EXCERPT FROM EXPERIMENT 9:
APPLICATIONS OF DIODE CIRCUITS

2. Diode-controlled battery backup system

For this portion of the lab, you will design a diode-controlled battery backup system, much like the one in a digital alarm clock. This battery backup system will be used to ensure that the voltage across a vibration motor in series with a 100 Ω never falls below the value required for vibration, even when the variable dc supply is lowered to 0 V.

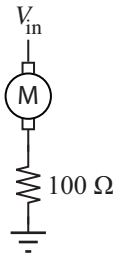


Figure 2. Circuit with vibration motor.

2.1 Assemble the circuit shown in Fig. 2 at right, using the variable dc supply for V_{in}. Starting from 5 V, decrease the voltage until the motor no longer vibrates. Record the largest voltage at which the motor no longer vibrates.

2.2 Using two AA batteries in a single holder (for a total of ~3 V) and 1N914 diodes, design a simple circuit that will switch over to the AA batteries when V_{in} falls below a certain value. Clearly explain the conditions under which the batteries will serve as the input voltage source and explain why this is the case (in terms of your understanding of diode behavior).

2.3 Construct your circuit and verify that the motor continues to vibrate even when V_{in} is lowered to approximately 1 V. If your circuit does not behave as expected, note this in your lab book and revise your design and test your revised circuit.

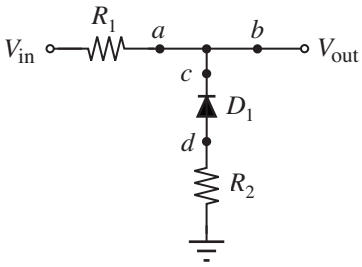
2.4 Use an ammeter to verify the following:

- There is no current through the battery when V_{in} = 5 V.
- There is no current through the +V dc supply when V_{in} = 1 V and the motor is vibrating.

Conceptual Question

Name_____

In the circuit at right, both resistors (R_1 and R_2) are identical. Assume that diode D_1 is ideal. Assume that the power supply is ideal and that *no load* is connected to the output of the circuit. Both V_{in} and V_{out} are measured with respect to ground. V_{in} is constant and is equal to +8.0 V.



1. Is the current through **point *a*** *to the right, to the left,* or *equal to zero?* Explain.

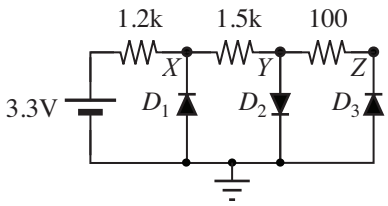
2. Rank, from largest to smallest, the absolute values of the currents through points *a, b, c,* and *d*. If any of the currents are equal in absolute value or are equal to zero, state so explicitly. Explain.

3. Rank, from largest to smallest, the absolute values of the voltages across resistor R_1, resistor R_2, and diode D_1. If any of the voltages are equal in absolute value or are equal to zero, state so explicitly. Explain.

Conceptual Question

Name_____

Three identical, ideal diodes are used in the circuit at right. Assume the battery is ideal.



Calculate the voltages at points *X*, *Y*, and *Z* (V_X, V_Y, and V_Z, respectively). Show your work and explain your reasoning.

V_X _____

V_Y _____

V_Z _____