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# Micro Pressure Sensors & The Wheatstone Bridge

## Final Assessment

### Instructor Guide

#### Notes to Instructor

The assessment can be used to determine the Wheatstone bridge operation and its application in microtechnology. This assessment could be compared with the results of the Knowledge Probe in order to determine what was learned as a result of completing the supporting PK and activities.

This activity is part of the Micro Pressure Sensors & the Wheatstone Bridge Learning Module:

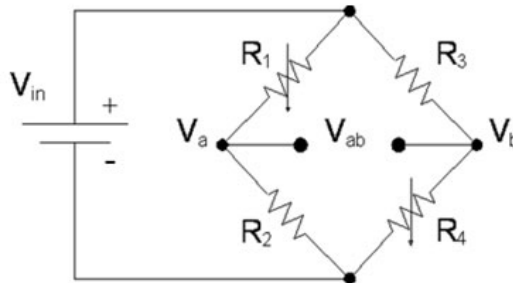
- Knowledge Probe (KP)
- Wheatstone Bridge Primary Knowledge
- Modeling a Micro Pressure Sensors Activity
- Wheatstone Bridge Derivation Activity
- **Wheatstone Bridge Final Assessment**

#### Introduction

The purpose of this assessment is to determine your understanding of Wheatstone bridge circuit and its application in microtechnology.

There are twelve (12) assessment questions.

Below is a Wheatstone Bridge circuit with two sensing transducers. Use this circuit to answer questions 1 through 4.



1. Which resistors are the sensing transducers?
  - a. R1 and R2
  - b. R2 and R3
  - c. R3 and R4
  - d. R4 and R1

**Answer: d (R4 and R1)**

2. What are the two voltage divider circuits in the bridge circuit?
  - a.  $R_1 / R_2$  and  $R_3 / R_4$
  - b.  $R_1 / R_3$  and  $R_2 / R_4$
  - c.  $R_1 / R_4$  and  $R_2 / R_3$

**Answer: a. ( $R_1 / R_2$  and  $R_3 / R_4$ )**

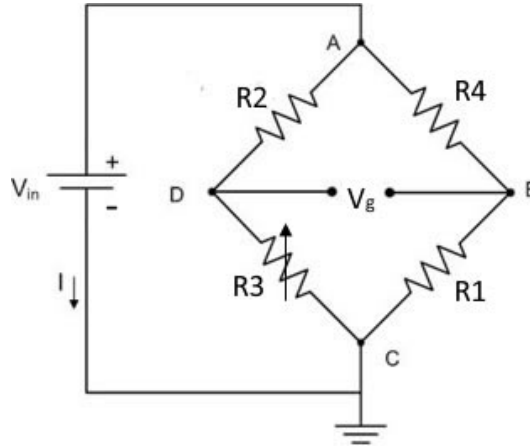
3. Which of the following R values would yield a  $V_{ab} = 0$  V?
  - a.  $R_1 / R_2 = R_3 / R_4$
  - b.  $R_1 / R_3 = R_2 / R_4$
  - c.  $R_1 / R_4 = R_2 / R_3$

**Answer: a. ( $R_1 / R_2 = R_3 / R_4$ )**

4. Given the following input voltage and resistor values, what is  $V_{ab}$ ?  
 ( $V_{in} = 5$  v,  $R_1 = 160 \Omega$ ,  $R_2 = 100 \Omega$ ,  $R_3 = 100 \Omega$ , and  $R_4 = 160 \Omega$ )
  - a. 0 volts
  - b. 1.15 volts
  - c. -1.15 volts
  - d. 5 volts

**Answer: c. -1.15 volts**

5. What is the formula in terms of voltage and resistance for  $V_g$  in the following circuit?



a.  $V_g = V_{in} \left( \frac{R_2}{R_3} - \frac{R_4}{R_1} \right)$

b.  $V_g = V_{in} \left( \frac{R_3}{R_3 + R_1} - \frac{R_4}{R_4 + R_2} \right)$

c.  $V_g = V_{in} \left( \frac{R_3}{R_3 + R_2} - \frac{R_1}{R_1 + R_4} \right)$

d.  $V_g = V_{in} \left( \frac{R_3}{R_2} - \frac{R_1}{R_4} \right)$

**Answer: c.**

$$V_g = V_D - V_B$$

$$V_D = V_{in} \frac{R_3}{R_3 + R_2}$$

$$V_B = V_{in} \frac{R_1}{R_1 + R_4}$$

$$V_g = V_D - V_B = V_{in} \frac{R_3}{R_3 + R_2} - V_{in} \frac{R_1}{R_1 + R_4}$$

$$V_g = V_{in} \left( \frac{R_3}{R_3 + R_2} - \frac{R_1}{R_1 + R_4} \right)$$

6. The Wheatstone bridge is commonly used as an effective sensing circuit for which of the following MEMS devices?
- a. Accelerometer
  - b. Cantilever array
  - c. Pressure sensor
  - d. Seismic sensor

*Answer: c. pressure sensor*

7. The sensing transducers of a Wheatstone bridge circuit are made from a piezoresistive material that changes in resistance when its length, width, and/or thickness changes. What is this type of transducer called?
- a. Strain gauge
  - b. Thermocouple
  - c. Thermister
  - d. Galvanometer

*Answer: a. Strain gauge*

8. In a MEMS device, the Wheatstone bridge is normally fabricated on top of a flexible layer such as a membrane or diaphragm. This allows the transducers of the bridge to stretch as the membrane stretches. The thin film used to construct a Wheatstone bridge sensor circuit on a membrane is usually made of which of the following materials?
- a. Silicon nitride
  - b. Silicon dioxide
  - c. Polysilicon
  - d. Metal or metal alloy

*Answer: d. metal or metal alloy*

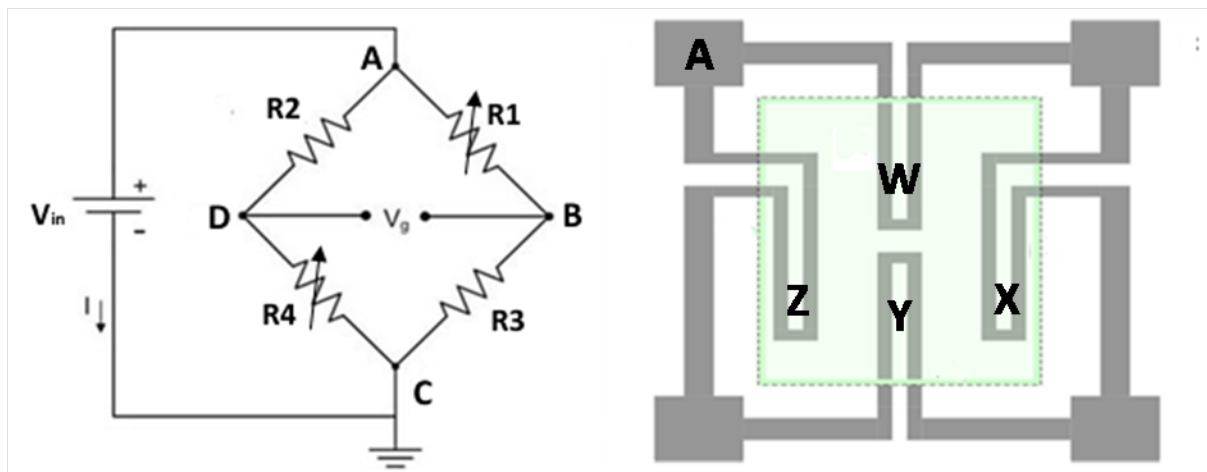
9. Which of the following statements BEST defines piezoresistive materials? Materials in which a change in electrical resistance occurs in response to changes in...
- a. an applied stress.
  - b. the material's length.
  - c. the material's cross-sectional area.
  - d. temperature.

*Answer: a. an applied stress*

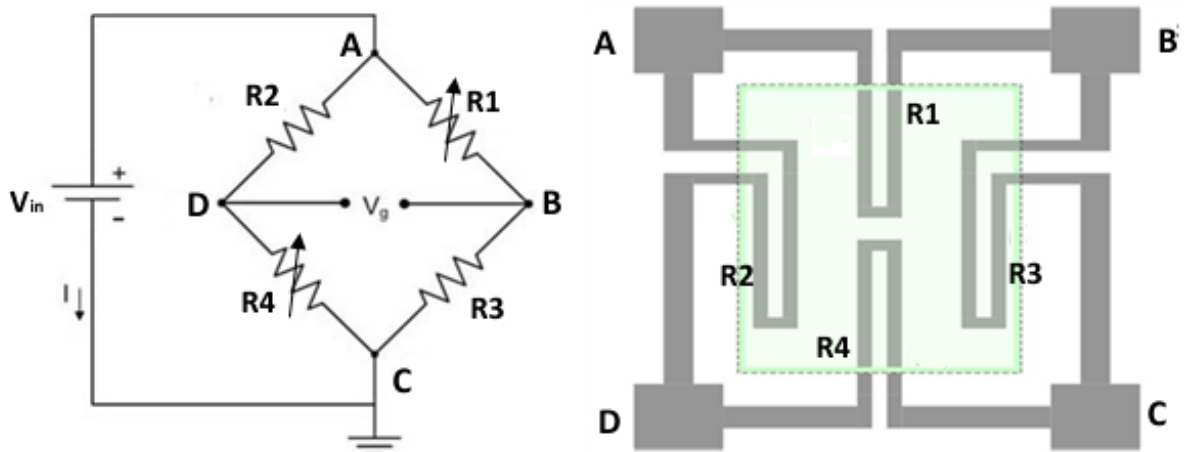
10. The resistance of piezoresistive material increases with
- a decrease in length and a decrease in cross-sectional area
  - an increase in length and a decrease in cross-sectional area
  - a decrease in length and an increase in cross-sectional area
  - an increase in length and an increase in cross-sectional area

**Answer: b. an increase in length and a decrease in cross-sectional area**

11. Below is the diagram for a fabricated MEMS Wheatstone bridge circuit. Referring to the components and contacts of the Wheatstone bridge circuit on the left, indicate which resistors are represented by W, X, Y, and Z, respectively, on the MEMS circuit to the right. Node A is indicated in both circuits.
- R2, R1, R4, R3
  - R1, R3, R4, R2
  - R1, R2, R3, R4
  - R2, R1, R3, R4

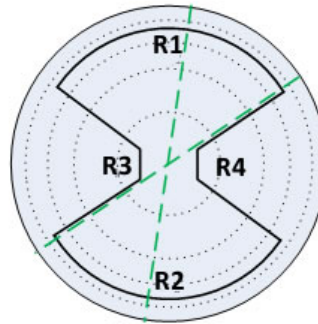


**Answer: b. R1, R3, R4, R2**



12. In the following circular membrane configuration, which are the fixed resistors?

- e.  $R1 / R2$
- f.  $R3 / R4$
- g.  $R1 / R4$
- h.  $R2 / R3$



**Answer: a.  $R1 / R2$**

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