Micro Pressure Sensors & The Wheatstone Bridge Knowledge Probe

Instructor Guide

Notes to Instructor

This Knowledge Probe (KP) can be used to determine the participants' current knowledge of Wheatstone bridge operation and its application in micro pressure sensors. If given prior to starting the Micro Pressure Sensors & The Wheatstone Bridge Learning Module, this KP could be used with the final assessment to determine the learning that took place as a result of this learning module.

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

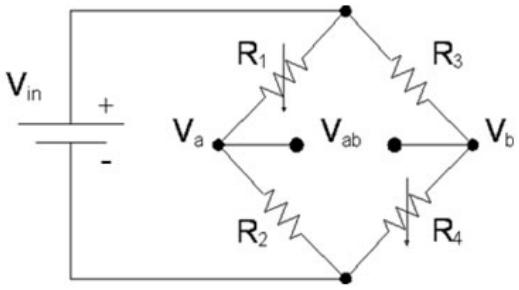
- **Knowledge Probe (KP) or pre-test**
- Wheatstone Bridge Overview Primary Knowledge
- Modeling a Micro Pressure Sensor Activity
- Wheatstone Bridge Derivation Activity
- Final Assessment

Introduction

The purpose of this knowledge probe is to determine your current understanding of a Wheatstone bridge circuit and its application in microtechnology.

There are twelve (12) questions. Answer them to the best of your knowledge.

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)

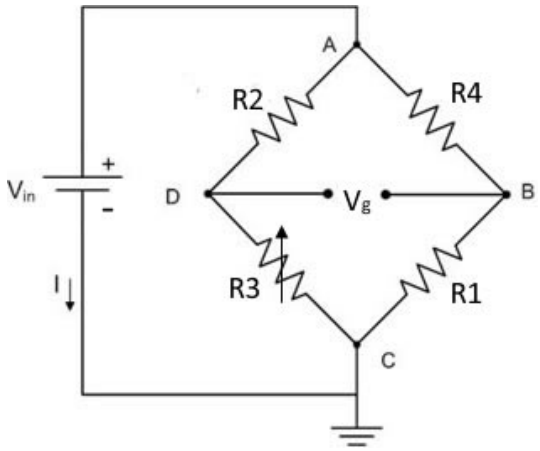
3. Which of the following R values would yield a Vab = 0 V?
   a. R_1 / R_2 = R_3 / R_4
   b. R_1 / R_3 = R_2 / R_4
   c. R_1 / R_4 = R_2 / R_3

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

4. Given the following input voltage and resistor values, what is Vab?
   (Vin = 5 v, R_1 = 300 Ω, R_2 = 100 Ω, R_3 = 100 Ω, and R_4 = 300 Ω)
   a. 5 volts
   b. 2.5 volts
   c. 0.0 volts
   d. -2.5 volts

Answer:d. -2.5 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 change. 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

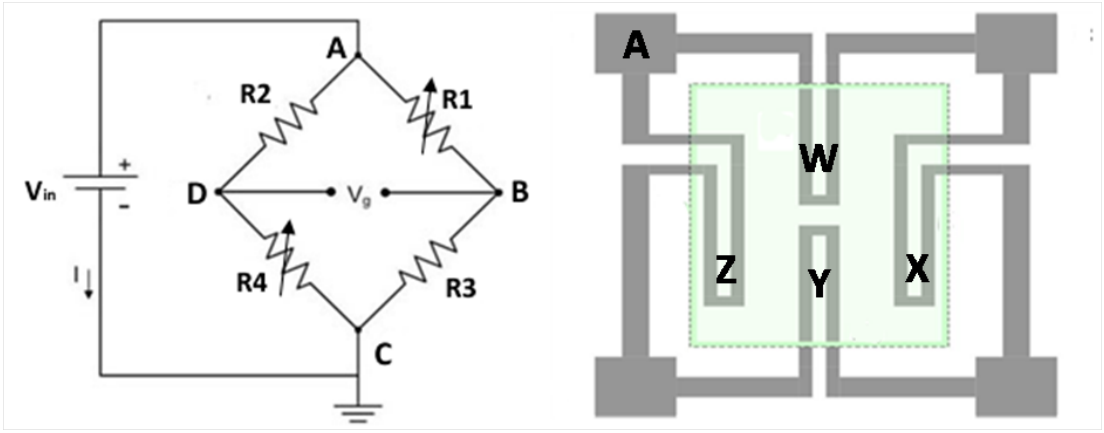
9. Which of the following statements BEST defines piezoresistive materials? Materials in which a change in electrical resistance occurs in response to changes in…
    a. an applied stress.
    b. the material's length.
    c. the material's cross-sectional area.
    d. temperature.

Answer: a. an applied stress

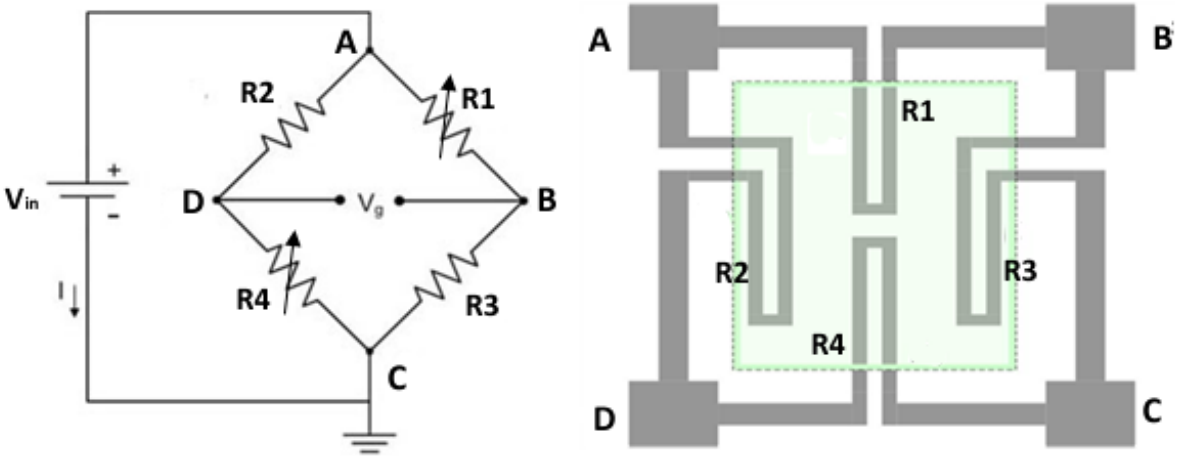
10. The resistance of piezoresistive material increases with
    a. a decrease in length and a decrease in cross-sectional area
    b. an increase in length and a decrease in cross-sectional area
    c. a decrease in length and an increase in cross-sectional area
    d. an increase in length and an increase 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.
    a. R2, R1, R4, R3
    b. R1, R3, R4, R2
    c. R1, R2, R3, R4
    d. R2, R1, R3, R4

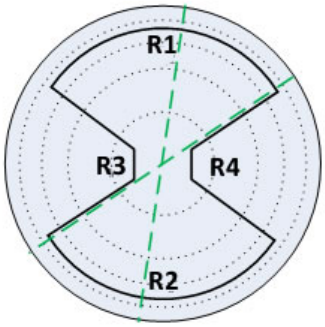


Answer: b. R1, R3, R4, R2



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

a. R1 / R2
b. R3 / R4
c. R1 / R4
d. R2 / R3



Answer: b. R3/R4

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