Bridges and Their Application

A bridge circuit is one kind of electrical circuit wherein the two branches of the circuit are linked to a third branch –which is connected in between the first two branches at some middle point along with them. The bridge circuit was mainly designed for measurement purposes in the laboratory. And, one of the middle linking points is adjusted when it is used for a specific purpose. These circuits are used in linear, nonlinear, power conversion, instrumentation, filtering, etc.

Bridge Circuits and their Circuit Diagrams

What is a Bridge Circuit?

Bridge circuit are extensively used for measuring component values, such as resistance,
inductance, capacitance, and other circuit parameters directly derived from component values such as frequency, phase angle, and temperature. Bridge accuracy measurements are very high because their circuit merely compares the value of an unknown component to that of an accurately known component (a standard).

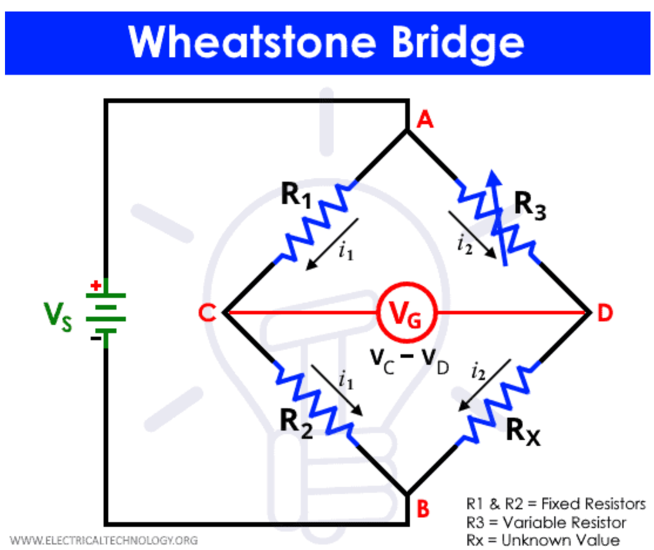
Types of Bridge Circuits

1- D.c Bridges:

The basic d.c bridges consist of four resistive arms with a source of emf (a battery) and a null detector usually galvanometer or other sensitive current meter.

D.c bridges are generally used for the measurement of resistance values.

a) Wheatstone Bridge:

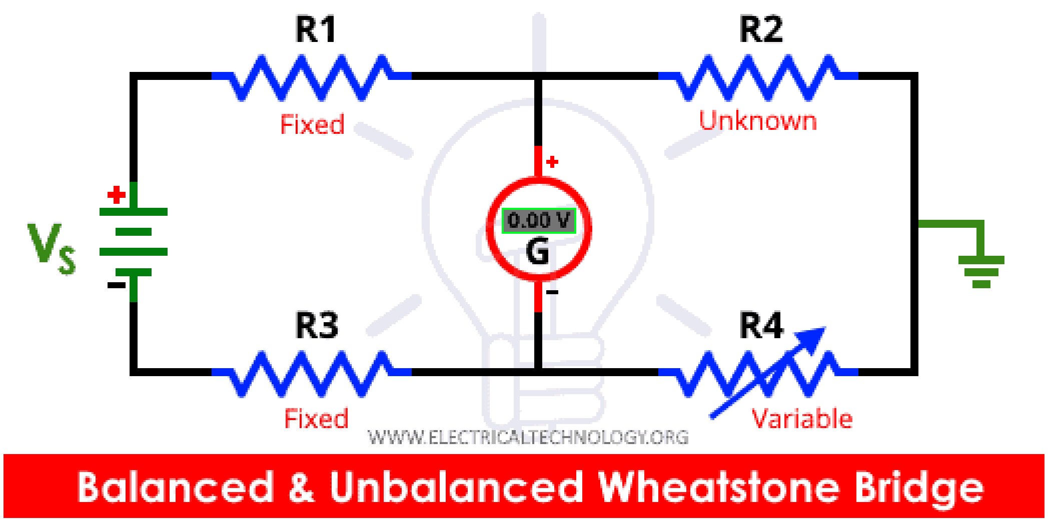


E-mail:zainab.kadum.jaber@uomus.edu.iq

A Wheatstone bridge circuit is mainly used to calculate an unknown electrical resistance by balancing two legs of a circuit; one leg of the circuit comprises an unknown component.

This is the best and commonest method of measuring medium resistance values in the range of 1Ω to the low megohm. The current through the galvanometer depends on potential difference between point (c) and (d). The bridge is said to be balance when potential difference across the galvanometer is zero volts, so there is no current through the galvanometer (Ig=0). This condition occurs when
Vca=Vda or Vcb=Vdb

The above bridge circuit is balanced when no current flows through the diagonal arm, DB. That means, there is no deflection in the galvanometer, when the bridge is balanced.



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The bridge will be balanced, when the following two conditions are satisfied.

- The voltage across arm AD is equal to the voltage across arm AB. i.e.,

$$V_{AD}=V_{AB}$$
$$\Rightarrow I_1R_1=I_2R_2$$

Equation 1

- The voltage across arm DC is equal to the voltage across arm BC. i.e.,

$$V_{DC}=V_{BC}$$
$$\Rightarrow I_3R_3=I_4R_4$$

Equation 2

From above two balancing conditions, we will get the following two conclusions.

The current flowing through the arm AD will be equal to that of arm DC. i.e.,

$$I_1=I_3$$

The current flowing through the arm AB will be equal to that of arm BC. i.e.,

$$I_2=I_4$$

E-mail:zainab.kadum.jaber@uomus.edu.iq

Take the ratio of Equation 1 and Equation 2.

$$\frac{I_1 R_1}{I_3 R_3} = \frac{I_2 R_2}{I_4 R_4} \qquad \text{Equation 3}$$

Substitute, $I_1 = I_3$ and $I_2 = I_4$ in Equation 3.

$$\frac{I_3 R_1}{I_3 R_3} = \frac{I_4 R_2}{I_4 R_4}$$

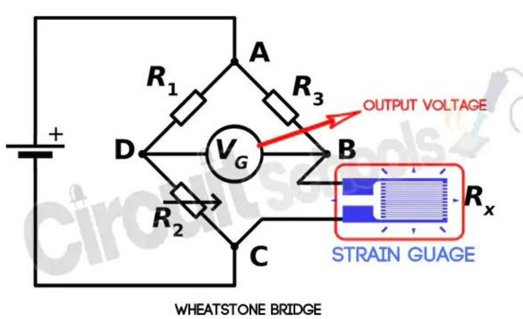
$$\Rightarrow \frac{R_1}{R_3} = \frac{R_2}{R_4}$$

$$\Rightarrow R_4 = \frac{R_2 R_3}{R_1}$$

By substituting the known values of resistors R_1, R_2 and R_3 in above equation, we will get the **value of resistor,** R_4.

Wheatstone bridge application

AStrain gauge is a sensor whose resistance varies with applied force; It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. When external forces are applied to a stationary object, stress and strain are the result.



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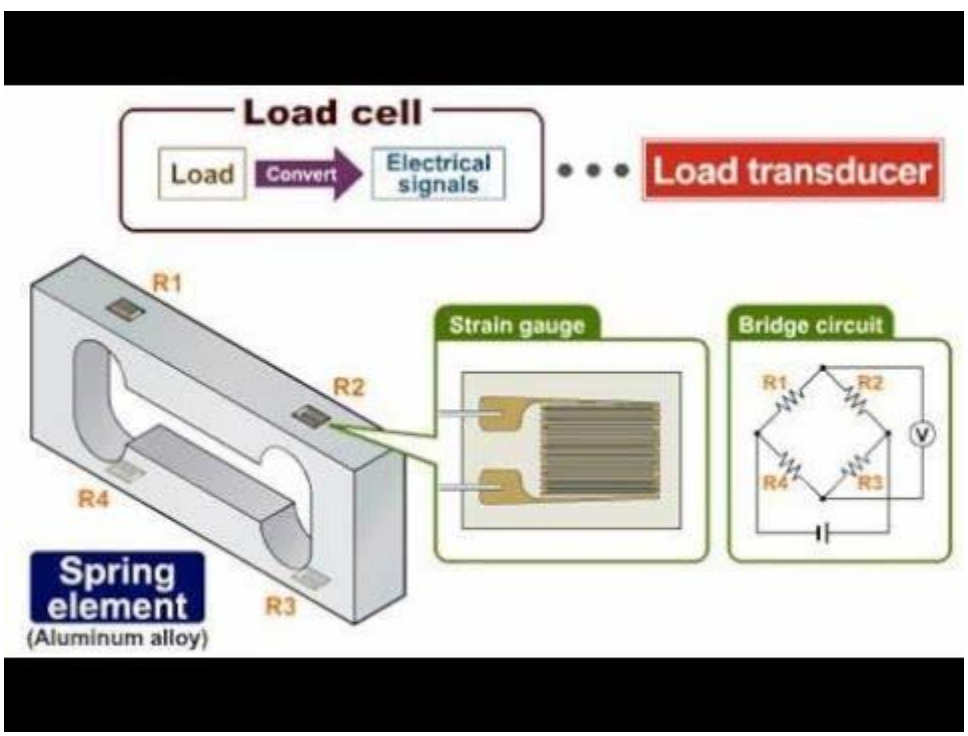
Load cells are sensors that detect force (mass, torque, etc.). When force is applied to a load cell, it converts the force into an electrical signal. Load cells are also known as "load transducers," because they convert a load (force) into electrical signals



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QUESTION:

The resistance of the four arms P,Q.R and S in a Wheatstones bridge are 10 ohm, 30 ohm, 30 ohm and 90 ohm, respectively .The emf and internl resistance of the cell are 7 volt and 5 ohm respectively. If the galvanometer resistance is 50 ohm , the current drawn from the cell will be …..?

b) Kelvin Bridge:

A Kelvin bridge circuit is used to measure unknown electrical resistors, beneath1 Ohm. It is particularly intended to measure resistors that are assembled as four-terminal resistors.

Kelvin bridge is a modification of the Wheatstone bridge and provides greatly increased accuracy in the measurement of low value resistance, generally below (1Ω). It is eliminate errors due to contact and leads resistance. (Ry) represent the resistance of the connecting lead from R3 to R4. Two galvanometer connections are possible, to point (m) or to point (n).

1- If the galvanometer connect to point (m) then

R4 = Rx + Ry therefore unknown resistance will be higher than its actual value by Ry

2- If the galvanometer connect to point (n) then

R4 = R3 + Ry therefore unknown resistance will be lower than its actual value by Ry

3- If the galvanometer connect to point (p) such that

$$\frac{R_{np}}{R_{mp}} = \frac{R_1}{R_2} \quad \ldots\ldots\ldots\ (1)$$

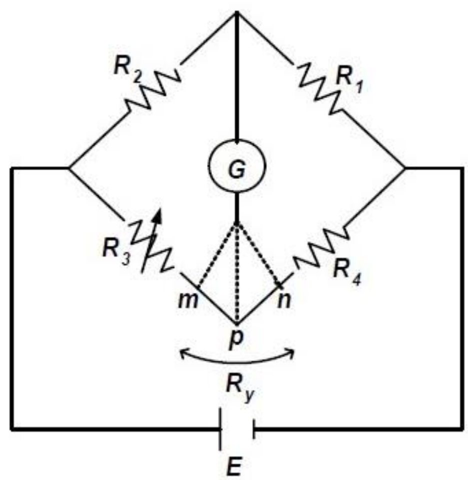
At balance condition

$$R_2\left(R_x + R_{np}\right) = R_1\left(R_3 + R_{mp}\right) \quad \ldots\ldots\ (2)$$

Substituting equ.(1) in to equ.(2) we obtain

$$R_x + \left(\frac{R_1}{R_1 + R_2}\right)R_y = \frac{R_1}{R_2}\left[R_3 + \left(\frac{R_2}{R_1 + R_2}\right)R_y\right]$$

This reduces to $\boxed{R_x = \frac{R_1}{R_2}R_3}$



So the effect of the resistance of the connecting lead from point (**m**) to point (**n**) has be eliminated by connecting the galvanometer to the intermediate position (**p**).

c) Kelvin Double Bridge:

Kelvin double bridge is used for measuring very low resistance values from approximately (1Ω to as low as 1x10-5Ω). The term double bridge is used because the circuit contains a second set of ratio arms labelled Ra and Rb. If the galvanometer is connect to point (p) to eliminates the effect of (yoke resistance Ry).

$$\frac{R_a}{R_b} = \frac{R_1}{R_2}$$

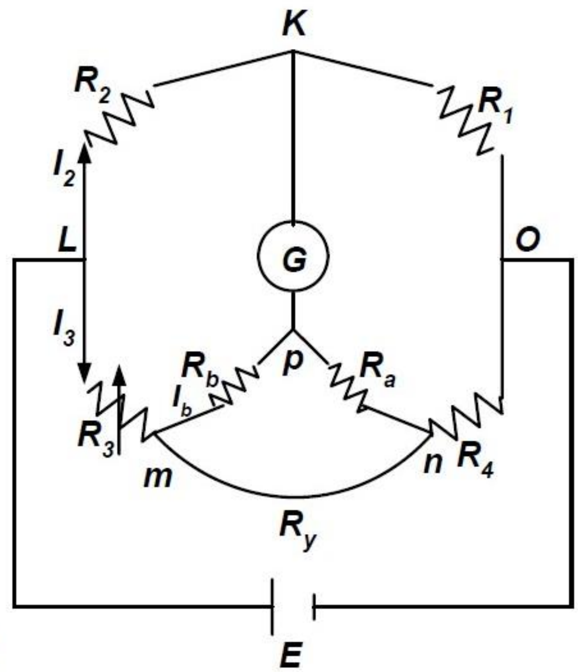
At balance $V_2 = V_3 + V_b$ .... (1)

$$V_2 = E\frac{R_2}{R_1 + R_2} \quad \text{.......... (2)}$$

$V_3 = I_3 R_3$ and $V_b = I_b R_b$ ..... (3)

$$I_b = I_3 \frac{R_y}{(Ra + Rb) + R_y} \quad \text{............ (4)}$$

$$E = I_3\left[R_3 + \frac{(Ra + Rb)R_y}{(Ra + Rb) + R_y} + R_4\right] \text{... (5)}$$



Sub.equ. (5) in to equ. (2) and equ. (4) into equ.(3) then substitute the result in equ.(1), we get

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$$I_3\left[R_3+\frac{(Ra+Rb)R_y}{(Ra+Rb)+R_y}+R_4\right]\frac{R_2}{R_1+R_2}=I_3R_3+I_3\frac{R_y}{(Ra+Rb)+R_y}R_b$$

$$R_x=\frac{R_3R_1}{R_2}+\frac{R_yRb}{Ra+Rb+R_y}\left[\frac{R_1}{R_2}+1-1-\frac{Ra}{Rb}\right]$$

$$\boxed{R_x=\frac{R_3R_1}{R_2}+\frac{R_yRb}{Ra+Rb+R_y}\left[\frac{R_1}{R_2}-\frac{Ra}{Rb}\right]}$$ This is the balanced equation

If $\frac{R_a}{R_b}=\frac{R_1}{R_2}$ then $\boxed{R_x=\frac{R_3R_1}{R_2}}$

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