Bridges and Their Application

Application for wheatstone bridge

1- Used in light detecting devices.
2- For measuring the change in the pressure.
3- For measuring the change in the strain of circuit.
4- Used for the sensing of mechanical and electrical quantites.
5- Also ,photoresistive devices use the circuit.
6- Thermometers also use wheatstone bridge, for the temperature measurment, that need to be accurate.
7- Value like capacitance, inductance. Impedance can be measured.
8- Used for measuring the very low resistance value.

Exampel 1:

Determine the value of the unknown resistor Rx , assuning the circuit is balanced at R_1= 12k ohm R_2= 15 K ohm and R_3= 32 K ohm ?

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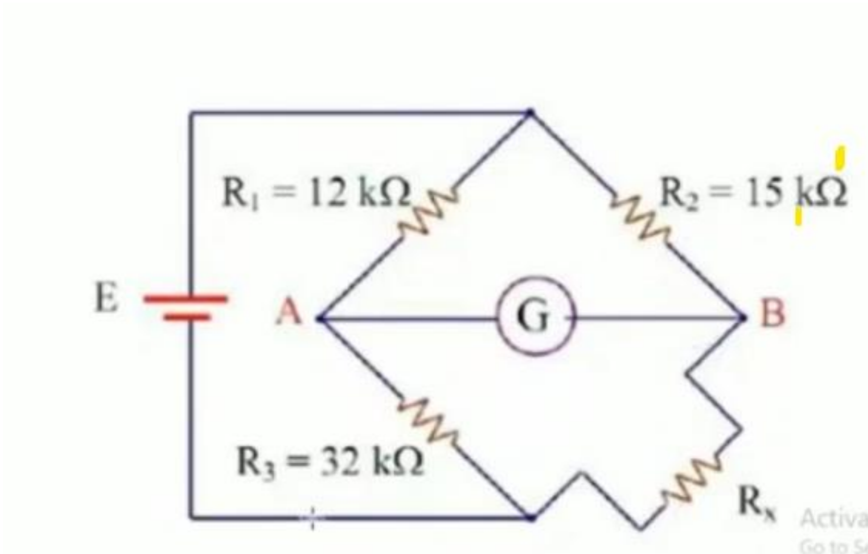
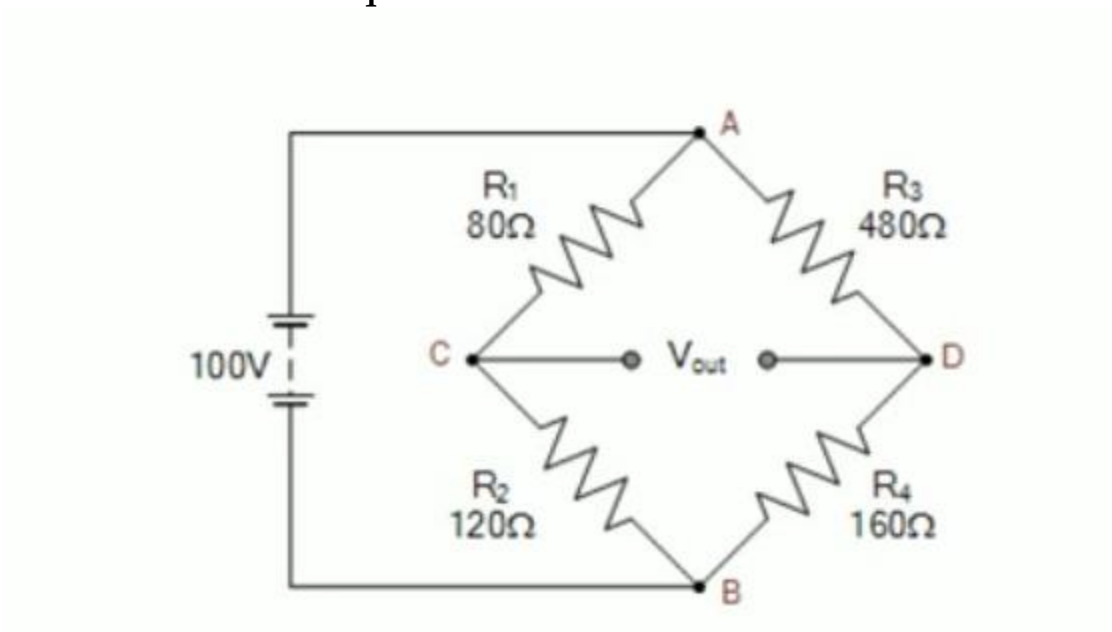


Exampel 2:
The following unbalanced wheatstone bridge is constructed , calculate the output voltage across point C and D, and the value of resisror R4 required to balance the circuit



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Note : we have seen above that the wheatstone bridge has 2 input terminals (A-B) , and 2 output terminals (C-D),
When the bridge is balanced the voltage across the output terminal = 0
When the bridge is unbalanced , however the output voltage maybe either positive or negative value depanding uopn the direction of unbalanced.

Exampel 3:
A wheatstone bridge has a ratio arm of 1\100 (R_1\R_2), at first balance R_3 is adjusted to 1000,3 ohm , the value of R_X is changed by the temperature , the new value of R_3 to achieve the balance condition again os 1002,1 ohm , find the change of R_X due to the tempreature change?

Thevenine Eequivalent circuit .

It is necessary to calculate the galvanometer circuit to determine wheather or not the galvanomater has the required sensitivity to detect unbalance conditions different galvanomater not only may require different currents per unit deflection (current sensitivity) but also may have a difference internal resistane

So we will used Thevenin's Theorem.
Thevenin's Theorem is a technique that allows us to convert a

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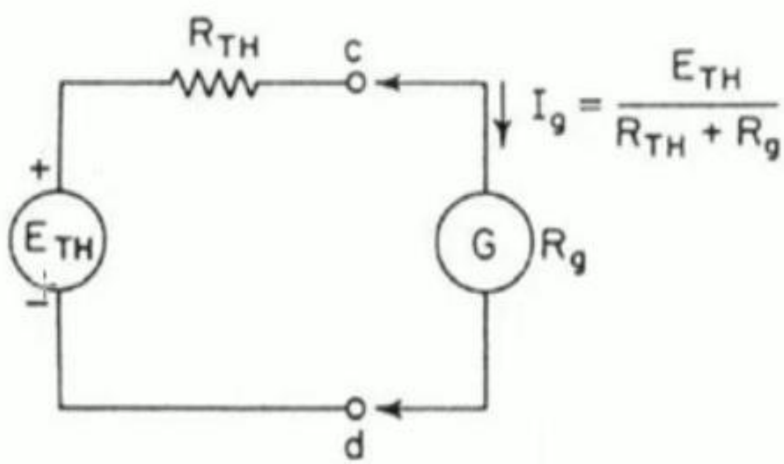
circuit (often a complex circuit) into a simple equivalent circuit. The equivalent circuit consists of a constant voltage source and a single series resistor called the Thevenin voltage and Thevenin resistance, respectively

- The deflection current in the galvanometer



$$I_g = \frac{E_{th}}{R_{th} + R_g}$$

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Converting the wheatstone bridge to this thevenin equivalent circuit in order to find the current follows in the galvanometer

There are two steps must be taken :

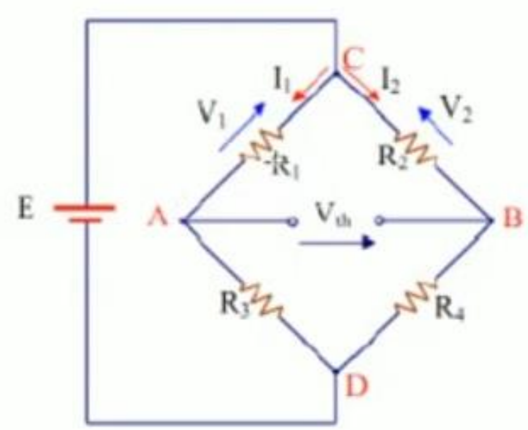
1- Finding the equivalent voltage (ETH), when the galvanometer Is removed from the circuit(the open voltage between A and B of bridge).

Calculate V_{th}

$$V_{th} = V_1 - V_2 = I_1 R_1 - I_2 R_2$$

$$V_{th} = \frac{E}{R_1 + R_3} R_1 - \frac{E}{R_2 + R_4} R_2$$

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



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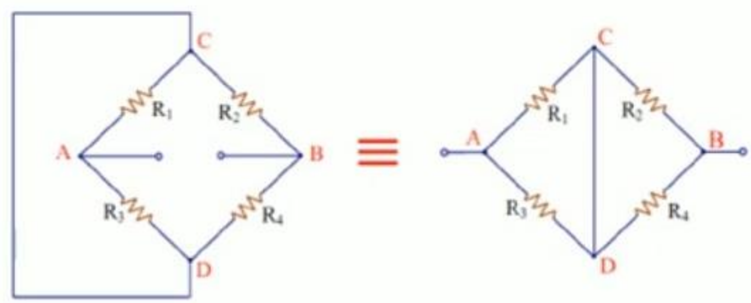
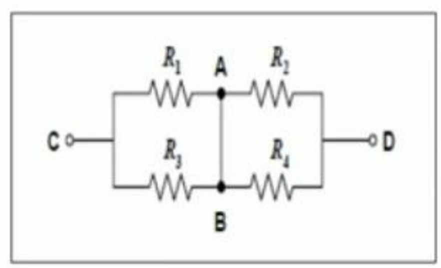
2- Finding the equivalent resistanc (RTH), with the battery replaced by its internal resistance (removing the voltage source and makes it is side short circuit and removing current source makes it is side open circuit).

Calculate r_{th}



$$r_{th} = \frac{R_1 R_3}{R_1 + R_3} + \frac{R_2 R_4}{R_2 + R_4}$$



$$I_g = \frac{E_{th}}{R_{th} + R_g}$$

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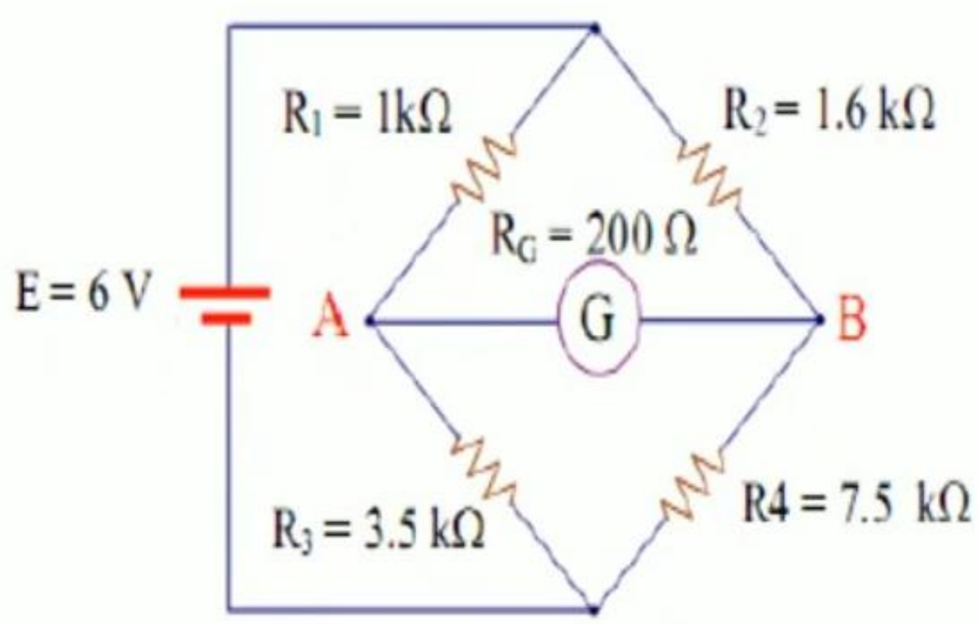
Exampel 4:

Calculate the current passes in the galvanometer of the following circuit?



First we must find the thevenin equivalent circuit

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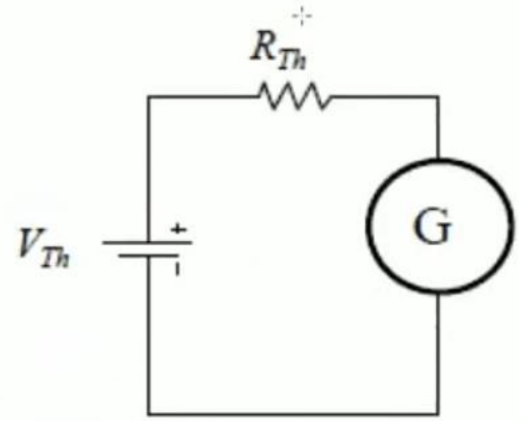

Solution:

1. Find V_{th}

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

$$V_{th} = 6\times\left(\frac{1k\Omega}{1k\Omega + 3.5k\Omega} - \frac{1.6k\Omega}{1.6\,k\Omega + 7.5\,k\Omega}\right) = 0.278V$$

2. Find r_{th}

$$r_{th} = \frac{R_1\,R_3}{R_1 + R_3} + \frac{R_2\,R_4}{R_2 + R_4}$$

$$r_{th} = \frac{1\,k\Omega \times 3.5\,k\Omega}{1\,k\Omega + 3.5\,k\Omega} + \frac{1.6\,k\Omega \times 7.5\,k\Omega}{1.6\,k\Omega + 7.5\,k\Omega} = 2.096\,k\Omega$$

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3. Find I_G

$$I_G = \frac{V_{th}}{r_{th} + R_G} = \frac{0.278\ V}{2.096 \times 10^3\ \Omega + 200\ \Omega} = 121.4\ \mu A$$

a) 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

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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

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

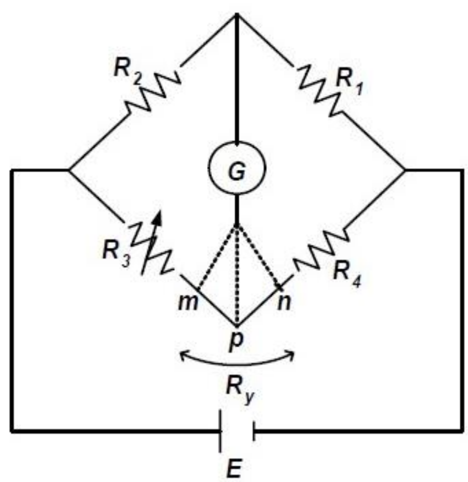
At balance condition

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

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**).

b) 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).

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

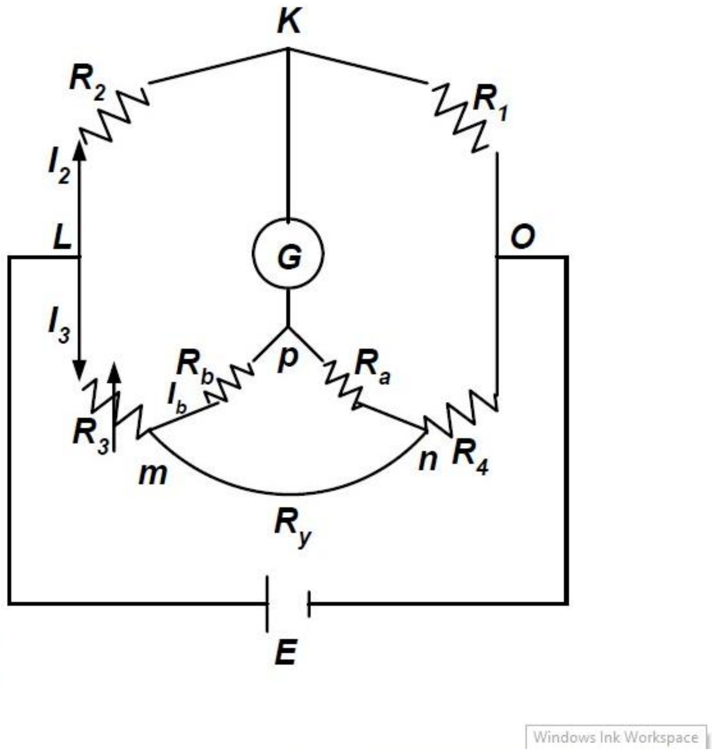
At balance $V_2 = V_3 + V_b$ .... (1)

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

$$V_3 = I_3 R_3 \quad \text{and} \quad V_b = I_b R_b \quad \text{..... (3)}$$

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

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



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

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

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