Purpose and history of a wheatstone bridge engineering essay

This Term Paper is about topic “ Wheatstone Bridge”. A Wheatstone bridge is a device which is used to find the unknown resisitance. It is an instrument or a circuit consisting of four resistors or their equivalent in series which is used to determine the value of an unknown resistance when the other three resistances are known. If talk in some little detail then wheatstone bridge contains the four resistance in which one is unkown resistance which we have to find , one is variable resistance which is also called the rheostat of the circuit and two known resistance. It also contains the galvanometer for the detection of the current and it is also use to find the direction of current.

The various use of wheatstone bridge is as under:-

It is is used by electrical power distributors to accurately locate breaks in a power line.

It is also used to monitor sensor devices such as strain gauges. Such devices change their internal resistance according to the specific level of strain (or pressure, temperature, etc.), and serve as the unknown resistor RX.

Meter bridge, post office box and Carey Foster bridge are instruments based on the principle of Wheatstone bridge

The basic use is to measure the unknown resistance.

What is a wheatstone bridge?

The wheatstone bridge is an instrument which is generally used to measure electrical resistance by balancing a bridge circuit. The bridge circuit contains four resistance, one of which contains the unknown resistance , one variable resistance and two known resistance.

Introductions to Wheatstone Bridge:-

Wheatstone Bridge, a device for measuring electrical resistance. In wheat-stone bridge four resistance R1, R2, R3and R4are connected end to end with each other to form a closed loop. A sensitive galvanometer " G" is connected between their junctions.

One form of Wheatstone bridge is shown in the following example:-

For example:- When the Wheatstone bridge is connected in an electrical circuit, part of the current flows to the object whose resistance is unknown and part of current flows to the resistor of known resistance. If more current flows through one side of the circuit than the other, the galvanometer shows the deflection. Due to potential difference create in between them when the current flows equally along both sides of the bridge then the galvanometer shows zero deflection.

Thus the bridge is balanced, the unknown resistance is calculated by using formula. The formula is:-

R1/R2= R3/R4

Where R1 is the unknown resistance.

R2 is the variable resistance

R3 and R4 are the known resistances

Generally wheat-stone bridge is used to determine unknown resistances.

Conditions for wheatstone bridge:-

There are two conditions for wheatstone bridge which is as under:-

Condition-1: Galvanometer is always in zero potential in the circuit.

Condition-2: We should have to take one variable resistance.

History of Wheatstone bridge:- [link 1]

Wheatstone's bridge circuit diagram.

A Wheatstone bridgeis an electrical circuit invented by Samuel Hunter Christie in 1833 and improved and popularized by Sir Charles Wheatstone in 1843. It is used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of bridge contains the unknown component and variable component. Its operation is similar to the originalpotentiometer.

Potentiometer :- [link 2]

A potentiometeris an instrument for measuring the potential (voltage) in a circuit, they were used in measuring voltage.

Creation of Wheatstone bridge by different scientists:- [link 5]

1) A scientist and mathematician, Samuel Hunter Christie, developed the circuit to measure unknown electrical resistances and first described it in 1833. The bridge worked because of the special diamond-shaped arrangement of the four resistors. Electrical current from a battery split into two parallel branches of the circuit. One consisted of a resistor with a fixed,

known resistance and an adjustable resistor, also with a known resistance. The other leg contained a resistor of fixed and known resistance and another whose resistance needed to be determined. By using a galvanometer to balance the current flowing through the two branches, Christie could, with the help of a little math, determine the value of the unknown resistor.

2) Then another British scientist, Wheatstone, came across Christie's description of the instrument, which Wheatstone referred to as a " differential resistance measurer." A prominent member of the Royal Society of London, Wheatstone was well-positioned to give the tool a popularity boost. He gave an account of Christie's invention at an 1843 lecture, and soon after it came to be called the Wheatstone bridge was used in telegraphy and other applications. Wheatstone himself, however, gave full credit for its invention to Christie. But in translations of his lecture that appeared in Germany and France the following year, Wheatstone's attribution was nowhere to be found.

In addition to bringing the device to public attention, Wheatstone improved the design (Wheatstone developed the rheostat, a variable resistor) and found several new uses for it. By changing the type of elements contained in its legs, the Wheatstone bridge can determine unknown capacitances, inductances, frequencies and other properties.

Besides Wheatstone, several other scientists helped extend the range of the device, including William Thomson, Lord Kelvin and James Clerk Maxwell. This sensitive, accurate method for measuring resistance is still widely used today.

Theory of Wheatstone Bridge:-

To understand this circuit, consider the following Figure to be two voltage dividers shown below:

When the bridge is balanced, the voltages measured by V1and V2are equal, hence no current flows through the Galvanometer G in above figure. Since V1and V2are at the same voltage, the resistance ratios Rx/RSand l1/l2are equal. Because the slide wire has a uniform resistance per unit length, the length ratios l1/l2is equivalent to resistance ratio R1/R2.

How Equipment of wheatstone bridge works:- [Link 8]

The current flows from positive to negative through the circuit. When it reaches Point Ain the diagram, it splits and travels through either one of two Known Resistors, R1 or R2. Resistance is measured in a unit called an ohm. Here we notice that when this applet initializes, the resistance at R1 is 1 K ohm, while at R2 it is also at 1 K ohm.

After the diverging currents pass through their respective resistors (R1 or R2), each reaches another fork in the road. At this point, if the bridge is not balanced, some or all of the current from either the R1 or R2 path will diverge down this middle path that bisects the square created by the circuit. The Galvanometer ispositioned on this middle path which generally tells the presence or absence of current. The direction of this current is determined by the value of the Variable Resistor(R3).

Here at this time the bridge is not balanced because the ratio of resistance on the known leg (R1/R2) is not equal to the ratio on the unknown leg

(R3/R4). This is where the variable resistor which is also called rheostat of the bridge comes into play. It can be adjusted until no current flows down the middle path. When that is achieved, the Galvanometer reads zero and the bridge is balanced. Achieve this balanced state by adjusting the Variable Resistorslider until the Galvanometer reads zero and no more current flows through the middle path. Notice how the arrows depicting current direction change as you manipulate the slider. The ohm value is displayed above the slider.

By discovering the value of the variable resistor in the balanced bridge, you are able to determine what the unknown resistance at R4 is, with a little math:

R1/R2 = R3/R4

or

R4 = (R2 * R3) /R1

So by using the above formula we can easily find out the unknown electrical resistance.

Derivations:-

Derivation of Wheatstone Bridge:-[link 1]

First, Kirchhoff's first rule is used to find the currents in junctions Band D:

When then

I3= Ixand I1= I2……………………………………(3)

Then, Kirchhoff’s second rule is used for finding the voltage in the loops ABDand BCD:

The bridge is balanced when Ig= 0, so the second set of equations can be rewritten as:

……………………………………………….(1)

……………………………………………….(2)

By dividing equation 1 by 2 we get:-

From the equation (3), I3= Ixand I1= I2. The desired value of Rxis now known to be given as:

If all four resistor values and the supply voltage (VS) are known, the voltage across the bridge (VG) can be found by working out the voltage from each potential divider and subtracting one from the other. The equation for this is:

This can be simplified to:

With node B being (VG) positive, and node D being (VG) negative.

Bridgeconatianing constant voltage and voltage gage :-

A basic Wheatstone bridge circuit contains four resistances, a constant voltage input, and a voltage gage, as illustrated below.

For a given voltage input Vin, the currents flowing through ABCand ADCdepend on the resistances, i. e.,

The voltage drops from Ato Band from Ato Dare given by, The voltage gage reading Vgcan then be obtained from,

Now suppose that all resistances can change during the measurement. The corresponding change in voltage reading will be,

If the bridge is initially balanced, the initial voltage reading Vgshould be zero. This yields the following relationship between the four resistances,

We can use this result to simplify the previous equation that includes the changes in the resistances. Doing so results in the solution for the change in Vg,

where h is defined by,

Moreover, when the resistance changes are small (<5%), the second order term h is approximately zero and can be ignored. We then have,

which is the basic equation governing the Wheatstone bridge voltage in strain measurement. The coefficient is called the circuit efficiency.

Equal-Resistance Wheatstone Bridge Circuit:-

In practice, one often uses the same resistance value for all four resistors, R1= R2= R3= R4= R. Noting that r = 1 in this case, the change in voltage can be further simplified to,

By thoughtfully selecting the target and reference resistances, the Wheatstone bridge circuit can amplify small changes in resistance and/or compensate for changes in temperature.

How to use the Wheatstone Bridge :-

In its basic application, a dc voltage (E) is applied to the Wheatstone Bridge, and a galvanometer (G) is used to monitor the balance condition. The values of R1 and R3 are precisely known, but do not have to be identical. R2 is a calibrated variable resistance, whose current value may be read from a dial or scale.

An unknown resistor, RX, is connected as the fourth side of the circuit, and power is applied. R2 is adjusted until the galvanometer, G, reads zero current. At this point, RX = R2Ã-R3/R1.

This circuit is most sensitive when all four resistors have similar resistance values. However, the circuit works quite well in any event. If R2 can be varied over a 10: 1 resistance range and R1 is of a similar value, we can switch decade values of R3 into and out of the circuit according to the range of value we expect from RX. Using this method, we can accurately measure any value of RX by moving one multiple-position switch and adjusting one precision potentiometer.

Significance of wheatstone bridge :- [link 1]

The Wheatstone bridge illustrates the concept of a difference measurement, which can be extremely accurate. Variations on the Wheatstone bridge can be used to measure capacitance, inductance, impedance and other quantities, such as the amount of combustible gases in a sample, with an explosimeter. The Kelvin bridge was specially adapted from the Wheatstone bridge for measuring very low resistances. In many cases, the significance of measuring the unknown resistance is related to measuring the impact of some physical phenomenon – such as force, temperature, pressure, etc – which thereby allows the use of Wheatstone bridge in measuring those elements indirectly.

Applications of Wheatstone Bridge:- [Link 6],[Link 7]

A number of resistance measuring devices have been devised on the principle of wheatstone bridge. For example :

1) Meter bridge, post office box and Carey Foster bridge are instruments based on the principle of Wheatstone bridge and are used to measure unknown resistance.

2) A very common application in industry today is to monitor sensor devices such as strain gauges. Such devices change their internal resistance according to the specific level of strain (or pressure, temperature, etc.), and serve as the unknown resistor RX. However, instead of trying to constantly adjust R2 to balance the circuit, the galvanometer is replaced by a circuit that can be calibrated to record the degree of imbalance in the bridge as the value of strain or other condition being applied to the sensor.

3) A third application is used by electrical power distributors to accurately locate breaks in a power line. The method is fast and accurate, and does not require a large number of field technicians.

Other applications abound in electronic circuits. We'll see a number of them in action as these pages continue to expand.

Bridge circuits are widely used for the measurement of resistance, capacitance, and inductance. The resistive bridge, also known as Wheatstone bridge.

Links used in the Term Paper:-

1)http://en. wikipedia. org/wiki/Wheatstone_bridge

2) http://en. wikipedia. org/wiki/Potentiometer_%28measuring_instrument %29

3)http://www. efunda. com/designstandards/sensors/methods/wheatstone_bridge. cfm

4) http://www. magnet. fsu. edu/education/tutorials/java/wheatstonebridge/index. html

5) http://www. magnet. fsu. edu/education/tutorials/museum/wheatstonebridge. html

6) http://www. citycollegiate. com/wheatstone_bridge. htm

7) http://www. transtutors. com/physics-homework-help/current-electricity/wheatstone-bridge-and-potentiometer. aspx

8) http://reocities. com/CapeCanaveral/8341/bridge. htm