SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

IIYEAR/ III SEMESTER

23ECT101 Electrical Engineering and Instrumentation

unit 5-MEASUREMENT SYSTEMS

BRIDGES-WHEATSTONE BRIDGE

If the electrical components are arranged in the form a bridge or ring structure, then that electrical circuit is called a **bridge**. In general, bridge forms a loop with a set of four arms or branches. Each branch may contain one or two electrical components.

The two Types of bridges are,

The D.C bridges are used to measure the resistance

A.C bridges are used to measure the impedances consisting capacitance and inductances.

The D.C bridges use the D.C voltages as the excitation voltage while the A.C bridges use the alternating voltage as the excitation voltage.

The two types of D.C bridges

Wheatstone Bridge

Kelvin Bridge

The various types of A.C Bridges are,

Capacitance Comparison Bridge

Inductance Comparison Bridge

Maxwell's Bridge

Hay's Bridge

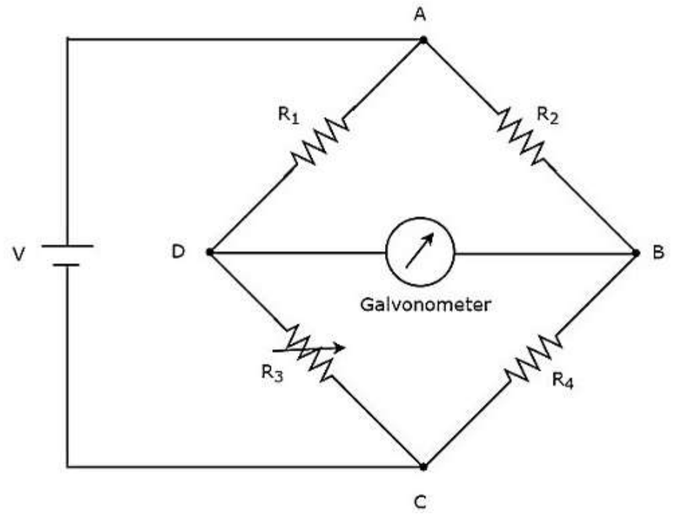
Anderson Bridge

Schering Bridge

Wien Bridge

DC BRIDGES

If the bridge circuit can be operated with only DC voltage signal, then it is a DC bridge circuit or simply **DC bridge**. DC bridges are used to measure the value of unknown resistance. The **circuit diagram** of DC bridge looks like as shown in below figure.



The above DC bridge has **four arms** and each arm consists of a resistor. Among which, two resistors have fixed resistance values, one resistor is a variable resistor and the other one has an unknown resistance value.

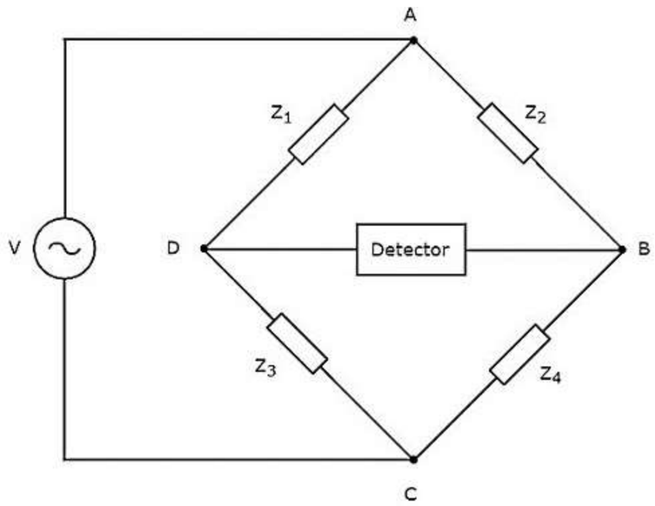
The above DC bridge circuit can be excited with a **DC voltage source** by placing it in one diagonal. The galvanometer is placed in other diagonal of DC bridge. It shows some deflection as long as the bridge is unbalanced.

Vary the resistance value of variable resistor until the galvanometer shows null (zero) deflection. Now, the above DC bridge is said to be a balanced one. So, we can find the value of **unknown resistance** by using nodal equations.

AC BRIDGE

If the bridge circuit can be operated with only AC voltage signal, then it is said to be AC bridge circuit or simply **AC bridge**. AC bridges are used to measure the value of unknown inductance, capacitance and frequency.

The **circuit diagram** of AC bridge looks like as shown in below figure.



The circuit diagram of AC bridge is similar to that of DC bridge. The above AC bridge has **four arms** and each arm consists of some impedance. That means, each arm will be having either single or combination of passive elements such as resistor, inductor and capacitor.

Among the four impedances, two impedances have fixed values, one impedance is variable and the other one is an unknown impedance. The above AC bridge circuit can be excited with an **AC voltage source** by placing it in one diagonal. A detector is placed in other diagonal of AC bridge. It shows some deflection as long as the bridge is unbalanced.

The above AC bridge circuit can be excited with an **AC voltage source** by placing it in one diagonal. A detector is placed in other diagonal of AC bridge. It shows some deflection as long as the bridge is unbalanced.
Vary the impedance value of variable impedance until the detector shows null (zero) deflection. Now, the above AC bridge is said to be a balanced one. So, we can find the value of **unknown impedance** by using balanced condition.

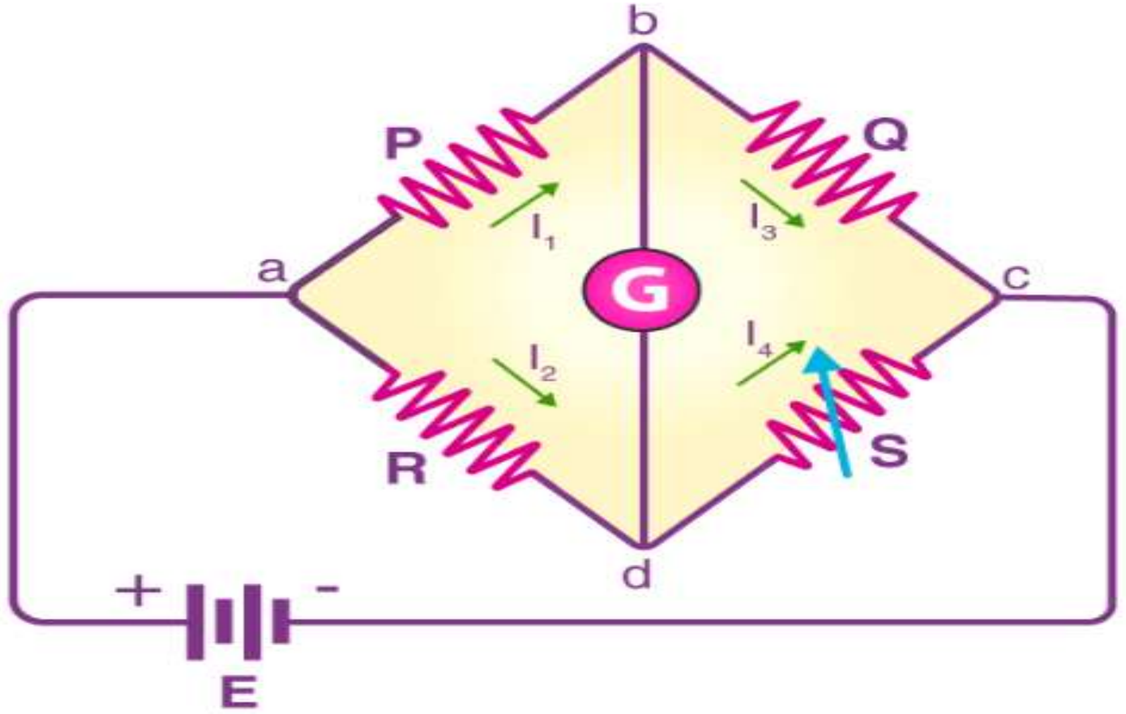
WHEAT STONE BRIDGE

Wheatstone bridge, also known as the resistance bridge, calculates the unknown resistance by balancing two legs of the bridge circuit. One leg includes the component of unknown resistance.

The Wheatstone Bridge Circuit comprises two known resistors, one unknown resistor and one variable resistor connected in the form of a bridge. This bridge is very reliable as it gives accurate measurements.

Construction

A Wheatstone bridge circuit consists of four arms, of which two arms consist of known resistances while the other two arms consist of an unknown resistance and a variable resistance. The circuit also consists of a galvanometer and an electromotive force source. The emf source is attached between points *a* and *b* while the galvanometer is connected between points *c* and *d*. The current that flows through the galvanometer depends on its potential difference.


b
P
Q
a
G
c
I_1
I_3
I_2
I_4
R
S
d
+
-
E

WORKING PRINCIPLE

The Wheatstone bridge works on the principle of null deflection, i.e. the ratio of their resistances is equal, and no current flows through the circuit. Under normal conditions, the bridge is in an unbalanced condition where current flows through the galvanometer. The bridge is said to be balanced when no current flows through the galvanometer. This condition can be achieved by adjusting the known resistance and variable resistance.

Wheatstone Bridge Derivation

The current enters the galvanometer and divides into two equal magnitude currents as I_1 and I_2. The following condition exists when the current through a galvanometer is zero,

$$I_1P = I_2R. . (1)$$

The currents in the bridge, in a balanced condition, are expressed as follows:

$$I_1 = I_3 = \frac{E}{P+Q}$$

$$I_2 = I_4 = \frac{E}{R+S}$$

Here, E is the emf of the battery.

By substituting the value of I_1 and I_2 in equation (1), we get

$$\frac{PE}{P+Q} = \frac{RE}{R+S}$$

$$\frac{P}{P+Q} = \frac{R}{R+S}$$

$$P(R+S) = R(P+Q)$$

$$PR + PS = RP + RQ$$

$$PS = RQ \ldots (2)$$

$$R = \frac{P}{Q} \times S \ldots (3)$$

Equation (2) shows the balanced condition of the bridge, while (3) determines the value of the unknown resistance.

In the figure, R is the unknown resistance, S is the standard arm of the bridge and P and Q are the ratio arm of the bridge.

APPLICATIONS & LIMITATIONS

Wheatstone Bridge Application

The Wheatstone bridge is used for the precise measurement of low resistance.

Wheatstone bridge and an operational amplifier are used to measure physical parameters such as temperature, light, and strain.

Quantities such as impedance, inductance, and capacitance can be measured using variations on the Wheatstone bridge.

Wheatstone Bridge Limitations

For low resistance measurement, the resistance of the leads and contacts becomes significant and introduces an error.

For high resistance measurement, the measurement presented by the bridge is so large that the galvanometer is insensitive to imbalance.

The other drawback is the resistance change due to the current's heating effect through the resistance. Excessive current may even cause a permanent change in the value of resistance.