DEPARTMENT OF BIOMEDICAL ENGINEERING

III Semester

BM3301 SENSORS AND MEASUREMENTS

UNIT – 4

4.5 A.C and D.C. Bridges

Wheatstone Bridge

Bridge circuits of various types are used in Instrumentation systems for the measurement of resistance, inductance and capacitance. The bridges may be either of the two types viz :

- A d.c. type, and
- A a.c. type

In case the output of resistive type of transducers is to be measured, either d.c. or a.c. bridges may be used. But when measuring inductance or capacitance which may be on account of output of inductive or capacitive transducers, a.c. bridges are used.

4.5.1 Wheatstone Bridge:

- A very important device used in the measurement of medium resistances is the Wheatstone bridge.
- The Wheatstone bridge is an instrument for making comparison measurements and operates upon a null indication principle.
- very high degrees of accuracy can be achieved using Wheatstone bridge. Accuracy of 0.1%

Construction and Working:

- Figure 4.5.1 shows the basic circuit of a Wheatstone bridge.

- It has four resistive arms, consisting of resistances P, Q, R and S together with a source of emf (a battery) and a null detector, usually a galvanometer G or other sensitive current meter.
- The current through the galvanometer depends on the potential difference between points c and d.
- The bridge is said to be balanced when there is no current through the galvanometer or when the potential difference across the galvanometer is zero.
- This occurs when the voltage from point ‘b’ to point ‘d’ equals the voltage from point ‘d’ to point ‘b’; or, by referring to the other battery terminal, when the voltage from point 'd' to point 'c’ equals the voltage from point 'b’ to point 'c’.

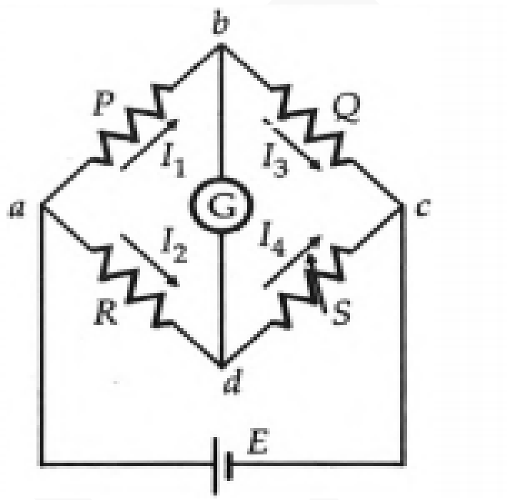

Figure 4.5.1 basic circuit of a Wheatstone bridge

For bridge balance, we can write,

$$I_1 P = I_2 R \qquad \text{--------------------- (1)}$$

For the galvanometer current to be zero, the following conditions also exist

$$I_1 = I_3 = \frac{E}{P+Q} \qquad \text{--------------------- (2)}$$

And

$$I_2 = I_4 = \frac{E}{R+S} \qquad \text{--------------------- (3)}$$

where E - emf of the battery

Combining Eqns. (1), (2) and (3) and simplifying, we obtain :

$$\frac{P}{P+Q} = \frac{R}{R+S} \quad \text{-------------------- (4)}$$

from which QR = PS -------------------- (5)

Equation 5 is the well-known expression for the balance of Wheatstone bridge. If three of the resistances are known, the fourth may be determined from Eqn. 5 and we obtain

$$R = S\,\frac{P}{Q} \quad \text{-------------------- (5)}$$

where R is the unknown resistance, S is called the ***'standard arm'*** of the bridge and P and Q are called the ***'ratio arms'***.

4.5.2 Sensitivity of Wheatstone Bridge:

Bridge sensitivity is defined as the deflection of the galvanometer per unit fractional change in the unknown resistance it is denoted as S_B.

$$S_B = \frac{\theta}{\Delta R/R}$$

where ΔR/R = unit fractional change in unknown resistance

4.5.3 Limitations of Wheatstone Bridge:

i. The use of Wheatstone bridge is ***limited*** to the measurement of resistances ranging from a few ohms to several megohms.
ii. The Wheatstone Bridge is sensitive to ***environmental factors*** such as temperature changes.
iii. For accurate measurements, the resistors in the bridge arms must be well-matched and have ***precise values***.
iv. The resistance of the ***connecting leads*** can influence the accuracy of the Wheatstone Bridge measurements. If the lead resistance is not negligible compared to the other resistances in the bridge, it can introduce errors.

4.5.4 Applications of Wheatstone Bridge:

i. Resistance Measurement:
ii. Strain Gauge Measurement:

iii. The Wheatstone bridge can be employed for temperature measurement using temperature-sensitive resistors
iv. Load Cell Calibration
v. Used in temperature Sensor for Biomedical Applications