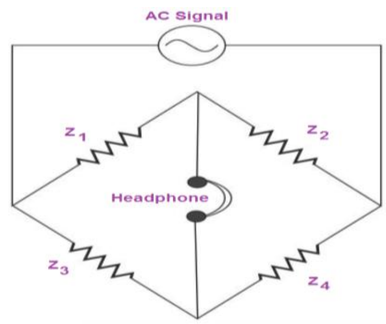
AC Bridges

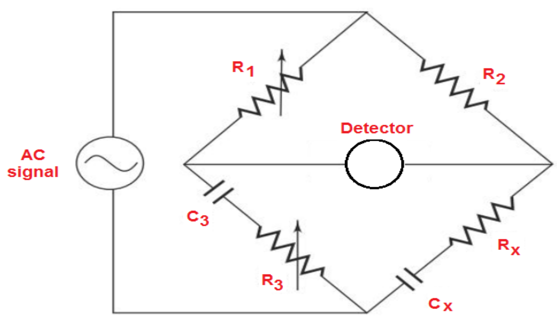
- Bridge circuit is operated (excited) with only AC voltage signal.
- AC bridges are used to measure the value of unknown inductance, capacitance and frequency.
- AC bridge has **four arms** and each arm consists of some impedance. Each arm will be having either single or combination of passive elements such as resistor, inductor and capacitor.



$$\frac{Z_1}{Z_2} = \frac{Z_3}{Z_4}$$

Necessary to adjust both the magnitude and phase angles of the impedance arms to achieve balance, i.e. the bridge must be balanced for both the reactance and the resistive component.

CAPACITANCE COMPARISION BRIDGE



The equation for balanced condition is

$$Z_1 Z_X = Z_2 Z_3$$

The capacitive balance gives

$$\mathbf{C_x} = \frac{\mathbf{C_3 R_1}}{\mathbf{R_2}}$$

The resistive balance gives

$$\mathbf{R_x} = \frac{\mathbf{R_2 R_3}}{\mathbf{R_1}}$$

The ratio arms *R1, R2 are resistive.* The known standard capacitor C3 is in series with *R3. R3 may also* include an added variable resistance needed to balance the bridge. *Cx* is the unknown capacitor and *Rx is* the small leakage resistance of the capacitor. In this case an unknown capacitor is compared with a standard capacitor and the value of the former, along with its leakage resistance. A fixed resistance ratio and variable standards are used. Balance is obtained by alternately varying C3 and R3

$Z_1 = R_1$

$Z_2 = R_2$

$Z_3 = R_3 - \frac{j}{WC_3}$

$Z_x = R_x - \frac{j}{WC_x}$

The condition for balance of the bridge is

$Z_1 Z_X = Z_2 Z_3$

$R_1 \left(R_x - \frac{j}{WC_x}\right) = R_2 \left(R_3 - \frac{j}{WC_3}\right)$ (1)

$R_1 R_x - \frac{R_1 j}{WC_x} = R_2 R_3 - \frac{R_2 j}{WC_3}$

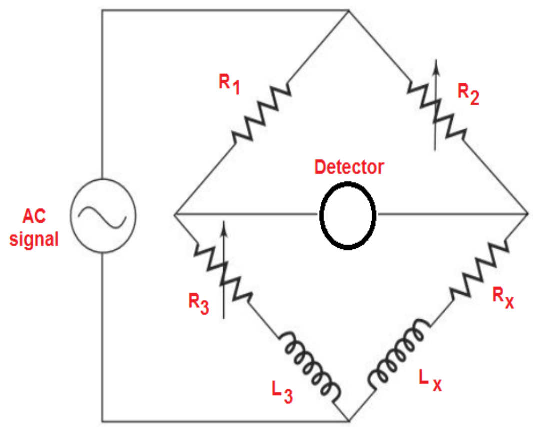
Two complex quantities are equal when both their real and their imaginary terms are equal.

$R_1 R_x = R_2 R_3$ and $\frac{R_2}{WC_3} = \frac{R_1}{WC_x}$ (2)

$$\mathbf{C_x = \frac{C_3 R_1}{R_2}}$$

$$\mathbf{R_x = \frac{R_2 R_3}{R_1}}$$

INDUCTANCE COMPARISION BRIDGE



The equation for balanced condition is

$$Z_1 Z_X = Z_2 Z_3$$

The inductive balance gives

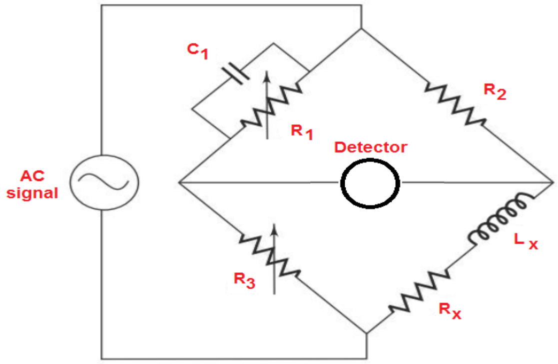
$$\mathbf{L_x = \frac{L_3 R_2}{R_1}}$$

The resistive balance gives

$$\mathbf{R_x = \frac{R_2 R_3}{R_1}}$$

Value of the unknown inductance *Lx and its internal resistance Rx are obtained* by comparison with the standard inductor and resistance, i.e. *L3 and R3.*
R2 is chosen as the inductive balance control and R3 as the resistance balance control.
Balance is obtained by alternately varying *L3 or R3.*
If the Q of the unknown reactance is greater than the standard Q, it is necessary to place a variable resistance in series with the unknown reactance to obtain balance.

MAXWELL BRIDGE



$$R_x = \frac{R_2 R_3}{R_1}$$

$$L_x = C_1 R_2 R_3$$

$$Q = WC_1 R_1$$

Maxwell's bridge measures an unknown inductance in terms of a known capacitor. One arm has a resistance *R1 in parallel with C1 and hence it is* easier to write the balance equation using the admittance of arm 1 instead of the impedance.

- Used for inductance measurements of low Q.
- Best suited since comparison with a capacitor is more ideal than with an inductor
- Measure from 1 µH to 1000 H with an accuracy of ±2 % (Q <10)

The condition for balance of the bridge is

$$Z_1 Z_X = Z_2 Z_3$$

$$Z_X = \frac{Z_2 Z_3}{Z_1} = Z_2 Z_3 Y_1 \quad (1)$$

$$Z_1 = \frac{1}{R_1} + jWC_1$$ (R_1 in parallel with C_1)

$$Z_2 = R_2$$

$$Z_3 = R_3$$

$$Z_x = R_x + WL_x$$

From eq.1 we have

$$(R_x + WL_x) = R_2 R_3 \left(\frac{1}{R_1} + jWC_1\right) \quad (2)$$

$$R_x + WL_x = \frac{R_2 R_3}{R_1} + jWC_1 R_2 R_3$$

Equating real and imaginary terms we have

$$\mathbf{R_x = \frac{R_2 R_3}{R_1} \text{ and } L_x = C_1 R_2 R_3} \quad (3)$$

$$\mathbf{Q = \frac{WL_x}{R_x} = \frac{WC_1 R_2 R_3 R_1}{R_2 R_3} = WC_1 R_1} \quad (4)$$