# Fundamentals of AC Bridge

## 1. AC Bridge

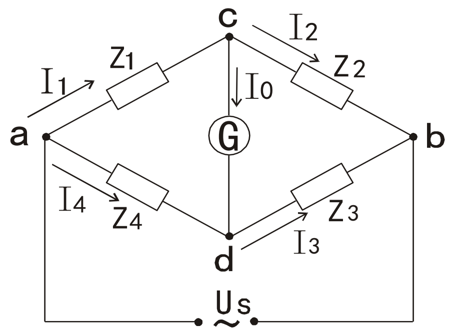


Figure 1 AC Bridge Principle

AC bridges consist of 4 pieces of AC electrical components,Z1,Z2,Z3,and Z4. They may be resistor, inductor and capacitor. One zero indicator G, it is used to check if the bridge in balance condition ,ie, I0=0. AC voltage is applied between terminals a and b.

## 2. The balance condition of AC Bridges

While one sinusoidal AC voltage is applied between terminals a and b, then the balance condition of AC Bridge as below:

$$\begin{cases} Z_1 Z_3 = Z_2 Z_4 \\ \varphi_1 + \varphi_3 = \varphi_2 + \varphi_4 \end{cases}$$

Both conditions above formulas must be met at the same time. i.e.

Z1Z3 amplitude product= the product of Z2 and Z4;

ϕ1 is the phase angle of Z1, So do ϕ3, ϕ2,and ϕ4. The sum ofϕ1 and ϕ3, must be equal to the sum ofϕ2,and ϕ4.

## 3. Commonly used AC Bridges

**3.1 Schering Bridge, also called Capacitance Bridge**

Actual capacitor doesn't pure capacitance, It has dielectric loss.

One actual capacitor could be equal to one pure capacitor and one resistor in serial or in parallel.

3.1.1 In serial for low dielectric loss bridge

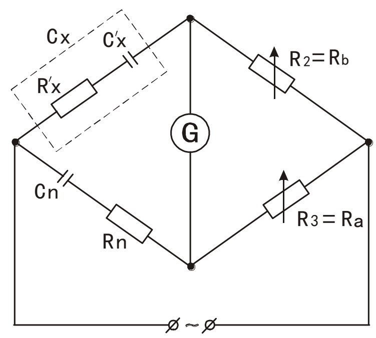


Figure 2. Schering Bridge-R'x in serial

he balance condition of AC Bridge as below:

$$\begin{cases} R_x = \dfrac{R_b}{R_a} R_n \\ C_x = \dfrac{R_a}{R_b} C_n \end{cases}$$

Both conditions above formulas must be met at the same time

$tg\delta = \omega C_x R_x = \omega C_n R_n$

3.1.2 In parallel for big dielectric loss bridge

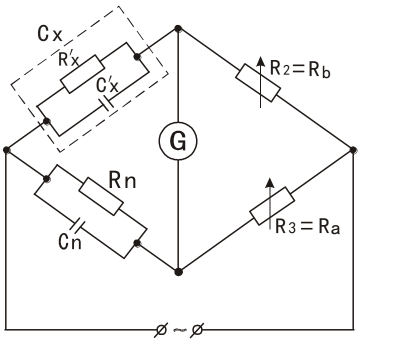


Figure 3. Schering Bridge-R'x in parallel

The balance condition of AC Bridge as below:

$$\begin{cases} C_x = C_n \dfrac{R_a}{R_b} \\ R_x = R_n \dfrac{R_b}{R_a} \end{cases}$$

Both conditions above formulas must be met at the same time

$$tg\delta = \frac{1}{\omega C_x R_x} = \frac{1}{\omega C_n R_n}$$

**3.2 Inductance Bridge**

Inductance Bridge is used to measure unknown inductance. Usually, standard capacitor is used as the criterion to measure unknown inductor.

Actual inductor doesn't pure inductance, It has resistance.

XL/R.is called Q vale of one inductor. $X_L = \omega L$

3.2.1 Maxwell Bridge which is used to measure low Q value inductor

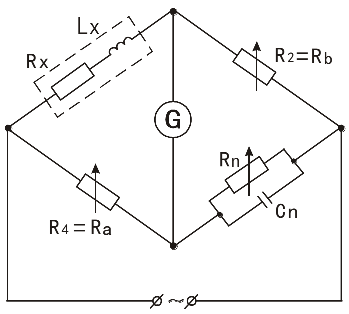


Figure 4. Maxwell Bridge

$$\begin{cases} LX = RbRaCn \\ Rx = \frac{R_b}{R_n} Ra \end{cases}$$

$$Q = \frac{\omega Lx}{Rx} = \omega RnCn$$

For Maxwell Bridge, its balance is independent of its AC power frequency.

3.2.2 Hay Bridge which is used to measure big Q value inductor

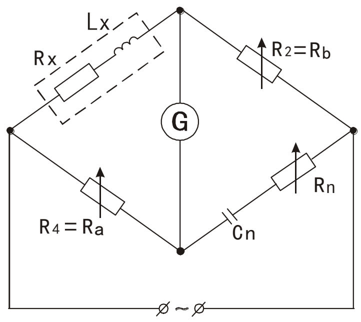


Figure 5. Hay Bridge

$$\begin{cases} LX = \frac{RbRaCn}{1+(\omega CnRn)^2} \\ RX = \frac{R_b R_a Rn(\omega Cn)^2}{1+(\omega CnRn)^2} \end{cases}$$

$$Q = \frac{\omega L}{Rx} = \frac{1}{\omega CnRn}$$

3.3 Wheatstone bridge to measure unknown resistances.

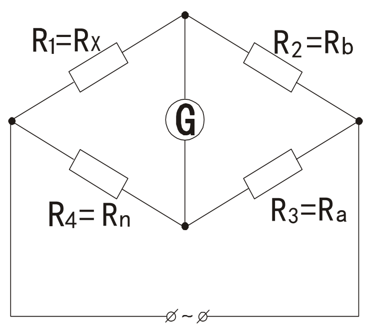


Figure 6. Wheatstone Bridge

$$R_X = \frac{R_n}{R_a} \cdot R_b$$

To measure unknown resistance, Usually AC bridge is replaced with DC bridge.