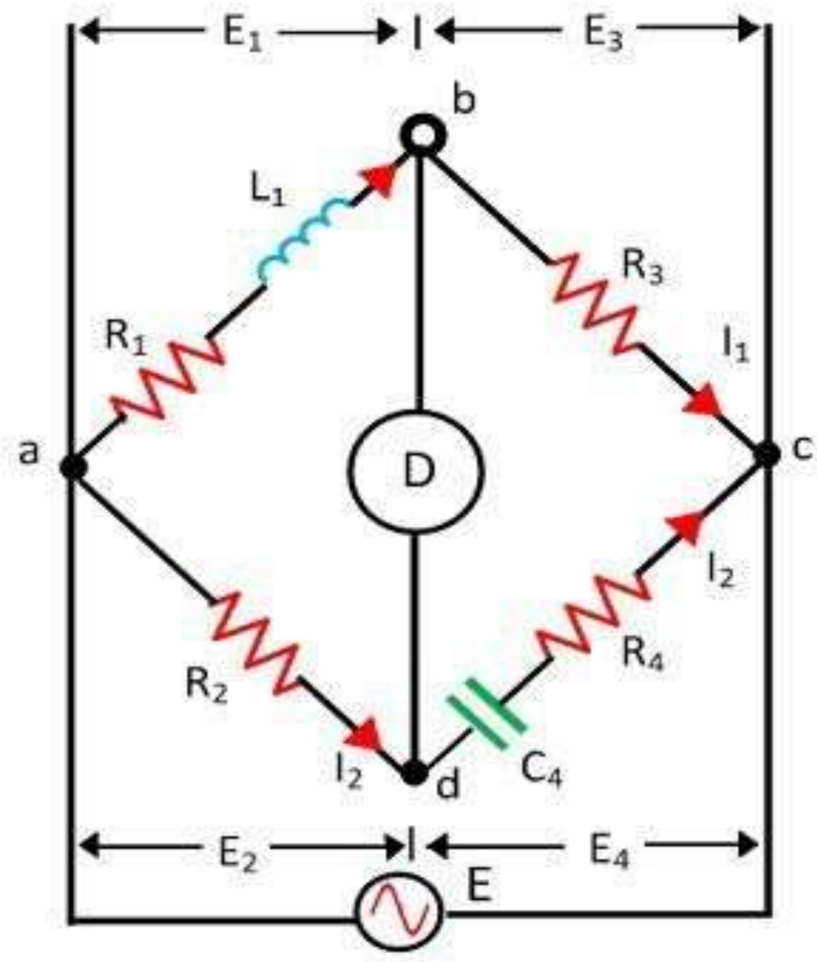
DSE 4A CLASS

Lecture-5

20/05/2021



Hay's Bridge

L_1 – unknown inductance having a resistance R_1

R_2, R_3, R_4 – known non-inductive resistance.

C_4 – standard capacitor

At balance condition,

$$(R_1 + j\omega L_1)(R_4 - j/\omega C_4) = R_2 R_3$$

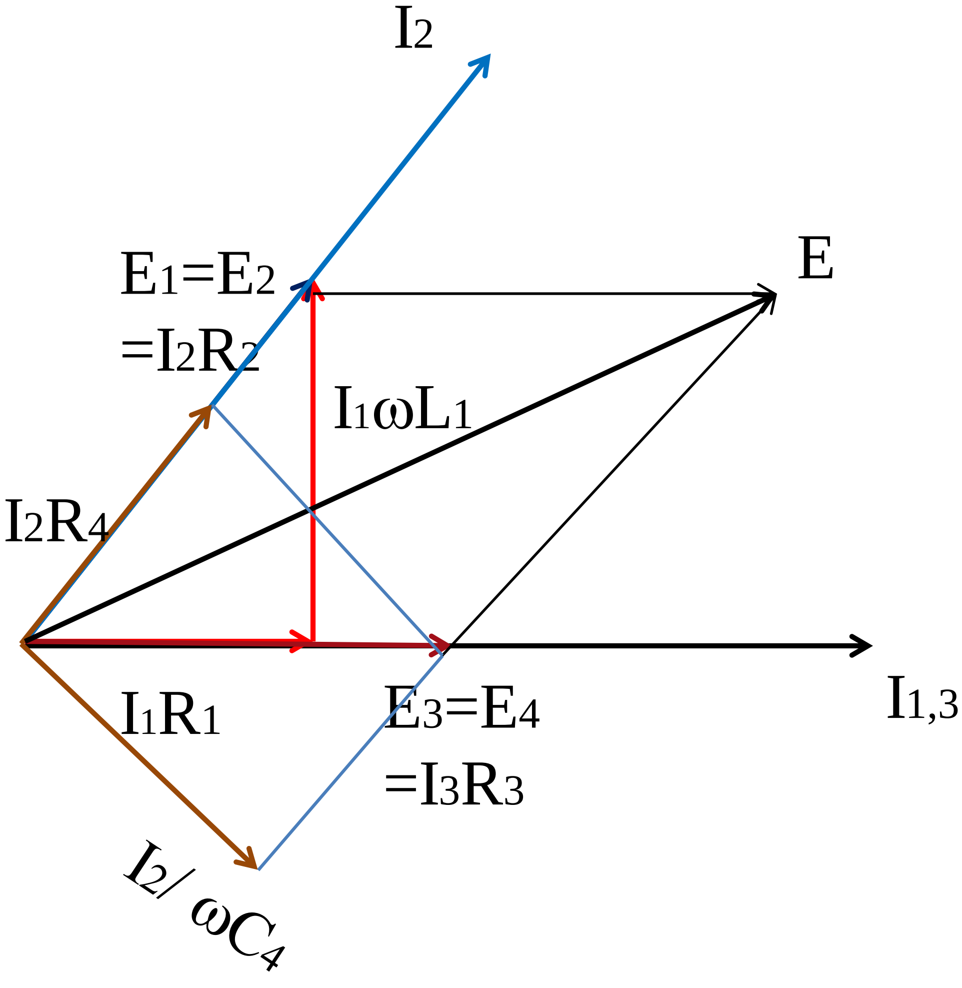
$$R_1 R_4 + \frac{L_1}{C_4} + j\omega L_1 R_4 - \frac{jR_1}{\omega C_4} = R_2 R_3$$

By separating the real and imaginary equation

$$R_1 R_4 + \frac{L_1}{C_4} = R_2 R_3 \quad and\ L_1 = \frac{-\ R_1}{\omega^2 R_4 C_4}$$

$$L_1 = \frac{R_2 R_3 C_4}{1 + \omega^2 R_4^2 C_4^2}$$

$$R_1 = \frac{\omega^2 C_4^2 R_2 R_3 R_4}{1 + \omega^2 R_4^2 C_4^2}$$



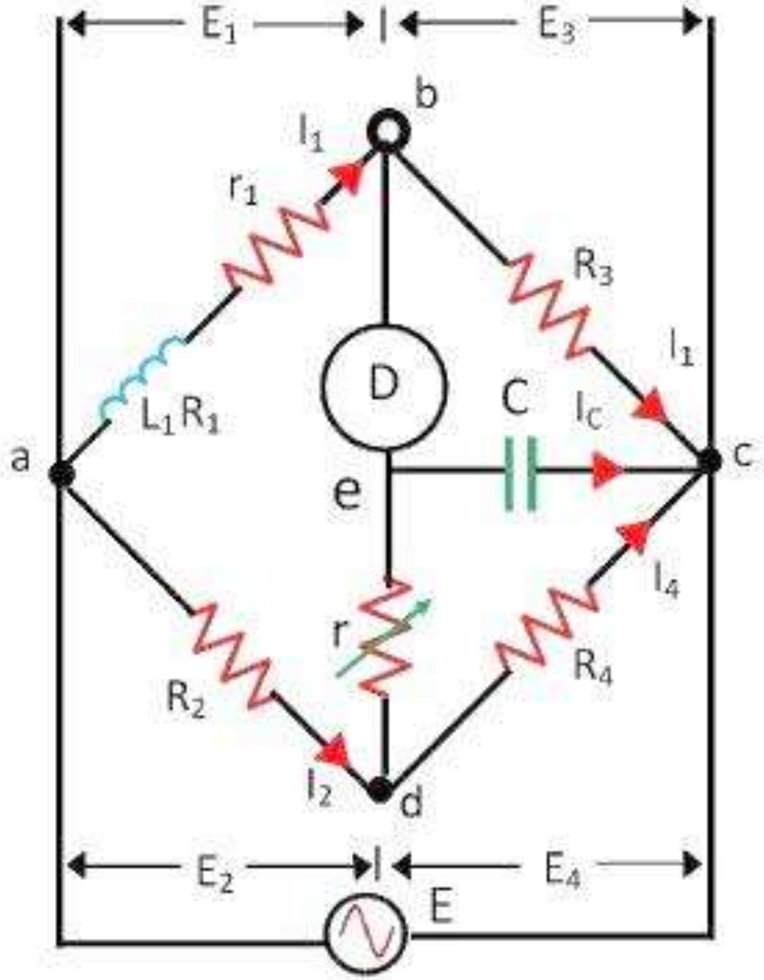
I2
E
E1=E2
=I2R2
I1ωL1
I2R4
I1R1
E3=E4
=I3R3
I1,3
I2/ ωC4

Advantages

- This bridge is used for the unknown inductances to provide a simple expression. It is appropriate for the coil that has a high Q factor > 10.
- It uses a small resistance value to determine the quality factor.

Disadvantages

- It is not applicable for the measurement of the coil which has less than 10 Q factor.
- The balanced equation of the bridge depends on operating frequency and thus the frequency change will influence the measurements.



Anderson's Bridge

The **Anderson's bridge** gives the **accurate measurement** of **self-inductance** of the circuit.

In Anderson bridge, the **unknown inductance** is compared with the **standard fixed capacitance** which is connected between the two arms of the bridge.

L_1 – unknown inductance having a resistance R_1.

R_2, R_3, R_4 – known non-inductive resistance

C_4 – standard capacitor

At balance Condition,

$$I_1 = I_3 \; and \; I_2 = I_C + I_4$$

$$I_1 R_3 = I_C \times \frac{1}{j\omega C}$$

$$I_C = I_1 \omega C R_3$$

Again

$$I_1(r_1 + R_1 + j\omega L_1) = I_2 R_2 + I_C r$$

$$I_c\left(r + \frac{1}{j\omega C}\right) = (I_2 - I_C) R_4$$

By substituting the value of I_c

$$I_1(r_1 + R_1 + j\omega L_1) = I_2 R_2 + I_1 j\omega C R_3 r$$

$$I_1(r_1 + R_1 + j\omega L_1 - j\omega C R_3 r) = I_2 R_2$$

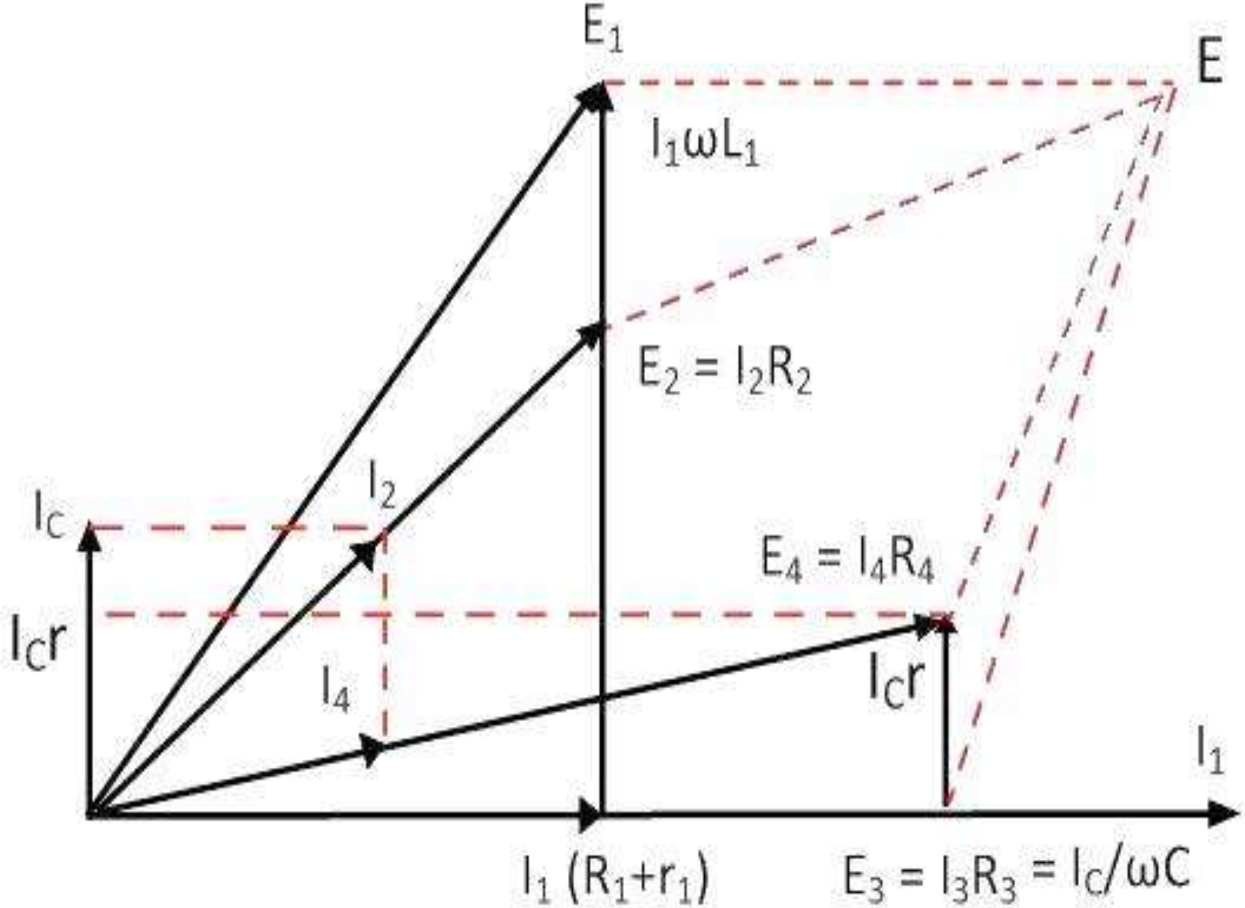
$$I_1(R_3 + j\omega R_3 R_4 + j\omega C R_3 r) = I_2 R_4$$

$$\boldsymbol{I_1(r_1 + R_1 + j\omega L_1 - j\omega C R_3 r) = I_1\left(\frac{R_2 R_3}{R_4} + \frac{j\omega C r R_2 R_3}{R_4} + j\omega C R_2 R_3\right)}$$

Equating the real and the imaginary part

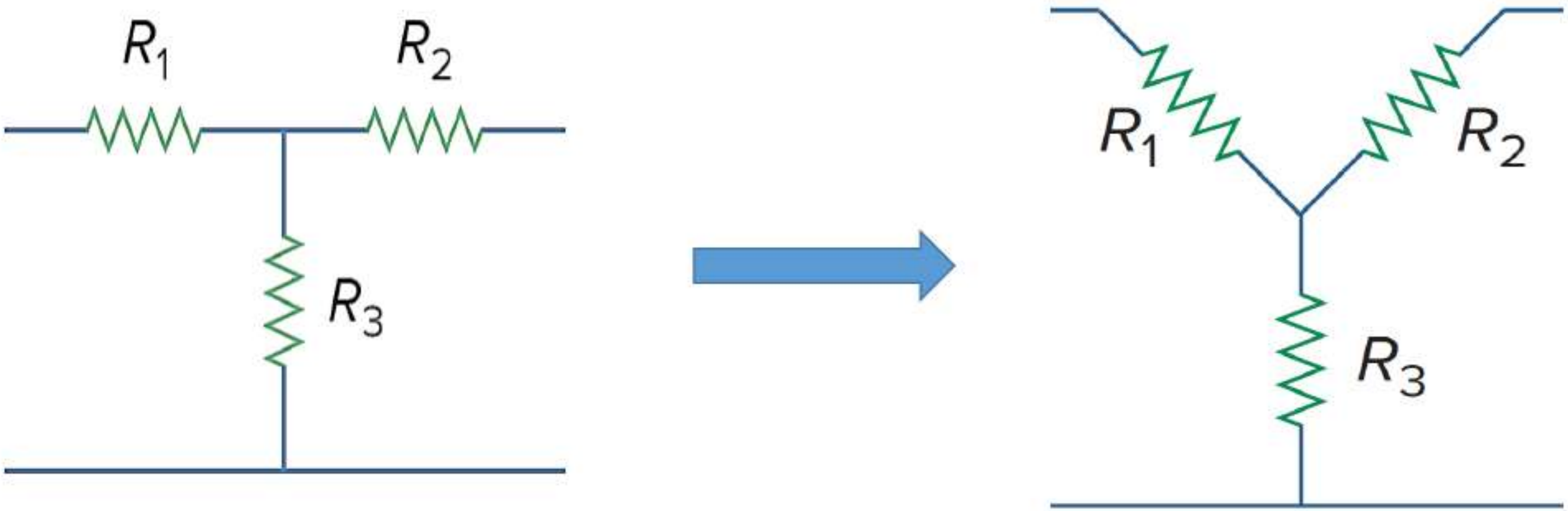
$$\boldsymbol{R_1 = \frac{R_2 R_3}{R_4} - r_1}$$

$$\boldsymbol{L_1 = C\frac{R_3}{R_4}[r(R_2 + R_4) + R_2 R_4]}$$

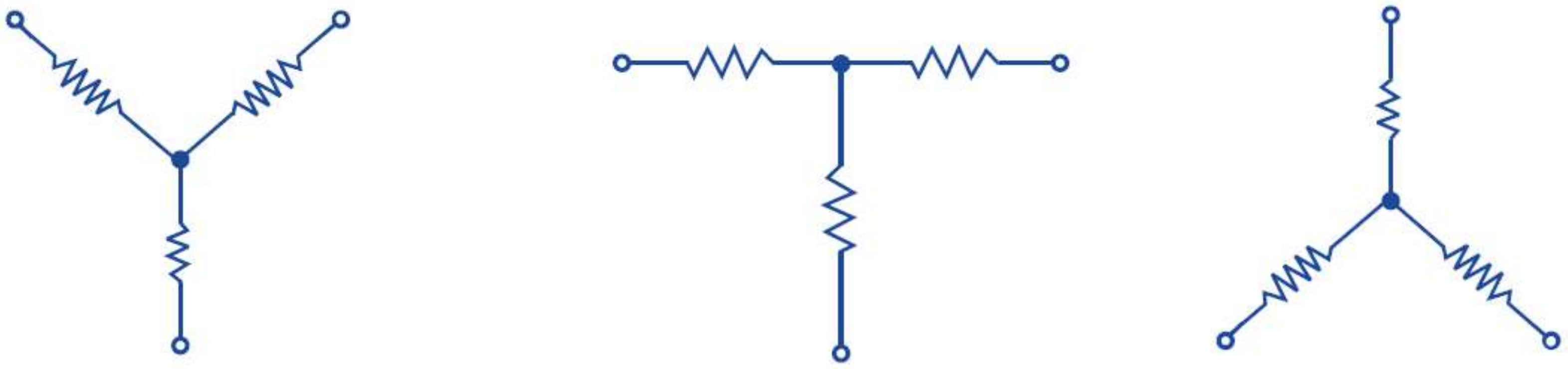


Anderson's Bridge

STAR CONNECTION

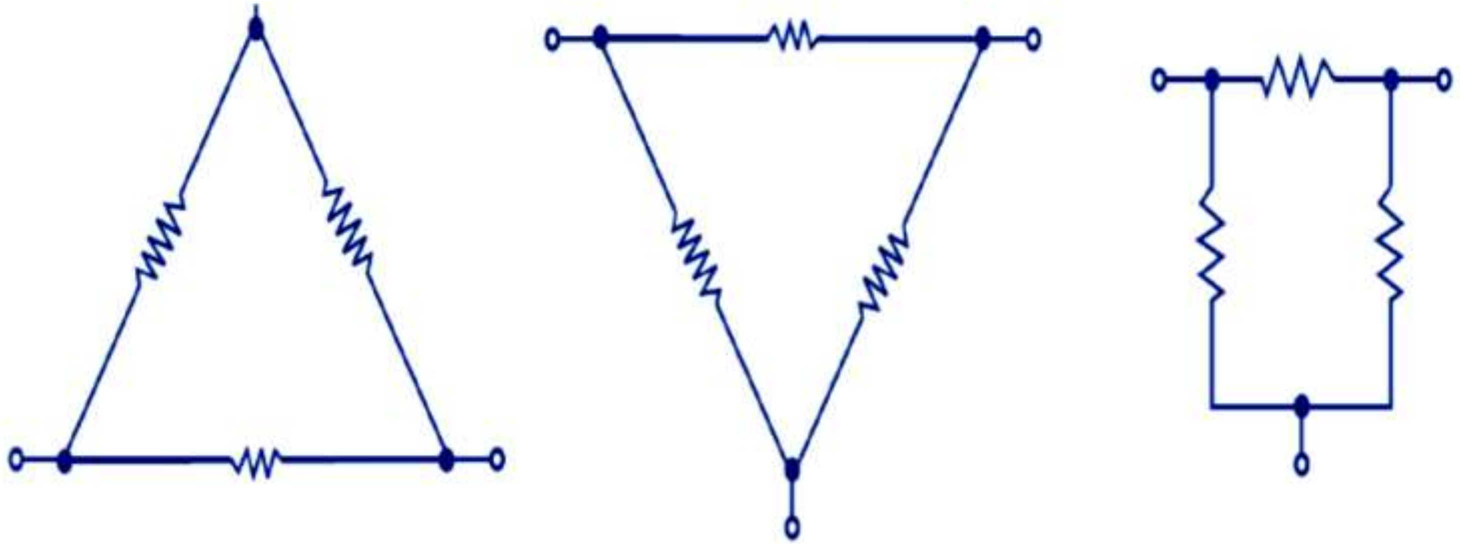


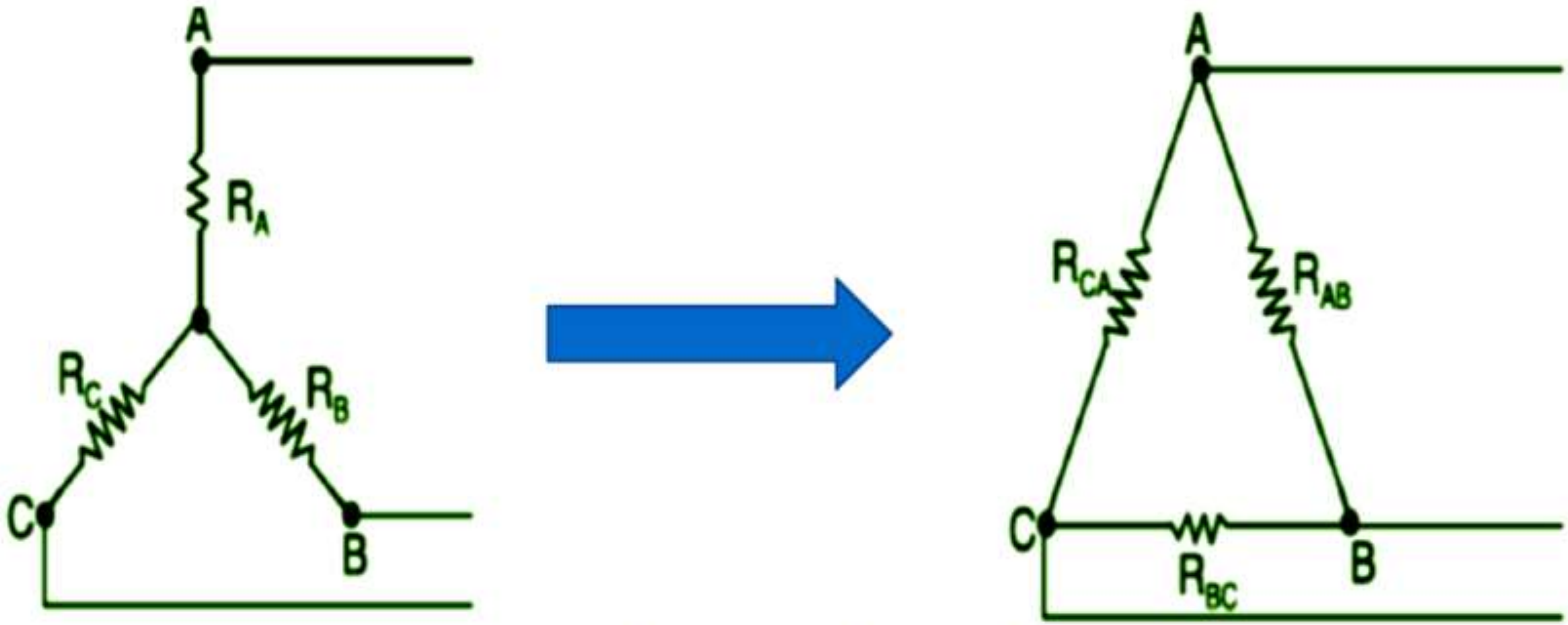
Three ways in which star connection may appear in a circuit.



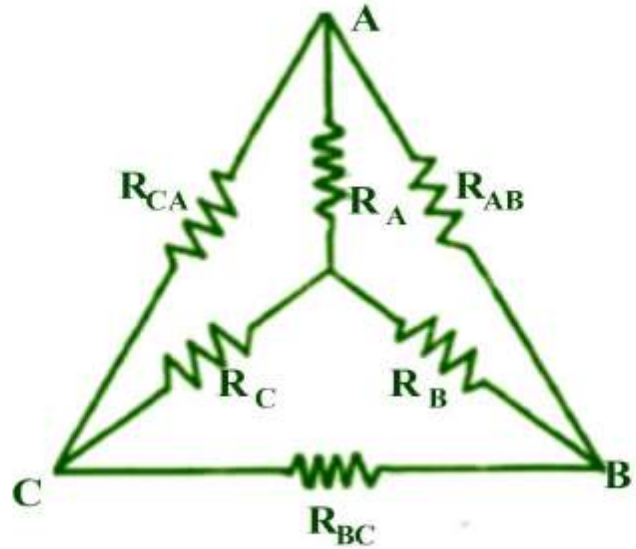
DELTA CONNECTION

Three ways in which delta connection may appear in a circuit.





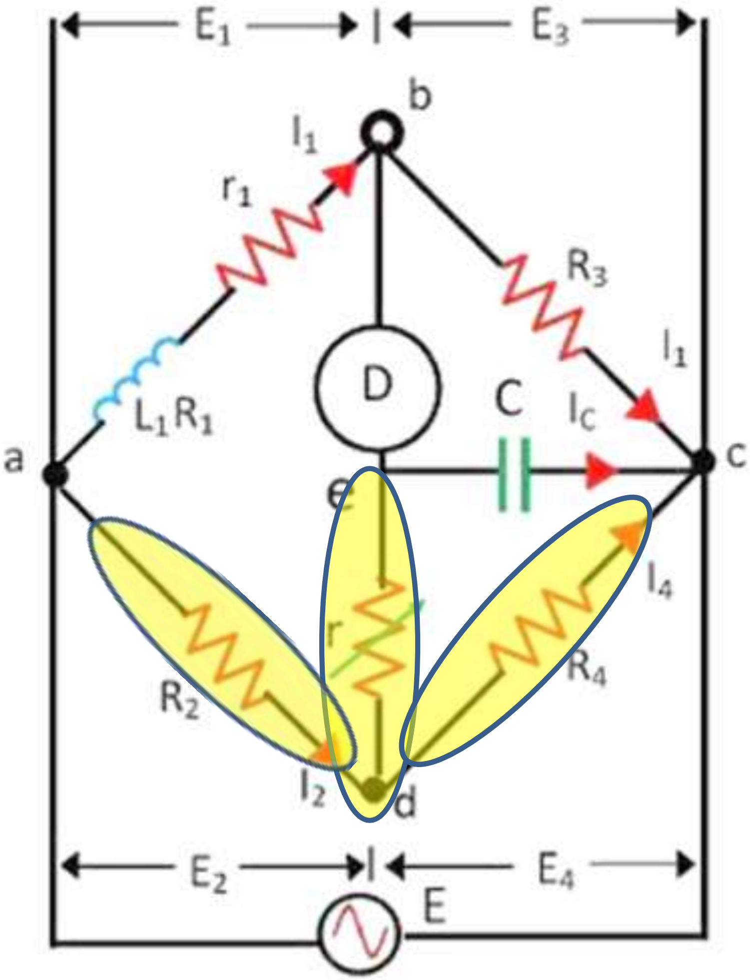
Star and its Equivalent Delta



Resistance between two terminals of Δ =
Sum of star resistances connected to those terminals + product of same two resistances divided by the third

$$R_{BC} = R_B + R_C + \frac{R_B R_C}{R_A} \qquad R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$R_{CA} = R_C + R_A + \frac{R_C R_A}{R_B}$$



Anderson's Bridge

Advantages of Anderson's Bridge:

1. In case adjustments are carried out by manipulating control over r1 and r, they become independent of each other. This is a marked superiority over sliding balance conditions met with low Q coils when measuring with Maxwell's bridge. A study of convergence conditions would reveal that it is much easier to obtain balance in the case of **Anderson's bridge** than in Maxwell's bridge for low Q-coils.

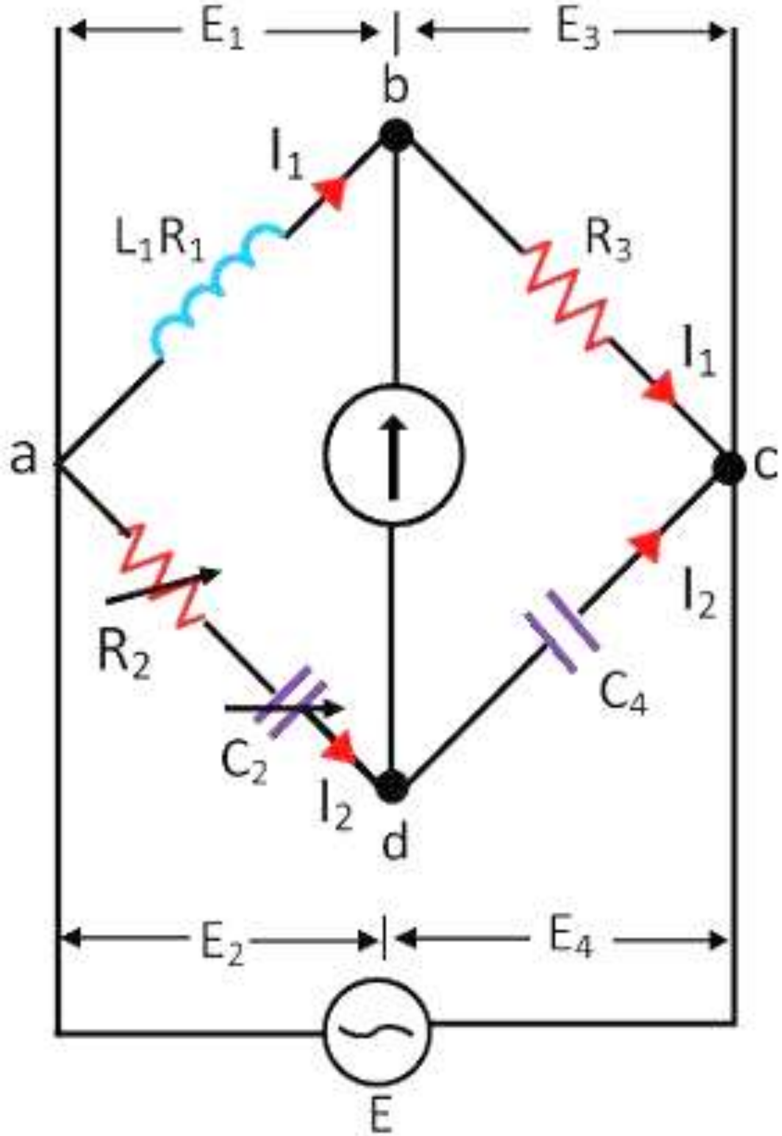
2. A fixed capacitor can be used instead of a variable capacitor as in the case of Maxwell's bridge.

3. **Anderson's Bridge** may be used for accurate *determination of capacitance in terms of inductance.*

Disadvantages of Anderson's Bridge :

1. The **Anderson's bridge** is more complex than its prototype Maxwell's bridge. The **Anderson's bridge has** more parts and is more complicated to set up and manipulate. The balance equations are not simple and in fact are much more tedious.

2. An additional junction point increases the difficulty of shielding the bridge.



Owen's Bridge

L_1 – unknown self-inductance of resistance R_1
R_2 – variable non-inductive resistance
R_3 – fixed non-inductive resistance
C_2 – variable standard capacitor
C_4 – fixed standard capacitor

At balance condition,

$$(R_1 + j\omega L_1)\left(\frac{1}{j\omega C_4}\right) = \left(R_2 + \frac{1}{j\omega C_2}\right)R_3$$

On separating the real and imaginary part

$$L_1 = R_2 R_3 C_4$$

$$R_1 = R_3 \frac{C_4}{C_2}$$

Advantages of Owen's Bridge

The following are the advantages of Owen's bridge.

1.The balance equation is easily obtained.

2.The balance equation is simple and does not contain any frequency component

3.The bridge is used for the measurement of the large range inductance.

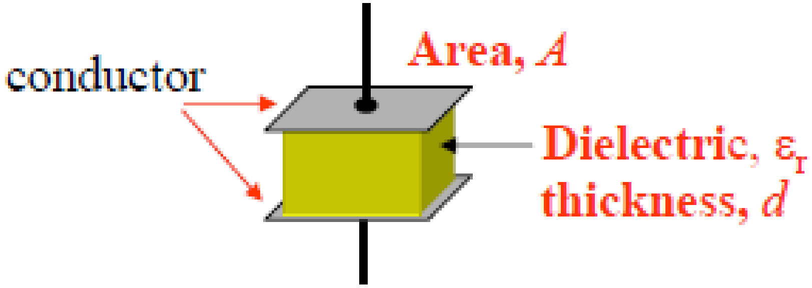
Disadvantages of Owen's Bridge

1.The bridge uses an expensive capacitor which increases the cost of the bridge and also it gives a one percent accuracy.

2.The value of the fixed capacitor C_2 is much larger than the quality factor Q_2

Capacitor

Capacitance – the ability of a dielectric to store electrical charge per unit voltage



$$C = \frac{A\,\varepsilon_0\,\varepsilon_r}{d}$$

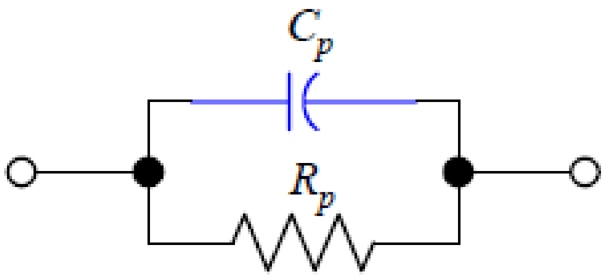
Mica Capacitors

Film Capacitors

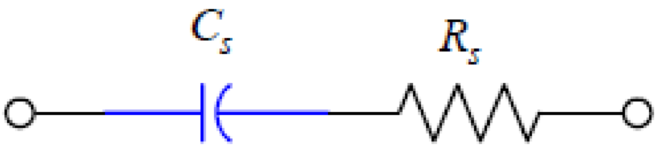
Ceramic Capacitors

Electrolytic Capacitors

Equivalent circuit of capacitance



Parallel equivalent circuit



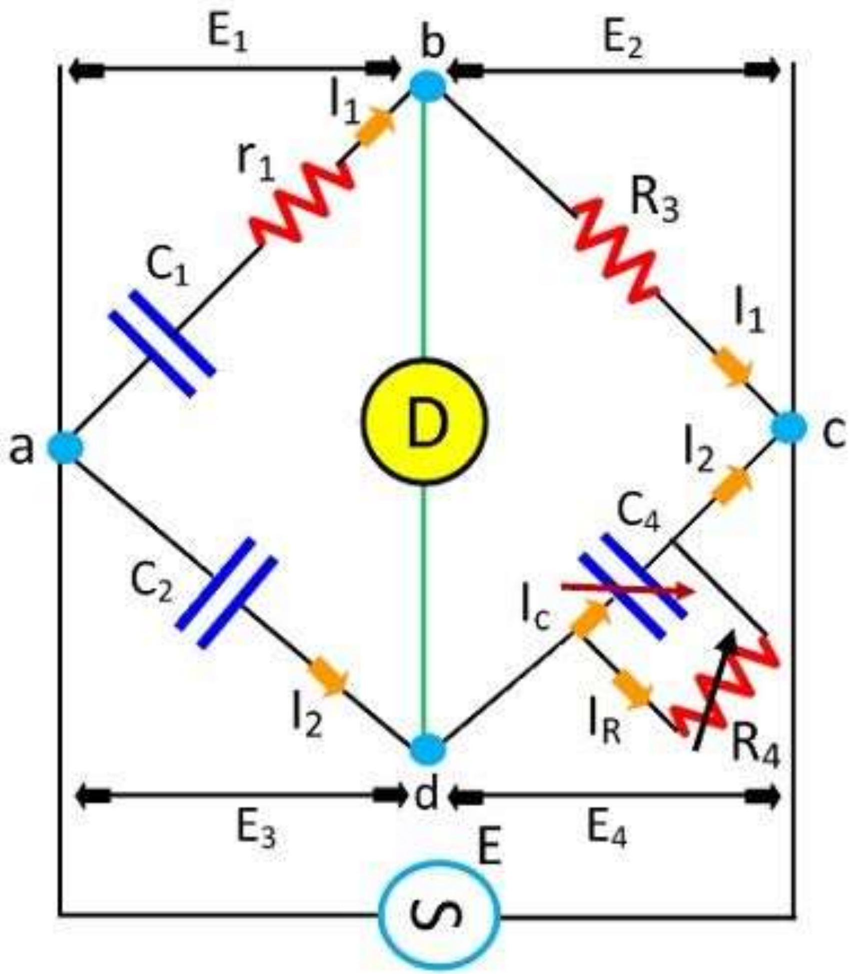
Series equivalent circuit

Dissipation factor of a capacitor: the ratio of reactance to resistance (frequency dependent and circuit configuration)

Capacitance parallel circuit: $D = \frac{X_p}{R_p} = \frac{1}{\omega C_p R_p}$ **Typical $D \sim 10^{-4} - 0.1$**

Capacitance series circuit: $D = \frac{R_s}{X_s} = \omega C_s R_s$

Schering Bridge



C_1 – capacitor whose capacitance is to be determined,

r_1 – a series resistance, representing the loss of the capacitor C_1.

C_2 – a standard capacitor (The term standard capacitor means the capacitor is free from loss)

R_3 – a non-inductive resistance

C_4 – a variable capacitor.

R_4 – a variable non-inductive resistance parallel with variable

$$\left(r_1 + \frac{1}{jwC_1}\right)\left(\frac{R_4}{1 + j\omega C_4 R_4}\right) = \frac{1}{j\omega C_2} . R_3$$

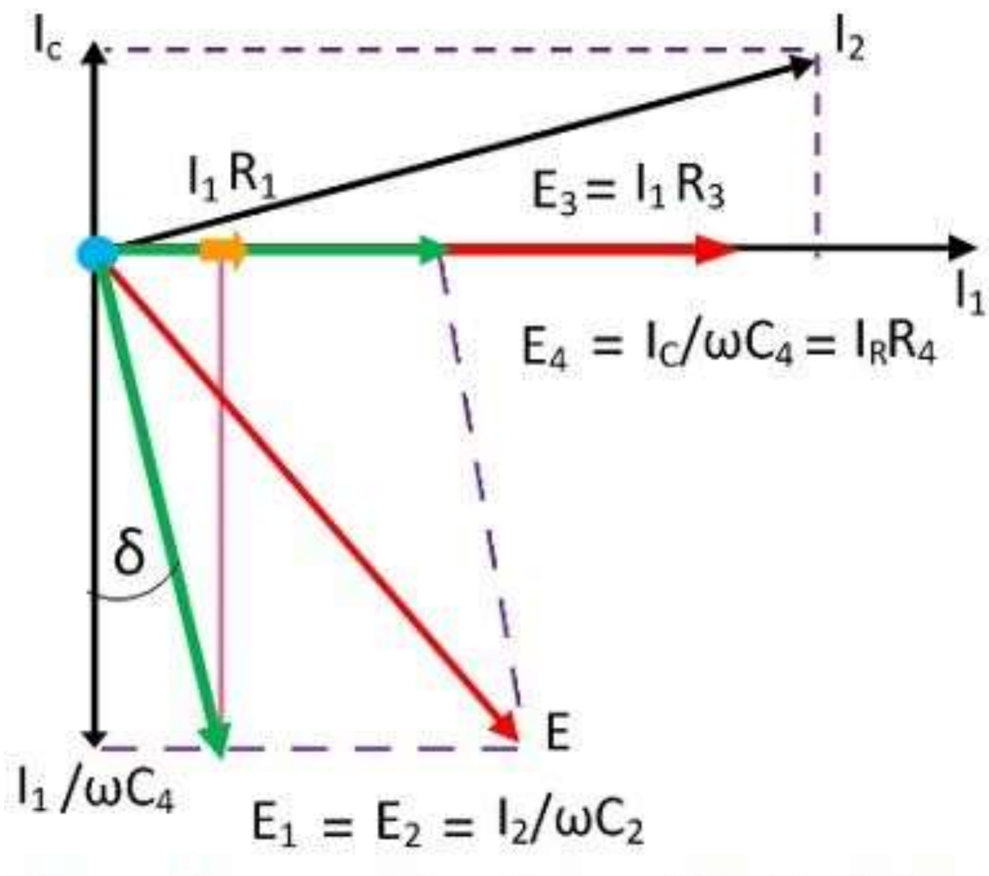
$$\left(r_1 + \frac{1}{jwC_1}\right) R_4 = \frac{R_3}{jwC_2}(1 + j\omega C_4 R_4)$$

$$r_1 R_4 - \frac{jR_4}{\omega C_1} = -j\frac{R_3}{\omega C_1} + \frac{R_3 R_4 C_4}{C_2}$$

Equating the real and imaginary equations,

$$r_1 = \frac{R_3 C_4}{C_2} \ldots\ldots$$

$$C_1 = C_2 \left({R_4}/{R_3} \right).$$



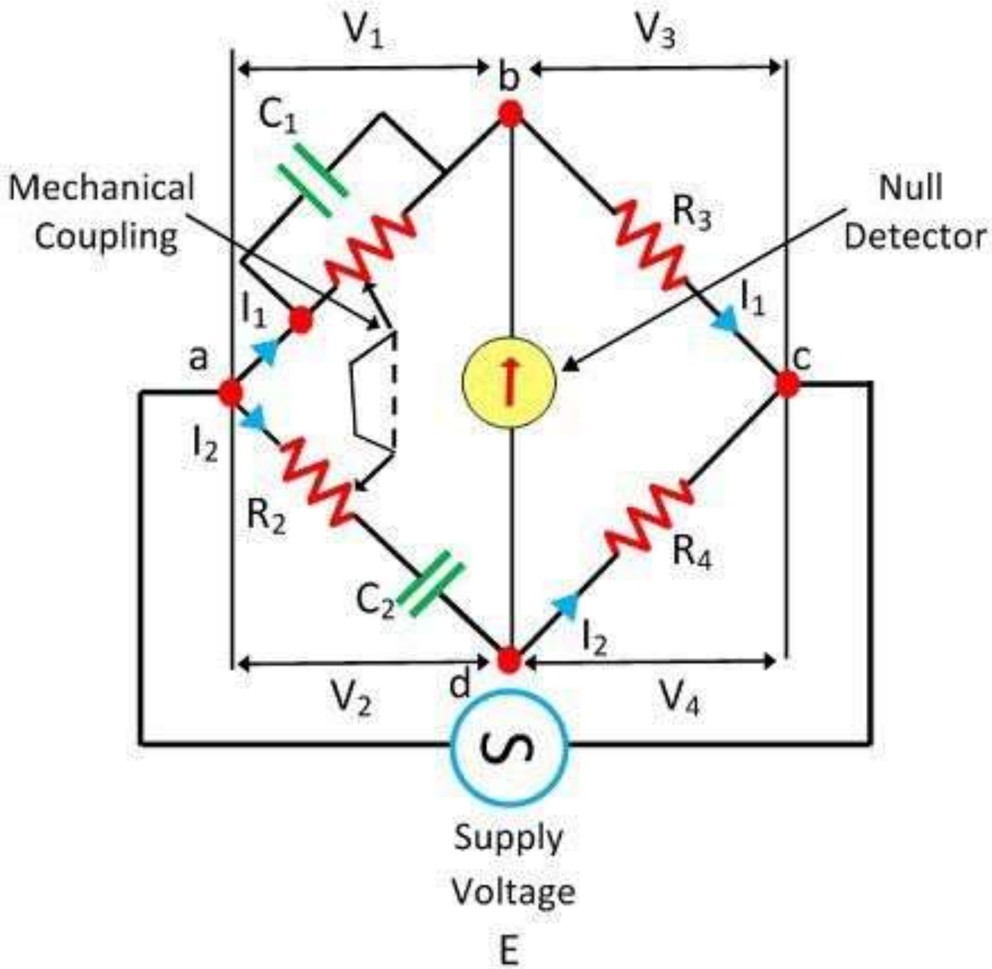
The dissipation factor determines the rate of loss of energy that occurs because of the oscillations of the electrical and mechanical instrument.

$$D_1 = tan\delta = \omega C_1 r_1 = \omega(C_1 r_1) = \omega(C_2 R_4/R_3) \times (R_3 C_4/C_2)$$

$$D_1 = \omega C_4 R_4$$

The Wien's bridge use in AC circuits for determining the value of unknown frequency.

The bridge measures the frequencies from 100Hz to 100kHz.



Wein's Bridge

The slider of the resistance R_1 and R_2 mechanically connect to each other.

So that, the $R_1 = R_2$ obtains.

At balance condition,

$$\left(\frac{R_1}{1 + j\omega C_1 R_1}\right) R_4 = \left(R_2 - \frac{j}{\omega C_2}\right) R_3$$

On equating the real part,

$$R_1 R_4 C_2 = R_2 C_2 R_3 + R_3 C_1 R_1$$

$$\frac{R_1 R_4 C_2}{R_1 R_3 C_2} = \frac{R_2 C_2 R_3}{R_1 R_3 C_2} + \frac{R_3 C_1 R_1}{R_1 R_3 C_2}$$

$$\frac{R_4}{R_3} = \frac{R_2}{R_1} + \frac{C_1}{C_2}$$

On comparing the imaginary part,

$$R_3 R_2 \omega^2 C_2 C_1 R_1 = R_3$$

$$R_2 \omega^2 C_2 C_1 R_1 = 1$$

$$\omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

$$f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$