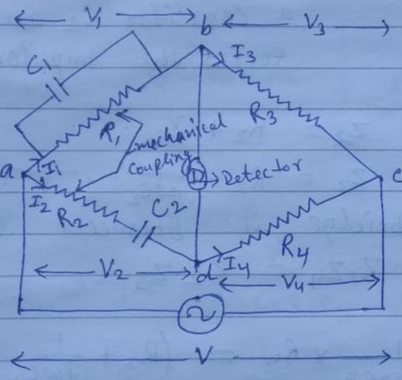
B.Sc. Part-2 Physics (Hons) Paper-iv, Lecture-20 on the topic "Wein's Bridge"

Dr. Mohammad Aslam, Dept. of Physics.
B.Sc. Part-2, Physics (Hons), Paper-IV.
Lecture-20

(1)

* Wein's Bridge :-

It is one of the application of wheatstone bridge and it is used to measure the frequency in the range from 100 Hz to 100 KHz.
The accuracy of the wein's bridge lies between 0.1% to 0.5%. Wein's bridge discovered by the scientist Wein. So that it is called weins bridge.
It contain four arms like wheatstone bridge.



arm a-b → Capacitance C_1 connected in parallel with resistance R_1.

Now the impedance is

$$\frac{1}{Z_1} = \frac{1}{R_1} + \frac{1}{X_{C_2}}$$

(X_C is the reactance) $X_C = \frac{1}{j\omega C}$

$$\frac{1}{Z_1} = \frac{1}{R_1} + \frac{1}{\frac{1}{j\omega C_1}}$$

$$\frac{1}{Z_1} = \frac{1}{R_1} + j\omega C_1$$

$$\frac{1}{Z_1} = \frac{1 + j\omega C_1 R_1}{R_1}$$

$$Z_1 = \frac{R_1}{1 + j\omega C_1 R_1}$$

$$Z_1 = \frac{R_1}{1+j\omega C_1 R_1} \quad \text{--- (1)}$$

Now arm b-c → In this arm only resistor is connected therefore,

$$Z_3 = R_3 \quad \text{--- (2)}$$

arm c-d → This arm also contain only resistor therefore the impedance is

$$Z_4 = R_4 \quad \text{--- (3)}$$

Now the arm d-a → In this arm a resistor R_2 and a capacitor C_2 are connected in series the impedance is

$$Z_2 = R_2 + X_{C_2}$$

$$Z_2 = R_2 + \frac{1}{j\omega C_2} \quad \text{--- (4)}$$

when the bridge is balanced then

$$Z_1 Z_4 = Z_2 Z_3$$

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

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

$$\frac{R_4}{R_3} = \frac{1+j\omega C_1 R_1 + j\omega C_2 R_2 + j^2\omega^2 C_1 C_2 R_1 R_2}{j\omega C_2 R_1}$$

$$\frac{R_4}{R_3} = \frac{1}{j\omega C_2 R_1} + \frac{C_1 \cancel{R_1}}{C_2 \cancel{R_1}} + \frac{\cancel{C_2} R_2}{\cancel{C_2} R_1} + \frac{j\omega C_1 \cancel{C_2} \cancel{R_1} R_2}{\cancel{C_2} \cancel{R_1}}$$

$$\frac{R_4}{R_3} = \frac{1}{j\omega C_2 R_1} + \frac{C_1}{C_2} + \frac{R_2}{R_1} + j\omega C_1 R_2$$

Now equating the real and imaginary parts we get

$$\boxed{\frac{R_4}{R_3} = \frac{C_1}{C_2} + \frac{R_2}{R_1}} \quad (\text{real part})$$

$$\frac{1}{j\omega C_2 R_1} + j\omega C_1 R_2 = 0$$

$$\frac{-j}{\omega C_2 R_1} + j\omega C_1 R_2 = 0$$

$$\frac{\cancel{+}\cancel{j}}{\omega C_2 R_1} = \cancel{+}\cancel{j}\omega C_1 R_2$$

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

$$\frac{1}{C_1 C_2 R_1 R_2} = \omega^2$$

$$\boxed{\omega = \frac{1}{\sqrt{C_1 C_2 R_1 R_2}}}$$ This is angular frequency.

Now ~~f~~ we find the frequency equating

$$\omega = 2\pi f$$

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

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

If the component are chosen such that

$$R_1 = R_2 = R$$

$$C_1 = C_2 = C$$ then.

$$f = \frac{1}{2\pi\sqrt{C^2 R^2}}$$

$$\boxed{f = \frac{1}{2\pi RC}}$$ Hz.

This is the frequency we have found with the help of wein's bridge.