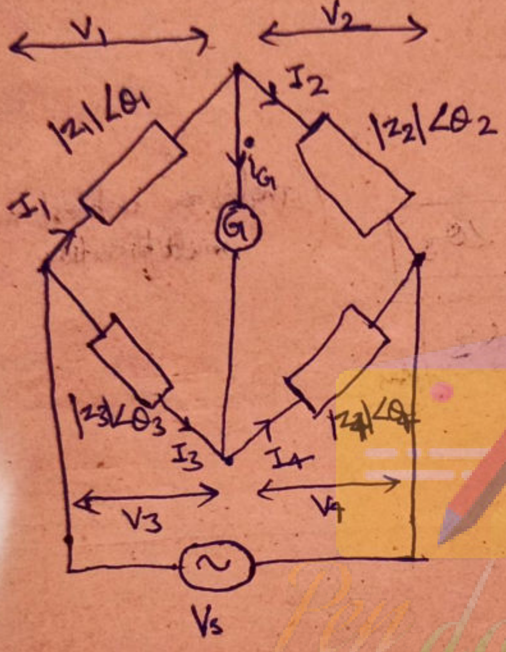
"Bridges"

AC-bridges: They are used to measure resistance, Inductance, Capacitance, Q-factor, discipiation factor, frequency etc.



$\boxed{\text{at balance } I_G = 0}$

① **At balance**

$V_1 = V_3$ $I_1|Z_1|\angle\theta_1 = I_3|Z_3|\angle\theta_3$ --- (i)

$V_2 = V_4$ $I_2|Z_2|\angle\theta_2 = I_4|Z_4|\angle\theta_4$ --- (ii)

$I_G = 0$ $I_1 = I_2$

$I_3 = I_4$

hence from equ^n (i) & (ii)

$$\frac{I_1}{I_3} = \frac{|Z_3|\angle\theta_3}{|Z_1|\angle\theta_1} \quad \& \quad \frac{I_2}{I_4} = \frac{|Z_4|\angle\theta_4}{|Z_2|\angle\theta_2}$$

And $\frac{I_1}{I_3} = \frac{I_2}{I_4} \Rightarrow$

$$\boxed{\frac{|Z_3|\angle\theta_3}{|Z_1|\angle\theta_1} = \frac{|Z_4|\angle\theta_4}{|Z_2|\angle\theta_2}}$$

$$|z_1||z_4| \angle\theta_1 \angle\theta_4 = |z_2||z_3| \angle\theta_2 \angle\theta_3$$

$$\boxed{Z_1 Z_4 = Z_2 Z_3}$$ Ans

hence
results

① $\boxed{|z_1||z_4| = |z_2||z_3|}$ Ans

and ~~$\angle\theta_1 \angle\theta_4 = \angle\theta_2 \angle\theta_3$~~

② $\Rightarrow \boxed{\angle\theta_1 + \angle\theta_4 = \angle\theta_2 + \angle\theta_3}$ (angles are added in multiplication)

$$\boxed{\angle\theta_1+\theta_4 = \angle\theta_2+\theta_3}$$ Ans

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Detectors :-

① DC bridges = Galvanometer

② AC bridges

ⓐ $f \rightarrow$ 2hz to 200hz $\Rightarrow$ Vibrational Galvanometer

$f \rightarrow$ 200hz to 2Khz $\Rightarrow$ ~~Televis~~ Telephone detector

$f \rightarrow \geq$ 2Khz $\Rightarrow$ tuned amplifier.

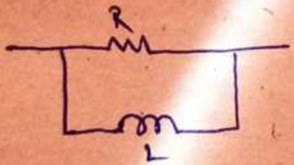
- **Quality factor & Dissipation faction-**

① Q-factor $= \dfrac{\text{Reactive Power}}{\text{Active Power}} = \underbrace{\dfrac{I^2X}{I^2R}}_{\text{series combination}} = \underbrace{\dfrac{V^2/X}{V^2/R}}_{\text{Parallel combination}}$

② D-factor $= \dfrac{1}{Q}$

Eg) ⓐ 

$Q = \dfrac{\omega L}{R}$, $D = \dfrac{R}{\omega L}$

ⓑ 

$Q = \dfrac{R}{\omega L}$, $D = \dfrac{\omega L}{R}$

ⓒ 

$Q = \dfrac{1}{\omega CR}$, $D = \omega CR$

ⓓ 

$Q = \omega CR$, $D = \dfrac{1}{\omega CR}$

Basics

① Principle of bridges = Null- indication to detector

② very high accurate

③ Types of bridges -

① DC → ⓐ wheatstone bridge
ⓑ kelvin bridge

② AC → ⓐ similar Angle bridge
ⓑ opposite Angle bridge / Hay bridge
ⓒ Maxwell bridge
ⓓ wein bridge

} Inductor

ⓔ ~~Radio frequency bridge~~ De Sauty bridg
ⓕ Schering bridge

} capacitor

ⓖ wien bridge

Maxwell Inductor $P<1$
Weinn $1<P<10$
Hay $P>10$
Anderson less P.f L

De-Sauty
Schering

④ Applications of AC bridges -

① measurement of Impedance
② phase shifting i.e oscillator
③ Amplifiers
④ filters.
⑤ Measuring frequencies

⑤ Ac bridge equation-

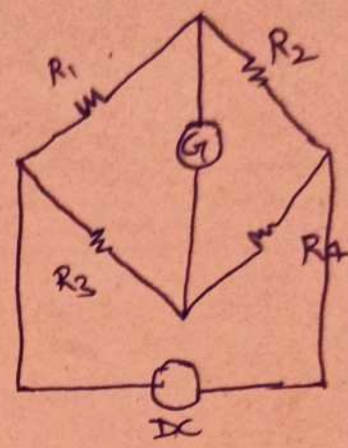
ⓐ $|Z_4||Z_1| = |Z_3||Z_2|$

ⓑ $\angle\theta_4 + \angle\theta_1 = \angle\theta_3 + \angle\theta_2$

Bridges

① wheatstone bridge:

$$\boxed{R_1 R_4 = R_2 R_3}$$



② Kelvin's bridge:

why?

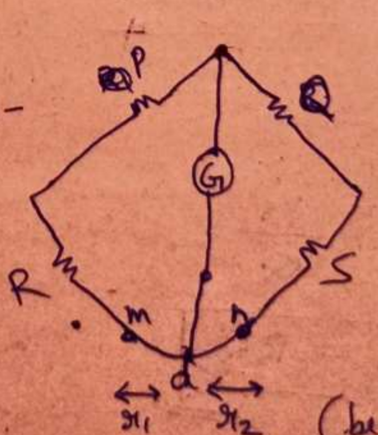
Ans: Used to measure unknown resistance.

ⓐ In wheatstone bridge value of Resistance is verylow so big value resistance cannot be measured by that effectively.

ⓑ To nullify lead resistance.

★ condition for nullify lead resistance -

$$\frac{r_1}{r_2} = \frac{P}{Q}$$



(be lead resistances)

At balance

$$P(S+r_2) = Q(R+r_1)$$

$$\boxed{P \cdot S = R \cdot Q}$$

Proof:-

$$\frac{r_1}{r_2} = \frac{P}{Q} \Rightarrow \frac{r_1}{r_1+r_2} = \frac{P}{P+Q}$$

$$\frac{r_2}{r_1+r_2} = \frac{Q}{P+Q}$$

Now

$$P(S+r_1) = Q(R+r_1)$$

(Let $r_1+r_2 = r$)

$$R+r_1 = \frac{P}{Q}(S+r_2)$$

$$R+\left(\frac{P \cdot r}{P+Q}\right) = \frac{P}{Q}\left(S+\frac{Qr}{P+Q}\right)$$

$$R+\frac{Pr}{P+Q} = \frac{PS}{Q} + \frac{P\cancel{Q}r}{\cancel{Q}(P+Q)}$$

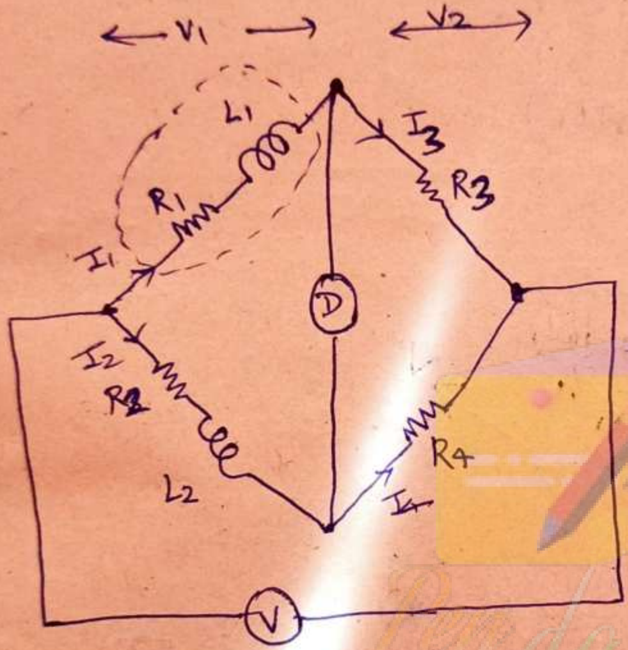
$$R = \frac{PS}{Q}$$

$$\boxed{P \cdot S = RQ}$$

AC bridges

Measurement of Inductance -

① Maxwell Inductance Bridge -



$$\boxed{R_1 = \frac{R_2 R_3}{R_4}}$$

$$\boxed{L_1 = L_2 \frac{R_3}{R_4}}$$

Proof:

$$Z_1 Z_4 = Z_2 Z_3$$

$$(R_1 + j\omega L_1)(R_4) = (R_2 + j\omega L_2)(R_3)$$

$$\boxed{R_1 R_4 = R_2 R_3}$$

$$\omega L_1 R_4 = \omega L_2 R_3$$

$$\boxed{L_1 = L_2 \frac{R_3}{R_4}}$$

② Maxwell

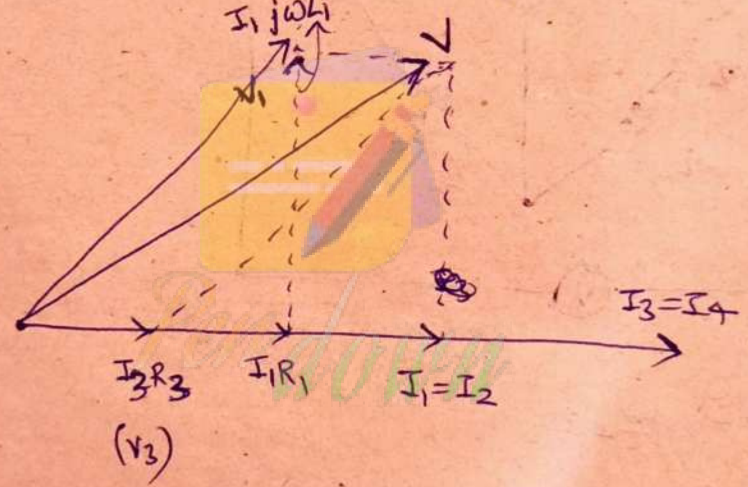
Phasor:- at balance, $I_1 = I_3$

$I_2 = I_4$

- $V = V_1 + V_2$

$V_1 = I_1 (R_1 + j\omega L_1)$

$V_2 = I_3 R_3$

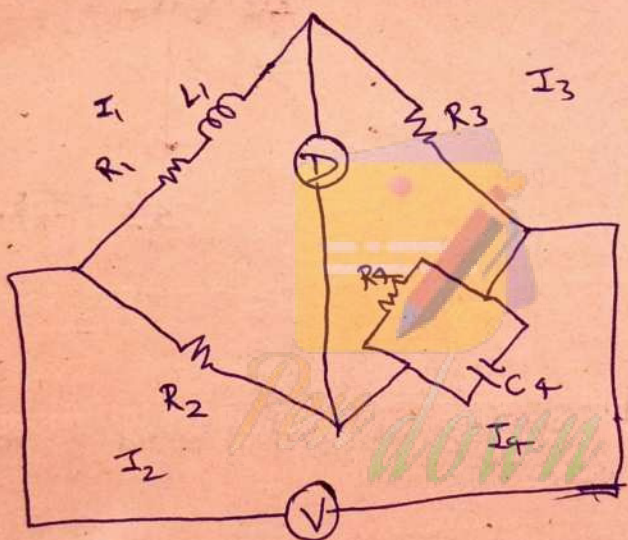


② Maxwell Wien Bridge / Maxwell Inductance - Capacitance bridge -

Advantage = ① Capacitance of capacitor is influenced by less external fields.

② capacitor has small size

③ low cost.

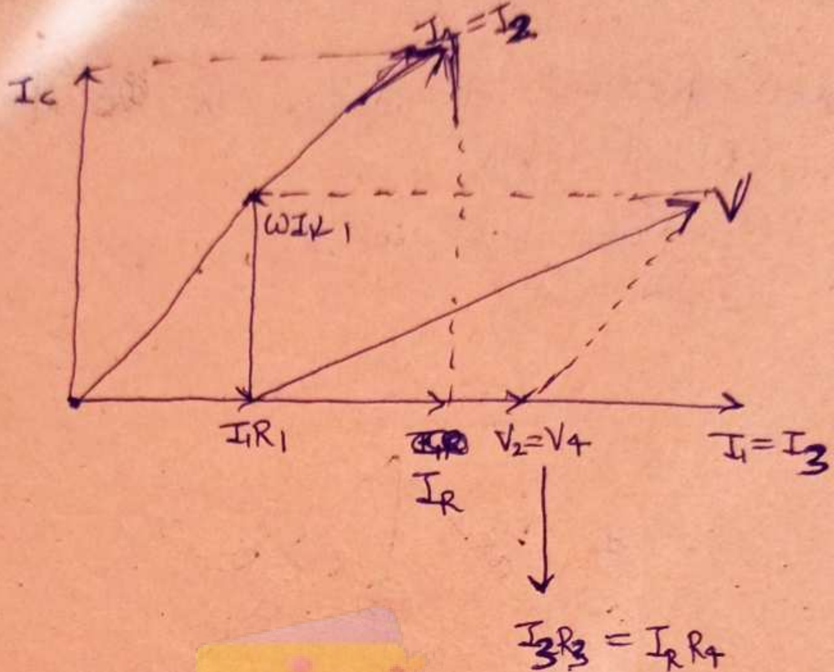


① basic equ^n ! $\boxed{R_1 = \frac{R_2 R_3}{R_4}}$ & $\boxed{L_1 = R_2 R_3 C_4}$

② $\boxed{Q\text{-factor} = \frac{\omega L_1}{R_1} = \omega C_4 R_4}$

③ only suitable for coil $\boxed{1 < Q\text{-factor} < 10}$

Phasor:



Advantages: ① fixed capacitor is used instead of variable capacitor in Wein

② Convergence is easier for Low Q-coil

③ balance condition is independent of frequency

④ can be used for heavy current carrying coil

Disadvantages: ① complicated than Maxwell. as variable capacitance is difficult to get

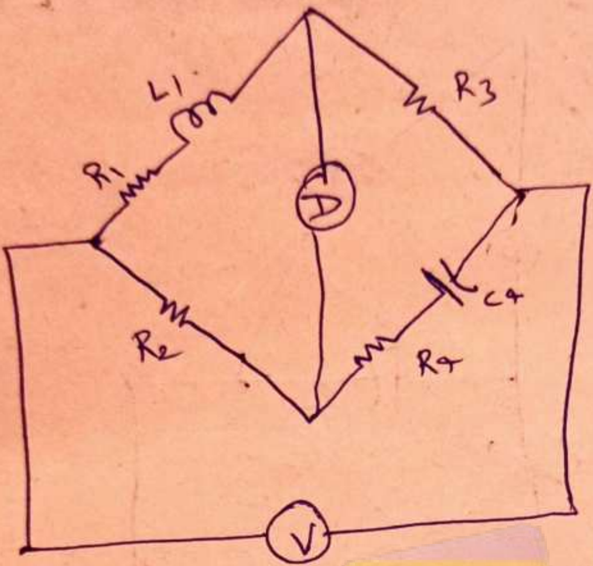
② Some parameter change with temp

③ Balance equ^n is more tedious

④ only applicable for $1 < Q < 10$

⑤ shielding of bridge is difficult.

(3) Hay's Bridge :- (for high Q-factors) (high L)



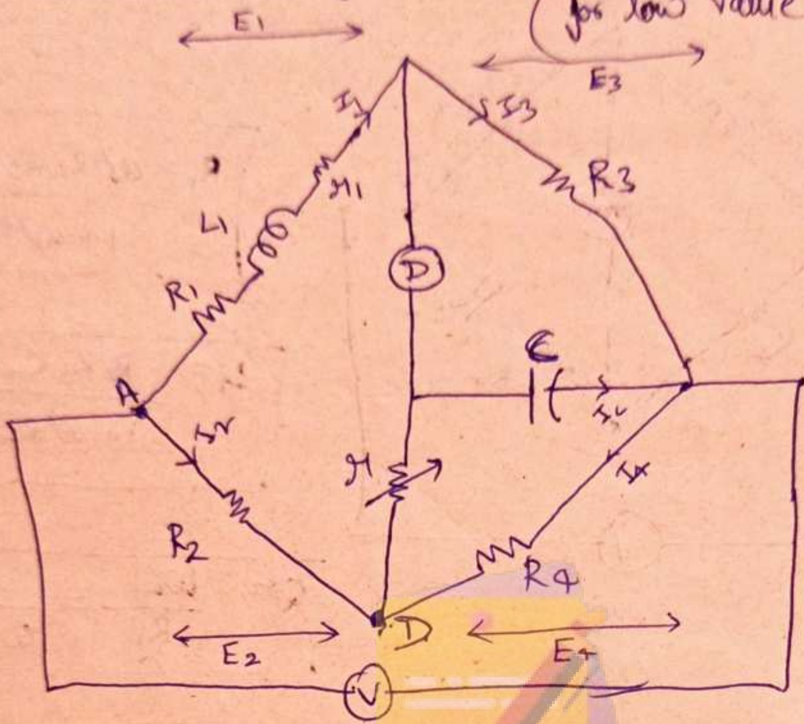
$$\boxed{R_1 = \frac{\omega^2 R_2 R_3 R_4 C_4^2}{1+\omega^2 R_4^2 C_4^2}}$$

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

$$\boxed{Q = \frac{\omega L_1}{R_1} = \frac{1}{\omega R_4 C_4}}$$

④ Anderson's Bridge: (for low Q-coil)

(for low value of L)



① Equⁿ:

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

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

Proof: Convert to star-delta transformation & get

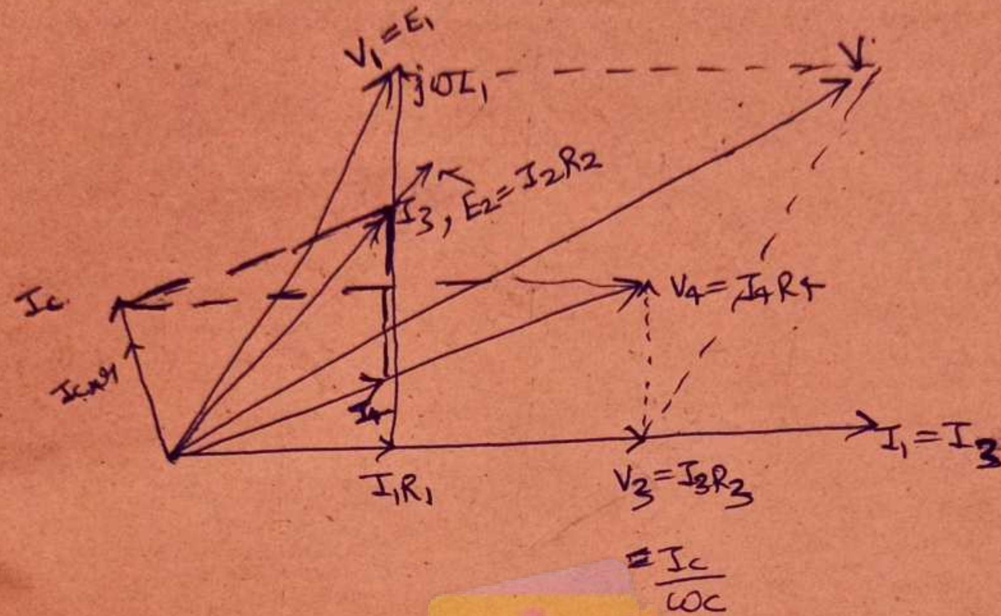
$$\boxed{R_1 = \frac{R_2 R_3}{R_4}}$$

$\boxed{\text{if } r_1 = 0\,\Omega}$

$L_1 = C R_2 R_{AD}$

$$\cancel{L_1 = \frac{CR_2}{R_4}\left[r(R_2+R_4) + R_2 R_4\right]}$$

Phasor:



$I_1 = I_3$

$I_2 = I_c + I_4$

$E_1 = I_1(R_1 + r_1) + j I_1 \omega L_1$

$E_2 = I_2 R_2$

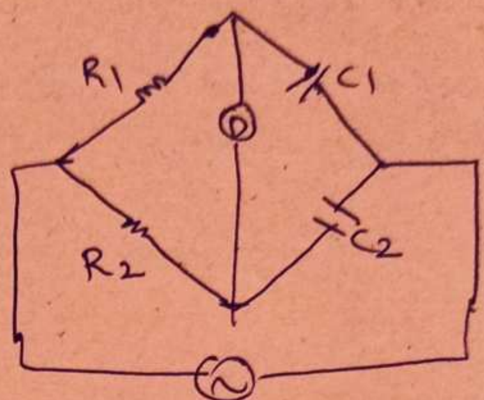
$E_3 = I_3 R_3 = \frac{I_c}{\omega C}$

$E_4 = j\frac{I_c}{\omega C} + I_c r = I_4 R_4$

$\boxed{\text{for Capacitor}}$

① De sauty bridge:

- both C air capacitor
- both C should free from dielectric loss

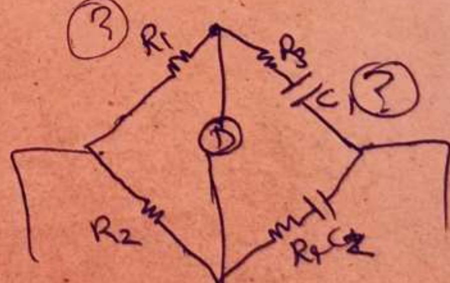


$$R_1\left(\frac{1}{j\omega C_2}\right) = R_2\left(\frac{1}{j\omega C_1}\right)$$

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

$$\boxed{C_1 = \frac{R_2}{R_1} C_2}$$

but no ideal capacitor exist so modified de-sauty →



$$\boxed{\frac{R_1}{C_2} = \frac{R_2}{C_1}}$$

$$\boxed{\tan\delta = R_4 \cdot \omega C_2}$$