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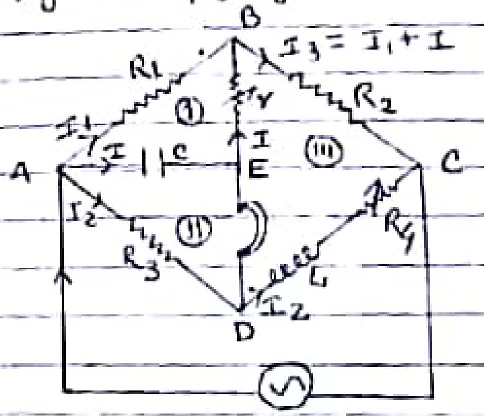
Anderson Bridge

Q-2(11) Paper IV

This is the modified form of Maxwell's L/C bridge. The double balance is obtained by adjusting resistances only, the standard condenser being invariable. Anderson's bridge shown in fig is formed by placing the condenser C and a non inductive resistance r in series with the condenser, the combination being parallel with R_1; the other components and the detector are placed as shown in fig. At the line of balance E and D are at the same potential and let the current vectors in the different parts of the bridge be as indicated in fig. Applying Kirchoff's law we have



$$R_1 I_1 - \left(r + \frac{1}{j\omega C}\right) I = 0 \quad [\text{for loop I}] \quad \text{— (1)}$$

$$\frac{1}{j\omega C} \cdot I - R_3 I_2 = 0 \quad [\text{for loop II}] \quad \text{— (2)}$$

$$R_2 (I_1 + I) + r I - (j\omega L + R_4) I_2 = 0 \quad [\text{for loop III}] \quad \text{— (3)}$$

Substituting the value of I_1 & I_2 from equ^n (1) & (2) in equ^n (3) we have,

$$\frac{R_2}{R_1}\left(r + \frac{1}{j\omega C}\right) I + R_2 I - \frac{(j\omega L + R_4)}{j\omega C R_3} I + r I = 0 \quad \text{— (4)}$$

Equating real & imaginary parts, we have

$$\frac{R_2}{R_1} r + R_2 - \frac{L}{C R_3} + r = 0$$

$$\text{or} \quad L = C R_3 \left[\frac{R_2}{R_1} r + R_2 + r\right]$$

$$= C R_3 \left[r\left(1 + \frac{R_2}{R_1}\right) + R_2\right] \quad \text{— (5)}$$

and $\frac{R_2}{R_1 \omega C} - \frac{R_4}{R_3 \omega C} = 0$ or $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ —— (6)

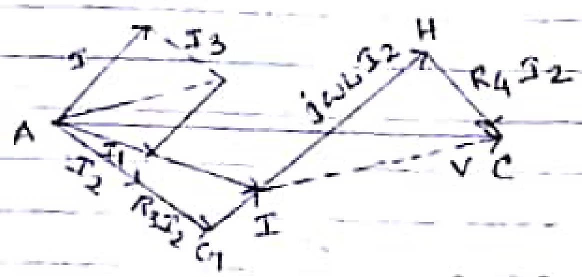
These conditions are independent of the frequency of the source and can be satisfied independently of each other by adjusting R_4 in the latter case and r in the former case. Equn (5) shows that balance is possible only when $L > C R_2 R_3$ otherwise r will be negligible negative. Since there is no other inductance all mutual reactions between neighbouring inductance is avoided.

It is best to use $R_1 : R_2 = 1:1$

The formula then reduces to

$$R_3 = R_4 \text{ and } L = C R_3 (2r + R_2) \quad \text{—— (7)}$$

The vector diagram for the Anderson bridge is shown below. In it AC is $\vec{V}$, the potential vector for the applied voltage. If I_2 represents the current in ADC, then $AG = R_3 I_2$ and $GH = j\omega L I_2$ and $HC = R_4 I_2$, so that HC ∥ to AG and



GH ⊥ to AG or HC. Since the potential of E is the same as that of D, hence

$$V_{AE} = V_{AD}$$

$$\text{or} \left(\frac{1}{j\omega C}\right) I = R_3 I_2$$

This relation shows that I is in quadrature with I_2. If we draw $GI = RI$ then the vector AI is $R_1 I_1$. The vector IC is $R_2 I_3 = R_2 (I_1 + I)$.

First of all the circuit is arranged as simple wheatstone Bridge connecting the inductance in the 4th arm CD. The resistance R_1 and R_2 are fixed to 10 ohm each and R_3 is varied until the galvanometer deflection changes direction. The expected value is calculated with the formula (6). The expt. is repeated with $\frac{R_1}{R_2} = 10$ and 100 and the actual resistance in the inductance arm R_2 is calculated. Now R_1 and R_2 are readjusted to the ratio 10 : 10 and a fractional resistance R' is placed in series with the inductance. Now R_3 and ~~R_4~~, R' are varied for no deflection in the galvanometer. In this case $R_L + R' = R_4 = R_3$. To increase the sensitivity the resistances are so arranged that $R_1 = R_2 = \frac{1}{2} R_3$.

Now galvanometer and D.C source are replaced by Headphone and A.C source respectively and capacitance C and resistance r are inserted as shown in fig. R_1, R_2, R_3 and R_4 are kept as such and the bridge is balanced for minimum sound with the help of resistance r. The expt. may be repeated by taking different capacitances. Substituting these values in equn (7) self inductance of a given coil can be calculated.