CHAPTER-5
BRIDGE MEASUREMENT, MEASUREMENT OF INDUCTANCE & CAPACITANCE

Two Marks Questions

33. Ans: (a)

Sol: Given data

$r_2 = 32.7\Omega$

$L_2 = 47.8mH$

$R = 1.36\Omega$

Under Balance conditions

$Z_1Z_4 = Z_2Z_3$

$Z_1 = R_1+r_1+j\omega L_1$

$Z_2 = 100\Omega$

$Z_4 = 100\Omega$

$Z_3 = r_2 + j\omega L_2$

$(R+r_1)+j\omega L_1) \times 100 = 100(r_2+j\omega L_2)$

Compare real part & img part

$R+r_1 = r_2$

$j\omega L_1 = j\omega L_2$

$L_1=L_2$

$1.36 + r_1 = 32.7$ $\qquad$ $L_1 = 47.8mH$

$r_1 = 31.34\Omega$

34. Ans: (b)

Sol: Given data

$R_2 = 400\Omega \quad R_3 = 600\Omega$

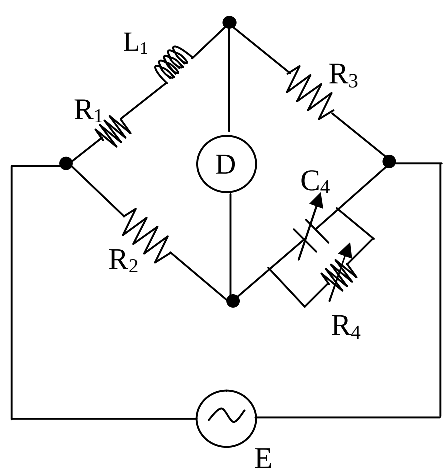
$R_4 = 1000\Omega \quad C_4 = 0.5\mu F$

f= 1000HZ

$Z_1 Z_4 = Z_2 Z_3$

$Z_1 = Y_4 Z_2 Z_3$

$Z_2 = R_2, \quad Z_3 = R_3, \qquad Y_4 = \frac{1}{R_4} + j\omega L_4$



$Z_1 = R_1 + j\omega L_1$

$(R_1 + j\omega L_1) = (\frac{1}{R_4} + j\omega C_4) \; R_2R_3$

$R_1 + j\omega L_1 = \frac{R_2R_3}{R_4} + j\omega C_4 R_2R_3$

Compare Real parts & img parts

$R_1 = \frac{R_2R_3}{R_4} \qquad \omega L_1 = \omega C_4 R_2R_3$

$L_1 = C_4R_2R_3$

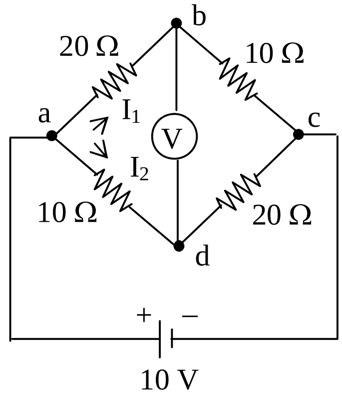
$R_1 = \frac{400 \times 600}{1000} \quad L_1 = 0.5\times10^{-6}\times400\times600$

$R_1 = 240\Omega$ $L_1 = 0.12H$

$$Q = \frac{\omega L_1}{R_1} = \frac{2\pi \times 1000 \times 0.12}{240} = 3.14$$

35. Ans: (d)

Sol: Voltmeter reading



$V = V_{ab} - V_{ad}$

$= I_1 \text{ x } 20 - I_2 \text{ x } 10$

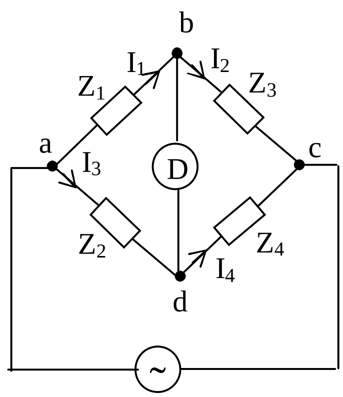
$$= \frac{10}{20+10} \text{ x } 20 - \frac{10 \text{ x } 10}{10+20}$$

$$V = \frac{10}{30}(20-10) = \frac{100}{30} = 3.33\text{V}$$

37. Ans: (a)

Sol: For the $Z_1 = 200\angle 30^0$ $Z_2 = 150\angle 0^0$ $Z_3 = 230\ \Omega\angle -40^0$

Under balanced condition



$Z_1 Z_4 = Z_2 Z_3$

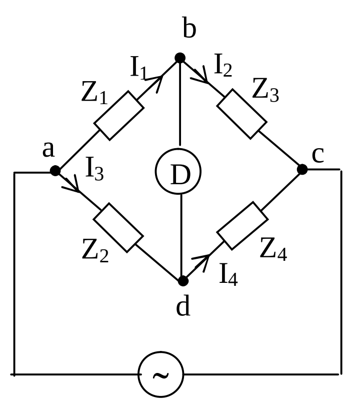
$200\angle 30^0\ Z_4 = 150 \text{ x } 230\ \angle 0^0 - 40^0$

$$Z_4 = \frac{150 \text{ x } 230}{200}\angle -70^0$$

$= 172.5\ \angle -70^0$

38. Ans: (c)

Sol: ab R in series with inductance



ad → pure resistance

bc → pure resistance

what about cd

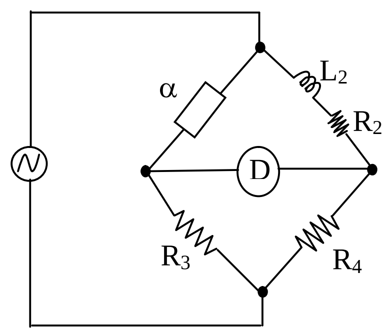
cd should consists of a variable resistance in series or parallel with a variable capacitance.

Parallel → Maxwell Inductance – capacitance bridge

Previous IES question

02. Ans: (a)

Sol:



X = self inductance having resistance, Maxwell's inductance bridge

03. Ans: (b)

Sol: $Q = \dfrac{\omega L_1}{R_1} = \dfrac{\omega C_4 R_2 R_3}{R_2 R_3 / R_4} = \omega C_4 R_4 = \omega C R$

Take Maxwell Inductance – capacitance Bridge

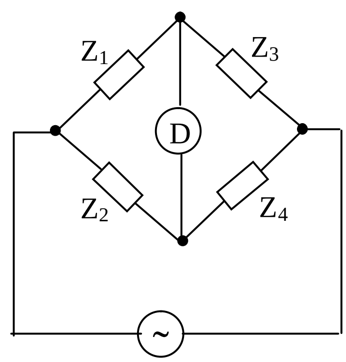
04. Ans: (b)

Sol: $Z_1 = 100\angle 30^0$

$Z_2 = 150\angle 0^0$

$Z_3 = 250\angle{-40^0}$

$Z_4 = ?$



Under balance condition

$Z_1 Z_4 = Z_2 Z_3$

$100\angle 30^0\ Z_4 = 150\angle 0^0 \text{ x } 250^0\ \angle{-40^0}$

$Z_4 = 375\angle{-\,40^0 - 30^0}$

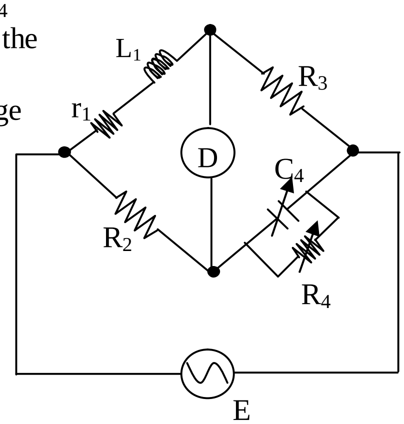
$Z_4 = 375\angle{-\,70^0}\ \Omega$

06. Ans: (c)

Sol: Given data $R_1 = R_2R_3 / R_4$ $L_1 = R_2R_3C_4$

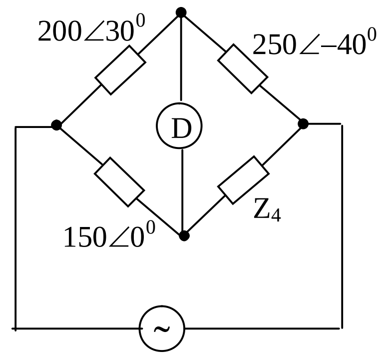
R_1 & L_1 are unknown quantities what are the variable parameters i.e. C_4 & R_4

eg: Maxwell Inductance – capacitance bridge



07. Ans: (c)

Sol: Under balance condition



$200\angle 30^0 \times Z_4 = 250\angle -40^0 \times 150\angle 0^0$

$= 187.5 \angle -70^0$

14. Ans: (a)

Sol: $Z_1 = Z_2 Z_3 / Z_4$

$Z_2 = \pm 1\%$ $Z_3 = \pm 1\%$ $Z_4 = \pm 3\%$

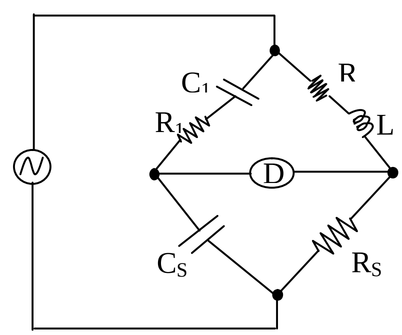
$$\text{Uncertainty} = \sqrt{(\pm 1)^2 + (\pm 1)^2 + (\pm 3)^2}$$

$$= \sqrt{1+1+9} = \sqrt{11}\ \%$$

15. Ans: (b)

Sol: Balanced condition

$$\left(R_1 + \frac{1}{j\omega C_1}\right) R_S = (R + j\omega L)\frac{1}{j\omega C_S}$$



$$R_1 R_S - \frac{jR_S}{\omega C_1} = \frac{-jR}{\omega C_S} + \frac{\omega L}{\omega C_S}$$

Compare real parts & img parts

$$R_1 R_S = \frac{L}{C_S}$$

$$R_1 = \frac{L}{R_S C_S} \qquad L = R_1 R_S C_S$$

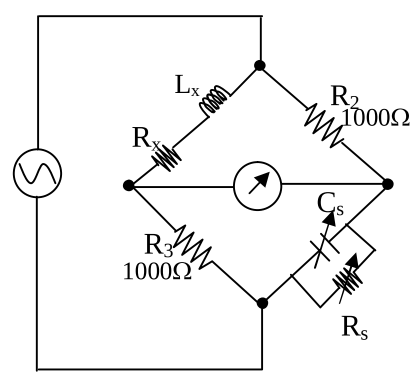
$$\frac{R_S}{\omega C_1} = \frac{R}{\omega C_S}$$

$$R = \frac{R_S C_S}{C_1}$$

16. Ans: (a)

Sol: $C_S = 0.5\mu F$ $R_S = 1000\Omega$

Under balanced condition similar to Maxwell's Inductance capacitance bridge



$L_x = C_S R_2 R_3$ $\qquad R_x = \dfrac{R_2 R_3}{R_S}$

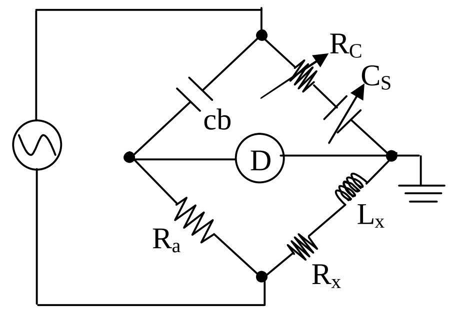
$= 0.5 \times 10^{-6} \times 1000 \times 1000$

$$= \frac{1000 \times 1000}{1000} = 1000\ \Omega$$

$= 0.5$ H

20. Ans: (d)

Sol: At balance



$$\left(\frac{1}{j\omega c_b}\right)(R_x + j\omega L_x) = \left(R_C - \frac{j}{\omega c_C}\right) R_a$$

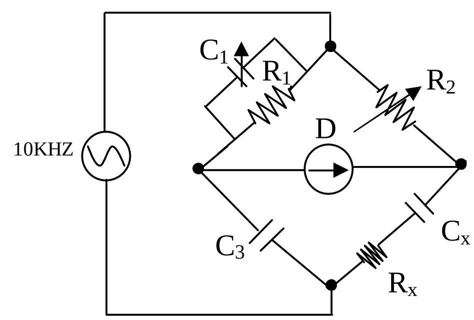
$$\frac{-R_x j}{\omega c_b} + \frac{L_x}{c_b} = R_C R_a - \frac{j R_a}{\omega c_c}$$

$$\frac{R_x}{\omega c_b} = \frac{R_a}{\omega c_c} \Rightarrow \frac{R_a c_b}{c_c}$$

$L_x = R_c R_a R_b$

22. Ans: (a)

Sol: $Z_1 Z_x = Z_2 Z_3$ $\qquad Z_x = Y_1 Z_2 Z_3$



$$Y_1 = \frac{1}{R_1} + j\omega c_1$$

$$z_2 = R_2 \;\; Z_3 = \frac{-j}{\omega c_3},\; z_4 = R_x \frac{j}{\omega c_x}$$

$$\left(R_x - \frac{j}{\omega c_x}\right) = R_2 \frac{-j}{\omega c_3} \text{ x } \left(\frac{1}{R_1} + j\omega c_1\right)$$

$$R_x - \frac{j}{\omega c_x} = \frac{-R_2 j}{\omega c_3 R_1} + \frac{\omega c_1 R_1}{\omega c_3}$$

Compare real part & img part

$$R_x = \frac{\omega c_1 R_2}{\omega c_3} = \frac{c_1 R_2}{c_3}$$

$$R_x = \frac{c_1 R_2}{c_3} \qquad \Rightarrow \qquad \frac{1}{\omega c_x} = \frac{+R_2}{\omega c_3 R_1}$$

$$c_x = \frac{c_3 R_1}{R_2}$$

23. Ans: (b)

Sol: $f = \dfrac{1}{2\pi\sqrt{L(c+c_S)}}$

$c_S \rightarrow$ self – capacitance

$$500 \text{ x } 10^3 = \frac{1}{2\pi\sqrt{L(c+36 \text{ x}10^{-12})}} \text{ .... (1)}$$

$$250 \text{ x } 10^3 = \frac{1}{2\pi\sqrt{L(c+160 \text{ x}10^{-12})}} \text{ .... (2)}$$

Dividing equation (1) by equation (2)

$$2 = \sqrt{\frac{c + 160 \times 10^{-12}}{c + 36 \times 10^{-12}}}$$

$$4 = \frac{c + 160 \times 10^{-12}}{c + 36 \times 10^{-12}}$$

$4c + 144 \times 10^{-12} = c + 160 \times 10^{-12}$

$3c = 16 \times 10^{-12}$

$c = 5.33$ pF

24. Ans: (c)

Sol: $c_1 = 150 \pm 2.4\ \mu F$ $c_2 = 120 \pm 1.5\ \mu F$

parallel $c_{eq} = c_1 + c_2$

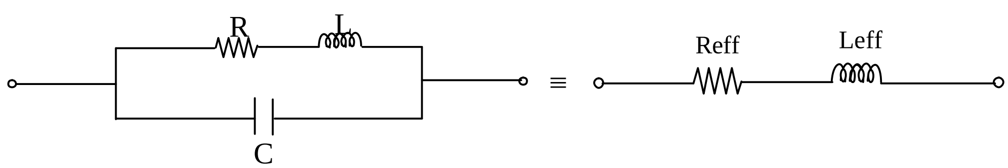
$= 150 \pm 2.4 + 120 \pm 1.5$

$= 270 \pm 3.9$

Limiting error = 3.9 μF

25. Ans: (b)

Sol:



$$Z = \frac{\left(\frac{1}{j\omega c}\right)(R + j\omega L)}{R + j\omega L + \frac{1}{j\omega c}}$$

$$= \frac{R + j\omega\left(L - \omega^2 L^2 c - cR^2\right)}{1 + \omega^2 c^2 R^2 - 2\omega^2 Lc + \omega^4 L^2 c^2}$$

Since these inductance & capacitance of a resistor are very small is value therefore $\omega^2 Lc << 1$ & $\omega^4 L^2 c^2 << 1$

$$Z = \frac{R + j\,\omega\left(L - cR^2\right)}{1 + \omega^2 c\left(cR^2 - 2L\right)}$$

effective inductive

$$L_{eff} = \frac{L - cR^2}{1 + \omega^2 c\left(cR^2 - 2L\right)}$$

for the resistor to be non inductive

$L - cR^2 = 0$ $L = cR^2$

27. Ans: (a)

Sol:

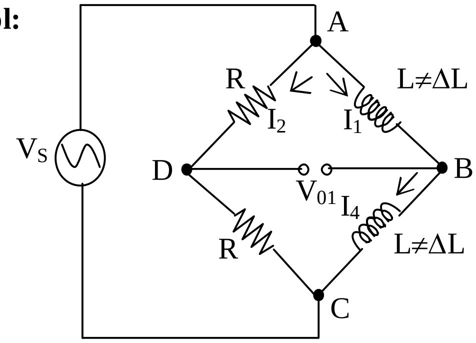


Fig.1

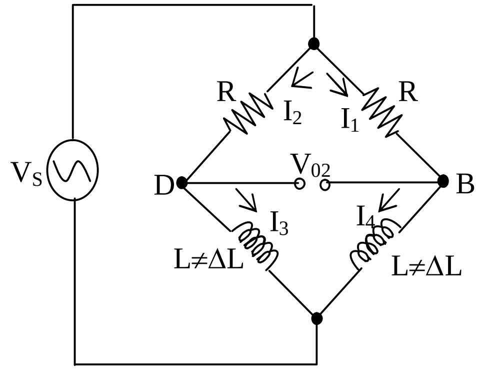


Fig.2

from fig. (1)

$V = V_{AB} - V_{AB}$

$= I_1(L \pm \Delta L) - I_2 R$

$$= \frac{V_S\, j\omega(L \pm \Delta L)}{j\omega(L \pm DL + L \pm \Delta L)} - \frac{V_S}{R+R} \text{ x } R = \frac{V_S\,(L \pm DL)}{2L} - \frac{V_S}{2R} \text{ x } R$$

$$= \frac{V_S}{2}\left[1 + \frac{DL}{L} - 1\right]$$

$$= \frac{V_S}{2} \text{ x } \frac{DL}{L} = \frac{V_S}{2} \text{ x } 0.1 \quad = 0.05\, V_S$$

from fig. (2)

$V = I_1 R - I_2 R$

$$= \frac{V_S}{R + j\omega(L \mp \Delta L)} \text{ x } R - \frac{V_S \text{ x } R}{R + j\omega(L \pm \Delta L)}$$

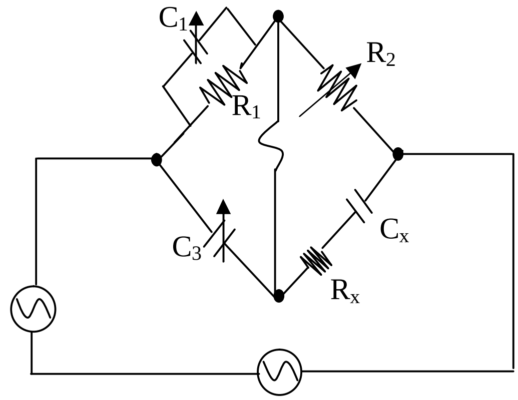
$$= V_S\, R\left[\frac{R + j\omega(L \pm \Delta L) - (R + j\omega)(L \mp \Delta L)}{[(R + j\omega)(L \mp \Delta L)] - R + j\omega(L \pm \Delta L)}\right]$$

$$= V_S\, R \quad \frac{2\, j\omega \Delta L}{(R + j\omega)(L \mp \Delta L)(R + j\omega)(L \pm \Delta L)}$$

$= V_{01} = V_{02}$

29. Ans: (a)

Sol: $Z_1 Z_x = Z_2 Z_3$ $Z_x = Y_1 Z_2 Z_3$



$$\left(R_x - \frac{1}{\omega c_x}\right) = R_2 \frac{1}{j\omega c_3} x \left(\frac{1}{R_1} + j\omega c_1\right)$$

$$R_x - \frac{j}{\omega c_x} = \frac{R_2}{j\omega c_3 R_1} + \frac{R_2 c_1}{c_3}$$

Compare two equations

$$R_x = \frac{R_2 c_1}{c_3} \qquad \frac{1}{\omega c_x} = \frac{-R_2}{\omega c_3 R_1}$$

$$c_x = \frac{c_3 R_1}{R_2}$$

41. Ans: (c)

Sol: $\frac{1}{2}(\Delta c)V^2$ = Fv displacement so

$$\Delta c = \frac{2 \text{ x force x displacement}}{V^2} \quad V = 12 \text{ KV}$$

$$= \frac{2 \text{ x } 0.006 \text{ x } 1.5 \text{ x } 10^{-12}}{12 \text{ x } 10^{-3} \text{ x } 12 \text{ x } 10^{3}} \qquad F = 0.006 \text{ N}$$

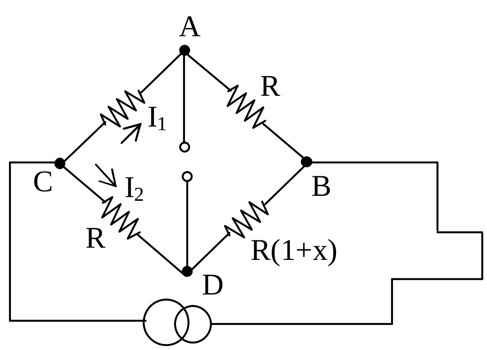
d = 1.5 mm

$= 0.125 \text{ x } 10^{-12}$ F = 0.125 pF

Previous gate questions

02. Ans: (a)

Sol: $V = V_{CA} - v_{CD}$



$I_1 = I_3$

$I_2 = I_4$

$$I = \frac{V_S}{R(1+x)+R}$$

$= I_1 R(1 + x) - I_2 R$

$$= \frac{V_S}{R(1+x)+R} R(1+x) - \frac{V_S}{R + R(1+x)} \times R$$

$$= \frac{V_S [R(1+x) - R]}{2R + Rx} = V_S \frac{Rx}{R(2+x)}$$

V = IRx