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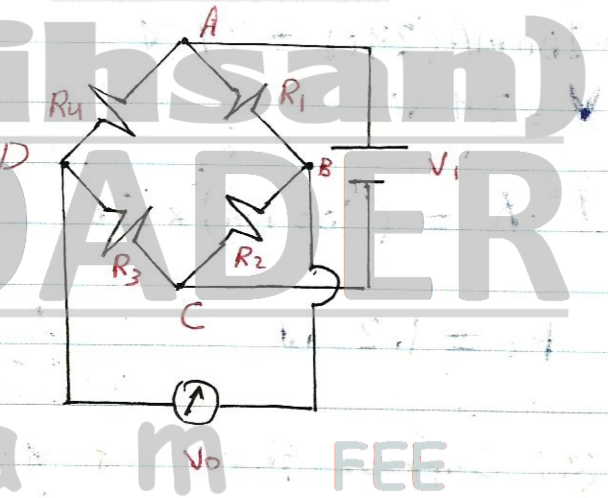
(بسم الله الرحمن الرحيم)

(sheet 5)

- Bridges -

1- if the elements in the d.c bridge circuit shown in Fig 5.2 have the following values: $R_u = 110\,\Omega$, $R_1 = 100\,\Omega$, $R_2 = 1000\,\Omega$, $R_3 = 1000\,\Omega$, $V_i = 10V$, Calculate the output voltage V_o if the impedance of the voltage measuring instrument is assumed to be infinite.

- Solution



$$V_o = V_i\left[\frac{R_u}{R_u+R_3} - \frac{R_1}{R_1+R_2}\right]$$

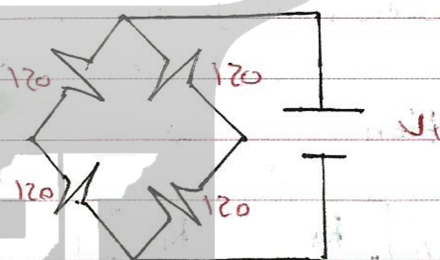
$$= 10\left[\frac{110}{110+1000} - \frac{100}{100+1000}\right]$$

$$\therefore V_o = 0.0819\ V$$

4- Four strain gauges of resistance 120 Ω each are arranged into a d.c bridge configuration such that each of the four arms in the bridge has one strain gauge in it. The maximum permissible current in each strain gauge is 100 mA. what is the maximum bridge supply voltage allowable, and what Power is dissipated in each strain gauge with that supply voltage?

Solution

$V_o = 0$ القنطرة في حالة إتزان



$V_i = I * 120 + I * 120$
$= 100\,mA(240) = 24\ V$
$\therefore V_i = 24\ V$

$P = I^2 \cdot R = (100\,mA)^2 * 120$

$P = 1.2\ W$

5) (a) Suppose that the variable shown in Figure 5.2 have the following values: $R_1 = 100\ \Omega$, $R_2 = 100\ \Omega$, $R_3 = 100\ \Omega$ $V_i = 12V$. R_u is a resistance thermometer with a resistance of $100\ \Omega$ at $100\ °C$ and a temperature coefficient of $+0.3\ \Omega/°C$ over the temperature range from $50°C$ to $150°C$ (i.e the increase as the temperature goes up). Draw a graph of bridge output voltage V_o for ten-degree steps in temperature between $100°C$ and $150°C$ (Calculating V_o according to equation 5.3)

Solution →

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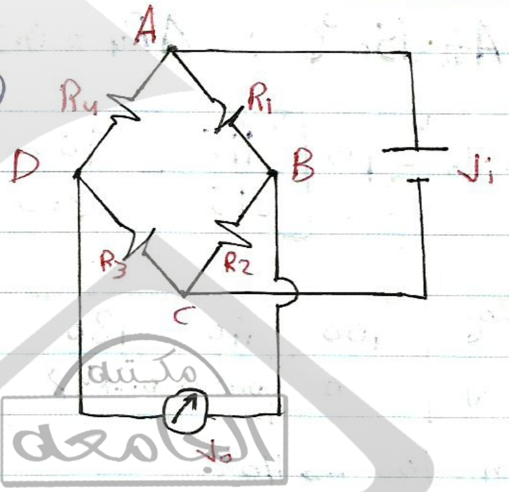
→* At $100°C$

$$\frac{\Delta R_4}{\Delta T} = 0.3\ \Omega/°C \ (50 \to 150°C)$$

→ *At $110°C$ ∴ $\Delta T = 110 - 100 = 10$

$$\therefore \frac{\Delta R_4}{10} = 0.3 \longrightarrow \Delta R_4 = 3\ \Omega$$



$$R_4 = 100 + 3 = 103\ \Omega$$

$$\therefore V_o = V_i \left[\frac{R_4}{R_4 + R_3} - \frac{R_1}{R_1 + R_2} \right]$$

$$= 12 \left[\frac{103}{103 + 100} - \frac{100}{100 + 100} \right]$$

$$\therefore V_o = 0.0887\ V$$

→* At $120°C$; $\Delta R_4 = 0.3 * 20 = 6\ \Omega \longrightarrow R_4 = 106\ \Omega$

$$\therefore V_o = 12 \left[\frac{106}{206} - \frac{100}{200} \right] = 0.1748\ V$$

→* At $130°C$ $\Delta R_4 = 0.3 * 30 = 9\ \Omega \longrightarrow R_4 = 109\ \Omega$

$$\therefore V_o = 12 \left[\frac{109}{209} - \frac{100}{200} \right] = 0.2584\ V$$

→* At $140°C$: $\Delta R_4 = 0.3 * 40 = 12\ \Omega \longrightarrow R_4 = 112\ \Omega$

$$\therefore V_o = 12 \left[\frac{112}{212} - \frac{100}{200} \right] = 0.3396\ V$$

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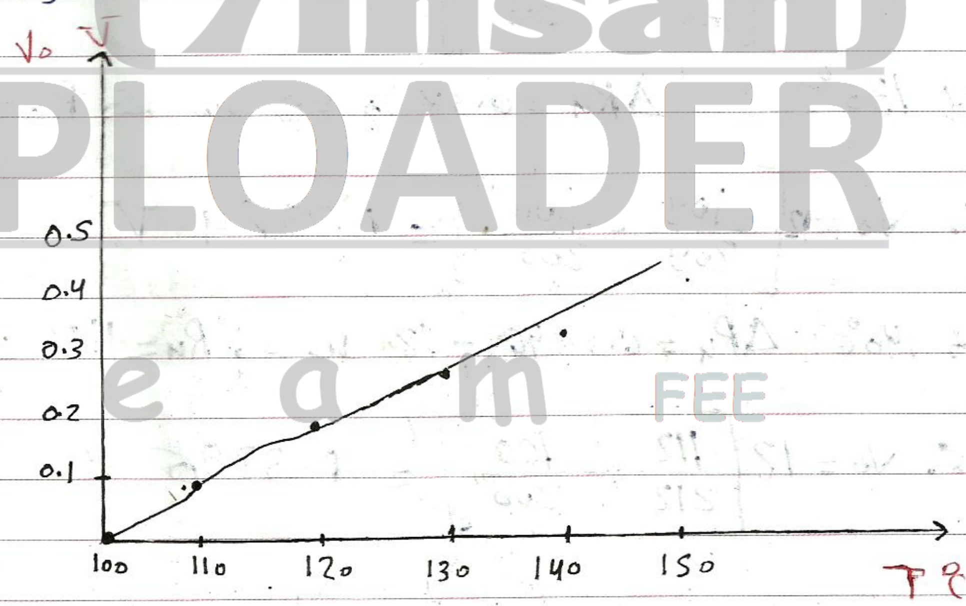
→ * At 150 °C : $\Delta R_u = 0.3 * 50 = 15\ \Omega \rightarrow R_u = 115\ \Omega$

$$\therefore V_o = 12\left[\frac{115}{215} - \frac{100}{200}\right] = 0.4186\ V$$

T°C	100	110	120	130	140	150
V_o V	0	0.0887	0.1748	0.2584	0.3396	0.4186

- From 100 → 110 °C
  $\Delta V = 0.0887\ V$
- From 110 → 120 °C
  $\Delta V = 0.0861\ V$
- From 120 → 130 °C
  $\Delta V = 0.0836\ V$
- From 130 → 140 °C
  $\Delta V = 0.0812\ V$
- From 140 → 150 °C
  $\Delta V = 0.079\ V$



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b) Draw a graph of V_o for similar temperature values if $R_2 = R_3 = 1000\ \Omega$ and all other components have the same values as given in part (a) above. Notice that the line through the data points is straighter than that drawn in part (a) but the output voltage is much less at each temperature point.

- At 100°C $\quad V_o = 0$
- At 110°C:-

$$V_o = 12\left[\frac{103}{1103} - \frac{100}{1100}\right] = 0.0297\ V$$

$\Delta V = 0.0297$

- At 120°C

$$V_o = 12\left[\frac{106}{1106} - \frac{100}{1100}\right] = 0.0592\ V$$

$\Delta V = 0.0295$

- At 130°C

$$V_o = 12\left[\frac{109}{1109} - \frac{100}{1100}\right] = 0.0885\ V$$

$\Delta V = 0.0293$

- At 140°C

$$V_o = 12\left[\frac{112}{1112} - \frac{100}{1100}\right] = 0.1177\ V$$

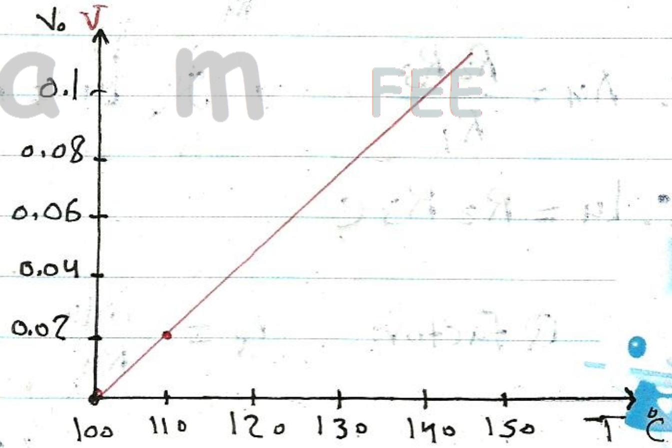
$\Delta V = 0.0292$

- At 150°C

$$V_o = 12\left[\frac{115}{1115} - \frac{100}{1100}\right] = 0.1468\ V$$

$\Delta V = 0.0291$

- we note that the data is straighter (linear) than in a but the voltage is much less at each temperature point.



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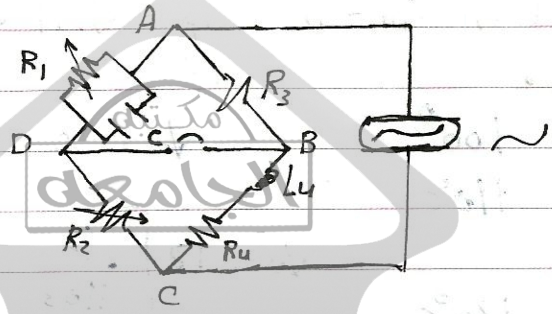
8- A Maxwell bridge, designed to measure the unknown impedance (R_u, L_u) of a coil, is shown in Figure 5.8.

Solution

a) Derive an expression for R_u and L_u under balance conditions.



At null (output) point

$$I_1 Z_{AD} = I_2 Z_{AB}$$

$$I_1 Z_{DC} = I_2 Z_{BC} \qquad \therefore \frac{Z_{BC}}{Z_{AB}} = \frac{Z_{DC}}{Z_{AD}}$$

$$Z_{BC} = \frac{Z_{DC} \cdot Z_{AB}}{Z_{AD}}$$

$$Z_{AD} = \frac{R_1 * \frac{1}{j\omega C}}{R_1 + \frac{1}{j\omega C}} = \frac{\frac{R_1}{\cancel{j\omega C}}}{\frac{1 + j\omega C R_1}{\cancel{j\omega C}}} = \frac{R_1}{1 + j\omega C R_1}$$

$$Z_{AB} = R_3 \ , \ Z_{DC} = R_2 \ , \ Z_{BC} = R_u + j\omega L_u$$

$$\therefore R_u + j\omega L_u = \frac{R_2 R_3 (1 + j\omega C R_1)}{R_1} = \frac{R_2 R_3}{R_1} + j\omega R_2 R_3 C$$

$$\therefore R_u = \frac{R_2 R_3}{R_1} \ , \ \cancel{j\omega} L_u = R_2 = \cancel{j\omega} R_2 R_3 C$$

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$$\therefore L_u = R_2 R_3 C$$

Q factor $\quad Q = \frac{\omega L_u}{R_u} = \frac{\omega R_2 R_3 C R_1}{R_2 R_3} = \omega C R_1$

b) if the fixed bridge component values are $R_3 = 100\ \Omega$ and $C = 20\ \mu f$, calculate the value of the unknown impedance if $R_1 = 3183\ \Omega$ and $R_2 = 50\ \Omega$ at balance.

$$R_u = \frac{R_2 R_3}{R_1} = \frac{50 \times 100}{3183} = 1.5708\ \Omega$$

$$L_u = R_2 R_3 C = 50 \times 100 \times 20 \times 10^{-6} = 0.1\ H$$

c) Calculate the Q factor for the coil if the supply frequency is 50 HZ.

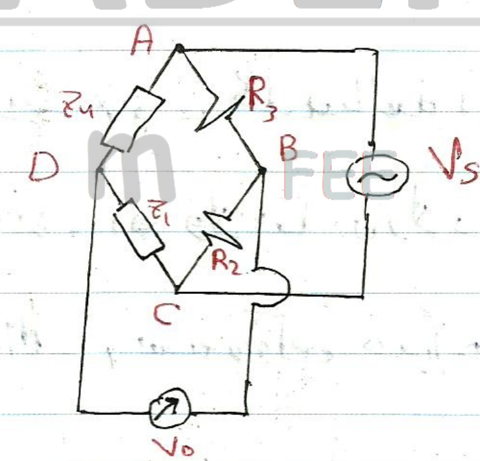
$$f = 50\ HZ$$

$$Q = \frac{\omega L_u}{R_u} = \frac{2\pi \times 50 \times 0.1}{1.5708} = 20$$

g) The deflection bridge shown in Figure 5.9 is used to measure an unknown inductance L_u. The components in the bridge have the following values: $V_s = 30\ V_{r.m.s}$, $L_1 = 80\ mH$, $R_2 = 70\ \Omega$, $R_3 = 30\ \Omega$. If $L_u = 50\ mH$, calculate the output voltage V_o.

Solution

$$V_o = V_s \left[\frac{L_u}{L_1 + L_u} - \frac{R_3}{R_2 + R_3} \right]$$



$$\therefore V_o = \left[\frac{50 \times 10^{-3}}{80 \times 10^{-3} + 50 \times 10^{-3}} - \frac{30}{70 + 30} \right]$$

$$\therefore V_o = 2.5385\ V$$

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10) An unknown capacitance C_u is measured using a deflection bridge as shown in Figure 5.9 The components of the bridge have the following values: $V_s = 10\ V_{r.m.s}$, $C_1 = 50\mu f$, $R_2 = 80\ \Omega$, $R_3 = 20\ \Omega$. if the output voltage is $3\ V_{r.m.s}$, Calculate the value of C_u.

Solution

$$V_o = V_s \left[\frac{C_1}{C_1 + C_u} - \frac{R_3}{R_2 + R_3} \right]$$

$$\therefore \frac{C_1}{C_1 + C_u} = \frac{V_o}{V_s} + \frac{R_3}{R_2 + R_3} = \frac{3}{10} + \frac{20}{100} = 0.5$$

$$\therefore C_1 = 0.5\, C_1 + 0.5\, C_u$$

$$0.5\, C_u = (1 - 0.5)\, C_1 \rightarrow 0.5\, C_u = 0.5\, C_1$$

$$\therefore C_u = C_1 = 50\ \mu f$$

كل التأخيرات في حياتك هي حكمة بالغة يعلمها الله
وحده لذا سلم أمرك له وثق به ولا تيأس ولا تأسف
ع ما مضى وفات وتيقن أن الله سيعوضك خيراً حتى
تطيب نفسك.