Ministry of Higher Education & Scientific Research
University of Technology
Laser & Optoelectronic Eng. Department
Branch: Laser & Optoelectronics Eng.
Class: 2nd Year
Subject: Measurements

Final Examination
Time: 180 minutes
Date: June 2016
Examiner: Assist. Lecturer. Saad Z. Sekhi
Code: LE2209 & OPE2204
Academic Year 2015-2016

Attempt only (5) questions

Q1) A: The inductance of a moving-iron ammeter with a full scale deflection of 90° at 1.5A is given by the expression: $L = (180 + 40\theta - 4\theta^2 - \theta^3)\mu H$

Where θ is the angular deflection in radians from zero position.

Determine (i) The spring constant.

(ii) The angular deflection of the pointer for a current of 1.0A

(6 Marks)

Q1) B: Define the following terms: 1. Loading effect. 2. Resolution. 3. Span. 4. Sensitivity. 5. Range.

(6 Marks)

Q2) A: A PMMC ammeter has the following specifications:

Coil dimension are 1cm×1cm. Spring constant is $0.15\times10^{-6}\,Nm/rad$. Flux density is $1.5\times10^{-3}\,wb/m^2$. Determine the no. of turns required to produce a deflection of 900 when a current $2mA$ flows the coil.

(6 Marks)

Q2) B: The following readings were recorded for voltage measurement: (8.2, 7.5, 8.2, 6.5, 7.5, 8.2, 6.5, 7.5, and 8.3), Calculate the following:

(1) Arithmetic mean. (2) Deviation from the mean.
(3) Average deviation. (4) Standard deviation.
(5) Variance. (6) Probable error.

(6 Marks)

Q3) A: Answer the following:

1. What are the errors usually occur in dynamometer type instruments?
2. How the electrical measuring instruments are classified?

(6 Marks)

Q3) B: Design an Aryton shunt to provide an ammeter with current ranges of 1A, 5A, 10A and 20A. A basic meter with an internal resistance of 50Ω and a full scale deflection current of 1mA is to be used.

(6 Marks)

Q4) A: In a certain dynamometer ammeter the mutual inductance M varies with deflection θ (expressed in degree) as: M = - 8 cos (θ + 30°) mH. Find the deflecting torque produced by a direct current of 60 mA corresponding to a deflection of 60 °.

(6 Marks)

Q4) B: Answer the following:

1. What are the functions of the two springs that used in the permanent magnet type moving coil instruments?
2. What are the sources of error in moving-iron instruments?

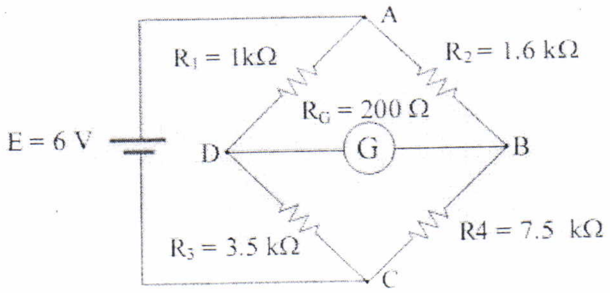
(6 Marks)

P.T.P

Q5) A: In an AC bridge ABCD, used for the measurement of small inductance, the A-B arm consists of a resistance (P), the arm B-C a resistance in parallel with a capacitance (C), arm C-D resistance (Q), arm D-A and inductance (L) with a resistance (R). The bridge is supplied at points A and C. derive the expression for (L), which is independent of (R) when the points B and D are of the same potential.

(6 Marks)

Q5) B: Calculate the current passes in the galvanometer of the following circuit.



(6 Marks)

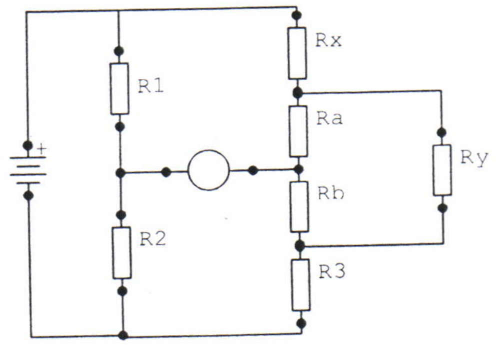
Q6) A: In a Kelvin's double bridge as shown in Fig., there is error due to mismatch between the ratios of outer and inner arm resistances. The bridge uses,

Standard resistance $= 50.1\ \mu\,\Omega$

Inner ratio arms $= 50.5\Omega$ *and* 100Ω

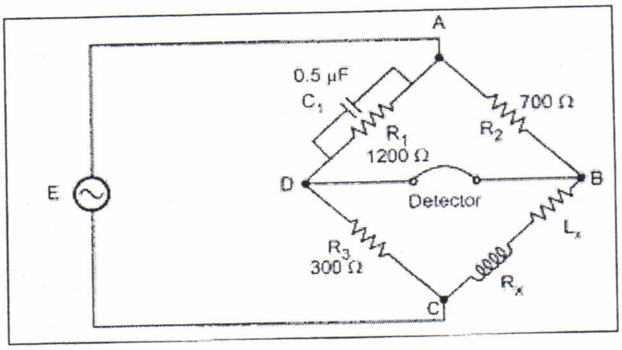
Outer ratio arms $= 50.2\Omega$ *and* 100Ω

The resistance of the connecting leads from standard to unknown resistance is $300\ \mu\Omega$. Calculate the unknown resistance under this condition.



(6 Marks)

Q6) B: From the bridge shown in fig., $C_1 = 0.5\ \mu F$, $R_1 = 1200\ \Omega$, $R_2 = 700\ \Omega$, $R_3 = 300\ \Omega$
Find the value of the unknown Rx and Lx.



(6 Marks)

الصف الثاني
مادة القياسات
م.م. سعد زهاو

حلول اسئلة الامتحان النهائى 2016-2015

Q1) A:

(i) $$\frac{dL}{d\theta} = (40 - 8\theta - 3\theta^2)\mu H / rad$$

$$= 40 - 8\frac{\pi}{2} - 3(\frac{\pi}{2})^2 = 40 - 12.566 - 7.401 = 20\ \mu H / rad$$

$$\theta = \frac{1}{2}\frac{I^2}{C}\frac{dL}{d\theta}$$

$$\frac{\pi}{2} = \frac{(1.5)^2}{2C} \times 20 \times 10^{-6}$$

$$C = 14.32 \times 10^{-6}\ Nm / rad$$

(ii) for I = 1A

$$\theta = \frac{1}{2}\frac{I^2}{C}\frac{dL}{d\theta} = \frac{(1)^2}{2(14.32 \times 10^{-6})} \times (40 - 8\theta - 3\theta^2) = 1.008\ rad = 57.8^0$$

Q1) B:

1. **Loading effect:** It's the change of circuit parameter, characteristic, or behaves due to instrument operation without maintains.
2. **Resolution:** The smallest change in input that the instruments can response to it, or the ratio of output to smallest change in input.
3. **Span:** It is algebraic difference of the upper and lower limits of the range.
4. **Sensitivity:** It's represent the ratio of output signal to a change in input, or its represent the response output of the instrument to a change of its input.
5. **Range:** It is defined as that region enclosed by the limits within which a particular quantity is measured.

Q2) A:

At Steady state condition $T_d = T_c$

$A=(1\times10^{-2} \times 1\times10^{-2})=1\times10^{-4}\ m^2$

$B = 1.5 \times 10^{-3}\ wb/m^2$

$C = 0.15 \times 10^{-6}$ Nm/rad

$I = 2 \times 10^{-3}$ A

$$\theta = 90^0 = \frac{\pi}{180} \times 90^0 = 1.57\ rad$$

BANI=Cθ

$$\therefore\ N = \frac{C\theta}{BAI} = \frac{0.15 \times 10^{-6} \times 1.57}{1.5 \times 10^{-3} \times 1 \times 10^{-4} \times 2 \times 10^{-3}} = \frac{0.2355 \times 10^{-6}}{3 \times 10^{-10}} = 785.$$

Q2) B:

1. $\overline{X} = \frac{\sum F_i \cdot X_i}{\sum F_i} = \frac{3(8.2)+3(7.5)+2(6.5)+(8.3)}{9} = \frac{68.4}{9} = 7.6 Volt$.

2. $d_i = X_i - \overline{X}$

   $d_1 = 8.2 - 7.6 = 0.6 volt$

   $d_4 = 7.5 - 7.6 = -0.1 volt$

   $d_7 = 6.5 - 7.6 = -1.1 volt$

   $d_9 = 8.3 - 7.6 = 0.7 volt$

3. $D = \frac{\sum |F_i \cdot d_i|}{\sum F_i} = \frac{3(0.6)+3(0.1)+2(1.1)+(0.7)}{9} = 0.55 Volt$.

4. $\sigma = \sqrt{\frac{\sum |F_i \cdot (d_i)^2|}{n-1}} = \sqrt{\frac{3(0.36)+3(0.01)+2(1.21)+(0.49)}{8}} = 0.7 Volt$.

5. $V = \sigma^2 = (0.7)^2 = 0.49 V^2$ 6. $r = \pm 0.67456\ \sigma = \pm 0.67456\ (0.7) = \pm 0.472192\ Volt$

Q3) A: (1)

1. Frictional Error.
2. Temperature error.
3. Error due to stray magnetic field.
4. Frequency error.
5. Error due to eddy currents.

(2) 1. Absolute Instruments

2. Secondary Instruments

   I. Indicating Instruments

   II. Recording Instruments

   III. Integration Instruments

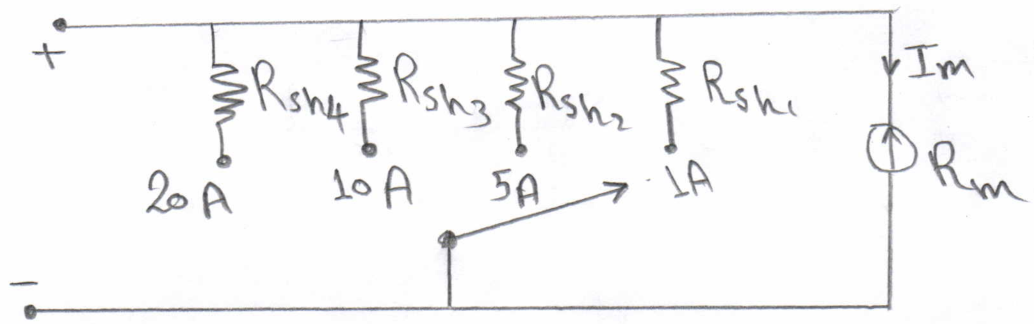
Q3) B:

$$R_{Sh1} = \frac{I_m R_m}{I_T - I_m} = \frac{I_m R_m}{I_1 - I_m} = \frac{50 \times 10^{-3}}{1 - 1 \times 10^{-3}} = 0.05\,\Omega$$

$$R_{Sh2} = \frac{I_m R_m}{I_2 - I_m} = \frac{50 \times 10^{-3}}{5 - 1 \times 10^{-3}} = 0.01\Omega$$

$$R_{Sh3} = \frac{I_m R_m}{I_3 - I_m} = \frac{50 \times 10^{-3}}{10 - 1 \times 10^{-3}} = 0.005\,\Omega$$

$$R_{Sh4} = \frac{I_m R_m}{I_4 - I_m} = \frac{50 \times 10^{-3}}{20 - 1 \times 10^{-3}} = 0.0025\,\Omega$$



Q4) A:

$$\frac{dM}{d\theta} = 8\sin(\theta + 30^0)mH$$

$$\left.\frac{dM}{d\theta}\right|_{\theta=60^0} = 8\sin(60^0 + 30^0) = 8\sin 90^0 = 8mH\ /\deg ree$$

$$T_d = I^2\frac{dM}{d\theta} = (60\times10^{-3})^2\times8\times10^{-3} = 28.8\mu Nm$$

Q4) B:

(1) 1. Provides the control of the coil movement.
2. Serve in leading the current in and out of the coil.
3. They are spiraled in opposite direction in order to neutralize the effects of temperature changes.

(2) 1. Error due to hysteresis in the iron parts of the moving system. This error is eliminated by using small iron parts with narrow hysteresis loop, which neglect hysteresis losses.
2. Error due to stray fields. This error can be removed by using magnetic shielding (using covering case of cast iron).
3. Error due to change in frequency. Change in frequency produces:
i. Change in the impedance of the coil.
ii. Change in the magnitude of the eddy currents.

Q5) A: $\frac{Z_1}{Z_2} = \frac{Z_4}{Z_3}$

$$Z_1 Z_3 = Z_2 Z_4$$

$$(R + j\omega L)\frac{R_s \frac{1}{j\omega C}}{R_s + \frac{1}{j\omega C}} = PQ$$

$$R + j\omega L\left(\frac{R_s}{j\omega R_s C + 1}\right) = PQ$$

$$(R + j\omega L)R_s = PQ(j\omega R_s C + 1)$$

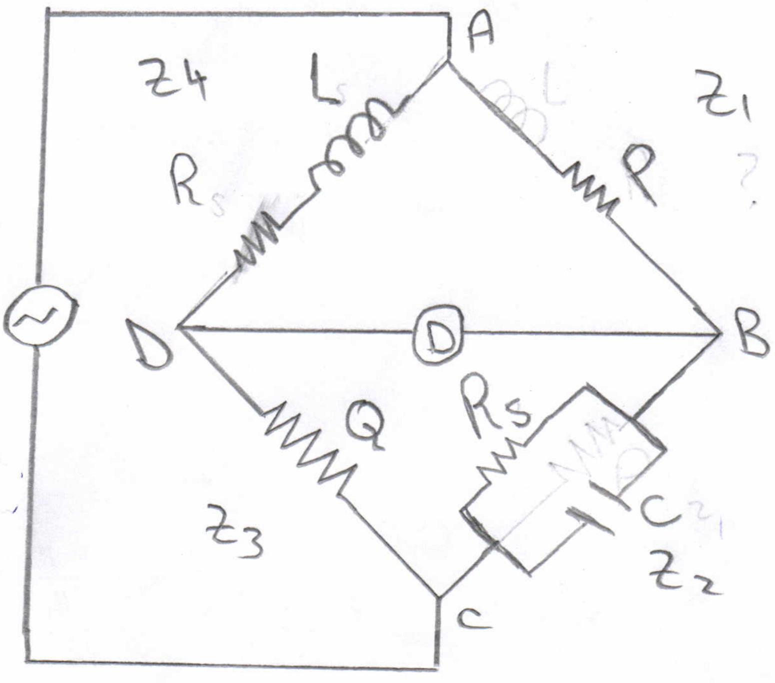
$$PR_s + j\omega L R_s = j\omega R_s CPQ + PQ$$

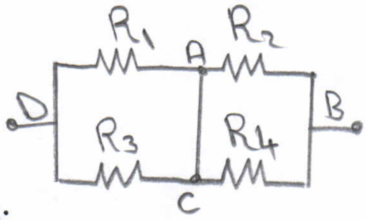
$$RR_s = PQ$$

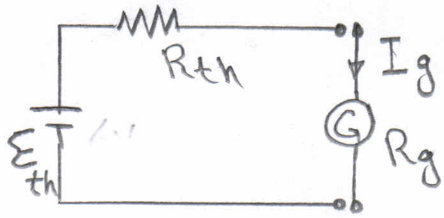
$$\boxed{R = \frac{PQ}{R_s}}$$

$$\omega L R_s = \omega R_s CPQ$$

$$\boxed{L = CPQ}$$







Q5) B:

$$E_{th} = E_{AD} - E_{AB} = 6 \times \left(\frac{1000}{1000 + 3500} - \frac{1600}{1600 + 7500} \right) = 6 \times (0.22222 - 0.17582) = 0.2784\ V$$

$$R_{th} = \frac{R_1 R_3}{R_1 + R_3} + \frac{R_2 R_4}{R_2 + R_4} = \frac{1000 \times 3500}{1000 + 3500} + \frac{1600 \times 7500}{1600 + 7500} = 777.777 + 1318.681 = 2K\Omega$$

$$I_g = \frac{E_{th}}{R_{th} + R_g} = \frac{0.2784}{2000 + 200} = 0.126\ mA$$

Q6) A:

$$R_X = \frac{R_1 R_3}{R_2} + \frac{bR_y}{[R_y + a + b]} \left\{ \frac{R_1}{R_2} - \frac{a}{b} \right\}$$

$$R_X = \frac{100 \times 50.1 \times 10^{-6}}{50.2} + \frac{50.5 \times 300 \times 10^{-6}}{[300 \times 10^{-6} + 100 + 50.5]} \left\{ \frac{100}{50.2} - \frac{100}{50.5} \right\}$$

$$R_X = 99.8 \times 10^{-6} + \frac{15150 \times 10^{-6}}{[150.5]} \{0.012\} = 101 \times 10^{-6}\,\Omega$$

Q6) B: at balance condition $Z_4 Z_1 = Z_2 Z_3$

$$(R_X + jWL_X) \frac{R_1 \cdot \frac{1}{jWC_1}}{R_1 + \frac{1}{jWC_1}} = R_2 R_3$$

$$R_X + jWL_X \left(\frac{R_1}{jWR_1C_1 + 1} \right) = R_2 R_3$$

$$R_X R_1 + jWL_X R_1 = jWR_1C_1R_2R_3 + R_2R_3$$

Separating the reals and imaginaries, we get:

$$RR_s = PQ$$

$$\therefore \quad \boxed{R_X = \frac{R_2 R_3}{R_1}}$$

and $\boxed{L_X = C_1 R_2 R_3}$, $R_X = \frac{R_2 R_3}{R_1} = \frac{700 \times 300}{1200} = 175\,\Omega$

$$L_X = R_2 R_3 C_1 = 700 \times 300 \times 0.5 \times 10^{-6} = 105\ mH$$