University of Technology
Department of Laser & Opto-electronic Engineering
Final Examination 2011-2012

Subject: measurements & Instrumentations | *Class: 2^{nd} year*
Division: Laser & Opto-electronic Eng. | *Time: 3 hours*
Examiner: Dr. Mohammed Jalal | *Date: 3٩/٥/2012*

Answer five questions only

Q_{1A}: Define the following terms: 1. Range. 2. Span and calculate the span of (0-10) voltmeter and the span of (-10 to +10) voltmeter. 3. Loading effect. 4. Sensitivity. 5. Error. **(6 Marks)**

Q_{1B}: A (0 to 150V) voltmeter has accuracy of 1% of full scale reading. The theoretical (true) expected value we want to measure is 83V. Determine the practical (measured) value and the percentage of error. **(6 Marks)**

Q_{2A}: How the electrical measuring instruments are classified? **(6 Marks)**

Q_{2B}: A moving coil instrument has a resistance of (10Ω) and gives a full scale deflection when carrying (50mA). Show how it can be adopted to measure voltage upto (750V) and current (100A). **(6 Marks)**

Q_{3A}: A Mega ohmmeter device having a resistance (R_1=2KΩ, R_2=1KΩ), find the torque of control coil and the torque of deflection coil when (R_x=35KΩ). Assume that the (dc) voltage is (70V) and (K_1=K_2=1) for uniform scale. **(6 Marks)**

Q_{3B}: The unknown resistance in a Wheatstone bridge is measure by using three known resistances, where $(R_1 = 100 \pm 0.5\%)$; $(R_2 = 500 \pm 0.5\%)$; $(R_3 = 280 \pm 0.5\%)$. Determine the magnitude of the unknown resistance and the limiting error in percent and in ohms (for the unknown resistance). **(6 Marks)**

Q_4: Consider the circuit shown in fig.1 and determine whether or not the bridge is in complete balance. If not, show two ways in which it can be made to balance and specify numerical values of any additional components. **(12 Marks)**

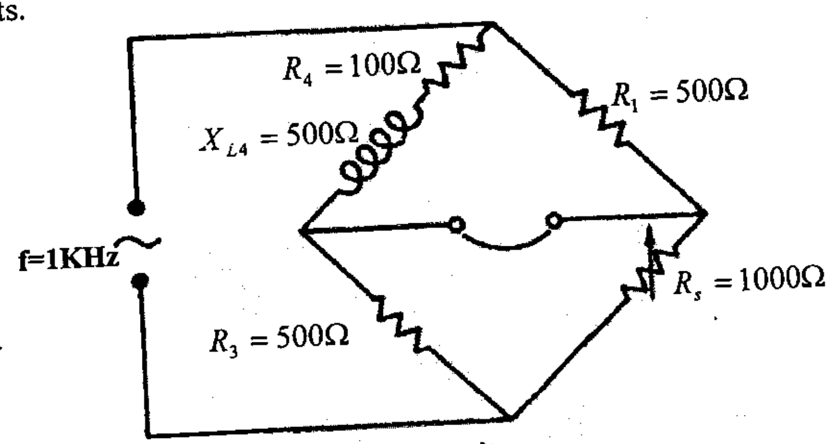

Fig.1 A.C bridge circuit

(اقلب الصفحة رجاءاً)

Q$_5$: A 50Ω basic movement requiring a full scale current of (1mA) is to be used as an ohmmeter. The internal battery voltage is (3V). a half scale deflection marking desired is (1000Ω). Calculate:

1- The values of R_1 and R_2.

2- Maximum value of R_2 to compensate for a 5% drop in battery voltage.

(12 Marks)

Q$_6$: What is the lowest full-scale voltage that could be displayed with (100μA) movement with an internal resistance of (150Ω)? What would the sensitivity of this meter be in Ω/V?

(12 Marks)

Solution of final 2011-2012
(1)

Q1A: 1. ***Range***

It is defined as that region enclosed by the limits within which a particular quantity is measured.

2. ***Span***

It is algebraic difference of the upper and lower limits of the range.

Example:

The span of (0 to10) voltmeter is Span= 10-0=10 state.

But the span for (-10 to +10) voltmeter is Span= 10-(-10) =20 state.

3. ***Loading effect***

It's the change of circuit parameter, characteristic, or behaves due to instrument operation with out maintains.

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. ***Error***

The deviation of the measured value from the true value.

Q2A: Classification of Electrical Instruments

The various electrical instruments may be divided into:

1. Absolute Instruments
2. Secondary Instruments
   I. Indicating Instruments
   II. Recording Instruments
   III. Integration Instruments

Q1B:

Example (1):
(Systematic, Human errors, the proper range of measurement)

A 0 to 150V voltmeter has accuracy of 1% of full scale reading. The theoretical (true) expected value we want to measure it is 83V. Determine the practical (measured) value and the percentage of error.

Sol.:

Tolerance= accuracy x V_{FSD}
Tolerance= 1% x 150 = 0.01 x 150 = 1.5V
Measured value= true ± tolerance
Measured value= 83 ± 1.5
Measured value= 84.5V or 81.5V

The percentage error is:

$$errors = \frac{true - measured}{true} \times 100\%$$

$$error = \frac{|83 - 84.5|}{83} \times 100\% = 1.81\% \text{, or} \qquad error = \frac{|83 - 81.5|}{83} \times 100\% = 1.81\%$$

$$\text{Or } error = \frac{|\pm Tolerance|}{True} \times 100\% = \frac{|\pm 1.5|}{83} \times 100\% = 1.81\%$$

If we want to measured anther readings on the same range and determine the error, suggest we take true 60V, and 30V.
For 60V the error is:

$$error = \frac{|\pm Tolerance|}{True} \times 100\% = \frac{|\pm 1.5|}{60} \times 100\% = 2.5\%$$

And for 30V

$$error = \frac{|\pm Tolerance|}{True} \times 100\% = \frac{|\pm 1.5|}{30} \times 100\% = 5\%$$

So we can see that the error is increased as smaller voltage is measured. thus take the proper range for every measured value, the range that give big deflection on the pointer as possible.

Q2B: - To measure a current of 100A, we need to put a shunt resistance of

$$R_{sh} = \frac{I_m R_m}{T_T - I_m} = 5 \times 10^{-3}\Omega$$

- To measure a current of 750V, we need to put a series resistance of

$$R_s = \frac{V}{I_m} - R_m = 14990\Omega \approx 15K\Omega$$

Q3A:

K1=K2=1

$T_L = K_1 I_1 \cos(\theta) = I_1 \cos(\theta)$

$T_L = K_2 I_2 \cos(90-\theta) = I_2 \sin(\theta)$

$I_1 = E/R_1 = 70/2000 = 0.035A$

$I_2 = E/R_x + R_2 = 70/(35x103 + 1000) = 1.9mA$

$\theta = I_1/I_2 = R_x/R_1 = 35mA/1.9mA = 18.4^o$

Q3B:

1. $R_4 = \frac{R_2 R_3}{R_1} = \frac{280 \times 500}{100} = 1400\Omega$

2.

$$R_2 = 500 + 0.5\% = 502.5\Omega$$
$$R_3 = 280 \pm 0.5\% = 281.4\Omega$$
$$R_1 = 100 \pm 0.5\% = 99.5\Omega$$
$$\therefore R_4 = 1421\ \Omega$$
$$error = \frac{1421 - 1400}{1421} = 1.5\%$$

3.

$$R_2 = 500 - 0.5\% = 497.5\Omega$$
$$R_3 = 280 - 0.5\% = 278.6\Omega$$
$$R_1 = 100 + 0.5\% = 100.5\Omega$$
$$\therefore R_4 = 1379\Omega$$
$$error = \frac{1379 - 1400}{1400} = -1.5\%$$
$$\therefore \%error = \pm 1.5\% = \pm 21\Omega$$

Q5:

Solution : The given values are, $R_h = 1000\ \Omega$, $R_m = 50\ \Omega$, $V = 3$ V, $I_{fsd} = 1$ mA

i) Now $\quad R_1 = R_h - \frac{I_{fsd} R_m R_h}{V}$

$$= 1000 - \frac{1 \times 10^{-3} \times 50 \times 1000}{3}$$

$$= 983.33\ \Omega$$

and $\quad R_2 = \frac{I_{fsd} R_m R_h}{V - I_{fsd} R_h} = \frac{1 \times 10^{-3} \times 50 \times 1000}{3 - 1 \times 10^{-3} \times 1000} = 25\ \Omega$

ii) Due to 5% drop in battery voltage, the voltage becomes,

$$V = 3 - 0.05 \times 3$$
$$= 2.85\ V$$

Hence the corresponding value of R_2 is,

$$R_2 = \frac{I_{fsd} R_m R_h}{V - I_{fsd} R_h} = \frac{1 \times 10^{-3} \times 50 \times 1000}{2.85 - 1 \times 10^{-3} \times 1000}$$

$$= 27.027\ \Omega$$

Q4: The circuit is not in complete balance, to be balanced:

1. Putting an inductance in series with Rs

L ~~R~~L4=(P/Q) x Ls

L4=79.5mH

2- Putting a capacitor in parallel with Rs

L4=CPQ

C= 31.8uF

Q6:

V=iR=15mV

S=R/V=10000 Ω/V.

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