Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
Student Number:

Dept. of Electrical Engineering
First Exam, Summer Semester: 2014/2015

Course Title: Instrumentation and Measurement	**Date: 10/8/2015**
Course No: (610332)	**Time Allowed: 50 Minutes**
Lecturer: Dr. Mohammad Abu-Naser	**No. of Pages: 1**

Question 1: ***(6Mark)***

Objectives: This question is related to statistical analysis

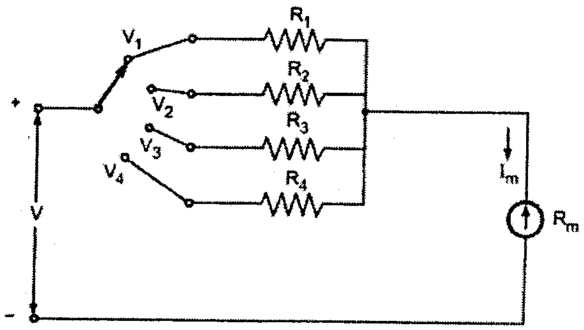
1) Define the terms (a) accuracy (b) precision.
2) Five voltage measurements were 10.1V, 10.5V, 9.6V, 9.8V, 10V. Assume only random errors are present. Calculate:
   (a) Arithmetic mean.
   (b) Standard deviation.
   (c) Variance.
   (d) Probable error.

Question 2: ***(7Mark)***

Objectives: This question is related to galvanometer

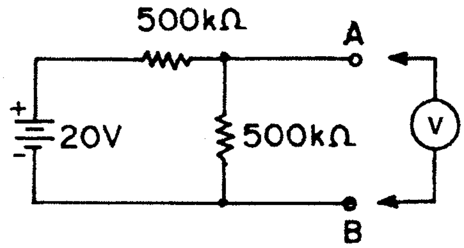
A basic D'Arsonval movement with a full scale deflection current of 50 μA and an internal resistance of 1800 Ω is to be converted into a 0-1 V, 0-5 V, 0-25 V, and 0 -125 V multi-range voltmeter using individual multipliers for each range.

(a) Calculate the individual multipliers R_1, R_2, R_3, and R_4.



(b) Calculate the sensitivity of the voltmeter.

(c) What would the voltmeter read on the 25 V range if connected across the 500 kΩ resistor between terminals A and B shown in the following figure.



Question 3: ***(7Mark)***

Objectives: This question is related to electrodynamometer

1) Prove that the average deflection of electrodynamometer type wattmeter is proportional to VIcosϕ.
2) Explain the advantages and disadvantages of electrodynamometer type instruments.

Instrumentation and Measurement

First Exam

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Question 1

1) **Accuracy**: the degree of closeness of a measured value compared to the true value.

Precision: a measure of repeatability of measurements. i.e, successive readings do not differ

2) $\bar{V} = \frac{1}{5}\sum_{i=1}^{5} V_i$

$= \frac{1}{5} \times 50 = 10\,V$

V	d	d^2
10.1	0.1	0.01
10.5	0.5	0.25
9.6	-0.4	0.16
9.8	-0.2	0.04
10	0	0
$\Sigma V = 50$		0.46

$\sigma = \sqrt{\frac{1}{4}\sum_{i=1}^{5} d_i^2}$

$= \sqrt{\frac{1}{4} \times 0.46} = 0.3391\,V$

$\sigma^2 = (0.3391)^2 = 0.115\,V^2$

$r = 0.6745\,\sigma = 0.6745 \times 0.3391 = 0.2287\,V$

Question 2

a) 1-V range

$R_T = \frac{V_1}{I_{fsd}} = \frac{1}{50 \times 10^{-6}} = 20\,K\Omega$

$\rightarrow R_1 = R_T - R_m = 20\,K\Omega - 1.8\,K\Omega = 18.2\,K\Omega$

5-V range

$R_T = \frac{V_2}{I_{fsd}} = \frac{5}{50 \times 10^{-6}} = 100\,K\Omega$

$\rightarrow R_2 = R_T - R_m = 100\,K\Omega - 1.8\,K\Omega = 98.2\,K\Omega$

25-V range

$$R_T = \frac{V_3}{I_{fsd}} = \frac{25}{50\times10^{-6}} = 500\,K\Omega$$

$$\rightarrow R_3 = R_T - R_m = 500K\Omega - 1.8K\Omega = 498.2\,K\Omega$$

125-V range

$$R_T = \frac{V_4}{I_{fsd}} = \frac{125}{50\times10^{-6}} = 2500\,K\Omega$$

$$\rightarrow R_4 = R_T - R_m = 2500K\Omega - 1.8K\Omega = 2498.2\,K\Omega$$

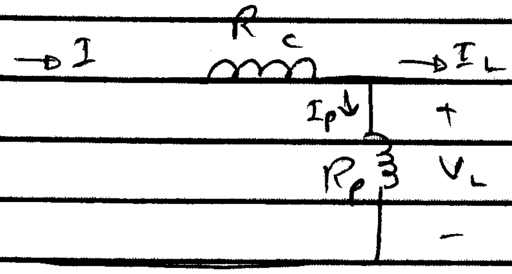
b) $$S = \frac{1}{I_{fsd}} = \frac{1}{50\times10^{-6}} = 20\,K\Omega/V$$

c) $$R_v = S \times V_{range}$$
$$= 20K\Omega/V \times 25V = 500K\Omega$$

$$R_p = 500K\Omega \,//\, R_v = 500K\Omega \,//\, 500K\Omega = 250\,K\Omega$$

$$V_{voltmeter} = 20V \times \frac{250K\Omega}{750K\Omega} = 6.67\,V$$

Question 3



1) $T \propto BAIN$

but $B \propto I_p$

and $I = I_L + I_p \approx I_L$

$\Rightarrow T \propto I_p I_L$ (AN)

since $I_p = \frac{V_L}{R_p}$

$\Rightarrow T \propto V_L I_L$

So due to inertia of moving coil

$$\text{Deflection} \propto \frac{1}{T}\int_0^T V_L I_L \, dt$$

let $V_L = V_m \sin(\omega t)$
and $I_L = I_m \sin(\omega t - \phi)$

$$V_L(t) I_L(t) = V_m I_m \sin \omega t \sin(\omega t - \phi)$$
$$= \frac{1}{2} V_m I_m [\cos\phi - \cos(2\omega t - \phi)]$$
$$= V I [\cos\phi - \cos(2\omega t - \phi)]$$

Hence

$$\text{Deflection} \propto \frac{1}{T}\int_0^T V I [\cos\phi - \underbrace{\cos(2\omega t - \phi)}_{\text{periodic} \rightarrow \text{average is zero}}] \, dt$$

$$\text{Deflection} \propto \frac{VI}{T}\int_0^T \cos\phi \, dt$$

$$\boxed{\text{Deflection} \propto V I \cos\phi}$$

) Advantages: 1) high accuracy
2) used for both AC and DC
3) accurate RMS value irrespective of waveform

Disadvantages: 1) high power consumption since it needs to supply its own magnetic flux
2) low sensitivity compared to PMMC, so it has high loading effect
3) expensive