Ch.2

Definitions

1) **True values** – The average of an infinite number of measured values when the average deviation tends to zero

2) **Accuracy**: The degree of closeness of measured quantity of instrument when this quantity of instruments approches to the true value

* قرب القيمه لقاسها من القيمه الحقيقيه

3) **Precision** :– The degree of agreement within a group of measurements.

4) **Significant Figures** :– An indication of the precision of measurement is obtained from the number of significant figures. (The more significant figures the better the precision measurement)

"More significant" 576.567 Better than
"less significant figures" 576.56

5) **Reproducibity** :– It is the degree of closeness with which a given value maybe repeatedly measured

* قرب القيمة اللي نقسها وأعيد قياسها.

6) **Drift** :– undesirable quantity in industrial instruments because it is rarely apparent and can not be easily compensated.

بيحصل تغير في القيمه اللي بعيد قياسها عشان كده هي غير مرغوب فيها.

الفرق بينهم

الحل

7) **Scale Range** :– The difference between the largest and the smallest reading of the instrument.

8) **Span** :– $X_{max} - X_{min}$ ..

ex. 0 to 1000°C → range = 1000°C, Span = 1000°C

200 to 500°C → range = 200°C to 500°C, Span = 500 − 200 = 300°C

9) **Static error** :– The difference between the measured value and the true value of a quantity

10) **Instrument efficiency**: The ratio of the measured quantity at full scale to the power taken by instrument at full scale

11) **Resolution**: The smallest measurable input change

أقل قيمه أقدر أدخلها

12) **Noise**: unwanted signals.

الوقت اللي بياخده الآله عشان تستجيب للدخل المتغير

13) **Dead Time** :– The time required for the instrument to respond when the input change

14) **Dead Zone** :– The largest change in the input when there is no output of the instrument.

Ch. 3 Definitions :-

① **Histogram :-** Presenting a measurement data which scatering about Central Value.

طريقة لعرض بيانات تكون منتشرة حول ال Central Value

② **Arithmetic mean :-** المتوسط الحسابي

$$\bar{x} = \frac{x_1 + x_2 \cdots x_n}{n}$$

③ **Dispersion :-** The property (خاصية) denotes (تشير) the extent of data to which the values are dispersed (منتشرة) about Central Value.

④ **Deviation :-** الانحراف

$d = x_1 - \bar{x}$ ← arthmetic mean

The depature of observed readings from arthmetic mean of the group of readings.

⑤ **average deviation :**

$$D = \frac{|d_1| + |d_2| \cdots |d_n|}{n}$$

⑥ **Standard deviation :-**

$$S.D = \sqrt{\frac{d_1^2 + d_2^2 + \cdots d_n^2}{n-1}}$$

The square root of the Sum of individual squared diviation divided by the number of readings

⑦ **Standard :-** Physical representation of unit of measurement

⑧ **Proto type :-** Made by Platinum and radium

⑨ **International Standard :-** They represent the units of measurements which are closest to the Possible accuracy attainable (سهل, المنال) with present day technological and scientific methods

⑩ **Primary standard :-** They are absolute standard of such high accuracy that can be used as the ultimate reference (مرجع نهائي) standards these standards are maintained by national standard laboratories in different Parts of the world

- Consideration while building Primary standard :-

1) The materials should have a long time stability
2) The temp. coef. of the material should be as small as possible
3) The material should be less effect of the environmental conditions

(11) Secondary Standards :- They are the basic reference standard used in industerial measurements laboratories. في المصانع

(12) Working Standards :- They are the major tools of a measurements laboratories they used to Calibrate and Check general laboratory instruments for their accuracy and Performance. بالمعامل

Ch.6 :-

Ch.8 :- Galvanometer "قوانين"

deflection Const → $G = NBA$

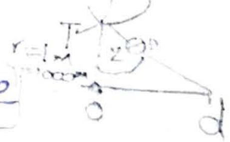
at steady state : $T_c = T_d$

Control Const → $K_c \theta_F = G i$ → Current

Final Steady state deflection

$$\theta_F \text{ in degrees} = \theta_F \times \frac{180}{\pi}$$

deflection (d) = od = radius x angle



$d = od = 1000\,mm \times 2\theta_F$

deflection, radius (scale), final steady deflection

$$R = \frac{G^2}{2\sqrt{KJ}}$$

G → deflection Const; K → Control Const; J → inertia Const.

$$W = 2\pi f = \frac{2\pi}{T}$$

@ Critical damping : $W = W_n = \sqrt{K/J} = \frac{D}{2J} = \alpha$

@ underdamping : $W = W_d = \frac{\sqrt{4KJ - D^2}}{2J}$

@ over damping : $W = W_d = \frac{\sqrt{D^2 - 4KJ}}{2J}$

~~Relatie~~

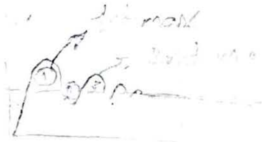
Relative damping $\zeta = \frac{D}{D_c} =$

@ under damping

$$\boxed{\theta_1 = \theta_f\left(1 + e^{-\pi\zeta/\sqrt{1-\zeta^2}}\right)}$$

(1st max)

ال deflection لأول قمة بتقابلني



ال deflection لتاني قمة بتقابلني تعتبر تالت deflection عشان بتقابلني ٣

$$\theta_3 = \theta_f\left(1 + e^{\left(-3\pi\zeta/\sqrt{1-\zeta^2}\right)}\right)$$

$$\frac{\theta_1 - \theta_f}{\theta_3 - \theta_f} = \frac{e^{\left(-\pi\zeta/\sqrt{1-\zeta^2}\right)}}{e^{\left(-3\pi\zeta/\sqrt{1-\zeta^2}\right)}} = e^{\left[2\pi\zeta/\sqrt{1-\zeta^2}\right]}$$

Logarthmic decrement $\boxed{\lambda = \pi\zeta/\sqrt{1-\zeta^2}}$

$$\therefore \frac{\theta_1 - \theta_f}{\theta_3 - \theta_f} = e^{2\lambda}$$

من المسائل بيدينا θ_1 , θ_3

ويطلب ال λ فنجيبه ب ln الطرفين

$$2\lambda = \ln\left(\frac{\theta_1 - \theta_f}{\theta_3 - \theta_f}\right)$$

$\lambda = \frac{\pi\zeta}{\sqrt{1-\zeta^2}}$ ومن λ بنجيب ال ζ (Relative damping)

Current sensitivity $= S_i = \frac{\theta_f}{i}$ (rad/A) $= \boxed{\frac{d}{i \times 10^{-6}}}$ Scale division / μA , mm / μA

Voltage sensitivity $= S_v = \frac{d}{i \times 10^{-6} \times R_g}$ mm / μV

Defintions :-

Current sensitivity : deflection produced by unit Current

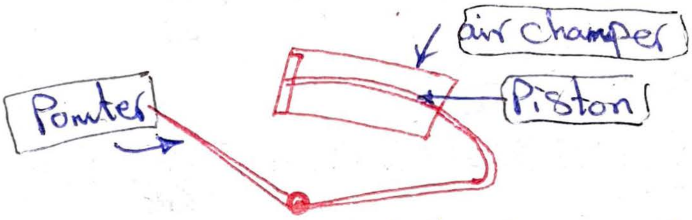
Voltage sensitivity :- The deflection in scale division by unit Voltage.

Megohm sensibvity :- The resistance of the Circuit in Megaohm so that the deflection will be one scale division with one volt impressed to the Circuit

$$S_o = \frac{d}{i \times 10^{-6}} \quad M\Omega / \text{Scale division}$$

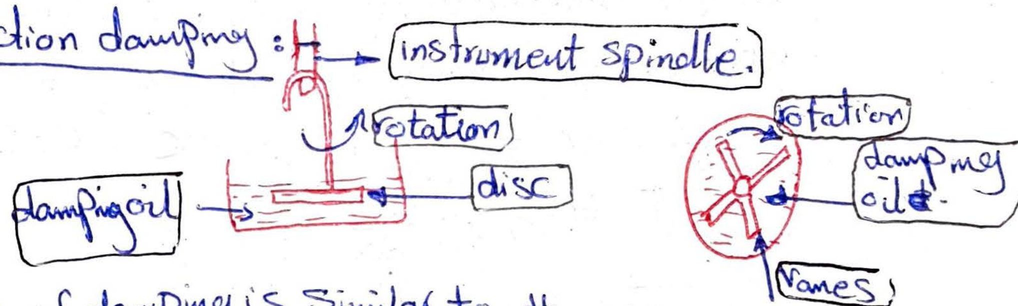
Different types of damping methods are:-

1 Air Friction damping:-



Provides a very simple and cheap method of damping but we must be carefull that the Piston is not twisted inorder not to have errors because of friction of the Piston to the air champer.

2 Fluid Friction damping :



This form of damping is similar to the air friction damping but we use oil instead of air as the velocity of oil is greater and the damping force is greater, it reduces friction errors, but the disadvantages → because of oil the instrument can't be clean. Also is used only for instruments in vertical position.

3 Eddy Current damping (also known as Electromagnetic damping):-

disadv • This method cannot be used in instruments where introduction of Permanent magnet required for producing eddy currents will distort the existing magnetic field.

When a conductor moves in ~~an emf~~ magnetic field an emf is produced in it, if a closed path is provided a current (Eddy current) flows, the current interacts with the magnetic field to produce an electromagnetic torque. Most efficient form.

4 Electromagnetic damping:-

The movement of a coil in a magnetic field produces a current in the coil which interacts with the magnetic field to produce a torque.

* Derive the equation torque of electrostatic Instrument

Energy $= \frac{1}{2} C V^2$

$I = \frac{dq}{dt} = \frac{d}{dt}(CV) = C\frac{dV}{dt} + V\frac{dC}{dt}$

$VI = CV\frac{dV}{dt} + V^2\frac{dC}{dt}$

input energy $= VI\,dt = CV\,dV + V^2\,dC$

Let $\begin{bmatrix} C = C + dC \\ V = V + dV \end{bmatrix}$

Change in stored energy $= \frac{1}{2}(C+dC)(V+dV)^2 - \frac{1}{2}CV^2$

$= \cancel{\frac{1}{2}CV^2} + \cancel{\frac{1}{2}C\,dV^2} + CV\,dV + \frac{1}{2}V^2 dC + \cancel{\frac{1}{2}dC\,dV^2} + \cancel{V\,dC\,dV} - \cancel{\frac{1}{2}CV^2}$

dV^2, $dC\,dV$ -> very small

Change in stored energy $= CV\,dV + \frac{1}{2}V^2 dC$

input energy = change in stored energy + Mechanical work ($F\,dx$)

$\cancel{CV\,dV} + V^2 dC = \cancel{CV\,dV} + \frac{1}{2}V^2 dC + F\,dx$

$F = \frac{1}{2}V^2\frac{dC}{dx}$

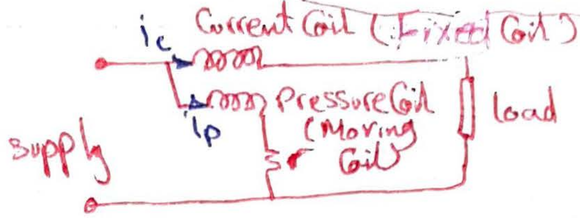
$T_d = \frac{1}{2}V^2\frac{dC}{d\theta}$

→ $T_d = T_C$ @ Steady state

$\frac{1}{2}V^2\frac{dC}{d\theta} = K\theta$

$$\boxed{\theta = \frac{1}{2}\frac{V^2}{K}\frac{dC}{d\theta}}$$

the equation of Electrodynamometer Wattmeter :—



$T_i \rightarrow$ instantaneous Torque

$$T_i = i_c \, i_p \frac{dM}{d\theta}$$

$$i_c = \sqrt{2}\, I \sin(\omega t - \phi)$$

$$i_p = \sqrt{2}\, I_p \sin(\omega t)$$

$$T_i = 2 I I_p \sin \omega t \sin(\omega t - \phi) \frac{dM}{d\theta}$$

$$= \cancel{2} I_p I \left[\tfrac{1}{\cancel{2}} [\cos\phi - \cos(2\omega t - \phi)] \right] \frac{dM}{d\theta}$$

$$= I_p I (\cos\phi - \cos(2\omega t - \phi)) \frac{dM}{d\theta}$$

$$\text{average} = \frac{1}{T}\int_0^T T_i \, d(\omega t) = \boxed{I_p I \cos\phi \frac{dM}{d\theta}}$$

@ Steady State

instantaneous Torque $\leftarrow$ $T = T_c$ $\hookrightarrow$ Control torque

$$I_p I \cos\phi \frac{dM}{d\theta} = K_c \theta$$

$$\therefore \theta = \frac{I_p I \cos\phi}{K_c} \frac{dM}{d\theta}$$

wattmeter reading

$$\theta = \frac{V}{R_p} * \frac{I}{K_c} \cos\phi \frac{dM}{d\theta}$$

Knowing that $VI\cos\phi$ = True Power , $K_1 = \frac{1}{K_c R_p}$

$$\boxed{\theta = K_1 * P \frac{dM}{d\theta}}$$

inductance of P.C. $Z = \sqrt{(R+r_p)^2 + \omega^2 L^2}$ & $\phi' = \phi - \beta$

$$\theta = \frac{VI}{Z_p K} \cos(\phi - \beta) \frac{dM}{d\theta}$$

Final Equation

$$@ Z_p = \frac{R_p}{\cos\beta} \rightarrow \boxed{\theta = \frac{VI}{R_p K} \cos\beta * \cos(\phi - \beta) \frac{dM}{d\theta}}$$

قوانين ال wattmeter مسائل :-

$$\tan\beta = \frac{\omega L}{R_p}$$

$$\text{True Power} = VI\,\boxed{\cos\phi}$$ Power factor

Precentage error

$$\%\,\text{error} = \frac{\text{actual} - \text{True}}{\text{True}} \times 100 = \tan\phi \tan\beta \times 100$$

$$\text{error} = \text{Actual Power}\left(1 - \frac{\cos\phi}{\cos\beta\,(\cos(\phi-\beta))}\right)$$

$$\text{Correction Factor} = \frac{\text{True Power}}{\text{actual power}} = \frac{\cos\phi}{\cos\beta\,\cos(\phi-\beta)}$$

lags

$$\text{Actual Power} = \text{True}\,(1 + \tan\phi \tan\beta)$$

$$\beta = \tan^{-1}\left(\frac{\omega L}{R_p}\right)$$

Types of Errors in electrodynamometer wattmeter

Error due to Inductance

$$\text{error} = \tan\phi\,\tan\beta * \underbrace{\text{True Power}}_{VI\cos\phi}$$

Error due to Connection

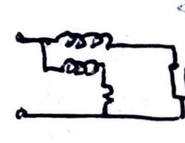
Pressure Coil at load side

C.C

P.C

$$\text{error} = \frac{V^2}{R_p}$$

P.C at Supply Side



$$\text{error} = I^2 R_c$$

Current Coil Res

* total error when P.C at load side

= error due to inductance + error due to Connection

Total error $= \left(\tan\phi \tan\beta * \text{True Power} + \frac{V^2}{R_p}\right)$

* Total error P.C at supply side $= \left(\tan\phi \tan\beta * \text{True Power} + I^2 R_c\right)$

$\theta \rightarrow$ angle between two Coils , $\phi \Rightarrow$ flux linking moving Coil

$M \rightarrow$ mutual inductance between two Coils

* $\phi = B * \text{area} = \frac{\pi}{4} D^2 B \cos\theta = \frac{\pi}{4} D^2 N B \cos\theta$

* $M = \frac{\phi}{i} = \frac{\pi}{4} \frac{D^2}{i} N B \cos\theta \longrightarrow M_{max} = \frac{\pi}{4} D^2 N \frac{B}{i}$

* $\frac{dM}{d\theta} = M_{max} * \sin\theta \; \# \rightarrow \boxed{T_i = I_p I \cos\phi * \frac{\pi}{4} D^2 N \frac{B}{i} \sin\theta}$

Minia University Electrical Eng. Dept. Course Title :Elec. Measurements Total Marks (40Marks)	Faculty of Engineering Mid-Term Nov. 2017 Course Code: EE215 Time Allowed: 2 Hours

Assume any missing data

Question #1 (12 marks)

a) What are the sources of noise in analog instruments? (3 Marks)

b) State the difference between the following:

i. Accuracy and precision?

ii. Reproducibility and drift?

iii. Dead time and dead zone? (3 Marks)

c) Design a shunt type ohmmeter uses a 1mA basic movement with an internal resistance 10 Ω. The battery voltage is 3 V find:

i. The value of resistance R_1?

ii. At what point (in percentage of full scale) will 100 Ω be marked on the scale? (6 Marks)

Question #(2) (13 Marks)

a) How to avoid the following: (3 Marks)

Gross error, Inherent shortcoming of instrument, Environmental error

b) Sketch the following in details:

1. The basic circuit of Galvanometer?
2. Types of support of analog instruments? (4 Marks)

c) A galvanometer gives a deflection of 150 mm on a linear scale distant 2.5 m for a steady current of 1μA. The period of oscillations is 4 second and the moment of inertia of moving system is 1×10^{-6} kg-m^2. Calculate the coil circuit resistance necessary to obtain critical damping? (6 Marks)

Question# (3) (15 Marks)

a) Derive the equation of over-damped motion of Galvanometer? (5 Marks)

b) What are the requirements of:

i. Spring control ii. Moving system (4 Marks)

c) The deflection of Galvanometer is 50 mm with steady state current of 3.2 μA, its first maximum deflection is 75 mm and the maximum deflection of next cycle is 60 mm determine the following:

I. Current sensitivity (S_i)?

II. The logarithmic decrement (λ)?

III. Relative damping (η)? (6 Marks)

مع أطيب التمنيات بالتوفيق والنجاح

Dr/ Ahmed Galal

Model (1)

1) The coil of a measuring instrument has a resistance of 1Ω and the instrument has a full scale deflection of 250 v when a resistance of 4999 Ω is connected in series with it , find :

a) the current range when used as an ammeter with the coil connected across a shunt of 1/499 Ω .

b) The value of the shunt resistance to give a full scale deflection of 50 A.

2) A certain circuit takes 10A at 200 V and the power absorbed is 1000W , if the wattmeter 's current coil has a resistance of 0.15 Ω and its pressure coil has a resistance of 5000 Ω and L=0.3H . Find:

a) the error due to resistance for each of two connections.

b) error due to inductance if the frequency is 50 Hz .

c) The total error in each case.

3) The four arms of a wheatstone bridge are as follows:

AB=100 Ω , BC=1000 Ω , CD=4 Ω and DA=400 Ω

The galvanometer has a resistance of 20 Ω and is connected across BD , A source of 10 V d.c is connected across AC.

Find the current through the galvanometer , what should be the resistance in the arm DA for no current passes through the galvanometer?

Minia University
2nd year Computer & System Dep.
Electrical & Electronic measurements
Total Marks (90 Marks)

Faculty of Engineering
Dec. 2017
Code: CS 215
Time: 3 hrs

الامتحان مكون من صفحتين

Assume any missing data

Answer the following questions

Question No.(1) (18 marks)

a) Define the following:

Instrument efficiency, Transducer, Resolution, Dispersion. (4 marks)

b) Deduce the current in the output of differential amplifier type of EVM? (4 marks)

c) The current coil of a wattmeter is connected in series with an ammeter and inductive load. A voltmeter and the voltage coil are connected across a 100Hz supply, the ammeter reading is 4.5 A and the voltmeter and wattmeter readings, are respectively, 240 V and 23 W. The inductance of voltage circuit is 10 mH and its resistance 2000Ω. If the voltage drops across the ammeter and the current coil are negligible, what is the percentage error in the wattmeter reading? (10 marks)

Question No.(2) (18 marks)

a) Explain the different methods of generating square wave? (4 marks)

b) Deduce the General toque equation of moving iron instruments? (4 marks)

c) A PMMC instrument has the following parameters; full scale deflection 90°=100 scale divisions, with a current of 1 mA. The period of free oscillations is 0.55 s, in order to measure the spring constant, a small weight having a gravitational force of 98.1×10^{-6} N is placed at a distance of 100 mm from the horizontal axis of rotation with the horizontal pointer, the resulting deflection being 35 divisions. The first maximum deflection is 106 divisions. The flux density in the air gap is 0.24 Wb/m^2. The length of the coil is 15 mm and the average diameter of coil is 14 mm. calculate: (10 marks)

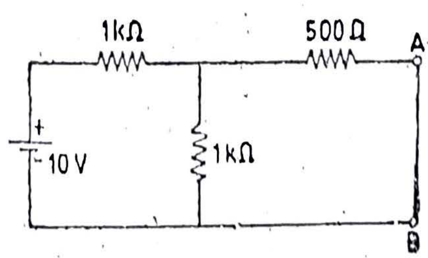
i. Spring constant ii. Moment of inertia iii. Number of turns
iv. Damping ratio v. damping constant

Question No.(3) (18 marks)

a) Derive the equation for critical damping oscillation of Galvanometer? (4 marks)

b) Sketch the different types of LC oscillators? (4 marks)

c) It is desired to measure the current in 500Ω resistor shown in the figure below by ammeter with internal resistance 100Ω find the actual value of current, measured value of current, and percentage error. (10 marks)



Model (2)

1) State the advantages and disadvantages of the following :

(i) Moving iron instrument (ii) Permanent magnet moving coil

2) Explain the error caused by both connections in the dynamometer wattmeter , and how to compensate it?

3)A moving coil instrument whose resistance is (25) ohm gives a full scale deflection with a current of (1) mA , this instrument is to be used with a manganin shunt to extend its range to (100) mA . calculate the error caused by a (10 °c) rise in temperature when :

(i) Copper moving coil is connected directly across the manganin shunt.

(ii) A (75) ohm manganin resistance is used in series with the instrument copper moving coil.

(The temperature coefficient of copper is 0.4% °c and that of manganin is 0.00015°c)