

Sem.4

Branch: ELECTRICAL ENGINEERING

2023(S)

12

Code: TH 3

Subject Name: EM&amp;I (Electrical Measurement &amp; Instrumentation)

Date of exam: 29/04/2023

Full Marks: 20

Time- 1 Hr

Answer any three Questions including Q No.1  
 Figures in the right-hand margin indicates marks

|    |  |     |    |    |
|----|--|-----|----|----|
| 1. | Answer All questions   | 5×2 | CO | PO |
|    | a. What do you mean by (a) accuracy<br>(b) precision                   |     |    |    |
|    | b. What is indicating type instrument ? give two example of it.        |     |    |    |
|    | c. Write down the torque associated with indicating type instrument.   |     |    |    |
|    | d. What is shunts and multiplier ?                                     |     |    |    |
|    | e. Write two errors in MI instrument ?                                 |     |    |    |
| 2. | a. Explain construction and working principle of PMMC type instrument. | 5   |    |    |
|    | b. Explain construction and working of electro dynamo type instrument. | 5   |    |    |
|    | c. Write advantages, disadvantages & errors in PMMC instrument.        | 5   |    |    |



em.4<sup>th</sup>

Branch: ELECTRICAL ENGINEERING

2023(S)

Code: TH 3

Subject Name: EM&amp;I (Electrical Measurement &amp; Instrumentation)

Date of exam: 29/04/2023

Full Marks: 20

Time- 1 Hr

## MODEL ANSWERS OF INTERNAL ASSESSMENT

|    |    |   |     |
|----|----|---|-----|
| 1. |    | Answer All questions  | 5×2 |
|    | a. | <p>What do you mean by</p> <p>(a) accuracy - It is the degree of closeness of readings from an instrument to the true value. Always accuracy is measured relative to the true value or actual value.</p> <p>(b) precision- It is the degree of closeness of reading with the previous reading. An instrument is said to be precise when there is negligible difference between successive readings.</p>   |     |
|    | b. | <p>What is indicating type instrument ? give two example of it.</p> <p>The measuring instruments which indicate the magnitude of the electrical quantity at the time when the quantity is being measured are known as indicating instruments. Eg- Voltmeter, Ammeter</p>  |     |
|    | c. | <p>Write down the torque associated with indicating type instrument.</p> <p>Deflecting Torque 2) damping torque 3) Controlling torque</p>   |     |
|    | d. | <p>What is shunts and multiplier ?</p> <p>A shunt is normally a very low value of resistance, connected in parallel with the ammeter coil. It is used to extend the ammeter range</p> <p>The multiplier is a non-inductive high-value resistance connected in series with the instrument whose range is to be extended. It is used to extend the range of voltmeter,</p>  |     |
|    | e. | <p>Write two errors in MI instrument ?</p> <p>Hysteresis error- The main source of this error is the tendency of the iron parts in the instrument to store magnetism for short periods. Due to this error, for decaying values of currents, the flux appears to be more than its corresponding value. As the deflecting torque is directly proportional to the flux, the meter reads high.</p> <p>Methods adopted to reduce this error are,</p> <p>Reducing the size of the iron part in the instrument.</p> <p>Reducing the value of operating flux density.</p> <p>Replacing the active iron part with nickel-iron alloy as it has a narrow hysteresis loop. With this method, the hysteresis error can be reduced to a large extent.</p> <p>Temperature error- The main source of this error is the temperature coefficient of the springs (for spring controlled instruments only), moving coil, and series resistance. Due to an increase in temperature, the overall resistance of the meter increases and so the current through the meter gets reduced. Hence. the meter reads low.</p> <p>In order to reduce this error, the series resistance being employed is made with the material having a negligible temperature coefficient (like manganin, constantan, etc). The value of series resistance should be comparatively much higher than that of moving coil and springs.</p> <p>Errors due to stray magnetic fields</p> <p>Errors due to change in frequency</p> |     |
| 2. | a. | <p>Explain construction and working principle of PMMC type instrument.</p> <p>Ans- The term PMMC is the short form of "permanent magnet moving coil". This instrument is simple as well as most frequently used on ships with sophisticated names. These instruments are</p>  | 5   |



used when an exact measurement is required as well as to aid while maintaining electrical equipment. Apart from PMMC, it is also called as D'alvanometer. It is a kind of galvanometer that works on the principle of D'Arsonval.

These instruments use permanent magnets to create the stationary magnetic field in the coils, and then it is used with the moving coil that is connected to the electric source for generating deflection torque according to the Fleming left-hand rule theory.

The PMMC instrument working principle is when the torque is applied to the moving coil that is placed within the permanent magnet field, and then it gives a precise result for DC measurement.

#### Working Principle of a PMMC Instrument

Whenever a current carrying conductor is located within a magnetic field, then it experiences a force that is perpendicular to the current & the field. Based on the rule of "Fleming left hand", if the thumb, middle and forefinger are at 90 degrees with each other.

After that the magnetic field will be in the forefinger, flow of current will be across the middle finger and finally, the force will be through the thumb finger.

Once the current flow within the coil on the aluminum former, the magnetic field can be generated in the coil in proportion to the current flow.

The electromagnetic force throughout the fixed magnetic field from the permanent magnet generates the deflection force within the coil. After that the spring generates the force to resist additional deflection; therefore it helps to balance the pointer.

So damping force can be generated within the system through the aluminum core movement of the magnetic field. It maintains the pointer stable to a point. Once it attains equilibrium by controlling & deflection torque to provide accuracy in measurement.

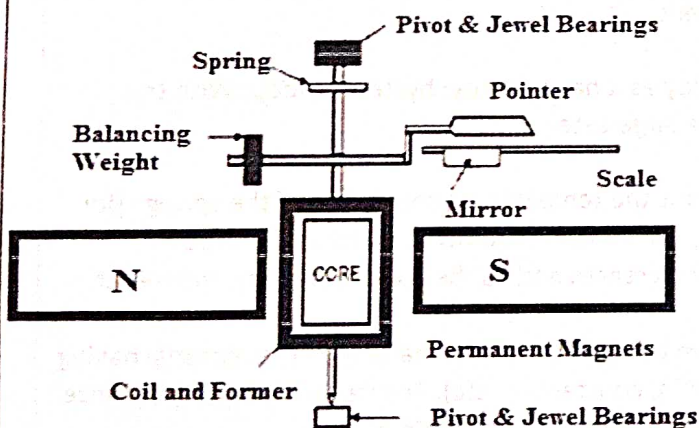
#### PMMC Instrument Construction

The construction of the PMCC instrument can be done using several parts where the permanent magnet and moving coils are essential parts. Each part of this instrument is discussed below.

##### Moving Coil

It is an essential component of the PMMC instrument. The designing of this coil can be done by winding copper coils to a rectangular block among the magnetic poles. It is made with Aluminum and the rectangular block can be called Aluminum former rotated into the jeweled bearing. So it permits the coil to turn freely.

Once the current is supplied throughout these coils, then it gets a deflection within the field, then it is used to find out the voltage or current magnitude. The aluminum is a non-metallic former, used to measure the current whereas the metallic former including high electromagnetic damping is used to calculate the voltage.



##### Magnet System

The PMMC instrument includes two high-intensity magnets otherwise a 'U' shaped magnet-based design. The designing of these magnets can be done with Alnico & Alcomax for higher superior field intensity & coercive force. In several designs, an extra soft iron cylinder can be arranged among the magnetic poles to create the field identical; while decreasing air reluctance for increasing the strength of the field.



### Control

In the PMMC device, the torque can be controlled due to the springs which are fabricated with phosphorous bronze. These springs are arranged among the two jewel bearings. The spring provides the lane to the lead current to supply in & out of the moving coil. The torque can be controlled mainly due to the delay of the ribbon.

### Damping Torque

Damping torque can be generated within the PMMC instrument using the aluminum core's movement within the magnetic field.

So the pointer can be kept at rest after the early deflection. It assists in the right measurement devoid of fluctuations. Because of the movement of the coil within the magnetic field, eddy current can be generated within the aluminum former. This generates the damping force otherwise torque to resist the motion of the coil. Gradually the deflection of the pointer will be reduced and lastly, it will stop at a permanent position.

### Pointer and Scale

In this instrument, the connection of the pointer can be done through the moving coil. It notices the moving coil's deflection. The magnitude of their derivation can be displayed on the scale. The pointer within the instrument can be designed with lightweight material. Thus, it can be simply deflected through the coil's movement. Sometimes, the parallax error can occur within the device which is simply decreased by properly arranging the pointer's blade.

### Torque Equation

The equation involved in the PMCC instrument is the torque equation. The deflecting torque induces due to the coil's movement and this can be expressed with the equation shown below.

$$T_d = NBLdI$$

Where,

'N' is the no. of turns in the coil

'B' is the density of flux within the air gap

'L' & 'd' are vertical as well as horizontal lengths of the surface

'I' is the flow of current in the coil

$$G = NBLd$$

The restoring torque can be provided to the moving coil can be done with the spring and it can be expressed as

$$T_c = K\theta \text{ ('K' is the spring constant)}$$

Final deflection can be done through the equation  $T_c = T_d$

Substitute the values of  $T_c$  &  $T_d$  in the above equation, then we can get

$$K\theta = NBLdI$$

We know that  $G = NBLd$

$$K\theta = GI$$

$$\theta = GI/K$$

$$I = (K/G) \theta$$

From the above equation, we can conclude that the deflection torque can be directly proportional to the flow of current in the coil.

- b. Explain construction and working of electro dynamo meter type instrument.

Ans- These instruments are the modified form of permanent magnet moving coils type. Here operating field is produced by a permanent but by another fixed coil. The moving system and the control system are similar to those of permanent magnet type. Such instruments can be used for both a.c and d.c circuits. They can be used as ammeters and voltmeters but are generally used as wattmeters.

Principle of Dynamometer type instruments:

These instruments are based on that principle the mechanical force exists between the current



carrying conductors.

**Construction of Dynamometer type instruments:**

A dynamometer type instrument as shown in fig essentially consists of a fixed coil and a moving coil. The fixed coil is split into two equal parts which are placed close together and parallel to each other. The moving coil is pivoted in between the two fixed coils. The fixed and moving coils may be excited separately or they may be connected in series depending upon the use to which the measurement is put. The moving coil is attached to the moving system so that under the action of deflecting torque, the pointer moves over the scale.

The controlling torque is provided by two springs which also serve the additional purpose of leading the current into and out of the moving coil. Air friction damping is provided in such instruments.

**Working of Dynamometer type instruments:**

When instrument is connected in the circuit, operating currents flow through the coils. Due to this, mechanical force exists between the coils. The result is that the moving coil moves the pointer over the scale. The pointer comes to rest at a position where deflecting torque is equal to the controlling torque.

By reversing the current, the field due to fixed coils is reversed as well as the current in the moving coil, so that the direction of deflecting torque remains unchanged. Therefore, such instruments can be used for both d.c and a.c measurements.

**Deflecting torque of Dynamometer type instruments:**

Let

$I_f$  = current through fixed coil

$I_m$  = current through moving coil

Since  $I_f = I_m$  because the fixed and coils are in series,

$$T_d = I^2$$

Since the control is by springs, therefore,

controlling torque is proportional to the angle of deflection

$T_c$  proportional deflection

The pointer will come to rest at a position when  $T_d = T_c$

We get deflection proportional  $I^2$

It is clear that deflection of the pointer is directly proportional to the square of the operating current. Hence, the scales of these instruments is non-uniform being crowded in their lower parts and spread out at the top.

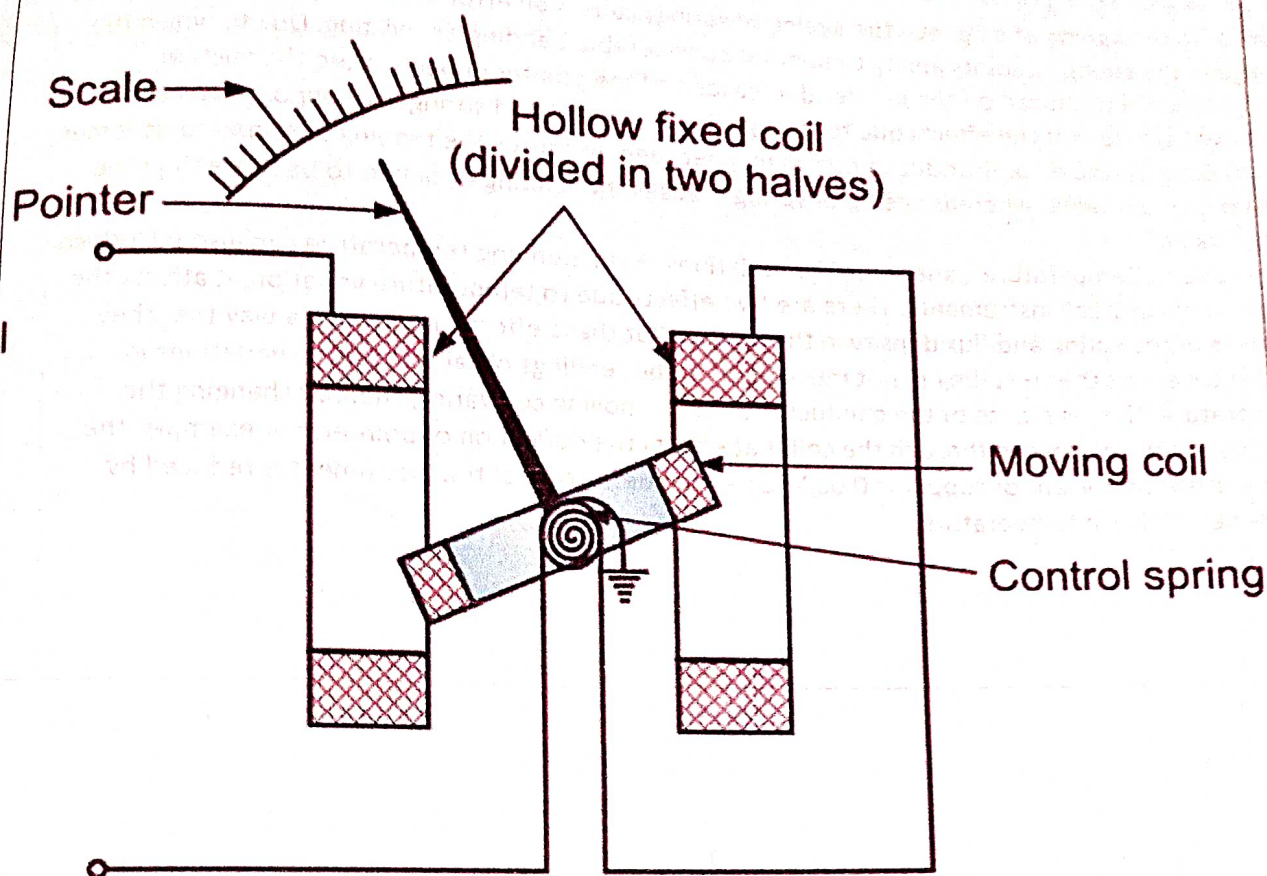
**Advantages of Dynamometer type instruments:**

1. These instruments can be used for both a.c and d.c measurements.
2. Such instruments are free from hysteresis and eddy current errors.

**Disadvantages of Dynamometer type instruments:**

1. Since torque / weight ratio is small, therefore, such instruments have frictional errors which reduce sensitivity.
2. Scale is not uniform.
3. A good amount of screening of the instruments are required to avoid the effect of stray fields.
4. These instruments are costlier than types and, therefore, they are rarely used as ammeters and voltmeters.





c. Write advantages, disadvantages & errors in PMMC instrument.

Advantages of PMMC Instrument

The advantages are

The scale in the instrument can be divided properly

It generates no losses because of hysteresis.

It uses less power

It is not influenced by the stray magnetic field.

High accuracy

It is used as a voltmeter/ammeter with appropriate resistance.

This instrument can measure the voltage & current with different ranges

This instrument uses shielded magnet so it is applicable in aerospace

Disadvantages of PMMC Instrument

The disadvantages are

It works with only DC

It is expensive compare with other alternative instruments

It is delicate

It shows an error because of the magnetism loss in permanent magnet

The most common errors in moving coil instruments are due to,

Ageing of permanent magnets,

Ageing of springs, and

Temperature variations.

Errors due to Ageing of Permanent Magnets :

Due to the use of permanent magnets, the ageing of magnets causes its weakening, thereby resulting in a reduced magnetic field. The decrease in the magnetic field reduces the deflection torque that has to be produced. Therefore, the pointer deflection decreases and the reading obtained will be lesser than the actual value.

### Errors due to Ageing of Springs :

Similar to the ageing of magnets, the ageing of springs causes an error in the readings obtained. Due to aging, the spring losses its ability to tolerate considerable bending or twisting. Due to which the control torque produced on the pointer decreases and the pointer deflects more than actual. Here we can see that the effects due to the ageing of magnets and springs are opposite to each other. Because the error introduced due to magnets aging causes the reading obtained to be lesser than the actual value, whereas ageing of springs causes the reading obtained to be more than the actual value.

**Errors due to Temperature Variations :** The variations in surrounding temperature can also introduce errors in moving coil instruments. There are two effects due to temperature variation, it affects the stiffness of the spring and flux density in the air gap. But these effects are in such a way that they will cancel each other resulting in not much error in the readings obtained. Due to variations in temperature, the resistance of the conductor used for moving coil varies, thereby changing the amount of current flowing through the coil that effects the deflection of pointer. For example, the temperature coefficient of copper is  $0.004/^{\circ}\text{C}$  i.e., the deflection of the instrument is reduced by 0.04% per  $^{\circ}\text{C}$  rise in temperature.