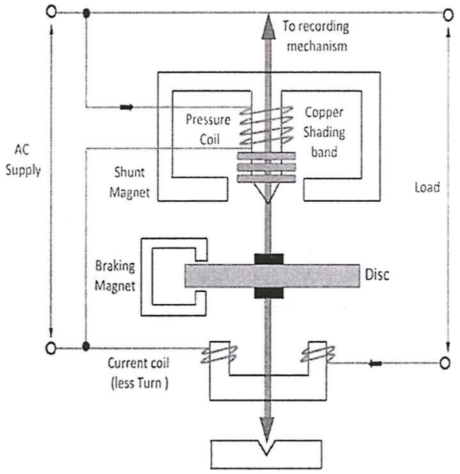
a.)Recall the principle of energy meter

Answer:- Construction of Energy Meter

The construction of the single phase energy meter is shown in the figure below.



Induction Type Energy Meter

The energy meter has four main parts. They are the

1. Driving System
2. Moving System
3. Braking System
4. Registering System

The detail explanation of their parts is written below.

1. Driving System – The electromagnet is the main component of the driving system. It is the temporary magnet which is excited by the current flow through their coil. The core of the electromagnet is made up of silicon steel lamination. The driving system has two electromagnets. The upper one is called the shunt electromagnet, and the lower one is called series electromagnet.

The series electromagnet is excited by the load current flow through the current coil. The coil of the shunt electromagnet is directly connected with the supply and hence carry the current proportional to the shunt voltage. This coil is called the pressure coil.

The centre limb of the magnet has the copper band. These bands are adjustable. The main function of the copper band is to align the flux produced by the shunt magnet in such a way that it is exactly perpendicular to the supplied voltage.

2. Moving System – The moving system is the aluminium disc mounted on the shaft of the alloy. The disc is placed in the air gap of the two electromagnets. The eddy current is induced in the disc because of the change of the magnetic field. This eddy current is cut by the magnetic flux. The interaction of the flux and the disc induces the deflecting torque.

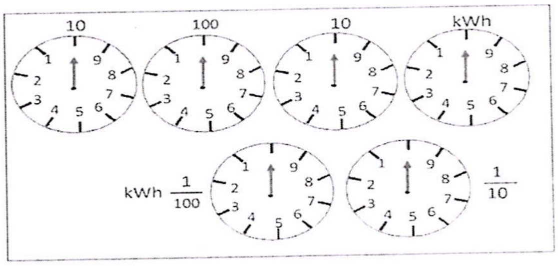
When the devices consume power, the aluminium disc starts rotating, and after some number of rotations, the disc displays the unit used by the load. The number of rotations of the disc is counted at particular interval of time. The disc measured the power consumption in kilowatt

3. Braking system – The permanent magnet is used for reducing the rotation of the aluminium disc. The aluminium disc induces the eddy current because of their rotation. The eddy current cut the magnetic flux of the permanent magnet and hence produces the braking torque.

This braking torque opposes the movement of the disc, thus reduces their speed. The permanent magnet is adjustable due to which the braking torque is also adjusted by shifting the magnet to the other radial position.

4. Registration (Counting Mechanism) – The main function of the registration or counting mechanism is to record the number of rotations of the aluminium disc. Their rotation is directly proportional to the energy consumed by the loads in the kilowatt hour.

The rotation of the disc is transmitted to the pointers of the different dial for recording the different readings. The reading in kWh is obtained by multiply the number of rotations of the disc with the meter constant. The figure of the dial is shown below.



Pointer Type of Register

Working of the Energy Meter

The energy meter has the aluminium disc whose rotation determines the power consumption of the load. The disc is placed between the air gap of the series and shunt electromagnet. The shunt magnet has the pressure coil, and the series magnet has the current coil.

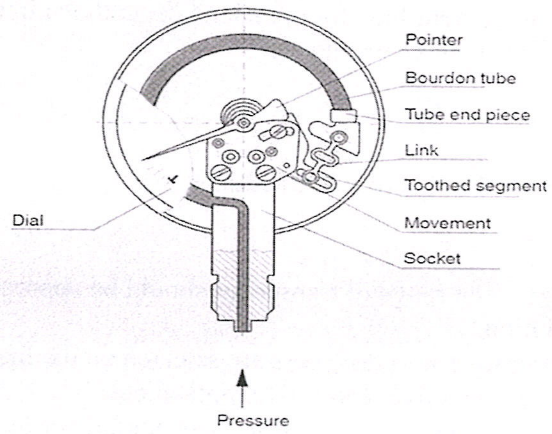
The pressure coil creates the magnetic field because of the supply voltage, and the current coil produces it because of the current.

The field induces by the voltage coil is lagging by 90° on the magnetic field of the current coil because of which eddy current induced in the disc. The interaction of the eddy current and the magnetic field causes torque, which exerts a force on the disc. Thus, the disc starts rotating.

The force on the disc is proportional to the current and voltage of the coil. The permanent magnet controls Their rotation. The permanent magnet opposes the movement of the disc and equalises it on the power consumption. The cyclometer counts the rotation of the disc.

Theory of Energy Meter

The pressure coil has the number of turns which makes it more inductive. The reluctance path of their magnetic circuit is very less because of the small length air gap. The current I_p flows through the pressure coil because of the supply voltage, and it lags by 90°.



c.)

Answer:- The primary significance of calibration is that **it maintains accuracy, standardization and repeatability in measurements, assuring reliable benchmarks and results**. Without regular calibration, equipment can fall out of spec, provide inaccurate measurements and threaten quality, safety and equipment longevity.

d.)

The set of criteria defined for the instruments, which are changes rapidly with time, is called 'dynamic characteristics'.

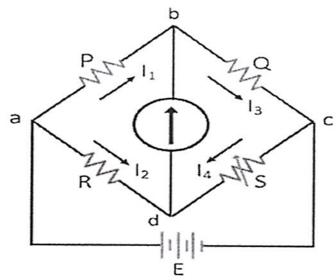
e.)

A Wheatstone bridge is an electrical circuit used to measure **an unknown electrical resistance** by balancing two legs of a bridge circuit, one leg of which includes the unknown component.

P=R1=30kΩ;Q=R2=40 kΩ;R=R3=60 kΩ;S=Rx=?

At Balance R1/R2=R3/R4

30/40=60/Rx   Therefore Rx=40/30*60=2400/30=80 kΩ



Wheatstone Bridge

f.)

Advantages of Instrument Transformer

- We can measure high quantities of voltages and currents with the instruments of moderate ratings.
- The measuring circuit is isolated from the high-power circuit.

- The readings of instrument transformers don't depend on circuit parameters like resistance, inductance, and capacitance.

g.)

Factors that Influence the Choice of a Transducer :

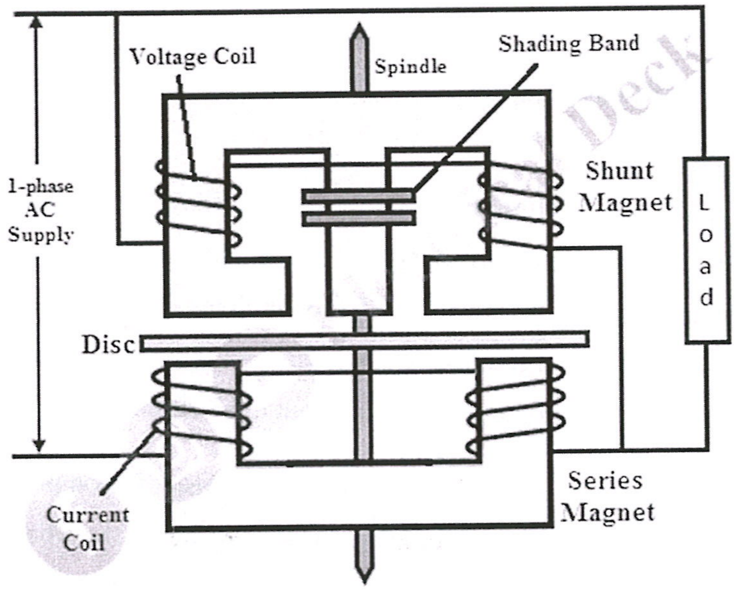
- **Operating range** : The range of transducer should be appropriate for measurement to get a good resolution.
- **Operating Principle**: The transducers are selected on the basis of operating principle it may be resistive, inductive, capacitive, optical etc.
- **Accuracy** : The accuracy should be as high as possible or as per the measurement.
- **Range** : The transducer can give good result within its specified range, so select transducer as per the operating range.
- **Sensitivity** : The transducer should be more sensitive to produce the output or sensitivity should be as per requirement.
- **Environmental compatibility** : The transducer should maintain input and output characteristic for the selected environmental condition.
- **Loading effect**: The transducer's input impedance should be high and output impedance should be low to avoid loading effect.
- **Errors** : The error produced by the transducer should be low as possible.

h.)

Construction of Induction Type Wattmeter :

It mainly consists of two laminated electromagnets wound with conductors known as shunt and series magnets. The upper electromagnet is known as a shunt magnet. It consists of three limbs, the side limbs carry the winding and it is connected across the load. These windings are excited by the current proportional to the voltage across the load, hence they are called voltage coils.

The lower electromagnet is connected in series with load in which power is to be measured and is known as a series magnet. It carries the windings called current coils and it is excited proportionally to the load current. The below shows the construction of an induction-type wattmeter.



A thin lightweight disc made up of copper or aluminum is pivoted at the center in the airgap present in between the two electromagnets (shunt & series). It is mounted with the help of a spindle so that the disc can rotate, which in turn rotates the spindle. A pointer is attached at top of the spindle and rotates with the spindle over the scale.

Q.2

a.)

Power is defined as the rate at which energy is transformed or made available. The power is a circuit at any instant is equal to the [product of the current in the circuit and the voltage across its terminal at that instant. The power in a dc circuit is best measured by separately measuring quantities V and I and by computing power by formula P = VI. In the case of ac circuit the instantaneous power varies continuously as the current and voltage of though a cycle of values. If the voltage and current are both sinusoidal the average power over cycle is given by the expression P = VI cos f watts where V and I are the r.m.s. values of voltage and current. A wattmeter is a device used to measure how much electrical power a circuit is producing, expressed in watts. It uses resistance to move a piece of metal, which is carefully calibrated along a display with wattage numbers on it, the higher the wattage, the more the piece of metal will move

b.)

The damping device should be such that it produces a damping torque only while the moving system is in motion. To be effective the *damping torque* should be proportional to the velocity of the moving system but independent of the operating current. It must not affect the controlling torque or increase the static friction. The **methods for producing damping torque** are :

(i) Air friction damping

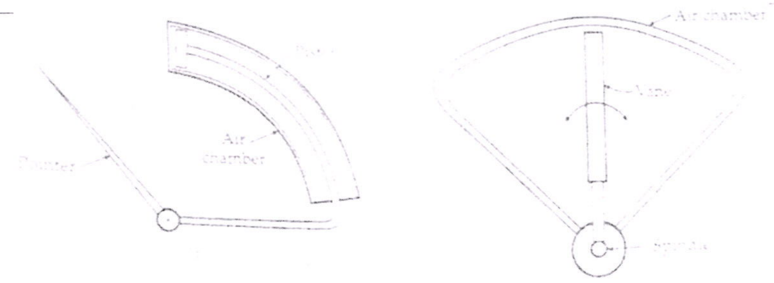
(iii) Eddy current damping

(iv) Electromagnetic damping

Air Friction Damping:

Two types of **air friction damping** devices are shown in the below figure. The arrangement of the below figure(a) consists of a light aluminium piston which is attached to the moving system. This piston moves in a fixed air chamber which is closed at one end. The clearance between piston and chamber walls is uniform throughout and is very small. When there are oscillations the piston moves into and out of an air chamber.

When the piston moves into the chamber, the air inside is compressed and the pressure of air thus built up, opposes the motion of the piston and hence the whole of the moving system. When the piston moves out of the air chamber, the pressure in the closed space falls, and the pressure on the open side of the piston is greater than on the other side. Thus there is again an opposition to the motion.



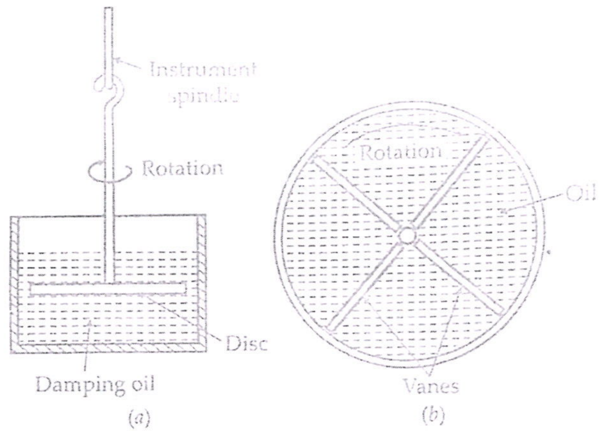
Air friction damping

The arrangement of the above figure(b), consists of an aluminium vane which moves in a quadrant (sector) shaped air chamber. This air chamber is a recess cast in a bakelite moulding or die casting. The chamber is completed by providing a cover plate at the top. The aluminium piston should be carefully fitted so that it does not touch the wall otherwise a serious error will be caused in readings.

Fluid Friction Damping:

This form of damping is similar to air friction damping. Oil is used in place of air and as the viscosity of the oil is greater, the *damping torque* is also correspondingly greater. A disc is attached to the moving system [below figure(a)], this disc dips into an oil pot and is completely submerged in oil.

When the moving system moves, the disc moves in oil and a frictional drag is produced. This frictional drag always opposes the motion. In the arrangement shown in the below figure(b), a number of vanes are attached to the spindle. These vanes are submerged in oil



Fluid friction damping

Eddy Current Damping:

When a conductor moves in a magnetic field an emf is induced in it and if a closed path is provided, a current (known as eddy current) flows. This current interacts with the magnetic field to produce an electromagnetic torque which opposes the motion. This torque is proportional to the strength of the magnetic field and the current produced.

The current is proportional to emf which in turn is proportional to the velocity of the conductor. Thus, if the strength of the magnetic field is constant (if it is produced by a permanent magnet), the torque is proportional to the velocity of the conductor.

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. This torque opposes the movement of the coil and slows the response. The magnitude of the current and hence the **damping torque** is dependent upon the resistance of the circuit to which the instrument is connected. The **electromagnetic damping** is used in galvanometers.

Comparison of types of damping torques:

Air friction damping provides a very simple and cheap method of damping. But care must be taken to see that the piston is not bent or twisted otherwise it will touch the walls of the air chamber thereby causing serious errors due to solid friction which is thus introduced. This method is used in hot wire and moving iron instruments.

Air friction damping has the advantage, that is, does not require the use of a permanent magnet whose introduction may lead to distortion of the operating field. Therefore, this type of damping is used in moving iron and dynamometer type of instruments where the operating magnetic field is weak and is likely to be get distorted with the introduction of a permanent magnet.

Fluid friction damping has the advantage that the oil which is required for damping, can be used for insulation purposes in some forms of instruments which are submerged in oil. A vane moving in oil instead of air does not require the same small clearances to give effective damping and therefore this method is suitable for instruments. such as electrostatic type where the movement is suspended rather than pivoted. Another advantage of **fluid friction damping** is that due to the upthrust of oil, the load on bearings or suspension is reduced thus reducing frictional errors.

The disadvantages of **fluid friction damping** are that it can be used only for instruments which are in vertical position. Also because of the creeping of oil, the instruments cannot be kept clean. Hence this type of damping can be used for laboratory type electrostatic instruments and there are obvious difficulties in the way of its applts.

Eddy current damping is the most efficient form of damping. It is very convenient to use in instruments where a metallic disc or a former and a permanent magnet already form part of the operating system. For these reasons this method is used in hot wire, moving coil and induction type instruments. This method cannot be used in instruments where the introduction of a permanent magnet required for producing eddy currents will distort the existing magnetic field as in moving iron or dynamometer type of instruments.

Q.3

a.
The basic moving-coil system can be converted into an instrument to measure dc as well as ac quantities like current, voltage and resistance etc. Without any modification, it can carry a maximum current of Im can withstand a maximum dc voltage $v = I_m R_m$.

DC instruments

(*a*) it can be made into a dc ammeter, milliammeter or micrometer by adding a suitable shunt resistor R_{sh} in parallel with it as shown in Fig. 3.5(*a*).

(*b*) it can be changed into a dc voltmeter by connecting a multiplier resistor Rmult in series with it as shown in Fig. 3.5(*b*).

Q.4

a.) Resistance of meter = $R_m = 10\Omega$

Full Scale deflection current $I_m = 50\,mA = 50 \times 10^{-3} A = 0.05 A$

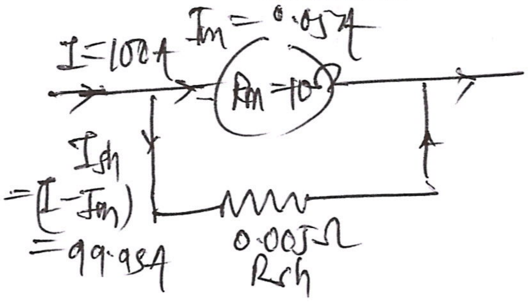
(i) To measure current upto 100A ; $R_{sh} = ?$

$R_{sh} I_{sh} = I_m R_m$

$R_{sh} \times 100 = 0.05 \times 10$

$\therefore R_{sh} = \frac{0.05 \times 10}{100}$

$R_{sh} = 0.005\,\Omega$



(ii) To measure voltage upto 750V.

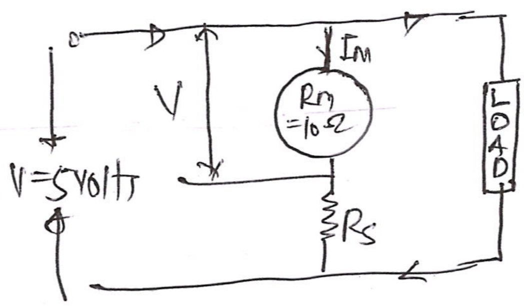
Now vtg across supply 100A = VD across (mA) + VD across external series resistance Rs

$V = I_m R_m + I_m R_s$

$750 = 0.05 \times 10 + 0.05 R_s$

$\therefore R_s = \frac{750 - (0.05 \times 10)}{0.05}$

$R_s = 14990\,\Omega$



b.)

The conventional mechanical energy meter is based on the phenomenon of "Magnetic Induction". It has a rotating aluminium Wheel called Ferriwheel and many toothed wheels. Based on the flow of current, the Ferriwheel rotates which makes rotation of other wheels. This will be converted into corresponding measurements in the display section. Since many mechanical parts are involved, mechanical defects and breakdown are common. More over chances of manipulation and current theft will be higher.

Electronic Energy Meter is based on Digital Micro Technology (DMT) and uses no moving parts. So the EEM is known as "Static Energy Meter" In EEM the accurate functioning is controlled by a specially designed IC called ASIC (Application Specified Integrated Circuit). ASIC is constructed only for specific applications using **Embedded System Technology**.

10

The D'Arsonval galvanometer is a moving coil ammeter. It uses magnetic deflection, where current passing through a coil causes the coil to move in a magnetic field. The voltage drop across the coil is kept to a minimum to minimize resistance across the ammeter in any circuit into which it is inserted.

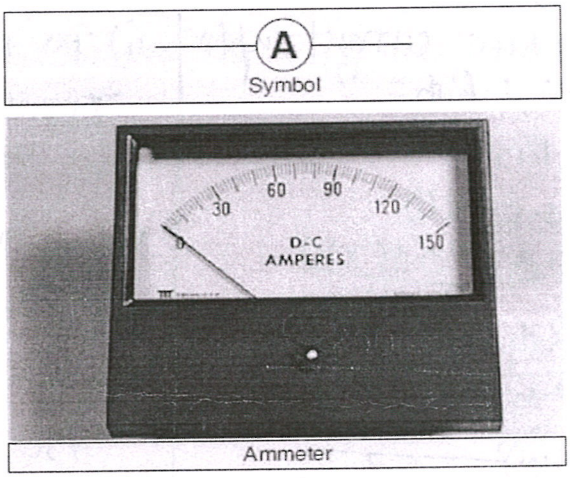


Fig. 3.6.

Ammeter Shunt Resistor

The basic movement of a dc ammeter is a PMMC D'Arsonval galvanometer. The coil winding of a basic movement is very small and light it can carry very small value of currents. When the large currents are to be measured it is necessary to bypass the major part of the current through a low resistance called shunt resistor. The shunt resistor is connected parallel with D'Arsonval movement. The ammeter is always connected in series with the load in the circuit.

b.)

Difference between C.T. and P.T. There are a few differences in the operation of a current transformer and a potential transformer.

(i) The potential transformer may be considered as a 'parallel' transformer with its secondary nearly under open circuit conditions whereas the current transformer may be thought as a 'series' transformer under virtual short circuit conditions. Thus the secondary of a P. T. can be open-circuited without any damage being caused either to the operator or to the transformer.

(ii) The primary current in a C.T. is independent of the secondary circuit conditions while the primary current in a P.T. certainly depends upon the seconda,ry burden.

(iii) In a potential transformer, full line voltage is impressed upon its terminals whereas a C.T. is connected in series with one line and a small voltage exists across its terminals. However, the C.T. carries the full line current.

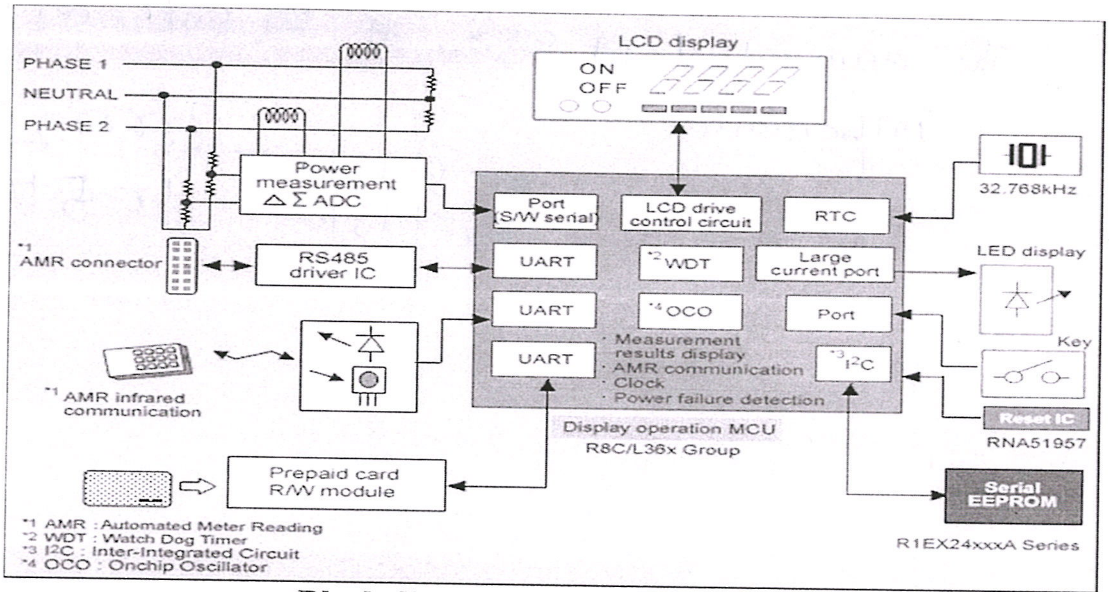
(iv) Under normal operation the line voltage is nearly constant and, therefore, the flux density and hence the exciting current of a potential transformer varies only over a restricted range whereas

the primary current and excitation of a C.T. vary over wide limits in normal operation.

Similar ASIC are now used in Washing Machines, Air Conditioners, Automobiles, Digital Camera etc.

In addition to ASIC, analogue circuits, Voltage transformer, Current transformer etc are also present in EEM to "Sample" current and voltage. The 'Input Data' (Voltage) is compared with a programmed "Reference Data' (Voltage) and finally a 'Voltage Rate' will be given to the output. This output is then converted into 'Digital Data' by the AD Converters (Analogue- Digital converter) present in the ASIC.

The Digital Data is then converted into an "Average Value". Average Value / Mean Value is the measuring unit of power. The output of ASIC is available as "Pulses" indicated by the LED (Light Emitting Diode) placed on the front panel of EEM. These pulses are equal to Average Kilo Watt Hour (kWh / unit). Different ASIC with various kWh are used in different makes of EEMs. But usually 800 to 3600 pulses / kWh generating ASIC s are used in EEMs.The output of ASIC is sufficient to drive a Stepper Motor to give display through the rotation of digits embossed wheels. The output pulses are indicated through LED. The ASIC are manufactured by Analogue Device Company. ADE 7757 IC is generally used in many countries to make EEMs. ADE 7555 / 7755 ASIC maintains the international standard CLASS I IEC 687/ 1036.



Block diagram of Electronic Meter

On the front panel of EEM there will be 4 LED indications

N OK LED ON Phase and Neutral OK

E / L LED OFF Earthing correct

LED ON Earth leakage and current loss

Imp / kWh LED Blinks Impulses per Kilo Watt Hour.

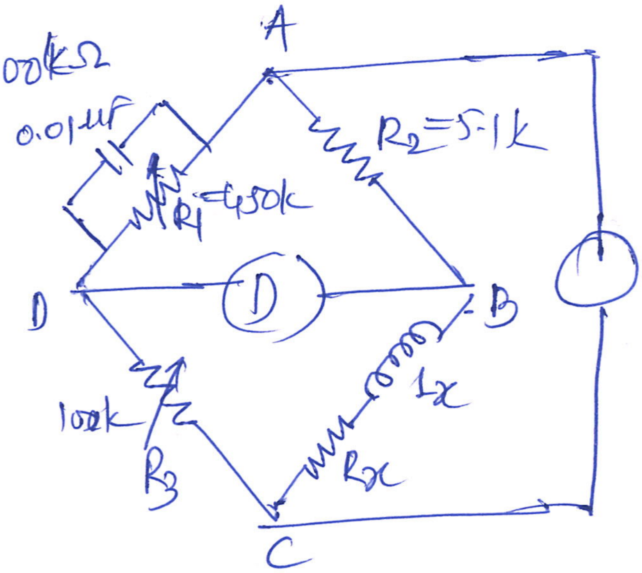
This LED is larger one.

Q.5

a.) Given data:- $R_1 = 450\,k\Omega$; $C_1 = 0.01\,\mu F$; $R_2 = 5.1\,k\Omega$; $R_3 = 100\,k\Omega$

$C_1 = 0.01 \times 10^{-6}\,F$.

R_x; L_x = ?



We know that

$$R_x = \frac{R_2 R_3}{R_1} = \frac{5.1 \times 100}{450}$$

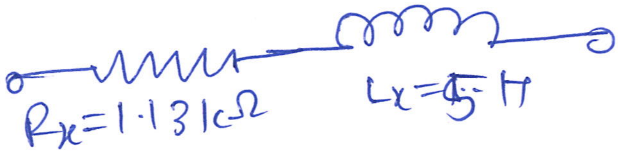
$R_x = 1.13\,k\Omega$

$L_x = C_1 R_2 R_3$

$= 0.01 \times 10^{-6} \times 5.1 \times 10^{3} \times 100 \times 10^{3}$

$L_x = 5.1\,H$

The equivalent series of the unknown impedance



Transformation Ratio. It is the ratio of the magnitude of the primary phasor to the secondary phasor.

Transformation ratio $R = \dfrac{|\text{primary phasor}|}{|\text{secondary phasor}|}$ ...(9·1)

$= \dfrac{\text{primary current}}{\text{secondary current}}$ for a C.T. ...(9·2)

$= \dfrac{\text{primary voltage}}{\text{secondary voltage}}$ for a P.T. ...(9·3)

Nominal Ratio. It is the ratio of rated primary current (or voltage) to the rated secondary current (or voltage).

Nominal ratio $K_n = \dfrac{\text{rated primary current}}{\text{rated secondary current}}$ for a C.T. ..(9·4)

$= \dfrac{\text{rated primary voltage}}{\text{rated secondary voltage}}$ for a P.T. ...(9·5)

Turns Ratio. Turns Ratio $n = \dfrac{\text{number of turns of secondary winding}}{\text{number of turns of primary winding}}$ for a C.T. ...(9·6)

$= \dfrac{\text{number of turns of primary winding}}{\text{number of turns of secondary winding}}$ for a P.T. ...(9·7)

Ratio Correction Factor (RCF). The ratio correction factor of a transformer is the transformation ratio divided by nominal ratio.

Transformation ratio = ratio correction factor × nominal ratio or $R = RCF \times K_n$ ...(9·8)

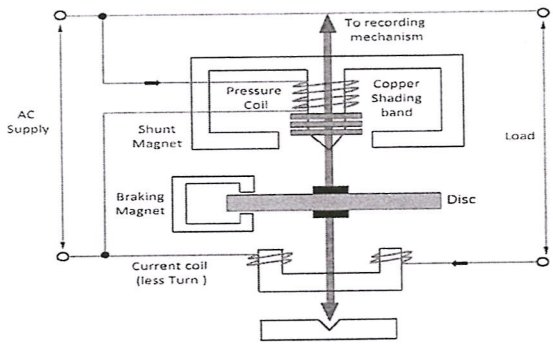
The ratio marked on the transformers is their nominal ratio.

b.)

Q.6

a.)Construction of Energy Meter

The construction of the single phase energy meter is shown in the figure below.



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The series electromagnet is excited by the load current flow through the current coil. The coil of the shunt electromagnet is directly connected with the supply and hence carry the current proportional to the shunt voltage. This coil is called the pressure coil.

The centre limb of the magnet has the copper band. These bands are adjustable. The main function of the copper band is to align the flux produced by the shunt magnet in such a way that it is exactly perpendicular to the supplied voltage.

2. Moving System – The moving system is the aluminium disc mounted on the shaft of the alloy. The disc is placed in the air gap of the two electromagnets. The eddy current is induced in the disc because of the change of the magnetic field. This eddy current is cut by the magnetic flux. The interaction of the flux and the disc induces the deflecting torque.

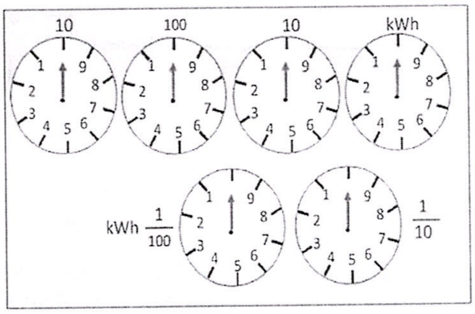
When the devices consume power, the aluminium disc starts rotating, and after some number of rotations, the disc displays the unit used by the load. The number of rotations of the disc is counted at particular interval of time. The disc measured the power consumption in kilowatt hours.

3. Braking system – The permanent magnet is used for reducing the rotation of the aluminium disc. The aluminium disc induces the eddy current because of their rotation. The eddy current cut the magnetic flux of the permanent magnet and hence produces the braking torque.

This braking torque opposes the movement of the disc, thus reduces their speed. The permanent magnet is adjustable due to which the braking torque is also adjusted by shifting the magnet to the other radial position.

4. Registration (Counting Mechanism) – The main function of the registration or counting mechanism is to record the number of rotations of the aluminium disc. Their rotation is directly proportional to the energy consumed by the loads in the kilowatt hour.

The rotation of the disc is transmitted to the pointers of the different dial for recording the different readings. The reading in kWh is obtained by multiply the number of rotations of the disc with the meter constant. The figure of the dial is shown below.



Pointer Type of Register

Working of the Energy Meter

The energy meter has the aluminium disc whose rotation determines the power consumption of the load. The disc is placed between the air gap of the series and shunt electromagnet. The shunt magnet has the pressure coil, and the series magnet has the current coil.

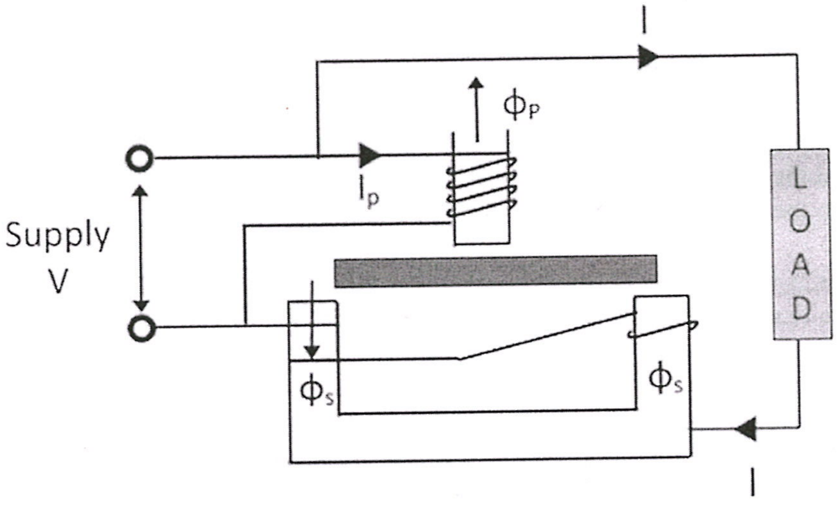
The pressure coil creates the magnetic field because of the supply voltage, and the current coil produces it because of the current.

The field induces by the voltage coil is lagging by 90° on the magnetic field of the current coil because of which eddy current induced in the disc. The interaction of the eddy current and the magnetic field causes torque, which exerts a force on the disc. Thus, the disc starts rotating.

The force on the disc is proportional to the current and voltage of the coil. The permanent magnet controls Their rotation. The permanent magnet opposes the movement of the disc and equalises it on the power consumption. The cyclometer counts the rotation of the disc.

Theory of Energy Meter

The pressure coil has the number of turns which makes it more inductive. The reluctance path of their magnetic circuit is very less because of the small length air gap. The current I_p flows through the pressure coil because of the supply voltage, and it lags by 90°.



Working of Energy Meter

The I_p produces the two Φ_p which is again divided into Φ_{p1} and Φ_{p2}. The major portion of the flux Φ_{p1} passes through the side gap because of low reluctance. The flux Φ_{p2} goes through the disc and induces the driving torque which rotates the aluminium disc.

The flux Φ_p is proportional to the applied voltage, and it is lagged by an angle of 90°. The flux is alternating and hence induces an eddy current I_{ep} in the disc.

The load current passes through the current coil induces the flux Φ_s. This flux causes the eddy current I_{es} on the disc. The eddy current I_{es} interacts with the flux Φ_p, and the eddy current I_{ep} interacts with Φ_s to produce the another torque. These torques are opposite in direction, and the net torque is the difference between these two.

11·3. Braking. In a motor meter the speed of the moving system is controlled by a braking system. The braking system consists of a permanent magnet (braking magnet) so placed that it induces eddy currents in some part of the moving system. These eddy currents produce a braking (retarding) torque which is proportional to the speed of the moving system. The part in which eddy currents are produced is usually an aluminium disc. The disc is mounted on the moving system and, therefore, when the moving system revolves this disc cuts through the field of the permanent magnet.

Emf generated in the disc $e = K_1 \Phi n$

where Φ = flux of the permanent magnet, n = speed of rotation, and K_1 = a constant.

Let r be the resistance of the eddy current paths. Therefore, eddy current produced is :

$$i = \frac{e}{r} = K_1 \frac{\Phi n}{r}.$$

The braking torque is produced by the interaction of the eddy current and the field of the permanent magnet. This torque is directly proportional to the product of flux of the magnet, magnitude of eddy current and the effective radius R from the axis of the disc.

$$\therefore \text{ Braking torque } T_B = K_2 \Phi i R = K_1 K_2 \frac{\Phi^2 n R}{r} = K_3 \frac{\Phi^2 n R}{r} \quad \ldots(11\cdot2)$$

where K_2 and K_3 are constants.

If the radius R of the disc is constant $T_B = K_4 \frac{\Phi^2 n}{r}$ ...(11·3)

The moving system attains a steady speed when the driving torque is equal to the deflecting torque.

Braking torque at steady speed N is : $T_B = K_3 \frac{\Phi^2 NR}{r} = K_5 N$ ...(11·4)

Let T_d be the driving torque at the steady speed N.

At steady speed, $T_B = T_d$ $\therefore K_3 \frac{\Phi^2 NR}{r} = T_d$

or steady speed $N = \frac{r}{K_3 \Phi^2 R} \cdot T_d$ ...(11·5)

$= K' T_d$ ...(11·6)

Hence the steady speed attained by a meter for a constant value of driving torque T_d is directly proportional to the resistance, r, of the eddy current paths, inversely proportional to square of flux Φ of permanent magnet and inversely proportional to radius R. In order that the calibration of the meter remain the same, it is essential that the value of Φ and r should remain constant. Thus it is very important that the strength of braking magnet shall remain constant throughout the life of the meter. This constancy is assured by careful design and proper treatment of the magnet during manufacture. Temperature changes affect the value of resistance r and thus cause errors. An increase in temperature increases the resistance r and thus the braking torque is reduced.

It is necessary that the steady speed of the meter should be low and in order to achieve this the disc resistance be low and that flux of the magnet and the effective radius of the disc be large. An aluminium disc is generally preferred to a copper disc since the resistance per unit weight of aluminium is smaller. Frictional forces are limiting factor on the weight and the size of the disc and thus the radius of the disc cannot be increased unduly. Therefore in order to obtain low steady speeds, strong magnets, having large pole areas are used. The air gap is kept as small as mechanical considerations permit.

The braking torque can be adjusted by using a magnetic shunt whose distance from the magnet can be changed. If the magnetic shunt is brought near the poles, it will bypass a larger amount of flux and so the disc will cut through a smaller flux resulting in reduced braking torque. On the other hand if it is moved away from the magnet, it will bypass lesser flux giving a larger braking torque. The braking torque can also be varied by varying the radius R (See page 136). If the magnet is placed at a larger radius, the braking torque would also be larger.

b.)

14.2 Transducer

Transducer is a device that converts one type of energy into one type of energy into other type for the purpose of measurement or transfer of information. For example, a microphone as an input device converts sound waves into electrical signals for the amplifier to amplify, and a loudspeaker as an output device converts the electrical signals back into sound waves as shown in Fig. 14.1.

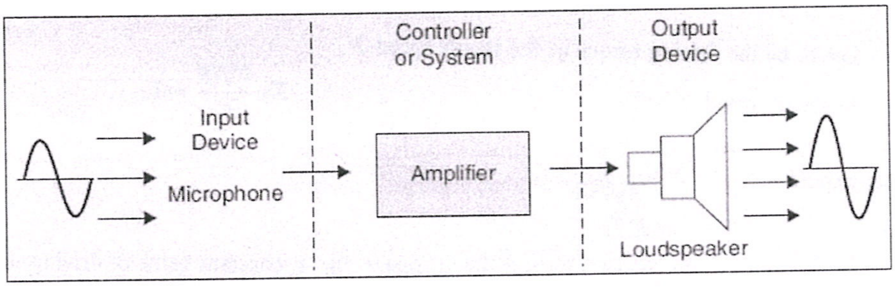


Fig. 14.1.

14.3 Classification of Transducer

The classification of transducers may be explained as follows:

1. Based on the physical phenomenon
   (*a*) Primary transducer
   (*b*) Secondary transducer

On the basis of application transducer may be classified as primary and secondary transducer. When the input signal is directly sense by the transducer, the non-electrical energy is converted into electrical energy directly then, this type of transducer is known as primary transducer. For example thermistor, senses the temperature directly and causes the change in resistance with the change in temperature.

When the input signal is first sensed by some sensor or detector, then its output signal is feed to the other instrument as an input. The output of this instrument is given as the input of transducer for converting into electrical energy. This type of transducer is in secondary transducer classification. For example in the case of pressure measurement, we use bourdon tube to convert pressure into displacement, then the pressure is converter into output voltage with the help of LVDT. Here the secondary transducer is LVDT. We will discuss the bourdon tube and LVDT in this chapter.

2. Based on the power type
   (*a*) Active transducer
   (*b*) Passive transducer

Active transducer does not require any auxiliary power source to produce their output. It is also called self generating type transducer.

Active and Passive Transducers

Active transducer is also known as self generating type transducer. It develops their own voltage or current from the physical phenomenon being measured. Active transducers generate electric current or voltage directly in response to environmental stimulation. Examples of active transducers are thermocouples and piezoelectric accelerometers. Thermocouples produce a voltage related to a temperature of two metals and if the two junctions are at different temperatures, electricity is generated.

Passive transducers is also known as externally powered transducers. It derive the power required for energy conversion from an external power source. Passive transducers produce a change in some passive electrical quantity, such as capacitance, resistance, or inductance, as a result of stimulation. These usually require additional electrical energy for excitation. A simple example of a passive transducer is a device containing a length of wire and a moving contact touching the wire. The position of the contact determines the effective length of the wire, varying the resistance of the length of wire. Other examples of passive transducers are strain gauges, resistance temperature detectors (RTDs), and thermistors.

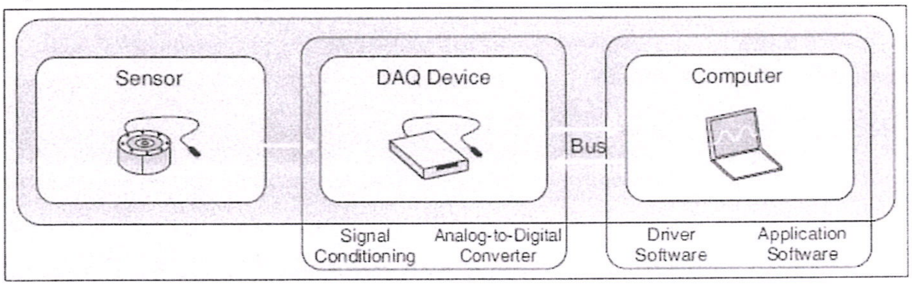
3. Based on the type of output
   (*a*) Analog transducer
   (*b*) Digital transducer
4. Based on the electrical phenomenon
   (*a*) Resistive transducer
   (*b*) Capacitive transducer
   (*c*) Inductive transducer
   (*d*) Photoelectric transducer
   (*e*) Photovoltaic transducer
5. Based on the non-electrical phenomenon
   (*a*) Linear displacement
   (*b*) Rotary displacement
6. Based on the transduction phenomenon.
   (*a*) Transducer
   (*b*) Inverse transducer.

b.)ii.

In most of the real world applications, the analog data must be digitized and transferred into a computer's or microcontroller system's memory. The process by which the microcontroller acquires these digitized analog data is referred to as **data acquisition**. The computer can do several things with the data, depending on the application. In a storage application, such as digital audio recording, video recording, ora digital oscilloscope, the microcontroller will store the data and then transfer them to a D/A converter at a later time to reproduce the original signal. In a process control application, the microcontroller can examine the data or perform computations on them to determine what control outputs to generate.

16.2 Data Acquisition System

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as



Code – Set-I

G. S. Mandal's

Maharashtra Institute of Technology, Aurangabad

(An Autonomous Institute)

END SEMESTER EXAMINATION

Second Year B.Tech (Electrical Engg.) – Feb/Mar-2023

Course Code :EED201 **Course Name : Electrical Measurement & Instrumentation**

Duration : 2 Hrs **Max. Marks : 50** **Date :3.2.2023**

Instructions :

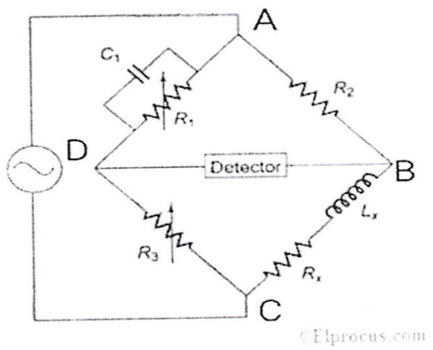
i) **All questions are compulsory**

ii) **Assume suitable data wherever necessary and clearly state it**

iii) **Figures to right indicate full marks**

Marking Scheme

		Marking Scheme
Q. 1		Principle-2 Marks
a)	Recall the principle of Energy meter.	
b)	Illustrate with diagram, the bourdon tube pressure gauge.	Well Labelled – diagram-2 Marks
c)	Why calibration of Instrument is needed?	Appropriate Answer-2 Marks
d)	Define the desirable dynamic characteristics.	Defination-1 Mark and Min 2 Characteristics-1 Mark
e)	Calculate the unknown resistor Rx and draw the Wheatstone bridge if, R_1=30kΩ; R_2=40kΩ; R_3=60kΩ.	2-Steps 1 Mark each
f)	What are the advantages of Instrument transformers?	Min 2 Advantages
g)	Enlist the points for selection of transducers.	Min 4 points for selection
h)	Show the constructional diagram of Induction type wattmeter.	Well Labelled – diagram-2 Marks
Q.2	**Answer/Solve any one of the following.** **a.)**Derive the equation for measurement of power in DC and AC circuits.	Detailed derivation-for DC 4-Marks for AC 4-Marks
	b.) What the damping devices in Indicating Instruments? Explain each one of them.	List-2Marks explanation with diagram of each-6 marks
Q.3	**Answer/Solve any one of the following.** **a.)**How the range of DC ammeter and DC voltmeter can be extended. Derive the expression to find the shunt resistance and multiplier resistance?	Range extention-2 Marks Derivation 6 Marks
	b.) Compare the Current and Potential Transformer	List-2Marks explanation with diagram -each-6 marks
Q.4	**Answer/Solve any one of the following.** **a.)**A moving coil instrument has a resistance of 10 Ω and gives a full-scale deflection when carrying 50mA.Show it can be	Given data=2-Marks equation-2-Mark Step -2 Marks

	adapted to measure voltage upto 750 volts and current upto 100 amperes.	Answer with unit 1-Mark representation-1 Mark
	b.) Explain the principle and working of electronic energy meter.	List-2Marks explanation with diagram of each-6 marks
Q.5	**Answer/Solve any one of the following.** **a.)**Define the following terms applied to instrument transformer i.)Burden of and instrument transformer. ii.)Transformation ratio(Actual) Kact iii.) Nominal Transformation ratio(Actual) Knom iv.) Turns ratio and Ratio correction Factor.	Definition of four terms 2 Marks each
	b.)A Maxwell bridge (Fig.1) is used to measure inductive impedance. The bridge constant at balance are:  Fig.1 R_1=450kΩ; C_1=0.01µF; R_2=5.1kΩ; R_3=100kΩ. Find the series equivalent and of the unknown impedance	Given data=1-Marks Balance equation-2-Mark Step -3 Marks Answer with unit 1-Mark series equivalent representation-1 Mark
Q.6	**Answer/Solve any one of the following.** **a.)**Describe the construction and working of a single phase induction type of energy meter. Show that the number of revolutions made by its disc during a particular time is proportional to the energy consumed.	Construction with diagram-4-Marks 6-Marks for proof
	b.) i.)Define transducer. Give its classification. ii.)Draw the generalised data acquisition system	4-Marks each

Signature of Paper setter