Model Sets-1

Electrical and Electronic Measurement

Q1.(a) What is an energymeter ?How it is differences from a wattmeter ?

Ans. The meter which is used for measuring the energy utilises by the electric load is known as the energy meter. The differences between Energy Meter and Wattmeter are as follows:

- The Wattmeter measures the power in a circuit while the energy meter measures the total energy consumes by the load.
- The Wattmeter measures power in watts, while the energy meter measures the energy in joules.
- The Wattmeter works on the principle that the force acts on the current carrying conductor when it is placed in an electromagnetic field. Whereas, the energy meter works on the principle of conversion of electrical energy into mechanical energy.
- The pressure and current coil, control system, damping system, scale and pointer are the central parts of the Wattmeter. While in an energy meter, driving, braking and moving system along with the counting mechanism are the main parts.
- The wattmeter is used for measuring the power of an electrical circuit. It is also used for determining the power rating of the homes and industries appliances. The energy meter is used for measuring the total power consumed by the load in industries and homes.

Q1.(b) Give the concept of ammeter and voltmeter ?State the basic difference between them .

Ans.Ammeter – It is an instrument which is used to measure the current in an electrical circuit. It gets its name from Ampere which is the unit of electric current.

Voltmeter – This instrument measures the voltage between two points in an electrical circuit. It is present in both, digital and analogue form.

The major difference between the ammeter and the voltmeter is that the ammeter measures the flow of current, whereas the voltmeter measures the emf or voltage across any two points of the electrical circuit.The other differences between the ammeter and voltmeter are presented below:

- The ammeter is defined as the device used for measuring the small value current flows in the circuit, whereas the voltmeter measures the potential difference between any two points of the electrical circuit.
- The resistance of the ammeter is low. So that, the whole current of the circuit will pass through it. Whereas, the internal resistance of the voltmeter is very low so that the current from the circuit does not disturb the measuring of the voltmeter.
- The ammeter is connected in series with the circuit for measuring the complete current, whereas the voltmeter is connected in parallel with the circuit. The potential difference of the parallel circuit remains same at all points. So for measuring the exact value of the potential difference, it is connected in parallel with the points whose voltage is to be measured.
- The accuracy of the ammeter is more as compared to the voltmeter.
- The measuring range of the voltmeter can be increases or decreases by changing the value of resistance whereas the range of ammeter can not be changed.

Q1.(c) Explain why cannot measure power in a.c circuit by using an ammeter and voltmeter ?

Ans. Normally ammeters and voltmeters are PMMC(permanent magnet moving coil) instruments which is suitable only for DC not for AC.The movement of the pointer is based on the torque produced by the magnetized coil.In case of AC supply, the torque produced changes it's direction according to the alternative half cycles .Movement of the pointing needle due one half cycle is opposite to that of other.There is no torque produced. Ultimately there is no movement of the needle.Thus the ordinary ammeters and voltmeters doesn't read AC quantities.

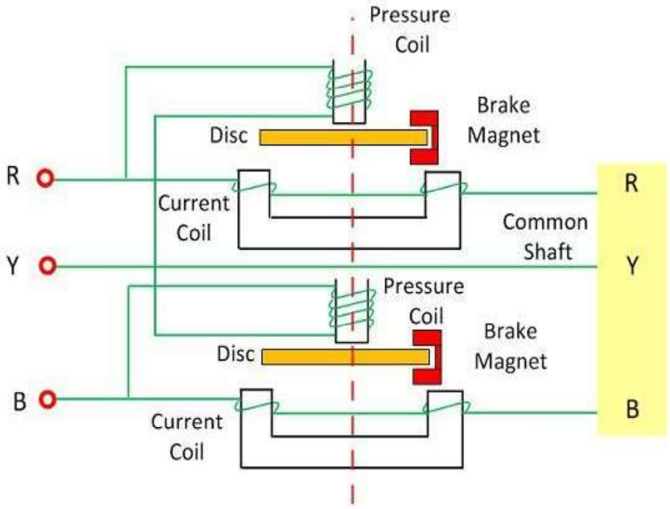
So for AC other type of instruments such as Moving iron (MI) or Dynamometer type(EDM) etc can be used.

Q2.Explain the constructional details and working principle of a three phase energy meter .Also write its advantages and disadvantages.

Ans. The meter which is used for measuring the power of three phase supply is known as the three phase energy meter. The three phase meter is constructed by connecting the two single phase meter through the shaft. The total energy is the sum of the reading of both the elements.

Working Principle of Three Phase Energy Meter: The torque of both the elements is added mechanically, and the total rotation of the shaft is proportional to the three phase energy consumption.

Construction of Three Phase Energy Meter: The three phase energy meter has two discs mounted on the common shaft. Both the disc has its braking magnet, copper ring, shading band and the compensator for getting the correct reading. The two elements are used for measuring the three phase power. The construction of the three phase meter is shown in the figure below.



Three Phase Energy Meter

For three phase meter, the driving torque of both the elements is equal. This can be done by adjusting the torque. The torque is adjusted by connecting the current coils of both the elements in the series and their potential coils in parallel. The full load current is passed through the coil due to which the two opposite torque is set up in the coil.

The strength of both the torques are equal, and hence they do not allow the disc to rotate. If the torque becomes unequal and the disc rotates then the magnetic shunt is adjusted. The balance torque is obtained before testing the meter. The position of the compensator and the braking magnet are separately adjusted to each of the element for obtaining the balance torque.

Advantage:

- High torque is to weight ratio.
- The moving element has no electrical contact with the circuit.
- Less affected bh stray magnetic field .
- More accurate on a wide range of loads
- It is used in Industrial metering.

Disadvantages:

- Induction type energy meter can use only for A.C measurements.
- They consume a considerable amout of power.
- The cost is high.

Q3. For a 5A-230V energymeter, the no. of revolution per kwh is 480.If in a test at fully load, unity power factor, the disc makes 6 revolution in 30 seconds.Calculate the error if any.

Ans. Actual energy consumed in 30sec.

$$= VI(\cos\phi \times t \times 10^{-3})$$

$$= 230 \times 5 \times 1 \times \frac{30}{3600} \times 10^{-3} = 9.583 \times 10^{-3}\ kwh$$

$$\text{Energy Recorded} = \frac{Number\ of\ \mathrm{Re}volutions\ made}{\mathrm{Re}volutions / Kwh}$$

$$= \frac{6}{480} = 0.0125 = 12.5 \times 10^{-3}\ Kwh$$

$$\%\,Error = \frac{12.5 - 9.583}{9.583} \times 100 = 0.30439$$

Q4. Find the torque equation of a PMMC instruments.Write its advantages and disadvantages.

Ans. The deflecting torque induces because of the movement of the coil. The deflecting torque is expressed by the equation shown below.

$$T_d = NBLdI \text{ ....(i)}$$

Where, N – Number of turns of coil
B – flux density in the air gap
L, d – the vertical and horizontal length of the side.
I – current through the coil.

$$G = NBLd \text{ ....(ii)}$$

The spring provides the restoring torque to the moving coil which is expressed as

$$T_C = K\theta \text{ ....(iii)}$$

Where K = Spring constant.
For final deflection,

$$T_C = T_d$$

By substituting the value of equation (1) and (3) we get,

$$K\theta = GI$$

$$\theta = \frac{GI}{K}$$

$$I = \frac{K}{G}\theta$$

The above equation shows that the deflection torque is directly proportional to the current passing through the coil.

Advantages of PMMC Instruments: The following are the advantages of the PMMC Instruments.

- The scale of the PMMC instruments is correctly divided.
- The power consumption of the devices is very less.
- The PMMC instruments have high accuracy because of the high torque weight ratio.
- The single device measures the different range of voltage and current. This can be done by the use of multipliers and shunts.
- The PMMC instruments use shelf shielding magnet which is useful for the aerospace applications.

Disadvantages of PMMC Instruments: The following are the disadvantages of the PMMC instruments.

- The PMMC instruments are only used for the direct current. The alternating current varies with the time. The rapid variation of the current varies the torque of the coil. But the pointer can not follow the fast reversal and the deflection of the torque. Thus, it cannot use for AC.
- The cost of the PPMC instruments is much higher as compared to the moving coil instruments.

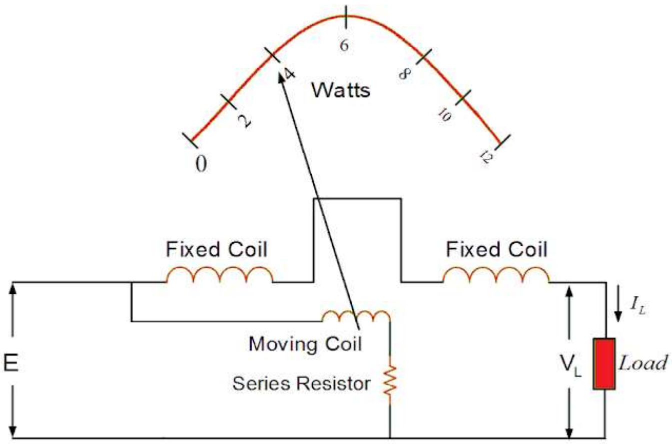
Q5. What is wattmeter ? Sketch the connections of a dynamometer type wattmeter. Explain its working.

Ans. Wattmeter: The wattmeter is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit. Electromagnetic wattmeters are used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements. The instruments in which fixed coils produce operating field are known as dynamometer type instruments.

The dynamometer type wattmeters are very important because we use very commonly for power measurement in AC circuits.

Dynamometer Type Wattmeter Working Principle: In these wattmeters, the field produced by the current-carrying moving coil tries to come in line with the field produced by the current-carrying fixed coil, and a deflecting torque is exerted on the moving system. As a result deflection takes place in the pointer.

Construction of Dynamometer Type Wattmeter: A dynamometer type wattmeter primarily consists of two coils called fixed coil and moving coil. The fixed coil is splitted into two equal parts, which are placed parallel to each other. The two fixed coils are air-cored to avoid hysteresis effects when used on AC.



The fixed coil is connected in series with the load and carries the circuit current. It is, therefore, called the current coil. The moving coil is pivoted between the two parts of the fixed coil and is mounted on a spindle.

A pointer is attached to the spindle, which gives deflection. The moving coil is connected in parallel with the load and carries the current proportional to the voltage. It is, therefore, called the potential coil.

Generally, a high resistance is connected in series with the moving coil to limit the current through it. By limiting the current, the moving coil is made lightweight, which in turn increases the sensitivity of the instrument.

The springs provide the controlling torque. They also serve the additional purpose of leading the current into and out of the moving coil. Air friction damping is employed in such instruments.

Dynamometer Type Wattmeter Working: We use the wattmeter for power measurements. Its current coil is connected in series with the load, carries the load current, and the potential coil, connected in parallel with the load, carries the current proportional to the voltage across the load.

The fixed coil produces a field Fm, and moving coil creates a field Fr. The field Fr tries to come in line with the main field Fm, which provides a deflecting torque on the moving coil.

Thus, the pointer attached to the spindle of the moving coil deflects. This deflection is controlled by the controlling torque produced by the springs.

Advantages:

- It can be used both on AC and DC circuits.
- It has a uniform scale.
- We can obtain a high degree of accuracy through careful design.

Disadvantages:

- At low power factors, the inductance of the potential coil causes serious errors.

- The reading of the instrument may be affected by stray fields acting on the moving coil. To prevent it, magnetic shielding is provided by enclosing the instrument in an iron case.

Q6.Write short notes of any two of following:

(a) Anderson's bridges **(b) RVDT**

(c) C.T and P.T **(d) LCR meter**

Ans.(a) Anderson's bridges: Refers to Chapter

Ans.(b) C.T and P.T: Refers to Chapter

Ans.(c) LCR meter: Refers to Chapter

Model Sets-2

Electrical and Electronic Measurement

Group A

1. Choose the most suitable answer from the following options:

(i) The errors mainly caused by human mistakes are:

(a) Gross errors (b) Systematic errors
(c) Instrumental errors (d) Observational errors

Ans.(a)

(ii) If two meters X and Y require 40 mA and 50 mA respectively, to give full scale deflection, then

(a) Y is more sensitive (b) X is more sensitive
(c) Both X and Y are equally sensitive
(d) None of these

Ans.(b)

(iii) The difference between the measured value and the true value is called:

(a) Gross error (b) Relative error
(c) Probable error (d) Absolute error

Ans.(d)

(iv) The damping torque must operate only when the moving system of the indicating instrument is

(a) Stationary (b) Actually moving
(c) Just starting to move (d) Near its full deflection

Ans.(d)

(v) The controlling torque is gravity controlled meter is proportional to:

(a) $\sin\theta$ (b) $\cos\theta$ (c) $\tan\theta$ (d) θ

Ans.(a)

(vi) The PMMC meter can measure

(a) Only de quantity (b) Only ac quantity
(c) Both ac and dc quantities
(d) Only very high frequency quantities

Ans.(a)

(vii) The pressure coil of a dynanmoter type wattmeter is:

(a) Highly inductive (b) Purely resistive
(c) Highly resistive (d) purely inductive

Ans.(c)

(viii) A dynamometer type wattmeter responds to the:

(a) Average value of active power
(b) Average value of reactive power
(c) Peak value of active power
(d) Peak value of reactive power

Ans.(a)

(ix) In a two-wattmeter method of measuring power, one of the wattmeters is reading zero watts. The zero watts. The power factor of the circuit is:

(a) Zero (b) 0.5 (c) 0.8 (d)

1

Ans.(b)

(x) Creaping is the phenomenon which occurs in

(a) Ammeter (b) Voltmeter
(c) Wattmeter (d) Energy meter

Ans.(d)

(xi) The pressure coil of an induction type energy meter is:

(a) Highly resistive (b) Highly inductive
(c) Purely resistive (d) Purely inductive

Ans.(b)

(xii) Measuring range of a voltmeter can be extended by using:

(a) Low shunt resistance (b) Low series resistance
(c) High shunt resistance (d) High series resistance

Ans.(d)

(xiii) The force responsible for reduction of oscillations of pointer in an ammeter is

(a) Controlling force (b) Damping force
(c) Deflecting force (d) None of these

Ans.(b)

(xiv) Voltmeter should be of very high resistance so that:

(a) Its range is high (b) Its accuracy is high
(c) It may draw minimum possible current
(d) Its sensitivity is high

Ans.(c)

(xv) The synchroscope is an instrument for

(a) Checking the voltage of the two circuits
(b) Checking of phase sequence of the two circuits
(c) Indicating differences of phases and frequencies of two circuit voltages
(d) Checking power factor of the two circuits

Ans.(c)

(xvi) Kelvin double bridge is best suited for the measurement of:

(a) Induction (b) Capacitance
(c) Low resistance (d) High resistance

Ans.(c)

(xvii) Weston frequency meter operates on the principle of:

(a) Variation of impedance of an inductive coil circuit
(b) Phenomenon of mechanical resonance
(c) Phenomenon of electrical resonance
(d) None of these

Ans.(a)

(xviii) Megger works on the principle of:

(a) Kirchhoff's current law (b) Ohm's law
(c) Gauss's law
(d) Electromagnetic induction

Ans.(d)

(xix) Output of a digital multimeter is.....

(a) Mechanical (b) Optical
(c) Electrical (d) Analog

Ans.(d)

(xx) Q-meter works on the principle of......

(a) Piezoelectric effect (b) Parallel resonance
(c) Series resonance (d) None of these

Ans.(c)

Group B

Answer all Five Questions.

Q2. What is measurement? Explain its significance in various fields of engineering.

Ans. Measurement is the process by which we can convert physical parameters to meaningful numbers.The measuring process is one in which the property of an object or system under consideration is compared to an accepted standard unit.

Significance of Measurement : Measurement gives the utilisation, presence of electrical energy in form of data which can be easily understood by other. Desirable qualities of measuring instruments :

1. More accuracy. 2. More precised value.
3. Low systematic error. 4. Low random error.
5. Low paralex error.

OR

Q2. Explain the different types of errors that may occur in measurement.

Ans. *Refers to Chapter*

Q3. Ammeter and voltmeter are connected in series and parallel respectively, why?

Ans. Ammeter is always connected in series because it has low internal resistance. The current to be measured in the circuit should not be practically affected by the Ammeter, hence the need to have a low internal resistance.

- Voltmeter is always connected in parallel because it has high internal resistance. A voltmeter, in reality, only needs a very small amount of current to measure the potential difference between its ends, hence the need to have a very high internal resistance.
- If, incorrectly and dangerously, an Ammeter is connected in parallel, the equivalent to a short circuit will be produced and if the Ammeter does not have effective protection systems, it will be destroyed.
- If a Voltmeter is connected incorrectly in series, it is most likely that nothing happens and that nothing is measured and that the circuit that follows does not do anything either.

OR

Q3. What are the major difference between attraction and repulsion type of moving iron instruments?

Ans. Attraction Type – The instrument in which the iron plate attracts from the weaker field towards the stronger field such type of instrument is known as the attraction type instrument.

The stationary coil of the attraction type instrument is flat and has a narrow opening. The moving element is the flat disc of the iron core. The current flow through the stationary coil produced the magnetic field which attracts the iron coil.

The iron vane deflects from the low magnetic field to the high magnetic field, and the strength of the deflection is directly proportional to the magnitude of the current flow through it. In short, we can say that the iron coil attracts towards in.

The attraction type instruments use spring, which provided the controlling torque. The deflection of the coil is reduced by the aluminium piston which is attached to the moving coil.

Repulsion Type Instruments – The repulsion type instrument has two vanes or iron plates. One is fixed, and the other one is movable. The vanes become magnetised when the current passes through the stationary coil and the force of repulsion occur between them. Because of a repulsive force, the moving coil starts moving away from the fixed vane.

The spring provides the controlling torque. The air friction induces the damping torque, which opposes the movement of the coil. The repulsion type instrument is a non-polarized instrument, i.e., free from the direction of current passes through it. Thus, it is used for both AC and DC.

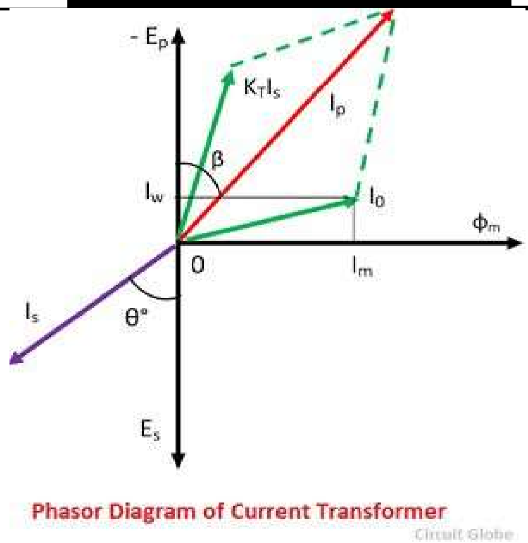
Q4. How would you extend the range of dc ammeters and voltmeter.

Ans. *Refers to Chapter*

OR

Q4. Explain with help of phasor diagram the principle of current transformer.

Ans. The phasor diagram of the current transformer is shown in the figure below. The main flux is taken as a reference. The primary and secondary induced voltages are lagging behind the main flux by 90º. The magnitude of the primary and secondary voltages depends on the number of turns on the windings. The excitation current induces by the components of magnetising and working current.



Phasor Diagram of Current Transformer

where,

I_s – secondary current

E_s – secondary induced voltage

I_p -primary current

E_p – primary induced voltage

K_t – turn ratio, number of secondary turn/number of primary turn

I_0 – excitation current

I_m – magnetising current

I_w – working component

ϕ_S – main flux

The secondary current lags behinds the secondary induced voltage by an angle θ^0. The secondary current relocates to the primary side by reversing the secondary current and multiply by the turn ratio. The current flows through the primary is the sum of the exciting current I_0 and the product of the turn ratio and secondary current $K_t I_s$.

Q5. Enumerate the errors introduced by dynamometer type wattmeter.

Ans. Errors in dynamometer type wattmeters are :

1. **Pressure coil inductance:** In an ideal dynamo-meter type watt meter the current in pressure coil in phase with the applied voltage . But in practically the pressure coil of wattmeter has an inductance and current in it will lag behind the applied voltage . If there is no inductance the current in pressure coil will be in phase with the applied voltage . In the absence of inductance in pressure coil of wattmeter , it will read correctly in all power factors and frequency .

The wattmeter will read high when the load power factor is lagging ,as in that case the effect of pressure coil inductance is to reduce the phase angle between load current and pressure coil current . Hence the wattmeter will read high . This is very serious error.

The wattmeter will read low when the load power factor is leading as in that case the effect of pressure coil inductance is to increase the phase angle between load current and pressure coil current .Hence the wattmeter will read low.

2. **Pressure coil capacitance:**The pressure coil circuit may have capacitance in addition with inductance.This capacitance mainly due to the inter turn capacitance of the series resistance.The effect of capacitance is opposite to that due to inductance.Therefore the wattmeter will read high when the load power factor is leading.
The inductance in pressure coil circuit will always more than inductance,hence the error caused by capacitance will be nullified by that due to inductance.
3. **Error due to mutual inductance:**Errors may occurred due to the mutual inductance between the current and pressure coils of the watt meter.These errors are quite low at power frequencies.But they increased with increase in frequencies.
The effect of mutual inductance can be avoid by arranging the coil system in such a way that they have no mutual inductance.So we can eliminate the errors due to mutual inductance.The Drysdale Torsion head wattmeter is an example for such type.
4. **Eddy Current errors:**Eddy currents are induced in the solid metal parts and within the thick conductors by the alternating magnetic field produced by the current coil.This eddy current produce their own magnetic field and it will alter that produced by the main current in the current coil and thus error occurred.
This error can be minimized by avoiding solid metal parts as much as possible and by using stranded conductors for high current applications.
5. **Stray Magnetic field Errors:**The electrodynamometer type wattmeters has a weak operating field and therefore it effected by stray magnetic fields it will resulting in serious errors. Hence these instruments should be shielded against stray magnetic field.
6. **Errors caused by vibration of moving system:**The torque on the moving system varies with frequency which is twice that of voltage.If the parts of the moving system has a natural frequency which is resonance with the frequency of torque pulsation,the moving system would vibrate with a considerable amplitude.These vibrations will cause errors.This error can be reduced by design.
7. **Temperature Error:**The change in room temperature may affect the indication of wattmeter. This is because of change in temperature will change in resistance of pressure coil and stiffness of springs which provide controlling torque.This effect are opposite in nature and cancel each other.The use of material of having negligible temperature coefficient of resistance will reduce change in resistance the pressure coil with change in temperature.

OR

Q5. What is the difference between an energy meter and a wattmeter?

Ans.

Basic for comparision	**Wattmeter**	**Energy Meter**
Definition	It measures the power flows in the circuit	The energy meter measures the energy consume by the electrical load.
Unit	Measures power in watt.	Measures energy in joules.
Working Principle	Current Carrying conductor place in a magnetic field experiences a torque.	Work on the principle of conversion of electrical energy into mechanical work.
Construction	Fixed and moving coil, Control system, damping system, Scale & pointer.	Driving system, moving system, braking system and counting mechanism are the four main parts of the energy meter.
Applications	It is used for measuring power in an electrical circuit and for determining the power rating of the appliances.	It is used for measuring electrical energy in homes and industries.

Q6. How will you test the single phase energy meter?

Ans.*Refers to Chapter*

OR

Q6. Compare between spring control and gravity control instruments.

Ans. The difference between spring control and gravity control instruments are :

1. In gravity control, adjustable small weight is used which produces the controlling torque. In spring control, two hair springs are used which exert controlling torque.
2. Controlling torque can be varied in gravity control whereas controlling torque is fixed in spring.
3. In gravity, the performance is not temperature dependent while in the spring the performance is temperature dependent.
4. The scale is nonuniform in gravity. The scale is uni-

form in spring control.

5. The controlling torque is proportional to sin(angle) in the first whereas in the second, the controlling torque is proportional to the angle.
6. The readings can not be taken accurately in the gravity. The readings can be taken very accurately in the spring.
7. The system must be used in vertical position only in gravity control. The system need not be necessarily in vertical position in spring control.
8. Proper leveling is required as gravity control. The leveling is not required.

Group C

Answer all Five Questions.

Q7. Classify the measuring system giving their advantages and limitations. What is meant by active and passive instruments. Explain it.

Ans.Electrical instrument : In electrical engg. we study across current, voltage, power, energy, flux, frequency etc which are not visible to eyes. The instrument which are to be measure these quantity are known as electrical measuring instruments. Electrical instrument may be classified as :

(a) Absolute instruments (b) Secondary instruments.

(a) Absolute instrument : These instrument which gives the value of the quantity to be measured in terms of the constant of the instrument are called Absolute instrument. e.g., tangent galvanometer.

(b) Secondary instrument : The instruments which is used to measure electrical quantity in terms of deflection are called **secondary instrument**. There instrument is used in practical lab. There are classified as :

(i) Indicating instruments : The instrument which indicate the magnitude of electrical quantity being measured instanteneously are called indicating instrument. In such instrument of pointer moves over the calibrated scale to indicates the magnitude of electrical quantity being measured. Ex : Ammeter, voltmeter, wattmeter.

(ii) Integrating instruments : The instrument which is used to measure the total energy in a given period are called **integrating instrument**. In such instruments the product of time and an electrical quantity under measurement for example; energy meter, Ampere power meter.

(iii) Recording instruments : The instrument which gives a continous record of the variation of the magnitude of an electrical quantity to be measured over a difinite period of time are called recording instruments. e.g; CRO, E-meter etc.

2nd Part :

Active Instruments: Active instruments are the instruments in which the quantity to be measured activates the magnitude of external power input source that produces the measurement.

An example of an active instrument is a float-type petrol-tank level indicator. In this instrument, the change in petrol level moves a potentiometer arm and the output signal consists of a proportion of the external voltage source applied across the two ends of the potentiometer. The energy in the output signal comes from the external power source; the primary transducer float system is merely modulating the value of the voltage from this external power source.

Passive Instruments: Passive instruments are instruments where the output is produced completely by the quantity that is measured.

An example of a passive instrument is the pressure measuring device. The pressure of the fluid is translated into movement of a pointer against a scale. The energy expended in moving the pointer is derived entirely from the change in pressure measured; there are no other energy inputs to the system.

OR

Q7. What are various source of systematic errors? How do these errors influence the accuracy of measurements?

Ans. Systematic error is predictable and either constant or else proportional to the measurement. Systematic errors primarily influence a measurement's accuracy.

Typical causes of systematic error include observational error, imperfect instrument calibration, and environmental interference. For example:

- Forgetting to tare or zero a balance produces mass measurements that are always "off" by the same amount. An error caused by not setting an instrument to zero prior to its use is called an offset error.
- Not reading the meniscus at eye level for a volume measurement will always result in an inaccurate reading. The value will be consistently low or high, depending on whether the reading is taken from above or below the mark.
- Measuring length with a metal ruler will give a different result at a cold temperature than at a hot temperature, due to thermal expansion of the material.
- An improperly calibrated thermometer may give accurate readings within a certain temperature range, but become inaccurate at higher or lower temperatures.
- Measured distance is different using a new cloth measuring tape versus an older, stretched one. Proportional errors of this type are called scale factor errors.

- Drift occurs when successive readings become consistently lower or higher over time. Electronic equipment tends to be susceptible to drift. Many other instruments are affected by (usually positive) drift, as the device warms up.
- Once its cause is identified, systematic error may be reduced to an extent. Systematic error can be minimized by routinely calibrating equipment, using controls in experiments, warming up instruments prior to taking readings, and comparing values against standards.
- While random errors can be minimized by increasing sample size and averaging data, it's harder to compensate for systematic error. The best way to avoid systematic error is to be familiar with the limitations of instruments and experienced with their correct use.

Q8. Derive the expression for torque produced in a moving coil of instrument and explain, briefly its working.

Ans.*Refers to Chapter*

OR

Q8. Explain the features of current and potential transformers.

Ans.*Refers to Chapter*

Q9. Describe the working principle and construction of an induction type wattmeter. How does this instrument compare with the dynamometer type?

Ans.*Refers to Chapter*

OR

Q9. Deduce an expression for the power factor of a balanced 3-ϕ load with the help of two wattmeter when the readings of the two wattmeters are equal.

Ans.*Refers to Chapter*

Q10. Explain the working principle of a multimeter. Also write its various applications.

Ans. A multimeter is a permanent magnet moving coil galvanometer. There is an iron cored coil pivoted on two jeweled bearings. The coil is wound on an aluminum former or bobbin. And this coil is free to rotate in the field of a permanent magnet. An aluminum pointer is attached to the coil and bobbin assembly and moves on a graduated scale.

There are two spiral springs attached to the coil assembly at the top and bottom, which provide a path for the flow of current and controlling torque.

A multimeter can measure voltage, current, and resistance for which its galvanometer is converted to a voltmeter, ammeter, and ohmmeter with the help of suitable circuits incorporated in it. The galvanometer used in a multimeter has always its pointer resting at zero position on the extreme left end various measurements are made on a multimeter .

Application of multimeter :

- Testing voltage: Use the voltage setting to measure voltage drop across circuit components and to measure total voltage across a circuit. You'll need the DC voltage setting for most small circuit components and for testing batteries and the AC voltage setting for testing residential circuit components, such as light switches, light fixtures and outlets. Note that you can measure voltage without disconnecting the circuit. Simply touch one probe to the negative terminal or, if testing AC voltage, to the hot terminal. Touch the other probe to the other terminal and record the reading.
- Testing current: You normally use the mA scale for testing current through a electronic circuits and the A scale for testing residential current. To test current, the meter must be part of the circuit. In most cases, you have to make a break in the circuit, and then connect one wire to one of the meter probes and the other wire to the other probe.
- Testing resistance: The meter has a built-in power source that is activated when you choose the resistance scale. It sends a small current from one probe, and the smaller the current recorded by the other probe, the higher the resistance. If the second probe records no current, the meter displays infinite resistance or the letters OL, which means open line. This function is useful for continuity testing. You can also use it to check a diode by checking the resistance in one direction across the device, then reversing the probes and checking resistance in the other direction. If the diode is good, you should get low resistance in one direction and near infinite resistance in the other.

Q11. Write notes an any two of the following:

(i) Frequency meter

(ii) Synchroscopes

Ans.(i)Frequency meter: Frequency meter, device for measuring the repetitions per unit of time (customarily, a second) of a complete electromagnetic waveform. Various types of frequency meters are used. Many are instruments of the deflection type, ordinarily used for measuring low frequencies but capable of being used for frequencies as high as 900 Hz. These operate by balancing two opposing forces. Changes in the frequency to be measured cause a change in this balance that can be measured by the deflection of a pointer on a scale. Deflection-type meters are of two types, electrically resonant circuits and ratiometers.

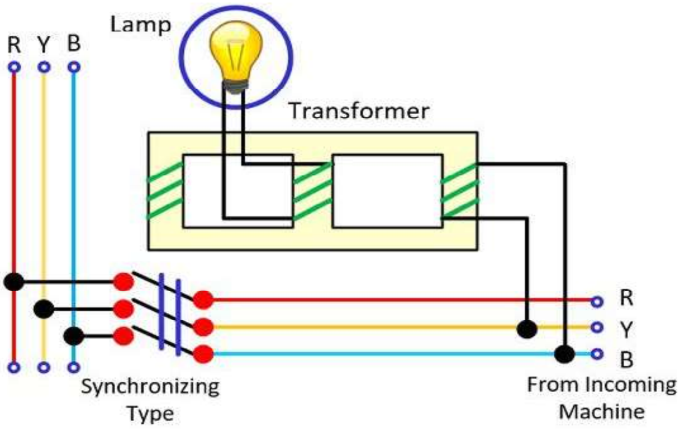
Ans.(ii)Synchroscopes: Synchroscope is the instrument that displays the exact instant where the two alternating current generators are in exact phase relation to be in parallel connection. It also shows whether the incoming generator has more operating speed when compared with that of an on-line generator.

Working Principle: The synchroscope working principle can be explained as follows. It has two phases wounded stator and a rotor. The alternators supply a two-phase kind of supply for the device. When there happens to match the phases, then the third phase will get automatically synchronized. The prevailing alternator in the device provides power supply for the stator, whereas incoming alternator provides supply for the rotor.

The phase difference that exists between these two supplies implies the frequency and phase variation of the alternators that are in parallel connection. The device also defines the operating speed (quick or slow) with that of the incoming alternator.

The device will start to function when the alternators of various frequencies have a connection with each other. When both rotor and stator frequency levels are similar, then the rotor will stop to rotate or stays as a constant which means that the dial also stays as static. And when the frequency of the stator and rotor supply varies, then the rotor initiates to rotate which means that the dial starts to deflect.

The rotor speed is based on the variation of the supply frequency level. When the variation is more, then rotor deflects at greater speed and when the variation is minimal then rotor deflects at less speed.



The synchroscopes are the special form of power factor meters and are of types

- Electrodynamic type synchroscopes.
- Moving iron type synchroscopes.

Model Sets-3

Electrical and Electronic Measurement

1. Choose the most suitable answer from the following options :

(i) The instrument for measuring ac only is

(a) PMMC type (b) Moving iron type
(c) Deflection ammeter type (d) Induction type

Ans.(d)

(ii) The difference between the measured value and the true value is called

(a) Accuracy (b) Error
(c) Sensitivity (d) Precision

Ans.(b)

(iii) The smallest value that can measured by the measuring instrument is called

(a) Accuracy (b) Precision
(c) Least count (d) Resolution

Ans.(c)

(iv) High a.c. voltages are usually measured with :

(a) Magnetic voltmeter (b) PTS with voltmeters
(c) Inductive voltmeters (d) CTS with voltmeters

Ans.(b)

(v) Which of the following instruments can be used both for A.C. and D.C.?

(a) PMMC type (b) Induction type
(c) Moving iron type (d) None of these

Ans.(c)

(vi) Measuring range of a voltmeter can be extended by using :

(a) Low shunt resistance (b) Low series resistance
(c) High shunt resistance (d) High series resistance

Ans.(d)

(vii) If the damping torque is more than the critical damping, the instrument is called :

(a) Under damped (b) Over damped
(c) Under critically damped (d)Over critically damped

Ans.(b)

(viii) The best method to measure the power in three phase balanced delta circuit is

(a) Two wattmeter method
(b) Three wattmeter method
(c) One wattmeter method (d) None of these

Ans.(a)

(ix) Induction type wattmeters can be used to measure

(a) DC power (b) AC power
(c) Both DC and AC power (d) None of these

Ans.(b)

(x) Creeping in a single phase induction type energy meter

may be due to

(a) Over compensation of friction (b) Over voltage
(c) Vibrations (d) All of the above

Ans.(d)

(xi) The fixed coil in a dynamometer type wattmeter is connected?

(a) In series with the moving coil (b) Across the load
(c) In series with the load (d) Across the supply

Ans.(c)

(xii) Which type of damping is used for providing damping torque in dynamometer type instruments?

(a) Air friction damping (b) Fluid friction damping
(c) Eddy current damping (d) None of these

Ans.(a)

(xiii) Speed error in induction type energy meter is compensated by

(a) Adjusting the position of the shading coil
(b) Changing the position of the brake shoe
(c) Drilling holes in the doee
(d) All of the above

Ans.(b)

(xiv) Vibrating reeds are employed in :

(a) Meggar (b) Power factor meter
(c) Frequency meter (d) None of these

Ans.(c)

(xv) Which of the following measuring instrument has no controlling device

(a) Induction type energy meter
(b) Moving iron type meter
(c) Dynamometer type wattmeter
(d) Electrodynamometer power factor meter

Ans.(d)

(xvi) All the meters used for measuring current, voltage and resistance are basically

(a) Voltmeters (b) Ammeters
(c) Multi meters (d) None of these

Ans(c).

(xvii) Kelvin double bridge is best suited for the measurement of :

(a) Inductance (b) High resistance
(c) Low resistance (d) Capacitance

Ans.(c)

(xviii) Which of the following is measured by the loss of charge method?

(a) Low R (b) High R (c) Low L (d) High L

Ans.(b)

(xix) For measurement of capacitance, the best bridge method is

(a) Ammeter-Voltmeter method
(b) Max Well's bridge method
(c) Wien's bridge method
(d) Schering bridge method

Ans.(d)

(xx) The controlling torque in a meggar is provided by:

(a) Spring (b) Weights attached to the moving system
(c) It does not need any controlling torque
(d) None of these

Ans.(a)

Group-B

Q2. What are the special features of indicating instruments?

Ans. All indicating instruments consist of the following three essential system :

(a) A deflecting System
(b) A controlling System
(c) A damping System

(a) A deflecting System : It is also called as moving system,. Is that part of the instrument which converts the electric current (or potential) into a mechanical force and hence produces a deflecting torque on the moving system. This causes motion of the moving system, there by indicating that the current is flowing. The deflecting system is thus the prime mover responsible for deflection of the pointer.

(b) A controlling System : The controlling system ensures that the current of different magnitudes should produce deflection of the pointer proportional to its value. The cotnrolling system brings into play a force of equal magnitude and of opposite direction to that of the deflecting system. Without such a control the pointer would swing over to its maximum deflected position for a current of any value, moreover, once deflected, the pointer would not return to its zero position on removing the current. Thus controlling system ensures that the deflecting force is porportional to the quantity under measurement (current) and it brings back the pointer to zero when quantity under measurement is zero. The controlling systems used in measuring instrument are spring control, gravity control.

(c) Damping system : Both the deflecting and control systems have mechanical inertia which will cause the pointer to overawing and move on both sides of actual reading; i.e. the pointer will oscillate about the mean steady deflected position. The damping system acts as a brake on these mechanical oscillations, so that the moving system moves rapidly, but smoothly to its final deflected position. The instrument is then said to be 'Dead-beat'. The damping systems used in measuring instruments are air friction damping, eddy current damping, fluid friction damping.

OR

Q2. Explain the difference between absolute and secondary instruments with examples.

Ans.Absolute instrument : These instrument which gives the value of the quantity to be measured in terms of the constant of the instrument are called Absolute instrument. e.g., tangent galvanometer.

They do not need to be calibrated and do not need any comparison with other standard instruments.
Absolute instruments are used in laboratories as standardizing instruments
Examples – Tangent Galvanometer, Absolute electrometer, and Raleigh current balance.
Secondary instrument : The instruments which is used to measure electrical quantity in terms of deflection are called **secondary instrument**.
These instruments need to be calibrated against an absolute instrument.
Secondary instruments are used in everyday work.
Examples – ammeter, voltmeter, ampere-hour meter, wattmeter etc.

Q3. Why damping is necessary for measuring instrument? Explain

Ans. In a measuring instrument, the damping torque is necessary to bring the moving system to rest to indicate steady reflection in a reasonable short time.It exists only as long as the pointer is in motion.
Such a torque is necessary to bring the pointer to rest quickly. If there is no damping torque, then the pointer will keep moving to and fro about its final deflected position for some time before coming to rest, due to the inertia of the moving system.
This damping torque acts only when the pointer is in motion and always opposes the motion. The position of the pointer when stationary is, therefore, not affected by damping torque. The degree of damping decides the behavior of the moving system.
If the instrument is under-damped, the pointer will oscillate about the final position for some time before coming to rest. On the other hand, if the instrument is over damped, the pointer will become slow and lethargic.

OR

Q3. The deflecting torque of an ammeter is directly proportional to the current passing through it and the instruments has full scale deflection of 70^0 for a current of 10A. What deflection will occur for a current of 5A when the instrument is gravity controlled.

Ans. Since deflecting torque varies as (current)2,we have

$$Td \, \alpha \, I^2$$

For gravity control,

$T_c \, \alpha \, \text{Sin}\,\theta$

$\text{Sin}\,\theta \, \alpha \, I^2$

$\text{Sin}70^0 \, \alpha \, 10^2$ and $\text{Sin}\,\theta \, \alpha \, 5^2$

$$\frac{\text{Sin}\,70^0}{\text{Sin}\,\theta} = \frac{100}{25}$$

$$\frac{0.94}{\text{Sin}\,\theta} = \frac{4}{1}$$

$$\text{Sin}\,\theta = 0.23$$

$$\theta = \text{Sin}^{-1}\,0.23 = 13.58^0$$

Q4. Explain creeping error.

Ans.Creeping Error : The slow but continuous rotation of the disc when only the pressure coils are excited but no current is flowing in the circuit is called “creeping”. It may be caused by various factors like incorrect friction compensation, vibration, stray magnetic fields, or due to the voltage supply being in excess of the normal.
To overcome this creeping effect on no-load, two holes are drilled in the disc on a diameter, i.e. on opposite sides of the spindle. This causes sufficient distortion of the field to prevent rotation when one of the holes comes under one of the poles of the shunt magnet.

OR

Q4. Calculate the value of shunt resistance to extend the range of a 0-5A moving iron ammeter to 0-50A. The value of resistance R = 0.09 Ω.

Ans. Multiplying Power of Shunt

$$m = \frac{I}{I_m}$$

$$= \frac{50}{5} = 10$$

Resistance of Shunt

$$R_{sh} = \frac{R}{m-1} = \frac{0.09}{10-1} = 0.01\Omega$$

Q5. Explain the function of a meggar.

Ans.*Refers to Chapter*

OR

Q5. What is synchroscope? Describe the term “Synchronizing”.

Ans.A synchroscope is used to determine the correct instant of synchronizing, between an unloaded incoming machine to the bus bar in order to share the load, for closing the synchronizing switch.
Synchronization is the coordination of events to operate a system in unison.

Q6. Define the terms “transformation ratio” and “Nominal ratio” in instrument transformers.

Ans. Same as Chapter

Group-C

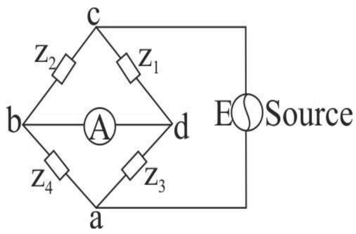
Answer all Five Questions.

Q7. Explain the method of low resistance measured by Kelvin double bridge method with its applications and conditions.

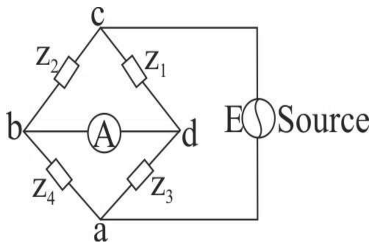
Ans. *Refers to Chapter*

OR

Q7. The four impedance of an a.c. bridge shown in figure are : $z_1 = 400\Omega\underline{|50^0}$; $z_2 = 200\Omega\underline{|40^0}$; $z_3 = 800\Omega\underline{|-50^0}$; $z_4 = 400\Omega\underline{|20^0}$. Find out whether thhe bridge is balanced under these conditions or not.



Ans.



Applying the first condition of balance for magnitudes

$z_1z_4 = z_2z_3$

Now, $z_1z_4 = 400 \times 400 = 1{,}60{,}000$

$z_2z_3 = 200 \times 800 = 1{,}60{,}000$

$z_1z_4 = z_2z_3$

Thus the first condition is satisfied.

Applying the second condition for balance required for phase.

$$\angle\theta_1 + \angle\theta_4 = \angle\theta_2 + \angle\theta_3$$

Now, $\angle\theta_1 + \angle\theta_4 = 50^0 + 20^0 = 70^0$

and $\angle\theta_2 + \angle\theta_3 = 40^0 - 50^0 = -10^0$

This indicates that the condition for phase relationship is not satisfied and therefore the bridge is unbalanced even through the condition for equality of magnitudes is satisfied.

Q8. An instrument spring made up of phosphor bronze strip has a length of 400 mm, a breadth of 0.5 mm, and a thickness of 0.08 mm. If E (Young's moduls) of phosphor-bronze is taken as 1.2 × 10^6 kg per sq. cm. Estimate the torque exerted by spring for a deflection of (a) 60^0 (b) 90^0.

Ans. Length of strip =400mm

=400×10^{-3}m

breadth of strip=0.5mm=0.5×10^{-3}m

thickness of strip=0.08mm=0.08×10^{-3}m

Young's modulus(E)=1.2×10^6Kg per Sq.cm

=117679.8N/m^2

(a) Controlling torque

$$\tau_c = \frac{Ebt^3}{12l}\theta$$

$$\tau_c = \frac{117679.8\times0.5\times10^{-3}\times\left(0.08\times10^{-3}\right)^3\times\pi/3}{12\times400\times10^{-3}}$$

=6.872×10^{-12}Nm

(b) $$\tau_c = \frac{Ebt^3}{12l}\theta$$

$$\tau_c = \frac{117679.8\times0.5\times10^{-3}\times\left(0.08\times10^{-3}\right)^3\times\pi/2}{12\times400\times10^{-3}}$$

=9.85×10^{-12}Nm

Q9. Explain the construction and working of permanent magnet moving coil instrument. Describe why it is used only in DC.

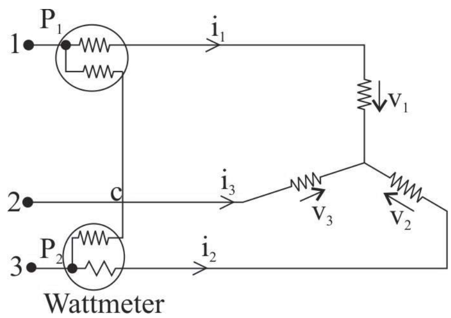
Ans. Construction and Working of PMMC: *Refers to Chapter*

These types of instruments are only used for measuring the DC quantities as if we apply AC current to these type of instruments the direction of current will be reversed during negative half cycle and hence the direction of torque will also be reversed which gives average value of torque zero. The pointer will not deflect due to high frequency from its mean position showing zero reading. However it can measure the direct current very accurately.

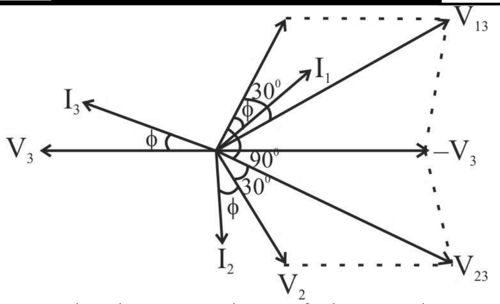
Q10. Show that in two wattmeter method of 3-phase power measurement, the sum of the readings of the two wattmeters give the total power consumed in 3-phasecircuit. Hence prove that, $\tan\phi = \sqrt{3}\dfrac{W_1 - W_2}{W_1 + W_2}$.

Where ϕ is the phase angle of the load and w_1 and w_2 are the readings of the wattsmeter.

Ans.



Phasor diagrams :



Let V_1, V_2, V_3 be the rms values of phase voltage and I_1, I_2, I_3 be the rms values of phase currents.

The load is balanced, therefore

phase voltage, $V_1 = V_2 = V_3 = V$ (say)

Line voltage, $V_{13} = V_{23} = V_{12} = \sqrt{3}\,V$

Phase currents, $I_1 = I_2 = I_3 = I$ (say)

Line currents, $I_1 = I_2 = I_3 = I$

Power factor = $\cos\phi$

The phase currents log the corresponding phasor voltages by an angle ϕ.

The current through wattmeter P, is I, and voltage across its pressure coil is V_{13}. I_1 leads V_{13} by an angle $(30^0 - \phi)$.

$\therefore$ Reading of P_1 wattmeter

$$P_1 = V_{13}I_1\cos(30^0 - \phi)$$

$$= \sqrt{3}VI\cos(30^0 - \phi)$$

The current through wattmeter P_2 is I_2 and voltage across its pressure coil is V_{23}. I_2 logs V_{23} by on angle $(30^0 + \phi)$.

$\therefore$ Reading of P_2 wattmeter

$$P_2 = V_{23}I_2\cos(30^0 + \phi)$$

$$= \sqrt{3}VI\cos(30^0 + \phi)$$

Sum of reading of two wattmeters

$$P_1 + P_2 = \sqrt{3}VI[\cos(30^0 - \phi) - \cos(30^0 + \phi)]$$

$$= 3VI\cos\phi$$

This is the total power consumed by load.

$\therefore$ Total power consumed by load

$P = P_1 + P_2$

Difference of readings of two wattmeters

$$P_1 - P_2 = \sqrt{3}VI[\cos(30^0 - \phi) - \cos(30^0 + \phi)]$$

$$= \sqrt{3}VI\sin\phi$$

$$\therefore \quad \frac{P_1 - P_2}{P_1 + P_2} = \frac{\sqrt{3}VI\sin\phi}{3VI\cos\phi} = \frac{\tan\phi}{\sqrt{3}}$$

$$\phi = \tan^{-1}\left(\sqrt{3}\,\frac{P_1 - P_2}{P_1 + P_2}\right)$$

$$\tan\phi = \sqrt{3}\,\frac{P_1 - P_2}{P_1 + P_2}$$

$$\tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

OR

Q10. Two wattmeters connected to measure the input to a balanced 3 ϕ circuit indicate 2000w and 500w respectively. Find tthe power factor of circuit:

(a) When both the reading are positive.

(b) When latter reading is obtained after reversing the connections to the current coil of first instrument.

Ans. P_1=2000W and P_2=500W

$$\text{(a)}\ \phi = \tan^{-1}\left(\sqrt{3}\,\frac{P_1 - P_2}{P_1 + P_2}\right)$$

$$\phi = \tan^{-1}\left(\sqrt{3}\,\frac{2000 - 500}{2000 + 500}\right)$$

$$\phi = \tan^{-1}\left(\sqrt{3}\,\frac{1500}{2500}\right)$$

$$\phi = \tan^{-1}\left(\sqrt{3} \times \frac{3}{5}\right)$$

$$\phi = 45.86^0$$

$\therefore$ Power factor= $\cos\phi = \cos 45.86^0$ =0.69

(b)When coil is reversed

$$\phi = \tan^{-1}\left(\sqrt{3} \times \frac{w_2 - w_1}{w_2 + w_1}\right)$$

$$\phi = \tan^{-1}\left(\sqrt{3} \times \frac{2000 - (-500)}{2000 - 500}\right)$$

$$\phi = \tan^{-1}\left(\sqrt{3} \times \frac{2500}{1500}\right)$$

$$\phi = \tan^{-1}\left(\sqrt{3} \times \frac{5}{3}\right)$$

$$\phi = 70.89^0$$

$\therefore$ Power factor= $\cos\phi = \cos 70.89^0$ =0.32

Q11.Describe how high voltages and currents are measured with the help of instrument transformer?

Ans. Current transformers has been standarized at 5A secondary winding current and the voltage transformers at from 100 to 120V secondary winding voltage .These are very moderate ratings and the instruments for measurements are rated near these.Thus ,a 5A ammeter may be used to measure 1000 A with the help of a 1000/5 A ratio current transformer or a 11V voltmeter may be used to measure a voltage of 66KV with the help of a

66000/110V potential transformer.Therefore,very cheat moderate rating instruments may be used tomeasure large current and high voltages.With Standardization of C.T and P.T secondary windig ratings and ,therefore there is great reduction in the costs of instrument transformer and instruments.

Instrument transformers are so important for insulating and range extension purposes that it is difficult to imagine the operation of a high voltage a.c system without them.

OR

Q11. Describe the construction and working principle of a single phase electrodynamometer type power factor meter. Prove that the special displacement of the moving system is equal to the phase angle of the system.

Ans.*Refers to Chapter*

Model Sets-4

Electrical and Electronic Measurement

Q1. Choose the most suitable answer from the following options.

(i) The errors committed by a person in the measurement are :

(a) gross error (b) random error
(c) instrumental error (d) environmental error

Ans.(a)

(ii) A set of observations has a wide range so it has :

(a) low accuracy (b) low precision
(c) high accuracy but low precision
(d) high precision but low accuracy

Ans.(c)

(iii) Which of the following is an obsolute instrument?

(a) power factor meter (b) ammeter
(c) wattmeter (d) tangent galvanometer

Ans.(d)

(iv) Which of the following types of instrument is an integrating instrument?

(a) power factor meter (b) energy meter
(c) wattmeter (d) frequency meter

Ans.(b)

(v) The torque produced by an indicating instrument by utilizing the effects of electric current is known as :

(a) controlling torque (b) deflecting torque
(c) damping torque (d) none of above

Ans.(a)

(vi) The controlling torque in a spring controlled instrument is proportional to :

(a) θ (b) θ^2 (c) $y\theta$ (d) $y\theta^2$

Ans.(a)

(vii)A hair spring attached to the wrong system in used to produce.

(a) damping torque (b) controlling torque
(c) balancing torque (d) deflecting torque

Ans.(b)

(viii)The force responsible for reduction of oscillations of the pointer in a ammeter is :

(a) controlling force (b) damping force
(c) deflecting force (d) none of these

Ans.(b)

(ix) The best suitable material for permanent magnet is:

(a) stainless steel (b) alnico
(c) tungston steel (d) soft iron

Ans.(b)

(x) The deflecting torque of a moving iron instrument is proportional to :

(a) 1 (b) 1^2 (c) $1^{1/2}$ (d) $1^{3/2}$

Ans.(b)

(xi) In PMMC instrument the torque/wt. ratio is :

(a) high (b) low (c) zero (d) infinity

Ans.(a)

(xii)The uniformity in the scale of an ammeter indicates that it is :

(a) rectifier type (b) PMMC type

(c) moving iron type (d) dynamometer type

Ans.(b)

(xiii)Which of the following instruments in undesirable for AC measurement?

(a) moving iron (b) electro-dynamic

(c) PMMC (d) hot wire

Ans.(c)

(xiv)The primary current in a current transformer is dictated by :

(a) the secondary burden

(b) the core of the transformer

(c) the load current (d) none of the above

Ans.(c)

(xv)Clamp-on ammeter is used for measurement of

(a) large alternating current

(b) small alternating current

(c) large direct current (d) small direct current

Ans.(a)

(xvi)Which of the following you will prefer to extend the range of an voltmeter ?

(a) low series resistance (b) high shunt resistance

(c) CT (d) PT

Ans.(d)

(xvii)In the measurement of 3 phase power by two wattmeter method, if the wattmeter readings are equal the power factor of the circuit is :

(a) 0.8 lagging (b) 0.8 loading

(c) zero (d) unity

Ans.(d)

(xviii)Vibrating reeds are employed in :

(a) frequency meter (b) pf meter

(c) synchro scope (d) megger

Ans.(a)

(xix)Voltbox is basically a device used for :

(a) measuring the voltage (b) measuring the current

(c) extending the voltage range of potentiometer

(d) measuring the power

Ans.(c)

(xx)Anderson bridge is used for the measurement of :

(a) time perior (b) phase difference

(c) inductance (d) capacitance

Ans.(c)

Q2.What is measurement? Explain the significance of measurement.

Ans. Measurement is the process by which we can convert physical parameters to meaningful numbers. The measuring process is one in which the property of an object or system under consideration is compared to an accepted standard unit

Significance of Measurements: Refers to Chapter 1

OR

Q2. Explain the different types of torque in Analog instruments.

Ans. The general commercial form of indicating instruments uses one of the physical effects expl. mud previously to convert an electrical current or potential into a mechanical force. This force is converted simultaneously into movement of pointer (torque), over a calibrated scale.

All analog instruments consist of the following three essential system :

(a) A deflecting System

(b) A controlling System

(c) A damping System

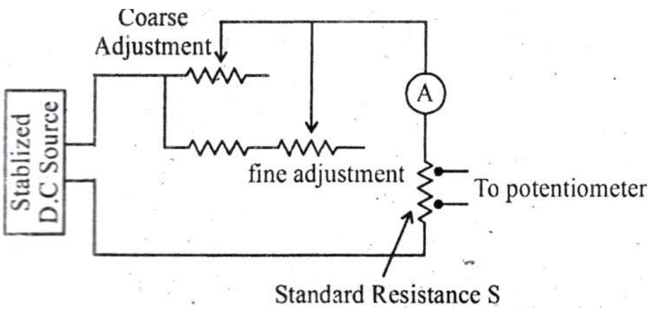
(a) A deflecting System : It is also called as moving system,. Is that part of the instrument which converts the electric current (or potential) into a mechanical force and hence produces a deflecting torque on the moving system. This causes motion of the moving system, there by indicating that the current is flowing. The deflecting system is thus the prime mover responsible for deflection of the pointer.

(b) A controlling System : The controlling system ensures that the current of different magnitudes should produce deflection of the pointer proportional to its value. The cotnrolling system brings into play a force of equal magnitude and of opposite direction to that of the deflecting system. Without such a control the pointer would swing over to its maximum deflected position for a current of any value, moreover, once deflected, the pointer would not return to its zero position on removing the current. Thus controlling system ensures that the deflecting force is porportional to the quantity under measurement (current) and it brings back the pointer to zero when quantity under measurement is zero. The controlling systems used in measuring instrument are spring control, gravity control.

(c) Damping system : Both the deflecting and control systems have mechanical inertia which will cause the pointer to overawing and move on both sides of actual reading; i.e. the pointer will oscillate about the mean steady deflected position. The damping system acts as a brake on these mechanical oscillations, so that the moving system moves rapidly, but smoothly to its final deflected position. The instrument is then said to be 'Dead-beat'. The damping systems used in measuring instruments are air friction damping, eddy current damping, fluid friction damping.

Q3. Explain how would you calibrate an ammeter by potentiometer

Ans. The calibrate is the process of checking the accuracy of the result by comparing it with the standard value.
It helps us in determining the error occur in the reading and adjusts the voltage for getting the ideal reading.
We calibrate an ammeter by potentiometer



The figure shows the circuit for the calibration of the ammeter with potentiometer.
The Standard resistance is connected in series with the ammeter which is to be calibrated. The poentiometer is used for measuring the voltage across the standard resister. To determines the current through the standard resistance

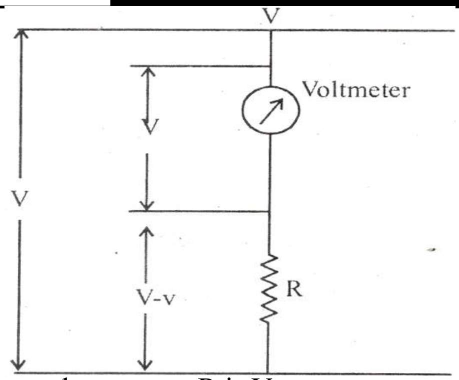
$$I = \frac{V_s}{S}$$

Where
V_S = Voltage across the standard resistor as indicated the potentiometer
S = Resistance of standard resistor
The method of calibration of the ammeter is VC accurate because in this method the value of standard resistance and the voltage across the potentiometer is exactly known by the instrument.

OR

Q3.Explain how the range of a voltmeter can be extended? Derive the expression required.

Ans. Multipliers are used for the range extension of voltmeters. The multiplier is a non-inductive high value resistance connected in series with the instrument whose range is to be extended. The combination is connected across the circuit whose voltage is to be measured.
Let
I_m = Full scale deflection current
R_m = gahanometer resistance
$V = R_m I_m$ = Full scale p.d across it
V = Voltage to be measured
R = Series resistance required.



Voltage drop across R is V-v
$R.I_m = V - v$

$$R = \frac{V - v}{I_m}$$

Q4. Write a short note on 'Gravity Control Method'.

Ans.Gravity Control Method : Refers to Chapter

OR

Q4. Define 'accuracy' precision', 'sensitivity' and 'resolution'.

Ans. (a) Accuracy : It is degree of closeness or conformity in which measured value approaches sa true value of quantity under measurement.
(b) Precision : It may be defined as the degree of closeness with which reading is produced again and again for the same value of input quantity. It is measure of consistency of the result.
(c) Sensitivity : It is defined as change in output quantity per unit change in input quantity.

$$S = \frac{\Delta q_o}{\Delta q_i}$$

(d) Resolution : It is defined as smallest change in input which can be measured by an instrument.

Q5. Discuss the effect of power factor variation on wattmeter readings in two wattmeter method.

Ans. We know that
Reading of P_1 wattmeter

$$P_1 = \sqrt{3}\,VI\cos(30-\phi)$$

Reading of P_2 wattmeter

$$P_2 = \sqrt{3}\,VI\cos(30+\phi)$$

Determine the different value of power factor
(a) With unity power factor $\cos\phi$ and $\phi = 0$

$$P_1 = \sqrt{3}\,VI\cos(30-\phi) = \sqrt{3}\,VI\cos 30^0$$

$$= \sqrt{3}\,VI \times \frac{\sqrt{3}}{2}$$

$P_1 = \frac{3}{2}VI$

$P_2 = \sqrt{3}\,VI\cos(30+\phi) = \sqrt{3}\,VI\cos 30^0$

$= \sqrt{3}\,VI \times \frac{\sqrt{3}}{2} = \frac{3}{2}VI$

Total power $P = P_1 + P_2$

$= \frac{3}{2}VI + \frac{3}{2}VI = 3VI$

At unity power factor, total power

$P = 3VI\cos\phi = 3VI$

Thus at unity power factor, the reading of the two wattmeter are equal, each wattmeter reads half of the total power.

(b) When power factor $\cos\phi = \frac{\sqrt{3}}{2}$ $\phi = 30^0$

$P_1 = \sqrt{3}\,VI\cos(30-\phi) = \sqrt{3}\,VI$

$P_2 = \sqrt{3}\,VI\cos(30+\phi) = \sqrt{3}\,VI\cos 60^0$

$P_2 = \frac{\sqrt{3}}{2}VI$

so $P_1 = 2P_2 =$

Total power $P = P_1 + P_2 = 3P_2$

$P = \frac{3\sqrt{3}}{2}VI$

At P.F $= \frac{\sqrt{3}}{2}$ the reading of one of the wattmeter is double than that of the other wattmeter.

(c) When power factor $\cos\phi = 0.5$ i.e. $\phi = 60^0$

$P_1 = \sqrt{3}\,VI\cos(30-\phi)$

$= \sqrt{3}\,VI\cos 30^0 = \frac{3}{2}VI$

$P_2 = \sqrt{3}\,VI\cos(30+\phi)$

$= \sqrt{3}\,VI\cos 90^0 = 0$

Total power

$P = P_1 + P_2 = \frac{3}{2}VI$

At power factor 0.5, one wattmeter reads total power and another wattmeter reads zero.

(d) When power factor $\cos\phi = 0$ i.e. $\phi = 90^0$

$P_1 = \sqrt{3}\,VI\cos(30-\phi)$

$= \sqrt{3}\,VI\cos(30-90) = \sqrt{3}\,VI\cos 60^0$

$= \frac{\sqrt{3}}{2}VI$

$P_2 = \sqrt{3}\,VI\cos(30+\phi)$

$= -\sqrt{3}\,VI\cos 30^0 = -\frac{\sqrt{3}}{2}VI$

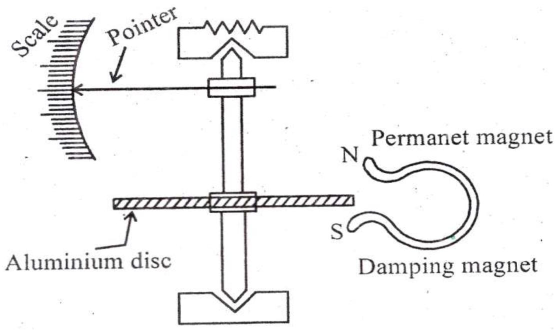
Total power

$P = P_1 + P_2 = \frac{\sqrt{3}}{2}VI - \frac{\sqrt{3}}{2}VI = 0$

OR

Q5. Explain how the damping torque is produced by Eddy current damping'.

Ans. An aluminum circular disc is fixed to the spindle this disc is made to move in the magnetic field produced by a permanent magnet. When the disc oscillates it cuts the magnetic flux produced by damping magnet. An emf is induced in the circular disc by faradays law.



Eddy current are established in the disc since it has several closed paths. By Lenz's law, the current carrying disc produced a force in a direction opposite to oscillating force. The damping force can be vairous by varying the projection of the magnet over the circular disc.

Q6. Explain creeping error.

Ans. *Refers to Chapter*

Group -C

Q7. What is an error? How many types of error are ? Explain any two of them.

Ans. Same as Chapter

OR

Q7. Discuss the desirable qualities of measuring instruments.

Ans. Same as Chapter

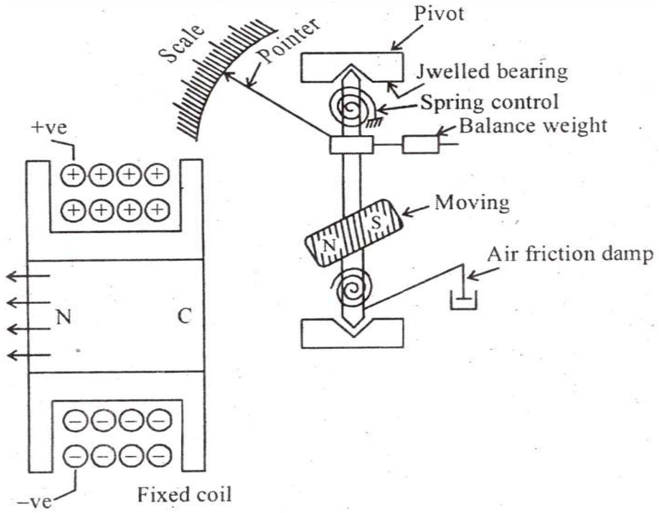
Q8. Explain construction and principle of moving iron attraction type instruments and derive the expression for deflecting torque.

Ans. The most accurate instrument used for both AC are DC measurement is moving iron instruments.

There are two types :

(i) Attraction type (ii) Repulsion type

The moving iron fixed to the spindle is kept near the hollow fixed coil.



The pointer and balance weight are attached to the spindle, which is supported with jeweled bearing. Here air friction damping is used.

Principle of operation :

The current to be measured is passed through the fixed coil. As the current is flow through the fixe coil, a magnetic field is produced. By magnetic induction the moving iron get magnetized.

The north pole of moving coil is attracted by the south poles of fixed coil. Thus the defecting force produced due to force of attraction. Since the more iron is attached with the spindle. The spindle rotates and the pointer moves over the calibrated scale. But the force of attraction depends on the current flowing through the coil.

Torque developed by M.I

Let θ be the deflection corresponding to a current of i amp.

Let the current increases by di the corresponding deflection is $\theta + d\theta$.

There is change in inductance since the position of moving iron change w.r.t the fixed electromgnet.

Let the new inductance value be L+dL

The current change by di at dt seconds

Let the emf induced in the coil be e volt.

$$e = \frac{d}{dt}(\text{Li}) = \frac{Ldi}{dt} + \frac{idL}{dt} \qquad ....(1)$$

Multiplying by idt in equation (1)

$$eidt = \frac{Lidi}{dt} \times idt + \frac{idL}{dt} + idt \qquad .... (2)$$

$$\text{eidt} = \text{Lidi} + i^2\text{dL} \qquad .... (3)$$

Equation (3) gives the energy is used into two form part of energy is stored in the inductance. Remaining energy is converted into mechanical energy which produce deflection

Change in energy stored

= Final energy - intial energy stored

$$= \frac{1}{2}(L + dL)(i + di)^2 - \frac{1}{2}Li^2$$

$$= \frac{1}{2}\left[(L + dL)(i^2 + di^2 + 2idi) - Li^2\right]$$

$$= \frac{1}{2}\left[(L + dL)(i^2 + 2idi) - Li^2\right]$$

$$= \frac{1}{2}\left[Li^2 + 2Lidi + i^2dL + 2ididL0Li^2\right]$$

$$= \frac{1}{2}\left(2Lidi + i^2dL\right)$$

$$= Lidi + \frac{1}{2}i^2dL$$

Mechanical work to move the pointer by dθ = $T_d\theta$

By low of conservation of energy

Electrical energy supplied = Increase in stored energy + mechanical work done.

Input energy + Energy stored + Mechanical energy

$$\text{Lidi} + i^2\text{dL} = \text{Lidi} + \frac{1}{2}i^2dL + T_d d\theta$$

$$\frac{1}{2}i^2dL = T_d d\theta$$

$$T_d = \frac{1}{2}i^2\frac{dL}{d\theta}$$

At steady state condition

$$T_d = T_c$$

$$\frac{1}{2}i^2\frac{dL}{d\theta} = k\theta$$

$$\theta = \frac{1}{2k}i^2\frac{dL}{d\theta}$$

$$\theta \propto i^2$$

When the instruments measure AC

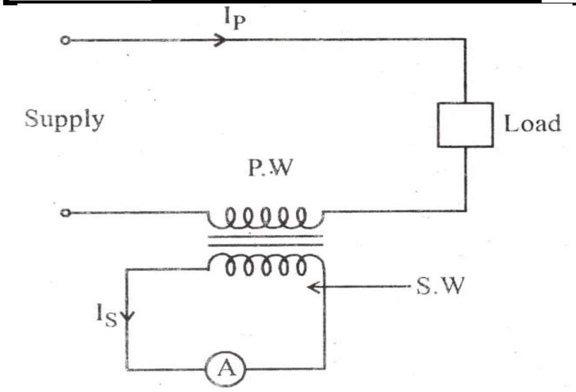
$$\theta \propto i_{rms}^2$$

Q8. What is instrument transformer ? Explain the construction and theory of current transformer. Draw its vector diagram.

Ans. Transformers used in conjunction with measuring instruments for measurement purpose are called instruments transformer.

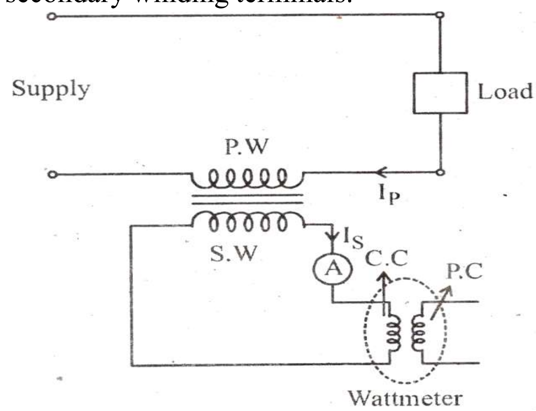
The transformer used for measurement of current is called a current transformer.

The primary winding is so connected that the current being measured passes through it and secondary winding is connected to an ammeter. The “CT” steps down the current to the level of ammeter.



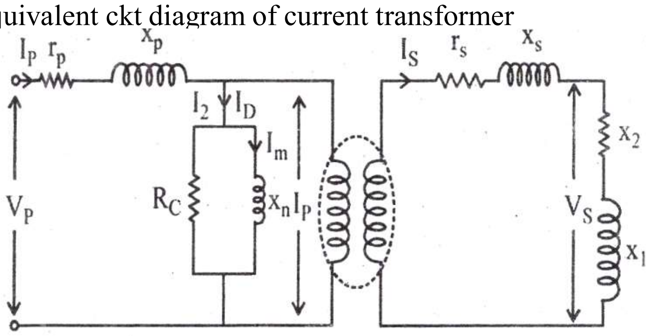
The current transformer is used with its primary winding connected in series with line carrying the current to be measured. The primary current is depend upon the load connected to the system and is not determined by the load connected on the secondary winding of the current transformer.

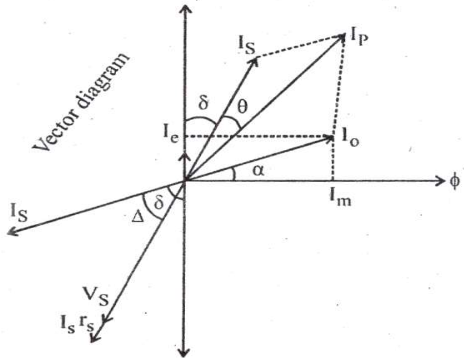
The primary winding consists of very few turns and there is no appreciable voltage drop across it. The secondary winding of the current transformer has large number of turns the exact number being determined by the turned the ammeter or wattmeter current coil connected directly across the secondary winding terminals.



A current transformer operates its secondary winding nearly under short circuit condition.

Equivalent ckt diagram of current transformer





Q9. A moving coil instrument has a resistance of 2Ω and FSD current of 50 mA. How can it be used to measure of (i) a current of 5A and (ii) a voltage of 500 V?

Ans. Given

$I_m = 50\text{mA}$, $R_m = 2\text{W}$

(i) $I_1 = 5\text{A}$

(ii) $V_1 = 500\text{V}$

(1) Short multiplying factor

$$\frac{I}{I_m} = \frac{5}{50\times10^{-3}} = \frac{5\times10^3}{50} = 100$$

$$R_{sh} = \frac{R_m}{m-1} = \frac{2}{100-1} = \frac{2}{99} = 0.02\Omega$$

(2) Voltage multiplying factor

$V = I_m \times R_m$

$V = 50 \times 2 \times 10^{-3} = 100\text{mv}$

$$\text{Ratio} = \frac{500}{100}\times10^3 = 5000$$

Multiplier resistance

$R_s = (m-1)\, R_m$

$= (5000-1) \times 2$

$= 4999 \times 2 = 9998\Omega$

OR

Q9. Explain the construction and principle of dynamometer type wattmeter. Derive the expression for deflection of ac operator.

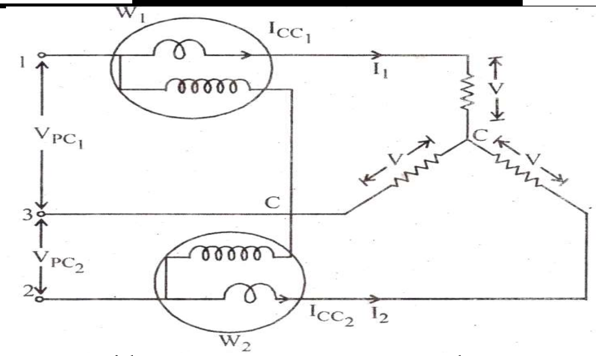
Ans. Same as Chapter

Q10. Explain how power is 3 phase circuit for balanced load can be measured by two wattmeter method. Draw the vector diagram.

Ans. In a three phase, three wire system, we require 3-elements, but if we make the common points of the pressure coils coincide with one of the line then we will require only n-1 = 3 - 1 = 2 elements.

Instantaneous power consumed by load is given

$P_1 = V_1 i_1 + V_2 i_2 + V_3 i_3$



Let us consider two wattmeters connected to measure power in three phase circuit in fig. (a) star connection.

Instantaneous reading of W_1 wattmeter

$$P_1 = i_1(V_1-V_3)$$

Instantaneous reading of W_2 wattmeter

$$P_2 = i_1(V_2-V_3)$$

Sum of instantaneous reading of two wattmeter

$$P = P_1+P_2$$

$$P = i_1(V_1-V_3) + i_2(V_2-V_3)$$

$$P = V_1i_1 + V_2i_2-V_3\,(i_1+i_2)$$

From kcl at node 0

$$i_1+ i_2+ i_3= 0$$

$$(i_1+i_2) = - i_3$$

Sum of instantaneous reading of two wattmeters.

$$P = V_1i_1 + V_2i_2+V_3i_3$$

Therefore,

The sum of the two wattmeter reading is equal to power consumed by the load.

This method is irrespective of whether the load balanced.

Power diagram/vector diagram

For a balanced star connected load.

Phase voltage

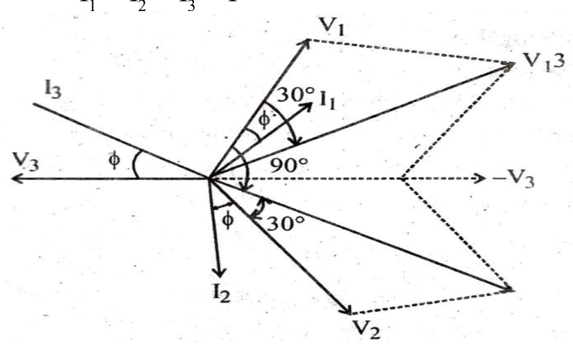
$$V_1 = V_2 = V_3 = V$$

Line voltage

$$V_{13} = V_{23} = V_{12} = \sqrt{3}V$$

Phase current

$$I_1 = I_2 = I_3 = I$$



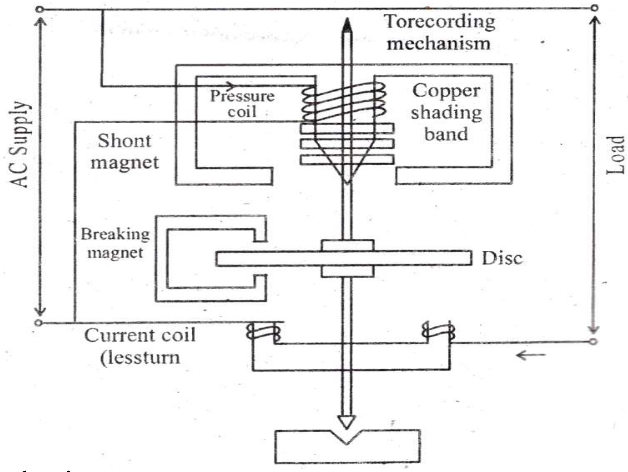
OR

Q10. Explain the construction and working principle of single phase induction type energymeter with neat ckt diagram and vector diagram.

Ans. The meter which is used for measuring the energy utilises by the electric load is known as the energy meter.

Construction of Energy meter :

The construction of the single phase energy meter



Induction type energy meter.

The energy meter has four main parts they are

1. Driving system
2. Moving system
3. Breaking system
4. Registering system

1. Driving system : The electromagnet is the main component of the arts system. It is the temporary magnet which is excited by the current flow through their coil.

The core of the electromegnet is made up of silicon steel lamination. The driving system has two electromagnet. The upper one is called the short electromgnet and the lower one is called series electromagnet.

The series electromagnet is excited by the load current flow through the current coil. The coil if 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. There bands are adjustable. The main function of the copper band is to align the flux produced by the shunt magent 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 it air gap of the two electromagnets. The eddy currents is induced in the disc because of the change of he magnetic field. The eddy current is cut by the magnetic flux. The interaction of the flux. The interaction of the flux are the disc induces the deflecting torque. When the devices consume power, the aluminium disc a starts rotating and after some number of rotation the disc displays the unit used by the load.

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 breaking torque opposes the movement of the disc thus reducer their speed. The permanent magnet is adjustable due to which the braking torque adjusted by shifting the magnet to the other radialpes.

Registration : The main function of the registration or counting is to record the number of rotation of the aluminium disc. Their rotation is directly proportion to the energy consumed by the loads in the kwt.

Working :

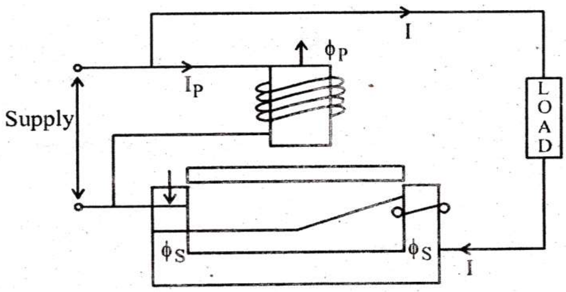
The energy meter has the all disc whose rotaion determines the power consumption of the load. The dics is placed between the air gap of the series and short electromagnet. The shunt magnet has the pressure coil and the series magnet has the current coil.

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

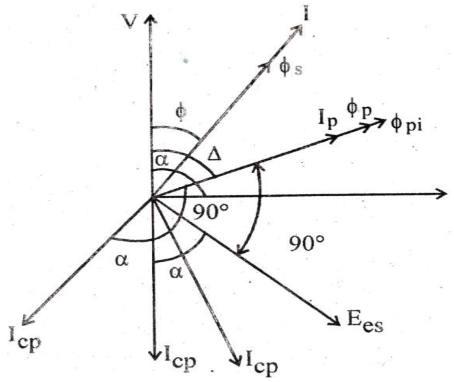
The field induces by the voltage coil is logging by 90^0 on the magnetic field of the current coil because of which eddy current induced in the disc.

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 control their rotation. The permanent magnet opposer the movement of the disc and equalises it on the power consumption. The cyclometer counts the rotation of the disc.



The phasor diagram of the energy meter.



Let :

V - applied voltage

I - load current

f - the phase angle of load current

I_p - pressure angle of load

Δ - the phase angle between supply voltage and pressure flux

F -Frequency

Z - impedance of eddy current

$\propto$ -the phase angle of eddy current paths

E_{ep} - eddy current induced by flux

I_{ep} - eddy current due to flux

E_{ev} - eddy current due to flux

I_{es} - eddy current due to flux

Q11. Explain the method of low resistance measurement by Kelvin Double Bridge with neat circuit diagram.

Ans. *Refers to Chapter*