Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

**1 Attempt any TEN of the following: 20**

1 a) Define following terms related to measuring instruments:
i) Sensitivity ii) Selectivity.

Ans:

**i) Sensitivity:** It is the ratio of the change in output signal to the change in input signal of quantity being measured. 1 mark each

**ii) Selectivity:** It is the term to describe fulfillment of the requirements of measurement by an instrument to be suitable for use in a given situation.

1 b) State the significance of term measurement.

Ans:

Measurement is the quantitative comparison between unknown quantities with known standard. For doing this process there is need of physical device, called as measuring instrument. The measurement confirms the validity of the hypothesis and also adds to its understanding. 2 marks

1 c) State the function of former and control spring in PMMC instrument.

Ans:

**Function of Former:** To support the coil and provide eddy current damping. 1 mark each

**Function of Control Spring:** To provide control torque or force and in some instruments springs can be used as current leads.

1 d) Identify the instrument transformer of Fig. 1(a) and Fig. 1(b).

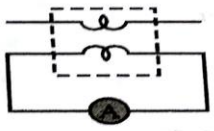


Fig. 1 (a)

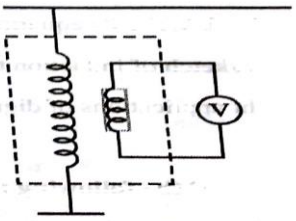


Fig. 1 (b)

Ans: 1mark each

**Figure 1(a):** Current Transformer(CT)

**Figure 1(b):** Potential transformer(PT)

1 e) Write any two disadvantages of ammeter shunts.

Ans:

**Disadvantages of ammeter shunts:** Any two disadvantages 1 mark each

1. Errors are caused because of change in temperature.
2. Most suitable for DC measurement.
3. Power loss takes place.

1 f) State any four errors that occur in dynamometer type wattmeter.

Ans:

**Errors that occur in dynamometer type wattmeter:** Any four errors ½ mark each

1. Errors due to method of connection.
2. Error due to pressure coil inductance.

3. Error due to pressure coil Capacitance.
4. Error due to mutual inductance effect**.**
5. Error due to stray magnetic fields.
6. Error due to eddy currents.
7. Temperature error.
8. Error due to vibration of moving system.

1 g) Write the expression for pf by two wattmeter method. State meaning of each term.
Ans:

**Expression for pf by two wattmeter method:** 1 mark

$\cos \emptyset = \cos\left[\tan^{-1}\frac{\sqrt{3}(W1-W2)}{(W1+W2)}\right]$ 1 mark

$W_1$,$W_2$ are two wttmeter readings.
$\emptyset$ is angle between phase voltage and phase current.

1 h) State any two advantages of digital energy meter over analog energy meter.
Ans:

**Advantages of digital energy meter:**

1) Easy to read.
2) High accuracy, high resolution and precision.
3) No frictional losses as there are no moving parts.
4) No external adujstments.
5) Large frequency range due to absence of moving parts.
6) Compact and portable.
7) It reduces the cost of theft and corruption.

Any two 1 mark each

1 i) Write the Ohmic range for low and high resistance.
Ans:

**Ohmic range for:** 1 mark each

1) **Low resistance:** Less than 1 ohm
2) **High resistance:** Greater than 0.1 Mega ohms.

1 j) State working principle of earth tester.
Ans:

**Working principle of Earth Tester:**

A DC is generated and fed to one of the two coils (current coil) placed (mutually fixed) at right angles to one another. The proportional current is then converted into AC and sent through the earth path whose resistance is to be measured. The voltage drop (alternating type) in the path due to this current is then converted into direct voltage and proportionally given to the second coil mentioned above (voltage coil). The set of the coils is placed between the poles of a magnet. The fluxes due to the two coils interact with the pole magnet field and create deflection depending on the ratio of the torques on voltage and current coils. As these torques are proportional to the respective quantities fed to the coils, the deflection is proportional to the resistance of earth section. 1 mark. 1 mark

1 k) List any four measure knobs on front panel on CRO.
Ans:

**Knobs on front panel of CRO:**

1. Power ON- OFF
2. Intensity control
3. Focus control
4. Astigmatism control
5. Volt/Div control
6. Vertical position control
7. Invert
8. Horizontal position control
9. Synchronization.
10. Channel selection.

Any four ½ mark each

1 l) List any four applications of function generator.

Ans:

**Applications of function generator:**

1. To test the bandwidth of audio frequency amplifier.
2. Used for troubleshooting of different analog and digital circuits.
3. Acts as source for alignment of receivers
4. For generation of different waves.

Any four ½ mark each

**2 Attempt any FOUR of the following**: **16**

2 a) State the meaning of secondary instrument. Classify secondary instruments.

Ans:

**Secondary instruments:**

- Gives reading directly of the quantity being measured.
- Calibrated with respect to absolute instruments

2 marks

**Classification** of **Secondary instruments:**

1. Depending on the principle of operation:
   i) Magnetic meters
   ii) Induction meters
   iii) Hot wire meters
   iv) Electrostatic meters
2. Depending on construction:
   i) Indicating instruments
   ii) Recording instruments
   iii) Integrating instruments
3. Depending on permissible error:
   i) Standard meters
   ii) Substandard meters
   **iii)** First grade instruments.

Classificati on on any two basis 1 mark each

2 b) List three types of errors in measuring instruments. Give reasons of occurring for any one of them.

Ans:

**Types of errors in measuring instruments:**

**A) Gross error:** These are due to mistakes on the part of person using the instrument.

**B) Systematic Error:**

**i) Instrumental Error:** These errors are caused due to the mechanical structure of measuring instrument. List 2 marks,
a) Inherent shortcomings of instruments: Instrument may read too low or too high. Reason 2 marks
b) Improper use of instruments: Improper handling e.g. overloading, overheating, failure to adjust zero, use of high resistance leads.
c) Loading effect: cause distortion in original signal.

**ii) Environmental Error:** These are because of surrounding conditions such as temperature, pressure, humidity, dust, vibrations, or external magnetic fields or electrostatic fields.

iii) **Observational Error:** Parallax errors, incorrect multiplying factor.

**C) Random error:** These persist even after gross and systematic errors are removed.

2 c) Compare PMMC and MI instruments on the following points:
i)Nature of scale ii) Working principle iii) Damping iv) use
Ans:

**Comparison of PMMC and MI instruments:**

| Points | PMMC instruments | MI instruments |
|---|---|---|
| **Nature of scale** | Uniform | Non-uniform |
| **Working principle** | When current carrying conductor is placed in a constant magnetic field, it experiences a force proportional to the current and produces proportional deflection | Piece of iron is attracted /repelled by magnet or induced magnetic field due to the quantity to be measured. |
| **Damping** | Eddy current | Air friction |
| **Use** | Used for only DC measurements | Used for DC as well as AC measurements |

1 mark each

2 d) Draw a neat circuit for reactive power measurement by one wattmter in star connected load. Write its equation.
Ans:

**Reactive power measurement by one wattmter in star connected load:**

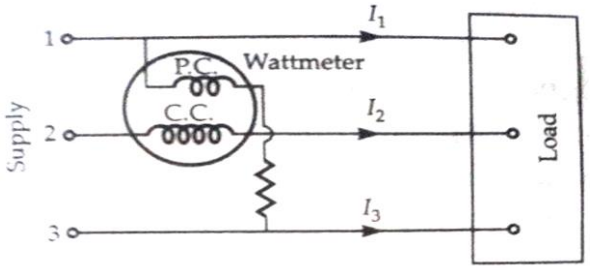



Diagram 2 marks

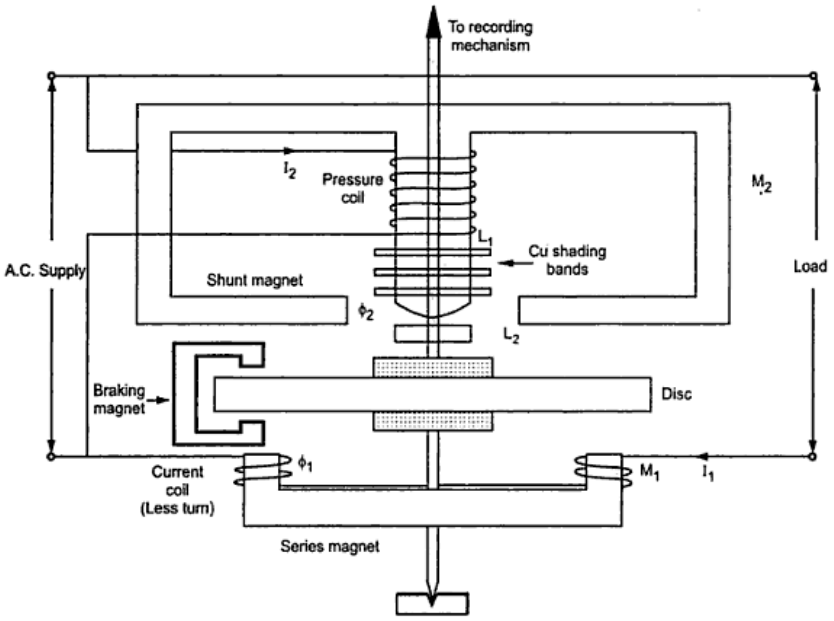
$$Wattmeter\ reading = V_L\ I_L \sin \emptyset$$

Reactive Power =√3 x Wattmeter reading in VAR.

Equations 2 marks

2 e) Draw a neat sketch of induction type 1 phase energy meter. Lable its parts.
Ans:

**Induction type 1 phase energy meter:**




Labeled diagram 4 marks

Partially Labeled diagram 3 marks

Unlabeled diagram 2 marks

2 f) List any eight applications of digital multimeter.

Ans:

**Applicatios of digital multimeter:**

1. Measurement of DC voltage.
2. Measurement of DC current.
3. Measurement of AC voltage.
4. Measurement of AC current.
5. Measurement of resistance.
6. Continuity testing.
7. Testing of transistors.
8. Measurement of frequency.
9. Testing of diode.

½ marks each any 8 applications

3 **Attempt any FOUR of the following**: 16

3 a) Write one advantage and one disadvantge each for spring control method and gravity control method.

Ans: **A)Spring control method:**

**Advantages:**

1) The spring control meters can be used in any position.
2) In some instruments springs can be used as current leads.
3) As springs are light in weight, practically there is no increase in weight of the moving system hence high torque to weight ratio.
4) Controlling torque can be adjusted easily.
5) Scale is uniform.

Any one advantage & disadvantage 2 marks

**Disadvantages**:

1) Temperature change affects spring length causing change in magnitude of controlling torque.
2) Accidental stress in the springs may damage them & spring get a permanent set if

stressed beyond their elastic limit.

**B)Gravity control method:**

**Advantages:**

1) Simple and economical method.
2) Unaffected by temperature changes.
3) Not subjected to fatigue.

Any one advantage & disadvantage 2 marks

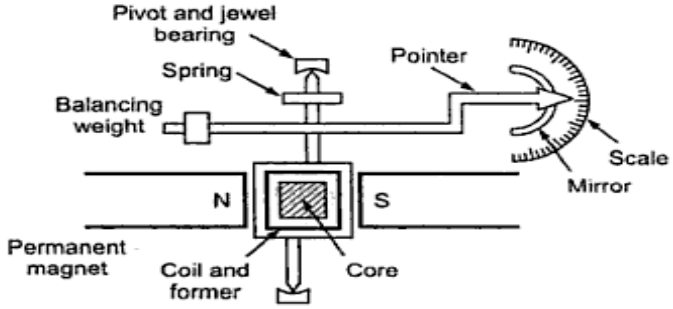
**Disadvantages**:

1) Instrument has to be kept in vertical position.
2) Scale is non-uniform.
3) Control weights add to the weight of instrument.

3 b) Draw a neat sketch of PMMC type instrument and label it.

Ans:

**PMMC type instrument:**




**Or Equivalent figure**

Labeled 4 marks, Unlabeled 2 mark, Partially labeled 3 marks.

3 c) A moving coil instrument gives FSD of 15mA and has a resistance of 100Ω. Calculate the value of shunt resistance so that it can be used as 0- 2.5 -5 A ammeter.

Ans**:**

**Given:**

FSD = $I_m$ = 15mA =$15\times10^{-3}$A, $R_m = 100\Omega$.

A) Value of shunt resistance for 2.5 A current range

$$R_{Sh} = \frac{Im\,Rm}{I-Im} = \frac{15\times10^{-3}\times100}{(2.5-15\times10^{-3})} = 0.603\Omega$$

2 marks

B) Value of shunt resistance for 5 A current range

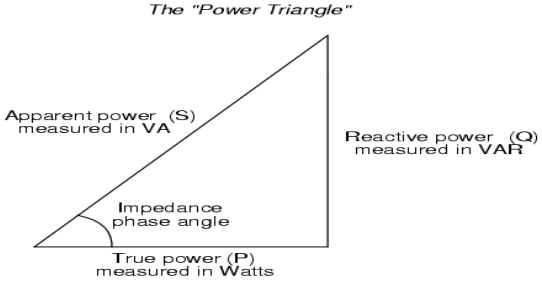
$$R_{Sh} = \frac{Im\,Rm}{I-Im} = \frac{15\times10^{-3}\times100}{(5-15\times10^{-3})} = 0.3009\Omega$$

2 marks

3 d) Draw a power triangle. Name each side with relation and unit.

Ans:

**Power triangle:**




Triangle 2 marks, Units 1 mark,

**Relations**:

True Power, P = V I CosΦ
Reactive Power, Q = V I SinΦ
Apparent Power, S= V I

Relations 1 mark

3 e) List any four errors in induction type energy meter. Give methods of compensation for each.

Ans:

**Errors in induction type energy meter with methods of compensation:**

1) **Error due to friction:** This error can be compensated by the additional shading band provided on the shunt electromagnet.
2) **Phase or low p.f. error:**To overcome this error the shading band is provided on the cetral limb of the shunt electromagnet.
3) **Error due to temprature variation:** The effects of temprature changes on the driving and braking system tend to balance each other, hence no need of compensation.
4) **Error due to variation of frequncy:** The frequency should be kept constant.
5) **Creeping error:** This error can be compensted by providing two small holes on the disc diametrically opposite side.When the hole comes under the pole of a shunt magnet,the disc stops running.
6) **Error in Registration:** This error can be compensted by adusting the braking magnet or changing registering system.
7) **Speed error:** This error can be compensted by readusting the compensating mechanism.
8) **Overload error:** This error can be compensated by providing a 'flux diverter' to the current magnet.

Any four errors with compensation 1 mark each

3 f) Write any two applications each of (i) Megger (ii)Earth tester.

Ans:

**i)Applications of Megger:**

Used for measurment of insulation resitance of – Trasfomer windings, motor windings, undergrond cables,insulating wires,overhed insulators etc.

**ii)Applications of Earth tester:**

Used for measurment of earth resistance of – generating stations, sub-stations, Residential/ commercial/industrial installations etc.

2 marks each

**4 Attempt any FOUR of the following: 16**

4 a) Name any four parts of MI instrument and state material for each.

Ans:

**Parts of MI instrument:**

1. Moving iron: Soft iron material is used.
2. Fixed iron: Soft iron material is used.
3. Spring: Phosphor bronze material.
4. Coil: Copper material.
5. Pointer**:** aluminum material.
6. Spindle**:** steel material.
7. Jeweled bearing: Bearing metal.
8. Damping vane & chamber: Iron sheet.

Any four parts with material 1 mark each

4 b) Write any four advantages of instrument transformer.

Ans:

**Advantages of instrument transformer:**

1. Extension of instrument range is possible.
2. Isolation of instruments from high voltage side.
3. Power loss is less as compared to shunts and multipliers.
4. Same instrument transformers can be used for different quantity measurement.
5. It is economical method of range extension.
6. Increases in safety of operator.

Any four advantages 1 mark each

4 c) State the effects of errors in dynamometer type wattmeter due to-

i) pc- inductance
ii) pc- capacitance
iii) mutual inductance
iv) Connection.

Ans:

**Errors in wattmeter:**

**i) pc - inductance:** Pressure coil inductance causes wattmeter to read more power than actual .

**ii) pc-capacitance:** The wattmeter reads less power.

**iii) Mutual inductance:** An emf induced in pressure coil due to current through the current coil. This emf of pressure coil opposes applied voltage.

**iv) Connection:** In uncompensated wattmeter , the reading of wattmeter includes the powerloss in coils.

1 mark each

4 d) Show that the torque produced in a 1- Φ dynamometer type wattmeter is proportional to the power to be measured.

Ans:

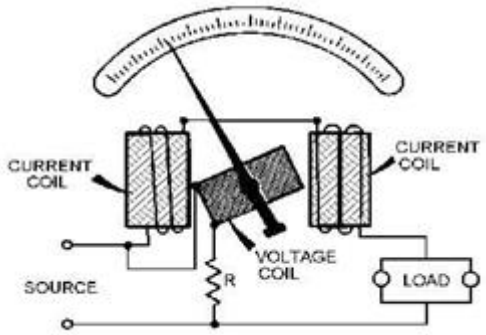



Diagram 1 mark

The deflecting torque $T_d$ is directly proportional to the product of current through current coil, current through pressure coil and pf, cosΦ. i.e.

$$Td\ \alpha\ (Ic \times Ip \times \cos\Phi)$$

Where Ic = Current flowing through C.C. and load

Ip = Current flowing through P.C.

Here $Ic=I_L$ And $Ip = \frac{V}{Rp}$

Where V = Voltage across P.C.

Rp =Resistance of pressure coil

We know $Td\ \alpha\ (Ic \times Ip \times \cos\Phi)$

$$Td\ \alpha\ (I_L \times \frac{V}{R_P} \times \cos\Phi)$$

$Td\ \alpha\ V \times I_L \times \cos\Phi$ (Since Rp is constant )

$$Td\ \alpha\ Power$$

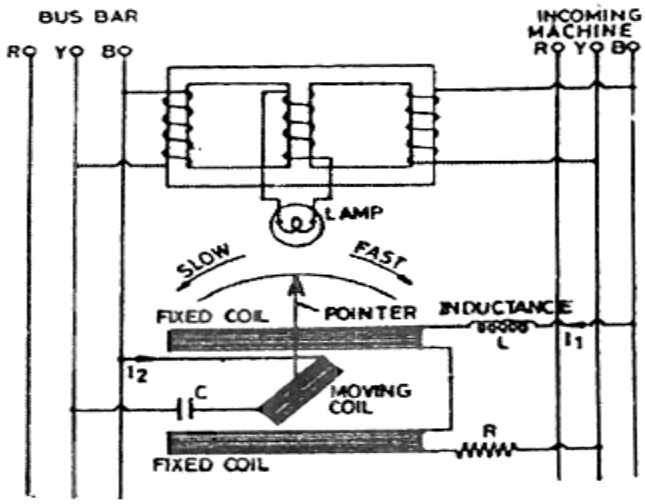
Derivation 3 marks

4 e) With neat sketch explain working of Weston type synchroscope.

Ans:

**Weston type synchroscope:**

**Working:** It consists of three limbed transformer. The winding on one of the outer limbs is excited from bus- bars and that on other limb by incoming machine. The two fluxes produced




by outer limbs are forced through the central limb. The resultant flux through central limb is equal to the Phasor sum of these fluxes.

When bus-bar and incoming machine voltages are in phase, the emf induced in central limb winding is maximum hence lamp glows with maximum brightness. When bus-bar and incoming machine voltages are $180^o$ out of phase, the emf induced in central limb is almost zero and lamp does not glow. When frequency of incoming machine is different than that of bus-bar, the lamp will flicker. Diagram 2 marks

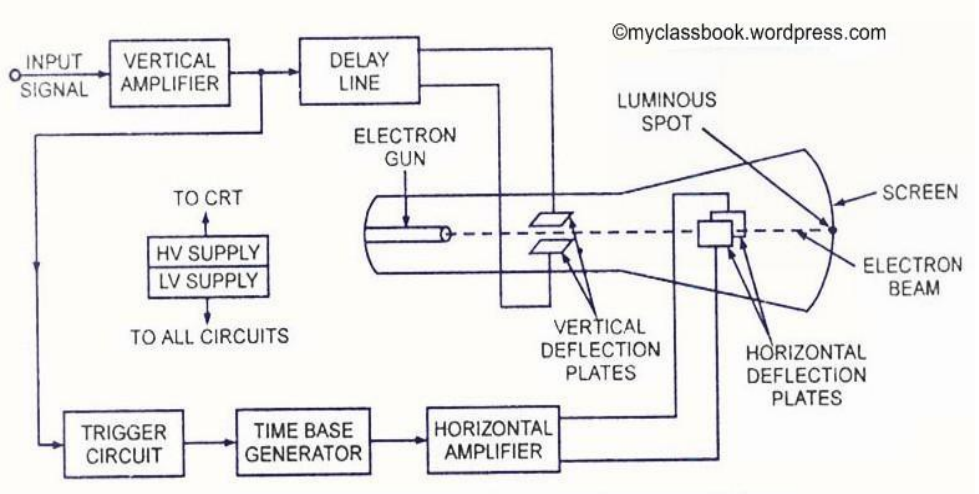
The correct instant of synchronizing is when the lamp is flickering at a very much slow rate and it is at its maximum brightness. Working 2 marks

4 f) Draw a neat block diagram of CRO and state function of each block.

Ans:

- Vertical amplifier strengthens the input signal applied to vertical depleting plates
- Trigger circuit gives input to time base circuit 2 marks
- The output of time base generator is amplified by horizontal amplifier and then applied to horizontal deflecting plates of CRT
- CRT consists of electron gun assembly which include thermally heated cathode, accelerating anode, focusing anode
- The electron beam coming out from electron gun assembly enters to deflecting plates.

The screen of CRT internally coated with Phosphors material on which we observe waveform of the input signal.

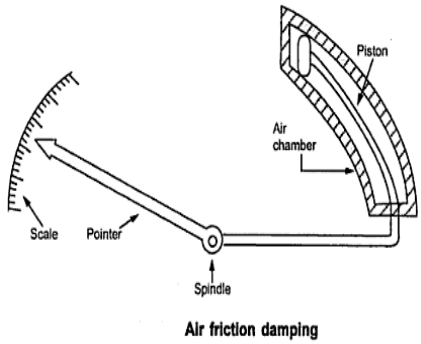



Labeled diag. 2 marks, Unlabeled 1 mark

**5 Attempt any FOUR of the following: 16**

5 a) Describe with neat sketch working of air friction damping used in instruments.

Ans:



Air friction damping

**Air friction damping:** air trapped in the chamber works as damping medium for the piston movement connected to the spindle. The piston moves in the air chamber. The clearance between piston and air chamber wall is very small. When the pointer system moves in either direction the piston arm experiences an opposing force due to either compression action on one side and opposition to expansion on the other side. Thus the oscillations of the pointer system are damped by the opposition by the damping system. The damping torque is directly proportional to the speed at which the piston (pointer/spindle) moves. Hence greater the speed higher will be the damping torque bringing the pointer to the equilibrium position quickly.

5 b) Write step by step procedure for calibration of ammeter.

Ans: **Procedure of calibration of ammeter:**

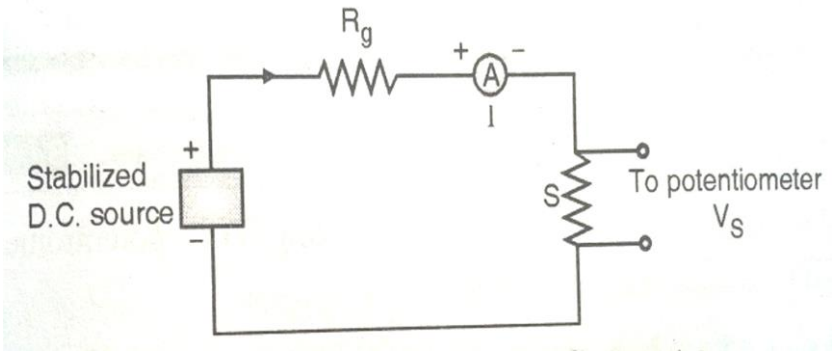



Diagram 2marks

In this methos DC potentiometer used for measurement of voltage across a standard low resistance.

- Connect the circuit as shown in above fig. the ammeter to be calibrated is connected in series with standard resistance and regulating resistace Rg.
- By varying Rg, voltage across potentiometer (S) is measured. Before measurement potentiometer is required to be standardized. At the same time current through ammeter is also measured (I). i.e. reading of ammeter under calibration.

Explanation 2 marks.

**OR**

The sub-standard or calibrated meter and meter under test are connected in series and readings are noted for corresponding currents.

- At each step, true value of ammeter is calculated as,

Where, Vs= Voltage across potentiometer

S= resistance of potentiometer.

and I are compared for finding out error in ammeter.

5 c) State the meaning of multiplying factor. 1-Φ wattmeter rated for 500V, 10A have FSD of 1000 W. Calculate its multiplying factor.

Ans:

Multiplying Factor is used for calculating the final value of wattmeter reading. Its

value is calculated by

multiplying factor = $\frac{Voltage\ Range \times Current\ Range \times PF}{FSD}$ 2 marks

multiplying factor = $\frac{500 \times 10}{1000} = 5$ 2 marks

5 d) Write any four merits of two wattmeter method for 3- Φ power measurement.

Ans:

**Merits of two wattmeter method:**

1. This method can be used for balanced as well as unbalanced loads.
2. Connections of wattmeters are independent of load connection.
3. For balanced loads PF can also be determined.
4. Only two wattmeters are required for power measurement which reduces cost.
5. Reactive power can also be measured for balanced loads.

Any four merits 1 mark each

5 e) Draw a neat block diagram of LCR meter. Label each block.

Ans:

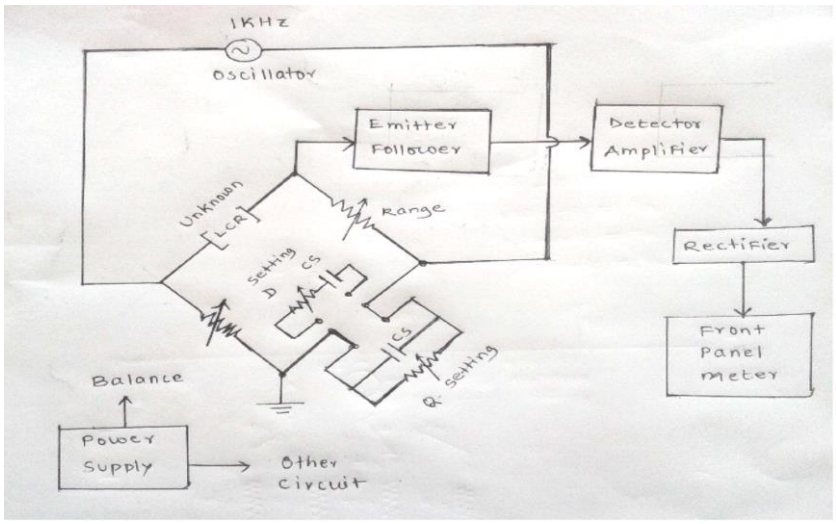
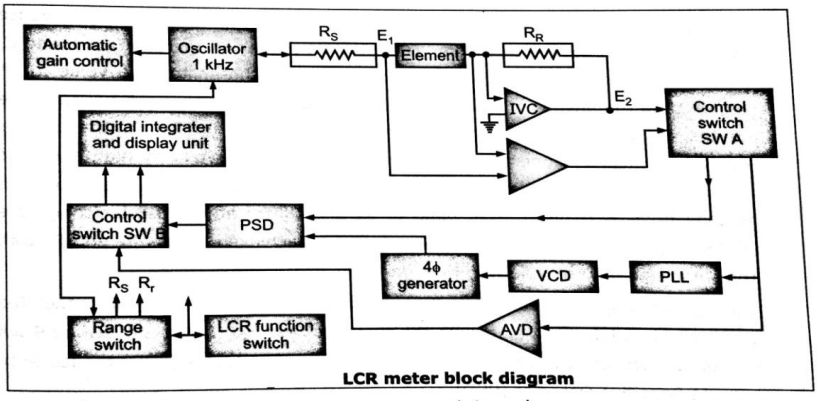



Diagram: labeled 4 marks,

unlabeled 2 marks,

partially labeled 3 marks.

**OR**




5 f) Draw a neat circuit to measure power of 3- Φ balanced star connected load used one wattmeter. Explain its working.

Ans:

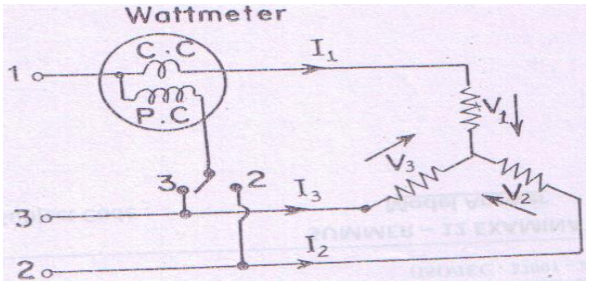



Diagram 2 marks

Here two readings of wattmeter are taken with a single wattmeter as shown in figure. The current coil of wattmeter is connected in one line and pressure coil is connected alternately between other two lines. The algebraic sum of two readings gives the total power drawn by balanced 3 phase star connected load.

In one wattmeter method the readings of wattmeters are given by the equations:

When switch is at position 3

$W_1 = V I \cos(30+ø)$

and When switch is at position 2

$W_2 = V I \cos(30-ø)$

And total power, $P = W_1 + W_2$

Working 2 marks

**6 Attempt any FOUR of the following: 16**

6 a) Derive the relation of shunt resistance for extension of ammeter range.

Ans: **Ammeter shunt:**

Let ,

$R_m$ = ammeter resistance, $R_{Sh}$ = Shunt resistance, $I_m$ = Full scale deflection of ammeter

$I_{Sh}$ = Shunt current

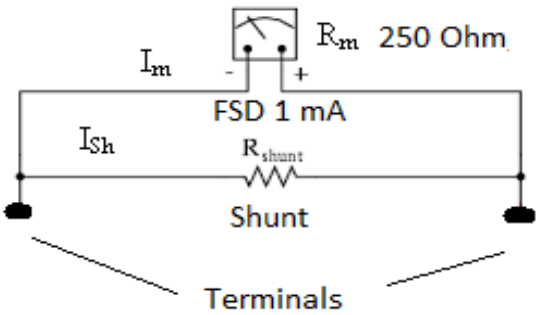



Diagram 1 mark (or equivalent)

$I = I_{Sh} + I_m$

$I_{Sh} = I - I_m$

As voltage across shunt and ammeter is same, hence

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

$(I - I_m) R_S = I_m R_m$

$R_s = \frac{I_m R_m}{(I - Im)}$

Derivation 3 marks

6 b) Find the total power consumed and pf of a balanced load when supplied with 400 V, 3- Φ, 50 Hz supply. Two wattmeters give readings as

i) Both reads 6 kW

ii) One reads 6 kW and other reads zero.

Ans:

**i) When both wattmeter reads 6 kW:**

Total power consumed= 6 + 6 = 12 kW

Pf = $\cos \emptyset = \cos\left[\tan^{-1} \frac{\sqrt{3}(W1-W2)}{(W1+W2)}\right]$

2 marks

$\cos\left[\tan^{-1}\frac{\sqrt{3}(6-6)}{(6+6)}\right]$ = Cos 0 = 1

**ii) One reads 6 kW and other reads zero:**

Total power consumed= 6 + 0 = 6 kW

Pf = $\cos\emptyset = \cos\left[\tan^{-1}\frac{\sqrt{3}(W1-W2)}{(W1+W2)}\right]$ 2 marks

$\cos\left[\tan^{-1}\frac{\sqrt{3}(6-0)}{(6+0)}\right]$ = Cos 60 = 0.5

6 c) State the function and shape of following parts used in induction type energy meter:

i) Series magnet
ii) Shunt magnet
iii) Al disc
iv) Brake magnet

Ans:

**i) Series magnet:** produce flux proportional to current (load current) of circuit and interact in the aluminum disc with flux produced by voltage magnet for torque production. Its shape is like letter U.

**ii) Shunt magnet:** produce flux proportional to voltage of circuit and interact in the aluminum disc with flux produced by current magnet for torque production. It is in the form of three-limb core. Its shape is like letter E.

**iii) Aluminum disc:** rotates due to interaction of fluxes by current & voltage magnet. Its shape is like circular lamina.

**iv) Brake magnet:** brakes the motion of the aluminum disc or slows it down. Its shape is like letter C.

1 mark each point

6 d) Name two methods for measurement of low, medium and high resistance. Give one advantage and one limitation of V- I method.

Ans:

**Methods for measurement of low resistance:**

1. Ammeter voltmeter method
2. Kelvin's bridge method
3. Ohm meter method
4. Potentiometer method
5. Digital/analog multi-meter method.

Any two methods 1 mark

**Methods for measurement of medium resistance:**

1. Ammeter voltmeter method
2. Digital/analog multi-meter method.
3. Wheatstone bridge method
4. Substitution method.
5. Carry- foster method

Any two methods 1 mark

**Methods for measurement of high resistance:**

1. Direct deflection method
2. Loss of charge method
3. Megger

Any two methods 1 mark

**Advantages of V-I method:**

1. Simple and economical method
2. Resonably accurate

One advantage

3. Instruments for test are easily available. ½ mark

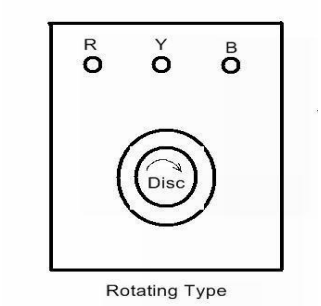
**Limitation of V- I method:**

1. Ammeter resitance must be zero and voltmeter resitance must be infinity for perfectly accurate measurment which is not possible. One limitation
2. Connection errors. ½ mark

6 e) Explain working of rotating type phase sequence indicator.

Ans:

**Rotating type phase sequence indicator:**



Rotating Type

1 mark for diagram

Consists of three coils mounted $120^0$ apart in space. The three ends of coils are brought out and connected to three terminals marked R-Y-B as shown in figure. The coils are star connected and are excited by supply whose sequence is to be determined. An aluminum disc is mounted on the top of coils. The coils produce rotating magnetic field, when three phase windings are energized by three phase supply. Which sweeps the stationary aluminum disc and produces eddy emf induced in the disc which circulates an eddy current in aluminum disc. A torque is produced with the interaction of eddy currents with the field. The disc revolves because of the torque and the direction of rotation depends upon the phase sequence of the supply. An arrow indicates the direction of rotation of the disc. If the direction of the rotations is same as that indicated by arrow head, the phase sequence of the supply is same as the marked on the terminals of the instrument. However if the disc revolves opposite to the direction indicated to arrow head, the sequence of the supply is opposite to that marked on the terminals.

3 marks for working

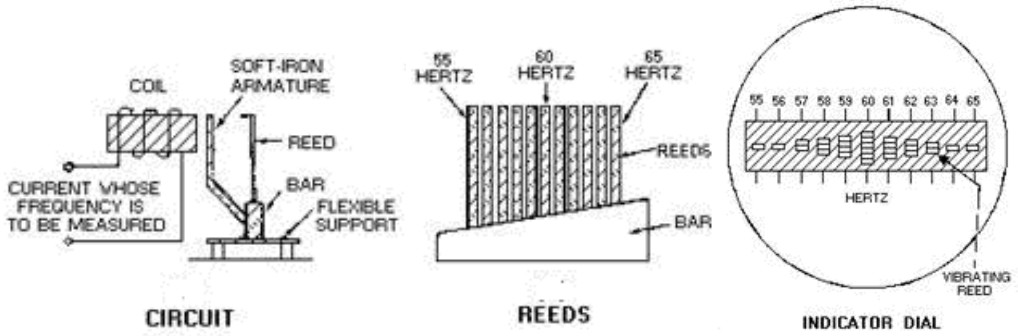
6 f) List different types of frequency meter. Explain working of reed type frequency meter.

Ans:

**Types of frequency meters**

1) Mechanical resonance (Vibrating reed) type
2) Electrical resonance type
3) Weston type
4) Ratio-meter type
5) Saturable core type
6) Digital type

½ mark each any two = 1 mark




Any one figure = 2 marks

**Working of reed type frequency meter**

When the instrument is connected across the supply whose frequency is to be measured,

an alternating flux is set up. Due to this flux an attractive force is experienced upon the reeds after every half cycle. Consequently the reeds tend to vibrate but only the reed whose actual frequency is double of supply frequency will be in resonance and vibrate with maximum amplitude normally the vibration other reeds is so slight as to be unobservable. 1 mark for working