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Internal Test II–OCT 2019

Sub:	**ELECTRICAL AND ELECTRONIC MEASUREMENTS**							Code:	18EE36
Date:	14/10 /2019	Duration:	90 mins	Max Marks:	50	Sem:	III(A&B)	Branch:	EEE

Note: Answer any **FIVE** full questions with neat diagram wherever necessary.

		Marks	OBE CO	OBE RBT
1.	Explain the construction and working of 1-phase induction type energymeter.Discuss the various adjustments in brief required in energymeter for accurate reading.	[10]	CO2	L2
2a.	Write a short note on Weston type frequency meter.	[5]	CO2	L3
2b.	Write a short note on phase sequence indicator.	[5]	CO2	L3
3.	Explain the construction of electrodynamometer type wattmeter and derive the torque expression.	[10]	CO2	L2
4.	Measurement of three phase real power in three phase circuit by two wattmeter method. Explain with a neat phasor diagram.	[10]	CO2	L2
5.	With a neat block diagram explain the working of true rms reading voltmeter.	[10]	CO4	L1
6.	With a neat block diagram explain the working of Electronic energymeter.	[10]	CO4	L1
7a.	The meter constant of a 230 V,10A watthour meter is 1800 revolutions per kWh. The meter is tested at half load and rated voltage and unity power factor. The meter is found to make 80 revolutions in 138sec.Determine the meter error at half load.	[5]	CO1	L3
7b.	A wattmeter has a current coil of 0.03ohm resistance and a pressure coil of 6000ohm resistance. Calculate the percentage error if the wattmeter is so connected that: (i)The current coil is on the load side (ii)The pressure coil is on the load side (a)If the load takes 20A at a voltage of 220V and 0.6 power factor in each case. (b) what load current would give equal errors with the two connections ?	[5]	CO1	L3

----ALL THE BEST----

1(a)SINGLE PHASE ENERGY METER

The induction type single phase energy meters are universally used for energy measurements in domestic and industrial establishments since they possess some of the very useful features such as :

Accurate characteristics

Lower friction

Higher torque weight ratio

Cheaper manufacturing methods and

Ease of maintenance.

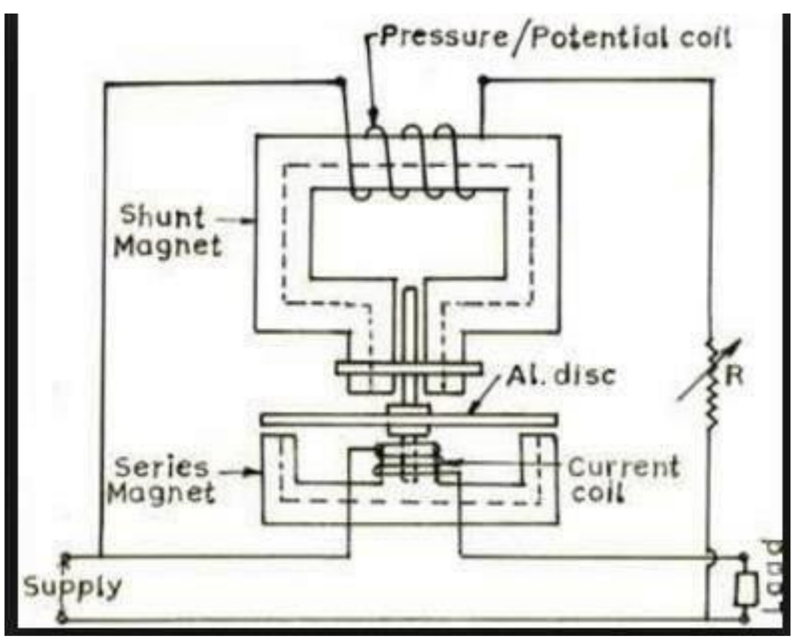
Constructional Details

The single phase induction energy meter is schematically shown in figure.Basically, it has four systems of operation: driving system, moving system, braking system and registering system. Driving system consists of a series magnet and a shunt magnet. The coil of the series magnet is excited by load current while that of the shunt magnet is excited by a current proportional to the supply voltage. These two coils are respectively referred as current coil and potential coil (or pressure coil) of the energy meter.

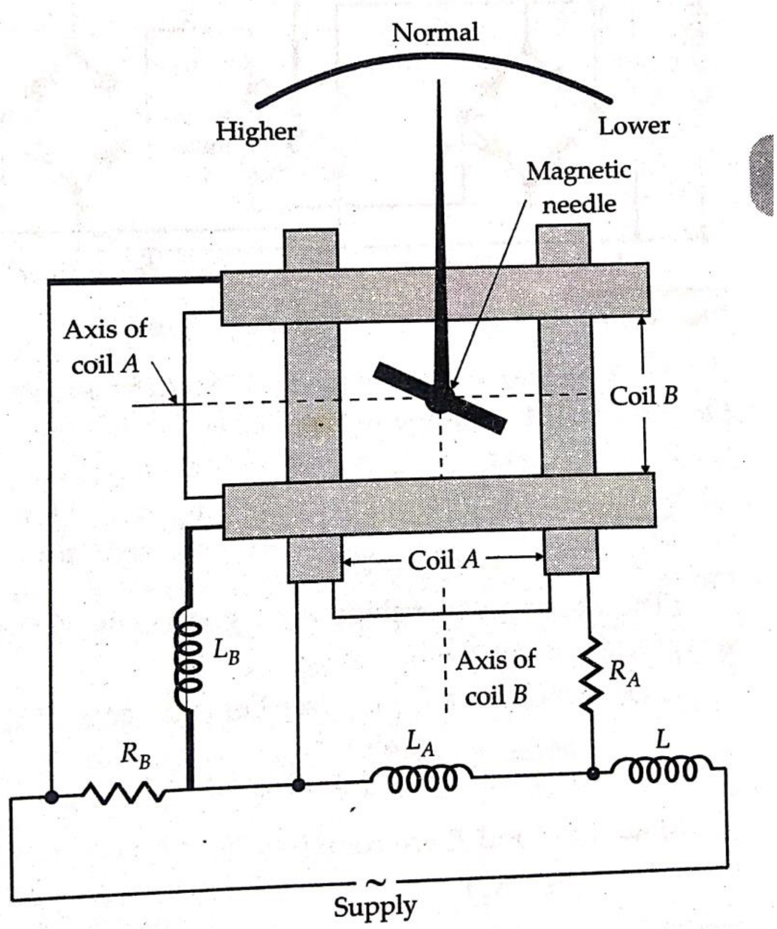
Moving system consists of a freely suspended, light aluminum disc mounted on an alloy shaft and placed admidst the air-gap of the two electromagnets.

Braking system consists of a position-adjustable permanent magnet placed near one edge of the disc. When the disc rotates in the gap between the two poles of the brake magnet, eddy currents are set up in the disc. These currents react with the brake magnet field and provide the required braking torque damping out the disc motion if any, beyond the required speed.. The brakingtorque can be adjusted as required by varying the position of the braking magnet.

Recording system is a mechanism used to record continuously a number which is proportional to the revolutions made by the disc. Thus it is the counter part of the pointer and scale of indicating instruments. The shaft that supports the disc is connected by a gear arrangement to a clock mechanism on the front of the meter. It is provided with a decimally calibrated read out of the total energy consumption in KWh.



The energy meter operates on the principle of Ferraris type meter. The supply voltage is fed across the potential coil as shown in figure 8.3. The current through the potential coil is proportional to the applied voltage and lags it by nearly 90^0, since its winding resistance is very small. The potential coil current- I_P produces a flux- ϕ_{PT}, which divides into ϕ_g, a major portion across the side gaps and ϕ_P across the disc, whose magnitude is smaller. Thus, flux- ϕ_P is responsible for producing the driving torque. It is proportional to I_P and is in phase with it. Flux- ϕ_P induces an eddy EMF in the disc setting up an eddy current- i_P. The load current- I flows through the current coil and produces a flux- ϕ_S. It is proportional to I and is in phase with it. Flux- ϕ_S induces an eddy EMF in the disc setting up an eddy current- i_S. The phasor diagram of the energy meter under working conditions is as shown in figure 8.4. The eddy current- i_S interacts with ϕ_P to produce a torque. The eddy current- i_P also interact with ϕ_S to produce another torque. These two torques are in opposite directions and hence the net torque, which is the difference between them, causes the disc to rotate.



2(a) **Fig. 13.16** Weston frequency meter.

(b) We have three phase system and by convention we write three phases as RYB. **Phase sequence indicator** is the indicator that determines the phase sequence of the three phase supply system.

When we give conventional three phase supply (i.e. RYB) to the induction motor, we see that the direction of the rotation of the rotor is in clockwise direction. Now what will happen to direction of rotation of rotor if the phase sequence is reversed, the answer to this question is that the rotor will rotate in the anticlockwise direction. Thus, we see that the direction of rotation of rotor depends on the phase sequence. Let us study how these phase instruments work and on what principle they work. Now there are two types of **phase sequence indicators** and they are:

1. Rotating type
2. Static type.

Rotating Type Phase Sequence Indicators

It works on the principle of induction motors. In this coils are connected in star form and the supply is given from three terminal marked as RYB as shown in the figure. When supply is given the coils produces the rotating magnetic field and these rotating magnetic fields produces eddy emf in the movable aluminium disc as shown in the diagram. These eddy emf produces eddy current on the aluminium disc, eddy currents interact with the rotating magnetic field due this a torque is produced which causes the light aluminum disc to move. If the disc moves in the clockwise direction then chosen sequence is RYB and if the direction of rotation is in anticlockwise the sequence is reversed.

Static Type Phase Sequence Indicators

When the phase sequence is RYB then the lamp B will glow brighter than the lamp A and if the phase sequence is reversed then the lamp A will glow brighter than the lamp B. Now let us see how this happens.

Here we assume that the phase sequence is RYB. Let us mark voltages as V_{ry}, V_{yb} and V_{br} as per the diagram. We have

$$V_{ry} = V$$

$$V_{yb} = V(-0.5 - j0.866)$$

$$V_{br} = V(-0.5 + j0.866)$$

Here we have assumed balance operation such that we have $V_{ry}=V_{br}=V_{yb}=V$. Since algebraic sum of all the phase currents is also equal, therefore we can write

$$I_r + I_y + I_b = 0$$

On solving the above equations we have ratio of I_r and I_y equals to 0.27. It implies that the voltage across the lamp A is only 27 percent of that of lamp B. Hence from this we can conclude that the lamp A will glow dimmer in case of RYB phase sequence while in case of reversed phase sequence we have lamp B is dimmer than lamp A. There is another kind of phase indicator also that works similar to that of the previous one.

(3) Now let us look at constructional details of electrodynamometer. It consists of following parts.

There are two types of coils present in the electrodynamometer. They are :

Moving Coil

Moving coil moves the pointer with the help of spring control instrument. Limited of current flows through the moving coil so as to avoid heating. So in order to limit the current we have connected the high value resistor in series with the moving coil. The moving is air cored and is mounted on a pivoted spindle and can move freely. In **electrodynamometer type wattmeter**, moving coil works as pressure coil. Hence moving coil is connected across the voltage and thus the current flowing through this coil is always proportional to the voltage.

Fixed Coil

The fixed coil is divided into two equal parts and these are connected in series with the load, therefore the load current will flow through these coils. Now the reason is very obvious of using two fixed coils instead of one, so that it can be constructed to carry considerable amount of electric current. These coils are called the current coils of **electrodynamometer type wattmeter**. Earlier these fixed coils are designed to carry the current of about 100 amperes but now the modern wattmeter are designed to carry current of about 20 amperes in order to save power.

Control System

Out of two controlling systems i.e.

1. Gravity control
2. Spring control, only spring controlled systems are used in these types of wattmeter. Gravity controlled system cannot be employed because there will be appreciable amount of errors.

Damping System

Air friction damping is used, as eddy current damping will distort the weak operating magnetic field and thus it may leads to error.

Scale

There is uniform scale which is used in these types of instrument as moving coil moves linearly over a range of 40 degrees to 50 degrees on either side.

We know that instantaneous torque in electrodynamic type instruments is directly proportional to the product of instantaneous values of currents flowing through both the coils and the rate of change of flux linked with the circuit.

Let I_1 and I_2 be the instantaneous values of currents in pressure and current coils respectively. So the expression for the torque can be written as:

$$T = I_1 \times I_2 \times \frac{dM}{dx}$$

Where, x is the angle.

Now let the applied value of voltage across the pressure coil be

$$v = \sqrt{2}V sin\omega t$$

Assuming the electrical resistance to the pressure coil be very high hence we can neglect reactance with respect to its resistance. In this the impedance is equal to its electrical resistance therefore it is purely resistive.

The expression for instantaneous current can be written as $I_2 = v / R_p$ where R_p is the resistance of pressure coil.

$$I_2 = \sqrt{2} \times \frac{V sin\omega t}{R_p}$$

If there is phase difference between voltage and electric current, then expression for instantaneous current through current coil can be written as
$$I_1 = I(t) = \sqrt{2}Isin(\omega t - \phi)$$
As current through the pressure coil is very very small compared to the current through current coil hence current through the current coil can be considered as equal to total load current. Hence the instantaneous value of torque can be written as
$$\sqrt{2} \times \frac{Vsin\omega t}{R_p} \times \sqrt{2} \times I \times sin(\omega t - \phi) \times \frac{dM}{dx}$$
Average value of deflecting torque can be obtained by integrating the instantaneous torque from limit 0 to T, where T is the time period of the cycle.
$$T_d = deflecting\ torque = \frac{VI}{R_p}cos\phi \times \frac{dM}{dx}$$
Controlling torque is given by $T_c = K_x$ where K is spring constant and x is final steady state value of deflection.

(4) **Two Wattmeter** Method can be employed to measure the power in a 3 phase, three wire star or delta connected the balanced or unbalanced load. In Two wattmeter method the current coils of the wattmeter are connected with any two lines, say R and Y and the potential coil of each wattmeter is joined on the same line, the third line i.e. B as shown below in figure (A). The total instantaneous power absorbed by the three loads Z_1, Z_2 and Z_3, are equal to the sum of the powers measured by the Two wattmeters, W_1 and W_2.

Measurement of Power by Two Wattmeter Method in Star Connection

Considering the above figure (A) in which Two Wattmeter W_1 and W_2 are connected, the instantaneous current through the current coil of Wattmeter, W_1 is given by the equation shown below.

$$W_1 = i_R$$

Instantaneous potential difference across the potential coil of Wattmeter, W_1 is given as

$$W_1 = e_{RN} - e_{BN}$$

Instantaneous power measured by the Wattmeter, W_1 is

$$W_1 = i_R\,(e_{RN} - e_{BN}) \ \ldots\ldots\ldots (1)$$

The instantaneous current through the current coil of Wattmeter, W_2 is given by the equation

$$W_2 = i_Y$$

Instantaneous potential difference across the potential coil of Wattmeter, W_2 is given as

$$W_2 = e_{YN} - e_{BN}$$

Instantaneous power measured by the Wattmeter, W_2 is

$$W_2 = i_Y\,(e_{YN} - e_{BN}) \ \ldots\ldots\ldots..(2)$$

Therefore, the Total Power Measured by the Two Wattmeters W_1 and W_2 will be obtained by adding the equation (1) and (2).

$$W_1 + W_2 = i_R (e_{RN} - e_{BN}) + i_Y (e_{YN} - e_{BN})$$

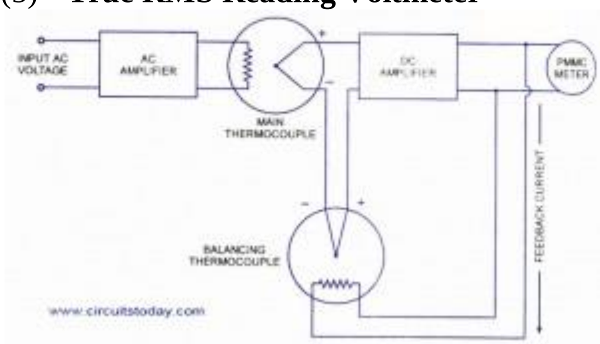
$$W_1 + W_2 = i_R e_{RN} + i_Y e_{YN} - e_{BN} (i_R + i_Y) \text{ or}$$

$$W_1 + W_2 = i_R e_{RN} + i_Y e_{YN} + i_B e_{BN} \quad (\text{i.e.}\, i_R + i_Y + i_B = 0)$$

$$W_1 + W_2 = P$$

Where P – the total power absorbed in the three loads at any instant.

(5) **True RMS Reading Voltmeter**



Block Diagram of True RMS Reading Voltmeter

RMS Reading Voltmeter

RMS value of the sinusoidal waveform is measured by the **average reading voltmeter** of which scale is calibrated in terms of rms value. This method is quite simple and less expensive. But sometimes rms value of the non-sinusoidal waveform is required to be measured. For such a measurement a true rms reading voltmeter is required. True rms reading voltmeter gives a meter indication by sensing heating power of waveform which is proportional to the square of the rms value of the voltage.

Thermo-couple is used to measure the heating power of the input waveform of which heater is supplied by the amplified version of the input waveform. Output voltage of the thermocouple is proportional to the square of the rms value of the input waveform. One more thermo-couple, called the balancing thermo-couple, is used in the same thermal environment in order to overcome the difficulty arising out of non-linear behaviour of the thermo-couple. Non-linearity of the input circuit thermo-couple is cancelled by the similar non-linear effects of the balancing thermo-couple. These thermo-couples form part of a bridge in the input circuit of a dc amplifier, as shown in block diagram.

AC waveform to be measured is applied to the heating element of the main thermocouple through an ac amplifier. Under absence of any input waveform, output of both thermo-couples are equal so error signal, which is input to dc amplifier, is zero and therefore indicating meter connected to the output of dc amplifier reads zero. But on the application of input waveform, output of main thermo-couple upsets the balance and an error signal is produced, which gets amplified by the dc amplifier and fedback to the heating element of the balancing thermo-couple. This feedback current reduces the value of error signal and ultimately makes it zero to obtain the

balanced bridge condition. In this balanced condition, feedback current supplied by the dc amplifier to the heating element of the balance thermo-couple is equal to the ac current flowing in the heating element of main thermo-couple. Hence this direct current is directly proportional to the rms value of the input ac voltage and is indicated by the meter connected in the output of the dc amplifier. The PMMC meter may be calibrated to read the rms voltage directly.
By this method, rms value of any voltage waveform can be measured provided that the peak excursions of the waveform do not exceed the dynamic range of the ac amplifier.

(6) An **Electronic Energy Meter** (**EEM**) functionally outperforms the traditional Ferrari's wheel meter. One important advantage of EEM is that in non linear loads, its metering is highly accurate and electronic measurement is more robust than that of the conventional mechanical meters. The Power companies benefits from EEM in three significant ways.

1. It reduces the cost of theft and corruption on electricity distribution network with electronic designs and prepayment interfaces.
2. Electronic energy meter measures current in both Phase and Neutral lines and calculate power consumption based on the larger of the two currents.
3. EEM improves the cost and quality of electricity distribution.

How EEM Works?

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

Electronic Energy Meter is based on Digital Micro Technology (DMT) and uses no moving parts. So the EEM is known as "Static Energy Meter" In EEM the accurate functioning is controlled by a specially designed IC called ASIC (Application Specified Integrated Circuit). ASIC is constructed only for specific applications using Embedded System Technology. Similar ASIC are now used in Washing Machines, Air Conditioners, Automobiles, Digital Camera etc.

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

7)

7(a) Actual energy consumed at half load during 138 sec.

$= VI\cos\phi\, t \times 10^{-3} = 230 \times 5 \times 1 \times (138/3600) \times 10^{-3}$

$= 44.08 \times 10^{-3}$ KWh

Energy recorded = $\frac{\text{number of revolutions made}}{\text{revolutions / KWhr}}$

$= \frac{80}{1800} = 44.4 \times 10^{-3}$ KWhr

% Error = $\frac{44.4 - 44.08}{44.08} \times 100 = 0.817$ %

7(b) (a) Power Consumed by load $= 220 \times 20 \times 0.6$

$= 2640W$

(i) The wattmeter measures the loss in the current coil for this connection.

Loss in Current coil $= I^2 R_c = (20)^2 \times 0.03 = 12W$

Error = $(12/2640) \times 100 = 0.45\%$

(ii) The wattmeter measures the loss in the pressure coil circuit for this Connection.

Loss in pressure coil circuit $= V^2/R_p = (220)^2/6000$

$= 8.06W$

Error = $(8.06/2640) \times 100 = 0.31\%$

(b) For equal error for the two Connections

$I^2 R_c = V^2/R_p$ or $I^2 = \frac{V^2}{R_p R_c} = \frac{(220)^2}{0.03 \times 6000} \Rightarrow I = 16.4A$.