CONTENTS

1. Measurement Systems and Error Analysis

Measurement is the process of determining the magnitude of a quantity in comparison with another quantity.

Introduction

- The advancement of science and technology is dependent upon a parallel progress in measurement techniques.
- As science and technology move ahead, new phenomena and relationships are discovered and these advances make new types of measurements imperative.

Measurements:

- The measurement of a given quantity essentially an act or the result of comparison between the quantity (whose magnitude is known) and a predefined standard.
- In fact, measurement is the process by which one can convert physical parameters to meaningful numbers.
- **In order that the results of measurement are meaningful, there are two basic requirements:**
  1) The standard used for comparison purposes must be accurately defined and should be commonly accepted.
  2) The apparatus used and the method adopted must be provable.

Instruments

- Absolute Instruments
  - Give the quantity to be measured in terms of instrument constant and its deflection
    Ex: Tangent galvanometer, Rayleigh's current balance
- Secondary Instrument
  - Give the magnitude of electrical quantity to be measured directly.
    Ex: Ammeter, voltmeter, pressure gauge, glass thermometer.

Instruments:

- Measurement generally involves using an instrument as a physical means of determining a quantity or variable.
- An instrument may be defined as "a device for determining the value or magnitude of a quantity or variable".

Measurement System Performance:

The treatment of instrument and measurement system characteristics can be divided in to,

1. Static Characteristics
2. Dynamic Characteristics

Static Characteristics of Measuring System:

- Static characteristics refer to the characteristics of the system when the input is either held constant or varying very slowly. The items that can be classified under the heading static characteristics are mainly,
    - Range (or span)
    - Sensitivity
    - Linearity
    - Hysteresis
    - Resolution
    - Accuracy
    - Precision
    - Drift
    - Threshold
    - Reproducibility
    - Repeatability
    - Static Error
    - Dead zone

Dynamic Characteristics of Measuring System:

- Dynamic characteristics refer to the performance of the instrument when the input variable is changing rapidly with time.
- The dynamic performance of an instrument is normally expressed by a differential equation relating the input and output quantities.
- Commonly available sensor characteristics can usually be approximated as either zero-th order, first order or second order dynamics.
- Here are few such examples:
    - Potentiometer
    - Thermocouple
    - Seismic Sensor
    - Step response performance
    - Frequency Response Performance
    - Bandwidth and Natural Frequency

Range (or span)

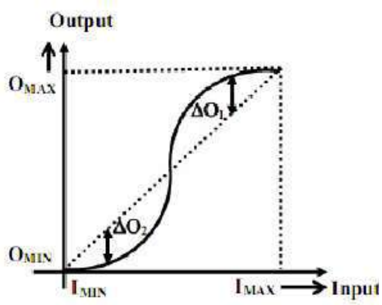
It defines the maximum and minimum values of the inputs or the outputs for which the instrument is recommended to use. For example, for a temperature measuring instrument the input range may be 100-500 o C and the output range may be 4-20 mA.

Linearity

Linearity is actually a measure of nonlinearity of the instrument. When we talk about sensitivity, we assume that the input/output characteristic of the instrument to be approximately linear. The linearity is defined as the maximum deviation from the linear characteristics as a percentage of the full scale output. Thus,

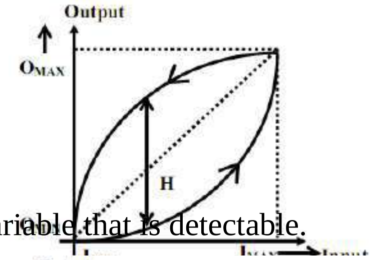
$$\text{Linearity} = \frac{\Delta Q}{O_{max} - O_{min}}$$

$$\Delta Q = \max(\Delta O_1, \Delta O_2)$$



Hysteresis

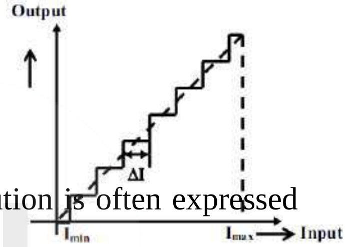
Hysteresis is a phenomenon which depicts different output effects when loading and unloading whether it is a mechanical system or an electrical system and for that matter any system. Hysteresis is non-incidence of loading and unloading curves. Hysteresis, in a system, arises due to the fact that all the energy put into the stressed parts when loading is not recoverable upon unloading. The hysteresis is expressed as the maximum hysteresis as a full scale reading, i.e., referring fig.,



$$\text{Hysteresis} = \frac{H}{O_{max} - O_{min}} \times 100$$

Resolution

- Resolution indicates the minimum change in input variable that is detectable.
- Resolution is also defined in terms of percentage as:



$$\text{Resolution} = \frac{\Delta I}{I_{max} - I_{min}}$$

- The quotient between the measuring range and resolution is often expressed as dynamic range and is defined as:

$$\text{Dynamic range} = \frac{\text{measurement range}}{\text{resolution}}$$

Note:

Resolution of the instrument can be improved by recalibrating it but sensitivity cannot be, because it is designed with respect to time characteristics.

Accuracy

- It is degree of closeness of conformity in which measured value approaches a true value of quantity under measurement.
- The accuracy of an instrument is often stated as a percentage.

(i) Point Accuracy
(ii) Accuracy as percentage of scale range:
(iii) Accuracy as percentage of true value:

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.
- In other words, precision is measure of consistency of the result.
- A quantity called "precision index" describes the dispersion of repeated result about a central value.
- Precision indicates the repeatability or reproducibility of an instrument (but does not indicate accuracy).
- Quantitatively, the precision can be expressed as:

Precis

Note:

- High precision does not means high accuracy. In other words, a highly précised instrument may be inaccurate.
- Accuracy of the instrument can be improved by the recalibration but precision of instrument cannot improved because, it is designed with respect to time characteristics (or inherent).

Sensitivity

- It can be defined as the ratio of the incremental output and the incremental input.

$$\text{Sensitivity K} = \frac{\text{change of output signal}}{\text{change of input signal}}$$

Threshold

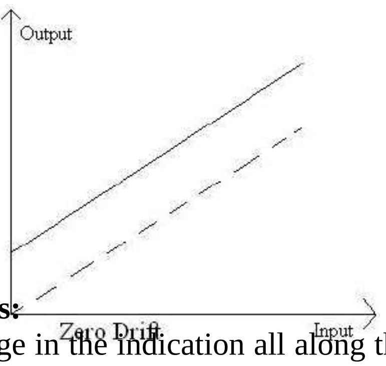
- It is a particular case of resolution.
- It is defined as the minimum value of input below which no output can be detected.

Drift

- Variation in output of an instrument from the desired value for a particular value of the input.
- Perfect reproducibility means that the instrument has no drift.
- No drift means that with a given input the measured values do not vary with time.

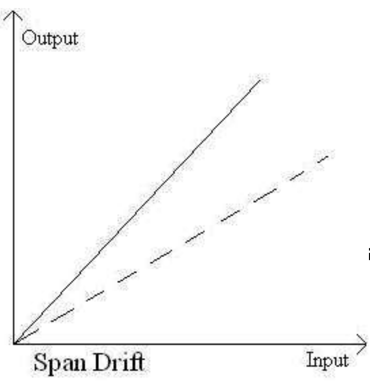
Zero drift:

- If the whole calibration gradually shifts due to slippage, permanent set, or due to undue warming up of electronic tube circuits, zero drift sets in. This can be prevented by zero setting.



Span drifts or Sensitivity drifts:

- If there is proportional change in the indication all along the upward scale, the drift is called span drift or sensitivity drift. These are due to stray fields.



Zonal drift:

- When the drift occurs only over a portion of span of an instrument, it is called zonal drift.

Note:

- The quantities like accuracy, sensitivity and reproducibility are desirable but drift, static error and dead zone are undesirable.
- Drift is an undesirable quantity in industrial instrument because it is rarely apparent and cannot be easily compensated for Drift is due to many environmental factors. This may be stray electric and magnetic fields, thermal emfs, mechanical terms etc.
- Thus it must be carefully guarded against by continuous prevention, inspection and maintenance.

Reproducibility

- It is the degree of closeness in which a given value is measured with an instrument over a specified period of time.

Repeatability

- It is the degree of closeness in which input quantity is measured again and again for a given set of an instrument.
- This is specified in terms of scale reading over a given period of time.

Errors and Statistical Analysis:

Error:

- It is measure of deviation from the true value of the measured variable.

Absolute error or static error:

- This is defined as the difference between the measured value and true value of the quantity.

i.e $\delta_A = A_m - A_T \Rightarrow \in_0$

δ_A = absolute static error of quantity 'A'

A_m = measured value of quantity 'A'

A_T = True value or Nominal value of quantity 'A'

Relative Error $(\in_r)$:

- It is defined as.

$$\in_r = \frac{Absolute\ error}{True\ value} = \frac{\delta_A}{A_T} = \frac{\in_o}{A_r}$$

$$\Rightarrow A_T = \frac{A_m}{1+\in_r}$$

If absolute static error $\delta_A = \in_o$ is very-very small then,

$$A_T = A_m(1-\in_r)$$

$$\in_r = \frac{A_m - A_T}{A_T} = \frac{\delta_A}{A_T}$$

- % Error

% $$\in_r = \frac{A_m - A_T}{A_T} \times 100 = \frac{\delta_A}{A_T} \times 100 = \in_r \times 100$$

- For finding the % error at reading "X" is equals,

$$\left(\frac{\text{Full scale value}}{X}\right) \times (\%\ \text{relative error of full Scale})$$

Limiting Error or Guarantee Errors:

The limits of the deviations from the specified values are defined as *Limiting Errors* or *Guarantee Errors.*

A_{act}

Where δ_A is the limiting error.

Eg. A = 100 $\pm$ 10 Ω or A $\geq$ 90 Ω and A $\leq$ 110 Ω

Relative Limiting Errors:

$$A_{Specified} \times 100$$

ified

$$\pm\delta_A = A_a - A_S$$

$$\in_r = \frac{\delta_A}{A_S}$$

$$\delta_A = \pm \in_r A_S$$

$$\pm A_S \in_r = A_a - A_s$$

$$A_a = A_S(1 \pm \in_r)$$

Limiting error for combination of quantities:

Sum of the quantities

The relative increment of the function is given by.

$$\frac{\partial X}{X} = \pm\left(\frac{\partial X_1}{X} + \frac{\partial X_2}{X} + \ldots\ldots\ldots \frac{\partial X_n}{X_n}\right)$$

% error = $$\frac{\partial X}{X} = \pm\left(\frac{\partial X_1}{X_1} \cdot \frac{X_1}{X} + \frac{\partial X_2}{X_2} \cdot \frac{X_2}{X} + \ldots\ldots\ldots\ldots\right)$$

Difference of quantities

The relative increments of component quantities,

% error = $$\frac{\delta X}{X} = \pm\left(\frac{\delta X_1}{X} \cdot \frac{X_1}{X} + \frac{\delta X_2}{X} \cdot \frac{X_2}{X}\right)$$

Multiplication of quantities

% error = $$\frac{\partial X}{X} = \pm\left(\frac{\partial X_1}{X_1} + \frac{\partial X_2}{X_2} + \frac{\partial X_3}{X_3}\right)$$

- From above equation we conclude that the limiting of multiplication of quantities is equal to the sun of relative limiting errors of individual quantity.

Division of quantity

∴ Relative limiting error in X (For unknown errors)

% error = $$\frac{\partial X}{X} = \pm\left(\frac{\partial X_1}{X_1} + \frac{\partial X_2}{X_2}\right)$$

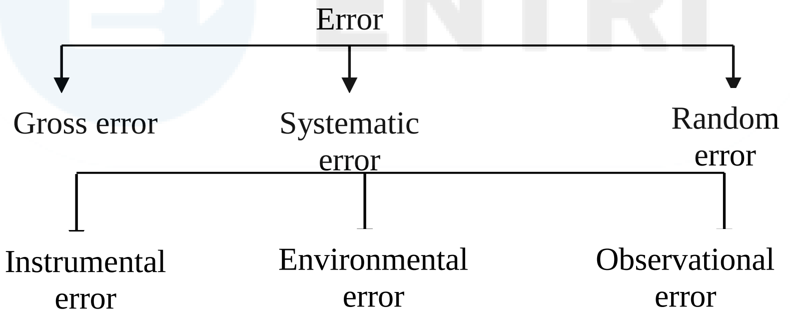
- From above equation we conclude that the limiting error of division of quantity is equal to the sum of relative limiting errors individual quantity.

Composite factors

% error = $$\frac{\partial X}{X} = \pm\left(m\frac{\partial X_1}{X} + n\frac{\partial X_2}{X} + p\frac{\partial X_3}{X_3}\right)$$

Types of Errors:

- No measurement can be made with perfect accuracy, but it is important to find out what the accuracy actually is and how different errors have entered into the measurement.
- Errors may come from different sources and are usually classified as:



Gross errors:

- Largely human errors among them misreading of instruments, incorrect adjustment and improper application of instrument and computational mistakes.

Systematic errors:

- Short comings of the instruments such as defective or worn parts and effects of the environment on the culpment or the user.

Random errors:

- Those due to causes that cannot be directly established because of random variations in the parameter or the system of measurement.
- These errors remain even after the systematic errors have been taken care of, we call these errors as Random errors.

Statistical Analysis:

- A statistical analysis of measurement data is common practice because it allows an analytical determination of the uncertainty of the final test result.
- LetX_1, X_2 ……… X_n are the 'n' no. of readings of an instrument then,

(i) Mean value:

$$X = \frac{X_1 + X_2 + X_3 + ...X_n}{n} = \frac{\sum X}{n}$$

(ii) Deviation:

- Deviation is the departure of a reading from the arithmetic mean of the group of readings.
- Let the deviation of first reading X_1 be 'd_1' and that of reading X_2 be 'd_2' and so on then deviation from the mean value can be expressed as,

$$d_1 = X_1 - \overline{X}, d_2 = X_2 - \overline{X} ....d_n = X_n - \overline{X}$$

(iii) Mean deviation or average deviation:

$$D = \frac{|d_1| + |d_2| + ...|d_n|}{n} = \frac{\sum |d|}{n}$$

- The average deviation is an indication of the precision of the instruments used in making the measurement
- Highly precise instruments yield will a low average deviation between readings.

Note:

- The deviation from the mean may have a (+)ve or (-) ve value and that the algebraic sum of all the deviation must be zero.

(iii) Standard deviation (σ) or RMS deviation: (S.D)

- Standard deviation in statistical analysis of random errors is the root mean square deviation.
- By definition, the S.D (σ) of an infinite no. of data is the square root of the sum of all the individual deviations squared, divided by the no. of readings (n).

for n > 20, $\sigma = \sqrt{\frac{\sum_{i=1}^{n} |d_i|^2}{n}}$

for n < 20, $\sigma = \sqrt{\frac{\sum_{i=1}^{n} |d_i|^2}{n-1}}$

(iv) Variance :

- The variance is the mean square deviation.
- It is same as S.D. except that the square root is not extracted.

for n > 20, $V = \sigma^2 = \frac{\sum_{i=1}^{n} |d_i|^2}{n}$

for n < 20, $V = \sigma^2 = \frac{\sum_{i=1}^{n} |d_i|^2}{n-1}$

- Relation between precision index (h) and standard deviation (σ).

$$h \alpha \frac{1}{\sigma}$$

i.e. $h = \frac{1}{\sqrt{2}\sigma}$

Probable Error (r):

- Probable error (r) is proportional to the standard deviation (σ) as

  $r = 0.6745\sigma$

CLASS ROOM OBJECTIVES

1. Three resistors R_1, R_2, R_3 where $R_1 = 37 \pm 5\%$, $R_2 = 75 \pm 5\%$, $R_3 = 50 \pm 5\%$ are connected in series. Find the magnitude of resistance, limiting error in Ω and in %.

2. The resistance of the circuit is measured by power fed in to the circuit and current passing through it. The relative limiting errors in the measurement of power and current are $\pm$ 1.5% and $\pm$ 1% respectively. Find the % limiting error in the measurement of resistance.

3. A variable 'w' is related to three other variables x, y, z as w = xy/z. The variables are measured with meters of accuracy $\pm$ 0.5% reading, $\pm$ 1% of full scale value and $\pm$ 1.5% reading the actual readings of the three meters are 80, 20 and 50 with 100 being the full scale value for all three. The maximum uncertainty in the measurement of 'w' will be

   (a) $\pm$ 0.5% rdg (b) $\pm$ 5.5% rdg (c) $\pm$ 6.7% rdg (d) $\pm$ 7.0 rdg

4. A (0-150) V full scale voltmeter has an accuracy specification of $\pm$1% of the full scale value. Find the relative limiting error in percentage if it is measuring 75 V in (0-150) V range.

5. A 0 to 1000 W wattmeter has an error specification of $\pm$ 1% of full scale deflection.
   (a) Find out the range of readings if it measures 100W
   (b) If the error is specified as % of true value, what should be the range of readings.

6. Four ammeters M_1, M_2, M_3 and M_4 with the following specifications are available, (Full scale, accuracy value as percentage of FS)
   $M_1 = 20 \pm 0.10$; $M_2 = 10 \pm 0.20$; $M_3 = 5 \pm 0.50$; and $M_4 = 1 \pm 1.00$
   A current of 1 A is to be measured. To obtain minimum error in the reading one should select meter
   (a) M_1 (b) M_2 (c) M_3 (d) M_4

PREVIOUS QUESTIONS

ERRORS

TWO MARKS QUESTIONS

01. A variable 'w' is related to three other variables x, y, z as w = xy/z. The variables are measured with meters of accuracy $\pm$ 0.5% reading, $\pm$ 1% of full scale value and $\pm$ 1.5% reading the actual readings of the three meters are 80, 20 and 50

with 100 being the full scale value for all three. The maximum uncertainty in the measurement of ‘w’ will be

(GATE-EE-2006)

(a) ± 0.5% rdg (b) ± 5.5% rdg (c) ± 6.7% rdg (d) ± 7.0 rdg

02. Suppose that resistors R_1 and R_2 are connected in parallel to give an equivalent resistor R. If resistors R_1 and R_2 have tolerance of 1% each, the equivalent resistor R for resistors R_1 =300 Ω and R_2=200 Ω will have tolerance of

(GATE-EE-2014)

(a) 0.5 % (b) 1 % (c) 1.2 % (d) 2 %

03. The resistance of a circuit is found by measuring current flowing and the power fed into the circuit. If the limiting errors in the measurement of power and current are ±1.5% and ±1.0% respectively, the limiting error in the measurement of resistance will be **(IES-EE-1992)**

(a) ±1% (b) ±1.5% (c) ±2.5% (d) ±3.5%

04. A 150V moving iron voltmeter of accuracy class 1-0 reads 75V when used in a circuit under standard condition. The maximum possible percentage error in the reading is

(IES-EE-1993)

(a) 0.5 (b) 1.0 (c) 2.0 (d) 4.0

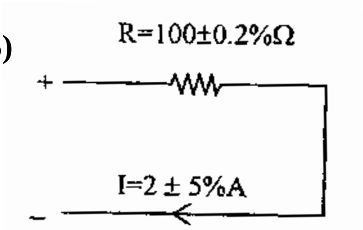
05. If the practical units of voltage and current were each made 20 times as large as they are at present, what would be the consequent alteration in the size of the unit of capacitance ?

(IES-EE-1994)

(a) 200 times (b) 60 times (c) 20 times (d) Nil

06. The circuit given in the figure, the limiting error in the power dissipation I^2, R’ in the resistor R is

(IES-EE-1995)



(a) 1.2% (b) 5.2% (c) 10.2% (d) 25.2%

07. The limiting errors of measurement of power consumed by and the current passing through a resistance are ±1.5% and ±1% respectively. The limiting error of measurement of resistance will then be **(IES-EE-1997)**

(a) ±0.5% (b) ±1.0% (c) ±2.5% (d) ±3.5%

08. The current ‘I’ through a resistance R is measured with the following uncertainties I = 4A ±0.5%, R = 100Ω ±0.2%. If power is computed form these two measured quantities, the uncertainty in the power computed will be

(IES-EE-1998)

(a) ±0.01% (b) ±0.29% (c) ±0.7% (d) ±1.2%

09. The total current I = I_1 + I_2 in a circuit is measured as I_1 = 150 ± 1A, I_2 = 250 ± 2A, where the limits of error are given as standard deviations. I is measured as

(IES-EE-2002)

(a) (400 ± 3)A (b) (400 ± 2.24)A (c) (400 ± 1.5)A (d)(400 ± 1)A

10. The difference between the indicated value and the true value of a quantity is

(IES-EE-2003)

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

11. Which one of the following statements is correct ? **(IES-EE-2004)**

The application of the instrument in wrong manner in the procedure of measurement results in a/an

(IES-EE-2004)

(a) systematic error (b) random error
(c) gross error (d) instrument error

12. Which one of the following statements correctly represents the systematic errors?
(a) These errors can be calculated from the details of the instruments
(b) These are the residual errors
(IES-EE-2004)
(c) These errors may occur under controlled conditions
(d) These are the errors committed by the experimenters

13. A 0 to 200V voltmeter has a guaranteed accuracy of 1% of full scale reading. The voltage measured by this instrument is 50V. What is the limiting error ?
(a) 4% (b) 2% (c) 1% (d) 0.25%
(IES-EE-2004)

14. A set of independent current measurements taken by four observers was recorded as; 117.02mA, 117.11mA, 117.08mA and 117.03mA. What is the range of error?

(IES-EE-2005)

(a) ± 0.045 (b) ± 0.054 (c) ± 0.065 (d) ± 0.056

15. To measures 5 volts, if one selects a 0-100 volt range voltmeter which is accurate with in ± 1%, then the error in this measurement may be up to **(IES-EE-2005)**
(a) ± 1.5% (b) ± 2.5% (c) ± 7.5% (d) ± 20%

16. **Assertion (A) :** It is always desirable to take the reading of an indicating instrument very close to the full scale reading.

Reason (R) : Accuracy of an indicating instrument is maximum at the full scale deflection and error increases as reading comes closer to the beginning of the scale

(IES-EE-2006)

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false
(d) A is false but R is true

17. When reading is taken at half scale in the instrument, the error is **(IES-EE-2006)**
 (a) exactly equal to half of full-scale error
 (b) equal to full-scale error
 (c) less than full-scale error
 (d) more than full-scale error

18. The errors introduced by an instrument fall in which category ? **(IES-EE-2008)**
 (a) Systematic error (b) Random errors
 (c) Gross errors (d) Environmental errors

19. **Assertion (A) :** Random errors can be minimized by statistical methods
 Reason (R) : These are caused by arithmetic error while taking readings
 (a) Both A and R are true and R is the correct explanation of A
 (b) Both A and R are true but R is NOT the correct explanation of A
 (c) A is true but R is false (d) A is false but R is true **(IES-EE-2009)**

20. A 0 to 300V voltmeter has an error of $\pm$ 2% of FSD. What is the range of readings if true voltage is 30V ? **(IES-EE-2009)**
 (a) 24V – 36V (b) 20V – 36V (c) 29.4V – 30.6V (d) 20V - 30V

21. A (0-25) A ammeter has a guaranteed accuracy of 1 percent of full scale reading. The current measured by this ammeter is 10A. The limiting error in percentage for this instrument is **(IES-EE-2010)**
 (a) 2.5% (b) 0.5% (c) 80% (d) 0.025%

22. A (0-250)V voltmeter has a guaranteed accuracy of 2 per cent of full scale reading. The voltage measured by this voltmeter is 150V. The limiting error in percentage is **(IES-EE-2010)**
 (a) 2.5% (b) 0.05% (c) 3.33% (d) 5.0%

23. A 0-100V voltmeter has an accuracy of 1 percent at full-scale reading. What will be the error if it reads 50V ? **(IES-EE-2011)**
 (a) 1 percent (b) 2 percent (c) 0.5 percent (d) 4 percent

24. What are the causes of gross error in the instruments ? **(IES-EE-2011)**
 1. Misreading of instruments
 2. Incorrect adjustment of instruments
 3. Errors due to defective instrument
 4. Errors due to effect of environment on the instrument
 Codes :
 (a) 1 and 2 (b) 2 and 3 (c) 3 and 1 (d) 4 and 1

25. Which of the following types of errors come under systematic errors ?

1. Irregular spring tension
2. Improper readings
3. Loading effects
4. Error due to the presence of electric field or magnetic field **(IES-EE-2011)**

Codes :

(a) 1 and 2 (b) 2 and 3 (c) 3 and 1 (d) 4 and 1

26. The value of a quantity and its uncertainty are given as 26455 ± 3754 without rounding off. Only two significant digits are relevant for error. Value of error rounded off to two significant figures is **(IES-EE-2011)**

(a) 26500 ± 3800 (b) 26400 ± 3800
(c) 26460 ± 3750 (d) 26400 ± 3700

27. Systematic error of an instrument for measurement can be minimized by
(a) selecting a proper measuring device for the particular application
(b) calibrating the measuring device against a standard device
(c) applying correction factors for change of ambient conditions
(d) carrying out all of the above
(IES-EE-2012)

28. The unknown resistance R_4 measured in a Wheatstone bridge by the formula $R_4 = \frac{(R_2 R_3)}{R_1}$ with $R_1 = 100 \pm 0.5\%\ \Omega$, $R_2 = 1000 \pm 0.5\%\ \Omega$, $R_3 = 842 \pm 0.5\%\ \Omega$

Resulting in R_4
(IES-EE-2013)

(a) 8420 ± 0.5% Ω (b) 8420 ± 1.0% Ω
(c) 8420 ± 1.5% Ω (d) 8420 ± 0.125% Ω

29. Four ammeters M_1, M_2, M_3 and M_4 with the following specifications are available, (Full scale, accuracy value as percentage of FS) **(IES-EE-2014)**

$M_1 = 20 \pm 0.10$; $M_2 = 10 \pm 0.20$; $M_3 = 5 \pm 0.50$; and $M_4 = 1 \pm 1.00$

A current of 1 A is to be measured. To obtain minimum error in the reading one should select meter

(a) M_1 (b) M_2 (c) M_3 (d) M_4

PRECISION:

30. A resistance of 105 ohms is specified using significant figures as indicated below:
(IES-EE-1994)

1. 105 ohms
2. 105.0 ohms
3. 0.000105 Mega ohms

Among these,
(a) 1 represents greater precision than 2 and 3
(b) 2 represents greater precision but 1 and 3 represent same precision
(c) 2 and 3 represent greater precision than 1
(d) 1, 2 & 3 represent same precision

31. **Assertion (A) :** Precision is a necessary prerequisite of accuracy
Reason (R) : Precision guarantees accuracy **(IES-EE-1994)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

32. Which one of the following has the highest accuracy **(IES-EE-1998)**
(a) Standard resistance (b) Standard inductance
(c) Standard capacitance (d) Standard mutual inductance

33. **Assertion (A) :** The precision instruments are always accurate
Reason (R) : Precision indicates the degree of agreement within a set of measurements of the same quantity by the instrument and accuracy refers to the degree of closeness true value of the quantity to be measured.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(IES-EE-2007)
(d) A is false but R is true

STATISTICAL ANALYSIS:

34. The voltage of a standard cell is monitored daily over a period of one year. The mean value of the voltage for every month shows a standard deviation of 0.1 mv. The standard deviation of the set constituted by the monthly mean values will be **(IES-EE-1999)**
(a) 0 (b) $\frac{0.1}{12}$ (c) $\frac{0.1}{\sqrt{12}}$ (d) 0.1

35. **Statement (I) :** For random error with normal distribution, Probable error = $\pm$ 0.6745 σ, where σ is the standard deviation **(IES-EE-2013)**
Statement (II) : Probable error ξ_p is that error value where there is a 50% chance that any observation has a random error no greater than $\pm\xi_p$
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false

(d) A is false but R is true

36. The technique used to check quantitatively whether the given data distribution is close to Gaussian distribution is
(IES-EE-2013)
(a) Curve fitting
(b) Method of least squares
(c) Chi-square test
(d) Standard deviation of mean

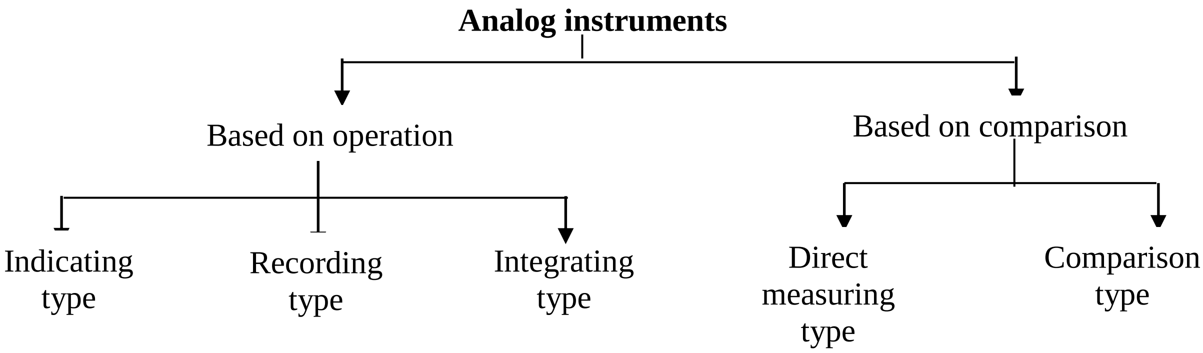
PRACTICE QUESTIONS

1. The reliability of the instrument refer to:
a) Measurement of changes due to temperature variations
b) Degree to which repeatability continues to remain within specified limits
c) The life of the instrument
d) The extent to which the characteristics remain linear
2. The damping torque must operate only when the moving system of the indicating instrument is:
a) Actually moving
b) Stationary
c) Just starting to move
d) Near its full deflection
3. In spring control instruments, controlling torque:
a) can be adjusted easily
b) cannot be adjusted easily
c) remains the same
d) varies with the load

4. A ______ device prevents the oscillation of the moving system and enables the latter to reach its final position quickly
(a) deflecting
(b) controlling
(c) damping
(d) any of the above

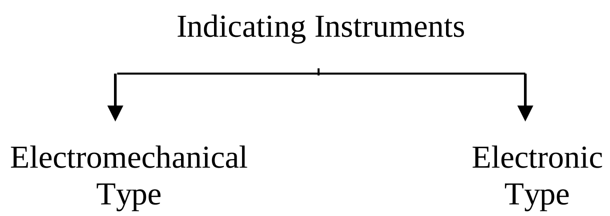
5. The spring material used in a spring control device should have the following property.
(a) Should be non-magnetic
(b) Most be of low temperature co-efficient
(c) Should have low specific resistance
(d) All of the above

2. Electromechanical Indicating Type Instruments



Indicating Instruments :

- Those instruments which indicate the magnitude of a quantity being measured
- They generally make use of a dial and a pointer for this purpose
- Example Ordinary voltmeters, ammeters and watt meters.



⇒ Electronic types of instruments are manufactured by addition of electronic circuits to electromagnetic indicators in order to increase the sensitivity and input impedance.

Recording Instruments:

- It gives a continuous record of quantity being measured over a certain period of time.
- Example: Recorders.

Integrating Instruments:

- Ampere hour meter and watt hour meter (Energy meter) are the example of this type.
-

Direct Measuring Instruments:

- Ammeters, voltmeters, watt meters and energy meters are the examples of this type.

Comparison Instruments :

Effects name	Instruments name
Electromagnetic effect	PMMC, Moving iron type, EMMC(Watt meters), Dynamometer types etc.
Induction effect	Energy meters
Electrostatic effect	Electrostatic type voltmeters
Heating effect	Thermocouple Hotwire, Bolometer
Hall effect	Flux meter, Ammeters, Poynting vector voltmeters

Types of operating forces:

- Deflecting force
- Controlling force
- Damping force

1. **Deflection force**
   - It is responsible for deflection in moving system.
   - It is proportional to quantity under measurement.
2. **Controlling force**
   - It is used to counter balanced to deflecting force.
   - It is responsible for steady deflection on pointer.
3. **Damping force**
   - It is responsible for damping of oscillation in the pointer.

Constructional details of Indicating type Instrument.

- It consist of:
  - ⇒ Moving system or Deflecting system
  - ⇒ Controlling system

⇒ Damping system

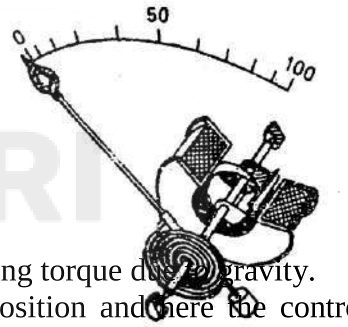
Deflecting System:

- It produces the deflecting force.
- The deflecting or operating force is required for moving the pointer from its zero position.
- The deflecting system of an instrument converts the electric current or potential into a mechanical force called deflecting force.

Controlling System:

- This system producing a "Controlling force"
- This system is responsible for the generation of "Controlling Torque" which is counter balance the "Deflecting torque" in order to have steady deflection of the pointer in order that the current produces deflection of the pointer proportional to its magnitude.
- This system has function to bring the moving system back to zero position when the force causing the instrument moving stem to deflect is removed.

Spring Control:



⇒ $T_c \alpha \theta$

∴ $T_c = K\theta$

Where K = spring constant

θ = angular deflection

Gravity control:

- In this control system, weight produces a controlling torque due to gravity.
- In below figure (a) shows the pointer at zero position and here the control torque is zero. Suppose the system deflects through an angle θ as shown in figure (b).
- The weight acts at a distance l from the centre, the component of weight trying to restore the pointer back to zero position is W sin θ. Therefore, controlling torque is

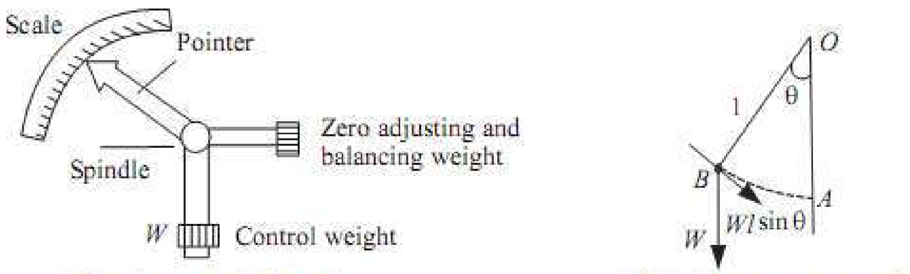
$$T_c = F \times r = W \sin\theta \times l$$

$$T_c = W\ l \sin\theta = K_g \sin\theta$$

$$T_c \alpha \sin\theta$$

Where,

$$K_g = Wl = a\ constant$$



(a) Gravity controlled moving system at zero deflection

(b) Moving system rotated by θ radian

- Thus the controlling torque is proportional to sine of angle of deflection of moving system.

Note:

⇒ Gravity control is used in panel type or wall mounted type of instruments.

⇒ It controlling force is absent, the pointer during beyond the full scale.

Damping System

- This system produces a "Damping Torque' (T_D) with should be of such magnitude that the pointer of moving system quickly and smoothly to its final steady position, without any oscillations.
- Damping torque (T_D)α velocity of moving system but independent of the operating current.
- If damping force is absent the pointer will oscillates around the mean position.

Various damping used in the instruments:

Types of damping	*Used instruments*
Air friction damping	Moving iron and Electro Dynamometer type
Fluid friction damping	Electrostatic type
Eddy current damping	PMMC, Hot wire and Induction type (Energy meter)

Analog Ammeter and Voltmeter:

- These instruments which are essentially called "Current measuring devices" are classed together because there are no fundamental differences in their operating principles (except electrostatic type of instruments).

- **Types of instruments used as Voltmeters and Ammeters** — **Types of measurement (AC or DC)**

Types of instruments used as Voltmeters and Ammeters	Types of measurement (AC or DC)
1. PMMC	DC purpose only
2. Induction type	AC purpose only
3. Moving iron type	AC and DC both purposes
4. Electrodynamometer type	AC and DC both purposes
5. Electrostatic type	AC and DC both purposes
6. Rectifier type	AC and DC both purposes
7. Electro-thermic type	AC and DC both purposes

LAST MINUTE REVISION

- Measurement is the process by which one can convert physical parameters to meaningful numbers.
- An instrument may be defined as "a device for determining the value or magnitude of a quantity or variable".
- Static characteristics refer to the characteristics of the system when the input is either held constant or varying very slowly.
- Dynamic characteristics refer to the performance of the instrument when the input variable is changing rapidly with time.
- Resolution indicates the minimum change in input variable that is detectable.

- Resolution of the instrument can be improved by recalibrating it but sensitivity cannot be, because it is designed with respect to time characteristics.
- Accuracy is degree of closeness of conformity in which measured value approaches a true value of quantity under measurement.

$$Accuracy = \frac{A_m}{A_t} \times 100$$

- Percentage of full-scale deflection = $\frac{\text{measured value-true value}}{\text{maximum scale value}}$
- Percentage of true value = $\frac{\text{meaured value-true value}}{\text{true value}}$
- Precision may be defined as the degree of closeness with which reading is produced again and again for the same value of input quantity.
- $\text{Sensitivity K} = \frac{\text{change of output signal}}{\text{change of input signal}}$
- Variation in output of an instrument from the desired value for a particular value of the input is called Drift.
- Zero drift can be prevented by zero setting.
- The limits of the deviations from the specified values are defined as *Limiting Errors* or *Guarantee Errors.*

$$A_{actual} = A_{specified} \pm \delta_A$$

- Probable error (r) is proportional to the standard deviation (σ) as

$$r = 0.6745\sigma$$

- **Comparison Instruments :**

Effects name	Instruments name
Electromagnetic effect	PMMC, Moving iron type, EMMC(Watt meters), Dynamometer types etc.
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PREVIOUS QUESTIONS

01. To achieve the optimum transient response, the indicating instruments are so designed as to **(IES-EE-2000)**

(a) be critically damped (b) be undamped
(c) provide damping which is slightly more than the critical value
(d) provide damping which is slightly less than the critical value

02. A first order instrument is characterized by **(IES-EE-2003)**

(a) Time constant only
(b) Static sensitivity and time constant
(c) Static sensitivity and damping coefficient
(d) Static sensitivity, damping coefficient and natural frequency of oscillations

03. Which one of the following decides the time of response of an indicating instrument? **(IES-EE-2004)**

(a) Deflecting system (b) Controlling system
(c) Damping system (d) pivot and Jewel bearings

04. Match List-I with List-II and select the correct answer using the codes given below the lists : **(IES-EE-2009)**

List-I	**List-II**
A. Indicating	1. Wattmeter
B. Absolute	2. Tangent
C. Recording	3. Aneroid barometer
D. Integrating	4. Energy meter

Codes :

	A	B	C	D
(a)	1	2	3	4
(b)	4	2	3	1
(c)	1	3	2	4
(d)	4	3	2	1

05. Consider the following statements regarding the controlling torque :
1. It is not present in power factor meter
2. It opposes the deflecting torque
3. It is provided by air friction or by fluid friction

Which of these statements are correct ? **(IES-EE-2011)**

(a) 1, 2 and 3 (b) 1 anb 3 only (c) 2 and 3 only (d) 1 and 2 only

06. The following is not essential for the working of an indicating instrument **(IES-EE-2012)**

(a) Deflecting torque (b) Braking torque
(c) Damping torque (d) Controlling torque

07. Two resistances R_1 = 100 $\pm 10\% \Omega$ and R_2 = 300 $\pm 5\% \Omega$ are connected in services. The resulting limiting error of the services combination is **(IES-EE-2012)**

(a) 5 Ω (b) 15 Ω (c) 25 Ω (d) 30 Ω

MISCELLANEOUS:

08. When, C_1, C_2, C_3, C = Capacitance,

L = self inductance

M_1, M_2, M = Mutual inductances

ω = angular frequency

r, R, R_1, R_2, R_3, R_4 = Resistances.

Which of the following is dimensionally incorrect ? **(IES-EE-1992)**

(a) $C = \frac{1}{\omega^2 M}$

(b) $r = \frac{R\omega^2 M_1 M_2}{R^2 + \omega^2 L^2}$

(c) $R_4 = \frac{R_2(1+\omega^2 R^2 C_3^2)}{\omega^2 R_1 R_2 C_3^2}$

(d) $I = \frac{V\omega M}{\left[(\omega M + R_2)^2 + \omega^2 L_1 L_2 R_1^2\right]^{1/2}}$

09. A circuit draws a current I when a single phase ac voltage V is applied to it. If the power factor is cos φ, then the dimensions of VI cos φ would be **(IES-EE-1997)**

(a) ML^3T^2 (b) ML^2T^3 (c) ML^3T^3 (d) ML^2T^3

10. Match List-I with List-II and select the correct answer using the codes given below the lists : **(IES-EE-1999)**

List-I	**List-II**
A. Sensitivity	1. Closeness to the true value
B. Resolution	2. A measure of reproducibility of the instrument
C. Accuracy	3. Ratio of response to the change in the input signal.
D. Precision	4. Smallest change in input to which the instrument can respond

Codes :

	A	B	C	D
(a)	3 4	1	2	
(b)	3	4	2	1
(c)	4	3	2	1
(d)	4	3	1	2

11. In the SI system, the dimension of emf is **(IES-EE-1999)**

(a) ML^3T^3I (b) $ML^3T^3I^{-1}$ (c) $ML^2T^3I^{-1}$ (d) $M^{-1}L^2T^3I$

12. Match List-I with List-II and select the correct answer using the codes given below the lists : **(IES-EE-2000)**

List- I **List- II**

A. Resistance
B. emf
C. Capacitance

1. $[M^{-1}L^{-2}T^{4}I^{2}]$
2. $[M^{-1}L^{-2}T^{2}I^{2}]$
3. $[ML^{2}T^{3}I^{-1}]$
4. $ML^{2}T^{3}I^{2}]$

Codes :

	A	B	C
(a)	1	2	3
(b)	4	2	1
(c)	3	4	2
(d)	4	3	1

13. Match List-I (Error parameters) with List-II (Values) and select the correct answer using the codes given below the lists (σ is the standard deviation of Gaussian error) : **(IES-EE-2001)**

List-I
A. Precision index
B. Probable error
C. Error limit
D. Peak probability density of error

List- II

1. $0.67\,\sigma$ 2. $3\,\sigma$ 3. $\frac{0.39}{\sigma}$ 4. $\frac{0.71}{\sigma}$

Codes :

	A	B	C	D
(a)	4	2	1	3
(b)	4	1	2	3
(c)	3	1	2	4
(d)	3	2	1	4

14. Match List-I (Accuracy) with List-II (Type of the standard) and select the correct answer using the codes given below the lists : **(IES-EE-2004)**

List-I (Accuracy) **List-II (Type of the standard)**
A. Least accurate
B. More accurate
C. Much more accurate
D. Highest possible accurate

1. Primary
2. Secondary
3. Working
4. International

Codes :

	A	B	C	D
(a)	3	4	1	2
(b)	1	4	3	2
(c)	3	2	1	4
(d)	1	2	3	4

PRACTICE QUESTIONS

01. The use of ______ instruments is merely confined within laboratories as standardizing instruments.

(a) absolute (b) indicating (c) recording (d) integrating

02. Which of the following instruments indicate the instantaneous value of the electrical quantity being measured at the time at which it is being measured ?
(a) Absolute instruments (b) Indicating instruments
(c) Recording instruments (d) Integrating instruments

03. ______ instruments are those which measure the total quantity of electricity delivered in a particular time.
(a)Absolute
(b)Indicating
(c)Recording
(d) Integrating

04. Which of the following are integrating instruments ?
(a)Ammeters
(b)Voltmeters
(c)Wattmeters
(d) Ampere-hour and watt-hour meters

05. Which of the following essential features is possessed by an indicating instrument ?
(a) Deflecting device (b) Controlling device
(c) Damping device (d) All of the above

KEY

1. Measurement Systems and Error Analysis

PREVIOUS QUESTIONS

1. D 2. B 3. D 4. C 5. D 6. C

7. D 8. D 9. B 10. B 11. D 12. A

13. C 14. A 15. D 16. A 17. D 18. A

19. C 20. A 21. A 22. D 23. B 24. A

25. C 26. A 27. D 28. C 29. D 30. B

31. C 32. A 33. D 34. D 35. A 36. D

PRACTICE QUESTIONS

1.B 2.A 3.D 4.C 5.D

2. Electromechanical Indicating Type Instruments

PREVIOUS QUESTIONS

1. D 2. A 3. C 4. A 5. D 6.B

7.C 8. D 9. D 10. A 11. C 12. D

13. C 14. C

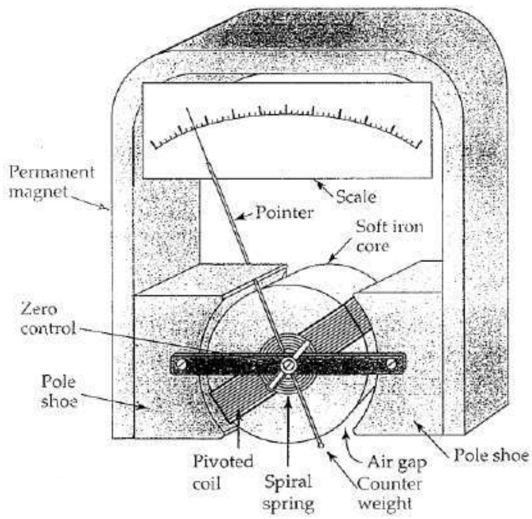
PRACTICE QUESTIONS

1.A 2.B 3.D 4.D 5.D

CONTENTS

ANALOG INSTRUMENTS

1. PMMC (Permanent Magnet Moving Coil) Type Instruments:

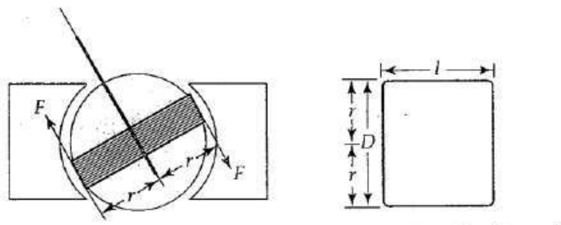


- In this instrument the strong magnetic field produced is provided by the high permeability iron core (stationary).
- Operating field (B) is produced by the permanent magnetic material and it may vary from 0.1 wb/$m^{2.}$
- It consist of fixed magnet made up of A*l* NiCO (Al + Ni + CO).
- Concentric magnetic construction is used to get longer angular movement of the pointer.
- Angular displacement can be over 300^0.
- In Voltmeter, PMMC is mounted on metallic frame to provide electromagnetic damping whereas in Ammeter, PMMC is wound on non-magnetic former because the electromagnetic damping is provided by coil of the ammeter shunt.
- The moving coil is sustained by control spring which is made up of "Phosphor Bronze" Provides:
- Controlling torque (Restoring torque)
- Lead current in and out of the coil.
- A*l*-former (Moving) is attached to the spindle is responsible for Eddy current damping.

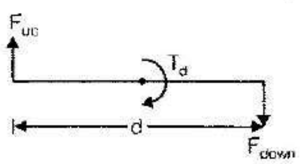
Note:

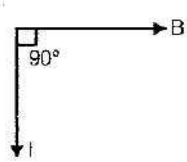
- The current through the PMMC instrument is range in 20 mA. The large current can damage the moving system of instrument.
- If spring of P.M.M.C. instrument is broken the reading is zero because the current does not flow in coil but in moving coil it shows full scale. Whereas in moving iron type spring broken the reading will be beyond full scale.

Expression of Torque Produced in PMMC:



(a) Force *F* acts on each side of the coil (b) Area enclosed by the coil





Force of conductor = F = NBI*l* sin 90^0 = NBI*l*
since two equal and opposite forces are produced on MC, so a deflecting torque (T_o) is developed.

$$T_d = F \times d$$

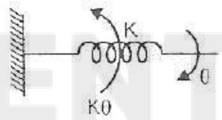
$$= NBIl \times d$$

$$T_o = NBIA$$

Also $$T_d = GI$$

where, N = No. of turns in coil
B = Magnetic flux density (wb/m^2)
I = Current through coil
A = $(l \times d)$ = area of cross section of coil
G = (NBA) = Galvanometer constant

Now the restraining torque (controlling torque) provide by spring control is.



At final or null deflection or at steady deflection,

$$T_c = T_d$$

$\Rightarrow$ $$K\theta_F = GI$$

$\Rightarrow$ $$\theta_F = \frac{G}{K}.I = \left(\frac{NBA}{K}\right) I$$

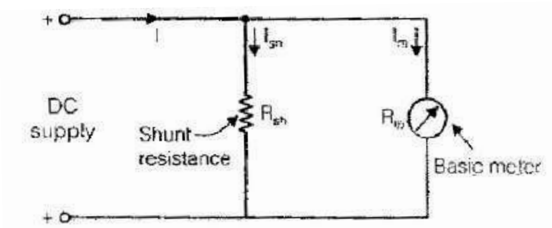
(where, θ_F = deflection produced in instrument)

$\therefore$ $\theta_F \alpha I$ and $\theta_F \alpha \frac{1}{K}$

Hence, the scale in PMMC is linear

Ammeter Shunt in PMMC:

- The basic movement of a d.c. ammeter is a PMMC d'Arsonal galvanometer.
- This is used to raise the current range of ammeter.



Basic ammeter circuit

Apply current division rule,

$$\frac{I \times R_{sh}}{R_m + R_{sh}}$$

$\Rightarrow$ $$\frac{R_m + R_{sh}}{R_{sh}} = \frac{I}{I_m} = m$$ = multiplying factor.

Where, R_{sh} = Shunt resistance (Ω)

R_m = Internal resistance of coil (Ω)

I_m = Full scale deflection current (A)

I = Current to be measured (A)

$$R_{sh} = \frac{R_m}{m-1}$$

- The ratio of total current to the current in the movement is called multiplying power(m)

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

Properties of Ammeter Shunt:

- Ammeter shunt should have only temperature coefficient, small size and low thermal e.m.f. with copper
- The copper shunts are not used because of its bulky size and its high resistivity.
- The most commonly used material for D.C shunt is "Manganin" because it has low thermal e.m.f. with copper and low temperature coefficient.
- The resistance of shunts should not vary with time.

Note:

"Constantan" is a useful material which is used for the construction of a.c measuring instrument.

Error in PMMC Ammeters:

Errors due to magnets:

In order to have permanence in magnetism, magnets are aged by heat and vibration treatment. This process results in the loss of initial magnetism but that remains is strongly held.

Error due to springs:

The weakening of magnets tends to decrease the deflection for a particular value of current, while the weakening of springs tends to increase the deflection.

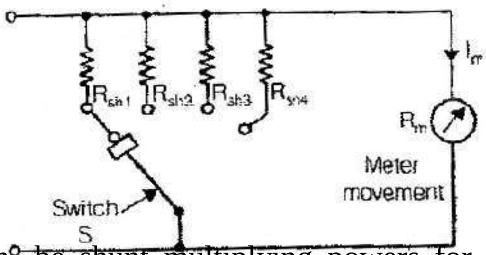
Error due to Variation in Temperature.

- Since material of shunt and moving coil are not same therefore their resistance varies at different rate with change in temperature The results is change in current through ammeter for fixed input current, this change of current through ammeter is error of the instrument.
  - ⇒ Error due to variation in temperature can be eliminated by connecting a resistance known as swamping resistance made up of manganin in series with moving coil.
  - ⇒ The value of swamping resistance is 20 to 30 times of moving coil resistance and it is made up of same material as of shunt i.e. manganin.
- Swamping resistance is only used in PMMC type instrument.

Multi-range Ammeters:

- The current range of a d.c ammeter may be further extended by a number of shunts, selected by a range switches which is called multi range ammeter.
- They are used for ranges from 1 to 50 A.
- Multi range ammeter can be obtained by
  (i) Separate shunt / individual shunt
  (ii) By using universal or Ayrton shunt

By using separate shunt / individual shunt:



Let m_1, m_2, m_3 and m_4 be shunt multiplying powers for current I_1, I_2, I_3, and I_4 respectively.

$$R_{sh_1} = \frac{R_m}{m_1 - 1}$$

where, $$m_1 = \frac{I}{I_m}$$

and $$R_{sh_2} = \frac{R_m}{m_2 - 1}$$

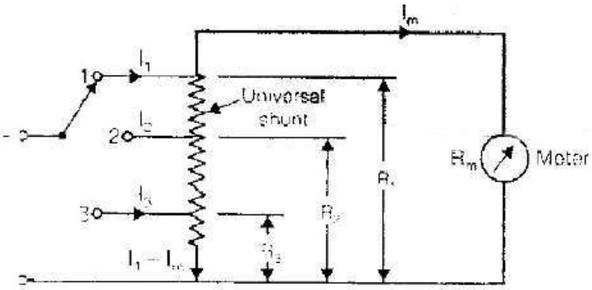
where, $$m_2 = \frac{I_2}{I_m}$$ and so on.

By using universal shunt or Ayrton shunt:

$$R_1 = \frac{R_m}{m_1 - 1}, \text{ where, } m_1 = \frac{I_1}{I_m}$$

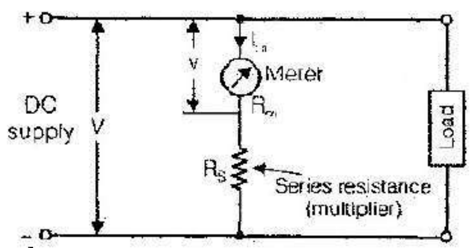
$$R_2 = \frac{R_m + R_1}{m_2}, \text{ where, } m_2 = \frac{I_2}{I_m}$$

$$R_3 = \frac{R_1 + R_m}{m_3}, \text{ where, } m_3 = \frac{I_3}{I_m}$$



PMMC as Voltmeter:

- This has main purpose to increase the voltage range of voltmeter.
- A d'Arsonal basic PMMC is converted into a voltmeter by connecting a series resistance (R_s) with it and this resistance is called multiplier resistance (R_s).
-



By using voltage division rule we get,

$$V = \frac{R_m}{R_s + R_m} V$$

Where, R_s= multiplier resistance (Ω)

V = extended full range voltage (Volt)

$I_m = I_{fs}$ = full scale the meter at full deflection.

and voltage across the meter movement for current I_m

$$V = I_m R_m$$

Now, $\frac{R_s + R_m}{R_m} = \frac{V}{v} = m_v$

where, m_v is the multiplying factor for multiplier.

- Resistance of multiplier for voltmeter

$$R_s = (m_v - 1) R_m$$

- Hence for the measurement of voltage m-times the voltage range of instrument, the R_{sv} should be (m – 1) times the meter resistance.
- Resistance of multiplier for ammeter,

$$R_{s_i} = \frac{R_{m_i}}{m_i - 1}$$

Sensitivity:

- Voltmeter sensitivity

$$S_v = \frac{1}{I_{is}}$$

$I_t \Rightarrow$ full scale deflection current.

$$I_m = \frac{V}{R_m} = I_{ts}$$

$$S_v = \frac{R_m}{V} \Rightarrow \Omega / V \text{ or } \frac{1}{A}$$

$$S_v = \frac{R_m}{V} \Rightarrow \Omega / V \text{ or } \frac{1}{A}$$

- Multiplier Resistance in terms of Sensitivity

$$V = I_m R_s + I_m R_m$$

$\Rightarrow$ $R_s = \frac{V}{I_m} - R_m$ (since $I_m = I_{ts}$)

$$R_s = VS_v - R_m$$

Properties of multipliers:

- Their resistance should not change with time.
- They should be non inductively wound for AC meters.
- Variation of resistance with respect to temperature should be small and it is eliminated by "swamp resistance".

Materials used for multipliers are as,

$\Rightarrow$ For DC application $\Rightarrow$ Manganin

$\Rightarrow$ For AC application $\Rightarrow$ Constantan

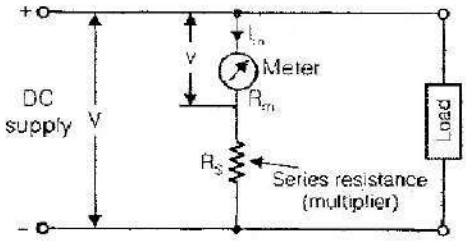
Multi range Voltmeter:

⇒ It can be obtained by using separate multiplier or by using potential divider.

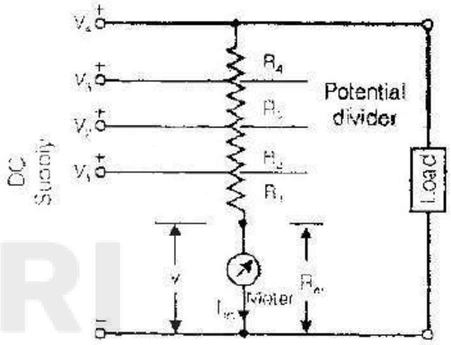
Separate multiplier arrangement

$$R_{s_1} = (m_1 - 1)R_m \quad m_1 = \frac{V_1}{V}$$

$$R_{s_2} = (m_2 - 1)R_m \quad m_2 = \frac{V_2}{V}$$ and so on.



Potential divider arrangement:



From figure, we have

$$R_1 = \frac{V_1}{I_m} - R_m$$

$$= \frac{V_1}{V/R_m} - R_m$$

$$= m_1R_m - R_m = (m_1 - 1)R_m$$

also,

$$R_2 = \frac{V_2}{I_m} - (R_m + R_1)$$

$$= \frac{V_2}{V/R_m} - R_m - R_1$$

$$= m_2R_m - R_n - R$$

$$= m_2R_m - R_m - (m_1 - 1)R_m$$

$$R_2 = (m_2 - m_1)R_m$$

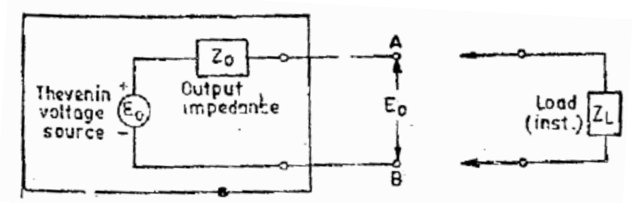
Similarly

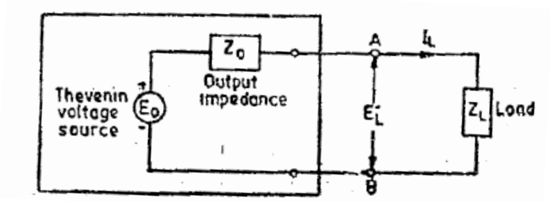
$$R_3 = (m_3 - m_2)R_m$$

$$R_4 = (m_4 - m_3)R_m$$ and so on

Loading Effect:

Loading Effects due to Shunt Connected Instruments:





- Ideally when the load is connected across terminals A & B the output voltage should remain the same.
- However, the load impedance is not infinite and therefore when a voltmeter with an input impedance Z_L is connected across A & B, the current I_L flows. This causes a voltage drop I_LZ_0.

∴ Output voltage under loaded conditions is,

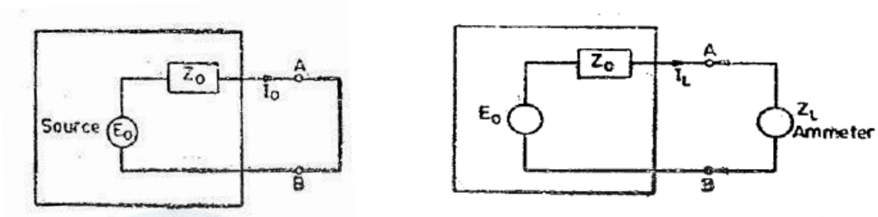
$$E_L = E_0 - I_LZ_0 = I_LZ_L \quad \text{or } E_0 = I_L(Z_L+Z_0)$$

$$\therefore \frac{E_L}{E_0} = \frac{I_L Z_L}{I_L(Z_L + Z_0)} = \frac{1}{(1+\frac{Z_0}{Z_L})}$$

$\therefore$ Actual voltage measured, $E_L = \dfrac{E_0}{1+\frac{Z_0}{Z_L}}$

- Thus the voltage which is measured is modified both in phase and magnitude. This means that the original voltage signal is distorted on account of connection of measuring instrument across it.

Loading Effects due to Series Connected Instruments:



- The value of current flowing between terminals A & B under ideal conditions is I_0. It is the current that flows when terminals A & B are shorted.

$$E_0 = I_0 Z_0$$

- However, when we actually measure the current, a current measuring device has to be introduced between terminals A & B.
- It is usually an ammeter. When an ammeter is placed in between output terminals, it adds to the impedance of circuit.
- This added impedance modifies the value of the current.
- Measured value of current $I_L = \dfrac{E_0}{Z_0 + Z_L} = \dfrac{I_0}{1+\frac{Z_L}{Z_0}}$
- Also $I_L = \dfrac{I_0}{1+\frac{Y_0}{Y_L}}$
- In other words the input admittance of the series elements should be very large as compared with the output admittance of the source in order to reduce loading effect.

Advantage of PMMC instruments

- Rectifier meters
- Ohm meters
- Scale is linear i.e. uniformly divided
- Sensitivity is very high because of high torque to weight ratio
- Accuracy is high

Disadvantage of PMMC instruments

- It is used only for DC measurement
- Cost is higher than moving iron instruments

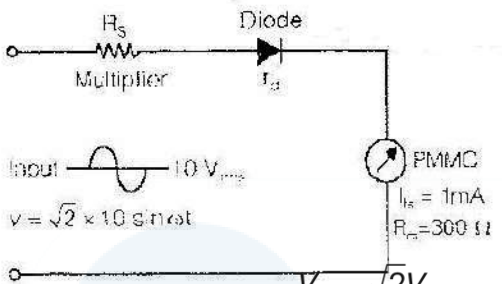
Note:

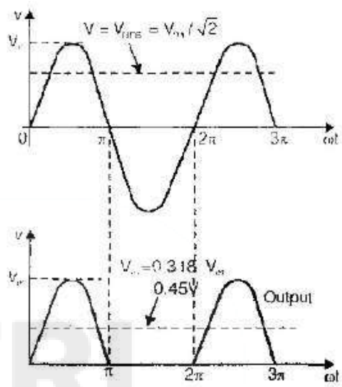
⇒ It AC supply is given in PMMC then it indicate zero because of inertia of coil.

Rectifier Type Instrument:

- These instruments employ a rectifier for the rectification (converts AC to unidirectional DC) and PMMC for detection.
- These instruments use PMMC for display and measure RMS value by calibrating the scale of instruments.
- These type of instruments are mostly used in “Communication circuits” or “High current application circuits” with maximum current application 1 mA, so that there should no any loading effects occurs.
- It has sensitivity ranges from 1000 Ω / V to $2000\,\Omega / V$ (PMMC has highest sensitivity).

Half – wave Rectifier Type:





$$V_{dc} = \frac{V_m}{\pi} = \frac{\sqrt{2}V}{\pi} = 0.45\,V$$

I_{av} = rms signal of input voltage

$$I_{av} = \frac{V_{dc}}{R_s + r_d + R_m} = \frac{0.45V}{R_s + r_d + R_m}$$

when only d.c. input of magnitude ‘V’ is applied. Current in PMMC meter will be

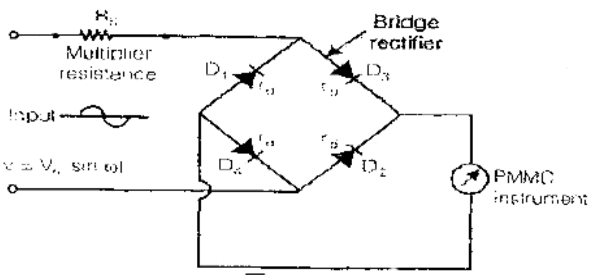
$$I_{av} = \frac{V}{R_s + r_d + R_m}$$

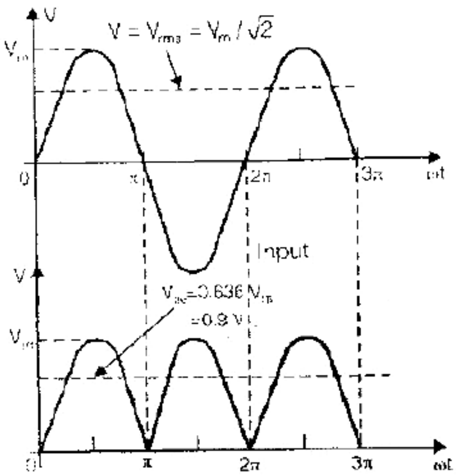
from above equations it can be calculated that AC sensitivity of half-wave rectifier instrument is 0.45 times d.c. sensitivity.

$$I_{av} = \frac{V}{R_s + r_d + R_m}$$

∴ sensitivity of d.c. $S_{dc} = \frac{1}{I_{fs}}\,\Omega / V$

Full-wave Rectifier Type:





Here, $V_{dc} = \frac{2V_m}{\pi} = \frac{2\sqrt{2}V}{\pi} = 0.9\ volt$

$$I_{av} = \frac{V_{dc}}{R_s + 2r_d + R_m}$$

$$I_{av} = I_m = \frac{0.9V}{R_s + 2r_d + R_m}$$

Note:

- Rectifier type instrument respond to average value of rectifies signal but their scale is to be calibrated for RMS value of the input signal.

- Extension of range of rectifier type instrument as Voltmeters can be done by adding a multiplier resistance in series.

Half wave rectifier:

For DC input:

$$I_{dc} = I_m = \frac{V_{dc}}{R_s + r_d + R_m}$$

$$R_s = \frac{V_{dc}}{I_m} - r_d - R_m$$

Since, $S = \frac{1}{I_{fs}} = \frac{1}{I_m}$

where, $I_m = I_{fs}$ = full scale reading of current of PMMC

∴ $R_s = \frac{V_{dc}}{I_m} - r_d - R_m$

$$R_s = S_{dc}V_{dc} - r_d - R_m$$

For AC input:

$$R_s = S_{ac}\,V_{rms} - r_d - R_m$$

$$R_s = 0.45S_{dc}V_{rms} - r_d - R_m$$

Full-wave rectifier

For DC input:

$$I_{dc} = I_m = \frac{V_{dc}}{R_s + 2r_d + R_m}$$

$$R_s = \frac{V_{dc}}{I_m} - 2r_d - R_m$$

$$R_s = S_{dc}V_{dc} - 2r_d - R_m$$

where, r_d is diode resistance.

Factors affecting the performance of rectifier type instrument:

- Waveform of input signal
- Diode resistances
- Diode capacitances
- Effect of temperature changes
- Decrease in sensitivity

Advantages of Rectifier type Instruments:

- The frequency ranges extends from about 20 Hz to High audio frequency.
- They have a practically uniform scale for most ranges.

- These may be used for both AC and DC operation.
- They are of high sensitivity.

Disadvantages of Rectifier type Instruments:

- Loading effect is more for AC than DC.
- They responds to Average value of input waveform applied but these are calibrated to RMS value of sinusoidal waveform.

CLASS ROOM OBJECTIVES

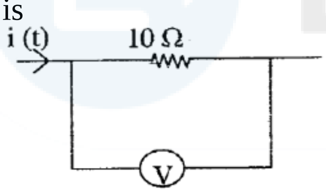
1. A (0 to 10) mA PMMC ammeter reads nearby 4 mA in a circuit, its bottom spring snaps suddenly the reading will non near by be,

   (a) 10 mA (b) 2 mA (c) 8 mA (d) 0

2. A Galvanometer with full scale current of 10 mA has a resistance of 1000Ω. The multiplying power of a 100Ω shunt with this galvanometer is ____________

   (a) 110 (b) 100 (c) 11 (d) 10

3. The current i(t) passing through 10Ω resistor as shown in fig A. as a waveform as shown in fig B. Then the reading of the d.c. voltmeter is connected across 10Ω resister is



D.C voltmeter

Fig. (A)

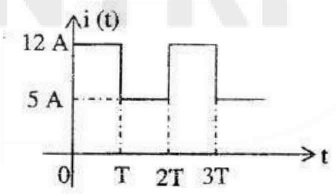
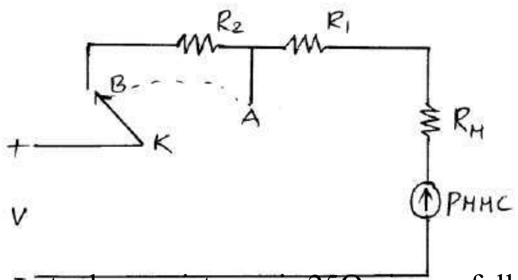


Fig. (B)

4. The ammeter shown in the figure can measure in (0-1) mA range. Now it has to be used in 10V & 50V range with the help of switch K. Design the meter. Given that the internal resistance is 10Ω.



5. A moving coil instrument when resistance is 25Ω gives a full scale deflection with a current of 1mA. The instrument is to be used with a manganin shunt to extent its range to 100mA. Calculate the error caused by 10^0C rain in temperature when

   (i) copper moving coil is connected across a manganin shunt.

   (ii) A 75Ω manganin resistance is used in series with the moving coil.

   The temperature coefficient of copper is $0.004/^0$C and that of manganin is $0.00015/^0$C.

6. Two PMMC ammeters with 100μA full scale current are to be used in 10V & 100V range respectively. The figure of merit (sensitivity) of these meters in kΩ/V is _____

(a) 10, 10 (b) 10, 1 (c) 1, 10 (d) 10, 100

7. A PMMC meter has a sensitivity of 1000Ω/V, when it is measuring half the full scale in 100V range, the meter current is _______

(a) 1mA (b) 10mA (c) 0.5mA (d) 50mA

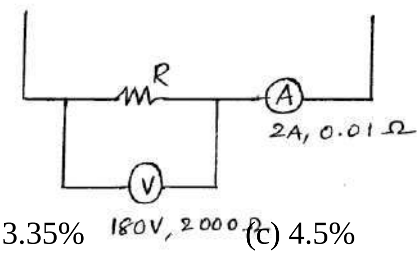
8. Two PMMC voltmeters with 100V full scale for both and with sensitivities 10 kΩ/V & 20 kΩ/V respectively are connected in series, the maximum voltage that can be measured by this series combination is _______. Also find the readings of individual meters when this combination is reading maximum.

9. A DC source of 35V is connected across a series combination of 600Ω & R_X. A voltmeter having 1200Ω as internal resistance when connect across 600Ω resistance reads 5V. Find R_X.

10. A DC circuit can be represented as a 50V source and with an output resistance of 100 kΩ. In order to measure the voltage across its terminals with an accuracy of 99%, the resistance of voltage measuring device should be nearly ________

(a) 10 kΩ (b) 100 kΩ (c) 1 MΩ (d) 10MΩ

11. A resistance is measured by the circuit shown in the figure. The voltmeter and ammeter reading are 180V & 2A given a measured resistance of 90Ω. The internal resistance of both the meters are 2000Ω & 0.01Ω respectively. The % error in the measurement of resistance is __________



(a) 2.25% (b) 3.35% (c) 4.5% (d) 4.71%

PREVIOUS QUESTIONS

ONE MARK QUESTIONS

01. A (0-10) mA PMMC ammeter reads 4 mA in a circuit. Its bottom control spring snaps suddenly. The meter will now read nearly **(GATE-EE-1994)**

(a) 10 mA (b) 8 mA (c) 2 mA (d) zero

02. Two 100V full scale PMMC type D.C voltmeter having figure of merits (FOM) of 10 kΩ /V and 20 kΩ /V are connected in series. The series Combination can be used to measure a maximum dc voltage of _______ **(GATE-EE-1995)**

03. An advantage of a permanent magnet moving coil instrument is that it is

(a) free from friction error

(GATE-EE-1996)

(b) has high (torque/weight of the moving parts) ratio

(c) has low (torque/weight of the moving parts) ratio
(d) can be used on both a.c. and d.c.

04. A d.c. voltmeter has a sensitivity of 1000 Ω /Volt. When it measures half full scale in 100 V range, the current through the voltmeter is **(GATE-EE-1998)**

(a) 100 mA (b) 1 mA (c) 0.5 mA (d) 50 mA

05. A manganin swamping resistance is connected in series with a moving coil ammeter consisting of a multi-ammeter and a suitable shunt in order to

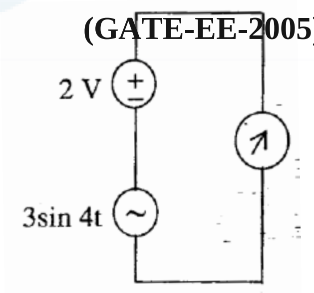
(a) minimize the effect of temperature variation **(GATE-EE-2003)**
(b) obtain large deflecting torque
(c) reduce the size of the meter
(d) minimize the effect of stray magnetic fields

06. A galvanometer with a full scale current of 10 mA has a resistance of 1000 Ω. The multiplying power (the ratio of measured current to galvanometer current) of a 100 Ω shunt with this galvanometer is
(GATE-EE-2004)

(a) 110 (b) 100 (c) 11 (d) 10

07. A PMMC voltmeter is connected across a series combination of a DC voltage source V_1 = 2V and an AC voltage source $V_2(t)$ = 3 sin(4t) V. The meter reads

(GATE-EE-2005)



(a) 2 V (b) 5 V (c) $(2+\sqrt{3}/2)\,V$ (d) $\sqrt{17}/2\,V$

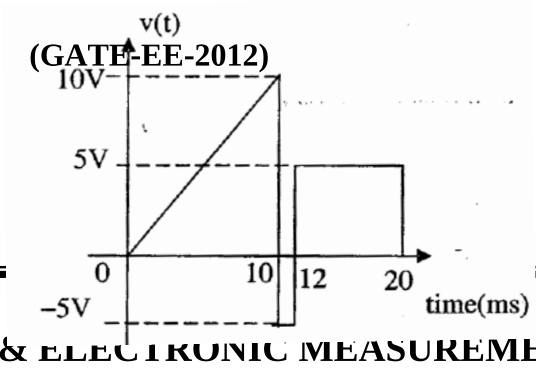
08. An ammeter has a current range of 0-5A, and its internal resistance is 0.2 Ω. In order to change the range to 0-25 A. We need to add a resistance of

(GATE-EE-2010)

(a) 0.8 Ω in series with the meter (b) 1.0 Ω in series with the meter
(c) 0.04 Ω in parallel with the meter (d) 0.05 Ω in parallel with the meter

09. A periodic voltage waveform observed on an oscilloscope across a load is shown. A permanent magnet moving coil (PMMC) meter connected across the same load reads

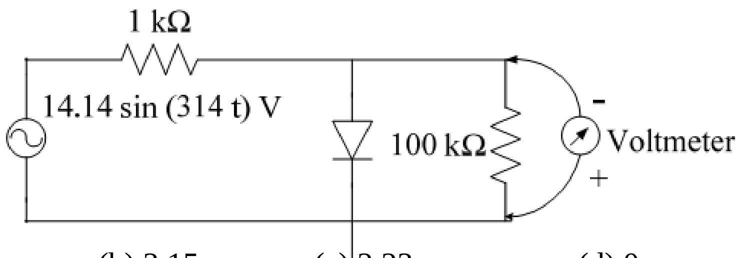
(GATE-EE-2012)



(a) 4 V (b) 5 V (c) 8 V (d) 10 V

10. The input impendance of the permanent magnet moving coil (PMMC) voltmeter is infinite. Assuming that the diode shown in the figure below is ideal, the reading of the voltmeter in Volts is

(GATE-EE-2013)

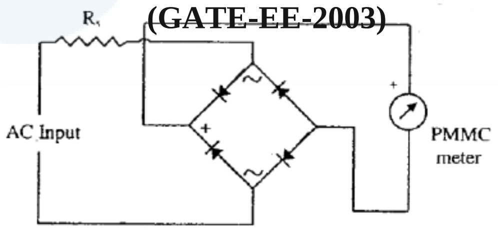


(a) 4.46 (b) 3.15 (c) 2.23 (d) 0

TWO MARKS QUESTIONS

11. An ac voltmeter uses the circuit shown below, where the PMMC meter has an internal resistance of 100 Ω and requires a dc current of 1 mA for full scale deflection. Assuming the diodes to be ideal, the value of R_s to obtain full scale deflection with 100 V (ac rms) applied to the input terminal would be

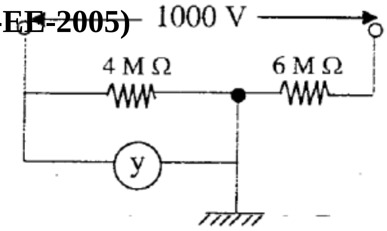
(GATE-EE-2003)



(a) 80 KΩ (b) 89 KΩ (c) 89.9 KΩ (d) 90 KΩ

12. A 1000 V DC supply has two 1-crore cables as its positive and negative leads: their insulation resistances to earth are 4 MΩ and 6 MΩ, respectively, as shown in the figure. A voltmeter with resistance 50 KΩ is used to measure the insulation of the cable. When connected between the positive core and earth, then voltmeter reads

(GATE-EE-2005)



(a) 8 V (b) 16 V (c) 24 V (d) 40 V

13. An analog voltmeter uses external multiplier settings. With a multiplier setting of 20 kΩ, it reads 440 V and with a multiplier setting of 80 kΩ, it reads 352 V. For

a multiplier setting of 40 kΩ, the voltmeter reads **(GATE-EE-2012)**

(a) 371 V (b) 383 V (c) 394 V (d) 406 V

14. Two ammeters X and Y have resistances of 1.2 Ω and 1.5 Ω respectively and they give full-scale deflection with 150 mA and 250 mA respectively. The ranges have been extended by connecting shunts so as to give full scale deflection with 15 A. The ammeters along with shunts are connected in parallel and then placed in a circuit in which the total current flowing is 15A. The current in amperes indicated in ammeter X is __________. **(GATE-EE-2014)**

15. If one of the central springs of a Permanent Magnet Moving Coil ammeter is broken then, when connected it will read **(IES-EE-1992)**

    (a) zero (b) half of the correct value

    (c) twice the correct value (d) an infinite value

16. Swamping resistance is a resistance which is added to the moving coil of a meter to **(IES-EE-1998)**

    (a) reduce the full-scale current (b) reduce the temperature error

    (c) increase the sensitivity (d) increase the field strength

17. An indicating instrument is more sensitive of its torque to weight ratio is (a) much larger than unity (b) of the order of unity **(IES-EE-1998)**

    (c) much less than unity (d) made deflection-dependent

18. In a flux meter, the controlling torque is **(IES-EE-1998)**

    (a) produced by weights attached to the moving coil

    (b) produced by spring (c) not provided at all

    (d) provided by crossed coil mechanism

19. In a PMMC instrument, the control spring stiffness and the strength of the magnet decrease by 0.04% and 0.02% respectively due to a rise in temperature by 1^0C. With a rise in temperature of 10^0C, the instrument reading will **(IES-EE-1999)**

    (a) increase by 0.2% (b) decrease by 0.2%

    (c) increase by 0.6% (d) decrease by 0.6%

20. In a permanent magnet moving coil instrument, if the control spring is replaced by another one having a higher spring constant, then the natural frequency and damping ratio will **(IES-EE-2000)**

    (a) decrease (b) increase and decrease respectively

(c) decrease and increase respectively (d) increase

21. The reflecting mirror mounted on the moving coil of a vibration galvanometer is replaced by a bigger size mirror. This will result in **(IES-EE-2002)**
    (a) lower frequency of resonance and lower amplitude of vibration
    (b) low frequency of resonance but the amplitude of vibration is unchanged
    (c) higher frequency of resonance and lower amplitude of vibration
    (d) higher frequency of resonance but the amplitude of vibration is unchanged
22. Torque/Weight ratio of an instrument indicates **(IES-EE-2003)**
    (a) Selectivity (b) Accuracy (c) Fidelity (d) Sensitivity
23. Which one of the following materials is used in the fabrication of swamping resistance of a PMMC instruments? **(IES-EE-2004)**
    (a) Copper (v) Aluminium (c) Manganin (d) Tungsten
24. Which one of the following statements is correct?
    Spiral springs are used in instruments to **(IES-EE-2004)**
    (a) provide controlling torque (b) provide damping torque
    (c) lead the current to moving coil as well as to provide the controlling torque
    (d) provide linear deflection
25. Which of the following factors limit the deflection of the pointer of a PMMC instrument of about 90^0?
    1. Its damping mechanism
    2. Linearity of the magnetic field in which the coil moves
    3. Control spring arrangement
    4. Shape of the pole shoe of the horseshoe magnet

    Select the correct answer using the code given below : **(IES-EE-2006)**
    Codes :
    (a) Only 1 and 3 (b) Only 2 and 4
    (c) Only 2 and 3 (d) Only 1 and 4

26. **Assertion (A) :** A PMMC instrument is used for reading both dc and ac signals
    Reason (R) : The deflecting torque in a PMMC instrument is directly proportional to the current in the moving coil. **(IES-EE-2008)**
    (a) Both A and R are true and R is the correct explanation of A
    (b) Both A and R are true but R is NOT the correct explanation of A
    (c) A is true but R is false
    (d) A is false but R is true

27. What is the 'swamping' resistance which is connected in series with the working coil of a voltmeter to drastically reduce the error in measurement caused due to variation in temperature, made of ? **(IES-EE-2008)**
    (a) Constantan (b) Eureka (c) Manganin (d) Nichrome

28. Due to which one of the following reasons bearings of PMMC instrument are made of jewel ? **(IES-EE-2008)**
    (a) To avoid wear and tear of the moving system

(b) To provide a small support
(c) It can be easily replaced (d) To make the system robust

29. When a steady current is passed through a ballistic galvanometer, then the deflection will be **(IES-EE-2012)**
(a) Maximum (b) Zero
(c) Twice the normal value as it depends on Hibbert magnetic standard
(d) None of the above

30. An angular deflection type indicating PMMC meter is provided with spring control and **(IES-EE-2012)**
(a) damping by air dashpot
(b) electromagnetic damping in the aluminum former only
(c) electromagnetic damping in the aluminum former and the moving coil as well
(d) no damping

31. An advantage of PMMC instrument is that it **(IES-EE-2012)**
(a) is free from friction error
(b) has high torque-to-weight ratio of moving parts
(c) has low torque-to-weight ratio
(d) can be used on both AC and DC

32. The galvanometer is protected during transport by **(IES-EE-2013)**
(a) connecting critical damping resistance across the galvanometer terminals
(b) shorting the galvanometer terminals
(c) keeping the galvanometer terminals open-circuited
(d) connecting a capacitor across the galvanometer terminals.

33. If one of the control springs of a permanent magnet coil ammeter is broken, then on being connected it will read. **(IES-EE-2013)**
(a) Zero (b) Half of the correct value
(c) Twice of the correct value (d) An infinite value

34. The working of a PMMC (Permanent magnet moving coil) meter is described by a second order differential equation

$$J\frac{d^2\theta}{dt^2} + D\frac{d\theta}{dt} + S\theta = T$$

Where
J = Moment of inertia of the system
D = Damping coefficient,

S = Spring constant
θ = Angular deflection and
T = Activating torque
Assuming D = 0, undamped natural angular frequency is **(IES-EE-2013)**

(a) $\sqrt{\frac{S}{J}}$ (b) $\sqrt{\frac{J}{S}}$ (c) $\frac{1}{\sqrt{JS}}$ (d) $\frac{1}{2\mu\sqrt{JS}}$

35. **Statement (I) :** A permanent magnet moving coil instrument is always slightly under damped.

Statement (II) : The pointer of the PMMC instrument should overshoot a little beyond the steady-state position to give the accurate reading. **(IES-EE-2014)**

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

36. A galvanometer has a current sensitivity of 1 μA/mm and a critical damping resistance of 1 kΩ. The voltage sensitivity and the meg-ohm sensitivity respectively are **(IES-EE-2014)**

(a) 1 mV/mm and 1 MΩ (b) 1 mV/mm and 2 MΩ
(c) 2 mV/mm and 2 MΩ (d) 2 mV/mm and 1 MΩ

37. A moving coil instrument of resistance 5 Ω requires a potential difference of 75 mV to give a full deflection. The value of shunt resistance needed to give a full scale deflection at 30 A is **(IES-EE-2014)**

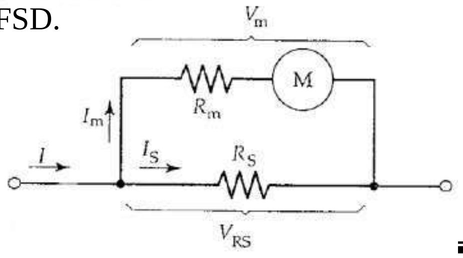
(a) 2.5 mΩ (b) 9.99 mΩ (c) 5 Ω (d) 9.95 Ω

PRACTICE QUESTIONS

01. A PMMC instrument with a 300-turn coil has a magnetic flux density in its air gaps of B = 200 mT. The coil dimensions are d = 2 cm and *l* = 1.5 cm. Calculate the torque produced on the coil for a current of 1 mA, and determine the controlling torque constant if the 1 mA current produces 40^0 deflection.

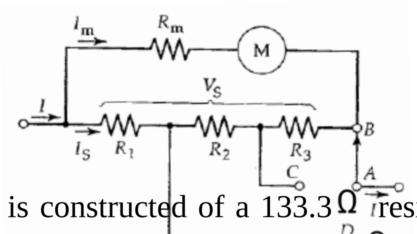
02. A PMMC instrument has an air gap flux density of 50 mT, and the 150-turn coil has dimensions of d = 2.5 cm and *l* = 3 cm. The spring controlling torque is 3×10^{-6} Nm/degree. Determine the coil current that will produce a 50^0 deflection.

03. An ammeter (as in Fig.) has a PMMC instrument with a coil resistance of R_m = 99Ω and FSD current of 0.1 mA. The shunt resistance is R_S = 1Ω. Determine the total current passing through the ammeter at (a) FSD, (b) 0.5 FSD, and (c) 0.25 FSD.



04. A PMMC instrument with 100 μA FSD and a 1 kΩ coil resistance is to be used in an ammeter. Calculate the required shunt resistance for (a) FSD = 100 mA, and (b) FSD = 1 A

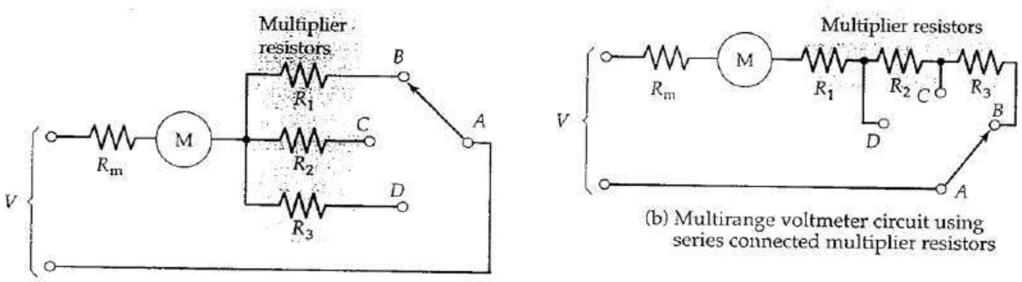
05. A PMMC instrument has a three-resistor Ayrton shunt connected in parallel with it to make an ammeter, as in Fig. The resistance values are : R_1 = 0.05Ω, R_2 = 0.45Ω, and R_3 = 4.5Ω. The meter has R_m = 1 kΩ and FSD = 50 μA. Calculate the three ranges of the ammeter.



06. A dc ammeter is constructed of a 133.3Ω resistance in parallel with a PMMC instrument. If the instrument has a 12 kΩ coil resistance and 30 μA FSD, determine the measured current at FSD, 0.5 FSD, and 0.33 FSD.

07. A PMMC instrument with 100 μA FSD and 1 kΩ and resistance is to be converted into a voltmeter. Determine the required multiplier resistance if the voltmeter is to measure 50 V at full scale. Also calculate the applied voltage when the instrument indicates 0.8, 0.5, and 0.2 of FSD.

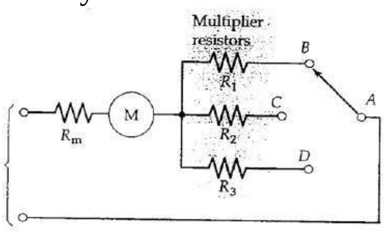
08. A PMMC instrument with FSD = 50 μA and R_m = 1700Ω is to be employed as a voltmeter with ranges of 10 V, 50 V, and 100 V/ Calculate the required values of multiplier resistors for the circuits of Figs. (a) and (b).



(b) Multirange voltmeter circuit using series connected multiplier resistors

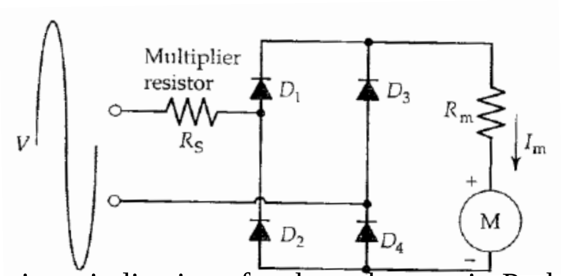
(a) Multirange voltmeter circuit using switched multiplier resistors

09. A PMMC instrument with a 900 Ω coil resistance and an FSD of 75 pA is to be used as a dc voltmeter as in Fig. 4-6(a). Calculate the individual multiplier resistance to give an FSD of (a) 100 V, (b) 30 V, and (c) 5 V. Also, determine the voltmeter sensitivity.



(a) Multirange voltmeter circuit using switched multiplier resistors

10. A PMMC instrument with FSD = 100 μA and R_m = 1 kΩ is to be employed as an ac voltmeter, as in Fig. 4-7. FSD is to be 100 V (rms), and silicon diodes are to be used. Calculate the required multiplier resistance value.



11. Calculate the pointer indications for the voltmeter in Problem 09, when the rms input voltage is (a) 75 V and (b) 50 V.
12. Calculate the sensitivity of the voltmeter in Problem 09.

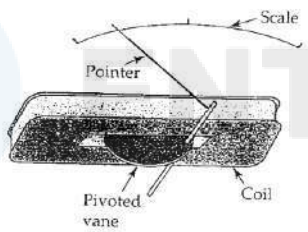
2. Moving Iron Type Instrument

- The most common Ammeters and Voltmeters for laboratory or switch board used as power frequencies are the Moving iron instruments.

  M.I. type instrument may be of

  1. Attraction type moving iron
  2. Repulsion type moving iron.

1. Attraction type M.I. instruments



- Attraction type consist of movable iron vane attached to the spindle iron vane is always attracted towards the centre of fixed coil.
- When the current flows through the coil, a magnetic field is produced and MI moves from weaker field outside the coil to the stronger field inside it or in other words the MI is attracted.
- The controlling torque (T_c) is provided by springs but gravity control can be used for panel of instruments.
- Damping is provided by "Air-friction damping" with the help of "Light A*l*-piston" which moves in a fixed chamber closed at one end as shown in above figure .
- The operating magnetic field in MI is very weak so, eddy current damping in not used.

  Range of magnetic field is 0.0062 to 0.0075 wb/m^2
- If frequency of input is large the eddy current induced in iron vane may distort the main flux or field of the coil. Therefore frequency of signal in moving iron type instrument is restricted to 0 – 125 Hz.

Expression for deflecting torque in MI type:

∴ Deflecting torque = $T_d = \frac{I^2}{2}\frac{dL}{d\theta}$ (for DC)

$\frac{I_{rms}^2}{2}\cdot\frac{dL}{d\theta}$ (for AC)

where,

L = inductance of coil.

I = current through the coil

θ = deflection of the pointer

And control torque,

$$T_o = k\theta$$

At balance condition or at final deflection

$$T_c = T_d$$

$$k\theta = \frac{I^2}{2}.\frac{dL}{d\theta}$$

$$\theta = \frac{I^2}{2k}.\frac{dL}{d\theta}$$

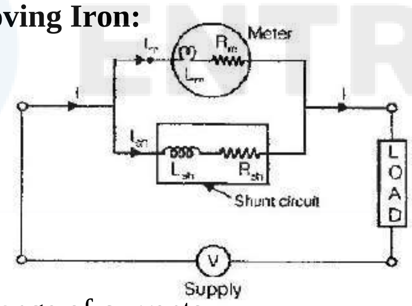
$$\theta \alpha I^2 \text{ if } \frac{dL}{d\theta} = \text{constant}$$

- The scale is non-linear or non-uniform because $\theta \, \alpha \, I^2$.

Note:

- Moving iron type instrument measures RMS value of input quantity.
- MI type instruments are less accurate but cheaper.

Ammeter Shunt for Moving Iron:



Shunt for moving iron instrument

- It is used to increase the range of currents.
- The currents in meter and shunt are in inverse ratio of their impedances.

$$\frac{|I_m|}{I_{sh}} = \frac{\sqrt{R_{sh}^2 + \omega^2 L^2 sh}}{\sqrt{R_m^2 + \omega^2 L_m^2}} = \frac{R_{sh}}{R_m} \frac{\sqrt{1 + \frac{\omega^2 L_{sh}^2}{R_{sh}}}}{\sqrt{1 + \frac{\omega^2 L_m^2}{R_m^2}}}$$

If,

$$\frac{\omega L_{sh}}{R_{sh}} = \frac{\omega L_m}{R_m}$$

then

$$\frac{|I_m|}{|I_{sh}|} = \frac{R}{R_m}$$

- For DC purpose, L_m is short circuited then,

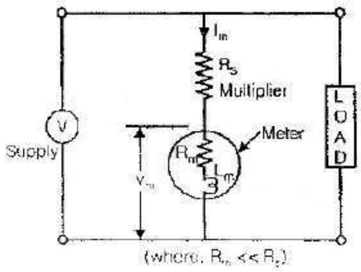
$$\frac{I_m}{I_{sh}} = \frac{R_{sh}}{R_m}$$

- For AC purpose.

$$\frac{|I_m|}{|I_{sh}|} = \frac{R_{sh}}{Z_m} = \frac{R_{sh}}{\sqrt{R_m^2 + \omega^2 L_m^2}}$$

- The distribution of current between shunt and meter changes with change in frequency resulting in an error called frequency error.
- This frequency error can be eliminated when time constant of shunt and time constant of meter are same i.e. $(T_m = T_{sh})$

Multipliers for Moving from Voltmeter:



Voltage multiplier for moving iron instruments

where, $$\frac{|V_m|}{|V|} = \frac{\sqrt{R_m^2 + \omega^2 L_m^2}}{\sqrt{(R_s + R_m)^2 + \omega^2 L_m^2}}$$

$m = \frac{V}{V_m}$ = voltage multiplying factor

R_m = resistance of meter.

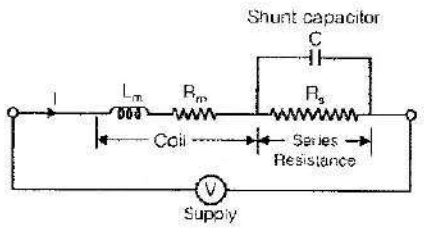
L_m = inductance of meter.

I_m = meter current for full scale defection.

ω = angular frequency.

⇒ With change infrequency, reading of instrument changes. This is called frequency error.

⇒ Frequency error can be eliminated by multiplier resistance (R_s) is shunted by capacitor (C).



Frequency compensation for M.I. voltmeters

⇒ To make "I_m" would be independent of frequency we should note that.

$c = 0.41\frac{L_m}{R_s^2}$ ⇒ Limited upto 125 Hz.

- M.I. (Moving iron) types are used for frequency range 0 to 125 Hz Beyond this frequency, eddy current become large which can distort the main magnetic field.
- To minimize or avoid the error due to "Hysterisis and Eddy current loss" the iron piece used in MI type is taken as "Soft iron" (i.e. Ni-Fe alloy).

Advantages of M.I. type

- These are inexpensive, robust and rugged. Therefore, these are widely used in industries.

- These instruments can be used for both AC and DC.
- Less frictional errors.

Disadvantages of M.I. type
- Their scale is non-linear and reading of instrument is affected by stray magnetic field.
- Sensitivity is poor.

CLASS ROOM OBJECTIVES

1. A MI voltmeter reads correctly on 250V DC. Find the reaching of the instrument if it is connected to 250V AC, 50Hz supply, given that the meter resistance is 500Ω and the inductance is 1H and the meter is connected with a non inductance series resistance of 2KΩ.

2. The inductance of certain MI instrument is expressed as L = 10 + 30 - $\frac{\theta^2}{4}$ μH where 'θ' is deflection in radians. The control spring torque 25 x 10^{-6} N-m/rad. The deflection of pointer when the meter carries a current 5A in rod is ______.
   (a) 2.4 (b) 1.2 (c) 2 (d) 1

3. A current of -8+6$\sqrt{2}$ Sin (Cot+30) is passed through 3 meters; they are centre zero PMMC meter, MI meter and true RMS meter. The readings of these meters are respectively__________
   (a) 8, 6, 8 (b) 8, 10, 10 (c) -8, 10, 10 (d) -8, 2, 2

4. A PMMC meter with a sensitivity of 1KΩ/V is to be used in (0-100)V range. Find the total resistance in the voltmeter given that meter full scale current is 0.1mA.
   (a) 10KΩ (b) 1000KΩ (c) 100KΩ (d) None

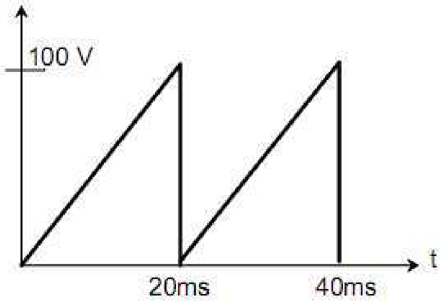
PREVIOUS QUESTIONS

<u>ONE MARK QUESTIONS</u>

01. An unshielded moving iron voltmeter is used to measure the voltage in an a.c. circuit. If a stray d.c. magnetic field having a component along the axis of the meter coil appears, the meter reading would be **(GATE-EE-1992)**
    (a) unaffected
    (b) decreased
    (c) increased
    (d) either decreased or increased depending on the direciton of the d.c. field

02. The effect of stray magnetic fields on the actuating torque of a portable instrument is maximum when the operating field of the instrument and the stray fields are **(GATE-EE-2003)**
    (a) perpendicular (b) parallel
    (c) inclined at 60^0 (d) inclined at 30^0

03. The saw-tooth voltage waveform shown in the figure is fed to a moving iron voltmeter. Its reading would be close to ___________. **(GATE-EE-2014)**



TWO MARKS QUESTIONS

04. The inductance of a certain moving-iron ammeter is expressed as $L = 10 + 3\theta - \frac{\theta^2}{4}\ \mu H$, where θ is the deflection in radians from the zero position. The control spring torque in 25 x 10^{-6} Nm/radian. The deflection of the pointer in radian when the meter carries a current of 5A, is **(GATE-EE-2003)**

(a) 2.4 (b) 2.0 (c) 1.2 (d) 1.0

05. Consider the following statements associated with moving iron instruments:

1. These can be used in d.c. as well a.c. circuits
2. The scale is non-uniform
3. The moving iron is placed in a field of a permanent magnet

Which of these statements are correct ? **(IES-EE-2002)**

(a) 1, 2 and 3 (b) 1 and 2 (c) 2 and 3 (d) 1 and 3

06. A spring controlled moving iron voltmeter draws a current of 1mA for full scale value of 100V. If it draws a current of 0.5mA, the meter reading is **(IES-EE-2002)**

(a) 25V (b) 50V (c) 100V (d) 200V

07. In moving iron instruments, eddy current damping cannot be used as

(a) They have a strong operating magnetic field **(IES-EE-2014)**

(b) They are not normally used in vertical position

(c) They need a large damping force, which can only be provided by air friction

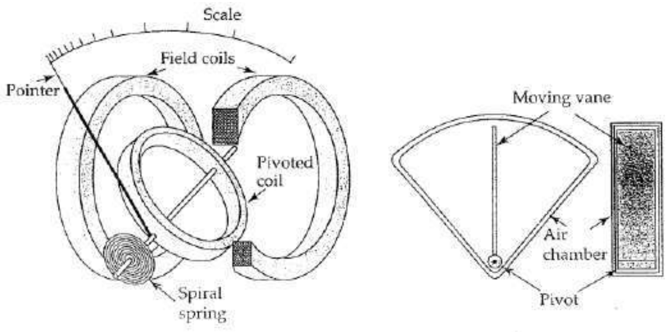
a. The introduction of a permanent magnet required for eddy current damping would distort the existing weak operating magnetic field.

PRACTICE QUESTIONS

01. The self inductance of a moving-iron instrument increases by 2.23 mH when the pointer deflects from zero to 80^0. If the controlling springs produce a torque of 10 μ Nm/degree, calculate the coil current.

02. A moving-iron instrument produces a 50^0 deflection when the coil current is 500 mA. The controlling torque exercised by the springs is 8 μ Nm/degree. Calculate the increase in the coil self inductance from the zero current level.

3. Electrodynamometer Type instrument



(a) Coil arrangement (b) Air damping system

- Electrodynamometer type instrument consists of two coil, fixed coil (FC) and Moving coil (MC).
- Fixed coil is split into two parts in order to have uniform distribution of flux around moving coil.
- FC is used to provide operating field.
- MC is a current carrying coil on which deflection torque (T_d) is produced.
- For measurement of voltage and current both coils are connected in series. Deflection produced in moving coil is same for a.c and d.c. and is proportional to the r.m.s. value of a.c. Therefore, these are first calibrated on d.c. This calibration is then transferred to the a.c. instrument on alternating current.
- Spring control is used and Control spring is provided for dual purposes as,
    * To generate spring control torque.
    * Provide path for current to the moving coil.
- If spring is broken, controlling torque is zero and Meter reads zero.
- Air friction damping is used
- Since operating field is weak so shielding is to be provided against stray magnetic field.
- At frequencies below 15 Hz pointer of electro dynamometer instrument start pulsating, therefore these instruments are used above the 15 Hz.

Expression of Torque in ED type Instruments:

- Instantaneous torque in dynamometer is given by

$$\boxed{T_i = i_1 i_2 \frac{dM}{d\theta}}$$

$i_1 =$ Instantaneous current in the fixed coil (FC)

$i_2 =$ Instantaneous current in the moving coil (MC)

M= the mutual inductance between FC and MC.

$$\boxed{T_d = I_1 I_2 \frac{dM}{d\theta}} \Rightarrow \text{For DC operation}$$

And
$$\boxed{T_d = \frac{tD}{d\theta} \cdot \frac{1}{T} \int_0^T i_1 i_2 \, dt}$$

⇓ for AC operation

For spring control

$$T_c = k\theta$$

Now, at final deflection

$$T_c = T_d$$

Caste –I

For d.c. current application.

$$\theta = \frac{I_1 I_2}{K}\frac{dM}{d\theta}$$

Case –II

For a.c. current application

Let, $i_1 = I_{m1}\sin\omega t$

$i_2 = I_{m2}\sin(\omega t - \varphi)$

So, $$\text{deflection} = \theta = \frac{I_1 I_2}{K}\cos\varphi\frac{dM}{d\theta}$$

PREVIOUS QUESTIONS

01. For a certain dynamometer ammeter the mutual inductance (M) varies with deflection θ^0 as M = -6 cos (θ + 30^0) mH. Find the deflecting torque produced a direct current of 50 mA corresponding to a deflection of 60^0. **(IES-EE-2013)**

(a) 10 N-m (b) 20 N-m (c) 15 μ N-m (d) 1.5 μ N-m

PRACTICE QUESTIONS

01. An electrodynamic instrument displays a 90^0 deflection when I_t = I_m = 100 mA. The controlling torque exercised by the springs is 0.067 μ Nm/degree. Calculate the increase in the mutual inductance from I = 0.

02. An electrodynamic instrument has I_t = I_m = 100^0 deflection, and the mututal inductance increase from zero deflection is measured as 23..3 mH. The controlling torque exercised by the springs I 0.75 μ Nm/degree. Calculate the measured current.

KEY

1. Permanent Magnet Moving Coil Instruments

PREVIOUS QUESTIONS

1. D	2. 150	3. B	4. C
5. A	6. C		

7. A 8. C 9. A 10. A 11. C 12. A

13. D 14. 10 15. A 16. B 17. A 18. C

19. A 20. B 21. B 22. B 23. C 24. C

25. C 26. D 27. C 28. A 29. B 30. B

31. B 32. A 33. C 34. A 35. A 36. A

37. A

PRACTICE QUESTIONS

1.0.45 x 10^{-6} Nm/deg 2. 27 mA 3. 10 mA, 5mA, 2.5mA

4. 1.001, 0.10001 5. 10 mA, 100mA, 1mA

6. 300µA, 150µA, 100µA 7. 499 kΩ, 40 V, 25 V, 10 V

8. R1 = 198.3 kΩ, R2 = 998.3 KΩ, R3 = 1.9983 kΩ
R1 = 198.3 kΩ, R2 = 800.0 KΩ, R3 = 1 MΩ

9. 1.33 MΩ, 399 kΩ, 65.8 kΩ, 13.3 kΩ/V

2. Moving Iron Instruments

PREVIOUS QUESTIONS

1. D 2. B 3. 58 4. C 5. B 6. A

7. D

PRACTICE QUESTIONS

1. A 2. 2.8 mH

3. Electrodynamometer Instruments

PREVIOUS QUESTIONS

1. C

PRACTICE QUESTIONS

1. 947 µH 2. 75 mA

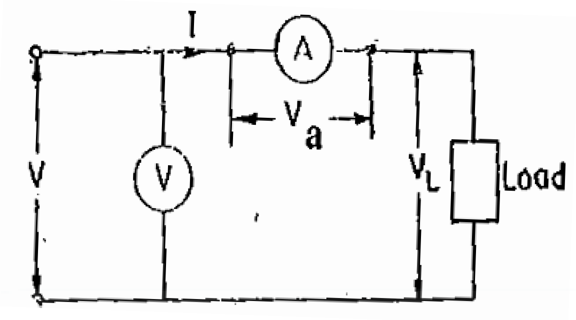
CONTENTS

1. MEASUREMENT OF POWER

Introduction

Watt meters are the instruments which indicate power consumed in electrical circuits. At any instant of time the power consumed by an electrical network is the product of the voltage across and current through the circuit.

Ammeter – voltmeter method for the measurement of power in D.C. circuits:
(i)Ammeter connected near to load:



Let R_A= internal resistance of the ammeter

$\therefore V_A = IR_A$

True power = $P_T = V_L I_L$

Measured power $= P_m =$ Voltmeter reading x Ammeter reading

$\Rightarrow P_m V \times I_L = (V_A + V_L) \times I_L$

$= V_A I_L + V_L I_L$

Power indicated by instrument = power loss in ammeter + power consumed in load.

Also $\boxed{P_m = I_L^2.R_A + V_L I_L}$ $(\because I = I_L)$

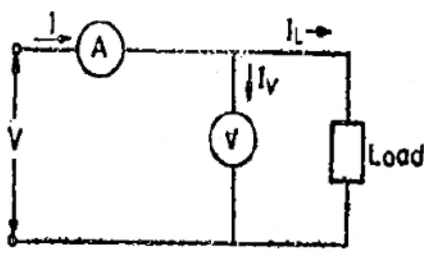
% error $= \in_r \% = \frac{P_m - P_r}{P_T} \times 100 = \frac{P_A}{P_T} \times 100$

Also, $\boxed{\% \in_r = \frac{R_A}{R_L} \times 100}$

Note:

- This above circuit in figure above (4.1) is preferred for large value of load resistances because in this case error would be reduced .

Voltmeter connected near to Load.



Let $R_V =$ internal resistance of voltmeter

$\therefore I_v = V / R_v$

Measured power = $P_m =$ Voltmeter reading $\times$ Ammeter reading

$$\Rightarrow P_m = V_L \times I = V_L \times (I_V + I_L) = V_L I_L + V_L I_V$$

$\therefore$ $\boxed{P_m = P_V + P_T}$

Power indicated by instrument = Power loss in voltmeter + Power consumed in load

Also $\boxed{P_m = \frac{V_L^2}{R_V} + V_L . I_L}$

% error $= \frac{P_m - P_T}{P_T} \times 100 = \frac{P_V}{P_T} \times 100$

Also, $\boxed{\% \in_r = \frac{R_L}{R_V} \times 100}$

Note:

$\Rightarrow$ This above circuit in figure above is preferred for low value of load resistances because in this case error would be reduced.

Power Measurement in A.C. Circuit by Wattmeter Method.

3 general types of wattmeters are:

$\Rightarrow$ Dynamometer type

$\Rightarrow$ Induction type

$\Rightarrow$ Electrostatic type

Average power over a cycle in an AC circuits in given by.

$$P = \frac{V_m I_m}{2} \cos\varphi = V\ I \cos\varphi$$

Where, $V = \frac{V_m}{\sqrt{2}} = RMS$ value of voltage

$I = \frac{I_m}{\sqrt{2}} = RMS$ value of current

And $\cos\varphi =$ Power factor of the load

Electrodynamometer type Wattmeter:

It consists of two coils, the “Fixed coil” or “Field coils” or “Current coils” (C.C) are connected in series with the load.

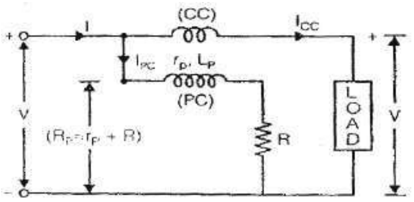
And the other coils is “Moving coil or “Pressure coil” or “Voltage coil” or “Potential coil (PC)”.

The CC is made up of thick conductor because it has to carry the higher load current.

The PC is made up thin conductor because it is designed to carry low load current.

Spring control is used in this instrument.

Air friction damping is used.



Let r_p and L_p are the resistance and inductance of the pressure coil or moving coil respectively and $R_p = (r_p + R) =$ total resistance of PC circuit

I=current in CC circuit $= I_{CC}$

Since, $I_{PC} = \frac{V}{R_p}$

also , $|Z_p| = \sqrt{(R+r_p)^2 + (\omega L_p)^2}$ = impedance of PC circuit.

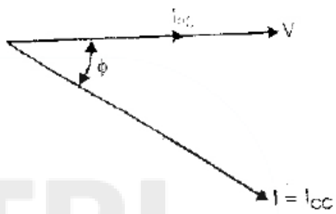
Let load p.f. $\cos\varphi$ lagging i.e I lags behind V by an angle φ.

Deflecting torque $= T_d = I.\frac{V}{R_p}.\cos\varphi\frac{dM}{d\theta}$

$$T_d = \frac{V_I \cos\varphi}{R_p}.\frac{dM}{d\theta}$$

and controlling torque $= T_c = K\theta$

At null deflection, $T_c = T_d$



$$\boxed{\theta = \frac{VI\cos\varphi}{KR_p}.\frac{dM}{d\theta}}$$

Since, $\theta \; \alpha \; VI\cos\theta$ it indicates the uniform scale.

Errors in electrodynamometer type wattmeter

1. Due to inductance of pressure coil i.e. "L_p"
2. Due to pressure coil capacitance
3. Due to mutual inductance
4. Due to connections.
5. Due to eddy currents
6. Due to stray magnetic fields.
7. Due to temperature variation.

1. Error due to PC inductance (L_p)

Since, $Z_p = R_p + J\omega L_p$

$= |Z_P| \angle \beta$

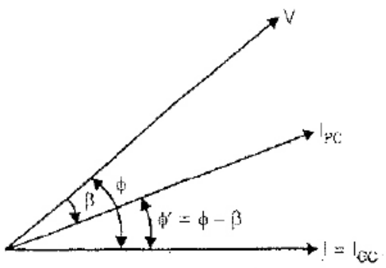
Where $\boxed{\beta = \tan^{-1}\left(\frac{\omega Lp}{R_p}\right)}$

Also, $\boxed{R_p = |Z_p|\cos\beta \; and \; \omega L_p = |Z_p|\sin\beta}$

Phasor diagram for Lagging p.f.

Deflecting torque.

$$T_d = I.\frac{V}{Z_p}\cos\varphi'\frac{dM}{d\theta}$$



$$T_d = \frac{VI\cos(\varphi-\beta)}{R_p}\cdot\frac{dM}{d\theta}$$

⇓

Lagging p.f. indicates inductive load

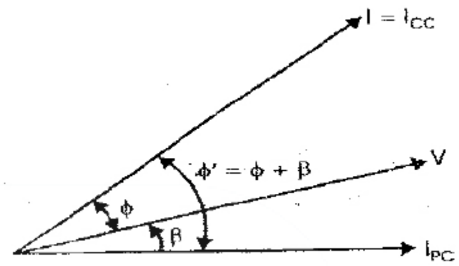
At final deflection,

$$T_c = T_d$$

$$\theta = \frac{VI\cos(\varphi-\beta)\cos\beta}{KR_p}\cdot\frac{dM}{d\theta}$$

$$\therefore \boxed{\text{deflection } (\theta) \propto VI\cos(\varphi-\beta)\cos\beta}$$

Phasro diagram of leading p.f.



$$T_d = \frac{VI\cos(\varphi+\beta)\cos\beta}{R_p}\cdot\frac{dM}{d\theta}$$

⇓

Leading p.f. indicates capacitive load

Finally $\boxed{deflection(\theta)\ \alpha\ VI\cos(\varphi+\beta)\cos\beta}$

- Due to "L_p" wattmeter reading is Higher at Lagging p.f.
- Due to "L_p" wattmeter reading is Lower at Leading p.f.

Correction Factor (CF):

$$CF = \frac{\text{True power}}{\text{Measured or reading power}}$$

For lagging power factor,

$$CF = \frac{\cos\varphi}{\cos(\varphi-\beta)\cos\beta}$$

Also if $\beta <<<$ then $\cos\beta \approx 1$

$$CF = \frac{1}{1+\tan\varphi\tan\beta}$$

∴ Measured or reading

Power = $(1+\tan\varphi\times\tan\beta)$ true power

Error due to "L_p" in wattmeter is given by,

Error $= \in_r = \text{Reading power} - \text{True power}$

$$\in_r = \tan\varphi\tan\beta\times VI\cos\varphi$$

$$\boxed{\in_r = VI\sin\varphi\tan\beta}$$

Also

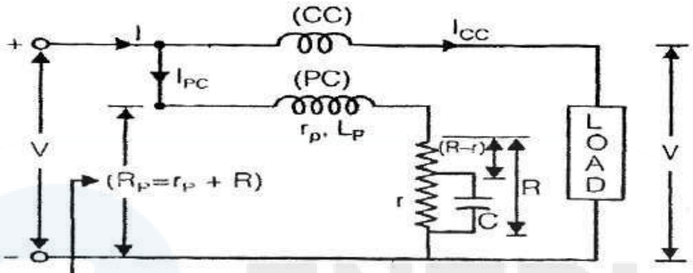
$$\% \in_r = \frac{\in_r}{\text{True power}} \times 100 = (\tan\varphi \tan\beta) \times 100$$

Now, for leading p.f.,

$$CF = \frac{\cos\varphi}{\cos(\varphi+\beta)\cos\beta}$$

Compensation for "L_p" of PC:

Error due to L_p can be eliminated by connecting a Capacitor 'C' parallel with "R" or the main circuit as in figure, then new circuits becomes.



Let a portion of series resistance R i.e. "r" is shunted with capacitor 'C' then,

$$Z_p = (r_p + J\omega L_p) + (R - r) + \left(r \parallel \frac{1}{J\omega C}\right)$$

$$\Rightarrow \quad Z_P (R - r) + J\omega L_p + \frac{r - J\omega C r^2}{1 + \omega^2 C^2 r^2}$$

At power frequency we assume, $\omega^2 C^2 r^2 << 1$ then,

$$Z_P \approx R_P + J\omega L_p - J\omega C r^2$$

$$\therefore Z_p \approx R_p + J\omega(L_p - Cr^2)$$

If we make, $L_p = Cr^2$ then $Z_p \approx R_p$ and then there is no "β" obtained.

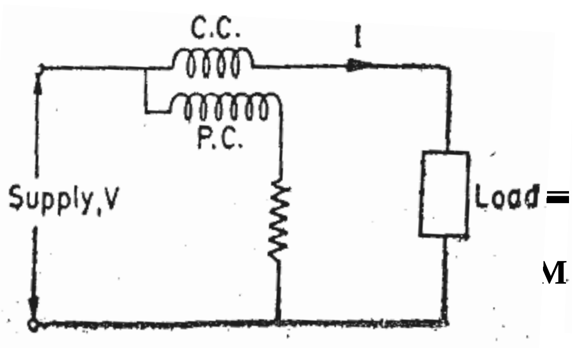
So by this compensation method error due to "L_p" is eliminated y shunt capacitor (C) and is given by

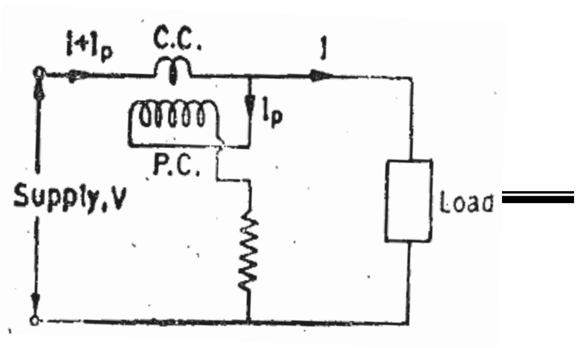
$$C = \frac{L_P}{r^2}$$

Note:

The frequency range over which the above compensation holds good is 10 KHz.

Error due to connections:





From left figure,

$$V_{PC} = V + V_{CC}$$

$$= V + I_{CC} R_C \left(where\ R_C = resistance\ of\ CC \right)$$

$$V_{PC} = V + I_{RC}$$

But, reading $= V_{PC}.I_{CC} = VI + V_{CC} I$

$$= P + I^2.R_c$$

$$\boxed{\therefore\ Error = I^2 R_c = Losses\ in\ CC}$$

Note:

This connection is suitable for Lower load current i.e., load power $(P)\downarrow$.

From right figure,

$V_{PC} = V$ and $I_P = \dfrac{V}{R_P}$ (Where R_P= resistance of PC)

and reading $= V_{PC} I_{CC} = P + \dfrac{V^2}{R_P}$

$$\boxed{\therefore\ Error = \frac{V^2}{R_P} = Losses\ in\ PC}$$

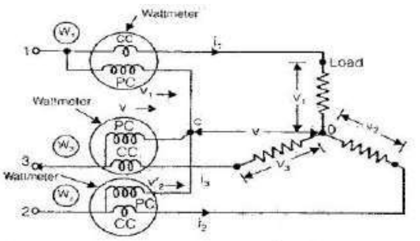
Note:

This connection is suitable for Large load current.

POWER MEASUREMENT IN POLYPHASE SYSTEM

Blondel's Theorem:

- If a network is supplied through n-conductors the total power is measured by summing the readings of n-wattmeterrs so arranged that a current element of a wattmeter is in each line and the corresponding voltage element is connected between that line and a common point.
- If the common point is located on one of the lines then the power may be measured by (n-1) wattmeters.



(Power measurement in a 3-ϕ, 3 wire system)

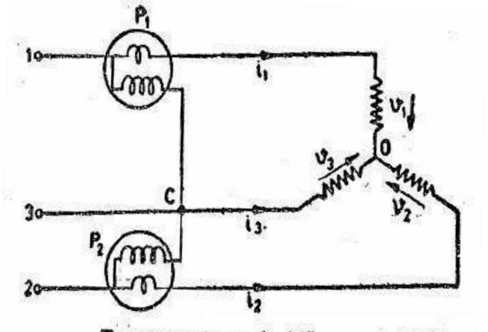
∴ Sum of the wattmeter reading $= v_1 i_1 + v_2 i_2 + v_3 i_3$

Measurement of 3-Phase power with two wattmeter method:

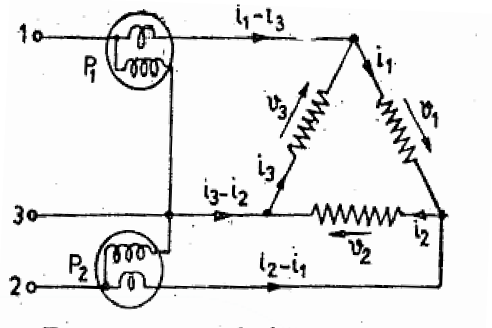
In a three phase, three wire system, we require 3-elements, but if we make te common points of the pressure coils coincide with one of the lines, then we will require only, n-1=3-1=2, elements.

Instantaneous power consumed by load is given by,

$$p_i = v_1 i_1 + v_2 i_2 + v_3 v_3$$



Two wattmeter method (Star connection)



Two wattmeter method (Delta connection)

Let us consider two watt meters connected to measure power in three phase circuit as shown in figure (star connection). Instantaneous reading of W_1 wattmeter

$$P_1 = i_1 (v_1 - v_3)$$

Instantaneous reading of W_2 wattmeter

$$P_2 = i_2 (v_2 - v_3)$$

Sum of instantaneous reading of two wattmeter is,

$$P = P_1 + P_2$$

$$P = i_1 (v_1 - v_3) + i_2 (v_2 - v_3)$$

$$P = v_1 i_1 + v_2 i_2 - v_3 (i_1 + i_2)$$

From KCL at node 'o'

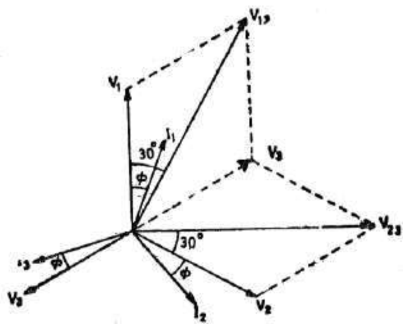
$$i_1 + i_2 + i_3 = 0$$

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

∴ Sum of instantaneous readings of two wattmeters

$$P = v_1 i_1 + v_2 i_2 + v_3 i_3$$

The phasor diagram for a balanced star connected load as shown in figure.



Since the load is balanced, therefore,

Phase voltages, $V_1 = V_2 = V_3 = V(say)$

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

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

and, Power factor = $\cos\varphi$

Actually phase currents and line currents both are same in star connection.

Then reading of wattmeter W_1 is,

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

$$P_1 = \sqrt{3}V\ I\cos\left(30^0 - \varphi\right)$$

And reading of wattmeter W_2 is,

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

$$P_2 = \sqrt{3}VI\ \cos\left(30^0 + \varphi\right)$$

∴ Sum of reading of two wattmeter is,

$$P = P_1 + P_2$$

$$P = \sqrt{3}\ VI\left[\cos\left(30^0 - \varphi\right) + \cos\left(30^0 - \varphi\right)\right]$$

$$P = \sqrt{3}VI\left(\sqrt{3}\cos\varphi\right)$$

$$\boxed{P = 3VI\cos\varphi = 3 - \varphi\ power}$$

This shows the total power consumed by the load.

Since, $\boxed{P_1 - P_2 = \sqrt{3}VI\ \sin\varphi}$

$$\boxed{\varphi = \tan^1\left[\sqrt{3}\left\{\left(\frac{P_1 - P_2}{P_1 + P_2}\right)\right\}\right]}$$

From this equation we have also find pf= $\cos\varphi$

Effects of Power Factor on the readings of Wattmeters;

When power factor = $\cos\varphi = 1\ i.e,\ \varphi = 0^0$

Then, $P_1 = \sqrt{3}VI\ \cos 30^0 = \frac{3}{2}VI$

$$P_2 = \sqrt{3}VI\ \cos 30^0 = \frac{3}{2}VI$$

∴ Total power $P = P_1 + P_2 = 3VI$

At unity power factor (UPF), both wattmeter readings are equal.

When power factor $= \cos\varphi = \frac{\sqrt{3}}{2}\ i.e\ \varphi = 30^0$

Then, $P_1 = \sqrt{3}VI$

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

So, $\boxed{P_1 = 2P_2}$

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

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

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

When power factor $= \cos\varphi = 0.5\ i.e\ \varphi = 60^0$

Then, $P_1 = \sqrt{3}VI\cos(30^0 - 60^0) = \sqrt{3}VI\cos 30^0 = \frac{3}{2}VI$

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

∴ 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.

When power factor $= \cos\varphi = 0^0\ i.e\ \varphi = 90^0$

then, $P_1 = \sqrt{3}VI\cos(30^0 - 90^0) = \sqrt{3}VI\cos 60^0 = \frac{\sqrt{3}}{2}VI$

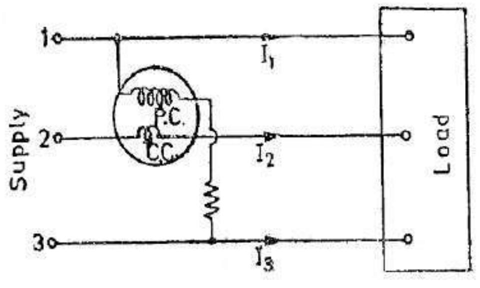
$P_2 = \sqrt{3}VI\cos(30^0 + 90^0) = -\frac{\sqrt{3}}{2}VI$

∴ Total power $= P = P_1 + P_2 = 0$

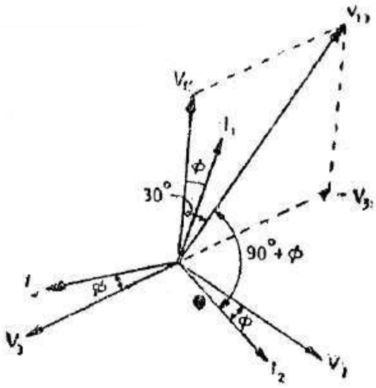
At zero power factor (ZPF) i.e. $\cos\varphi = 0,$ both wattmeter reads equal but with opposite sign.

Measurement of Reactive Power

- The reactive power in a circuit is Q = 3VI sinφ. It is often convenient and even essential that the reactive power be measured.
- The current coil of the wattmeter is connected in one line and the pressure coil is connected across the other two lines.



Reactive power measurement with one wattmeter



Phasor diagram for connections (a).

Current through the current coil = I_2

Voltage across the pressure coil = V_{13}

∴ The reading of watt meter = V13 I2 cos(90+φ) = $\sqrt{3}$VI cos(90+φ)

= -$\sqrt{3}$VI sinφ

Total reactive volt amperes of the circuitQ = 3VIsinφ

=(-$\sqrt{3}$) x reading of watt meter

Phase angle φ = $\tan^{-1}\frac{Q}{P}$

CLASS ROOM OBJECTIVES

01. The reactance of pressure coil of a wattmeter is 1% of its resistance. The % error in the measurement, while measuring a load at 0.5 pf lagging is?

02. A dynamometer wattmeter measures power in a 50 Hz, 1-Φ circuit without error at all power factors. The resistance of the voltage coil and its series resistance are 400 Ω and 10000 Ω respectively. The series coil has a distributed self capacitance equivalent to a shunt capacitance of 20 pF. What is the self inductance of pressure coil.

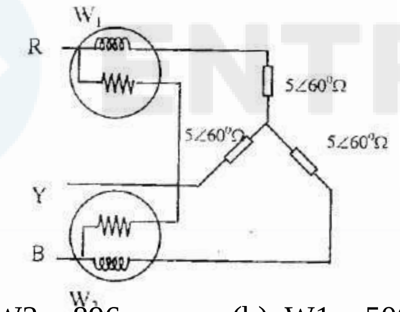
03. A water boiler at home is switched on to the a.c. mains supplying power at 230 v/ 50 Hz. The frequency of instantaneous power consumed by the boiler is

(a) 0 Hz (b) 50 Hz (c) 100 Hz (d) 150 Hz

04. Electro dynamic type watt meters have large errors while measuring power in a.c. circuits at low power factor conditions, since the voltage across and the current though the

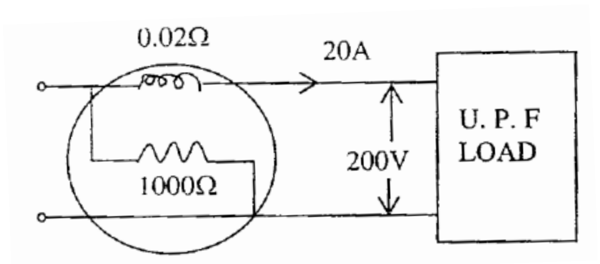
(a) current coil are not in phase (b) current coil are not in quadrature
(c) pressure coil are not in phase (d) pressure coil are not in quadrature

05. The line to line input voltage to the 3 phase, 50Hz, ac circuit shown in fig is 100V r.m.s. Assuming that the phase sequence is RYB the wattmeter would read



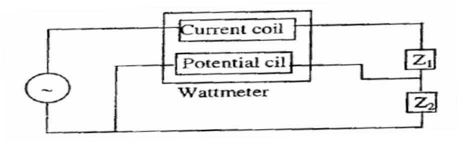
(a) W1 = 886w and W2 = 896w (b) W1 = 500w and W2 = 500w
(c) W1 = 0w and W2 = 1000w (d) W1 = 250w and W2 = 750w

06. The circuit in fig is used to measure the power consumed by the load. The current coil and the voltage coil of the watt meter have 0.02 Ω and 1000 Ω resistance respectively. The measured power compared to the load power will be



(a) 0.4% less (b) 0.2% less (c) 0.2% more (d) 0.4% more

07. A wattmeter is connected as shown in the fig. the wattmeter reads



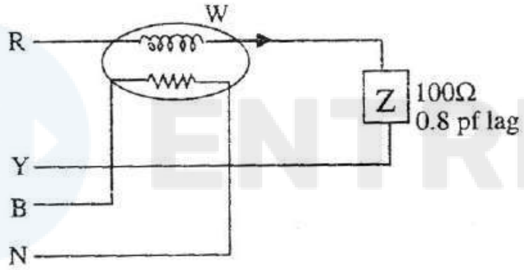
(a) zero always (b) Total power consumed by Z_1 & Z_2

(c) power consumed by Z_1 (d) power consumed by Z_2

08. A wattmeter reads 400 W when its current coil is connected in the R phase and its pressure coil is connected between this phase and the neutral of a symmetrical 3-phase system supplying a balanced star connected 0.8 p.f. inductive load. The phase sequence is RYB. What will be the reading of this wattmeter if its pressure coil alone is reconnected between the B and Y phases, all other connections remaining as before ?

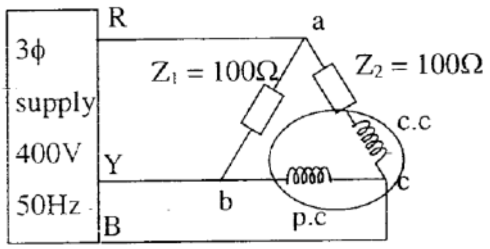
(a) 400.0 (b) 519.6 (c) 300.0 (d) 692.8

09. A single-phase load is connected between R and Y terminals of a 415 V, symmetrical, 3-phase, 4-wire system with phase sequence RYB. A wattmeter is connected in the system as shown in figure. The power factor of the load is 0.8 lagging. The wattmeter will read



(a) -795 W (b) -597 W (c) +597 W (d) +795 W

10. The figure shows a three phase delta connected load supplied from a 400 V, 50 Hz, 3φ balanced source. The pressure coil and current coil of a wattmeter are connected to the load as shown. With the coil polarities suitably selected to ensure a positive deflection. The wattmeter reading will be.

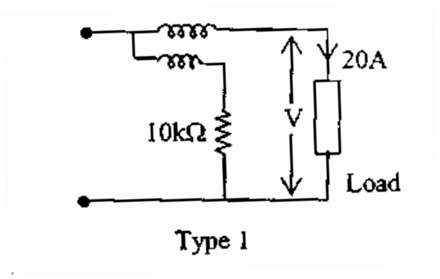


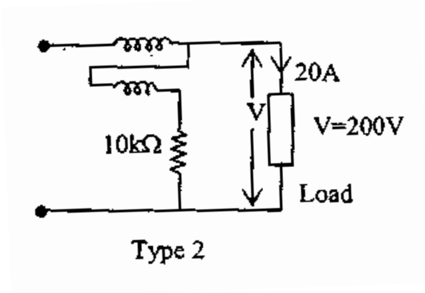
(a) 0 (b) 1600 Watt (c) 800 Watt (d) 400 Watt

11. A 3 V DC supply with an internal resistance of 2 Ω supplies a passive nonlinear resistance characterized by $V_{NL} = I_{NL}^2$. The power dissipated in the nonlinear resistance is

(a) 1W (b) 27W (c) 1W or 27 W depending on current direction (d) 3 W

12. Two types of connections of Wattmeter pressure coil are shown in the figure. The value of the Wattmeter current coil resistance r, which makes the connection errors the same in the two cases is





(a) 0.05 Ω (b) 0.1 Ω (c) 0.01 Ω (d) 0.125 Ω

13. Two wattmeters, which are connected to measure the total power on a three-phase system supplying a balanced load, read 10.5 kW and -2.5 kW, respectively. The total power and the power factor, respectively, are

(a) 13.0 kW, 0.334 (b) 13.0 kW, 0.684
(c) 8.0 kW, 0.52 (d) 8.0 kW, 0.334

PREVIOUS QUESTIONS

01. V_{RN}, V_{YN} and V_{BN} are the instantaneous line to neutral voltages and i_R, i_Y and i_B are instantaneous line currents in a balanced three-phase circuit, the computation, $V_{RN}(i_Y - i_B) - (V_{YN} - V_{BN})\, i_R$ will yield a quantity proportional to

(GATE-EE-1993)

(a) The active power (b) The power factor
(c) The reactive power (d) The complex power

02. A water boiler at home is switched on to the a.c. mains supplying power at 230 v/ 50 Hz. The frequency of instantaneous power consumed by the boiler is **(GATE-EE-1996)**

(a) 0 Hz (b) 50 Hz (c) 100 Hz (d) 150 Hz

03. The moving coil in a dynamometer wattmeter is connected **(GATE-EE-1996)**

(a) in series with the fixed coil (b) across the supply
(c) in series with the load (d) across the load

04. A dynamometer type wattmeter responds to the **(GATE-EE-1997)**

(a) average value of active power (b) average value of reactive power
(c) peak value of active power (d) perak value of reactive power

05. Electro dynamic type watt meters have large errors while measuring power in a.c. circuits at low power factor conditions, since the voltage across and the current though the

(GATE-EE-1999)

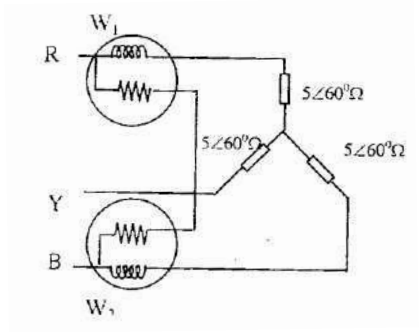
(a) current coil are not in phase (b) current coil are not in quadrature
(c) pressure coil are not in phase (d) pressure coil are not in quadrature

06. The minimum number of wattmeters (s) required to measure 3 – phase, 3 – wire balanced or unbalanced power is **(GATE-EE-2001)**

(a) 1 (b) 2 (c) 3 (d) 4

07. The line to line input voltage to the 3 phase, 50Hz, ac circuit shown in fig is 100V r.m.s. Assuming that the phase sequence is RYB the wattmeter would read

(GATE-EE-



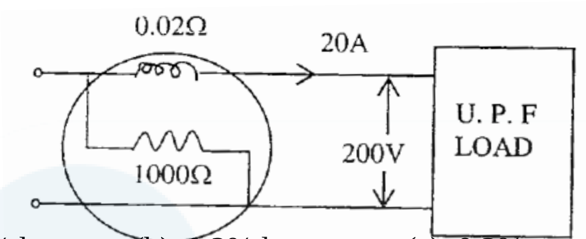
2002)

(a) W1 = 886w and W2 = 896w (b) W1 = 500w and W2 = 500w

(c) W1 = 0w and W2 = 1000w (d) W1 = 250w and W2 = 750w

08. The circuit in fig is used to measure the power consumed by the load. The current coil and the voltage coil of the watt meter have 0.02 Ω and 1000Ω resistance respectively. The measured power compared to the load power will be

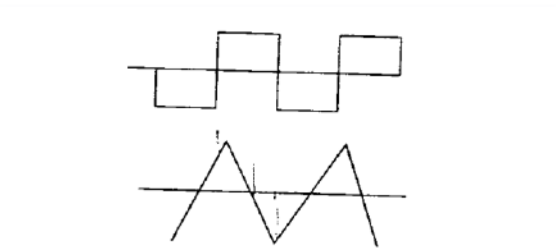
(GATE-EE-2004)



(a) 0.4% less (b) 0.2% less (c) 0.2% more (d) 0.4% more

09. A sampling wattmeter (that computes power from simultaneously sampled values of voltage and current) is used to measure the average power of a load. The peak to peak voltage of the squre wave is 10V and the current is triangular wave of 5A p-p as shown in the figure. The period is 20ms. The reading in w will be

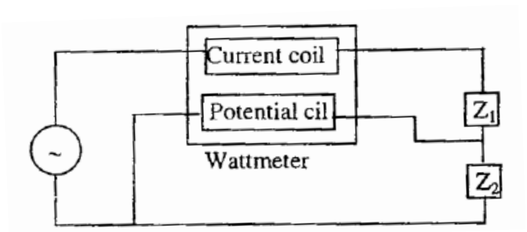
(GATE-EE-2006)



(a) 0W (b) 25W (c) 50W (d) 100W

10. A wattmeter is connected as shown in the fig. the wattmeter reads

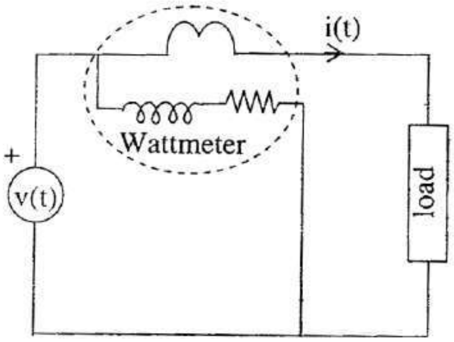
(GATE-EE-2010)



(a) zero always (b) Total power consumed by Z_1 & Z_2

(c) power consumed by Z_1 (d) power consumed by Z_2

11. For the circuit shown in the figure, thand current expressions are $v(t) = E_1 \sin(\omega t) + E_2 \sin(3\omega t)$ and $i(t) = I_1 \sin(\omega t - \varphi_1) + I_3 \sin(3\omega t - \varphi_3) + I_5 \sin(5\omega t)$. The average power measured by the Wattmeter is **(GATE-EE-2012)**



(a) $\frac{1}{2}E_1 I_1 \cos\varphi_1$

(b) $\frac{1}{2}[E_1 I_1 \cos\varphi_1 + E_1 I_3 \cos\varphi_3 + E_1 I_5]$

(c) $\frac{1}{2}[E_1 I_1 \cos\varphi_1 + E_3 I_3 \cos\varphi_3]$

(d) $\frac{1}{2}[E_1 I_1 \cos\varphi_1 + E_3 I_1 \cos\varphi_1]$

12. Power consumed by a balanced 3-phase, 3-wire load is measured by the two wattmeter method. The first wattmeter reads twice that of the second. Then the load impedance angle in radians is

(GATE-EE-2014)

(a) $\pi/12$ (b) $\pi/8$ (c) $\pi/6$ (d) $\pi/3$

13. While measuring power of a three-phase balanced load by the two-wattmeter method, the readings are 100 W and 250 W. The power factor of the load is _________.

(GATE-EE-2014)

14. An LPF wattmeter of power factor 0.2 is having three voltage settings 300 V, 150 V and 75 V, and two current settings 5 A and 10 A. The full scale reading is 150. If the wattmeter is used with 150 V voltage setting and 10 A current setting, the multiplying factor of the wattmeter is _________. **(GATE-EE-2014)**

Two Marks Questions

15. The two wattmeter method is used to measure active power on a three phase, three wise system. If the phase voltage is unbalanced, then the power reading is

(GATE-EE-2000)

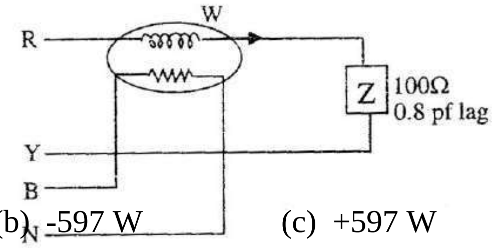
(a) affected by both negative sequence and zero sequence voltages
(b) affected by negative sequence voltage but not by zero sequence voltages
(c) affected by zero sequence voltages but not by negative sequence voltages
(d) not affected by negative or zero sequence voltages

16. A wattmeter reads 400 W when its current coil is connected in the R phase and its pressure coil is connected between this phase and the neutral of a symmetrical 3-phase system supplying a balanced star connected 0.8 p.f. inductive load. The phase sequence is RYB. What will be the reading of this wattmeter if its pressure coil alone is reconnected between the B and Y phases, all other connections remaining as before ?

(GATE-EE-2003)

(a) 400.0 (b) 519.6 (c) 300.0 (d) 692.8

17. A single-phase load is connected between R and Y terminals of a 415 V, symmetrical, 3-phase, 4-wire system with phase sequence RYB. A wattmeter is connected in the system as shown in figure. The power factor of the load is 0.8 lagging. The wattmeter will read **(GATE-EE-2004)**

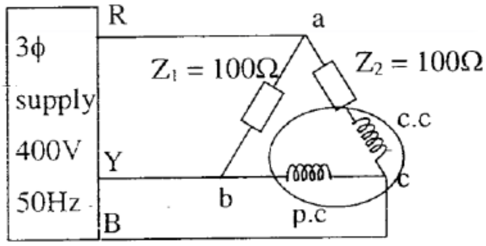


(a) -795 W (b) -597 W (c) +597 W (d) +795 W

18. Two wattmeters, which are connected to measure the total power on a three-phase system supplying a balanced load, read 10.5 kW and -2.5 kW, respectively. The total power and the power factor, respectively, are **(GATE-EE-2005)**

(a) 13.0 kW, 0.334 (b) 13.0 kW, 0.684 (c) 8.0 kW, 0.52 (d) 8.0 kW, 0.334

19. The figure shows a three phase delta connected load supplied from a 400 V, 50 Hz, 3φ balanced source. The pressure coil and current coil of a wattmeter are connected to the load as shown. With the coil polarities suitably selected to ensure a positive deflection. The wattmeter reading will be. **(GATE-EE-2009)**



(a) 0 (b) 1600 Watt (c) 800 Watt (d) 400 Watt

20. Which of the following statement is true about two wattmeter method for power measurement in three phase current. **(IES-EE-1992)**

(a) power can be measured using two wattmeter method only for star connected three phase circuits

(b) when two meters show identical readings, thepower factor is 0.5

(c) when power factor is unity, one of the wattmeter reads zero

(d) when the readings of the two wattmeters are equal but of opposite sign, the power factor is zero.

21. What are the other methods of measuring power in a three phase circuit without using wattmeter. **(IES-EE-1992)**

1. One voltmeter and one ammeter
2. Two voltmeter and two ammeters
3. Three voltmeters
4. Three ammeters

(a) 1 and 2 only (b) 3 and 4 only
(c) 1 and 3 only (d) 4 only

22. The resistances of two coils of a wattmeter are 0.01 ohm and 1000 ohms respectively and both are non-inductive. The load current is 20A and the voltage across the load is 30V. In one of the two way of connecting the voltage coil, the error in the reading would be
(IES-EE-1993)
(a) 0.1% too high (b) 0.2% too high
(c) 0.15% too high (d) zero

23. In the statement "the wattmeter commonly used for power measurement at commercial frequencies is of the X-type. This meter consists of two coil systems, the fixed system being the Y-coil and moving system being the Z-coil". X, Y and Z stand respectively for **(IES-EE-1993)**
(a) dynamometer, voltage and current (b) dynamometer, current and voltage
(c) induction, voltage and current (d) induction, current and voltage

24. Two-wattmeter method is employed to measure power in a 3-phase balanced system with the current coils connected in the A and C lines. The phase sequence is ABC. If the wattmeter with its current coil in A-phase line reads zero, then the power factor of the 3-phase load will be **(IES-EE-1993)**
(a) zero lagging (b) zero leading
(c) 0.5 lagging (d) 0.5 leading

25. The ratio of the readings of two wattemeters connected to measure power in a balanced 3-phase load is 5:3 and the load is inductive. The power factor of load is
(IES-EE-1994)
(a) 0.917 lead (b) 0.917 lag (c) 0.6 lead (d) 0.6 lag

26. A compensated wattmeter has its reading corrected for error due to
(IES-EE-1995)
(a) the frequency (b) friction
(c) power consumed in current coil (d) power consumed in potential coil

27. While measuring power in a three-phase load by two-wattmeter method, the reading of the two wattmeter will be equal and opposite when **(IES-EE-1995)**
(a) power factor is unity (b) load is balanced
(c) phase angle is between 60^0 and 90^0 (d) the load is purely inductive

28. **Assertion (A) :** General purpose dynamometer type wattmeter cannot indicate the correct value of power at low power factors.
Reason (R) : The presence of self-inductance in the pressure coil circuit introduces an error in the indicated value which increases appreciably with decrease in power factor of the load. **(IES-EE-1996)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

29. In two-wattmeter mjethod of power measurement, one of the wattmeter will show negative reading when the load pf angle is strictly **(IES-EE-1996)**

(a) < 30^0 (b) < 60^0 (c) > 30^0 (d) > 60^0

30. An electrodynamometer type wattmeter is connected in a 3-phase supply and having a 3-phase balanced load.E and I are the values of phase voltage and current and φ is the phase angle between them. The wattmeter reading will be **(IES-EE-1996)**

(a) Proportional to EI sin φ (b) Proportional to EI cos φ

(c) proportional to EI tan φ (d) zero

31. In the case of power measurement by two wattmeter method in a balanced 3-phase system with a pure inductive load, **(IES-EE-1997)**

(a) both the wattmeters will indicate the same value but of opposite sign

(b) both the wattmeters will indicate zero

(c) both the wattmeters will indicate the same value and of the same sign

(d) one wattmeter will indicate zero and the other will indicate some non-zero value

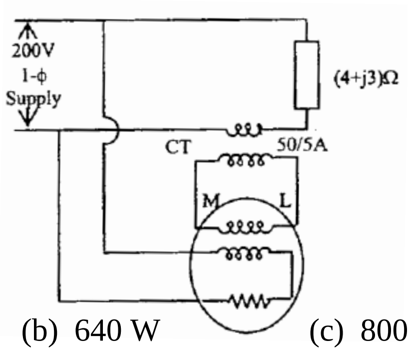
32. In a two-wattmeter method of measuring power, one of the wattmeter is reading sero watts. The power factor of the circuits is **(IES-EE-1998)**

(a) Zero (b) 1 (c) 0.5 (d) 0.8

33. If the readings of the two wattmeters are equal and positive in two wattmeter method, the load pf in a balanced 3-phase 3-wire circuit will be **(IES-EE-1999)**

(a) zero (b) 0.5 (c) 0.866 (d) unity

34. In the circuit shown in the given figure, the wattmeter reading will be **(IES-EE-1999)**



(a) 480 W (b) 640 W (c) 800 W (d) 1000 W

35. A wattmeter has a range of 1000 W with an error of ± 1% of full scale deflection. If the true power passed through it is 100W, then the relative error would b **(IES-EE-2000)**

(a) ± 10% (b) ± 5% (c) ± 1% (d) ± 0.5%

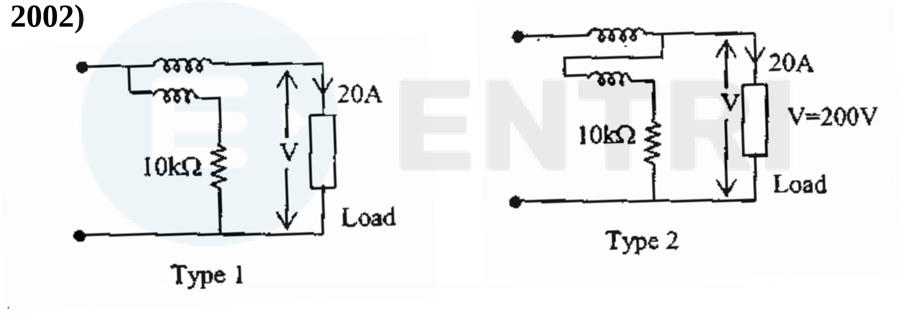
36. In a single-phase power factor meter, the controlling torque is **(IES-EE-2001)**

(a) provided by spring control
(b) provided by gravity control
(c) provided by stiffness of suspension
(d) not required

37. In the measurement of power on balanced load by two-Wattmeter method in a 3-phase circuit, the readings of the Wattmeters are 3kw and 1kW respectively, the latter being obtained after reversing the connections of the current coil. The power factor of the load is
(IES-EE-2002)

(a) 0.277 (b) 0.554 (c) 0.625 (d) 0.866

38. Two types of connections of Wattmeter pressure coil are shown in the figure. The value of the Wattmeter current coil resistance r, which makes the connection errors the same in the two cases is **(IES-EE-2002)**



(a) 0.05 Ω (b) 0.1 Ω (c) 0.01 Ω (d) 0.125 Ω

39. In calibration of a dynamometer Wattmeter by potentiometer, phantom loading arrangement is used because **(IES-EE-2002)**

(a) The arrangement gives accurate results
(b) The power consumed in calibration work is minimum
(c) The method gives quick results
(d) The onsite calibration is possible

40. When two-Wattmeter method of measurement of power is used to measure power in a balanced three phase circuit; if the Wattmeter reading is zero, then

(IES-EE-2002)

(a) power consumed in the circuit is zero
(b) power factor of the circuit is zero
(c) power factor is unity
(d) power factor is 0.5

41. The power of a three-phase three-wire balanced system was measured by two Wattmeter method. The reading of one of the Wattmeter was found to be double

that of the other. What is the power factor of the system ? **(IES-EE-2004)**

(a) 1 (b) 0.866 (c) 0.707 (d) 0.5

42. What is the effect of inductance in the pressure coil on performance of a dynamometer type wattmeter ? **(IES-EE-2005)**
   (a) It reads low on lagging power factor and high on leading power factor
   (b) It reads high on lagging power factor and low on leading power factor
   (c) Its reading is not affected to all
   (d) It always reads low
43. Which one of the following is the correct statement? **(IES-EE-2007)**
   Due to inductance in the pressure coil the dynamometer wattmeter
   (a) reads low on lagging p.f. and high on leading p.f
   (b) reads high on lagging p.f and low on leading p.f
   (c) reading is not affected at all
   (d) always reads low
44. Which of the following statements are correct in case of a power factor meter?
   1. The deflection is proportional to the phase angle between field coil and crossed coil
   2. The restoring torque is provided by a controlling torque
   3. It consists of two coils mouned at right angles to each other

   Select the correct answer using the code given below : **(IES-EE-2007)**

   Of these statements

   (a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 1, 2 and 3

45. In a low power fator wattmeter, why is a compensating coil employed? **(IES-EE-2007)**
   (a) To neutralize the capacitive effect of pressure coil
   (b) To compensate for inductance of pressure coil
   (c) To compensate for the error caused by power loss in the pressure coil
   (d) To compensate for the error caused by eddy currents
46. Which one of the following is used for the measurement of 3-phase power factor? **(IES-EE-2008)**
   (a) Power factor meter (b) Crossed coil power factor meter
   (c) Phase-angle watt hour meter (d) Polarised-vane power factor meter
47. Consider the following statements regarding measurement of 3-phase power by two-wattmeter method; one of the wattmeter reads negative employing **(IES-EE-2010)**

1. Power factor is less than 0.5
2. Power flow is in the reverse
3. Load power fator angle is greater than 60^0
4. Load is unbalanced

Which of the above statements are correct

(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 1, 2, 3 and 4

48. In the power measurement by ammeter – voltmeter method, if the voltmeter is connected across the load, then the value of the power will be **(IES-EE-2010)**
    (a) The power consumed by the load
    (b) The sum of power consumedby the load and ammeter
    (c) The sum of power consumed by the load and voltmeter
    (d) The sum of power consumed by the load ammeter and voltmeter
49. The current and potential coil of a dynamometer type wattmeter were accidentally interchanged while connecting. After energizing the circuit, it was observed that the wattmeter did not show the reading. The could be due to the **(IES-EE-2011)**
    (a) Damage to potential coil (b) Damage to current coil
    (c) Damage to both the potential and current coil (d) Loose contacts
50. A capacitor is connected across a portion of resistance of the muoltiplier in order to make the pressure coil circuit of the wattmeter non-inductive. The value of this resistance is r while the total resistance and inductance of the pressure circuit are respectively R_p and L. The value of the capacitance C **(IES-EE-2011)**

    (a) $\frac{L}{R_P^2}$ (b) $\frac{0.41L}{r^2}$ (c) $\frac{L}{r^2}$ (d) $\frac{0.41L}{R_P^2}$
51. The magnetic field responsible for theproduction of the deflecting torque in an accurate dynamometer type wattmeter, being very weak, the accuracy of the measurement can be increased by providing a **(IES-EE-2011)**
    (a) Magnetic shiedl around the instrument
    (b) Compensating winding along with the pressure coil
    (c) Astatic arrangement to the moving system of the instrument
    (d) Capacitance shunt across a portion of the pressure coil
52. Due to the effect of inductance in the pressure coil, a dynamometer type wattmeter **(IES-EE-2011)**
    (a) Reads low on lagging power Factor and high on leading power factor
    (b) Reads high on lagging power factor and low on leading power factor
    (c) Readings is independent of the power factor
    (d) Always reads lower than the actual value
53. **Assertion (A) :** Electrodynamometer wattmeter is not suitable for low power factor power measurement
    Reason (R) : Many wattmeter are compensated for errors caused by inducatance of voltage coil by means of a capacitor connected in parallel with a portion of multiplier series resistance
    (IES-EE-2011)

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

54. **Statement (I) :** Electrostatic Wattmeter is not widely used commercially because of its inability to measure power of high value
Statement (II) : It is used mainly for very small power measurement at high voltages and low power factors.
(IES-EE-2013)

55. A 3-phase moving coil type power factor meter has three fixed and symmetrically spaced current coils, inside of which are three other similarly placed moving potential coils. While in operation, rotating magnetic field is produced.
(a) in the current coils but not in the potential coils **(IES-EE-2013)**
(b) in the potential coils but not in the current coils
(c) in both potential coils and the current coils
(d) in neither the potential coils nor the current coils.

56. The current and potential coil of a watt-meter were accidentally interchanged while connecting. After energizing the circuit, it was observed that the watt-meter did not show the reading. This would be due to **(IES-EE-2013)**
(a) damage done to the potential coil
(b) damage done to the current coil
(c) damage done to both potential and current coils (d) loose contact.

57. In the two-wattmeter method of measuring 3-phase power, the wattmeters indicate equal and opposite readings when load power factor is **(IES-EE-2013)**
(a) 90 leading (b) 90 lagging (c) 30 leading (d) 30 lagging

58. If 3-phase power is measured with the help of two-wattmeter method in a balanced load with the application of 3-phase balanced voltage, variation in readings of wattmeters will depend on **(IES-EE-2013)**
(a) Load only (b) Power factor only
(c) Load and power factor (d) Neither load nor power factor

59. In two-wattmeter method of measuring power in a balanced 3-phase circuit, the readings of the two wattmeters are in the ratio of 1 : 2, the circuit power factor is
(IES-EE-2013)
(a) $\frac{1}{\sqrt{2}}$ (b) $\frac{1}{2}$ (c) $\frac{\sqrt{3}}{2}$ (d) 1

60. In a low power factor wattmeter, some times compensating coil is connected in order to
(IES-EE-2013)
(a) neutralize the capacitive effect of pressure coil
(b) compensate for inductance of pressure coil
(c) compensate for power loss in the pressure coil
(d) reduce the error caused by eddy current

61. **Statement (I) :** The simplest method of power measurement is b means of electrodynamic type wattmeters, having two fixed coils, and one moving coil.

Statement (II) : Either of the fixed and themoving coils can be used as the current or the voltage coils **(IES-EE-2014)**

62. Two wattmeters are used to measure the power in a 3-phase balanced system. What is the power factor of the load when one wattmeter reads twice the other ? **(IES-EE-2014)**

(a) 0 (b) 0-5 (c) 0.866 (d) 1

63. In a balanced 3-phase 200 V circuit, the line current is 115.5 A. When the power is measured by two wattmeter method, one of the wattmeters reads 20 kW and the other one reads zero. What is the power factor of the load ?**(IES-EE-2014)**

(a) 0.5 (b) 0.6 (c) 0.7 (d) 0.8

64. Two wattmeter method is employed to measure power in a 3-phase balanced system with the current coil connected in the A and C lines. The phase sequence is ABC. If the wattmeter with its current coil in A-phase line reads zero, then the power factor of the 3-phase load will be **(IES-EE-2014)**

(a) zero laggin (b) zero leading (c) 0.5 lagging (d) 0.5 leading

2. MEASUREMENT OF ENERGY

- Energy is the total power delivered or consumed over a time interval, that is

Energy = power x time

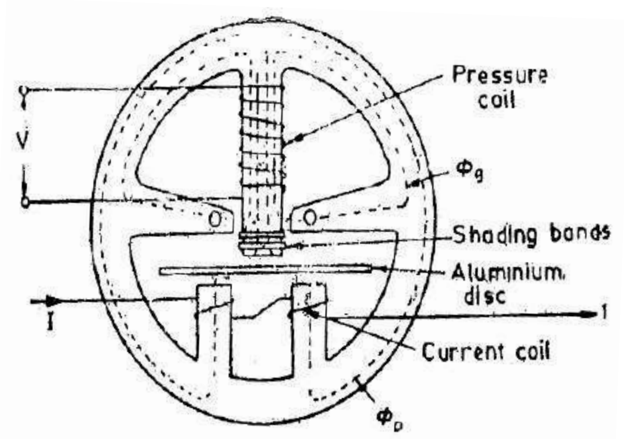
- Electrical energy developed as work or dissipated as heat over an interval of time t may be expressed as:

$$W = \int_0^t VI\,dt$$

Note:

1. Units of electrical energy is kilowatt hours (kwh). Energy consumed when power Is delivered at an average rate of 1000 w for one hour.
2. Motor meters are used for measurement of energy in both d.c. and a.c. circuits. For d.c.circuits.The meters may be an ampere hour meter or watt hour meter.
3. Meter constant is defined as the number of revolutions made per kilowatt - hour (kwh).
4. The total number of revolutions made by a watt hour meter in a given interval of time is proportional to the energy supplied and in case of ampere hour meters, it is to the total quantity of electricity supplied.

Construction and Principle of Single Phase Induction Energy Meter :



Single phase energy meter.

- The figure shows construction details of single phase induction energy meter.
- It mainly consists of two electromagnets. One electromagnet carries current coil in which load current flows and other carries current proportional to supply voltage since it applied across supply which is known as pressure coil, consequently the two electromagnets are known as series and shunt magnets respectively.

Net driving torque is given as, $T_d = k1\,\varphi_1\,\varphi_2\,(f/z)\sin\beta\cos\alpha$

Where β =phase between fluxes $\varphi_1 and\ \varphi_2$

α =phase angle of eddy current paths.

These two fluxes will be produced by two currents which are described earlier.

At steady speed the driving torque must equal to the breaking torque.

K_4 N=K_3 V I sin $(\Delta - \Phi)$

$if\,\Delta = 90^0,\ speed,\ N = KVI\sin(90-\varphi)$

$= K\ V\ I\cos\varphi$

$= k\ x\,(power)$

$Total\ number\ of\ revolutions = \int N\,dt = k\int VI\sin(\Delta-\Phi)\,dt$

$If\,\Delta = 90^0,\ total\ number\ of\ revolutions = k\int V\ I\cos\varphi dt$

$= k*(energy)$

Note:

1. Copper shading band which are provided on the central iimb, are adjusted such that A 90 , hence known as lag adjustment devices.
2. A permanent magnet positioned near the edge of aluminium disc, provides required braking torque.

CREEPING:

- In some energy meters, slow but continuous rotations are obtained even when there is no current flowing through the current coil and only pressure coil is energized, this is called creeping.
- The major cause for creeping is over compensation for friction.

- In order to prevent this creeping two diametrically opposite holes are drilled in the disc, the disc will come to rest with one of the holes under the edge of a pole of the shunt magnet.
- The rotation being thus limited to a maximum of a half a revolution.

Note:

1. In order to test an energy meter of high current rating the actual loading arrangements would involve a considerable waste of power. These meters will be tested by "Phantom" or "Fictitious" methods.
2. The maximum power taken by a consumer during a particular period, is given by maximum demand indicator. Merz Price maximum demand indicator is usually used type maximum demand indicators.

CLASS ROOM OBJECTIVES

01. An energy meter connected to an immersion heater (resistive) operating on an AC 230 V, 50 Hz, AC single phase source reads 2.3 units (kWh) in 1 hour. The heater is removed from the supply and now connected to a 400 V peak to peak square wave source of 150 Hz. The power in kW dissipated by the heater will be

(a) 3.478 (b) 1.739 (c) 1.540 (d) 0.870

02. The voltage-flux adjustment of a certain 1-phase 220 V induction watt-hour meter is altered so that the phase angle between the applied voltage and the flux due to it 85^0 (instead of this 90^0). The rrors introduced in the reading of this meter when the current is 5 A at power factors of unity and 0.5 lagging are respectively.

(a) 3.8 mW, 77.4 mW (b) -3.8 mW, -77.4 mW
(c) -4.2 W, -85.1 W (d) 4.2 W, 85.1 W

03. The voltage flux adjustment of energy meter is such that the flux due to shunt magnet has an angle departure of 3^0 from ideal. The speed of the disc at full load UPF is 40 rpm. At ¼ fill load, 0.5 pf lag, the speed of the disc will be?

PREVIOUS QUESTIONS

Two Marks Questions

01. The voltage-flux adjustment of a certain 1-phase 220 V induction watt-hour meter is altered so that the phase angle between the applied voltage and the flux due to it 85^0 (instead of this 90^0). The rrors introduced in the reading of this meter when the current is 5 A at power factors of unity and 0.5 lagging are respectively.

(GATE-EE-2003)

(a) 3.8 mW, 77.4 mW (b) -3.8 mW, -77.4 mW
(c) -4.2 W, -85.1 W (d) 4.2 W, 85.1 W

02. A dc A-h meter is rated for 15 A, 250 V. A-sec/rev. The meter constant at rated voltage may be expressed as
(GATE-EE-2004)

(a) 3750 rev/kWh (b) 3600 rev/kWh (c) 1000 rev/kWh (d) 960 rev/kWh

03. An energy meter connected to an immersion heater (resistive) operating on an AC 230 V, 50 Hz, AC single phase source reads 2.3 units (kWh) in 1 hour. The heater is removed from the supply and now connected to a 400 V peak to peak square wave source of 150 Hz. The power in kW dissipated by the heater will be
(GATE-EE-2006)

(a) 3.478 (b) 1.739 (c) 1.540 (d) 0.870

04. The meter constant of a single-phase 240V induction watt-hour meter is 400 revolutions per kWh. The speed of the meter disc for a current of 10 ampere at 0.8 p.f. lagging will be
(IES-EE-1993)
(a) 12.8 rpm (b) 16.02 rpm (c) 18.2 rpm (d) 21.1 rpm

05. The major cause of creepng in an energy meter is **(IES-EE-1995)**
(a) over-compensation for friction
(b) mechanical-vibrations
(c) excessive voltage across the potential coil
(d) stray magnetic fields

06. Match List-I (Expression for torque) with List-II (Type of instrument) and select the correct answer using the codes given below the lists : **(IES-EE-1996)**

List-I

A. $\varphi_1\varphi_2 \cos\varphi$

B. $I_1 I_2 \cos\varphi$

C. ki

List-II

1. Ferrodynamic instruments
2. D' Arsonval instruments
3. Electrodynamometer instruments

Codes :

	A	B	C
(a)	2	1	3
(b)	3	2	1
(c)	1	3	2
(d)	3	1	2

07. A single – phase energy meter is operating on 230V, 50Hz supply with a load of 20A for two hours at upf. The meter makes 1380 revolutions in that period. The meter constant is **(IES-EE-1996)**
(a) 695 rev/kWh (b) 150 rev/kWh

(c) 0.15 rev/kWh (d) 1/150 rev/kWh

08. Consider following statements : A 'phantom' load used while testing a high capacity energy meter,

1. Consist of inductances and capacitances so that there is no energy loss during testing
2. saves energy during testing because its value changes very rapidly from the highest to the lowest, thus enabling quick measurement
3. involves supplying the voltage circuit with the required voltage and the current circuit form a separate low voltage supply

Of theses correct statements are **(IES-EE-1996)**

(a) 1, 2 & 3 (b) 1 & 2 (c) 1 & 3 (d) 2 & 3

09. A 230V, 10A, single-phase energy meter makes 90 revolution in 3 minutes at half load rated voltage and unity PF. If the meter constant is 1800 revolutions/KWh, then its error at half load will be **(IES-EE-1997)**

(a) 13.04% slow (b) 1304% fast

(c) 15% slow (d) 15% fast

10. The disc of a house service energy meter of 230V, 1-φ, 50Hz, 5A, 2400 rev. per KWh creeps at 1rev. per min. The creep error (in prcent) of full load unity pf is **(IES-EE-1999)**

(a) $+\frac{60}{2400}\times 100$ (b) $-\frac{60}{2400}\times 100$

(c) $+\frac{60}{1.15\times 2400}\times 100$ (d) $-\frac{60}{1.15\times 2400}\times 100$

11. In a single-phase induction type energy meter, the lag adjustment is done to ensure that **(IES-EE-2000)**

(a) current coil flux lags the applied voltage by 90^0

(b) pressure coil flux lags the applied voltage by 90^0

(c) pressure coil flux is in phase with the applied voltage

(d) current coild flux lags the presssure coil flux by 90^0

12. If an inductance type energy meter runs fast, it can be slowed down by **(IES-EE-2001)**

(a) lag adjustment (b) light load adjustment

(c) adjusting the position of braking magnet and moving it closure to the centre of the disc

(d) adjusting the position of braking magnet and moving it away from the centre of the disc

13. An energy meter having a meter constant of 1200 rev per kwh is found to make 5 revolution in 75s. The load power is **(IES-EE-2002)**

(a) 500 W (b) 100 W (c) 200 W (d) 1000 W

14. The energy capacity of a storage battery is rated in **(IES-EE-2003)**

    (a) kwh (b) kw (c) Ampere hours (d) Jouls

15. The pressure coil of an induction type energy meter is **(IES-EE-2003)**

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

16. Which one of the following defects is responsible for creeping in an induction type energy meter ? **(IES-EE-2005)**

    (a) Imperfect lag compensation (b) Over friction compensation
    (c) Imperfect overload compensation (d) Misalignment of brake magnet

17. **Assertion (A) :** The rotating dise in an energy meter is made up of magnetic material

    Reason (R) : Braking takes place due to eddy current generated by the braking magnet **(IES-EE-2006)**

    (a) Both A and R are true and R is the correct explanation of A
    (b) Both A and R are true but R is NOT the correct explanation of A
    (c) A is true but R is false (d) A is false but R is true

18. The voltage coil of a single-phase house service energy meter **(IES-EE-2006)**

    (a) is highly resistive (b) is highly inductive
    (c) is highly capacitive (d) has a phase angle to load power factor angle

19. Which one of the following is the main cause of creeping in the induction type energy meters? **(IES-EE-2007)**

    (a) Friction compensation (b) Lag/Lead compensation
    (c) Overload compensation (d) Braking torque producing system

20. Consider the following statements associated with an energy meter :

    1. It is an integrating type instrument
    2. It is an induction type instrument
    3. It uses a permanent magnet for rotation of aluminium disc
    4. It employs a high control torque

    Which of these statements are correct **(IES-EE-2011)**

    (a) 1, 2, 3 and 4 (b) 1 and 2 only (c) 2 and 3 only (d) 3 and 4 only

21. A single-phase energy meter having meter constant of 200 rev/kWh is operating on 230V, 50 Hz supply with a load of 10A and at unity power factor for three hours continuously. The number of revolutions shown by the meter during this period is **(IES-EE-2012)**

(a) 13800 (b) 1380 (c) 276 (d) 138

22. The meter constant of a single-phase energy meter is 500rev/kWh. It is found that with a load of 5kW, it makes 40 revolutions in 50 sec. The percentage error is **(IES-EE-2012)**

(a) 5.25% (b) 10.5% (c) 15.25% (d) 20%

23. **Statement (I) :** A Watt-hour meter mustbe calibrated at both full rated load as well as at 10% of rated load.

Statement (II) : The source of error at full load is inaccurate damping and at light loads, the torque is not exactly proportional to load **(IES-EE-2013)**

24. Creep error may occur in induction type energy meter due to **(IES-EE-2013)**

(a) incorrect position of brake magnet
(b) incorrect adjustment of position of shading band
(c) over voltage across voltage coil
(d) increase in temperature.

25. Consider the following statements :

Adjustment is required in an induction type energy meter in the following manner so that it can be compensated for slowdown of speed on the specified load due to some unspecified reason :

1. Adjusting the Position of braking magnet and moving it away from the centre of the disc
2. Adjusting the Position of braking magnet and moving it closer to the centre of the disc.
3. Adjusting the load

Which of these statements are correct? **(IES-EE-2013)**

(a) 1, 2 and 3 (b) 1 only (c) 2 only (d) 3 only

26. One single-phase energy meter operating on 230 V and 5 A for 5 hours makes 1940 revolutions. Meter constant is 400 rev/kWh. Thepower factor of the load is

(a) 1.0 (b) 0.8 (c) 0.7 (d) 0.6 **(IES-EE-2014)**

27. The current oil of a single-phase energy meter is wound on **(IES-EE-2014)**

(a) One limb of the laminated core
(b) Both the limbs of the laminated core with same number of turns
(c) Both the limbs of the laminated core with different number of turns
(d) The centre of the limb on the laminated core

28. For controlling the vibration of the disc of ac energy meter, damping torque is produced by

(IES-EE-2014)

(a) Eddy current (b) Chemical effect

(c) Electrostatic effect (d) Magnetic effect

29. The meter constant of a single-phase 230 V induction watt hour meter is 400 revolutions per kW/h. The speed of the meter disc for a current of 10 A of 0.9 pf lagging will be

(IES-EE-2014)

(a) 13.80 rpm (b) 16.02 rpm (c) 18.20 rpm (d) 21.10 rpm

30. In an induction type energy meter, the steady speed attained by the rotating disc is

(IES-EE-2014)

1. Proportional to the deflecting torque.
2. Proportional to the resistance of the path of eddy currents
3. Inversely proportional to the effective readings of disc from its axis
4. Inversely proportional to the square of brake magnet flux.

Which of the above are correct ?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only

(c) 2, 3 and 4 only (d) 1, 2, 3 and 4

3. MEASUREMENT OF R, L & C

Measurement of Medium Resistances:

The different Methods used fro measurement of medium resistances are:

i. Ammeter voltmeter method
ii. Substitution method
iii. Wheatstone bridge method
iv. Ohmmeter method

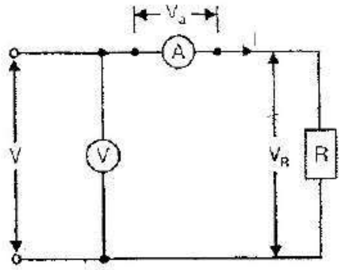
Ammeter –Voltmeter Method

This method is very popular since the instruments required for this test are usually available in the laboratory.

Measured value of resistance is given by

$$R_m = \frac{\text{Voltmeter reading}}{\text{Ammeter reading}}$$

<u>Ammeter connected near the load</u>



Let R_a be the resistance of the ammeter

∴ Voltage across the ammeter, $V_a = IR_a$

Now measured value of resistance

$$R_{m1} = \frac{V_a}{I} = \frac{V_R + V_a}{I} = \frac{IR + IR_a}{I}$$
$$= R + R_a$$

∴ True value of resistance, $R = R_{m1} - R_a$

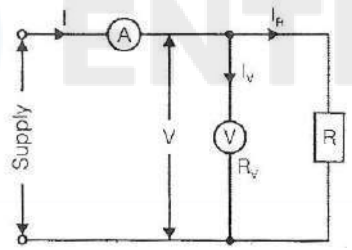
$$R = R_{m1}\left(1 - \frac{R_a}{R_{m1}}\right)$$

Thus the measured value of resistance is higher than the true value. It is also clear from above that the true value is equal to measured value only when the ammeter resistance, R_a is zero.

$$\therefore \boxed{Relative\,error(\in_r) = \frac{R_{m1} - R}{R} = \frac{R_a}{R}}$$

- The error in measurements would be small if the value of resistance under measurement is large as compared to the internal resistance of the ammeter.
- So this type of circuit should be used when measuring high resistance values.

Voltmeter connected near the load



In this circuit the voltmeter measures the true value of voltage but the ammeter measures the sum of currents through the resistance R and the voltmeter V.

$$I = I_R + I_V$$

Let R_v be the resistance of the voltmeter

∴ Current through the voltmeter,

$$I_V = \frac{V}{R_v}$$

Measured value of resistance,

$$R_{m2} = \frac{V}{I} = \frac{V}{I_R + I_V} = \frac{V}{\left(\frac{V}{R} + \frac{V}{R_V}\right)} = \frac{R}{1 + \frac{R}{R_V}}$$

$$\therefore \boxed{\in_r = -\frac{R_{m2}^2}{RR_v}}$$

If $R_{m2} = R$

∴ then relative error is,

$$\boxed{\in_r = \frac{R}{R_v}}$$

Note:
This method is used when measuring low resistance values.
The error in measurement would be small if the value of resistance under measurement is very small as compared to the resistance of the voltmeter.
The relative errors for the both connections above are equal when:

$$\frac{R_a}{R} = \frac{R}{R_v}$$

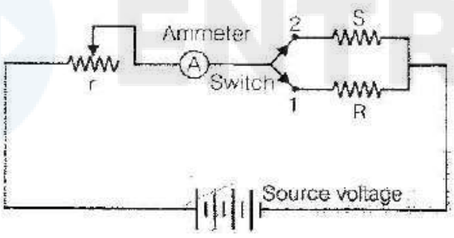
then we may say;

$$\boxed{\text{true value of resistance} = R = \sqrt{R_a R_v}}$$

In 1st case : $R > \sqrt{R_a R_v}$
(when ammeter connected near the load)
In IInd case : $R < \sqrt{R_a R_v}$
(when voltmeter connected near the load)

Substitution Method

Substitution method is more accurate method than the ammeter voltmeter method, as it is not subject to the errors encountered in this method.



Let, R = unknown resistance
S = standard variable resistance
r = regulating resistance
and there is a switch for putting R and S into the circuit alternately

Operation

The switch is put at position 1, and resistance R is connected in the circuit. The regulating resistance r is adjusted till the ammeter pointer is at a chosen scale mark.
Now the switch is thrown to position 2. Putting the standard variable resistance S in the circuit. The value of S is varied till the same deflection, as was obtained with R in the circuit, is obtained. The settings of the dials of S are read.
Thus the value of unknown resistance R is equal to the dial settings of resistance S,

$$\frac{\theta_1}{\theta_2} = \frac{R+G}{S+G}$$

$$\therefore \boxed{\text{unknown resistance} = R = (S+G)\frac{\theta_1}{\theta_2} - G}$$

Where, θ_1 = the deflection with standard resistor
and θ_2 = the deflection with unknown resistor in circuit.
and G is the galvanometer

Note:

The substitution principle, however, is very important and finds many applications in bridge methods and in high frequency AC measurements.

It is generally used for high resistance measurement.

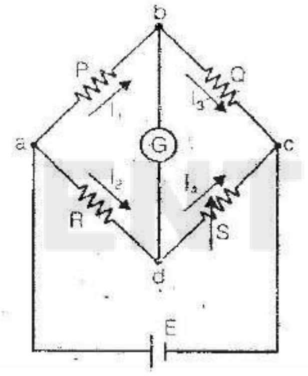
Wheatstone Bridge Method:

The wheatstone bridge is an instrument for making comparision measurements and operation upon a null deflection principle.

A very important device used in the measurement of medium resistance is the wheatstone bridge.

It is highly accurate and reliable instruments, because the indication is independent of the calibration of the null indicating instrument or any of its characteristics.

This method is extensively used in industry.



Where, R is the unknown resistance.

S is called the standard arm or known resistance of the bridge

The bridge

and P and Q are called the ratio arms

for bridge balance, we can write

$$I_1 P = I_2 R$$

$$\frac{I_1}{I_2} = \frac{R}{P}$$

$$\frac{R+S}{P+Q}$$

$$\therefore \boxed{\frac{P}{Q} = \frac{R}{S}}$$

$$\therefore \boxed{\text{Unknown resistance} = R = \frac{P}{Q}.S}$$

Sensitivity of wheatstone bridge (S_B)

The bridge sensitivity (S_B) is defined as the deflection of the galvanometer per unit fractional change in unknown resistance.

$$\therefore \boxed{\text{Bridge sensitivity} = S_B = \frac{\theta}{\Delta R / R}}$$

Where, θ is the deflection of the galvanometer and

$$\theta = S_v e$$

and $"S_v"$ is the voltage sensitivity and "e" is the voltage difference between points d and b:

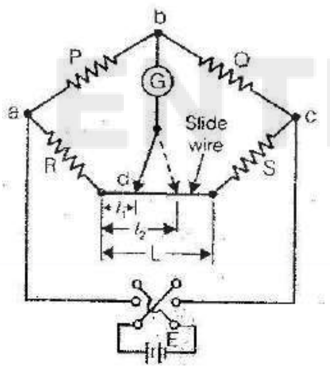
$$\therefore \quad \boxed{S_B = \frac{S_v E}{\frac{P}{Q} + \frac{Q}{P} + 2}}$$

For a bridge with equal arms i.e. $R = S = P = Q$ then,

$$\boxed{\text{Briedge sensitivity} = S_B = \frac{S_v E}{4}}$$

Carry – Foster Slide – wire Bridge

This method is used for the purpose of determining the difference between the standard and the unknown resistances.



Exact balance is obtained by adjustment of the sliding contact on the side – wire

Let l_1 be the distance of the sliding contact from the left hand end of the slide wire. The resistances R and S are then interchanged and balance is again obtained. Let the distance now be l_2

Ist case: For the Ist balance

$$\frac{P}{Q} = \frac{R + l_{1r}}{S + (L - l_1) r}$$

where r is the resistance per unit length of the slide – wire.

IInd case : For the 2nd balance,

$$\frac{P}{Q} = \frac{S + l_2 r}{R + (L - l_2) r}$$

$$\boxed{S - R = (l_1 - l_2) r}$$

Thus the difference between S and R is obtained from the resistance per unit length of the slide – wire together with the difference $(l_1 - l_2)$ between the two slide – wire lengths at balance.

The slide wire is calibrated i.e. r is obtained by shunting either S or R by a known

resistnaces and again determining the difference in length $\left(l_1^{'} - l_2^{'}\right)$.
Suppose that S is known and S’ is its value when shunted by known resistance, then

$$S - R = \left(l_1 - l_2\right) r \quad \text{and} \quad S' - R = \left(l_1^{'} - l_2^{'}\right) r$$

$$\therefore \quad \frac{S - R}{l_1 - l_2} = \frac{S' - R}{l_1^{'} - l_2^{'}}$$

$$\therefore \quad R = \frac{S\left(l_1^{'} - l_2^{'}\right) - S'\left(l_1 - l_2\right)}{\left(l_1^{'} - l_2^{'} - l_1 + l_2\right)}$$

Equation shows that this method gives a direct comparision between S and R in terms of lengths only, the resistances of P and Q contact resistances and the resistances of connecting leads being eliminated.

Note:

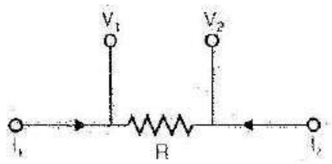
This bridge is specially suited for the comparision of two nearly equal resistances.

Ohmmeter method

Ohm meter method is used for measuring resistnace of field coils of machines.
It is used for measurement of heating element resistance.
It is also used in measuring and sorting of resistors.

Measurement of Low Resistnace

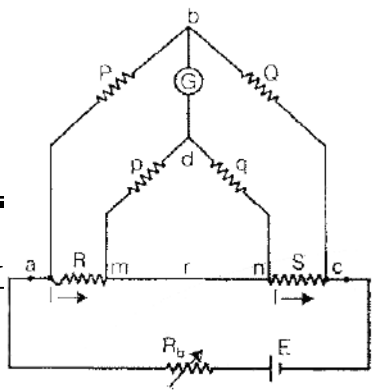
Construction: These are provided with four terminal to eliminate the effect of contract resistance. Out of four terminals, two terminals are used for current injection, these are current terminals and remaining two terminals are used for measurement of potential dropped across the resistances. These terminals are called voltage terminals.



Here, I_1 and I_2 are current terminal V_1 and V_2 are voltage terminal.
Methods for measurements of low resistance
Ammeter – voltmeter method.
Kelvin’s double bridge method.
Potentiometer method
Ammeter voltmeter methods are already discussed in this chapter previously.

Kelvin’s Double Bridge Method for Measurement of Low Resistnaces:

The Kelvin’s bridge is a modification of the wheatstone bridge and provides greatly increased accuracy in measurement of low value resistnaces.
The Kelvins’ bridge arrangement are given in figure below.



The first set of ratio arms is P and Q. The second set is of ratio arms, p and q which is used to connect the galvanometer to point d at the appropriate potential between points m and n to eliminate the effect of connecting lead of resistance r between the known resistance, R and standards resistance S.

The ratio p/q is made equal to P/Q. Under balance conditions there is no-current through the galvanometer, the voltage drop between a and b i.e. E_{ab} is equal to voltage drop E_{amd} between a and c.

Now, $$E_{ab} = \frac{P}{P+Q} E_{ac} \text{ and } E_{ac} = I\left[R+S+\frac{(p+q)r}{p+q+r}\right]$$

and $$E_{amd} = I\left[R+\frac{p}{p+q}\left(\frac{(p+q)r}{p+q+r}\right)\right]$$

$$R = \frac{P}{Q}S+\frac{qr}{p+q+r}\left[\frac{P}{Q}-\frac{p}{q}\right]$$

$$\frac{P}{Q}=\frac{p}{q}$$

$$R=\frac{P}{Q}.S$$

Note:

This equation shows the usual working equation for the Kelvin bridge.

It indicates that the resistance of connecting lead, r_1 has no effect on the measurement, provided that the two sets of ratio arms have equal ratios.

Potentiometer Method

This method is a comparison type method measurement using comparison methods are capable of a high degree of accuracy deflection of a pointer, as is the case in deflect ional methods, but only upon the accuracy with which the voltage of the reference source is known.

Measurement of High resistance

The different methods employed are:

Direct deflection method

Loss of charge method

Mega ohm bridge method

Meggar method

High resistance of the order of hundreds or thousands of mega ohm are often encountered in electrical equipment, and frequently must be measured.

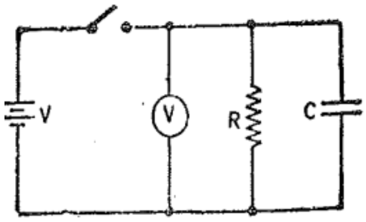
Difficulties in Measuring High Resistances

Error due to leakage current

Error due to electrostatic effect or charges are gathered.

Error due to capacitive effect.

Loss of Charge Method:



- The voltage across the capacitor at any instant 't' after the application of voltage is

$$v = V e^{-\frac{t}{RC}}$$

or Insulation Resistance $$R = \frac{0.4343\, t}{C \log_{10} V / v}$$

AC BRIDGES

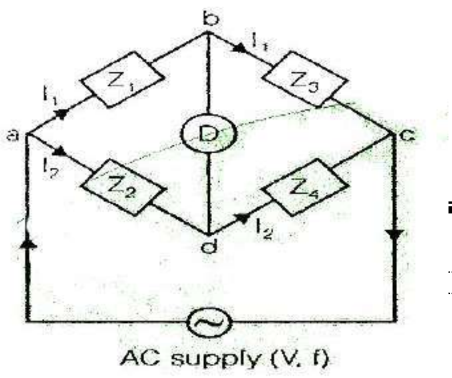
Introduction

- The 'AC Bridges' is a natural outgrowth of the DC bridge (Wheatstone bridge) in its basic form consists of Four bridge arms a source of excitation and a null or balanced detector.
- These bridge methods are very useful for the measurement of
  - Inductance (L)
  - Capacitance (C)
  - Frequency (f)
  - Mutual inductance (M)
  - Storage factor
  - Loss factor, etc.
- Type of sources in AC Bridges
  - For low frequency measurement the power line supply can serve as the source of excitation.
  - For high frequency measurement the electronic oscillator is used as excitation voltage.
- Types of detectors in AC Bridges
- Head phones
  - It is used a frequencies of 250 Hz and over upto 3 to 4 KHz.
  - Most sensitive detector for this ranges of frequency.
- Vibration galvanometer
  - It can be used from 5 Hz to 1000 Hz but suitable mainly upto 200 Hz.
  - The are extremely useful for power and low AF ranges.
- Tuneable Amplifier Detector (TAD)
  - It can be used at 10 Hz to 100 KHz.
- Cathode Ray Oscilloscope (CRO)
- It is used for higher frequency more than 5 KHz

Note:

For a DC bridge, the "PMMC" instrument acts as a detector

General Theory for an AC Bridge Balance:



The condition for the bridge balance is that the PD from b to d i.e

$V_{bd=0}$

So $V_{ab} = V_{ad}$

$\Rightarrow IZ_1 = I_2 Z_2$

Also, at balance condition,

$$I_1 = \frac{V}{Z_1 + Z_3}$$

and
$$I_2 = \frac{V}{Z_2 + Z_4}$$

Now, from equation we get

$$\boxed{Z_1 Z_4 = Z_2 Z_3}$$

Incase of admittances we have

$$\boxed{Y_1 Y_4 = Y_2 Y_3}$$

$$\therefore \boxed{|Z_1||Z_4| \angle (\theta_1 + \theta_4) = |Z_2||Z_3| \angle (\theta_2 + \theta_3)}$$

For balance bridge condition.

From equation it shows that two conditions are met simultaneously for the bridge to be balanced and they are,

- The products of the magnitudes of the opposite arms must be equal.

  i.e. $\boxed{|Z_1||Z_4| = |Z_2||Z_3|}$

- The sum of the phase angles of the opposite arms must be equal.

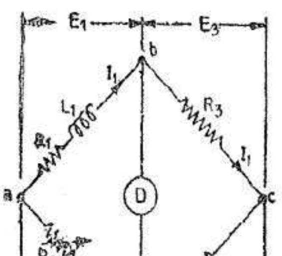
  i.e $\boxed{\angle \theta_1 + \angle \theta_4 = \angle \theta_2 + \angle \theta_3}$

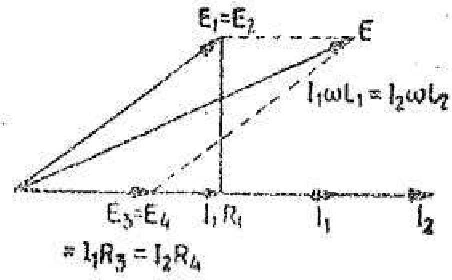
AC Bridges through which inductance (L) is measured:

1. Maxwell's inductance bridge
2. Maxwell's inductance – capacitance bridge
3. Hay's bridge
4. Anderson's bridge
5. Owen's bridge

Maxwell's Inductance Bridge

The bridge measures an unknown inductance by comparison with a variable standard self inductance.





Let R_1 and L_1 are unknown quantity

L_2 = Variable inductance of fixed resistance 'r_2'

R_2 = Variable resistance connected in series with "L_2"

R_3= and R_4 = Known non inductive resistances.

At balance condition.

$$Z_1 Z_4 = Z_2 Z_3$$

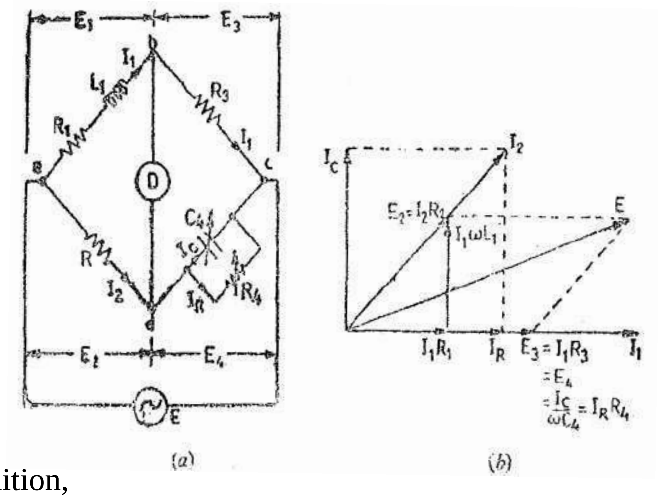
$$\Rightarrow (R_1 + J\omega L_1) R_4 = |(R_2 + r_2) + J\omega L_2| \times R_3$$

Equating real and imaginary part we get

$$\boxed{R_1 = \frac{R_3}{R_4}(R_2 + r_2)} \quad \text{and} \quad \boxed{L_1 = \frac{R_3}{R_4}.L_2}$$

Maxwell's Inductance capacitance Bridge

This bridge measures an unknown inductance in terms of a known capacitance.



At balance condition,

$$Z_1 Z_4 = Z_2 Z_3$$

$$\therefore (R_1 + J\omega L_1)\left(R_4 \,||\, \frac{1}{J\omega C_4}\right) = R_2 R_3$$

Equating real part we get,

$$\boxed{R_1 = \frac{R_2 R_3}{R_4}}$$

and equating imag. Part we get,

$$\boxed{L_1 = R_2 R_3 C_4}$$

Quality factor $= Q = \frac{\omega J_1}{R_1} = \omega R_4 C_4$

$$\boxed{i.e\, if\ C_4 \uparrow\ then\ Q \uparrow}$$

This bridge is suitable for the measurement of "medium –Q coils" $(1 < Q < 10)$.

Advantages

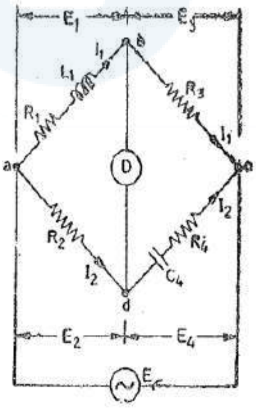
- Circuit is simple.
- Obtained balance equations are free from the frequency term.
- Balance equations are independent if we choose R_4 and C_4 as variable elements.
- It is very useful for measurement of a wide range of inductances at power and audio frequencies

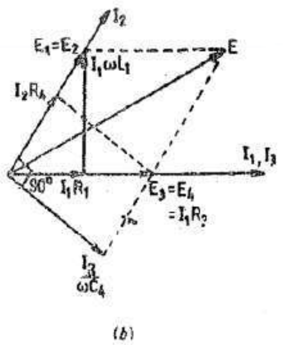
Disadvantages

- It requires variable standard capacitor which is very costly
- For high or low Q-coils, it is not suitable .

Hay's Bridge

- It is a modification of Maxwell's bridge
- This bridge uses a resistances in series with the standard capacitor as shown in figure below.





At balance condition,

$$Z_1 Z_4 = Z_2 Z_3$$

$$\therefore \left(R_1 + J\omega L_1\right)\left(R_4 \,||\, \frac{1}{J\omega C_4}\right) = R_2 R_3$$

Equating real and imaginary parts we get,

$$\boxed{L_1 = \frac{R_2 R_3 C_4}{1 + \left(\omega C_4 R_4\right)^2}} \quad \text{and} \quad \boxed{R_1 = \frac{\omega^2 R_2 R_3 R_4 C_4^2}{1 + \left(\omega C_4 R_4\right)^2}}$$

Quality factor $Q = \frac{\omega L_1}{R_1} = \frac{1}{\omega C_4 R_4}$

i.e. $\boxed{\omega C_4 R_4 = \frac{1}{Q}}$

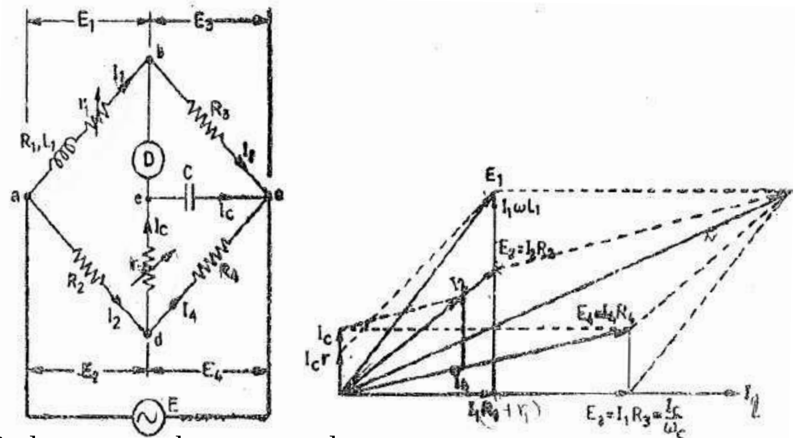
Now $\boxed{L_1 = \frac{R_2 R_3 R_4}{1+(1/Q)^2}}$ and $\boxed{R_1 = \frac{\omega^2 R_2 R_3 R_4 C_4^2}{1+(1/Q)^2}}$

In this bridge, the expression for the unknown inductance and resistance involves the frequency term.
So, for the higher Q. (i.e. Q>10)
$1+(1/Q)^2 \approx 1$ and then,
$\boxed{L_1 = R_2 R_3 C_4}$ *and* $\boxed{R_1 = \omega^2 R_2 R_3 R_4 C_4^2}$
So, we can say this bride is suitable for high Q-coils (i.e Q>10)

Advantages
It gives a simple expression for Q-factor.
For high Q-coils it gives simple expression for unknown R_1 and L_1

Disadvantages
It is not suitable for medium or Low Q-coils

Anderson's Bridge
It is modification of the Maxwell's inductance – capacitance bridge
In this bridge method, the self inductance is measured in terms of standard capacitor.



Let L_1 = self-inductance to be measured
R_1 = resistance of self inductor
r_1 = resistance connected in series with self inductor
At balance, $I_1 = I_3$ and $I_2 = I_c + I_4$

Now $I_1R_3 = I_c \times \frac{1}{j\omega C}$

$$\therefore I_c = I_1 j\omega C R_3$$

Writing the other balance equations and equating the real and imaginary parts,

$$R_1 = \frac{R_2 R_3}{R_4} - r_1$$

And
$$L_1 = C\frac{R_3}{R_4}\left[r(R_2 + R_3) + R_2 R_4\right]$$

Quality factor
$$= Q = \frac{\omega L_1}{R_1}$$

For Low Q-coil, $L_1 \downarrow \text{ and } C \downarrow$ So, it is suitable for Low Q-coils (i.e Q<1).

Advantages

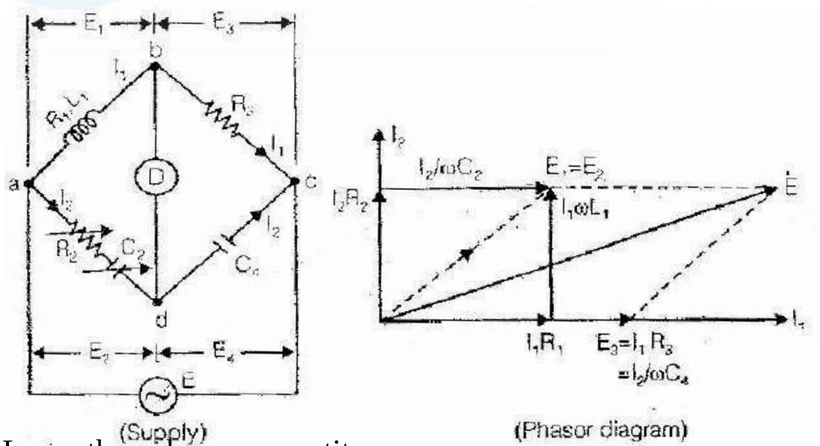
- It may be used for accurate estimation of capacitance in terms of inductance
- It is relatively cheaper because here fixed capacitance is used
- It is much easier to obtain the balance.

Disadvantages

- It is more complex circuit
- The balance equations are not simple and infact are much more tedious.
- An additional junction point increases the difficulty of shielding the bridge network.

Owen's Bridge

This bridge may also be used for the measurement of inductance in terms of capacitance.



Let R_1 and L_1 are the unknown quantity
R_2= Variable non inductive resistance
R_3= Fixed non inductive resistance
C_2= variable standard capacitor
C_4 = Fixed standard capacitor

At balance condition.

$$Z_{ab} Z_{cd} = Z_{ad} . Z_{bc}$$

$$\Rightarrow (R_1 + J\omega L_1)(1/J\omega C_4) = \{R_2 + (1/J\omega C_2\} R_3$$

Equating real and imaginary part we get,

$$\boxed{R_1 = R_3 \frac{C_4}{C_2}} \quad \text{and} \quad \boxed{L_1 = R_2 R_3 C_4}$$

Quality factor $= Q = \frac{\omega L_1}{R_1} = \omega R_2 C_2$

Advantages

It has independent balance equations.
The unknown quantities expressions are free from frequency term.
This can be used over a wide range of measurement of inductances.

Disadvantages

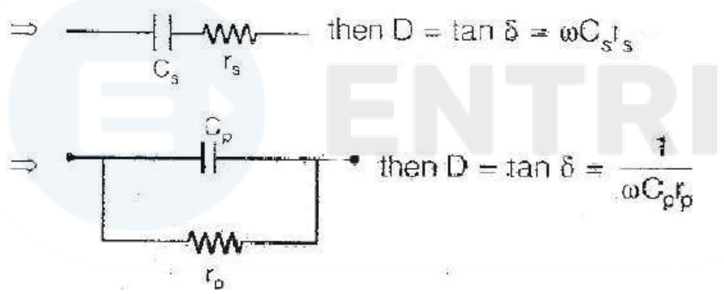
It requires a variable capacitor so it is very costly network
Its accuracy is about only 1%

AC Bridge through which capacitances are measured

1. De Sauty's bridge
2. Schering bridge

De Sauty's Bridge

It is the simplest method of comparing two capacitances.
It may also be used for determining the dissipation factor (D).
Note.



Considering ideal capacitor, the bridge circuit is,

Let C_1= Unknown capacitor
C_2= a standard capacitor
R_3= R_4 = non – inductive resistors

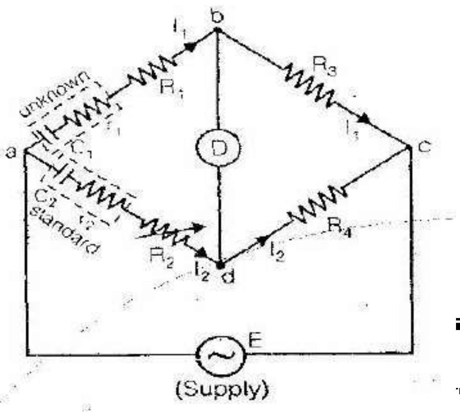
At balance condition

$$Z_{ab}.Z_{cd} = Z_{ad}.Z_{bc}$$

$$\Rightarrow \frac{1}{J\omega C_1}.R_4 = \frac{1}{J\omega C_1}.R_3$$

$$\therefore \boxed{C_1 = \frac{R_4}{R_3}.C_2}$$

The advantage of this bridge is its simplicity but from this we can not determine "Dissipation Factor (D)", so some modification are needed in the above bridge.
Now we consider the lossy capacitor and bridge in figure becomes "Modified De-Sauty's Bridge.



⇒ Given C_2 so, $D_2 = \omega C_2 r_2$ and we have to estimate C_1 and hence D_1 $= \omega C_1 r_1$

At balance condition,

$$Z_{ab}.Z_{cd} = Z_{bc}.Z_{ad}$$

$$\left[(R_1 + r_1) + \frac{1}{J\omega C_1}\right].R_4 = \left[(R_2 + r_2) + \frac{1}{J\omega C_2}\right].R_3$$

Equating real part we get,

$$(R_1 + r_1) R_4 = (R_2 + r_2) R_3$$

$$\Rightarrow \boxed{r_1 = \frac{R_3}{R_4}(r_2 + R_2) - R_1}$$

Now equating imaginary part we have,

$$\boxed{C_1 = \frac{R_4}{R_3}.C_2} \quad \text{and} \quad \boxed{\frac{C_1}{C_2} = \frac{R_4}{R_3}}$$

From the equation (3.18) and (3.19) we may obtained,

$$D_1 = \omega C_1 r_1$$

Also, we have,

$$\boxed{\frac{C_1}{C_2} = \frac{R_2 + r_2}{R_1 + r_1} = \frac{R_4}{R_3}}$$

This bridge can not determine the accurate result for dissipation factor because ewe have,

$$D_2 - D_1 = \omega\left[C_1 r_2 - C_1 r_1\right]$$

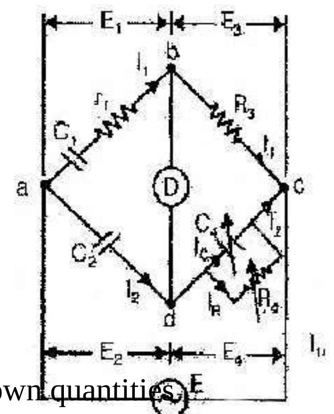
$$D_2 - D_1 = \omega C_1\left[\frac{R_1 R_4}{R_3} - R_2\right]$$

Since $(D_2 - D_1)$ is very – very small so it is difficult to determine "D_1" accurately

Schering Bridge

It is widely used for the measurement of capacitance and dissipation factor (D)

In particular, it may be used in the measurement of relative permittivity, it may be used in the measurement of relative permittivity, properties of insulators, capacitor bushings, insulating oil .



Let C_1 and r_1 are the unknown quantities.

C_2= variable standard capacitor

C_4 = Fixed standard capacitor
R_3= a non inductive resistance
R_4= a variable non inductive resistance

At balance condition.

$$\left(r_1 + \frac{1}{J\omega C_1}\right)\left(R_4 \parallel \frac{1}{J\omega C_4}\right) = \frac{R_3}{J\omega C_2}$$

Equating real part we get,

$$\boxed{r_1 = \frac{R_3 C_4}{C_2}}$$

Equating imaginary part we get,

$$\boxed{C_1 = C_2 . \frac{R_4}{R_3}}$$

Here two independent balance equations (3.22) and (3.23) are obtained if C_4 and R_4 are chosen as the variable elements.

$$\boxed{\therefore \ Dissipation\ Factor = D_1 = \omega C_1 r_1 = \omega C_4 R_4}$$

For the low value of unknown capacitance "C_1" so, $Z \uparrow$ and then detector can not detected.

For the detector to be detects the supply frequency "f" should be higher and higher. At this stage, this type of Schering bridge is called "High voltage Schering bridge".

Due to "High frequency effect", "Stray capacitance of Earth" will be generated and so leakage currents are significant so it can not be neglected. Finally there is an error in measurement.

To eliminate this error, bridge should be balanced in such a manner that $\boxed{V_d = V_d = 0}$ i.e both 'b' and 'd' should be virtually grounded.

For this purpose a new arrangement is used and such device is called "Wagner's Earthling Device".

AC bridge through which frequency can be measured:

1. Wein's Bridge

Wein's Bridge

It is primarily well known as a frequency determining bridge.

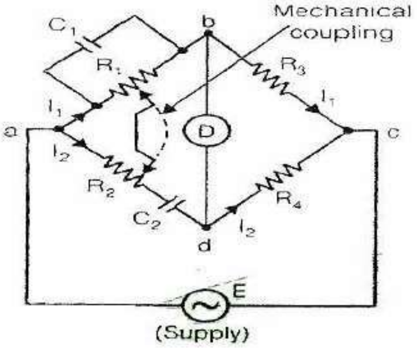
It may be employed in a "Harmonic distortion analyzer" where it is used as "Notch filter"

They also finds applications in Audio and High frequency oscillators as the frequency determining device (100Hz-100KHz).

At balance condition,

$$Z_{ab}.Z_{cd} = Z_{ab}.Z_{bc}$$

$$\left(R_1 \parallel \frac{1}{J\omega C_1}\right) R_4 = \left(R_1 \frac{1}{J\omega C_2}\right) R_3$$



Equating real part we get,

$$R_1 R_4 = R_2 R_3 + \frac{C_1}{C_2} R_1 R_3$$

$$\boxed{\frac{R_4}{R_3} = \frac{R_2}{R_1} + \frac{C_1}{C_2}}$$

Equating imaginary part we get,

$$\omega C_1 R_1 R_2 - \frac{1}{\omega C_2} = 0$$

$$\Rightarrow \boxed{\omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}} rad/sec \qquad \text{also,} \qquad \boxed{f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}} Hz$$

In most of the wein's bridges

$$R_1 = R_2 = R$$

and $C_1 = C_2 = C$

Then, equation (3.24) becomes

$$\boxed{R_4 = 2R_3}$$

And equation (3.25) and (3.26) becomes

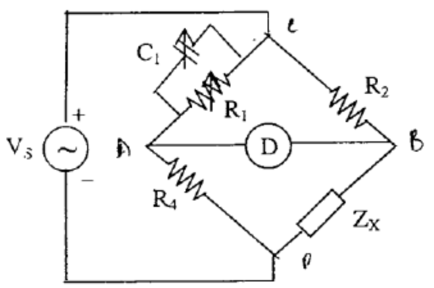
$$\boxed{\omega = \frac{1}{RC} \text{ and } f = \frac{1}{2\pi RC}}$$

The bridge may be used in "Frequency determining device" balanced by a single control and this control may be calibrated directly in terms of frequency.
It may also be used for the measurement of "Capacitance"
Because of its "Frequency sensitivity", the Wein's bridge may be difficult of balance (unless the waveform of the supplied voltage is sinusoidal).
It is possible to obtain an accuracy of 0.1-0.5%

PREVIOUS QUESTIONS

One Mark Questions

01. A Kelavin double bridge is best suited for the measurement of **(GATE-EE-1995)**
    (a) Inductance (b) capacitance
    (c) Low resistance (d) high resistance
02. Kelvin double bridge is best suited for the measurement of **(GATE-EE-2002)**
    (a) Resistances of very low value (b) Low value capacitance
    (c) Resistance of very high value (d) High value capacitance
03. The bridge circuit shown in the fig below is used for the measurement of an unknown element Z_x. The bridge circuit is best suited when Z_x is a
(GATE-EE-2011)



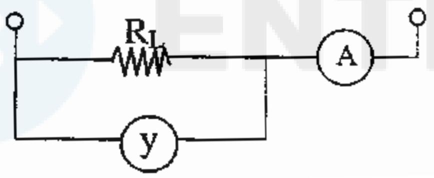
(a) Low resistance (b) High resistance
(c) Low Q Inductor (d) lossy Capacitor

Two Marks Questions

04. Resistances R_1 and R_2 have, respectively, nominal values of 10 Ω and 5 Ω. And tolerances of ± 5% and ± 10%. The range of values for the parallel combination of R_1 and R_2 is **(GATE-EE-2005)**

(a) 3.077 Ω to 3.636 Ω (b) 2.805 Ω to 3.371 Ω
(c) 3.237 Ω to 3.678 Ω (d) 3.192 Ω to 3.435 Ω

05. The set-up in the figure is used to measure resistance R. The ammeter and voltmeter resistance are 0.01 Ω and 2000 Ω, respectively. Their readings are 2A and 180 V, respectively, giving a measured resistance of 90 Ω. The percentage error in the measurement is **(GATE-EE-2005)**



(a) 2.25% (b) 2.35% (c) 4.5% (d) 4.71%

06. The items in **List-I** represent the various types of measurements to be made with a reasonable accuracy using a suitable bridge. The items in **List-II** represent the various bridges available for this purpose. Select the correct choice of the item in List-II for the corresponding item in List-I from the following **(GATE-EE-2003)**

List-I
List-II

A. Resistance in the milli Ohm range
B. Low values of Capacitance
C. Comparison of resistances Which are nearly equal
D. Inductance of a coil with a large time – constant

1. Wheatstone Bridge
2. Kelving Double Bridge
3. Schering Bridge
4. Wien's Bridge
5. Hay's Bridge
6. Carey – Foster Bridge

Codes :

	A	B	C	D
(a)	2	3	6	5
(b)	2	6	4	5
(c)	2	3	5	4
(d)	1	3	2	6

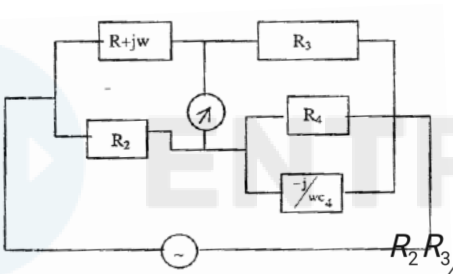
07. A moving iron ammeter produces a full scale torque of 240 μ Nm with a deflection of 1200 at a current of 10 A. The rate of change of self inductance (μ H/radian) of the instrument at full scale is **(GATE-EE-2004)**

(a) 2.0 μ H/radian (b) 4.8 μ H/radian
(c) 12.0 μ H/radian (d) 114.6 μ H/radian

08. R_1 and R_2 are the opposite arms of a wheatstone bridge as are R_3 and R_2. The source voltage is applied across R_1 and R_3 under balanced conditions which one of the following is true ? **(GATE-EE-2006)**

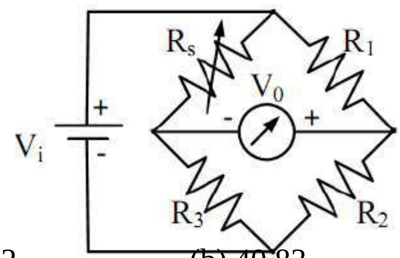
(a) $R_1 = R_3 R_4 / 2$ (b) $R_1 = R_2 R_3 / 4$
(c) $R_1 = R_2 R_4 / 3$ (d) $R_1 = R_2 + R_3 + R_4$

09. The maxwell's bridge shown in the fig. is at balance the parameters of the inductive coil are **(GATE-EE-2010)**



(a) $R = R_2 R_3 / R_4$ L = $C_4 R_2 R_3$ (b) L = $R_2 R_3 / R_4$ R = $C_4 R_2 R_3$
(c) $R = R_4 / R_2 R_3$ $L = 1 / C_4 R_2 R_3$ (d) $L = R_4 / R_2 R_3$ $R = 1 / C_4 R_2 R_3$

10. A strain gauge forms one arm of the bridge shown in the figure below and has a nominal resistance without any load as R_s = 300 Ω. Other bridge resistances are $R_1 = R_2 = R_3 = 300\Omega$. The maximum permissible current through the strain gauge is 20 mA. During certain measurement when the bridge is excited by maximum permissible voltage and the strain gauge resistance is increased by 1% over the nominal value, the output voltage V_0 in mV is **(GATE-EE-2013)**



(a) 56.02 (b) 40.83 (c) 29.85
(d) 10.02

11. A 100 μ A ammeter has an internal resistance of 100 Ω. For extending its range to measure 500 μ A, the shunt required is of resistance (in Ω) **(GATE-EE-2001)**

(a) 20.0 (b) 22.22 (c) 25.0 (d) 50.0

12. A DC ammeter has a resistance of 0.1 Ω and its current range is 0-100A. If the range is to be extended to 0-500A, then meter requires the following shunt

resistance **(GATE-EE-2005)**

(a) 0.010 Ω (b) 0.011 Ω (c) 0.025 Ω (d) 1.0 Ω

13. A wheatstone bridge requires a change of 6 ohms in the unknown arm of the bridge to produce a change in deflection of 3mm of the galvanometer. The sensitivity of the instrument is : **(IES-EE-1992)**

(a) 0.5 percent (b) 2.0 (c) 0.5 mm/ohm (d) 2.0 ohm/mm

14. Match List-I with List-II and select the correct answer using the **Codes** given below the lists :

(IES-EE-1992)

List-I

A. Digital Counter B. Schering bridge

C. Megger D. Spectrum Analyzer

List-II

1. Measurement of harmonics
2. Measurement of frequency
3. Measurement of loss angle in a dielectric
4. Measurement of insulation resistance

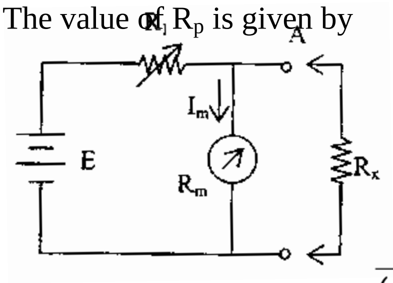
Codes :

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	2	3	4	1
(d)	4	1	2	3

15. A shunt type ohmmeter is shown in the figure. With R_x disconnected, the meter reads full scale. 'S' represents the meter current as a fraction fo full scale current with R_x connected such that,

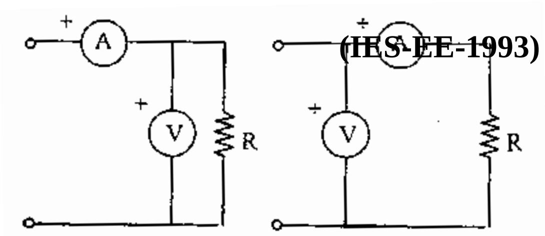
(IES-EE-1993)

$S = \frac{R_x}{R_x + R_p}$, The value of R_p is given by



(a) Rm (b) $R_1 + R_m$ (c) $\frac{R_1 R_x}{(R_1 + R_m)}$ (d) $\frac{R_1 . R_m}{(R_1 + R_m)}$

16. The power in a resistor R is estimated by measuring the voltage and current using the voltmeter-ammeter method. Two different arrangements can be used as shown in circuits I and II. Less erroneous results are obtained by adopting **(IES-EE-1993)**



Circuit I Circuit II

(a) circuit I for low values of R (b) circuit II for low values of R
(c) circuit I for high values of R (d) circuit II for low and high values of R

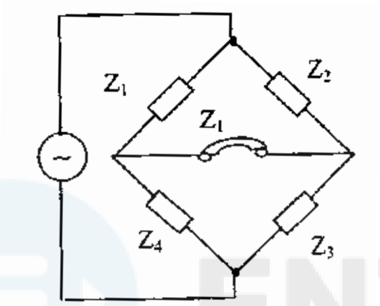
17. In the bridge shown in the figure **(IES-EE-1993)**

$Z_1 = 450\,\Omega$

$Z_2 = (300 - j600)\,\Omega$

$Z_3 = (200 + j100)\,\Omega$

The value of unknown impedance Z_4 at balance is

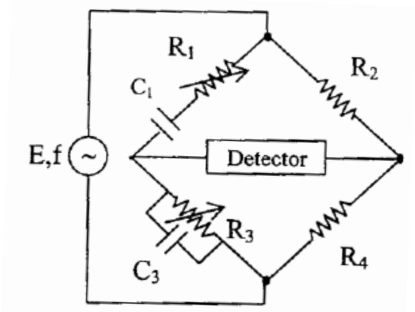


(a) $100 + j150\,\Omega$ (b) $(100 - j150)\,\Omega$
(c) $(300 + j100)\,\Omega$ (d) $(0 + j150)\,\Omega$

18. Which of the following conditions are to be satisfied so that the common variable shaft of resistance R_1 and R_3 can be graduated in frequency to measure the frequency of E under balanced condition ?

1. $R_1 = R_3$ 2. $C_1 = C_3$ 3. $R_2 = 2R_4$ 4. $R_2 = R_4$

Select the correct answer using the codes given below : **(IES-EE-1993)**



(a) 1 and 4 (b) 1 and 2 (c) 2 and 4 (d) 1, 2 and 3

19. The shunt type ohmmeter is NOT suitable for high resistance measurements because **(IES-EE-1993)**

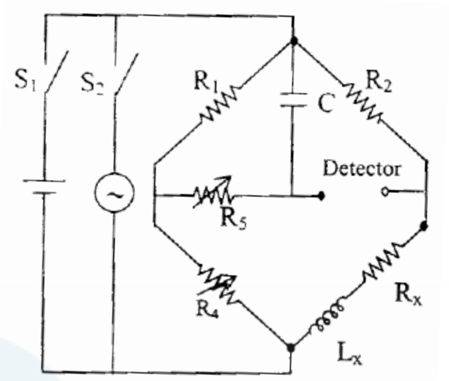
(a) very low resistance of the meter would short the high unknown resistance
(b) scale is highly cramped for high resistance values
(c) full scale value of the meter may be exceeded
(d) battery cannot supply the necessary current for proper meter deflection

20. The bridge network shown in the figure is connected up with a view to estimate the increase in the resistance of a coil due to skin effect. The procedure involves

the following steps, not necessarily in that order : **(IES-EE-1993)**

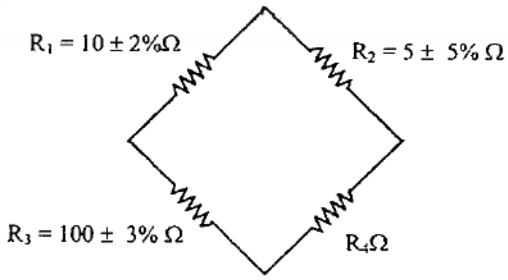
1. Switch on S_2 with S_1 off
2. Swit on S_1 with S_2 off
3. Adjust R_4
4. Adjust R_5

The correct sequence of these steps (a step could be repeated) is



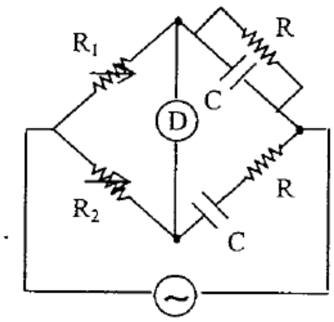
(a) 1, 3, 2, 4, 3 (b) 2, 4, 1, 4, 3 (c) 1, 4, 2, 3, 4 (d) 2, 3, 1, 3, 4

21. The arms of a Wheatstone bridge are shown in the given figure. For the balanced condition, the least tolerance value of R_4 will be **(IES-EE-1994)**



(a) 50 ± 2% Ω (b) 50 ± 3% Ω (c) 50 ± 5% Ω (d) 50 ± 10% Ω

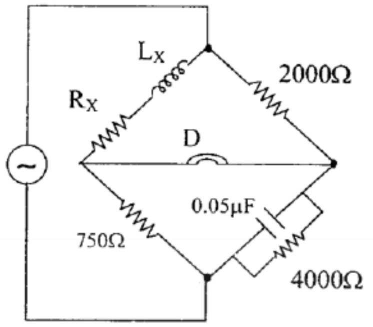
22. The given figure shows Wien bridge connetion for frequency measurement. C and R are variables and ganged together. For balanced condition, the expression for frequency is $f = \frac{1}{2\pi CR}$ when **(IES-EE-1994)**



(a) $R_1 = R_2$ (b) $R_1 = 2R_2$ (c) $R_1 = \frac{R_2}{2}$ (d) $R_1 = 3R_2$

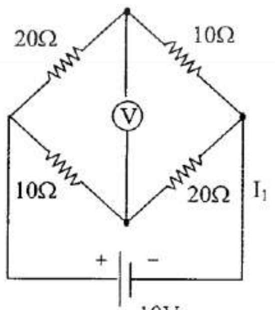
23. The bridges suitable for the measurement of an unknown inductance in terms of a known capacitance would include
(IES-EE-1995)
(a) Maxwell and Hay
(b) Maxwell and Schering
(c) Hay and Schering
(d) Maxwell, Hay and Schering

24. In the Maxwell bridge as shown in given figure, the values of resistance R_x and inductance L_x of a coil are to be calculated after balancing the bridge. The component values are shown in the figure at balance. The values of R_x and L_x will respectively be **(IES-EE-1995)**



(a) 375Ω , 75mH
(b) 75Ω , 150mH
(c) 37.5Ω , 75mH
(d) 75Ω , 75mH

25. In the bridge given inn figure, the reading of the high impedance voltmeter is
(IES-EE-1995)



(a) zero
(b) 6.66 V
(c) 4.20V
(d) 3.33V

26. The Wheatstone bridge method of resistance measurement is ideally suitable for the measurement of resistance values in the range of **(IES-EE-1995)**

(a) 0.001 Ω to 1Ω
(b) 0.1 Ω to 100Ω
(c) 100 Ω to 10kΩ
(d) 100kΩ to 10MΩ

27. **Assertion (A) :** While using an ohmmeter for the measurement of resistance, the meter is to be disconnected from the external voltage source, if already connected.
Reason (R) : No current is needed for meter movement **(IES-EE-1996)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

28. Match List-I (Bridges) with List-II (Quantity measured) and select the correct answer using the **Codes** given below the lists : **(IES-EE-1996)**

List-I

A. Anderson Bridge

B. Kelvin Double Bridge

C. Schering Bridge

D. Wien Bridge

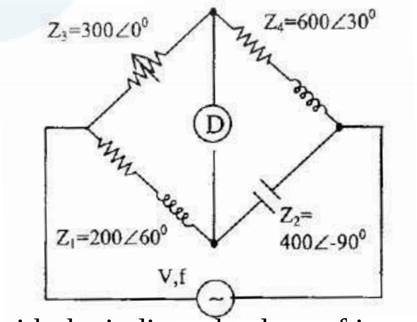
List-II

1. Frequency
2. Resistance
3. Inductance
4. Capacitance

Codes :

	A	B	C	D
(a)	3	2	1	4
(b)	3	2	4	1
(c)	2	1	3	4
(d)	2	3	4	1

29. In the A.C. bridge shown in the giv en figure, the impedances Z_1, Z_2, Z_3 and Z_4 ohms at the supply frequency are as indicated Z_3 is variable impedance. The bridge **(IES-EE-1996)**



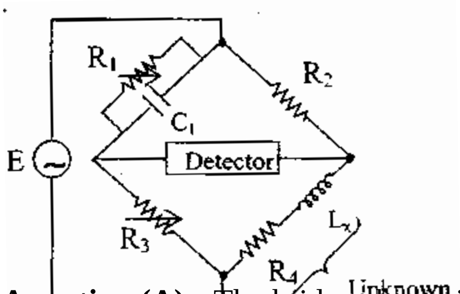
(a) is balanced with the indicated values of impedances

(b) can be balanced if $Z_3 = 400\angle 0^0$

(c) can be balanced if $Z_4 = 600\angle 60^0$

(d) cannot be balanced with the given configuration

30.



Assertion (A) : The bridge shown in the figure is balanced by first adjusting R_1 for inductive balance and then adjusting R_3 for resistive balance; and this is repeated till balance is achieved.

Reason (R) : For medium – Q coils, the resistance effect is not pronounced and balance is reached after a few adjustments **(IES-EE-1997)**

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false (d) A is false but R is true

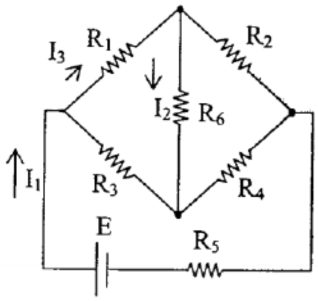
31. The resistance of a shunt for a precision grade ammeter can be best measured by

(a) De Sauty bridge (b) Schering bridge

(IES-EE-1998)

(c) Maxwell bridge (d) Kelvin double bridge

32. In the balance Wheatstone bridge shown in the figure, if the value of R_6 is increased, the current I_2 **(IES-EE-1998)**



(a) will increase (b) will decrease (c) will remain (d) unchanged

33. Match List-I with List-II and select the correct answer using the Codes given below the lists : **(IES-EE-1998)**

List-I

A. Low value of R

B. High –Q inductor

C. Low –Q inductor

D. High voltage capacitors

List-II

1. Schering bridge 2. Maxwell bridge

3. Kelving double bridge 4. Hay bridge

Codes :

	A	B	C	D
(a)	1	2	4	3
(b)	1	4	2	3
(c)	3	2	4	1
(d)	3	4	2	1

34. In a balanced Wheatstone bridge, if theposition of detector and source are interchanged, the bridge will still remain balanced. This inference can be drawn form

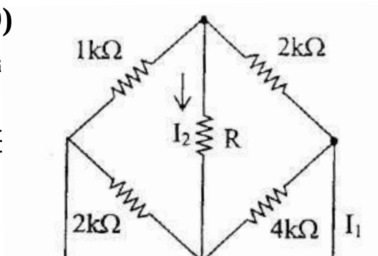
(IES-EE-1999)

(a) reciprocity theorem (b) duality principle

(c) compensation theorem (d) equivalence theorem

35. A bridge is shown in the given figure. If the resistance R_s is increased from 2kΩ to 2.5kΩ , the current I_2 will.

(IES-EE-1999)



(a) increase (b) decrease (c) not change

(d) increase or decrease depending on the polarity of E

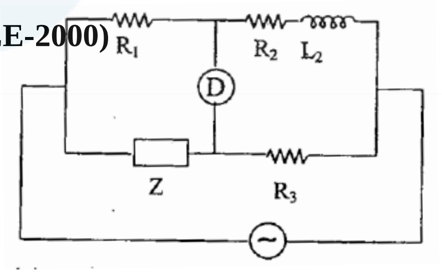
36. Consider the following statements in respect of a Wien bridge.

1. It is suitable for measurement of capacitance
2. It is not affected by harmonics present in the applied voltage
3. It is suitable for measurement of frequency

Which of these statements are correct? **(IES-EE-1999)**

(a) 1, 2 and 3 (b) 1 and 2 (c) 2 and 3 (d) 1 and 3

37. The ac bridge shown in the given figure will remain balanced if impedance Z consists of **(IES-EE-2000)**



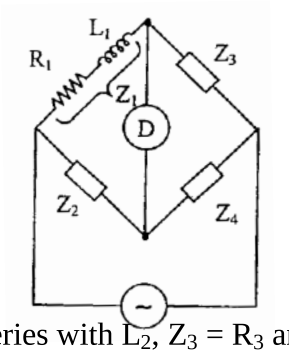
(a) resistance and inductancfe in series

(b) resistance and capacitance in parallel

(c) capacitance only

(d) inductance only

38. Consider the following statements regarding the balanced ac bridge shown in the given figure for measurement of a coil Z_1 : **(IES-EE-2000)**



1. $Z_2 = R_2$ is series with L_2, $Z_3 = R_3$ and $Z_4 = R_4$
2. $Z_2 = R_2$, $Z_3 = R_3$ and $Z_4 = R_4$ in parallel with L_4

3. $Z_2 = R_2$, $Z_3 = R_3$ and $Z_4 = R_4$ in series with L_4

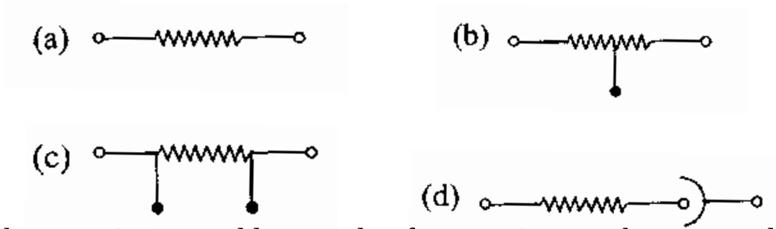
4. $Z_2 = R$ in parallel with L_2, $Z_3 = R_3$ and $Z_4 = R_4$

Which of these statements are correct ?

(a) 1 and 4 (b) 1 and 2 (c) 2 and 3 (d) 3 and 4

39. Which one of the following resistance configurations is best suited for the construction of a low resistance ?

(IES-EE-2000)



40. The capacitance and loss angle of a capacitor can be accurately measured by

(IES-EE-2000)

(a) Kelvin's bridge (b) Andferson's bridge

(c) Schering bridge (d) Carey-Foster's bridge

41. **Assertion (A) :** A four-arm 'Wien bridge network is sometimes used in feedback circuit of tuned amplifer

Reason (R) : The balance equation of such a Wien bridge contains 'frequency' term along with arm parameters **(IES-EE-2002)**

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

42. The accuracy of Kelvin's double bridge for the measurement of low resistance is high because the bridge

(IES-EE-2002)

(a) uses two pairs of resistance arms

(b) has medium value resistances in the ratio arms

(c) uses a low resistance link between standard and test resistance

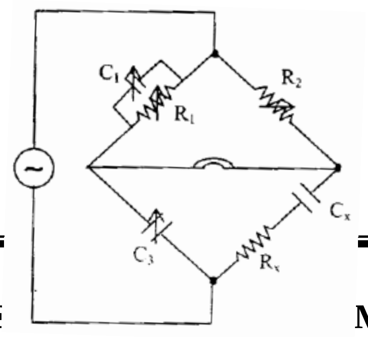
(d) uses a null indicating galvanometer.

43. An imperfect capacitor is represented by a capacitance C in parallel with a resistance R. The value of its dissipation factor tan δ is **(IES-EE-2002)**

(a) ωCR (b) $\omega^2 CR$ (c) $\frac{1}{\omega^2 CR}$ (d) $\frac{1}{\omega CR}$

44. For the bridge shown in the given figure, at balance the values of R_x, C_x and Q_x will be

(IES-EE-2002)



(a) $R_x = \frac{C_1R_2}{C_3}, C_x = \frac{R_1C_3}{R_2}, Q_x = \omega C_1R_1$

(b) $R_x = \frac{C_1R_2}{C_3}, C_x = \frac{R_1C_3}{R_2}, Q_x = \frac{1}{\omega C_1R_1}$

(c) $R_x = \frac{C_1R_2}{C_3}, C_x = \frac{R_2C_3}{R_1}, Q_x = \frac{1}{\omega C_1R_1}$

(d) $R_x = \frac{C_1R_1}{C_3}, C_x = \frac{R_2C_3}{R_1}, Q_x = \omega C_1R_1$

45. Vibration galvanometers, tunable amplifiers and head phones are used in

(IES-EE-2003)

(a) d.c. bridges (b) a.c. bridges

(c) Both d.c and a.c bridges (d) Kelvin double bridge

46. A wien-bridge is used to measure the frequency of the input signal. However the input signal has 10% third harmonic distortion. Specifically the signal is 2sin400 πt+0.2sin1200πt (with t in sec.) With this input the balance will

(IES-EE-2003)

(a) Lead to a null indication and setting will correspond to a frequency of 200 Hz

(b) Lead to a null indication and setting will correspond to 260 Hz

(c) Lead to a null indication and setting will correspond to 400 Hz

(d) Not lead to null indication

47. The capacitance and loss angle of a given capacitor specimen are best measured by

(IES-EE-2003)

(a) Wheatstone bridge (b) Maxwell bridge

(c) Anderson bridge (d) Schering bridge

48. **Assertion (A) :** A Schering Bridge used for testing of a porcelain insulator is shielded by a metallic screen

Reason (R) : Earth's magnetic field is blocked by a metallic scrren

(IES-EE-2003)

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

49. A resistor R is measured using the V-I method, with V read as 10.14V and I as 5.07mA. Which one of the following express the value of resistance

(IES-EE-2004)

(a) 2kΩ (b) 2.00kΩ (c) 2000Ω (d) 2.0kΩ

50. Low resistance from few homs down to one micro ohm is measured using which one of the following instruments ?
(IES-EE-2004)
(a) Ohmmeter (b) A series type ohmmeter
(c) A shunt type ohmmeter (d) A voltmeter and an ammeter

51. Which one of the following is measured by the loss of charge method ?
(IES-EE-2004)
(a) Low R (b) High R (c) Low L (d) High L

52. Which of the following bridges can be used for inductance measurement?
1. Maxwell's bridge 2. Schering bridge 3. Wein bridge
4. Hay's bridge 5. Wheatstone bridge
Select the correct answer using the code given below : **(IES-EE-2005)**
(a) 1 and 2 (b) 2 and 3 (c) 3, 4 and 5 (d) 1 and 4

53. Match List-I (Frequency) with List-II (Detector) and select the correct answer using the **Codes** given below the lists : **(IES-EE-2005)**

List-I
A. Zero frequency
B. 50 Hz
C. 1200 Hz
D. 10 KHz

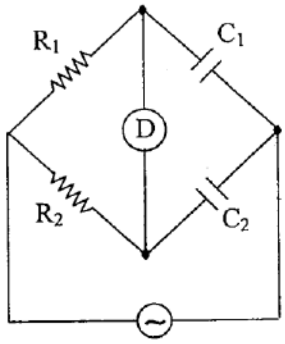
List-II
1. Head phone
2. D' Arsonval galvanometer
3. Cathode ray oscilloscopre
4. Vibration galvanometer
5. BGallistic galvanometer

Codes :

	A	B	C	D
(a)	2	1	5	3
(b)	3	4	1	2
(c)	2	4	1	3
(d)	3	1	5	2

54. Which of the following factors decide the accuracy in a bridge measurement ?
1. Accuracy of the null indicator
2. Accuracy of the bridge components
3. Senstivity of the null indicator
4. Applied voltage to the bridge system
Select the answer using the Codes given below **(IES-EE-2005)**
(a) 1 and 2 (b) 2 and 3 (c) 3 and 4 (d) 1 and 3

55. Which one of the following is represented by the circuit shown below ?



(IES-EE-2006)

(a) DeSauty bridge (b) Anderson bridge
(c) Heaviside-campbell bridge (d) Hay's bridge

56. What should be the main characteristic(s) of the null detector in a bridge measurement ?
1. Accuracy 2. Precision 3. Sensitivity 4. Resolution
Select the correct answer using the code given below : **(IES-EE-2006)**
Code :
(a) Only 1 and 2 (b) Only 2 and 3 (c) Only 3 and 4
(d) Only 3

57. Match List-I with List-II and select the correct answer using the Codes given below the lists : **(IES-EE-2006)**
List-I
A. Average value of current
B. RMS value of current
C. Frequency of a wave
D. Strain gauge resistance
List-II
1. Self balancing bridge
2. Wien bridge
3. PMMC ammeter
4. Moving iron ammeter
Codes :

	A	B	C	D
(a)	3	4	2	1
(b)	2	1	3	4
(c)	3	1	2	4
(d)	2	4	3	1

58. Match List-I with List-II and select the correct answer using the Codes given below the lists : **(IES-EE-2006)**
List-I
A. Digital Counter
B. Schering Bridge
C. Megger
D. Spectrum analyzer

List-II

1. Measurement of harmonics
2. Measurement of frequency
3. Measurement of dielectric loss
4. Measurement of insulation resistance

Codes :

	A	B	C	D
(a)	1	3	4	2
(b)	2	4	3	1
(c)	1	4	3	2
(d)	2	3	4	1

59. Maxwell's inductance capacitance bridge is used for measurement of inductance of
(IES-EE-2006)
(a) low Q coils only (b) medium Q coils only
(c) high Q coils only (d) low and medium Q coils

60. Match List-I with List-II and select the correct answer using the **Codes** given below the lists : **(IES-EE-2007)**

List-I (Name of Instrument)

A. Ohmmeter
B. Watt hour meter
C. Null balance recorder
D. Releigh current balance

List-II (Classificaiton)

1. Absolute
2. Indicating
3. Recording
4. Integrating

Codes :

	A	B	C	D
(a)	1	2	3	4
(b)	2	4	3	1
(c)	2	4	1	3
(d)	1	2	4	3

61. Match List-I with List-II and select the correct answer using the Codes given below the lists : **(IES-EE-2007)**

List-I (Name of Instrument)

A. Telephone detector
B. Vibration galvanometer
C. Tunable amplifier
D. D' Arsonval galvanometer

List-II (Frequency Range)

1. 200 Hz   2. 100 Hz

3. 1 kHz   4. dc

Codes :

	A	B	C	D
(a)	3	4	2	1
(b)	2	1	3	4
(c)	3	1	2	4
(d)	2	4	3	1

62. Which one of the following bridge is used for measurement of dielectric loss and power factor of a capacitor ? **(IES-EE-2007)**
(a) Maxwell's bridge   (b) Anderson bridge
(c) De Sautty's bridge   (d) Schering bridge

63. Hay's bridge is suitable for the measurement of which one of the following **(IES-EE-2007)**
(a) Inductance with $Q < 10$ (b) Inductance with $Q > 10$
(c) Capacitance with high dissipation
(d) Capacitance with low dissipating factors

64. **Assertion (A) :** The accuracy of the null detector does not play any role in a bridge measurement
Reason (R) : Undfer balance condition of the bridge, no current flows through the null detector **(IES-EE-2007)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

65. Schering bridge can be used to measure which one of the following **(IES-EE-2008)**
(a) Q of a coil   (b) Inductance and its Q-value
(c) Very small resistance   (d) Capacitance and its power factor

66. Inductance is measured by which one of the following ? **(IES-EE-2008)**
(a) Wien bridge   (b) Schering bridge
(c) Maxwell bridge   (d) Owen bridge

67. The dielectric loss of a capacitor can be measured by which one of the following?
(a) Wien bridge   (b) Owen bridge
(IES-EE-2008)
(c) Schering bridge   (d) Maxwell bridge

68. Which bridge is used to determine frequency ? **(IES-EE-2008)**
(a) Anderson bridge   (b) De Sauty bridge

(c) Wien bridge (d) Campbell bridge

69. For low resistance (from micro ohms to one ohm) measurement, which bridge is used ?
(IES-EE-2008)
(a) Wheatstone bridge (b) Kelvin bridge
(c) Guarded Wheatstone bridge (d) Maxwell bridge

70. The imperfect capacitance which is shunted by a resistance can be measured by which one of the following ?
(IES-EE-2008)
(a) Carey Foster bridge (b) Owen bridge
(c) Schering bridge (d) Wien bridge

71. Which one of the following bridges will be used for the measurement of very low resistance ?
(IES-EE-2009)
(a) Kelvin bridge (b) Maxwell's bridge
(c) Wheatstone bridge (d) Hay's bridge

72. Dissipation factor, tan δ, of a capacitor is measured by which bridge
(IES-EE-2009)
(a) Anderson bridge (b) Hay bridge
(c) Schering bridge (d) Wien bridge

73. Which one of the following is a frequency sensitive bridge ? **(IES-EE-2009)**
(a) De-Sauty bridge (b) Schering bridge
(c) Wien's bridge (d) Maxwell's bridge

74. How can the power supplied to a high frequency heating system be measured?
(IES-EE-2009)
(a) By dynamometer wattmeter
(b) By induction wattmeter
(c) By thermocouple type wattmeter
(d) By moving iron ammeter and voltmeter

75. **Assertion (A) :** In a bridge type of measurement, it is required that the indicator used to show the balance condition of the bridge should have veryhigh sensitivity
Reason (R) : The accuracy of the null-indicator does pot play any role in a bridge measurement **(IES-EE-2009)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

76. Match List-I with List-II and select the correct answer using the **Codes** given below the lists : **(IES-EE-2010)**
List-I (Meter)
A. Reed frequency meter
B. Weston frequency meter
C. Weston synchroscope
D. Ohm meter
List-II (Type)

1. Moving iron
2. Vinbrating
3. Moving coil
4. Electrodynamics

Codes :

	A	B	C	D
(a)	2	1	4	3
(b)	3	1	4	2
(c)	2	3	4	1
(d)	3	4	1	2

77. Consider the following statements in connection with deflection and null type instruments :
1. Null type instrument is more accurate than the deflection type one
2. Null type of instrument can be highly sensitive as compared with deflection type instrument
3. Under dynamic conditions, null type instrument is not preferred to deflection type instrument
4. Response is faster in null type instrument as compared to deflection type instrument.

Which of these statements are correct ? **(IES-EE-2011)**

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 2, 3 and 4 only (d) 1, 2, 3 and 4

78. Match List-I with List-II and select the correct answer using the Codes given below the lists : **(IES-EE-2011)**

List-I
A. Average value of current
B. Frequency of a wave form
C. Starin-gauge resistance

List-II
1. Self-balancing bridge
2. Wein's bridge
3. PMMC ammeter

Codes :

	A	B	C
(a)	2	1	3
(b)	3	1	2
(c)	1	2	3
(d)	3	2	1

79. Match List-I with List-II and select the correct answer using the Codes given below the lists : **(IES-EE-2011)**

List-I
A. Hay bridge
B. Wheatstone bridge

C. Wein bridge
D. Schering bridge

List-II

1. Medium   2. Frequency
3. Capacitance   4. High Q-inductance

Codes :

	A	B	C	D
(a)	4	2	1	3
(b)	3	2	1	4
(c)	4	1	2	3
(d)	3	1	2	4

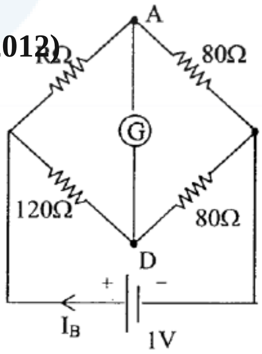
80. **Assertion (A) :** AC bridge methods are the best and most usual methods for the precise measurement of self and mutual inductances and capacitances

Reason (R) : Wagner earthing device is used in AC bridge for eliminating the effect of the earth capacitance **(IES-EE-2011)**

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

81. In the circuit shown, when the current through the branch AD is zero, the battery current I_B is

(IES-EE-2012)



(a) 1 mA   (b) 2 mA   (c) 10 mA   (d) 20 mA

82. The measurement of requency can be carried out with **(IES-EE-2012)**

(a) Owen's bridge   (b) Wien's bridge
(c) Maxwell's inductance-capacitance bridge
(d) Schering bridge

83. Match List-I with List-II and select the correct answer using the Codes given below the lists : **(IES-EE-2012)**

List-I

A. Mutual inductance
B. High-Q inductance
C. Audio frequency
D. Dielectric loss

List-II

1. Wien bridge

2. Schering bridge
3. Hay bridge
4. Heaviside-Campbell bridge

Codes :

	A	B	C	D
(a)	4	1	3	2
(b)	2	3	1	4
(c)	4	3	1	2
(d)	2	1	3	4

84. The preferred methods of measuring low resistance and the resistance of cable insulation are respectively. **(IES-EE-2012)**
(a) V/I method amd loss-of-charge method
(b) Kelvin's double bridge and Megger test
(c) Wheatstone bridge and Kelvin's double bridge
(d) potentiometer method and Wheatstone bridge

85. Wagner's earthing devices is used in A.C. bridges for **(IES-EE-2013)**
(a) shielding the bridge element
(b) eliminating the stray of earth capacitance
(c) Eliminating the effect of earth capacitances
(d) Eliminating the effect of inter-component capacitances.

86. A bridge circuit works at a frequency of 2 kHz. The following can be used as detectors for detection of null conditions in the bridges. **(IES-EE-2013)**
(a) Vibration galvanometers and Head-phones
(b) Headphones and tunable amplifiers
(c) Vibration galvanometers and Tunable amplifiers
(d) Vibration galvanometers, Head phones and Tunable amplifier

87. **Statement (I) :** Bridge measurements are considered to be more accurate as compared to measurements done using indicating instruments.
Statement (II) : In a bridge measurement, the accuracy of the components used in the different arms of the bridge alone comes into picture. **(IES-EE-2014)**

88. A basic D'Arsonval movement showing full scale deflection for a current of 50 μA and having internal resistance of 500 Ω is used as a voltmeter. What is the value of multiplier resistance needed to measure a voltage range of 0-20 V ? **(IES-EE-2014)**
(a) 398.5 kΩ (b) 399 kΩ (c) 399.5 kΩ (d) 400 kΩ

89. In De Sauty Bridge (unmodified form) it is possible to obtain balance. **(IES-EE-2014)**
(a) Even if both the capacitors are imperfect
(b) If one of the capacitors is perfect
(c) Only if both the capacitors are perfect

(d) All of the above

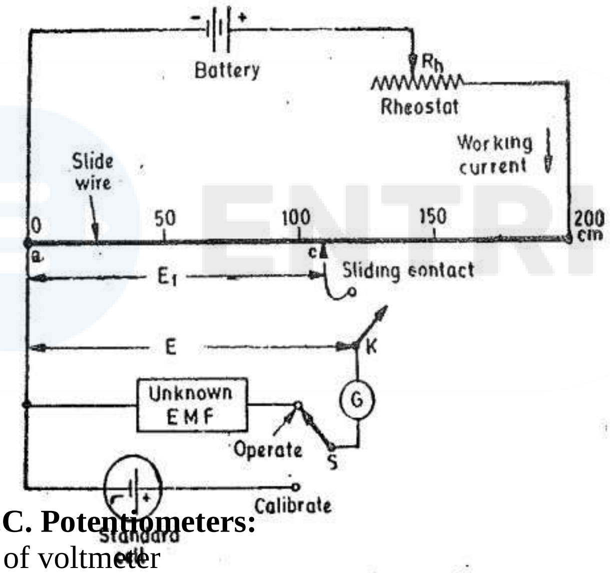
90. With the help of which bridge are the capacitance and dielectric loss of a capacitor generally measured ? **(IES-EE-2014)**

(a) De Sauty (b) Wien series (c) Anderson (d) Schering

4. POTENTIOMETERS

D.C. Potentiometers:

- Potentiometer is an instrument for measurement of an unknown electromotive force(e.m.f.) or potential difference produced by the flow of a known current in a network of circuits of known characteristics.
- It is an instrument by which an unknown voltage is measured by comparing it with a known voltage. The known voltage may be supplied by a standard cell or any other known voltage-reference source.
- Potentiometers are used extensively in measurements where
  I. Precision required is very high s compared to that can be obtained by deflection instruments
  II. It is important that no current be drawn from the source under measurements
  III. The current must be limited to a small value.



Applications of D.C. Potentiometers:

1. Calibration of voltmeter
2. Calibration of ammeter
3. Measurement of resistance

A.C. Potentiometers:

The d.c. potentiometer is an accurate and versatile instrument and thus it is obvious that the potentiometer principle can be applied to measurement of alternating current and voltages. The most important difference between a d.c. and an a.c. potentiometer voltage drop have to be made equal to obtain balance, in the a.c. instrument both the magnitudes and phases of the two have to be same to obtain balance.

Types of A.C. Potentiometer:

1. **Polar type:**

In these instruments, the magnitude of the unknown voltage is read from one scale and its phase angle, with respect to some reference phasor, is read directly from a second scale. The voltage is read in the form of $V\angle\theta$.

2. **Coordinate type:**

These instruments are provide with two scales to read respectively the inphase component V_2 of the unknown voltage v.

Then the voltage $V = \sqrt{V_1^2 + V_2^2}$ and its phase angle w.r.t current in the "inphase" portion of the potentiometers is $\theta = \tan^{-1}(V_2/V_1)$.

CLASS ROOM OBJECTIVES

01. A potentiometer is basically a
    (a) deflection type instrument
    (b) null type instrument
    (c) deflection as well as null tyupe instrument
    (d) a digital instrument

02. A d.c. potentiometer is designed to measure up to about 2 v with a slide wire of 800 mm. A standard cell of emf 1.18v obtains balance at 600 mm. A test cell is seen to obtain balance at 680 mm. The emf of the test cell is
    (a) 1.00 v (b) 1.34 v (c) 1.50 v (d) 1.70 v

03. A potentiometer of length 11m obtains balance at 10.18m with a test cell of 1.018V. The emf of the battery supplying current through potentiometer is 2 V. The resistance that should be connected to a potentiometer circuit assuming that slide wire has the resistance of 1 Ω/m is?

PREVIOUS QUESTIONS

One Mark Questions

01. In d.c. potentiometer measurements, a second reading is often taken after reversing the polarities of the d.c. supply and the unknown voltage, and the average of the two readings is taken. This is with a view to eliminate the effects of
    (GATE-EE-1992)
    (a) ripples in the d.c. supply (b) stray magnetic fields
    (c) stray thermal emf's (d) erroneous standardization

02. A potentiometer is basically a
    (GATE-EE-1997)
    (a) deflection type instrument
    (b) null type instrument
    (c) deflection as well as null tyupe instrument
    (d) a digital instrument

03. A transfer instrument employed in the standardization of a polar type a.c. potentiometer is ___
    (GATE-EE-1997)
    (a) an electro static instrument (b) a thermal instrument
    (c) a dynamo meter instrument (d) a moving coil instrument

Two Marks Questions

04. A d.c. potentiometer is designed to measure up to about 2 v with a slide wire of 800 mm. A standard cell of emf 1.18v obtains balance at 600 mm. A test cell is seen to obtain balance at 680 mm. The emf of the test cell is **(GATE-EE-1994)**
    (a) 1.00 v (b) 1.34 v (c) 1.50 v (d) 1.70 v

05. A simple dc potentiometer is to be standardized by keeping the slide wire setting at 1.0183V. If by mistake, the setting is at 1.0138V and the standardization is made to obtain a source voltage of 1.0138V, then the reading of the potentiometer will be

(IES-EE-1993)

(a) 1.0138V (b) 1.0183V (c) $\frac{(1.0138)^2}{1.0183}V$ (d) $(1.0138)^2$ V

06. Consider the following statements :

DC potentiometer is the best means available for measurement of dc voltages because

1. The precision in measurement is independent of the type of detector used.
2. It is based on null-balance technique
3. It is possible to standardize before a measurement is undertaken
4. It is possible to measure dc voltage ranging in value from mill volts to hundreds of volts

(IES-EE-1995)

Of these statements

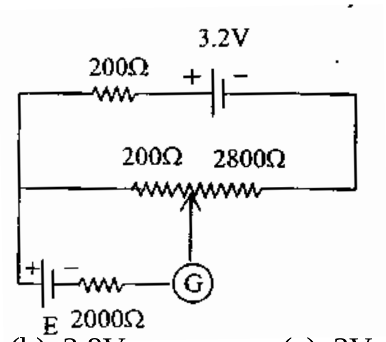
(a) 2 and 3 are correct (b) 1 and 4 are correct
(c) 2 and 4 are correct (d) 3 and 4 are correct

07. A slide wire potentiometer has 10 wires of 1m each. With the help of a standard voltage source of 1.018V it is standardized by keeping the jockey at 101.8cm. If the resistance of the potentiometer wires is 1000 ohm, then the value of the working current is

(IES-EE-1996)

(a) 0.1mA (b) 0.5mA (c) 1 mA (d) 10mA

08. In the potentiometer circuit shown in the given figure, the value of unknown voltage 'E' under balanced condition will be **(IES-EE-2000)**



(a) 200mV (b) 2.8V (c) 3V (d) 3.2V

09. **Assertion (A) :** A resistance potentiometers used for measurement of displacement, sensitivity and linearity are conflicting requirements.

Reason (R) : The voltmeter used for measurement of output voltage of the potentiometer has a finite resistance which causes loading effects

(IES-EE-2001)

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false (d) A is false but R is true

10. A single slide wire is used for the measurement of current in a circuit. The voltage drop across a standard resistance of 1.0 Ω is balanced at 70cm. What is the magnitude of the current, if the standard cell having an emf of 1.45 volts is balanced at 50 cm ? **(IES-EE-2006)**

(a) 3.09 A (b) 2.65 A (c) 2.03 A (d) 1.45 A

11. Which one of the following instruments is used for standardization of a Drysdale a.c. potentiometer ? **(IES-EE-2007)**

(a) Rectifier type ammeter (b) PMMC ammeter
(c) precision type electrodynamometer (d) Thermocouple ammeter

12. Which one of the following is not the criterion used to select potentiometer in a control system ? **(IES-EE-2009)**

(a) Accuracy (b) Noise
(c) Time response (d) Frequency response

13. Match List-I with List-II and select the correct answer using the codes given below the lists : **(IES-EE-2010)**

List-I

A. Iron loss of a choke carrying AC current of 50Hz along with DC
B. Calibration of a dynamometer type wattmeter
C. Dielectric loss of a capacitor at 20Hz
D. Power loss of an insulator testing at High voltage

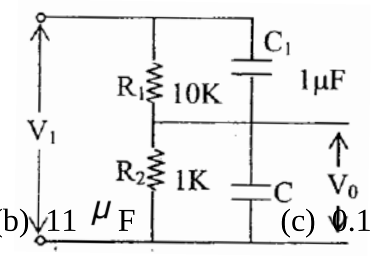
List-II

1. Electrostatic wattmeter
2. Oscilloscope
3. DC Potentiometer
4. AC potentiometer

Codes :

	A	B	C	D
(a)	3	1	4	2
(b)	2	1	4	3
(c)	3	4	1	2
(d)	2	4	1	3

14. A RC potentiometer to measure ac voltage, it is desired that $\frac{V_0}{V_1}$ should be independent of frequency. The value of C should be **(IES-EE-2011)**



(a) 10 μF (b) 11 μF (c) 0.1 μF (d) 0.09 μF

15. Volt-box is basically a device used for **(IES-EE-2013)**
   (a) measuring the voltage
   (b) extending the range of voltmeter
   (c) extending the voltage range of the potentiometer
   (d) measuring power

KEY

MEASUREMENT OF POWER

PREVIOUS QUESTIONS

1. C	2. C	3. B	4. A	5. C	6. B
7. C	8. C	9. A	10. D	11. C	12. C
13. 0.8	14. 2	15. D	16. B	17. B	18. D
19. C	20. D	21. A	22. C	23. B	24. C
25. B	26. D	27. D	28. A	29. D	30. A
31. A	32. C	33. D	34. B	35. A	36. D
37. A	38. C	39. B	40. D	41. B	42. B
43. B	44. C	45. C	46. B	47. C	48. C

49. B 50. B 51. A 52. B 53. A 54. A

55. C 56. B 57. B 58. B 59. C 60. C

61. C 62. C 63. A 64. C

MEASUREMENT OF ENERGY

PREVIOUS QUESTIONS

1. C 2. C 3. B 4. A 5. A 6. C

7. B 8. A 9. A 10. C 11. B 12. D

13. C 14. C 15. B 16. B 17. D 18. B

19. A 20. B 21. B 22. C 23. A 24. C

25. C 26. B 27. B 28. A 29. A 30. D

MEASUREMENT OF R, L & C

PREVIOUS QUESTIONS

1. C 2. A 3. C 4. A 5. D 6. A

7. D 8. B 9. A 10. C 11. C 12. C

13. C 14. C 15. D 16. A 17. D 18. D

19. B 20. D 21. D 22. C 23. A 24. A

25. D 26. D 27. D 28. B 29. D 30. D

31. D 32. C 33. D 34. A 35. C 36. D

37. B 38. B 39. C 40. C 41. C 42. A

43. C 44. D 45. A 46. B 47. D 48. D

49. C 50. B 51. C 52. B 53. D 54. C

55. C 56. A 57. D 58. A 59. D 60. B

61. B 62. C 63. D 64. B 65. A 66. D

67. C 68. C 69. C 70. B 71. D 72. A

73. C 74. C 75. C 76. C 77. A 78. A

79. D 80. D 81. A 82. C 83. B 84. C

85. B 86. C 87. B 88. A 89. C 90. C

POTENTIOMETERS

PREVIOUS QUESTIONS

1. C 2. B 3. B 4. B 5. C 6. A

7. D 8. A 9. B 10. C 11. C 12. B

13. D 14. A 15. C

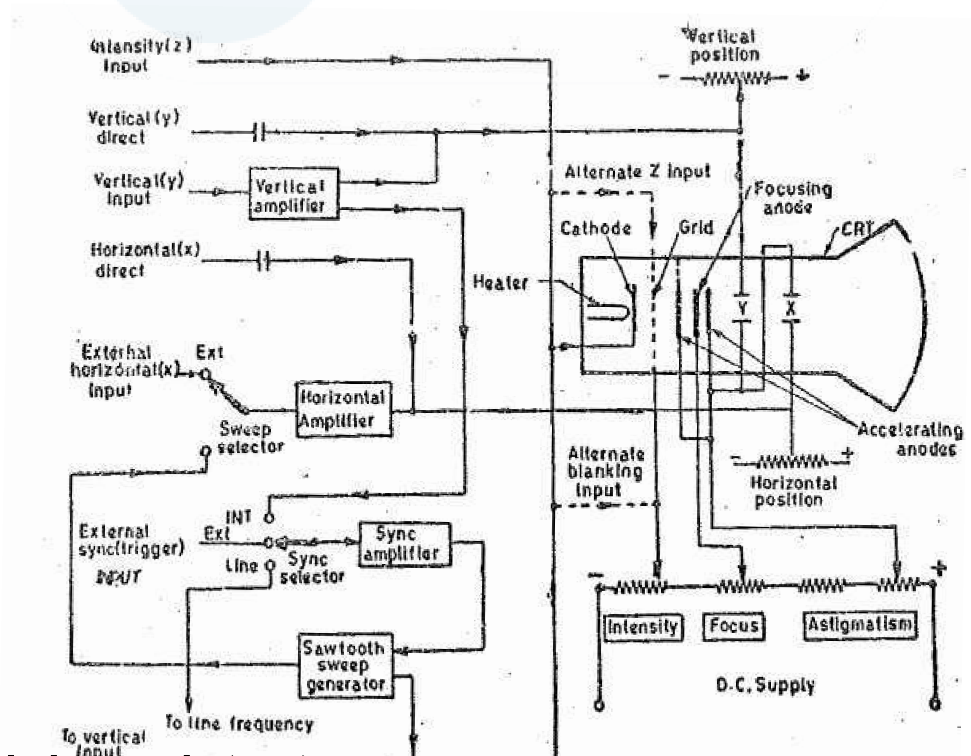
CONTENTS

1. CATHODE RAY OSCILLOSCOPE

Introduction

- The CRO is a device that allows the amplitude of electrical signals, whether they be voltages, current power etc, to be displayed primarily as a function of time.
- The cathode ray oscilloscope (CRO) is a very useful and versatile laboratory instruments used for display, measurement and analysis of waveforms and other phenomena in electrical and electronics circuits.
- The normal from of a CRO uses a horizontal input voltage which is an internally generated ramp voltage called “TIME BASE”. Where as the vertical input to the CRO is the voltage under investigation.
- CROs operate on voltages, However, it is possible to convert current, strain, acceleration, pressure and other physical quantities into voltage with the help of transducers and thus to present visual representations of a wide variety of dynamic phenomena on CROs.
- CROs are also used to investigate waveforms, transient phenomena, and other time varying quantities from a very low frequency range to the radio frequencies.
- Many additional features are available with some oscilloscope and these include built in digital multimeter and counters.

Construction of CRO:



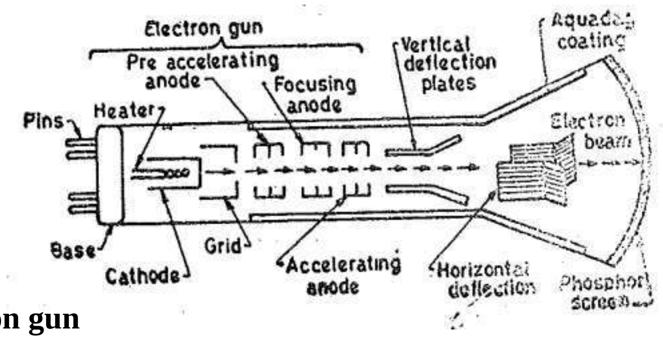
Cathode Ray Tube (CRT)

The Heart of the CRO is the CRT, which generates the electron beam, accelerates the beam to a high velocity, deflects the beam to create the image and contains the phosphor screen where the electron beam eventually becomes visible

The main parts of CRTs are following

1. Electron gun assembly
2. Deflection plate assembly

3. Glass envelope
4. Base



Electron gun

The source of focused and accelerated electron beam is the electron gun.

The electron gun which emits electrons and forms them into a beam consists of several elements which are given below.

Heating element

Heating element is used to heat up the cathode.

Cathode

It is cylindrical shaped with layer of barium and strontium oxide is deposited on the end of the cathode which is obtain high emission of electrons at moderate temperatures.

Control grid

The control grid is used to control the number of electron emitted from cathode.

This control grid is usually a nickel cylinder, with a centrally located hole, co-axial with the CRT axis.

The grid with its negative bias controls the number of electrons emitted from cathode and hence the intensity of electron beam is controlled by the grid.

Pre accelerating and accelerating anode

The electrons, emitted from the cathode and passing through the hole in the control grid are accelerated by the high positive potential which is applied to the pre accelerating and accelerating anode.

The pre-accelerating anode and the accelerating anode are connected to a common positive high voltage of 1500V.

Focusing anode

The electron beam is focused by the focusing anode

The focusing anode is connected to a lower adjustable voltage of 500V.

There are two methods of focusing an electron beam.

Electrostatic focusing

Electromagnetic focusing

Deflecting plates

From figure (4.2) we observe that the electron beam, after leaving the electron gun passes through two pairs of deflection plates.

Vertical deflecting plates or Y-plates

It is responsible for vertical deflection of electron beam

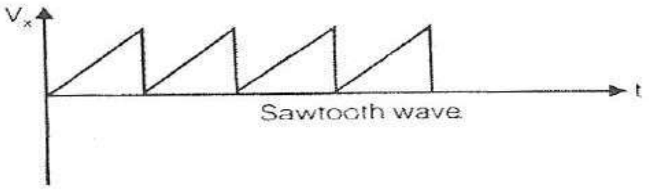
These plats are supplied with external signal fed via one of the input channel of CRO.

Horizontal deflecting plates or X-plates

These plates are responsible for horizontal motion of electron beam.

In normal mode of CRO, horizontal plates are connected to output signal of sweep generator which is inside the CRO.

For the display of a waveform horizontal plates are given a saw tooth wave which result into continuous motion electron beam from left to right on the screen.



Screen of CRTs

Screen of CRO is made up of optical fibre with special characteristics

When the electron beam strikes the screen of the CRT, a spot of light is produces. The screen material on the inner surface of the CRT that produces this effect is the PHOSPHOR.

The phosphor absorbs the K.E. of the bombarding electrons and reemits energy at a lower frequency in the visual spectrum.

Traces of some element called activator are added to phosphor to increase luminous efficiency, spectral emission and persistence.

Activators in current use are metals such as silver, manganese, copper and chromium.

The intensity of the light emitted from the CRT screen is called Luminance depends upon the following factors.

The light intensity is controlled by the number of bombarding electrons striking the screen per second

And beam current increases luminance also increases

Luminance depends on the energy with which the bombarding electrons strike the screen, and this, in turn, is determined by accelerating potential.

And accel. potential increases luminance also increases

Luminance is function of time the beam strikes a given area of the phosphor; so sweep speed will effect the luminance.

On non – viewing side of screen are thin metal (Aluminium) is deposited to serve the following purposes.

It acts as a heat sink.

It provides conduction part for secondary emitted electron from screen to aquadag.

It reflects that light scattered from screen forwards the viewal.

Aquadag

It is an aqueous solutions of graphite which is used to collect secondary electrons emitted from the screen.

It is connected to second anode, collection of secondary electrons is necessary to keep the CRT screen in a state of electrical equilibrium.

Oscilloscope amplifiers

The purpose of an oscilloscope amplifies is to provide a faithful representation applied to its input terminals, considerable attention has to be paid to the designing of these amplifiers for faithful representation of input signals.

Vertical amplifier
This type of amplifier amplifies the signal to be supplied to vertical deflecting plate.
It determines sensitivity and band width of CRO.

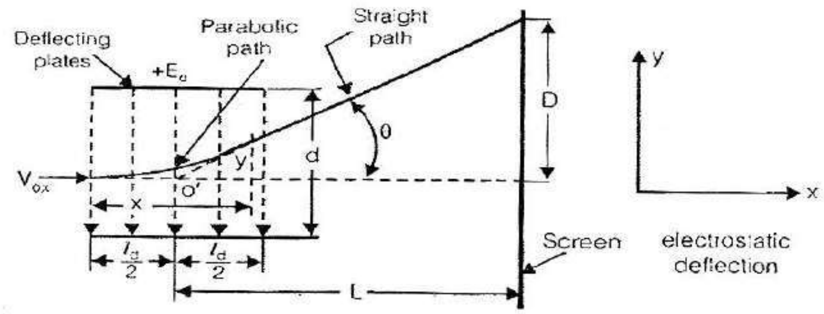
Band width $$B.W = \frac{0.35}{t_r}\ Hz$$

where, t_r = rising time measured in second.

The rise time (t_r) of a pulse is defined as the time required for the edge to rise from 10% to 90% of its maximum amplitude.
The BW (Bandwidth) of an oscilloscope determines the range of frequencies that can be accurately reproduced on the CRT screen.

Horizontal amplifier
This types of amplifiers serves the following two purposes.
In normal mode of CRO it amplifies the output of the sweep generator.
In X-Y mode, it amplifies the signal coming from X-input channel of CRO.

Electrostatic Deflection:
A general arrangement for electrostatic deflection is shown in figure. There are two plates with a potential applied between them.
These plates produce a uniform electrostatic field in the Y direction. Thus any electron entering the field will experience a force in the Y direction and will be accelerated in that direction.
There is no force either in X direction or Z direction and hence there will be no acceleration of electrons in these directions.



Expression of Electrostatic Deflection

Let E_a= voltage of pre – accelerating anode (V),
e= charge of an electron (C)
m=mass of electron (kg)
v_{ox}=velocity of electron when entering the field of deflecting plates (m/s)
E_d=potential between deflecting plates (V)
d=distance between deflecting plates (m),
l_d=length of deflecting plates (m),
L=distance between screen and the centre of the deflecting plates (m),
And D=deflection of electron beam on the screen in Y direction (m)

The loss of potential energy (P.E) when the electron moves from cathode to accelerating anode.

$$P.E = eE_a$$

The gain in kinetic energy (K.E) by an electron,

$$K.E=(1/2)mV_{ox}^2$$

(The mass of an electron is $m=9.109 \times 10^{-31}$kg)

On equating (4.2) and (4.3) we have

$$V_{ox} = \left(2eE_a/m\right)^{1/2}$$

This is the velocity of the electron in the X direction when it enters the deflecting plates.

The velocity in the X direction remains the same throughout the passage of electrons through the deflecting plates as there is no force acting in this direction.

So the electric field intensity in the Y-direction $\varepsilon_y = E_d/d$

Force acting on an electron in Y-direction = $F_y = e\varepsilon_y = eE_d/d$

Suppose a_y is the acceleration of the electron in Y-direction therefore, $F_y = ma_y$

or $$a_y = \frac{e\varepsilon_y}{m}$$

As there is no initial velocity in the Y direction the displacement y at any instant t in the Y direction is:

$$y = \frac{1}{2}a_y t^2 = \frac{1e\varepsilon_y}{2m}t^2$$

As the velocity in X-direction is constant, the displacement in X-direction is given by:

$$x = v_{ox}t$$

$$t = \frac{x}{v_{ox}}$$

Substituting the above value of t in equation we have,

$$y = \frac{1}{2}\frac{e\varepsilon_y}{mv_{ox}^2}x^2$$

Equation represents the equation of a parabola

∴ The slope at any point (x,y) is

$$\frac{dy}{dx} = \frac{e\varepsilon_y}{mv_{ax}^2}x$$

Putting $x = l_d$ in equation we get the value of $\tan\theta$

or $$\frac{dy}{dx} = \tan\theta = \frac{e\varepsilon_y}{mv_{ox}^2}l_d = \frac{eE_d l_d}{mdv_{ox}^2}$$

After leaving the deflection plates, the electrons travel in a straight line. The straight line of travel of electrons is tangent to the parabola at $x = l_d$ and this tangent intersects the X-axis at point O. The location of this point is given by :

$$x = \frac{y}{\tan\theta} = \frac{\dfrac{e\varepsilon_y l_d^2}{2mv_{ox}^2}}{\dfrac{e\varepsilon_y}{mv_{ox}^2}l_d} = \frac{l_d}{2}$$

The apparent origin is thus at the centre of deflection plates. The deflection 'D' on the screen is given by:

$$D = L\tan\theta$$

$$= \frac{LeE_d l_d}{md_{ox}^2}$$

Substituting the value, $V_{ox}^2 = \frac{2eE_a}{m}$ in equation we get,

$$D = \frac{LeE_d l_d}{md} \cdot \frac{m}{2eE_a} = \frac{Ll_d E_d}{2dE_a}$$

From above equation we conclude:

- For a given accelerating voltage E_a, and for particular dimensions of CRT, the deflection of the electron of the electron beam is directly proportional to the deflecting voltage. This means that the CRT may be used as a linear indicating device.
- The discussion above assumes that E_d is a fixed d.c. voltage. The deflection voltage is usually a time varying quantity and the image on the screen thus follows the variations of the deflection voltage in a linear manner.
- The deflection is independent of the e/m ratio. In a cathode ray tube (CRT), in addition to the electrons many types of negative ions such as oxygen, carbon, chlorine etc, are present.
- With electrostatic deflection system, because deflection is independent of e/m, the ions travel with the electrons and are not concentrated at one point. Hence cathode ray tube (CRT) with electrostatic deflection system does not produce an ion burn.

Deflection Sensitivity:

- The deflection sensitivity of a CRT is defined as the deflection of the screen per unit deflection voltage.

∴ Deflection sensitivity (S) $(S) = \frac{D}{E_d} = \frac{L\,l_d}{2dE_a}\ m/V$

The deflection factor (G) of a CRT is defined as the reciprocal of sensitivity,

∴ Deflection factor $(G) = \frac{1}{S} = \frac{2dE_a}{L\,l_d}\ V/m$

It is clear from above equation, that the sensitivity can be increased by decreasing the value of accelerating voltage E_a.

Application of CRO

Measurement of Voltage and Currents

- The electrostatic deflection given in equation shows that the deflection is proportional to the deflection – plate voltage. The value of a current can be obtained by measuring the voltage drop across a known resistance connected in the circuit.

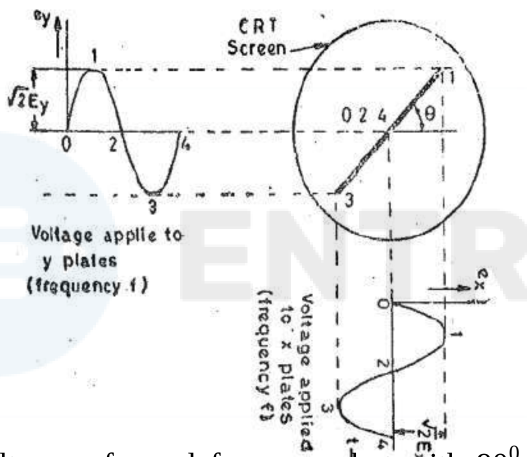
- Direct voltage may be obtained from the static deflection of the spot, alternating voltages from the length of the line produced when the voltage is applied to Y-plates while no voltage is applied to X-plates. The length of this line corresponds to peak to peak voltage.

- When dealing with sinusoidal voltages, the rms value is given by dividing the peak to peak voltage by $2\sqrt{2}$.

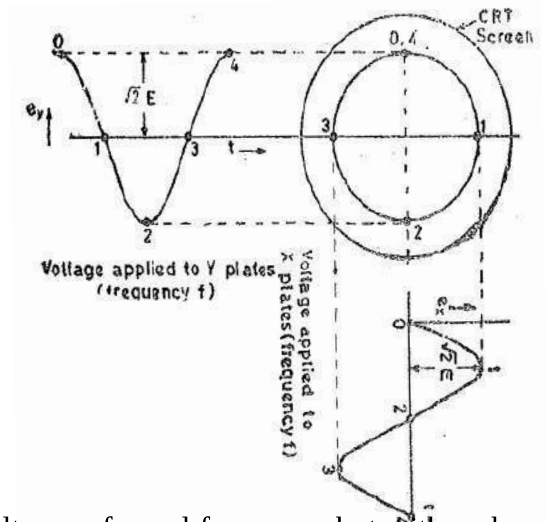
Measurement of Phase

- It is interesting to consider the characteristics of pattern that appear on the screen of a CRT when sinusoidal voltages are simultaneously applied to horizontal and vertical deflection plates. These patterns are called "Lissajous patterns".

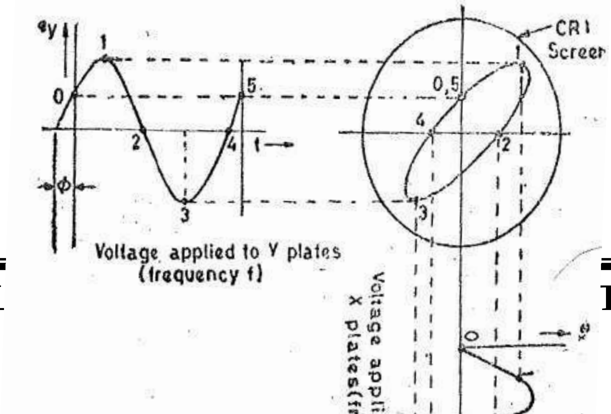
- When two equal voltages of equal frequency which are in phase with each other are applied to the horizontal and vertical deflection plates, the lissajous pattern appearing on the screen is a straight line as is clear in figure below.



When two equal voltages of equal frequency but with 90^0 phase displacement are applied to a CRO the trace or lissajous pattern on the screen is a circle as shown in figure below.



When two equal voltages of equal frequency but with a phase shift φ (not equal to 0^0 or 90^0) are applied to a CRO we obtain an ellipse as shown in figure below.



A number of conclusions can be drawn from the above examples. When two sinusoidal voltages of same frequency are applied.

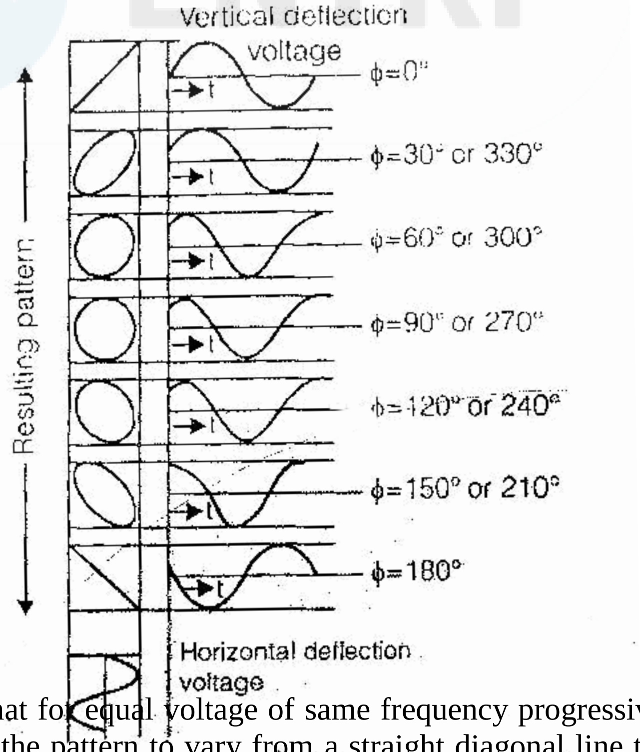
It produces Lissajous pattern, which may be a straight line, a circle or an ellipse depending upon the phase and magnitude of voltages.

A straight line results when the two voltages are equal and are equal and are either in phase with each other or 180^0 out of phase with each other. The angle formed with the horizontal is 45^0. When the magnitudes of voltages are equal.

A circle can be formed only when the magnitude of the two signals are equal and the phase difference between them is either 90^0 or 270^0.

However, if the two voltages are not equal and/ or out of phase an ellipse is formed.

If the vertical Y-plates voltage is larger, an ellipse with vertical major axis is formed while if the X-plate voltage has a greater magnitude, the major axis of the ellipse lies along horizontal axis.



Lissajous patterns with different phase shifts

From figure it is clear that for equal voltage of same frequency progressive variation of phase voltage causes the pattern to vary from a straight diagonal line to ellipse of different eccentricities and then to a circle, after that through another series of ellipses and finally diagonal straight line again.

Measurement of Frequency

Lissagous pattern may be used for accurate measurement of frequency.

Frequency of signal with CRO can be detrmined by operating it in X-Y mode. In this Y-input channel. The frequency of the signal can be given by using following formula.

$$\frac{f_y}{f_x} = \frac{\text{Max. no. of intersection of a horizontal line with lissajous pattern}}{\text{Max. no. of intersection of a vertical line with lissajous pattern}}$$

Where, f_y = unknown frequency

f_x = known frequency

Also,

$$\frac{f_y}{f_x} = \frac{\text{No. of times tangent touches top or bottom}}{\text{No. of times tangent touches either side}}$$

$$\frac{f_y}{f_x} = \frac{\text{No. of horizontal tnagencies}}{\text{No. of vertical tangencies}}$$

Where, f_y = frequency of signal applied to Y-plates

f_x = frequency of signal applied to X-plates.

Dual Trace of CRO

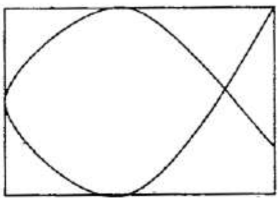
In dual trace CRO, horizontal plates are always connected to output of sweep generator but vertical deflecting plate are connected to z-input terminal will be amplified by horizontal amplifier.

Therefore, single electron beam given traces of 2-separate waveforms connected at input channel.

PREVIOUS QUESTIONS

One Mark Questions

01. A lissajous pattern, as shown in figure below, is observed on the screen of a CRO when voltages of frequencies f_x and f_y are applied to the x and y plates respectively. $f_x : f_y$ is then equal to **(GATE-EE-1994)**



(a) 3 : 2 (b) 1 : 2 (c) 2 : 3 (d) 2 : 1

02. A certain oscilloscope with 4 c.m screen has its own sweep out put fed to its input. If the x and y sensitivities are same, the oscilloscope will display a. **(GATE-EE-1995)**

(a) triangular wave (b) diagonal line

(c) sine wave (d) circle

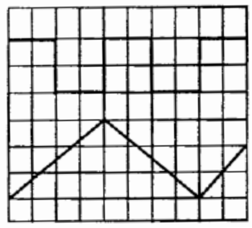
03. Two in phase 50Hz sinusoidal wave form of unit amplitude are fed into channel-1 and channel-2 respectively of and oscilloscope, Assuming that the voltage scale, time scale and other settings are exactly the same for both the channels. What would be observed if the oscilloscope is operated in x-y mode?**(GATE-EE-2002)**

(a) A circle of unit radius (b) An ellipse

(c) A parabola

(d) A straight line inclined at 45^0 with respect to the x-axis.

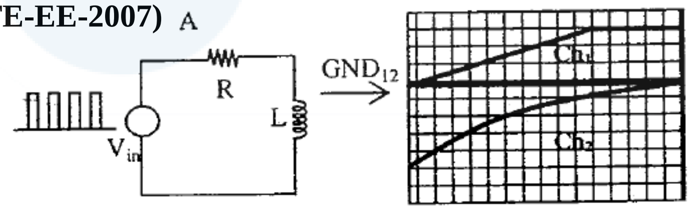
04. The time/div and voltage/div axes of an oscilloscope have been erased. A student connects a 1 KHz, 5V p-p square wave calibration pulse to channel-1 of the scope and observes the screen to be as shown in the upper trace of the fig. An unknown signal is connected to channel-2 (lower trace) of the scope. If the time/div and V/div on both channels are the same, the amplitude (p-p) and period of the unknown signal are respectively **(GATE-EE-2006)**



(a) 5V, 1ms (b) 5V, 2ms (c) 7.5V, 2ms (d) 10V, 1ms

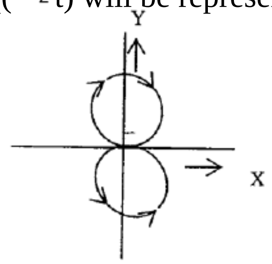
05. The probes of a non-Isolated, two-channel oscilloscope are clipped to points A, B, and C in the circuit of the adjacent fig. V_{in} is a square wave of a suitable low frequency. The display of ch_1 and ch_2 are as shown on the right. Then the "signal" and "Ground" probes S_1, G_1 and S_2, G_2 of ch_1 and ch_2 respectively are connected to points.

(GATE-EE-2007)



(a) A, B, C, A (b) A, B, C, B (c) C, B, A, B (d) B, A, B, C

06. Two Sinusoidal signal $p(\omega_1 t) = A \text{ Sin } \omega t$, and $q(\omega_2 t)$ are applied to X and Y inputs of a dual channel C.R.O, the lissajous figure displayed on the screen is shown below. The signal $q(\omega_2 t)$ will be represented as **(GATE-EE-2008)**



(a) $q(\omega_2 t) = A \sin \omega_2 t$, $w_2 = 2w_1$ (b) $q(\omega_2 t) = A \sin \omega_2 t$, $w_2 = w_1/2$

(c) $q(\omega_2 t) = A \text{ Cos } \omega_2 t$, $w_2 = 2w_1$ (d) $q(\omega_2 t) = A \text{ Cos } \omega_2 t$, $w_2 = w_1/2$

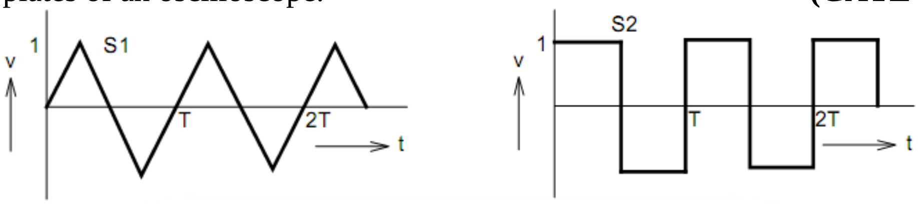
07. The two inputs of a CRO are fed with two stationary periodic signals. In the X-Y mode, the screen shows a figure which changes from ellipse to circle and back to ellipse with its major axis changing orientation slowly and repeatedly. The following inference can be made form this. **(GATE-EE-2009)**

(a) The signals are not sinusoidal
(b) The amplitudes of the signals are very close but not equal
(c) The signals are sinusoidal with their frequencies very close but not equal
(d) There is a constant but small phase difference between the signals.

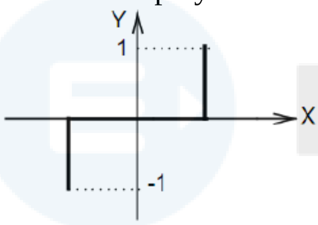
08. In an oscilloscope screen, linear sweep is applied at the **(GATE-EE-2014)**

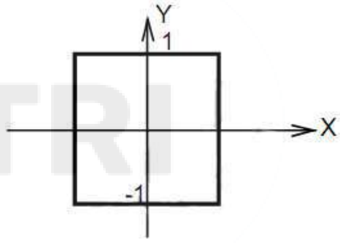
(a) vertical axis (b) horizontal axis
(c) origin (d) both horizontal and vertical axis

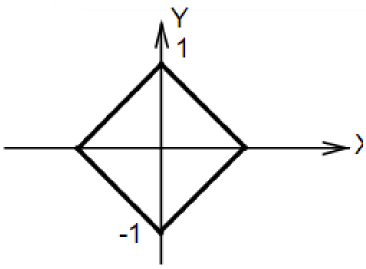
09. The two signals S1 and S2, shown in figure, are applied to Y and X deflection plates of an oscilloscope. **(GATE-EE-2014)**

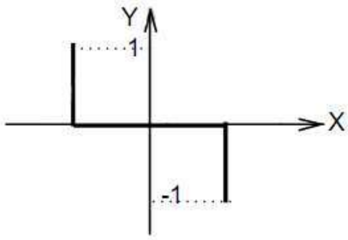


The waveform displayed on the screen is

(a)


(b)


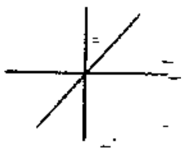
(c)


(d)


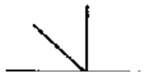
Two Marks Questions

10. List-I represents the figures obtained on a CRO screen when the voltage signals. $V_x = V_{xm} \sin \omega t$ and $V_y = V_{ym} \sin(\omega t + \Phi)$ are given to its X and Y plates respectively and Φ is changed. Choose the correct value of Φ from List-I to match with the corresponding figure of List-II **(GATE-EE-2003)**

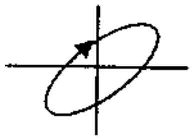
List-I **List-II**

(a) $\Phi = 0$ 1. 

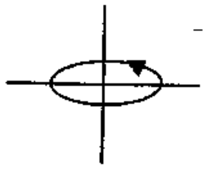
(b) $\Phi = \pi/2$

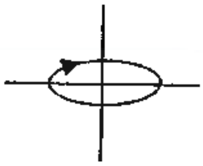
2. 

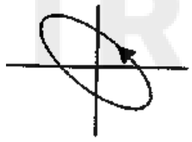
(c) $\pi < \Phi < 3\pi/2$

3. 

(d) $\Phi = 3\pi/2$

4. 

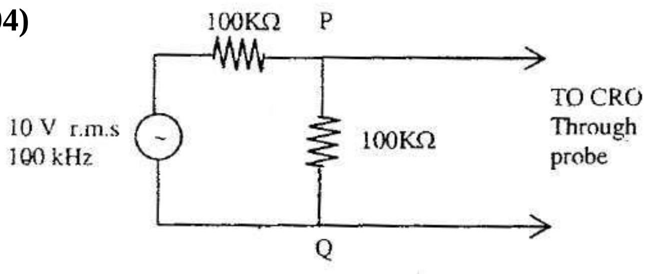
5. 

6. 

Codes :

	A	B	C	D
(a)	1	3	6	5
(b)	2	6	4	5
(c)	2	3	5	4
(d)	1	5	6	4

11. A CRO probe has an impedence of 500kΩ in parallel with a capacitance of 10pF. The probe is used to measure the voltage between P and Q as shown in Fig. The measured voltage will be **(GATE-EE-2004)**



(a) 3.53 V (b) 4.37 V (c) 4.54 V (d) 5.00 V

12. The simultaneous application of signals x(t) and y(t) to the horizontal and vertical plates, respectively, of an oscilloscope, produces a vertical figure-of-8 display. If P and Q are constants, and x(t) = P sin(4t + 30), then y(t) is equal to

(GATE-EE-2005)

(a) Q sin (4t – 30) (b) Q sin (2t + 15)

(c) Q sin (8t + 60) (d) Q sin (4t + 30)

13. In CRT aquadog carries **(IES-EE-1992)**

(a) aqueous solution of graphite (b) sweep voltage

(c) secondary emission electrons (d) none of the above

14. In a dual beam oscilloscope **(IES-EE-1992)**

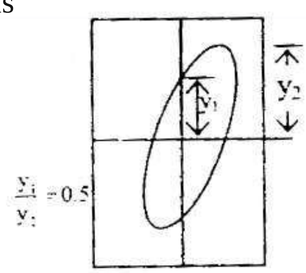
(a) There are two separate vertical input and two separate borizontal inputs

(b) there are two separate vertical inputs and there is only one set of horizontal deflection plates.

(c) there is only one vertical input but there are two separate horizontal deflection plates.

(d) there is only one vertical and one horizontal input.

15. Two sine waves of the same frequency are impressed on the X and Y plates of a CRO and the Lissajous figure seen is shown in the diagram. The phase difference between the signals is **(IES-EE-1993)**



(a) 30^0 or 330^0 or 150^0 or 21^0 (b) 30^0 or 330^0 or 150^0

(c) 30^0 or 33^0 (d) 30^0

16. When the horizontal deflection plates of a CRO are kept at the ground potential and a 30 volt dc is applied to the vertical deflecting plates, the bright spot moves 1 cm away from the centre. If with the same setting, a 30 volt ac is applied to the vertical deflecting plates, then the picture observed on the screen would be

(IES-EE-1993)

(a) a spot approximately 3 cm away from the centre

(b) a vertical line 2 cm long

(c) a vertical line approximately 3 cm long

(d) two spots 2 cm vertically above each other

17. How many time base circuits does a dual trace CRO have ? **(IES-EE-1994)**

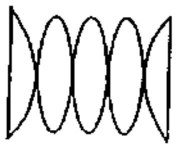
(a) 1 (b) 2 (c) 3 (d) 4

18. A Lizzajous pattern on an oscilloscope has 5 horizontal tangencies and 2 vertical tangencies. The frequency of the horizontal input is 1000 Hz. What is the frequency of the vertical input ? **(IES-EE-1994)**

(a) 400 Hz (b) 2500 Hz (c) 4000 Hz (d) 5000 Hz

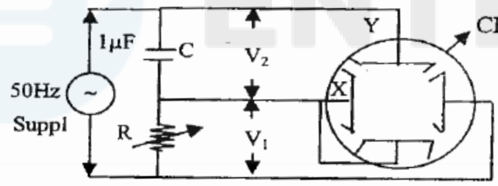
19. The Lissajous pattern obtained on a CRO screen is shown in the given figure:

The frequency ration of the vertical signal to the horizontal one is **(IES-EE-1995)**



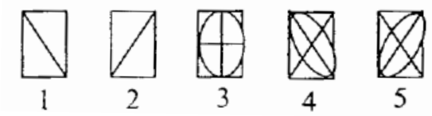
(a) 3 : 2 (b) 5 : 1 (c) 1 : 5 (d) 2 : 3

20. Two voltages V_1 and V_2 are connected to the X and Y plates of a CRO as shown in the gtiven figure. To get a circular pattern on the CRO screen, R should be adjusted to a value of **(IES-EE-1996)**



(a) 1 kΩ (b) 16 kΩ (c) 2.35 kΩ (d) 3.18 kΩ

21. Horizonal deflection in a CRO is due to E sinωt while vertical deflection is due to Esin(ωt+θ) with a positive θ. Consider the following patterns obtained in the CRO **(IES-EE-1997)**



The correct sequence of these patterns in increasing order of the value of θ is :

(a) 3, 2, 5, 1, 4 (b) 3, 2, 4, 5, 1 (c) 2, 3, 5, 1, 4 (d) 2, 3, 5, 4, 1

22. The X-and Y-inputs of a CRO are respectively Vsinωt and -Vsinωt. The resulting Lissajous pattern will be **(IES-EE-1998)**

(a) a straight line (b) a circle

(c) an ellipse (d) a figure of eight

23. **Assertion (A) :** The vertical deflecting plates of a CRT are kept farther away form the screen as compared to the horizontal deflecting plates.

Reason (R) : This improves accuracy in measurement. **(IES-EE-1998)**

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

24. Two equal voltages of same frequency applied to the X and Y plates of a CRO, produce a circle on the screen. The phase difference between the two voltages is **(IES-EE-1999)**

(a) 30^0 (b) 60^0 (c) 90^0 (d) 150^0

25. Match List-I (Type of CRO) with List-II (Appropriate use) and select the correct answer using the codes given below the lists : **(IES-EE-2000)**

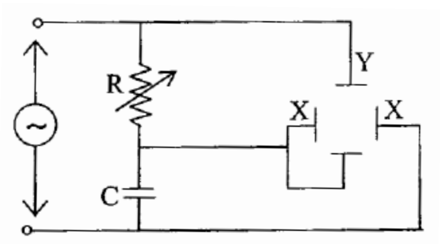
List-I
A. Storage
B. Electrostatic deflection
C. Magnetic deflection
D. Multi trace

List-II
1. Voltage and current transient studies
2. Comparison of waveform in time domain
3. Television receiver
4. Accurage voltage measurements

Codes :

	A	B	C	D
(a)	4	1	2	3
(b)	1	4	2	3
(c)	4	1	3	2
(d)	1	4	3	2

26. In the CRO plate connections shown in the given figure, the supply frequency is 500 Hz and the capacitance 'C' is $\frac{0.2}{\pi}\mu F$. The value of resistance 'R' required to obtain a circule on the CRO screen (X and Y plates have equal sensitivities) is **(IES-EE-2000)**



(a) 2 k Ω (b) 5 k Ω (c) 7 k Ω (d) 10 k Ω

27. Which one of the following statements correctly represents the post acceleration in a Cathode-Ray Tube ? **(IES-EE-2001)**

(a) it provides deflection of the beam

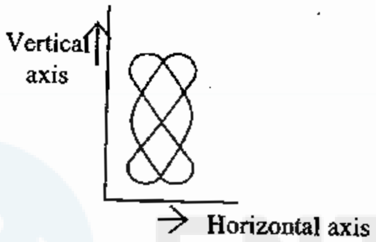
(b) it increases the brightness of the trace if the signal frequency is higher than 10MHz.

(c) it accelerates the beam before deflection

(d) it increases the brightness of the trace of low frequency signal

28. A screen pattern oscillogram, shown in the given figure is obtained when a sine-wave signal of unknown frequency is connected to the vertical input terminals, and at the same time, a 600 Hz sine-wave voltage is connected to the horizontal input terminals of an oscilloscope. What is the value of unknown frequency?

(IES-EE-2002)



(a) 300 Hz (b) 400 Hz (c) 600 Hz (d) 900 Hz

29. Which of the following statements is NOT correct for a storage type oscilloscope? **(IES-EE-2002)**

(a) The storage target is a conductive mesh covered area with magnesium fluoride

(b) Secondary emission electrons fetch a positively charged pattern

(c) The flood guns used for display, emit high velocity electrons

(d) the flood guns are placed between the deflection plates and storage target

30. In an oscilloscope, two Lissajous figure (X) and (Y) are observed. This indicates that ratio of vertical input signal frequency to that horizontal input frequency are

(IES-EE-2002)

Fig. x

Fig. y

(a) 5/3 for X and 3/2 for Y (b) 3/2 for X and 5/3 for Y

(c) 5/3 for X and 5/3 for Y (d) 3/2 for X and 3/2 for Y

31. A C.R.O is operated with X and Y setting of 0.5 ms/cm and 100mV/cm. The screen of the C.R.O is 10cm x 8 cm (X and Y). A sine wave of frequency 200 Hz and r.m.s amplitude of 300 mV is applied to the Y-input. The screen will show

(IES-EE-2003)

(a) one cycle of the undistorted sine wave

(b) Two cycles of the undistorted sine wave

(c) one cycle of the sine wave with clipped amplitude

(d) two cycles of the sine wave with clipped amplitude

32. **Assertion (A) :** Cathode ray oscilloscopes using CRT employing electrostatic deflection are used in laboratories for scientific measurements.
Reason (R) : CRT using electrostatic deflection systems has more deflection sensitivity as compared to CRT employing magnetic deflecting system.
(IES-EE-2004)
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

33. **Assertion (A) :** A dual trace CRO can display two input signals simultaneously
Reason (R) : A dual trance CRO uses a CRT having two electron guns to generate two electron beams simultaneously **(IES-EE-2004)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

34. Which of the following measurements can be made using Lissajous figures ?
1. Frequency
2. phase difference
3. Time interval between pulses
4. pulse width
5. Fundamental and higher harmonic components

Select the correct answer using the code given below **(IES-EE-2005)**
(a) 1 and 2 (b) 2 and 3 (c) 3 and 4 (d) 4 and 5

35. Beam of electrons in a cathode ray tube emanates because of **(IES-EE-2005)**
(a) second emission (b) thermionic emission
(c) diffusion (d) post acceleration

36. One cycle of a square wave signal observed on an oscilloscope is found to occupy 6 cm at a scale setting of 30 μs/cm. What is the signal frequency ?
(IES-EE-2006)
(a) 1.8 kHz (b) 5.55 kKHz (c) 1.8 kHz (d) 55.5 kHz

37. In a CRO astigmatism is : **(IES-EE-2006)**
(a) A source of generating fast electrons
(b) A medium for absorbing secondary emission electrons
(c) An additional focus control
(d) A time-delay control in the vertical deflection system

38. The oscilloscope has an input capacitance of 50pF and a resistance of 2MΩ and the voltage divider ratio (k) of 10. What are the parameters of a high-impedance probe ? **(IES-EE-2009)**

(a) C_1 = 5.55 pF and R_1 = 9 MΩ (b) C_1 = 5.55 pF and R_1 = 18 MΩ

(c) C_1 = 3.33 pF and R_1 = 9 MΩ (d) C_1 = 1.11 pF and R_1 = 18 MΩ

39. If the bandwidth of an oscilloscope is given as direct current to 10MHz, what is the fastest rise time a sine wave can have to be produced accurately by the oscilloscope ? **(IES-EE-2009)**

(a) 35 n sec (b) 10 n sec (c) 3.5 n sec (d) 0.035 n sec

40. **Statement (I) :** The measurement of voltage magnitude by a cathode-ray oscilloscope is very fast as compared to other methods of measurement.

Statement (II) : Cathode-ray beam travels at the speed of light. **(IES-EE-2012)**

41. In a two-channel oscilloscope operating in x-y mode, two in-phase 50 Hz sinusoidal waveforms of equal amplitude are fed to the two channels. What will be the resultant pattern on the screen ? **(IES-EE-2014)**

(a) An ellipse

(b) A parabola

(c) Straight line inclined at 45^0 with respect to x-axis

(d) A circle

42. The functionof input attenuators in measuring instruments, like VTVM and CRO, is to **(IES-EE-2014)**

(a) Increase the input impedance

(b) Attenuate the frequency range

(c) Attenuate the input signal amplitude without altering the frequency contents

(d) Attenuate the input impedance

43. Delay line is essential in a CRO, the ensure that **(IES-EE-2014)**

(a) Vertical signal starts after the retrace period of sweep signal

(b) The sweep reaches the horizontal plates before the desired signal under consideration

(c) Initial part of signal to be observed is not lost

(d) All of the above

2. ELECTRONIC INSTRUMENTS FOR MEASURING BASIC PARAMETERS

Digital Voltmeter (DVMs):

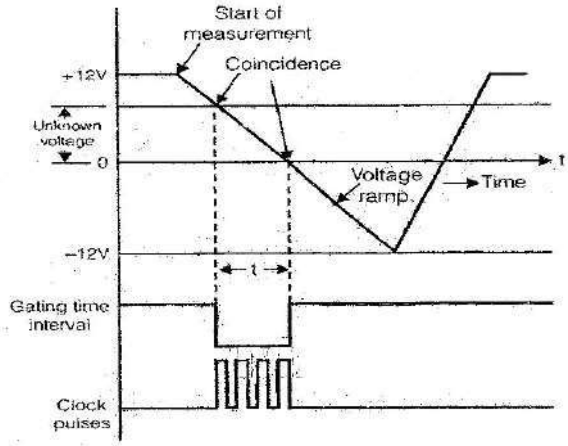
- A digital voltmeter (DVM) displays the value of AC or DC voltge being measured directly as discrete numerals in the decimal number system.
- Numerical readout is advantages in many applications because it reduces human reading and interpolations errors and eliinates parallax errors.
- The used of digital voltmeters increases the speed with which reading can be taken, also the output of digital voltmeters can be fed to memory devices for storage and future computations.
- A digital voltmeter is a versatile and accurate voltmeter which has many laboratory applicators.

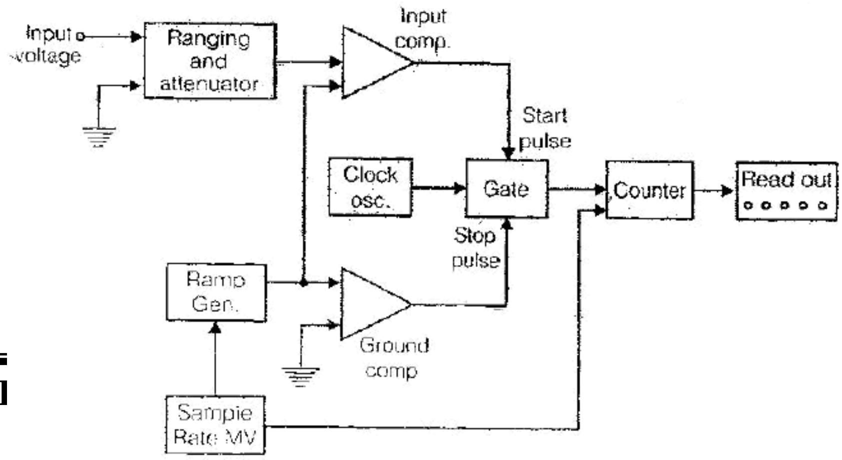
Types of DVMs

- Ramp type DVM
- Integrating type DVM
- Potentiometric type DVM
- Successive approximation type DVM
- Continuous type DVM.

Basic function

- In every case the basic function that is performed, is an analog to digital (A/D) conversion.
  - For example a voltage value may be changed to a proportional time interval, which starts and stops a clock oscillator. In turn the oscillator output is applied to an electronic counter which is provided with a read out in terms of voltage valued.
- **Ramp type digital voltmeter**
  - When an analog voltage of ramp type is applied the ramp type digital voltmeter it measures the time interval with an electronic time interval counter and count is displayed as a number of digits on electronic indicating tubes of the output readout of the voltmeter.
  - The conversion of a voltage value of a time interval is as shown in figure.





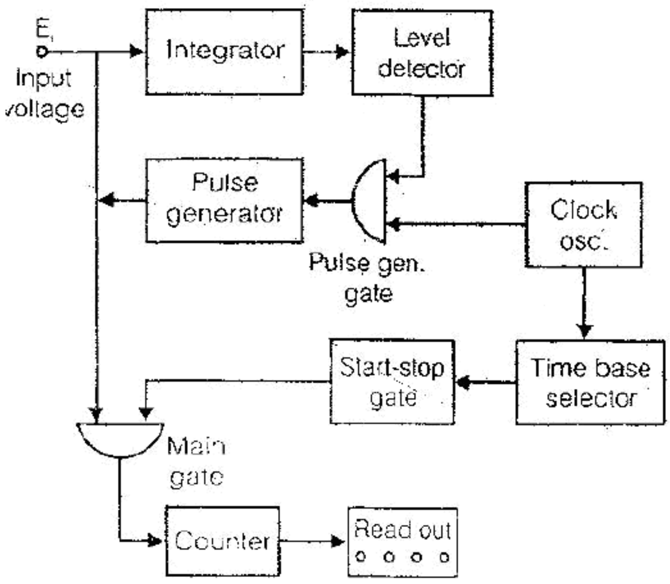
Block diagram of a ramp type DVM

The decimal number as indicated by the readout is a measure of the value of input voltage.
The sample rate multivibrator determines the rate at which the measurement cycles are initiated.
The sample rate circuit provides an initiating pulse for the ramp generator to start its next ramp voltage.
At the same time it sends a pulse to the counter which sets all of them to 0. This momentarily removes the digital display of the readout.

Integrating type DVM:
In this type the voltmeter employs an integration technique which uses a voltage to frequency conversion.
This voltmeter measures the true average value of the input voltage over a fixed measuring period.
The heart of this technique is the operational amplifier acting as an integrator.
Output voltage of integrator is,

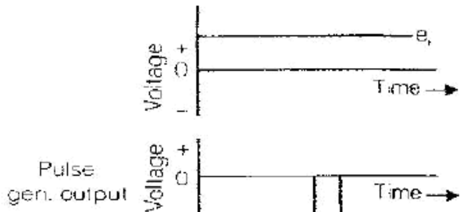
$$E_0 = E_i \frac{1}{R_C} t$$

When E_i, applied voltage (input) and E_0 is the output voltage rises at a uniform rate and has a polarity opposite to that of input voltage.
In other words, it is clear that for a constant input voltage the integrator produces a ramp output voltage of opposite polarity.



Block diagram of integrating type DVM

The output pulse of Level detector opens the pulse generation gate, permitting pulses from a fixed frequency CLOCK OSCILLATOR to pass through pulse generator.



Potentiometric type DVM

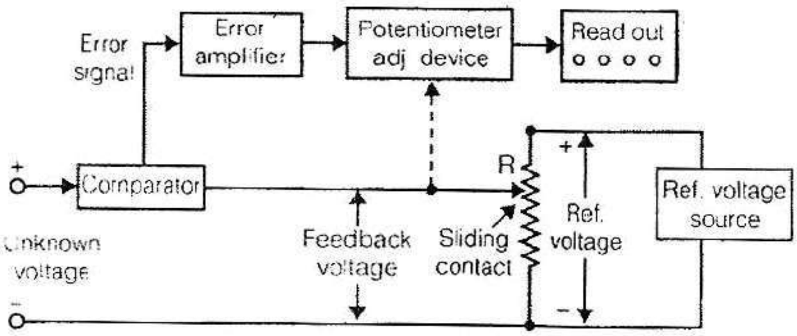
A potentiometric type of DVM, employs voltage comparison technique.

In this DVM the unknown voltage is compared with a reference voltage whose value is fixed by the setting of the calibrated potentiometer.

The potentiometer setting is changed to obtain balance (i.e null conditions). When null conditions are obtained the value of the unknown voltage is indicated by the dial setting of the potentiometer.

The unknown voltge is filtered and attenuated to suitable level and get compare after getting a feedback voltages, we compare these two and the difference is called the error signal.

This error signal is amplified and is fed to a potentiometer adjustment device and there the reading of readout device indicates the value of unknown voltage.



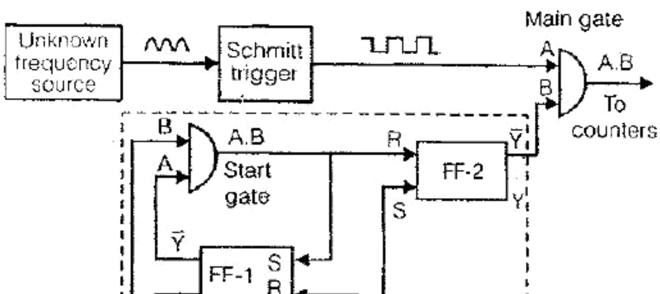
Basic block diagram of a potentiometric DVM

Digital Frequency Meter (DFM):

The signal whose frequency is to be measured is converted into a train of pulses. Then the number of pulses appearing in a definite interval of time is counted by means of an electronic counter.

Since the pulse represents the cycles of unknown signal so it is a direct indication of frequency of unknown signal.

The complete circuit for measurement of frequency is shown in figure below.



Basic Circuit Construction Element
Source of unknown frequency
Amplifier
Schmitt trigger (convert sine wave to train of pulses)
Main gate
Digital counter
Gate control flip flop
Time base selector. (It is used to select the period for which main gate is enabled by flip flop gate control.

Operation

- To enable the main gate of the digital frequency meter, a starting counting signal is given to gate control flip flop. This signal reset the flip flop FF_1 which in turn enables start gate, and disable stop gate.
- When start gate is enable, the pulse coming from time base selector passes throught it. This pulse ressets the flip flpp FF_2 which in turn enables the main gate and thus pulses coming from source of unknown frequency via Schmitt trigger are passed to digital counter.
- The pulse coming from start gate sets flip flo FF_1. Semultaneously when FF_1 is set it disable the start gate and enable the stop gate. Thus pulse coming from base time selector passing through stop gate and sets FF_2 which in terms disables the main gate.
- The period for which main gate remains enable is equal to one time period of clock.
- The frequency of the signal can be obtained by dividing the reading of digital counter by period of clock pulse coming from time base selector.
- The period of clock pulse coming from time base selector can be selected from dial of the selector.

Electronic counters

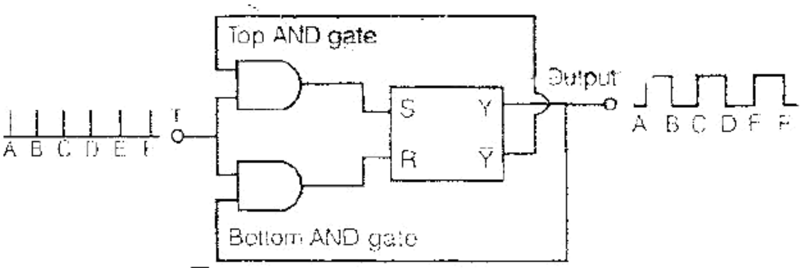
- Electronic counters are capable of making many measurements involving frequency, time, phase angle, radiation events and totalizing electric evetns.
- The electronic counter normally employs a frequency divider circuit known as a scaler
- A scaler produces a single pulse for every set of number of input pulses.

Examples :2:1 scaler produces one output pulse for 2 input pulses.

- A scaler is essentially a frequency divisor.
- The absis of counters is frequency division, this is done by a 2:1 scalar called a bistable multi vibrator or a flip flop (FF) circuit.

Functional view of T and RST Flip flops:

- A train of narrow pulses is applied to the Toggle (T) flip flop input terminal.
- This circuit uses two AND gates and a RS flip flop. Every time a pulse is applied, the output of the flip flop changes state.



- Suppose Y=0 and $\overline{Y}=1$, just before the pulse A is applied to terminal T. On application of this pulse, the inputs to the top AND gate are 1 and 1. Therefore the top gate is enabled (opened).
- A pulse is applied to terminal S. On the other hand the two input to bottom AND gate are 1 and 0 and is thus disabled (closed) and no input is applied to terminal R. This sets the flip flop resulting in $Y=1 \; and \; \overline{Y}=1$
- When the next pulse B is applied to terminal this resets the flip flop resulting in $Y=0 \; and \; \overline{Y}=1$.
- Thus each coming positive pulse is alternately steered into the set and reset inputs and hence the flip flop toggles i.e. alternately sets and resets producing 1 or 0 states at the output.
- Therefore two input pulses produce one output pulse. This means that the frequency of the output is half of that of the input.
- Thus a T flip flop acts as a frequency divisor which divides the input frequency by two.

Digital Instruments

- The analog instruments disaplay the quantity to be measured in terms of the deflection of a pointer but Digital instruments indicate the value of te measured in the form of a digital number.
- The digital meters work on the principle of quantization.

Advantages of digital instruments

- The readings are indicated directly in decimal numbers and therefore errors on account of human factrors, such as errors due to parallax and approximation, are limited.
- The readings may be carried to any significant figures by merely positioning the decimal point, i.e. They have is higher accuracy.
- As compared to analog meter, digital instruments have got a very high resolution/
- Since output is in digital form, it may be directly fed into memory devices like tape recorders, printers, floppy discs and digital computer etc, for storage and future computations.
- Power requirement is les here in comparison to analog instruments.

Resolution in Digital Meters

- The number of digit positions used in a digital meter determines the resolution.
- Thus a 3-digit display voltmeter (DVM0 for a 0-IV range will be able to indicate value from zero to 999 mV , with the smallest increment or resolution of 1 mV.
- In practice a fourth digit, usually capable of indicating 0 or 1 only, is placed to the left of active digits. This permits going above 999-1999 to give an overlap between ranges for convenience.
- This is called over ranging this type of display is known as a $3\frac{1}{2}$ digit display.

$N\frac{1}{2}$ digit resolution

The resolution of a digital meter, is determined by the number of active or full digits used.

Let, N□ represents the number of full digit

$\frac{1}{2} \rightarrow$ hall digit.

Then, $\boxed{\text{Resolution}(R)\frac{1}{10^N}}$

Also $\boxed{\text{Resolution}(R)=\frac{V_{max}}{10^N}}$ in volt

V_{max} = full scale voltage of maximum voltage to display.

Resolution of $N\frac{1}{2}$ display is decided by full digits only.

Half digit of display gives over ranging.

Full digit: It can display any value from 0 to 9

Half digit : It can display only 0 or 1

Loction of decimal point is decided from right side of the display.

e.g. A 4 digit display has

Resolution $= \frac{1}{10^4}$

$= 0.0001 \text{ } or \text{ } 0.01\%$

$\boxed{0-1}\boxed{0-9}\boxed{0-9}\boxed{0-9}$

half digit full digit

Note:

For an 8-digit display, the resolution is 1 in 10^8, while analog meters in general it is only 1 in 500.

Sensitivity of digital meters

Sensitivity is defined as the smallest change in the input which a digital meter is able to detect.

$\boxed{\text{Sensitivity (S)}=(Fs)_{min} \times R}$

Where $(FS)_{min}$ the lowest full scale value of meter and R is the resolution expensed as decimal.

❖ **Electronic Voltmeter (EVM_S):**

- EVMs circuit is used to produce current proportional to the quantity being measured
- Advantages of Electronic voltmeter:
- Detection of low level signals
  For the case of AC measurements the use of an amplifier for detection of low level signals is even more necessary for sensitive measurements.
- Low power consumption
- EVM gives less loading effects
- EVM utilizes the amplifying properties of transistor. While the circuit whose voltage is being measured controls the sensing element of the voltmeter the power drawn from the circuit under measurement is very small or that the voltmeter circuit has a very high input impedance
- This feature of electronic voltmeters is indispensible for voltage measurements in many high impedance circuits such as encountered in communication equipments
- High frequency range
- The most important feature of electronic voltmeters (EVM_S) is that their response can be made practically independent of frequency within extremely wide limits
- Some EVM_S permit the measurement of voltage from direct current to frequencies of the order of 100 MHz.
- The high frequency range may also be attributed to low input capacitance of most electronic device.

PREVIOUS QUESTIONS

One Mark Questions

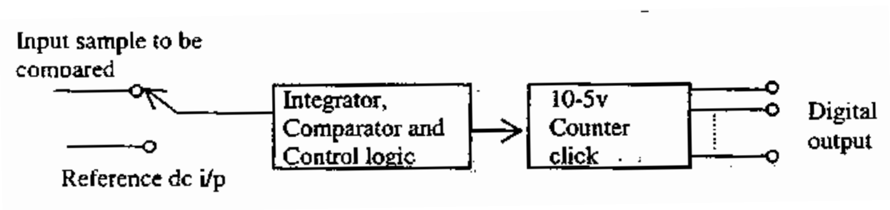
01. A digital-to-analog converter with a full-scale output voltage of 3.5 V has resolution close to 14mV. It's bit size is _____ **(GATE-EE-2005)**
(a) 4 (b) 8 (c) 16 (d) 32

02. Two 8 bit A D C s one of single slope integrating type and other of successive approximation type. Take T_A and T_B times to connect 5v analog input signal to equivalent deigital output. If the input analog signal is reduced to 2.5v, the approximate time taken by the two ADC's will respectively by **(GATE-EE-2008)**

(a) T_A, T_B (b) $T_A/2$, T_B (c) T_A, $T_B/2$ (d) $T_A/2$, $T_B/2$

Two Marks Questions

03. The simplified block diagram of a 10bit A/D Converter of dual slope integrator type is shown in fig. The 10-bit counter at the output is clocked by a 1MHz clock. Assuming negligible timing overhead for the control logic, the maximum frequency of the analog signal that can be converted using this A/D converter is approximately. **(GATE-EE-2003)**



(a) 2KHz (b) 1KHz (c) 500Hz (d) 250Hz

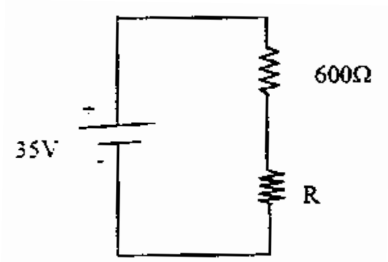
04. A $4\frac{1}{2}$ digit DMM has the error specification as 0.2% of reading +10 counts. If a dc voltage of 100 v is read on its 200v full scale. The maximum error that can be expressed in the reading is _____ **(GATE-EE-2011)**

(a) $\pm$ 0.1% (b) $\pm$ 0.2% (c) $\pm$ 0.3% (d) $\pm$ 0.4%

05. Two voltmeters of 0-300 V range are connected in parallel to a ac circuit. One voltmeter is moving iron type and reads 200 V. If the other instrument is moving coil type, its reading will be **(IES-EE-1992)**

(a) $200\sqrt{3}$ volts (b) 200×1.41 volts
(c) slightly less than meter (d) zero

06. A 35V source is connected to a series circuit of 600 ohm and R as shown. If a voltmeter of internal resistance 1.2 kilo ohms is connected across 600 ohm resistor, it reads 5 V. The value R is **(IES-EE-1992)**



(a) 1.2 kΩ (b) 2.4 kΩ (c) 3.6 kΩ (d) 7.2 kΩ

07. Two meters X and Y required 40 mA and 50 mA respectively for full scale deflection. Then, **(IES-EE-1992)**

(a) X is more sensitive (b) Y is more sensitive
(c) Both are equally sensitive
(d) Not possible to determine from the given data

08. A digital voltmeter has a read-out range from 0 9999 counts. When full reading is 9.999 V, the resolution of the full scale reading is **(IES-EE-1992)**

(a) 0.001 (b) 1000 (c) 3 digit (d) 1 mV

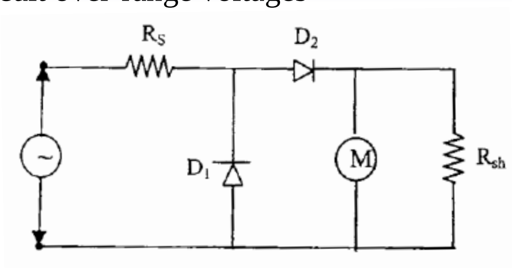
09. The measurement of very low and very high frequencies is invariably done using of frequency counter/timer in the **(IES-EE-1993)**

(a) frequency measurement modfe only
(b) period measurement mode only
(c) frequency and period measurement modes respectively
(d) period and frequency measurement modes respectively

10. A digital voltmeter uses a 10 MHz clock and has a voltage controlled generator which provides a width of 10 μ sec per volt of unit signal. 10 volt of input signal would correspond to a pulse count of **(IES-EE-1993)**
(a) 500 (b) 750 (c) 1000 (d) 1500

11. The A to D converter used in a digital instrument could be **(IES-EE-1993)**
1. successive approximation converter type
2. flash converter type
3. dual slope converter type
The correct sequence of the increasing order of conversion time taken by these type is
(a) 1, 2, 3 (b) 2, 1, 3 (c) 3, 2, 1 (d) 3, 1, 2

12. In the multi meter circuit shown in the figure for ac voltage measurement, the function of diode D1 is to **(IES-EE-1993)**
(a) provide half – wave rectification
(b) make the rectifier D_2 perform full – wave rectification
(c) by-pass reverse leakage current of D_2 in the negative cycle of the input
(d) short circuit over-range voltages

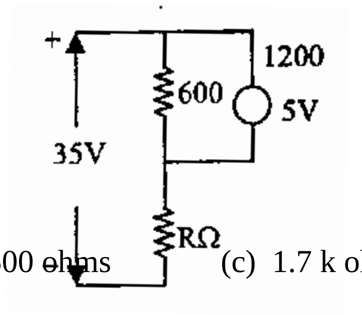


13. A 50 Hz are voltage is measured with a amoving iron voltmeter and a rectifier type ac voltmeter connected in parallel. If the meter readings are V_1 and V_2 respectively and the meters are free from calibration errors, then the form factor of the ac voltage may be estimated as **(IES-EE-1993)**
(a) $\frac{V_1}{V_2}$ (b) $1.11\frac{V_1}{V_2}$ (c) $2\frac{V_1}{V_2}$ (d) $\pi\frac{V_1}{2V_2}$

14. In modern electronic multic meters a FET or MOSFET is preferred over BJT because **(IES-EE-1994)**
(a) its input resistance is high
(b) its input resistance is high and does not vary with the change of range
(c) its input resistance is low (d) it is cheapter

15. A 35 Vdc supply is connected across a combined resistance of 600 ohms and an unknown resistance of R ohms in series. A voltmeter having a resistance of 1.2K

Ω is connected across 600 ohms resistor and reads 5V. The resistance R will be **(IES-EE-1994)**



(a) 120 ohms (b) 500 ohms (c) 1.7 k ohms (d) 2.4 k ohms

16. If two 300 V full-scale voltmeters V_1 and V_2 having sensitivities of 100k Ω/V and 150 k Ω/V are connected in series to measure 500 V, then **(IES-EE-1994)**
 (a) V_1 and V_2 will read 250 V each
 (b) V_1 will read 200 V and V_2 will read 300 V
 (c) V_1 will read 300 V and V_2 will read 200 V
 (d) V_1 and V_2 will read 0 V each
17. The important characteristics of a frequency counter are given below : **(IES-EE-1994)**
 1. Time base accuracy
 2. Least significant Bit count
 3. Gain of the input amplifier

 The more important characteristic (s) responsible for the overall accuracy of frequency measurement using the counter would include
 (a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 2 alone

18. The number of flip flops required in a decade counter is **(IES-EE-1994)**
 (a) 2 (b) 3 (c) 4 (d) 10

19. In a digital voltmeter, the oscillator frequency is 400 KHz, the ramp voltage falls from 8 V to 0 V in 20 m sect.The number of pulse counted by the counter is **(IES-EE-1994)**
 (a) 8000 (b) 4000 (c) 3200 (d) 1600

20. A digital voltmeter has $4\frac{1}{2}$ digit display. The 1 volt range can read up to **(IES-EE-1994)**
 (a) 1.000 (b) 1.1111 (c) 1.9999 (d) 19999

21. In a digital voltmeter, the oscillator frequency is 400 KHz and the ramp voltage falls from 8 V to 0 V in 20 m sec. The number of pulses counted by the counter is **(IES-EE-1995)**
 (a) 800 (b) 2000 (c) 4000 (d) 8000

22. **Assertion (A) :** Dual-slope A/D converter provides high accuracy in A/D conversion approach in digital multi meter.

Reason (R) : Dual-slope A/D converter provides high accuracy in A/D conversion while at the same time suppressing the hum effect on the input signal.

(IES-EE-1995)

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

23. Pulses of a frequency of 1 MHz are applied to the time base selector of a digital frequency meter which consists of 6 frequency dividers, each dividing the incoming frequency by a factor of 10. The time-base setting at the output of 4^{th} frequency divider starting from the input is **(IES-EE-1995)**

(a) 1 ms (b) 10 ms (c) 100 ms (d) 1 s

24. Rectifier Moving Coil Instruments respond to **(IES-EE-1995)**

(a) Peak value, irrespective of the nature of the waveform
(b) average value, for all waveforms
(c) rms value for all waveforms
(d) rms value, for symmetrical square waveforms

25. An average response rectifier type electronic ac voltmeter has a dc voltage of 10 V applied to it. The meter reading will be **(IES-EE-1995)**

(a) 7.1 V (b) 10.0 V (c) 11.1 V (d) 22.2 V

26. An advantage which a VTVM has over a non electronic voltmeter is

(IES-EE-1995)

(a) lower power consumption
(b) Lower input impedance
(c) the ability to measure wider ranges of voltage and resistance
(d) greater portability

27. A permanent magnet moving coil type ammeter and a moving iron type ammeter are connected in series in a resistive circuit fed from output of a half wave rectifier voltage source. If the moving iron type instrument reads 5 A, the permanent magnet moving coil type instrument is likely to read **(IES-EE-1995)**

(a) zero (b) 2.5 A (c) 3.18 A (d) 5 A

28. In a digital voltmeter, 'iver-ranging' implies that **(IES-EE-1996)**

(a) the next four digits are switched on
(b) ½ digit is switched off
(c) ½ digit is switched on

(d) an over – range indicator starts glowing

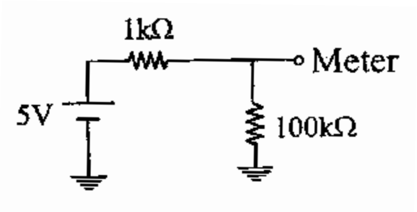
29. Which of the following features determine the precision of an integrating type digital Voltmeter **(IES-EE-1996)**
   (a) Time constant of the integrator
   (b) Input impedance of the integrator
   (c) Referene voltage of the comparator
   (d) Operning taime of the gate before the counter

30. **Assertion (A) :** The resolution of $3\frac{1}{2}$ digit voltmeter is 0.0001.
   Reason (R) : Addition of $\frac{1}{2}$ digit to a digital voltmeter increases the range of the meter **(IES-EE-1997)**
   (a) Both A and R are true and R is the correct explanation of A
   (b) Both A and R are true but R is NOT the correct explanation of A
   (c) A is true but R is false
   (d) A is false but R is true

31. Electronic voltmeter provides are accurate readings in high resistance circuits as compared to a non-electronic voltmeter because of its **(IES-EE-1997)**
   (a) High V/ohm ratings (b) High ohm ratings
   (c) High meter resistance (d) Low resolution

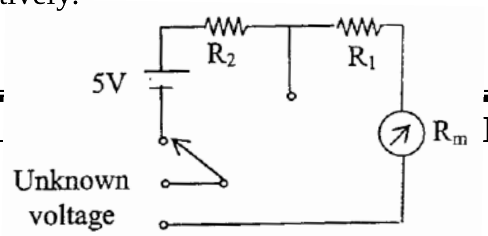
32. Modern electronic multimeters measure resistance by **(IES-EE-1997)**
   (a) Using a bridge circuit
   (b) Using an electronic bridge compensator for nulling
   (c) Forcing a constant current and measuring the voltage across the unknown resistor
   (d) Applying a constant voltage and measuring the current through the unknown resistor.

33. What voltage would a voltmeter with impedance 20,000 Ω and range 0-1V show in the circuit given below ? **(IES-EE-1997)**



   (a) 82 mV (b) 100 mV (c) 118 mV (d) 5 V

34. For the voltmeter circuit shown in the given figure, the basic D' Arsonval meter used has full-scale current of 1 mA and meter resistance (R_m) of 100 ohms. The values of the series resistance R_1 amd R_2 required for 10V range and 50V range will be respectively. **(IES-EE-1997)**



(a) 9.9kΩ and 40kΩ (b) 10kΩ and 50kΩ
(c) 20kΩ and 30kΩ (d) 200kΩ and 250kΩ

35. Which of the following measurement can be made with the help of a frequency counter ? **(IES-EE-1998)**
1. Fundamental frequency of input signal
2. Frequency components of the input signal at least upto third harmonic
3. Time interval between two pulses
4. Pulse width

Select the correct answer using the codes given below :
(a) 1, 3 and 4 (b) 1, 2 and 3 (c) 2 and 4 (d) 1 and 2

36. A high frequency ac signal is applied to a PMMC instrument. If the rms value of the ac signal is 2V, then the reading of the instrument will be **(IES-EE-1998)**
(a) zero (b) 2V (c) $2\sqrt{2}$ V (d) $4\sqrt{2}$ V

37. A current I = (10 + 10 sint) amperes is passed through a ideal iron type ammeter. Its reading will be **(IES-EE-1998)**
(a) 0 A (b) 10 A (c) $\sqrt{150}$ A (d) $10\sqrt{2}$ A

38. A dc electronic voltmeter using chopper stabilization is free from errors due to **(IES-EE-1999)**
(a) low CMMR (b) amplifier drift
(c) source output impedance (d) interference

39. A symmetrical square wave voltage is read on an average response electronic voltmeter whose scale is calibrated in terms of rms value of a sinusoidal wave. The error in the readings is **(IES-EE-1999)**
(a) - 3.9% (b) + 3.9% (c) - 11% (d) + 11%

40. Consider the following A/D converters used commonly in digital instruments : **(IES-EE-1999)**
1. Successive approximation type
2. Flash type
3. Dual slope type

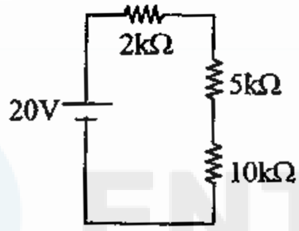
The correct sequence in increasing order of their conversion times is

(a) 1, 2, 3 (b) 2, 3, 1 (c) 2, 1, 3 (d) 3, 1, 2

41. When a current $i(t) = 5 + 10\cos 314t$ is measured by an electro dynamic ammeter, the meter will read **(IES-EE-1999)**

(a) $\sqrt{5^2 + 10^2}$ (b) $\sqrt{5^2 + \left(\frac{10^2}{2}\right)}$ (c) $\sqrt{5^2 + \left(\frac{10}{2}\right)^2}$ (d) $\sqrt{\frac{5^2 + 10^2}{2}}$

42. Consider the network shown in the given figure if a voltmeter of internal resistance 10 kΩ reads V_1 and V_2 respectively when connected across 5 kΩ and 10 kΩ in turn, then **(IES-EE-1999)**



(a) $V_1 > V_2/2$ (b) $V_1 < V_2/2$ (c) $V_1 = V_2/2$ (d) $V_1 = 6.67V$

43. Consider the following statements in respect of thermoelectric instruments :
   1. They indicate the rms value of current or voltage.
   2. They suffer from waveform errors.
   3. They can be used for frequency ranges of the order MHz.
   4. They have a low overload capacity.

   Which of these statements are correct ? **(IES-EE-2000)**

   (a) 1, 3 and 4 (b) 1, 2 and 4 (c) 1, 2 and 3 (d) 2, 3 and 4

44. To eliminate 50Hz pick-up in a dual slope DVM, the minimum period of integration of the input signal is **(IES-EE-2000)**

(a) 1 ms (b) 20 ms (c) 1 s (d) 100 s

45. Which one of the following sets of building block mainly decides the accuracy of a frequency counter ? **(IES-EE-2000)**

(a) Crystal and ADC (b) ADC and DAC
(c) DAC and gate width generator (d) Gate width generator and crystal

46. A dc circuit can be represented by an internal voltage source of 50V with an output resistance of 100 kΩ. In order to achieve accuracy better than 99% for voltage measurement across its terminals, the voltage measuring device should have a resistance of at least **(IES-EE-2001)**

(a) 10MΩ (b) 1MΩ (c) 10kΩ (d) 1kΩ

47. Which of the following are the characteristics of a thermocouple type of indicating instrument ? **(IES-EE-2001)**

1. Its accuracy is very high, as high as about 1 percent.
2. It has a linear scale because a d'Arsonval movement is used for measuring the output.
3. It is an RF instrument and can be used for frequency up to about 50 MHz.
4. It cannot be damaged by overloads.

(a) 1 and 2 (b) 2 and 3 (c) 3 and 4 (d) 1 and 3

48. An ac voltmeter using full-wave rectification and having a sinusoidal input has an ac sensitivity equal to **(IES-EE-2001)**

(a) 1.414 times dc sensitivity (b) dc sensitivity
(c) 0.90 times dc sensitivity (d) 0.707 timnes dc sensitivity

49. The circuit generally used in digital instruments to convert sine waves into rectangular pulses is a **(IES-EE-2001)**

(a) saw tooth amplifier (b) differential amplifier
(c) sample and hold circuit (d) Schmitt trigger

50. **Assertion (A) :** A full-wave rectifier type a.c. voltmeter reads the true rms value of the input waveform.

Reason (R) : The full wave rectifier type a.c. voltmeter has a rectifier unit first which feed its output to the PMMC indicative instrument **(IES-EE-2002)**

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

51. Consider the following statements about the D' Arsonval Movement:

1. It is best suited for d.c. current measurement
2. It responds to the average value of current
3. It measures the r.m.s value of a.c. currents
4. It could be used for power measurement

Which of these statements is/are correct? **(IES-EE-2002)**

(a) Only 1 (b) 1 and 2 (c) 2 and 3 (d) 1, 2, 3 and 4

52. Two meters X and Y require 40mA and 50mA, respectively, to give full-scale deflection, then **(IES-EE-2002)**

(a) Sensitivity can not be judged with given information
(b) Both are equally sensitive
(c) X is more sensitive

(d) Y is more sensitive

53. Three d.c. voltmeters are connected in series across a 120 V dc supply. The voltmeters are specified as follows: **(IES-EE-2003)**

Voltmeter A : 100V, 5mA

Voltmeter B : 100V, 250ohms/V

Voltmeter C : 10mA, 15,000 ohms

The voltages read by the meters A, B and C are respectively

(a) 40, 50 and 30 V (b) 40, 40 and 40 V

(c) 60, 30 and 30 V (d) 30, 60 and 30 V

54. Which one of the following multi-range voltmeters has high and constant input impedance ? **(IES-EE-2003)**

(a) Permanent magent moving coil voltmeter

(b) Electronic voltmeter

(c) Moving iron voltmeter

(d) Dynamometer type voltmeter

55. A multimeter is used for the measurement of the following

1. Both a.c. and d.c. voltage
2. Both a.c. & d.c. current
3. Resistance
4. Frequency
5. Power

Select the correct answer using the codes given below : **(IES-EE-2003)**

(a) 1, 2 and 4 (b) 1, 2 and 5 (c) 1, 3 and 5 (d) 1, 2 and 3

56. Which of the following are data representation elements in a generalized measurement system ?

1. Analog indicator
2. Amplifier
3. A/D converter
4. Digital display

Select the correct answer using the codes given below **(IES-EE-2003)**

(a) 1 & 2 (b) 1 & 4 (c) 2 & 4 (d) 3 & 4

57. Integrating principle in the digital measurement is the conversion of **(IES-EE-2003)**

(a) Voltage to time (b) Voltaghe to frequency

(c) Voltage to current (d) Current to voltage

58. Which of the following are data representation elements in a generalized measurement system ? **(IES-EE-2003)**

1. Analog indicator
2. Amplifier
3. A/D converter
4. Digital display

Select the correct answer using the codes given below

(a) 1 and 2 (b) 1 and 4 (c) 2 and 4 (d) 3 and 4

59. Which one of the following decides the precision of integrating digital voltmeter ?

(IES-EE-2004)

(a) Reference voltage of analog comparator
(b) Slope of the generated ramp
(c) Width of the generated pulses
(d) Electronic counter

60. Which one of the following is basically a current sensitive instrument ?

(IES-EE-2004)

(a) Permanent magnet moving coil instrument
(b) Cathode ray oscilloscope
(c) Electrostatic instrument
(d) FET input electronic voltmeter

61. Which one of the following types of instruments can be used to determine the r.m.s value of a.c. voltage of high magnitude (10 kV) and of any wave shape ?

(IES-EE-2004)

(a) Moving iron instruments (b) Dynamometer type instruments
(c) Induction instruments (d) Electrostatic instruments

62. Match List-I with List-II and select the correct answer using the codes given below the lists : **(IES-EE-2004)**

List-I

A. Dynamometer instrument
B. Thermocouple based instrument
C. Ramp generator
D. Weston standard cell

List-II

1. True r.m.s valuemeter
2. Transfer instrument between a.c and dc
3. time base of CRO
4. Standard of electromotive force (Emf)

Codes :

	A	B	C	D
(a)	4	1	3	2
(b)	4	3	1	2
(c)	2	1	3	4
(d)	2	3	1	4

63. Which one of the following statements I correct? An electronic voltmeter is more reliable as compared to multi meter for measuring voltage across low impedance because **(IES-EE-2004)**

(a) its sensitivity is high

(b) it offers high input impedance

(c) it does not alter the measured voltage

(d) its ensitivity, and input impedance are high and do not alter the measured value.

64. **Assertion (A) :** An electronic voltmeter measures the voltage across a high resistance more accurately as compared to an ordinary multimeter.

Reason (R) : The electronic voltmeter consists of a voltage amplifier which is not present in an ordinary multi meter. **(IES-EE-2004)**

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

65. Which one of the following statements is correct? **(IES-EE-2004)**

The deflection of hot wire instrument depends on

(a) r.m.s value of the a.c. current (b) r.m.s value of the a.c. voltage

(c) average value of the a.c. current (d) average value of the a.c. voltage

66. A d'Arsonval movement with internal resistance R = 100 Ω and full scale current of 1mA is to be converted into (0 – 10)V range. What is the required resistance? **(IES-EE-2004)**

(a) 10 KΩ (b) 10100Ω (c) 9900 Ω (d) 12000 Ω

67. In modern electronic multi meter a FET or MOSFET is preferred over BJT because **(IES-EE-2005)**

(a) its input resistance is low (b) its input resistance is high

(c) its input resistance is high and does not vary with the change or range

(d) it is cheapter

68. Match List-I (type of Electronic voltmeter) with List-II (major characteristic) and select the correct answer using the codes given below the lists : **(IES-EE-2005)**

List-I

A. Amplifier – rectifier B. Rectifier - amplifier

C. True R.M.S D. Logarithmic

List-II

1. wide input-signal dynamic range
2. High sensitivity, limited bandwidth
3. Limited sensivity, large bandwidth
4. Capability to read non-sinusoidal ac

Codes :

A B C D

(a)	4	1	2	3
(b)	2	3	4	1
(c)	4	3	2	1
(d)	2	1	4	3

69. Match List-I (Specifications of Voltages to be measured) with List-II (Type of Most suitable instruments) and select the correct answer using the codes given below the lists : **(IES-EE-2005)**

List-I

A. 0-10 mV form a source of internal resistance of 1MΩ

B. Thermo-emf ranging up to 5mV – from a thermocouple

C. Supply voltage of 230 V, 50 Hz

D. R.M.S value of a voltage containing DC and ripples of 50 Hz and harmonic

List-II

1. Thermal
2. Moving Iron
3. Permanent magnetic moving coil
4. Electronic
5. Ballistic galvanometer

Codes :

	A	B	C	D
(a)	2	3	5	1
(b)	4	1	2	3
(c)	2	1	5	3
(d)	4	3	2	1

70. Chopper stabilized d.c. amplifier type electronic voltmeter overcomes the effect of **(IES-EE-2005)**

(a) Amplifier CMRR
(b) Amplifier sensitivity
(c) Amplifier drift
(d) Electromagnetic interference

71. The reference voltage and the input voltage are sequentially connected to the integrator with the help of a switch in a **(IES-EE-2005)**

(a) Successive approximation A/D converter
(b) Dual slope integration A/D converter
(c) Voltage to time converter
(d) Voltage to frequency converter

72. Match List-I (Type of DVM) with List-II (Sub-component in ADC) and select the correct answer using the codes given below the lists : **(IES-EE-2005)**

List-I	**List-II**
A. Ramp type	1. DAC
B. Dual slope	2. Voltage to time Converter
C. Servo-type	3. Pulse-generator
D. Successive approximation	4. Potentiometer
	5. Capacitor

Codes :

	A	B	C	D
(a)	2	1	4	5
(b)	4	5	3	1
(c)	2	5	4	1
(d)	4	1	3	5

73. Which one of the following digital voltmeter is most suitable to eliminate the effect of period noise ? **(IES-EE-2005)**
(a) Ramp type digital voltmeter
(b) Integrating type digital voltmeter
(c) Succesive approximation type digital voltmeter
(d) Servo type digital voltmeter

74. Consider the following statements : **(IES-EE-2005)**
1. Buffer
2. Differentiator
3. Integrator
4. Comparator

Which of the above is/are components in a dual slope integrating type voltmeter?
(a) 1, 3 and 4 (b) 1 and 2 (c) 3 and 4 (d) 2 only

75. What is the range for a $3\frac{1}{2}$ digital meter ? **(IES-EE-2006)**
(a) 0 to 1999 (b) 0 to 1500 (c) 0 to 999 (d) 0 to 19999

76. Principle of Hall effect is used in the construction of which one of the following? **(IES-EE-2006)**
(a) Ammeter (b) Voltmeter (c) Galvanometer (d) Gauss meter

77. A rectifier instrument is used to measure an alternating square wave, of amplitude 100 V. What is the meter reading ? **(IES-EE-2006)**
(a) 100 V (b) 70.7 V (c) 111 V (d) none of the above

78. Which of the following indicating instruments has/have linear scale ?
1. Moving – iron meter
2. Permanent magnet moving – coil meter
3. Thermocouple meter
4. Rectifier type meter

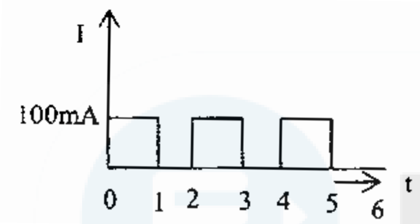
Select the correct answer using the code given below : **(IES-EE-2006)**
(a) only 1 and 2 (b) only 2 and
(c) only 3 and 4 (d) only 2

79. A sinusoidal voltage of 1 V r.m.s value at 10Hz is applied across the two terminals of a PMMC type of voltmeter. What is the deflectin of the pinter ? **(IES-EE-2006)**

(a) Zero volt (b) 1 volt (c) 2 volt
(d) The pointer oscillates around zero volt

80. A moving coil instrument gives full – scale deflection for 1 mA and has a resistance of 5 Ω is connected in parallel to the instrument, what is the maximum value of current it can measure. **(IES-EE-2006)**
(a) 5mA (b) 10mA (c) 50mA (d) 100mA

81. What is the series resistance required to extend the 0-100V range of a 20000 Ω /V meter to 0-1000 V ? **(IES-EE-2006)**
(a) 10MΩ (b) 16MΩ (c) 18MΩ (d) 20MΩ

82.


A waveform shown in the figure above, is fed to a d.c. ammeter. What is the reading shown by the meter ? **(IES-EE-2008)**

(a) Zero (b) 50mA (c) 75mA (d) 100mA

83. The principle of Hall effect is made use of in the construction of which one of the following ? **(IES-EE-2008)**
(a) Ammeter (b) Voltmeter (c) Gauss meter (d) Galvanometer

84. **Assertion (A) :** A PMMC instrument is used for reading both d.c. and a.c. signals
Reason (R) : The deflecting torque in a PMMC instrument is directly proportional to the current in the moving coil **(IES-EE-2008)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

85. How can a milli-ammeter be used as a voltmeter ? **(IES-EE-2008)**
(a) By connecting a low resistance in parallel with the instrument
(b) By connecting a high resistance in parallel with the instrument
(c) By connecting a low resistance in series with the instrument
(d) By connecting a high resistance in series with the instrument

86. A D'Arsonval galvanometer, 1 mA, 50 ohm is to be converted ot a 5 Amp-ammeter. What is the value of the shunt resistor, R_{sh}? **(IES-EE-2009)**

(a) 10 ohm (b) 1 ohm (c) 0.01 ohm (d) 100 ohm

87. Which amplifier is used in an electronic multimeter ? **(IES-EE-2008)**

(a) Power amplifier (b) buffer amplifier

(c) Differential amplifier (d) wideband amplifier

88. A 100 KV, 50 Hz supply is fed to a rectifier ammeter (using a bridge rectifier) though a capacitor. The PMMC ammeter of the rectifier instrument reads 45×10^{-3} Amp. What is the value of the capacitor ? **(IES-EE-2009)**

(a) 15.90×10^{-10} F (b) 15.90×10^{-12} F

(c) 17.66×10^{-9} F (d) 17.66×10^{-11} F

89. **Assertion (A) :** An electronic millivoltmeter used to read very low a.c voltage at high frequencies is an amplifier-rectifier type of meter

Reason (R) : The diodes cannot rectify low a.c. voltages of millivolt order.

(IES-EE-2009)

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

90. **Assertion (A) :** To increase the range of an ammeter to measure high currents, it is required to connect a high resistor in shunt across the ammeter.

Reason (R) : The shunt resistor will divert the excess current an allow nly the rated current to pass through the deflecting system of the ammeter

(IES-EE-2009)

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

91. **Assertion (A) :** The sensitivity of a voltmeter is often expressed in terms of ohms-per volt.

Reason (R) : High sensitivity voltmeters use a basic d'Arsonval meter which has high sensitivity **(IES-EE-2009)**

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

92. In a digital voltmeter, the oscillator frequency is 400 kHz. The ramp voltage falls from 8V to 0V in 20 ms. What is the number of pulses counted by the counter ?

(IES-EE-2009)

(a) 8000 (b) 4000 (c) 3200 (d) 1600

93. Consider the following statements :

The A to converter used in a digital instrument could be

1. Successive approximation converter type
2. Flash converter type
3. Dual slope converter type

The correct sequence in the increasing order of the conversion time taken by these type is **(IES-EE-2010)**

(a) 1, 2 and 3 (b) 2, 1 and 3 (c) 1, 3 and 2 (d) 2, 3 and 1

94. Consider the following statements :

1. The main drawback of digital system is that the real wold is mainly analog
2. The major advantage of digital instruments over analog instruments is higher accuracy and better resolution.
3. Digital instruments are ordinarily used for the measurement of both analog and digital quantities.

Which of the above statements is/are correct ? **(IES-EE-2010)**

(a) 1, 2, 3 and 4 (b) 1 and 3 only

(c) 2 only (d) 1 and 2 only

95. A 4-digit DVM (digital voltmeter) with a 100mV lowest full-scale range would have a sensitivity of how much value while resolution of this DVM is 0.0001?

(IES-EE-2010)

(a) 0.1 mV (b) 0.01 mV (c) 1.0 mV (d) 10 mV

96. The precision of a ramp type digital voltmeter depends on **(IES-EE-2010)**

(a) frequency of the generator and slope of the ramp

(b) frequency of the generator

(c) slope of the ramp

(d) switching time of the gate

97. A 1 mA meter movement with an internal resistance of 100 Ω is to be converted into (0 – 100) mA. To achieve this, value of shunt resistance R_{sh} is given by

(IES-EE-2010)

(a) 1 kΩ (b) 200 Ω (c) 1.01 Ω (d) 1.01 kΩ

98. The value of a shunt resistance required to convert an ammeter of 1mA with 100 Ω omterma; resostamces omtp (0-100) mA ammeter is **(IES-EE-2010)**

(a) 22 Ω (b) 1.01 Ω (c) 1.2 Ω (d) 1.1Ω

99. A moving coil ammeter having a resistance of 1 ohm gives full scale deflection when a current of 10mA is passed through it. The instrument can be used for the measurement of voltage up to 10V by **(IES-EE-2010)**
   (a) connecting a resistance of 999 ohm in series with the instrument
   (b) connecting a resistance of 999 ohm parallel to the ammeter
   (c) connecting a resistance of 999 ohm parallel to the load
   (d) connecting a resistance of 1000 ohm in series with the load

100. The value of the multiplier resistance for a dc voltmeter, having 50V range with 5 kΩ /V sensitivity, employing a 200 μA meter movement and having internal resistance of 100Ω , is given by **(IES-EE-2010)**
   (a) 249.9 kΩ (b) 200 kΩ (c) 200 kΩ (d) 2.5 kΩ

101. A basic D'Arsonval movement with a full scale deflection of 50 μA and internal resistance of 500Ω is used as voltmeter. The value of the multiplier resistance needed to employ this meter to measure a voltage range of (0-10)V is given by **(IES-EE-2010)**
   (a) 100 kΩ (b) 500 kΩ (c) 199.5 kΩ (d) 2×10^5 kΩ

102. The sensitivity of 200 μA meter movement when it is used as a dc voltmeter is given by **(IES-EE-2010)**
   (a) 500 Ω /mV (b) 5Ω /V (c) 0.5Ω /mV (d) 5Ω /mV

103. If a high frequency AC signal, whose r.m.s. value is $\sqrt{2}$ V, is applied to a PMMC instrument, then the reading of the instrument will be **(IES-EE-2010)**
   (a) 2 V (b) $\sqrt{2}$ V (c) 1 V (d) zero

104. **Assertion (A) :** A thermocouple type of indicating instrument measures the true rms value of the current that passes through it.
   Reason (R) : It uses a PMMC type of indicating instrument to measure the current **(IES-EE-2010)**
   (a) Both A and R are true and R is the correct explanation of A
   (b) Both A and R are true but R is NOT the correct explanation of A
   (c) A is true but R is false
   (d) A is false but R is true

105. **Statement (I) :** A hot-wire instrument gives the r.m.s value of the current measured.
   Statement (II) : The heat generated is dependent on the average value of the current **(IES-EE-2012)**

106. A shunt resistance of 25 Ω is required for extending the range of an ammeter from 100 μA to 500 μA. The value of internal resistance of this ammeter will be **(IES-EE-2012)**

(a) 25 Ω (b) 50 Ω (c) 100 Ω (d) 1000 Ω

107. By mistake, an ammeter is used as a voltmeter. In all probabilities, it will **(IES-EE-2012)**

(a) give much higher reading (b) give extremely low reading
(c) indicate no reading at all (d) get damaged

108. A 50 μA meter with an internal resistance of 1 kΩ is to be used as a DC voltmeter of range 50V. Then the voltage multiplying factor m is **(IES-EE-2012)**

(a) 100 (b) 10 (c) 1000 (d) 10000

109. The value of resistance R_s to be added in series with an ammeter whose full-scale deflection is of 0.1 mA and internal resistance is of 500 Ω, to make it suitable to measure (0-10) V is **(IES-EE-2012)**

(a) 0.02 kΩ (b) 99.5 kΩ (c) 500.02 Ω (d) 499.98 Ω

110. An electronic voltmeter gives more accurate readings in high resistance circuits as compared to a non-electronic voltmeter because of its **(IES-EE-2012)**

(a) low meter resistance (b) high kΩ/V rating
(c) high V/kΩ rating (d) high resolution

111. Modern electronic multimeters measure resistance by **(IES-EE-2012)**

(a) taking advantage of an electronic bridge compensator for nulling
(b) forcing a constant current and measuring the voltage across unknown resistance
(c) using a bridge circuit
(d) applying a constant voltage across the unknown resistance and measuring the current through it.

112. **Statement (I) :** An electronic voltmeter measures the voltage across high-value resistor more accurately ad compared with an ordinary multimeter.

Reason (R) : The input impedance of many orders of magnitude higher then that of an ordinary multimeter. **(IES-EE-2012)**

113. A frequency counter can be used for the measurement of **(IES-EE-2012)**

1. fundamental frequency of input signal
2. time interval between two pulses

Which of these is/are correct?

(a) 1 only (b) 2 only (c) Neither 1 nor 2 (d) Both 1 and 2

114. In a digital voltmeter, the oscillator frequency is 400 kHz. A ramp voltage to be measured by this voltmeter falls from 8 V to 0 V in 20 ms. The number of pulses counted by the counter is **(IES-EE-2013)**

(a) 8000 (b) 4000 (c) 3200 (d) 1600

115. While using a frequency counter for measuring frequency, two modes of measurement are possible. (i) Period mode (ii) Frequency mode. There is a 'cross-over frequency' below which the period mode is preferred. Assuming the crystal oscillator frequency to be 4 MHZ the corss-over frequency is given by **(IES-EE-2013)**

(a) 8 MHz (b) 2 MHz (c) 2 kHz (d) 1 kHz

116. An 8-bit successive approximation DVM of 5V range is used to measure 1.2 v. the contents of the SAR after 5 clock pulses is **(IES-EE-2013)**

(a) 01010000 (b) 00111100 (c) 00111000 (d) 00110111

117. A frequency counter needs to measure a frequency of 15 Hz. Its signal gating time is 2s. What is the percentage accuracy of the counter, taking into account the gating error ? **(IES-EE-2013)**

(a) 3.33% (b) 13.33% (c) 98.67% (d) 96.67%

118. The number of bits of A/D converter required to convert an analog input in the range of 0-5 volt to an accuracy of 10mV is **(IES-EE-2013)**

(a) 8 (b) 9 (c) 10 (d) 16

119. A current i = 5 + 14.14 sin(314t + 45^0) is passed through a centre-zero PMMC, hot-wire, and moving-iron instrument, the respective readings are **(IES-EE-2013)**

(a) -5, 15 and $\sqrt{125}$ (b) 5, $\sqrt{125}$ and $\sqrt{125}$

(c) -5, $\sqrt{125}$ and 19.14 (d) 5, 10 and 10

120. Which of the following instrument will be used to measure a small current of very high frequency ? **(IES-EE-2013)**

(a) Electrodynamic ammeter (b) Moving coil galvanometer

(c) Thermocouple type instrument (d) Induction type instrument

121. A 0.5 Ω resistance is required to be connected in parallel to a moving coil instrument whose full scale deflection is 1 mA; so that this instrument can measure 10 mA current. Internal resistance of this instrument is **(IES-EE-2013)**

(a) 5.0 Ω (b) 4.5 Ω (c) 2.25 Ω (d) 0.45

122. An 1-m Amp, 50 Ω Galvanometer is required to measure 5 Amp (full scale). Find out the value of resistance to be added, across (shunt) the Galvanometer to accomplish this measurement. **(IES-EE-2013)**

(a) 10 Ω (b) 0.01 Ω (c) 1.0 Ω (d) 0.001 Ω

123. To minimize voltmeter loading **(IES-EE-2013)**

(a) Voltmeter operating current has to be very small
(b) Voltmeter operating current has to be very high
(c) resistance connected in series with the coil should be low
(d) resistance connected in parallel with the coil should be high.

124. Electronic voltmeters which use rectifiers employ negative feedback. This is done **(IES-EE-2013)**

(a) to increase the overall gain
(b) to improve the stability
(c) to overcome the non-linearity of diodes
(d) to increase the bandwidth

125. Electrostatic voltmeters are particularly suitable for measuring high voltages because the construction is simplified due to **(IES-EE-2014)**

(a) Large electrostatic forces (b) Small electrostatic forces
(c) Large value of current (d) Small value of current

126. A DVM uses 10 MHz clock and has a voltage controlled generator which provides a width of 5 μs/volt of unit signal. 10 V input signal would correspond to a pulse count of **(IES-EE-2014)**

(a) 500 (b) 750 (c) 250 (d) 1000

3. FREQUENCY METERS & POWER FACTOR METERS

Frequency Meters

The different types of frequency meters are:

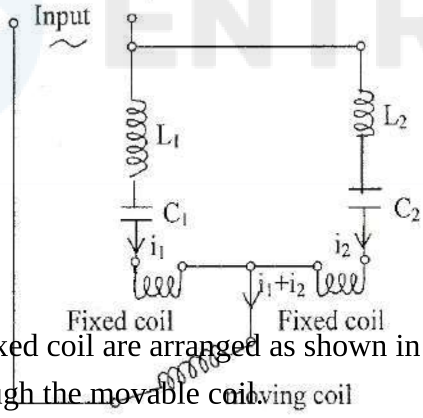
1. Mechanical Resonance type.
2. Electrical Resonance type
3. Electrodynamometer type
4. Weston type
5. Ratio meter type
6. Saturable core type

1. MECHANICAL RESONANCE TYPE FREQUENCY METER:

- It is also called as vibrating Reed type frequency meter.
- The meter consists of a number of thin steel strips called reeds.
- These reeds are placed in a row alongside and close to an electromagnet.

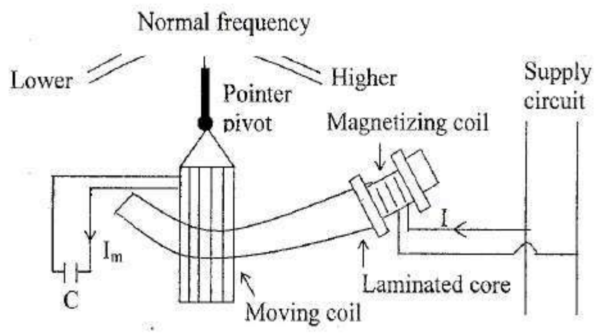
- The natural frequency of vibration of the reeds, depends upon their weights and dimensions
- Since the reeds have different weights and sizes, their natural frequencies of vibration are different.
- The reeds are fixed at the bottom end and are free at the top end.
- When the frequency meter is connected across the supply whose frequency is to be measured, the coil of electromagnet carries a current *i* which alternates at the supply frequency.
- The force of attraction between the reeds and the electromagnet is proportional to i^2 therefore this force varies at twice the supply frequency.
- Thus the force exerted on the reeds varies every half cycle. All the reeds will tend to vibrate, but the reed whose natural frequency is equal to twice the frequency of supply will be in resonance and will vibrate most.
- The **disadvantage** is that such instruments cannot be read much closer than half the frequency difference between adjacent reeds.

2. ELECTRODYNAMOMETER TYPE FREQUENCY METER:



- The two parts of fixed coil are arranged as shown in the diagram, their return circuits being through the movable coil.
- The torque on the movable element is proportional to the current through the moving coil.
- This current is the sum of the currents in the two parts of the fixed coil.
- For applied frequency, within the limits of the frequency range of the instrument, the circuit of fixed coil I operates above resonant frequency (as $X_{Lz} > X_{C1}$) with current i_1 through it, lagging the applied voltage.
- The circuit of fixed coil 2 operates below the resonant frequency (as $X_{c2} > X_{L2}$) with current i_2 leading the applied voltage.
- One fixed coil circuit is inductive and the other is capacitive and therefore the torques produced by the two currents i_1 *and* i_2 *act* in opposition on the moving coil.
- The resultant torque is a function of frequency of the applied voltage, and therefore the meter scale can be calibrated in terms of frequency.

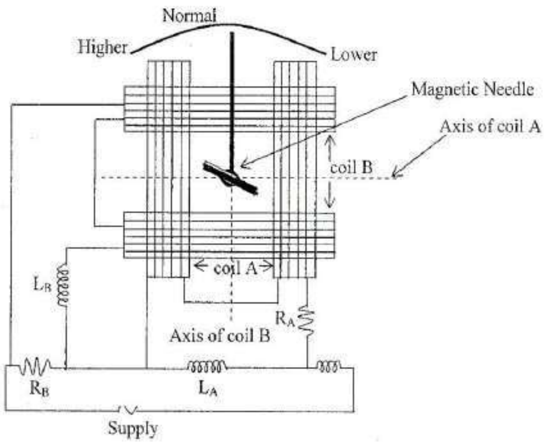
3. FERRO DYNAMIC TYPE FREQUENCY METER:



- It consists of a fixed coil which is connected across the supply whose frequency is to be measured.
- This coil is called magnetizing coil.
- The magnetizing coil is mounted on a laminated iron core.
- The iron core has a cross section which varies gradually over the length, being measured near the end where the magnetizing coil is mounted and minimum at the other end.
- A moving coil is pivoted over this iron core.
- A pointer is attached to the moving coil.
- The terminals of the moving coil are connected to a suitable capacitor C.
- For a fixed frequency the capacitance reactance is constant and the inductive reactance of moving coil is not constant.
- The is becaue the inductance of moving coil is dependent upon the position which the moving coil occupies on the iron core.
- This inductance and hence inductive reactance is maximum when the moving coil occupies a position close to the magnetizing coil and minimum when it is at the other end.
- The value of capacitance C is so chosen that the moving coil occupies a convenient mean
  Position on the iron core when the frequency is at its normal value.
  The coil will come to rest when $X_L = X_C \surd$
  or when $f = \dfrac{1}{2\pi\sqrt{LC}}$ (i.e) under conditions of electrical resonance.

4. WESTON FREQUENCY METER:

- This frequency meter consists of two coils mounted perpendicular to each other.
- Each coil is divided into two sections.
- The meter is connected across the supply and the two coils carry currents.
- These currents set up two magnetic fields which are at right angles to each other.
- Both these field act upon the soft iron needle and the needle takes up a position which depends upon the relative magnitudes of the two field and hence of the currents.



- The meter is so designed that the values of various resistance and inductance are such that for normal frequency of supply the value of voltage drops across reactance L_A and resistance R_B send equal currents through coils A and B.
- Now if the frequency increases above its normal value, reactances of L_A and L_B increase while resistance R_A and R_B remain the same.
- This means that with an increase in frequency, the voltage impressed upon coil A increases as compared with that across the coil B.
- Hence the current in coil A increases while it decreases in coil B.
- The tendency of the needle is to deflect towards the stronger field and therefore, it tends to set itself in line with axis of coil A.
- Thus the pointer deflects to the left.

5. SATURABLE CORE FREQUENCY METER:

- This meter has a saturable core transformer as its primary detector.
- The core assembly consists of three parts viz:
  - (i) An outer core which is made of magnetic material and has a sufficiently large cross-section so that it does not saturate;
  - (ii) A leg A made of non – magnetic material;
  - (iii) A leg B which is made of magnetic material, the cross section of leg A being the same as that of B. The leg B saturates at low values of m.m.f.
- The primary winding is wound around both legs A and B.
- The secondary winding consists of two coils, one around leg and the other around B.
- The two coils are connected in series.
- The emf's induced in these coils oppose each other.
- When there is saturation, the rate of increase of induced voltage in the secondary coil over leg A will equal the rate of increase of induced voltage in secondary coil wound over magnetic leg B.
- Thus the rate of increase in these two coils will cancel, and the secondary output voltage will not be a function of the primary voltage but will be a function of frequency only.

POWER FACTOR METERS:

Power factor can be calculated from the relationship cosφ=(P/VI) where i is the current in the circuit, v is the voltage measured and P is the power measured. This method of determining the power factor of an electric circuit, is however, of low accuracy, in contrast, power factor meters indicate directly, by a single reading, the power factor of the circuit to which they are connected.

There are two types of power factor meters:

- Electrodynamometer type
- Moving Iron type.

1. SINGLE PHASE ELECTRODYNAMOMETER POWER FACTOR METER:

- The construction of a single phase electrodynamometer type power factor meter is as shown
- It consists of a fixed coil which acts as the current coil.
- This coil is split up into two parts and carries the current of the circuit under test.
- Two identical pressure coils A and B pivoted on a spindle constitute the moving system.
- This values of R and L are so adjusted that the two coils carry the same value of current at normal frequency (I,e) R =w L.
- The current through coil A is in phase with the circuit voltage while that through coil B lags the voltage by an angle Δwhich is nearly equal to 90^0
- The angle between the planes of coils is also made equal to Δ

Deflecting torque acting on coil A is: T_A = KVI M_{max} CosΦ sin θ where θ =angular deflection from the plane of reference. M_{max} = Maximum value of mutual inductance between the two coils. This torque say acts in the clockwise direction.

Deflecting torque acting on coil B is: T_B = KVI M_{max}cos $(90^0 + \varphi)$ =KVI M_{max}sin φcosθ this torque acts in anticlockwise direction. At equilibrium, T_A = T_B = $\theta = \Phi$ therefore the deflection of the instrument is a measure of phase angle of the circuit

2. MOVING IRON POWER FACTOR METER:

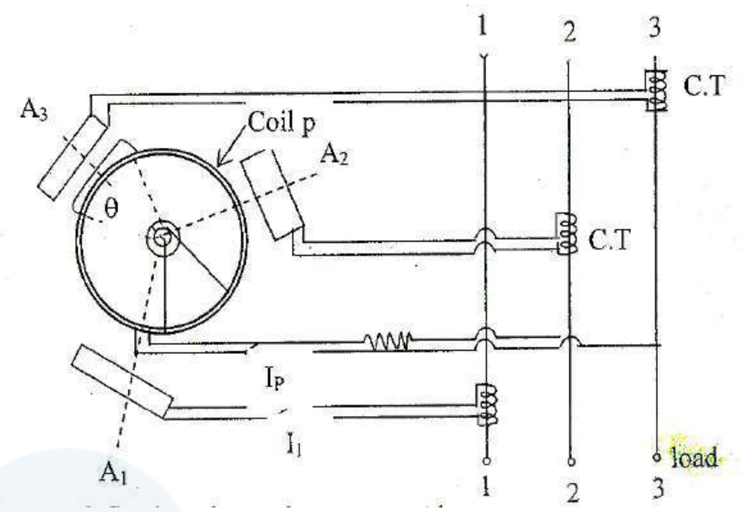
Rotating Field Power Factor Meter:

- A_1, A_2,$A_3$are three fixed coils, with their axes displaced $120^0$from each other and intersecting on the centre line of the instrument. These three coils are connected respectively in lines 1,2 and 3 of a three phase supply
- Two sector shaped iron vanes V re fixed to the cylinder C, The two are 180^0 apart in space. The spindle also carriers damping vanes and a pointer. There are no control springs.
- Coil P and the iron sstem produce an alternating flux, which interacts with the fluxes produced by coils A_1 ,A_2 and A_3, this causes the moving system to take up an angular position determined by the phase angle of the current.

The total deflecting torque, $T_d \alpha [I_1 I_P \cos(90^0 - \varphi)\sin(90^0 + \theta)$ +

$I_2 I_P \cos(330^0 - \varphi)\sin(210^0 + \theta)$ +

$I_3 I_P \cos(210^0 - \varphi)\sin(330^0 + \theta)]$ +



For a steady state deflection, the total torque must be zero.
Also considering the system to be balanced (I, e) $I_1 = I_2 = I_3$, we have,

$$\cos(90^0 - \varphi)\sin(90^0 + \theta) + \cos(330^0 - \varphi)\sin(210^0 + \theta) + \cos(210^0 - \varphi)\sin(330^0 + \theta) = 0$$

Solving the above expression, we have : $\theta = \varphi$

PREVIOUS QUESTIONS

One Mark Questions

01. For a given frequency, the deflecting torque of an induction ammeter is directly proportional to **(GATE-EE-1996)**

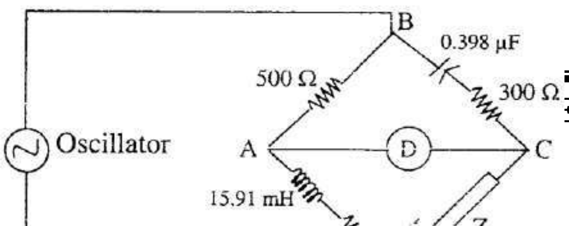
 (a) current^2 (b) current^3 (c) $\sqrt{current}$ (d) current

02. A two-phase load draws the following phase currents: $i_1(t) = I_m \sin(\omega t - \varphi_1)$, $i_2(t) = I_m \cos(\omega t - \varphi_2)$, These currents are balanced if φ_1 is equal to **(GATE-EE-2012)**

 (a) $-\varphi_1$ (b) φ_2 (c) $(\pi/2 - \varphi_2)$ (d) $(\pi/2 + \varphi_2)$

Two Marks Questions

03. The ac bridge shown in the figure is used to measure the impedance Z. If the bridge is balanced for oscillator frequency f = 2 kHz, then the impedance Z will be **(GATE-EE-2008)**



(a) (260 + j0) Ω (b) (0 + j200) Ω

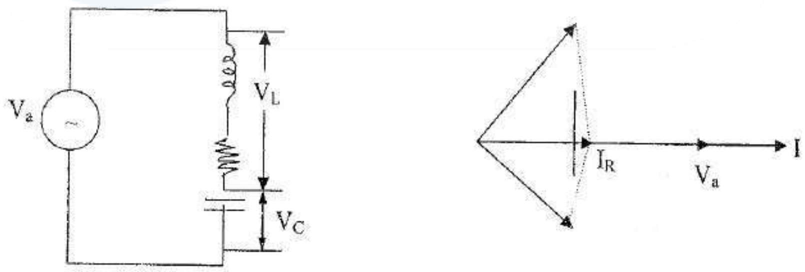
(c) (260 – j200) Ω (d) (260 + j200) Ω

4. Q- METER

Q Meter are intended to measure the Q (quality factor) of an inductance or capacitor.

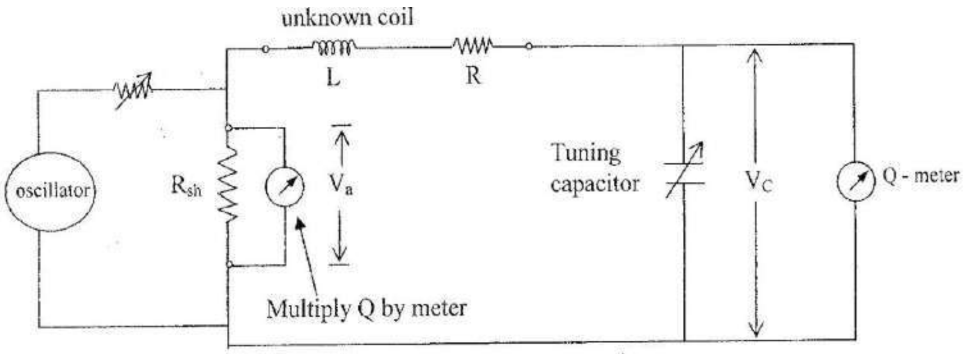
$$Q = wL = 1 = IX_L = IX_c = V_c \text{ or } V_a$$

So the voltage across the capacitor or coil is Q times the applied voltage. If the applied voltage is kept constant, a voltmeter across the coil or capacitor can be calibrated in terms of Q.



- The basic circuit for the measurement of Q consists of an oscillator having a range up to 50MHz whose output is connected to a very low resistor (0.02Ω).
- The voltage across the resistor is measured by a thermo couple voltmeter.
- This is the applied voltage by which the Q value has to be multiplied.
- The oscillator voltage across the low resistor is applied to a series resonant circuit consisting of unknown coil and inherent resistance and a variable capacitor.
- The capacitor is tuned to the oscillator frequency and the voltage across the capacitor is measured by a voltmeter calibrated is Q value.
- This Q value multiplied by the Q value across the resistor is the actual Q.

Unknown coil



The method described is a direct measurement of Q These are two other methods, series connection and parallel connection.

Series Connection:

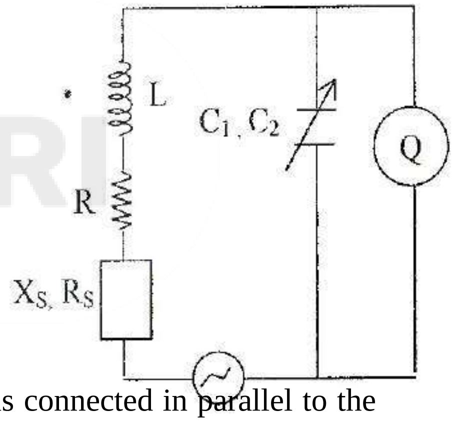
In series connection method the unknown value component is connected in series with the resonant circuit. This method is employed for measurement of low value resistors, small coils and large capacitors.

At resonance, $\omega L = \frac{1}{\omega C_1}$ and $Q_1 = \frac{\omega L}{R} = \frac{1}{\omega C_1 R}$

$$X_s = \frac{C_1 - C_2}{\omega\, C_1 - C_2}$$

$$R_s = \frac{Q_1 C_1 - Q_2 C_2}{\omega\, C_1 C_2 Q_1 C_2}$$

$$Q_x = X_s = (C_1 - C_2)\, Q_1$$



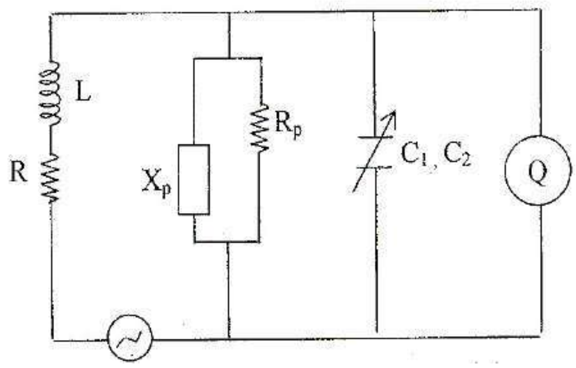
Parallel Connection:

In parallel connection, the unknown component is connected in parallel to the capacitor, in the series resonant circuit. This method is employed for measurement of high value resistors, certain inductors and small capacitors.

$$\frac{1}{R_P} = \frac{\omega C_1}{Q_2} = \frac{1}{RQ_1}$$

$$X_P = \frac{1}{\omega(C_2 - C_1)}$$

$$Q_x = \frac{R_P}{X_P} = \frac{(C_1 - C_2) Q_1 Q_2}{Q_1 C_1 - Q_2 C_2}$$



The main error in the measurement of Q is due to distributed or stray capacitance of the circuity. To check for this, the Q is measured at two frequencies f_1 and $2f_1$. It should be same if not,

$$C_d = \frac{C_1 - C_1 C_2}{3}$$

PREVIOUS QUESTIONS

One Mark Questions

01. A reading of 120 is obtained when a standard inductor was connected in the circuit of a Q-meter and the variable capacitor is adjusted to a value of 300 pF. A lossless capacitor of unknown value C, is then connected and the same reading was obtained when the variable capacitor is readjusted to a value of 200 pF. The value of C_x in pF is **(GATE-EE-2003)**

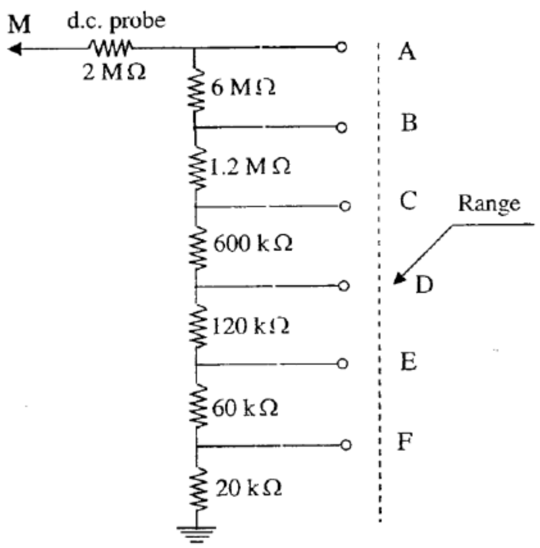
    (a) 100 (b) 200 (c) 300 (d) 500

02. The Q-meter works on the principle of **(GATE-EE-2005)**

    (a) a mutual inductance (b) self inductance
    (c) series resonance (d) parallel resonance

Two Marks Questions

03. The figure shows input attenuator of a multimeter. The meter reads full-scale with 12 V at M with the range switch at position B obtain full-scale deflection with the range switch position at D ? **(GATE-EE-1998)**



    (a) 1 V (b) 150 V (c) 120 V (d) 147 V

04. The voltage phasor of a circuit is $10\angle 15^0$ V and the current phasor is $2\angle -45^0$ A The active and the reactive powers in the circuit are **(GATE-EE-1999)**

    (a) 10 W and 17.32 V Ar. (b) 5 W and 8.66 V Ar.

(c) 20 W and 60 V Ar. (d) $20\sqrt{2}$ W and $10\sqrt{2}$ V Ar.

05. When esting a coil having a resistance of 10 ohms. Resonance occurred when the oscillator frequency was 10 MHz and the rotating capacitor was set at 500/2 pF. The effective value of Q of the coil is **(IES-EE-1993)**

(a) 200 (b) 254 (c) 314 (d) 542

06. In measurements made using a Q-meter, high impedance should preferably be connected in **(IES-EE-1994)**

(a) star (b) delta (c) series (d) parallel

07. Consider the following statements regarding the sources of error in a Q – meter :

1. If a coil with a resistance R is connected in the direct measurement mode and if the residual resistance of the Q-meter is 0.1 R, then the measured Q of the coil would be 1.1 times the actual Q.

2. If the inductance to be measured is less than 0.1 μ M, the error due to the presence of residual inductance cannot be neglected.

3. The presence of distributed capacitance in a coilo modifies the effective Q of the coil. Of these statements **(IES-EE-1995)**

(a) 1, 2 and 3 are correct (b) 1 and 2 are correct

(c) 2 and 3 are correct (d) 1 and 3 are correct

08. **Assertion (A) :** Q – meter cannot be used with a acapacitive element

Reason (R) : The Q value of a coil is the ratio of ωL to its resistance R.

(IES-EE-1995)

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

09. If Q_e is the effective Q of the coil, C is the resonance capacitance and C_d is the distributed capacitance, then the true Q in a Q – meter will be **(IES-EE-1996)**

(a) $Q_e[(C + C_a) / C]$ (b) $Q_e[C/(C + C_d)]$

(c) $Q_e[C_d/(C + C_d)]$ (d) $Q_e[(C + C_d)/C_d]$

10. A Q-meter is supplied with an oscillator having a 500 mV output voltage. While testing an unknown inductor, the voltage across the variable capacitance of the Q – meter, measured by a VTM, is obtained as 10 V. The Q – factor of the inductor is **(IES-EE-1996)**

(a) 5 (b) 10 (c) 20 (d) 100

11. In a Q-meter, a small resistance R is added to the series resonance circuit to inject the oscillatory voltage to the circuit. If R_s is the apparent series resistancfe of the circuit at resonance, then the value of the actual Q will be equal to

(IES-EE-1998)

(a) observed $Q\dfrac{1}{1+\dfrac{R}{R_s}}$ (b) observed $Q\left(1+\dfrac{R}{R_s}\right)$

(c) observed $Q\dfrac{1}{1+\dfrac{R_s}{R}}$ (d) observed $Q\left(1+\dfrac{R_s}{R}\right)$

12. In a Q-meter, an inductor tunes to 2 MHz with 450 pF and to 4MHz with 90pF. The distributed capacitance of the inductor is **(IES-EE-1999)**
(a) 30pF (b) 45 pF (c) 90pF (d) 360pF

13. **Assertion (A) :** The basic principle of operation of a Q-meter is based on the property of a series – resonant circuit
Reason (R) : If a fixed voltage is applied to a series resonant circuit, the voltage developed across its capacitor is times the applied voltage. **(IES-EE-2000)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

14. In a Q meter measurement to determine the self capacitance of a coil, the first resonance occurred at f_1 with C_1 = 300pF. The second resonance occurred at $f_2 = 2f_1$ with C_2 = 60pF. The self capacitance of coil works out to be **(IES-EE-2003)**
(a) 240pF (b) 60pF (c) 360pF (d) 20pF

15. **Assertion (A) :** The Q-meter measures the Q-factor of a coil when the circuit is in resonance
Reason (R) : The Q-meter of a coil depends only on its inductance and not on its resistance **(IES-EE-2010)**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

KEY FOR PREVIOUS QUESTIONS

Cathode Ray Oscilloscope

01. C	02. B	03. D	04. C	05. B	06. D
07. D	08. B	09. A	10. D	11. A	12. B

13. C	14. B	15. C	16. B	17. A	18. B
19. B	20. D	21. D	22. A	23. A	24. C
25. D	26. B	27. B	28. B	29. C	30. D
31. C	32. C	33. C	34. A	35. B	36. B
37. C	38. B	39. A	40. D	41. D	42. C
43. C					

Electronic Instruments For Measuring Basic Parameters

01. B	02. A	03. B	04. D	05. D	06. B
07. A	08. D	09. A	10. C	11. B	12. C
13. B	14. B	15. D	16. B	17. A	18. C
19. A	20. C	21. D	22. A	23. B	24. B
25. C	26. A	27. C	28. C	29. C	30. B
31. C	32. C	33. A	34. A	35. A	36. A
37. C	38. A	39. D	40. C	41. B	42. A
43. A	44. B	45. D	46. A	47. D	48. C
49. D	50. D	51. B	52. C	53. A	54. B
55. D	56. B	57. A	58. B	59. A	60. A
61. D	62. C	63. D	64. A	65. A	66. C
67. C	68. B	69. D	70. C	71. B	72. C
73. B	74. C	75. A	76. D	77. C	78. B
79. D	80. B	81. C	82. B	83. C	84. D
85. D	86. C	87. C	88. A	89. A	90. D
91. A	92. A	93. B	94. D	95. B	96. A
97. C	98. B	99. A	100. A	101. C	102. D
103. D	104. B	105. C	106. C	107. D	108. C

109. B	110. B	111. B	112. A	113. D	114. A
115. C	116. B	117. B	118. B	119. B	120. C
121. B	122. B	123. A	124. C	125. D	126. A

Frequency Meters and Power Factor Meters

01. A	02. B	03. A

Q - Meter

01. A	02. C	03. C	04. A	05. A	06. D
07. C	08. B	09. A	10. C	11. B	12. A
13. A	14. D	15. C			