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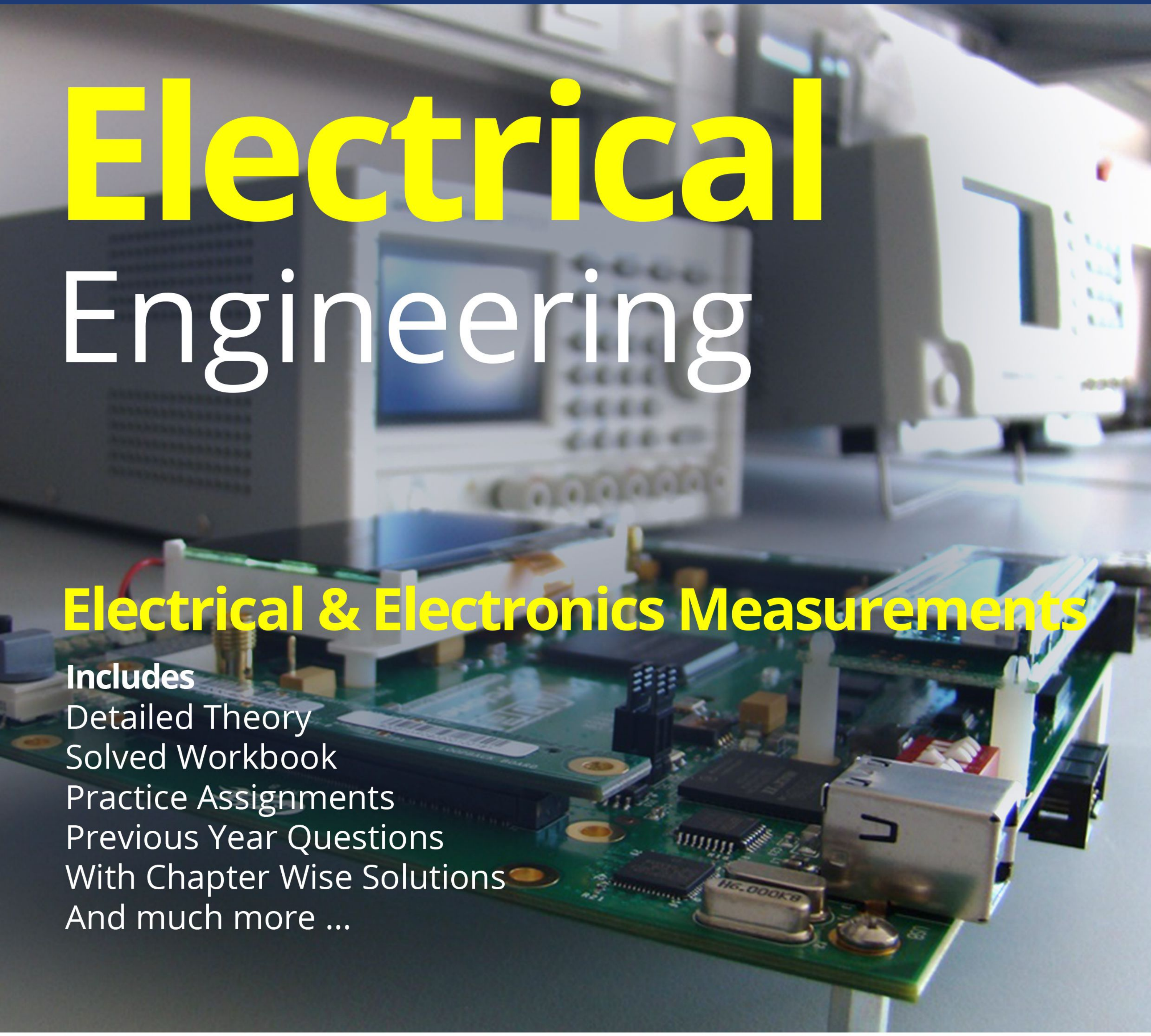

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# CONTENTS

# CHAPTER - 1
# *MEASUREMENTS AND MEASUREMENT SYSTEMS*

## 1.1 MEASUREMENTS
Measurement of quantity is result of comparison of the quantity under measurement, also called as measurand, with perfect standard. The result is expressed in numerical values.
There are two methods to measure:
**1. Direct Method**
The measurement is compared directly with the standard.
**Example**. Measurement of length by tape.
**2. Indirect Method**
The measurand is measured by use of measuring instruments.

### 1.1.1 Measurement Instruments
***1.Mechanical Instruments***
They are good for static measurement i.e. measurand is not varying with time. Due to inertia, mechanical instruments are not suitable for dynamic measurement.
***2. Electrical Instruments***
They are better than mechanical instruments for dynamic measurements. However electrical systems use mechanical parts.
***3. Electronic Instruments***
Because the mass of electron is very less, the electronic systems are fastest.
In these, amplification of the signal can be done, hence very weak signals can also be measured.

### 1.1.2 Properties
1. Highest sensitivity
2. Power consumption is least
3. Most reliable
4. Fastest response
5. Low weight

### 1.1.3 Classification of Instruments
***1. Absolute Instruments***
The magnitude of measurand is measured in terms of the instruments constants. For eg: Tangent Galvanometer, rayleigh current balance. They are used for caliberating secondary instruments.

***2. Secondary Instruments***
They are caliberated with absolute instruments. The measurand is observed by output indication.

***3. Deflection – Type Instruments***
The measurand produces force or torque for deflection. Opposing torque to this deflection is produced externally. At the point of balance,
Deflection torque = controlling torque.

# ESE OBJ QUESTIONS

**1.** A resistance of 108 Ω is specified using significant figures as indicated below:
1. 108 Ω
2. 108.0 Ω
3. 0.00108 Ω

**[EE ESE - 2011]**

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

**2.** A resistance of 105 ohms is specified using significant figures as indicated below:
1. 105 ohms
2. 105.0 ohms
3. 0.000105 MΩ

**[EE ESE - 2010]**

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

**3.** What is the prefix tera equivalent to?

**[EE ESE - 2008]**

(a) $10^3$ (b) $10^6$
(c) $10^9$ (d) $10^{12}$

**4.** For defining the standard meter, wavelength of which material is considered?

**[EE ESE - 2006]**

(a) Neon (b) Krypton
(c) Helium (d) Xenon

**5.** Which one of the following is the most stable frequency primary atomic standard for frequency

**[EC ESE - 2005]**

(a) Caesium beam standard
(b) Hydrogen maser standard
(c) Rubidium vapour standard
(d) Quartz crystal standard

**6.** Match List-I (Accuracy) with List-II (Type of the standard) and select the correct answer:
**List-I**
A. Least accurate
B. More accurate
C. Much more accurate
D. Highest possible accurate
**List-II**
(i) Primary
(ii) Secondary
(iii) Working
(iv) International

**[EE ESE - 2004]**

**Codes:**
(a) A-iii, B-iv, C-i, D-ii
(b) A-i, B-iv, C-iii, D-ii
(c) A-iii, B-ii, C-i, D-iv
(d) A-i, B-ii, C-iii, D-iv

**7.** For time and frequency, the working standard is

**[EE ESE - 2003]**

(a) Microwave oscillator
(b) Crystal controlled oscillator
(c) Laser
(d) ARF oscillator

**8.** The most suitable primary standard for frequency is

**[EC ESE - 2002]**

(a) Rubudium vapour standard
(b) Quartz standard
(c) Hydrogen maser standard
(d) Ceasium beam standard

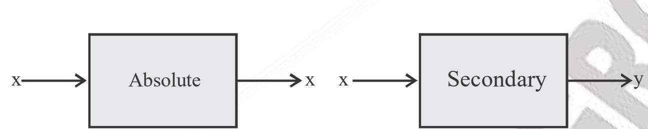
**9.** The modern standard of time

**[EE ESE - 2001]**

(a) A second defined as 1/86400 of a mean solar day.
(b) A second defined as time constant of an RC series circuit having R = 2 MΩ, C = 500 pF.

# CHAPTER - 2
## CHARACTERISTICS OF INSTRUMENTS AND MEASUREMENT SYSTEMS

### 2.1 STATIC CHARACTERISTICS
**1. Calibration Curve**
In this process, a known quantity is given as an input to instrument and output is seen. If output varies then instrument is adjusted accordingly using absolute instruments.




Adjust instrument so that output is x

**2. Accuracy**
Confirmity to truth, or true value. True value is impossible to calculate. However, most agreed value by experts may be considered as true value.
Measured in terms of its error.
Static error = Measured value – True value
$\delta A = A_m - A_t$
Absolute error/static error ($\delta A$) = $E_0 = A_m - A_t$
Relative error,
$$E_r = \frac{\delta A}{A_t}$$
***(i) Accuracy is specified in three ways***
(a) Point Accuracy
Only for a particular value the instrument is accurate to measure
(b) Accuracy as percentage of scale range i.e., x% of full scale deflection.
(c) Accuracy as percentage of true value i.e., x% of true value.

**3. Static Correction**
$\delta C = -(\delta A)$
Error is corrected in opposite to the error.

**4. Scale Range**
The range from minimum to maximum that instrument can measure.

**5. Scale Span**
$X_{max} - X_{min}$ = Scale Span

**6. Reproducibility and Drift**
The degree of closeness with which a given value can be measured repeatedly at different times in reproducibility.
If there is perfect reproducibility over time that is called No Drift.

# ESE OBJ QUESTIONS

**1. Statement (I):** The smallest change of input detectable at the output is called the resolution of a transducer.
**Statement (II):** A high resolution means high accuracy.
**[EC ESE - 2016]**
(a)Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b)Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c)Statement (I) is true but statement (II) is false.
(d)Statement (I) is false but statement (II) is true.

**2.** Loading by the measuring instrument introduces an error in the measured parameter. Which of the following devices gives the most accurate result ?
**[EE ESE - 2016]**
(a) PMMC (b) Hot – wire
(c) CRO (d) Electrodynamics

**3.** The reliability of an instrument refers to
**[EE ESE - 2015]**
(a)The measurement of changes due to temperature variation
(b)The degree to which repeatability continues to remain within specified limits
(c)The life of an instrument
(d)The extent to which the characteristics remain linear

**4. Statement (I):** The ammeter loading effect is due to the high resistance of the ammeter.
**Statement (II):** Increasing the resistance voltmeter will reduce the voltmeter loading effect.
**[EE ESE - 2015]**
(a) Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b) Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c) Statement (I) is true but statement (II) is false.
(d) Statement (I) is false but statement (II) is true.

**5. Statement (I):**In instruments where spring control is used for providing controlling torque, the scale is uniform, and where gravity control is used, the scale is non-uniform.
**Statement (II):**In instruments where controlling torque is provided by spring control, the current is proportional to the deflection, and where the controlling torque is provided by gravity control, the current is proportional to sine of the deflection.
**[EE ESE - 2015]**
(a) Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b) Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c) Statement (I) is true but statement (II) is false.
(d) Statement (I) is false but statement (II) is true.

**6.** The following is not essential for the working of an indicating instrument
**[EE ESE - 2012]**
(a) Deflecting torque
(b) Braking torque
(c) Damping torque
(d) Controlling torques

**7.** Consider the following statement 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.

# CHAPTER - 3
## *ERRORS IN MEASUREMENTS AND THEIR STATISTICAL ANALYSIS*

### 3.1 INTRODUCTION
#### 3.1.1 Limiting Errors/ Guarantee Errors
Limiting error is the deviation from nominal value guaranteed by manufacturer.

$A_a = A_s \pm \delta A$

Where $A_a$ is Actual value

Relative limiting Error($E_r$) = $\frac{\text{Actual Value} - \text{Nominal Value}}{\text{Nominal Value}} = \frac{\delta A}{As}$

**Example** A wattmeter has fsd 1000W and error ± 1% fsd. What will be the range of value if we measure 100W if error was specified as percentage of true value.

**Solution.**

Magnitude of limiting error at fsd = $\pm\frac{1}{100}\times 1000 = \pm 10\text{W}$

$\Rightarrow$ 100 ± 10W i.e., Between 90W to 110W

Percentage of $E_r$ = $\pm\frac{10}{100}\times 100 = \pm 10\%$

If error given as percentage of true value

Magnitude = $\pm\frac{1}{100}\times 100 = \pm 1\text{W}$

Hence, meter will read from 99 to 101 W

**Example** A 0 – 150V voltmeter has guaranteed accuracy of 1% of fsd. At = 75V. what is the limiting error ?

**Solution.**

$\delta A = \frac{1}{100}\times 150 = 1.5$

$A_t = 75\text{V}$

Percentage of $E_r$ = $\frac{1.5}{75}\times 100 = 2\%$

#### 3.1.2 Limiting error of components/combination of quantities
***1. Addition***

$x = x_1 + x_2$

$$\frac{dx}{x} = \pm\frac{d(x_1 + x_2)}{x}$$

$$\frac{dx}{x} = \pm\left[\left(\frac{\partial x_1}{x_1}.\frac{x_1}{x}\right) + \left(\frac{\partial x_2}{x_2}.\frac{x_2}{x}\right)\right]$$

# ESE OBJ QUESTIONS

**1.** An ammeter of 0–25 A range has a guaranteed accuracy of 1% of full –scale reading. The current measured is 5A. The limiting error is

**[EC ESE - 2018]**

(a) 2% (b) 3%
(c) 4% (d) 5%

**2.** A liquid flow through a pipe of 100 mm diameter at a velocity of 1 m/s. If the diameter is guaranteed within ±% and the velocity is known to be within ±3% of measured value, the limiting error for the rate of flow is

**[EC ESE - 2017]**

(a) ±1% (b) ±2%
(c) ±3% (d) ±5%

**3.** Consider the following statements regarding precision in measurements of a quantity.

**[EC ESE - 2017]**

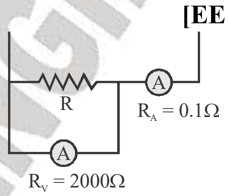
1. Precision is the measure of the spread of the incident errors.
2. precision is independent of the realizable correctness of the measurement.
3. Precision is usually described in terms of number of digits used in the measurement by a digital instrument.

Which of the above statements are correct?

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

**4.** The values of ammeter and voltmeter resistance are 0.1Ω and 2000 Ω respectively as shown in the figure below. The percentage error in the calculated value of R = 100Ω (voltmeter reading 200V/ammeter reading 2A) is nearly

**[EE ESE – 2016]**




(a) –2% (b) –5%
(c) 2% (d) 5%

**5.** Four ammeters $M_1$, $M_2$, $M_3$ and $M_4$ with the following specification 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 1A is to be measured. To obtain minimum error in the reading one should select meter

**[EE ESE - 2014]**

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

**6.** Consider the following statements:
The causes of error in the measurement of temperature using a thermistor are

1. Self heating
2. Poor sensitivity
3. Non-linear characteristics

Which of these statements are correct?

**[EE ESE - 2013]**

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

**7.** Five observers have taken a set of independent voltage measurements and recorded as 110.10 V, 110.20 V, 110.15 V, 110.30 V and 110.25 V. Under the situation mentioned above, the range of error is

**[EE ESE - 2013]**

(a) ± 0.3 (b) ± 0.1
(c) ± 0.2 (d) ± 1.0

**8.** The technique used to check quantitatively whether the given data distribution is close to Gaussian distribution is

**[EE ESE - 2013]**

(a) Curve fitting
(b) Method of least squares
(c) Chi-square test
(d) Standard deviation of mean

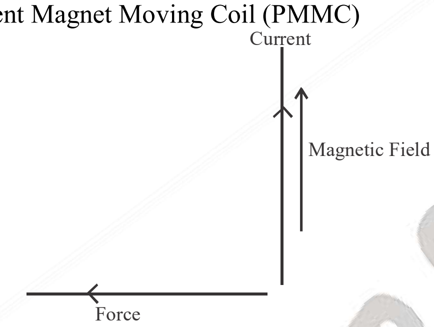
**9.** The unknown resistance $R_4$ measured in a Wheatstone bridge by the formula

# CHAPTER - 4
# *ANALOG INSTRUMENTS*

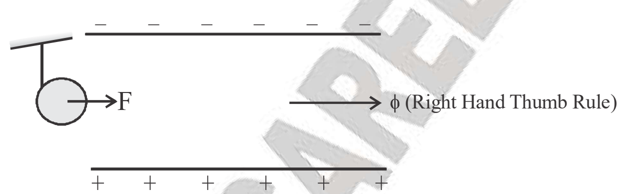
## 4.1 INTRODUCTION

### 4.1.1 Fleming's Left Hand Rule

This rule is used in Permanent Magnet Moving Coil (PMMC)




When an iron piece is placed near magnetic field then magnetic energy acts in such a way so as to reduce reluctance.




Reluctance = $\frac{\text{mmf}}{\text{flux}} = \frac{NI}{\phi}$

Where mmf is Magneto Motive Force
emf is Electro Motive Force

### 4.1.2 Ampere's Law

$\oint H.d\ell = I_{enclosed}$

where H is Magnetic Field Intensity
$\oint$ is magnetic path enclosed

$H \times \ell_m = NI$

Where $\ell_m$ is length of magnetic path

### 4.1.3 Right Hand Thumb Rule

Thumb is the direction of current and curl of fingers is the direction of flux.

# GATE QUESTIONS

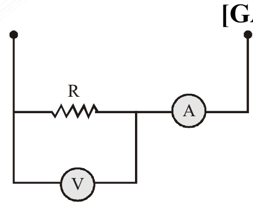
**1.** A current of $-8+6\sqrt{2}(\sin\omega t+30°)$ A is passed through three meters. They are a centre zero PMMC meter, a true rms meter and a moving iron instrument. The respective reading (in A) will be

**[GATE - 2006]**

(a) 8, 6, 10 (b) 8, 6, 8
(c) –8,10,10 (d) –8, 2, 2

**2.** The set-up in the figure is used to measure resistance *R*. The ammeter and voltmeter resistances are 0.01Ω and 2000 Ω, respectively. Their readings are 2 A and 180 V, respectively, giving a measured resistances of 90 Ω The percentage error in the measurement is

**[GATE - 2005]**




(a) 2.25% (b) 2.35%
(c) 4.5% (d) 4.71%

**3.** A moving coil of a meter has 100 turns, and a length and depth of 10 mm and 20 mm respectively. It is positioned in a uniform radial flux density of 200 mT. The coil carries a current of 50 mA, The torque on the coil is

**[GATE - 2004]**

(a) 200 μNm (b) 100 μNm
(c) 2 μNm (d) 1 μNm

**4.** A dc A-h meter is rated for 15 A, 250 V. The meter constant is 1.4,4 A-sec/rev, The meter constant at rated voltage may be expressed as

**[GATE - 2004]**

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

**5.** A moving iron ammeter produces a full scale torque of 240 μNm with a deflection of 120° at a current of 10 A. The rate of change of self induction (μH/radian) of the instrument at full scale is

**[GATE - 2004]**

(a) 2.0 μH/radian (b) 4,8 μH/radian
(c) 12.0 μH/radian (d) 114.6 μH/radian

# ESE OBJ QUESTIONS

**1.** Consider the following statements in connection with deflection –type and null – type instruments:
1. Null – type instruments are more accurate than the deflection –type ones.
2. Null – type of instrument can be highly sensitive compared to a deflection – type instrument.
3. Under dynamic conditions, null – type instruments are less preferred to deflection- type instruments.
4. Response is faster in null – type instruments as compared to deflection –type instruments.
Which of the above statements are correct ?

**[EC ESE - 2016]**

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

**2.** Consider the following types of damping;
1. Air – friction damping
2. Fluid – friction damping
3. Eddy – current damping
PMMC type instruments use which of the above?

**[EE ESE - 2016]**

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

**3.** Consider the following instruments:
1. MI instrument
2. Electrostatic instrument
3. Electrodynamometer instrument
Which of the above instruments is/are free from hysteresis and eddy – current losses?

**[EE ESE - 2016]**

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

**4. 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.

**[EE ESE - 2014]**

(a) Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b) Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c) Statement (I) is true but statement (II) is false.
(d) Statement (I) is false but statement (II) is true.

**5.** The deflection of a hot wire instrument depends on

**[EE ESE - 2014]**

(a) Instantaneous value of alternating current
(b) Average value of current
(c) Rms value of alternating current
(d) Voltage instead of current

**6.** Which of the following instrument will be used to measure a small current of very high frequency?

**[EE ESE - 2013]**

(a) Electrodynamic ammeter
(b) Moving coil galvanometer
(c) Thermocouple type instrument
(d) Induction type instrument

**7.** If one of the control springs of a permanent magnet coil ammeter is broken, then on being connected it will read

**[EE ESE - 2013]**

(a) Zero
(b) Half of the correct value
(c) Twice of the correct value
(d) An finite value

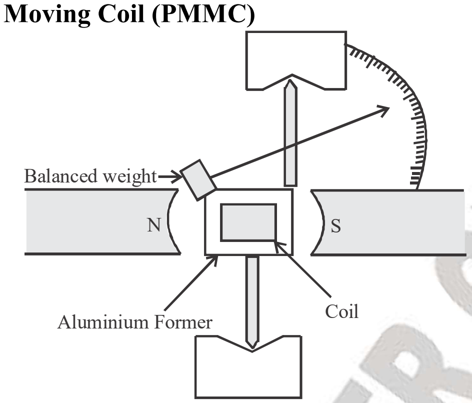
**8.** Volt-box is basically a device used for

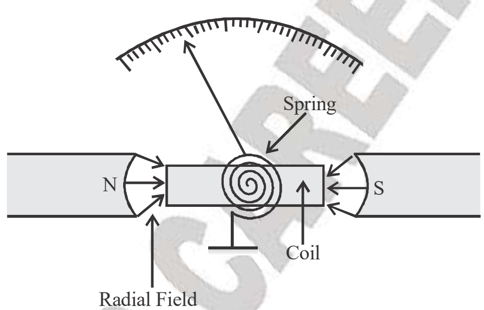
**[EE ESE - 2013]**

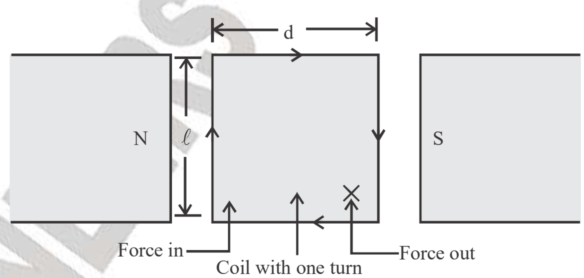
(a) Measuring the voltage
(b) Extending the range of voltmeter
(c) Extending the voltage range of the potentio-meter

# CHAPTER - 5
# *ANALOG AMMETER, VOLTMETER AND OHMETER*

## 5.1 INTRODUCTION
### 5.1.1 Permanent Magnet Moving Coil (PMMC)




F = NIBl sin θ

For radial field; $\theta = 90^0$

$T_d = F.d$

F = NIB ld

∵ A = ld

F = NIBA

∵ G = NBA

F = GI //$T_d$ in PMMC

# GATE QUESTIONS

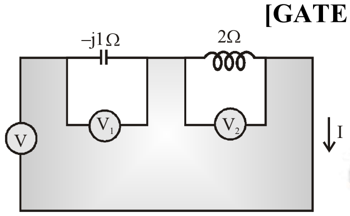
**1.** Consider the following statements:
1. Better memory utilization is possible with non – continuous allocation using fixed size pages.
2. Associative memory is used for providing fast access to data stored in cache memory.
3. Direct mapping of cache memory is hard to implement
Which of the above statements are correct?

**[GATE - 2018]**

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

**2.** Three moving iron type voltmeter are connected as shown below. Voltmeter readings are V, $V_1$ and $V_2$ as indicated. The correct relation among the voltmeter readings is

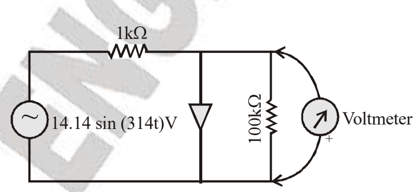
**[GATE - 2013]**




(a) $V = \frac{V_1}{\sqrt{2}} + \frac{V_2}{\sqrt{2}}$
(b) $V = V_1 + V_2$
(c) $V = V_1V_2$
(d) $V = V_2 - V_1$

**3.** The input impedance 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

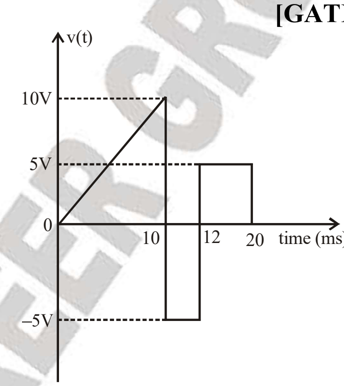
**[GATE - 2013]**




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

**4.** 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 - 2012]**




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

**5.** An analog voltmeter uses external multiplier settings. With a multiplier setting of 20 kΩ, it reads 440V and with a multiplier setting of 80 kΩ, it reads 352V, For a multiplier setting of 40 kΩ, the voltmeter reads

**[GATE - 2012]**

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

**6.** An ammeter has a current range of 0.5 A, 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 - 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

**7.** The Q-meter works on the principle of

**[GATE - 2005]**

# ESE OBJ QUESTIONS

**1.** A 0-1 mA FSD ammeter is to be used to measure 0–100 mA full scale deflection using a shunt. If the internal resistance of the meter is 200Ω, what is the required shunt resistance ?

**[EC ESE - 2018]**

(a) 4.0 Ω (b) 3.03 Ω
(c) 2.02 Ω (d) 1.01 Ω

**2.** A $3\frac{1}{2}$ digit digital voltmeter is accurate to ±0.5% of reading ±2 digits. What is the percentage error, when the voltmeter reads 0.10V on its 10V range?

**[EC ESE - 2017]**

(a) 0.025% (b) 0.25%
(c) 2.05% (d) 20.5%

**3.** A PMMC instrument if connected directly to measure alternating current, it indicates

**[EC ESE - 2017]**

(a) The actual value of the subject AC quantity
(b) Zero reading
(c) $\frac{1}{\sqrt{2}}$ of the scale value where the pointer rests
(d) $\frac{\sqrt{3}}{2}$ of the scale value where the pointer rests.

**4.** Consider the following statements:
Sphere gap method of voltage measurement is used
1. For measuring r.m.s. value of a high voltage
2. For measuring peak value of a high voltage
3. As the standard for calibration purposes
Which of the above statements are correct ?

**[EC ESE - 2017]**

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

**5.** A voltmeter having a sensitivity of 1000 Ω/V reads 100 V on its 150 V scale when connected across at resistor of unidentified specifications in series with a milliammeter. When the milliammeter reads 5 mA, the error due to the loading effect of the voltmeter will be nearly

**[EC ESE - 2017]**

(a) 13% (b) 18%
(c) 23% (d) 33%

**6. Statement (I):** Moving iron instruments are used in ac circuits only.
**Statement (II):** The deflecting torque in moving iron instruments depends on the square of the current.

**[EE ESE - 2017]**

(a) Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b) Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c) Statement (I) is true but statement (II) is false.
(d) Statement (I) is false but statement (II) is true.

**7. Statement (I):** PMMC instruments are suitable in aircraft and air space applications.
**Statement (II):** PMMC instruments use a core magnet which possesses self– shielding property.

**[EE ESE - 2017]**

(a) Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b) Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c) Statement (I) is true but statement (II) is false.
(d) Statement (I) is false but statement (II) is true.

# GATE QUESTIONS

**1.** The solution of the differential equation

$$\frac{d^2y}{dx^2}-\frac{dy}{dx}-2y=3e^{2x}$$

Where, y(0) = 0 and y(0) = –2 is

**[GATE - 2018]**

(a) $y = e^{-x} - e^{2x} + xe^{2x}$
(b) $y = e^{x} - e^{-2x} - xe^{2x}$
(c) $y = e^{-x} + e^{2x} + xe^{2x}$
(d) $y = e^{x} - e^{-2x} + xe^{2x}$

**2.** The bridge method commonly used for finding mutual inductance is

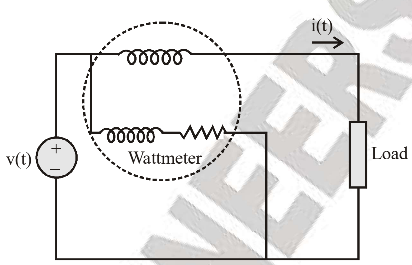
**[GATE - 2012]**

(a) Heaviside Campbell bridge
(b) Schering bridge
(c) De Sauty bridge
(d) Wien bridge

**3.** For the circuit shown in the figure, the voltage and current expressions are $V(t) = E_1 \sin(\omega t) + E_3 \sin(3\omega t)$ and $i(t) = I_1 \sin(\omega t - \phi_1) + I_3 \sin(3\omega t - \phi_3) + I_5 \sin(5\omega t)$

The average power measured by the wattmeter is

**[GATE - 2012]**




(a) $\frac{1}{2}E_1I_1\cos\phi_1$

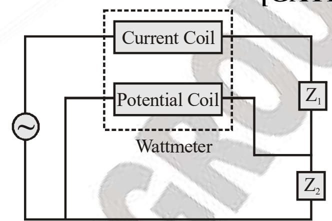
(b) $\frac{1}{2}[E_1I_1\cos\phi_1 + E_1I_3\cos\phi_3 + E_1I_s]$

(c) $\frac{1}{2}[E_1I_1\cos\phi_1 + E_3I_3\cos\phi_3)$

(d) $\frac{1}{2}[E_1I_1\cos\phi_1 + E_3I_1\cos\phi_1]$

**4.** A wattmeter is connected as shown in figure. The wattmeter reads.

**[GATE - 2010]**




(a) Zero always
(b) Total power consumed by $Z_1$ and $Z_2$
(c) Power consumed by $Z_1$
(d) Power consumed by $Z_2$

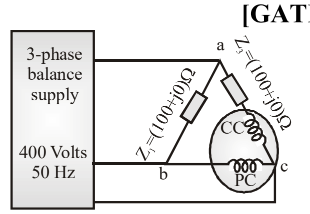
**5.** The pressure coil of dynamometer type wattmeter is

**[GATE - 2009]**

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

**6.** The figure shows a three-phase delta connected load, supplied from a 400V, 50 Hz, 3-phase balanced source. The pressure coil (PC) and current coil (CC) 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 - 2009]**




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

**7.** 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 square wave is 10 V and the current is a triangular wave of 5 A p-p as shown in the

# ESE OBJ QUESTIONS

**1.** An energy meter makes 100 revolutions of its disc per unit of energy. The number of revolution made by the disc during one hour when connected across 210V source and drawing a current of 20A at 0.8p.f. leading is

**[EE ESE - 2018]**

(a) 336 (b) 316
(c) 286 (d) 256

**2. Statement (I):** A general purpose dynamometer type wattmeter does not read accurately at low power factors.
**Statement (II):** The presence of self – inductance of the pressure coil introduces an error.

**[EE ESE - 2018]**

(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but statement (II) is false
(d) Statement (I) is false; but statement (II) is true

**3. Statement (I):** A dynamometer type wattmeter has a linear scale while a dynamometer type voltmeter has a non – linear scale.
**Statement (II):** Deflecting torque developed in a dynamometer type wattmeter is proportional to the power and that developed in a dynamometer type ammeter is proportional to the square of the current.

**[EE ESE - 2018]**

(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but statement (II) is false
(d) Statement (I) is false; but statement (II) is true

**4. Statement (I):** The rotating disc in an energy meter is made of a magnetic material.
**Statement (II):** Braking takes place due to eddy current generated by the braking magnet.

**[EE ESE - 2018]**

(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but statement (II) is false
(d) Statement (I) is false; but statement (II) is true

**5. Statement (I):** To measure power consumed by the load, it is necessary to interchange the pressure coil terminals when the pointer of a wattmeter kicks back.
**Statement (II):** The pressure coil terminals are interchanged to get upscale reading in a wattmeter without affecting the continuity of power to the load.

**[EE ESE - 2017]**

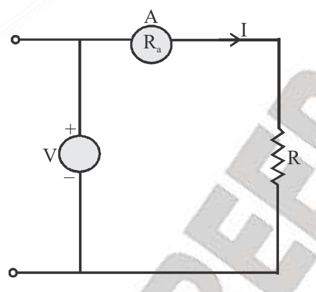
(a)Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b)Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c)Statement (I) is true but statement (II) is false.
(d)Statement (I) is false but statement (II) is true.

**6.** Consider the following statements with regard to induction type wattmeter.
1. Can be used on both ac and dc systems.

# CHAPTER - 7
## *MEASUREMENT OF RESISTANCE*

### 7.1 THREE CATEGORY FOR MEASUREMENT OF RESISTANCE
(i) Low R: of order of 1Ω or less
(ii) Medium R: of order of 1 Ω – 100 kΩ
(iii) High R: R > 100kΩ

### 7.2 METHOD TO CALCULATE RESISTANCE
**Type-I. Ammeter Voltmeter Method**
This method is suitable for measuring high resistance

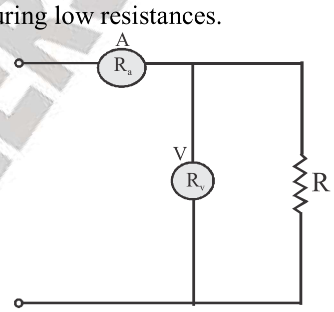



Measured value of $R_m = \frac{V}{I}$

If $R_a$ then, $R_m = \frac{V}{I} = \frac{I_R + R_a}{I} = R + R_a$

Percentage error = $\frac{R_a}{R}$

**Type-II.**
This method is suitable for measuring low resistances.




$$R_m = \frac{V}{I} = \frac{V}{I_v + I_R}$$

$I_v = \frac{V}{R_v}$ and $I_R = \frac{V}{R -}$

# ESE OBJ QUESTIONS

**1.** The Wheatstone bridge consists of a power source, 3 known resistors, a resistor whose value is to be measured and a null detector. Which of the following is not a source of errors in a Wheatstone bridge?

**[EC ESE - 2018]**

(a) Limiting errors of the known resistors
(b) Poor sensitivity of the null detector
(c) Fluctuations in the power supply voltage
(d) Thermal e.m.f.s in the bridge circuit

**2.** During the measurement of resistance by Carey Foster bridge, no error is introduced due to

**[EE ESE - 2017]**

1. Contact resistance
2. Connecting leads
3. Thermoelectric e.m.f

Which of the above are correct ?

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

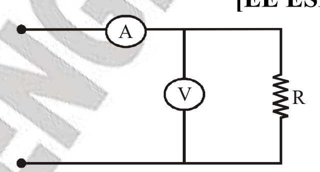
**3.** The precision resistors are

**[EE ESE - 2016]**

(a)Carbon composition resistors
(b)Wire - wound resistors
(c)Resistors with a negative temperature coefficient
(d)Resistors with a positive temperature coefficient

**4.** In the circuit shown below, the ammeter reads 0.1 A and the voltmeter reads 10 V. The internal resistance of the ammeter is 1Ω and that of the voltmeter is 500 Ω. What is the value of R?

**[EE ESE - 2015]**




(a) 100 Ω (b) 125 Ω
(c) 90 Ω (d) 120 Ω

**5.** In measuring resistance by voltmeter-ammeter method, the voltmeter can be connected either across supply or cross the resistance. If the resistance is low, the voltmeter should be connected.

**[EE ESE - 2015]**

(a)Across the supply
(b)Across the resistance
(c)Either across the supply or across the resistance
(d)Neither across the supply nor across the resistance

**6.** A 3-turn 100 kΩ potentiometer with 1% linearity uses 30 V supply. What is the potentiometer constant?

**[EE ESE - 2015]**

(a) 0.1 V/turn (b) 10 V/turn
(c) 33.33 V/turn (d) 0.3 V/turn

**7.** In vector impedance meter, the coverage of the instrument can be obtained with

**[EE ESE - 2015]**

(a)V-I characteristics of the test system
(b)Power-frequency plot
(c)Sweep frequency plots of impedance and phase angle versus frequency
(d)Voltage-angle plot

**8. Statement (I):** Ammeter and voltmeter method is used for measurement of low as well as medium resistances.

**Statement (II):** Carey-Foster slide wire bridge is a modification of the Wheatstone bridge.

**[EE ESE - 2015]**

(a)Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b)Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c)Statement (I) is true but statement (II) is false.

# CHAPTER - 8
## AC BRIDGES

### 8.1 INTRODUCTION

AC bridges are used for measurement of inductance, capacities, quality factor of coils and dissipation factor of capacitances etc.

Source is an electronic oscillator with controllable frequencies.

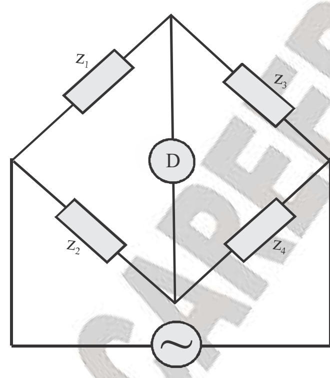
**1. Detectors are**

1. Headphones: 250Hz to 4 kHz
2. Vibration galvanometer: This is most sensitive for 5Hz to 200 Hz.
3. Wide frequency range, tunable amplifier: 100Hz to 10 kHz

At balance, $\overline{z}_1\overline{z}_4 = \overline{z}_2\overline{z}_3$

$|z_1||z_4| = |z_2||z_3|$ …(i)

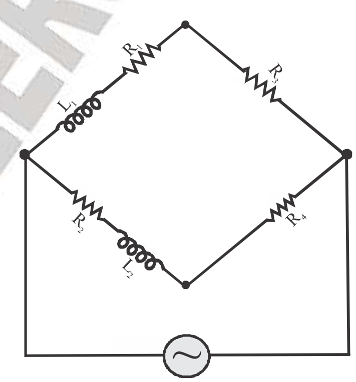
$\angle\theta_1 + \theta_4 = \angle\theta_4 + \theta_3$




Two equations: two unknown variable can be known in terms of known variable. For quick balance, the known variables shall not come in the equation.

$(R_1 + j\omega L_1)R_4 = (R_2 + j\omega L_2)R_3$

$R_1R_4 = R_2R_3$




And $L_1R_4 = L_2R_3$

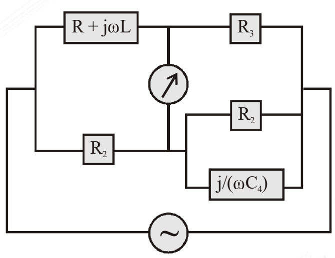
# GATE QUESTIONS

**1.** Consider the following statement
(1) The compensating coil of a low power factor wattmeter compensates the effect of the impedance of the current coil.
(2) The compensating coil of a low power factor wattmeter compensates the effect of the impedance of the voltage coil circuit.

**[GATE - 2011]**

(a) (1) is true but (2) is false
(b) (1) is false but (2) is true
(c) Both (1) and (2) are true
(d) Both (i) and (2) are false

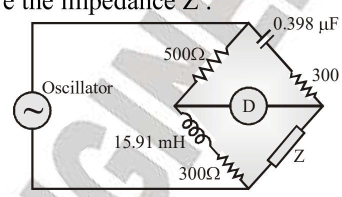
**2.** The Maxwell's bridge shown in the figure is at balance. The parameters of the inductive coil are.




**[GATE - 2010]**

(a) $R = R_2R_3/R_4$, $L = C_4R_2R_3$
(b) $L = R_2R_3/R_4$, $R = C_4R_2R_3$
(c) $R = R_4/R_2R_3$, $L = 1/(C_4R_2R_3)$
(d) $L = R_4/R_2R_3$, $R = 1/(C_4R_2R_3)$

**3.** The ac bridge shown in the figure *is* used to measure the impedance Z .



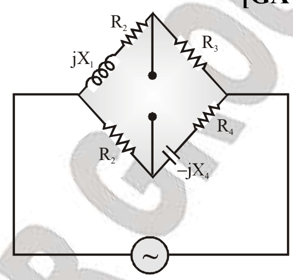

If the bridge is balanced for oscillator frequency f = 2 kHz, then the impedance *Z* will be

**[GATE - 2008]**

(a) (260 + J0)Ω (b) (0 + j200)Ω
(c) (260 – j200)Ω (d) (260 + j200) Ω

**4.** A bridge circuit is shown in the figure below. Which one of the sequence given below is most suitable for balancing the bridge ?

**[GATE - 2007]**




(a) First adjust (b) First adjust
(c) First adjust (d) First adjust

**5.** $R_1$ and $R_4$ are the opposite arms of a Wheatstone bridge as are $R_2$ and $R_1$. The source voltage is applied across $R_1$ and $R_3$. Under balanced conditions which one of the following is true

**[GATE - 2006]**

(a) $R_1 = R_3R_4/R_2$
(b) $R_1 = R_2R_3/R_4$
(c) $R_1 = R_2R_4/R_3$
(d) $R_1 = R_2 + R_3 + R_4$

**6.** The items in Group-I represent the various types of measurements to be made with a reasonable accuracy using a suitable bridge. The items in Group-II represent the various bridges available for this purpose. Select the correct choice of the item in Group-II for the corresponding item in Group-I from the following

**List-I**
A. Resistance in the milli-ohm range
B. Low values of Capacitance
C. Comparison of resistance which are nearly equal
D. Inductance of a coil with a large time-constant

# ESE OBJ QUESTIONS

**1. Statement (I):** A ballistic galvanometer is preferred as a detector in an AC bridge to measure inductance supplied by a source at power frequency.
**Statement (II):** An AC bridge to measure inductance is balanced at the fundamental component.

**[EE ESE - 2017]**

(a) Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).
(b) Both statement (I) and statement (II) are individually true but statement (II) is not the correct explanation of statement (I).
(c) Statement (I) is true but statement (II) is false.
(d) Statement (I) is false but statement (II) is true.

**2.** A Wien bridge oscillator is suitable for
1. Audio frequency applications
2. Radio frequency applications
3. Very low frequency applications
Which of the above frequency applications is/are correct ?

**[EE ESE - 2017]**

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

**3.** Schering bridge is a very versatile AC bridge and is used for capacitor testing in terms of
1.Capacitance value (magnitude)
2.Loss angle measurement
3.Simple balance detector like PMMC instrument
4.Providing safety to operators by incorporating Wagner earthing device which of the above are correct?

**[EE ESE – 2016]**

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

**4.** A bridge circuit works at a frequency of 2 kHz. Which of the following can be used as detectors for detection of null conditions in the bridge?

**[EE ESE - 2015]**

(a)Vibration galvanometers and headphones
(b)Headphones and tunable amplifiers
(c)Vibration galvanometers and tunable amplifiers
(d)Vibration galvanometers, headphones and tunable amplifiers

**5.** A Wheatstone bridge has got three resistances taken in clockwise direction as 120 Ω, 150 Ω, and 150 Ω. The value of the fourth resistance for null balance would be

**[EE ESE - 2015]**

(a) 150 Ω (b) 120 Ω
(c) 300 Ω (d) 750 Ω

**6. Assertion (A):** Bridge measurements are considered to be more accurate as compared to measurements done using indicating instruments.
**Reason (R):** In a bridge measurement, the accuracy of the components used in the different arms of the bridge along comes into picture.

**[EE ESE - 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

**7.** In De Sauty Bridge (unmodified form) it is possible to obtain balance.

**[EE ESE - 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

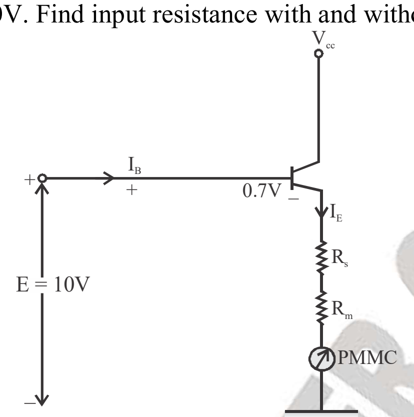
**8.** With the help of which bridge are the capacitance and dielectric loss of capacitor generally measured?

**[EE ESE - 2014]**

# CHAPTER - 9
# *ELECTRONIC MEASUREMENTS*

## 9.1 ELECTRONIC MEASUREMENT

**Example** Find $I_m$ when E = 10V. Find input resistance with and without transistor.




$R_s + R_m = 9.3\ k\Omega$

$I_{fsd} = 1mA$

$\beta = 100$

**Solution.**

E = 10V = V

$I_m$ = ImA

$10 - 0.7 = (9.3 \times 10^3)\ I_m$

$I_m = 1mA$

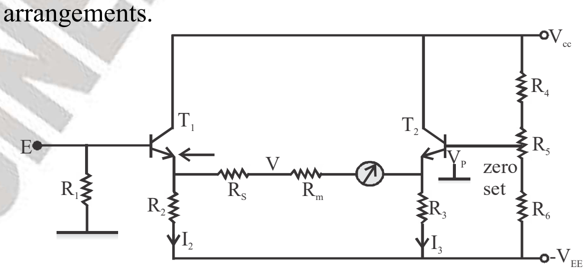
$Z_{in} = (h_{fe} + 1)Re.$

$$Z_{in} = \frac{E}{I_B} \Rightarrow Z_{in} = \frac{10}{0.1\mu A} = 100M\Omega$$

$$I_B \simeq \frac{I_E}{B} = 0.1\mu A$$

$Z_{in} = R_s + R_m = R_E$

Input impedance should be high to avoid loading effect. Thus, to eliminate the error due to $V_{BE}$, we will make certain arrangements.




No two transistors can be same.

When E = 0, $I_m$ shall be zero, that is done b y adjusting bias voltage $V_P$ of $T_2$.

# ESE OBJ QUESTIONS

**1. Statement (I):** Analog to digital conversion is essentially a sampling process.
**Statement (II):** A hold element is digital to analog converter.
**[EE ESE - 2018]**
(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but statement (II) is false
(d) Statement (I) is false; but statement (II) is true

**2.** An 8-bit DAC uses a ladder network. The full – scale output voltage of the converter is +10V. The resolution expressed in percentage and in volts is, respectively.
**[EE ESE - 2018]**
(a) 0.25% and 30 mV
(b) 0.39% and 30 mV
(c) 0.25% and 39 mV
(d) 0.39% and 39 mV

**3.** Consider the following statements:
1. Flash type ADCs are considered the fastest
2. In successive approximation type ADCs, conversion time depends upon the magnitude of the analog voltage
3. Counter –type ADCs work with fixed conversion time
4. Dual slope ADCs are considered the slowest
Which of the above statements are correct?
**[EE ESE - 2018]**
(a) 2 and 3 only (b) 2 and 4 only
(c) 1 and 4 only (d) 1 and 3 only

**4.** A vector impedance meter measures
**[EC ESE - 2018]**
(a) The magnitude of the impedance
(b) The power dissipation in the impedance
(c) The phase angle of the impedance
(d) Both the magnitude and the phase angle of the impedance

**5.** A vector voltmeter can be used to measure
1. Complex insertion loss
2. Two – port network parameters
3. Amplifier gain and phase shift
4. Harmonic distortion
Which of the above are correct?
**[EC ESE - 2018]**
(a) 1, 2 and 4 (b) 1, 2 and 4
(c) 1, 3 and 4 (d) 2, 3 and 4

**6.** An ADC has a total conversion time of 200 μs. what is the highest frequency that its analog input should be allowed to contain?
**[EC ESE - 2018]**
(a) 2.5 kHz (b) 25 kHz
(c) 250 kHz (d) 0.25 kHz

**7.** Which of the following ADC has highest accuracy?
**[EE ESE - 2015]**
(a) Successive is approximation type
(b) Flash or parallel type
(c) Single slope integration type
(d) Dual slope integration type

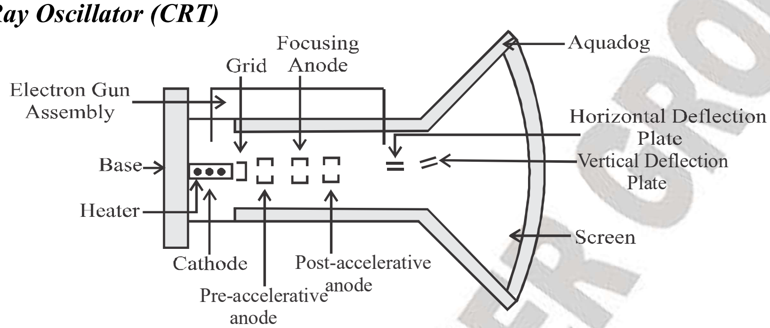
**8.** An analog transducer with a 0-10 V input is able to distinguish a charge of 10 mV in its input signal. What is the number of bits of an A/D converter in binary code so that the digital output has almost the same resolution as the transducer?
**[EE ESE - 2015]**
(a) 8 (b) 10
(c) 12 (d) 4

**9.** In a 4-bit R-2R ladder type digital-to-analog convertor with $R_F$ = R and $V_R$ = 5V, where $R_F$ and R are the feedback and input resistances respectively to realize the gain of the inverting amplifier using an op-amp, the resolution and full-scale output respectively are
**[EE ESE - 2015]**

# CHAPTER - 10
# *CATHODE RAY OSCILLOSCOPE (CRO)*

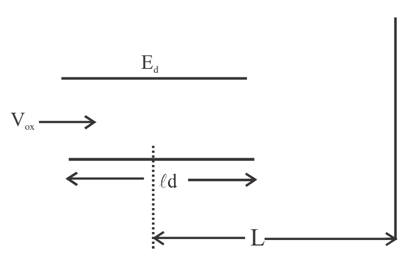
## 10.1 INTRODUCTION
Cathode Ray Oscillator is basically a XY plotter, the CRO can measure frequency upto 1GHz. CRO is basically voltage meter.

### 10.1.1 Part of CRO
***1. Cathode Ray Oscillator (CRT)***




Electron gun assembly produces sharp beam of accelerated electrons.
**(i)** ***Cathode:*** It produces electrons when heated. A layer of stromdium oxide is placed over cathode to increase efficiency. Cathode is cylindrical with a hole in it.
**(ii)** ***Grid:*** The intensity/ brightness spots on screen depends on no. of electrons. This can be controlled by putting a negative bias on grid.
**(iii)** ***Pre – Accelerative Anode:*** By placing positive high voltage, speed of electron increases.
**(iv)** ***Focusing Anode:*** The scattered beam is focused by electrostatic focusing in CRO and by magnetic focusing in TV sets.
**(v)** ***Post –Accelerative Anode:*** It is required to accelerate the electrons.
**(vi)** ***Horizontal Deflection Plate :*** Its function is to move electrons beam horizontally on the screen.
**(vii)** ***Vertical Deflection Plate:*** Its function is to move electrons beam vertically on the screen.
**(viii)** ***Screen:*** It is made of glass coated with phosphor. When electrons strike on phosphor, the energy is increased and it produces light that is called cathode luminance.
**(ix)** ***Gratiule:*** Horizontal and vertical divisions on screen for measurement.
**(x)** ***Aquadog:*** When electrons strike over screen, they cause emission of electrons from screw which is called secondary emission. Aquadog is aqueous summation of device which collect through secondary emitted electrons.

## 10.2 ELECTROSTATIC DEFLECTION



# GATE QUESTIONS

**1.** A stationary closed lissajous pattern on an oscilloscope has 3 horizontal tangencies and 2 vertical tangencies for a horizontal input with frequency 3kHz. The frequency of the vertical input is

**[GATE - 2017]**

(a) 1.5 kHz (b) 2 kHz
(c) 3 kHz (d) 4.5 kHz

**2.** The slope and level detector circuit in a CRO has a delay of 100ns. The start – stop sweep generator has a response time of 50ns In order to display correctly, a delay line of

**[GATE - 2017]**

(a) 150 ns has to be inserted into the y-channel
(b) 150 ns has to be inserted into the x-channel
(c) 150 ns has to be inserted into both x and y channels
(d) 100 ns has to be inserted into both x and y channels

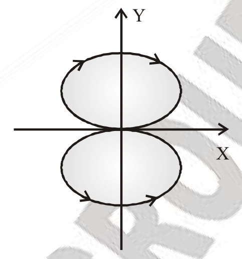
**3.** The two inputs of a CRO are fed with two stationary periodic signals. In the X-Y mode, the screen shows a figure which changes from ellipse to circle and back to ellipse with its major axis changing orientation slowly and repeatedly. The following inference can be made from this.

**[GATE - 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

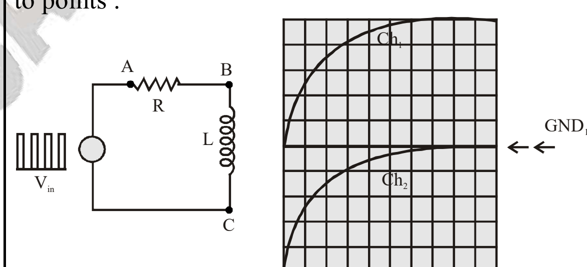
**4.** Two sinusoidal signals $p(\omega_1, t) = A \sin\omega_1 t$ and $q(\omega_2 t)$ are applied to X and Y inputs of a dual channel CRO. The Lissajous figure displayed on the screen shown below :
The signal $q(\omega_2 t)$ will be represented as

**[GATE - 2008]**




(a) $q(\omega_2 t) = A \sin \omega_2 t,\ \omega_2 = 2\omega_1$
(b) $q(\omega_2 t) = A\sin\omega_2 t,\ \omega_2 = \omega_1/2$
(c) $q(\omega_2 t) = A\cos\omega_2 t,\ \omega_2 = 2\omega_1$
(d) $q(\omega_2 t) = A\cos\omega_2 t,\ \omega_2 = \omega_1/2$

**5.** The probes of a non-isolated, two channel oscillocope are clipped to points A, B and C in the circuit of the adjacent figure. $V_{in}$ is a square wave *of a* suitable low frequency. The display on $Ch_1$ 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 - 2007]**

(a) A, B, C, A (b) A, B, C, B
(c) C, B, A, B (d) B, A, B, C

**6.** 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 - 2005]**

(a) Q sin (4t – 30°) (b) Q sin (2t + 15°)
(c) Q sin (8t + 60°) (d) Q sin (4t + *30°)*

# ESE OBJ QUESTIONS

**1.** What will be seen on the screen of a CRO, when a sinusoidal voltage signal is applied to the vertical deflection plate of this CRO with no simultaneous signal applied to the horizontal deflection plate?

**[EC ESE - 2018]**

(a) A horizontal line
(b) A vertical line
(c) A sinusoidal signal
(d) A spot at the centre of the screen

**2.** High frequency (in the MHz range) and low amplitude (in the mV range) signals are best measured using

**[EC ESE - 2017]**

(a) VTVM with high impedance probe
(b) CRO
(c) Moving–iron instrument
(d) Digital multimeter

**3.** Consider the following statements with regard to Lissajous pattern on a CRO.
1. It is a stationary pattern on the CRO.
2. it is used for precise measurement of frequency of a voltage single.
3. the ratio between frequencies of vertical and longitudinal voltage signals should be an integer to have a steady Lissajous pattern.
Which of the above statements is/are correct?

**[EE ESE - 2017]**

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

**4.** A CRO screen has 10 divisions on the horizontal scale. If a voltage signal 5 sin 9314t + 45°) is examined with a line base setting of 5 ms/div, the number of signals displayed on the screen will be

**[EE ESE - 2016]**

(a) 1.25 cycles (b) 2.5 cycles
(c) 5 cycles (d) 10 cycles

**5.** A dual-beam CRO

**[EE ESE - 2015]**

(a) Has one set of vertical deflection plates
(b) Has two sets of horizontal deflection plates
(c) Has two separate electron beams
(d) None of the above

**6.** If the bandwidth of an oscilloscope is 10 MHz, what is the fastest rise time a square wave can have to be accurately reproduced by the instrument?

**[EE ESE - 2015]**

(a) 10 ns (b) 35 ns
(c) 28 ns (d) 100 ns

**7.** If $V_1$ is the fundamental voltage, $V_3$ and $V_5$ are the amplitudes of the 3rd and 5th harmonic and $\frac{V_3}{V_1} = x\%$, $\frac{V_5}{V_1} = y\%$ then the total harmonic distortion of the system will be

**[EE ESE - 2015]**

(a) $\sqrt{x^2 + y^2}$ (b) $\frac{y}{x}$
(c) $x + y$ (d) $\frac{1}{\sqrt{x^2 + y^2}}$

**8.** 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 channel. What will be the resultant pattern on the screen?

**[EE ESE - 2014]**

(a) An ellipse
(b) A parabola
(c) Straight line inclined at 45° with respect to x-axis
(d) A circle

**9.** The function of input attenuators in measuring instruments, like VTVM and CRO, is to

**[EE ESE - 2014]**

(a) Increase the input impedance
(b) Attenuate the frequency range

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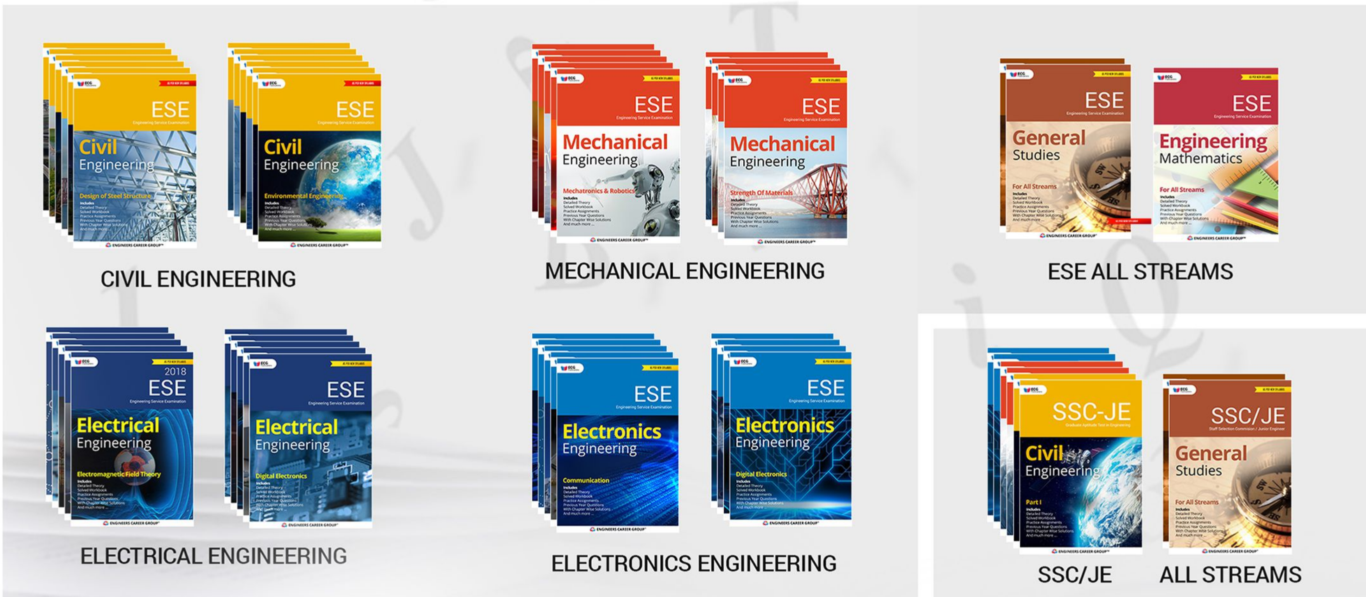


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